

TECHNICAL MANUAL
AVIATION UNIT AND INTERMEDIATE
TROUBLESHOOTING MANUAL
FOR
ARMY MODEL
AH-64A HELICOPTER
(NSN 1520-01-106-9519) (EIC: RHA)
THEORY OF OPERATION

SUPERSEDURE NOTICE: This manual supersedes TM 1-1520-238-T-9, dated 05 SEPTEMBER 1990, including all changes.

DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited.

HEADQUARTERS, DEPARTMENT OF THE ARMY
30 APRIL 1992

CHANGE }
NO. 11 }

HEADQUARTERS
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WASHINGTON, D.C., 25 MAY 2001

TECHNICAL MANUAL
AVIATION UNIT AND INTERMEDIATE
TROUBLESHOOTING MANUAL
FOR
ARMY MODEL
AH-64A HELICOPTER
NSN: (1520-01-106-9519) EIC: (RHA)

THEORY OF OPERATION

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TM 1-1520-238-T-9, 30 April 1992 is changed as follows:

1. Remove and insert pages as indicated below. New or changed text material is indicated by a vertical bar in the margin. An illustration change is indicated by a miniature pointing hand.

Remove pages

A through C/(D blank)
2-3 and 2-4
16-37 through 16-40

Insert pages

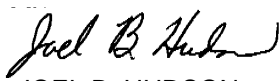
A through C/(D blank)
2-3 and 2-4
16-37 through 16-40

2. Retain this sheet in front of manual for reference purposes.

By Order of the Secretary of the Army:

ERIC K. SHINSEKI
General, United States Army
Chief of Staff

Official: _____


JOEL B. HUDSON
Administrative Assistant to the
Secretary of the Army

0110905

DISTRIBUTION:

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TM 1-1520-238-T-9

CHANGE }
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TECHNICAL MANUAL
AVIATION UNIT AND INTERMEDIATE
TROUBLESHOOTING MANUAL
FOR
ARMY MODEL
AH-64A HELICOPTER
NSN: (1520-01-106-9519) EIC: (RHA)
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Remove pages

Insert pages

22-19 and 22-20

A through C/(D) blank)

22-19 and 22-20

2. Retain this sheet in front of manual for reference purposes.

TM 1-1520-238-T-9

C10

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*Administrative Assistant to the
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0007004

ERIC K. SHINSEKI

*General, United States Army
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AVIATION UNIT AND INTERMEDIATE
TROUBLESHOOTING MANUAL
FOR
ARMY MODEL
AH-64A HELICOPTER
NSN: (1520-01-106-9519) EIC: (RHA)
THEORY OF OPERATION

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1. Remove and insert pages as indicated below. New or changed text material is indicated by a vertical bar in the margin. An illustration change is indicated by a miniature pointing hand.

Remove pages

v and vi
18-1 through 18-6
- - - -
Glossary 7 and Glossary 8
Glossary 13 and Glossary 14

Insert pages

v and vi
18-1 through 18-6
18-6.1 through 18-6.3/(18-6.4 blank)
Glossary 7 and Glossary 8
Glossary 13 and Glossary 14

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By Order of the Secretary of the Army:

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JOEL B. HUDSON

Administrative Assistant to the
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CHANGE }
NO. 8 }

HEADQUARTERS
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**TECHNICAL MANUAL
AVIATION UNIT AND INTERMEDIATE
TROUBLESHOOTING MANUAL
FOR
ARMY MODEL
AH-64A HELICOPTER
NSN: (1520-01-106-9519) EIC: (RHA)
THEORY OF OPERATION**

DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited.

TM 1-1520-238-T-9, 30 April 1992 is changed as follows:

1. Remove and insert pages as indicated below. New or changed text material is indicated by a vertical bar in the margin. An illustration change is indicated by a miniature pointing hand.

Remove pages

i and ii
v and vi
1-1 and 1-2
10-1 and 10-2
10-5 and 10-6
10-9 through 10-12
10-19 and 10-20
16-1 through 16-4
16-4.1 through 16.4.3/(16-4.4 blank)

16-16 through 16-18
16-18.1 through 16.18.5/(16.18.6 blank)

16-19 through 16-22
Glossary 3 through Glossary 16

Insert pages

i and ii
v and vi
1-1 and 1-2
10-1 and 10-2
10-5 and 10-6
10-9 through 10-12
10-19 and 10-20
16-1 through 16-4
16-4.1 through 16-4.4
16-4.5/(16-4.6 blank)
16-16 through 16-18
16-18.1 through 16-18.6
16-18.7/(16-18.8 blank)
16-19 through 16-22
Glossary 3 through Glossary 16

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Official:


JOEL B. HUDSON

**Administrative Assistant to the
Secretary of the Army
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**DENNIS J. REIMER
General, United States Army
Chief of Staff**

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CHANGE }
NO.7 }

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**AVIATION UNIT AND INTERMEDIATE
TROUBLESHOOTING MANUAL
FOR
ARMY MODEL
AH-64A HELICOPTER
NSN: (1520-01-106-9519) EIC: (RHA)
THEORY OF OPERATION**

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1. Remove and insert pages as indicated below. New or changed text material is indicated by a vertical bar in the margin. An illustration change is indicated by a miniature pointing hand.

Remove pages

i and ii
v and vi
4-15 and 4-16
5-7 through 5-10
6-7 and 6-8
9-13 and 9-14
11-15/(11-16 blank)
14-1 and 14-2

14-3 through 14-6

14-7 through 14-10
14-41 through 14-44

14-45 and 14-46
14-49 through 14-54
14-57 and 14-58
14-61 through 14-64

14-65 through 14-67/(14-68 blank)
16-1 through 16-4.2

16-7 and 16-8
---- 16-8.1/(16-8.2 blank)
16-9 and 16-10
16-17 and 16-18
16-23 and 16-24
16-35 through 16-38
16-41 through 16-43/(16-44 blank)

22-31 through 22-34
Glossary-1 through Glossary-16
Index-1 through Index-12

Insert pages

i and ii
v and vi
4-15 and 4-16
5-7 through 5-10
6-7 and 6-8
9-13 and 9-14
11-15/(11-16 blank)
14-1 and 14-2
14-2.1 and 14-2.2
14-3 through 14-6
14-6.1/(14-6.2 blank)
14-7 through 14-10
14-41 through 14-44
14-44.1/(14-44.2 blank)
14-45 and 14-46
14-49 through 14-54
14-57 and 14-58
14-61 through 14-64
14-64.1 through 14-64.11/(14-64.12
blank)
14-65 through 14-67/(14-68 blank)
16-1 through 16-4.2
16-4.3/(16-4.4 blank)
16-7 and 16-8

16-9 and 16-10
16-17 and 16-18
16-23 and 16-24
16-35 through 16-38
16-41 through 16-44
16-45 through 16-47/(16-48 blank)
22-31 through 22-34
Glossary-1 through Glossary-16
Index-1 through Index-12

2. Retain this sheet in front of manual for reference purposes.

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Official:



JOEL B. HUDSON
*Administrative Assistant to the
Secretary of the Army*
02545

DENNIS J. REIMER
*General, United States Army
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NO. 6

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AVIATION UNIT AND INTERMEDIATE
TROUBLESHOOTING MANUAL
FOR
ARMY AH-64A HELICOPTER
NSN: (1520-01-106-9519) EIC: (RHA)

THEORY OF OPERATION

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1. Remove and insert pages as indicated below. New or changed text material is indicated by a vertical bar in the margin. An illustration change is indicated by a miniature pointing hand.

Remove pages

v and vi

4-5 through 4-8

4-15 through 4-18

5-5 and 5-6

6-1 and 6-2

6-21 and 6-22

14-61 and 14-62

14-65 and 14-66

18-1 through 18-6

20-11 through 20-14

21-19 and 21-20

22-19 and 22-20

Insert pages

v and vi

4-5 through 4-8

4-15 through 4-18

5-5 and 5-6

6-1 and 6-2

6-21 and 6-22

14-61 and 14-62

14-65 and 14-66

18-1 through 18-6

20-11 through 20-14

21-19 and 21-20

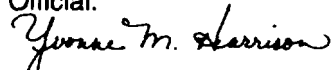
22-19 and 22-20

2. Retain this sheet in front of manual for reference purposes.

TM 1-1520-238-T-9
C6

By Order of the Secretary of the Army:

Official:



YVONNE M. HARRISON
*Administrative Assistant to the
Secretary of the Army*
01291

DENNIS J. REIMER
General, United States Army
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NO. 5

HEADQUARTERS
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AVIATION UNIT AND INTERMEDIATE
TROUBLESHOOTING MANUAL
FOR
ARMY MODEL
AH-64A HELICOPTER
NSN (1520-01-106-9519) EIC: (RHA)

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TM 1-1 520-238-T-9, 30 April 1992, is changed as follows:

1. Remove and insert pages as indicated below. New or changed text material is indicated by a vertical bar in the margin. An illustration change is indicated by a miniature pointing hand.

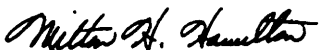
Remove pages
4-5 through 4-8
6-7 and 6-8
10-13 and 10-14
10-25 and 10-26
15-15 and 15-16
22-3 and 22-4

Insert pages
4-5 through 4-8
6-7 and 6-8
10-13 and 10-14
10-25 and 10-26
15-15 and 15-16
22-3 and 22-4

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By Order of the Secretary of the Army:

Official:


MILTON H. HAMILTON
Administrative Assistant to the
Secretary of the Army
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GORDON R. SULLIVAN
General, United States Army
Chief of Staff

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CHANGE

NO. 4

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WASHINGTON, D.C., 30 December 1993

Aviation Unit and Intermediate
Troubleshooting Manual
for
ARMY MODEL
AH-64A HELICOPTER
(NSN 1520-01-106-9519) (EIC: RHA)
THEORY OF OPERATION

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Remove pages

v and vi
2-3 and 2-4
4-5 and 4-6
4-11 and 4-12
6-1 and 6-2
16-3 and 16-4
16-7 and 16-8
16-24.1 and 16-24.2
22-1 and 22-2

Insert pages

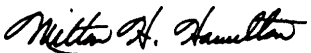
v and vi
2-3 and 2-4
4-5 and 4-6
4-11 and 4-12
6-1 and 6-2
16-3 and 16-4
16-7 and 16-8
16-24.1 and 16-24.2
22-1 and 22-2

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By Order of the Secretary of the Army:

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Official:


MILTON H. HAMILTON
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URGENT

TM 1-1520-238-T-9
C3

CHANGE

NO. 3

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D. C., 7 July 1993

Aviation Unit and Intermediate
Troubleshooting Manual
for
ARMY MODEL
AH-64A HELICOPTER
(NSN 1520-01-106-9519) (EIC: RHA)
THEORY OF OPERATION

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Remove pages

v and vi
8-7 through 8-10
6-19 and 6-20
8-3 and 8-4
15-1 and 15-2

Insert pages

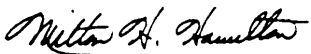
v and vi
6-7 through 6-10
6-19 and 6-20
8-3 and 8-4
15-1 through 15-2.1/(15-2.2 blank)

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By Order of the Secretary of the Army:

GORDON R. SULLIVAN
General, United States Army
Chief of Staff

Official:


MILTON H. HAMILTON
*Administrative Assistant to the
Secretary of the Army*

03931

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CHANGE }
NO. 2 }

HEADQUARTERS
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WASHINGTON, D.C., 15 January 1993

Aviation Unit and Intermediate
Troubleshooting Manual
For
Army Model

AH-64A HELICOPTER
(NSN 1520-01-106-9519) (EIC: RHA)

Theory of Operation

DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited

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1. Remove and insert pages as indicated below. New or changed text material is indicated by a vertical bar in the margin. An illustration change is indicated by a miniature pointing hand.

Remove pages

v and vi
2-1 and 2-2
3-3 and 3-4
5-5 through 5-8
11-1 through 11-4
11-9 and 11-10
11-13 and 11-14
12-1 and 12-2
12-5 and 12-6
12-9 and 12-10
13-1 and 13-2
13-5 through 13-8
14-15 and 14-16
14-55 and 14-56
15-5 and 15-6
16-4.1/(16-4.2 blank)
16-25 through 16-32
- - - -

17-1 and 17-2
17-9 and 17-10
22-3 and 22-4

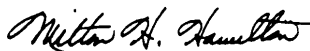
Insert pages

v and vi
2-1 and 2-2
3-3 and 3-4
5-5 through 5-8
11-1 through 11-4
11-9 and 11-10
11-13 and 11-14
12-1 and 12-2
12-5 and 12-6
12-9 and 12-10
13-1 and 13-2
13-5 through 13-8
14-15 and 14-16
14-55 and 14-56
15-5 and 15-6
16-4.1 and 16-4.2
16-25 through 16-32
16-32.1 through 16-32.3/
(16-32.4 blank)
17-1 and 17-2
17-9 and 17-10
22-3 and 22-4

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By Order of the Secretary of the Army:

Official:

A handwritten signature in black ink, appearing to read "Milton H. Hamilton".

MILTON H. HAMILTON
*Administrative Assistant to the
Secretary of the Army*
03627

GORDON R. SULLIVAN
*General, United States Army
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CHANGE }
NO. 1 }

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AVIATION UNIT AND INTERMEDIATE
TROUBLESHOOTING MANUAL
FOR
ARMY MODEL

AH-64A HELICOPTER
(NSN 1520-01-106-9519) (EIC: RHA)

THEORY OF OPERATION

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1. Remove and insert pages as indicated below. New or changed text material is indicated by a vertical bar in the margin. An illustration change is indicated by a miniature pointing hand.

Remove pages

5-1 through 5-16
7-1 through 7-4
10-13 and 10-14
10-25 and 10-26
12-9 through 12-14
13-1 and 13-2
13-5 through 13-8
14-1 and 14-2
16-1 through 16-4
- - - -
16-17 and 16-18
- - - -

16-21 through 16-24
- - - -

19-1 through 19-4
20-9 through 20-16
20-19 and 20-20
22-11 and 22-12
22-37/22-38
Glossary-1 through
Glossary-15/Glossary-16
Index-3 through Index-13/
Index-14

Insert pages

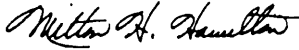
5-1 through 5-10
7-1 through 7-4
10-13 and 10-14
10-25 and 10-26
12-9 through 12-14
13-1 and 13-2
13-5 through 13-8
14-1 and 14-2
16-1 through 16-4
16-4.1/16-4.2
16-17 and 16-18
16-18.1 through 16-18.5/
16-18.6
16-21 through 24
16-24.1 through 16-24.3/
16-24.4
19-1 through 19-4
20-9 through 20-16
20-19 and 20-20
22-11 and 22-12
22-37/22-38
Glossary-1 through
Glossary-16
Index-3 through Index-13/
Index-14

2. Retain this sheet in front of manual for reference purposes.

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Official:



MILTON H. HAMILTON

*Administrative Assistant to the
Secretary of the Army*

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INSERT LATEST CHANGED PAGES: DESTROY SUPERSEDED PAGES.

LIST OF EFFECTIVE PAGES

NOTE: The portion of the text affected by the changes is indicated by a vertical line in the outer margins of the page. Changes to illustrations are indicated by miniature pointing hands. Changes to wiring diagrams are indicated by shaded areas.

Date of issue for original and change pages are:

Original	0	30 April 1992	Change	6	1 February 1996
Change	1	15 December 1992	Change	7	30 September 1996
Change	2	15 January 1993	Change	8	19 December 1997
Change	3	7 July 1993	Change	9	27 February 1998
Change	4	30 December 1993	Change	10	3 May 2000
Change	5	28 December 1994	Change	11	25 May 2001

TOTAL NUMBER OF PAGES IN THIS PUBLICATION IS 608, CONSISTING OF THE FOLLOWING:

Page No.	*Change No.	Page No.	*Change No.
Cover	0	6-20	3
Blank	0	6-21	0
A – C Added	11	6-22	6
D Blank Added	11	6-23 – 6-31	0
a – b	0	6-32 Blank	0
i	8	7-1	0
ii – v	0	7-2 – 7-4	1
vi	9	7-5 – 7-16	0
1-1	0	8-1 – 8-3	0
1-2	8	8-4	3
1-3 – 1-6	0	8-5	0
2-1	2	8-6 Blank	0
2-2	0	9-1 – 9-12	0
2-3	11	9-13	7
2-4	4	9-14 – 9-15	0
2-5 – 2-9	0	9-16 Blank	0
2-10 Blank	0	10-1 – 10-2	8
3-1 – 3-2	0	10-3 – 10-4	0
3-3	2	10-5 – 10-6	8
3-4 – 3-7	0	10-7 – 10-9	0
3-8 Blank	0	10-10 – 10-11	8
4-1 – 4-4	0	10-12	0
4-5 – 4-7	6	10-13	5
4-8 – 4-10	0	10-14 – 10-18	0
4-11 – 4-12	4	10-19	8
4-13 – 4-14	0	10-20 – 10-24	0
4-15	7	10-25	5
4-16 – 4-18	6	10-26 – 10-31	0
5-1 – 5-4	1	10-32 Blank	0
5-5	2	11-1	2
5-6	6	11-2 – 11-3	0
5-7	2	11-4	2
5-8 – 5-9	7	11-5 – 11-9	0
5-10	1	11-10	2
5-11 – 5-16 Deleted	1	11-11 – 11-13	0
6-1	6	11-14	2
6-2 – 6-6	0	11-15	7
6-7	5	11-16 Blank	7
6-8	7	12-1	0
6-9	3	12-2	2
6-10 – 6-19	0	12-3 – 12-5	0

*Zero in this column indicates an original page.

INSERT LATEST CHANGED PAGES: DESTROY SUPERSEDED PAGES.

LIST OF EFFECTIVE PAGES

Page No.	*Change No.	Page No.	*Change No.
12-6	2	16-4.1 – 16-4.4	8
12-7 – 12-8	0	16-4.5 Added	8
12-9	2	16-4.6 Blank Added	8
12-10 – 12-11	1	16-5 – 16-6	0
12-12	0	16-7	4
12-13	1	16-8	7
12-14 – 12-17	0	16-8.1 Added	7
12-18 Blank	0	16-8.2 Blank Added	7
13-1	1	16-9	7
13-2	2	16-10 – 16-15	0
13-3 – 13-5	0	16-16	8
13-6 – 13-8	2	16-17	7
14-1 – 14-2	7	16-18	8
14-2.1 Added	7	16-18.1 – 16-18.6	8
14-2.2 Added	7	16-18.7 Added	8
14-3 – 14-6	7	16-18.8 Blank Added	8
14-6.1 Added	7	16-19	8
14-6.2 Blank Added	7	16-20	0
14-7	0	16-21	8
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LIST OF EFFECTIVE PAGES

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19-2	0	22-33	7
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21-20	6	Glossary-14 – Glossary-16	8
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*Zero in this column indicates an original page.

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D. C., 30 April 1992

TECHNICAL MANUAL
AVIATION UNIT AND INTERMEDIATE
TROUBLESHOOTING MANUAL
FOR
ARMY MODEL
AH-64A HELICOPTER
(NSN 1520-01-106-9519) (EIC: RHA)

REPORTING ERRORS AND RECOMMENDING IMPROVEMENTS

You can help improve this manual. If you find any mistakes, or if you know of a way to improve the procedures, please let us know. Mail your letter, DA Form 2028 (Recommended Changes to Publications and Blank Forms), or DA Form 2028-2 located in the back of this manual directly to: Commander, U.S. Army Aviation and Missile Command, ATTN: AMSAM-MMC-MA-NP, Redstone Arsenal, AL 35898-5230. A reply will be furnished directly to you.

You may also submit your recommended changes by E-mail directly to 2028@redstone.army.mil or by fax 256-842-6546/DSN 788-6546. Instructions for sending an electronic 2028 may be found at the end of this manual immediately preceding the hard copy 2028.

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* **SUPERSEDURE NOTICE:** This manual supersedes TM 1-1520-238-T-9, dated 05 SEPTEMBER 1990, including all changes.

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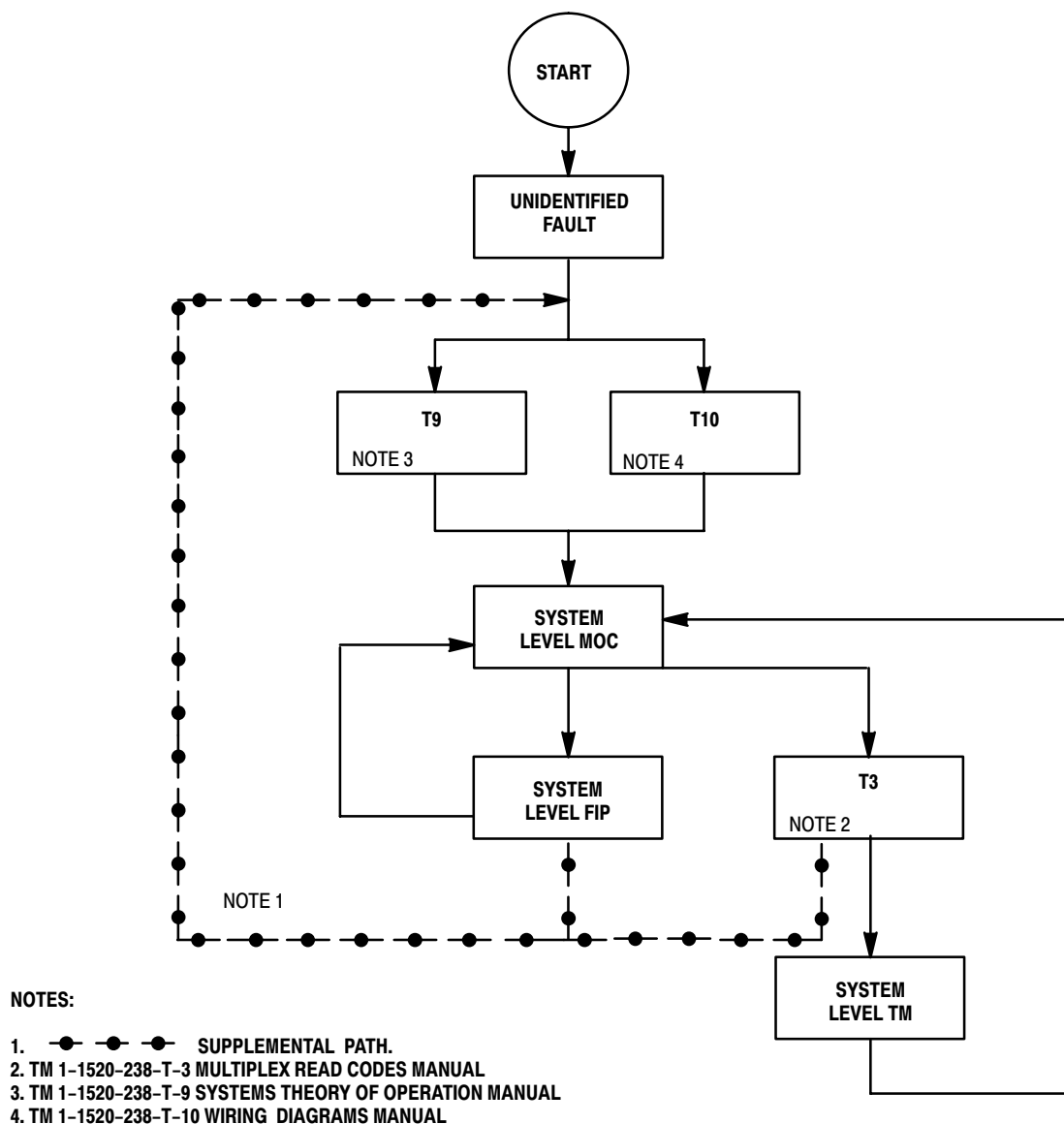
HOW TO USE THIS VOLUME

GENERAL

This volume (TM 1-1520-238-T-9) may be used in conjunction with the wiring information in the Army AH-64A helicopter Wiring Diagrams volume (TM 1-1520-238-T-10) to troubleshoot any fault not isolated by the appropriate maintenance operational check (MOC) and the associated fault isolation procedures (FIPs), the Army AH-64A helicopter Multiplex Read Codes volume (TM 1-1520-238-T-3), or the Army AH-64A helicopter Fault Detection/Location System (FD/LS) manual (TM 1-1520-238-T-1)

After the fault has been identified and the suspected component(s) is (are) replaced, the MOC, the multiplex read codes and/or the FD/LS must be performed again to prove the system is operational.

The following diagram shows how this volume relates to the other troubleshooting volumes within this manual and to other manuals.



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Use of this Volume to Isolate Faults that the Normal Troubleshooting Process Failed to Isolate

HOW TO USE THIS VOLUME (cont)

OVERVIEW

If you can't find information, you can't do the job. Learn how to use this volume. Check how the volume is put together. Look at these examples. Before using the volume, learn how it works.

CHAPTERS

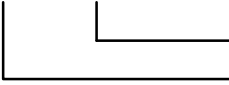
The volume is made up of chapters. The chapters are made up of paragraphs and all are numbered. Chapter 1 contains several paragraphs on introductory discussion, general information about the AH-64A helicopter physical configuration and the features of the 22 systems installed aboard the AH-64A helicopter. Chapters 2 through 23 have three paragraphs which present the system's purpose, major components, and theory of operation.

PARAGRAPHS

Paragraphs make up chapters. The paragraph contains the information you need to do the job. USE A PARAGRAPH NUMBER TO FIND THE INFORMATION YOU NEED. DON'T USE THE PAGE NUMBERS unless you are using the Table of Contents which shows page numbers.

Paragraph numbers are in two parts separated by a dash as shown in the example. The first is the chapter number. The second is the paragraph number.

15 - 1



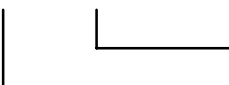
Paragraph

Chapter

PAGE NUMBERING

All page numbering is by chapters. The first number is the number of the chapter; the second number is the number of the page in that chapter. The numbers are separated by a dash as shown in the example.

15 - 1



Page

Chapter

NOTE

Page numbers are not used to find information. Use paragraph numbers.

HOW TO USE THIS VOLUME (cont)

APPENDIX

APPENDIX A lists all official publications referenced in this volume.

GLOSSARY

The glossary in this volume is a list of abbreviations and acronyms. Abbreviations are shortened terms for words. Acronyms are shortened terms for several words and may use only the first letter of each of the words. Abbreviations and acronyms are defined the first time they are used within the text of the chapter where they are found. The list in the glossary is the place to check if you have any doubt.

Look over the glossary and become familiar with abbreviations, acronyms, and unusual terms.

INDEX

An alphabetical index is located in the back of this volume. The index lists all paragraph titles in an alphabetical order. After you find the title in the index, it tells the paragraph number. For example, if you need information on theory of operation for the area weapons system, go to the "A" section of the index and look under area weapons system. There you will find:

Area Weapons System Theory of Operation (Para) 20–3

The index informs you that the area weapons system theory of operation is in chapter 20, paragraph 3. The information may also be located in the "T" section of the index under the heading "Theory of Operation."

USING AH-64A HELICOPTER EFFECTIVITY CODES


Helicopter effectivity codes designate differences between helicopters by helicopter serial numbers. These codes consist of three letters that represent various helicopter serial number blocks.

The codes are used to designate serial number block differences as follows:

When used within narrative text and fault isolation procedures, effectivity codes appear within parenthesis.

For Example: Narrative text and fault isolation procedures (AAA)

When used inside interconnect diagrams and major component locations, effectivity codes appear within triangular borders and are placed on the line which represents that particular helicopter's configuration.

For Example: Wiring interconnect diagrams 

This volumes uses these effectivity codes and corresponding helicopter serial numbers for reference.

HOW TO USE THIS VOLUME (cont)

To use the helicopter effectivity codes, note the helicopter serial number on the left side of the fuselage directly below the CPG window. Use this serial number to determine which procedure to use or which path in an interconnection diagram or fault isolation procedure to use.

The effectivity codes and helicopter serial number blocks applicable to this volume are as follows:

<u>Effectivity Code</u>	<u>Helicopter Serial No.</u>
AAA	82-23355 thru 82-23365
AAK	82-23355 thru 85-25488
AAN	83-23787 thru 85-25415
ABD	82-23355 thru 85-25415
ABQ	86-8940 and Subsequent
ACA	82-23355 thru 88-0199
ACB	88-0200 and Subsequent
ACD	85-25416 and Subsequent
ACJ	82-23355 thru 90-0290, 90-0292 thru 90-0301 (Before MWO 1-1520-238-50-07)
ACK	82-23355 thru 90-0290, 90-0292 thru 90-0301 (After MWO 1-1520-238-50-07) 90-0291, 90-0302 and Subsequent
ACQ	82-23355 thru 90-0448 (Before MWO 1-1520-238-50-36)
ACR	82-23355 thru 90-0448 (After MWO 1-1520-238-50-36) 90-0449 and Subsequent
ACV	89-0192 thru 90-0434 with T700-GE-701C engines (Before MWO 1-1520-238-50-38)
ACW	89-0192 thru 90-0434 with T700-GE-701C engines (After MWO 1-1520-238-50-38) 90-0435 and subsequent with T700-GE-701C engines
ACY	82-23355 thru 92-0485 (Before MWO 9-1230-476-50-01)
ACZ	82-23355 thru 92-0485 (After MWO 9-1230-476-50-01) 94-0328 and Subsequent
ADC	Before MWO 1-1520-238-50-49
ADD	After MWO 1-1520-238-50-49
ADF	Before MWO 1-1520-238-50-52
ADG	After MWO 1-1520-238-50-52
ADH	Before MWO 1-1520-238-50-15
ADI	After MWO 1-1520-238-50-15
ADN	AN/APR-39(V)1 installed
ADO	AN/APR-39A(V)1 installed
ADP	After MWO 1-1520-238-50-50

CHAPTER 1 INTRODUCTION

CHAPTER INDEX

<u>Para Title</u>	<u>Para No.</u>
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Scope	1-1
Maintenance Forms, Records, and Reports	1-2
Destruction of Army Material to Prevent Enemy Use	1-3
Quality Assurance/Quality Control	1-4
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AH-64A Helicopter System Interfaces	1-7
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SECTION I. GENERAL INFORMATION

1-1. SCOPE

This theory of operation manual is an Aviation Unit Maintenance (AVUM) and Aviation Intermediate Maintenance (AVIM) volume. The material will assist you to understand the overall description and principles of operation of integrated helicopter systems and how they interrelate. The information presented enhances information contained in the system/subsystem troubleshooting manuals. The information contained in this manual may be used by anyone capable of using the present AH-64A technical manuals. (Appendix A lists all official publications referenced in this manual).

1-2. MAINTENANCE FORMS, RECORDS AND REPORTS

1-2**1-2. MAINTENANCE FORMS, RECORDS, AND REPORTS**

Department of Army forms and instructions for those forms will be those described by DA PAM 738-751, The Army Maintenance Management System–Aircraft (TAMMS-A).

1-3. DESTRUCTION OF ARMY MATERIAL TO PREVENT ENEMY USE

Destruction procedures you need to know are found in TM 750-244-1-5, Procedures for the Destruction of Aircraft and Associated Equipment to Prevent Enemy Use.

1-4. QUALITY ASSURANCE/QUALITY CONTROL

Quality assurance information you are required to use is explained in FM 1-511, Army Aircraft Quality Control and Technical Inspection.

1-5. DEFICIENCY REPORTING

If your equipment needs correction or improvement, let us know. Send us a Deficiency Report. You, the user, are the only one who can tell us what you don't like about the design. Put it on SF 368 (Quality Deficiency Report). Mail it to us at Commander, U.S. Army Aviation and Missile Command, Attn: AMSAM-MMC-RE-FD, Redstone Arsenal, AL 35898-5230. A reply will be furnished directly to you.

SECTION II. EQUIPMENT DESCRIPTION AND DATA**1-6. GENERAL**

The AH-64A advanced attack helicopter (fig. 1-1) is a twin engine helicopter designed specifically for the attack helicopter role. The helicopter accommodates an aircrew of two in a tandem configuration. The helicopter delivers various combinations of ordnance while providing maximum helicopter survivability and aircrew protection.

a. Maximum helicopter survivability is achieved by providing redundant systems/components, flight maneuverability and agility, critical components ballistic resistance, high impact survivability, reduced detectability, and wire strike protection.

b. The wings provide mounting surfaces for four external pylons, which can carry external fuel tanks, point target missiles, 2.75-inch folding fin aerial rocket (FFAR) launchers, or a symmetrically loaded combination of any two weapon racks.

c. A turret-mounted 30 mm chain gun, under the forward fuselage, can fire as many as 625 rounds per minute.

d. The helicopter is powered by two T700-GE-701 or T700-GE-701C engines which drive the main rotor through individual engine nose-mounted gearboxes and a main transmission. The main transmission power takeoff shaft drives the tail rotor through intermediate and tail rotor gearboxes.

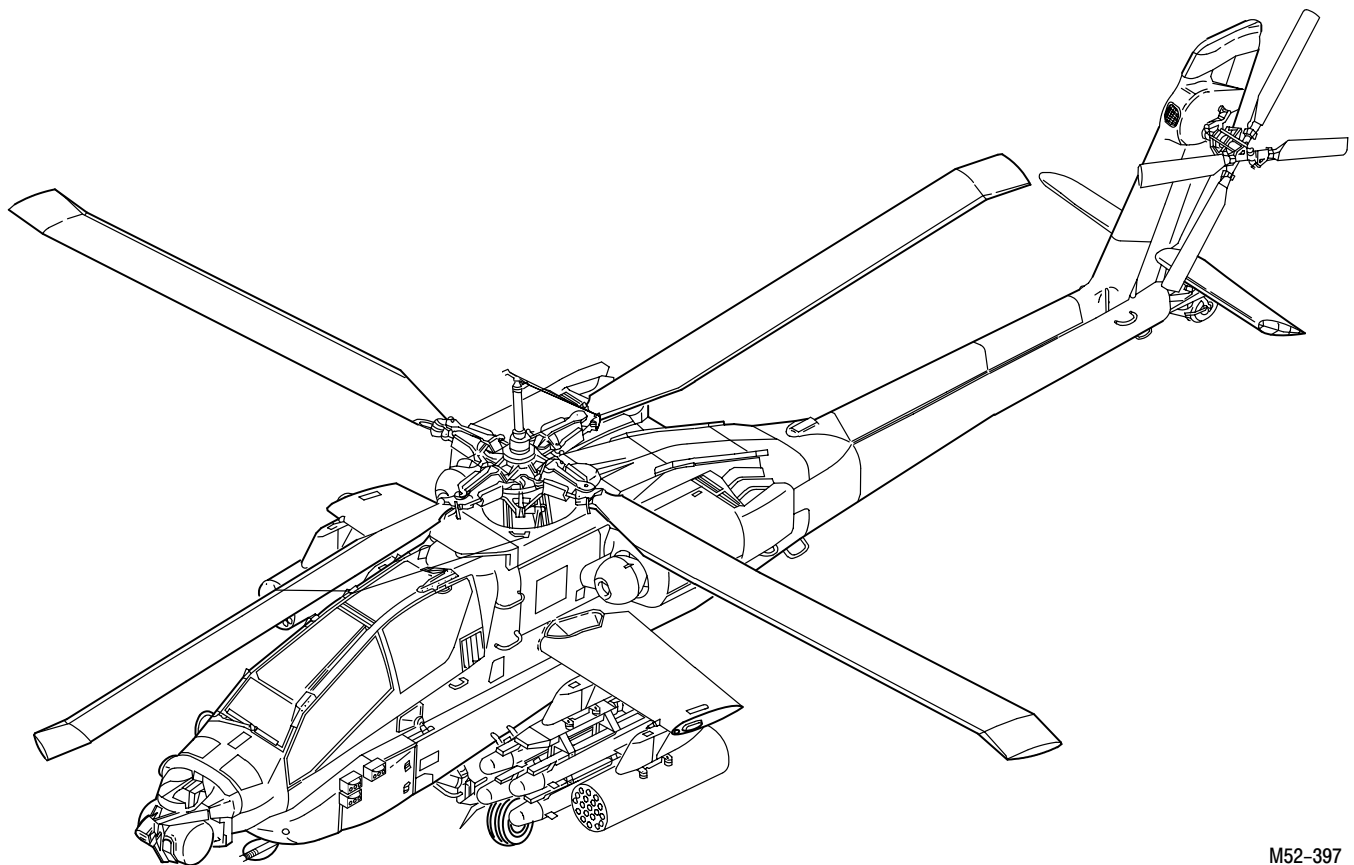
1-6. GENERAL (cont)

1-6

e. The auxiliary power unit (APU) drives the accessory drive section of the main transmission to provide full electrical, pneumatic, and hydraulic power to the helicopter when the main engines are not on line. The APU is also used to provide pressurized air system (PAS) air to start the main engines.

f. The flight controls are mechanically actuated, hydraulically powered, and electrically assisted in all flight control axes.

g. A curved canopy structure provides integral rollover protection. The canopy has a blast shield between the two crew stations. Each crew station contains an adjustable armored seat. The seats incorporate armored wings which pivot to facilitate entrance to, and exit from, the crew stations.



M52-397

Figure 1-1. AH-64A Helicopter

1-7. AH-64A HELICOPTER SYSTEM INTERFACES

The AH-64A is composed of airframe systems/subsystems. Chapters 2 thru 23 of this manual describe the following airframe system/subsystems.

a. **Airframe.** The airframe (Chapter 2) is a one-piece integral design. The airframe provides mounting points for the helicopter systems and components, and absorbs load during high-impact landings. The wings mount two external pylons per wing which provide external stores stations.

1-7. AH-64A HELICOPTER SYSTEM INTERFACES (cont)

1-7

b. **Landing Gear System.** The landing gear system (Chapter 3) supports the helicopter during ground operations and enhances survivability during high-impact landings. The helicopter has a conventional landing gear system with two main wheel assemblies and a tail wheel assembly.

c. **Fuel System.** The fuel system (Chapter 4) stores and distributes fuel to the engines and auxiliary power unit (APU). The fuel cells are crash worthy with a self-sealing capability and are located fore and aft of the ammunition bay. To prevent fuel cell combustion in the two main fuel cells, a nitrogen-inerting unit (NIU) replaces expended fuel with nitrogen. Auxiliary fuel tanks (extended range kit) are mounted one per pylon on the wings.

d. **Auxiliary Power Unit.** The APU (Chapter 5) drives the main transmission accessory drive section to provide pneumatic, hydraulic, and electrical power during main engine start and maintenance operations. The APU makes the helicopter self supporting in a field environment by eliminating the need for aviation ground power units (AGPU). The APU also supplies pressurized air to the environmental control system, fuel transfer system, fuel boost system, and utility and external air receptacles during ground operations when main engines are not on line.

e. **Engine System.** The engine system (Chapter 6) drives the main transmission. The engine system consists of two T700-GE-701 or T700-GE-701C front-drive turboshaft engines. The engines drive the main transmission through individual engine nose-mounted gearboxes.

f. **Drive System.** The drive system (Chapter 7) drive shafts and gearboxes transmit engine power to the main rotor, tail rotor, and accessories. The gearboxes provide a change of drive angle and RPM reduction. The engine nose-mounted gearboxes drive the main transmission. The main transmission drives the main rotor and the intermediate and tail gearboxes. The intermediate and tail gearboxes drive the tail rotor assembly.

g. **Rotor System.** The rotor system (Chapter 8) is comprised of a four-blade single main rotor and a tail rotor assembly. The main rotor provides lift/thrust and allows each of the four blades to flap, feather, lead or lag independently of each other. The tail rotor assembly provides yaw/anti-torque.

h. **Electrical System.** The electrical system (Chapter 9) provides all electrical power requirements of the helicopter, distributes the power, and provides circuit protection. The electrical system consists of ac and dc systems, and an emergency dc system.

i. **Hydraulic System.** The hydraulic system (Chapter 10) provides power to the flight controls, APU start motor, and hydraulically operated auxiliary equipment. The hydraulic system consists of two independent closed loop systems, and an emergency system.

j. **Flight Controls System.** The flight controls system (Chapter 11) provides control of the helicopter during all flight maneuvers. The flight controls are mechanically actuated, hydraulically powered, and electrically assisted for vertical, longitudinal, lateral, and directional flight control.

k. **Pressurized Air System (PAS).** The PAS (Chapter 12) filters, pressurizes, regulates, and distributes air to the AH-64A pneumatically dependent systems and components.

l. **Environmental Control System (ECS).** The ECS (chapter 13) provides conditioned and/or outside air to the crew stations for crew comfort. The ECS provides cooling air to electrical components located in the forward avionics bays.

m. **Multiplex (MUX) Data Bus System.** The MUX (Chapter 14) is a general-purpose information transfer system. The MUX provides a flexible interface between components/systems and fault detection/location system (FD/LS) signal routing for processing information critical to helicopter survival.

1-7. AH-64A HELICOPTER SYSTEM INTERFACES (cont)

1-7

n. **Instrument Systems.** Instruments (Chapter 15) are grouped into four functional areas.

- (1) Engine. The engine instruments provide system status and operation monitoring.
- (2) Flight. The flight instruments provide attitude, altitude, and airspeed information.
- (3) Navigation. The navigation instruments provide position reference/fixing to permit day, night, and instrument meteorological condition (IMC) flight operations.
- (4) Miscellaneous. Miscellaneous instruments provide additional information on icing, g-force, hydraulic, fuel quantity, and rotor.

o. **Avionics Systems.** Avionics (Chapter 16) provides the AH-64A crew with communication, navigation, and identification aids, heading and altitude reference, automatic stabilization and survivability aids.

p. **Digital Automatic Stabilization Equipment (DASE) System.** The DASE (Chapter 17) provides helicopter hover and flight stabilization to establish a stable weapons platform while decreasing the pilot's workload.

q. **Active and Passive Aircraft Survivability Equipment (ASE).** The ASE (Chapter 18) includes the following systems.

- (1) Radar warning and jamming. The radar warning and jamming equipment detects enemy radar and provides automatic countermeasures against land based or airborne radar systems.
- (2) Infrared (IR) jamming. The IR jamming equipment provides automatic countermeasures against IR seeking missiles.
- (3) Wire strike protection. The wire strike protection equipment protects the helicopter from damage due to striking power lines and other wires during nap-of-the-earth operations.
- (4) Chaff/flare. The chaff/flare equipment provides countermeasures to decoy radar guided weapons away from the aircraft.

r. **Air Data Subsystem (ADSS).** The ADSS (Chapter 19) provides air data information for DASE functions, LDNS operation, fire control solution, and FD/LS.

s. **Armament Systems.** The armament system (Chapter 20) provides quick-response helicopter weapon systems selection, programming, and firing for close-in, medium, and long-range targets. The armament includes the 30mm chain gun, point target weapon system (Hellfire missile), aerial rocket Hydra 70, and external stores.

t. **Sighting/Display System.** The sighting/display system (Chapter 21) includes the target acquisition designation sight (TADS) and pilot night vision sensor (PNVS) assemblies, video recorder, and internal boresight. The TADS provides a means for the CPG to scan the landscape to locate, track, range and designate targets. The PNVS provides a means for the pilot to fly nap-of-the-earth (NOE), and enhances navigation at night or in adverse weather.

u. **Utility System.** The utility system (Chapter 22) includes the following systems.

- (1) Windshield Wipers. The windshield wipers remove moisture from the windshield.
- (2) Anti-ice/De-ice. The anti-ice/de-ice provides heat to remove ice to maintain visibility, engine operation, rotor performance, and air data sensing.

1-7. AH-64A HELICOPTER SYSTEM INTERFACES (cont)

1-7

(3) Defog. The defog provides canopy defogging.

(4) Fire Detection and Extinguishing. The fire detection and extinguishing provides for the detection and extinguishing of fires in the engines, APU and SDC.

(5) Canopy Jettison. The canopy jettison provides a means of jettisoning the canopy.

v. **Exterior Lighting System.** The exterior lighting system (Chapter 23) is composed of the landing/searchlight, navigational lights, anti-collision lights, and formation lights. The exterior lighting provides omnidirectional landing and search visibility during low-visibility conditions, navigational and formation position during flight, and anti-collision warning during takeoff and landing.

1-8. THEORY DESCRIPTIONS

The equipment that makes up each of the systems/subsystems, and the relationships of these system/subsystems to each other, are presented with illustrations and supporting text. Carefully read this material to understand the normal operation of the AH-64A helicopter system interfaces.

2-1. PURPOSE

2-1

CHAPTER 2 AIRFRAME

2-1. PURPOSE

a. The airframe provides mounting points for the helicopter systems/subsystems and components. The design features incorporated into the airframe increase both aircraft and aircrew survivability. The airframe is a one piece integral design that has the strength to withstand compression, tension, torsion, and shearing force loads that exceed the required design limits throughout the entire flight envelope.

b. The fuselage is a semi-monocoque construction which greatly reduces the potential of catastrophic damage to the fuselage. Fuselage strength and rigidity is obtained through the structural members and the skin. Some airframe components are constructed with Kevlar. Kevlar is a synthetic resin-base fiber composite.

2-2. DESCRIPTION

The airframe (ACB) components have silver/aluminum tape, aluminum tape, conductive gaskets and retainers, and conductive surfaces for gaskets installed to prevent electro-magnetic interference (EMI). The airframe includes the following major components.

a. **Canopy.** The canopy (fig. 2-1) is an aluminum frame with five acrylic panels, two glass windshields, and a blast shield. The canopy attaches to the forward and center fuselage sections.

b. **Engine Nacelle.** The engine nacelles (fig. 2-1) are two aluminum alloy structures with titanium fire walls which cover each of the engines and attach to the center fuselage section. The nacelles provide structural support for the engines.

c. **Upper Fairing.** The upper fairing (fig. 2-1) is a Kevlar structure which covers the main transmission, APU, and aft equipment bay, and attaches to the center fuselage section.

d. **Vertical Stabilizer and Fairings.** The vertical stabilizer and fairings (fig. 2-1) are an aluminum alloy structure which attaches to the aft fuselage and tailboom section, and provides mounting points for the horizontal stabilator, gearbox mounts, Kevlar fairings, and VHF antenna.

e. **Horizontal Stabilator.** The horizontal stabilator (fig. 2-1) is an aluminum alloy symmetrical airfoil that is swept and tapered, and attaches to the vertical stabilizer.

f. **Aft Fuselage and Tailboom Section.** The aft fuselage and tailboom section (fig. 2-1) are an aluminum alloy structure which attaches to the center fuselage section to provide the aft avionics bay, flyaway kit storage area, and survival kit bay. The aft fuselage and tailboom section also provides mounts for the tail rotor drive shaft, vertical stabilizer, horizontal stabilator, tail landing gear, utility hydraulic manifold, and Kevlar drive shaft covers.

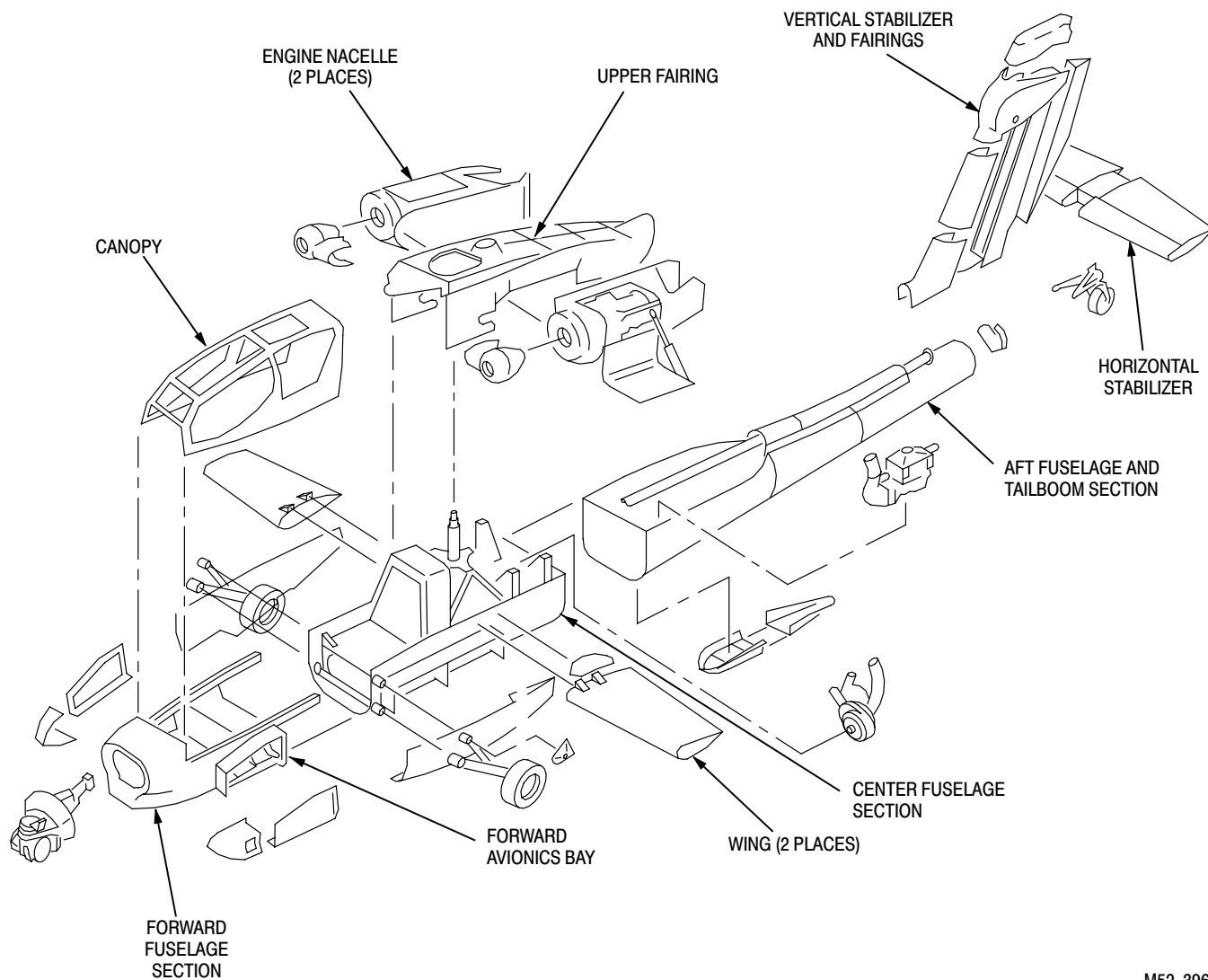
g. **Center Fuselage Section.** The center fuselage section (fig. 2-1) is the primary support structure of the airframe which forms the pilot station and aft equipment bay, and provides mounting points for the canopy, engine nacelles, upper fairing, aft fuselage and tailboom section, wings, forward fuselage section, main transmission, APU, main landing gear (MLG) shock strut, power distribution center, ammo magazine support, and the fuel cells.

h. **Wings.** The wings (fig. 2-1) are two aluminum alloy structures that have four pylons (two per wing), to provide mounting points for external stores, and to provide a maintenance work platform.

2-2. DESCRIPTION (cont)

2-2

i. **Forward Fuselage Section.** The forward fuselage section (fig. 2-1) is an aluminum structure which forms the CPG station, left and right forward avionics bays, attaches to the center fuselage section and provides mounting for TADS/PNVs, FABs, and the gun.



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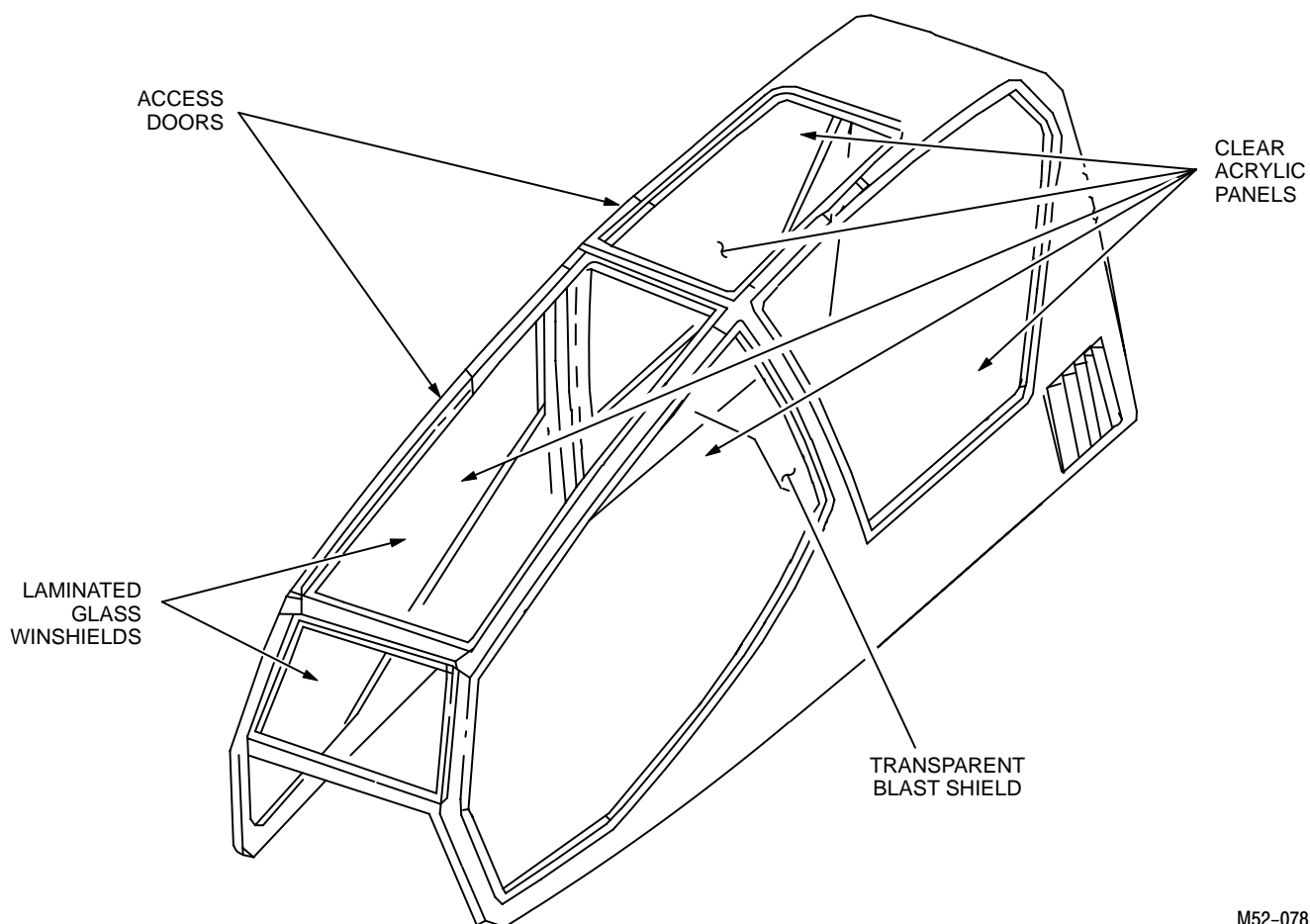
Figure 2-1. Airframe Major Components

2-3. THEORY OF OPERATION (cont)

2-3

2-3. THEORY OF OPERATION

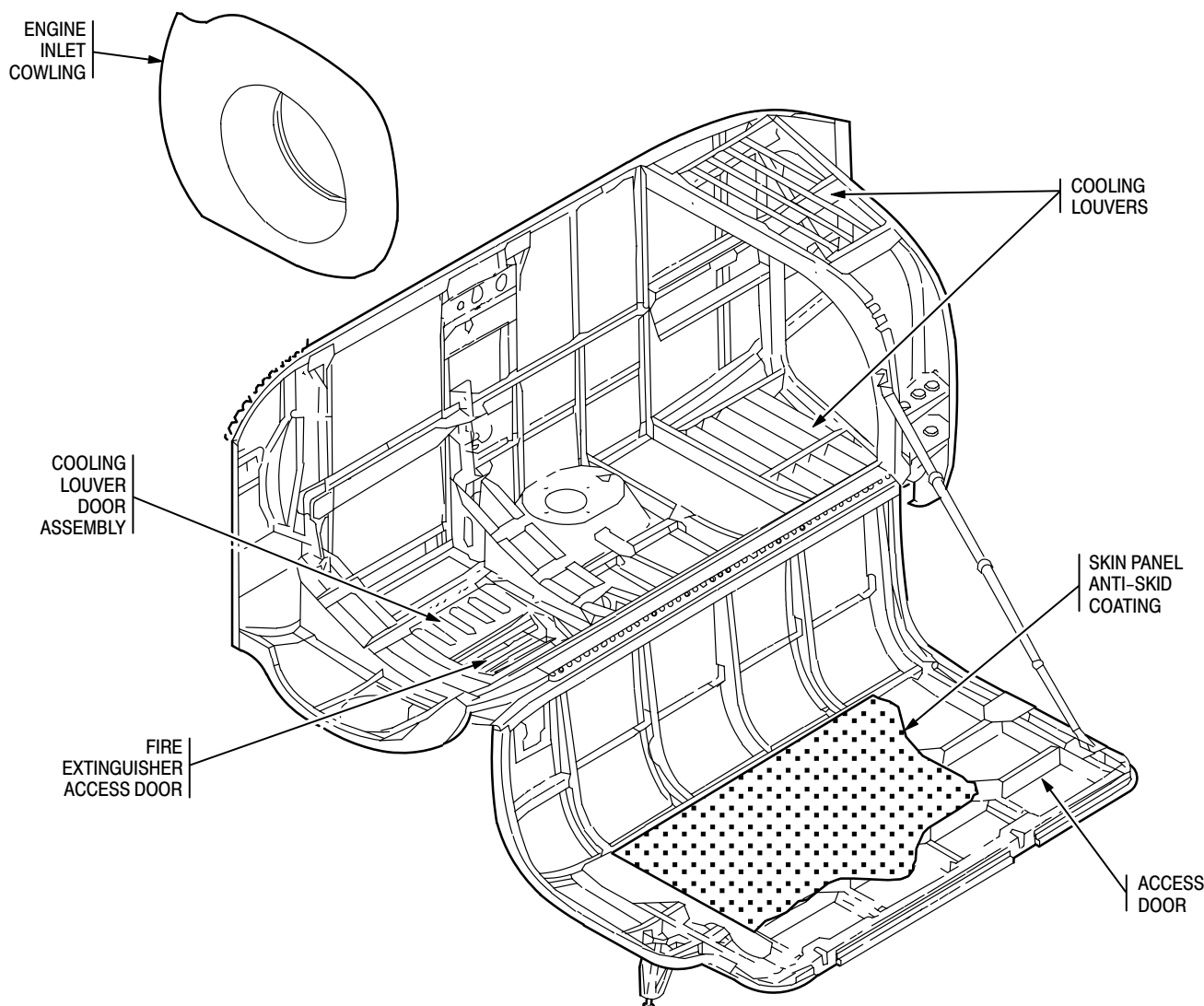
a. **Canopy.** The canopy (fig. 2-2) is an enclosure that provides an aircrew controlled environment while providing protection from the elements. The canopy was designed to aid in crew protection in case of an aircraft rollover. Five clear acrylic panels and two laminated glass windshields are fitted into an aluminum frame to form the side panels and upper canopy panel. Two access doors are attached to the right side of the canopy for aircrew entrance to, and exit from the helicopter. The shatterproof windshields provide anti-ice capabilities. The transparent blast shield prevents fatal injuries to both aircrew members from a single 23mm hit. If the access doors are jammed or blocked a jettison system can be operated by the aircrew to blow out the side panels and provide egress paths.



M52-078

Figure 2-2. Canopy

b. **Engine Nacelles.** Each of the engine nacelles (fig. 2-3) provides engine-to-airframe interface and structural support for each engine while providing protection from the elements. An engine inlet cowl is attached to the inlet section of each engine. Each nacelle has a cooling louver door assembly which is opened to cool the engine. The door assembly is closed by fifth stage engine bleed air and is spring loaded open. Cooling louvers on the top and bottom of the aft section provide cooling air for the engine exhaust infrared (IR) suppression system. The louvers also provide a means for isolating the nacelle in the event of fire. A fire extinguisher access door is also located on each of the nacelles. The access door, when opened to service the engine, becomes a work platform which can support up to 400 pounds. The work platform is coated with an anti-skid material.

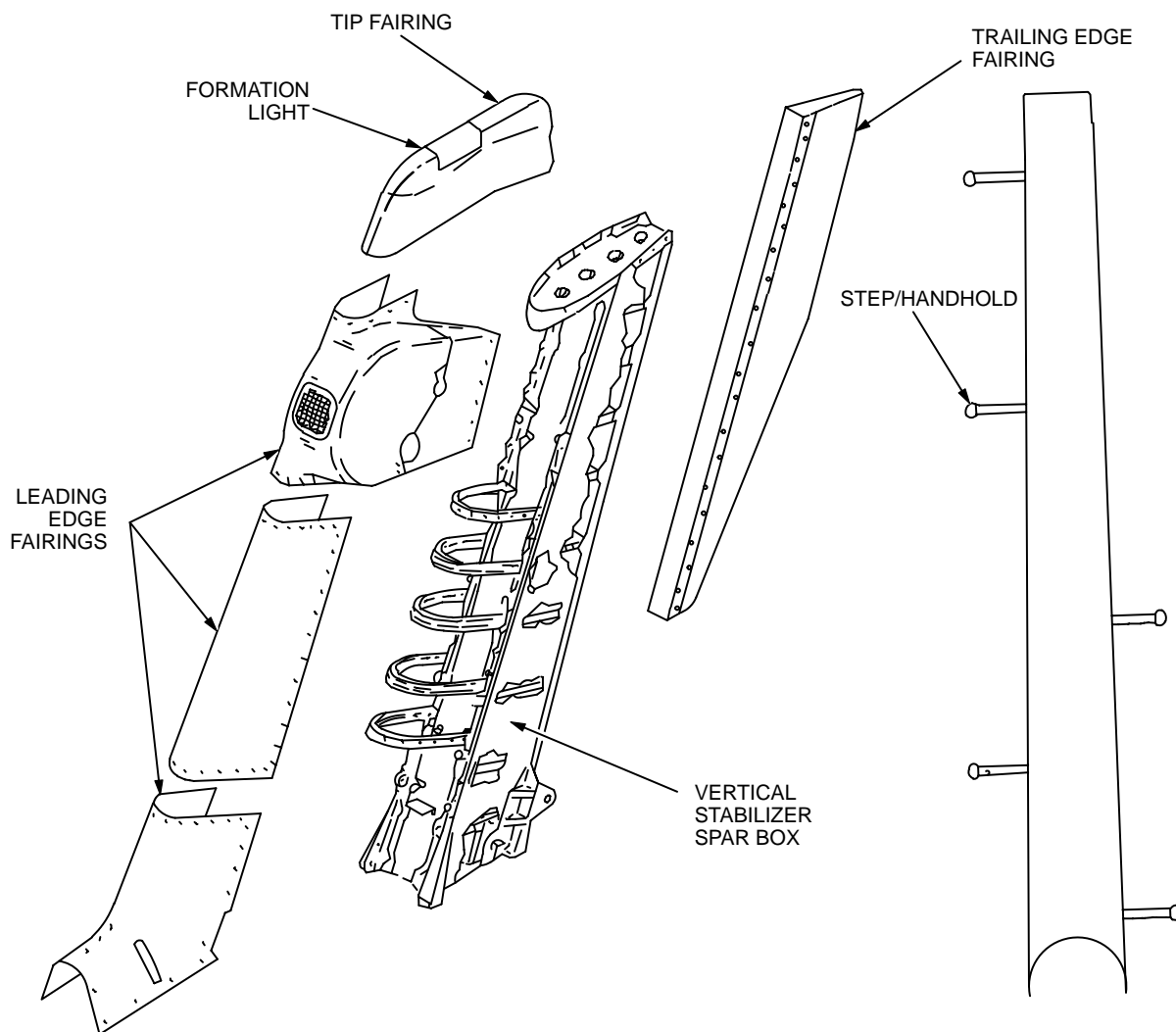


M52-079

Figure 2-3. Engine Nacelle (Typical)

c. **Upper Fairing.** The upper fairing covers the main transmission and APU and provides protection from the elements. The upper fairing, constructed of Kevlar (a synthetic resin-base fiber composite), provides ballistic protection.

d. **Vertical Stabilizer and Fairings.** The vertical stabilizer (fig. 2-4) provides directional stability for the helicopter during forward flight. The vertical stabilizer spar box is the main support structure that provides mounting points for the intermediate gearbox (IGB), tail rotor driveshaft, tail rotor gearbox, (TRG), and horizontal stabilator. The vertical stabilizer contains three leading edge fairings that are attached using quick release fasteners. The tip fairing, located on the tip of the vertical stabilizer, provides mounting for formation and navigation lights, two radar warning antennas, and a very high frequency (VHF) noise canceling antenna (ACS). The trailing edge fairing contains an integral VHF antenna (ACR). Five step/handhold assemblies permit ground personnel to access the vertical stabilizer.

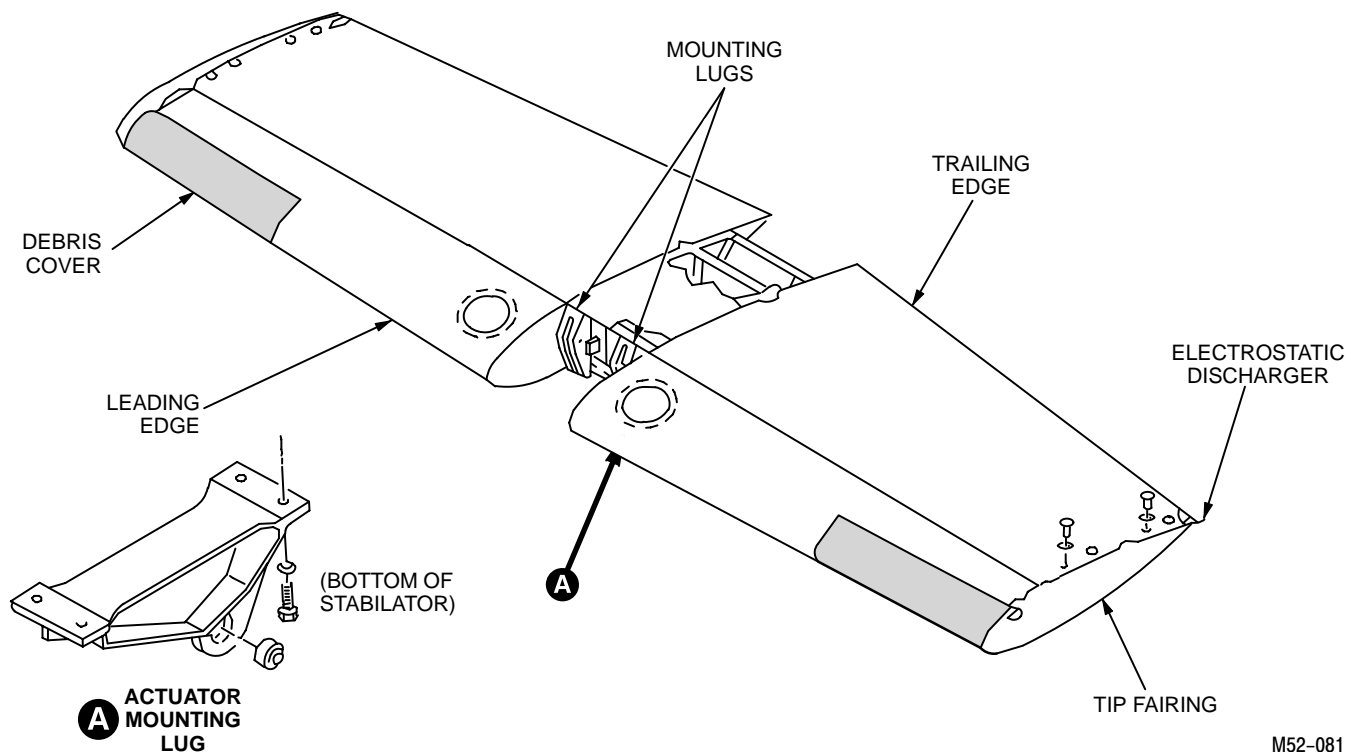


M52-080

Figure 2-4. Vertical Stabilizer

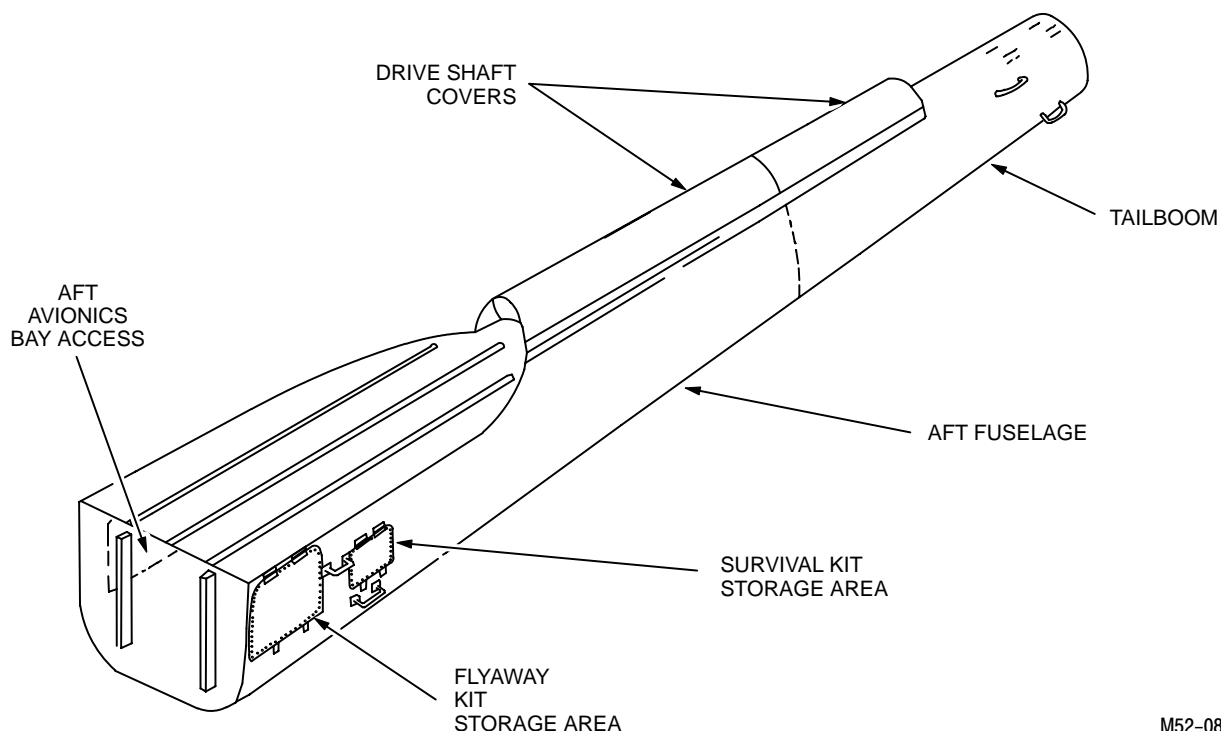
e. **Horizontal Stabilizer.** The horizontal stabilizer (fig. 2-5) improves handling characteristics of the helicopter and enhances the forward field of view. The horizontal stabilizer attaches to the lower portion of the vertical stabilizer. An actuator mounting lug, attached to the lower portion of the horizontal stabilizer, provides a mount for the horizontal stabilizer control actuator. A mounting bracket for the horizontal stabilizer position transducer clamp is also attached to the horizontal stabilizer. Electrostatic dischargers are attached to the left and right trailing edges of the horizontal stabilizer to dissipate static electricity. The horizontal stabilizer has removeable tip fairings. A debris sheet is bonded to a portion of the left and right leading edges and bottom surfaces to protect the skin from missile and rocket launch expulsion debris.

f. **Aft Fuselage and Tailboom Section.** The aft fuselage and tailboom section (fig. 2-6) provides mounting for the utility hydraulic manifold, tail rotor driveshafts 4 and 5, tail landing gear, (TLG) and the vertical stabilizer. Two driveshaft covers protect the driveshafts from the elements. The covers are hinged with quick release fasteners for easy access. The aft avionics bay is accessible from the right side of the fuselage. The flyaway kit storage area is accessible from the left side of the fuselage. The survival kit storage area is accessible from either side of the fuselage catwalk.



M52-081

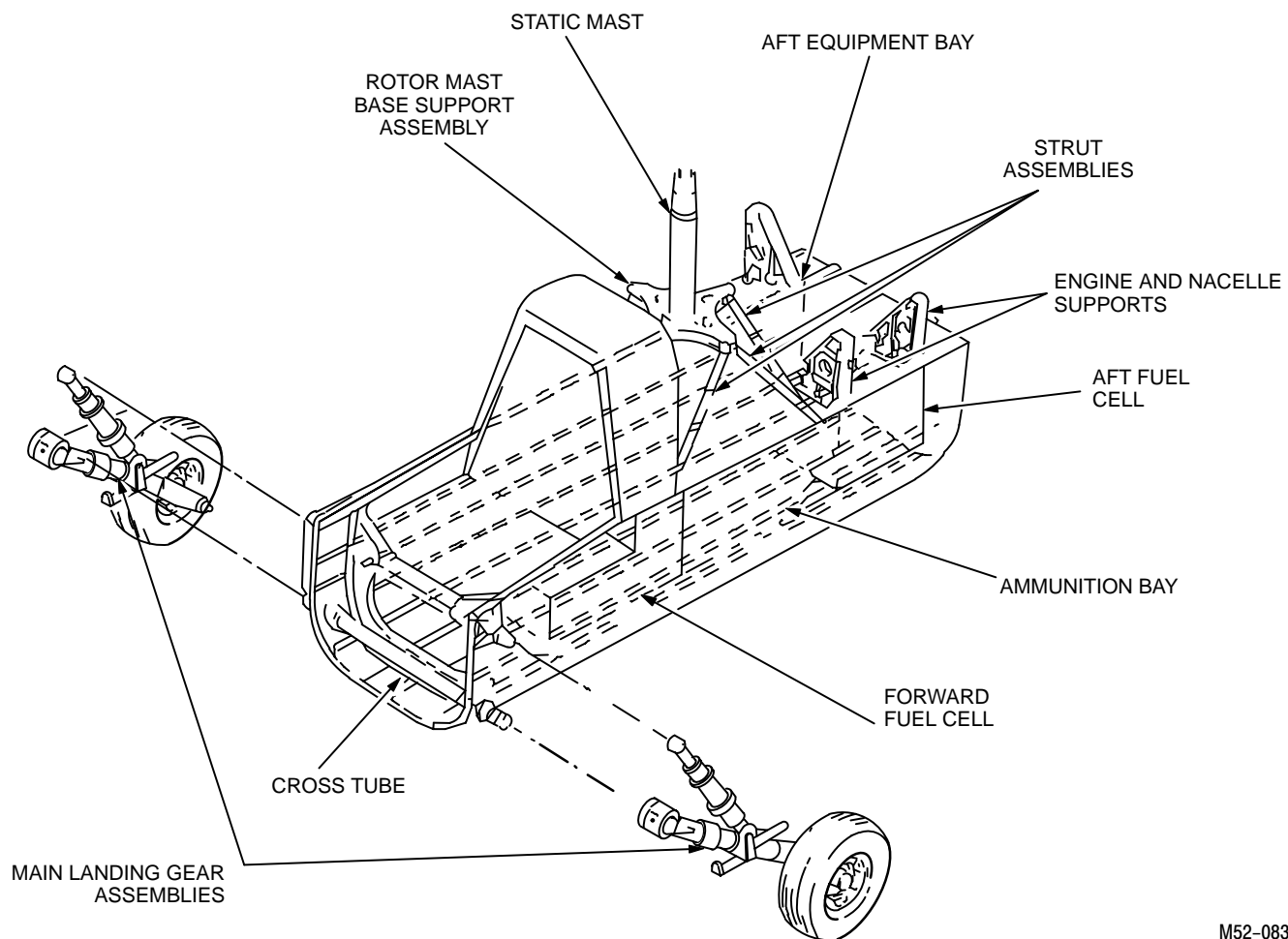
Figure 2-5. Horizontal Stabilator



M52-082

Figure 2-6. Aft Fuselage and Tailboom Section

g. Center Fuselage Section. The center fuselage section (fig. 2-7) is the primary support structure of the airframe. The center fuselage section provides mounting points for the pilot armored seat, main landing gear (MLG) assemblies and cross tube. The center fuselage section provides attachment points for the rotor mast base support assembly and strut assemblies which support the main transmission, static mast, and main rotor. The center fuselage section accepts flight loads from the main rotor system to reduce stress on the main transmission. Mounting points for the engines and engine nacelles are also provided. The forward fuel cell, ammunition bay, aft fuel cell, and the electrical power distribution center are also located in the center fuselage section. Rigid foam is installed between the frames that support the fuel cells to provide added structural integrity and to keep the fuel cell from sagging between the frames.



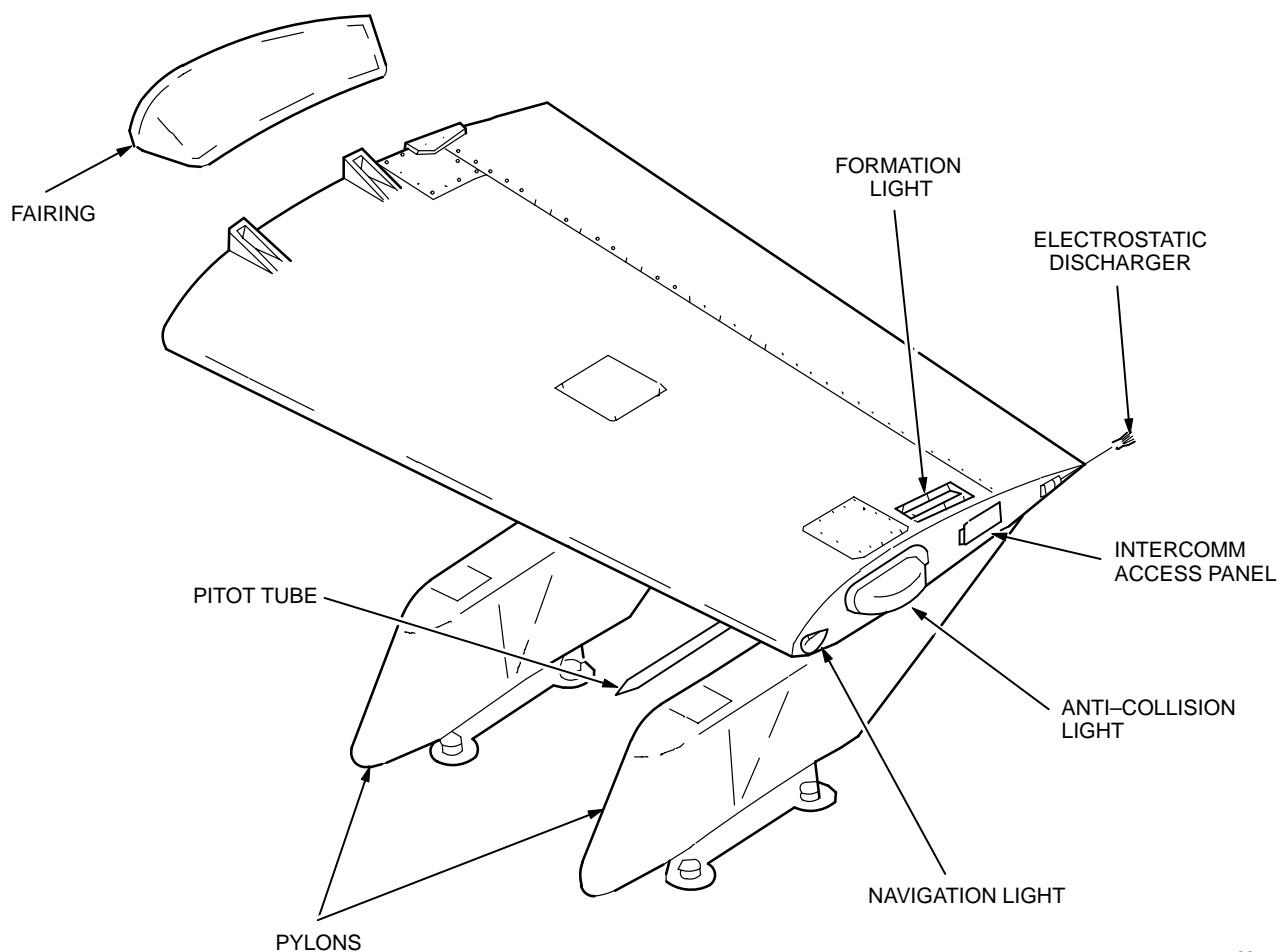
M52-083

Figure 2-7. Center Fuselage Section

2-3. THEORY OF OPERATION (cont)

2-3

h. **Wings.** Each wing (fig. 2-8) provides mounting points for two pylons, formation, navigation, and anti-collision lights, External intercommunication system (ICS) receptacle, and pitot tubes. The two pylons provide mounting of missile launchers, rocket pods, or auxiliary fuel tanks. Electrostatic Dischargers are located on the trailing edge of each wing to dissipate static electricity. Each wing is mounted to center fuselage section and a fairing covers the attachment mounts for protection from the elements. The wing also serves as a work platform and access area. The wing is coated with an anti-skid material.



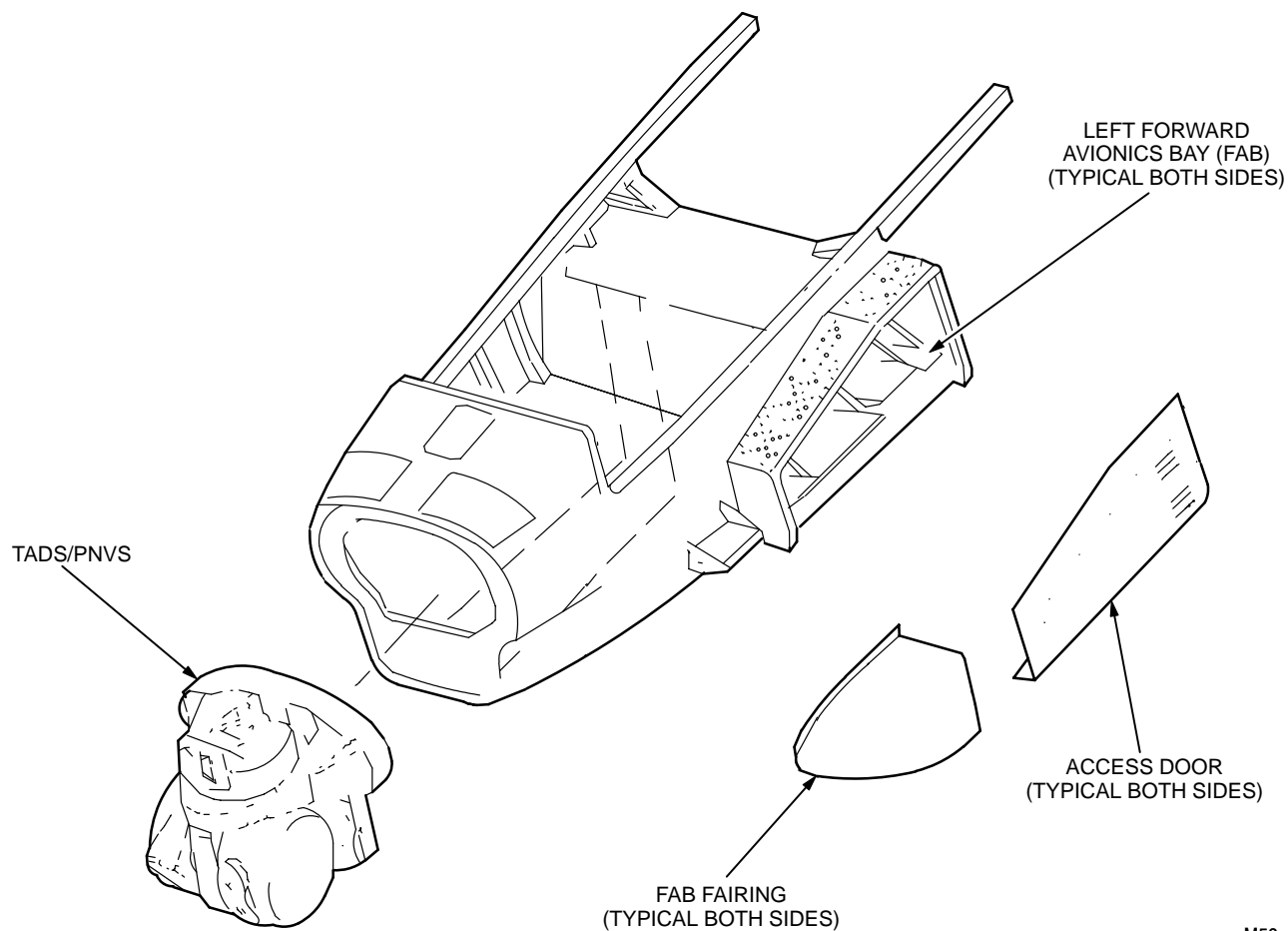
M52-084

Figure 2-8. Wing (Typical)

2-3. THEORY OF OPERATION (cont)

2-3

i. **Forward Fuselage Section.** The forward fuselage section (fig. 2-9) forms the CPG station, and provides mounting for the CPG armored seat, target acquisition and designation sight/pilot night vision sensor (TADS/PNVS), and area weapons system. The forward fuselage section also provides base support for the left and right forward avionics bays (FAB). Each FAB provides mounting for a number of electronic line replaceable units (LRUs). Each FAB contains an upper shelf which provides a crew station access area for the aircrew or maintenance personnel. The access area is covered with an anti-skid material. Each FAB has a FAB fairing and FAB doors which protect the LRUs from the elements.



M52-085

Figure 2-9. Forward Fuselage Section

3-1. PURPOSE

3-1

CHAPTER 3 LANDING GEAR SYSTEM

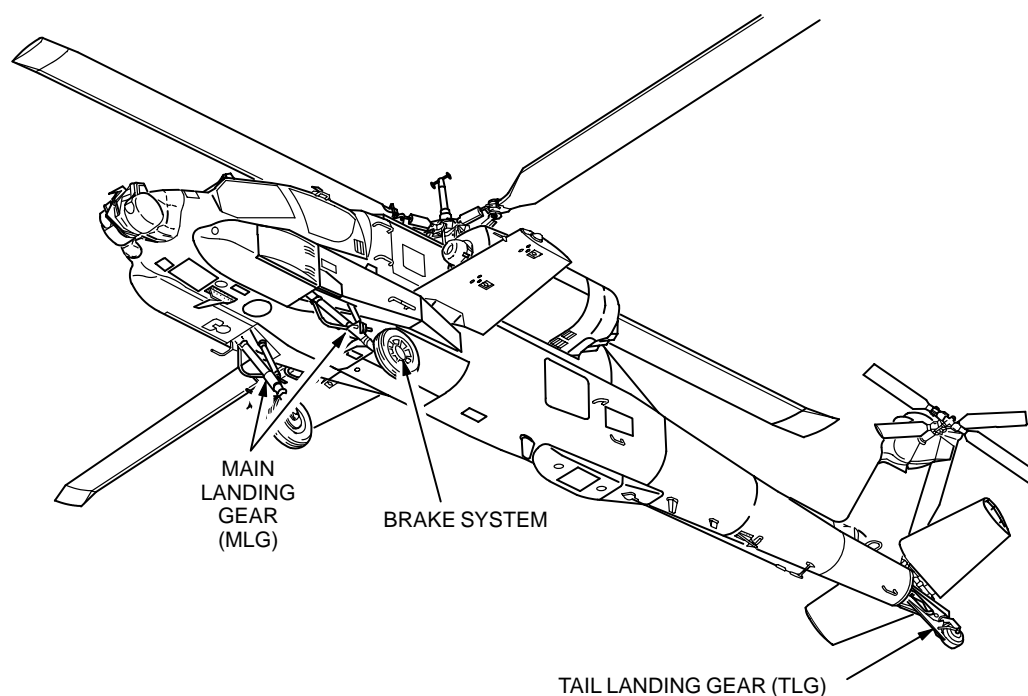
3-1. PURPOSE

The landing gear system provides support and ground stability for the helicopter fuselage during taxiing, takeoff, landing, towing, and parking. The system damps and absorbs landing shocks before they can be transmitted to the airframe structure. The system provides for mounting of helicopter wheel brakes. The brake system provides ground speed control and braking, and assistance in maneuvering the helicopter during ground taxi operations.

3-2. DESCRIPTION

The landing gear system includes the following major components.

- a. **Main Landing Gear (MLG).** The MLG (fig. 3-1) consists of two main wheel assemblies with tubeless tires and shock struts.
- b. **Tail Landing Gear (TLG).** The TLG (fig. 3-1) consists of a tail wheel assembly with a tubeless tire, inner tube, and shock strut.
- c. **Brake System.** The brake system (fig. 3-1) consists of brakes on left and right MLGs.



M52-070

Figure 3-1. Landing Gear System Major Components

3-3. THEORY OF OPERATION

3-3

3-3. THEORY OF OPERATION

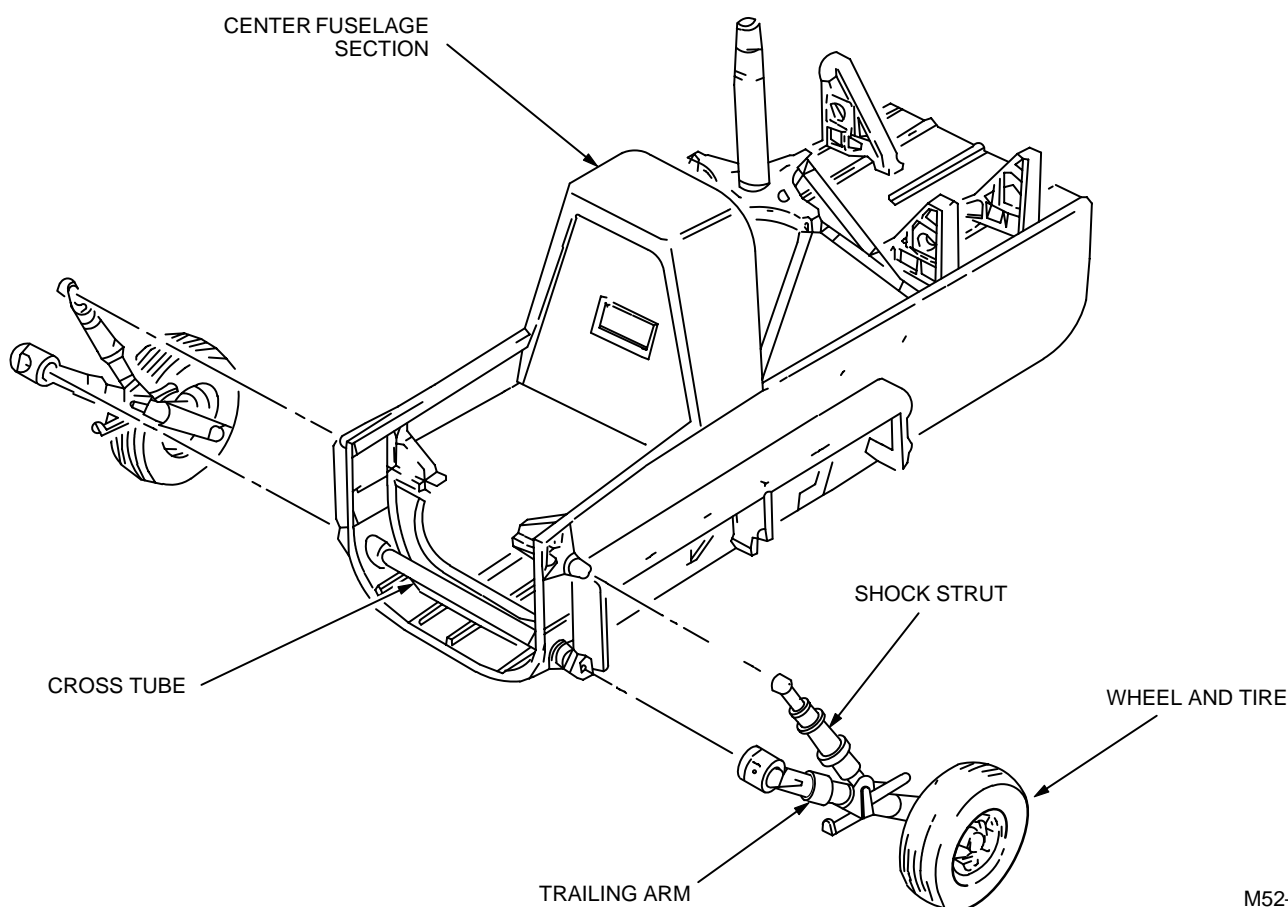
a. **Main Landing Gear (MLG).** The MLG supports the helicopter during all modes of ground operations. Operation of MLG components (fig. 3-2) are described below.

(1) The shock struts absorb (dampen) vertical forces induced by landing. The struts provide the capability to lower (kneel), and to raise (erect) the helicopter for transporting. The struts also provide a high-impact energy absorption capability.

(2) The wheel and tire assemblies permit helicopter ground movement (taxiing, run-on landing, and towing). The wheel and tire assemblies also aid in cushioning landing shocks, and provide parking support.

(3) The trailing arms transmit vertical loads to the shock struts, and the arms absorb longitudinal and lateral loads during landing. The trailing arms are the main support for the MLG components.

(4) The cross tube provides an interconnecting pivot mount for the left and right MLG trailing arms. The cross tube transmits loads from the trailing arms to the fuselage. The cross tube also provides load-bearing support for the aircraft.



M52-071

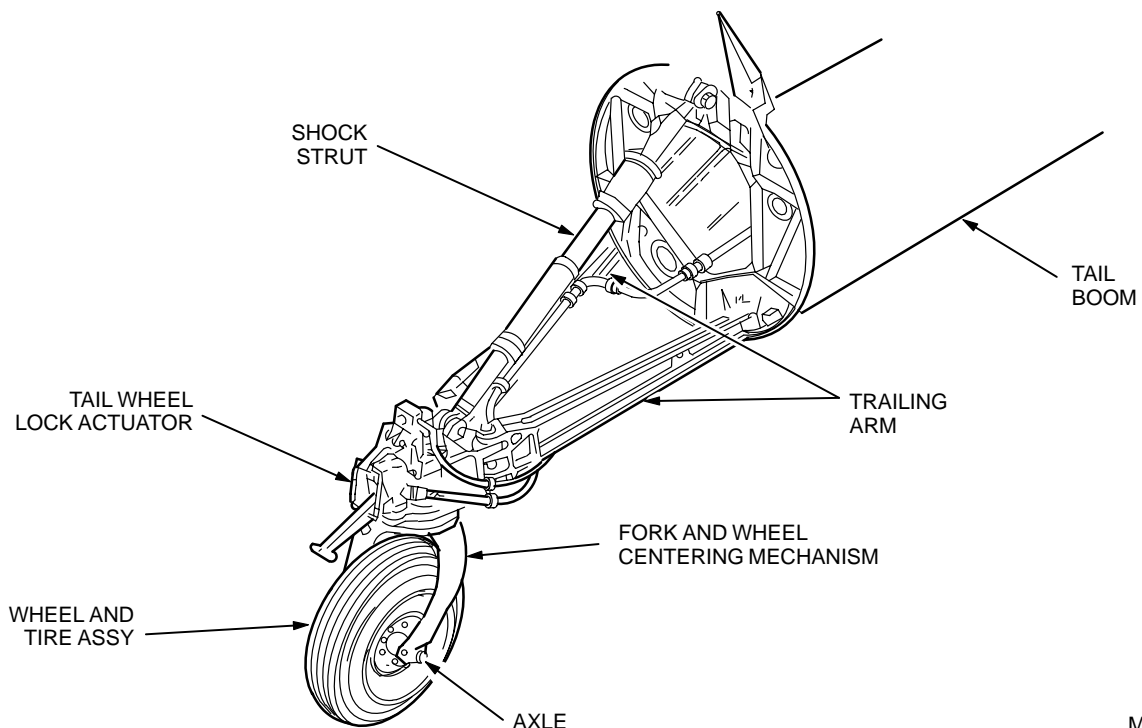
Figure 3-2. Main Landing Gear Major Components

3-3. THEORY OF OPERATION (cont)

3-3

b. **Tail Landing Gear (TLG).** The TLG supports the helicopter during all modes of ground operations. The TLG provides the capability of maneuvering the helicopter during taxiing and towing. The TLG also reduces pitching velocities and the possibility of blade-to-boom contact during tail-low landing impacts. Operation of TLG components (fig. 3-3) are described below.

- (1) The shock strut absorbs and cushions vertical impact loads resulting from normal and high-impact landings.
- (2) The trailing arms provide support for the tail landing gear. The trailing arms absorb loads during landing and taxiing and transfers the loads to the tail boom structure. The trailing arms also provide mounting for the TLG components.
- (3) The fork provides 360° swiveling of the tail wheel. The fork also provides an interface between the wheel/axle and the trailing arms. The fork contains a wheel centering mechanism to center the tail landing gear. At takeoff, the centering mechanism causes the fork assembly to center as the weight is removed from the wheel. The fork (ACB) has a special cable attached to prevent electro-magnetic interference (EMI).
- (4) The axle provides support for the tail wheel, and a means for towing the helicopter.
- (5) The wheel and tire assembly provides the capability of helicopter ground movement (taxiing, run-on landing, and towing).
- (6) The tail wheel lock actuator assembly provides a means for locking the tail wheel in the center position (either mechanically or hydraulically). The tail wheel lock is controlled electrically/hydraulically by the tail wheel **LOCK/UNLOCK** switch through the tail wheel lock control valve or manually at the TLG.



M52-072A

Figure 3-3. Tail Landing Gear Major Components

3-3. THEORY OF OPERATION (cont)

3-3

c. **Brake System.** The brake system provides braking and directional control during ground taxiing, ground handling, and parking. The brake system has the following capabilities.

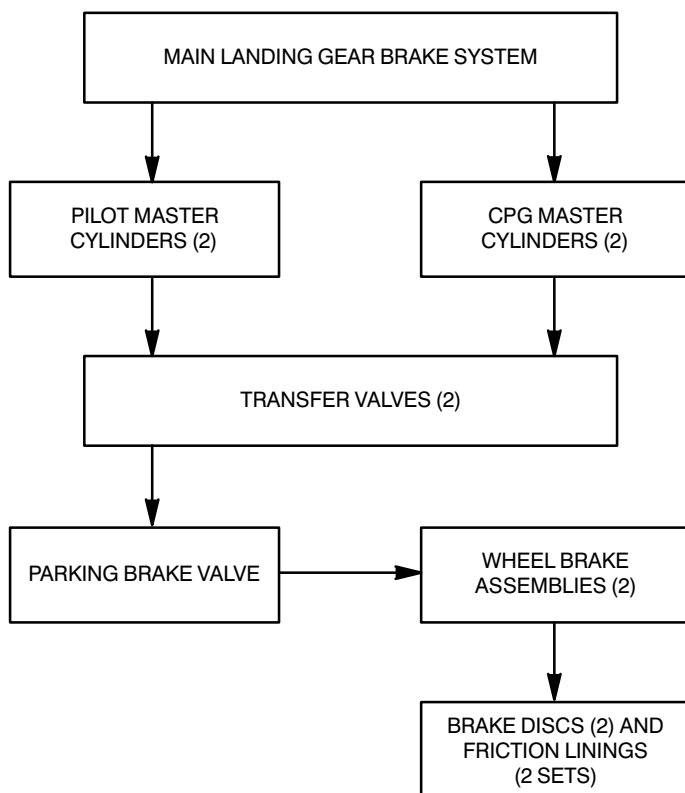
- (1) Can hold maximum alternate gross weight on a 12° slope.
- (2) Has separate systems for left and right wheels.
- (3) Can be operated from the pilot or CPG stations.
- (4) Has parking brake which can be locked from the pilot station only but can be released from either station.
- (5) Operation of brake system components (fig. 3-4) is described below.

(a) The master cylinders (4 ea.) (fig. 3-5) provide a means of changing force, applied by the crew member's foot, into fluid pressure. The master cylinders supply hydraulic fluid to other brake system components, and serve as reservoirs for brake fluid.

(b) The transfer valves (2 ea.) allow either pilot or CPG master cylinder pressure to operate the brakes without mixing the fluids.

(c) The parking brake valve traps fluid pressure in the wheel brake assemblies to keep the brakes applied for parking.

(d) The two wheel brake assemblies and discs convert hydraulic pressure into a retarding force that stops wheel rotation.

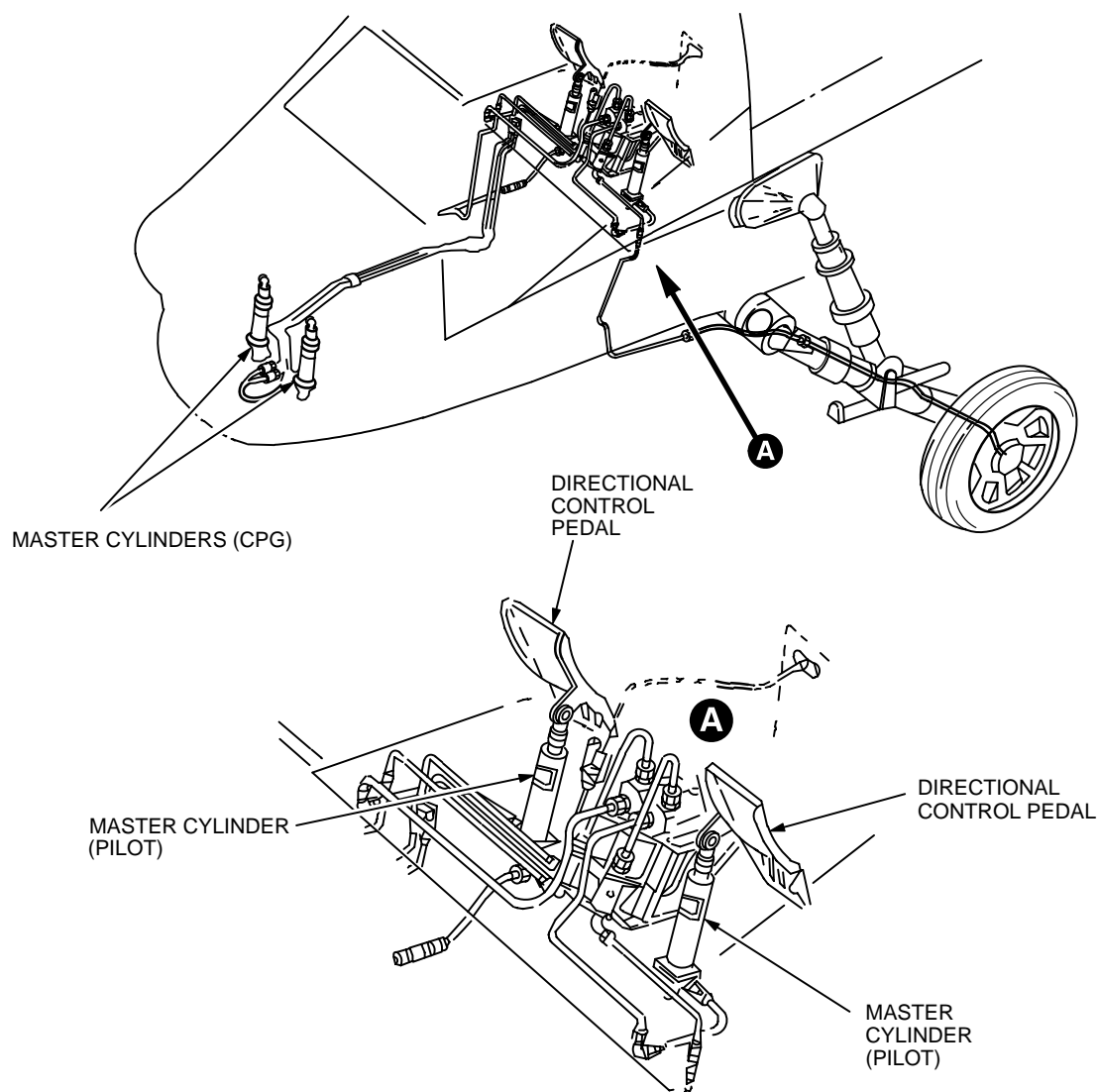


M52-073

Figure 3-4. Brake System Major Components

3-3. THEORY OF OPERATION (cont)

3-3



M52-074

Figure 3-5. Master Cylinder Locations

(6) The brake system (fig. 3-6) includes the following controls.

(a) The toe portion of the directional control pedals (2 in each crew station) is used to put a downward force on the master cylinders.

(b) The **PARK BRAKE** handle (on the right of the pilot center console) is used by the pilot to set the parking brake. The parking brake may be released by either crew member.

3-3. THEORY OF OPERATION (cont)

3-3

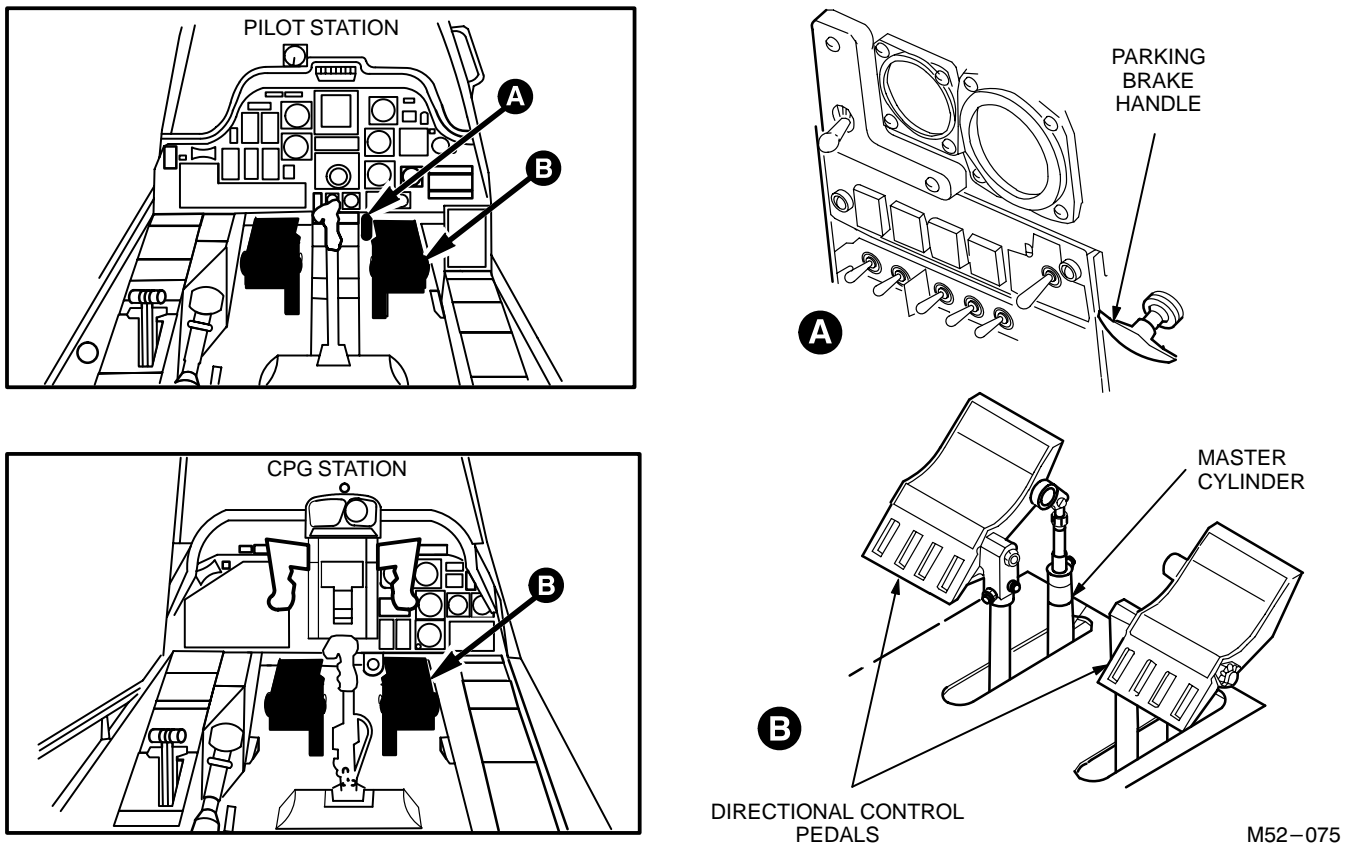


Figure 3-6. Brake System Controls

The brake system operates as follows (fig. 3-7). Braking action is initiated from either crew station by applying foot pressure to the top (toe) portion of the directional control pedals. This activates the master cylinders, which pressurize the hydraulic fluid in the brake system.

The pressure in the system is transmitted through tubing to the transfer valves and parking brake valve to the wheel brake assemblies. The pressure activates pistons in each wheel brake assembly, causing friction linings to move against a floating brake disc (keyed to the wheel) to stop wheel rotation.

When the brakes are operated from the pilot station, the transfer valves perform no mechanical function. Fluid is routed through the parking brake valve to the wheel brakes.

When the brakes are operated from the CPG station, fluid pressure from the CPG master cylinder displaces the piston in the transfer valve, causing the poppet to seat and close the inlet port from the pilot station. The piston pressurizes the closed fluid path to the wheel brakes.

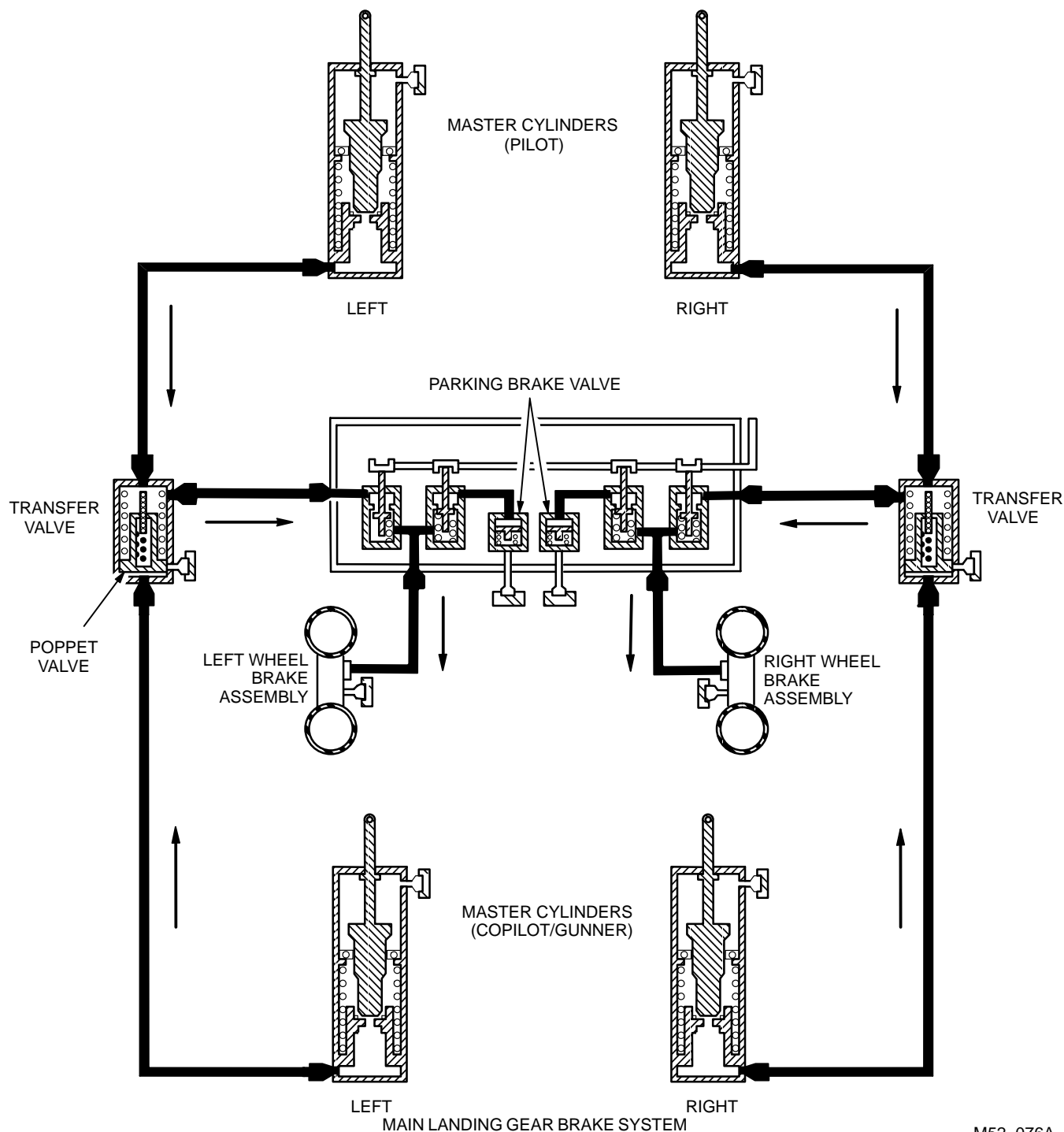
Exerting pressure on the pilot's directional control pedal overrides the poppet valve to allow pilot pressure to operate wheel brakes.

When the helicopter is to be parked, either crew member can apply and maintain pressure on the brakes until the pilot pulls out the **PARK BRAKE** handle to lock the parking brakes.

3-3. THEORY OF OPERATION (cont)

3-3

When the parking brake has been set, the control pedals are released. Hydraulic pressure is maintained in the system by the parking brakes valve. Either crew member can release the parking brake by exerting pressure on the direction control pedals.



M52-076A

Figure 3-7. Brake System Operation

CHAPTER 4 FUEL SYSTEM

4-1. PURPOSE

The fuel system stores and supplies fuel for distribution to the engines and auxiliary power unit (APU). The fuel system stores 375 gallons (2437 pounds) internally, and 920 gallons (5978 pounds) with four auxiliary external fuel tanks for a total fuel capacity of 1295 gallons (8415 pounds). The AH-64A can cruise approximately 2.0 hours on internal fuel with a 30 minute reserve for a total endurance of 2.5 hours, or for 7.0 hours with four auxiliary tanks with a 20 minute reserve. The fuel system also provides a means of controlling refuel/defuel operations while monitoring the fuel quantity. In addition, the fuel system allows the crew to transfer fuel from either the forward fuel cell or the aft fuel cell to maintain a center of gravity, or remove fuel from a damaged fuel cell. Fuel cannot be transferred from the internal fuel cells to the auxiliary tanks.

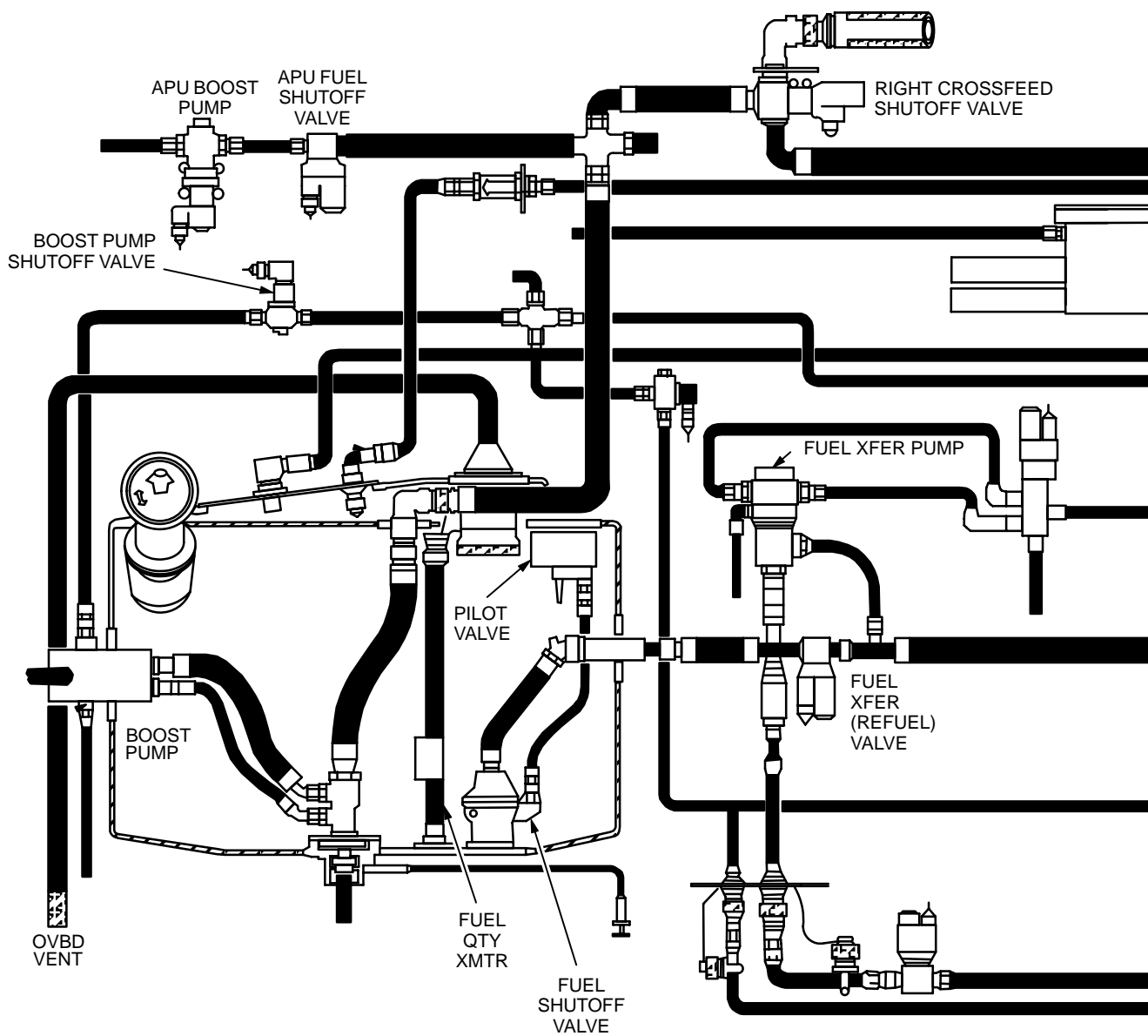
4-2. DESCRIPTION

Fuel System. The fuel system (fig. 4-1) consists of the following components.

- a. **Nitrogen Inerting Unit (NIU).** The NIU unit removes oxygen molecules from pressurized air system (PAS) air, and supplies nitrogen rich air at a level that will not support combustion to the fuel cells.
- b. **Fuel Transfer Pump.** The fuel transfer pump is a vane-type air driven pump which transfers fuel from one fuel cell to the other.
- c. **Auxiliary Fuel Tank Air Shutoff Valve.** The auxiliary fuel tank air shutoff valve is a 28 VDC electrically opened valve that controls airflow used to transfer fuel from the auxiliary tanks to the fuel cells.
- d. **Fuel Boost Pump.** The fuel boost pump is a vane-type air-motor driven pump that provides pressurized fuel to the engines during starting and high altitude operations.
- e. **APU Fuel Boost Pump.** The APU fuel boost pump is a 28 VDC motor-operated pump that provides pressurized fuel to the APU.
- f. **Aft Fuel Cell.** The aft fuel cell is a bladder-type cell that normally supplies fuel to engine 2 (right) (part of engine system), APU (part of APU system), and has a capacity of 220 gallons (1430 pounds).
- g. **Refuel Transfer Valve.** The refuel transfer valve is a 24 VDC motor operated valve which controls refueling and suction defueling of the aft fuel cell.
- h. **Auxiliary Fuel Tank.** The auxiliary fuel tank is an aluminum alloy fuel tank which attaches to the wing pylons (part of airframe), and has a capacity of 230 gallons (1495 pounds).
- i. **Forward Fuel Cell.** The forward fuel cell is a bladder-type cell that normally supplies fuel to engine 1 (left) (part of engine system) and has a capacity of 155 gallons (1007.5 pounds).
- j. **Fuel Quantity Indicators and Controls.** The fuel quantity indicators and controls (not shown) are various indicators and controls which electronically measure the quantity of fuel in the fuel cells and provide the pilot and CPG with fuel system status.

4-2. DESCRIPTION (cont)

4-2

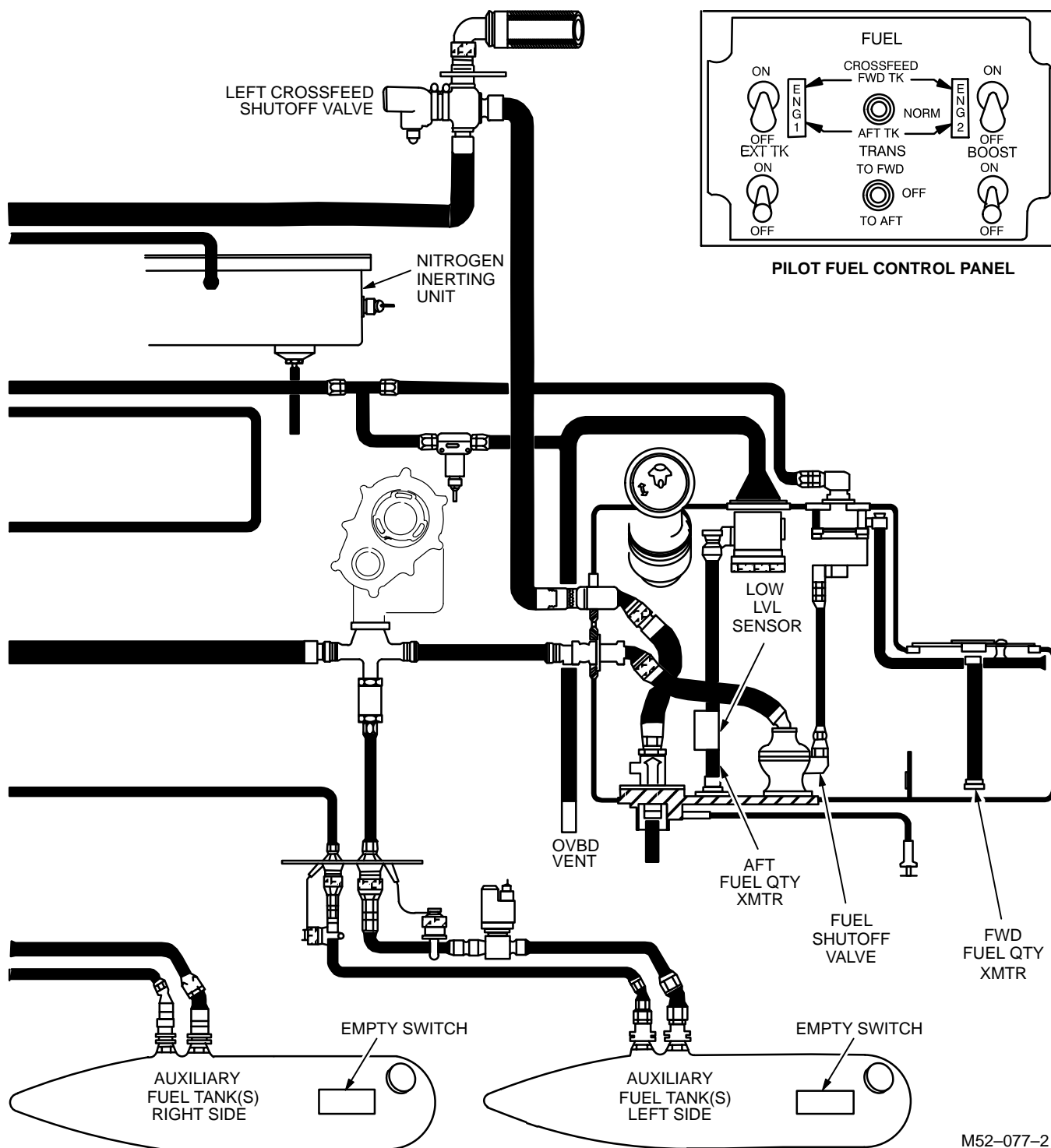


M52-077-1

Figure 4-1. Fuel System Major Components (Sheet 1 of 2)

4-2. DESCRIPTION (cont)

4-2



M52-077-2

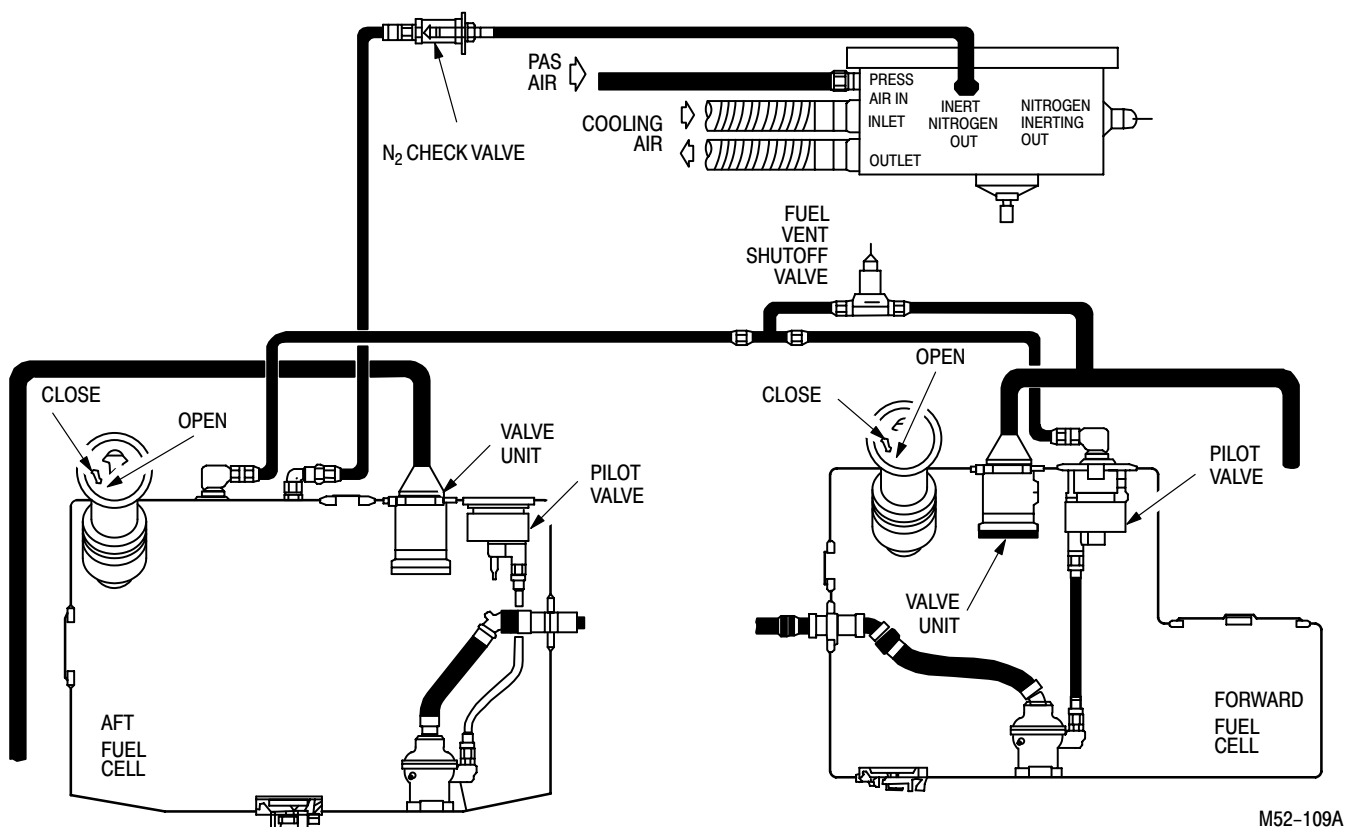
Figure 4-1. Fuel System Major Components (Sheet 2 of 2)

4-3. THEORY OF OPERATION

4-3

4-3. THEORY OF OPERATION

a. **NIU.** The NIU is part of the nitrogen inerting system. Operation of the nitrogen inerting system components (fig. 4-2) is described below.



M52-109A

Figure 4-2. Nitrogen Inerting System Major Components

(1) Pressurized air from the air pressure manifold (part of pressurized air system (PAS)) enters the NIU. The pressurized air is regulated by the NIU to 25 ± 3 psi at 94 % nitrogen and delivered to the aft fuel cell. The aft fuel cell pressurizes the forward fuel cell.

(2) The N₂ check valve is an in-line valve that provides one-way flow of nitrogen-rich air to the forward and aft fuel cells.

(3) The fuel vent shutoff valve is a spring-loaded closed valve that is closed during NIU operation to prevent nitrogen from venting the forward and aft fuel cells.

4-3. THEORY OF OPERATION (cont)

4-3

b. **Fuel Transfer Pump.** The fuel transfer pump is part of the fuel transfer system. Operation of the fuel transfer system components (fig. 4-3) is described below.

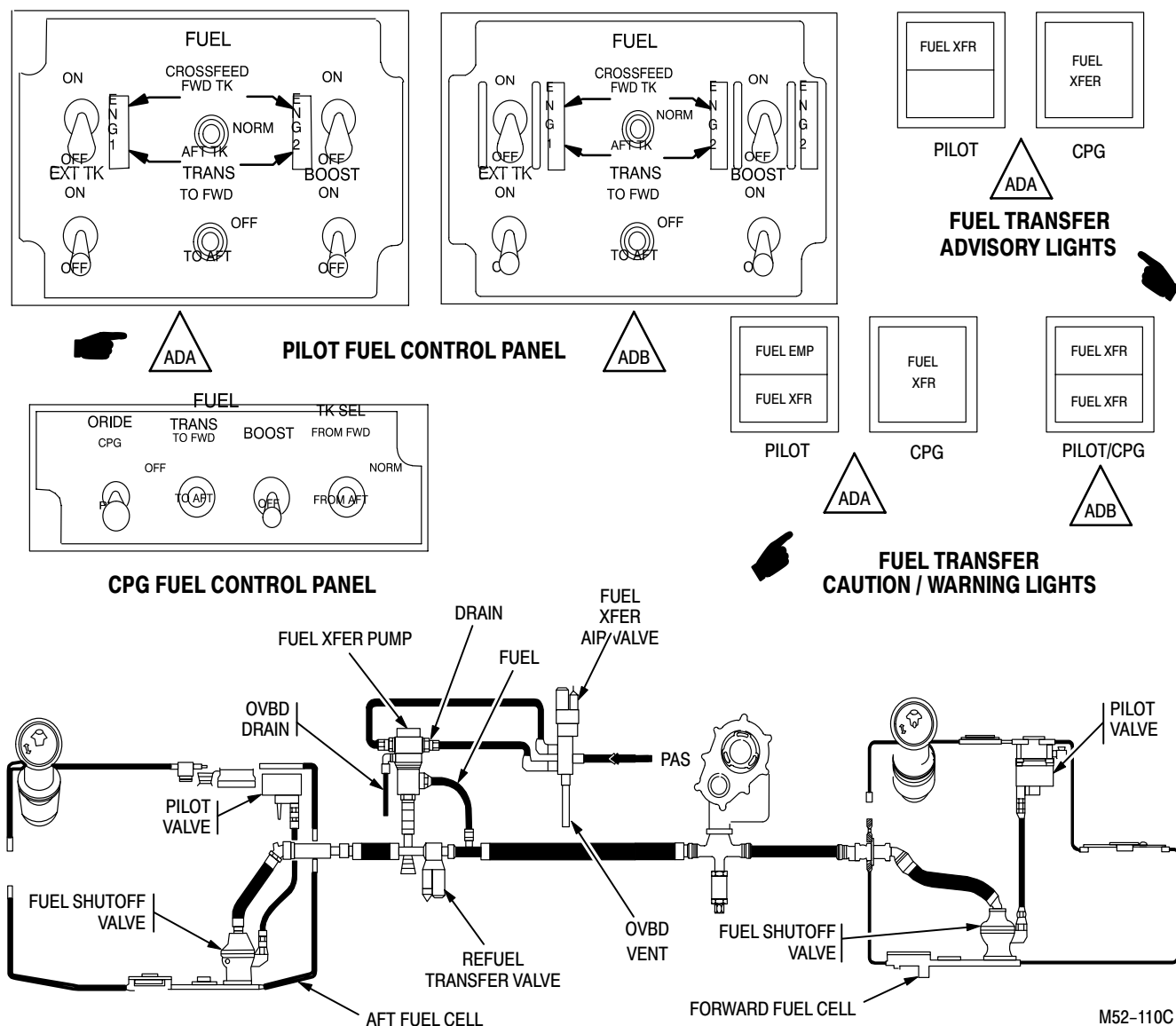


Figure 4-3. Fuel Transfer System Major Components

(1) **Pilot FUEL Panel.** Dc bus 2 supplies 28 VDC to the pilot's **FUEL** panel transfer switch (**TRANS**). When the **TO FWD** or **TO AFT** positions are selected, 28 VDC is applied to the fuel transfer air valve and the fuel transfer (**FUEL XFER**) advisory lights turn on.

(2) **CPG FUEL panel.** Dc 2 bus supplies 28 VDC to the CPG **FUEL** panel override (**ORIDE**) switch. In the **PLT** position, the pilot **TRANS** switch is armed and the **CPG TRANS** switch is disarmed. In the **CPG** position, the pilot **TRANS** switch is disarmed and the **CPG TRANS** switch is armed. When the **TO FWD** or **TO AFT** positions are selected, 28 VDC is applied to the fuel transfer air valve and the fuel transfer (**FUEL XFER**) advisory lights turn on.

4-3. THEORY OF OPERATION (cont)

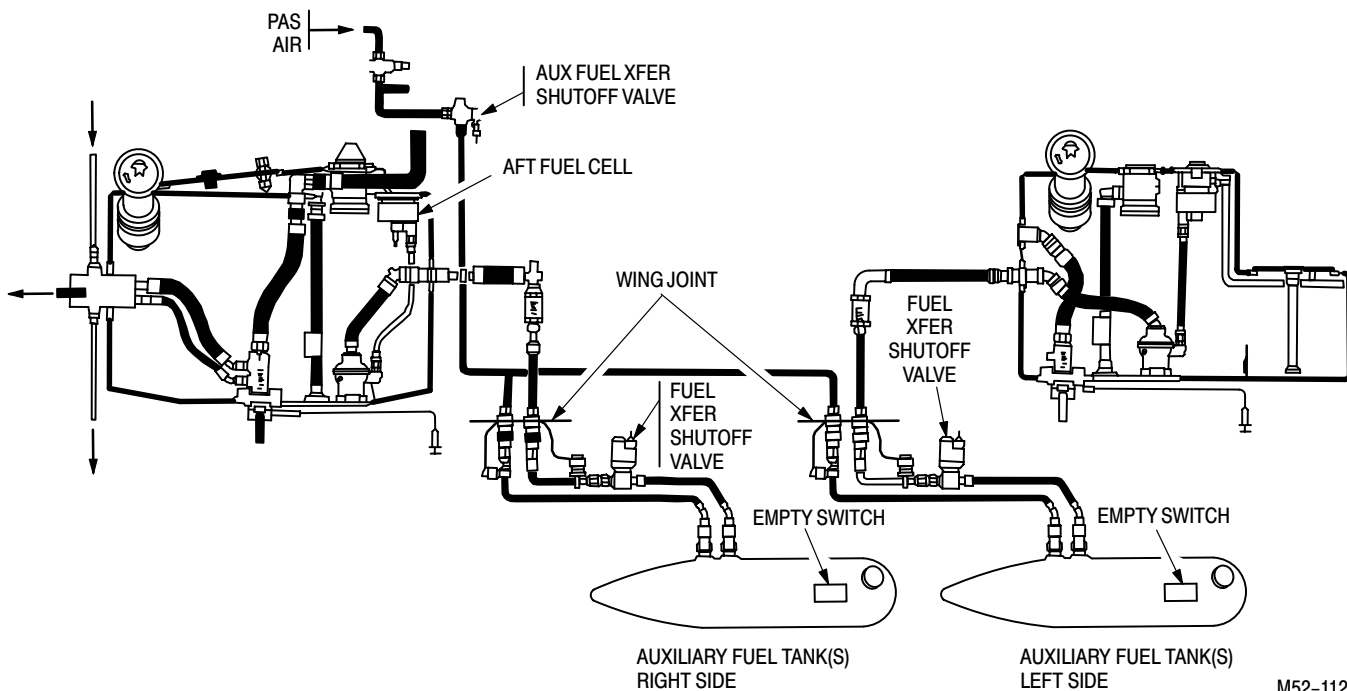
4-3

(3) **Fuel Transfer Pump.** The fuel transfer pump pumps fuel from one fuel cell to the other. When the pilot selects the **TO FWD** position of the fuel transfer switch on the **FUEL** panel, PAS air is directed from the fuel transfer air valve to drive the pump, in a direction to pump fuel from the aft fuel cell to the forward fuel cell. When the **TO AFT** position is selected, air is directed from the fuel transfer air valve to drive the pump in the opposite direction.

(4) **Fuel Transfer Air Valve.** This valve is a four-way, three-position, in-line 28 VDC motor-operated valve which controls PAS airflow to the fuel transfer pump.

(5) **Fuel Shutoff Valve.** Two valves, located in each of the fuel cells, automatically cease refueling or transfer operations as the affected cell becomes full. The valves provide a three percent fuel expansion space (ullage): and pressure (suction) defueling capability.

c. **Auxiliary Fuel Tank Air Shutoff Valve.** The auxiliary fuel tank air shutoff valve is part of the auxiliary fuel tank transfer system. Operation of the auxiliary fuel transfer system components (fig. 4-4) is described below.



M52-112

Figure 4-4. Auxiliary Fuel Tank Transfer System Major Components

(1) **Pilot FUEL Panel.** When the pilot sets the external tank (**EXT TK**) switch of the **FUEL** panel to **ON**, the auxiliary tank air shutoff valve and the auxiliary fuel tank shutoff valve are energized open by 28 VDC from dc bus 2.

(2) **Auxiliary Fuel Tank Air Shutoff Valve.** This valve, a spring-loaded closed and electrically opened shutoff valve. When the **EXT TK** switch is placed to **ON**, the auxiliary tank air shutoff valve and the auxiliary tank fuel shutoff valve are energized open by 28 VDC from dc bus 2. Pressurized air (16 to 22 PSI) from the PAS system pressurizes the auxiliary tanks to force fuel to flow through the fuel shutoff valve into the internal tanks. If four auxiliary tanks are installed, the PAS air hoses are connected to the outboard tanks only. The PAS air forces the fuel from the outboard tanks into the inboard tanks and then into the internal fuel cells. When internal cells are full, the fuel level control valves close and terminate fuel flow.

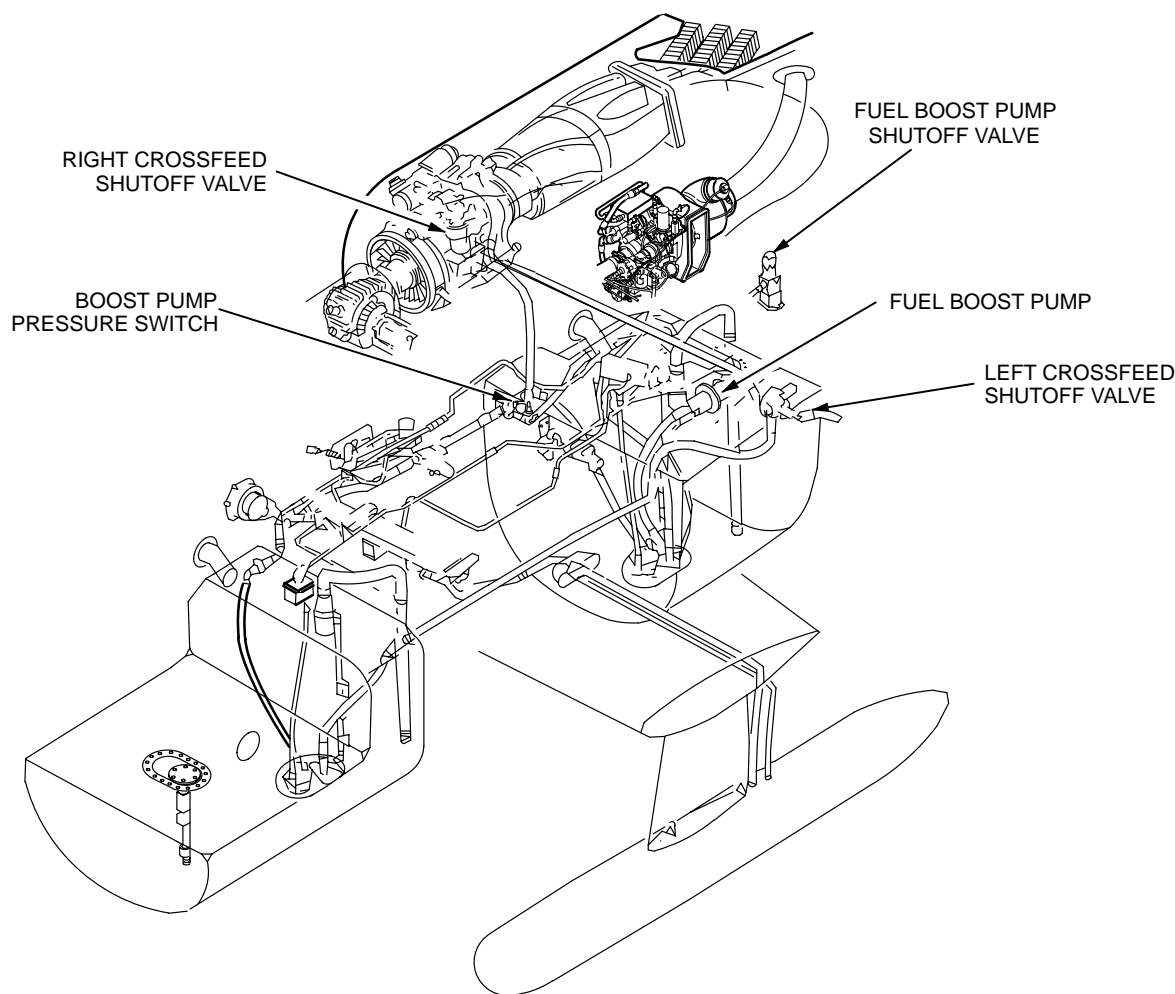
4-3. THEORY OF OPERATION (cont)

4-3

(3) **Auxiliary Fuel Tanks Shutoff Valves.** These positive fuel shutoff valves, located in the trailing edge of each wing, prevent PAS system supplied air from being drawn from the auxiliary fuel tanks during internal fuel transfer. They are controlled by the **EXT TK** transfer switch on the pilot **FUEL** control panel.

(4) **Auxiliary Tank Fuel Empty Switches.** These switches, located in each auxiliary tank, complete an electrical circuit when the fuel level is below the float. The switches are connected in a series so that all the auxiliary tanks must be empty before the external tanks empty (**EXT EMP**) light on the pilot caution/warning panel turns on.

d. **Fuel Boost Pump.** The fuel boost pump is part of the fuel distribution system. Operation of the fuel distribution system components (fig. 4-5) is described below.



M52-113

Figure 4-5. Fuel Distribution System Major Components

(1) **Pilot FUEL Panel.** The dc bus 2 supplies 28 VDC to the **BOOST** switch when the switch is set to **ON**. When the **ON** position is selected, 28 VDC is applied to the fuel boost pump pressure shutoff valve. 28 VDC from the dc bus 2 is applied to the engine 1 fuel switch when the **ENG 1** switch is set to **ON**. When the **ON** position is selected, 28 VDC from the dc bus 2 is applied to the left crossfeed shutoff valve. 28 VDC from the dc bus 2 is applied to the engine 2 fuel switch when the **ENG 2** switch is set to **ON**. When the **ON** position is selected, 28 VDC from the dc bus 2 is applied to the right crossfeed shutoff valve.

4-3. THEORY OF OPERATION (cont)

4-3

(2) **CPG FUEL Panel.** The dc bus 2 supplies 28 VDC to the **CPG** override (**ORIDE**) switch. In the **PLT** position the pilot **BOOST** switch and **CROSSFEED** switch are armed, and the CPG **BOOST** switch and tank select (**TK SEL**) are disarmed. When the **CPG ORIDE** switch is in the **CPG** position the pilot **BOOST** switch and **CROSSFEED** switch are disarmed while the CPG **BOOST** switch and **TK SEL** are armed. When the **BOOST** switch is set to **ON**, 28 VDC is applied to the fuel transfer air valve. When the **TO FWD** or **TO AFT** positions are selected, 28 VDC is applied to the fuel transfer air valve. When the **TO FWD** or **TO AFT** positions are selected, 28 VDC is applied to the fuel boost pump pressure shutoff valve.

(3) **Fuel Boost Pump Pressure switch.** The fuel boost pump pressure switch gives an indication of boost pump operation to the pilot. Electrical power is applied to the fuel boost pump pressure switch from the boost (**BST**) pump circuit breaker. The pressure switch is normally open, and closes only when fuel boost pump output pressure reaches 8.5 to 10 psi. When the pressure switch closes, the **BOOST PMP ON** advisory light on the pilot caution/warning panel turns on.

(4) **Right Crossfeed Shutoff Valve.** This three-way, four-position, electronically controlled ball valve provides a means of selecting a fuel source for the engine 2, and provides positive fuel shutoff during emergencies. The right crossfeed shutoff valve is mounted on the upper forward section of the engine 2 firewall.

(a) With the **ENG 2** switch of the pilot **FUEL** panel set to **ON** and the **CROSSFEED** switch set to normal (**NORM**), the crossfeed shutoff valve opens to supply fuel to the engine 2 from the aft fuel cell. With the **ENG 2** switch set to **ON** and the **CROSSFEED** switch set to forward tank (**FWD TK**), the engine 2 is supplied with fuel from the forward fuel cell by the crossfeed shutoff valve. With the **ENG 2** switch set to **ON** and the **CROSSFEED** switch set to aft tank (**AFT TK**), the engine 2 is supplied with fuel from the aft fuel cell by the crossfeed shutoff valve. When the **ENG 2** switch is set to **OFF** the crossfeed shutoff valve closes and engine 2 fuel supply is discontinued.

(b) During engine start the right crossfeed shutoff valve supplies fuel to the engine 2 from the aft fuel cell, due to fuel boost pump operation. If the pilot or CPG **ENG 2 FIRE PULL** handle is pulled, the right crossfeed shutoff valve is closed and the engine 2 fuel supply is discontinued.

(5) **Fuel Boost Pump Shutoff Air Valve.** This spring-loaded-closed valve is electrically energized open to supply PAS system air to drive the fuel boost pump. The shutoff valve is energized by the dc bus 2 when the pilot **BOOST** switch on the **FUEL** panel is set to **ON**.

(6) **Fuel Boost Pump.** The fuel boost pump provides pressurized fuel to the engines during starting and high altitude operation. The fuel boost pump is driven by PAS system air, controlled by the fuel boost pump shutoff valve, to supply pressurized fuel to the engines through crossfeed shutoff valves. If fuel pressure exceeds 10 psi the pressure relief valve cracks, and is fully open at 23 psi, recirculating the fuel through the boost pump.

(7) **Left Crossfeed Shutoff Valve.** This three-way, four-position, electronically controlled ball valve provides a means of selecting a fuel source for the engine 1, and provides positive fuel shutoff during emergencies. The left crossfeed shutoff valve is mounted on the upper forward section of the engine 1 firewall.

(a) With the **ENG 1** switch of the pilot **FUEL** panel set to **ON** and the **CROSSFEED** switch set to normal (**NORM**), the crossfeed shutoff valve opens to supply fuel to the engine 1 from the forward fuel cell. With the **ENG 1** switch set to **ON** and the **CROSSFEED** switch set to forward tank (**FWD TK**), the engine 1 is supplied with fuel from the forward fuel cell by the crossfeed shutoff valve. With the **ENG 1** switch set to **ON** and the **CROSSFEED** switch set to aft tank (**AFT TK**), the engine 1 is supplied with fuel from the aft fuel cell by the crossfeed shutoff valve. When the **ENG 1** switch is set to **OFF**, the crossfeed shutoff valve closes and stops the engine 1 fuel supply.

(b) During engine start the left crossfeed shutoff valve supplies fuel to the engine 1 from the aft fuel cell, due to fuel boost pump operation. If the pilot or CPG **ENG 1 FIRE PULL** handle is pulled, the left crossfeed shutoff valve is closed and the engine 1 fuel supply is discontinued.

4-3. THEORY OF OPERATION (cont)

4-3

e. **APU Fuel Boost Pump.** The APU fuel boost pump is part of the APU fuel distribution system. Operation of the APU fuel distribution system components (fig. 4-6) is described below.

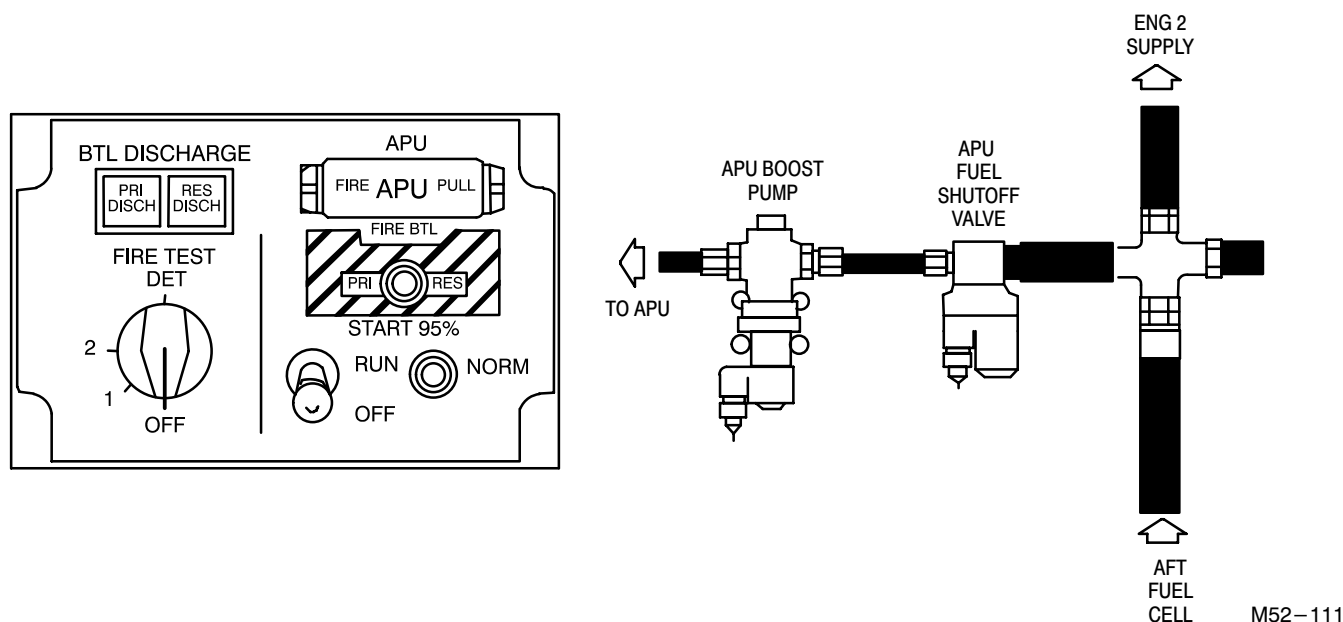


Figure 4-6. APU Fuel Distribution System

(1) **APU Control Panel.** The emergency dc bus supplies 28 VDC to the **APU START/RUN/OFF** switch when the switch is set to **START** or **RUN**. 28 VDC is removed from the switch when set to **OFF**.

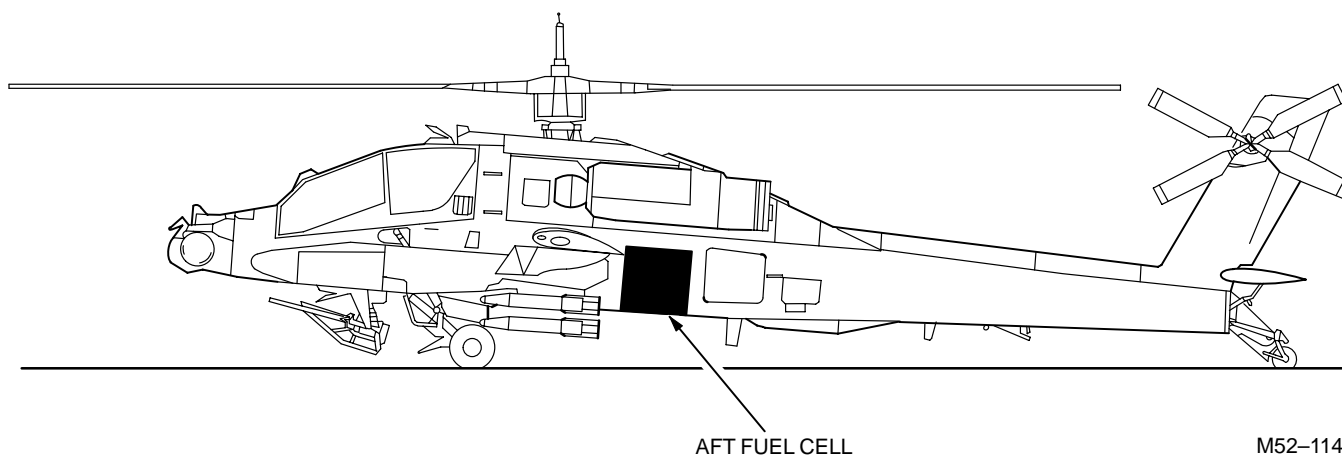
(2) **APU Fuel Boost Pump.** This 28 VDC motor-operated pump provides pressurized fuel to the APU for starting and operation. When the **APU START/RUN/OFF** switch on the **APU** control panel is set to **RUN** or **START**, 28 VDC is supplied to the APU fuel boost pump from the **APU START/RUN/OFF** switch. The APU fuel boost pump draws fuel through the APU fuel shutoff valve from the aft fuel cell, pressurizes the fuel to 10 ± 3 psi, and supplies the fuel to the APU. When the **APU START/RUN/OFF** switch is set to **OFF** or the **APU FIRE PULL** handle is pulled, 28 VDC is removed from the APU fuel boost pump, and the APU fuel boost pump operation discontinues.

(3) **APU Fuel Shutoff Valve.** This 28 VDC motor-operated ball-type shutoff valve controls fuel flow to the APU fuel boost pump. When the **APU START/RUN/OFF** switch on the APU control panel is set to **RUN** or **START** position, 28 VDC is supplied to the APU fuel shutoff valve from the **APU START/RUN/OFF** switch. The fuel shutoff valve opens and provides fuel to the APU fuel boost pump. When the **APU START/RUN/OFF** switch is set to **OFF** or the **APU FIRE PULL** handle is pulled, 28 VDC is removed from the boost pump and applied to the close winding of the fuel shutoff valve, discontinuing fuel flow.

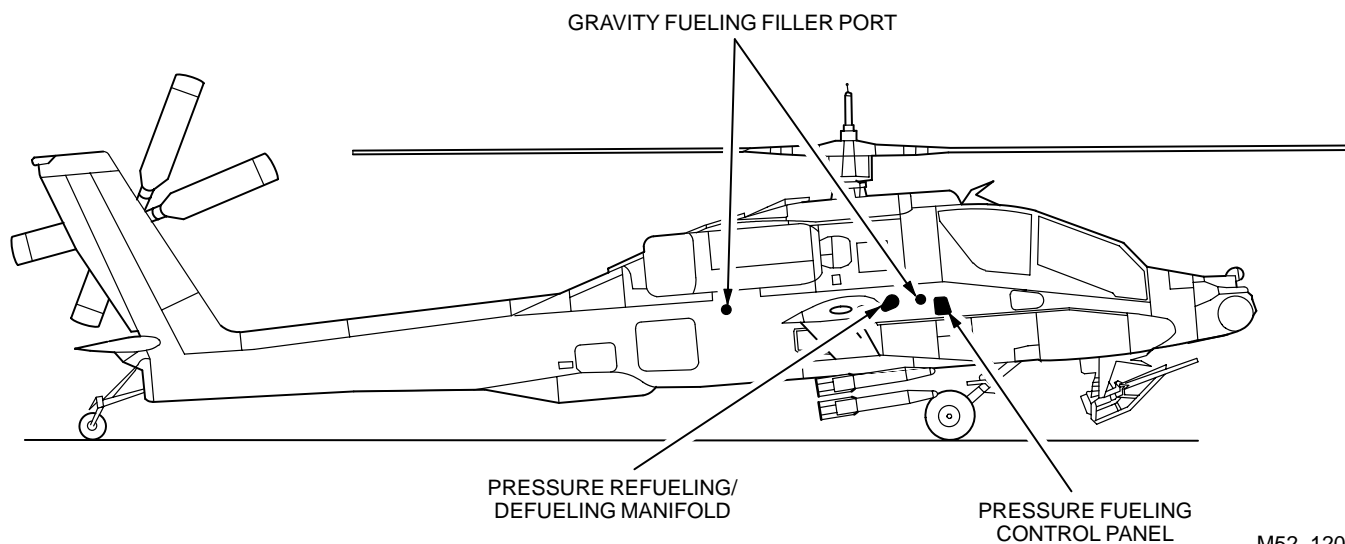
f. **Aft Fuel Cell.** The aft fuel cell (fig. 4-7) is located in the center fuselage section, behind the ammunition bay. The aft fuel cell is a 220 gallon (1430 pounds) bladder-type cell which is crash resistant and self sealing. The outer and inner layers are made of several layers of rubber impregnated nylon. The intermediate layer consists of uncured rubber which forms a sealant material. The uncured rubber reacts to fuel when the fuel cell is punctured. This reaction causes the uncured rubber to swell and seal the puncture in the fuel cell from 50 caliber (cal) and 14.5 mm hits. The fuel cell is surrounded at the bottom and sides by the helicopter fuselage, rigid foam, a Kevlar liner, and backing boards. These materials reduce fuel cell chafing and add ballistic protection.

4-3. THEORY OF OPERATION (cont)

4-3

**Figure 4-7. Aft Fuel Cell Location**

g. **Refuel Transfer Valve.** The refuel transfer valve is part of the refuel/defuel system. Figure 4-8 shows refuel/defuel service points. Operation of refuel/defuel system components (fig. 4-9) is described below.

**Figure 4-8. Refuel/Defuel Service Points**

4-3. THEORY OF OPERATION (cont)

4-3

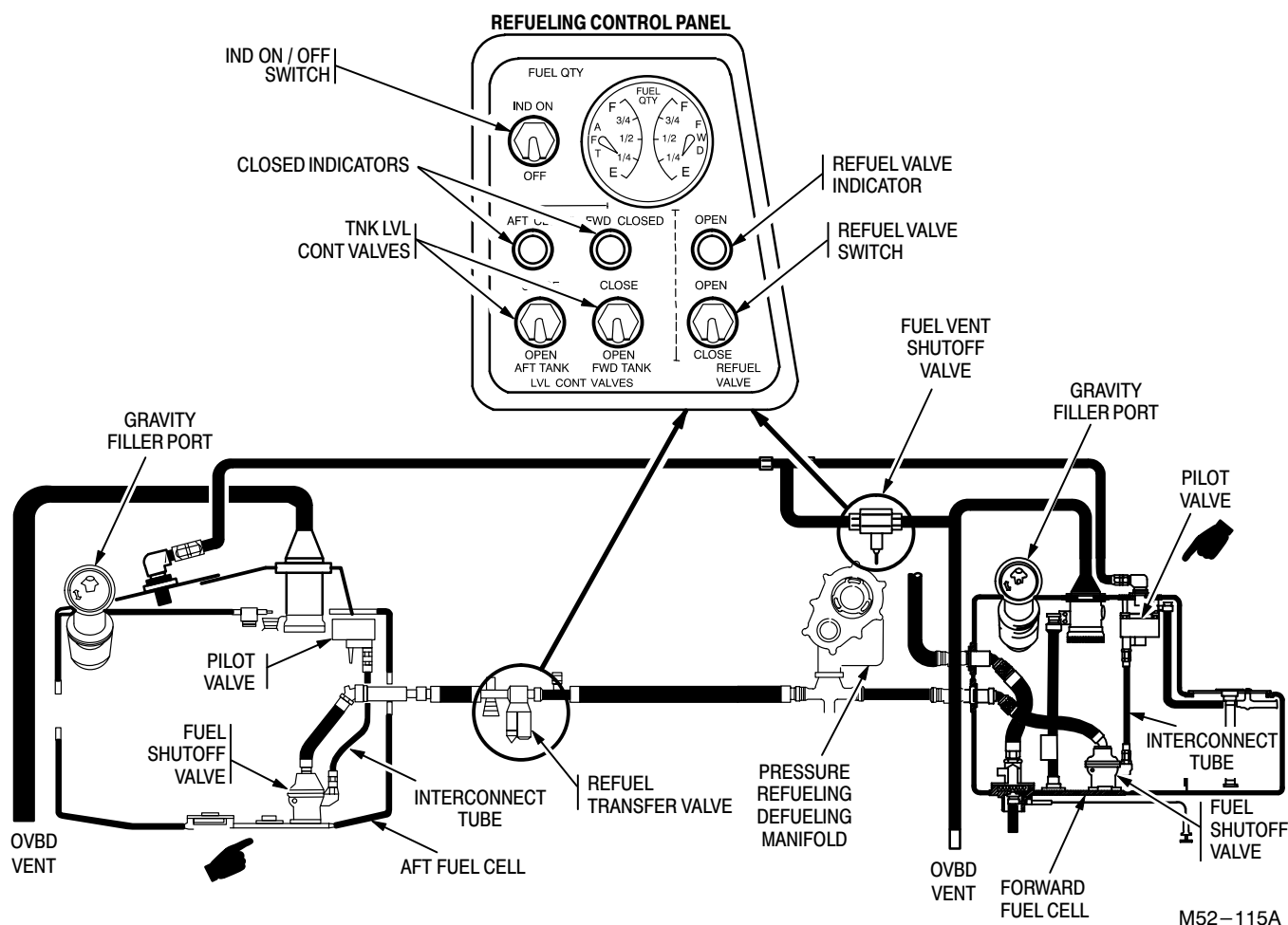


Figure 4-9. Refuel/Defuel System

(1) **Refueling Control Panel.** This panel provides a means of controlling refuel and defuel operations, and monitoring fuel quantity. The **IND ON/OFF** switch and **REFUEL VALVE** switch are supplied with power from the battery. Positioning the **IND ON/OFF** switch to **ON** enables the fuel quantity indicator to display fuel quantity in forward and aft fuel cells.

(a) When the **REFUEL VALVE** switch is set to **OPEN**, the fuel transfer valve and fuel vent shutoff valve are energized, and the **REFUEL VALVE** indicator light turns on. The **REFUEL VALVE OPEN** light on the pilot caution/warning panel also turns on.

(b) The **FWD** and **AFT TNK LVL CONT VALVES** switches are set to **CLOSE** after refueling begins to check the operation of the fuel level control valves for automatic shutoff. When the switches are set to **CLOSE** the fuel control valves in fuel cell close, terminating refueling and illuminating the **FWD CLOSED** and **AFT CLOSED** indicator lights. When the switches are set to **OPEN** the fuel control valves in the fuel cells open, turning off the indicators, and refueling can be continued.

(2) **Gravity Filler Port.** A gravity filler port is located on the right side of the fuselage for each of the fuel cells. Each filler port provides a means for gravity refueling or defueling of the forward or aft fuel cells in forward operating areas with portable fuel supplies.

4-3. THEORY OF OPERATION (cont)

4-3

(3) **Fuel Shutoff Valve.** This float-actuated valve contained in each fuel cell performs fuel shutoff, based on the operation of the pilot valve and provides a reverse flow inlet for defueling operations. Each fuel level control valve can be electrically shutoff when the **TNK LVL CONT VALVES** switches on the refueling control panel are set to **CLOSE**.

(4) **Interconnect Tube.** The interconnect provides a passage for fuel to flow between the pilot valve and fuel shutoff valve.

(5) **Pilot Valve.** The pilot valve is a solenoid operated poppet valve. The pilot valve triggers automatic fuel shutoff during refueling or fuel transfer.

(6) **Isolation Switches.** The isolation switches minimize electrical current flow through the contacts of the spring action diaphragm of the fuel shutoff valve. The contacts provide an electrical current path to the advisory light on the refueling panel. The aft isolation switch is located in the aft fuel cell ammo bay. The forward isolation switch is located in the gun bay underneath the pilot's floor.

(7) **Fuel Vent Shutoff Valve.** This 24 VDC electrically opened and spring-loaded closed valve controls venting of air from the fuel cells. Battery power is applied to the fuel vent shutoff valve when the **REFUEL VALVE** switch on the refueling control panel is set to **OPEN**. The fuel vent shutoff valve opens and air vents from the forward and aft fuel cells through the forward fuel cell overboard vent. When the **REFUEL VALVE** switch is set to **CLOSE**, the fuel shutoff valve closes and stops air venting from the forward fuel cell overboard vent.

(8) **Air Vent/Pressure Relief Valve.** A vent provided for each of the fuel cells exits excess fuel overboard to prevent over-expansion of the fuel cells. The aft fuel cell overboard vent has a cracking pressure of 2.0 ± 0.13 psi. The forward fuel cell has a cracking pressure of 1.5 ± 0.13 psi. Each overboard vent operates to vent the fuel cells during NIU system operation.

(9) **Pressure Refueling/Defueling Manifold.** The refuel/defuel manifold is mounted on the right side of the fuselage, forward of the wing (fig. 4-8). The manifold houses a single point adapter and a closed circuit adapter. Each adapter has a spring-loaded check valve that is forced open when the fuel nozzle is connected, to permit fuel flow for refueling or defueling. The single point adapter allows a refueling rate of 100 gallons per minute (gpm), and the closed circuit adapter allows a refueling rate of 60 gpm.

(10) **Refuel Transfer Valve.** The 24 VDC motor-operated valve allows pressure refueling and suction defueling of the aft tank. Battery power is applied to the fuel transfer valve when the **REFUEL VALVE** switch on the refueling control panel is set to **OPEN**. The fuel transfer valve opens and fuel enters or exits the aft fuel cell through the gravity fuel port or pressure refueling/defueling manifold during refuel or defuel operations. When the **REFUEL VALVE** switch is set to **CLOSE**, the fuel transfer valve closes and fuel does not enter or exit the aft fuel cell.

4-3. THEORY OF OPERATION (cont)

4-3

h. **Auxiliary Fuel Tanks.** The 4 auxiliary fuel tanks (2 per wing maximum) (fig. 4-10) store and supply additional fuel for ferry operations. The auxiliary tanks are constructed of aluminum alloy and have a capacity of 230 gallons (1495 pounds). With four tanks, 920 additional gallons (5978 pounds) can be ferried.

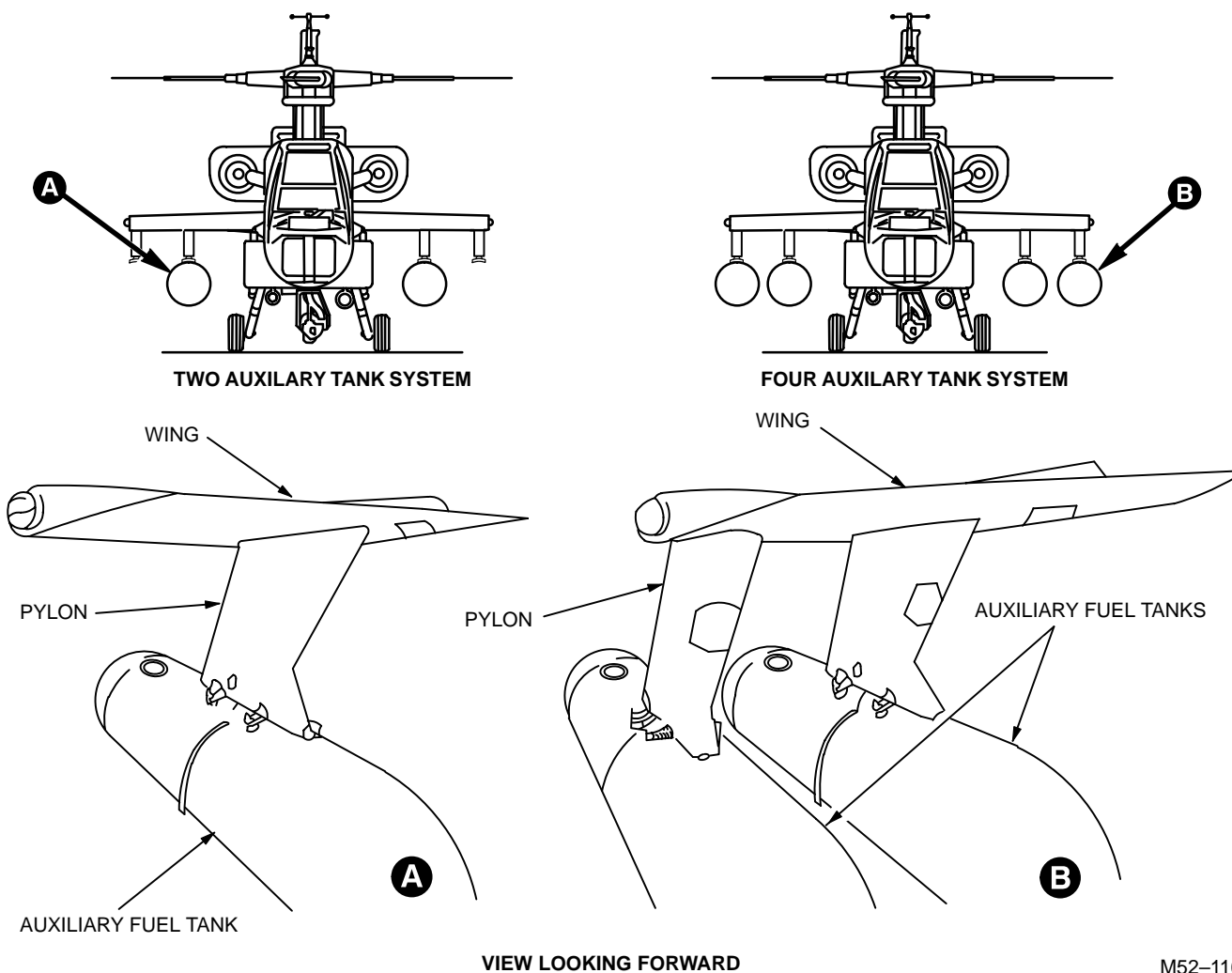


Figure 4-10. Auxiliary Fuel Tanks Location

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4-3. THEORY OF OPERATION (cont)

4-3

i. **Forward Fuel Cell.** The forward fuel cell (fig 4-11) is located in the center fuselage section, in front of the ammunition bay. The forward fuel cell is a 155 gallon (1007.5 pounds) bladder-type cell which is crash resistant and self sealing. The outer and inner layers are made of several layers of rubber impregnated nylon. The intermediate layer consists of uncured rubber which forms a sealant material. The uncured rubber reacts to fuel when the fuel cell is punctured. This reaction causes the uncured rubber to swell and seal the puncture in the fuel cell from 50 caliber (cal) and 14.5 mm hits. The fuel cell is surrounded at the bottom and sides by the helicopter fuselage, rigid foam, Kevlar liner, and backing boards. These materials reduce fuel cell chaffing and add ballistic protection.

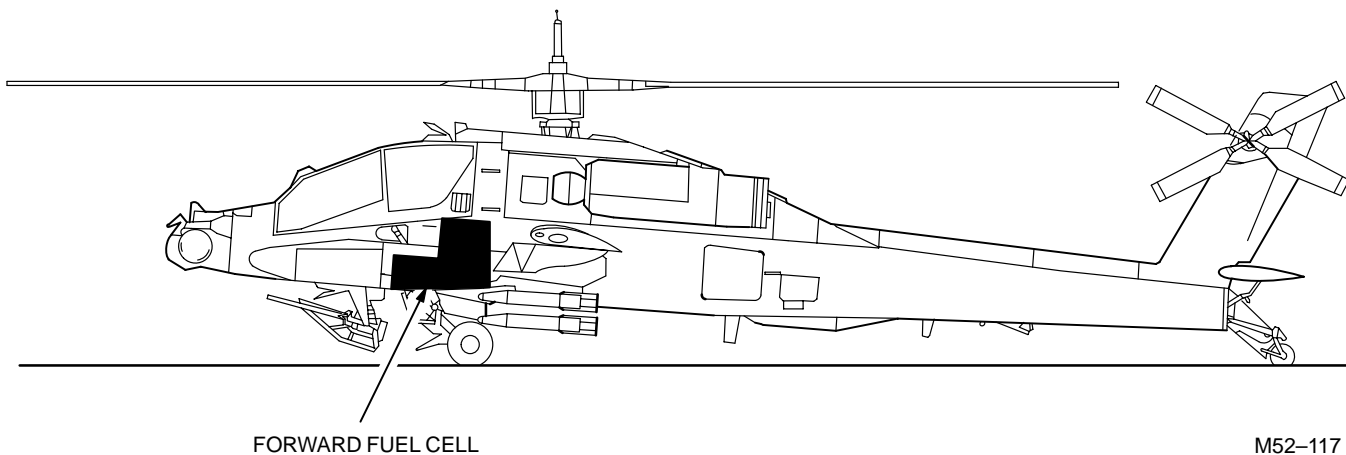


Figure 4-11. Forward Fuel Cell Location

j. **Pilot Fuel Indicators and Controls.** The pilot fuel indicators and controls inform and provide the pilot fuel system control information during flight or ground operations. Operation of the indicators and controls (fig. 4-12) are described below.

(1) **Fuel Quantity Indicator.** The fuel quantity indicator provides the pilot with forward and aft fuel cell vertical display scale fuel quantity indications in pounds. The fuel quantity indicator also provides total pounds fuel quantity indication on a digital readout. The fuel quantity indicator is energized when electrical power is applied to the aircraft.

(2) **Fuel Transfer Advisory Light.** The fuel transfer advisory light turns on when the **TRANS** switch on the **FUEL** panel is set **TO FWD** or **TO AFT**.

(3) **ENG 1 FIRE PULL Handle.** The handle closes the left fuel crossover shutoff valve to discontinue the fuel supply to the engine 1.

(4) **ENG 2 FIRE PULL Handle.** The handle closes the right fuel crossover shutoff valve to discontinue the fuel supply to the engine 2.

(5) **Caution/Warning Panel.** The panel contains caution/warning lights used during fuel system operation.

(a) The **FUEL LOW FWD** light turns on when fuel level in the forward fuel cell is below 280 ± 20 pounds.

(b) The **EXT EMP** light turns on when the auxiliary tanks are empty with the **EXT TK** switch set to **ON**.

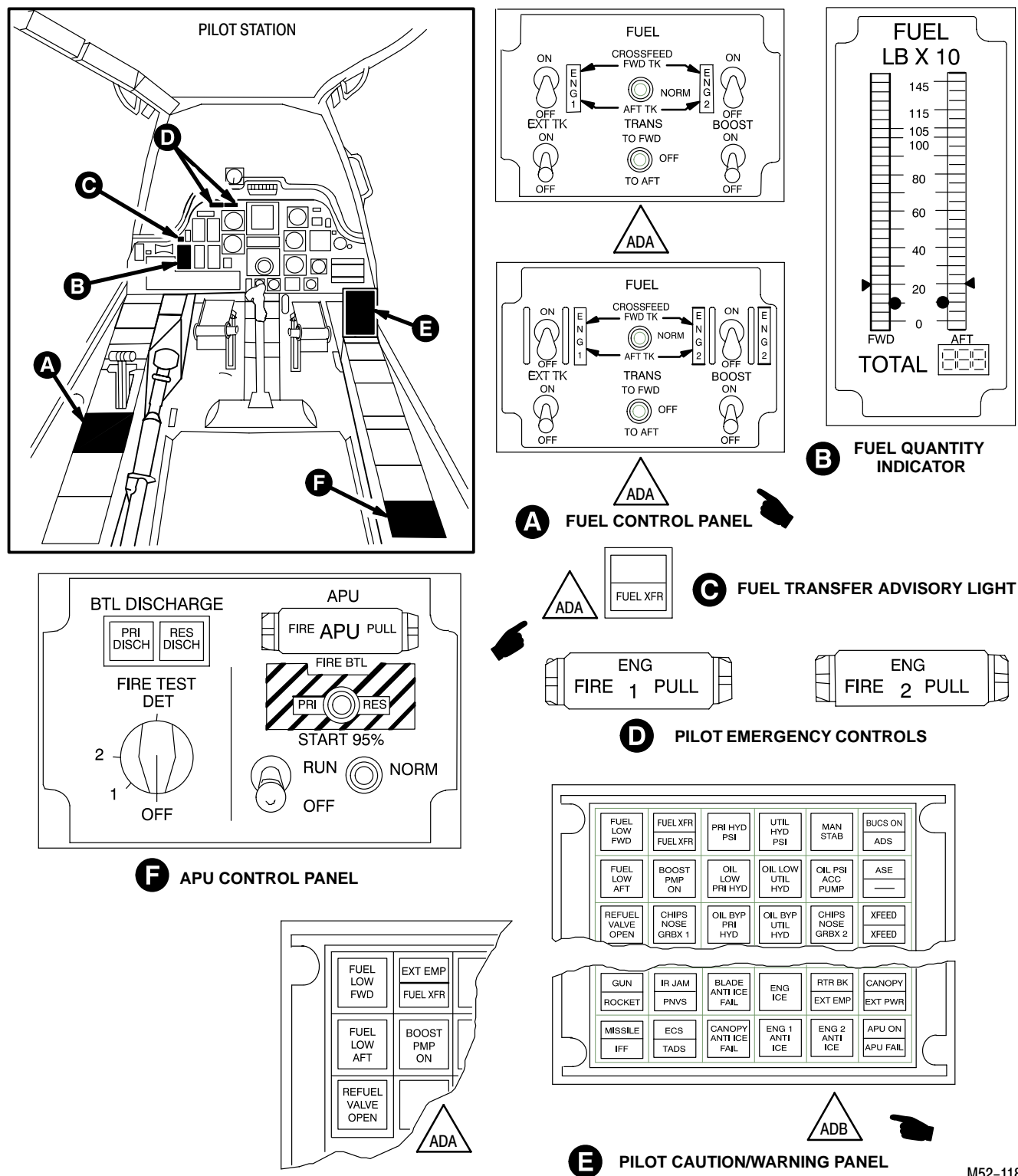
4-3. THEORY OF OPERATION (cont)

4-3

- (c) **(ADB)** The green **FUEL XFR** light turns on when fuel transfer is selected and transfer occurs.
 - (d) The amber **FUEL XFR** light turns on when fuel transfer is selected and does not occur.
 - (e) The **FUEL LOW AFT** light turns on when the fuel level in the aft fuel cell decreases to 240 ± 20 pounds.
 - (f) The **BOOST PMP ON** light turns on when the boost pump is operating.
 - (g) The **REFUEL VALVE OPEN** light turns on when the refuel transfer valve is open.
 - (h) **(ADB)** The green **XFEED** light turns on when crossfeed is selected and one or both engine fuel valves are correctly positioned.
 - (i) **(ADB)** The amber **XFEED** light turns on when one or both engine fuel valves are closed or crossfeed is selected and one or both valves are incorrectly positioned.
- (6) **APU Control Panel.** The panel provides pilot control of the APU fuel distribution system.
- (a) The **APU FIRE PULL** handle de-energizes the APU fuel boost pump and APU fuel shutoff valve to discontinue the APU fuel supply.
 - (b) The **APU START/RUN/OFF** switch controls the APU, energizes the APU fuel boost pump and APU fuel shutoff valve, to provide fuel to the APU.
- (7) **FUEL Panel.** The panel provides pilot control of fuel system operation.
- (a) The **ENG 1** switch, when set to **ON**, opens the left crossover shutoff valve to provide fuel to the engine 1. When set to **OFF** the switch closes the crossover shutoff valve to discontinue supplying fuel to the engine 1.
 - (b) The **CROSSFEED** switch, when set to **FWD TK**, supplies the engines with fuel from the forward fuel cell. The engines are supplied fuel from the aft fuel cell when the **CROSSFEED** switch is set to **AFT TK**. The engine 1 is supplied fuel from the forward fuel cell and the engine 2 is supplied fuel from the aft fuel cell when the **CROSSFEED** switch is set to **NORM**.
 - (c) The **ENG 2** switch, when set to **ON**, opens the right crossover shutoff valve to provide fuel to the engine 2. When set to **OFF** the switch closes the crossover shutoff valve to discontinue supplying fuel to the engine 2.
 - (d) The **EXT TK** switch is set to **ON** to energize auxiliary fuel tank air and fuel shutoff valves and routes pressurized air to external tanks for transfer of fuel to internal tanks. When four external tanks are installed, PAS air only pressurizes outboard tanks. Fuel is forced from outboard tanks, through inboard tanks, and into aircraft internal tanks. The switch is set to **OFF** to discontinue the transfer operation.
 - (e) The **TRANS** switch is set to **FWD** to transfer fuel from the aft fuel cell to the forward fuel cell. The switch is set to **AFT** to transfer fuel from the forward fuel cell to the aft fuel cell.
 - (f) The **BOOST** switch is set to **ON** to energize the fuel boost pump pressure shutoff valve. The switch is set to **OFF** to discontinue fuel boost pump pressure shutoff valve operation.

4-3. THEORY OF OPERATION (cont)

4-3



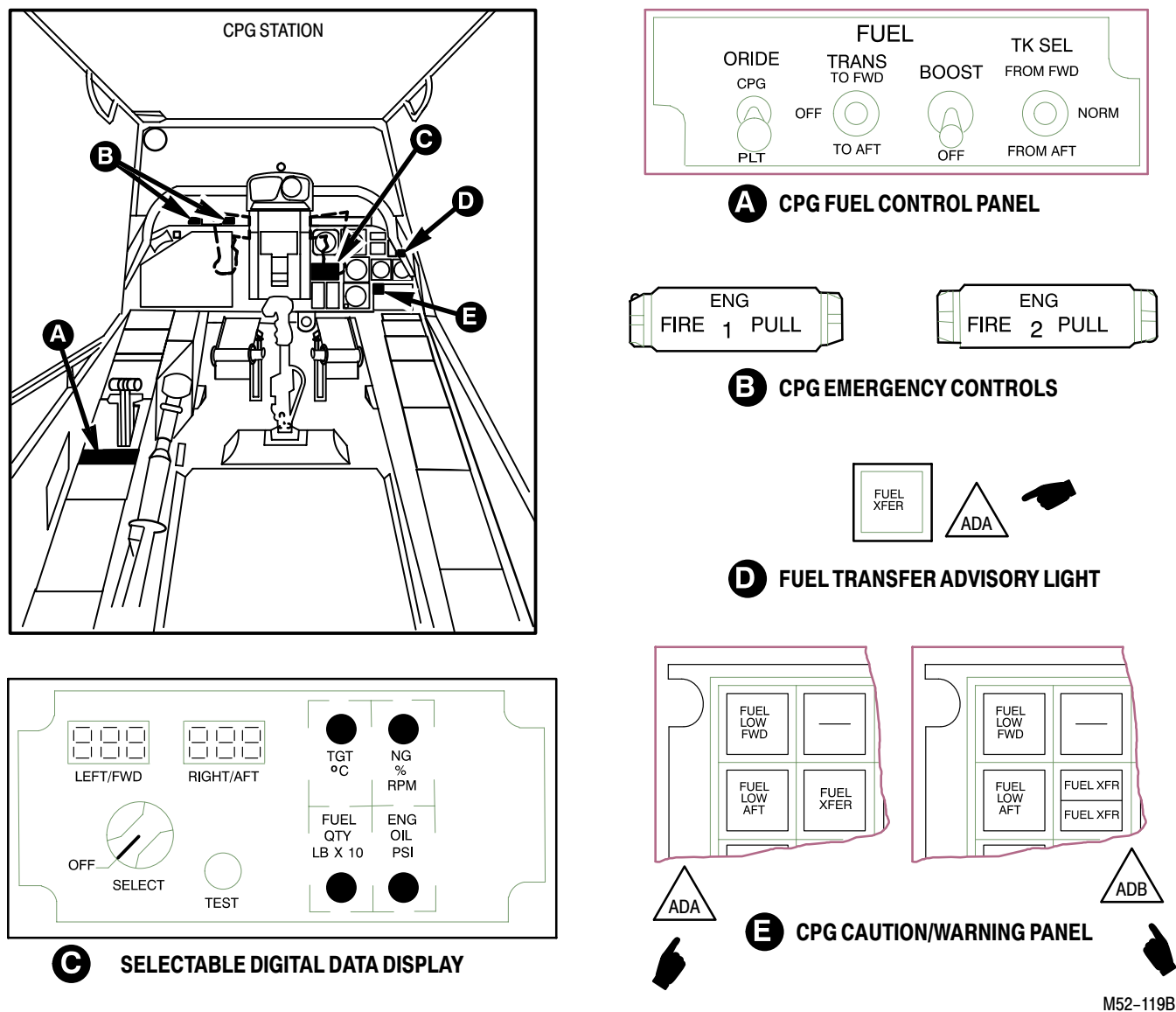
M52-118A

Figure 4-12. Pilot Fuel Indicators and Controls

4-3. THEORY OF OPERATION (cont)

4-3

k. **CPG Fuel Indicators and Controls.** The CPG fuel indicators and controls inform and provide the CPG fuel system control during flight or ground operations. Operation of the indicators and controls (fig. 4-13) are described below.



M52-119B

Figure 4-13. CPG Fuel Indicators and Controls

(1) The **ENG 1 FIRE PULL** handle closes the left fuel crossover shutoff valve to stop the fuel supply to the engine 1.

(2) The **ENG 2 FIRE PULL** handle closes the right fuel crossover shutoff valve to stop the fuel supply to the engine 2.

4-3. THEORY OF OPERATION (cont)

4-3

(3) The selectable digital data (SDD) display provides CPG selection for fuel quantity indication of the forward fuel cell and aft fuel cell. When the select control knob is set to **SELECT** position, at the fuel quantity detent, the SDD display fuel quantity light turns on. The **LEFT/FWD** digital readout displays the forward fuel cell fuel quantity in pounds. The **RIGHT/AFT** digital readout displays the aft fuel cell fuel quantity in pounds.

(4) The **FUEL XFER** advisory light turns on when the **TRANS** switch on the **FUEL** panel is set **TO FWD** or **TO AFT**.

(5) The caution/warning panel provides caution/warning light illumination during fuel system operation.

(a) The **FUEL LOW FWD** light turns on when fuel level in the forward fuel cell is below 280 ± 20 pounds.

(b) The **FUEL LOW AFT** light turns on when the fuel level in the aft fuel cell decreases to 240 ± 20 pounds.

(c) **(ADA)** The **FUEL XFER** light turns on when fuel transfer is selected and does not occur. **(ADB)** The amber **FUEL XFR** light turns on when fuel transfer is selected and does not occur.

(d) **(ADB)** The green **XFEED** light turns on when crossfeed is selected and both engine fuel valves are correctly positioned.

(e) **(ADB)** The amber **XFEED** light turns on when one or both engine fuel valves are closed or crossfeed is selected and one or both valves are incorrectly positioned.

(6) The **FUEL** panel. The panel provides CPG control of fuel system operation.

(a) The **ORIDE** switch, when set to **PLT**, arms the pilot **FUEL** panel and disarms the CPG **FUEL** panel. When the **ORIDE** switch is set to **CPG** the pilot **FUEL** panel is disarmed and the CPG **FUEL** panel is armed.

(b) The **FUEL TRANS** switch is set to **FWD** to transfer fuel from the aft fuel cell to the forward fuel cell. The switch is set to **AFT** to transfer fuel from the forward fuel cell to the aft fuel cell.

(c) The **FUEL BOOST** switch is set to **ON** to energize the fuel boost pump pressure shutoff valve. The switch is set to **OFF** to discontinue fuel boost pump pressure shutoff valve operation.

(d) The **TK SEL** switch is set to **ON** to transfer fuel from the auxiliary fuel tanks to the aft fuel cell. The switch is set to **OFF** to discontinue the transfer operation.

5-1. PURPOSE**5-1****CHAPTER 5 AUXILIARY POWER UNIT****5-1. PURPOSE**

a. The auxiliary power unit (APU) drives the accessory section of the main transmission to provide pneumatic, hydraulic, and electrical power.

b. The APU provides the AH-64A with a self-supporting means in a field environment, by eliminating the need for an external pneumatic source, hydraulic power, and electrical power.

5-2. DESCRIPTION

The APU is a self-contained, fully automatic constant speed gas turbine engine requiring only dc power, fuel, and input signals from the helicopter for operation. Table 5-1 lists the APU operating parameters.

Table 5-1. APU Operating Parameters

Item	Parameters
Weight (dry)	100 pounds
Shaft Power Output	125 shaft horsepower (shp)
APU Speeds:	
Turbine Rotor	59,566 revolutions per minute (rpm)
PTO Clutch	8216 counter-clockwise (ccw) rpm
Electrical System Voltage	14 to 30 VDC
Lubrication System:	
Type Oil	MIL-L-23699 or MIL-L-7808
Capacity	2 Quarts
Fuel System:	
Type Fuel	Grades JP4, JP5, and JP8
Consumption:	
Full Load	155 pounds per hour (pph)
No Load	80 pounds per hour

5-2. DESCRIPTION (cont)

5-2

Table 5-1. APU Operating Parameters (cont)

Item	Parameters
Automatic Shutdown Conditions:	
Overspeed	107% (63,736 rpm)
Overcurrent:	
Fuel Shutoff Valve Solenoid	1.2 ± 0.5 amp
Ignition Unit	4.0 ± 0.5 amp
PTO Clutch Solenoid	1.0 ± 0.5 amp
Start Valve Solenoid	1.0 ± 0.5 amp
Low Oil Pressure	75 psi
Over Temperature	1785°F (973°C) at 60%
	1325°F (717.6°C) at 100%
Loss of Thermocouple Signal	
Operating Range	-65 to 135°F (-54 to 57°C) (sea level to 15,000 feet)
Start Motor Hydraulic Fluid	MIL-H-83282 or MIL-H-5606

a. The APU is located on the right-hand side of the aft equipment bay, aft of the main transmission, between the engines 1 and 2 (fig. 5-1).

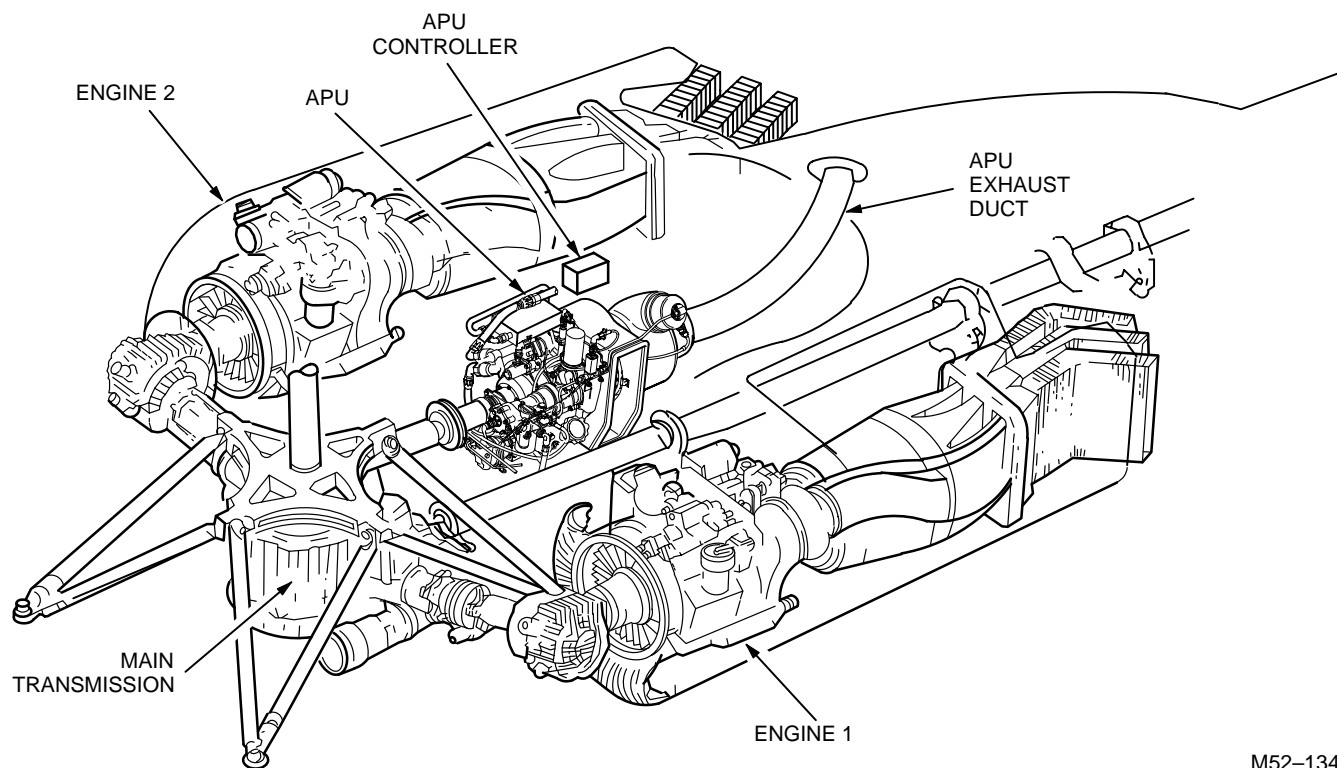
The APU major components are described below.

b. **Elapsed Time Indicator.** The elapsed time indicator (fig. 5-2) located in the aft equipment bay, is mounted on top of the APU enclosure to provide protection from engine vibration. The elapsed time indicator is shielded from engine and APU operating temperatures. The elapsed time indicator indicates the operating hours of the APU.

c. **Exhaust Duct.** The exhaust duct (fig. 5-2) is located in the aft equipment bay. The exhaust duct is located to efficiently exit APU exhaust just aft of engine 2 nacelle.

5-2. DESCRIPTION (cont)

5-2



M52-134

Figure 5-1. APU Location

d. **APU Controller.** The APU controller (fig. 5-2) located in the aft equipment bay, is mounted on top of the APU enclosure to provide protection from engine vibration. The APU controller is shielded from engine and APU operating temperatures. The APU controller is a solid state device which monitors input signals, provides output control signals, and provides automatic shutdown sequence to the APU.

(1) The APU controller monitors Nr rotor speed, motional transducer, low oil pressure (LOP) switch, and exhaust gas temperature.

(2) The APU controller provides output control signals for ignition, fuel, power take-off (PTO) clutch solenoid, LOP switch, elapsed time indicator, hydraulic start solenoid valve, fault detection and location system (FD/LS), caution/warning lights.

e. **Igniter Unit.** The igniter unit is a sealed low voltage capacitive discharge system that converts 28 VDC to 2900-3200 VAC for use by the igniter plug. The igniter unit is located on top of the accessory gearbox.

f. **Low Oil Pressure (LOP) Switch.** The LOP is a normally closed, solenoid operated pressure switch that measures oil pressure. When the oil pressure decreases below 75 psi at 95% rpm, the switch illuminates the **APU FAIL** light on the pilot caution/warning panel and signals the controller to shut down APU operation. The LOP is mounted on the APU to the right of the oil filter.

5-2. DESCRIPTION (cont)

5-2

g. **Oil Filter.** The oil filter (s a canister with a disposable paper filter that removes contaminants 10 to 25 microns absolute from the oil system. The oil filter has no bypass capabilities. A clogged filter will result in immediate APU shutdown. The oil filter is mounted on the left side of the APU at the 11 o'clock position.

h. **Fuel Solenoid Valve.** The fuel solenoid valve opens at 5% rpm allowing fuel to enter the fuel nozzle. The fuel solenoid valve is located on the upper aft section of the accessory gearbox.

i. **APU Fuel Control.** The APU fuel control meters the amount of fuel needed for starting, acceleration, and normal operation. The APU fuel control is located on the left front section of the accessory gearbox.

j. **Fuel Filter.** The fuel filter is a canister with a three micron disposable filter that removes contaminants from the fuel system. The fuel filter is located on the bottom left side of the APU fuel control.

k. **Power Take Off (PTO) Clutch.** The PTO clutch receives electrical signals from the APU controller to move a two-way ball type valve, allowing oil to engage and disengage the clutch. The PTO clutch is mounted on the front of the accessory gearbox. The clutch couples the APU to the main transmission accessory section. The clutch is a LRU. The friction disk lasts for approximately 1000 engagements. The data plate can be removed to inspect the friction disk.

l. **Magnetic Chip/Drain Plug.** The magnetic chip/drain plug permits oil sump drainage, and inspection for metal particles in the oil. The magnetic chip/drain plug is mounted on the forward lower center section of the APU. The magnetic chip/drain plug is a two plug permanent magnet which attracts ferrous metal particles. The drain plug closes when the magnetic chip plug is removed from the oil sump. A special tooling plug is installed in place of the magnetic chip plug to drain the oil from the sump. Oil change intervals are every 500 helicopter operating hours.

m. **Oil Level Sight Indicator.** The oil level sight indicator allows visual inspection of the oil sump oil level. The oil level sight indicator is mounted on the lower right side of the oil sump. The oil sight indicator is a circular eye indicator with an aluminum ball that floats at the top of the indicator when the oil sump is full. The oil level is checked through an access panel under the engine 2 nacelle on the right hand side of the airframe.

n. **Motional Transducer.** The motional transducer is a magnetic sensing device that measures the % of APU rpm by magnetically counting the teeth of the APU main drive gear. The motional transducer is mounted on the right side of the APU.

o. **Hydraulic Starter.** The hydraulic starter generates APU rotation when supplied with high pressure hydraulic fluid from the utility hydraulic accumulator. The hydraulic starter is a nine piston axial motor attached to the upper right side of the APU.

p. **Fuel Nozzle.** The fuel nozzle consists of a primary, secondary and piloted air blast atomizer orifice which makes up a flow divider. The fuel nozzle provides atomized fuel to the combustor section during APU operation. The fuel nozzle is attached to the top of the combustor cap.

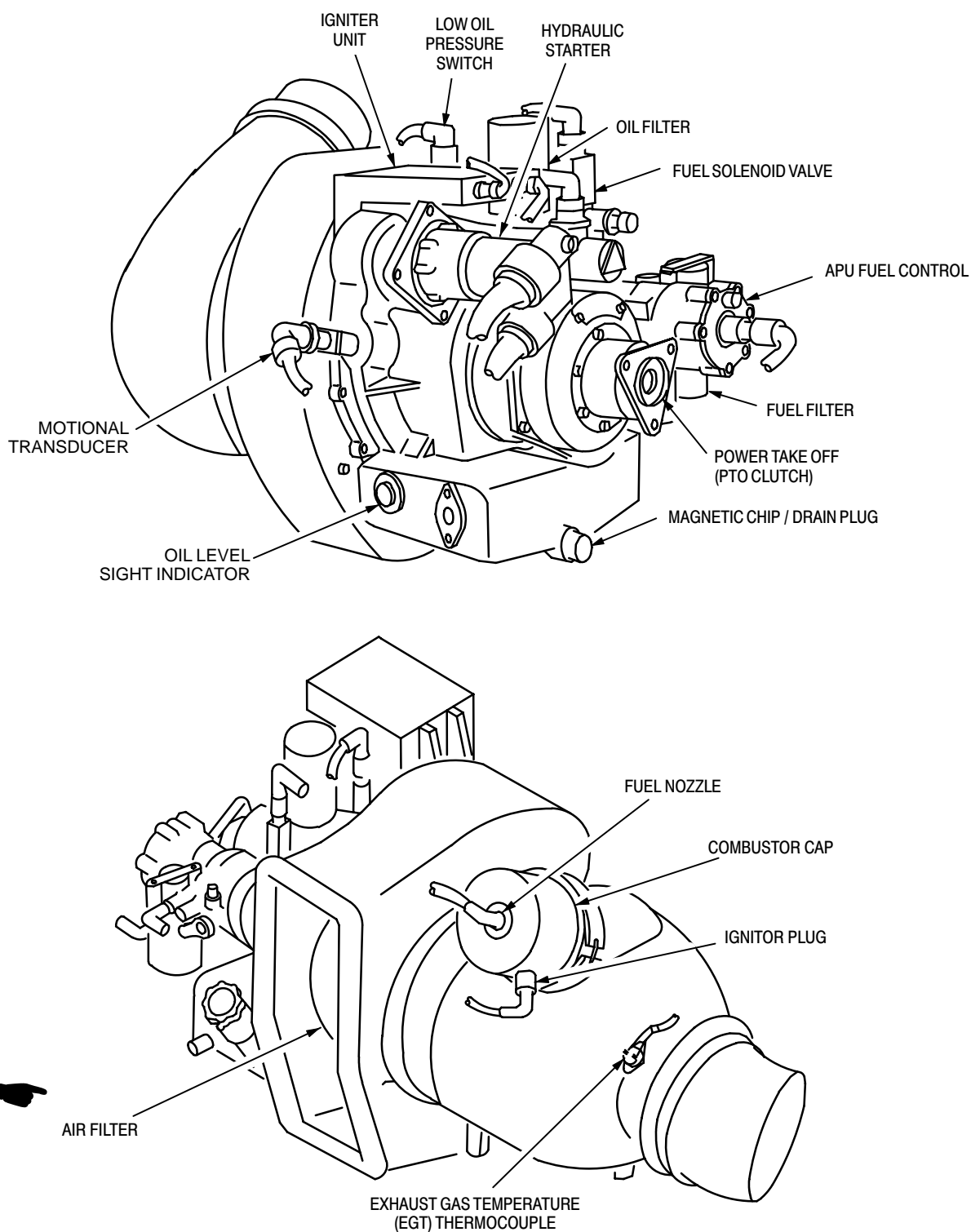
q. **Combustor Cap.** The combustor cap contains the igniter and fuel nozzle. The combustor cap is removable as an assembly for combustor can inspection.

r. **Igniter Plug.** The igniter plug provides spark in the combustion section to ignite the fuel/air mixture during start sequence. The igniter plug is attached to the side of the combustor cap.

s. **Exhaust Gas Temperature (EGT) Thermocouple.** The EGT thermocouple provides an electronic signal proportional to the exhaust gas temperature. The EGT thermocouple is located at the back of the APU at the 10 o'clock position to insure it is completely immersed in the APU exhaust gases.

5-2. DESCRIPTION (cont)

5-2



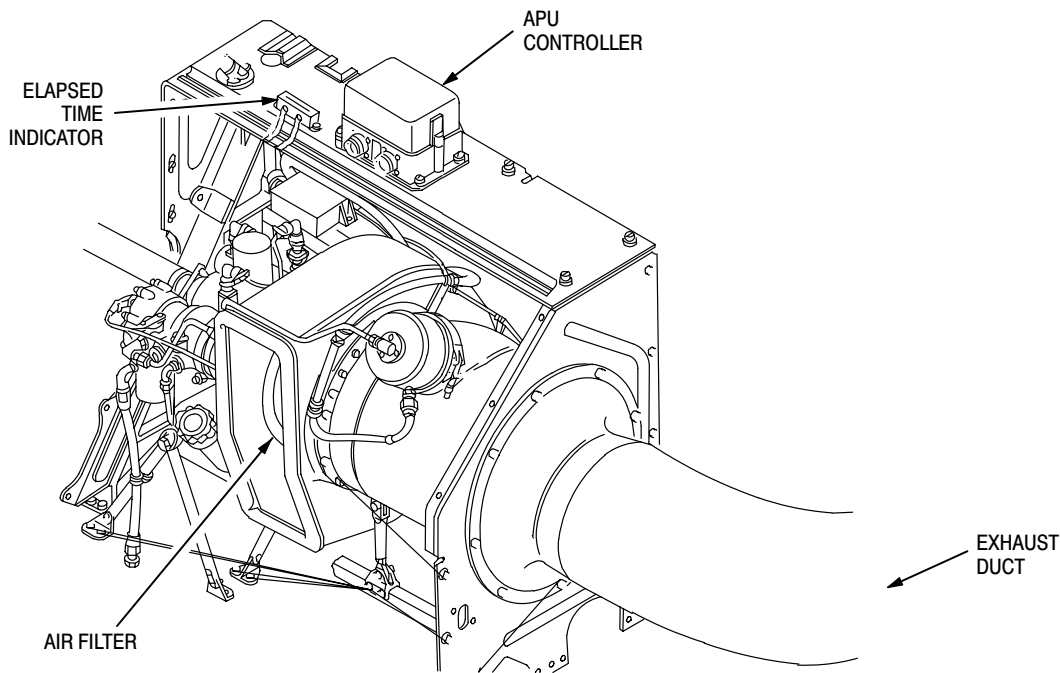
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Figure 5-2. APU Major Components (Sheet 1 of 2)

5-3. THEORY OF OPERATION

5-3

t. **APU Air Filter.** Some helicopters have an APU air filter installed on the air inlet to prevent ingestion of small particles.



M52-135-2B

Figure 5-2. APU Major Components (Sheet 2 of 2)

5-3. THEORY OF OPERATION

a. The pilot center circuit breaker panel, APU fire panel assembly and pilot caution/warning panel (fig. 5-3) provide the controls and indications for the APU.

(1) **Pilot Center Circuit Breaker Panel.** The pilot center circuit breaker panel **FUEL APU**, **FUEL BST**, and **APU HOLD** circuit breakers provide circuit protection and 28 VDC for APU operation.

(2) **Pilot Caution/Warning Panel.** The pilot caution/warning panel provide the pilot with **APU ON** and **APU FAIL** indications.

(a) **APU ON** indicator. The **APU ON** indicator lights when the APU reaches 95% rpm.

(b) **APU FAIL** indicator. The **APU FAIL** indicator lights when oil pressure drops below 75 psig, except when the **START/RUN/OFF** switch is in the **START** position.

(3) **APU Fire Panel Assembly.** The **APU** fire panel assembly controls APU start/run operation and APU fire indication.

(a) **APU FIRE PULL** handle. The **APU FIRE PULL** handle warns the pilot that a fire exists in the APU shroud assembly, SDC area, or may be an indication of a fire in the transmission area. When **FIRE TEST DET** switch is set to **1**, the **APU FIRE PULL** handle lights to indicate the upper flame detector circuits and components are functioning. When **FIRE TEST DET** switch is set to **2**, the **APU FIRE PULL** handle lights to indicate the lower flame detector circuits and components are functioning. When the **APU FIRE PULL** handle is pulled, the APU fuel shutoff valve is closed and the selected fire bottle is discharged.

5-3. THEORY OF OPERATION (cont)

5-3

(b) **95%/NORM** switch. The **95%** position is used during cold weather starts when the outside air temperature is 0°F (-18°C) or below. The **NORM** position is used during normal starts when the outside air temperature is above 0°F (-18°C).

(c) **START/RUN/OFF** switch. The **START** position initiates the APU start sequence. The **START** position is spring-loaded to the **RUN** position. The **RUN** position allows steady state automatic APU operation. In the **OFF** position, no voltage is supplied to the APU.

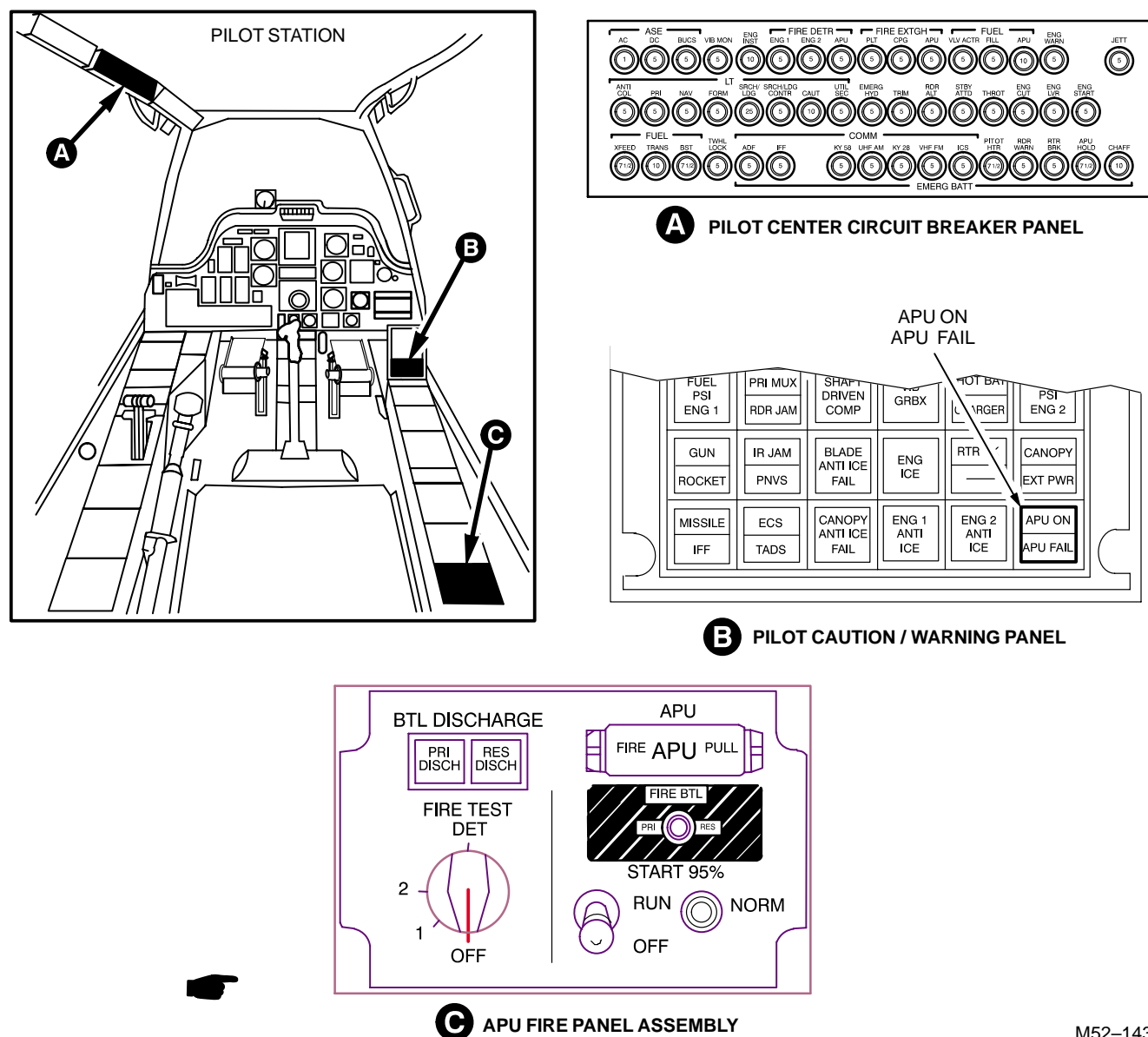


Figure 5-3. APU Controls and Indicators

M52-143B

5-3. THEORY OF OPERATION (cont)

5-3

b. **APU** circuit breaker (CB148) (fig. 5-4) and **APU HOLD** circuit breaker (CB10) protect the APU start system circuitry from excessive current and provide 24 VDC from the battery to the **APU** fire panel assembly for **START/RUN** power.

c. When the **START/RUN/OFF** switch is set to the **START** position, **FUEL APU** circuit breaker (CB9) supplies 28 VDC to the APU fuel boost pump and APU fuel shutoff valve.

(1) The APU fuel shutoff valve provides automatic control of fuel flow from the aft fuel cell to the APU fuel boost pump.

(2) The APU fuel boost pump provides a positive fuel flow to the APU fuel solenoid valve.

(3) The APU fuel solenoid valve is opened by the APU controller when the APU reaches 5% rpm, providing fuel to the APU fuel control.

(4) The APU fuel control meters and modulates the fuel flow to the fuel nozzle.

(5) The fuel nozzle provides atomized fuel for combustion.

d. **FUEL BST** circuit breaker (CB57) supplies 28 VDC to the time delay relay and to the APU controller. The SDC time delay relay de-energizes the shaft driven compressor throttle valve for 60 seconds. The APU controller initiates, controls and monitors the start sequence, normal operation, and automatic shutdown as follows.

(1) The hydraulic start solenoid valve is energized open by the APU controller. The hydraulic start solenoid valve opens to release 3000 psi hydraulic pressure from the utility hydraulic accumulator through the hydraulic starter. APU rotation begins.

(2) When the APU reaches 5% rpm as determined by the motional transducer, the APU controller energizes the fuel solenoid valve and excites the igniter unit. The fuel shutoff valve opens to provide fuel through the fuel control to the fuel nozzle. The igniter unit supplies a series of high energy sparks to the igniter plug. With fuel, ignition, and rotation the APU generates combustion and accelerates to become self sustaining.

(3) After two to three seconds, **START/RUN/OFF** switch is released to **RUN**. The **APU FAIL** indicator lights. The **APU FAIL** indicator goes out when the LOP switch measures oil pressure above 75 psi.

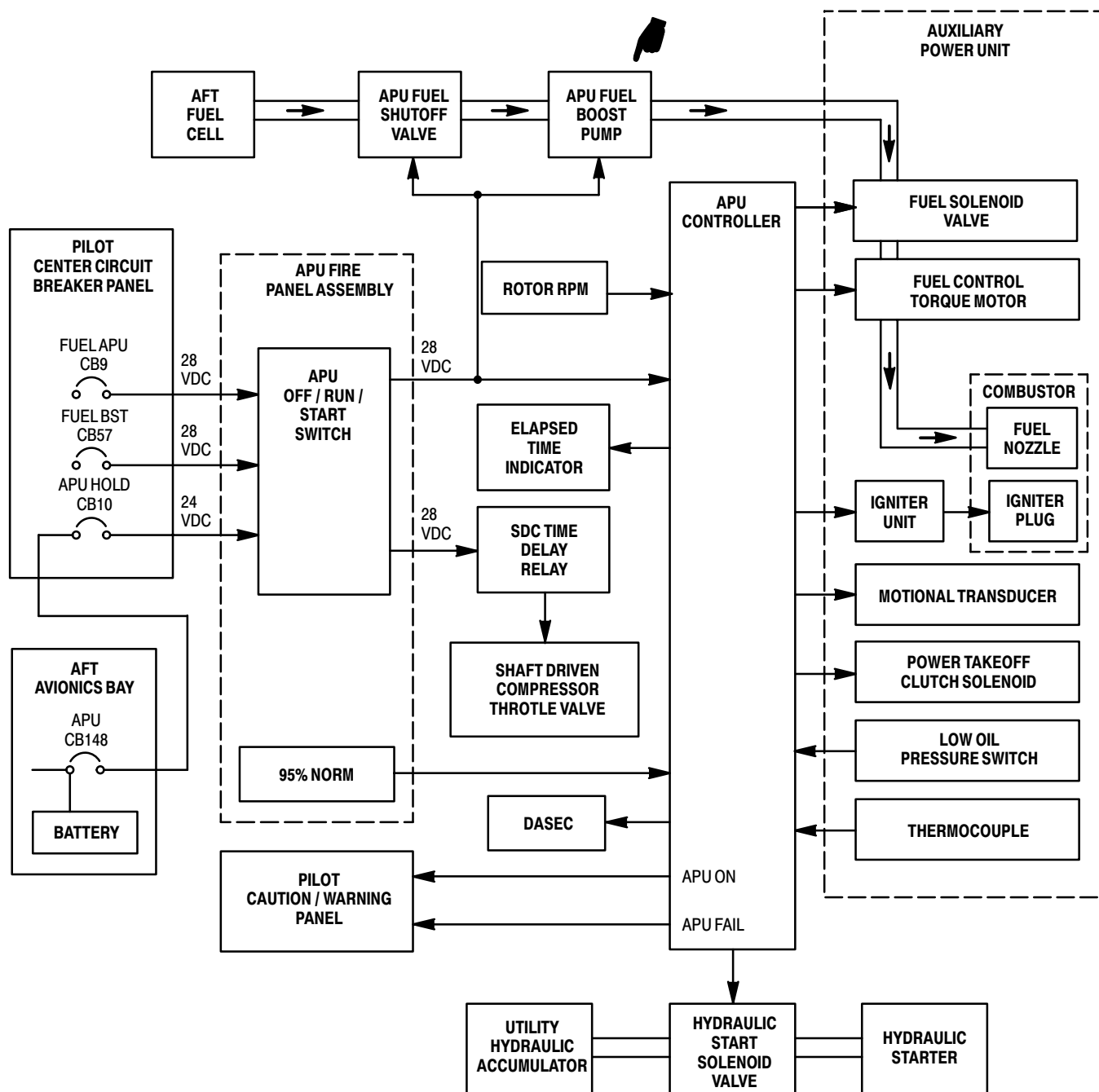
(4) When the APU reaches 60% rpm as determined by the motional transducer, the APU controller de-energizes the hydraulic start solenoid valve. The hydraulic start solenoid valve closes allowing the utility hydraulic accumulator to rebuild hydraulic pressure. If the helicopter main rotor speed is below 95% N_r , the PTO clutch engages unless the **APU 95%** switch is used for a cold weather start. When the **APU 95%** switch is used, the **APU ON** indicator provides an indication that 95% rpm has been reached. The **95%** switch is released and the PTO clutch engages. The PTO clutch drives the main transmission accessory section. The elapsed time indicator is operating whenever the PTO clutch is engaged.

(5) When the APU reaches 95% rpm as determined by the motional transducer, the APU is self sustaining. The APU controller de-energizes the hydraulic start solenoid valve and engages the PTO clutch. The PTO clutch drives the main transmission accessory section. The **APU ON** indicator lights. The igniter unit is de-energized four seconds after the controller signals 95% APU rpm.

(6) The APU stabilizes at 100% rpm.

5-3. THEORY OF OPERATION (cont)

5-3



M52-136C

Figure 5-4. APU Block Diagram

5-3. THEORY OF OPERATION (cont)

5-3

(7) The APU controller provides automatic shutdowns for the following conditions and provides system status to the fire control computer (FCC) via the digital automatic stabilization equipment computer (DASEC).

- (a) Loss of monopole signal or overspeed (rpm exceeds 107%).
- (b) Loss of thermocouple signal or overtemperature. EGT exceeds 1785°F (973°C) up to 60% APU rpm, or 1325°F (718.3°C) at 100% APU rpm.
- (c) Loss of oil pressure (below 75 psi).
- (d) Fuel control shutoff valve overcurrent.
- (e) Hydraulic start solenoid overcurrent.
- (f) Igniter unit overcurrent.
- (g) PTO clutch solenoid overcurrent.

e. When the **APU** fire panel assembly **START/RUN/OFF** switch is set to the **OFF**, 28 VDC is removed from the APU fuel solenoid valve, APU fuel boost pump, and APU controller resulting in a normal APU shutdown.

6-1. PURPOSE

6-1

CHAPTER 6 ENGINE SYSTEM

6-1. PURPOSE

The engine system consists of two General Electric T700-GE-701 or T700-GE-701C front drive turboshaft engines. The T700-GE-701 provides 1690 shaft horsepower (shp) and the T700-GE-701C provides 1800 shp, intermediate rated power (IPR) at 59 °F (15 °C) standard day condition with 20,900 rpm (Np), to drive the main transmission.

6-2. DESCRIPTION

The engine system major components and subsystems (fig. 6-1) are described below.

- a. **Engine Sensors.** The engine sensors (fig. 6-2) are described below.
- b. **Engine Control System.** The engine control system is a mechanical system that increases or decreases fuel to the engines to compensate for increased or decreased engine power demands.
- c. **Np Overspeed System.** The Np overspeed system is an electromechanical system that provides engine overspeed protection.
- d. **Engine Bleed Air System.** The engine bleed air system is an electromechanical system that provides engine fifth stage compressor bleed air for the anti-ice system and pressurized air system (PAS).
- e. **Engine Cooling System.** The engine cooling system is an electromechanical system that provides engine cooling and engine nacelle cooling during engine operation and after engine shutdown.
- f. **Engine Exhaust System.** The engine exhaust system is a mechanical system that provides an exit for engine exhaust gases and reduces exhaust gas temperatures.
- g. **Engine Start and Ignition Systems.** The engine start system is an electromechanical system that provides initial engine rotation and ignition so that the engines will become self sustaining.

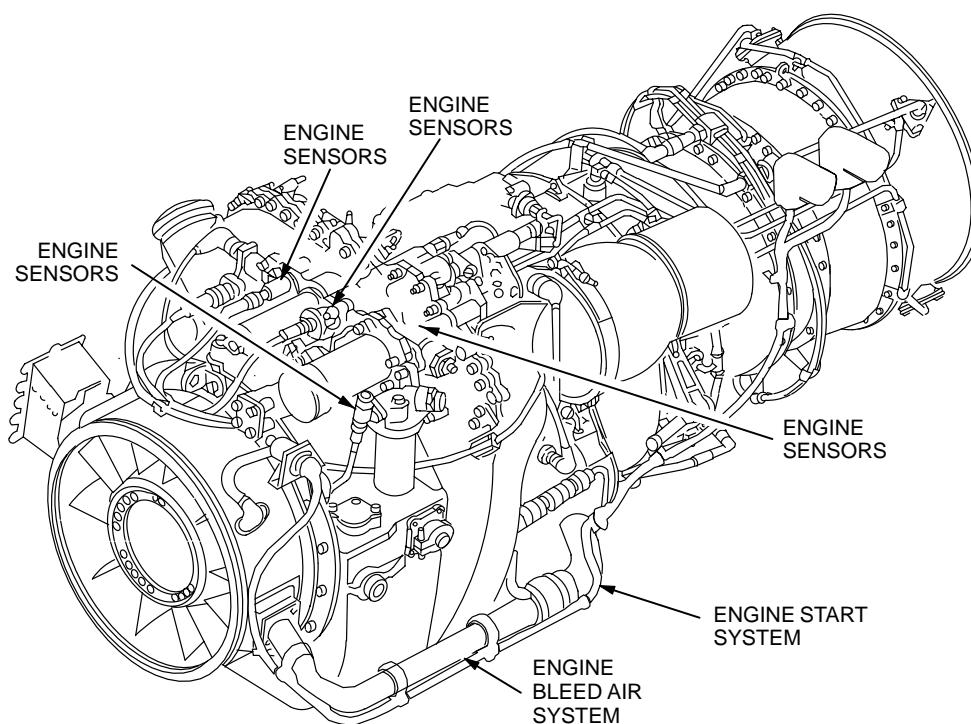
6-3. THEORY OF OPERATION

- a. **Engine Sensors.** The engine sensors (fig. 6-2) are described in the following subparagraphs.
 - (1) The oil pressure transducer (fig. 6-3) is a variable reluctance pressure transmitter. The oil pressure transducer sends an electrical signal proportional to the engine oil pressure to the oil pressure indicator. The oil pressure transducer is located on the upper left section of the engine.
 - (2) Np rpm sensor (fig. 6-4) is a monopole permanent magnet pickup that sends a signal to the engine control unit (ECU) or digital engine control unit (DECU) proportional to the power turbine speed (Ng).
 - (3) The Ng sensor (fig. 6-5) is a three phase 115 VAC sensor located on the engine alternator. The engine alternator is driven by the engine to drive the gas generator turbine speed (Ng) which provides a Ng signal to the pilot Ng indicator.
 - (4) The turbine gas temperature (TGT) sensors (fig. 6-6) are chromel-alumel sensors that form the TGT harness. There are seven sensors that increase in voltage output as the engine exhaust temperature increases. The average value of the sensors is displayed on the pilot TGT indicator.

6-3. THEORY OF OPERATION (cont)

6-3

(5) The fuel filter bypass sensor (fig. 6-7) is a pressure sensitive switch that closes when differential pressure across the fuel filter is below 18 to 22 psi. The fuel filter bypass sensor provides an electrical signal to illuminate the **FUEL BYP ENG 1** or **FUEL BYP ENG 2** lights on the pilot caution/warning panel, and the appropriate **ENG 1** or **ENG 2** light on the pilot and copilot/gunner (CPG) caution/warning panels. The fuel filter bypass sensor is mounted on the forward lower left section of the engine.



M52-287-1

Figure 6-1. Engine System Major Components and Subsystems (Sheet 1 of 2)

6-3. THEORY OF OPERATION (cont)

6-3

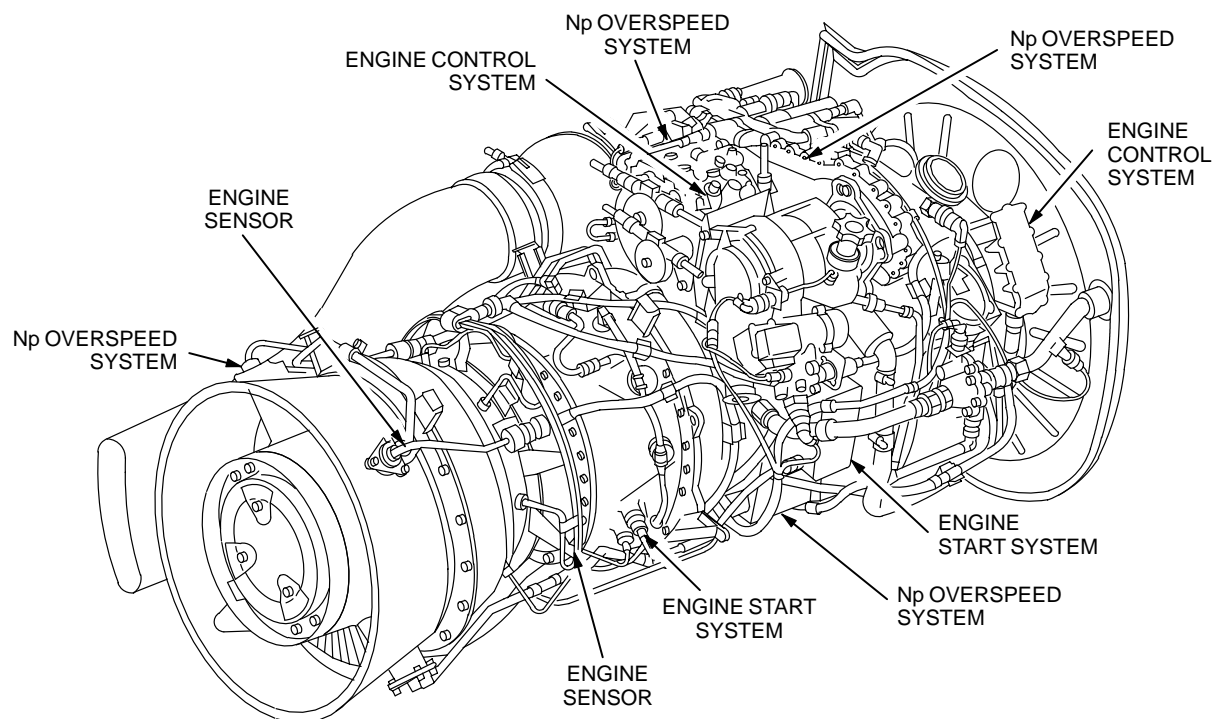
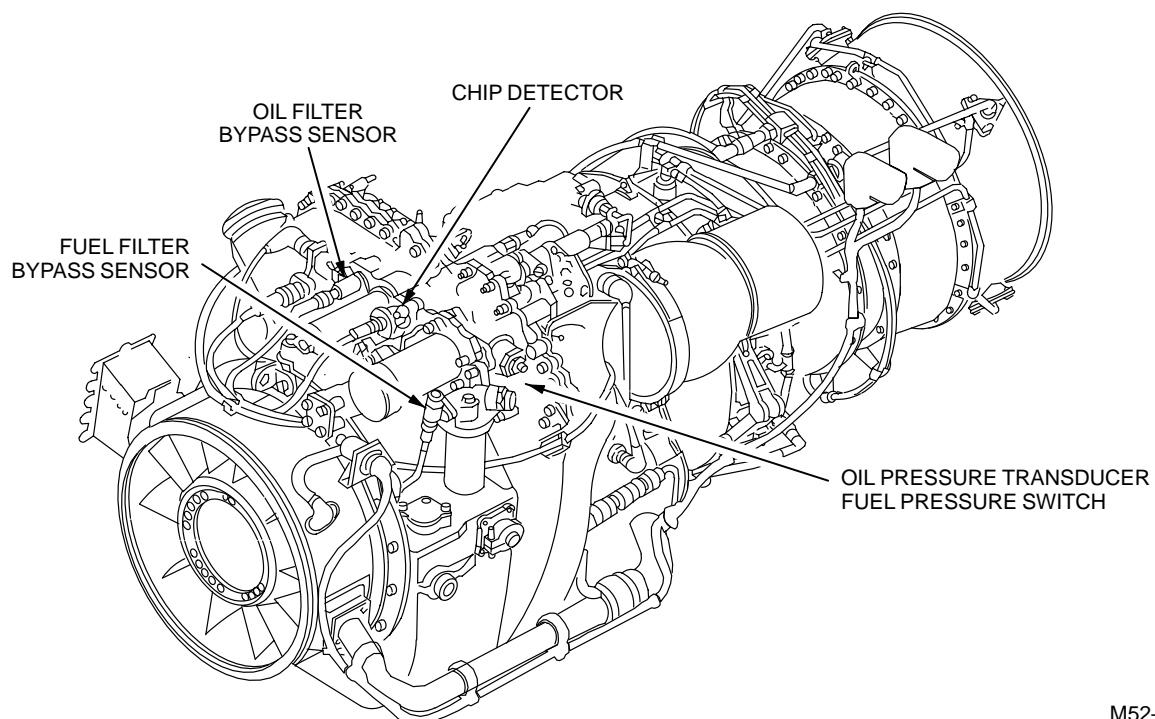


Figure 6-1. Engine System Major Components and Subsystems (Sheet 2 of 2)



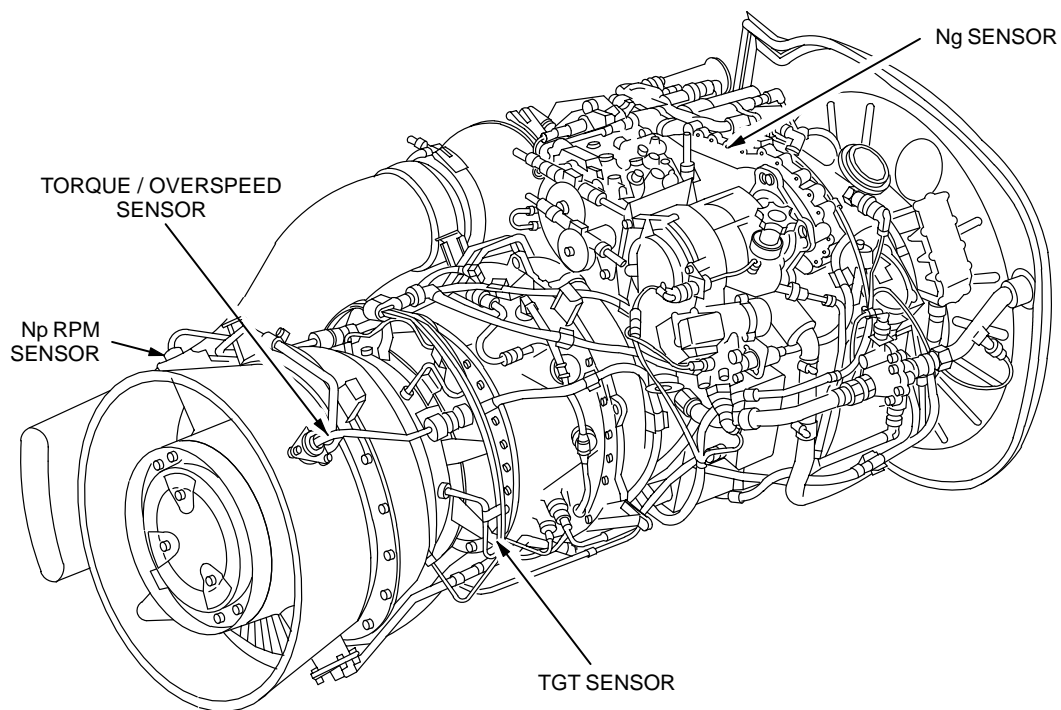
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Figure 6-2. Engine Sensors (Sheet 1 of 2)

6-3

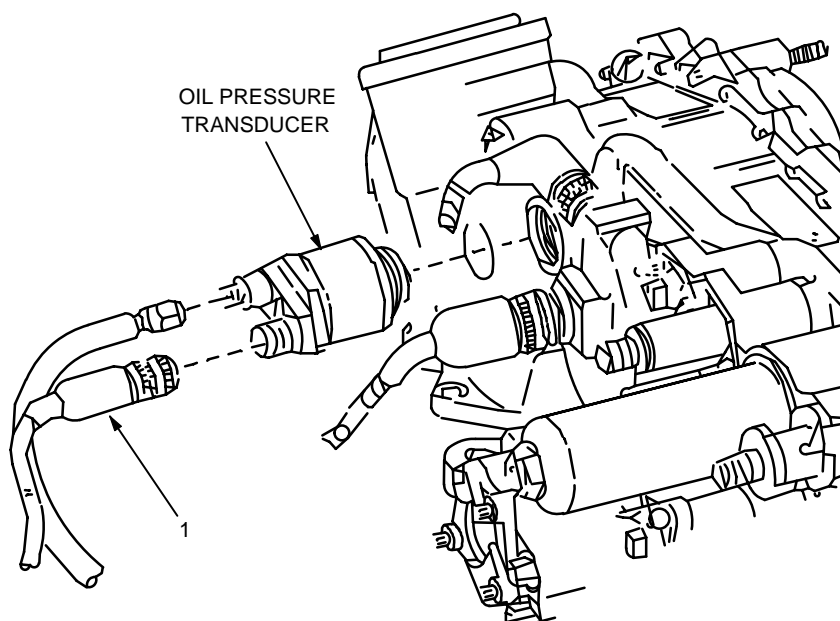
6-3. THEORY OF OPERATION (cont)

6-3



M52-288-2

Figure 6-2. Engine Sensors (Sheet 2 of 2)



M52-289

Figure 6-3. Oil Pressure Transducer

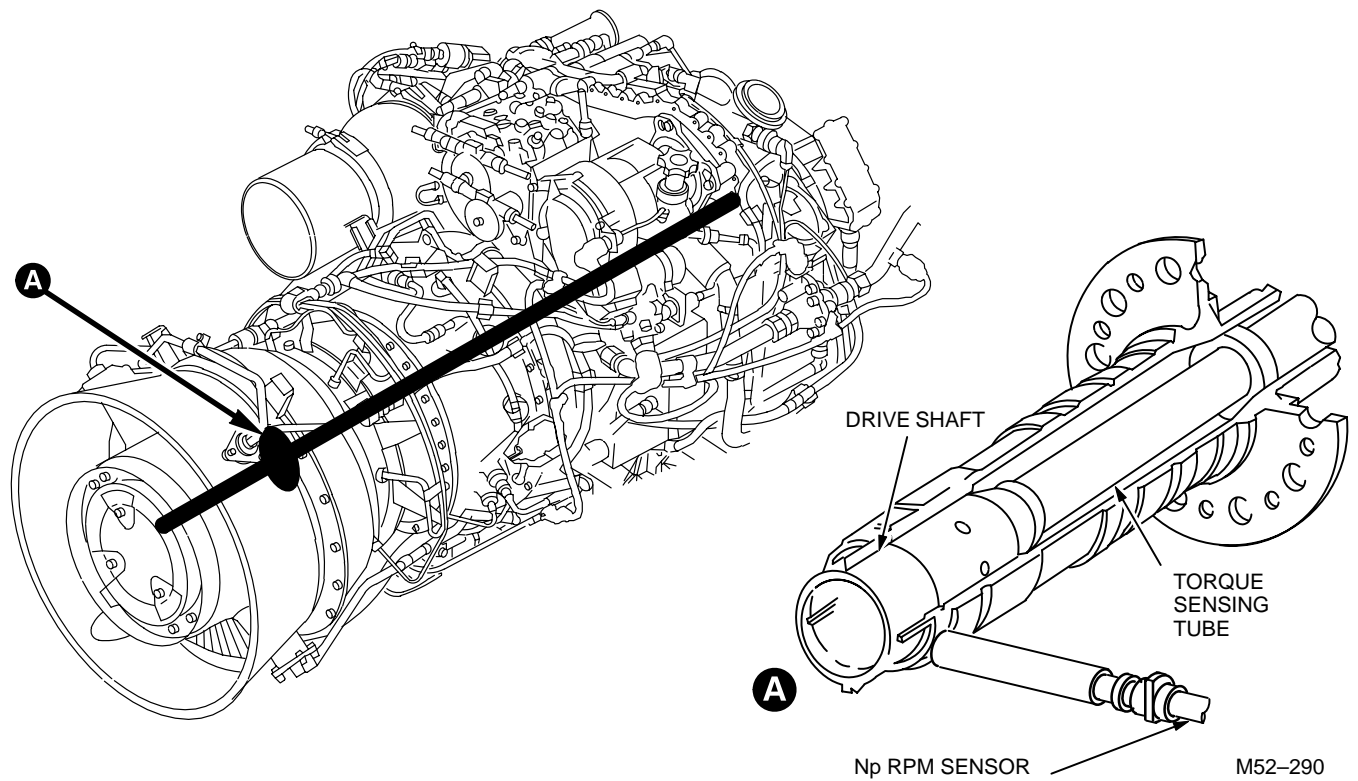


Figure 6-4. Np RPM Sensor

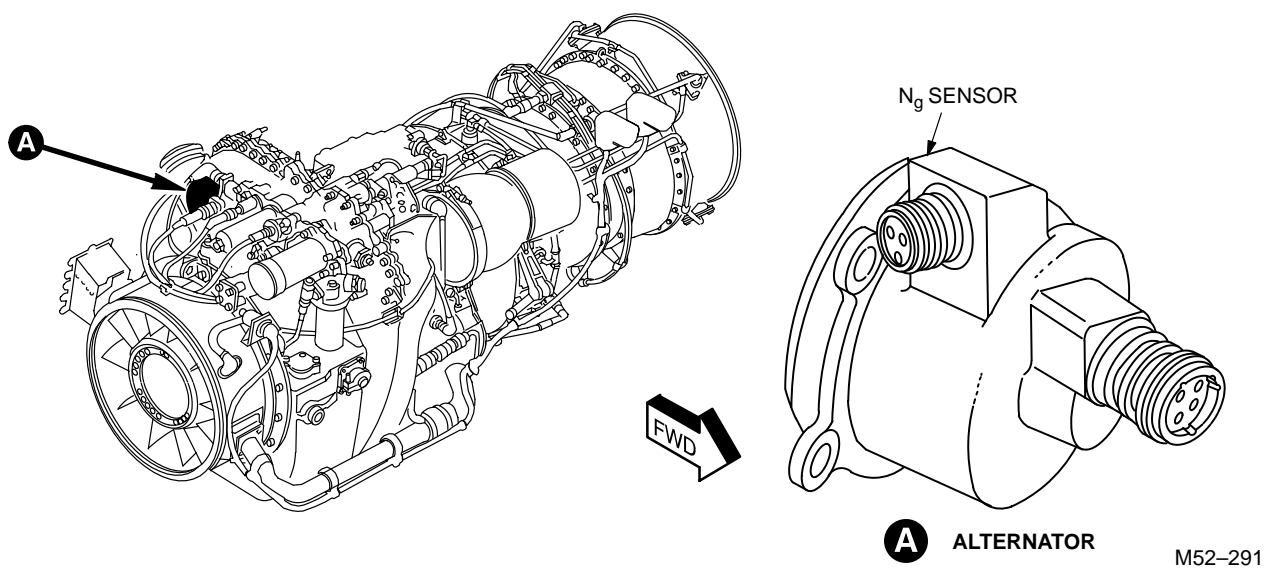
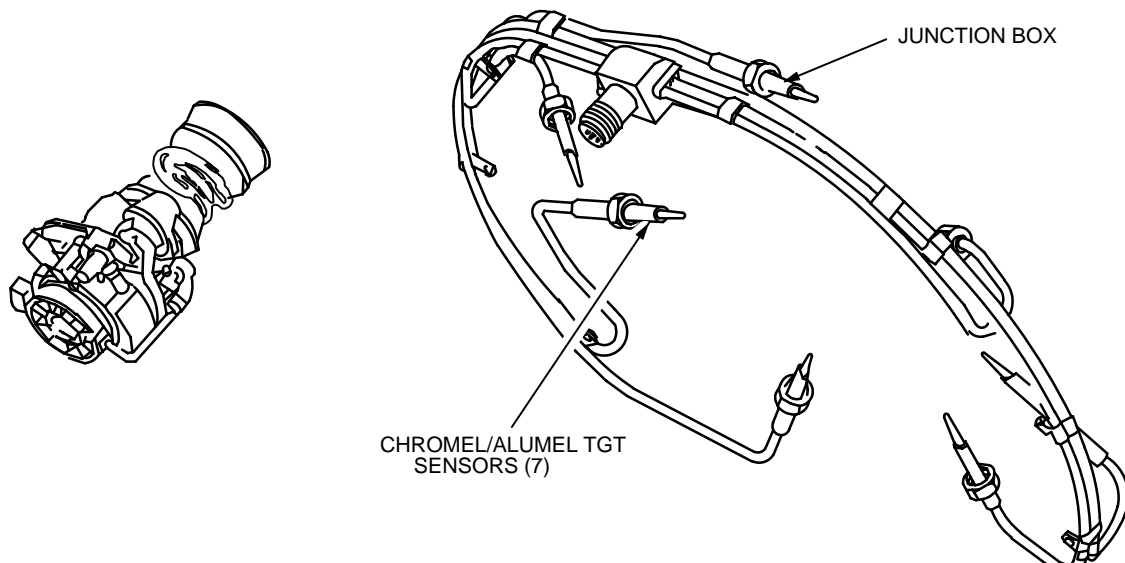
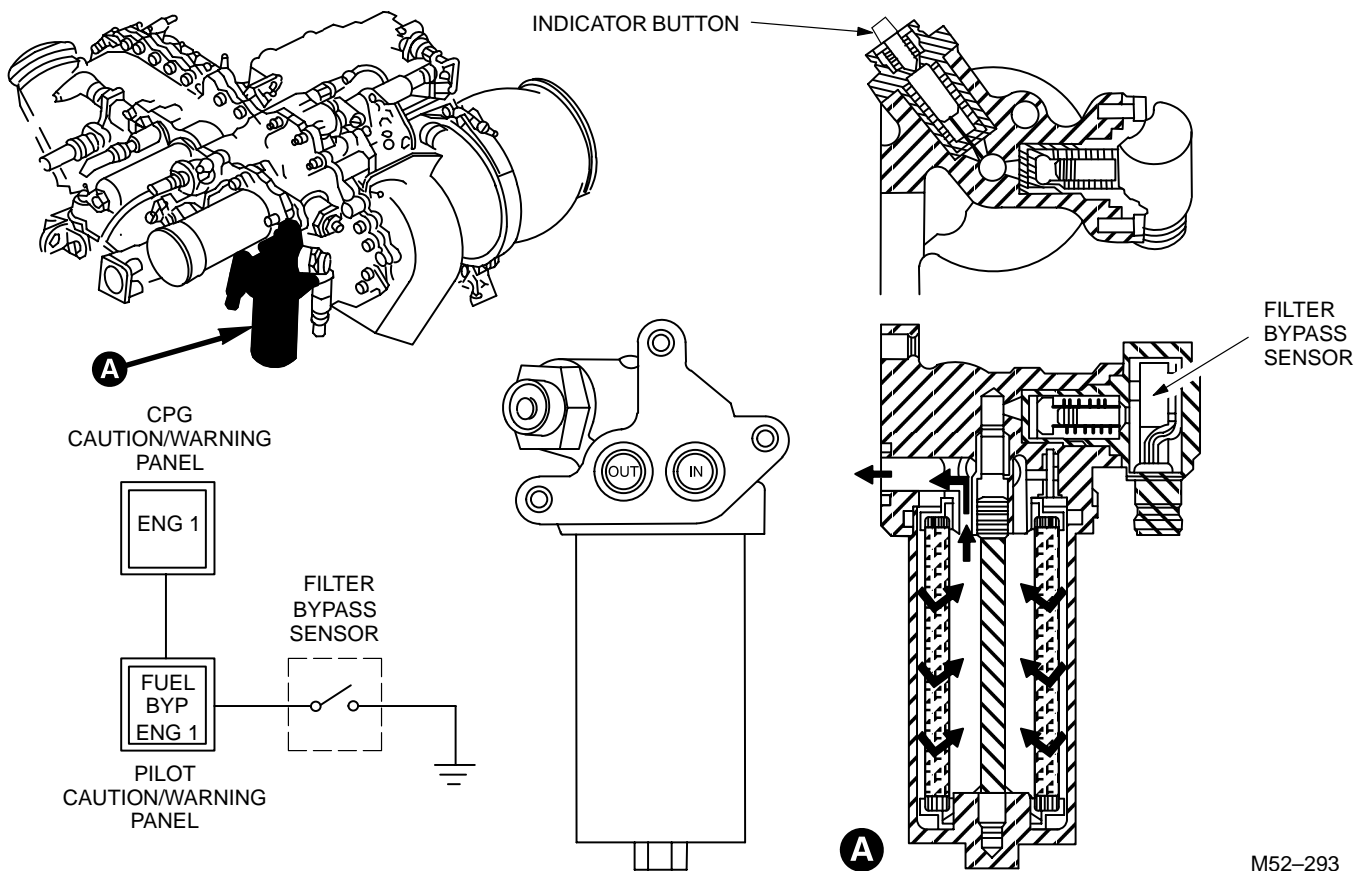


Figure 6-5. Ng Sensor



M52-292

Figure 6-6. TGT Sensors



M52-293

Figure 6-7. Fuel Filter Bypass Sensor

6-3. THEORY OF OPERATION (cont)

6-3

(6) The Nr sensor (fig. 6-8) is a monopole magnetic sensor that sends an electrical signal proportional to the main rotor speed (Nr) to the pilot Nr indicator. The Nr sensor is mounted on the left rear section of the main transmission. The Nr sensor sends electrical signals to the APU controller to allow the PTO clutch to engage or disengage.

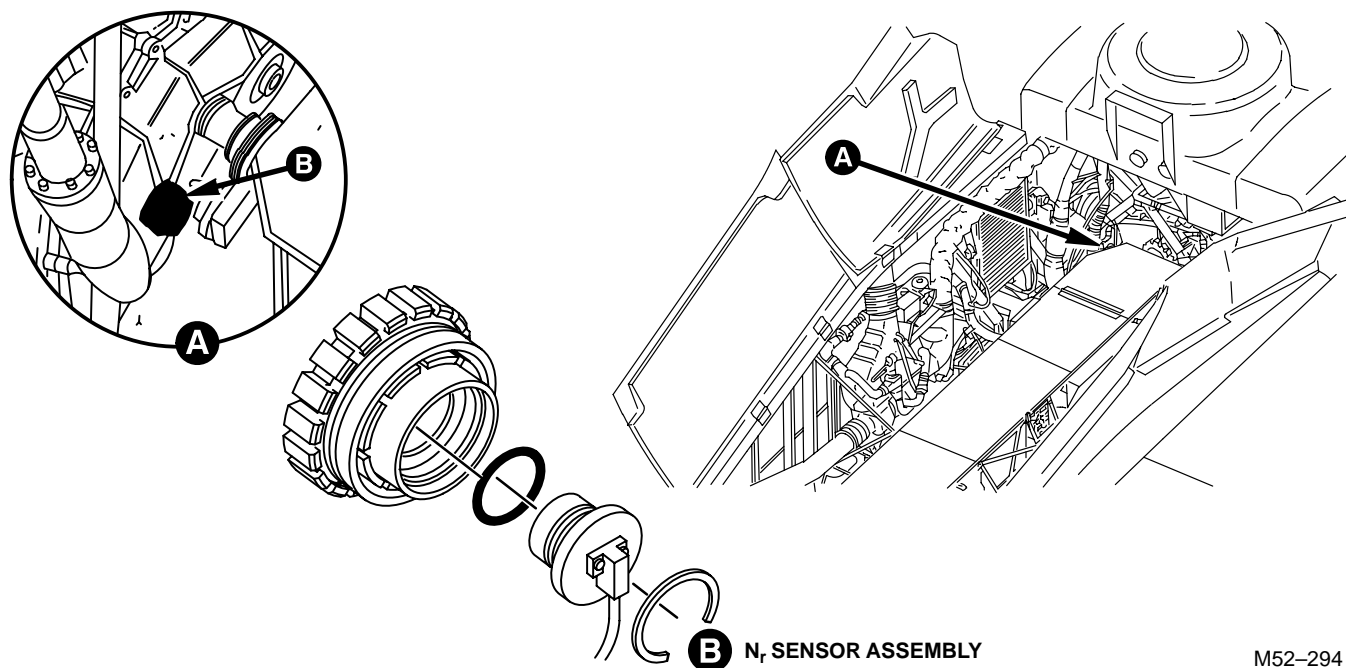


Figure 6-8. Nr Sensor

(7) The oil filter bypass sensor (fig. 6-9) is a pressure sensitive switch that closes when differential pressure across the oil filter reaches 60 to 80 psi. The oil filter bypass sensor provides an electrical signal to illuminate the appropriate pilot **OIL BYP ENG 1** or **2** light and the appropriate CPG **ENG 1** or **2** light on the pilot and CPG caution/warning panels. The sensor is mounted on the oil filter.

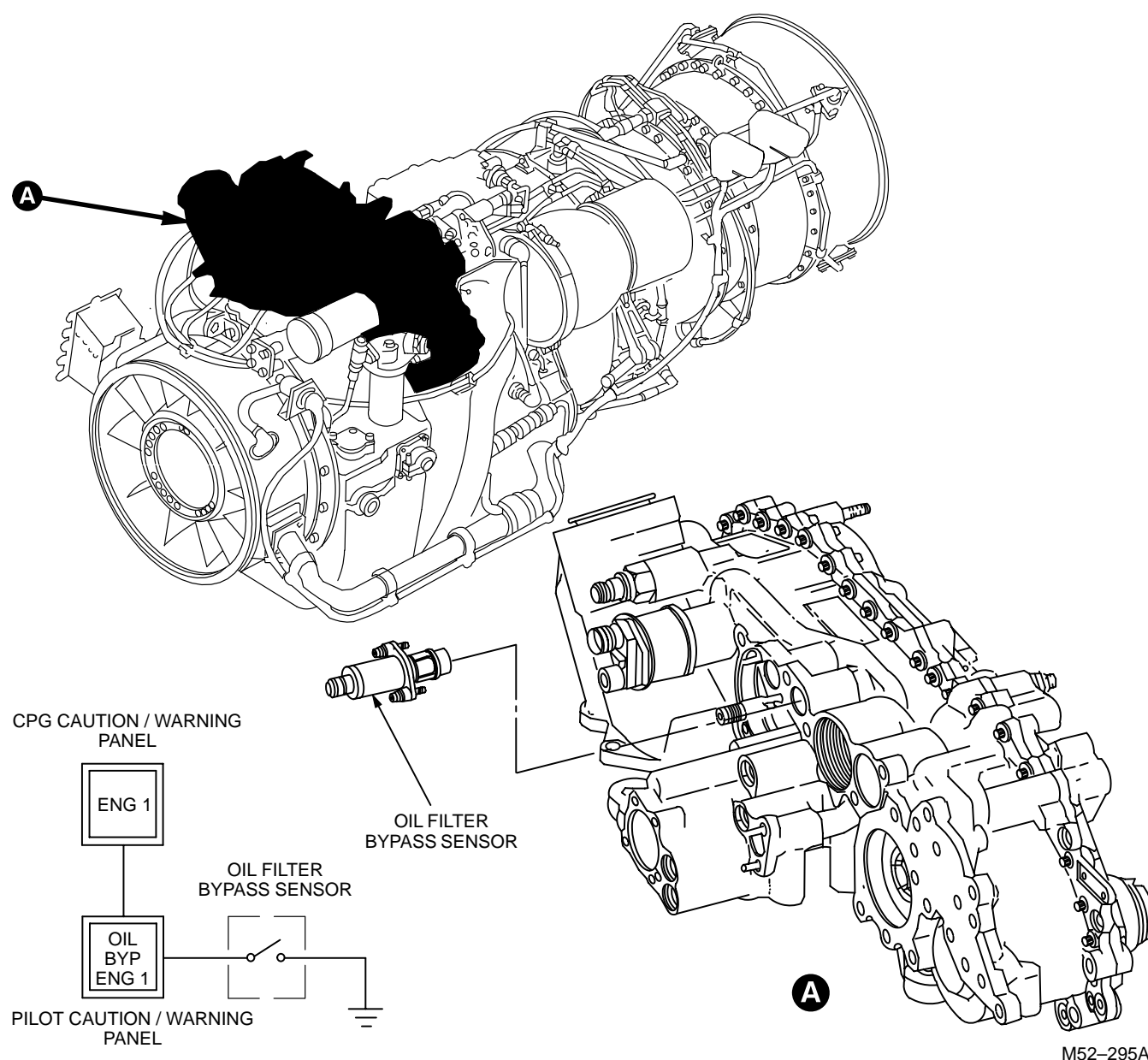


Figure 6-9. Oil Filter Bypass Sensor

(8) The engine out warning unit (fig. 6-10) is a solid state LRU that provides visual and audible warning when main rotor or engine rpm is low. The engine out warning unit receives voltage from the emergency dc bus. The unit monitors N_P speed, N_G speed, engine torque, and power quadrant position. When either engine N_P is below 94%, while engine torque is under 28 % or 100 foot pounds, the engine out warning unit triggers the engine out warning tone and illuminates the appropriate **ENG OUT** light on the pilot and CPG master caution/warning panels. When either engine N_G is below 63 %, the engine out warning unit triggers the engine out warning tone and illuminates the appropriate **ENG OUT** light on the pilot or CPG master caution/warning panels.

6-3. THEORY OF OPERATION (cont)

6-3

When N_R decreases to 94 %, the engine out warning unit triggers the engine out and rotor low warning tone, and illuminates the **LOW RPM ROTOR** light on the pilot and CPG master caution/warning panels. When N_G increases above 104 %, the engine out warning unit illuminates the **HIGH RPM ROTOR** light on the pilot and CPG master caution/warning panels.

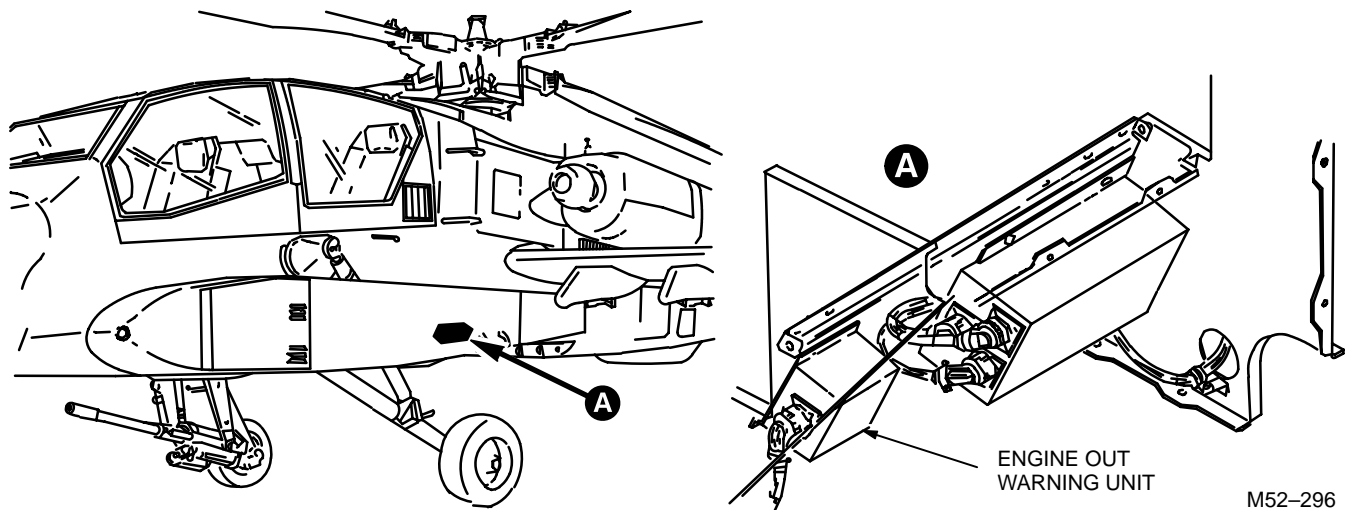


Figure 6-10. Engine Out Warning Unit

(9) The chip detector (fig. 6-11) is a permanent magnet metal detector that attracts metal particles present in the engine oil system. As oil flows past the chip detector, the permanent magnet attracts metal particles. When the particles bridge the gap between the magnet and the magnet housing, a circuit is completed, lighting the appropriate pilot **CHIPS ENG 1** or **CHIPS ENG 2** light and the appropriate **ENG 1** or **ENG 2** light on the pilot or CPG caution/warning panels.

(10) The fuel pressure switch (fig. 6-12) is a pressure activated switch that is normally closed. When the switch is closed, the appropriate pilot **FUEL PSI ENG 1** or **FUEL PSI 2** light and the appropriate **ENG 1** or **ENG 2** light on the pilot and CPG caution/warning panels light. When fuel pressure increases above 11 psi the switch opens and the light extinguishes. The fuel pressure switch is mounted on the left side of the engine.

b. **Engine Control System.** The engine electrical control system (fig. 6-13) will allow sustained engine operation, despite individual component failures. The electrical control system is designed so that the prevalent failure is to drive the engine to high power. Engine power is then limited by the hydromechanical unit (HMU) and controlled by the use of the PAS. The only electrical failure that can cause an engine overspeed shutdown is a failure that results in the tripping of the N_P overspeed system. A double electrical failure is required for inadvertent actuation of the overspeed system due to independent and redundant circuitry. The engine electrical control system major components (fig. 6-13) are described in the following subparagraphs.

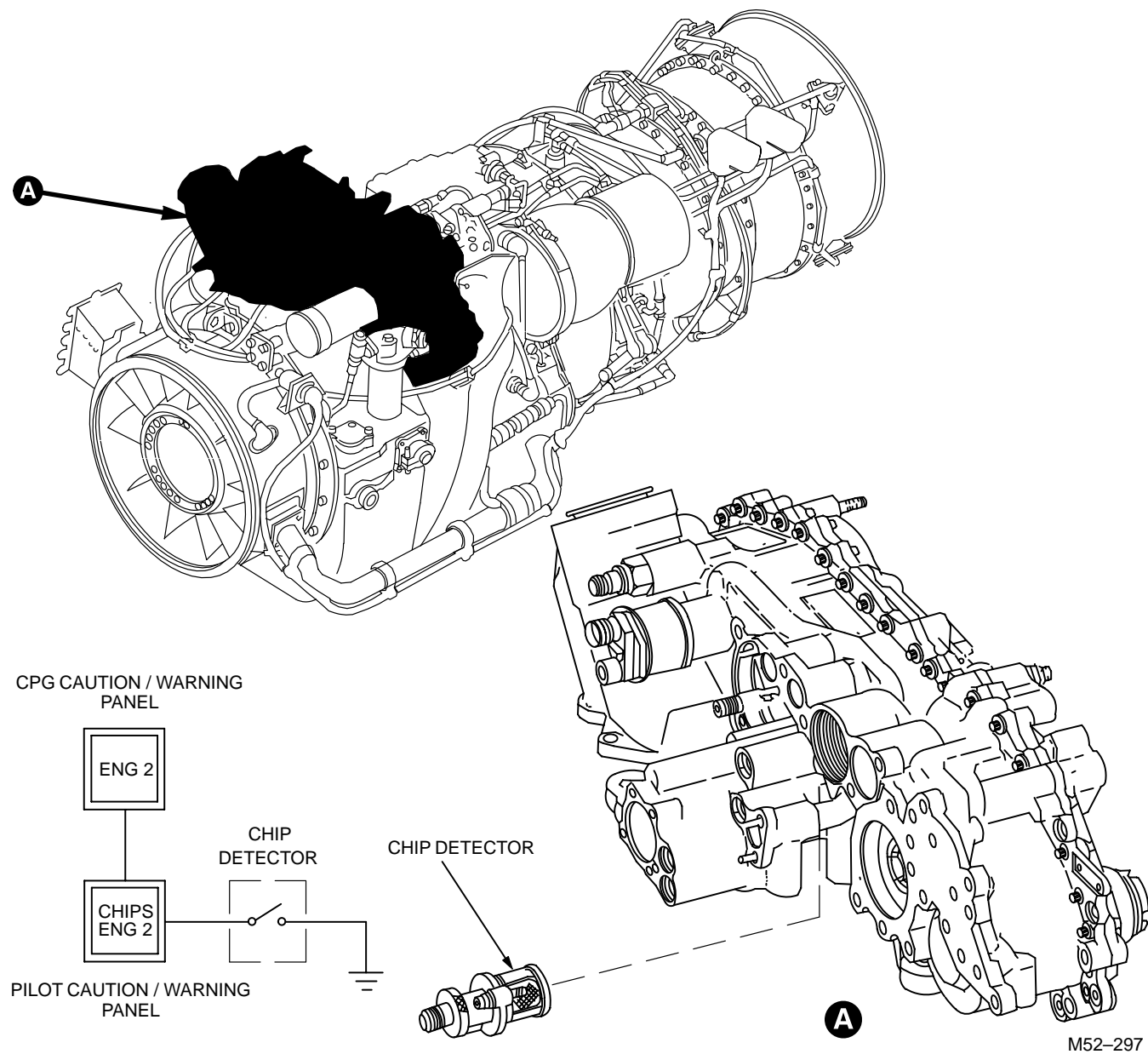
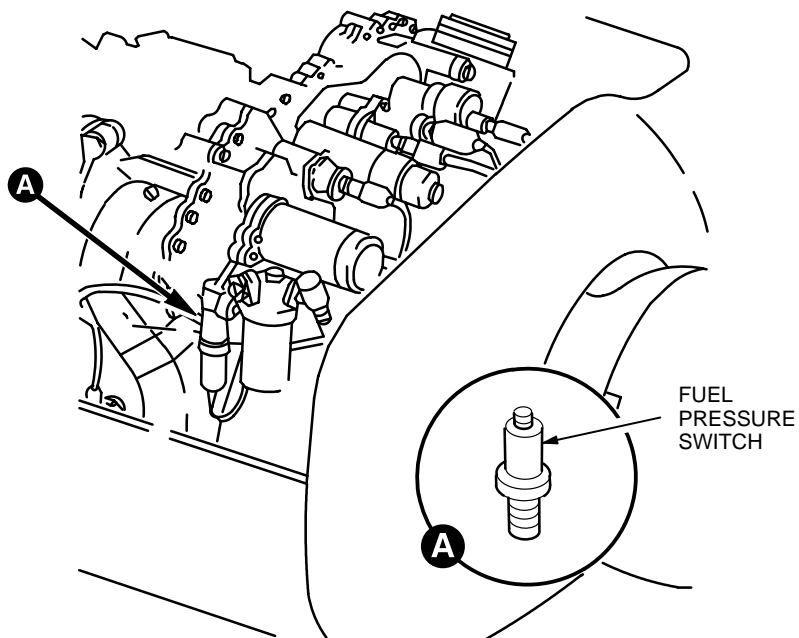
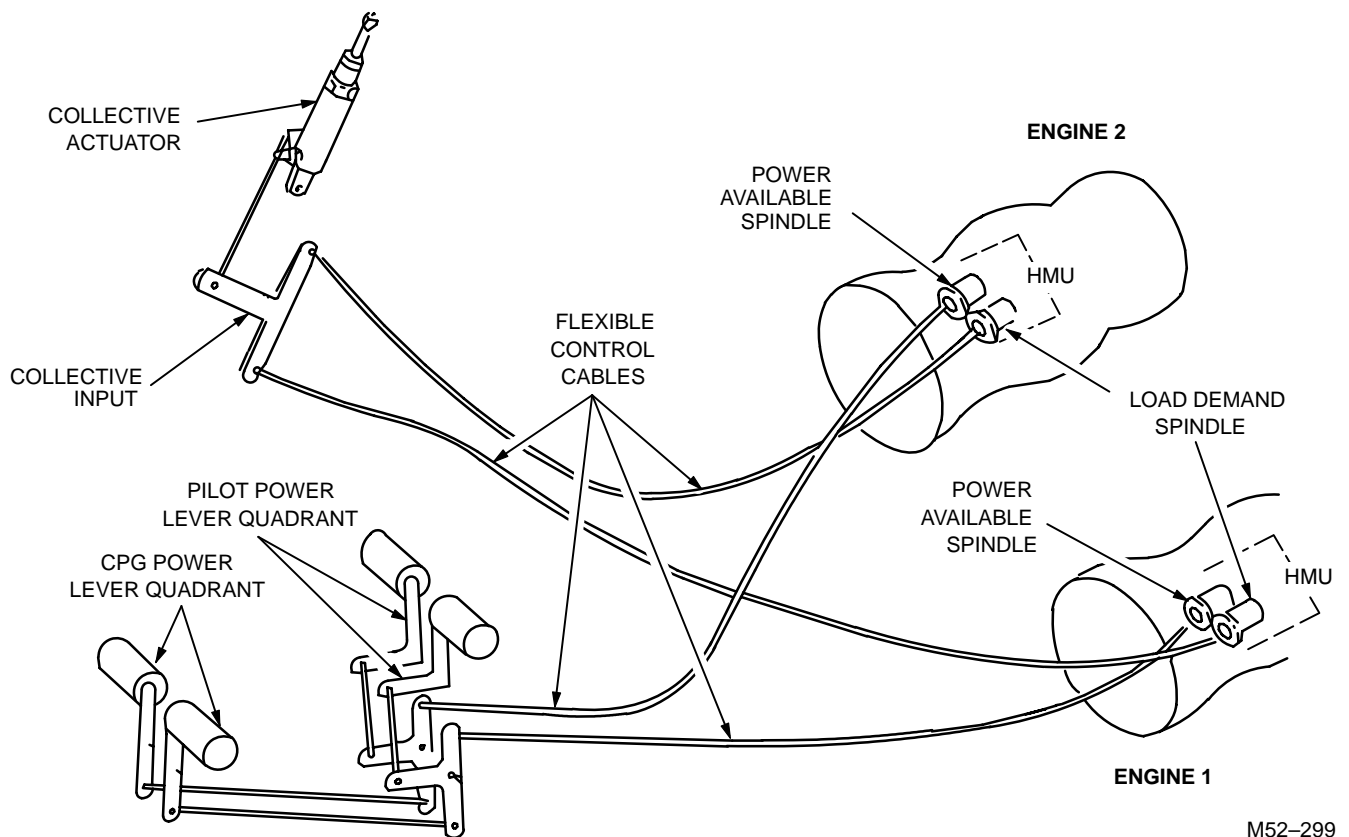


Figure 6-11. Chip Detector



M52-298

Figure 6-12. Fuel Pressure Switch



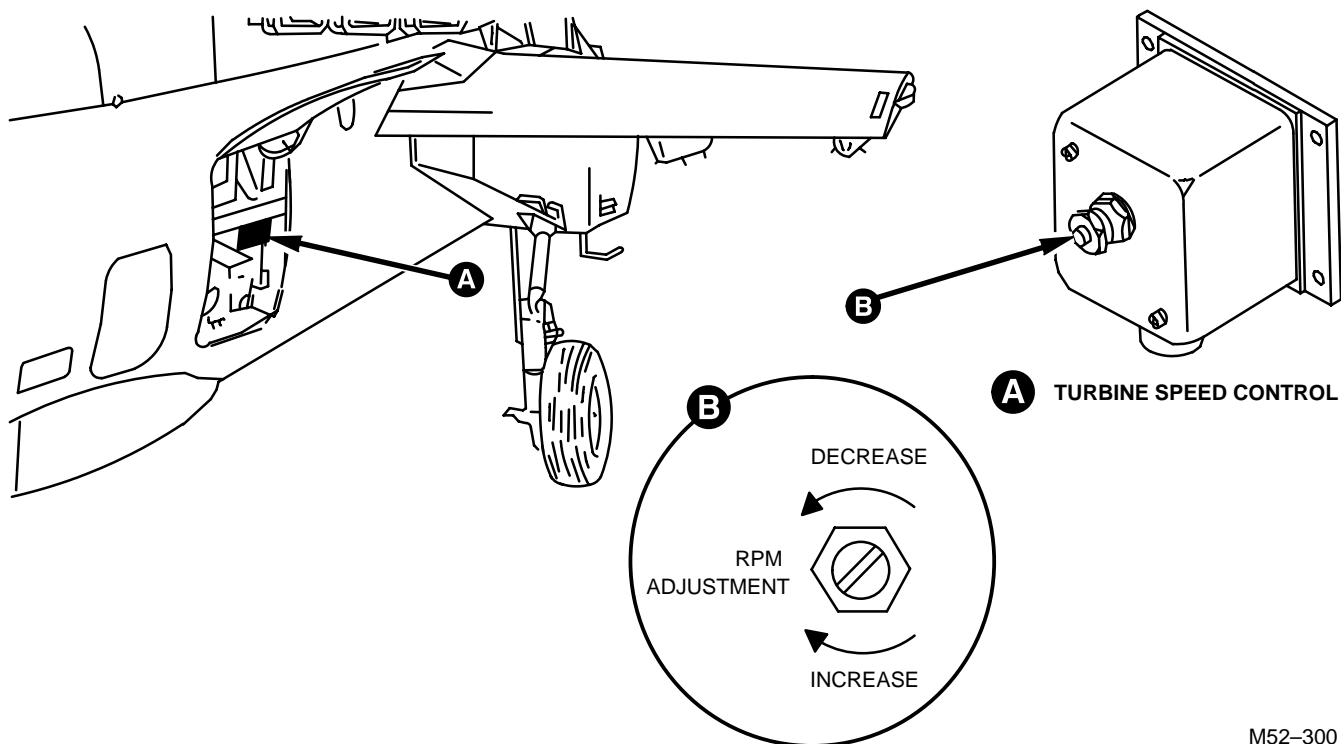
M52-299

Figure 6-13. Engine Control System Major Components

6-3. THEORY OF OPERATION (cont)

6-3

(1) The turbine speed control (fig. 6-14) provides a means of adjusting and controlling the Np reference signal from the Np sensor to each engine ECU or DECU. The turbine speed control has a rpm adjustment screw that is turned clockwise to increase Np speed of both engines. The adjustment screw is turned counterclockwise to decrease Np speed of both engines.



M52-300

Figure 6-14. Turbine Speed Control

6-3. THEORY OF OPERATION (cont)**6-3**

(2) The HMU torque motor (fig. 6-15) schedules the engine fuel supply to Ng speed as directed by the ECU or DECU for 100 % Np speed control. The HMU torque motor is mounted on the center on the center aft section of the engine. The HMU torque motor receives inputs from the inlet air temperature sensor (T2), power levers, collective control stick, and ECU or DECU.

(a) The power available spindle converts power levers push-pull motion into rotary motion for HMU torque motor input shaft rotation.

(b) The load demand spindle (LDS) converts power levers push-pull motion into rotary motion for HMU torque motor input shaft rotation.

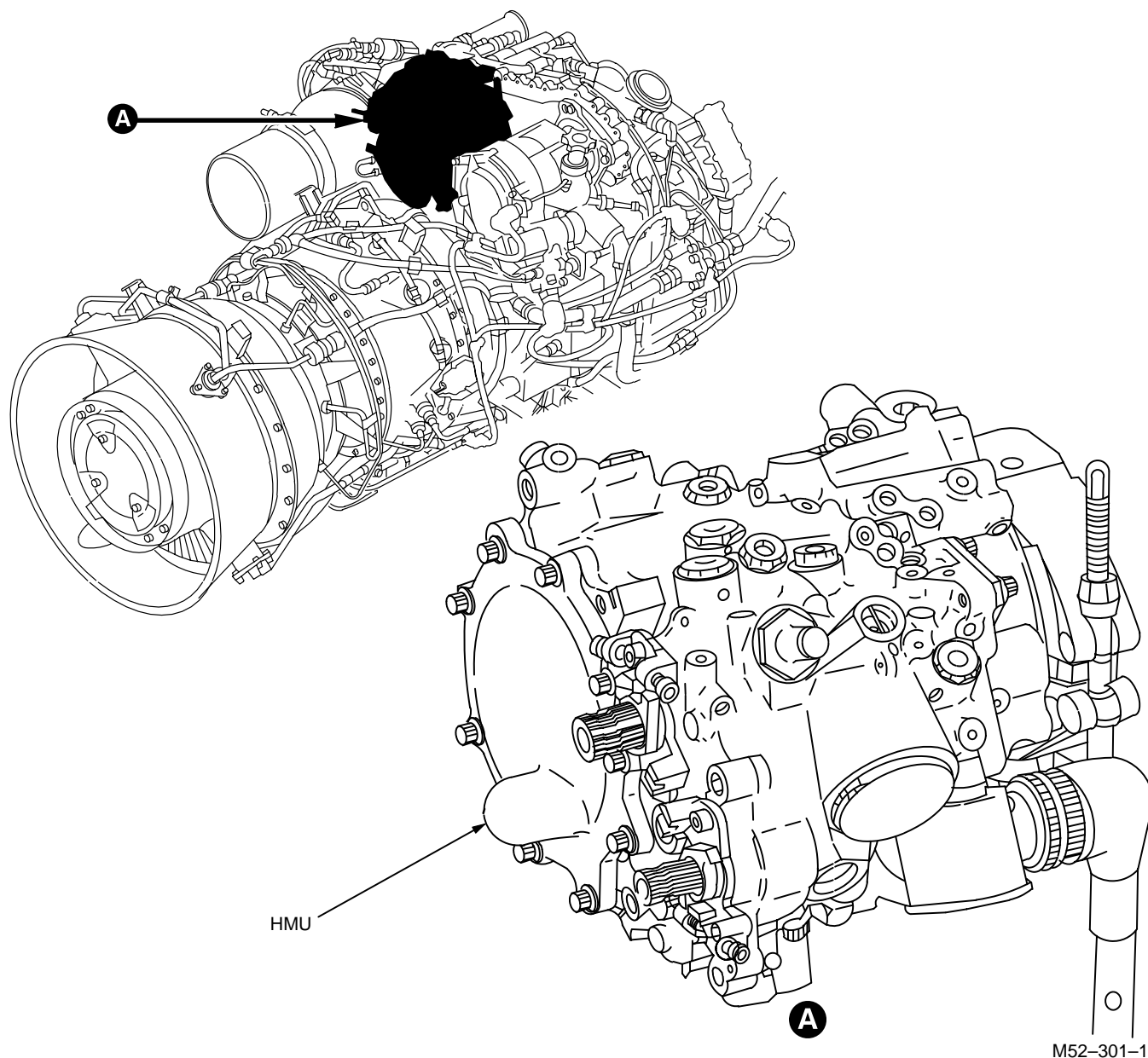
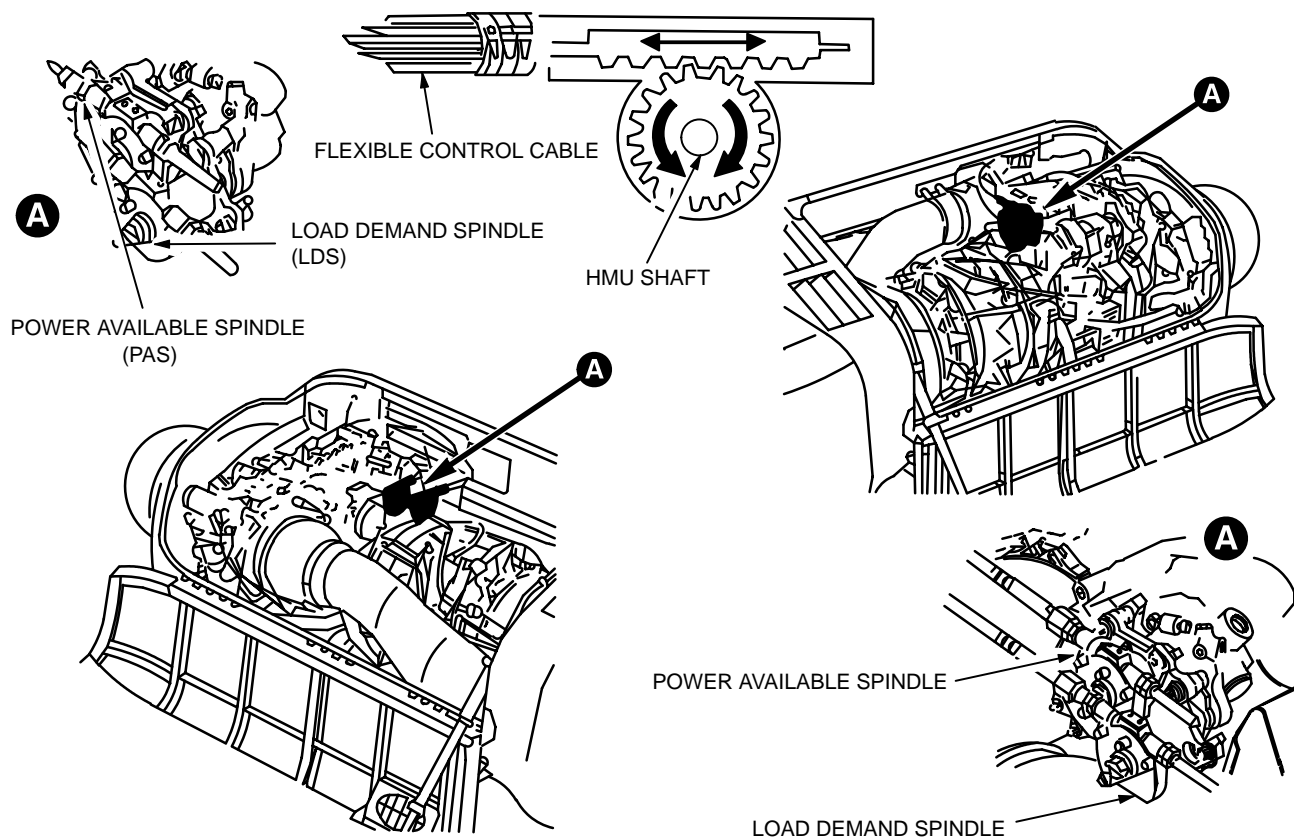


Figure 6-15. HMU Torque Motor (Sheet 1 of 2)

6-3. THEORY OF OPERATION (cont)

6-3



M52-301-2

Figure 6-15. HMU Torque Motor (Sheet 2 of 2)

(3) The collective control sticks (fig. 6-16) provide mechanical inputs to the HMU torque motor to maintain constant engine speed as collective pitch is increased or decreased. The collective control sticks are connected to the HMU torque motor by flexible cables.

(a) The engine chop collar is located on the upper end of each collective control stick. The collar is rotated to the **CHOP** position to rapidly reduce both engines simultaneously to idle rpm.

When the collar is rotated to the **CHOP** position, 28 VDC is supplied from the emergency dc bus to engine cutout relays 1 and 2. The Np reference signal is removed from the ECU or DECU causing both engines to decrease to idle rpm. When the collar is rotated to **RESET**, 28 VDC is interrupted and the Np reference signal returns to the ECU or DECU causing both engines to resume their rpm settings.

(b) The engine droop LVDT is connected to the pilot collective stick. The LVDT sends a signal proportional to collective control stick movement to the ECU or DECU to prevent rotor droop during flight.

(4) The history recorder (fig. 6-17) records and displays the engine operating hours, time/temperature index, and low cycle fatigue (LCF) events. The history recorder is mounted on the engine swirl frame at the 2 o'clock position.

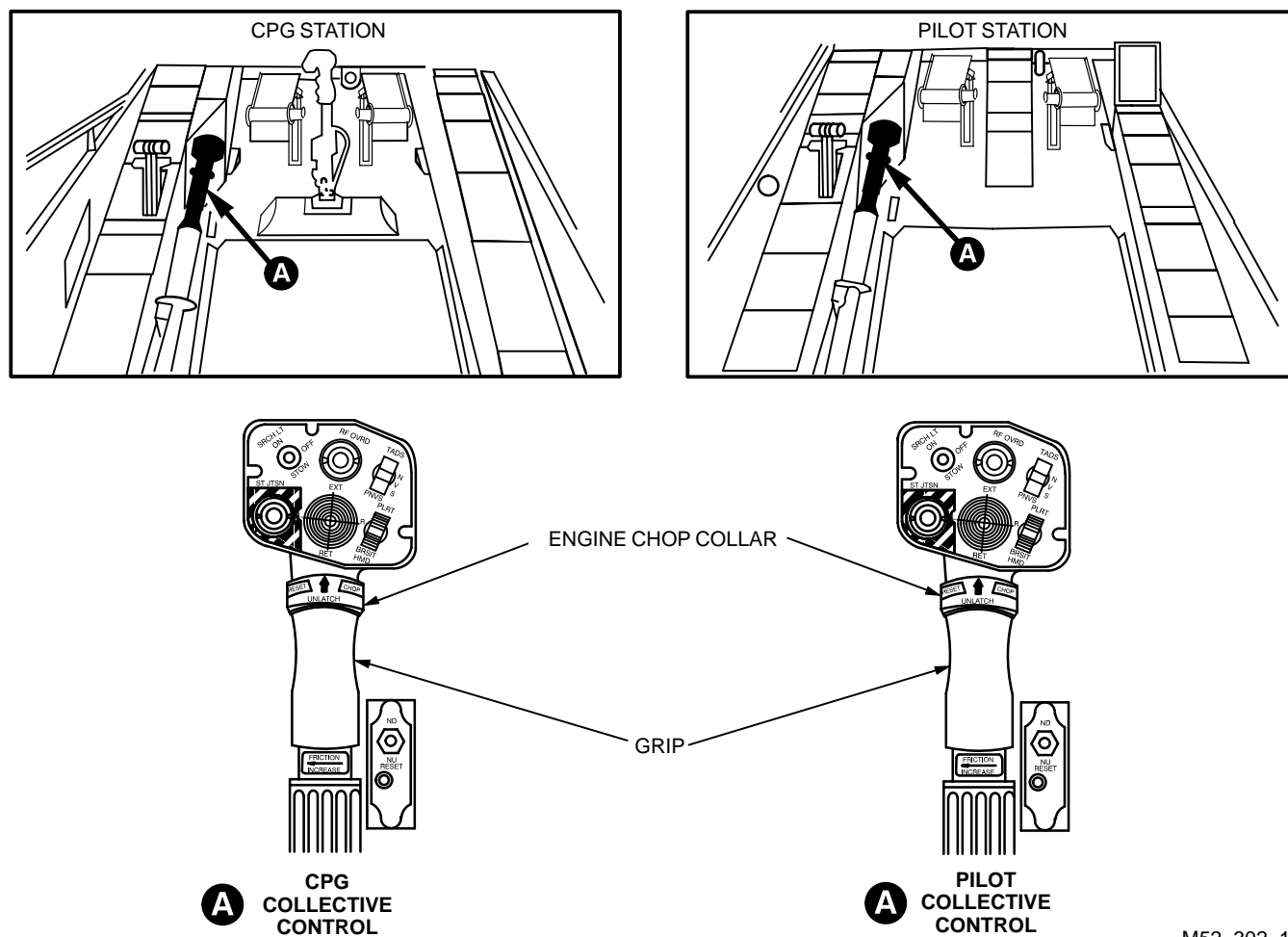
The **LCF 1** and **LCF 2** display the actual number of times the engine experiences mechanical stress up to 99,999. The **LCF 1** advances when the engine speed exceeds 95 % Ng and will not advance again until engine speed decreases to 50 % Ng and reaches 95 % Ng again.

6-3. THEORY OF OPERATION (cont)

6-3

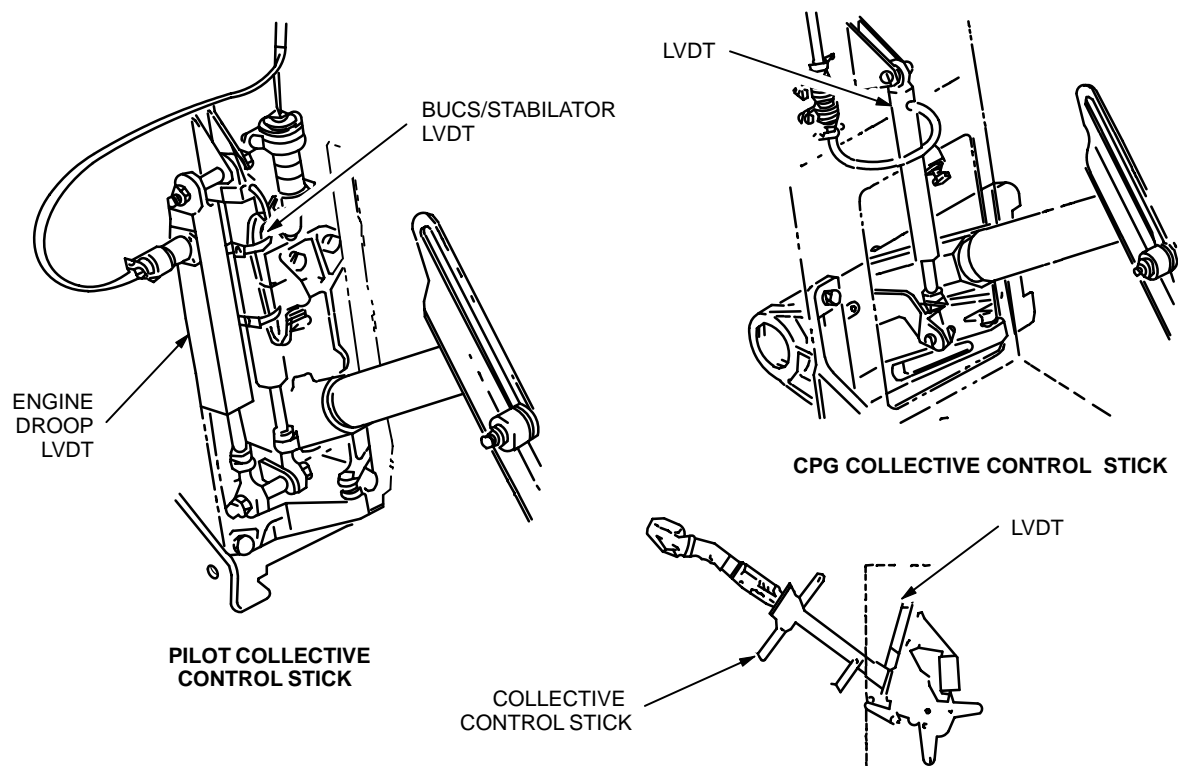
The **LCF 2** advances when the engine speed exceeds 95 % Ng and will not advance again until engine speed decreases to 86 % Ng and reaches 95 % Ng again.

The index advances when the TGT reaches approximately 90 % of the maximum continuous power value. The hours indicate the actual operating time up to 9999 when Ng exceeds 50 %.



M52-302-1

Figure 6-16. Collective Control Sticks (Sheet 1 of 2)



M52-302-2

Figure 6-16. Collective Control Sticks (Sheet 2 of 2)

6-3. THEORY OF OPERATION (cont)

6-3

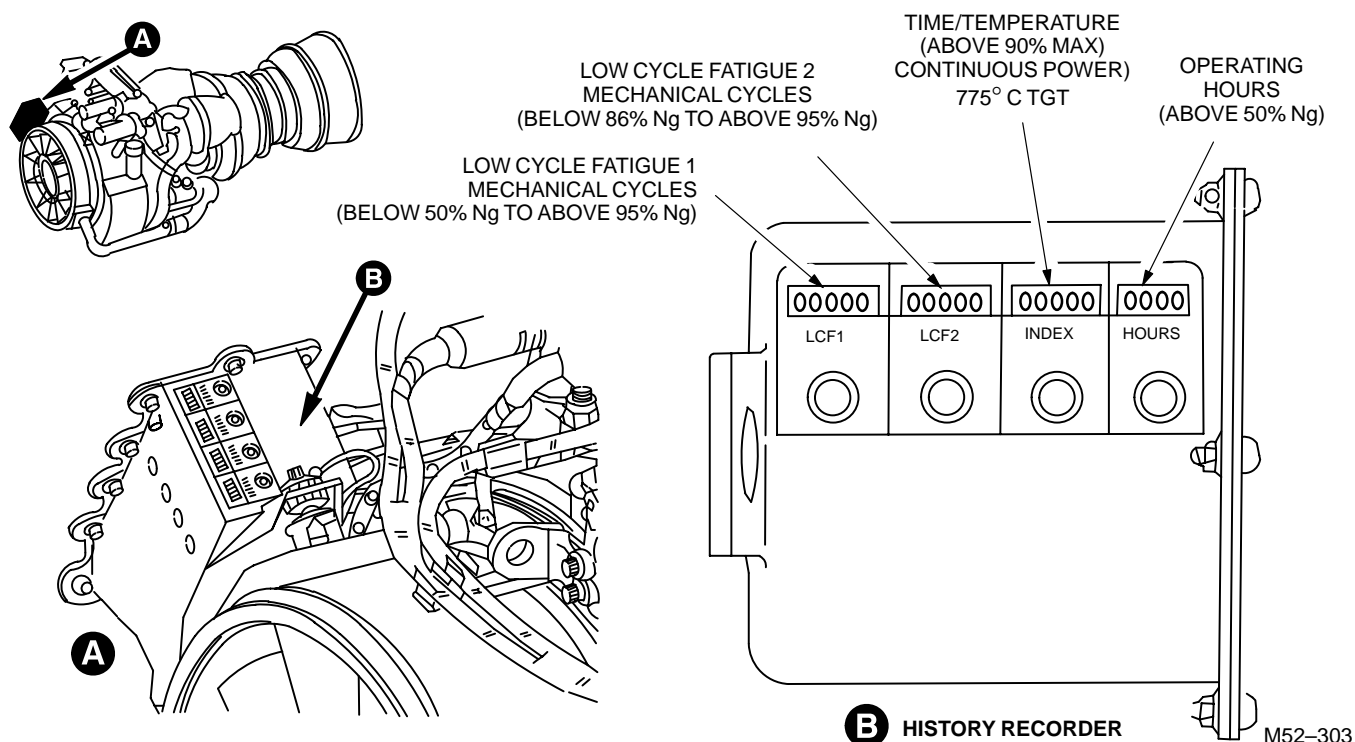


Figure 6-17. History Recorder

(5) The power quadrants (fig. 6-18) have engine power levers 1 and 2 with stop release levers. The power levers are connected together with flexible control cables. The quadrants transmit power selections from the power levers to the HMU torque motor. The pilot power quadrant provides engine start controls and indicators. Each power lever has four positions.

- **OFF.** 0° of travel, no fuel flow to the engines.
- **IDLE.** 26° of travel, for low ground power operation.
- **FLY.** 120° of travel, normal flight position.
- **LOCKOUT.** Disables the ECU or DECU and allows manual control of the engine by positioning the power lever between **IDLE** and **FLY** to maintain desired power.

The pilot power quadrant has mechanical stops which prevent the power levers being moved accidentally from **FLY** to **LOCKOUT** or from **IDLE** to **OFF**. The pilot stop release levers, located on the power levers, mechanically release the mechanical stops to move the power levers from **FLY** to **LOCKOUT** or **IDLE** to **OFF**. The CPG stop release levers electrically release the mechanical stops. A friction adjustment lever located on the right side of the quadrant is moved to increase or decrease power lever ease of movement.

(a) The pilot power quadrant provides the following controls.

- Engine start/ignition override switches. Provide electrical power to the fuel system, ignition system, and pressurized air system.
- Master ignition switch (key operated). Provides electrical power for engine start.
- Engine start indicators. A split green light segment that indicating applicable engine operation.
- Rotor brake switch. Provides electrical power to the rotor brake.

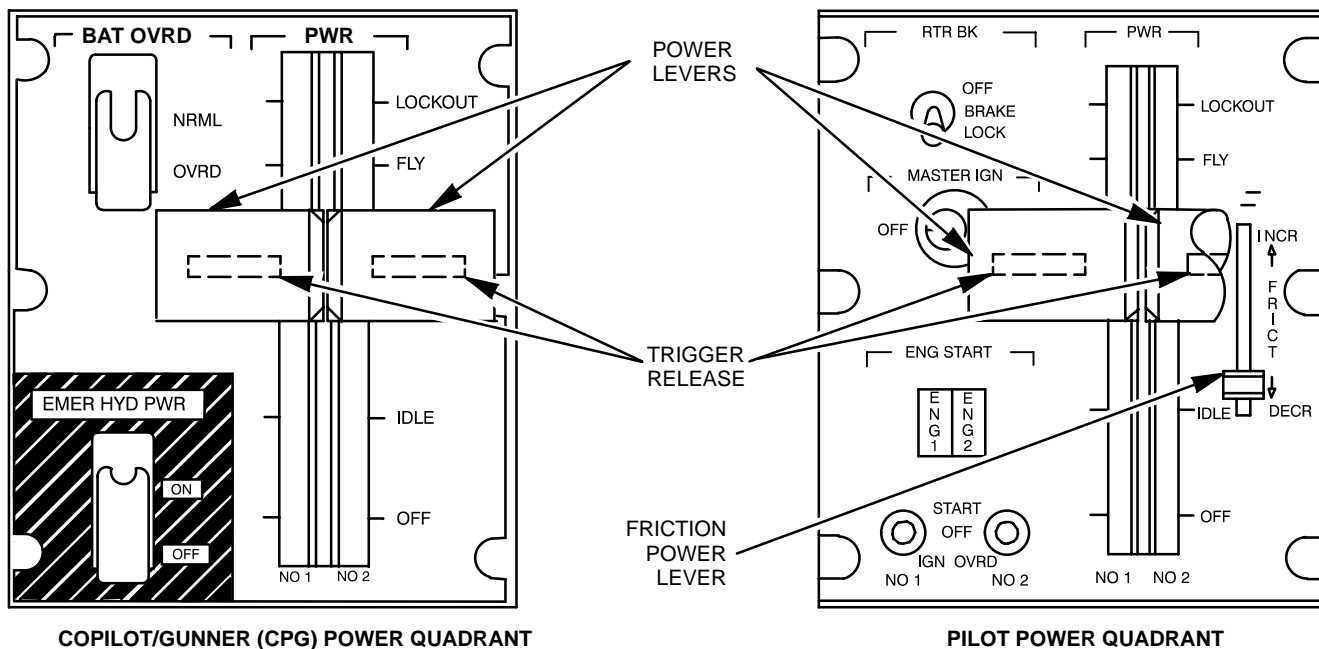
6-3. THEORY OF OPERATION (cont)

6-3

(b) The CPG power quadrant provides the following controls.

- Emergency hydraulic power switch. Provides electrical power to the emergency hydraulic accumulator.
- Battery override switch. Overrides normal electrical power supply operation and provides electrical power from the battery.

(6) The flexible control cables transmit control inputs from the power levers and collective control sticks to the HMU torque motor. There are six sections of cable between the power levers and HMU torque motor PAS. There are four sections of cable between the collective bellcrank and the HMU torque motor LDS. The flexible control cables are composed of balls, ball guides, and outer and inner races inside flexible steel tubing encased in plastic.



M52-304

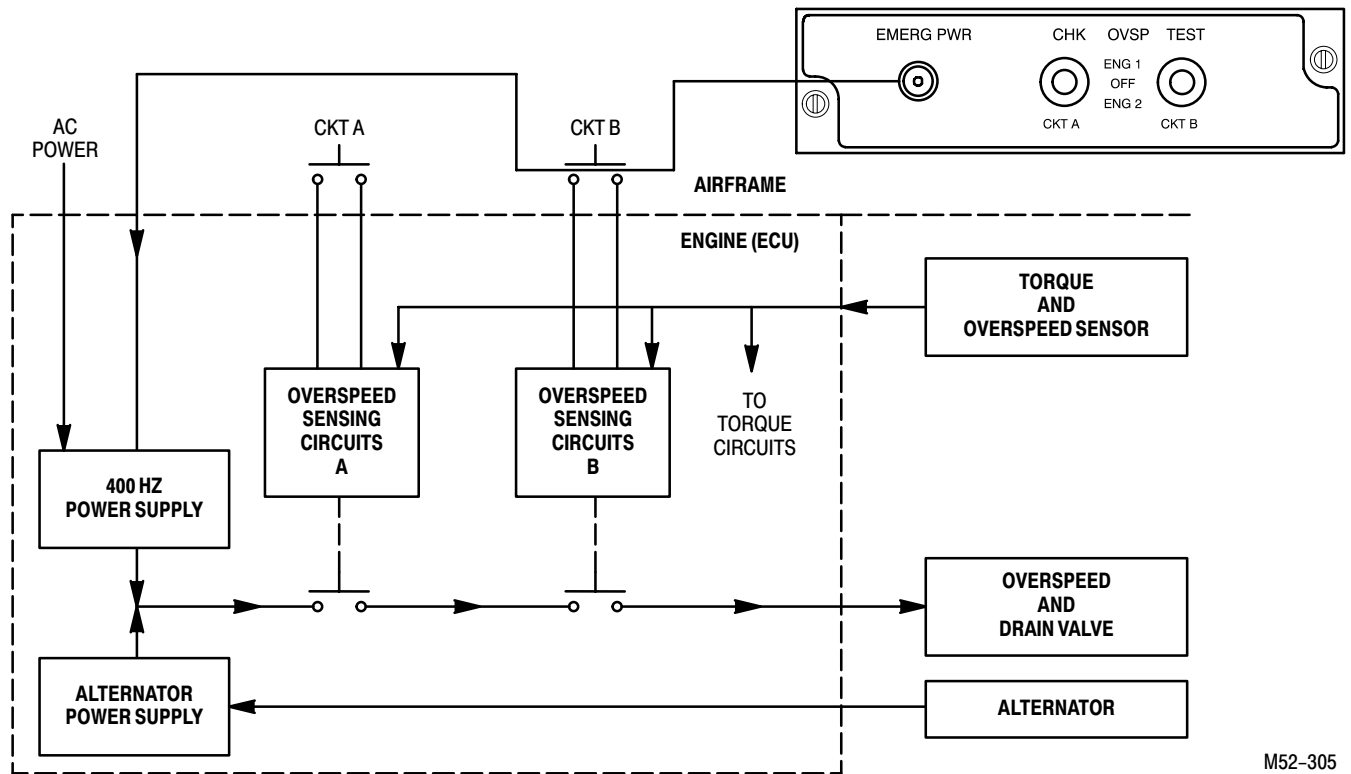
Figure 6-18. Power Quadrants

c. **Np Overspeed System.** The Np overspeed system operation (fig. 6-19) and components are described in the following subparagraphs.

(1) The engine alternator (fig. 6-20) supplies ac power to the engine control unit (ECU) or digital engine (DECU) control unit for Np overspeed system operation and pilot Ng indicator. The alternator is mounted on the forward face of the engine, and consists of three sets of electrical windings and two electrical connectors.

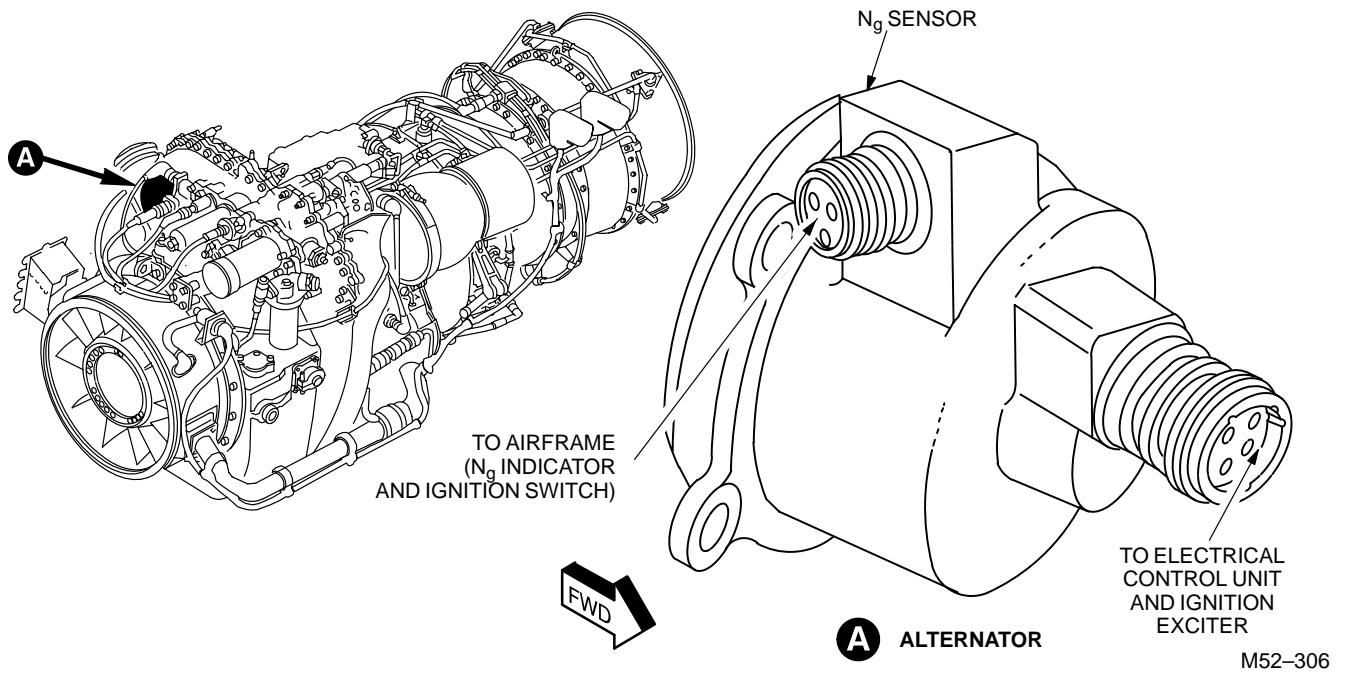
6-3. THEORY OF OPERATION (cont)

6-3



M52-305

Figure 6-19. Np Overspeed System Operation



M52-306

Figure 6-20. Engine Alternator

6-3. THEORY OF OPERATION (cont)

6-3

(2) The ECU or DECU (fig. 6-21) is an electrical control unit mounted on the forward right section of the engine at the two o'clock position. The ECU or DECU is a solid state device that sends an electrical signal to the HMU torque motor to schedule fuel for engine power requirements, maintaining rotor speed, rotor speed load sharing, and limiting engine Np inlet temperature.

The ECU or DECU receives electrical power from the alternator and input signals (fig. 6-22) from the following components.

(a) TGT sensors. TGT sensors are thermocouples that signal the ECU or DECU to limit TGT and provide TGT signals to the TGT indicator.

(b) Np rpm sensor. The Np rpm sensor governs Np rpm and provide Np signals to the Np indicator.

(c) Torque and overspeed sensor. The torque and overspeed sensor receives torque indication for load sharing and overspeed protection.

(d) Engine droop LVDT. The engine droop LVDT is a transducer that provides collective control stick position signals to the ECU or DECU.

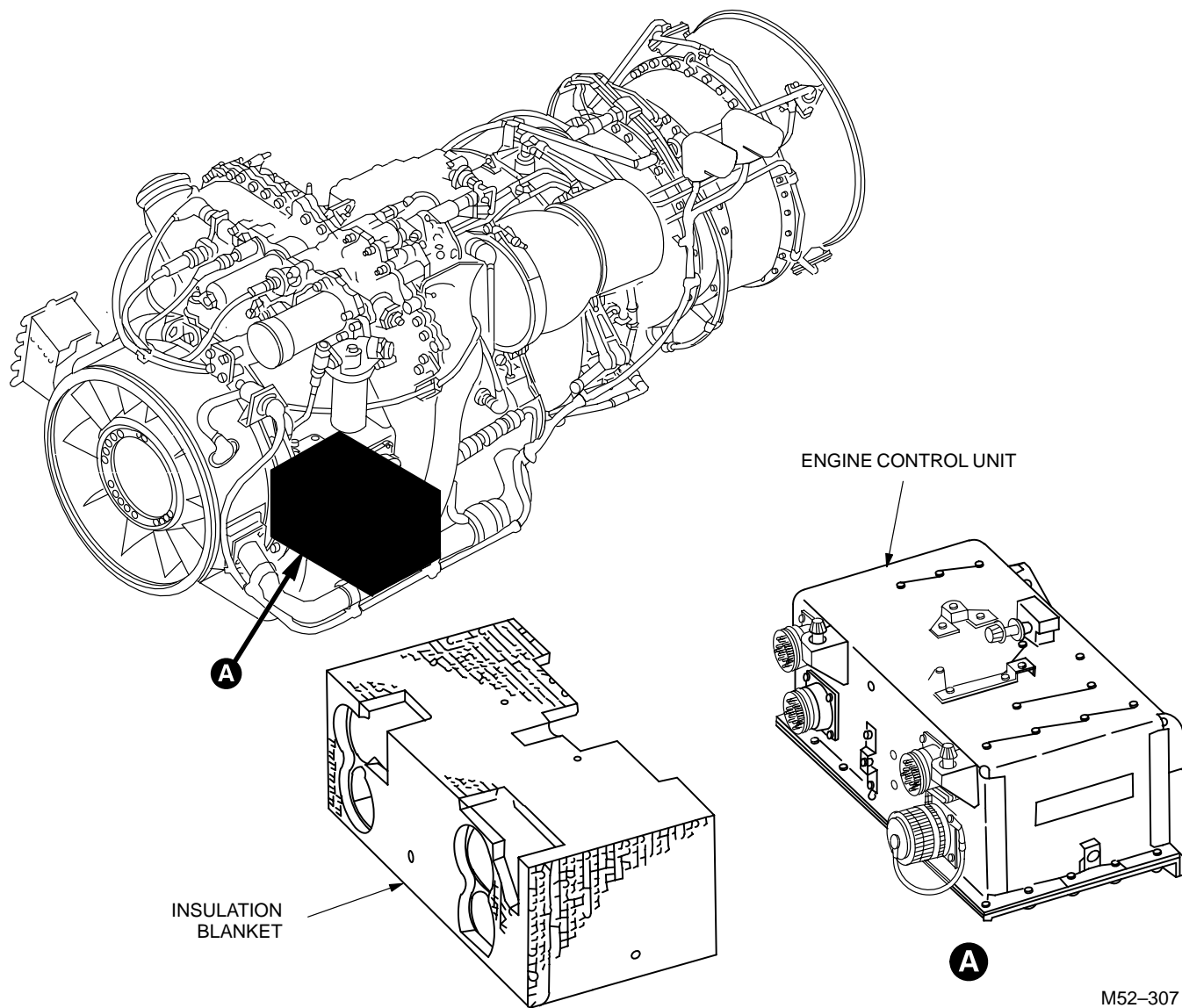
(e) Np reference adjustment. The Np reference adjustment is an adjustment screw that provides adjustment of Np speed in the ECU only.

(f) HMU torque motor feedback signal. The HMU torque motor feedback signal is an electrical signal that monitors HMU torque motor stability.

The ECU or DECU monitors the Np speed and develops an output signal to the HMU torque motor to modulate fuel flow. The ECU or DECU receives collective control stick position from the engine droop LVDT to develop a signal to the HMU torque motor to increase fuel flow before Np decreases to prevent engine droop.

The ECU or DECU monitors the torque and overspeed signal from both engines through overspeed sensing circuits A (engine 1) and B (engine 2). When the torques do not match, a signal is developed by the ECU or DECU for the HMU torque motor, to increase the fuel flow to the lower-torque engine. The ECU or DECU monitors Np sensor signals, if Np exceeds 119.6 %, the ECU or DECU energizes the Np overspeed/drain valve to shut off fuel flow to the engines.

When TGT reaches 867° C the TGT limit amplifier overrides the ECU or DECU to reduce HMU torque motor fuel flow to the engines to maintain a constant 867° C TGT.

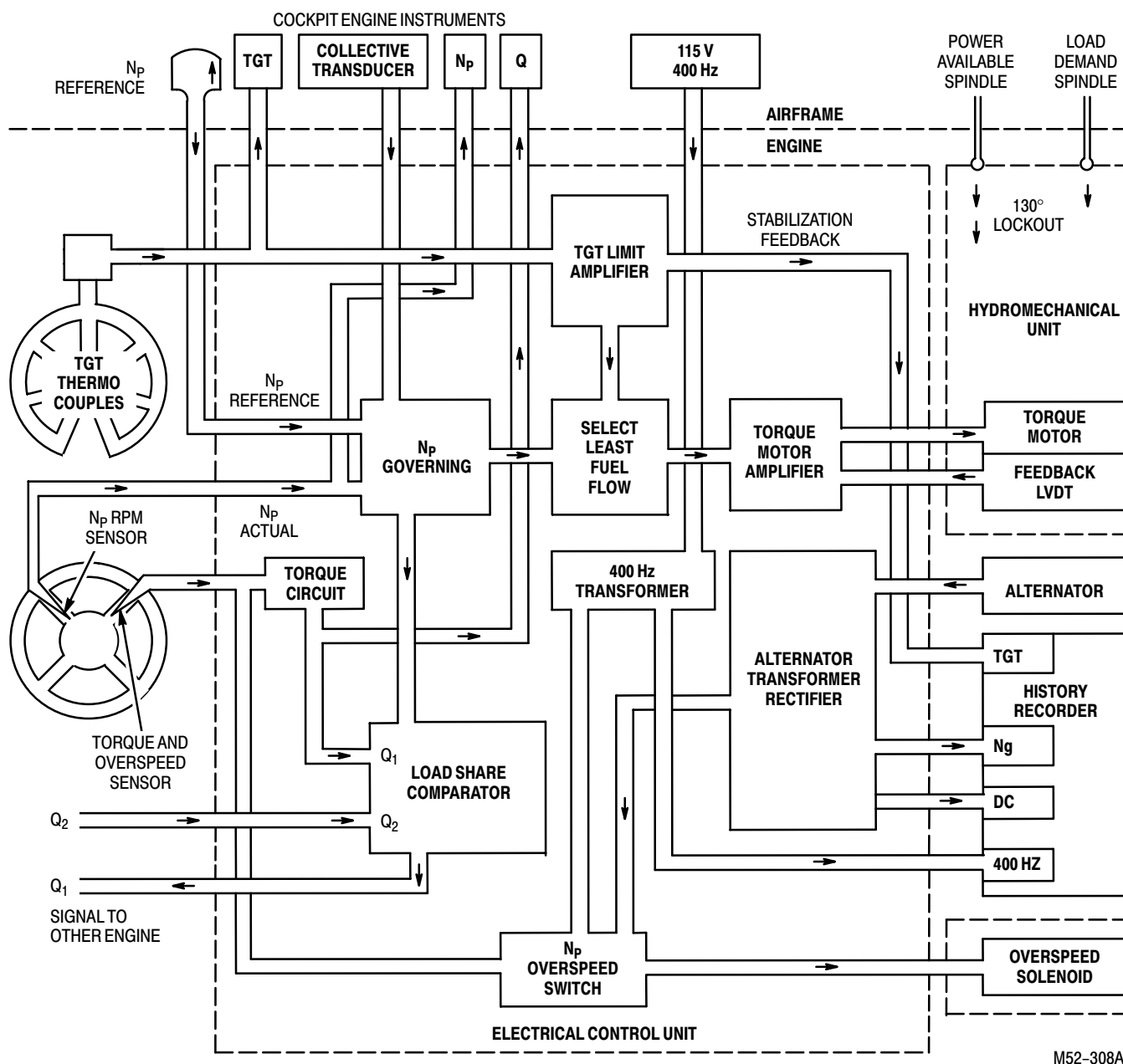


M52-307

Figure 6-21. Engine Control Unit or Digital Engine Control Unit

6-3. THEORY OF OPERATION (cont)

6-3



M52-308A

Figure 6-22. ECU and DECU Operation

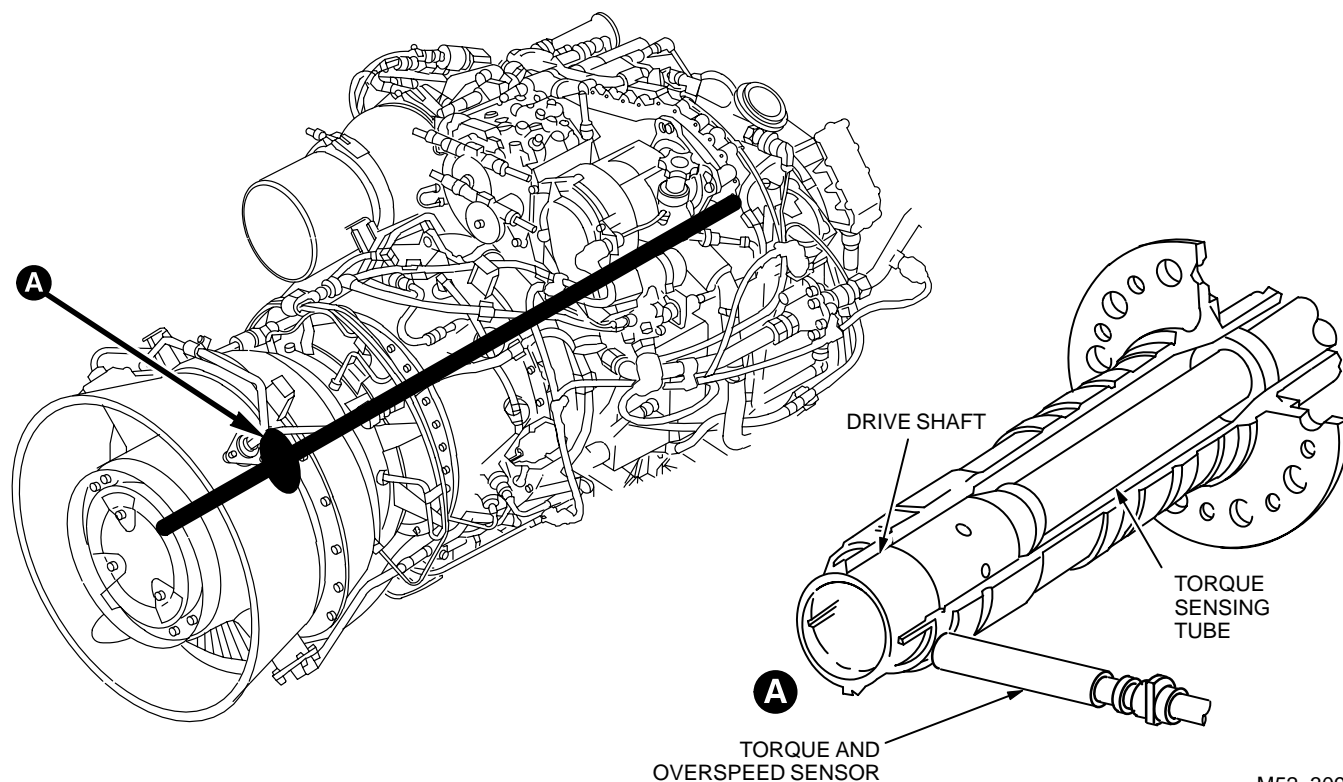
(3) The torque and overspeed sensor (fig. 6-23) is a monopole permanent magnet pickup that sends a signal to the ECU or DECU and pilot torque indicator proportional to the N_p speed.

(4) The engine overspeed test panel, located on the pilot's left console, provides switches to test the engine overspeed system. Each test switch is a three-position spring-loaded **OFF** toggle switch. When the **CKT A** switch is set to the **ENG 1** position N_g should remain stable. If N_g decreases **CKT B** is malfunctioning.

6-3. THEORY OF OPERATION (cont)

6-3

When the **CKT B** switch is set to the **ENG 1** position N_g should remain stable. If N_g decreases **CKT A** is malfunctioning. When the **CKT B** switch is set to the **ENG 2** position the **EMER PWR** caution light on the test panel illuminates. When both **CKT 1** and **2** switches are set to the **ENG 1** or **ENG 2** position N_g should decrease.



M52-309

Figure 6-23. Torque and Overspeed Sensor

(5) The overspeed/drain valve (ODV, fig. 6-24) provides metered fuel to the engine through the fuel injectors, purges fuel from the fuel injectors on engine shutdown, and controls N_p overspeed by terminating fuel flow to the injectors.

During normal operation fuel enters the ODV and passes through to the fuel injectors to supply fuel to the engine. When the engine N_p exceeds 25,000 rpm the ECU or DECU signals the ODV. The ODV closes and fuel to the fuel injectors is bypassed and routed back to the HMU torque motor. This stops engine fuel supply and shuts down the engine.

d. **Engine Bleed Air System.** The fifth stage bleed air manifold (fig. 6-25) is a 1.25 inch diameter tube that connects the fifth stage compressor bleed air port to the bleed air shutoff valve. The engine bleed air system allows fifth stage bleed air to flow to the bleed air shutoff valve. The fifth stage bleed air manifold attaches to the engine 1 at the nine o'clock position.

6-3. THEORY OF OPERATION (cont)

6-3

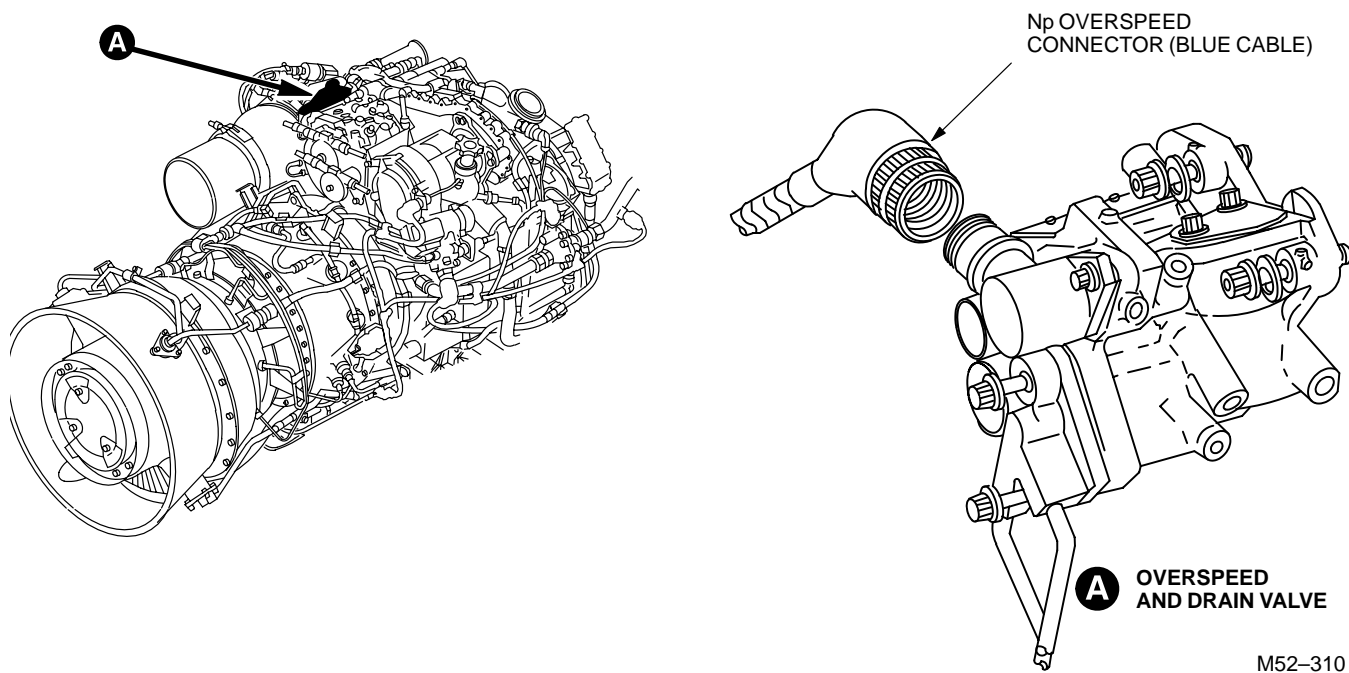


Figure 6-24. Overspeed/Drain Valve

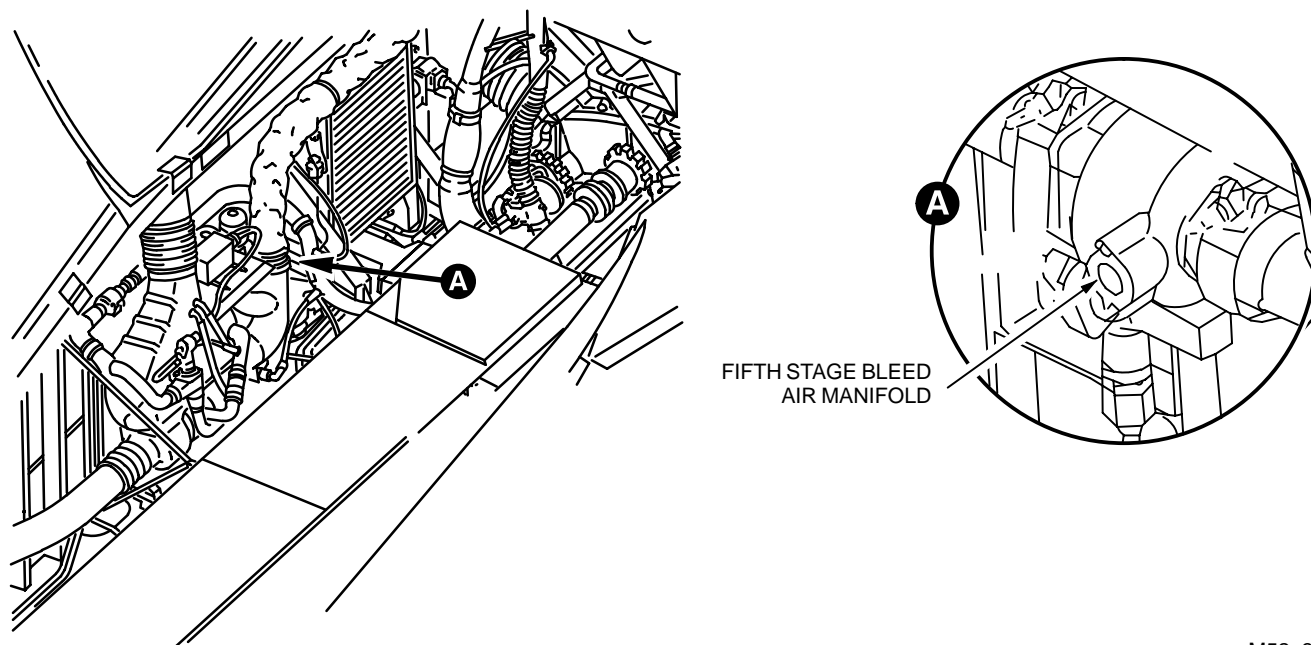


Figure 6-25. Bleed Air Manifold

e. **Engine Cooling System.** The engine cooling system major components (fig. 6-26) are described in the following subparagraphs.

6-3. THEORY OF OPERATION (cont)

6-3

(1) The louver assembly is a rectangular box frame with moveable horizontal vanes mounted on the engine nacelle firewall between each of the engines and the aft equipment bay. Each assembly is opened by a louver actuator to allow air from the main transmission area to enter each engine nacelle. The louver assembly is closed to isolate each engine nacelle in the event of a fire.

(2) The louver actuator is a pneumatic actuator, spring-loaded to extend, which is controlled by the directional control valve to open or close the louver assembly. The actuator is mounted on the rear of the left louver assembly, and the front of the right louver assembly. Pressurized air enters the actuator through the directional control valve to retract the actuator closing the louver assembly. The directional control valve stops pressurized airflow to the actuator and the spring force overrides air to the venting actuator, extending the actuator, opening the louver assembly.

(3) The directional control valve is an electrically actuated, three-way pneumatically controlled valve that controls pressurized airflow to the louver actuators. The directional control valve is mounted on the rear of the left louver assembly and the front of the right louver assembly. When the **ENG FIRE PULL 1** or **ENG FIRE PULL 2** handles are pulled, 28 VDC is supplied to the directional control valve. The directional control valve opens to allow pressurized air to enter the louver actuator. When the handles are pushed in 28 VDC is removed from the directional control valve stopping pressurized airflow to the louver actuator.

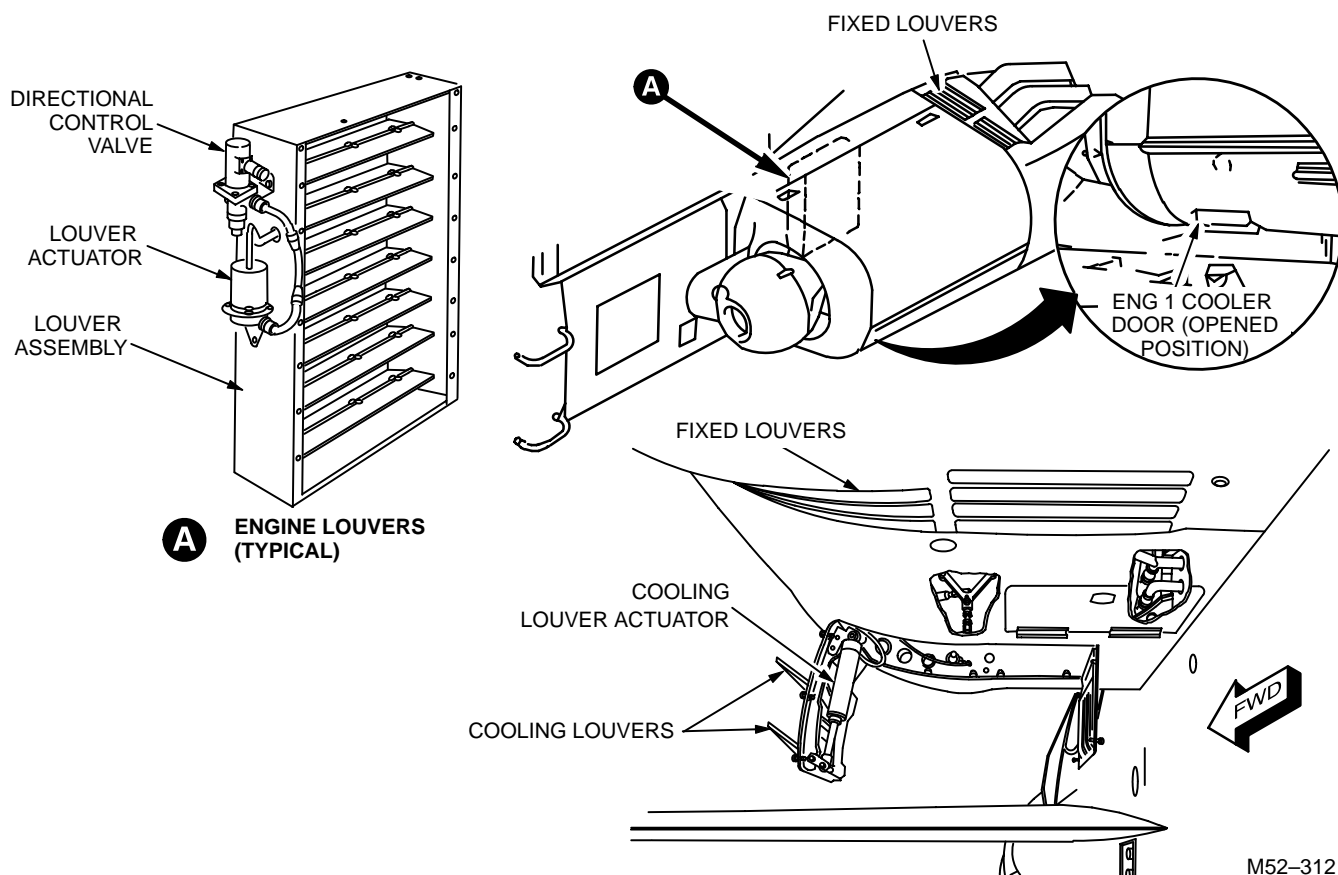
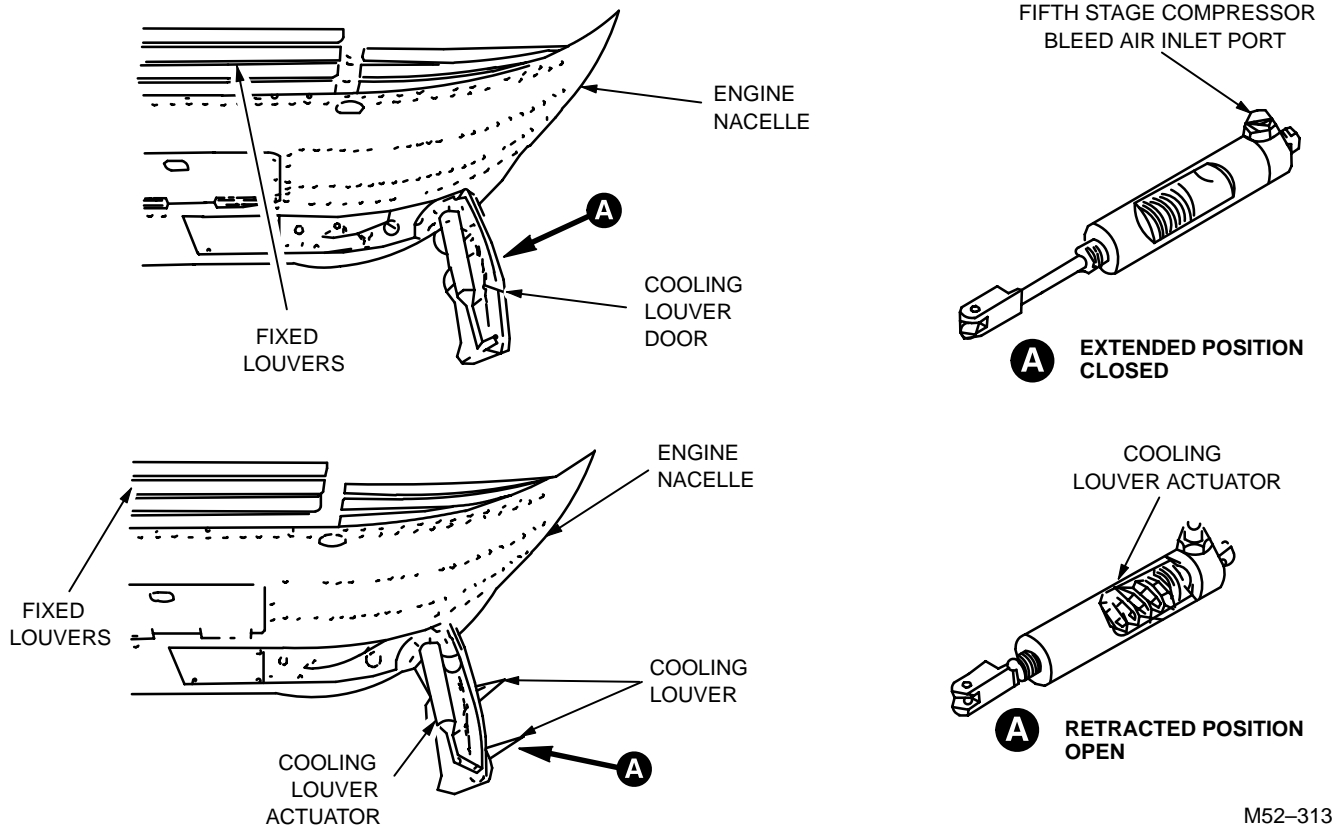


Figure 6-26. Engine Cooling System

6-3. THEORY OF OPERATION (cont)

6-3

(4) The cooling louvers (fig. 6-27) are moveable louver type vanes attached to the cooling louver doors on the bottom of each engine nacelle. The cooling louvers open after engine shutdown to provide engine cooling airflow. The cooling louvers are moved by the cooling louver actuator. Fifth stage engine bleed air retracts the cooling louver actuator during engine operation, closing the cooling louvers. After engine shutdown fifth stage engine bleed air supply stops, and spring force from the spring-loaded cooling louver actuator overrides the air venting the actuator, to extend the actuator opening the cooling louvers. The fixed louvers located on top and bottom of each engine nacelle provide an airflow opening to cool the engines during flight.



M52-313

Figure 6-27. Cooling Louver

f. **Engine Exhaust System.** The engine exhaust system major components (fig. 6-28) are described in the following subparagraphs.

(1) The inlet particle separator duct is located on the left forward side of the engine. The inlet particle separator duct provides an exit for foreign objects from the inlet particle separator while routing inlet cooling air to the engine primary and secondary nozzles.

(2) The primary nozzle (fig. 6-29) is attached to each engine exhaust frame to provide a path for engine exhaust gas airflow. The engine exhaust gases flow through the primary nozzle creating an ejector pumping action that draws air from the engine cooling system through the secondary nozzle.

(3) The secondary nozzle and assembly support (fig. 6-28) are attached to each engine nacelle between the primary nozzle and the rear of the engine nacelle. The secondary nozzle mixes exhaust gases with engine cooling system air. The assembly support attaches the secondary nozzle to the primary nozzle and the engine nacelle.

6-3. THEORY OF OPERATION (cont)

6-3

Exhaust gases enter the secondary nozzle and intermix with engine cooling system air to cool the exhaust gases. A low pressure area is created in the engine nacelle as cooling air enters the secondary nozzle. This causes ambient air to enter the engine nacelle through the cooling louvers to cool the engine. The cooled exhaust gases exit the secondary nozzle and are dispersed by the main rotor blades downwash.

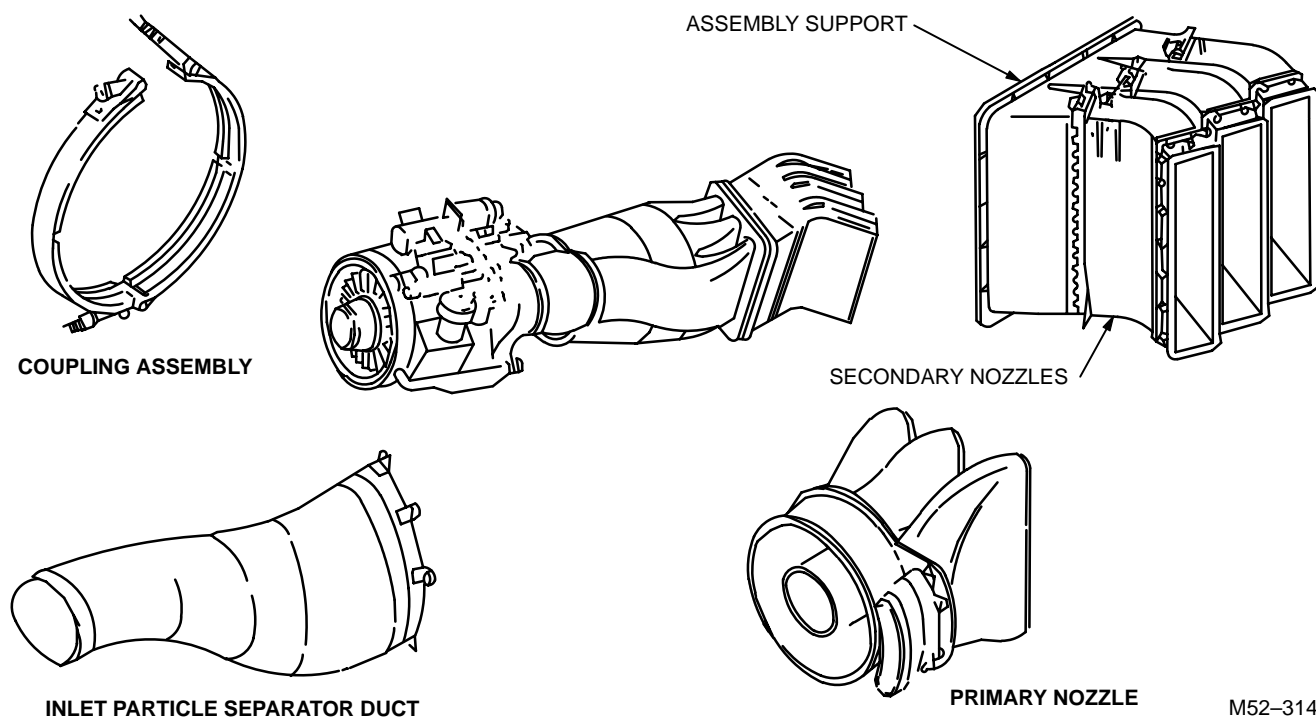


Figure 6-28. Engine Exhaust System

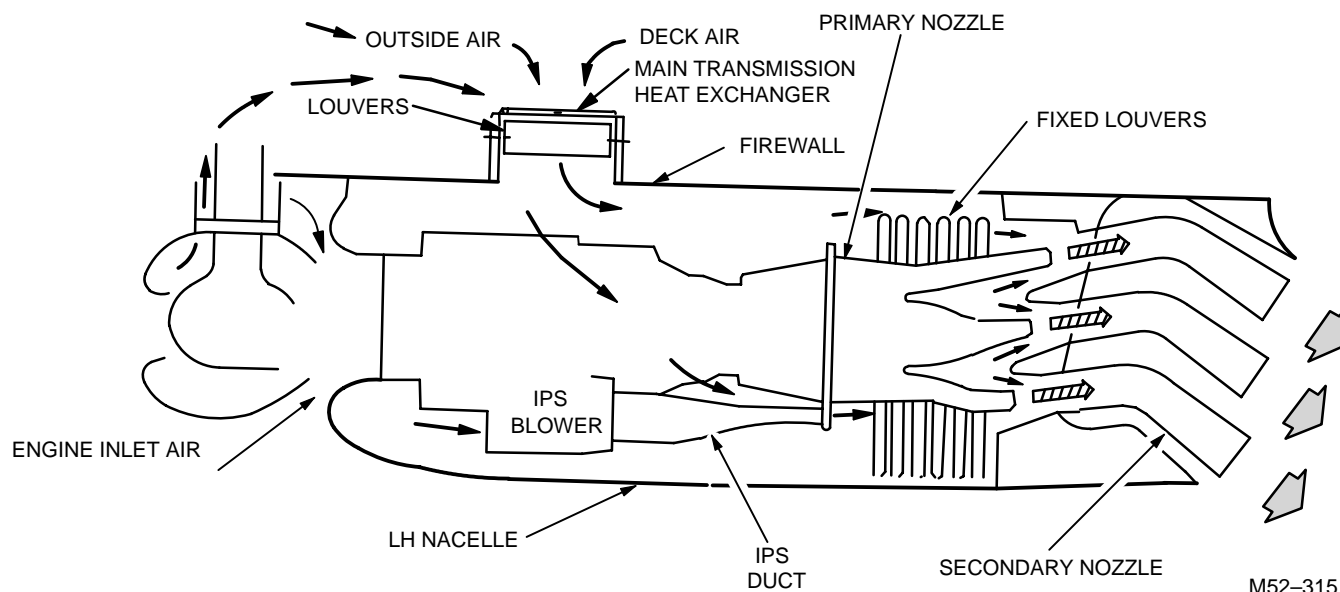


Figure 6-29. Engine Exhaust System

6-3. THEORY OF OPERATION (cont)

6-3

g. **Engine Start and Ignition System.** The start and ignition system major components are described in the following subparagraphs.

(1) The air turbine starter (fig. 6-30) is a pneumatically operated starter that rotates the compressor through the engine accessory gearbox until the engine reaches an Ng speed that permits the engine to be self-sustaining. The air turbine starter is mounted on the rear right side of the engine accessory gearbox. The starter is controlled by the air pressure regulator shutoff valve.

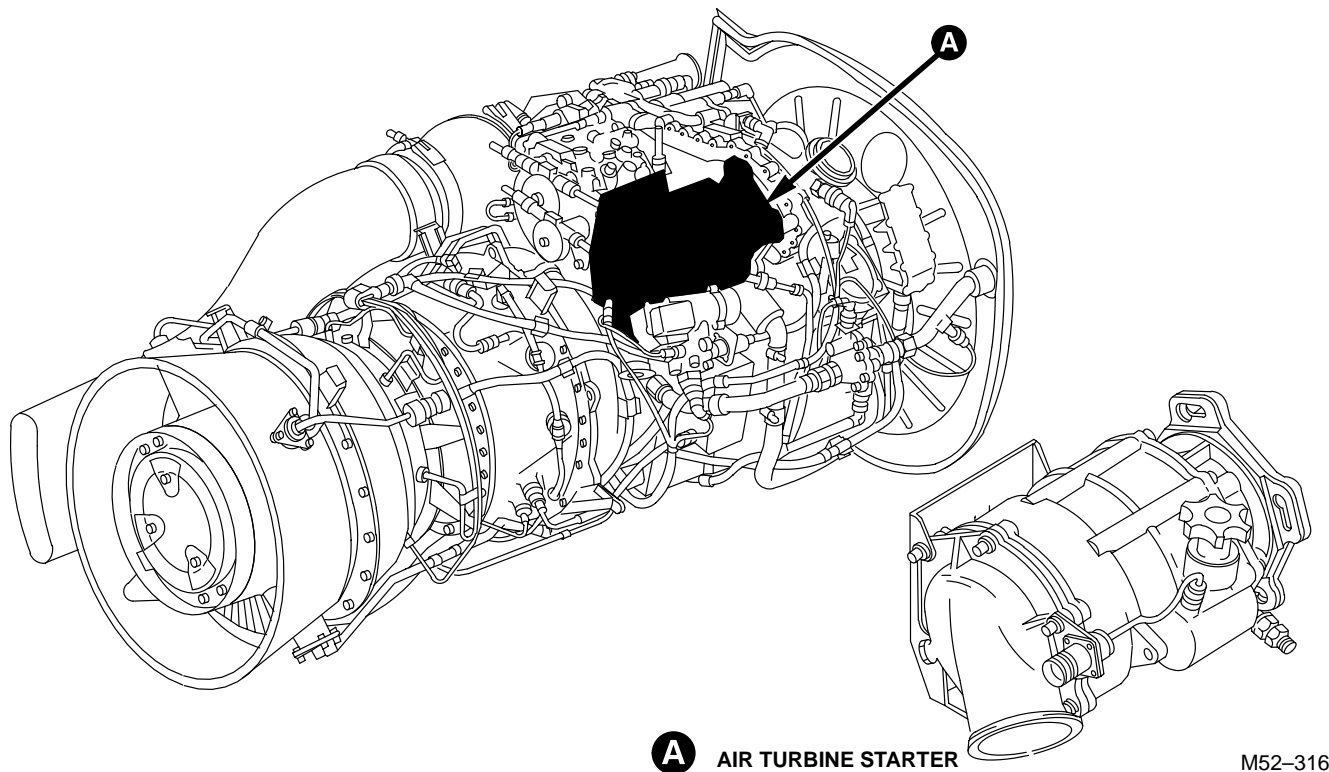


Figure 6-30. Air Turbine Starter

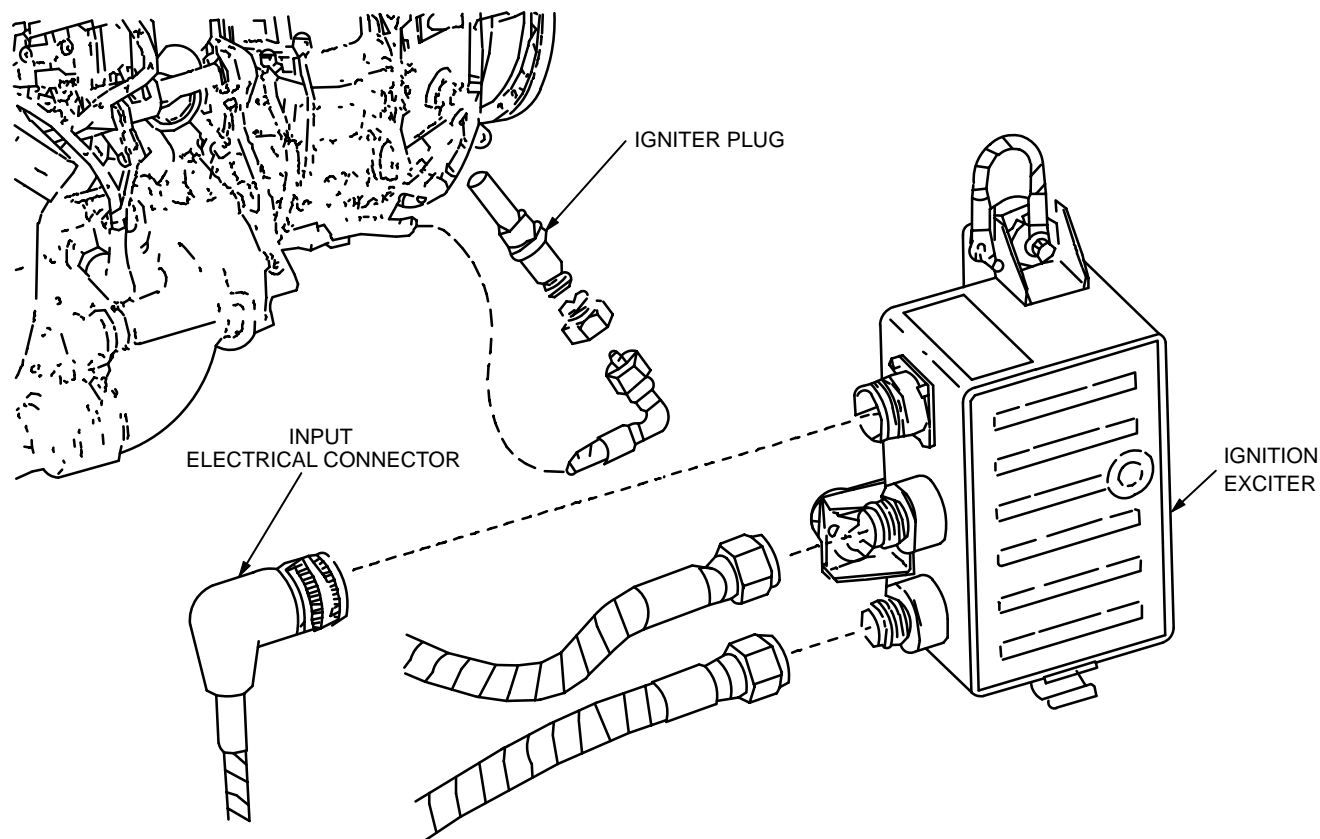
(2) The ignition exciter and igniter plugs (fig. 6-31) supply high voltage sparks to ignite the fuel during engine start.

(a) The ignition exciter is a noncontinuous ac-powered capacitor discharge type unit mounted on the right forward section of the engine at the three o'clock position. The ignition exciter supplies high voltage to the exciters from operating voltage supplied by the alternator. The exciter rectifies the alternator voltage to 5000 to 7000 VDC and applies the voltage to the igniters. The air turbine speed cutout switch controls ignition exciter operation. The duty cycle is 2 minutes on, 3 minutes off, 2 minutes on, and 23 minutes off.

(b) The two igniter plugs are spark-type plugs located at the center section of each engine at the four and eight o'clock positions. The igniters provide the initial spark to ignite the fuel/air mixture in the combustion section of the engine. The spark rate is two sparks per second.

6-3. THEORY OF OPERATION (cont)

6-3



M52-317

Figure 6-31. Ignition Exciter and Igniter Plug

(3) The air pressure regulator and shutoff valve (fig. 6-32) is an air actuated, solenoid controlled spring-loaded closed valve that provides air from the pressurized air system to the air turbine starter. The valve is coupled to the air turbine starter. When opened, the valve provides pressurized air to the air turbine starter. When closed the valve stops pressurized airflow to the starter. The regulator is energized by the air turbine starter speed cutout switch.

(4) The air turbine starter speed cutout switch (fig. 6-32) is a sealed electronic unit mounted aft of the electrical power distribution center in the left main transmission area. The cutout switch holds the ignition exciter energized, and maintains air pressure regulator and shutoff valve operation until the engine reaches a self-sustaining speed. When the **ENG START/OFF/IGN OVRD 1** or **ENG START/OFF/IGN OVRD 2** switch is set to the **START** position the cutout switch is energized and controls the ignition exciter and air pressure regulator and shutoff valve operation.

At 55 % Ng the air turbine starter monopole speed sensor develops enough voltage to de-energize the cutout switch. The cutout switch stops air pressure regulator and shutoff valve operation and de-energizes the ignition exciter.

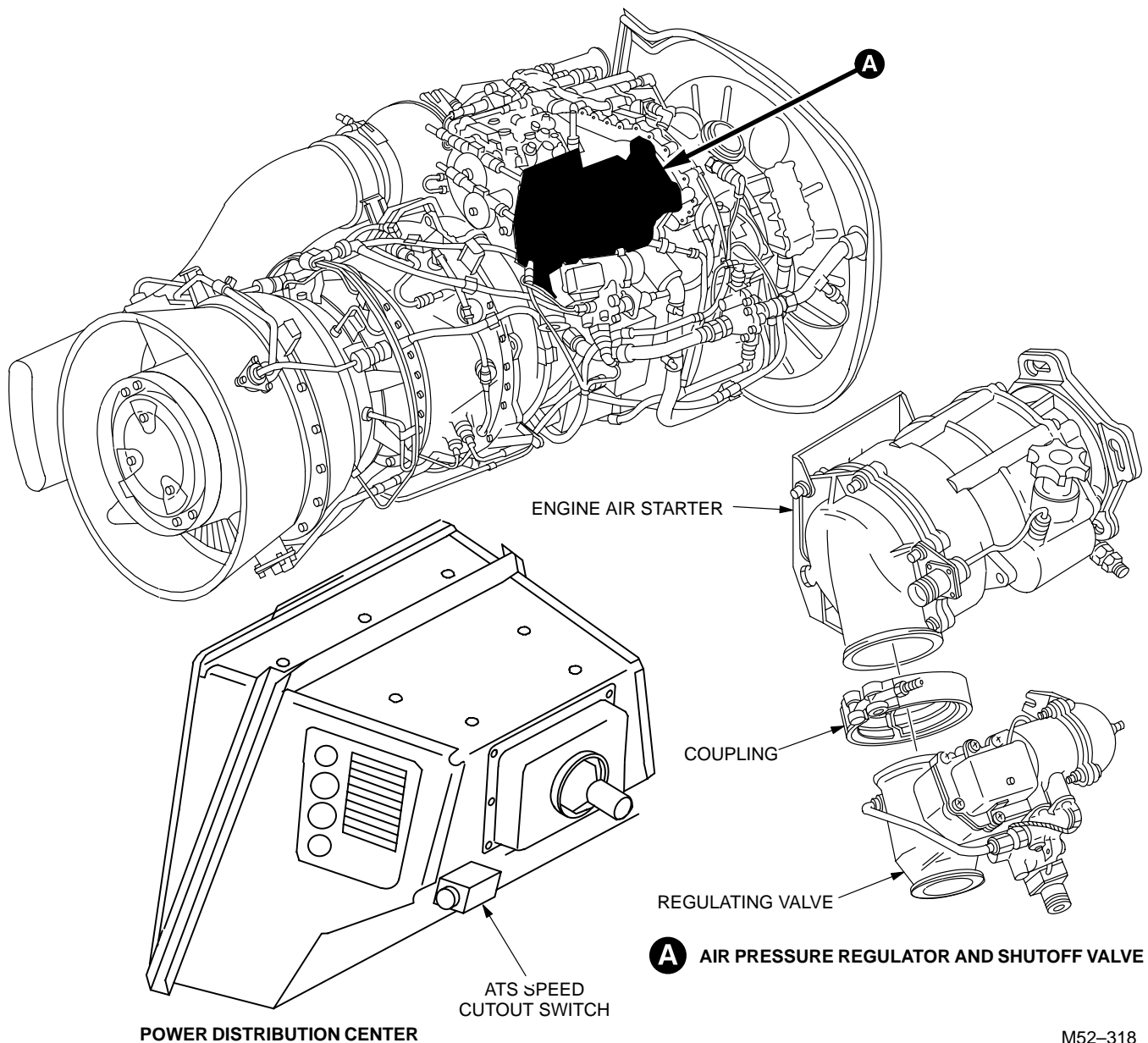


Figure 6-32. Air Pressure Regulator and Shutoff Valve

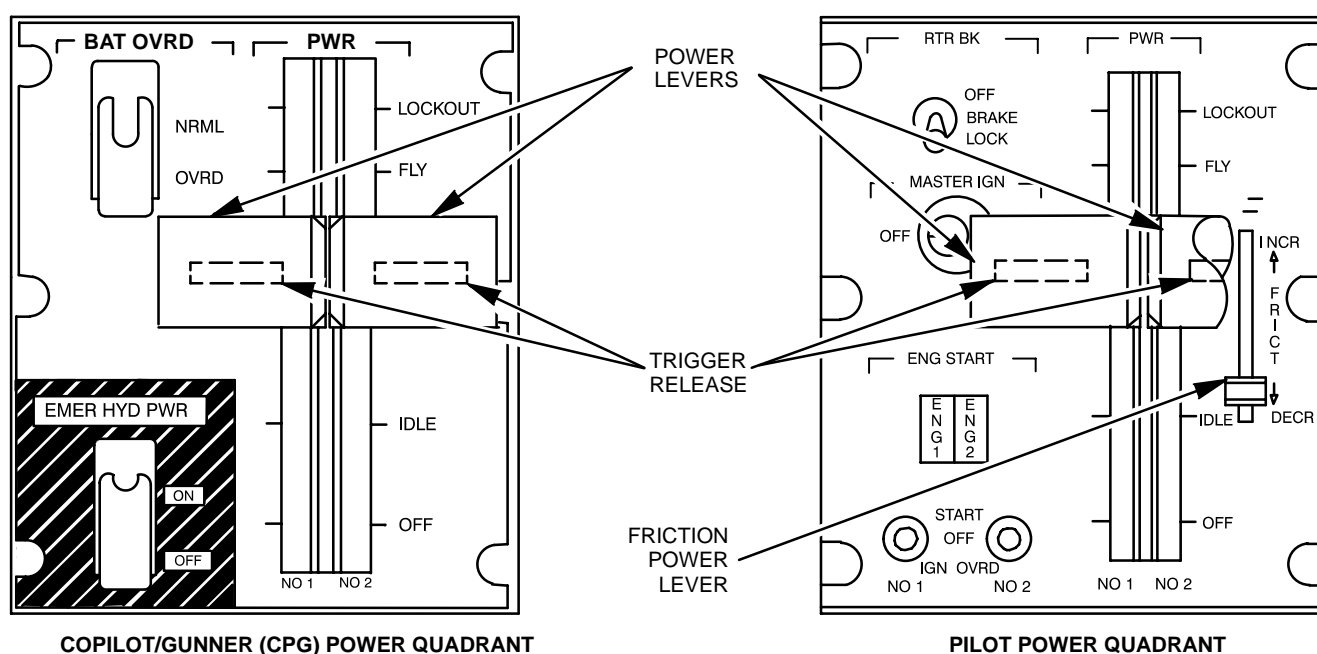
(5) The pilot power quadrant (fig. 6-33) provides electrical contact to energize the starting system. The master ignition switch, located on the left side of the quadrant, is a key operated **ON/OFF** switch that supplies electrical power to the start system. When the **MASTER IGN** switch is turned to **ON**, 28 VDC is supplied to **ENG START/IGN OVRD 1** and **2** switches.

6-3. THEORY OF OPERATION (cont)

6-3

The **ENG START/IGN OVRD** switches are three position spring-loaded **OFF** switches located on the left side of the quadrant. The switches activate the fuel and ignition systems, and the air pressure regulator and shutoff valve. When the **ENG START/IGN OVRD 1** or **ENG START/IGN OVRD 2** switch is set to **START**, 28 VDC is applied to the air turbine starter speed cutout switch, the fuel system boost pump air valve, and fuel system crossfeed shutoff valves. The cutout switch energizes and holds the air pressure regulator and shutoff valve, and the ignition exciter operation while the **ENG START/IGN OVRD** switch is released and returns to **OFF**.

When the **ENG START/IGN OVRD 1** or **ENG START/IGN OVRD 2** switch is set to **IGN OVRD**, 28 VDC is applied to the air pressure regulator and shutoff valve to motorize the engine to 25 % Ng. When the switch is released and returns to **OFF**, 28 VDC supplied to the air pressure regulator and shutoff valve is interrupted and motoring of the engine stops.



M52-319

Figure 6-33. Pilot and CPG Power Quadrants

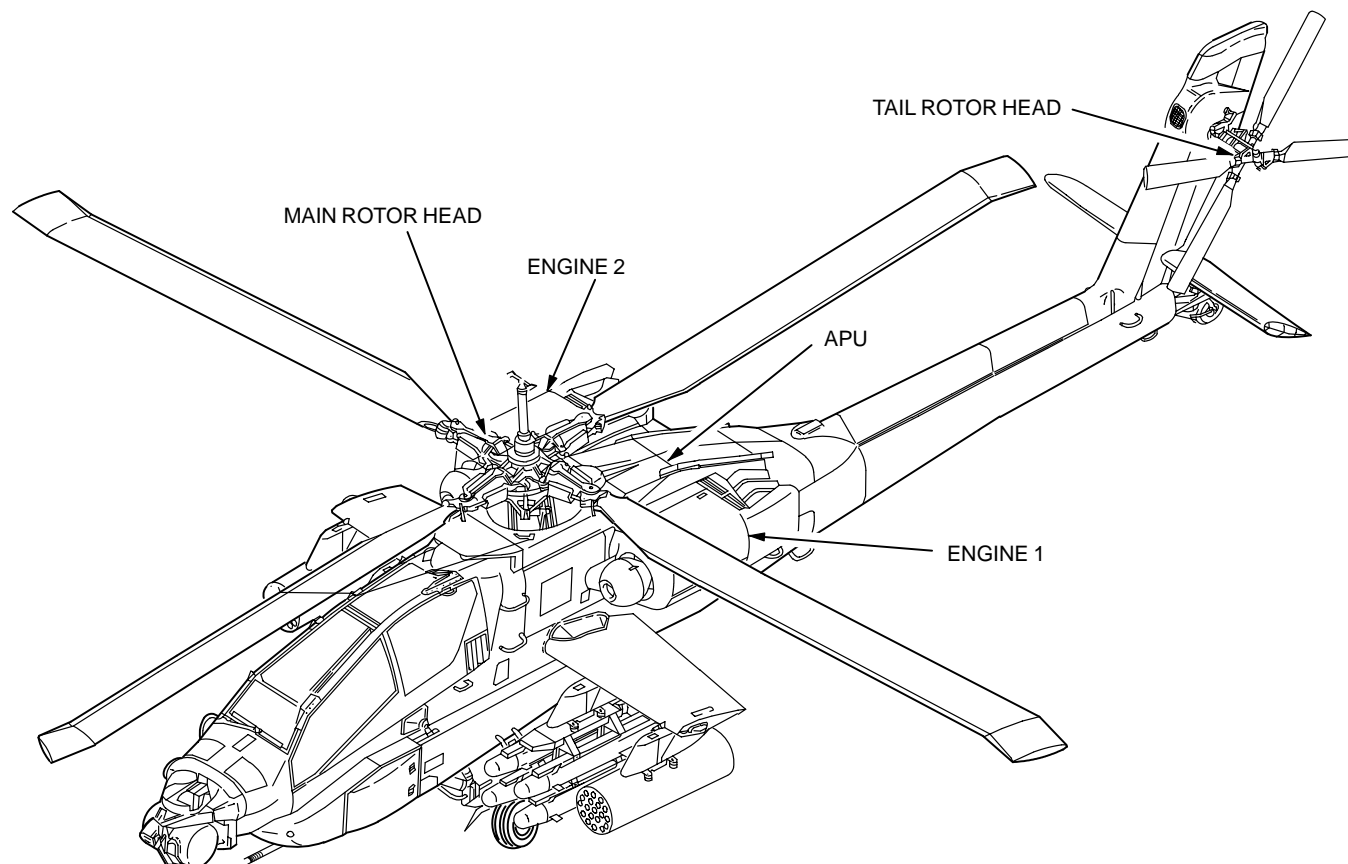
7-1. PURPOSE

7-1

CHAPTER 7 DRIVE SYSTEM

7-1. PURPOSE

The drive system (fig. 7-1) changes engine 1 and 2 drive angle, converts the output rpm of the engines into usable power, and transmits the power to the main and tail rotor heads.



M52-171

Figure 7-1. Drive System Interface

7-2. DESCRIPTION

The drive system operates with either engine. When the engines are not operating, the drive system utilizes APU power to drive the aircraft accessories. The drive system major components are described in the following subparagraphs.

a. **Tail Rotor Gearbox (TGB).** The TGB (fig. 7-2) is mounted on the vertical stabilizer. The TGB changes the drive angle 90° and transmits power from the intermediate gearbox (IGB) to drive the tail rotor head.

b. **Drive Shaft 6 (Tail Rotor Drive Shaft).** Drive shaft 6 (fig. 7-2) transmits drive power from the intermediate gearbox (IGB) to the TGB.

7-2. DESCRIPTION (cont)

7-2

c. **IGB.** The IGB (fig. 7-2) is a light-weight magnesium alloy gearbox that transmits power from the main transmission to the TGB. The IGB is mounted on the vertical stabilizer.

d. **Drive Shaft 3 (Tail Rotor Drive Shaft).** Drive shaft 3 (fig. 7-2) transmits power from the main transmission to drive shaft 4.

e. **Main Rotor Drive Shaft.** The main rotor drive shaft (fig. 7-2) is a semi-floating drive shaft mounted inside the static mast. The main rotor drive shaft transmits power from the main transmission to drive the main rotor.

f. **Nose Gearbox 1 (NGB).** The NGB 1 (fig. 7-2) is a magnesium alloy gearbox mounted on the swirl frame. The engine 1 nose gearbox changes engine 1 drive angle 90° and drives the main transmission through the input drive shaft 1.

g. **Input Drive Shaft 1.** Input drive shaft 1 (fig. 7-2) is an aluminum drive shaft that transmits power from the engine 1 NGB to the main transmission.

h. **Main Transmission.** The main transmission is the primary drive for the main rotor, tail rotor, and accessories. The main transmission is located beneath the main rotor support mast base assembly.

i. **Input Drive Shaft 2.** Input drive shaft 2 (fig. 7-2) is an aluminum drive shaft that transmits power from engine 2 NGB to the main transmission.

j. **Nose Gearbox 2 (NGB).** The NGB 2 (fig. 7-2) is a magnesium alloy gearbox mounted on the swirl frame. Engine 2 nose gearbox changes engine 2 drive angle 90° and drives the main transmission through input drive shaft 2.

k. **Drive Shaft 7.** Drive shaft 7 (fig. 7-2) is a titanium drive shaft that transmits power from the APU to the main transmission accessory section.

l. **Drive Shaft 4 (Tail Rotor Drive Shaft).** Drive shaft 4 (fig. 7-2) transmits drive power from drive shaft 3 to drive shaft 5.

m. **Drive Shaft 5 (Tail Rotor Drive Shaft).** Drive shaft 5 (fig. 7-2) transmits drive power from drive shaft 4 to the IGB. Drive shaft 5 drives the IGB fan which provides cooling for the IGB and tail rotor gearbox.

7-3. THEORY OF OPERATION

7-3

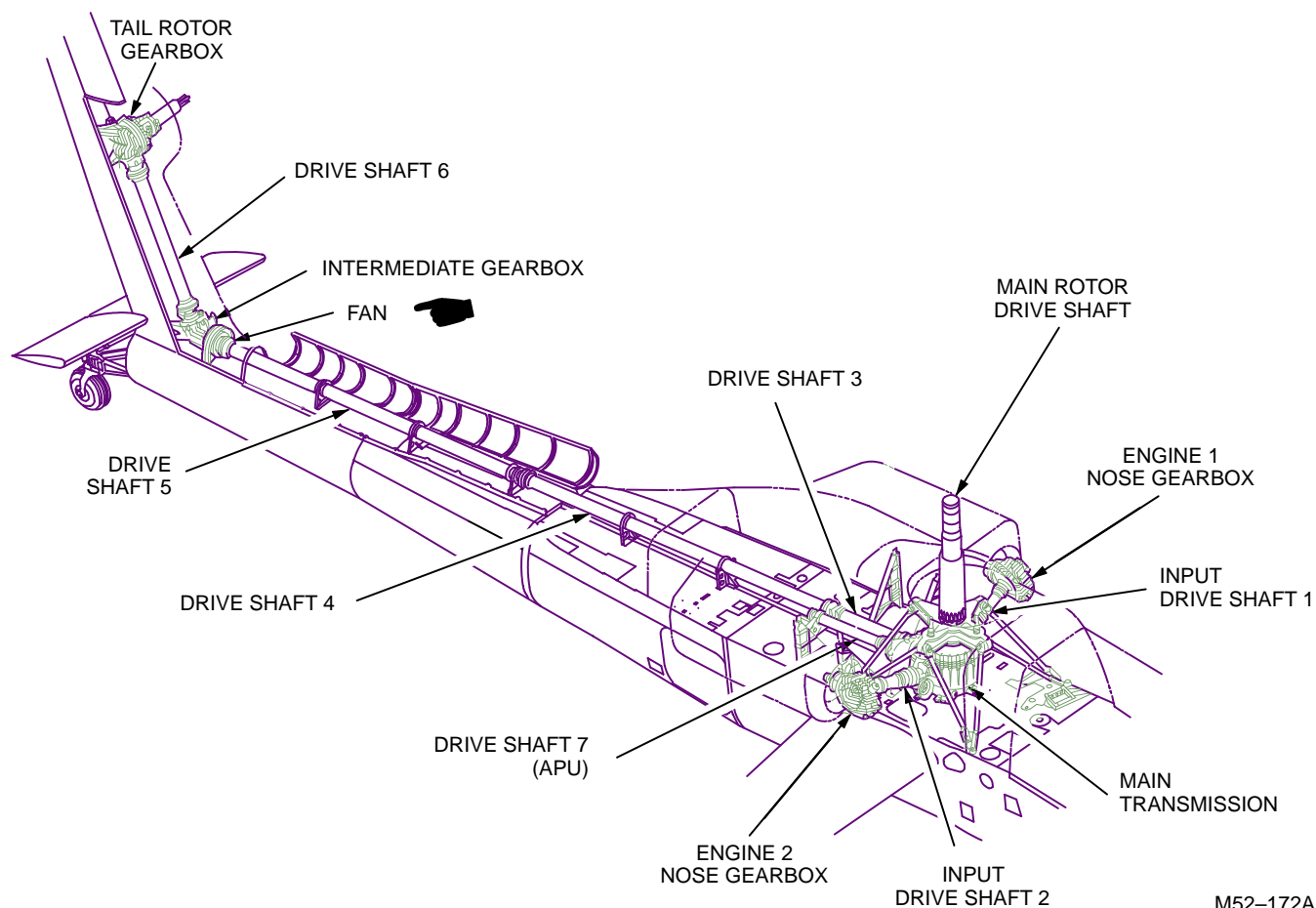


Figure 7-2. Drive System Major Components

7-3. THEORY OF OPERATION

The drive system theory of operation (fig. 7-3) is described in the following subparagraphs.

a. **Tail Rotor Gearbox (TGB).** The TGB transmits power from the IGB to the tail rotor head while changing the drive angle 90°. The gearbox reduces input of 3636 rpm to an output of 1403 rpm. This is accomplished by a 2.6:1 gear ratio. The TGB components (fig. 7-4) are described below.

- (1) The housing supports the TGB internal gears, bearings, and drive shaft. The housing is constructed of light weight magnesium alloy. The housing provides mounting points for the TGB to be mounted to the upper portion of the vertical stabilizer.
- (2) The static support provides mounting for the tail rotor head. The gearbox internal gears, bearings, and drive shaft transmits all drive loads to the tail rotor head through the center of the static support. In addition, the static support transmits all tail rotor head flight loads to the housing. The static support is constructed of corrosion resistant steel.
- (3) Four thermistors are installed in the TGB to monitor bearing temperatures. Each is a coil activated temperature sensing switch, spring-loaded to maintain contact with the bearings. When bearing temperatures exceed operating limits, the thermistors close and the pilot and copilot/gunner **TEMP TR** caution lights illuminate.

7-3. THEORY OF OPERATION (cont)

7-3

(4) The accelerometer monitors vibrations inside the TGB. Excessive vibration causes the accelerometer to illuminate the pilot and CPG **VIB GRBX** caution lights.

b. **Drive Shaft 6.** Drive shaft 6 is an aluminum tubular shaft that is part of the tail rotor drive shaft, and is located between the IGB and the TGB. Drive shaft 6 transmits drive power from the IGB to the TGB to drive the tail rotor head. Couplings attach the drive shaft to the IGB and TGB.

A hangar assembly supports the drive shaft allowing the drive shaft to turn. A damper assembly permits the drive shaft to rotate through critical speeds while damping natural frequencies.

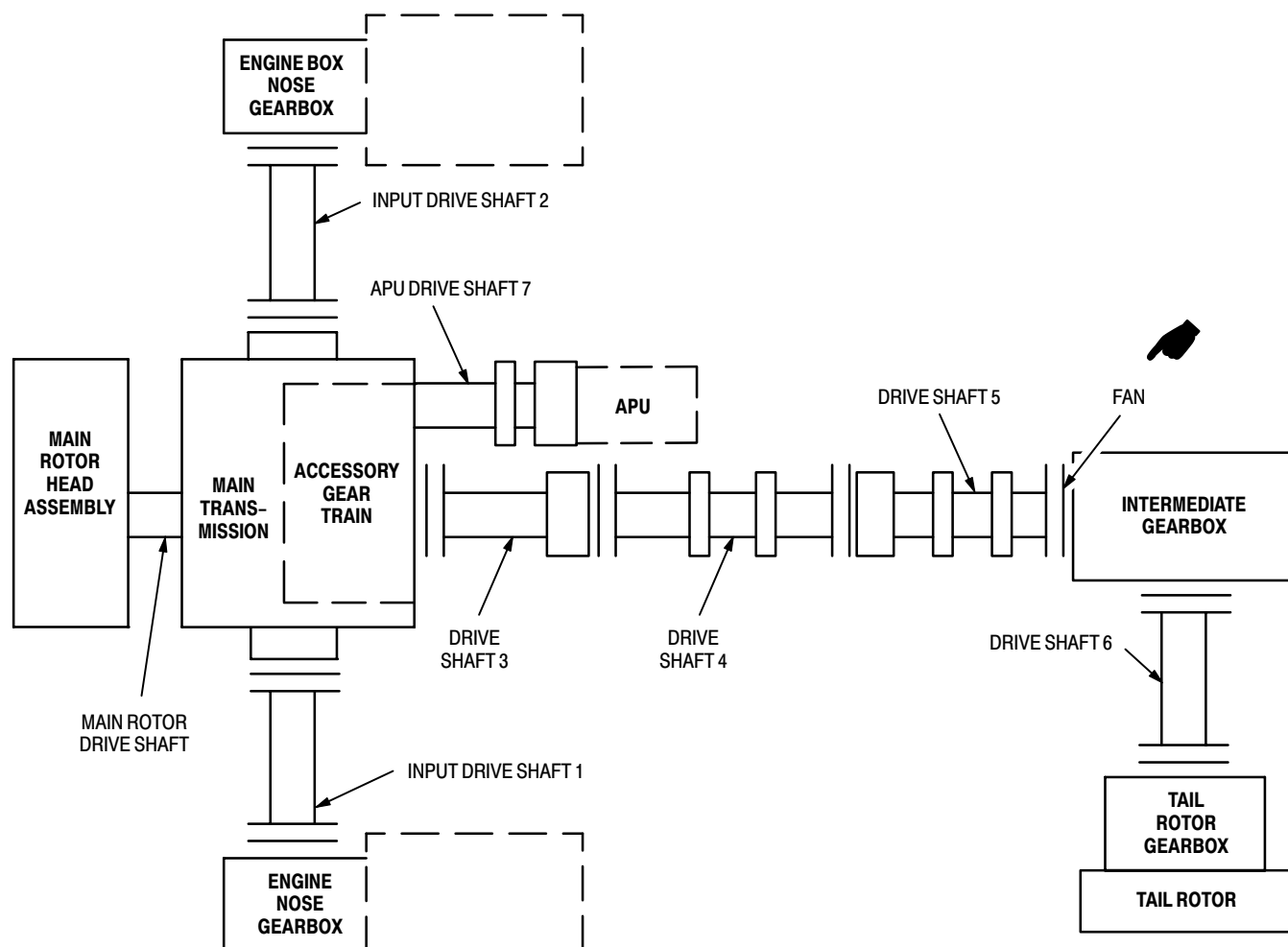
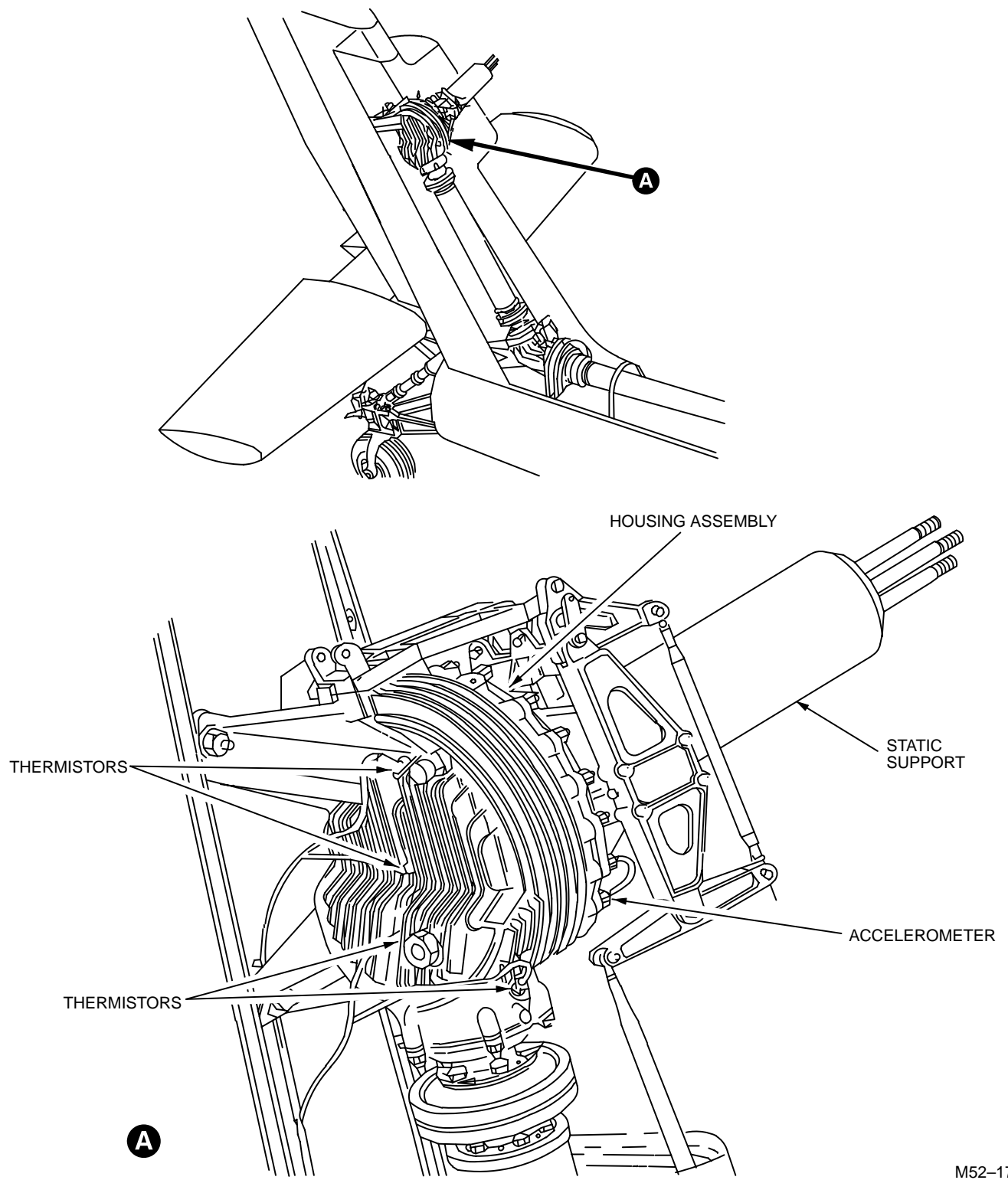


Figure 7-3. Drive System Theory of Operation

M52-173A



M52-174

Figure 7-4. Tail Rotor Gearbox

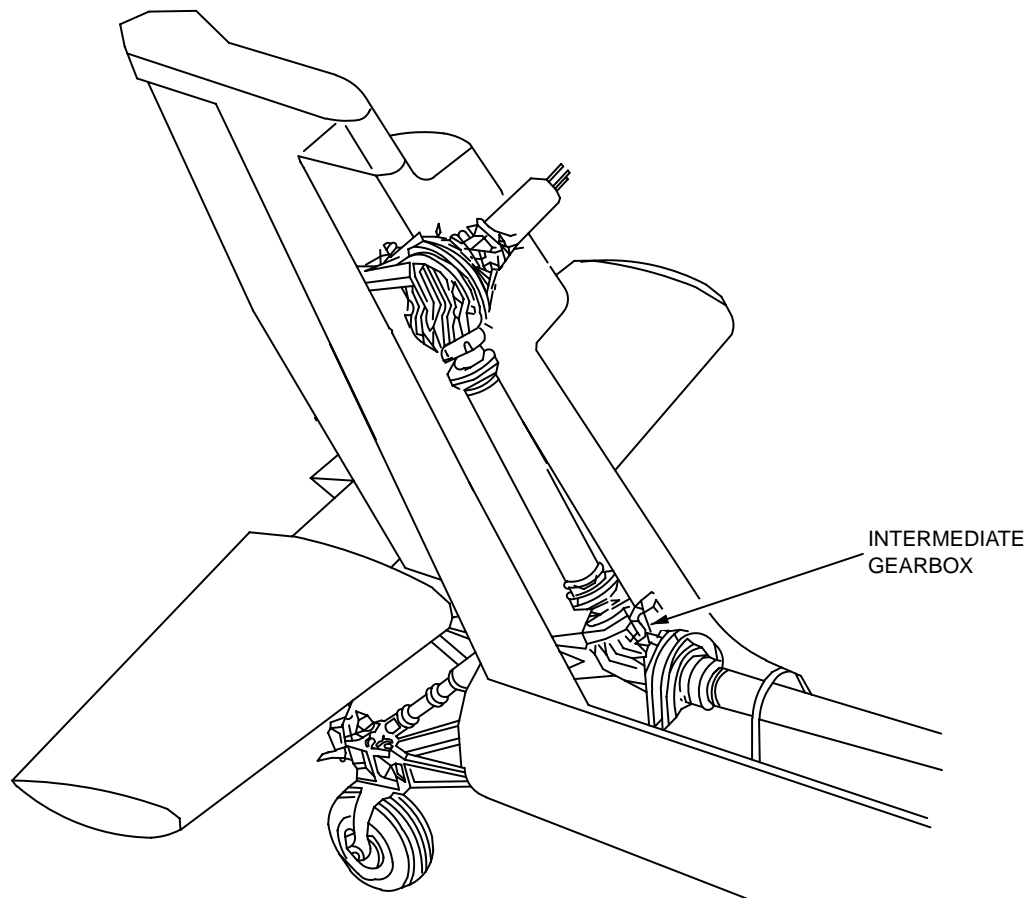
7-3. THEORY OF OPERATION (cont)7-3

c. **IGB.** The IGB transmits power from the main transmission to the TGB while changing the drive angle 71° . The IGB reduces input of 4815 rpm to an output of 3636 rpm. This is accomplished by a gear ratio of 1.32:1 between the internal gears. The IGB is mounted at the base of the vertical stabilizer. The IGB components (fig. 7-5) are described below.

(1) Four thermistors are installed into the IGB to monitor bearing temperatures. Each is a coil activated temperature sensing switch, that is spring-loaded to maintain contact with the bearings. When bearing temperatures exceed operating limits, the thermistors close and the pilot and CPG **TEMP INT** caution lights illuminate.

(2) An accelerometer monitors vibrations inside the IGB. Excessive vibration causes the accelerometer to illuminate the pilot and CPG **VIB GRBX** caution light.

(3) The housing supports the IGB internal gears, bearings, and drive shaft. The housing is constructed of light-weight magnesium alloy. The housing provides mounting points for the IGB to be mounted to the lower portion of the vertical stabilizer.



M52-175

Figure 7-5. Intermediate Gearbox

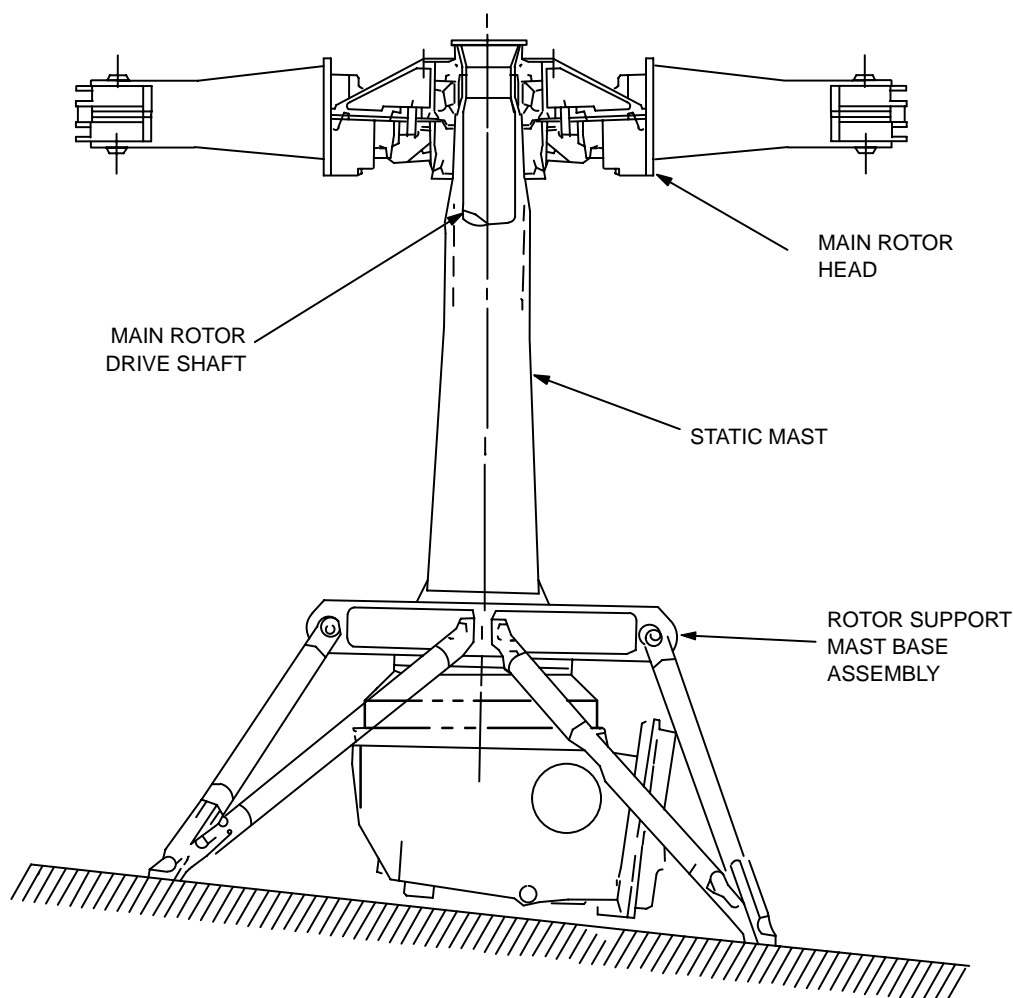
d. **Drive Shaft 3.** Drive shaft 3 is located between the main transmission accessory section and drive shaft 4. Drive shaft 3 transmits drive power from the main transmission accessory section to drive shaft 4.

7-3. THEORY OF OPERATION (cont)

7-3

Couplings attach the drive shaft to the main transmission and drive shaft 4. A hangar assembly supports the drive shaft allowing the drive shaft to turn. A damper assembly permits the drive shaft to rotate through critical speeds while damping natural frequencies.

e. **Main Rotor Drive Shaft.** The main rotor drive shaft (fig. 7-6) transmits power from the main transmission to the main rotor head. The drive shaft is mounted inside the static mast. The static mast is mounted on the rotor support mast base assembly. The main rotor drive shaft is a semi-floating shaft that accepts torsional loads from the main transmission. The drive shaft is turned by the main transmission, the driving torque is transmitted to the main rotor head. If the main transmission seizes, the drive shaft shears.



M52-401

Figure 7-6. Main Rotor Drive Shaft

f. **Engine 1 NGB.** Engine 1 NGB (fig. 7-7) drives the main transmission through input drive shaft 1 while changing the drive angle 90°. When engine 1 is operating at 100% rpm the NGB reduces engine output rpm from 20,952 to 9,841 rpm. This is accomplished through an internal gear ratio of 2.13:1. The engine 1 NGB is mounted to the swirl frame of engine 1. The NGB components (fig. 7-8) are described in the following subparagraphs.

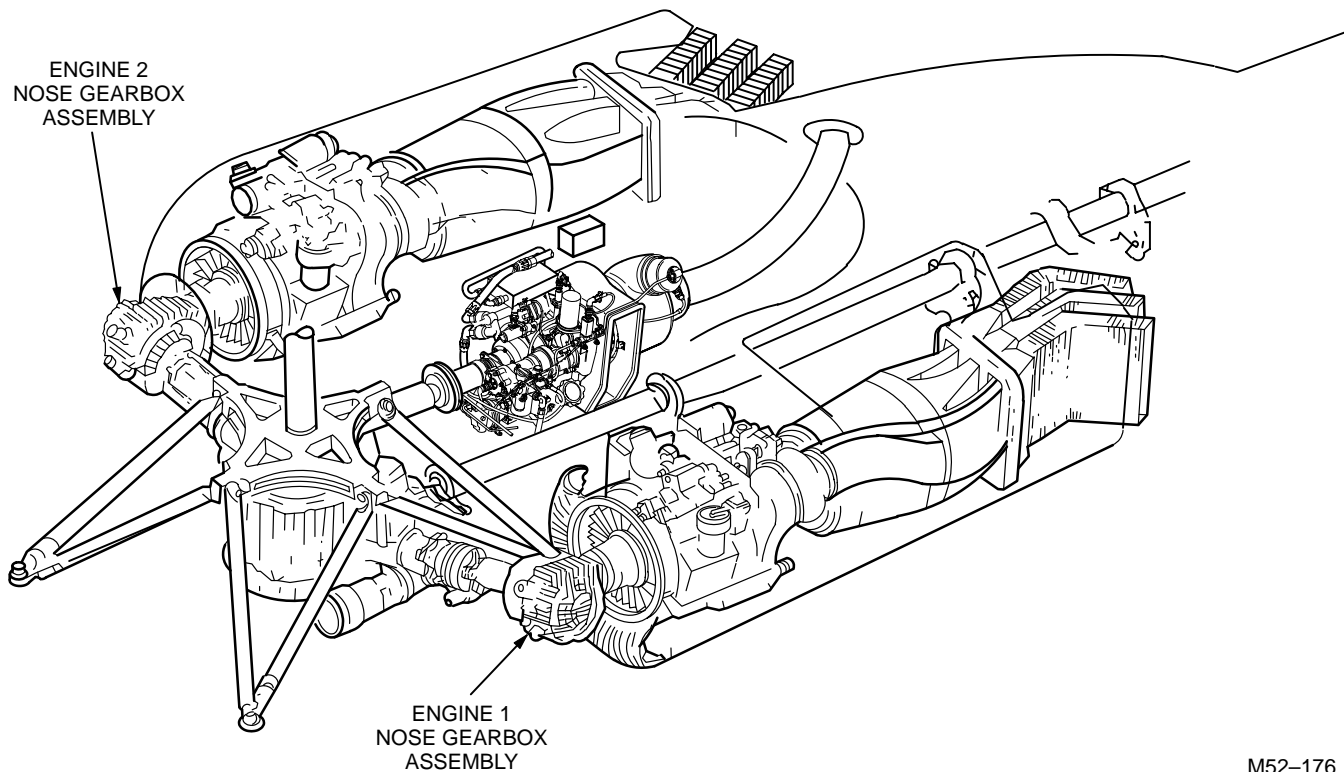
7-3. THEORY OF OPERATION (cont)**7-3**

(1) The housing is constructed of magnesium alloy and is completely finned for cooling. The housing houses the gears, bearings, and oil system.

(2) The oil pressure transducer mounts on the forward side of the NGB. The oil pressure transducer monitors and transmits the NGB operating oil pressure to the Fault Detection/Location System (FD/LS).

(3) The chip detector/temperature switch is installed on the lower forward side of the NGB. The switch senses the presence of large metal chips in the oil and monitors oil temperature.

(4) The oil temperature transducer is located to the left of the chip detector/temperature switch. The oil temperature transducer transmits a temperature reading to the FD/LS.

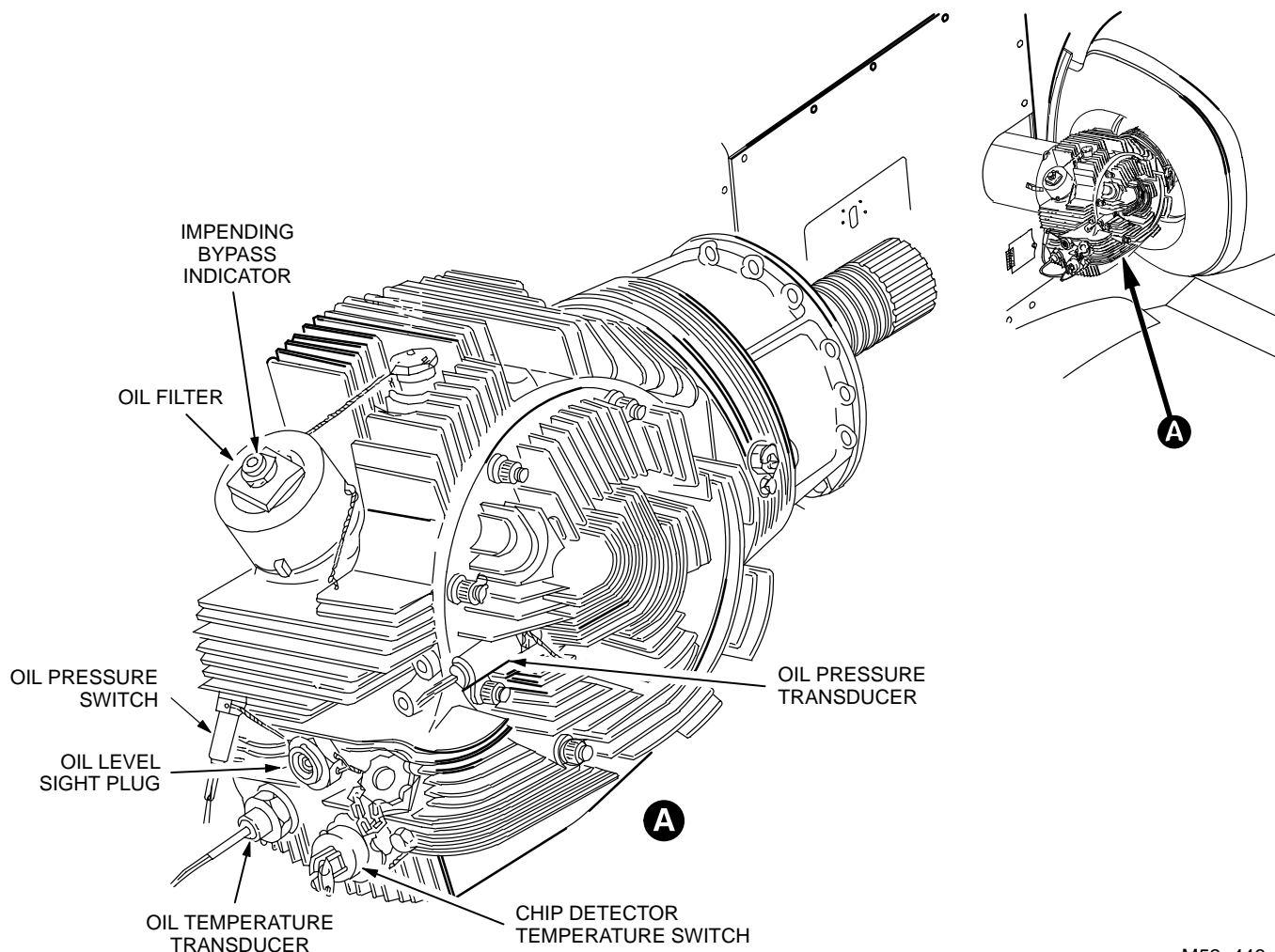


M52-176

Figure 7-7. Engine Nose Gearboxes

7-3. THEORY OF OPERATION (cont)

7-3



M52-446

Figure 7-8. Engine Nose Gearbox Components

(5) The oil pressure switch is installed in the front center section of the housing. The switch monitors oil system pressure during NGB operation. When NGB oil pressure exceeds 45 psi the oil pressure switch turns off the pilot **OIL PSI NOSE GRBX 1** and the **CPG ENG 1** lights on the pilot and CPG caution/warning panel. When NGB oil pressure is less than 28 ± 2 psi the lights are illuminated.

(6) The oil level sight plug is a bull's-eye indicator, mounted on the forward side of the housing. The oil level sight plug permits flight and maintenance personnel to visually inspect the oil quantity when the engines are not operating.

(7) The oil filter with impending bypass indicator is mounted on upper forward section of the housing. The oil filter removes impurities from the oil while giving visual warning of oil filter pressure differential and bypass during NGB operation.

g. **Input Drive Shaft 1.** Input drive shaft 1 (fig. 7-9) transmits drive power from the engine 1 NGB to the main transmission. The input drive shaft 1 is a large diameter hollow aluminum shaft that is interchangeable with the engine 2 input drive shaft.

7-3. THEORY OF OPERATION (cont)

7-3

Flexible couplings attach the drive shaft to the engine 1 NGB and the main transmission. Antifail bearings are incorporated in each flexible coupling to support the drive shaft during flexible coupling failure.

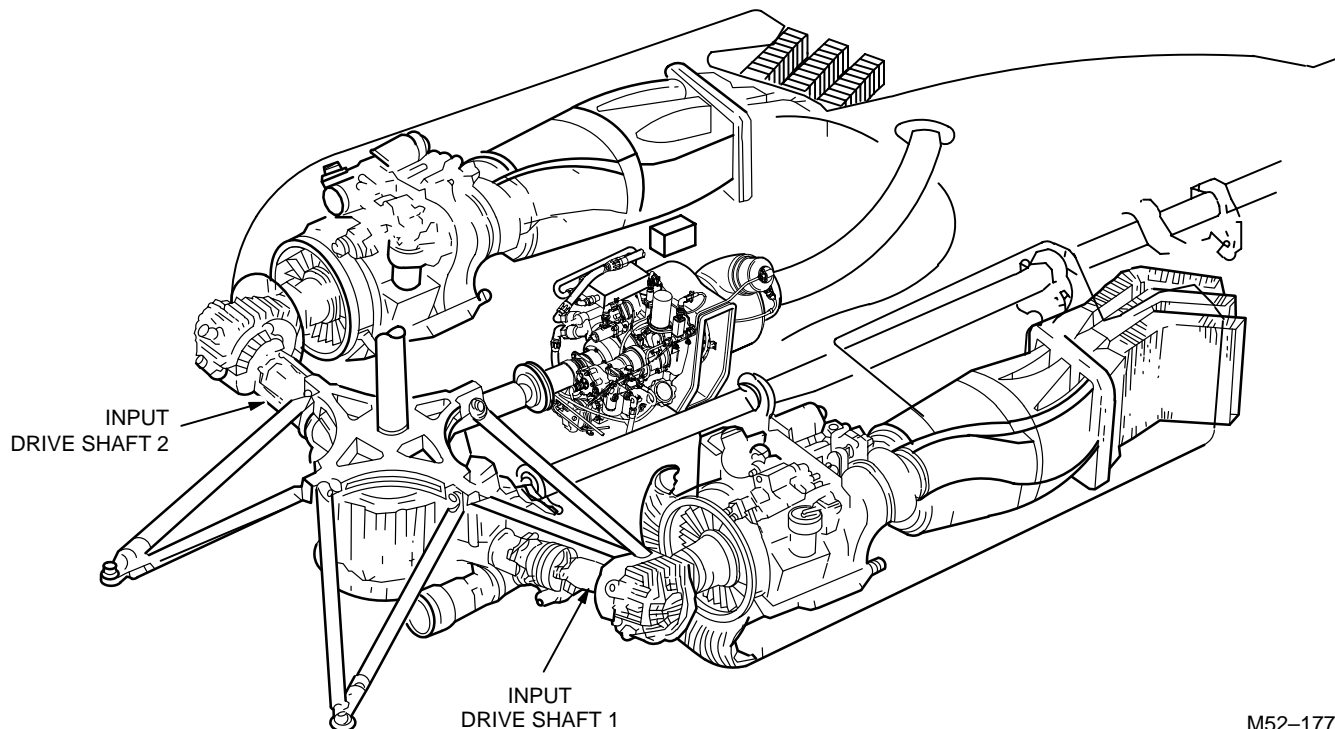
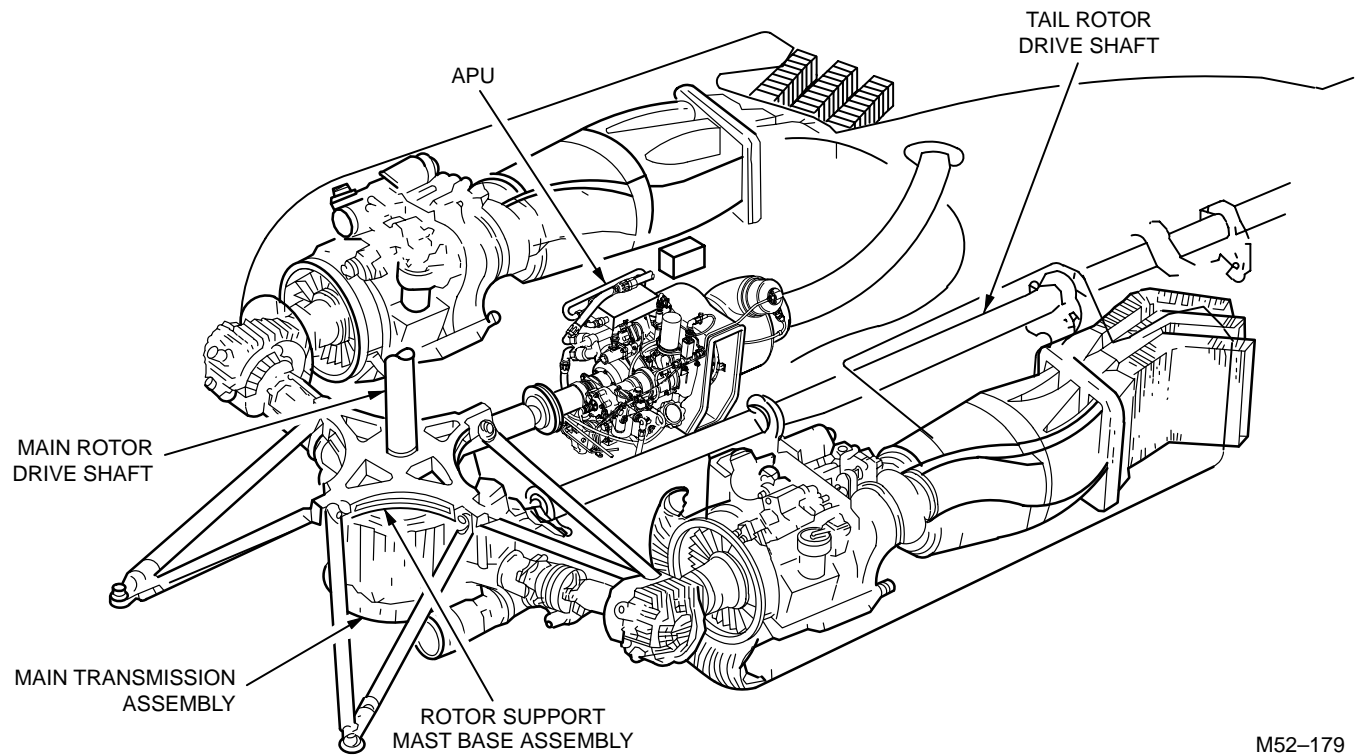


Figure 7-9. Input Drive Shafts

h. **Main Transmission.** The main transmission (fig. 7-10) provides primary drive for the main and tail rotor drive shafts. The main transmission is mounted beneath the main rotor support mast base assembly. The main transmission reduces the engine NGBs or APU rpm while increasing torque. The main transmission major components (fig. 7-11) are described in the following subparagraphs.

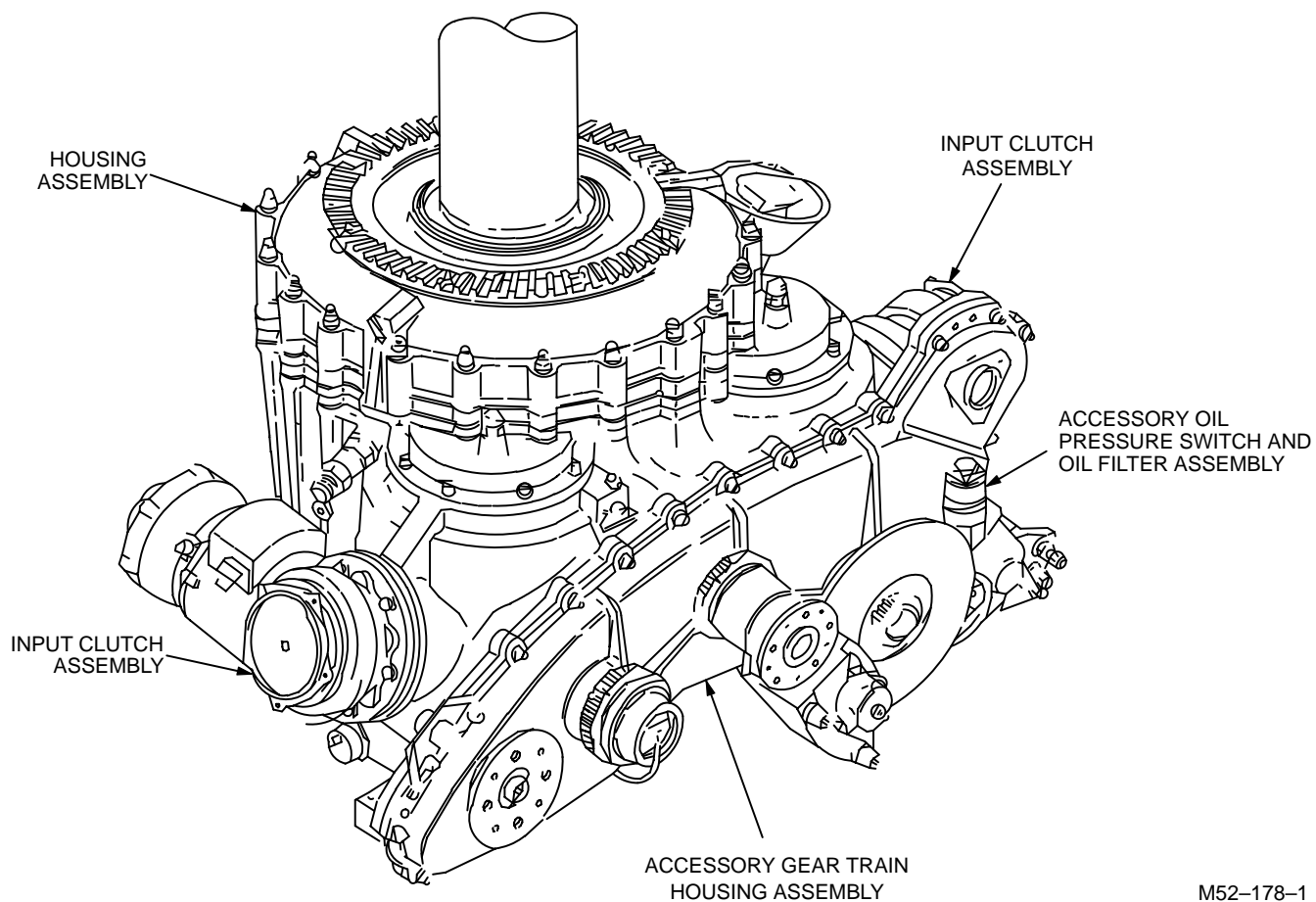
(1) The housing supports the primary gears, bearings, lubrication system, and provides a hub in which the internal gears drive the main rotor drive shaft.

(2) The input clutch assemblies provide engine 1 and engine 2 drive power engagement and disengagement from the main transmission.



M52-179

Figure 7-10. Main Transmission Interface



M52-178-1

Figure 7-11. Main Transmission Major Components (Sheet 1 of 2)

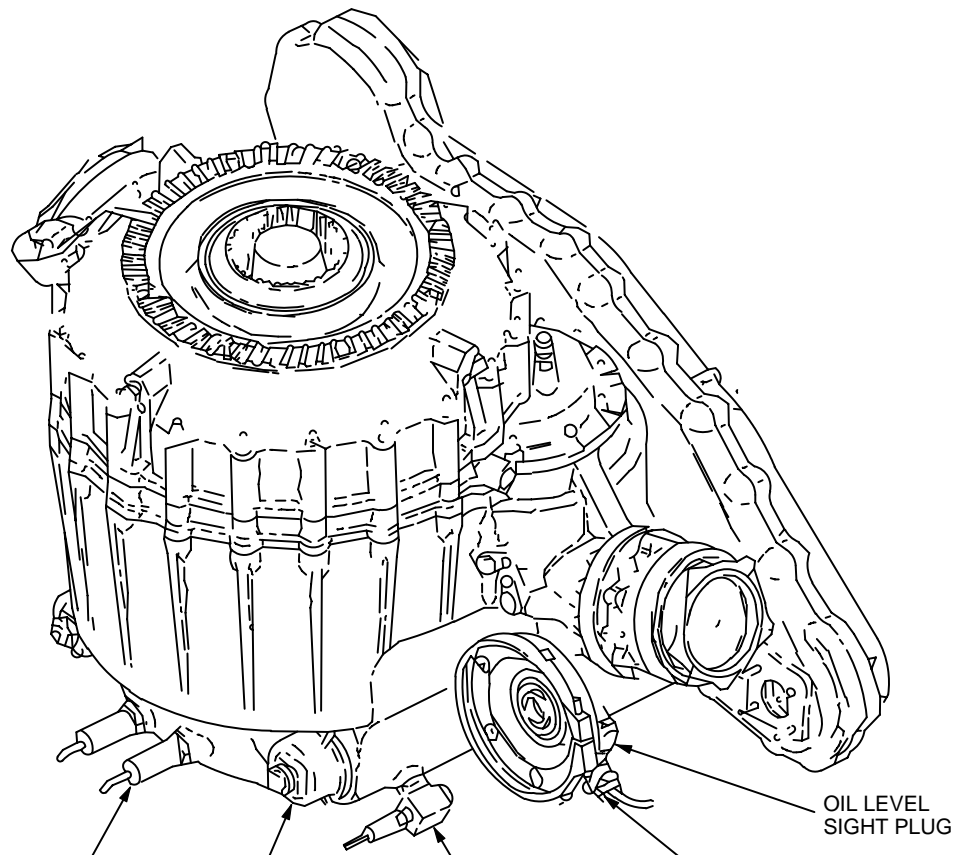


Figure 7-11. Main Transmission Major Components (Sheet 2 of 2)

(3) The accessory drive section can be driven by one or both engines through the input drive shafts. When the engines are not operating, the APU drives the accessory drive section through drive shaft 7 (fig. 7-12). The accessory drive section drives the following components.

(a) Accessory drive lubrication pump. The accessory drive lubrication pump is mounted on the right side of the accessory section. The accessory drive lubrication pump pressurizes the lubrication system.

(b) Rotor brake disk. The rotor brake disk is installed on the center of the accessory section to retard or prevent main rotor drive shaft rotation.

(c) Tail rotor drive shaft. The tail rotor drive shaft is mounted on the center of the accessory drive section to provide a means in which the main transmission can drive the tail rotors. The tail rotor drive shaft consists of drive shafts 3, 4, 5, and 6.

(d) Magnetic pickup. The magnetic pickup is mounted on the left face of the accessory section to signal main rotor rpm readout on the pilot and CPG **RTR RPM %** indicators. The magnetic pickup also signals to illuminate the **HIGH RPM ROTOR** or **LOW RPM ROTOR** caution lights on the pilot or CPG caution/warning panels.

(e) Shaft driven compressor. The shaft driven compressor (SDC) is mounted on the left rear face of the main transmission and provides pressurized air for the pressurized air system (PAS).

(f) Hydraulic pump (2 ea). The hydraulic pumps are mounted on the forward left and the forward right side of the main transmission. The hydraulic pumps provide pressurized hydraulic fluid during operation.

7-3. THEORY OF OPERATION (cont)

7-3

(g) Generator (2 ea). The generators are installed on each side of the accessory section to provide A/C electrical power for the helicopter.

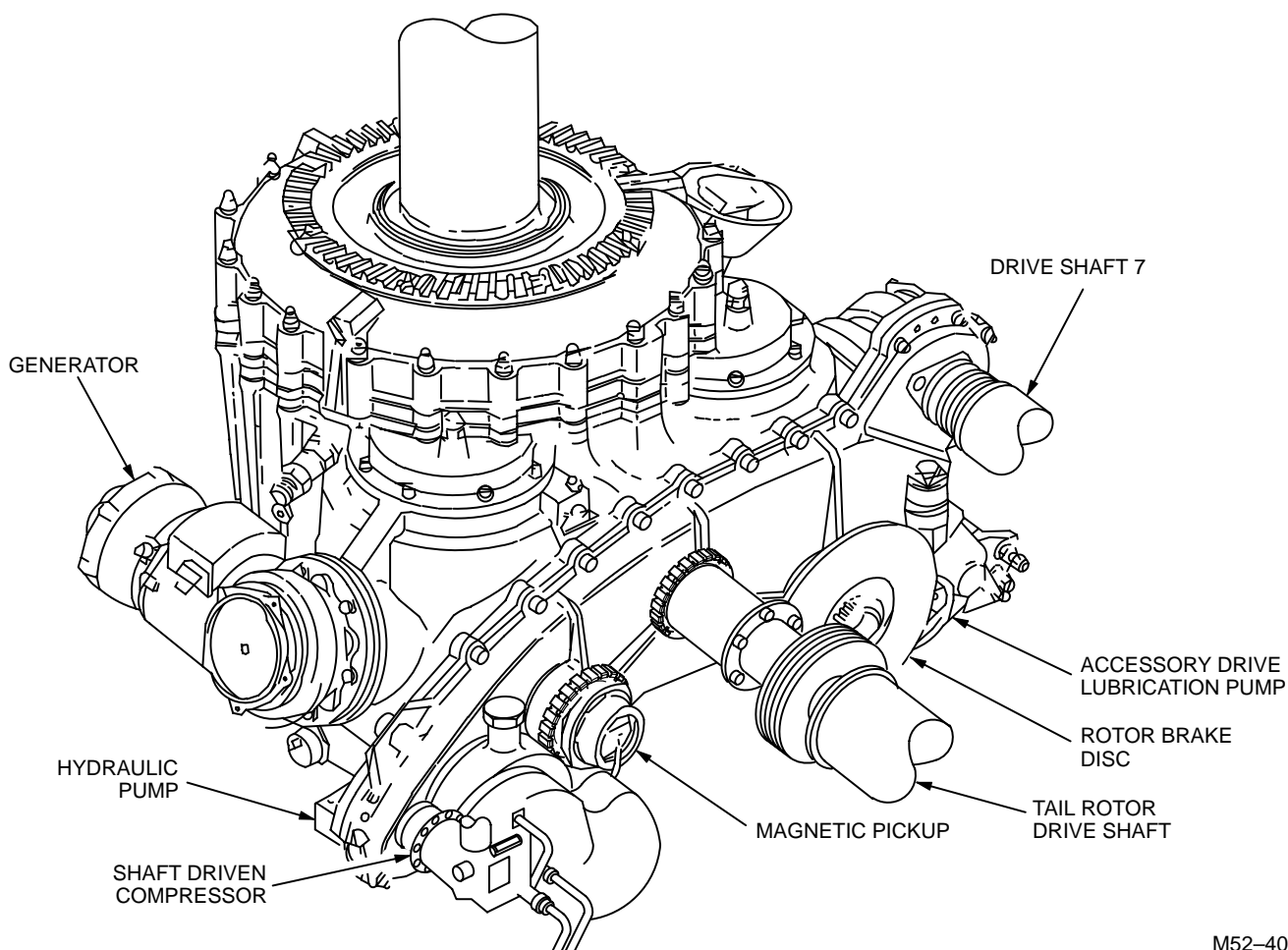
(4) An oil level sight plug is located on the left and right side of the main transmission housing. The oil level sight plugs are bull's eye type indicators that permit visual inspection of oil quantity.

(5) A chip detector/temperature switch is located on each side of the main transmission housing below the oil sight plug. The switches warn of metal particles in the oil system and monitor oil temperature. The switches will illuminate the pilot **OIL HOT MAIN XMSN 1** or **OIL HOT MAIN XMSN 2** lights, and the CPG **MAIN XMSN 1** or **MAIN XMSN 2** lights on the pilot and CPG caution/warning panels, when the oil temperature is above 274 to 294°F (134.4 to 145.5°C).

(6) The oil pressure switch is mounted on the lower right side of the main transmission housing. The oil pressure switch monitors main transmission oil pressure. The switch illuminates the pilot **OIL PSI MAIN XMSN 1** or **OIL PSI MAIN XMSN 2** lights, and the CPG **MAIN XMSN 1** or **MAIN XMSN 2** lights on the pilot and CPG caution/warning panels, when oil pressure is less than 28 ± 2 psi. The switch turns the lights off when oil pressure exceeds 45 psi.

(7) The oil temperature transducer is mounted on the forward section of the main transmission housing. The transducer monitors the operating temperature of the main transmission and sends a temperature reading to the fault detection/location system (FD/LS).

i. **Input Drive Shaft 2.** Input drive shaft 2 (fig. 7-9) transmits drive power from engine 2 NGB to the main transmission. Input drive shaft 2 is a large diameter hollow aluminum shaft that is interchangeable with input drive shaft 1. Flexible couplings attach the drive shaft to the engine 2 NGB and the main transmission. Antifail bearings are incorporated in each flexible coupling to support the drive shaft during flexible coupling failure.



M52-400

Figure 7-12. Main Transmission Accessory Drive Section Interface

j. **Engine 2 NGB.** The engine 2 NGB (fig. 7-7) drives the main transmission through the input drive shaft 2 while changing the drive angle 90°. When the engine 2 is operating at 100% rpm the NGB reduces engine output rpm from 20,952 to 9,841 rpm. This is accomplished through an internal gear ratio of 2.13:1. The engine 2 NGB is mounted to the swirl frame of the engine 2. The NGB components (fig. 7-8) are described in the following subparagraphs.

(1) The housing is constructed of magnesium alloy and is completely finned for cooling. The housing houses the gears, bearings, and oil system.

(2) The oil pressure transducer mounts on the forward side of the NGB. The oil pressure transducer monitors and transmits the NGB operating oil pressure to the (FD/LS).

(3) The chip detector/temperature switch is installed on the lower forward side of the NGB. The chip detector/temperature switch senses the presence of large metal chips in the oil and monitors oil temperature.

(4) The oil temperature transducer is located to the left of the chip detector/temperature switch. The transducer transmits a temperature reading to the FD/LS.

7-3. THEORY OF OPERATION (cont)

7-3

(5) The oil pressure switch is installed in the front center section of the housing. The oil pressure switch monitors oil system pressure during NGB operation. When NGB oil pressure exceeds 45 psi the oil pressure switch turns off the pilot **OIL PSI NOSE GRBX 1** and the CPG **ENG 1** lights on the pilot and CPG caution/warning panel. When the NGB oil pressure is less than 28 ± 2 psi the lights are illuminated.

(6) The oil level sight plug is a bulls-eye indicator, mounted on the forward side of the housing. The oil level sight plug permits flight and maintenance personnel to visually inspect the oil quantity when the engines are not operating.

(7) The oil filter with impending bypass indicator is mounted on upper forward section of the housing. The oil filter with impending bypass indicator removes impurities from the oil while giving visual warning of oil filter pressure differential and bypass during NGB operation.

k. **Drive Shaft 7.** Drive shaft 7 is hollow titanium shaft located between the main transmission accessory section and the APU. Drive shaft 7 transmits drive power from the APU to the main transmission accessory section. Couplings attach the drive shaft to the APU and main transmission. antifrail bearings are incorporated in each flexible coupling to support the drive shaft during flexible coupling failure.

l. **Drive Shaft 4.** Drive shaft 4 is located between the drive shaft 3 and drive shaft 5. Drive shaft 4 transmits drive power from drive shaft 3 to drive shaft 5. Couplings attach the drive shaft to drive shafts 3 and 5. A hangar assembly supports the drive shaft allowing the drive shaft to turn. A damper assembly permits the drive shaft to rotate through critical speeds while damping natural frequencies.

m. **Drive Shaft 5.** Drive shaft 5 is located between drive shaft 4 and the IGB. Drive shaft 5 transmits drive power from drive shaft 4 to the IGB. Couplings attach the drive shaft to drive shaft 4 and the IGB. A hangar assembly supports the drive shaft allowing the drive shaft to turn. A damper assembly permits the drive shaft to rotate through critical speeds while damping natural frequencies.

CHAPTER 8 ROTOR SYSTEM

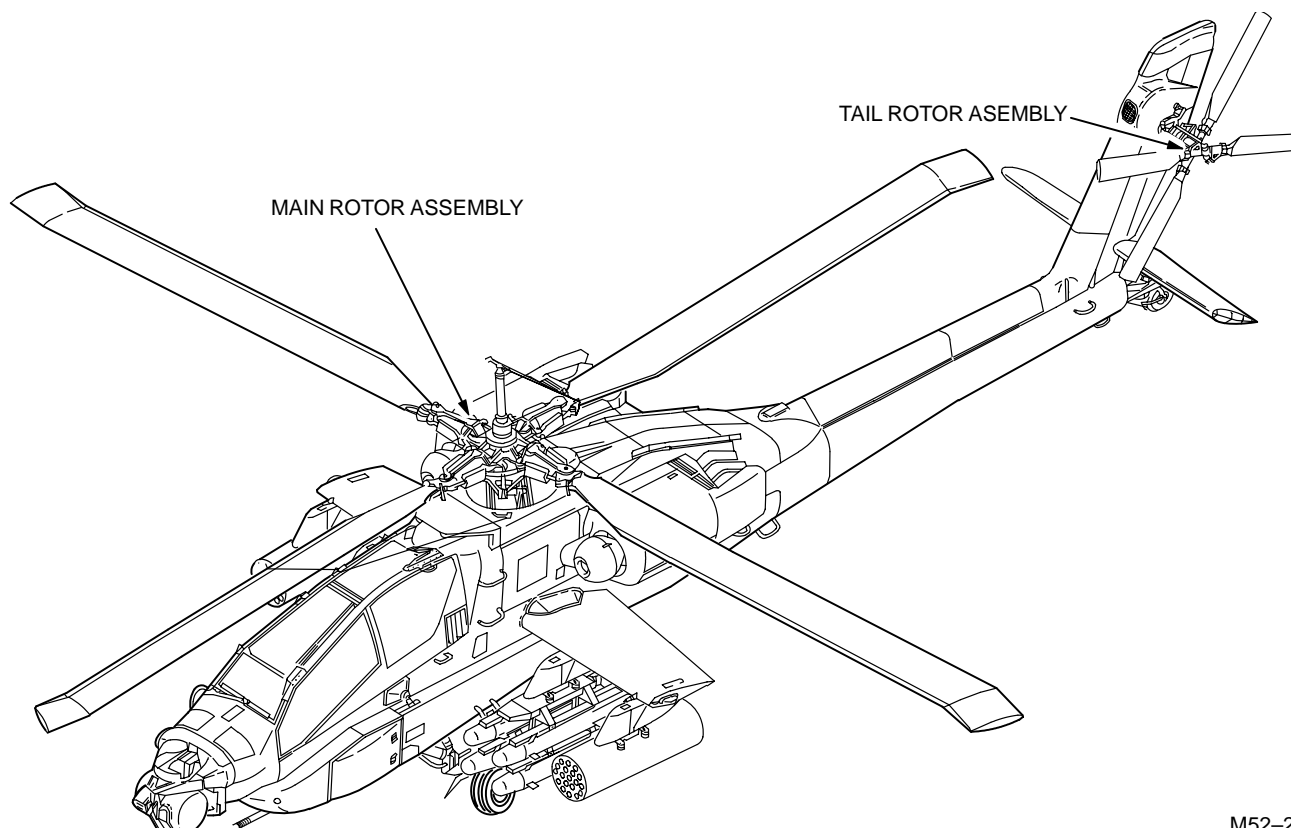
8-1. PURPOSE

The rotor system interfaces with the drive system and flight controls system. The rotor system provides lift, thrust, directional flight, and anti-torque control for the helicopter.

8-2. DESCRIPTION

The rotor system includes the following major components (fig. 8-1).

- a. **Main Rotor Assembly.** The main rotor assembly is a single, four-bladed, 48 foot diameter main rotor that provides vertical, longitudinal, and lateral flight capabilities for the helicopter.
- b. **Tail Rotor Assembly.** The tail rotor assembly is a single, four-bladed, 9 foot diameter teetering tail rotor that provides anti-torque and directional flight capabilities for the helicopter.
- c. **Controls and Indicators.** Various cockpit mounted controls and indicators (not illustrated) are used by the aircrew for operating the rotor system. The controls and indicators provide indications of system operational performance.



M52-283

Figure 8-1. Rotor System Major Components

8-3. THEORY OF OPERATION

8-3

8-3. THEORY OF OPERATION

a. **Main Rotor Assembly.** The main rotor assembly (fig. 8-2) is secured to the upper portion of the static mast and main drive shaft. The main rotor assembly components are described in the following subparagraphs.

(1) The main rotor head assembly is a fully articulated assembly that provides attachment points for the four main rotor blade assemblies. The main rotor head assembly provides the means to drive the main rotor blade assemblies in a counterclockwise rotation while providing feathering, flapping, and lead-lag movement of each blade.

The main rotor head assembly is attached to the main drive shaft and static mast and provides mounting points for the scissors and pitch change links (4 ea). The main rotor head assembly transfers flight loads from the main rotor assembly to the static mast, into the airframe. The main rotor head assembly requires no periodic lubrication.

(2) The main rotor blade assemblies are rotating airfoils with swept tips that are constructed of stainless steel and fiberglass. Each attaches to the main rotor head assembly by a lead-lag link and blade attachment pin.

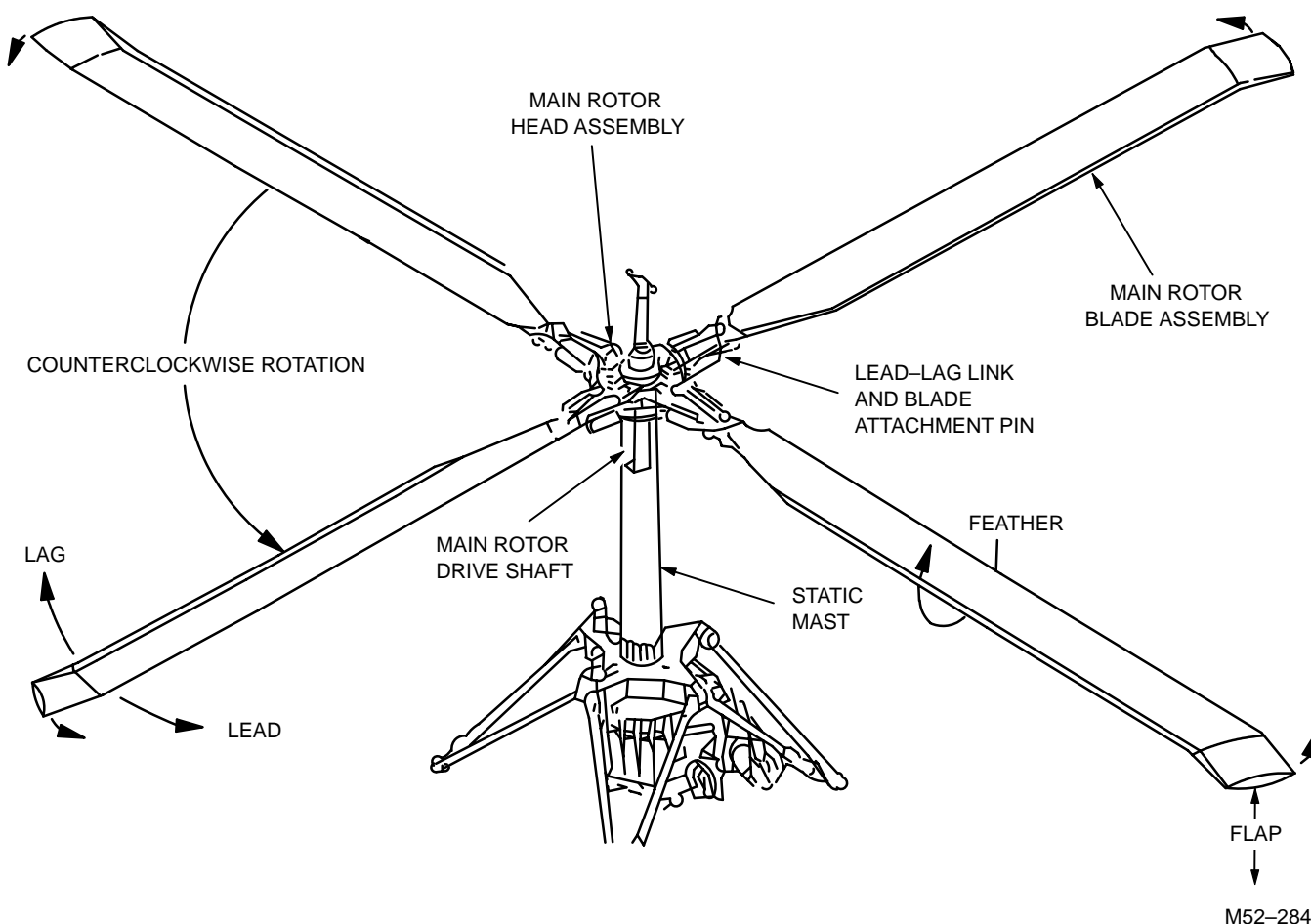


Figure 8-2. Main Rotor Assembly Major Components

8-3. THEORY OF OPERATION (cont)

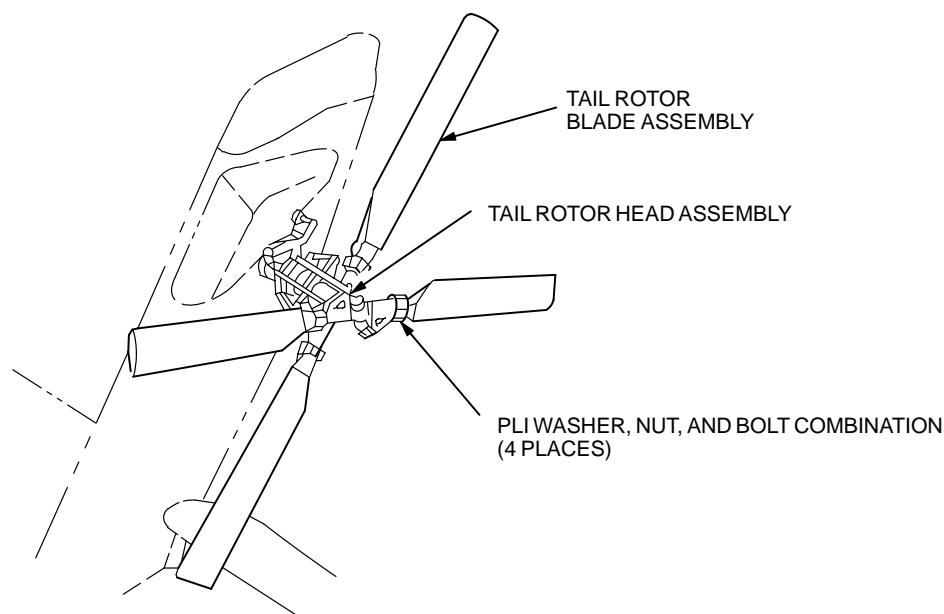
8-3

(3) The four lead-lag links are titanium mounts that provide a mounting point for each the main rotor blade assemblies.

(4) The four blade attachment pins are steel pins that attach to each of the lead-lag links to secure each main rotor blade assembly to the main rotor head assembly.

b. **Tail Rotor Assembly.** The tail rotor assembly (fig. 8-3) is installed on the tail rotor gearbox output shaft (part of drive system). The tail rotor assembly major components are described in the following subparagraphs.

(1) The tail rotor head assembly is a two armed, teetering assembly that provides attachment points for the four tail rotor blade assemblies. The tail rotor head assembly provides a means to drive the tail rotor blade assemblies in a clockwise rotation providing feathering anti-torque control for the helicopter. The tail rotor head assembly attaches to the tail gearbox output shaft and static support, providing mounting points for the four pitch change links. The tail rotor head assembly transfers flight loads from the tail rotor assembly to the static support, into the airframe.



M52-285

Figure 8-3. Tail Rotor Assembly Major Components

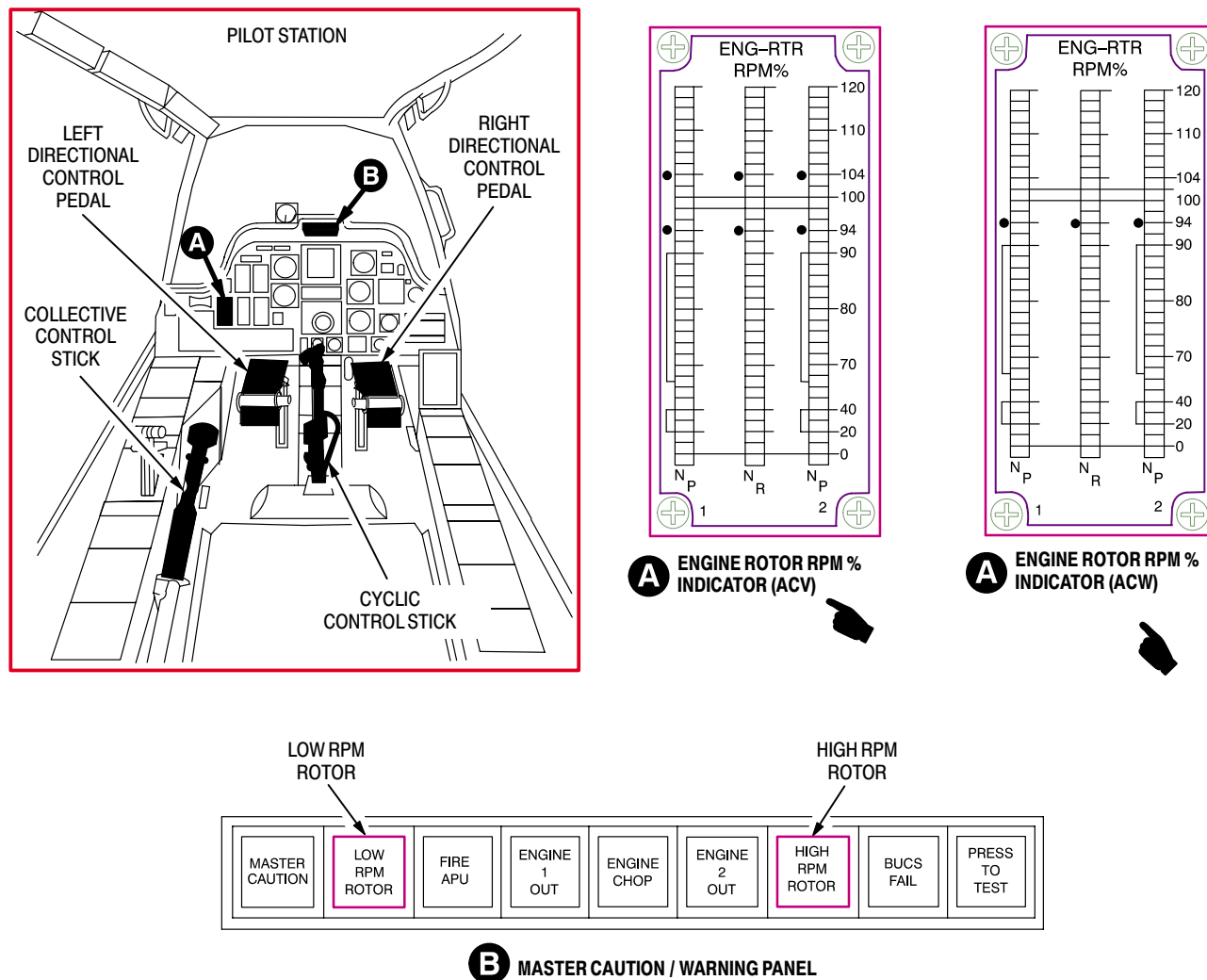
(2) The four tail rotor blade assemblies are rotating airfoils that are constructed of aluminum. Each tail rotor blade assembly is attached to the tail rotor head assembly by a preload indicating (PLI) washer, bolt, and nut combination.

c. **Controls and Indicators.** The controls and indicators (fig. 8-4) are described in the following subparagraphs.

(1) The **ENG-RTR RPM %** indicator provides the pilot and CPG with a visual reference of the main rotor speed (Nr) in %. The **ENG-RTR RPM %** is located on the center section of the pilot and CPG instrument panels. The indicator receives 28 VDC signals from the Nr sensor.

8-3. THEORY OF OPERATION (cont)

8-3

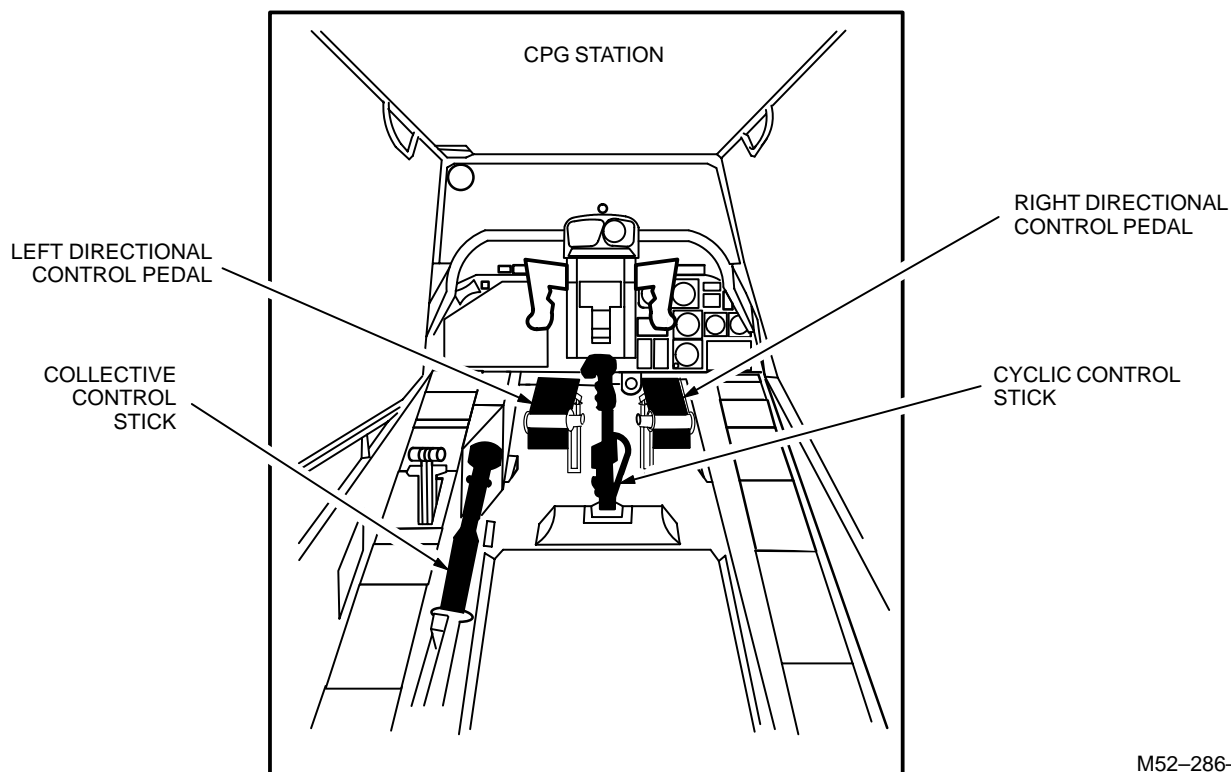


M52-286-1A

Figure 8-4. Controls and Indicators (Sheet 1 of 2)

(2) The **LOW RPM ROTOR** light located on the pilot and CPG master caution/warning panel provides visual warning whenever the speed of the main rotor assembly decreases below 94%. The light is illuminated by 28 VDC signal from the engine control unit (ECU) or digital engine control unit (DECU) and N_R sensor.

(3) The **HIGH RPM ROTOR** light located on the pilot and CPG master caution/warning panel provides visual warning whenever the main rotor speed exceeds 104% (ACV) or 108% (ACW). The light is illuminated by a 28 VDC signal from the ECU or DECU and N_R sensor.



M52-286-2

Figure 8-4. Controls and Indicators (Sheet 2 of 2)

(4) The directional control pedals are located on the forward floor section of the pilot and CPG stations. Each provides the pilot and CPG with the ability to supply mechanical inputs to the flight controls system to move the tail rotor assembly to establish and maintain helicopter directional control.

(5) The cyclic control stick is located on the center floor section of the pilot and CPG stations. Each cyclic control stick provides the pilot and CPG with the ability to supply mechanical inputs to the flight controls system. The mechanical inputs move the main rotor assembly, establishing and maintaining helicopter longitudinal and lateral control.

(6) The collective control stick is located on the left side of the pilot and CPG station. Each collective stick provides the pilot and CPG with the ability to supply mechanical inputs to the flight controls system. The mechanical inputs move the main rotor assembly, establishing and maintaining helicopter vertical control.

9-1. PURPOSE

9-1

CHAPTER 9 ELECTRICAL SYSTEM

9-1. PURPOSE

The electrical power generation and distribution system on the AH-64A is composed of the following four systems.

- **AC Electrical System.**
- **DC Electrical System.**
- **Emergency DC Electrical System.**
- **External AC Power System.**

a. The ac and dc electrical systems each contain a subsystem 1 and 2. Normally, both subsystems operate to supply all of the electrical power for the aircraft. When both systems are operating, the subsystem 1 supplies approximately 50% of the required load and the subsystem 2 supplies 50%. However, if one subsystem fails, the remaining subsystem automatically supplies all electrical requirements for the aircraft.

b. The emergency dc electrical system allows the pilot to connect a battery to the dc emergency bus for limited operation in case of a total electrical system failure.

c. The external ac power system allows an external (ground) power unit to operate the aircraft electrical systems.

9-2. DESCRIPTION

The electrical system includes the following components (fig. 9-1).

- a. **Ground Service Utility Receptacle.**
- b. **Power Distribution Center.**
- c. **Transformer/Rectifiers 1 and 2.**
- d. **AC Generators 1 and 2.**
- e. **Battery.**
- f. **External Power Receptacle.**
- g. **Battery Charger.**
- h. **External Power Monitor.**
- i. **Pilot ELEC PWR Control Panel.**
- j. **CPG Power Quadrant.**

9-3. THEORY OF OPERATION

9-3

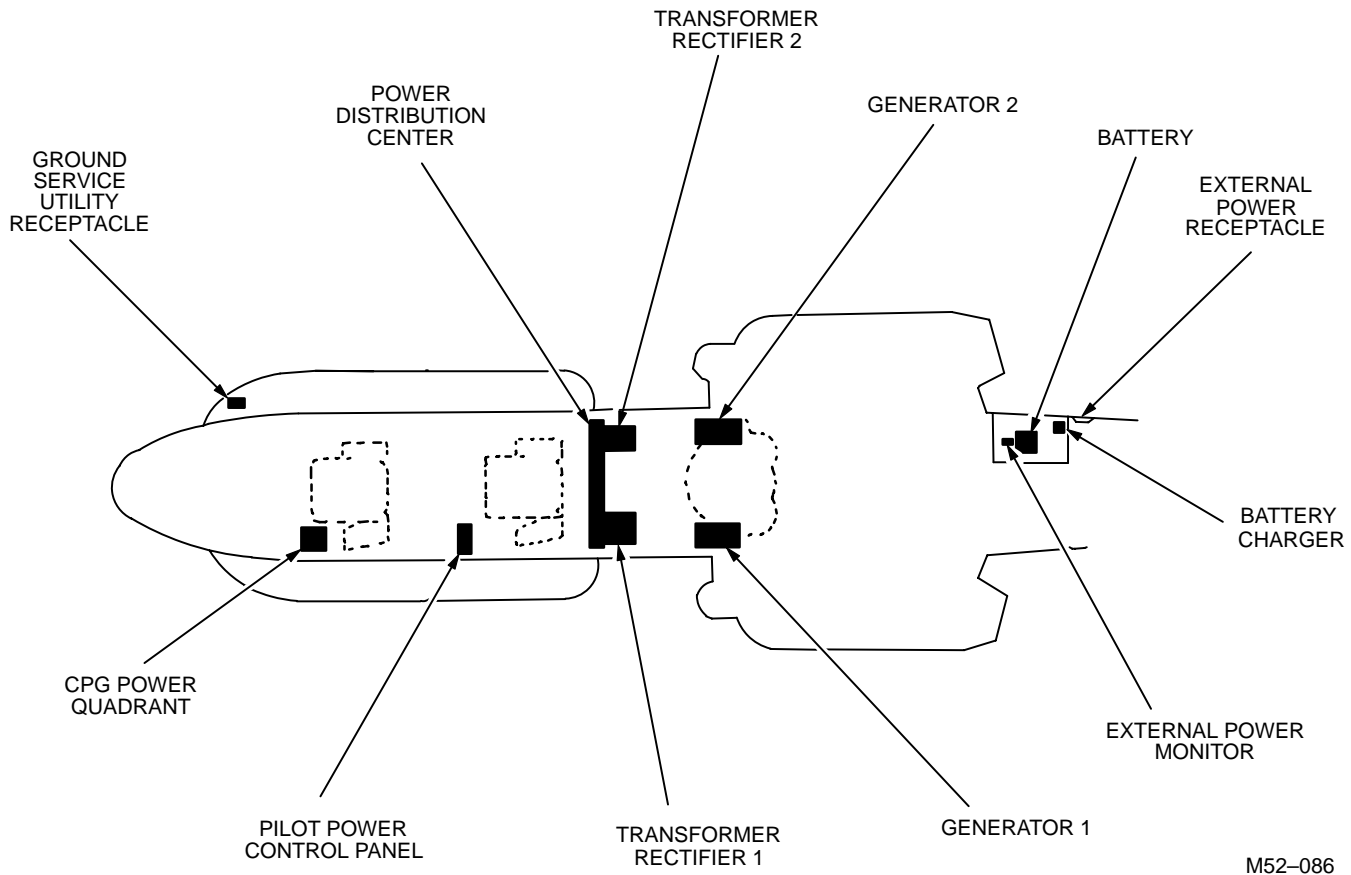


Figure 9-1. Electrical System Major Components

9-3. THEORY OF OPERATION

a. AC Electrical System.

(1) Operation. The ac electrical power system generates and distributes the ac electrical power required to operate the AH-64A systems, and supplies ac power to two transformer/rectifiers that produce 28 VDC for systems requiring dc power.

(a) The system (fig. 9-2) consists of two identical and redundant electrical power systems. Either system can supply all electrical power requirements. If either system malfunctions, automatic switching ensures continued electrical operation.

Each system includes an ac generator that converts mechanical energy into electrical energy. A generator control unit (GCU) controls the generator, and provides circuit protection for the generator. An ac generator contactor provides the following functions.

- Connects the ac generator output to the appropriate ac bus.
- Provides bus tie operation if one generator is not operating.
- Prevents application of external power if either generator is operating.
- Prevents the generators from operating if external power is connected to the ac system.

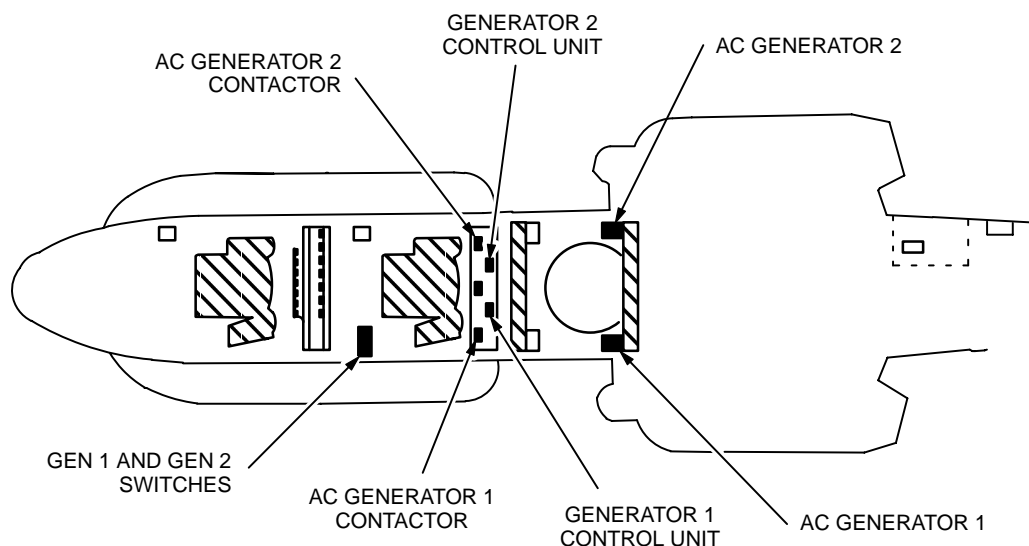
9-3. THEORY OF OPERATION (cont)

9-3

(b) The ac electrical power system generates three-phase, 115/200 VAC, 400-Hz power at 35 KVA (Kilo-Volt-Amperes). The ac electrical power system distributes the voltage to ac distribution points.

(c) The system shuts down if a fault is detected and is self monitoring for the following faults:

- Overvoltage.
- Undervoltage.
- Underfrequency (on ground only).
- Overcurrent.



M52-091

Figure 9-2. AC Electrical System

(2) Pilot Electrical Power Control Panel. The **GEN 1** and **GEN 2** switches (fig. 9-3) provide operational control for the ac generators. The switches have the following positions.

- (a) **GEN 1, GEN 2.** The **GEN 1, GEN 2** position brings the ac generator on line.
- (b) **OFF/RESET.** The **OFF/RESET** position disconnects the ac generator from the respective bus and resets the generator control unit fault sensing logic.
- (c) **TEST.** The **TEST** position permits the ac generator output to be tested without connecting the generator to the bus.

(3) Ground Service Utility Receptacle. The ground service utility receptacle supplies aircraft ac power for lights and hand tools for ground maintenance personnel.

(4) Power Distribution Box. The power distribution box routes ac power throughout the aircraft.

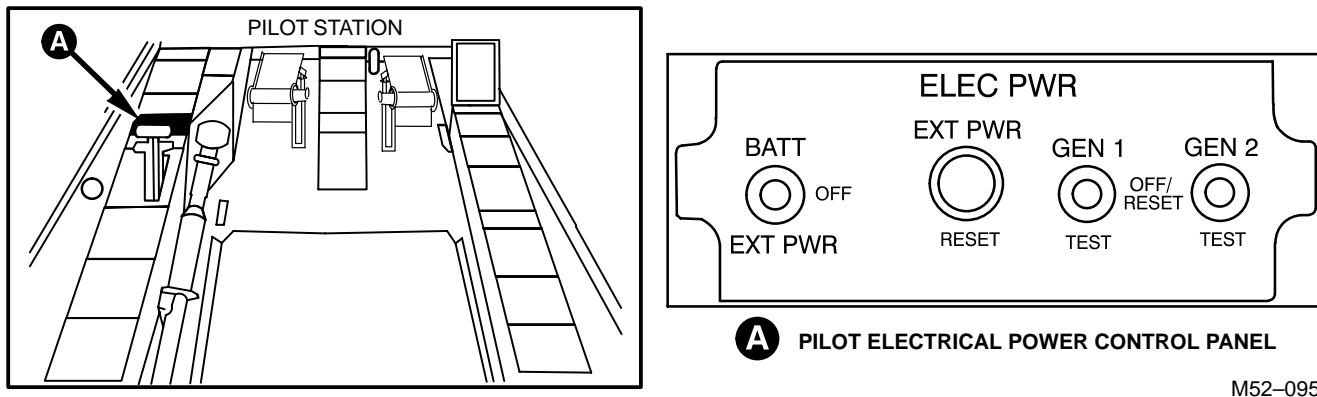


Figure 9-3. Pilot Electrical Power Control Panel

b. DC Electrical System.

(1) Operation. The dc electrical power system receives three-phase, 115/200 VAC, 400-Hz power from the ac electrical power system, and supplies 28 VDC for systems requiring dc power.

(a) The dc system consists of two identical and redundant dc electrical power systems, and a bus tie contactor. Either system can supply all dc electrical power requirements. If either system malfunctions, automatic switching of the bus tie contactor ensures continued electrical operation.

(b) Each system contains a transformer/rectifier (T/R) and a filter network. The system (fig. 9-4) operates as follows.

During normal operation, the 115/200 VAC input is applied to the primary of transformer T1. Full-wave rectified voltage, developed by rectifiers CR1 thru CR12, is induced in the secondary.

This rectified voltage is filtered by a network consisting of capacitor C5, inductor L1, capacitors C4, C6 and C7, and bleeder resistor R1. This circuit also prevents the ripple voltage from exceeding the required limit of 1.5 VAC and reduces radio noise.

Fan motor B1, a 115/200 VAC, three-phase motor, drives the fan to cool the T/R.

In the event of an overtemperature condition (usually due to a cooling fan failure), a thermal sensor is activated. The thermal sensor completes a circuit to turn on the appropriate **HOT RECT** light on the pilot caution/warning panel.

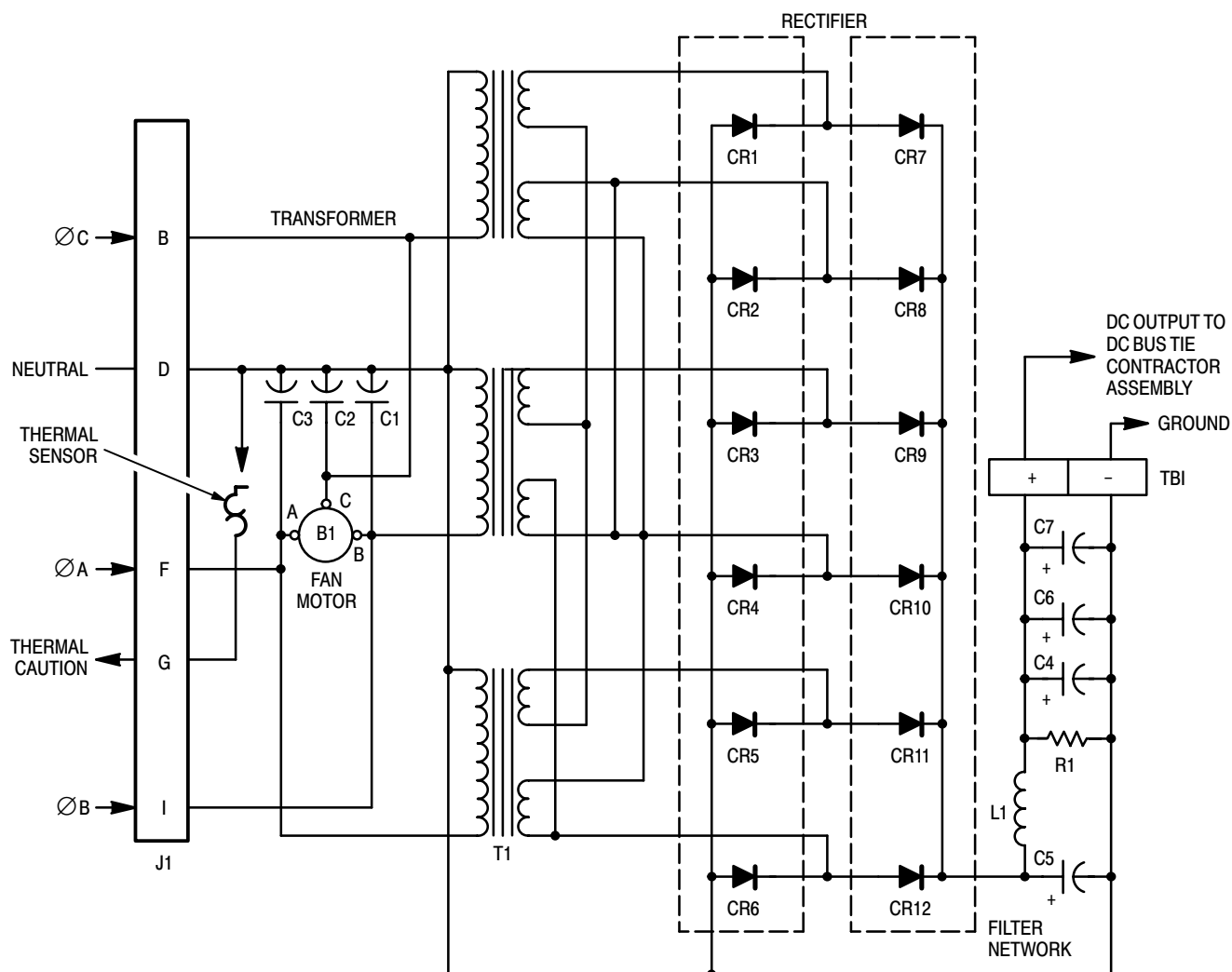
(c) The bus tie contactor assembly connects the T/R outputs to the appropriate dc bus, and provides bus tie functions in case of a T/R failure.

During normal operation, T/R 1 is connected to the dc bus 1, and T/R 2 is connected to the dc bus 2. Both buses are both connected to dc bus 3 through isolation diodes, and either or both buses power the dc bus 3 and the dc emergency bus.

If either T/R fails, the dc bus tie contactor switches the output of the remaining T/R, so that buses 1, 2, 3, and emergency buses are powered by the operating T/R.

9-3. THEORY OF OPERATION (cont)

9-3



M52-088A

Figure 9-4. T/R DC System Functional Schematic

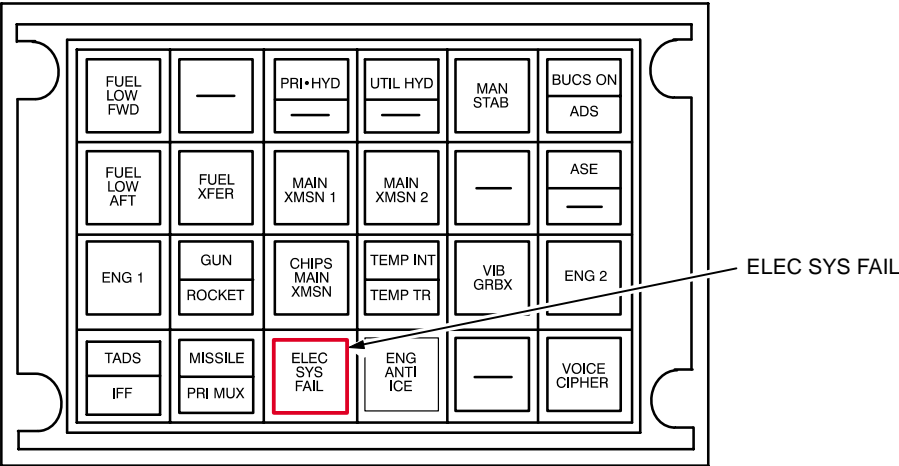
(2) DC Electrical System Caution Lights. The following caution lights are used.

(a) CPG caution/warning panel (fig. 9-5).

- **ELEC SYS FAIL.** Red light that turns on when both transformer/rectifiers (T/R) are inoperative.
- (b) Pilot caution/warning panel (fig. 9-6).
- **RECT 1, RECT 2.** Amber lights that turn on when the respective T/R has no output.
- **HOT RECT 1, HOT RECT 2.** Amber lights that turn on when the internal temperature of the T/R reaches 190°F (87.7°C).

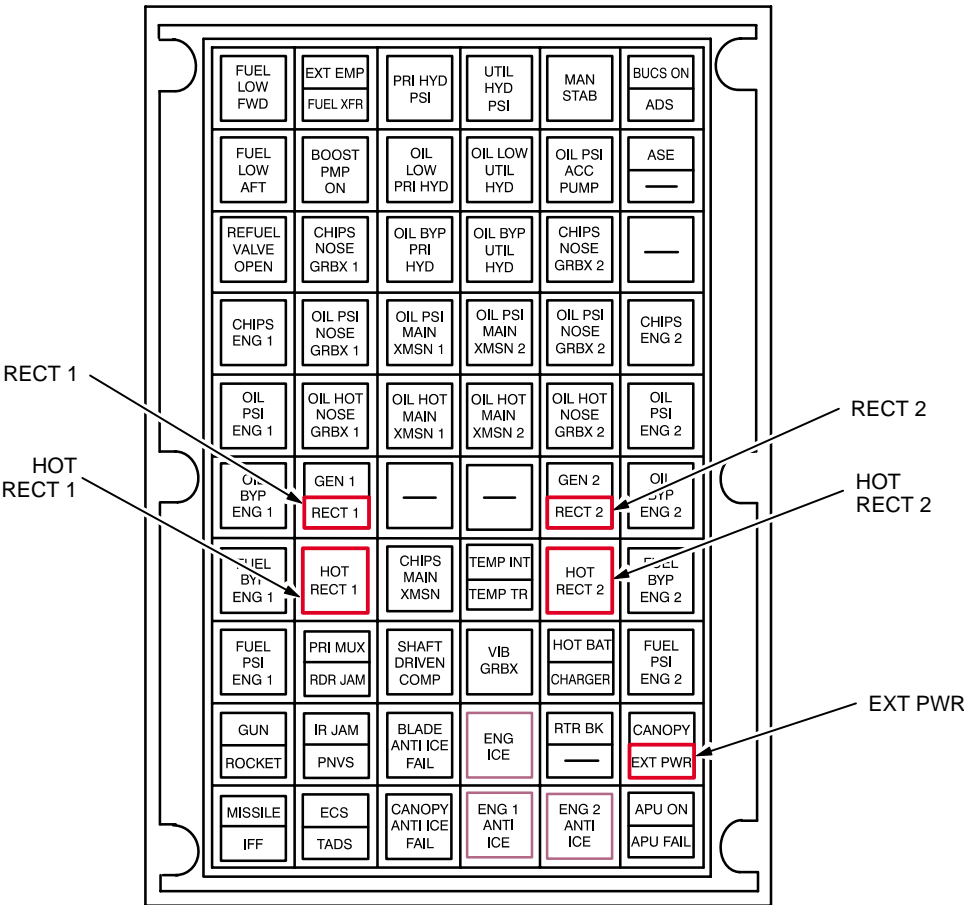
(3) Ground Service Utility Receptacle. The ground service utility receptacle supplies aircraft dc power for lights and hand tools for ground maintenance personnel.

(4) Power Distribution Box. The power distribution box routes dc power throughout the aircraft.



M52-089

Figure 9-5. CPG Caution/Warning Panel



M52-090

Figure 9-6. Pilot Caution/Warning Panel

9-3. THEORY OF OPERATION (cont)

9-3**c. Emergency DC Electrical System.**

(1) Operation. The emergency dc electrical system allows the pilot to connect the battery to the dc emergency bus in case of an electrical system failure. The system (fig. 9-7) consists of the following components.

- (a) Battery.
- (b) Battery charger.
- (c) Battery relay.

(2) Battery. The battery supplies 24 VDC for APU starting, and for emergency operation during total electrical system failures. In an electrical failure, the pilot connects the battery to the dc emergency bus through the **ELEC PWR** control panel **BATT/OFF/EXT PWR** switch and the battery relay.

(3) Battery Charger. The battery charger recharges the battery. The battery charger operates as follows.

(a) The battery charger completely recharges a discharged battery in two hours. The charger stops charging the battery if any of the following conditions occur:

- Battery temperatures rise above $50 \pm 3^{\circ}\text{C}$ ($122 \pm 5^{\circ}\text{F}$). Charging resumes when the temperature drops below $46 \pm 3^{\circ}\text{C}$ ($115 \pm 5^{\circ}\text{F}$).
- An open or short circuit occurs in the battery temperature transducer circuit.
- The tenth cell voltage falls below or exceeds respectively 45 to 60% of battery terminal voltage for more than three minutes.
- External power is applied to the helicopter (prevents the buildup of explosive gases).

(4) Battery Relay. The battery relay, when energized, connects the battery to the dc emergency bus.

(5) Pilot Power Control Panel. The **BATT/OFF/EXT PWR** switch allows the pilot to connect the battery to the dc emergency bus. The switch has the following positions.

- (a) **BATT.** The **BATT** position provides a ground for the battery relay.
- (b) **EXT PWR.** The **EXT PWR** position is used when applying external power.
- (c) **OFF.** The **OFF** position interrupts the circuit for the battery relay and the external power contactor.

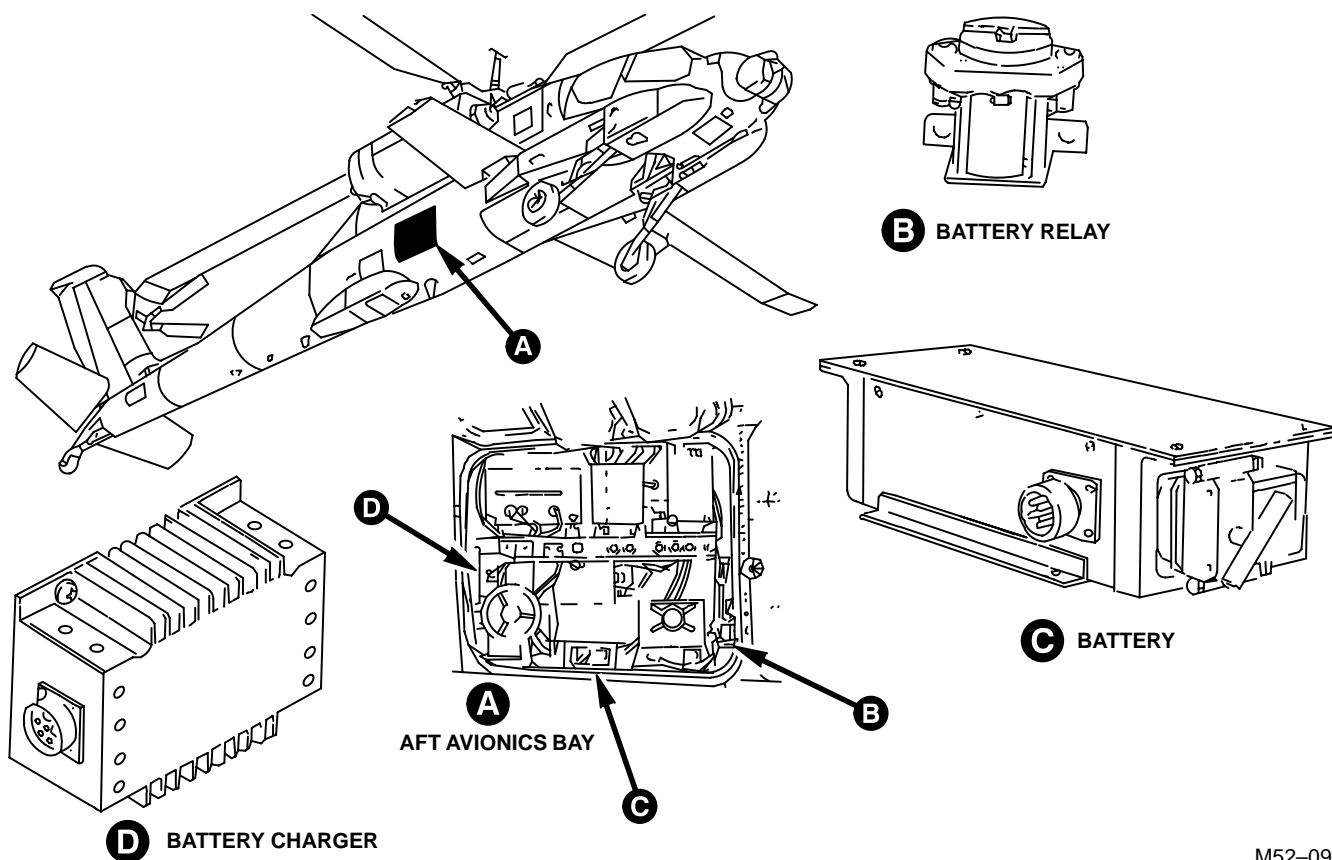
(6) CPG Power Quadrant. The **BAT OVRD** switch (fig. 9-8) allows the CPG to disconnect the battery in the event of an emergency. The switch has the following positions.

(a) **NRML.** The **NRML** position completes a circuit from the pilot's **BATT/OFF/EXT PWR** switch to the battery relay coil. A guard locks the switch in this position to prevent the CPG from accidentally disconnecting the battery.

(b) **OVRD.** The **OVRD** position interrupts the circuit to the battery relay coil to disconnect the battery.

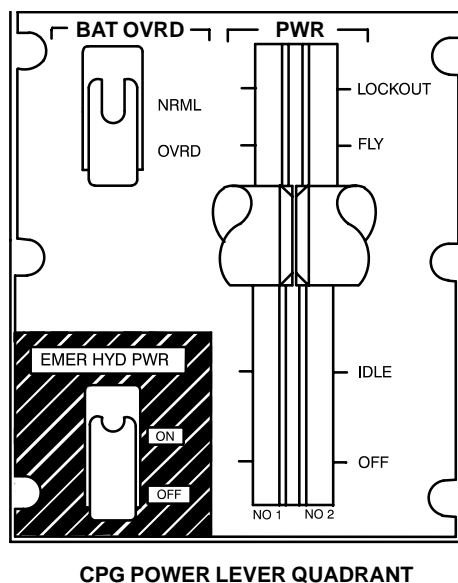
9-3. THEORY OF OPERATION (cont)

9-3



M52-092

Figure 9-7. Emergency DC Components



CPG POWER LEVER QUADRANT

M52-096

Figure 9-8. CPG Power Quadrant

9-3. THEORY OF OPERATION (cont)

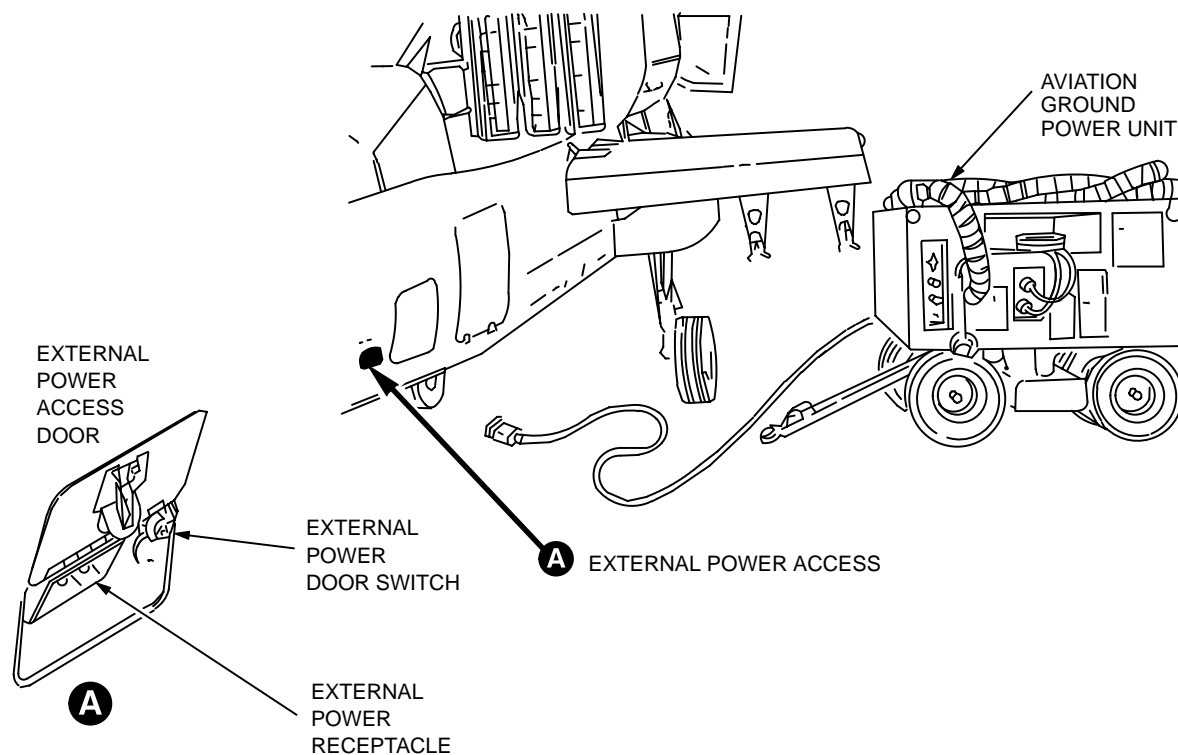
9-3

d. External AC Power System.

(1) Operation. The external ac power system allows ac electrical power to be connected to the helicopter for systems operation and/or checkout on the ground. The system consists of the following components.

- (a) External power receptacle.
- (b) External power monitor.
- (c) External power contactor.

(2) External Power Receptacle. The external power receptacle (fig. 9-9) provides a means of connecting a three-phase, 115/200 VAC, 400 Hz ground power source to the aircraft. The external power access door activates a switch that turns on the **EXT PWR** light on the pilot caution/warning panel (fig. 9-6) when the door is open.



M52-093

Figure 9-9. External Power Receptacle

(3) External Power Operation. When external power (fig. 9-10) is connected to the helicopter, three-phase, 115 VAC power is applied directly to the external power monitor and to the external power contactor. The external power contactor is de-energized open.

The external power monitor checks the incoming power for proper frequency, voltage and phasing. If the incoming power is correct, the external power monitor develops a 28 VDC interlock voltage.

The 28 VDC interlock voltage is applied back through the external power receptacle. This ensures that the external power connector is properly seated in the receptacle.

9-3. THEORY OF OPERATION (cont)

9-3

From the connector, the interlock voltage is applied to the generator 2 contactor. If the generator is operating, the contactor interrupts the interlock circuit. If the generator 2 is not operating, the generator contactor applies the interlock voltage to the **BATT/OFF/EXT PWR** switch on the **ELECT PWR** control panel in the pilot station.

When the **BATT/OFF/EXT PWR** switch is set to **EXT PWR**, the interlock circuit is completed to generator contactor 1.

If the generator is not operating (contactor de-energized), the interlock voltage is applied through contactor 1 to the coil of the external power contactor.

When the external power contactor energizes, three-phase external power is connected directly to ac bus 1, and the 28 VDC interlock is connected to the coil of the bus tie relay (B coil) in generator contactor 1.

Bus tie 1 energizes and connects ac bus 1 to ac bus 2. External power is supplied from the ac bus 1, through bus tie 1, to ac bus 2.

The external power monitor constantly checks the incoming power for proper voltage, frequency and phasing. If either parameter exceeds the maximum or minimum limits, the external power contactor ceases to develop the 28 VDC interlock voltage.

Without the interlock voltage, the external power contactor de-energizes and removes the incoming external power from ac buses 1 and 2.

e. Wiring and Circuit Protection System.

(1) The wiring system distributes and interconnects ac electrical power required to operate the AH-64A electrical and electronic systems. The wiring system consists of wiring harnesses and connectors. The wiring harnesses are made of space-saving, high-density wiring using various connectors. Figure 9-11 shows a typical wiring harness.

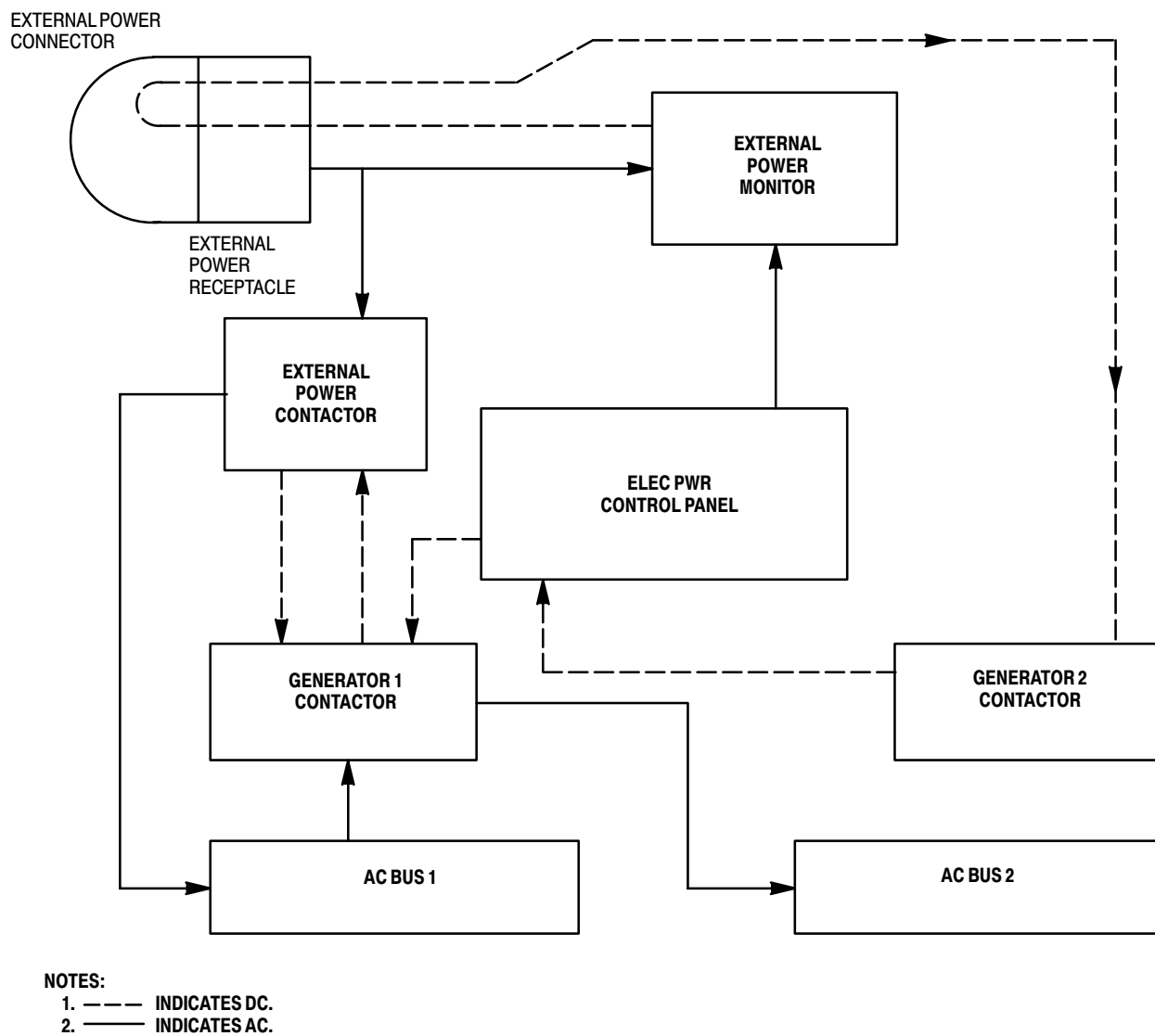
(2) The circuit protection system provides thermal overload protection for electrical circuits.

(a) The pilot's circuit breakers are on three circuit breaker panels (fig. 9-12) located overhead of the left side of the pilot station. The panels are as follows.

- Forward circuit breaker panel.
- Center circuit breaker panel.
- Aft circuit breaker panel.

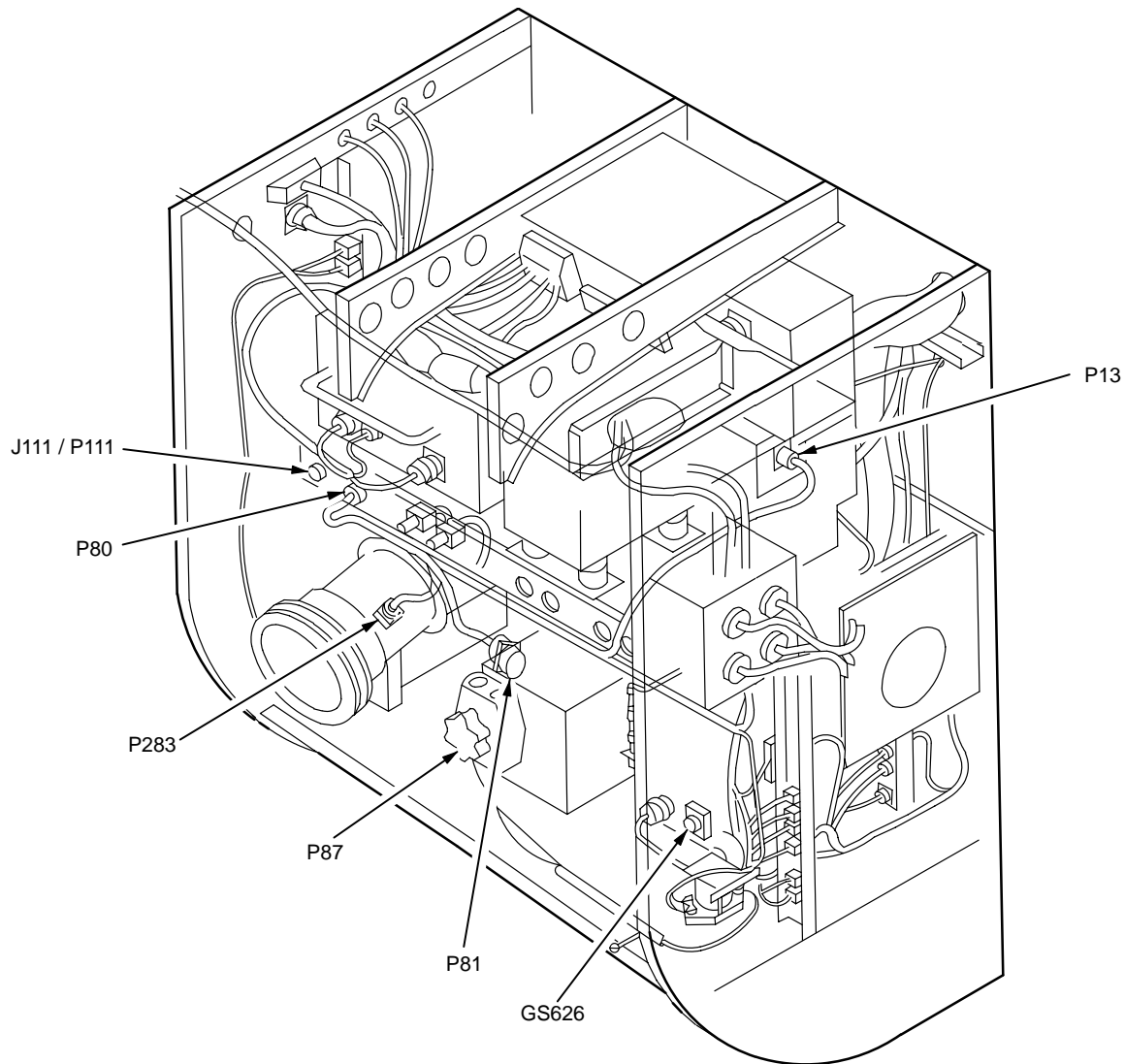
9-3. THEORY OF OPERATION (cont)

9-3



M52-094

Figure 9-10. External Power Circuit

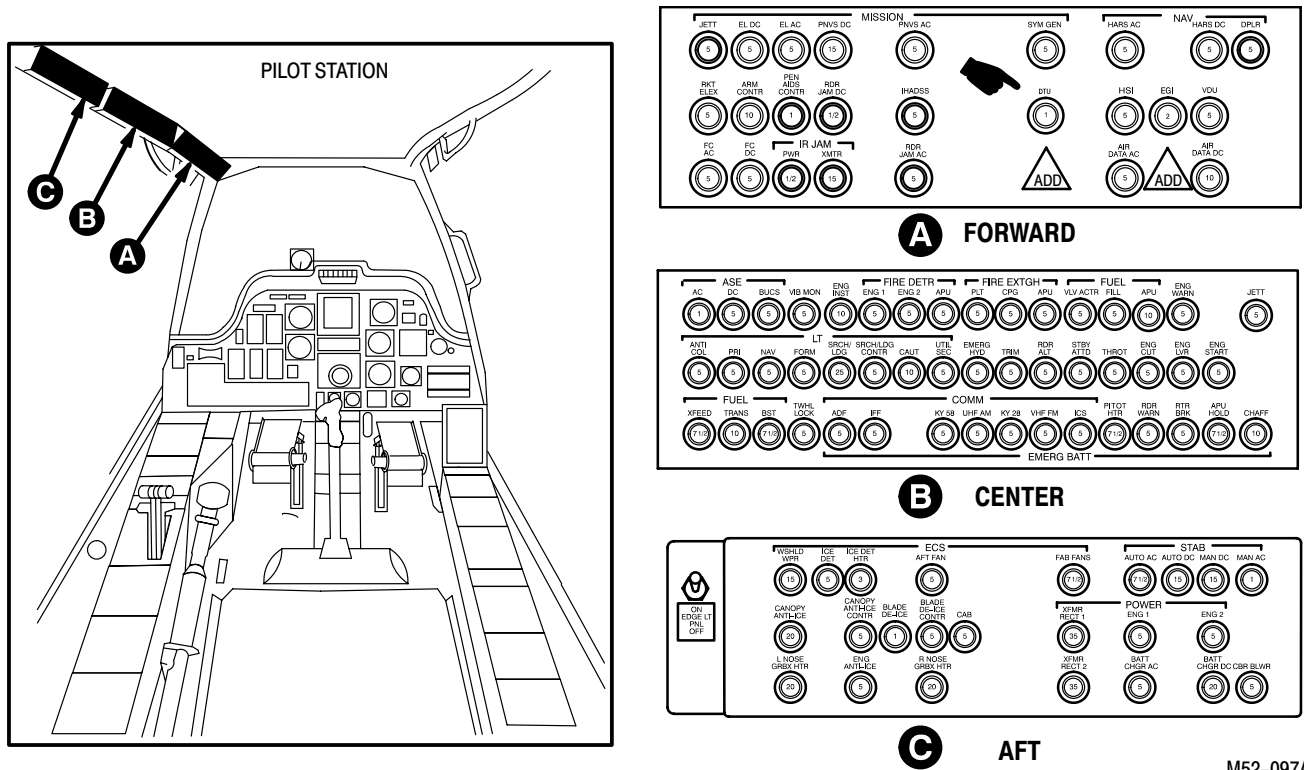


M52-087

Figure 9-11. Typical Wiring Harness (W108)

9-3. THEORY OF OPERATION (cont)

9-3



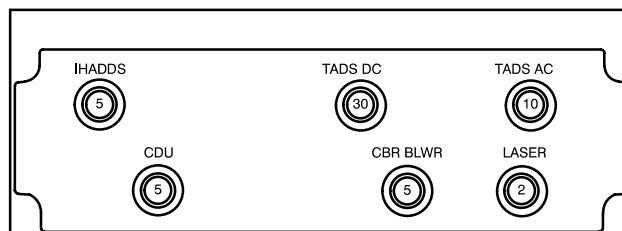
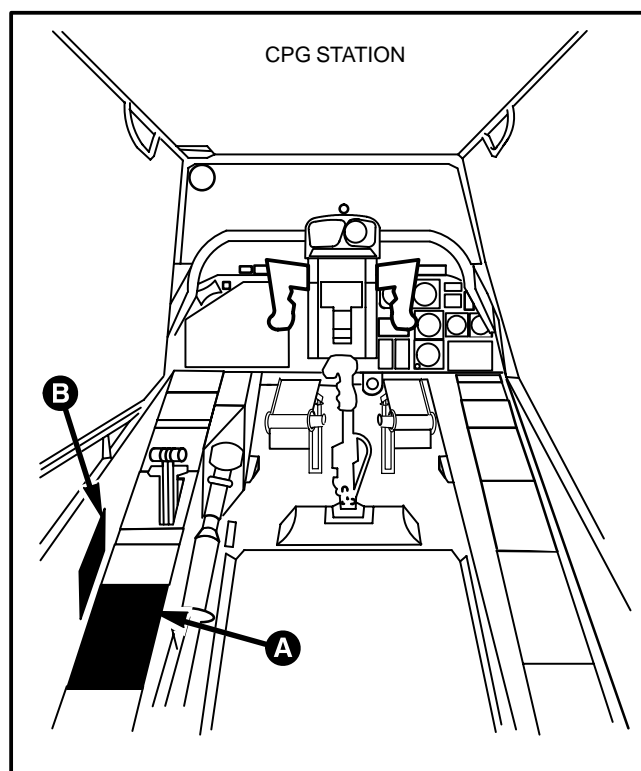
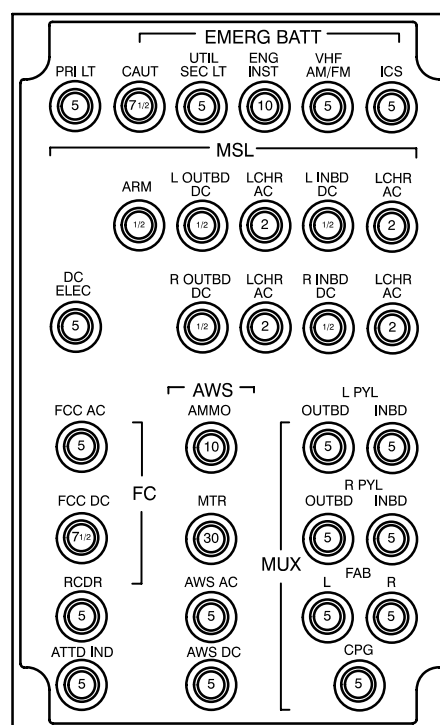
M52-097A

Figure 9-12. Pilot Circuit Breaker Panels

9-3. THEORY OF OPERATION (cont)

9-3

(b) The CPG circuit breaker panels (fig. 9-13) are located on the left side of the CPG station.

**B** CPG CIRCUIT BREAKER PANEL 2**A** CPG CIRCUIT BREAKER PANEL 1

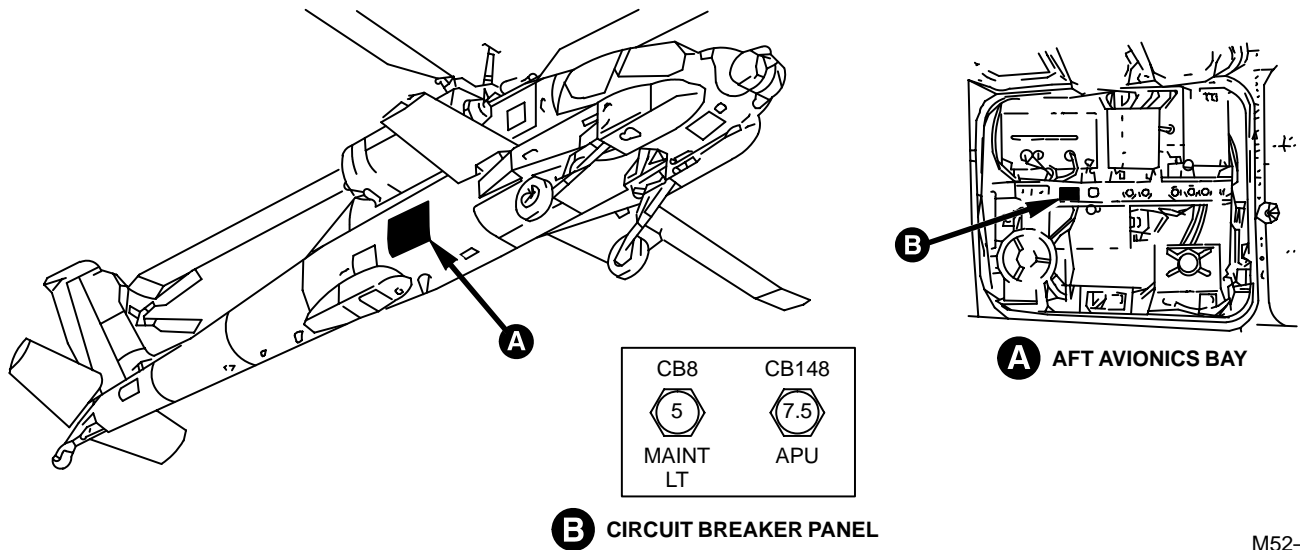
M52-098

Figure 9-13. CPG Circuit Breaker Panels

9-3. THEORY OF OPERATION (cont)

9-3

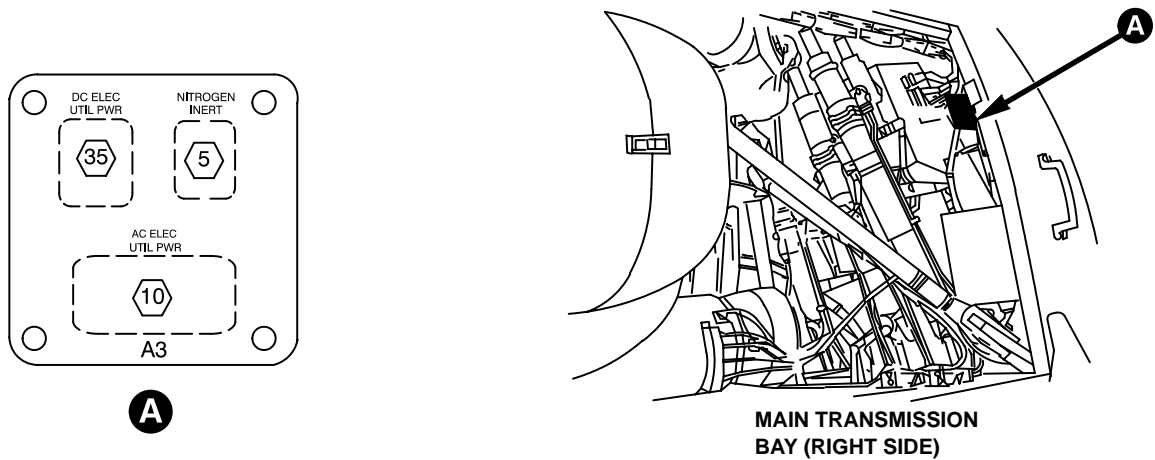
(c) The aft avionics bay circuit breakers (fig. 9-14) are mounted on the center shelf.



M52-099

Figure 9-14. Aft Avionics Bay Circuit Breakers

(d) The main transmission bay circuit breakers (fig. 9-15) are located on a panel in the right side of the bay.



M52-100

Figure 9-15. Main Transmission Bay Circuit Breakers

10-1. PURPOSE

10-1

CHAPTER 10 HYDRAULIC SYSTEM

10-1. PURPOSE

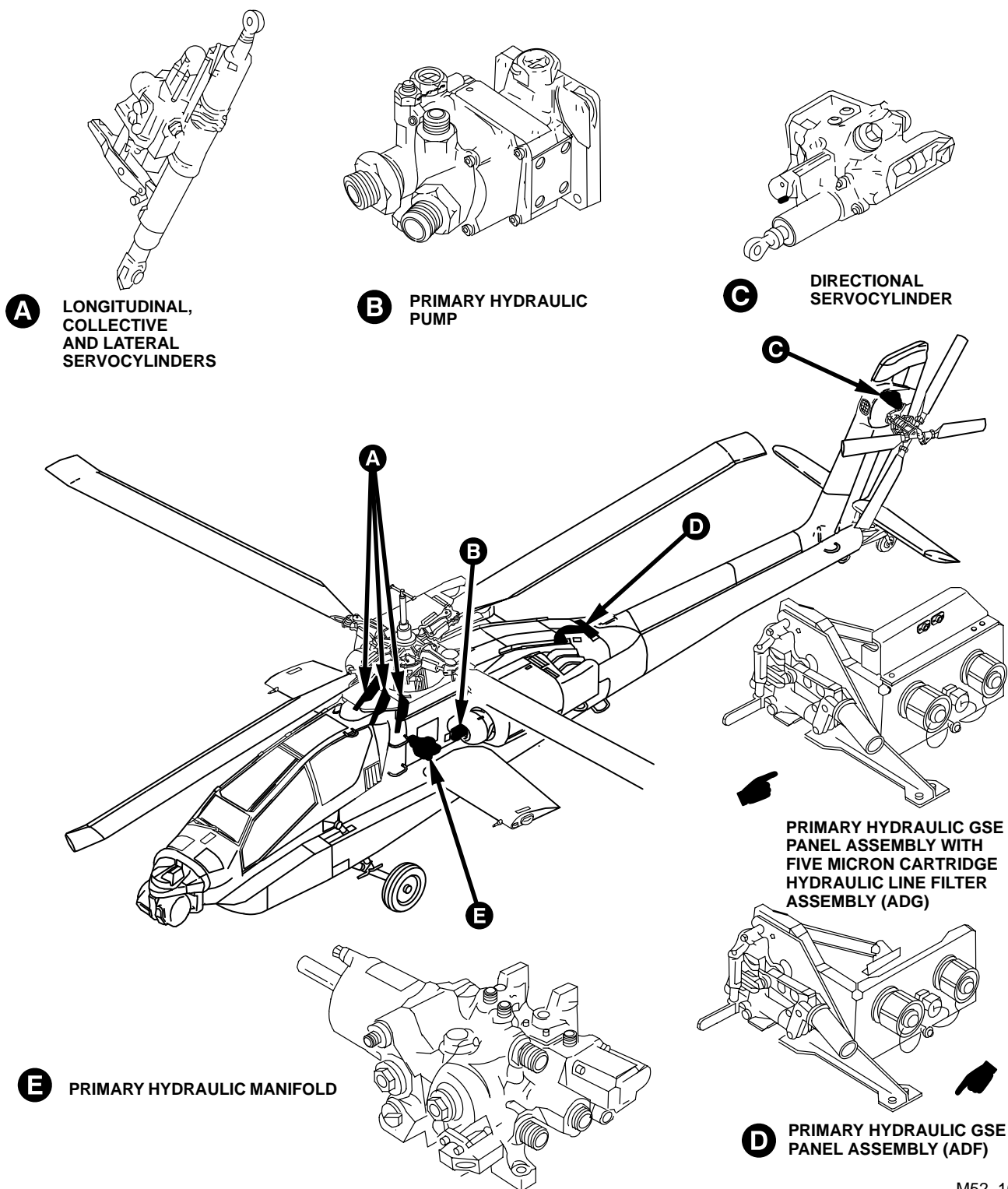
Two independent hydraulic systems are installed so that failure of one system will not affect operation of the other. They are designated as the primary and the utility hydraulic systems.

- a. The primary hydraulic system provides power for the operation of the upper flight controls and the tail rotor assembly.
- b. The utility hydraulic system provides high pressure fluid for the operation of main rotor and tail rotor servocylinders, auxiliary power unit (APU) start motor, rotor brake, tail wheel lock actuator, and weapon system components. The system also provides a source of stored high pressure fluid for emergency operation of the flight control servocylinders.

10-2. DESCRIPTION

The primary hydraulic system major components are described below (fig. 10-1).

- a. **Longitudinal Servocylinder.** The longitudinal servocylinder is mounted on the transmission deck in front of and to the right of the transmission.
- b. **Primary Hydraulic Pump.** The primary hydraulic pump is constructed of steel and is a constant pressure, variable delivery, piston-type pump.
- c. **Primary Hydraulic GSE Panel Assembly.** The primary hydraulic GSE panel assembly provides for external hydraulic power application and is mounted to the right side of the aft equipment bay deck, aft of the APU. A hand pump is mounted to a support bracket at the aft end of the GSE panel. The primary fill line contains a 45 micron screen filter (ADF) or a 5 micron cartridge filter element (ADG).
- d. **Directional Servocylinder.** The directional servocylinder is mounted on top of the tail rotor gearbox.
- e. **Primary Hydraulic Manifold.** The primary hydraulic manifold is made of aluminum alloy. The primary hydraulic manifold contains a reservoir and is mounted on the main transmission deck, forward and left of the main transmission.
- f. **Lateral Servocylinder.** The lateral servocylinder is mounted on the transmission deck in front of and to the left of the transmission.
- g. **Collective Servocylinder.** The collective servocylinder is mounted on the transmission deck in front of the transmission.



M52-167A

Figure 10-1. Primary Hydraulic System Major Components

10-2. DESCRIPTION (cont)

10-2

The utility hydraulic system major components are described below (fig. 10-2).

h. **Utility Hydraulic Accumulator.** The utility hydraulic accumulator assembly is mounted on the right side of the aft equipment bay deck under the APU and contains a restrictor valve located in the accumulator pressure line along the aft inboard side of the accumulator.

i. **Utility Hydraulic Ground Support Equipment Panel.** The utility hydraulic ground support equipment panel assembly is mounted on the aft equipment bay deck, outboard of the utility manifold.

j. **Tail Wheel Lock Control Valve.** The tail wheel lock control valve is located on top of the tail boom, slightly forward of the intermediate gearbox.

k. **Emergency Hydraulic Shutoff Valve.** The emergency hydraulic shutoff valve is located in the forward top portion of the tail boom, just aft of the ground support equipment (GSE) panels.

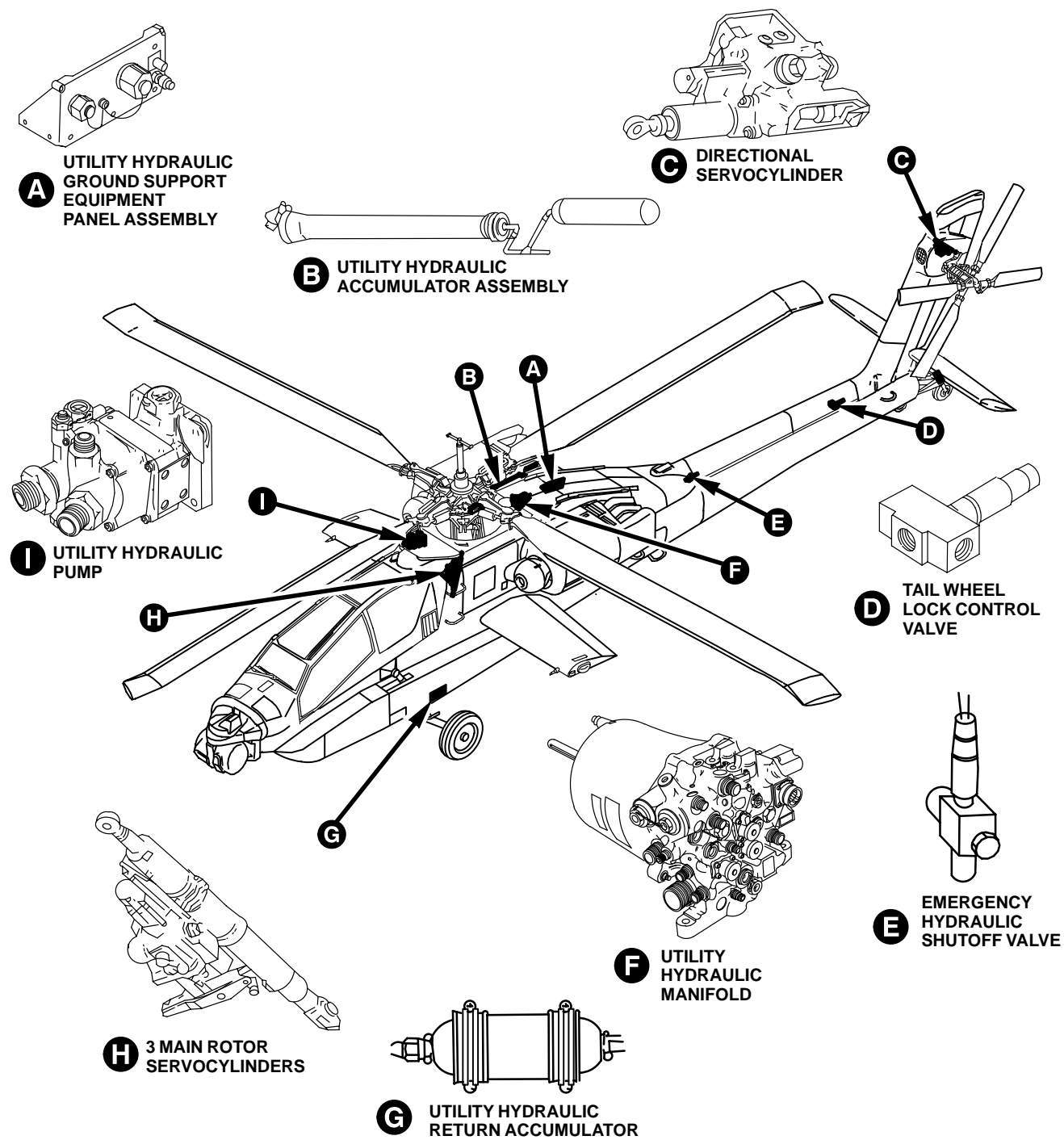
l. **Utility Hydraulic Manifold.** The utility hydraulic manifold is mounted on the right side of the aft equipment bay deck, aft of the APU and inboard of the hydraulic ground service panels.

m. **Utility Hydraulic Return Accumulator.** The utility hydraulic return accumulator is located in the left FAB.

n. **Utility Hydraulic Pump.** The utility hydraulic pump is mounted on the right forward drive pad of the transmission accessory gear train housing.

10-2. DESCRIPTION (cont)

10-2



M52-169

Figure 10-2. Utility Hydraulic System Major Components

10-3. THEORY OF OPERATION

10-3**10-3. THEORY OF OPERATION****a. Primary Hydraulic System Operation (fig. 10-3).**

- (1) The primary hydraulic reservoir supplies low pressure hydraulic fluid to the pump assembly.
- (2) If reservoir fluid level reaches minimum permissible operating volume, the low level switch closes and illuminates a caution/warning light.
- (3) The pump draws low pressure fluid from the reservoir and pressurizes to a rated pressure of 3000 psi.
- (4) Once fluid is pressurized the fluid is returned to the manifold. The pressure switch senses pressure and illuminates a caution/warning light.
- (5) Fluid is then filtered and sent past the pressure transducer before exiting the manifold.
- (6) The manifold then distributes high pressure hydraulic fluid to the following servocylinders:
 - Longitudinal.
 - Collective.
 - Lateral.
 - Directional.
- (7) The GSE panel provides a means for servicing and bleeding the primary hydraulic system with the use of ground support equipment. The primary fill line contains a 45 micron screen filter (ADF) or a 5 micron cartridge filter element (ADG).

10-3. THEORY OF OPERATION (cont)

10-3

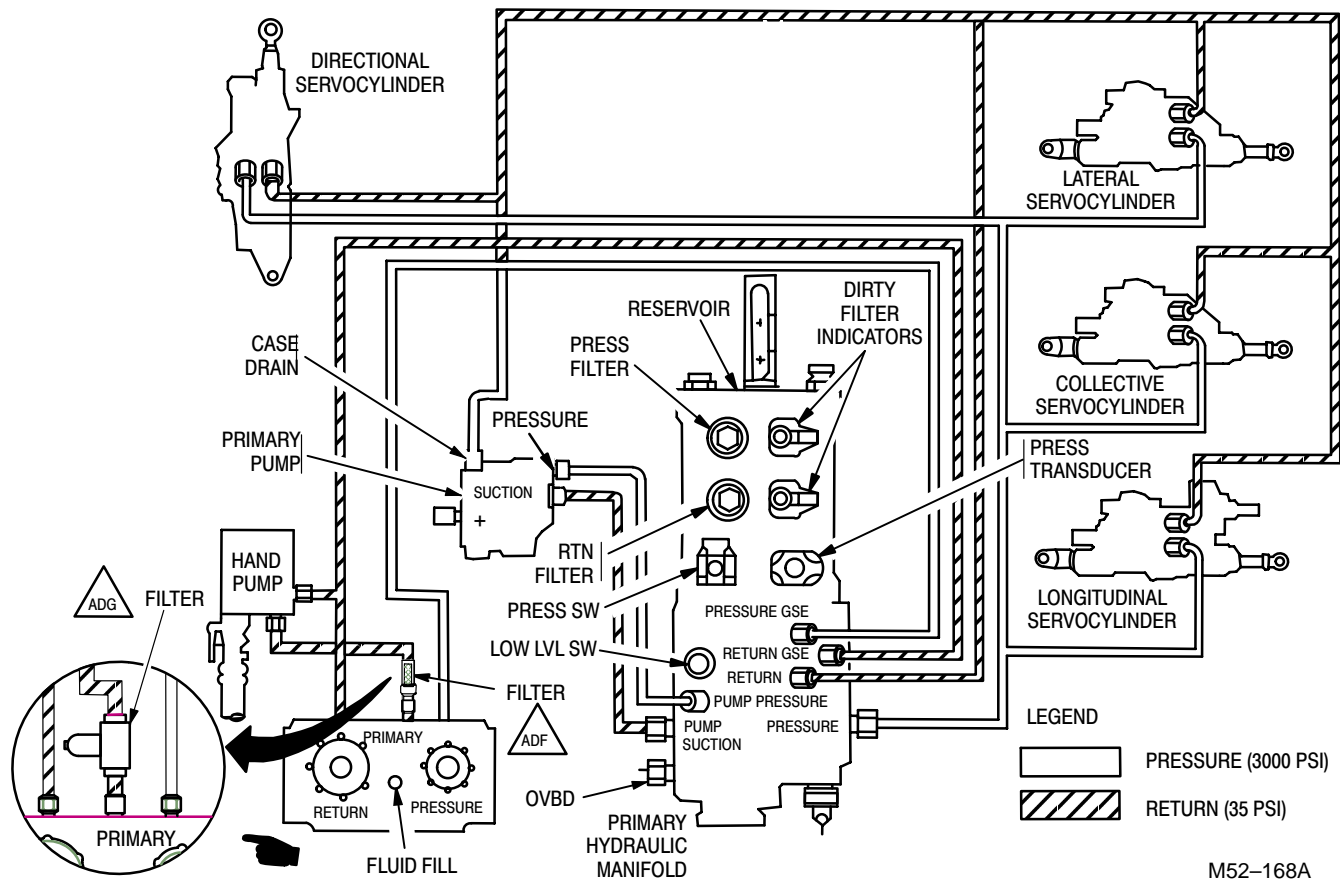


Figure 10-3. Primary Hydraulic System Functional Diagram

b. Primary System Crew Station Indicators (fig. 10-4).

(1) Dual hydraulic pressure indicator provides a visual indication of both primary and utility hydraulic system pressure. The indicator is mounted to the lower center portion of the pilot's instrument panel.

(2) The pilot's caution/warning lights consists of the **PRI HYD PSI** indicator which indicates low system oil pressure, the **OIL LOW PRI HYD** indicator which indicates that system fluid is at minimum, and the **OIL BYP PRI HYD** indicator which indicates that a pressure differential has been detected in either the pressure or return filter.

(3) CPG's caution/warning lights consist of the **PRI HYD** indicator which indicates system oil pressure is low.

10-3. THEORY OF OPERATION (cont)

10-3

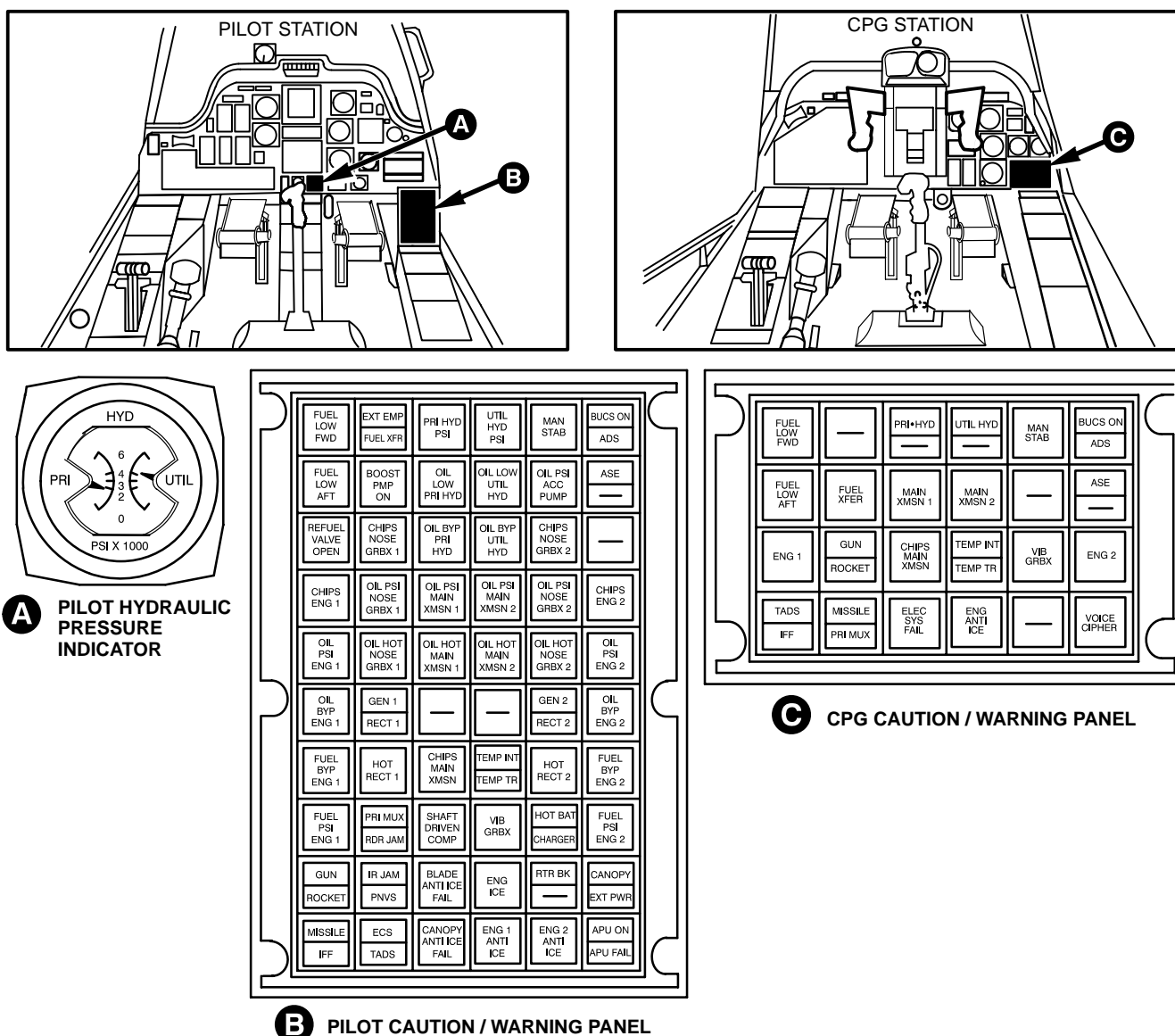
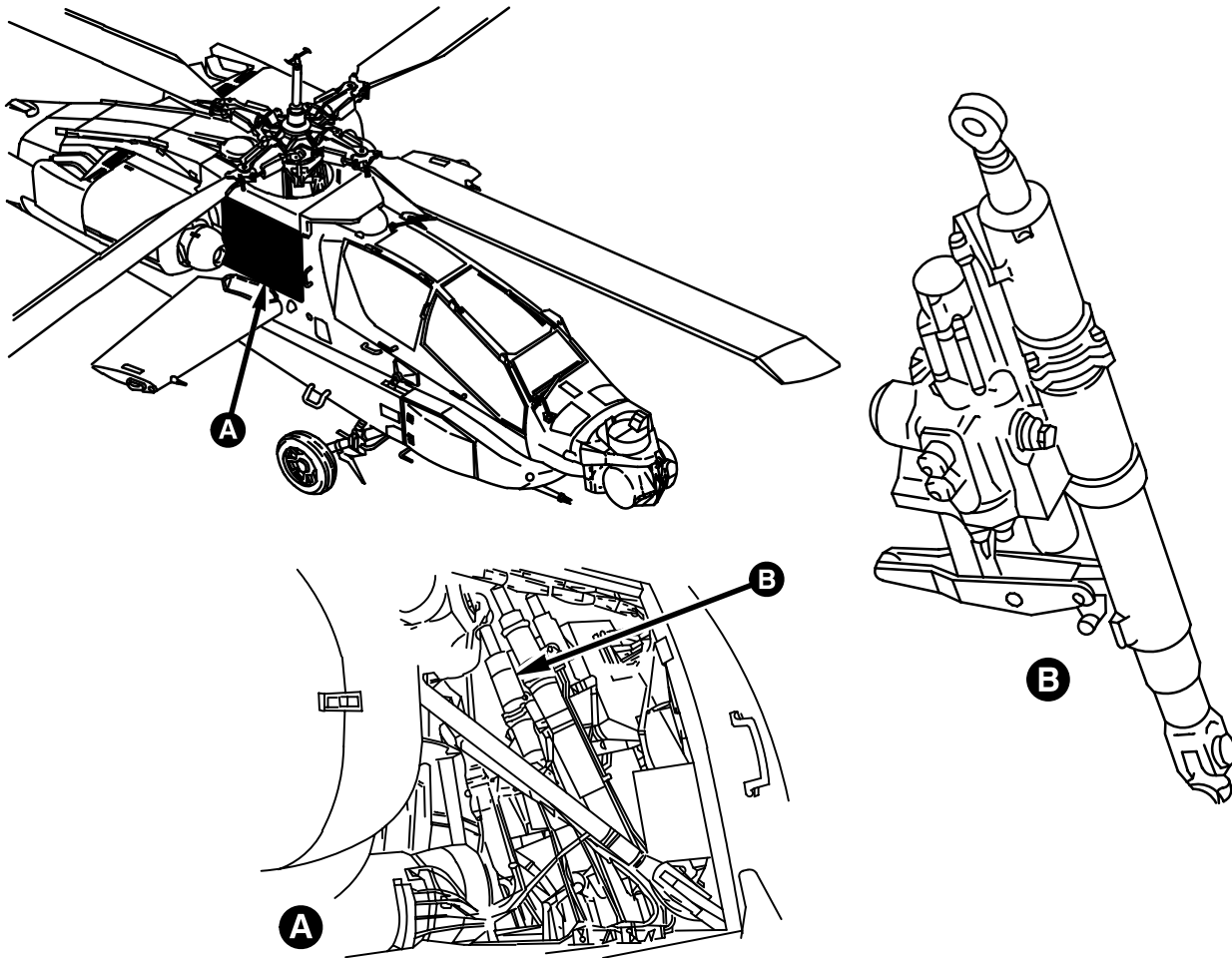


Figure 10-4. Primary System Crew Station Indicators

c. Longitudinal Servocylinder.

- (1) The longitudinal servocylinder (fig. 10-5) is constructed of electroslag remelt (ESR) steel for purposes of ballistic protection.
- (2) The tandem design of the actuator allows for both separate primary and utility manifolds, cylinders, barrels, and pistons that utilize primary and utility system fluid respectively.
- (3) The longitudinal servocylinder modes of operation are normal and BUCS.
- (4) The longitudinal servocylinder differs slightly from the lateral and the collective servocylinders at the attachment points.

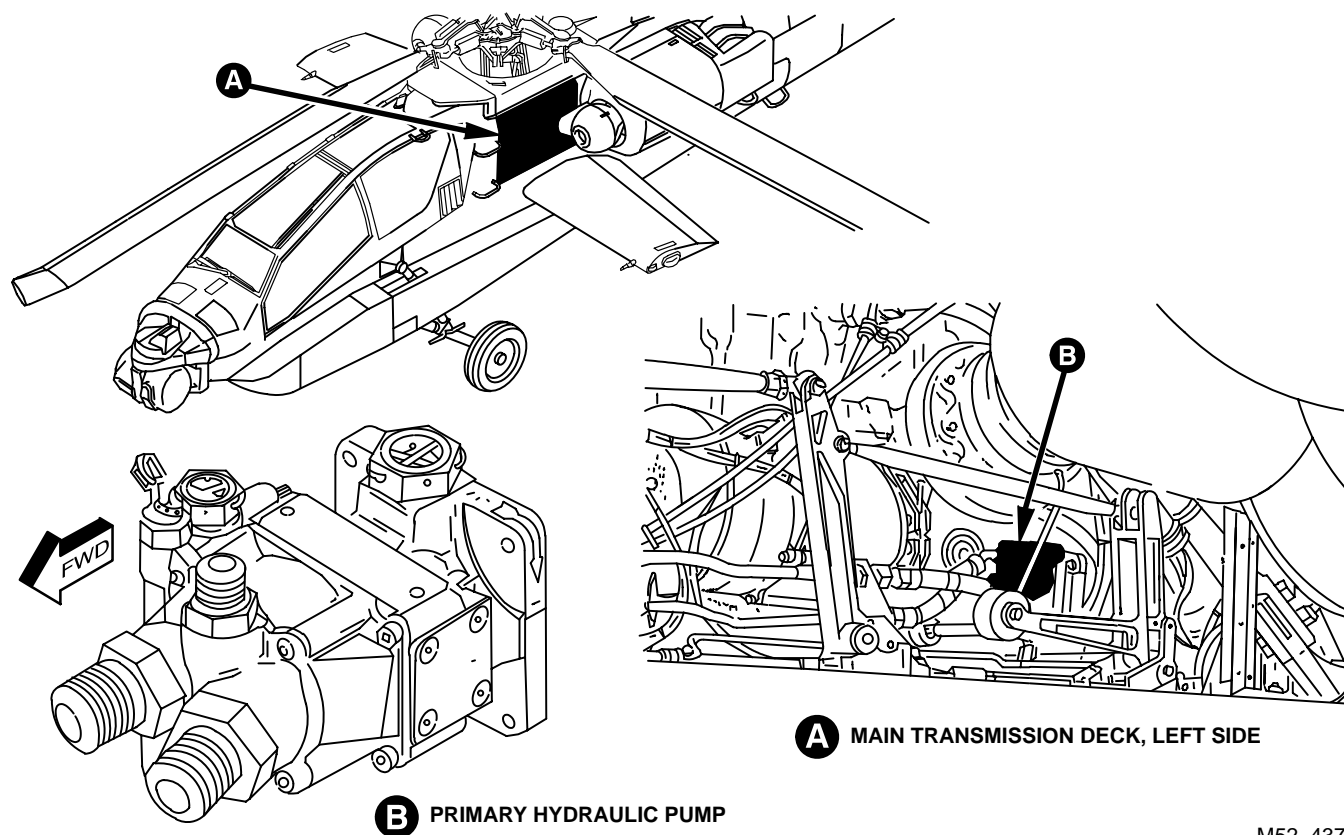


M52-436

Figure 10-5. Longitudinal Servocylinder**d. Primary Hydraulic Pump.**

(1) The primary hydraulic pump (fig. 10-6) pressurizes fluid and allows for the transfer of fluid for system operation.

(2) The pump incorporates a gear shaft and is driven by the transmission accessory gear train.



M52-437

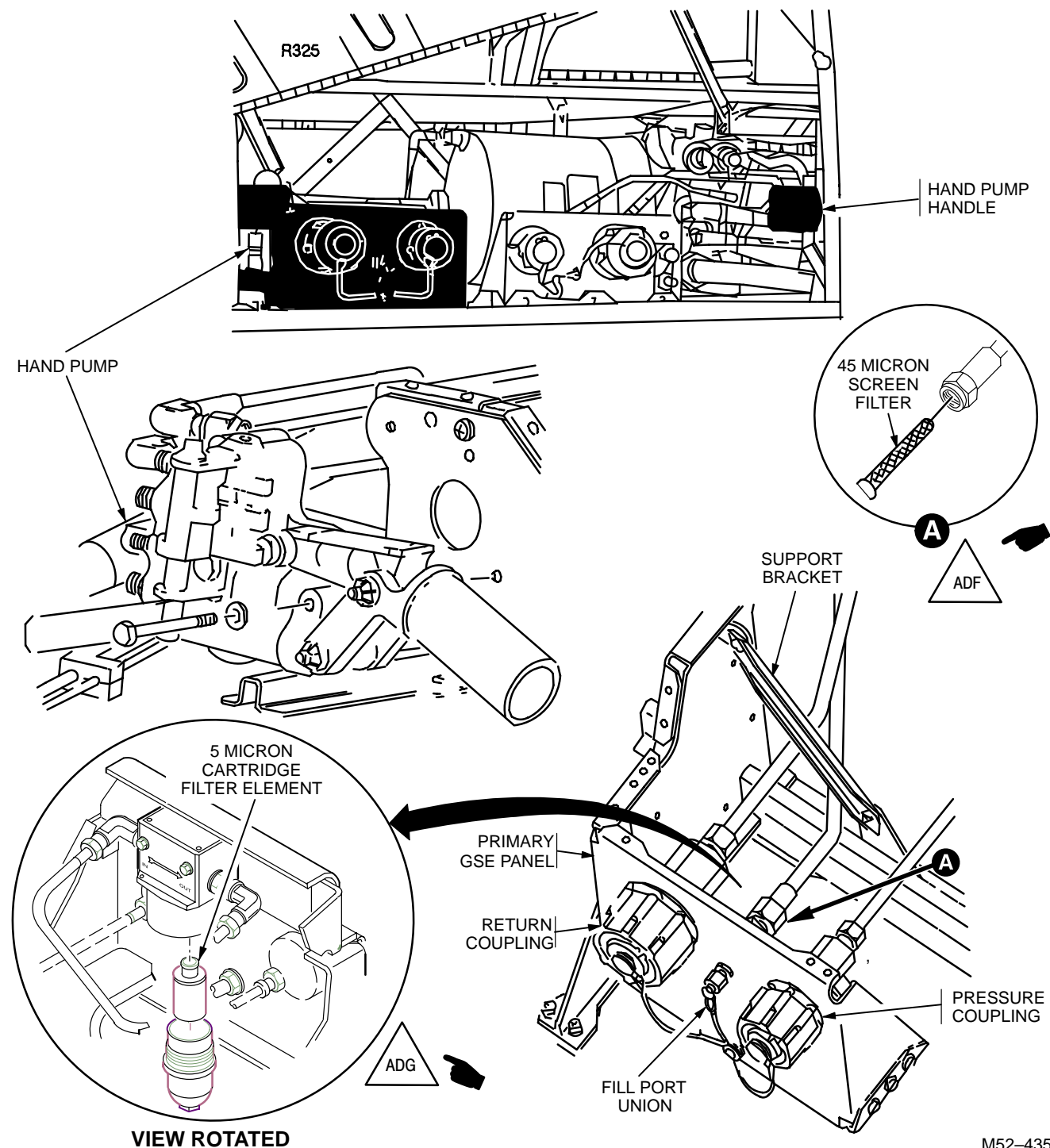
Figure 10-6. Primary Hydraulic Pump

e. Primary Hydraulic GSE Panel Assembly.

(1) The primary hydraulic GSE panel assembly (fig. 10-7) provides a method of servicing both primary and utility reservoirs and also provides for a method of charging the accumulator with fluid.

10-3. THEORY OF OPERATION (cont)

10-3

**Figure 10-7. Primary Hydraulic GSE Panel Assembly**

(2) A single action ram hand-operated pump (fig. 10-8) provides a means for drawing hydraulic fluid from a bulk container and directing fluid to the primary and utility reservoir and the accumulator (pressurizes the accumulator to 3000 psi). The following describes the operation of the hand pump.

10-3. THEORY OF OPERATION (cont)**10-3**

(a) Prior to using the hand pump to service any systems, the accumulator must be properly serviced with nitrogen.

(b) With a hydraulic servicing unit connected to the fill port of the GSE panel, low pressure fluid is filtered by a 45 micron screen filter (ADF) or a 5 micron cartridge filter element (ADG) and allowed to enter the pump manifold by overriding the spring poppet of check valve B.

(c) Positioning the selector lever outboard rotates the camshaft, causing the M2 check valve to be mechanically opened.

(d) The hand pump is then used to force the fluid to open M3 and be delivered to the utility reservoir.

(e) Check valve A will remain closed due to the accumulator pressure acting on the backside of the poppet.

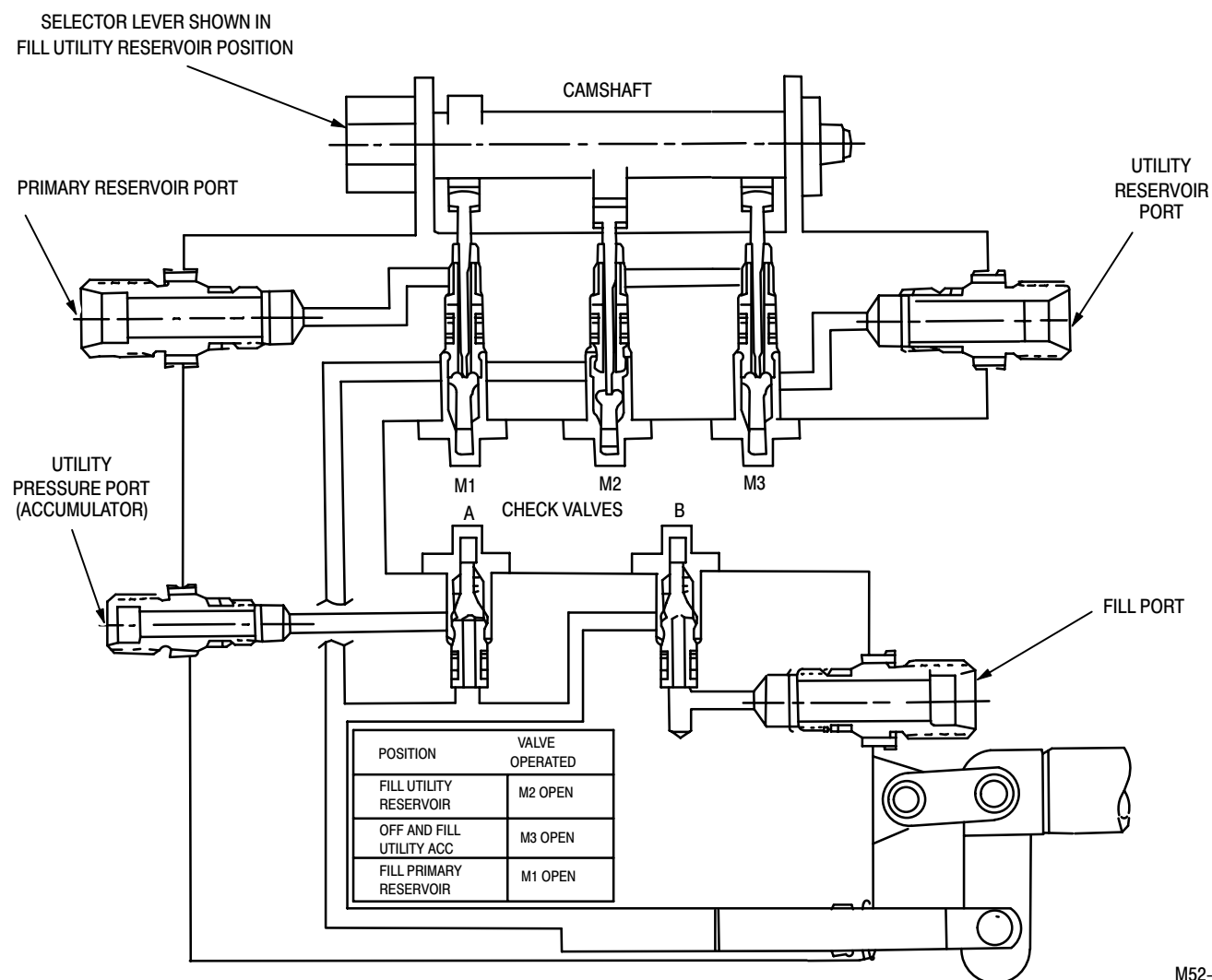


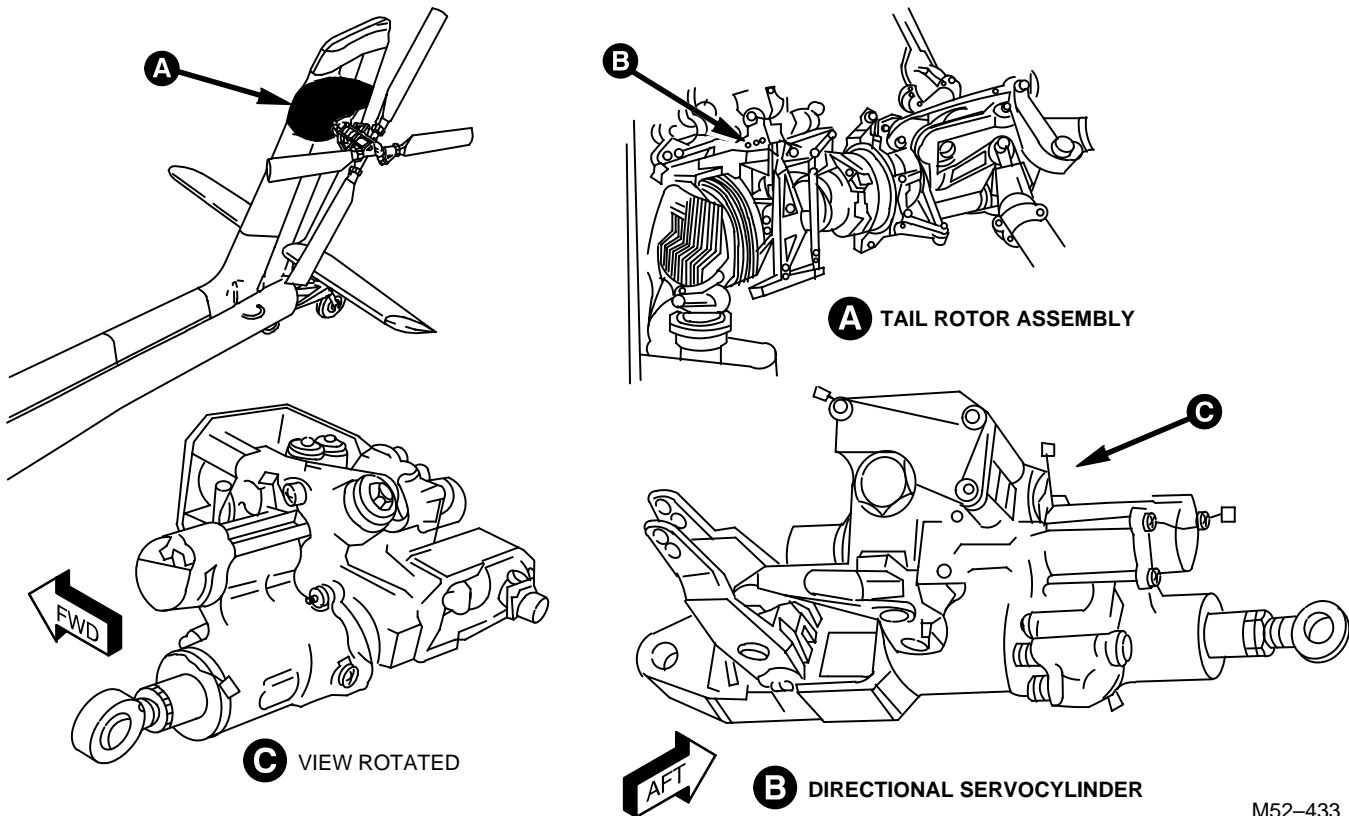
Figure 10-8. Hand Pump Operation

10-3. THEORY OF OPERATION (cont)

10-3

f. Directional servocylinder.

- (1) The directional servocylinder is the tail rotor actuator (fig. 10-9).
- (2) The directional servocylinder modes of operation are normal and BUCS.



M52-433

Figure 10-9. Directional Servocylinder

g. **Primary Hydraulic Manifold Components.** The primary hydraulic manifold stores, filters, and routes hydraulic fluid for system operation. The primary hydraulic manifold components (fig. 10-10) are described as follows.

- (1) The fluid level indicator provides a visual indication of reservoir fluid level. The indicator is color coded green (normal) and red (refill). Reading is taken at the end of the reservoir piston rod.
- (2) The return dirty filter indicator senses pressure upstream and downstream of the filter. At fluid temperature above 115°F (46°C) and a fluid pressure of 60 to 80 psi, a pop-up visual indicator extends, closing an electrical switch and illuminating a caution light on the pilot's caution/warning panel.
- (3) The pressure dirty filter indicator provides for visual indication of filter clogging at the manifold. The pressure dirty filter indicator incorporates an electrical switch and a small red pop-up visual indicator. At a temperature above 115°F (46°C) the indicator will extend if pressure is greater than 60 to 80 psi causing a caution/warning light to illuminate.

10-3. THEORY OF OPERATION (cont)

10-3

(4) The reservoir stores low pressure hydraulic fluid for system use. The reservoir has a fluid capacity of one pint and is pressurized by the PAS to 30 ± 5 psi. The reservoir contains a piston assembly that moves back and forth inside the reservoir to separate air and fluid in the reservoir and to aid in reservoir fluid pressurization.

(5) The air inlet check valve is part of the reservoir components and permits one way air flow into the reservoir to maintain reservoir air pressure. An in-line filter in the PAS line and check valve removes contaminants from the pressurized inlet air.

(6) The air bleed valve is part of the reservoir components and provides a means of relieving reservoir air pressure for maintenance purposes. The valve is push-button activated to open.

(7) The low level switch monitors fluid level in the reservoir. As fluid reaches minimum permissible operating volume (1.5 cu. in.) the reservoir piston contacts a piston in the switch causing the piston to retract. The retraction of the piston causes a microswitch to close illuminating the caution/warning light.

(8) The GSE return isolation valve isolates the GSE return port during normal system operation. The valve is held closed by normal hydraulic system pressure and opens when GSE pressure enters the manifold.

(9) The pressure transducer monitors fluid pressure that is available to the servocylinders and sends a dc voltage linear dependent on inlet pressure to the primary side of the hydraulic pressure gauge.

(10) The pressure switch is a small modular microswitch which provides a signal to the caution/warning panels indicating low hydraulic system pressure and provides an indication as to the condition of the hydraulic pump. At 2050 psi increasing pressure, the pressure switch opens, extinguishing the caution light. At 1250 psi decreasing pressure, the pressure switch closes, illuminating the caution light.

(11) The GSE check valve isolates the GSE circuit during normal system operation. The valve is held closed by normal hydraulic system pressure entering the manifold, and opens when GSE hydraulic pressure enters the manifold.

(12) The pressure filter is a cleanable steel wire mesh that removes particles larger than 5 microns from fluid entering the manifold.

(13) The filter bypass valve allows return hydraulic fluid to bypass the return filter when the filter is clogged.

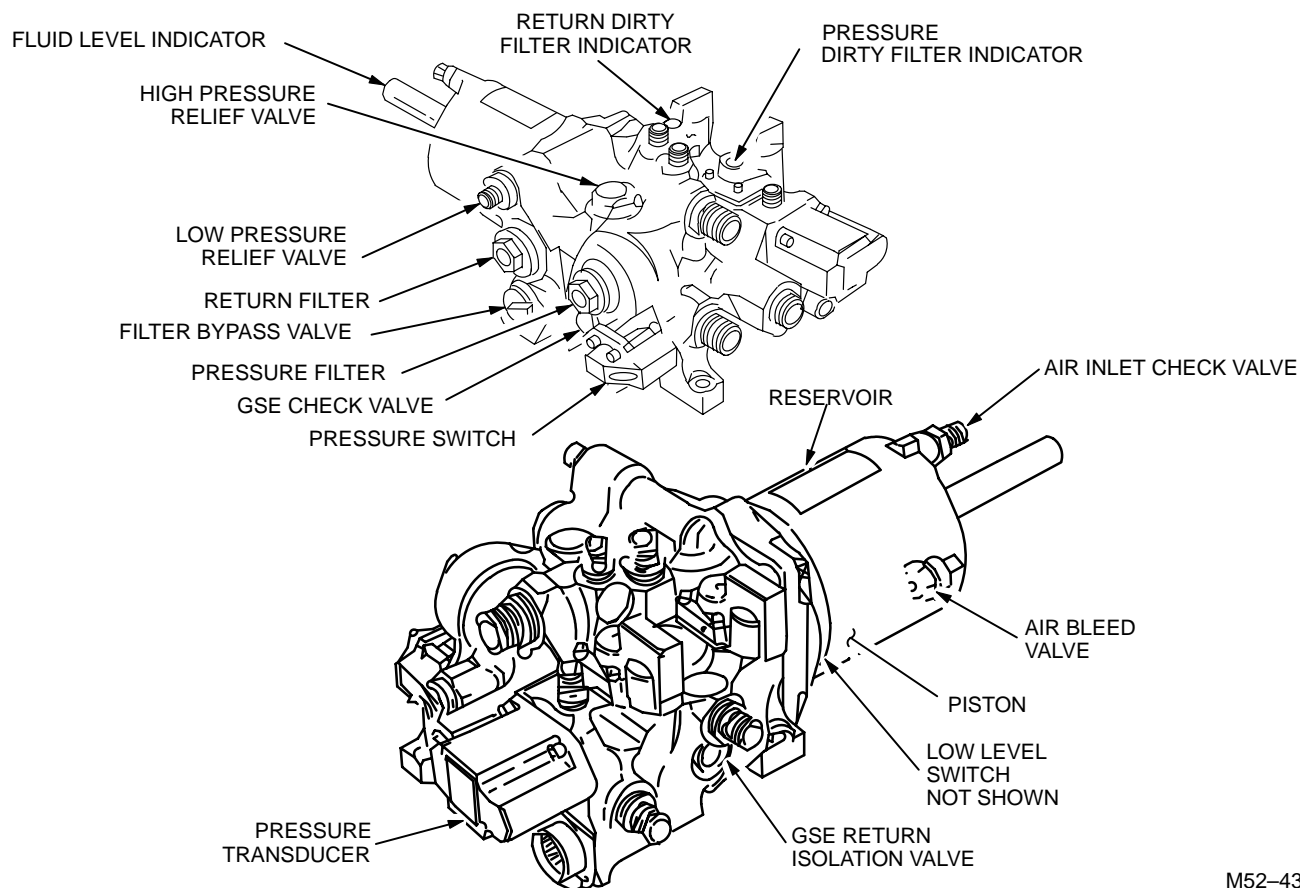
(14) The return filter is a cleanable steel wire mesh that removes particles larger than 5 microns from fluid returning from upper flight control actuators before entering the manifold reservoir.

(15) The low pressure relief valve relieves excess reservoir fluid pressure and provides the reservoir with self-bleeding capability. An air bleed passage leading to the relief valve is located at the highest point of the reservoir to aid in bleeding off trapped air. The valve opens at 215 psi to dump fluid overboard (full flow of 12 gpm) and closes at 150 psi.

(16) The high pressure relief valve returns excess fluid pressure in the high pressure portion of the manifold into the return side of the manifold. The high pressure relief valve protects system components from high pressure by sensing pump output pressure within the manifold and cracking at 3500 psi.

10-3. THEORY OF OPERATION (cont)

10-3



M52-438

Figure 10-10. Primary Hydraulic Manifold Components

h. Primary Hydraulic Manifold Electrical Operation (fig. 10-11).

(1) The high pressure switch provides ground when closed to illuminate the **PRI HYD PSI** caution light on the pilot caution/warning panel and the **PRI HYD** caution light on the CPG caution/warning panel.

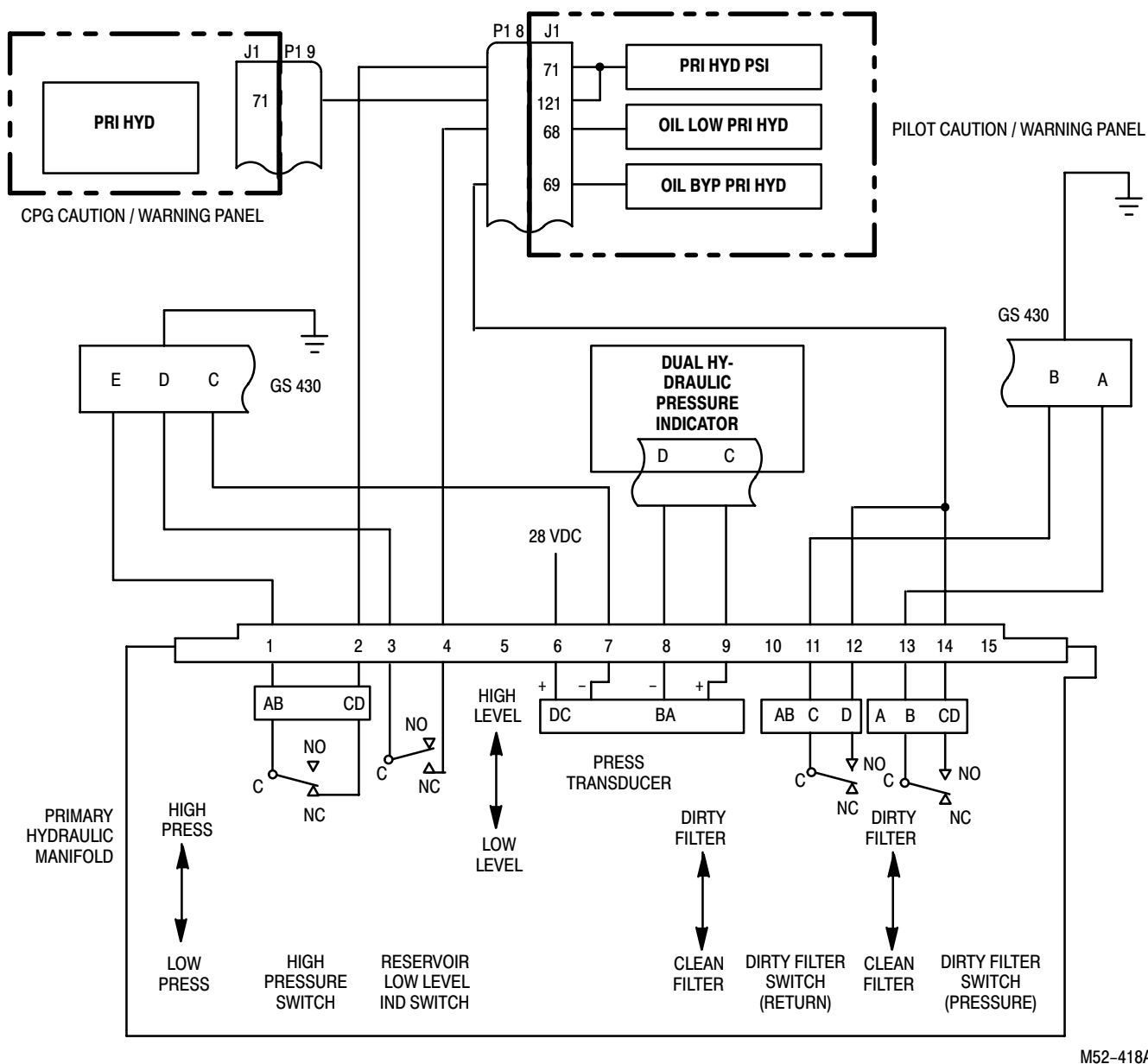
(2) The low level indicator switch, when closed, provides ground to illuminate the **OIL LOW PRI HYD** caution light on the pilot caution/warning panel.

(3) The pressure transducer supplies a signal to the dual hydraulic pressure indicator, proportional to system hydraulic pressure. The output is 1.37 VDC per 1000 psi.

(4) The pressure and return dirty filter switches are wired in parallel. When either switch closes, a ground illuminates the **OIL BYP PRI HYD** light on the pilot caution/warning panel.

10-3. THEORY OF OPERATION (cont)

10-3



M52-418A

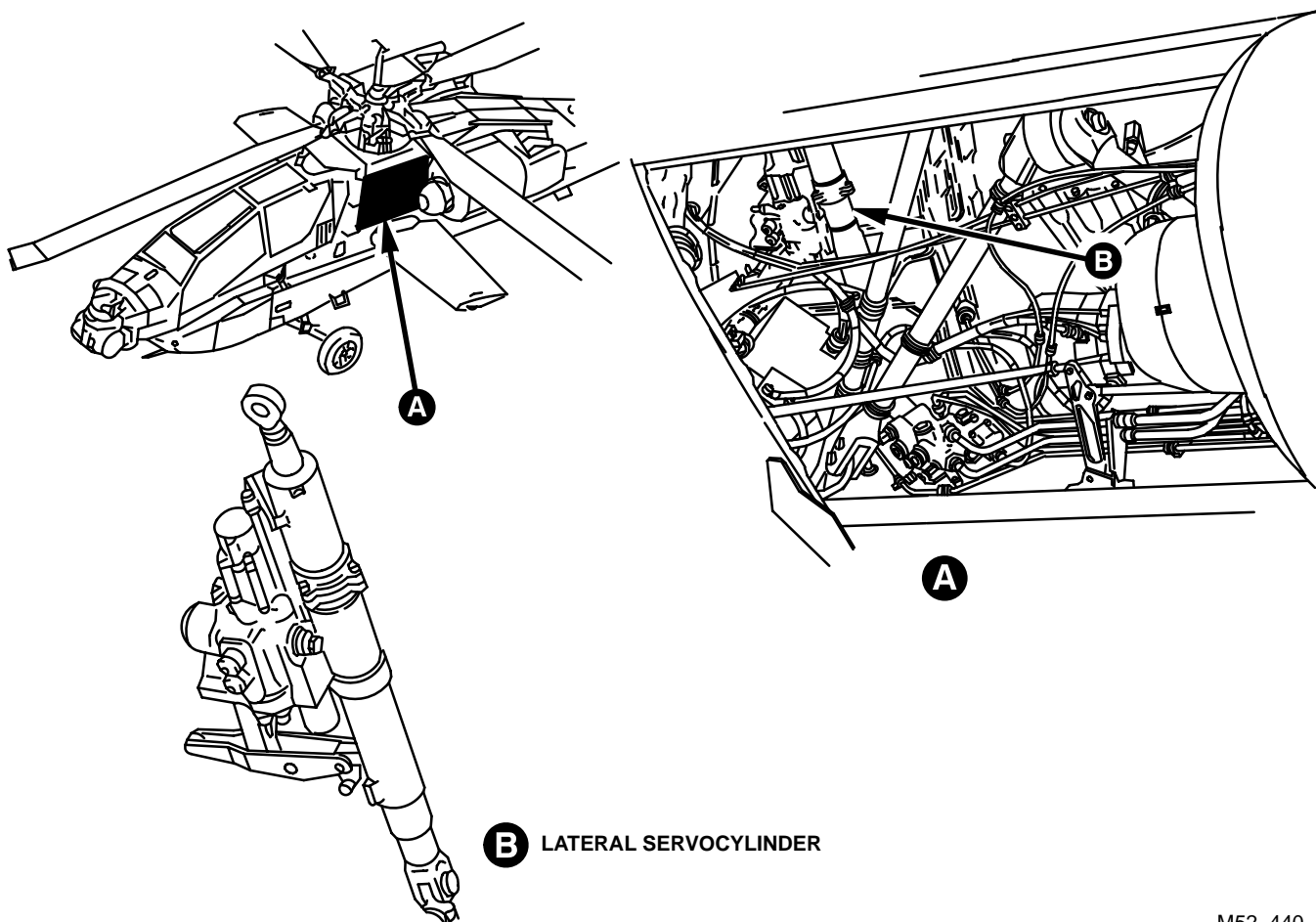
Figure 10-11. Primary Hydraulic Manifold Electrical Operation

10-3. THEORY OF OPERATION (cont)

10-3

i. Lateral Servocylinder.

- (1) The lateral servocylinder (fig. 10-12) and the collective servocylinders are identical.
- (2) The lateral servocylinder is an upper flight control actuator and is approximately 6.5 inches wide and 18.3 inches long at the mid-stroke position.
- (3) The lateral servocylinder modes of operation are normal and BUCS.



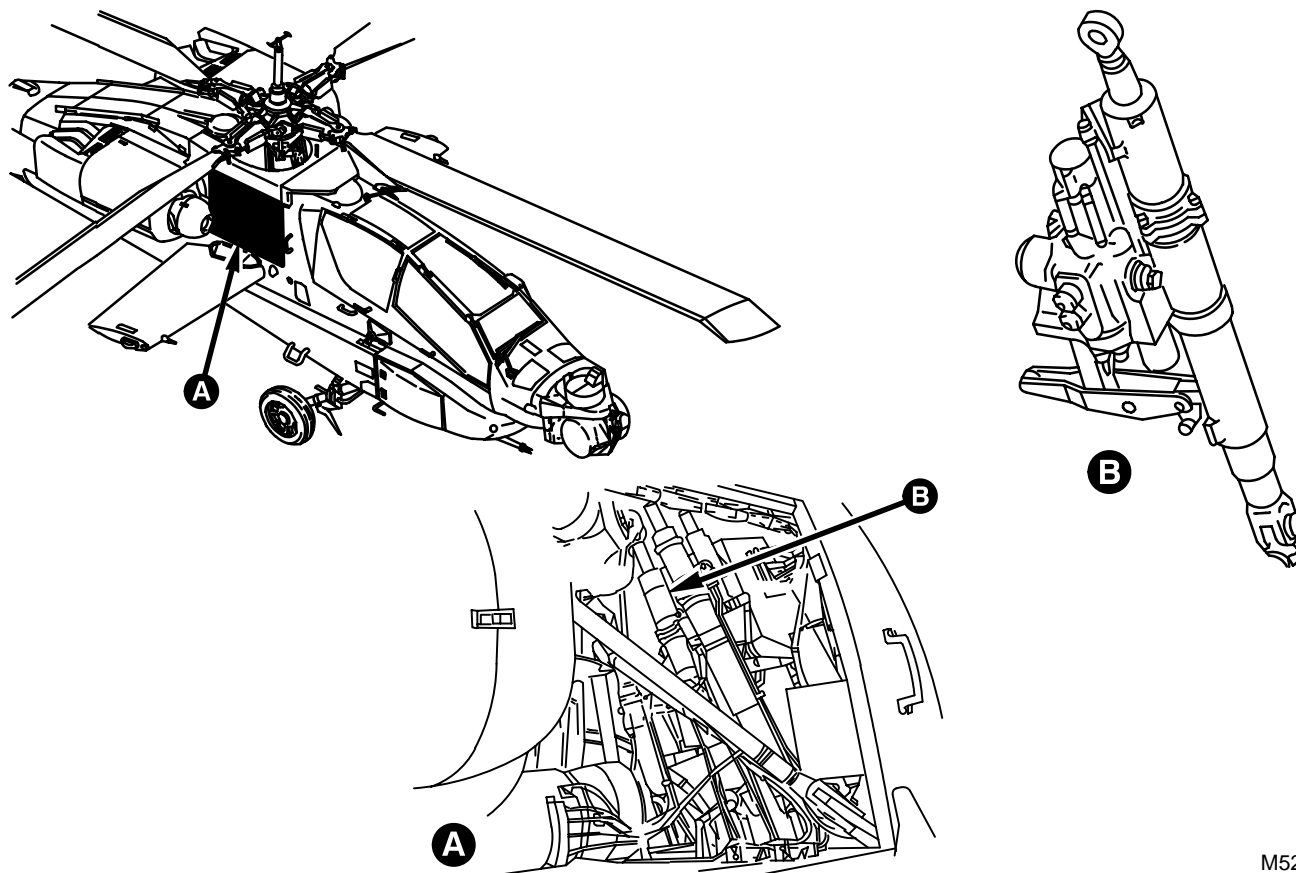
M52-440

Figure 10-12. Lateral Servocylinder**j. Collective Servocylinder.**

- (1) The collective servocylinder (fig. 10-13) is an upper flight control actuator and is approximately 6.5 inches wide and 18.3 inches long at the mid-stroke position.
- (2) The collective servocylinder is identical to the lateral servocylinder.
- (3) The collective servocylinder modes of operation are normal and BUCS.

10-3. THEORY OF OPERATION (cont)

10-3



M52-439

Figure 10-13. Collective Servocylinder

k. Utility Hydraulic System Operation (fig. 10-14).

- (1) The utility hydraulic reservoir supplies low pressure fluid to the utility hydraulic pump assembly (pressurized by the PAS manifold).
- (2) The pump (driven by the transmission at 12,635 rpm) draws low pressure fluid from the reservoir and pressurizes the fluid to a rated pressure of 3000 psi.
- (3) Once fluid is pressurized, the fluid is transferred back to the manifold. The manifold then distributes high pressure hydraulic fluid to the following components:
 - Directional servocylinder.
 - Lateral servocylinder.
 - Collective servocylinder.
 - Longitudinal servocylinder.
 - Four external stores actuators.
 - Area weapon azimuth motor.
 - Area weapon elevation motor.

10-3. THEORY OF OPERATION (cont)

10-3

- Utility accumulator (via the restrictor valve).

(4) During normal operation of the area weapon system (AWS) hydraulic pressure spikes are developed. The pressure return spikes are dampened by the utility hydraulic return accumulator.

(5) The manifold can be directed to supply hydraulic pressure to the rotor brake utilizing the pilot's rotor brake switch.

(6) Hydraulic pressure is available to the tail wheel control valve which is activated by the pilot's tail wheel lock switch to apply pressure to actuate the tail wheel lock assembly.

(7) The emergency hydraulic shutoff valve will shutoff the flow of fluid to the directional actuator and the tail wheel lock control valve when the fluid level is low.

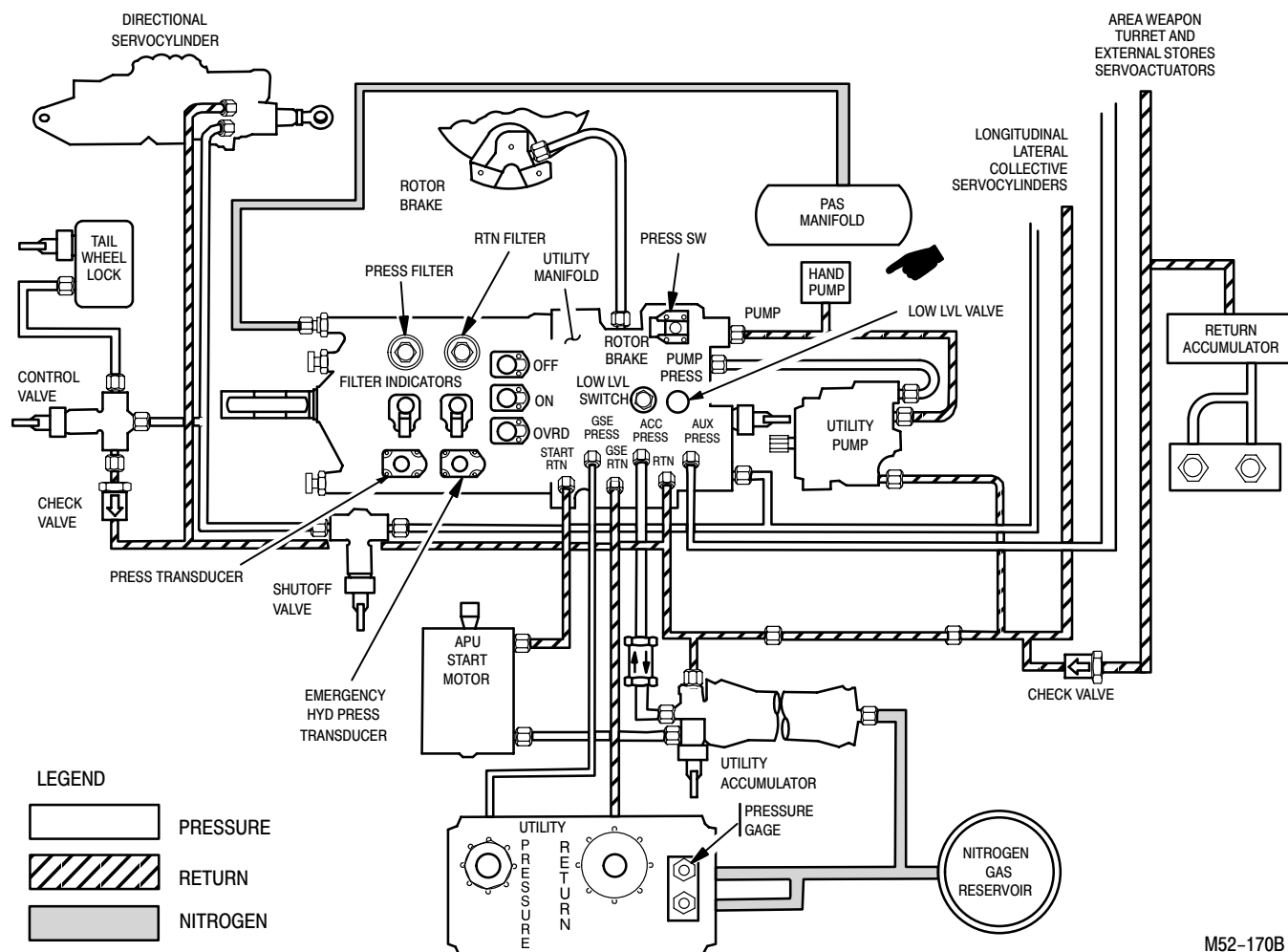
(8) When the APU start sequence is initiated, the APU start motor is supplied with hydraulic pressure from the accumulator.

(9) Pressurized fluid in the accumulator can also be used as a limited power source for the flight control servocylinders.

(10) The system can be operated in a static mode by connecting a ground power unit to the utility GSE panel assembly return and pressure couplings. Nitrogen servicing of the utility accumulator is also accomplished at the utility GSE panel assembly.

10-3. THEORY OF OPERATION (cont)

10-3



M52-170B

Figure 10-14. Utility Hydraulic System Functional Diagram

I. Utility System Crew Station Controls And Indicators.

(1) The pilot utility accumulator pressure indicator (fig. 10-15) consists of a numbered, scale dial (0-5), and a dial pointer, and provides visual indication of accumulator pressure. The pilot utility accumulator is mounted to the center of the pilot's instrument panel.

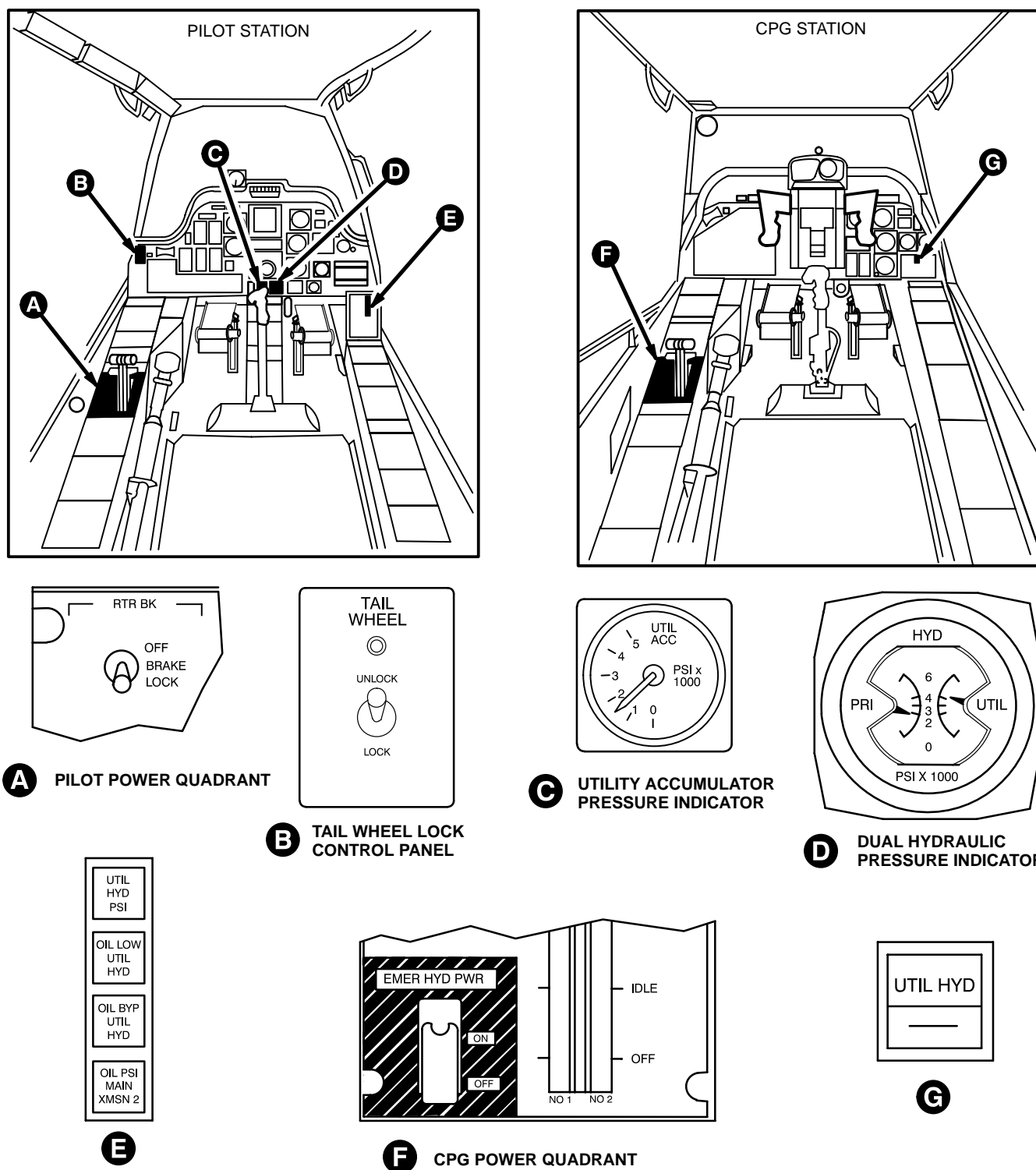
(2) The tail wheel switch controls the application of pressure to the tail wheel lock actuator, and is located upper left side of the pilot's instrument panel.

(3) The rotor brake switch **RTR BK** is a three position switch on the pilot's power quadrant in the lower left console. The rotor brake switch allows the utility system to regulate pressure to stop the rotor brake disc.

(4) The rotor brake caution/ warning light **RTR BK** provides a visual indication of rotor brake on. The rotor brake caution/ warning light is located on the pilot's caution/warning panel.

10-3. THEORY OF OPERATION (cont)

10-3



M52-402A

Figure 10-15. Utility System Crew Station Controls and Indicators

10-3. THEORY OF OPERATION (cont)

10-3

m. Utility Hydraulic Accumulator Assembly.

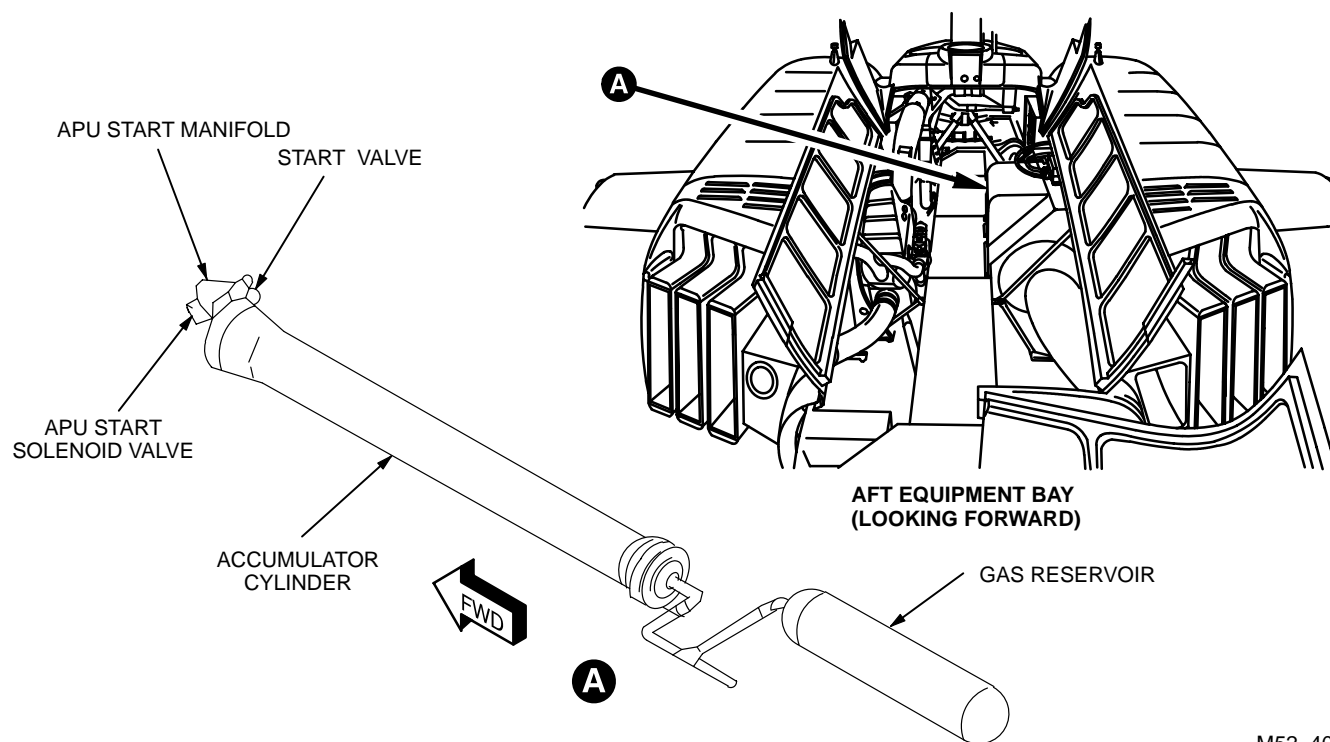
(1) The utility hydraulic accumulator assembly (fig. 10-16) stores hydraulic fluid under high pressure for APU starting, rotor brake operation, and emergency operation of flight control servocylinders.

(2) The accumulator cylinder and gas reservoir are precharged with 1650 psi of nitrogen gas. The precharge causes the accumulator piston to be moved to the manifold end of the accumulator.

(3) The fluid enters the accumulator through the pressure line and start valve.

(4) Fluid entering the accumulator moves the piston back and forth, compressing nitrogen gas until the precharge is obtained.

(5) Fluid pressure is allowed to pass freely through the lower start valve to provide pressure to the utility hydraulic manifold for rotor brake and emergency operation.



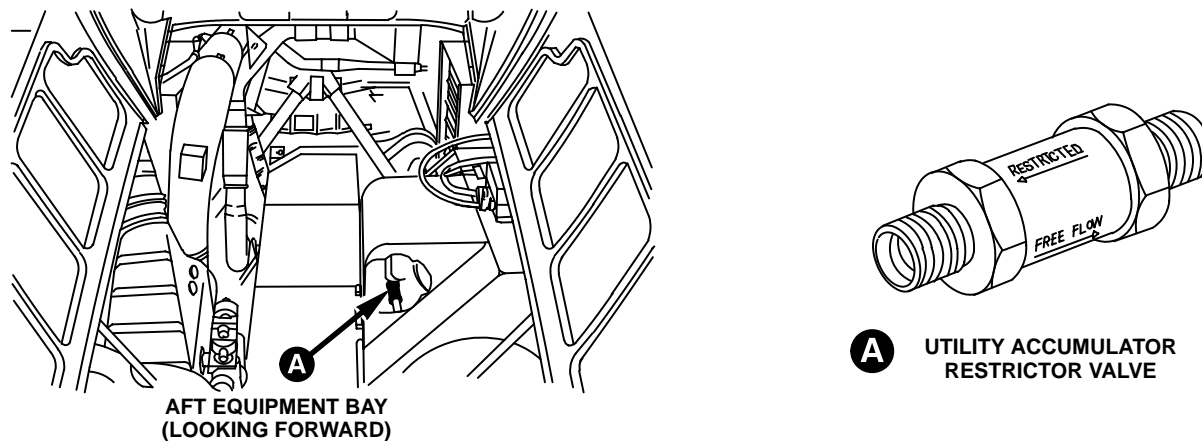
M52-404

Figure 10-16. Utility Hydraulic Accumulator Assembly

(6) The utility accumulator restrictor valve (fig 10-17) limits the rate of fluid that can flow into the accumulator from the utility hydraulic manifold during an APU start. Hydraulic fluid cannot flow from the manifold through the restrictor valve to the accumulator at a rate higher than 1.2 gpm.

10-3. THEORY OF OPERATION (cont)

10-3



M52-405

Figure 10-17. Utility Accumulator Restrictor Valve

n. Utility Hydraulic Ground Service Equipment Panel Assembly.

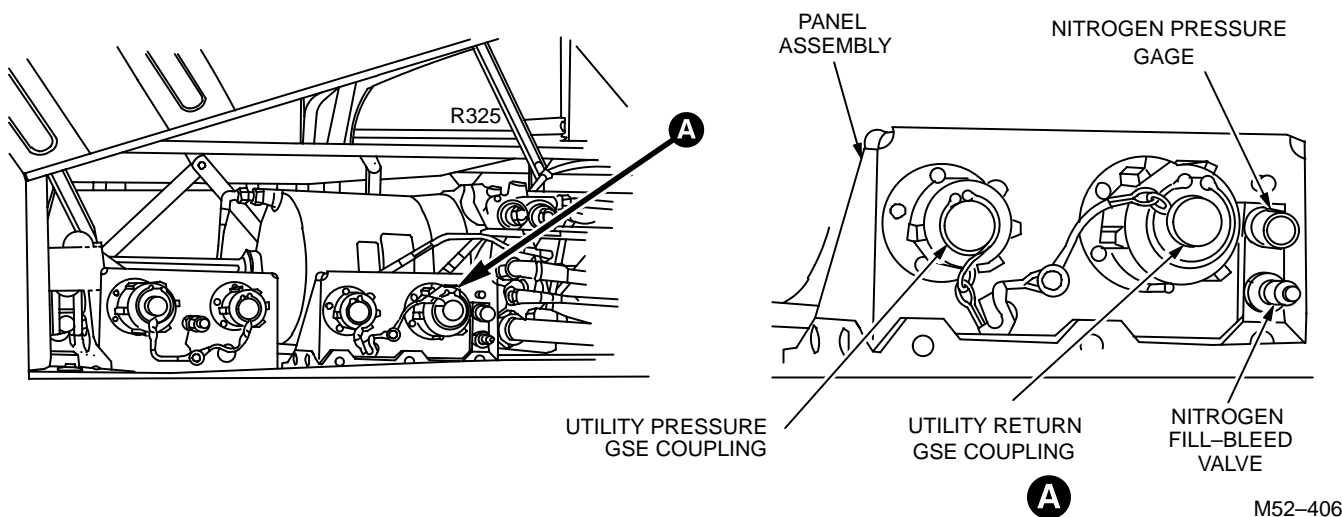
(1) The utility hydraulic ground service equipment panel assembly (fig. 10-18) provides connections to operate the system from an external hydraulic source.

(2) The utility pressure GSE coupling mates with the ground power unit (GPU) pressure hose coupling.

(3) The utility return GSE coupling mates with the GPU return hose coupling and is a quick-disconnect aluminum coupling.

(4) The nitrogen pressure gage provides an indication (0 to 4000 psi) of nitrogen pressure in the accumulator.

(5) The nitrogen fill-bleed valve provides for a means to charge or bleed the gas reservoir and accumulator.



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Figure 10-18. Utility Hydraulic Ground Service Equipment Panel Assembly

10-3. THEORY OF OPERATION (cont)

10-3

o. **Directional Servocylinder.** The directional servocylinder is the tail rotor servocylinder. Operation is the same as the three main rotor servocylinders.

p. **Tail Wheel Lock Control Valve.**

(1) The tail wheel lock control valve (fig. 10-19) controls hydraulic pressure to the tail wheel lock actuator.

(2) The valve is a two-position, three-way solenoid-operated hydraulic valve made of aluminum alloy.

(3) When the tail wheel switch is placed in the **LOCK** position, the control valve solenoid is de-energized shutting off hydraulic pressure to the lock actuator and opening the return line to the manifold reservoir.

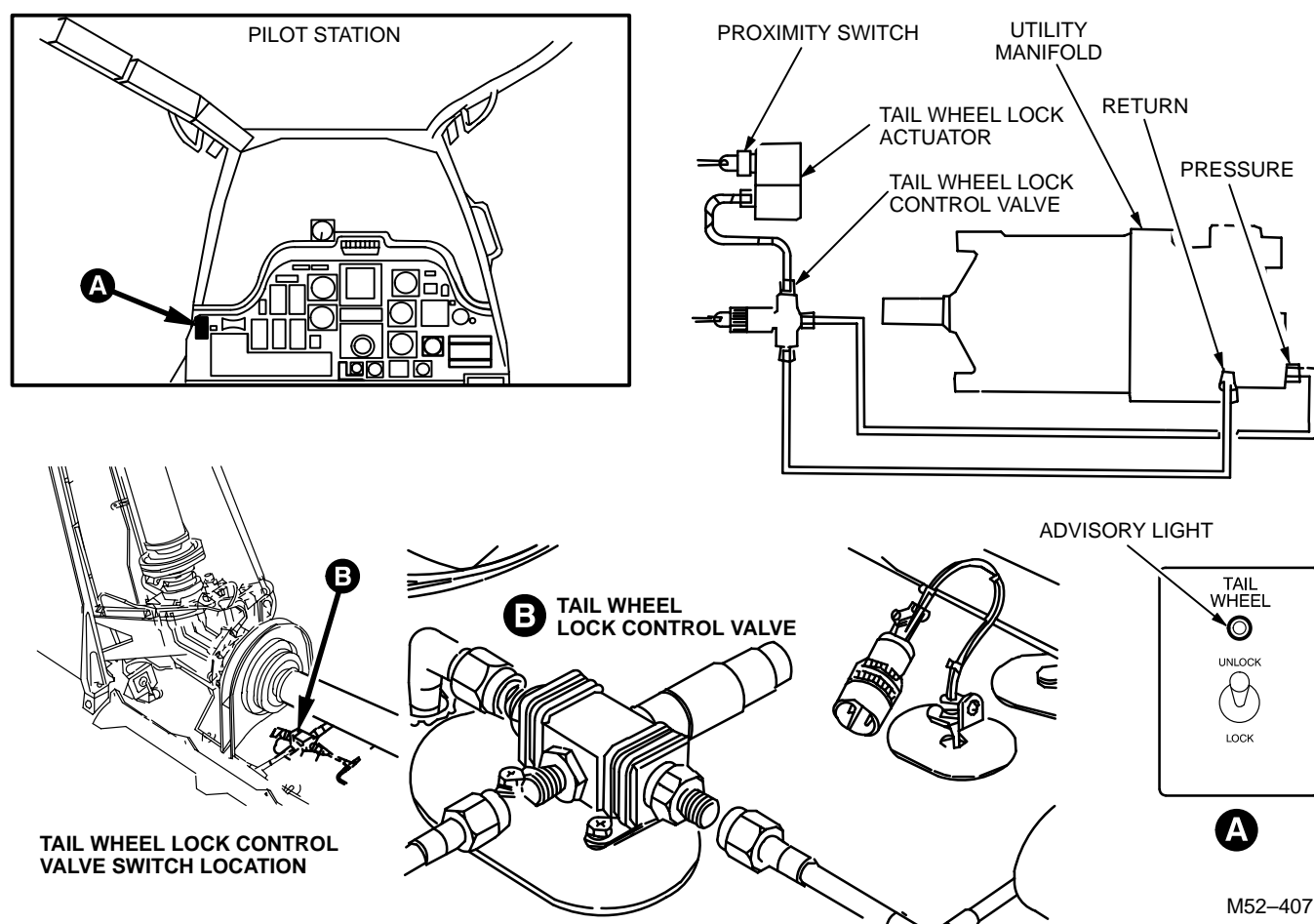


Figure 10-19. Tail Wheel Lock Control Valve

(4) When the tail wheel switch is placed in the **UNLOCK** position, the control valve solenoid is energized closing the return line to the lock actuator and opening the pressure line to the lock actuator.

10-3. THEORY OF OPERATION (cont)

10-3

(5) A proximity switch at the tail wheel lock actuator is closed, completing the circuit illuminating the advisory light on the **TAIL WHEEL** lock panel in the pilot station.

q. **Emergency Hydraulic Shutoff Valve.**

(1) The emergency hydraulic shutoff valve (fig. 10-20) shuts off utility hydraulic fluid flow to the directional servocylinder and tail wheel lock control valve.

(2) During normal utility system operation, the valve is open allowing fluid to flow from the utility manifold to power the directional servocylinder.

(3) If the utility manifold's low-level switch is actuated, a 28 VDC signal will close the emergency hydraulic shutoff valve preventing fluid flow to the directional servocylinder, conserving fluid for use by the main flight control servocylinders.

(4) Closing the valve also shuts off operating fluid to the tail wheel lock control valve.

(5) The tail wheel lock control valve controls hydraulic pressure to the tail wheel lock actuator. The valve is a two-position, three-way solenoid-operated hydraulic valve. The **TAIL WHEEL** unlock advisory light is located above the switch.

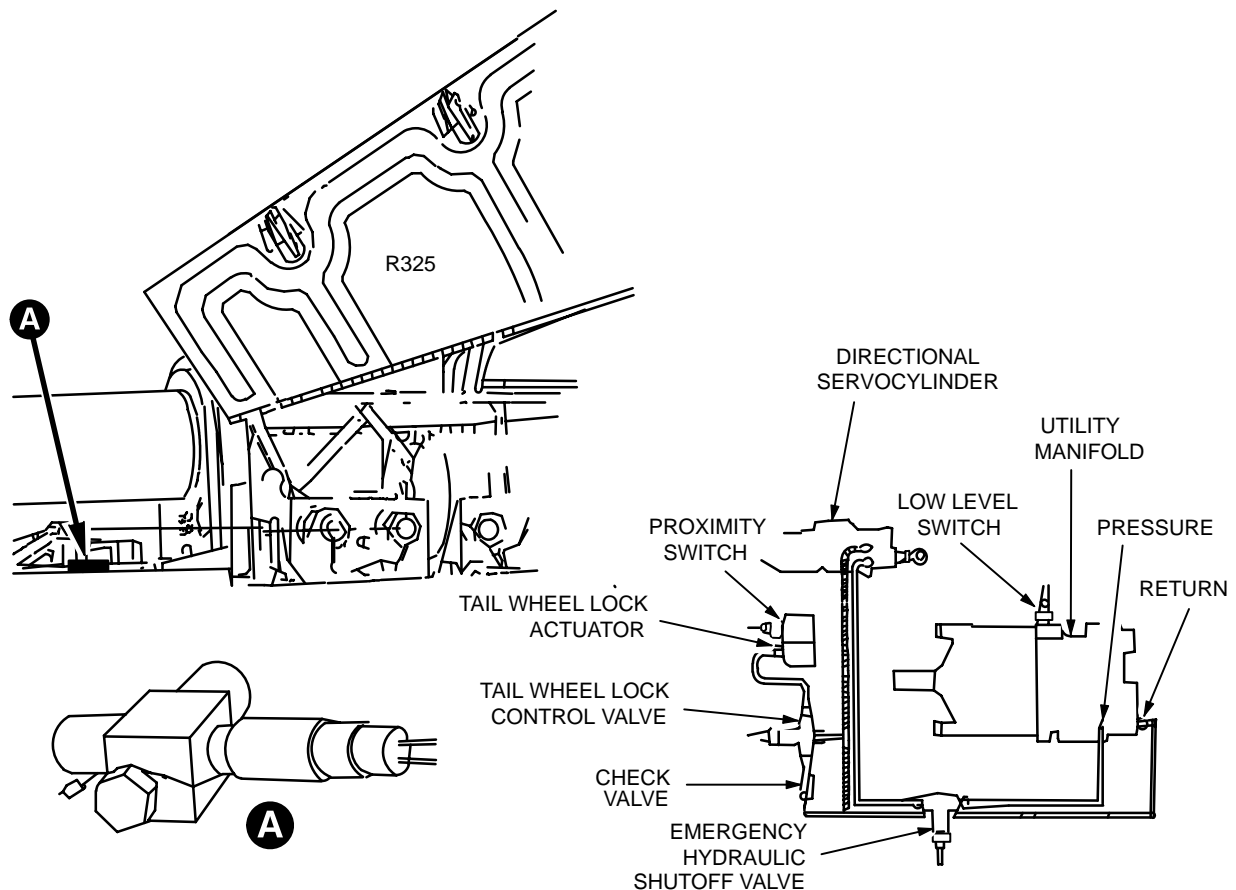


Figure 10-20. Emergency Hydraulic Shutoff Valve

10-3. THEORY OF OPERATION (cont)

10-3

r. **Utility Hydraulic Manifold Components.** The utility hydraulic manifold (fig. 10-21) stores, controls, filters, and routes hydraulic fluid to components using utility hydraulic system pressure. The utility hydraulic system components are described as follows.

(1) The reservoir stores low pressure hydraulic fluid for system operation. The reservoir is bolted to the utility hydraulic manifold housing. Normal reservoir operating capacity is 1.3 gallons and fluid in the reservoir is pressurized to 30 ± 5 psi by the PAS.

(2) The dirty filter indicator (return and pressure) provides visual indication at the manifold and at the pilot station (**OIL BYP UTIL HYD**) of a clogged filter condition. The indicator consists of an electrical pop-up indicator that senses differential pressure. If clogging causes a pressure differential between the inlet side and the outlet side of 60 to 80 psi, the indicator will pop-up.

(3) The pressure transducer senses utility system pressure available to user components and sends a signal to the utility side of the dual hydraulic pressure indicator in the pilot station. System pressure is sensed at the manifold and is converted to a voltage.

(4) The pressure switch provides system low fluid pressure indication in both crew stations and mates with the sensing port providing a signal to the pilot **UTIL HYD PSI** light and the CPG **UTIL HYD** light.

(5) The low level valve is operated by the reservoir piston when a low fluid level condition exists. The valve prevents system pressure from being routed to the auxiliary isolation valve.

(6) The low level switch along with the low level valve senses low fluid level. When the piston contacts the switch, the **OIL LOW UTIL HYD** caution light in the pilot station illuminates.

(7) The accumulator isolation inlet check valve prevents accumulator pressure from entering the system pump when the pump is not operating.

(8) The accumulator isolation valve allows pump pressure to flow to flight control servocylinders and auxiliary equipment while isolating accumulator pressure when pump pressure is not available. Pump pressure acting on the valve unseats pistons, allowing fluid to pass through system components.

(9) The pressure filter and return filter are made of corrosion resistant steel wire mesh. The filter cleans incoming fluid from the pump, filtering particles larger than 5 microns.

(10) The rotor brake-off solenoid valve and the rotor brake-on solenoid valve controls and directs fluid to the transmission mounted rotor brake. There are two brake-hold check valves and two solenoids S2 (brake off) and S1 (brake on). The two check valves control fluid routing when pressures are applied to different areas of the valves. The solenoids are operated by 28 VDC and control fluid pressure for rotor brake operation.

(11) The override solenoid valve allows accumulator pressure to enter the system for emergency flight control operation. When the pilot or CPG **EMERG HYD** switch is moved to either **EMERG HYD** or **ON** positions, accumulator pressure is allowed to pass through the accumulator isolation valve to the flight control servocylinders.

(12) The APU starter return check valve allows fluid to enter the manifold from the APU starter and prevents a reverse flow. Fluid entering the manifold from the APU starter flows through the check valve to the manifold reservoir.

(13) The auxiliary isolation check valve provides the capability of eliminating fluid pressure to auxiliary components automatically during loss of system pump pressure or low fluid level conditions. During emergency hydraulic operation the valve closes preventing fluid flow to auxiliary equipment.

10-3. THEORY OF OPERATION (cont)

10-3

(14) The return filter bypass valve is operated by differential pressure. When returning fluid reaches 100 psi, fluid bypasses the filter eliminating excessive back pressure.

(15) The brake metering valve regulates brake valve fluid pressure. Accumulator fluid flow through the brake valve is restricted by an orifice. The fluid is routed through the brake metering valve which reduces the pressure to 337 psi before the fluid enters the rotor brake to slow down the rotation of the main rotor.

(16) The GSE return isolation valve provides the capability of pressurizing the utility hydraulic system using an external power source. GSE pressure flows through the GSE check valve to the GSE return isolation valve which moves a piston that opens the valve and creates a path to the GSE return port.

(17) The emergency hydraulic pressure transducer senses accumulator fluid and sends a signal to the **UTIL ACC** hydraulic pressure indicator in the pilot station by sensing pressure at the manifold and converting the pressure to an electrical voltage.

(18) The rotor brake-hold check valves are part of the rotor brake operation. When pressure to the two check valves is bled back to the reservoir by the brake-on solenoid, the valves close reducing pressure of the brake metering valve allowing full accumulator pressure to flow to the rotor brake actuator. This locks the main rotor blades in place.

(19) The GSE check valve is a one-way check valve. The valve prevents, along with the return isolation valve, pressurization of the GSE return and pressure lines during normal system operation.

(20) The high pressure relief valve relieves excessive system fluid pressure generated by the pump. The high pressure relief valve senses pump output pressure within the manifold prior to being routed to system components.

10-3. THEORY OF OPERATION (cont)

10-3

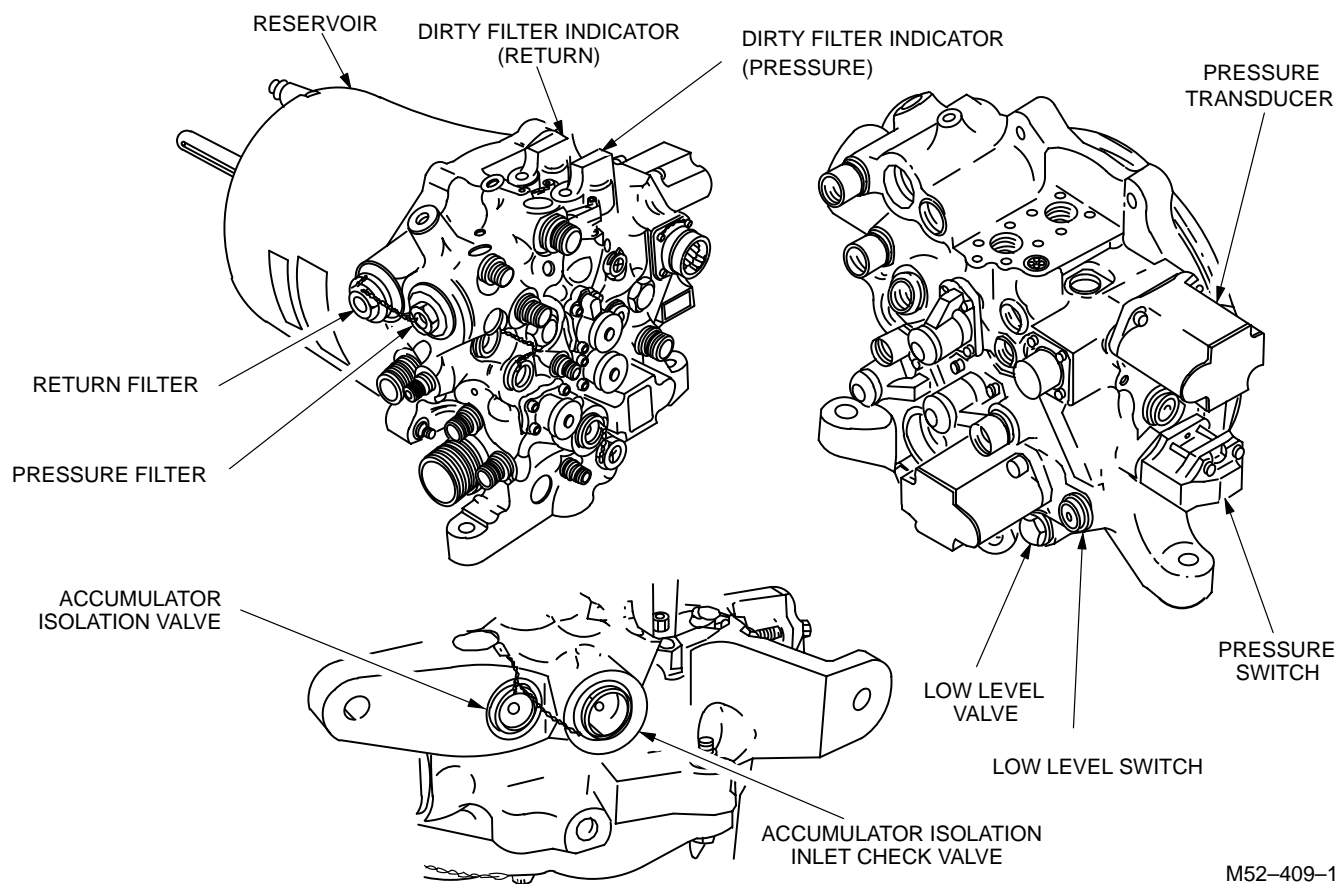


Figure 10-21. Utility Hydraulic Manifold Components (Sheet 1 of 2)

10-3. THEORY OF OPERATION (cont)

10-3

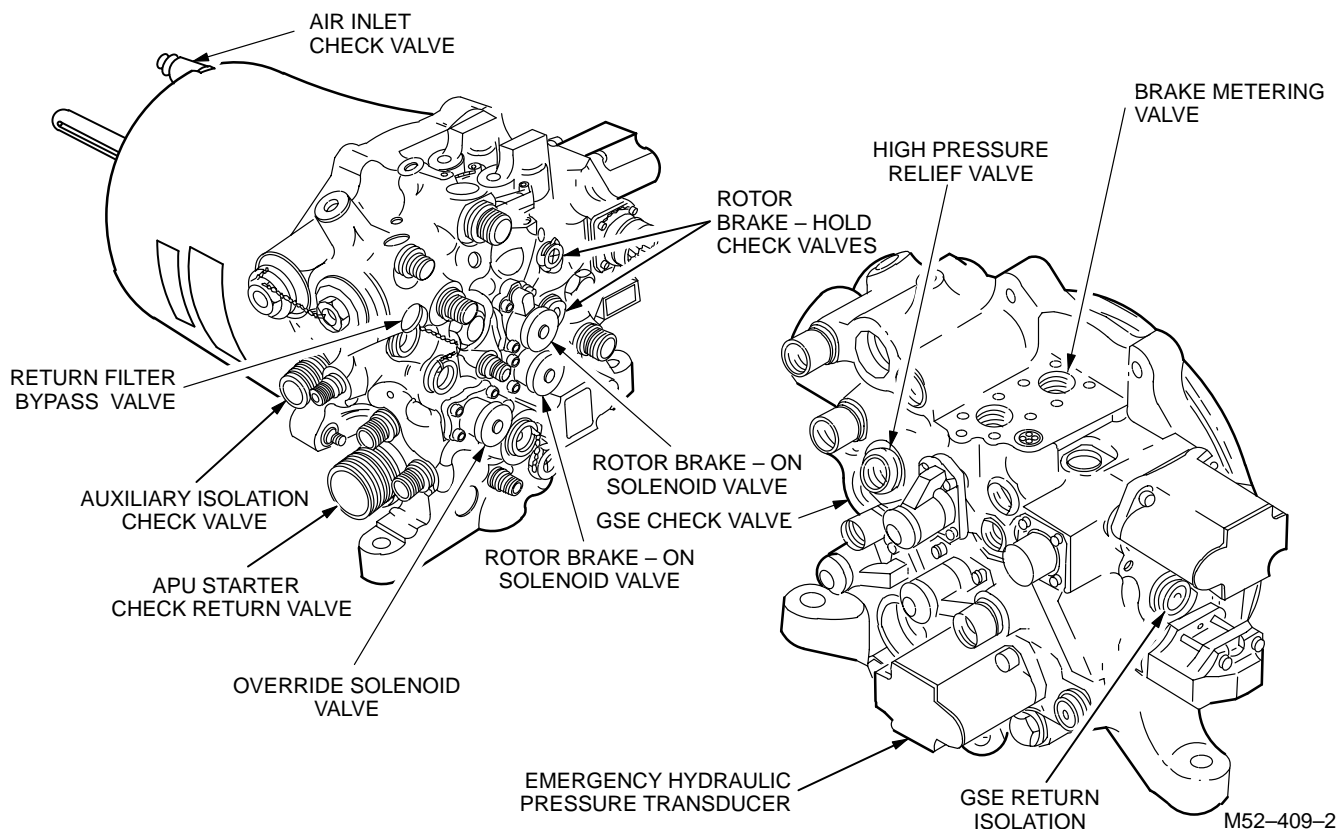


Figure 10-21. Utility Hydraulic Manifold Components (Sheet 2 of 2)

s. Utility Hydraulic Manifold Electrical Operation.

(1) The brake on solenoid (fig. 10-22) energizes when the engine power levels are in **IDLE** or below and the rotor brake switch is in **BRAKE** or **LOCK** position.

(2) The pressure transducer supplies a signal to the utility hydraulic accumulator pressure indicator proportional to accumulator pressure.

(3) The override solenoid is energized when either crewmember activates the **EMER HYD PWR** switch. When energized, utility hydraulic fluid is allowed to enter the manifold for emergency flight control operation.

(4) The pressure switch is normally closed and opens when hydraulic pressure increases to 2050 psi, and closes when pressure decreases to 1250 psi. When closed, the switch provides a ground to illuminate the **UTIL HYD PSI** light on the pilot caution/warning panel and **UTIL HYD** light on the CPG caution/warning panel.

(5) The low level indicator switch closes when fluid level in the reservoir decreases to 10 cu. in. The switch provides a ground to illuminate the **OIL LOW UTIL HYD** light on the pilot's caution/warning panel.

(6) The pressure dirty filter switch and the return dirty filter switch are normally open and close at 60 to 80 psi. The switches are wired in parallel and provide a ground to illuminate the **OIL BYP UTIL HYD** light on the pilot's caution/warning panel.

(7) The brake off solenoid energizes when the rotor brake switch is placed in the **OFF** position.

10-3. THEORY OF OPERATION (cont)

10-3

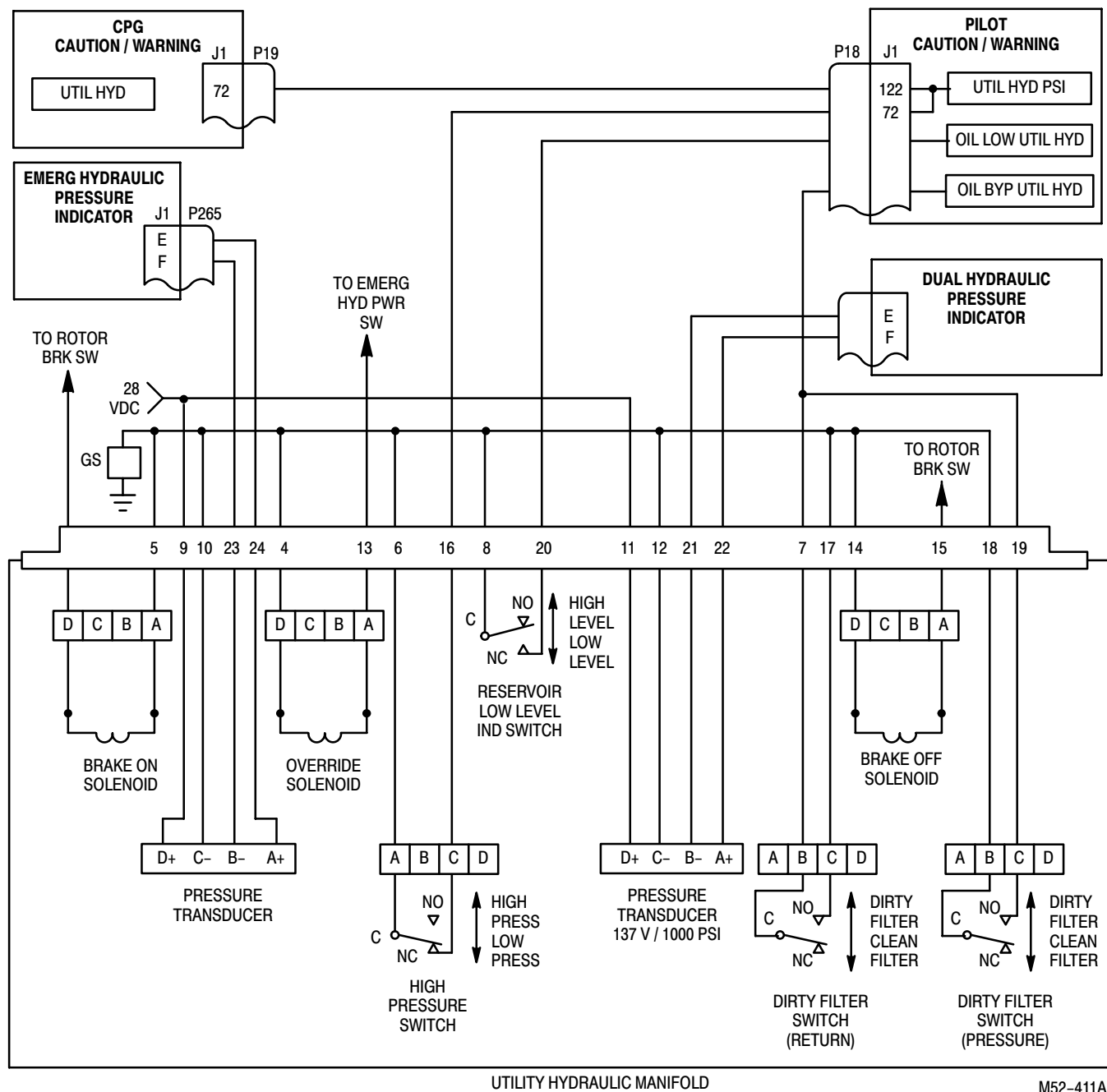
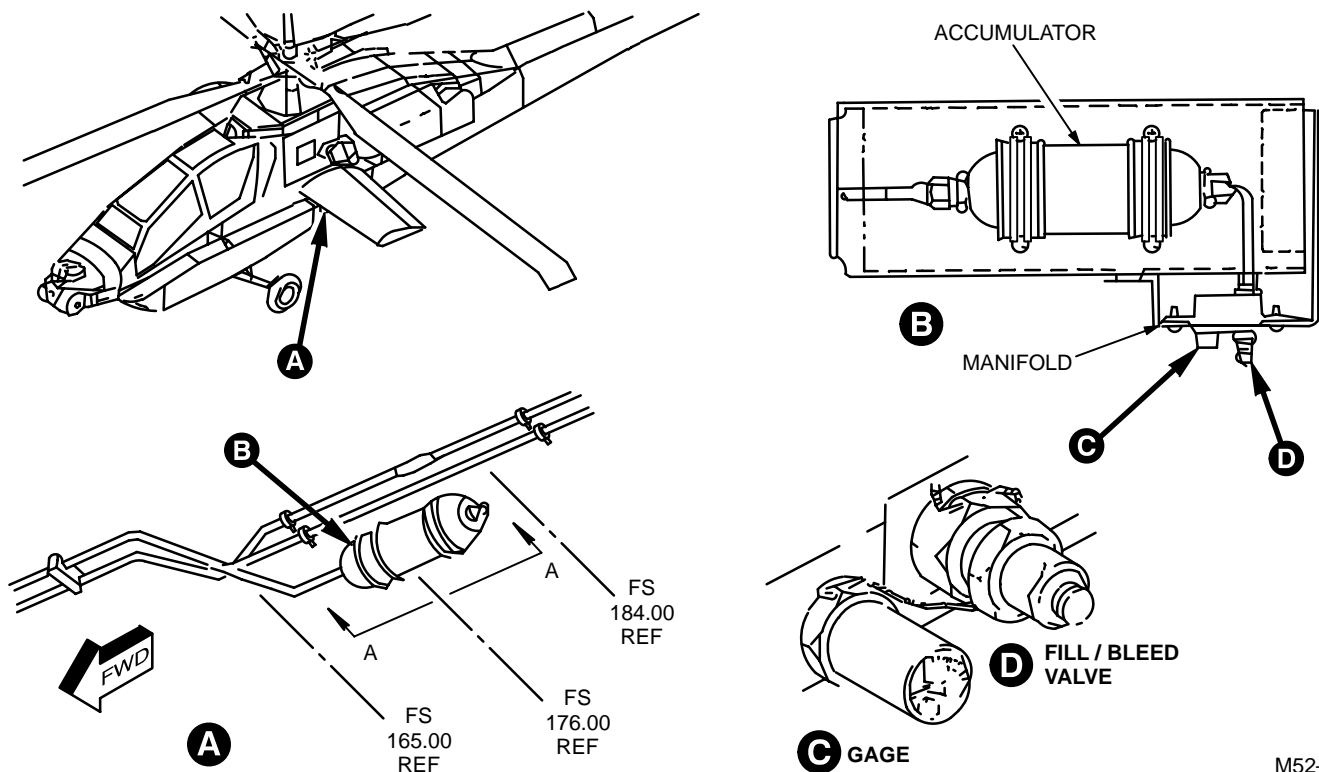


Figure 10-22. Utility Hydraulic Manifold Electrical Diagram

t. **Utility Hydraulic Return Accumulator.** The utility hydraulic return accumulator (fig. 10-23) dampens pressure spikes in the hydraulic system return lines resulting from area weapon subsystem operation.



M52-412

Figure 10-23. Utility Hydraulic Return Accumulator

u. Main Rotor Servocylinders.

(1) Servocylinder operation is the same for the three main rotor servocylinders and the tail rotor servocylinder.

(2) Pressurized fluid from the utility manifold (fig. 10-24) enters the servocylinder through port P2. Fluid is routed internally through a one-way check valve.

(3) The check valve prevents pressurized fluid from being forced back through the pressure port.

(4) The position of the manual servo valve and stability augmentation actuator determine if fluid pressure and return are held or routed to one side of the piston or the other. When one side of the piston is pressurized the other side is routed to the return port.

(5) The manual servo valve and stability augmentation actuator control both primary and utility system fluids in the servocylinder.

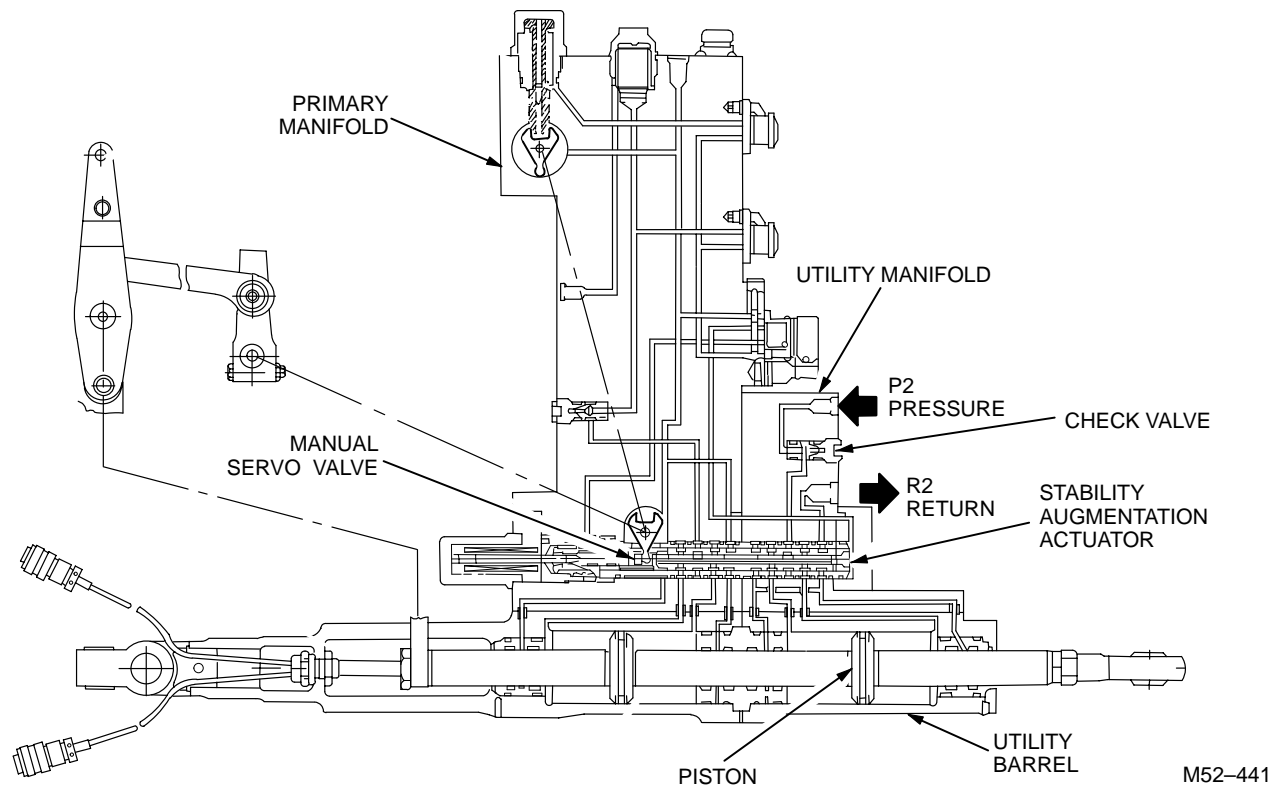


Figure 10-24. Servocylinder Operation

v. **Utility Hydraulic Pump.** The utility hydraulic pump (fig. 10-25) pressurizes system low pressure fluid to a high pressure for system component operation and is interchangeable with the primary hydraulic pump.

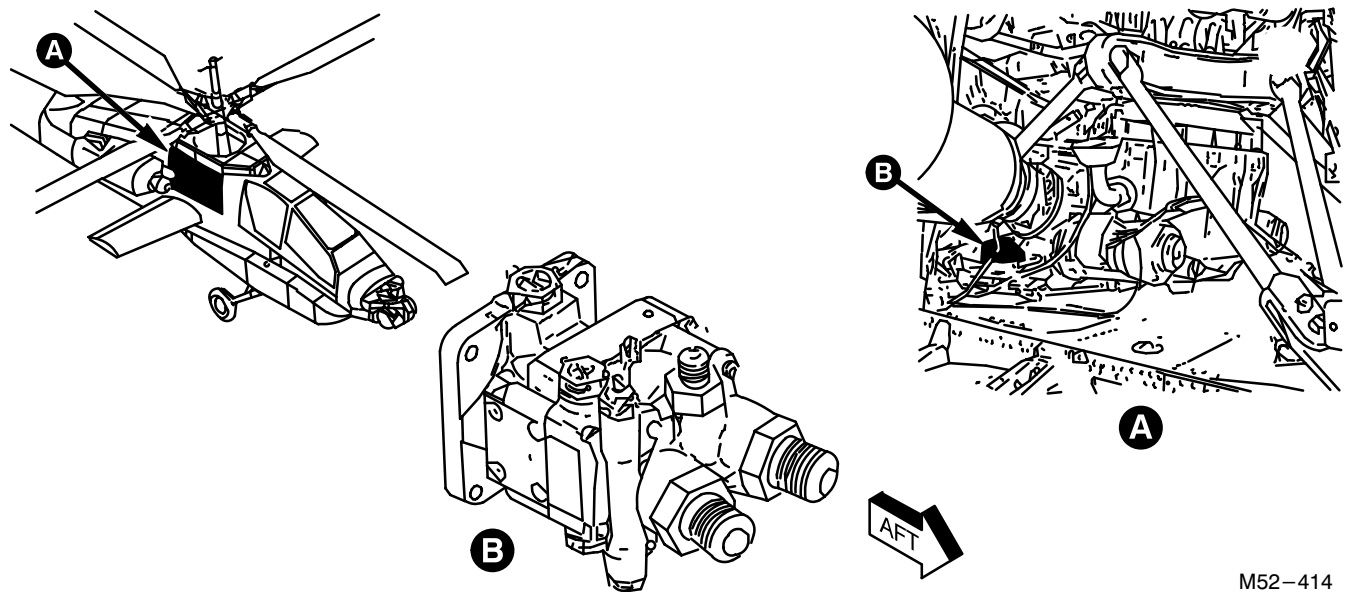


Figure 10-25. Utility Hydraulic Pump

CHAPTER 11 FLIGHT CONTROLS SYSTEM

11-1. PURPOSE

The flight controls system establishes vertical (up and down), longitudinal (forward and backward), lateral (left and right), and directional (heading) flight of the helicopter through crew-initiated mechanical inputs. Helicopter flight control is maintained by demand inputs to the main rotor, tail rotor and stabilator in the pitch, roll, and yaw axes.

11-2. DESCRIPTION

a. System Description.

- (1) Mechanical flight controls are provided for the pilot and CPG.
- (2) Hydraulic pressure boosts crew-initiated control stick and pedal movements by use of servocylinders operating at 3000 psi.
- (3) The primary hydraulic system provides power for the collective, longitudinal, lateral, and directional control servocylinders. The servocylinders (ACB) are grounded to prevent electro-magnetic interference (EMI).
- (4) The utility hydraulic system provides redundant hydraulic power to the servocylinders and utility hydraulic system components.
- (5) Digital automatic stabilization equipment (DASE) aids in stabilizing helicopter flight attitudes and reducing pilot workload.
- (6) Flight control can be maintained by use of a fly-by-wire backup control system (BUCS) if mechanical control is lost. All mechanical control linkages are routed separately from the BUCS to preclude the loss of both systems from a single projectile impact.
- (7) Selectable and adjustable trim/feel units are provided for the cyclic control sticks and directional pedals to maintain desired stick and pedal position.
- (8) A horizontal stabilator improves handling characteristics of the helicopter at various airspeeds.

b. Subsystems. The flight controls system (fig. 11-1) consists of five major subsystems.

- (1) Cyclic Control Subsystem. The cyclic control subsystem consists of various components that are mechanically or electrically actuated by the pilot or CPG, to provide mechanical inputs to the main rotor for longitudinal and lateral control of the helicopter.
- (2) Upper Flight Controls Subsystem. The upper flight controls subsystem consist of hydraulic and mechanical assemblies activated by the collective and cyclic control subsystems, that combine and deliver control inputs to the main rotor head, for vertical, longitudinal, and lateral control of the helicopter.
- (3) Stabilator Control Subsystem. The stabilator control subsystem consists of various components that are electrically activated by the pilot or CPG, to vary the longitudinal control of the helicopter at various airspeeds.

11-2. DESCRIPTION (cont)

11-2

(4) **Collective Control Subsystem.** The collective control subsystem consists of various components that are mechanically or electrically actuated by the pilot or CPG, to provide mechanical inputs to the upper flight controls, for vertical control of the helicopter.

(5) **Directional Control Subsystem.** The directional control subsystem consists of various components that are mechanically or electrically actuated by the pilot or CPG, to provide mechanical inputs to the tail rotor head, for directional and anti-torque control of the helicopter.

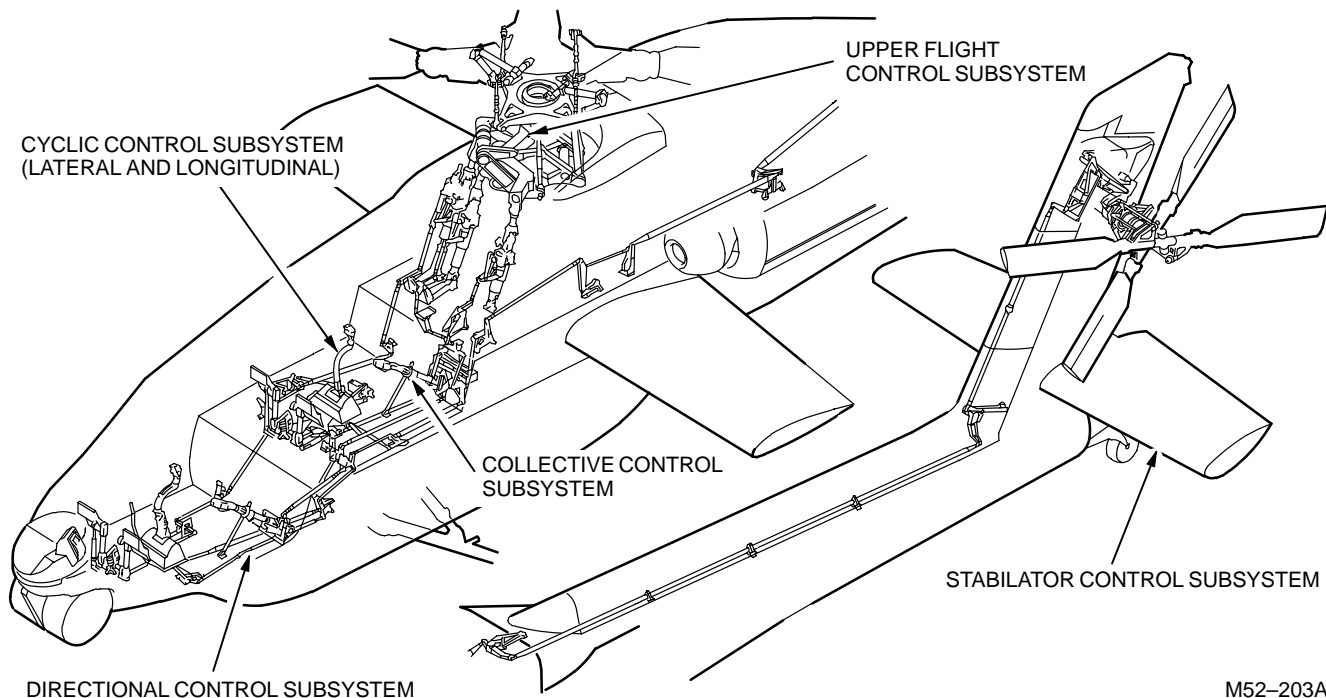


Figure 11-1. Flight Controls Major Subsystems

11-3. THEORY OF OPERATION

a. **Cyclic Control subsystem.** Longitudinal (pitch) and lateral (roll) control of the helicopter is established and maintained by the cyclic control subsystem from either crew station. The cyclic control subsystem major components (fig. 11-2) are described in the following paragraphs.

(1) The longitudinal servocylinder is a hydraulically operated actuator that is initiated by mechanical or electrical inputs. The longitudinal servocylinder is mounted on the transmission deck, to the left of the main transmission. The servocylinder allows hydraulic power to assist the longitudinal mechanical control linkage, to provide inputs that move the upper flight controls forward or aft.

(2) The lateral servocylinder is a hydraulically operated actuator that is initiated by mechanical or electrical inputs. The lateral servo cylinder is mounted on the transmission deck, to the right of the main transmission. The servocylinder allows hydraulic power to assist the lateral mechanical control linkage, to provide inputs that move the upper flight controls left or right.

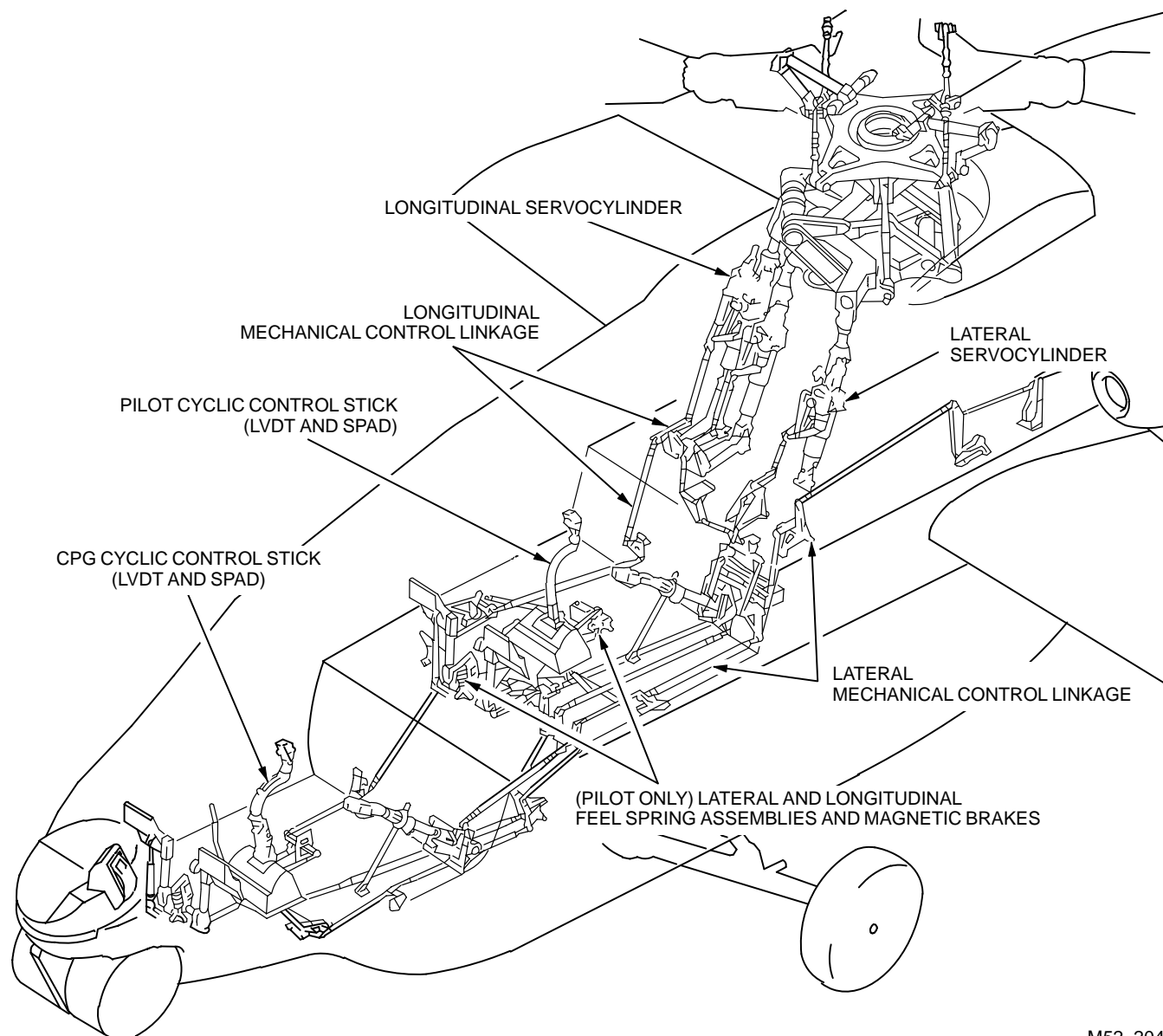
(3) The longitudinal mechanical control linkage incorporates various bellcranks and push-pull tubes constructed of aluminum alloy. The linkage is routed through the right side of the fuselage. The linkage provides longitudinal cyclic control stick inputs to the longitudinal servocylinder during all phases of flight.

11-3. THEORY OF OPERATION (cont)

11-3

(4) The lateral mechanical control linkage incorporates various bellcranks and push-pull tubes constructed of aluminum alloy. The linkage is routed through the left side of the fuselage. The linkage provides lateral cyclic control stick inputs to the lateral servocylinder during all phases of flight.

(5) The pilot and CPG cyclic control sticks are mounted to the floor centerline in each crew station. The cyclic sticks are moved to control the main rotor head for longitudinal and lateral flight control of the helicopter. The cyclic control sticks are moved forward or aft to provide inputs to the longitudinal mechanical control linkage. The cyclic sticks are moved left or right to provide lateral inputs to the lateral mechanical control linkage. If mechanical control is lost, the backup control system (BUCS) will maintain longitudinal and lateral control.



M52-204

Figure 11-2. Cyclic Control Subsystem

11-3

11-3. THEORY OF OPERATION (cont)

11-3

(6) The feel spring assembly (fig. 11-3) is located beneath the pilot cyclic control stick. The feel spring assembly is a spring-loaded device that overrides the magnetic brake assembly when the cyclic control stick is moved against the assembly. The feel spring assembly allows cyclic control stick inputs to override the longitudinal and lateral flight trim setting. When the cyclic control stick is not engaged against the feel spring assembly, the longitudinal and lateral flight trim maintain the current trim position.

(7) The magnetic brake assembly is located beneath the pilot cyclic control stick. The magnetic brake assembly is a 28 VDC controlled unit that engages to lock and establish a new trim position. The unit disengages to unlock and track the cyclic control stick position.

(8) Two linear variable differential transducer (LVDT) assemblies are located at the base of the cyclic control stick (fig. 11-4). One monitors cyclic control stick longitudinal movements, and the other monitors cyclic control stick lateral movements. Each LVDT generates an electrical signal proportional to cyclic control stick movement which is sent to the DASEC. BUCS is activated when the LVDTs sense a difference between the control input and servo output. The LVDTs (ACB) are grounded to prevent EMI.

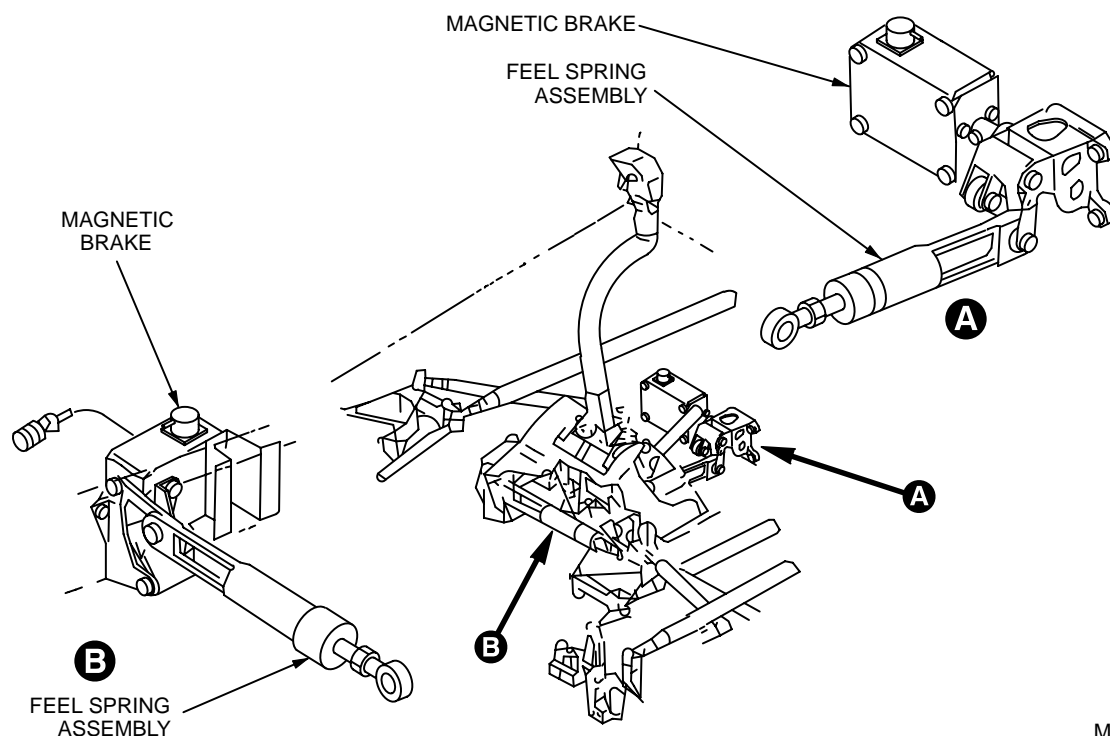
(9) Two shear pin activated decoupler (SPAD) assemblies are attached to the bellcrank assembly of each cyclic control stick (fig. 11-4). One SPAD initiates BUCS operation during longitudinal mechanical control linkage jam or sever, and the other initiates BUCS operation during lateral control linkage jam or sever.

(a) When the longitudinal mechanical control linkage jams, the CPG applies a 50 pound force (pilot 43 pound force) to the cyclic control stick to break the longitudinal SPAD shear pin, severing the longitudinal control linkage. The SPAD switch assembly initiates BUCS operation, and illuminates the pilot or CPG **BUCS ON** light on the caution/warning panels.

(b) When the lateral mechanical control linkage jams, the CPG applies a 30 pound force (pilot 26 pound force) to the cyclic control stick to break the lateral shear pin, severing the lateral control linkage. The SPAD switch assembly initiates BUCS operation, and illuminates the pilot or CPG **BUCS ON** light on the caution/warning panels.

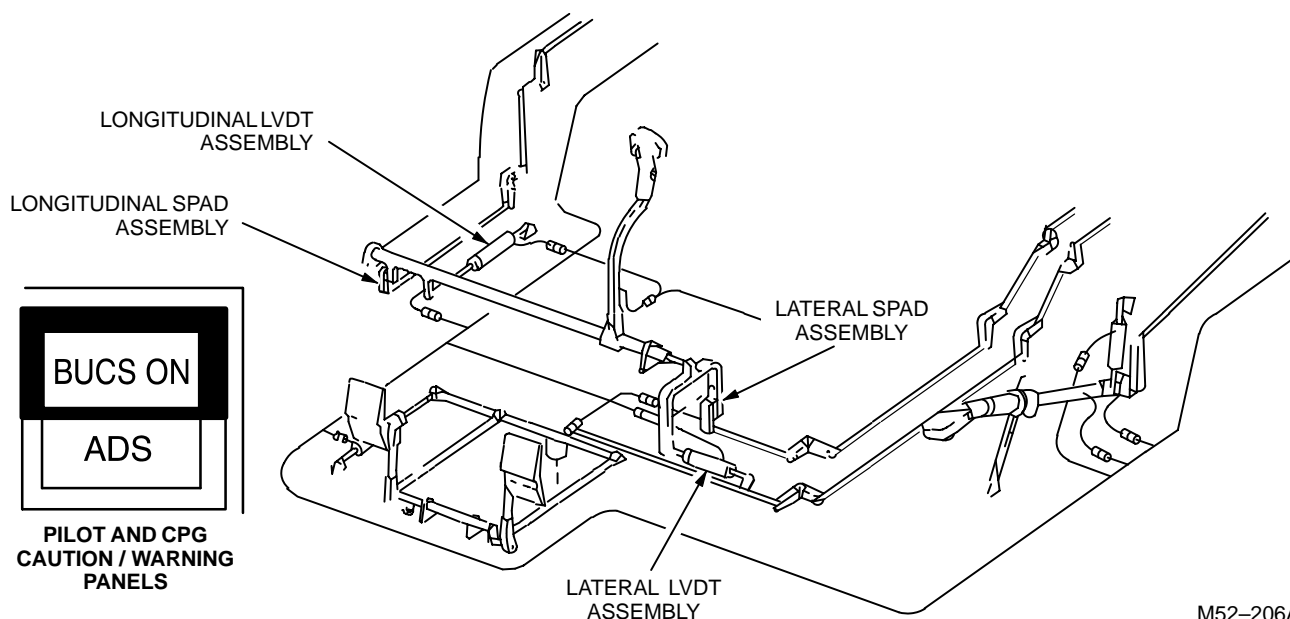
11-3. THEORY OF OPERATION (cont)

11-3



M52-205

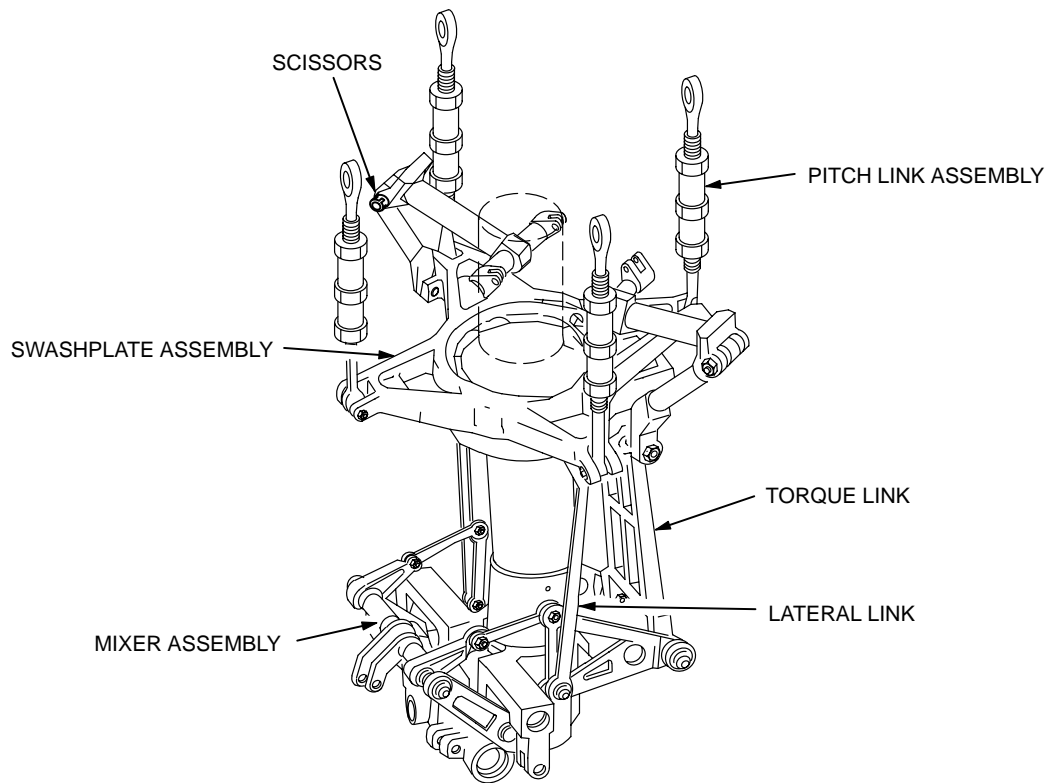
Figure 11-3. Cyclic Control Subsystem Feel Spring and Magnetic Brake Assemblies



M52-206A

Figure 11-4. Cyclic Control Subsystem LVDT and SPAD Assemblies

b. **Upper Flight Controls.** The upper flight controls combine inputs received from the collective and cyclic control subsystems for vertical, longitudinal, and lateral flight control of the helicopter. The upper flight controls major components (fig. 11-5) are described in the following paragraphs.



M52-207

Figure 11-5. Upper Flight Controls

(1) The scissors are aluminum arms connected to the swashplate assembly and the main rotor head. The scissors transmit rotational drive power to the swashplate assembly from the main rotor head.

(2) The pitch link assemblies are mounted between the swashplate assembly and the horns on the pitch housings. The four adjustable pitch links receive and transmit linear motion from the swashplate assembly to the pitch change horns. The pitch link assemblies are adjustable to facilitate main rotor blade tracking.

(3) The torque link is constructed of heavy steel and mounts between the mixer assembly and swashplate assembly. The torque link prevents the stationary portion of the swashplate assembly from rotating. The torque link also moves the swashplate up or down during helicopter vertical flight, and forward or aft during longitudinal flight in accordance with inputs received from the collective and cyclic sticks.

(4) The lateral links (2 ea) mount between the mixer assembly and swashplate assembly to move the swashplate assembly up or down during helicopter vertical flight, and left or right during lateral flight.

(5) The mixer assembly is mounted above the main rotor support base assembly and main transmission. The mixer assembly receives and combines collective and cyclic control subsystem inputs, and transmits linear motion to the swashplate.

(6) The swashplate assembly is mounted on the static mast between the mixer assembly and the main rotor head. The swashplate assembly receives and transmits linear motion from the mixer assembly to the pitch links.

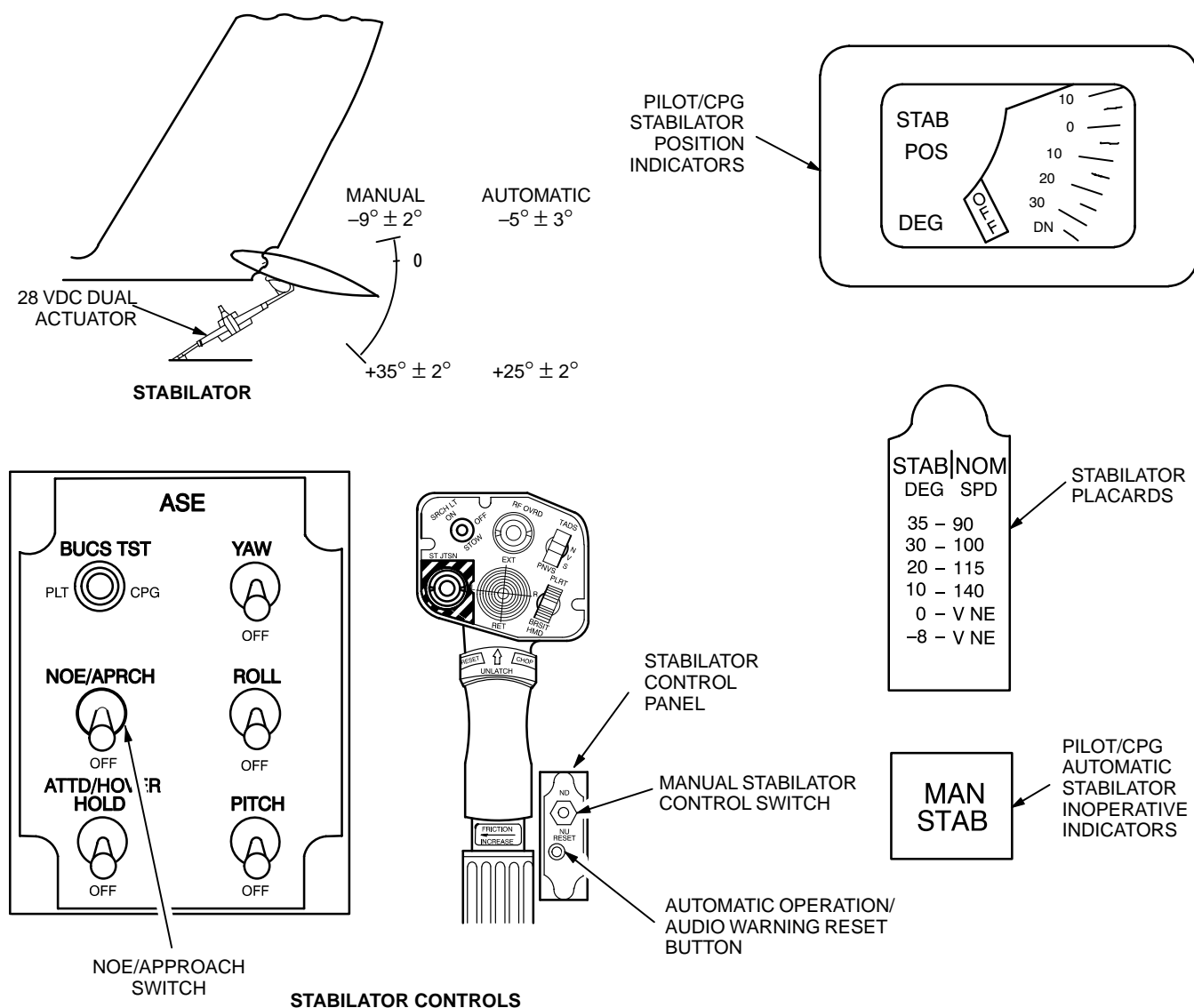
(a) The stationary portion of the swashplate assembly receives linear motion from the mixer assembly. The stationary portion of the swashplate assembly transmits linear motion to the rotating portion of the swashplate assembly.

11-3. THEORY OF OPERATION (cont)

11-3

(b) The rotating portion of the swashplate assembly transmits linear motion to the pitch change links, while receiving rotational drive power from the scissors.

c. **Stabilator Control Subsystem.** The stabilator control subsystem components (fig. 11-6) are described in the following paragraphs.



M52-208

Figure 11-6. Stabilator Control Subsystem

(1) The stabilator is a wing shaped airfoil located at the lower portion of the vertical stabilizer. The stabilator moves up and down to improve handling characteristics and aircrew forward visibility.

11-3. THEORY OF OPERATION (cont)

11-3

(2) The stabilator is moved up or down by two stabilator actuators. The stabilator operates in two modes (automatic and manual) that are controlled by two independent electrical subsystems.

(3) In the automatic mode the stabilator changes position according to airspeed and pitch attitude, above forward airspeeds of 30 knots. In the manual mode the pilot and CPG control the stabilator movement.

(4) The stabilator actuators are two electromechanical units that are driven by two independent dc powered electrical motors. The stabilator actuators are tandem mounted to the bottom of the stabilator and attached to the aft fuselage and tail boom section. The actuators operate in either the automatic or manual mode to position the stabilator.

(5) The indicators are used by the pilot and CPG to monitor the stabilator subsystem. The indicators are described below.

(a) The stabilator position indicators are located in the upper right corner of the pilot and CPG instrument panels to provide stabilator position visual indication.

(b) The stabilator placards are located to the right of the stabilator position indicators for airspeed to stabilator position reference.

(c) The pilot and CPG **MAN STAB** lights on the pilot and CPG caution/warning panels illuminate when the manual stabilator control switch is set to the **UP** or **DOWN** positions.

(6) The controls are used by the pilot and CPG to operate the stabilator control subsystem. The controls are described below.

(a) The **NOE/APRCH** switch is located on the automatic stabilization equipment (**ASE**) panel on the pilot forward left hand console. When set to **NOE/APRCH**, electrical power from the DASE system energizes the stabilator actuator to position the stabilator at 25° trailing edge down at forward airspeeds below 80 knots.

(b) The manual stabilator control switch is mounted on the pilot and CPG collective control stick. When set to **UP** or **DOWN**, dc bus 1 energizes the stabilator actuator to position the stabilator. During manual operation the stabilator can be positioned from -9 ± 2° trailing edge up to +35 ± 2° trailing edge down.

(c) The automatic operation/audio warning reset button is mounted on the stabilator control panel on the pilot or CPG collective control sticks. When the switch is pressed the stabilator subsystem is reset to automatic operation. During automatic operation the stabilator is positioned from -5 ± 3° trailing edge up to 25 ± 2° trailing edge down.

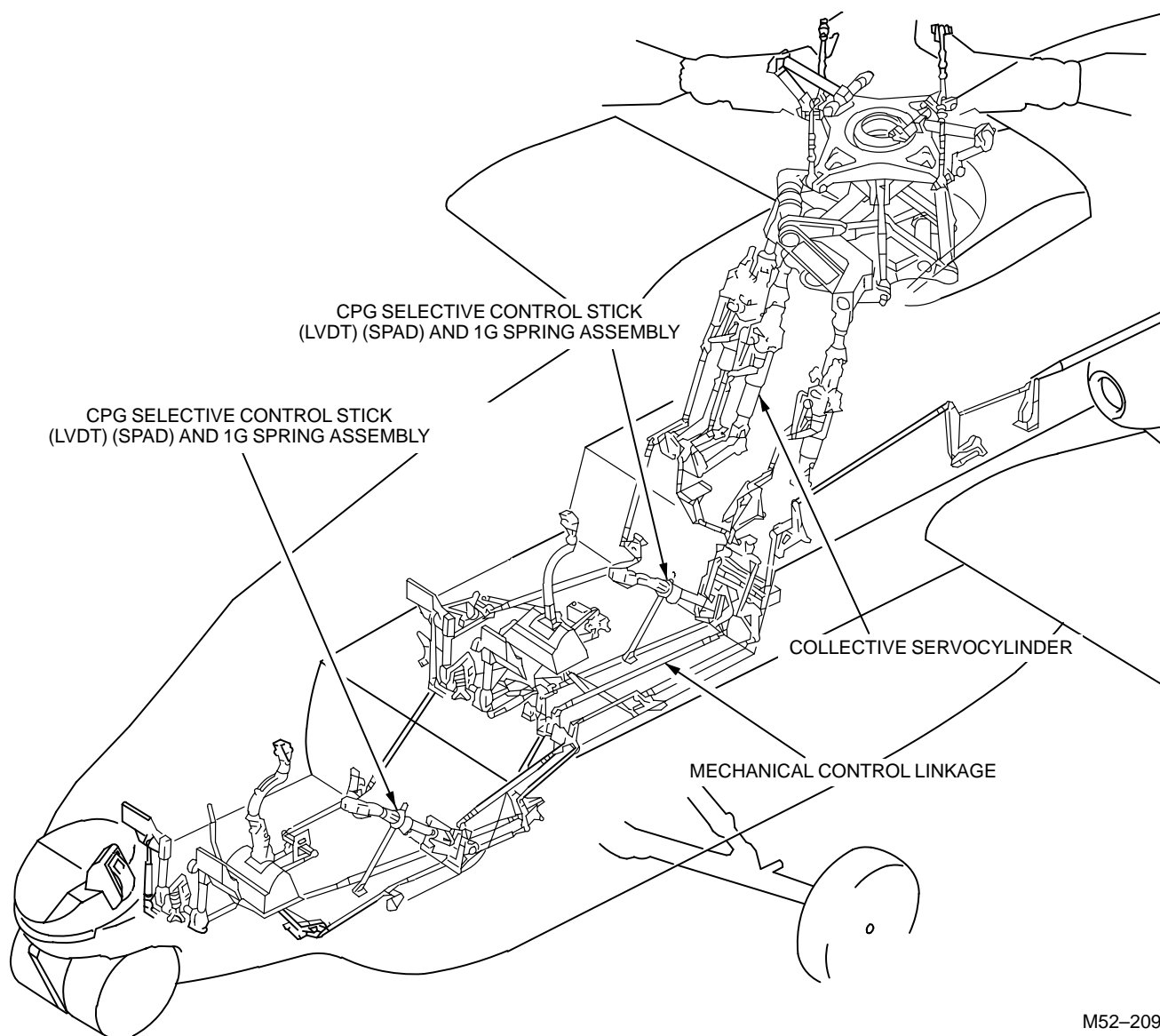
d. **Collective Control Subsystem.** Vertical control of the helicopter is established and maintained by the collective control subsystem from either crew station. The collective control subsystem major components (fig. 11-7) are described below.

(1) The mechanical control linkage incorporates various bellcranks and push-pull tubes made of aluminum. The linkage is routed through the left side of the fuselage. The mechanical control linkage provides collective control stick inputs to the collective servocylinder during all phases of flight.

(2) The collective servocylinder is a hydraulically operated actuator that is initiated by mechanical or electrical inputs. The collective servocylinder is mounted on the transmission deck, center line and forward of the main transmission. The servocylinder allows hydraulic power to assist the mechanical control linkage, to provide inputs that move the upper flight controls up or down.

11-3. THEORY OF OPERATION (cont)

11-3

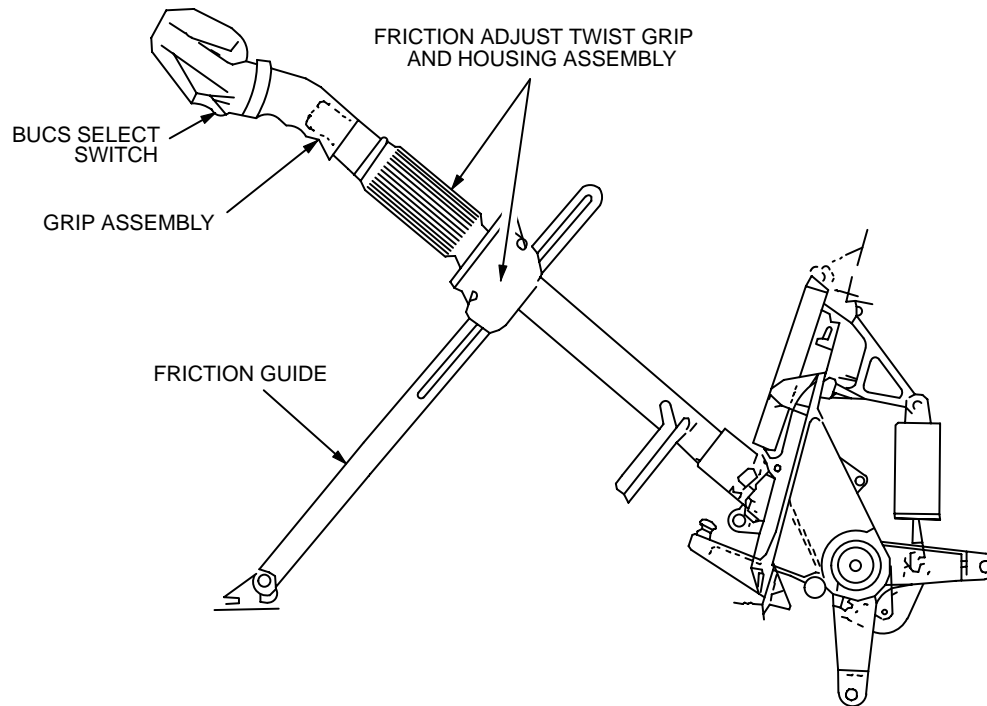


M52-209

Figure 11-7. Collective Control Subsystem Major Components

(3) The pilot and CPG collective control sticks (fig. 11-8) are mounted to the left of the crew seat in the pilot and CPG crew stations. They are moved to control the main rotor head for vertical flight control of the helicopter. The collective control sticks are moved up or down to provide inputs to the mechanical control linkage.

A friction adjust twist grip and housing assembly locks the collective control stick in a desired position. Rotation of the grip (counter clockwise) applies pressure through the housing assembly to the slotted friction guide, holding the collective control stick to the desired position. Rotation of the grip (clockwise) releases pressure, allowing the collective control stick to move. A guarded **BUCS** select switch is mounted on the lower forward portion of the CPG collective control stick. When the guard is raised and the switch pressed **BUCS** control is transferred from the pilot to the CPG.



M52-210

Figure 11-8. Collective Control Stick

(4) Two LVDT assemblies are located at the base of the pilot collective control stick (fig. 11-9). One LVDT assembly is located at the base of the CPG collective control stick. The pilot main rotor engine speed droop LVDT monitors collective control stick movements to provide signals to the engine control units (ECUs) or digital engine control units (DECUs) to maintain 100% rotor RPM. The collective LVDTs monitor collective control stick movements during DASEC command augmentation subsystem (CAS) and BUCS operation. Each LVDT generates an electrical signal proportional to collective control stick movements. The LVDTs are grounded to prevent EMI.

(5) The SPAD assemblies are located at the output linkage of each collective control stick (fig. 11-10). Each initiates BUCS operation during mechanical control linkage jam or sever. When the mechanical control linkage jams, the CPG applies a 45 pound force (pilot 38 pound force) to the collective control stick to break the SPAD shear pin, severing the collective control linkage. The SPAD switch assembly initiates BUCS operation, and illuminates the pilot and CPG **BUCS ON** light on the caution/warning panel.

(6) The collective 1 G spring assemblies (fig. 11-11) are connected to each collective control stick and bulkheads. The collective 1 G spring assembly is a spring assembly that when compressed exerts a force of 54 pounds. The spring assemblies counterbalance the weight of the collective control sticks.

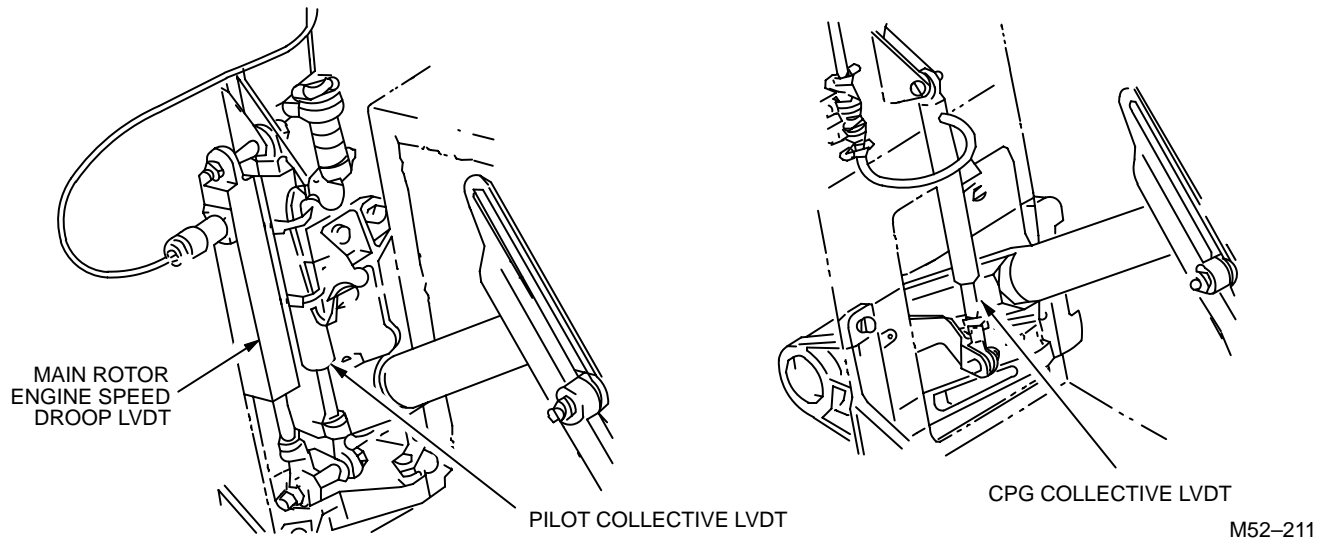


Figure 11-9. Collective Control Subsystem LVDT Assemblies

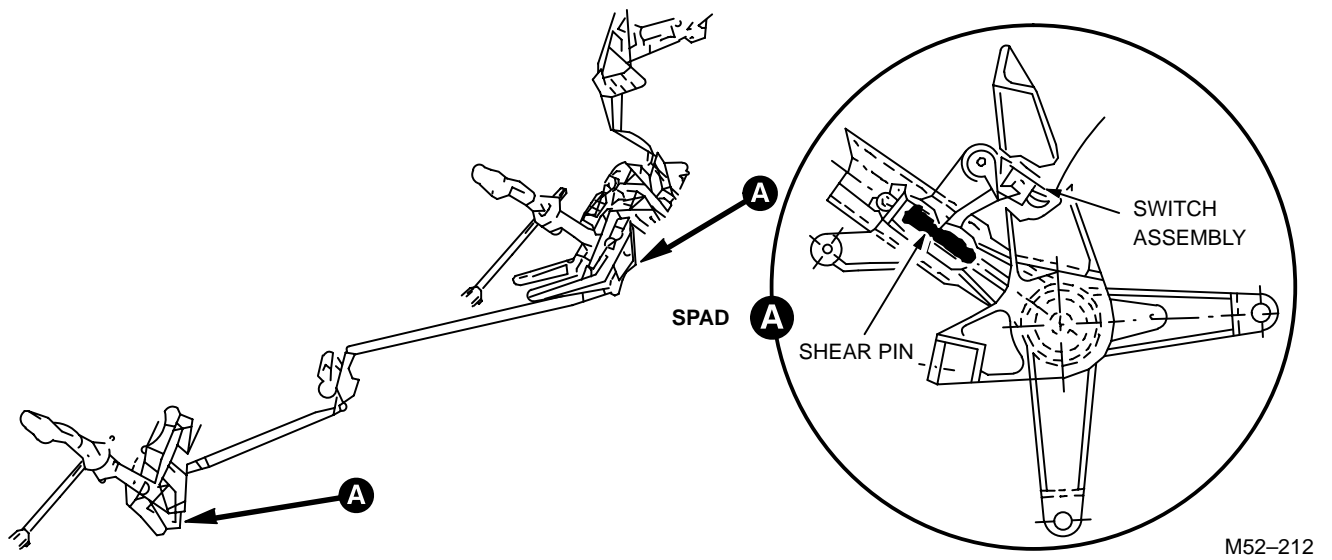
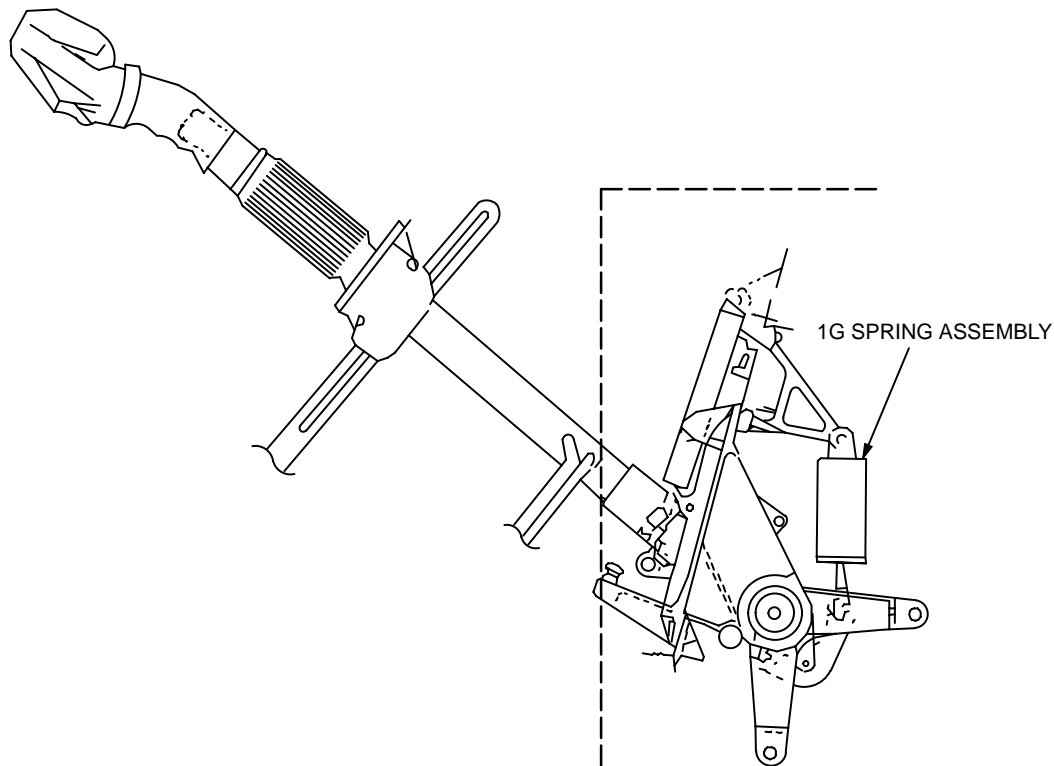


Figure 11-10. Collective Control Subsystem SPAD Assemblies



M52-213

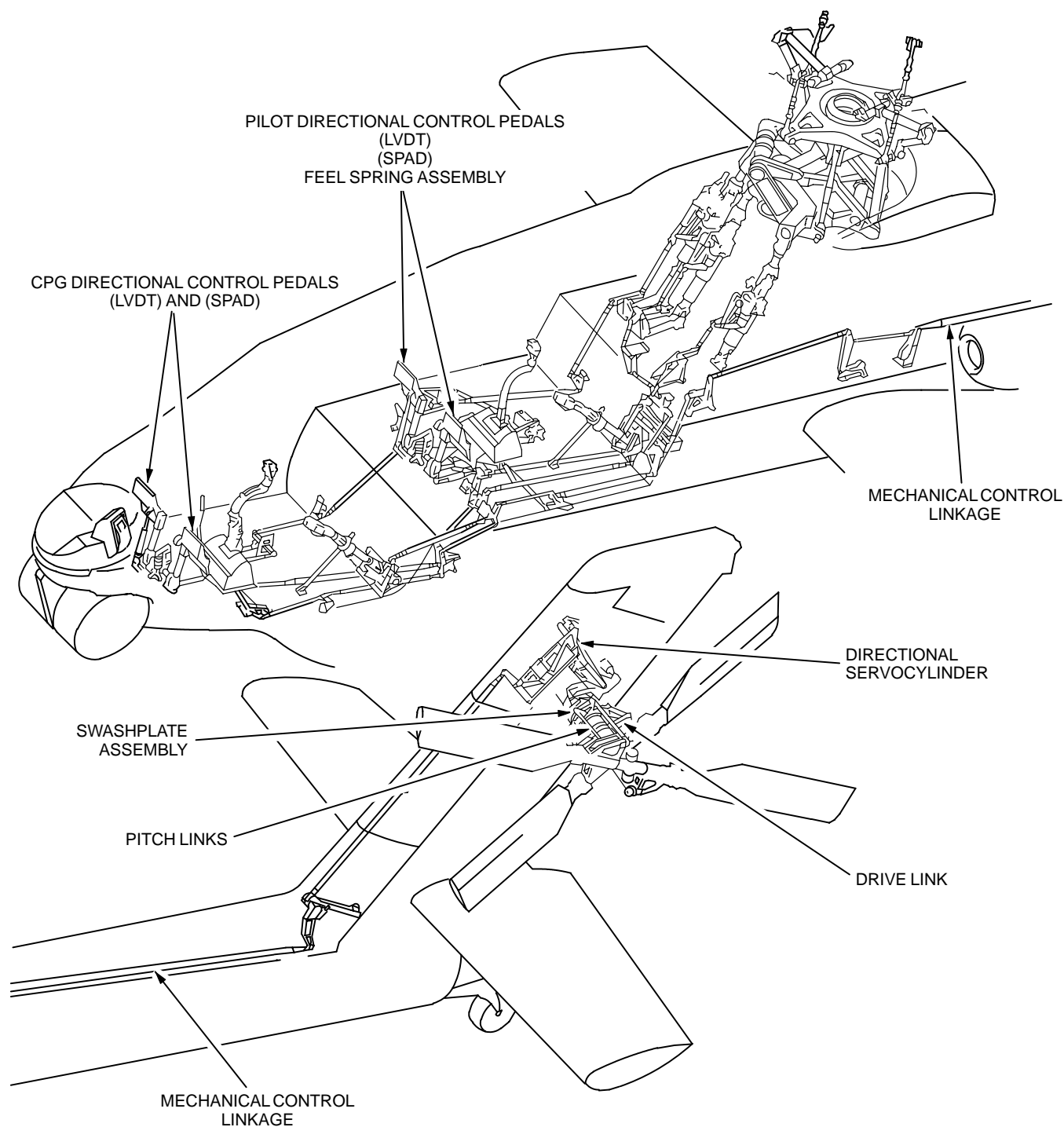
Figure 11-11. Collective Control Subsystem 1 G Spring Assembly

e. **Directional Control Subsystem.** Directional (yaw) and anti-torque control of the helicopter is established and maintained by the directional control subsystem from either crew station. The directional control subsystem major components (fig. 11-12) are described in the following subparagraphs.

(1) The pilot and CPG directional control pedals are located at the floor centerline in each crewstation. The control pedals are moved to control the tail rotor head for directional flight control of the helicopter and to counteract the torque generated by the main rotor head. The control pedals are moved forward and aft to provide inputs to the directional mechanical control linkage.

11-3. THEORY OF OPERATION (cont)

11-3



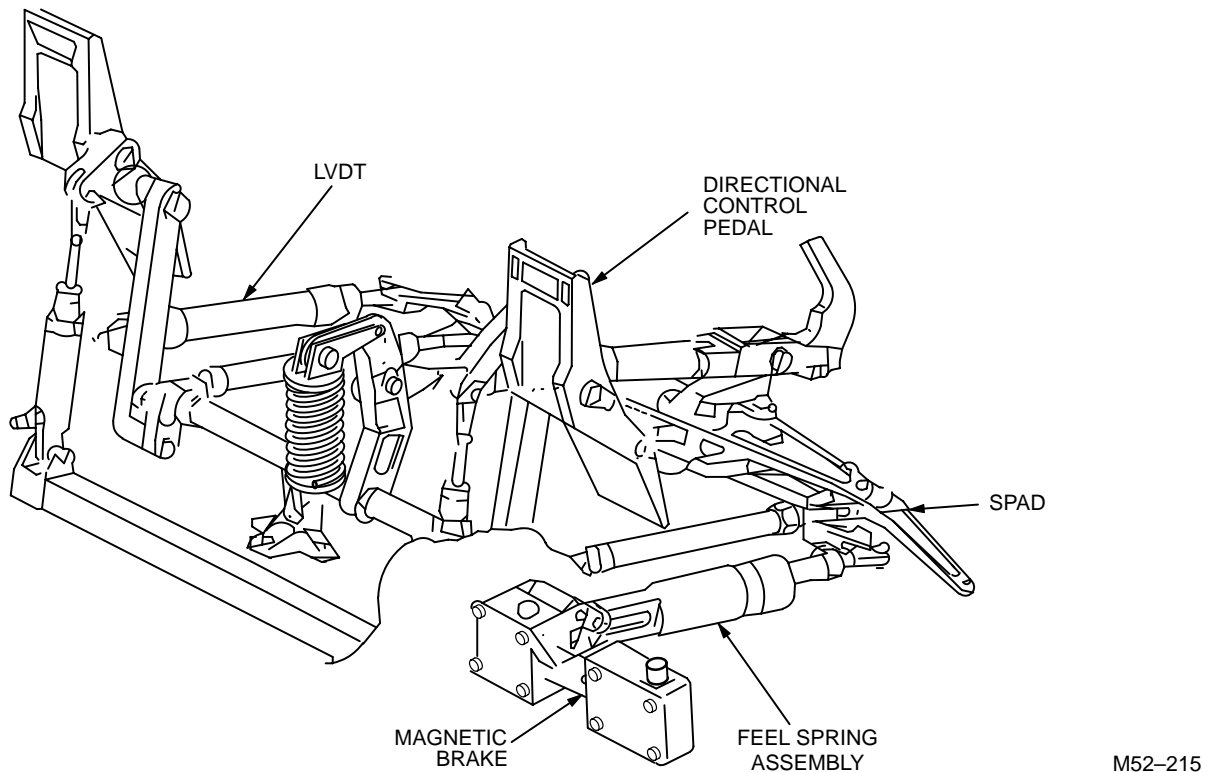
M52-214

Figure 11-12. Directional Control Subsystem Major Components

11-3. THEORY OF OPERATION (cont)

11-3

(2) The LVDT assemblies are located at the base of the directional control pedals (fig. 11-13). They monitor control pedal movements during DASEC CAS and BUCS operation. Each LVDT generates an electrical signal proportional to the directional control pedal movements. The LVDTs are grounded to prevent EMI.



M52-215

Figure 11-13. Directional Control Subsystem LVDTs, SPADs, Feel Spring, and Magnetic Brake Assemblies

(3) The SPAD assemblies are located at the output linkage of each directional control pedal. The SPAD assemblies initiate BUCS operation during directional mechanical control linkage jam or sever.

When the directional mechanical control linkage jams, the CPG applies a 90 pound force (pilot 77 pound force) to either foot pedal to break the SPAD shear pin, severing the directional control linkages. The SPAD switch assembly initiates BUCS operation, and illuminates the pilot and CPG **BUCS ON** light on the caution/warning panels.

(4) The feel spring assembly is located beneath the pilot directional control pedals. The feel spring assembly is a spring-loaded device, that overrides the magnetic brake assembly when the directional control pedals are moved against the assembly. The feel spring assembly allows directional control pedal inputs to override the directional flight trim setting. When the directional control stick is not engaged against the feel spring assembly, the directional flight trim maintains the current trim position.

(5) The magnetic brake assembly is located beneath the pilot directional control pedal. The magnetic brake assembly is a 28 VDC controlled unit that engages to lock and establish a new trim position. The unit disengages to unlock and track the directional control pedals position.

11-3. THEORY OF OPERATION (cont)

11-3

(6) The directional servocylinder is a hydraulically operated actuator that is initiated by mechanical or electrical inputs. The directional servocylinder is horizontally mounted on the top of the tail rotor gearbox on the upper portion of the vertical stabilizer. The servocylinder allows hydraulic power to assist directional mechanical control linkage, to provide inputs that move the tail rotor swashplate assembly.

(7) The tail rotor swashplate assembly (fig. 11-14) is mounted on the tail rotor gearbox static support. The swashplate assembly receives inputs from the directional servocylinder and transmits linear motion to the pitch change links. The stationary portion of the tail rotor swashplate assembly receives inputs from the directional servocylinder and transmits linear motion to the rotating portion of the swashplate assembly. The rotating portion of the tail rotor swashplate assembly transmits linear motion to the pitch change links, while receiving rotational drive power from the drive links.

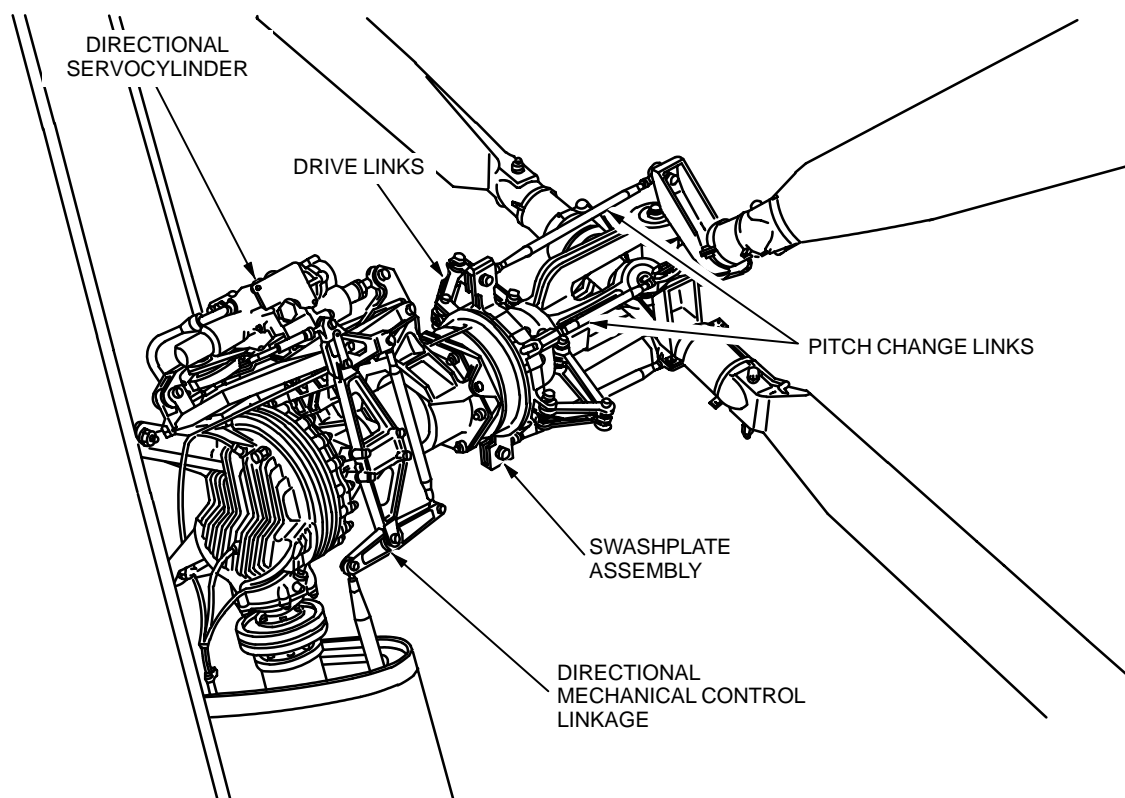


Figure 11-14. Tail Rotor Controls

(8) The drive links (2 ea) are aluminum arms connected to the tail rotor swashplate assembly and the tail rotor head. The drive links transmit rotational drive power to the swashplate assembly from the tail rotor head.

(9) The pitch change links are mounted between the tail rotor swashplate assembly and the tail rotor blades. The four non-adjustable pitch change links receive and transmit linear motion from the tail rotor swashplate assembly to the tail rotor blades.

(10) The directional mechanical control linkage incorporates various bellcranks and push-pull tubes constructed of aluminum alloy. The linkage is routed through the left centerline of the fuselage, along the aft fuselage and tailboom section, and up the vertical stabilizer. The directional mechanical control linkage provides directional control pedal inputs to the directional servocylinder during all phases of flight.

CHAPTER 12 PRESSURIZED AIR SYSTEM

12-1. PURPOSE

The pressurized air system (PAS) cleans, pressurizes, regulates, and distributes air to the pneumatically operated systems and components of the AH-64A. All PAS components are located in the aft equipment bay except the external air and utility receptacles which are located in the bottom of the engine 1 nacelle.

12-2. DESCRIPTION

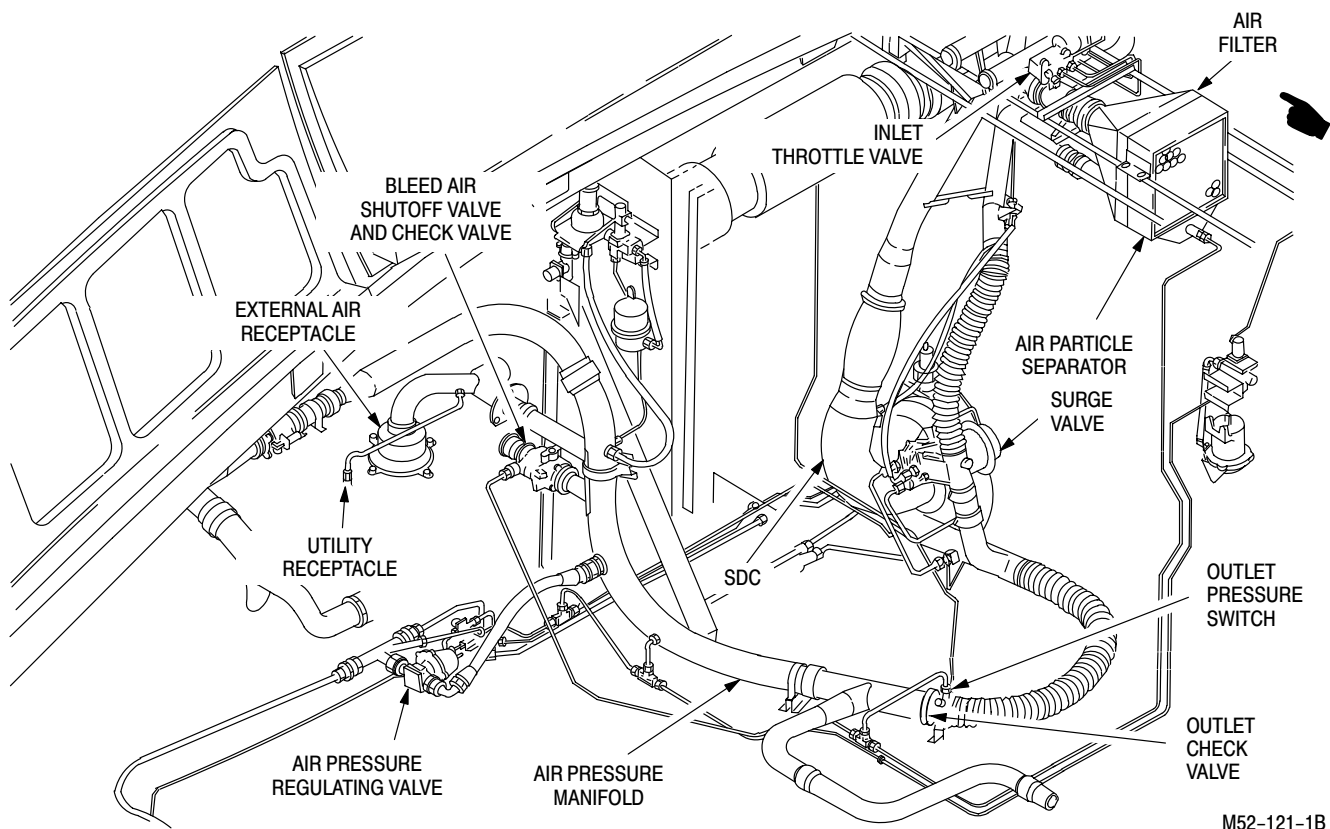
The PAS includes the following major components (fig. 12-1).

- a. **Inlet Throttle Valve.** The inlet throttle valve is an electrically controlled and pneumatically actuated butterfly valve that reduces the APU starting load; mounted to the upper fuselage fairing frame.
- b. **Air Particle Separator.** The air particle separator is a welded aluminum air inlet duct that removes 85 % of the particles 20 microns or larger; mounted to the upper fuselage fairing frame.
- c. **Shaft Driven Compressor (SDC).** The SDC is a single-stage centrifugal compressor encased in an aluminum housing mounted on the left rear face of the main transmission accessory section.
- d. **Surge Valve.** The surge valve is a pneumatically operated, modulating, butterfly valve mounted on the SDC.
- e. **Outlet Pressure Switch.** The outlet pressure switch is a 28 VDC sealed switch mounted on the SDC check valve tube assembly.
- f. **Outlet Check Valve.** The outlet check valve is a pneumatically operated dual flapper valve, mounted on the SDC check valve tube assembly, located between the flexible outlet hose and the air pressure manifold.
- g. **Air Pressure Manifold.** The air pressure manifold is an aluminum alloy tube that receives air from the SDC and distributes the air to the user systems and components; mounted on the aft equipment bay deck.
- h. **Air Pressure Regulating Valve.** The air pressure regulating valve is a pneumatically controlled, diaphragm operated, metering valve mounted on the floor of the aft equipment bay that regulates PAS air for the fuel system.
- i. **Bleed Air Shutoff Valve.** The bleed air shutoff valve is a pneumatically operated poppet valve, mounted on the engine 1 bleed air input and air pressure manifold.
- j. **Bleed Air Check Valve.** The bleed air check valve is a pneumatically operated dual flapper valve which allows air flow in one direction, mounted on the air pressure manifold.
- k. **External Air Receptacle.** The external air receptacle is a one-way corrosion resistant check valve, located on the bottom of the engine 1 nacelle, that provides a means to connect an auxiliary ground pneumatic unit (AGPU) to the helicopter.
- l. **Utility Air Receptacle.** The utility air receptacle is a brass female quick disconnect coupling connected to the air pressure manifold, mounted in the engine 1 nacelle, that permits the use of low pressure air tools and test equipment.

12-2. DESCRIPTION (cont)**12-2**

The PAS interfaces with or supplies air to the following aircraft systems and components (fig. 12-2).

- (1) APU control panel.
- (2) Engine air turbine starters.
- (3) Environmental control unit.
- (4) Window defog unit.
- (5) Louver actuators.
- (6) Fuel boost pump.
- (7) Fuel transfer pump.
- (8) Auxiliary fuel tanks.
- (9) Hydraulic reservoirs.
- (10) Nitrogen inerting system.
- (11) Utility receptacle.

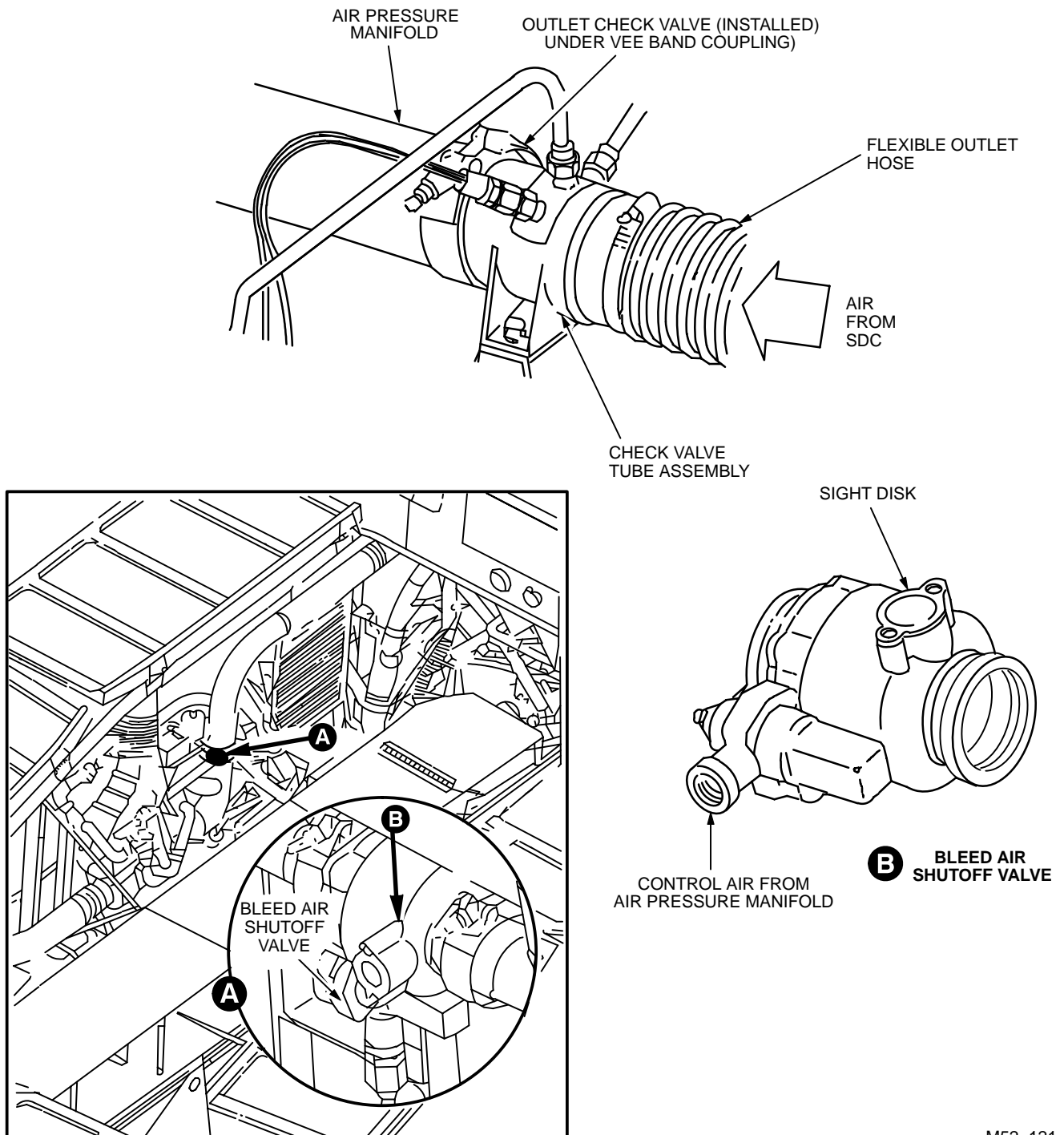


M52-121-1B

Figure 12-1. PAS Major Components (Sheet 1 of 2)

12-2. DESCRIPTION (cont)

12-2

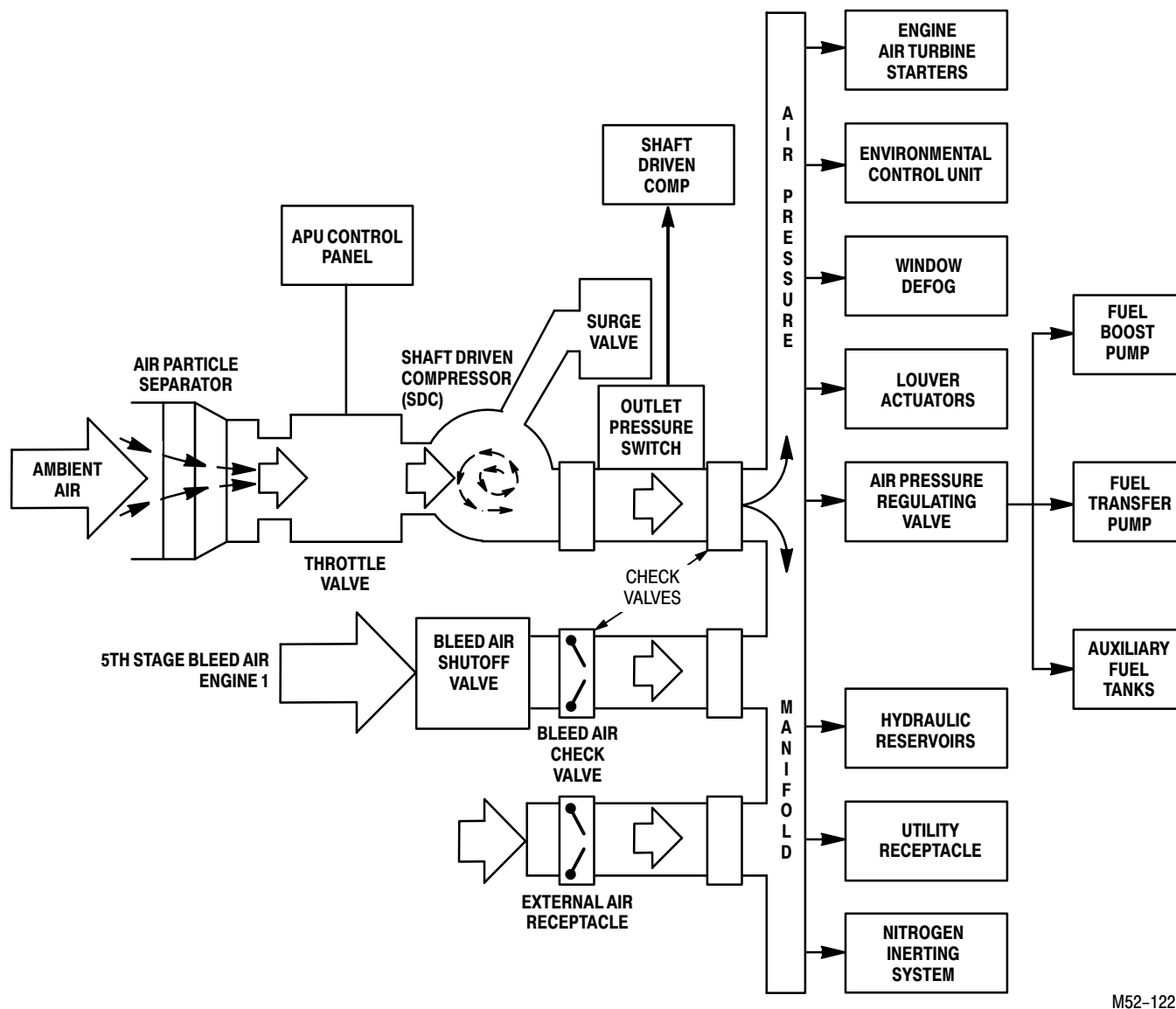


M52-121-2

Figure 12-1. PAS Major Components (Sheet 2 of 2)

12-2. DESCRIPTION (cont)

12-2



M52-122

Figure 12-2. PAS System Block Diagram

12-3. THEORY OF OPERATION

12-3**12-3. THEORY OF OPERATION**

The PAS theory of operation (fig. 12-3) is described in the following paragraphs.

a. **SDC Inlet Throttle Valve.** The SDC throttle valve is a butterfly valve which is solenoid controlled and pneumatically actuated. The throttle valve is normally open during SDC operation. The throttle valve closes during APU start to reduce starting loads. Operation of the throttle valve components (fig. 12-4) is described below in the following subparagraphs.

(1) The throttle valve solenoid is controlled by the **APU START/RUN** switch on the **APU** control panel through a 60-second time delay relay, which is powered by the dc bus 2. During APU start the APU **START/RUN** switch energizes the 60 second time delay relay, which de-energizes the throttle valve solenoid. The solenoid moves to close the air pressure port while opening the air vent port.

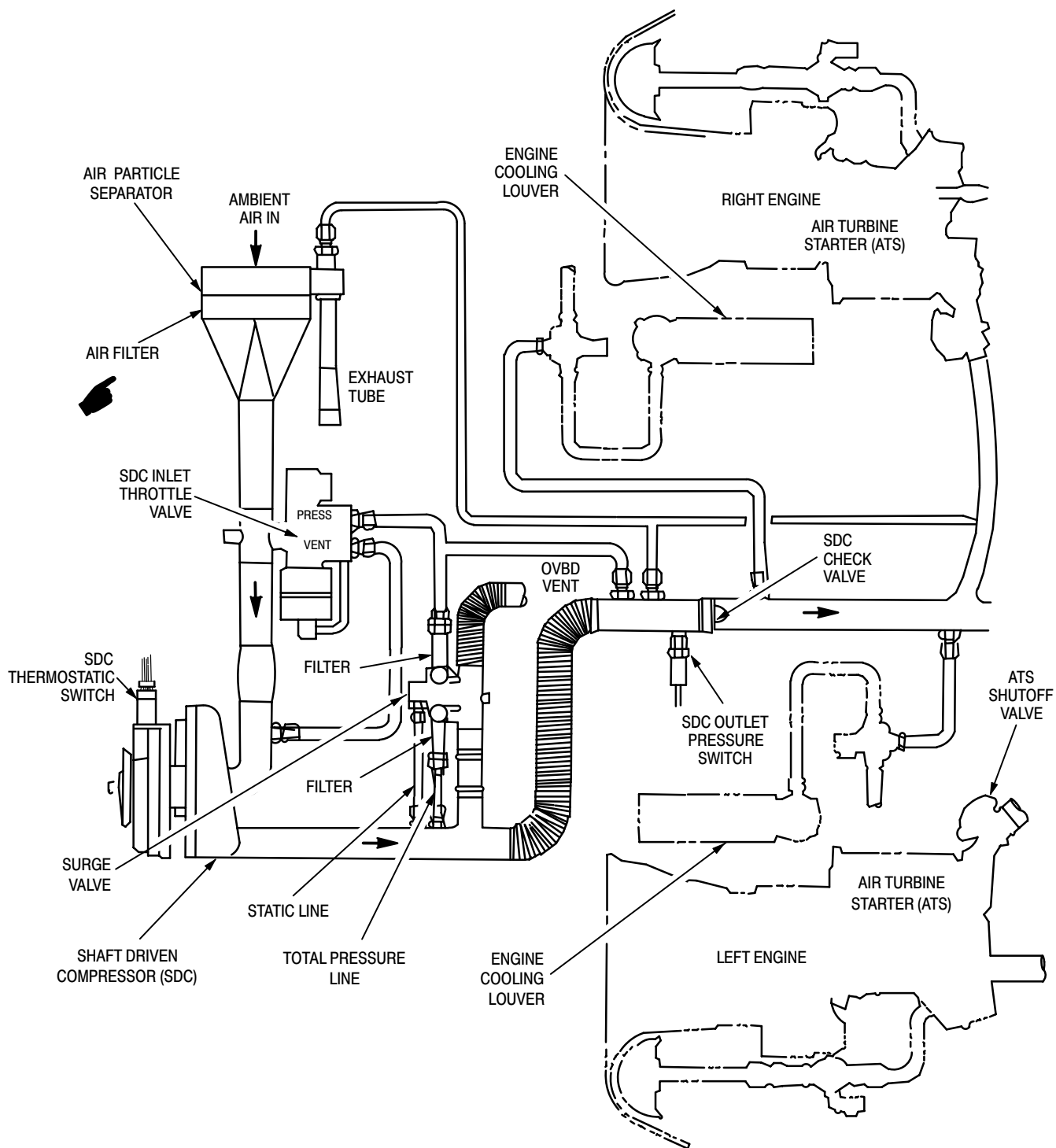
After 60 seconds the time delay relay de-energizes causing the solenoid to energize. The solenoid moves to open the air pressure port and closes the air vent port.

(2) The air pressure port is closed when the throttle valve solenoid is de-energized, and SDC outlet air is not permitted to enter the diaphragm chamber. When the solenoid is energized, the air pressure port is opened and SDC air is permitted to enter the diaphragm chamber.

(3) The air vent port is opened when SDC outlet air is not permitted to enter the throttle valve diaphragm chamber, and diaphragm chamber air pressure is vented. When SDC outlet air is permitted to enter the diaphragm chamber, the air vent port is closed and diaphragm air pressure is not vented.

(4) When the diaphragm chamber air pressure is vented, the spring load overrides the diaphragm chamber air pressure to close the butterfly plate. When the diaphragm air pressure is not vented, the diaphragm chamber air pressure overrides the spring load to open the butterfly plate.

(5) The butterfly plate closes to the minimum area stop position when the throttle valve solenoid is de-energized. With the butterfly plate in the stop position, airflow is restricted from the air particle separator to the SDC inlet port, reducing APU starting loads. The closed inlet throttle valve reduces the amount of air available to the SDC by approximately 70%. When the throttle valve solenoid is energized the butterfly plate opens allowing unrestricted airflow to the SDC Inlet.

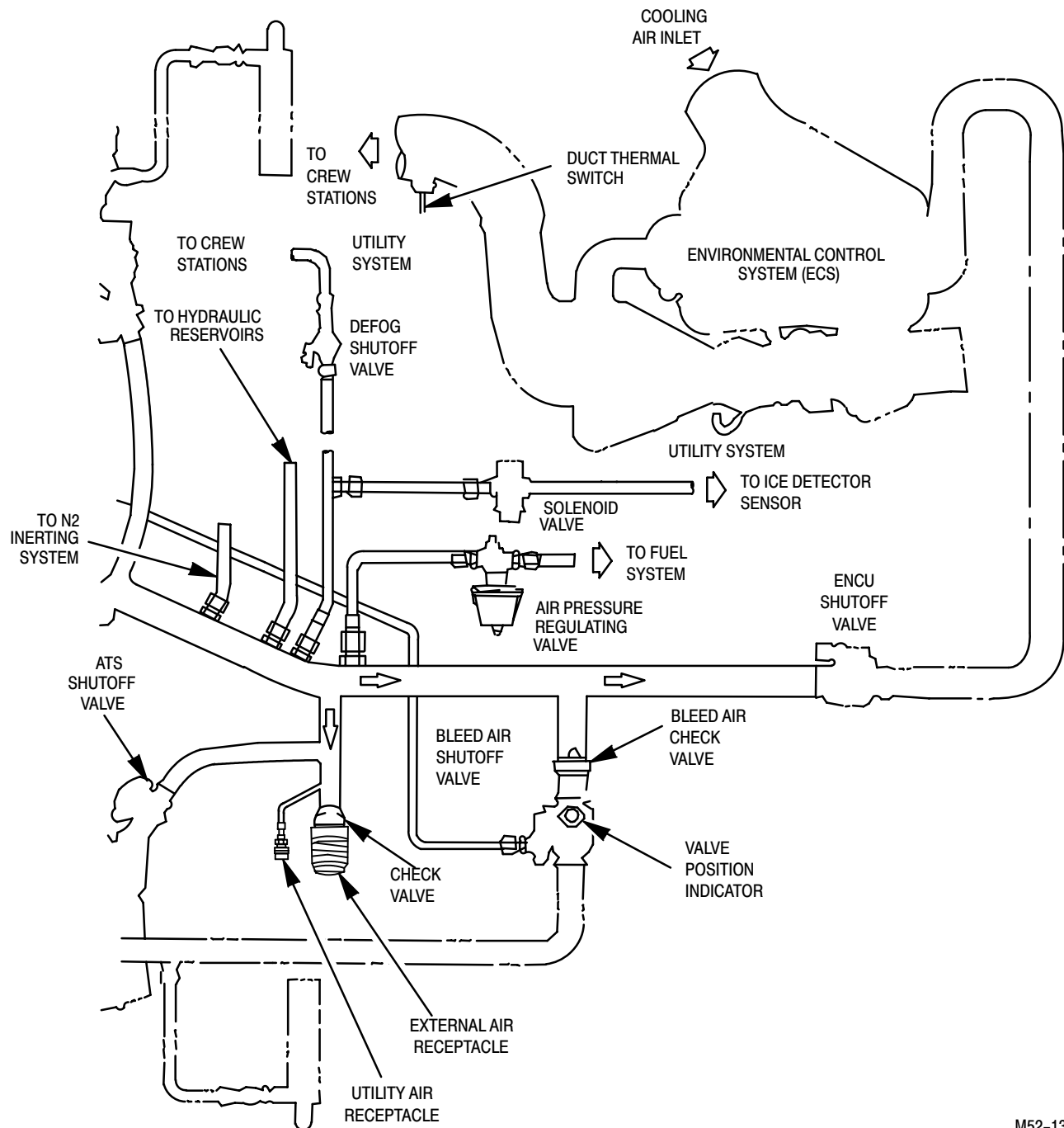


M52-133-1B

Figure 12-3. PAS Operation (Sheet 1 of 2)

12-3. THEORY OF OPERATION (cont)

12-3



M52-133-2A

Figure 12-3. PAS Operation (Sheet 2 of 2)

12-3. THEORY OF OPERATION (cont)

12-3

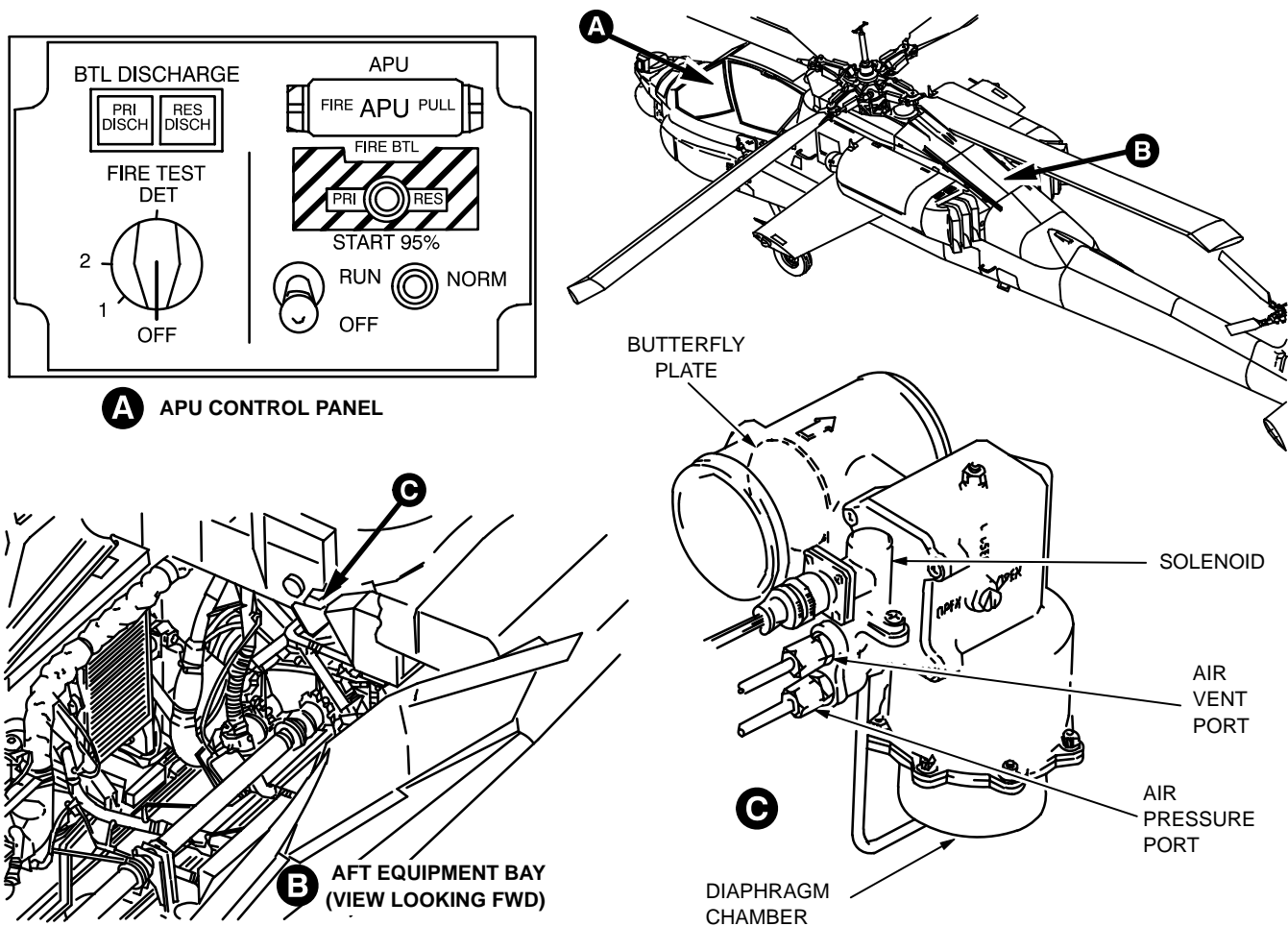


Figure 12-4. SDC Throttle Valve Major Components

12-3. THEORY OF OPERATION (cont)

12-3

b. **Air Particle Separator.** The air particle separator is an inlet duct that removes 85% of particles 20 microns or larger from ambient air routed to the SDC. Some helicopters have an air filter installed to prevent ingestion of smaller particles. Operation of the air particle separator components (fig. 12-5) is described in the following subparagraphs.

(1) Outside air is drawn into the air particle separator by SDC operation. The ambient air swirls outward, separating the dirt particles from the air. The clean air travels through a filter in the center of the separator to the SDC while the dirt travels outward in the separator to the collector box.

(2) The particle collector box collects the dirt separated from the ambient air by the air particle separator.

(3) The air pressure scavenge line directs an air supply from the air pressure manifold through the particle collector box and out the ejector to create a low pressure area that pulls the dirt out of the collector box.

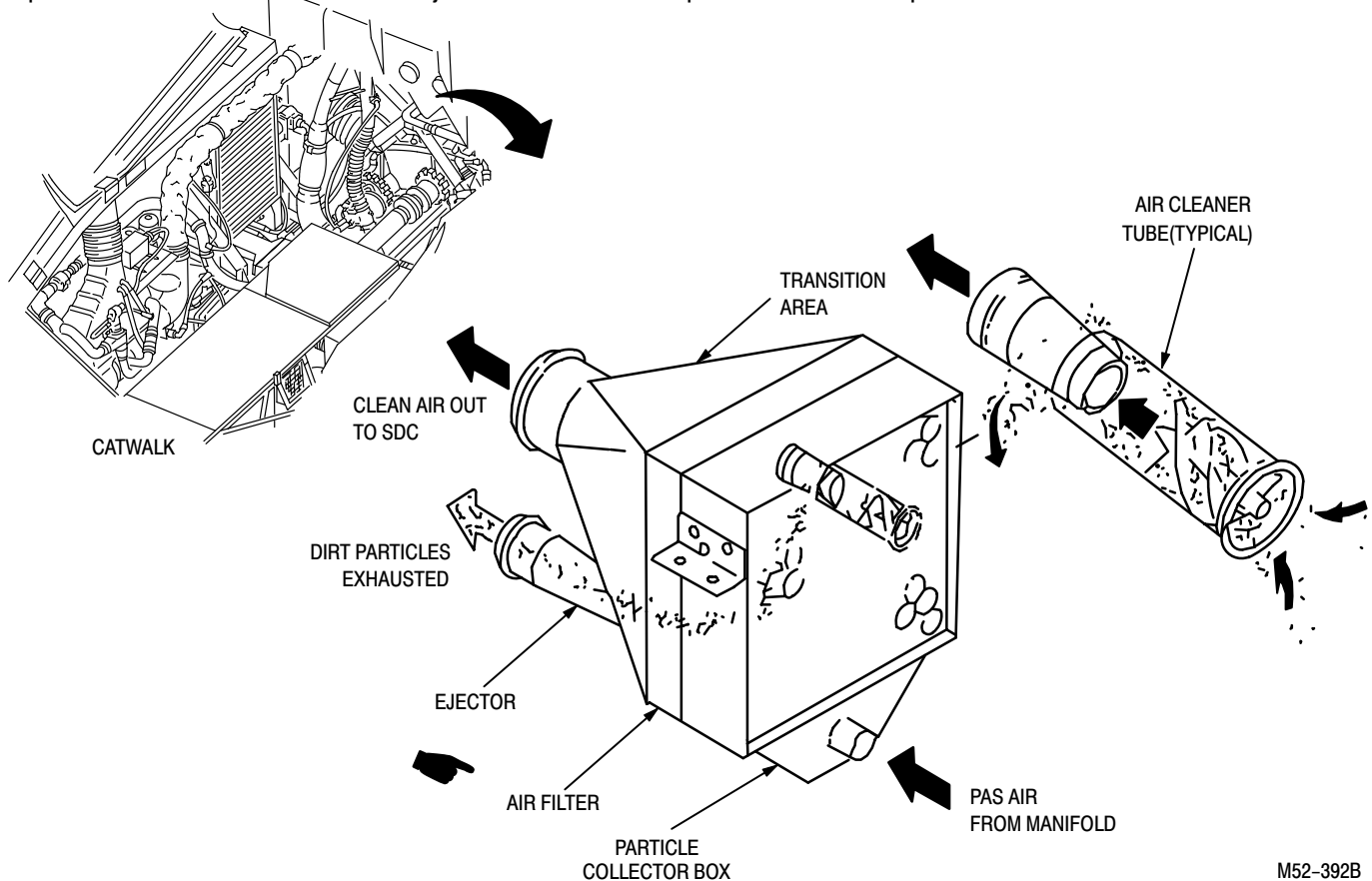


Figure 12-5. Air Particle Separator Major Components

(4) The ejector ejects dirt collected in the particle collector box using low pressure air provided by the air pressure scavenge line.

c. **SDC.** The SDC is a single-stage centrifugal shaft driven compressor driven by the main transmission accessory section. Fire overheat detectors located under the main deck and on left and right engine firewall louvers provide fire protection in the APU/SDC area. Operation of the SDC major components (fig. 12-6) and SDC oil system major components (fig. 12-7) is described in the following subparagraphs.

12-3. THEORY OF OPERATION (cont)**12-3**

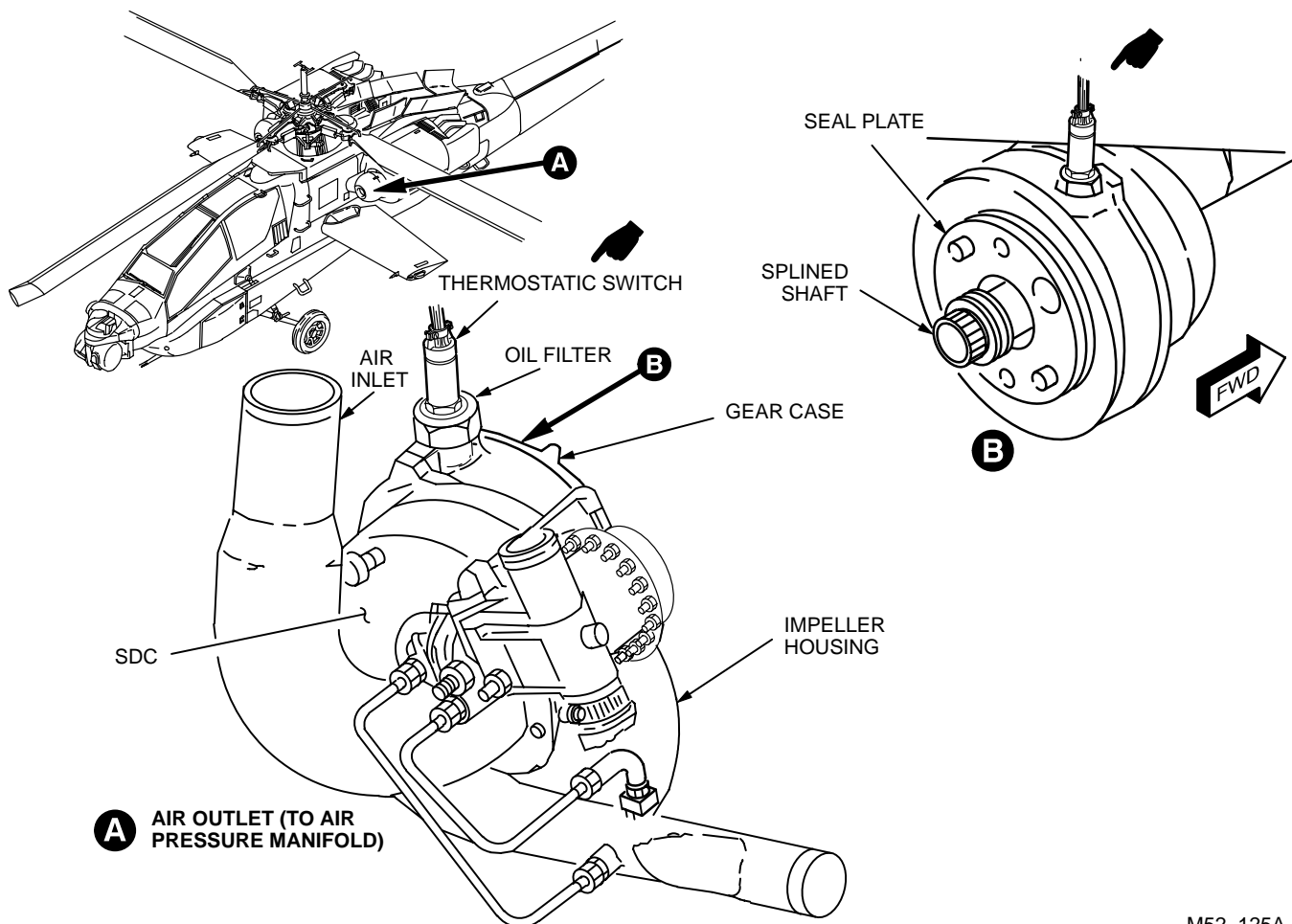
(1) The SDC air inlet provides ambient air, cleaned by the air particle separator, to enter the impeller housing.

(2) The oil filter is a line replaceable unit (LRU) that threads into the gear case. A thermostatic switch (oil temperature switch) is installed into the top of the oil filter plug.

(3) The gear case operates when the APU is on, or either main engine is driving the main transmission. The main transmission gear train turns the splined shaft which rotates the gear in the gear case. The splined shaft is designed to shear under excessive loads, to prevent damage to the main transmission.

(a) The gear rotates the impeller in the impeller housing to 86,431 rpm. The impeller pulls ambient air through the air particle separator and SDC air inlet, and the impeller pushes the pressurized air through the air outlet to the air pressure manifold.

(b) The gear case seal plate contains two oil ports. One is the oil supply passage from the main transmission accessory section. The other is the oil return passage to the main transmission accessory section.



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Figure 12-6. SDC Shaft Driven Compressor (SDC) Major Components

12-3. THEORY OF OPERATION (cont)

12-3

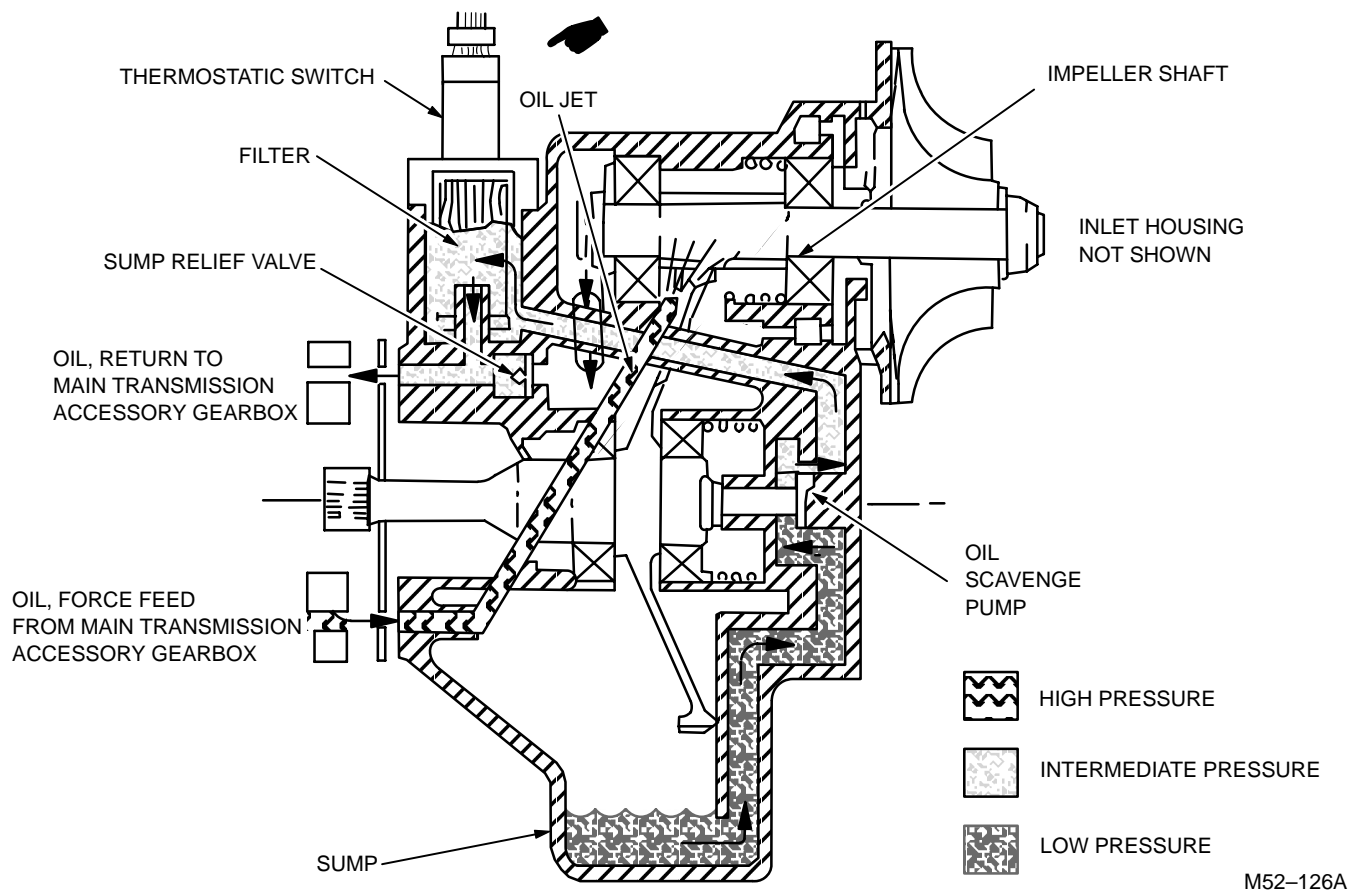


Figure 12-7. Shaft Driven Compressor (SDC) Oil System Major Components

(4) The SDC utilizes the main transmission accessory section oil supply to provide lubrication to the gear case gear and bearings (4 ea). High pressure oil, force fed from the main transmission accessory section, is routed through the SDC oil jet.

(5) The oil jet sprays oil onto the impeller shaft and the oil migrates to the ball bearings (2 ea) that support the impeller shaft. The oil lubricates the impeller shaft bearings and is gravity fed through internal passages to lubricate the ball bearings (2 ea) that support the splined shaft and gear.

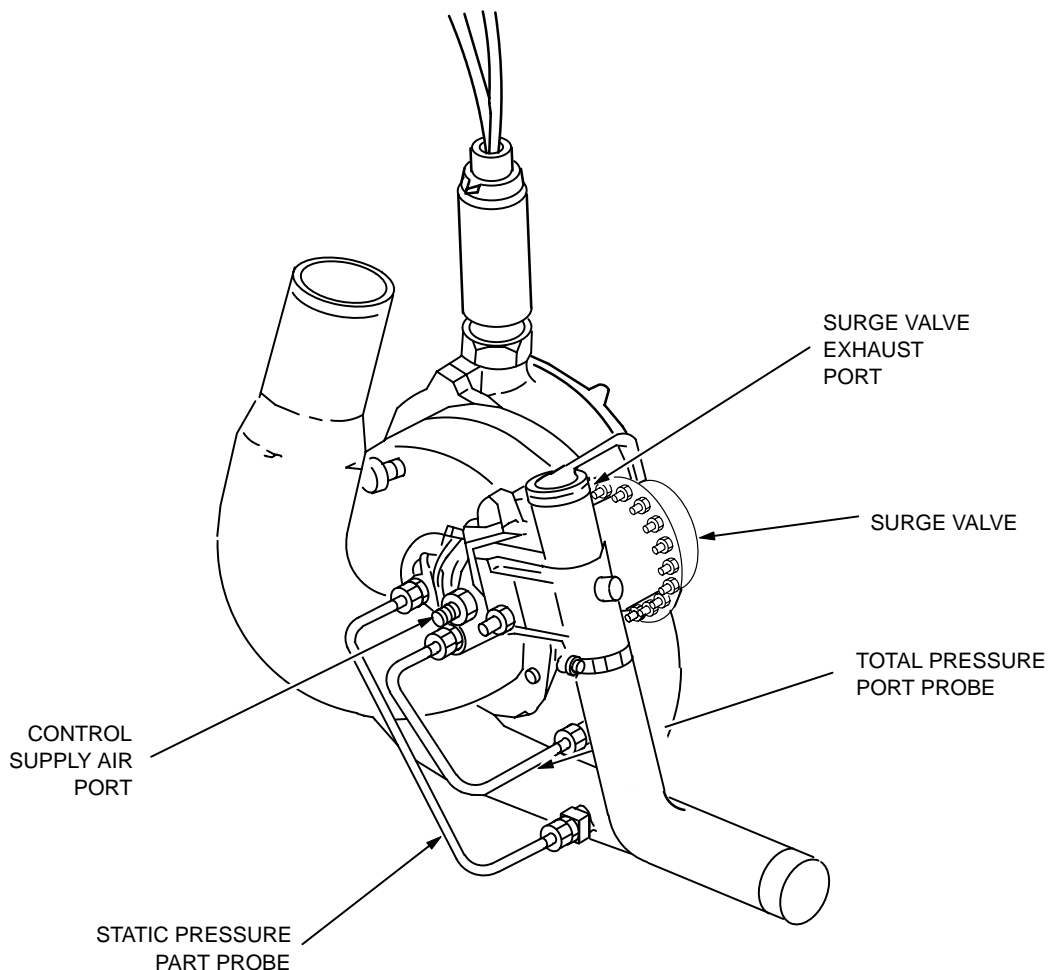
(6) The oil returns to the SDC gear case sump. The oil is drawn from the sump by a scavenge pump driven by the splined shaft. A sump relief valve allows excessive oil scavenge pump pressure to be vented. The oil is sent to the filter and contaminants are removed. The oil is routed from the filter, through internal passages, back to the main transmission accessory section.

(7) The thermostatic switch (oil temperature switch) is installed in the SDC oil filter cavity. The switch is a temperature sensitive electrical device with both normally open and normally closed contacts. The switch actuates when temperature rises to $350 \pm 10^\circ \text{ F}$ ($176.67 \pm 5^\circ \text{ C}$). Upon temperature decrease, the switch resets after the temperature drops by 10° F (5° C) and before temperature reaches 315° F (157.23° C). When the switch actuates, the **SHAFT DRIVEN COMP** pilot caution/warning light will light. This informs the pilot of low oil pressure, low oil pressure flow, high oil temperature to the SDC, high oil temperature from the SDC, or a SDC malfunction.

12-3. THEORY OF OPERATION (cont)12-3

d. **Surge Valve.** The surge valve is a lightly spring-loaded closed, pneumatically actuated, modulating butterfly type valve. The surge valve measures the SDC airflow. If the SDC airflow is not correct, the surge valve opens to eliminate pressure surges, and closes to maintain the proper SDC airflow. Operation of the surge valve components (fig. 12-8) is described in the following subparagraphs.

- (1) The surge valve exhaust port discharges excessive SDC air flow.
- (2) The surge valve diaphragm chamber measures the control supply airflow, total pressure airflow, and static pressure airflow pressure differential to modulate the surge valve. The surge valve opens to exit excessive SDC airflow. The surge valve closes to maintain SDC airflow.
- (3) The total pressure port probe interfaces with the SDC air outlet to provide the diaphragm chamber with total pressure airflow.
- (4) The static pressure port probe interfaces with the SDC air outlet to provide the diaphragm chamber with static pressure airflow.
- (5) The control supply air port interfaces with the air pressure manifold to provide the diaphragm chamber with control supply air pressure.



M52-127

Figure 12-8. Surge Valve Major Components

12-3. THEORY OF OPERATION (cont)

12-3

e. **Outlet Pressure Switch.** The outlet pressure switch monitors SDC outlet pressure and controls the **SHAFT DRIVEN COMP** caution light on the pilot caution/warning panel. The outlet pressure switch (fig. 12-9) closes when there is no air pressure in the air pressure manifold. When the switch is closed, a 28 VDC circuit is energized and the **SHAFT DRIVEN COMP** light on the pilot caution/warning panel lights. When the air pressure manifold air pressure increases to 15 psi, the outlet pressure switch opens. The switch will again light the **SHAFT DRIVEN COMP** light if the PAS pressure drops below seven psi. When the switch is opened, a 28 VDC circuit is de-energized and the **SHAFT DRIVEN COMP** light is extinguished.

f. **Outlet Check Valve.** The outlet check valve is a pneumatically operated dual flapper valve which allows airflow in one direction. The outlet check valve opens when the SDC outlet air pressure is greater than the air pressure manifold air pressure. SDC outlet air rotates the hinged flappers to the open position and SDC outlet air flows to the air pressure manifold.

The valve closes when the SDC outlet air pressure is less than the air pressure manifold air pressure. The air pressure manifold air rotates the hinged flappers to the closed position to prevent air pressure manifold air from flowing into the SDC outlet. The valve contains an arrow to facilitate proper installation. The arrow indicates proper airflow.

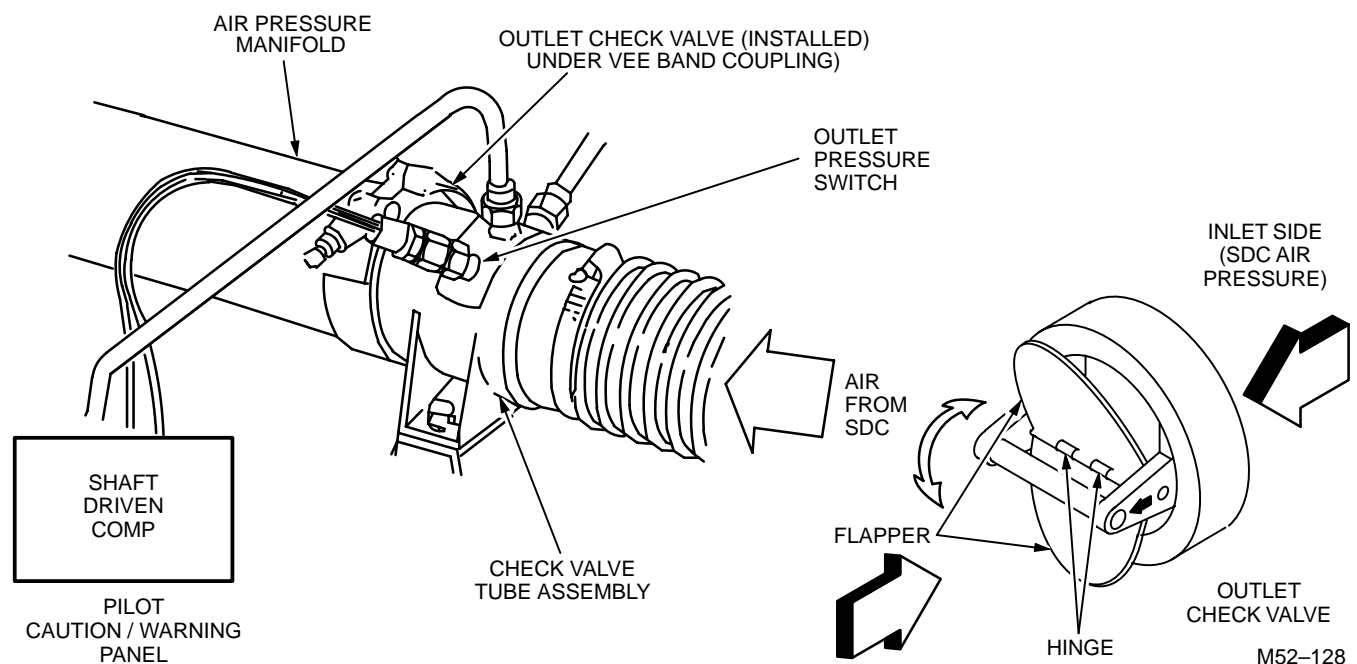
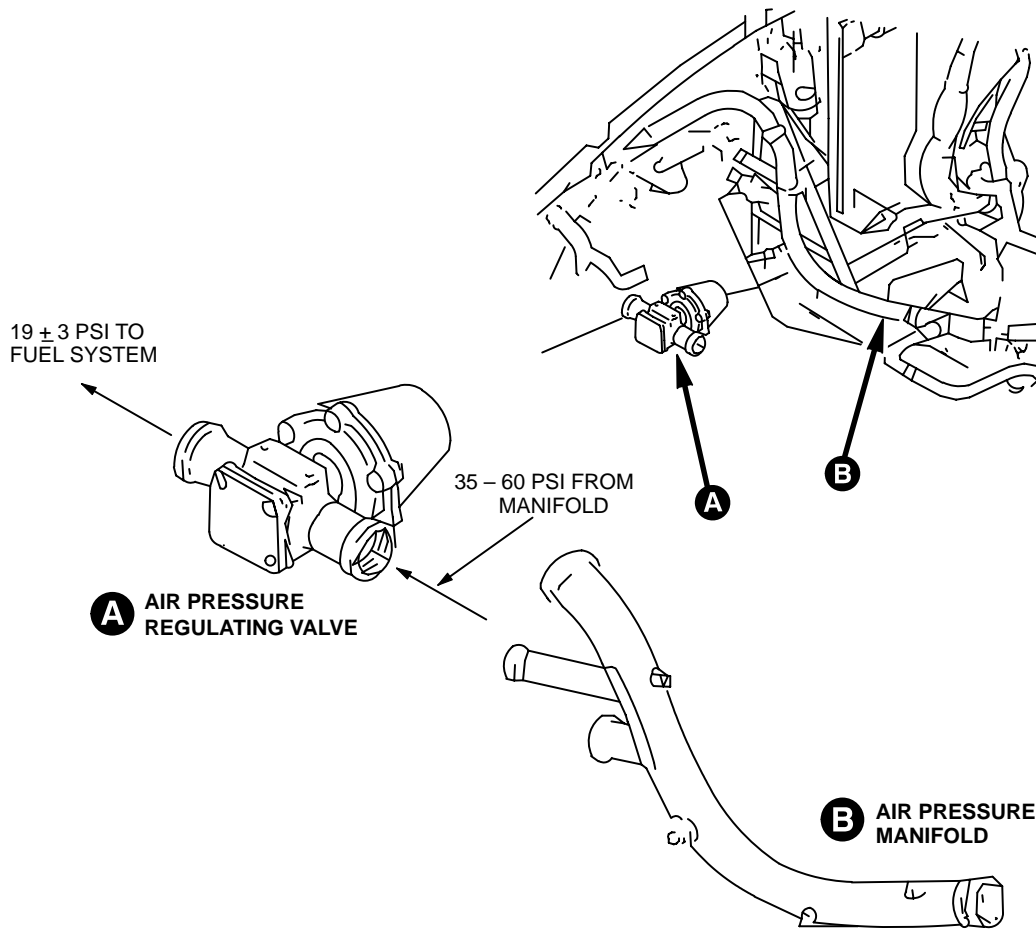


Figure 12-9. Outlet Pressure Switch and Outlet Check Valve

g. **Air Pressure Manifold.** The air pressure manifold (fig. 12-10) is an aluminum alloy tube with inlet and outlet ports that receives airflow from the SDC through the outlet check valve, and distributes air to the helicopter systems and components.

h. **Air Pressure Regulating Valve.** The air pressure regulating valve (fig. 12-10) is a diaphragm operated, pneumatically controlled metering valve. The air pressure manifold air pressure (35 to 60 psi) enters the valve and is regulated by a pneumatically controlled diaphragm to flow air to the fuel system at 19 ± 3 psi.



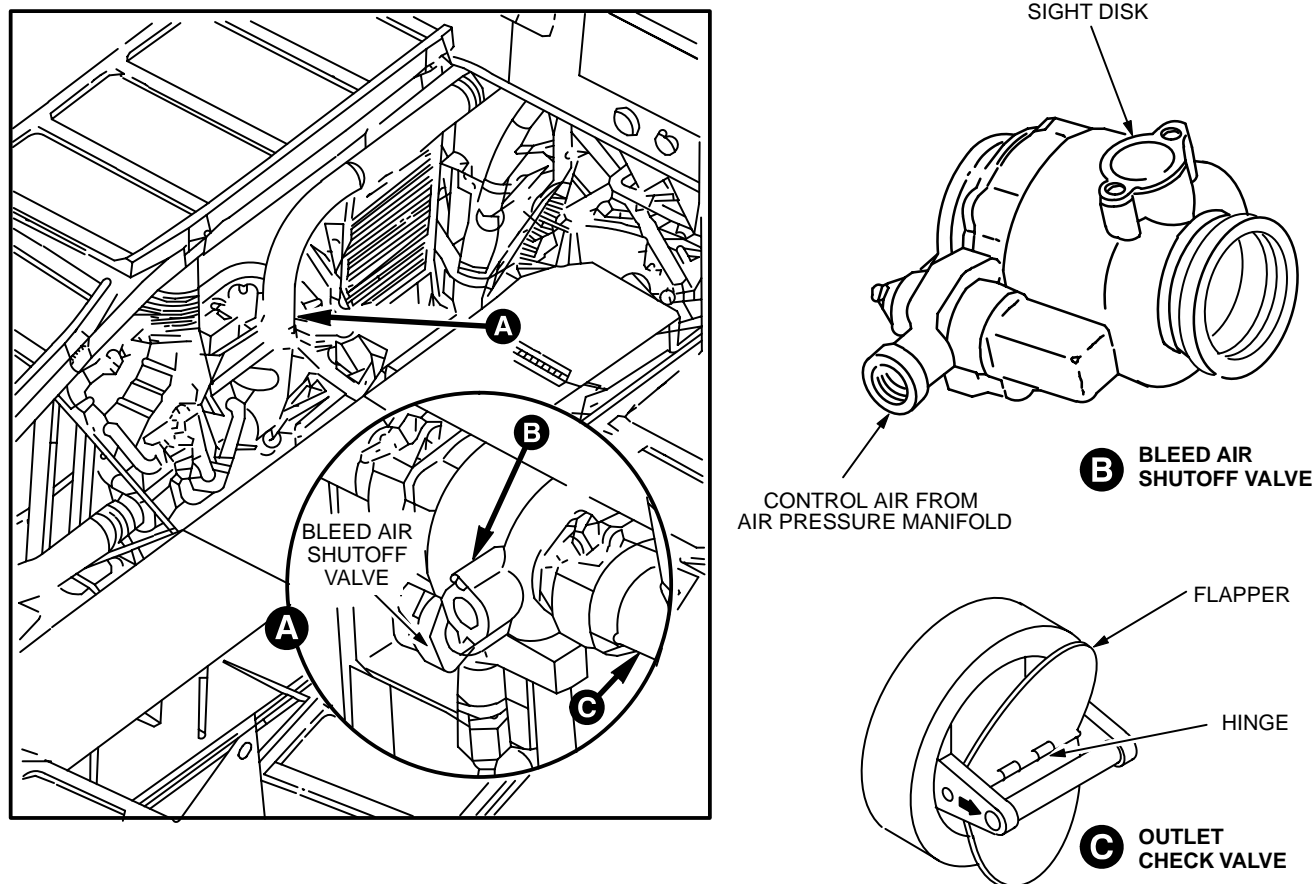
M52-129

Figure 12-10. Air Pressure Manifold and Air Pressure Regulating Valve

i. **Bleed Air Shutoff Valve.** The bleed air shutoff valve (fig. 12-11) is a pneumatically controlled and operated spring loaded closed poppet valve that prevents engine 1 fifth stage bleed air (60 psi) from entering the air pressure manifold. The valve opens when the control air pressure from the air pressure manifold drops below 14 psi. Engine 1 fifth stage bleed air enters the shutoff valve, bleed air check valve, and the air pressure manifold.

When the control air pressure from the air pressure manifold increases above 14 psi, the valve closes, and engine 1 fifth stage bleed airflow is restricted. A sight disk provides valve open or closed position indication for troubleshooting purposes.

j. **Bleed Air Check Valve.** The bleed air check valve (fig. 12-11) is a pneumatically operated, dual stage flapper valve, which permits airflow in one direction. The check valve prevents air pressure manifold air from entering the bleed air shutoff valve during SDC operation, or when using an external air source. When bleed air shutoff valve opens, engine 1 fifth stage bleed air enters the check valve. The bleed air rotates the hinged flappers to the open position. In the open position bleed air enters the air pressure manifold. When the bleed air shutoff valve closes, air pressure manifold air pressure rotates the hinged flappers to the closed position. In the closed position bleed air flow is restricted.



M52-132

Figure 12-11. Bleed Air Shutoff Valve and Bleed Air Check Valve.

k. **External Air Receptacle.** The external air receptacle (fig. 12-12) is located on the bottom of engine 1 nacelle. The external air receptacle provides a means to connect an external AGPU to the helicopter and prevent loss of air pressure manifold air pressure overboard. When external air pressure is applied, the air receptacle (fig. 12-13) hinged flappers are rotated opened by external air. The external air overrides the flappers spring force and air enters the air pressure manifold.

(1) When external air pressure is applied, the air receptacle (fig. 12-13) hinged flappers are rotated opened by external air. The external air overrides the flappers spring force and air enters the air pressure manifold.

(2) When external air pressure is removed, the flapper spring force rotates the hinged flappers closed. This prevents loss of air pressure manifold air pressure overboard.

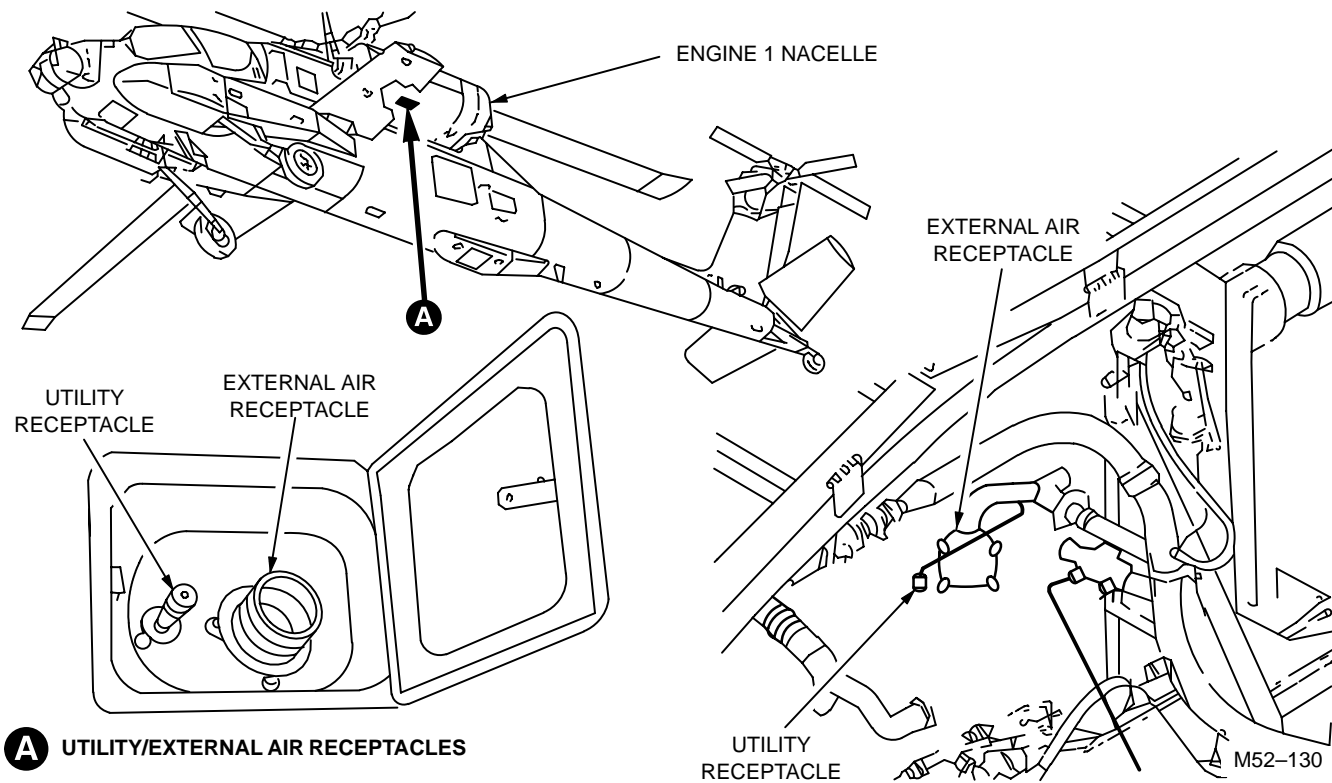
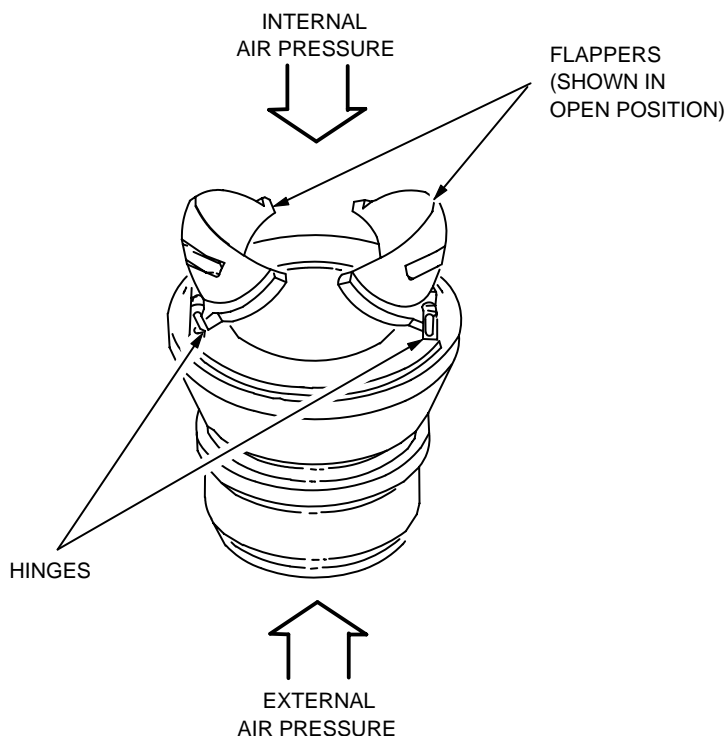


Figure 12-12. External Air Receptacle and Utility Receptacle Location

12-3. THEORY OF OPERATION (cont)

12-3



M52-131

Figure 12-13. External Air Receptacle

I. Utility Receptacle. The utility receptacle (fig. 12-12) is located on the bottom of the engine 1 nacelle. The utility receptacle provides a means to connect low pressure (35 psi) driven pneumatic tools and test equipment for maintenance purposes when the air pressure manifold is pressurized.

m. System Operation. The PAS has three modes: primary, secondary and external.

(1) Primary Mode.

- (a) With the APU or the engines driving the SDC, ambient air is drawn through the air particle separator and cleaned.
- (b) The clean air passes to the SDC inlet throttle valve, which is open except during APU start.
- (c) The SDC compresses the air to 35 psi, raising the temperature to approximately 400° F (204° C).
- (d) The surge valve maintains a constant pressure in the PAS system.
- (e) The hot pressurized air is routed to the air pressure manifold, where the air is distributed to the user systems.

(2) Secondary Mode.

- (a) If SDC outlet pressure drops below 14 psi, the bleed air shutoff valve opens, allowing 60 psi bleed air from engine 1 to enter the air pressure manifold.
- (b) The air pressure manifold distributes the bleed air in the same manner as SDC air.

(3) External Mode.

- (a) The external air receptacle allows high-pressure air from an auxiliary ground power unit to enter the air pressure manifold.

12-3. THEORY OF OPERATION (cont)

12-3

- (b) The air pressure manifold distributes the air in the same manner as SDC air.

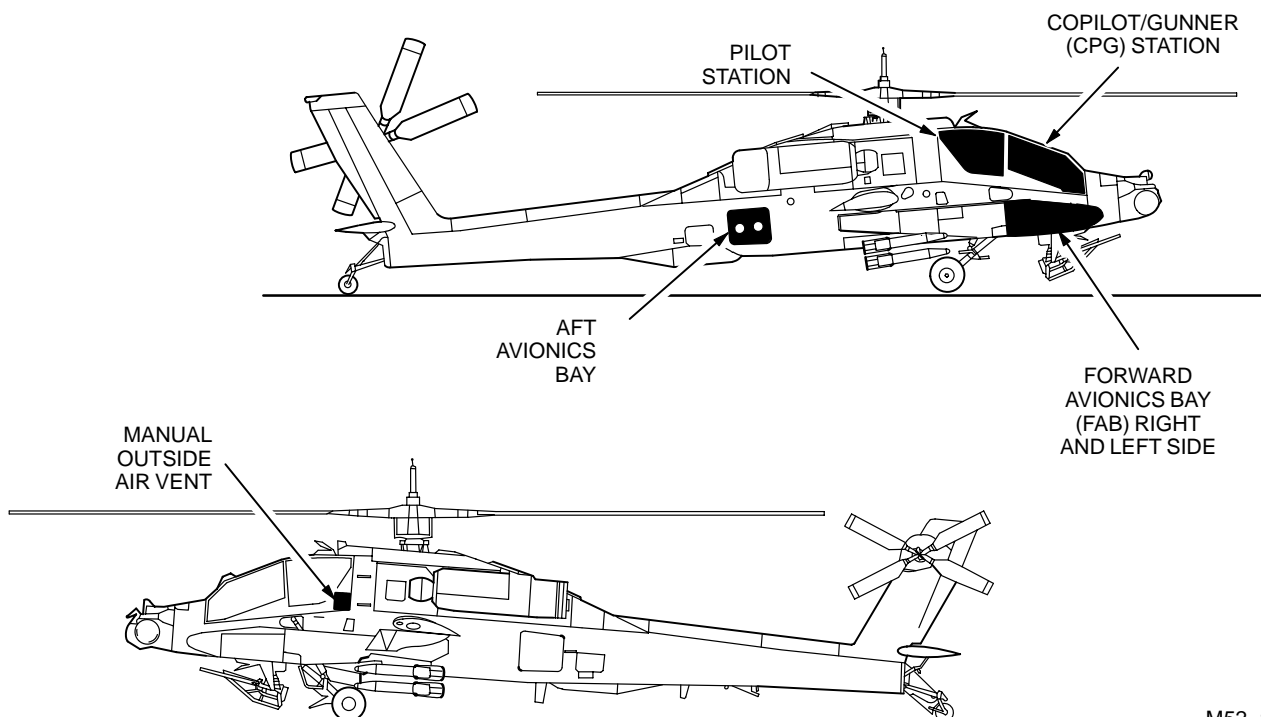
13-1. PURPOSE

13-1

CHAPTER 13 ENVIRONMENTAL CONTROL SYSTEM

13-1. PURPOSE

The environmental control system (ECS) provides conditioned air for the crew station and forward avionics bays (FAB), and exhaust fans for the electrical power distribution center and aft avionics bay. Figure 13-1 shows the aircraft areas supplied with ECS air. The system can be operated from the helicopter pressurized air system (PAS), or from an external air source. Manual outside air vents at the pilot's station supplement the system by providing ambient ram air flow.



M52-104

Figure 13-1. Areas Supplied by ECS Air

13-2. DESCRIPTION

The ECS includes the following components (fig. 13-2).

- a. **Environmental Control Unit (ENCU).** The ENCU contains a primary heat exchanger, temperature control valve, condenser/reheater, water extractor, water spray nozzle, cooling turbine, temperature control/sensor, and associated hoses, ducting, and clamps. The ENCU supplies conditioned air for cooling and heating the crew stations and avionics bays by extracting heat energy from the PAS air.
- b. **ENCU Shutoff Valve.** The ENCU shutoff valve is a normally closed, pneumatically operated, solenoid-controlled poppet valve with a valve position indicator.
- c. **Air Ducts.** The air ducts are made of Kevlar, consisting of 22 sections, with air outlets in each crew station.

13-2. DESCRIPTION (cont)

13-2

d. **ECS Control Panels.** The ECS control panels contain switches for the crew members to control the ECS, and speed of the FAB fans.

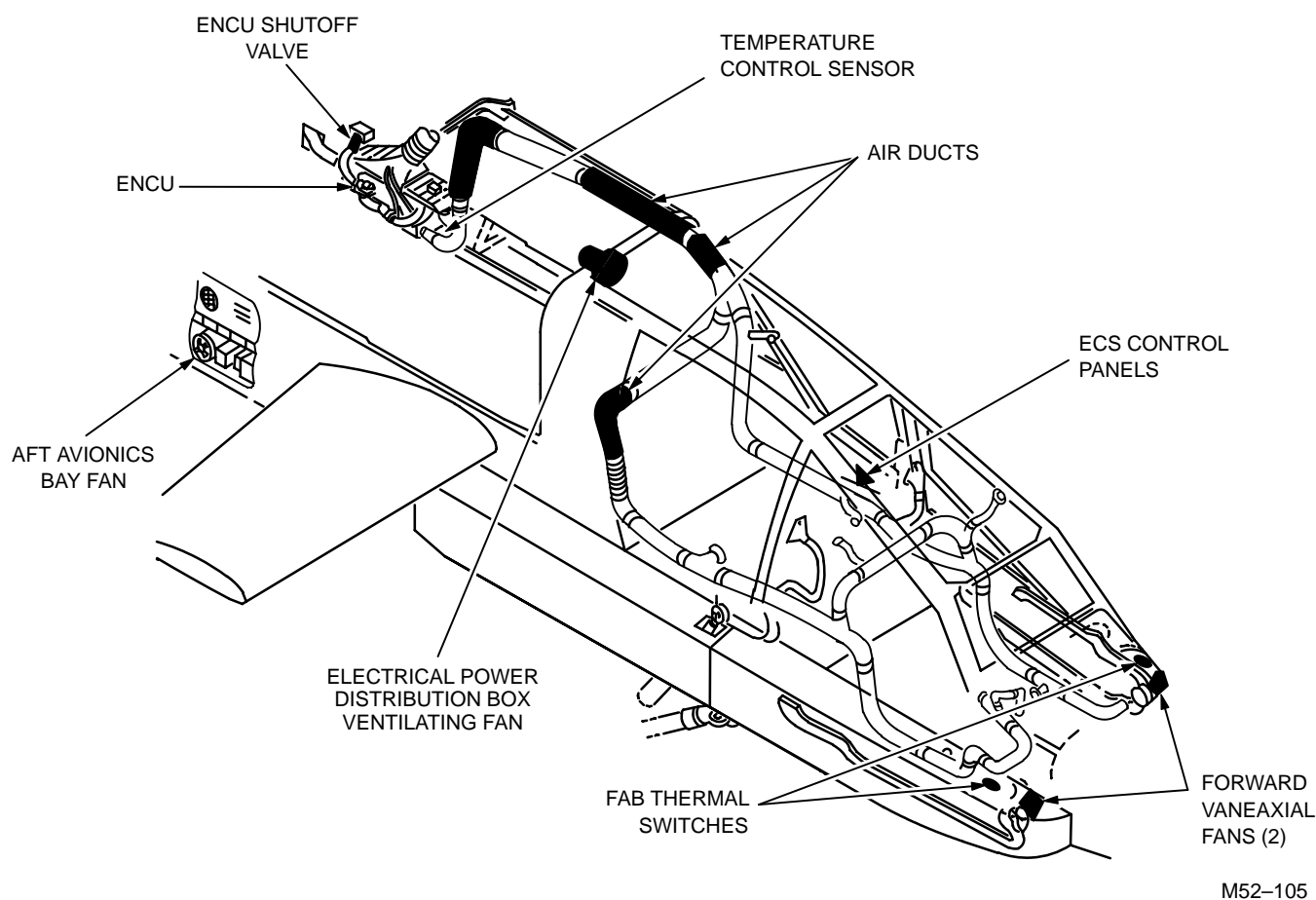
e. **Forward Vaneaxial Fans (2 ea).** The forward vaneaxial fans are driven by 115 VAC, 3 Ø two-speed motors to cool the forward avionics bays (FAB).

f. **FAB Thermal Switches.** The FAB thermal switches provide signals to the temperature control sensor according to air temperature in the FAB.

g. **Electrical Power Distribution Box Ventilating Fan.** The electrical power distribution box ventilating fan is driven by a single-speed, 115 VAC, 3 Ø motor.

h. **Aft Avionics Bay Fan.** The aft avionics bay fan is driven by a single-speed, 115 VAC, 3 Ø motor to ventilate the aft avionics bay. Some helicopters have an air filter installed in the aft avionics bay door to remove small particles.

i. **Manual Outside Air Vents.** Manual outside air vents supplement the ECS by providing ambient ram air to the pilot's station (fig. 13-1).



M52-105

Figure 13-2. ECS Major Components

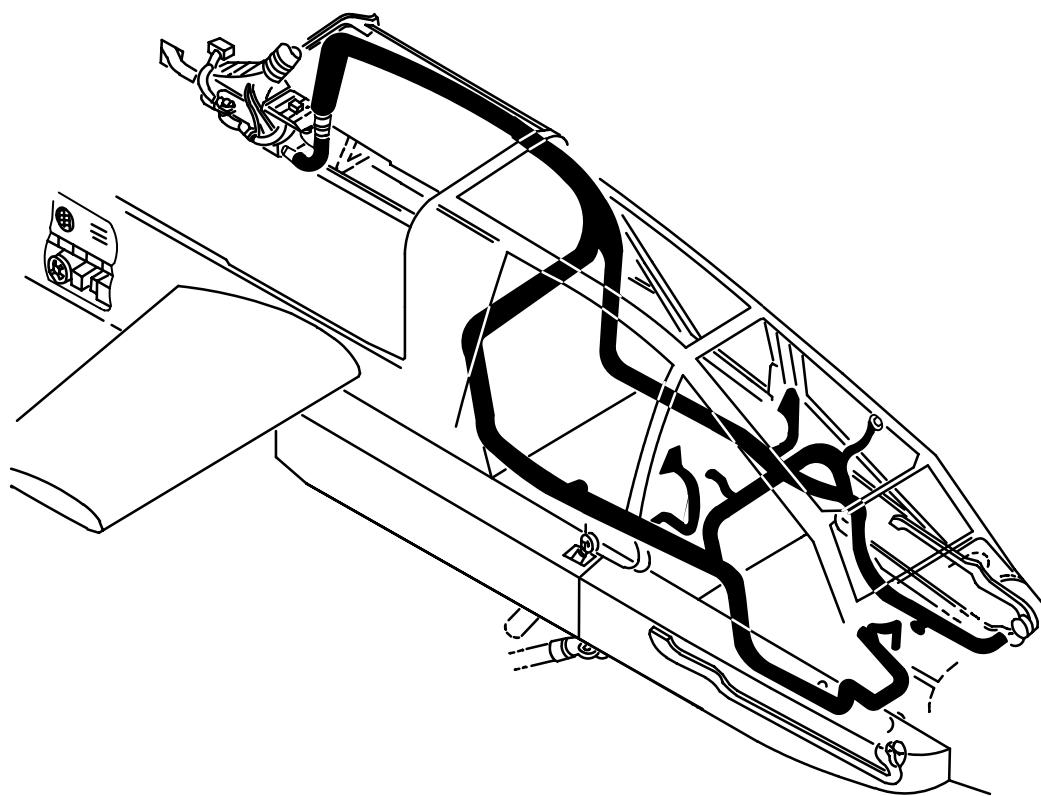
13-3. THEORY OF OPERATION

13-3

13-3. THEORY OF OPERATION

a. **ENCU Shutoff Valve.** The ENCU shutoff valve controls pressurized air to the ENCU. The valve is normally closed, shutting off air flowing to the ENCU. The visual valve-position indicator shows the valve is closed. Energizing the solenoid allows air to flow through the valve chamber and out to the ENCU. The visual valve-position indicator shows the valve is open. The valve opens and closes in a maximum of one second with an inlet pressure of 25 to 50 psi.

b. **Air Ducts.** The air ducts (fig. 13-3) carry air from the ENCU to the crew stations and the FABs through 22 separate sections.



M52-106

Figure 13-3. ECS Air Ducts

c. **ECS Control Panels.** The ECS control panels (fig. 13-4) allow the pilot to control the ECS. The panels also allow either crew member to control the speed of the FAB fans. The panels contain the following switches.

(1) The pilot **ECS** panel contains three switches.

(a) The **ENCU** switch has two functions.

- **ON.** The **ON** position supplies 28 VDC operating voltage to the temperature control sensor; supplies 28 VDC to energize the ENCU shutoff valve (valve opens).
- **OFF.** The **OFF** position removes 28 VDC from the temperature control sensor and ENCU shutoff valve (valve closes).

13-3. THEORY OF OPERATION (cont)

13-3

(b) The **TEMP** (rotary) switch has the following range.

- **COLD.** The **COLD** position allows a minimum ECS air temperature of 36°F (2°C).
- **WARM.** The **WARM** position allows a maximum ECS air temperature of 170°F (77°C).

(c) The **NORM/STBY FAN** switch has two functions.

- **NORM.** In the **NORM** position, FAB fans operate at low speed.
- **STBY.** In the **STBY** position, FAB fans operate at high speed.

(2) CPG **AUX/ANTI-ICE** panel contains one switch for the ECS system. The **STBY FAN/OFF** switch has two functions.

(a) **STBY.** In the **STBY** position, FAB fans operate at high speed.

(b) **OFF.** In the **OFF** position, FAB fans are controlled by pilot's **STBY FAN** switch.

d. **Forward Vaneaxial Fans.** The vaneaxial fans (2 ea) circulate cooling air around electronic and electrical equipment in the avionics bays. The fans operate on 115 VAC from **FWD AVIONICS FAN** circuit breaker CB88, controlled by the pilot's **NORM/STBY FAN** and the CPG's **STBY FAN/OFF** switches. The fans operate whenever power is available and the circuit breaker is closed.

e. **FAB Thermal Switches.** The FAB thermal switches maintain air temperature in the LH and RH FABs. When the FAB temperature reaches 75°F (24°C), S27 signals the temperature control sensor to reduce the output temperature 15°F (-9°C). When the FAB temperature reaches 85°F (29°C), S29 signals to reduce the temperature 15°F (-9°C) further. When the bay temperature reaches 105°F (40°C), the ECS light on pilot caution/warning panel (fig. 13-5) turns on.

f. **Electrical Power Distribution Center Ventilating Fan.** The electrical power distribution center ventilating fan operates on 115 VAC from **AFT AVIONICS FAN** circuit breaker CB75. When ac power is available and the circuit breaker is closed, the fan operates.

g. **Aft Avionics Bay Fan.** The fan is controlled by a thermal switch which controls the aft avionics fan relay. When the temperature in the bay is above 25°F (-4°C), the thermal switch is open, the relay is de-energized, and the fan operates.

(1) When the temperature in the bay decreases to 10°F (-12°C), the thermal switch closes, the relay energizes, and the fan stops.

(2) As the temperature in the bay varies between 10° F (-12°C) and 25°F (-3.9°C), the fan motor cycles on and off automatically.

13-3. THEORY OF OPERATION (cont)

13-3

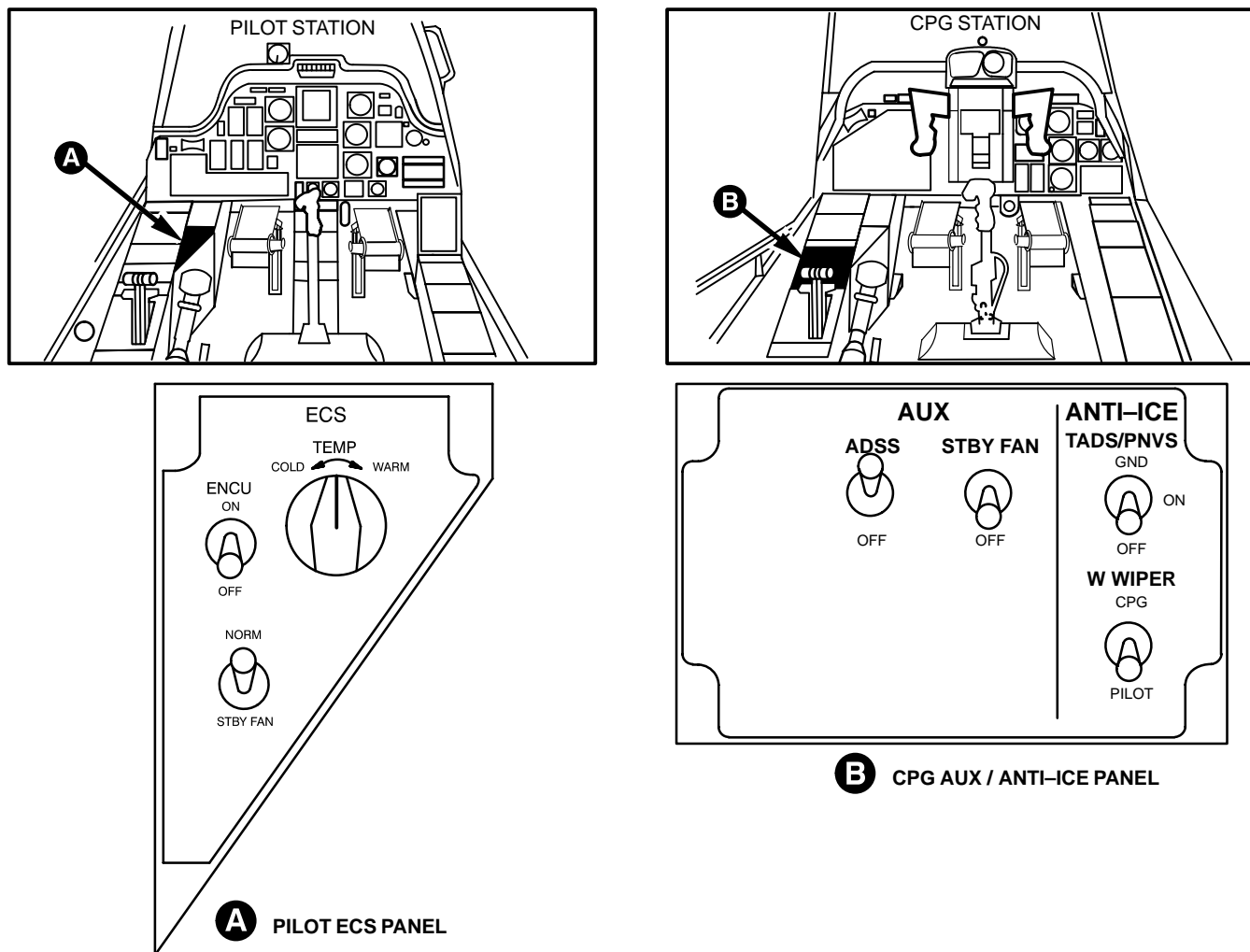
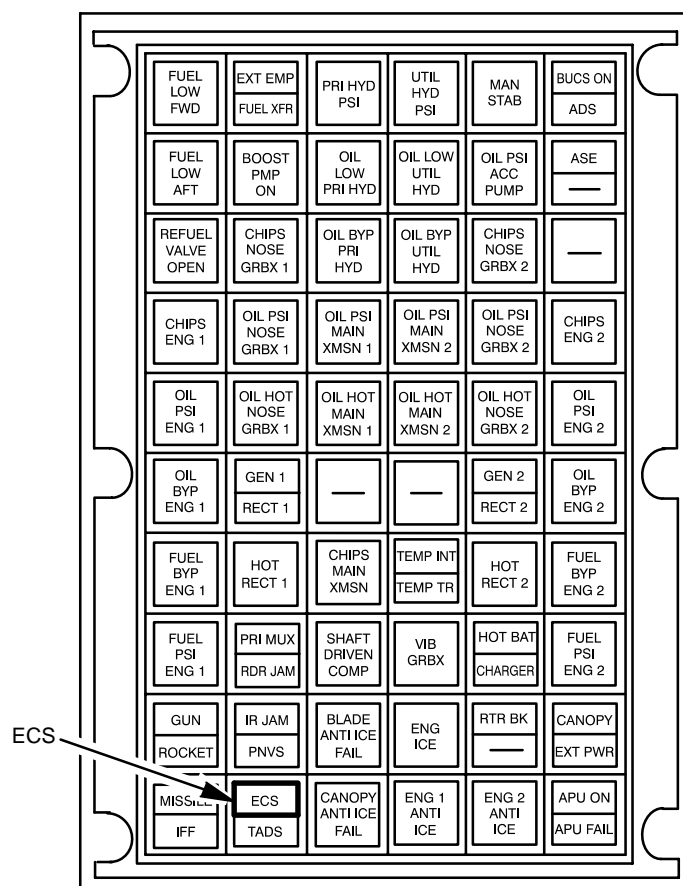


Figure 13-4. ECS Control Panels



M52-108

Figure 13-5. Pilot Caution/Warning Panel

h. **ENCU.** Hot PAS air (fig. 13-6) flows through the ENCU shutoff valve and is ducted to the primary heat exchanger and the temperature control valve.

(1) The PAS air flows through the heat exchanger where the air becomes partially cooled to near ambient temperature by a high airflow of air driven by the turbine fan. The turbine fan draws ambient air through the primary heat exchanger and exhausts the air overboard. Some helicopters have an air filter installed in the cooling air inlet to prevent small particle ingestion.

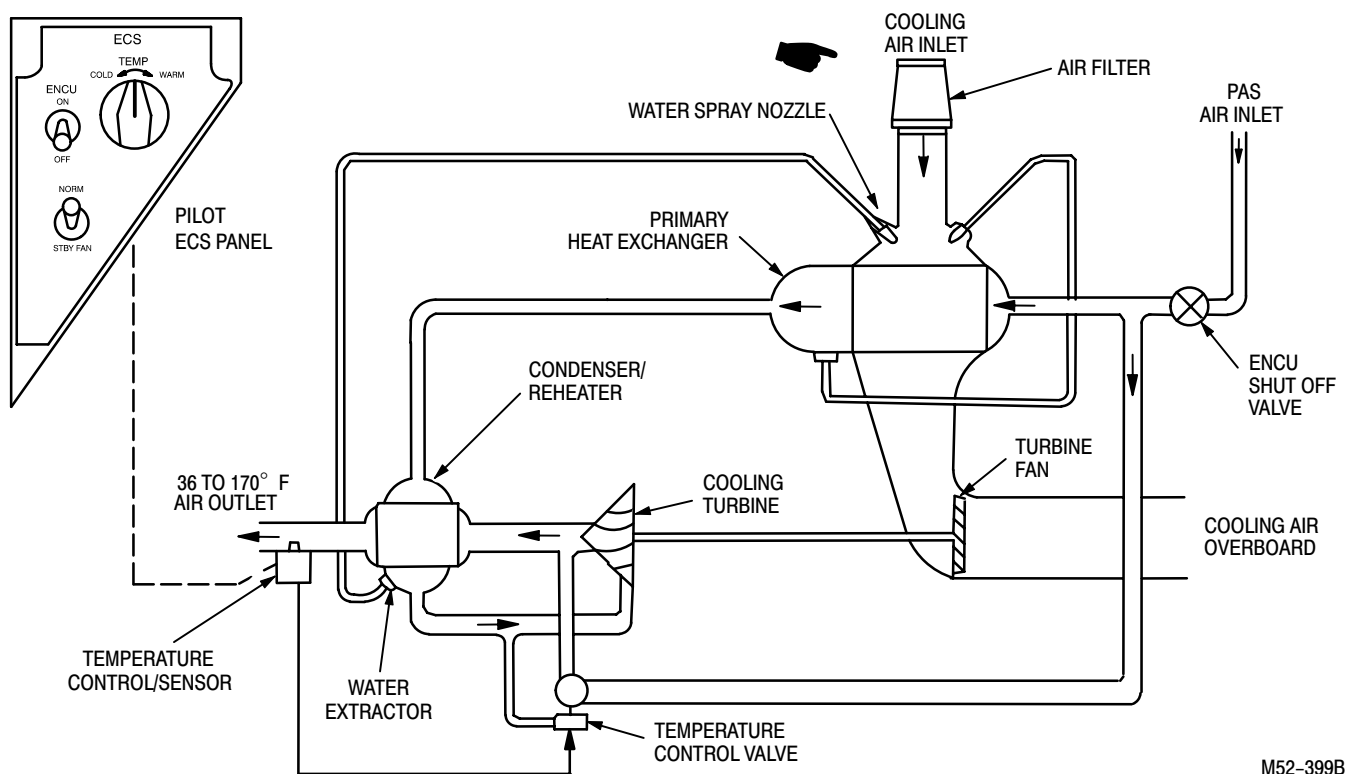
(2) The cooled air next goes to the condenser/reheater where very cold air from the cooling turbine causes moisture in the air to condense into water droplets. The water extractor removes the water droplets and permits dry air to flow to the cooling turbine. Air pressure routes the condensation to the water spray nozzles which spray the condensation into the cooling air inlet of the heat exchanger to increase the cooling efficiency.

(3) The cooled air leaving the cooling turbine is ducted again through the condenser/reheater providing cooling air for the condenser/reheater. The turbine discharged air flows past the temperature control/sensor and out the air outlet. The temperature control/sensor compares the temperature leaving the ENCU with the temperature selected by the pilot.

13-3. THEORY OF OPERATION (cont)

13-3

(4) The temperature control/sensor positions the temperature control valve through an electrical signal to the torque motor of the valve. If the temperature control/sensor determines the air being delivered is too cold, a signal is sent to the temperature control valve to position more towards open. This permits hot PAS air which has bypassed the heat exchanger to be added to the cold turbine discharge air, causing the temperature to increase. If the temperature control/sensor determines the air being delivered is too hot, a signal is sent to the temperature control valve to position more towards closed. This restricts hot PAS air which has bypassed the heat exchanger from being added to the cold turbine discharge air, causing the temperature to decrease.



M52-399B

Figure 13-6. ENCU Operation

13-3. THEORY OF OPERATION (cont)

13-3

i. **System Operation.** Hot PAS air enters the ENCU (fig. 13-7) through the ENCU shutoff valve. The hot air enters the heat exchanger, where the air is cooled to approximately ambient temperature.

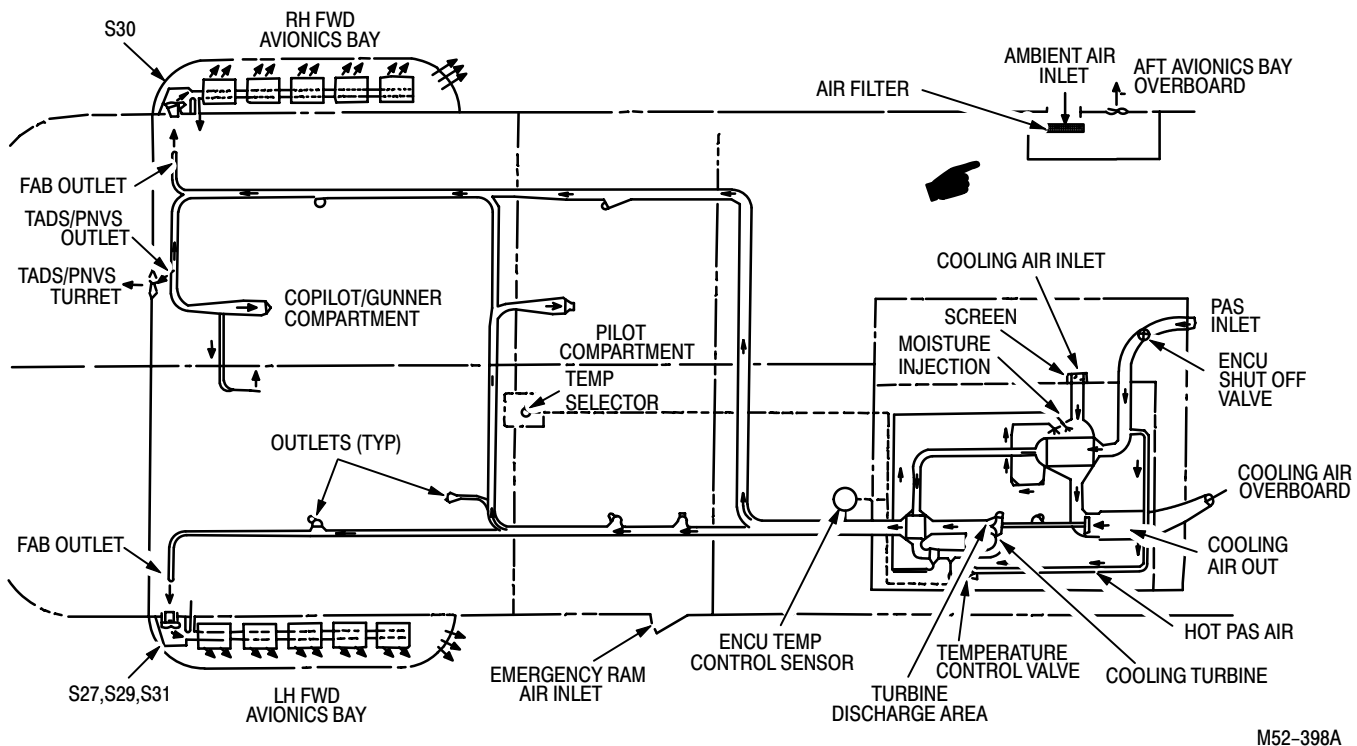
(1) The air passes to the cooling turbine which expands the compressed air and reduces the temperature to below freezing. To prevent the condenser/reheater from freezing, the temperature control sensor causes the temperature control valve to open. That mixes hot PAS air with the cold air at the turbine discharge area. The minimum temperature for air leaving the condenser-reheater is 36°F (2°C).

(2) To maintain a desired temperature, the pilot sets the **ECS TEMP** control switch. The switch controls the temperature control sensor. The sensor monitors the duct temperature and causes the temperature control valve to mix hot air with the cold air to maintain the selected temperature.

(3) The conditioned air flows to the crew stations, where the conditioned air maintains crew comfort provides cooling for TADS/PNVS and cools electronic gear.

(4) The FAB fans draw air from the CPG crew station and routes the air through the avionics gear before exhausting the air overboard.

(5) When the FAB temperature reaches 75°F (24°C), S27 signals the temperature control sensor to reduce the output temperature 15°F (-9°C). When the FAB temperature reaches 85°F (29°C), S29 signals to reduce the temperature 15°F (-9°C) further. When the bay temperature reaches 105°F (40°C), the **ECS** light on pilot caution/warning panel (fig. 13-5) turns on. When the **ECS** light is lit, it indicates a failed ECS or high FAB temperature.



M52-398A

Figure 13-7. ECS System Operation

CHAPTER 14 MULTIPLEX DATA BUS SYSTEM

14-1. PURPOSE

- a. **System.** The multiplex (MUX) data bus system serves the following purposes.
- (1) Computes and processes data for employment of weapons systems.
 - (2) Performs command and control functions of avionics and mission equipment.
 - (3) Monitors, evaluates, and indicates conditions of flight and mission critical components.
- b. **Fire Control Computer (FCC).** The FCC serves the following purposes.
- (1) Computes and processes data for employment of the point target weapon system (PTWS), area weapon system (AWS), and aerial rocket control system (ARCS).
 - (2) Provides data bus control (bus controller) of the MUX buses.
 - (3) Interrogates fault detection/location system (FD/LS) signals and reports status to each crew member.
 - (4) Performs mathematical functions of accepting, transferring, conditioning, and outputting discrete, analog, and digital signals for armament, fire control, and navigation functions.
- c. **MRTU Type I (FAB).** Accepts, transfers and outputs discrete, analog and digital signals for multiplexing and operation of the mission subsystems.
- d. **Remote HELLFIRE Electronics (RHE).** Performs the logic, processing, and control functions required to ensure operation of the PTWS.
- e. **MRTU Type II Pylon.** Accepts, transfers, and outputs discrete, analog, and digital signals to the pylon, for mission system operations.
- f. **Digital Automatic Stabilization Equipment Computer (DASEC).** Provides stability and command augmentation, backup control, turn coordination, attitude hold, heading hold, and hover augmentation.
- g. **Data Link Termination Unit (DLTU).** Two DLTUs connect each multiplex component to the data bus, one for the primary bus and one for the secondary bus.
- h. **Data Entry Keyboard (DEK).** Provides the CPG with the primary means of communicating with the FCC (ADC). Provides the CPG with the backup means of communicating with the FCC (ADD).
- i. **Symbol Generator.** The symbol generator serves the following purposes.
- (1) Provides symbology for the pilot's and CPG integrated helmet and display sight system (IHADSS).
 - (2) Provides symbology to the CPG TADS optical relay tube (ORT).
 - (3) Provides symbology to the pilot's video display unit (VDU).
- j. **Transformer Rectifier.** Provides +12 VDC to the data entry keyboard, fire control panel, and video recorder panel.

14-1. PURPOSE (cont)**14-1**

k. **CPG MRTU Type III.** The CPG MRTU Type III (includes the backup bus controller (BBC)) and serves the following purposes.

- (1) Accepts, transfers, and outputs discrete, analog, and digital signals.
- (2) Computes and processes data for employment of weapons systems.
- (3) Monitors the FCC for faults during normal operations.
- (4) Takes command of the MUX system if the FCC fails.

l. **Primary and Secondary Data Buses.** Provide interconnection between components.

m. **Control Display Unit (CDU) (ADD).** Provides the CPG with the means of communicating with the FCC. The CDU is not interfaced to the MUX bus in (ADC) configuration.

14-2. DESCRIPTION

The system includes the following components (fig. 14-1).

a. **FCC.** The FCC functions as the multiplex bus controller and contains software that initiates, processes, and controls all data communication.

b. **MRTU Type I (FAB)** (2 ea). The MRTUs Type I are a 1553A remote terminal interface between the bus controller and helicopter subsystems. A MRTU Type I is located in the right hand (RH) forward avionics bay (FAB) and another is located in the left hand (LH) FAB. Both MRTUs receive and transmit data in the form of discrete inputs, discrete outputs, switch closures, and dc analog signals.

c. **Remote HELLFIRE Electronics.** The RHE provides missile control and processing functions to the FCC.

d. **MRTU Type II Pylon** (4 ea). The MRTUs Type II are a 1553A remote terminal interface between the bus controller and pylon mounted weapons systems. The MRTUs are located in each pylon. The type of information transferred includes fire control commands and pylon status.

e. **DASEC.** The DASEC provides flight data to the FCC.

f. **DLTU.** The DLTUs provide isolation and signal conditioning between the multiplex bus and data transfer components.

g. **Data Entry Keyboard.** The DEK provides a crewmember a primary electronic interface to the MUX system (ADC). The DEK is used as backup electronic interface to the mux system (ADD). The DEK contains a seven position switch. The operator can initiate DEK built-in test (BIT), input range data, interrogate the fault detection/location system (FD/LS), program missile codes, input waypoint targeting data, input preflight data, and access FCC memory locations.

h. **Symbol Generator.** The symbol generator receives data from the FCC. The symbol generator provides flight, navigation, and weapon symbology which can be combined video and symbols or symbology only.

i. **Transformer Rectifier.** The transformer rectifier provides 12 VDC operating power to the DEK, CPG fire control panel, and video recorder.

j. **CPG MRTU Type III** (backup bus controller). The CPG MRTU Type III provides backup bus control and encoding/decoding capability. The CPG MRTU Type III receives and transmits data in the form of discrete inputs, discrete outputs, switch closures, and dc analog signals.

k. **Primary and Secondary Data Buses.** The primary and secondary data buses provide command and control functions between the FCC and interfacing components.

14-2. DESCRIPTION (cont)

14-2

l. Control Display Unit (ADD). The CDU provides a crewmember an electronic interface to the MUX system. The CDU is not interfaced to the MUX bus in (ADC) configuration. The CDU contains eight variable action buttons (VABs), a cathode ray tube (CRT), eleven active fixed action buttons (FABs) and a keyboard. The operator can control and display information relating to the following:

- (1) Navigation.
- (2) Data.
- (3) Weapons.
- (4) Laser Codes.
- (5) FD/LS.
- (6) Flight Plan/Waypoints.
- (7) Targets.
- (8) Embedded GPS Inertial (EGI) Boresighting.
- (9) Gun Harmonization.
- (10) FCC Memory Locations.
- (11) AND Echo.
- (12) Data Transfer Unit (DTU).
- (13) Zeroize.
- (14) Hover Bias Calibration Mode (HBCM).

m. Embedded GPS Inertial (EGI) (ADD). The EGI provides inertial navigation system (INS) and global positioning system (GPS) information to the FCC.

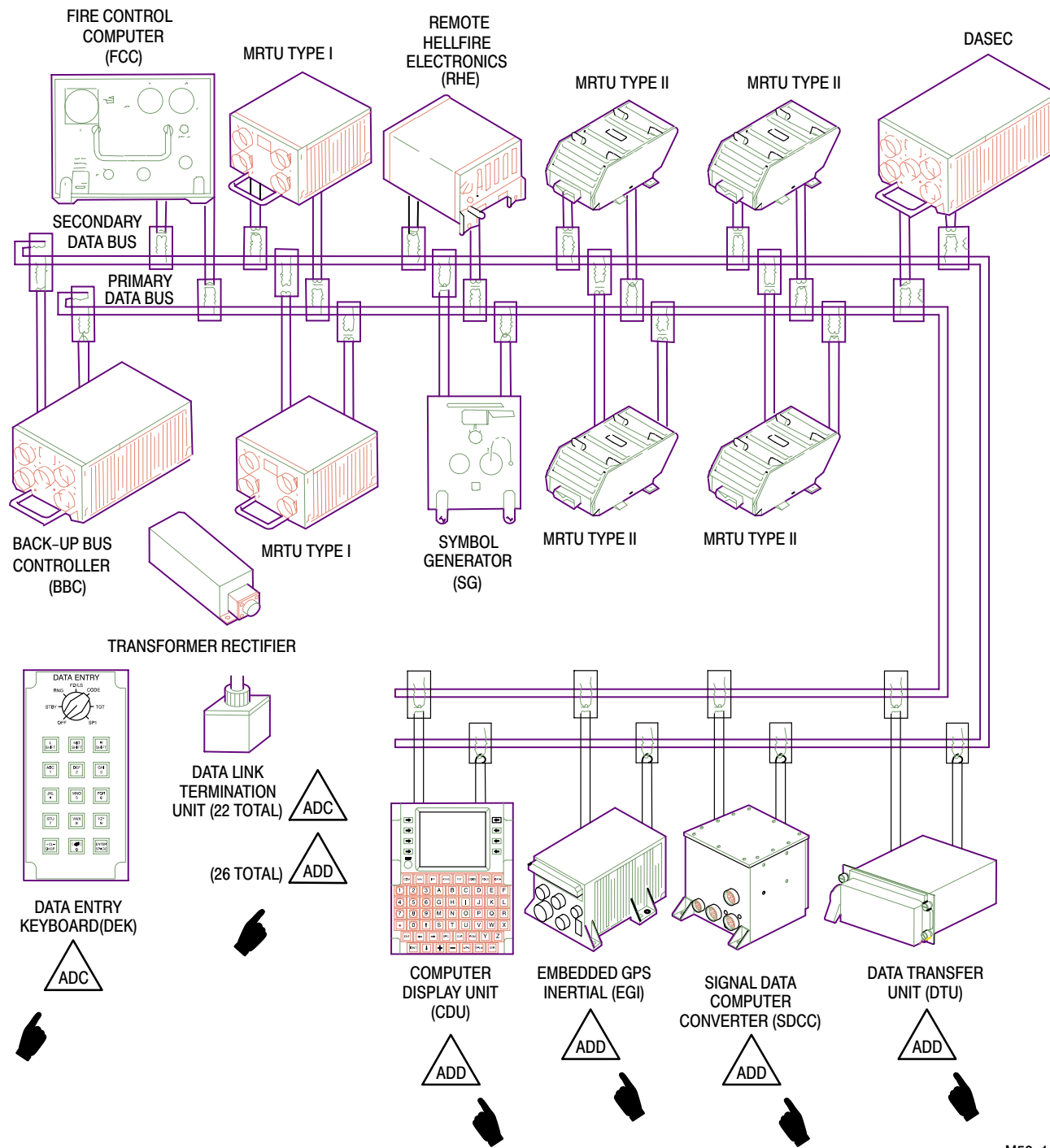
n. Data Transfer Unit (DTU) (ADD). The DTU provides the capability to load and save cartridge data to and from the FCC.

o. BBC In Control Detector (ADD). The BBC in control detector enables the DEK when the BBC takes control of the bus.

p. Doppler Navigation System (DNS) (ADD). The DNS provides navigation information to the FCC via the MUX bus. The DNS is not interfaced to the MUX bus in (ADC) configuration.

14-2. DESCRIPTION (cont)

14-2



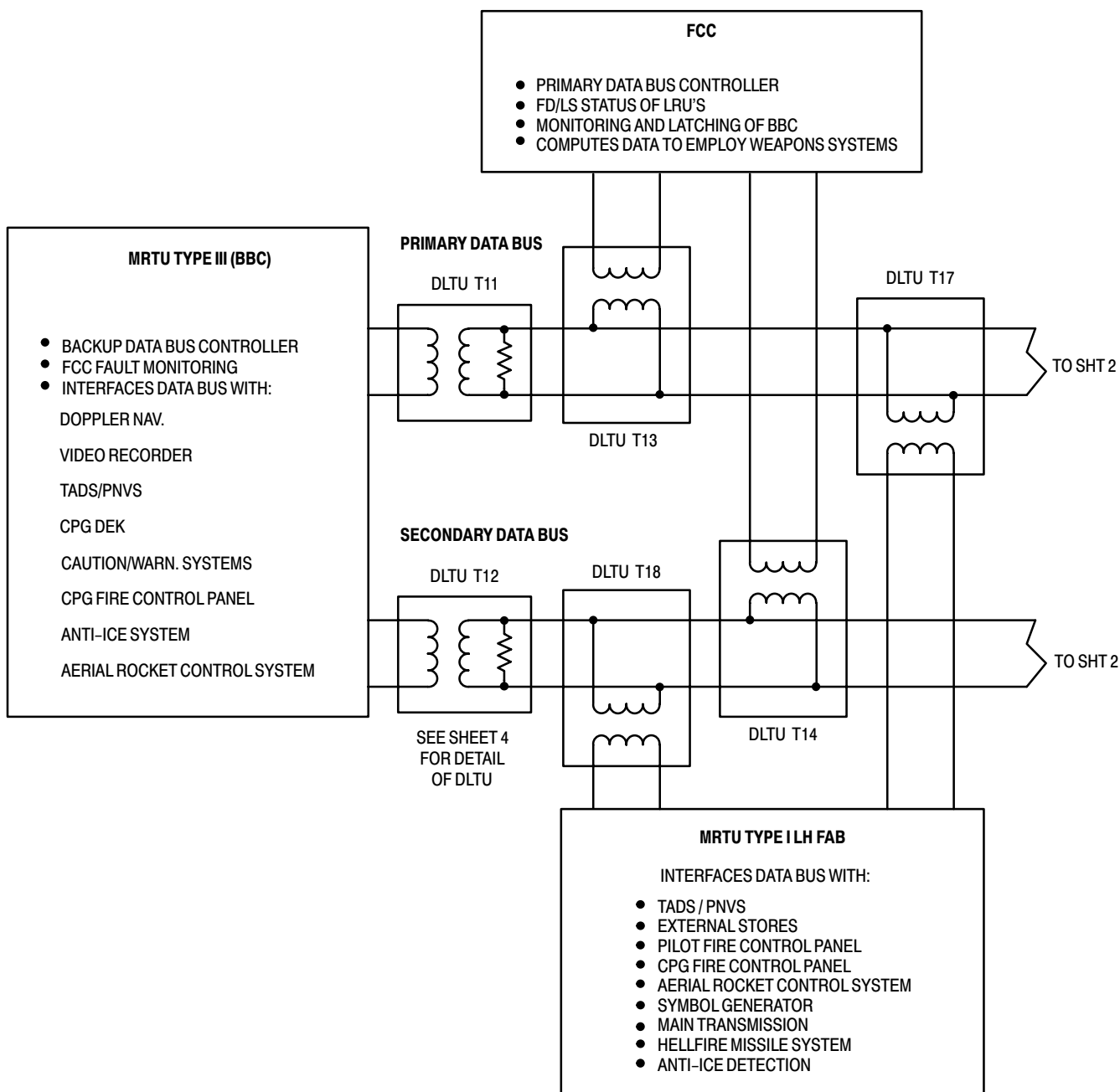
M52-146A

Figure 14-1. MUX System Major Components

14-3. THEORY OF OPERATION (cont)

14-3**14-3. THEORY OF OPERATION****a. FCC Interface.**

- (1) The FCC is wired directly to the following components (fig. 14-2).
 - (a) DLTUs T14 and T13 for MUX Bus interface.
 - (b) BBC for FCC monitoring and control latching.
 - (c) Electrical power distribution box.
 - (d) BBC in control detector for enabling the DEK when the BBC takes control of the bus (ADD).
- (2) The FCC is connected, via the data bus, to the following components to provide status and data information transfer:
 - (a) MRTU Type I (2 ea).
 - (b) RHE.
 - (c) Symbol Generator (SG).
 - (d) MRTU Type II Pylon (4 ea).
 - (e) DASEC.
 - (f) EGI (ADD).
 - (g) DTU (ADD).
 - (h) CDU (ADD).
 - (i) DNS (ADD).



M52-147-1A
SHEET 1 OF 4

Figure 14-2. FCC Interface (Sheet 1 of 4)

14-3. THEORY OF OPERATION (cont)

14-3

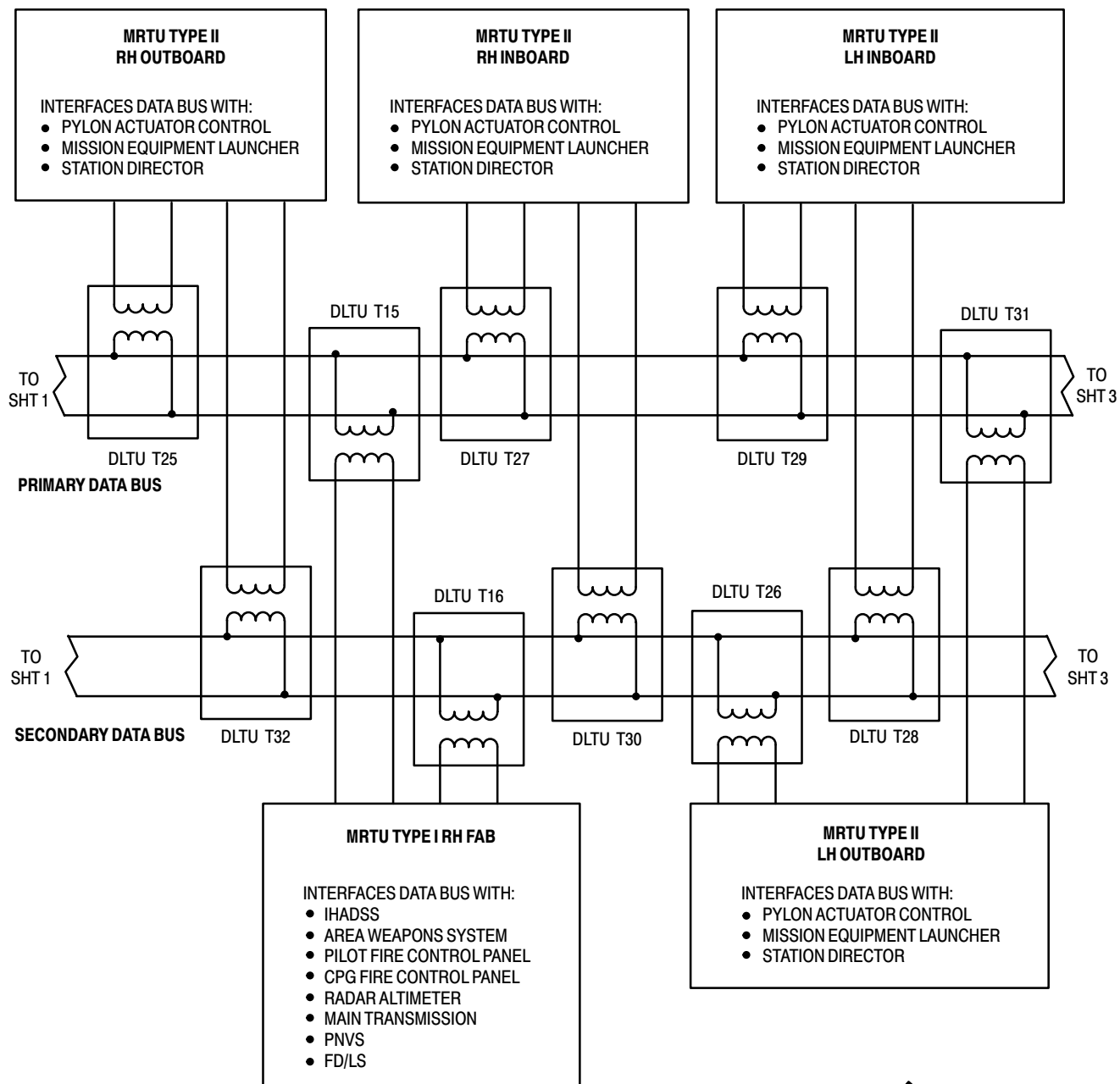
M57-147-2A
SHEET 2 OF 4

Figure 14-2. FCC Interface (Sheet 2 of 4)

14-3. THEORY OF OPERATION (cont)

14-3

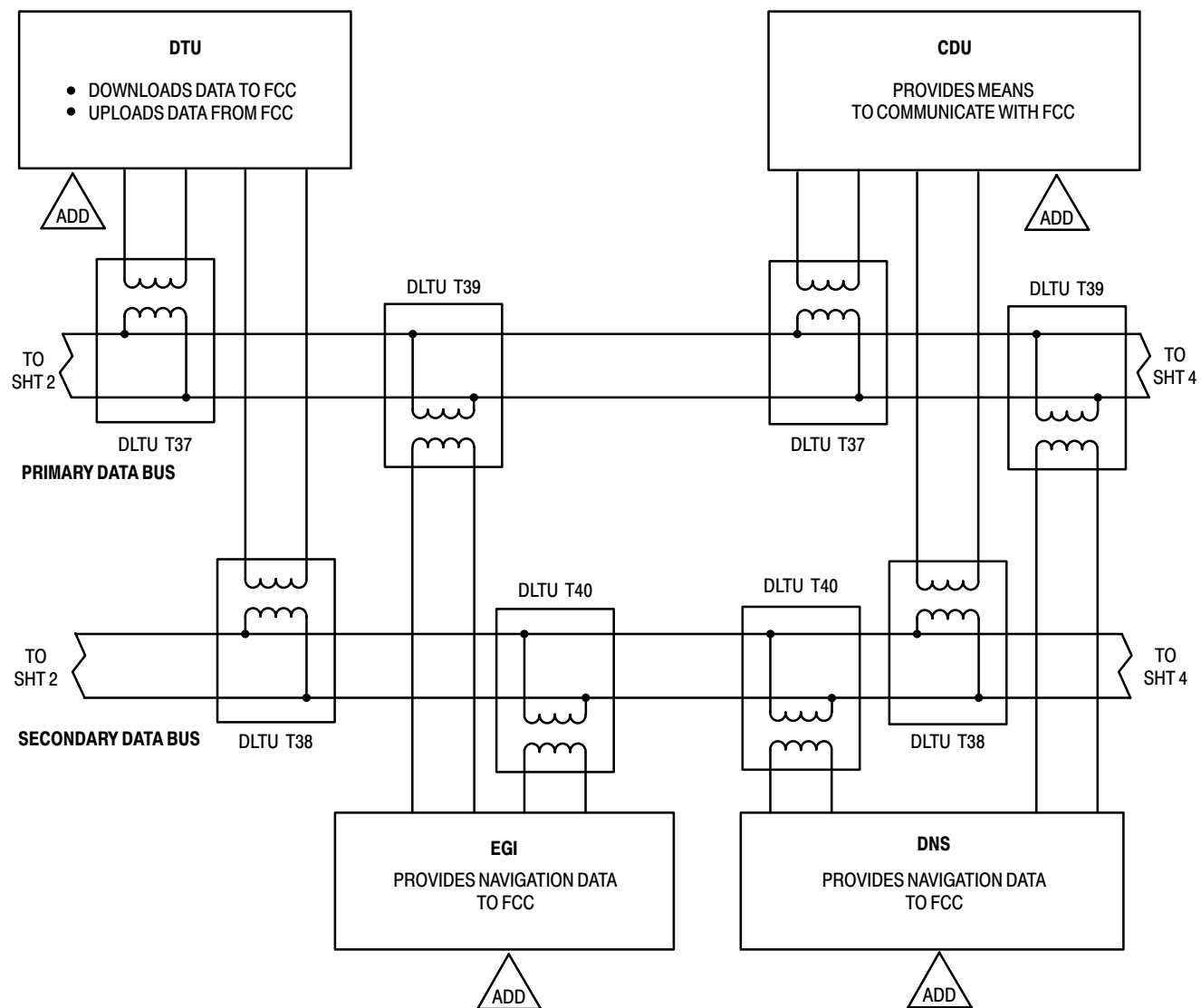
M57-147-3
SHEET 3 OF 4

Figure 14-2. FCC Interface (Sheet 3 of 4)

14-3. THEORY OF OPERATION (cont)

14-3

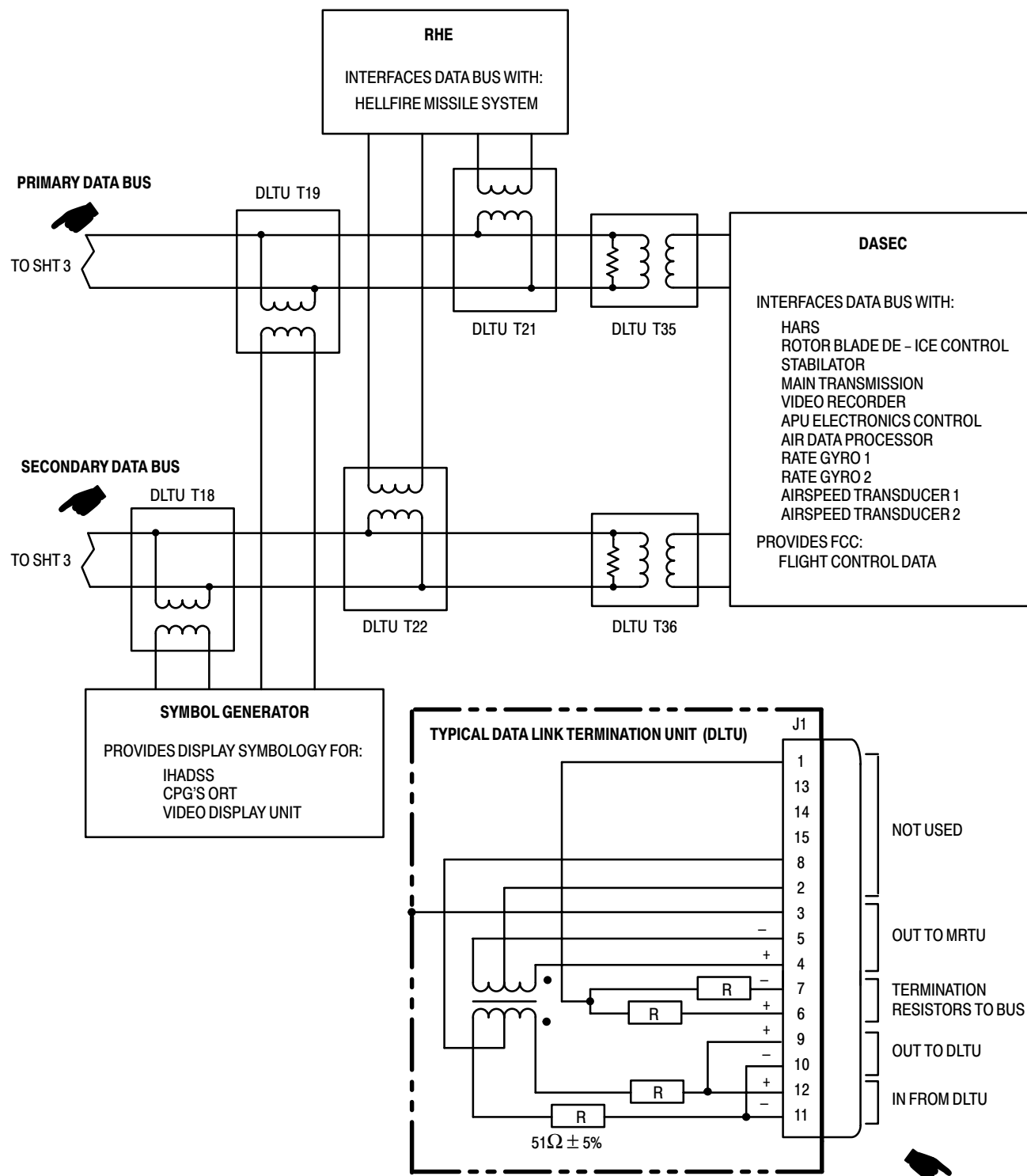
M57-147-4
SHEET 4 OF 4

Figure 14-2. FCC Interface (Sheet 4 of 4)

14-3. THEORY OF OPERATION (cont)

14-3

(3) In the normal mode of operation, whenever aircraft power is applied, 115 VAC 400 Hz from the CPG **FCC AC** circuit breaker (CB16) is applied to the FCC (fig. 14-3).

(a) Circuit breaker **FCC DC** (CB4) supplies 28 VDC through the A2 and A3 contacts of relay K2-7/8 to the FCC, when energized.

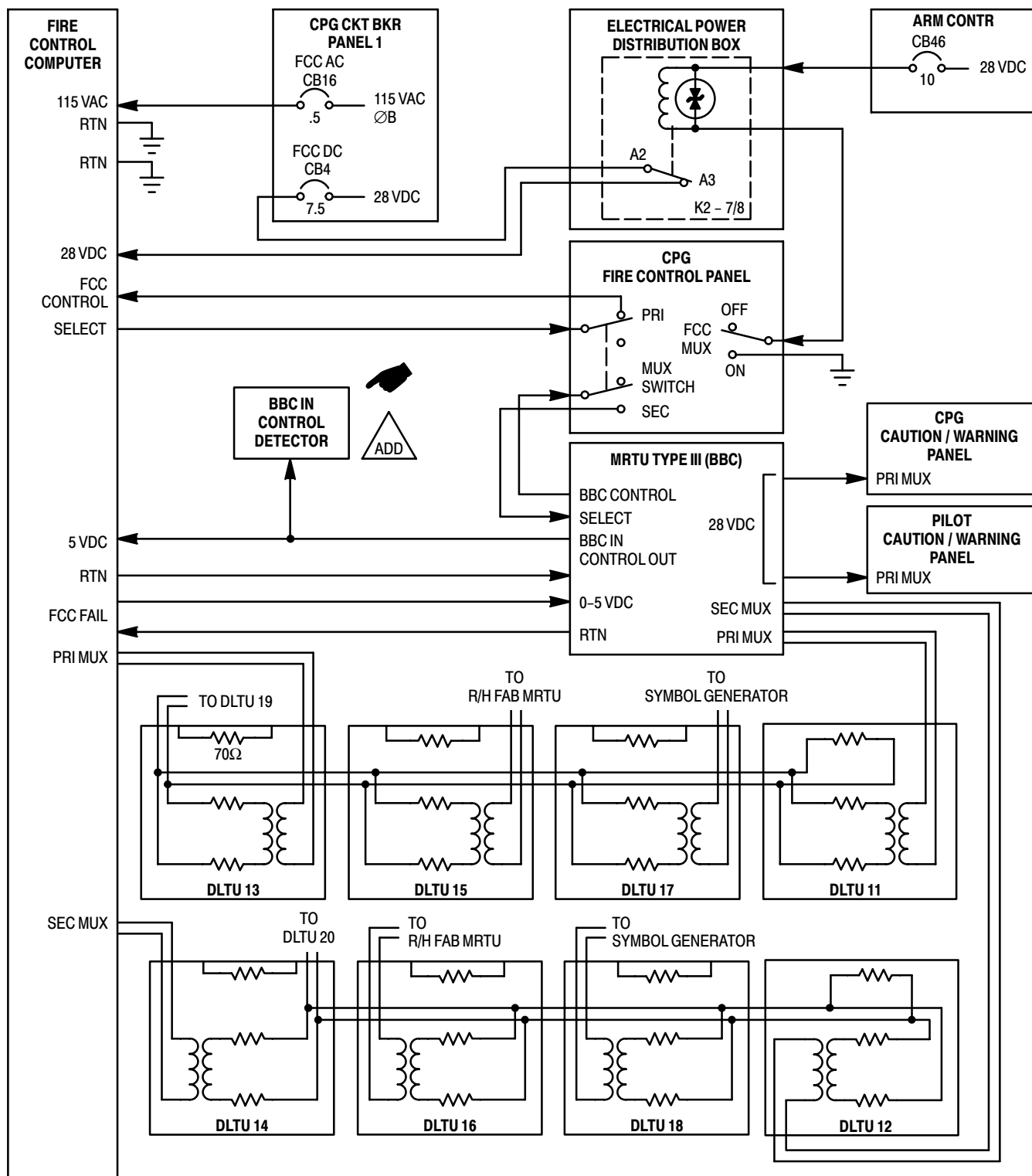
(b) Circuit Breaker **ARM CONTR** (CB46) supplies 28 VDC to the coil of relay K2-7/8. The **FCC MUX** switch's **OFF** position de-energizes the relay which removes power from the FCC.

(c) When the **FCC MUX** switch is set to on, relay K2-7/8 is energized applying 28 VDC to the FCC. A 5 VDC signal is routed through the **PRI SEC MUX** switch and back to the FCC turning the FCC on selecting the FCC as bus controller. In turn, the FCC generates a 5 VDC signal out on the FCC fail line, deactivating bus controller functions in the BBC.

(d) The FCC (bus controller) generates a series of transmit commands and sends them out to appropriate MRTUs via DLTU T13 and the primary MUX bus. The MRTUs respond with the requested data, depending on subsystem inputs, via DLTU T13 and the primary MUX bus.

14-3. THEORY OF OPERATION (cont)

14-3



M52-148B

Figure 14-3. FCC Operation

14-3. THEORY OF OPERATION (cont)

14-3

(e) The FCC then processes this data and sends out a series of receive commands and data via DLTU T13 and the primary MUX bus.

(f) The MRTUs decode data and apply required discrete, analog, or synchronization signals to the subsystems.

(g) If the FCC receives an error from an MRTU during a MUX frame, the FCC reissues the command during the next frame. If an error is not received on the next frame, the FCC continues to issue commands on the primary data bus. If two successive errors are received, the FCC switches command to DLTU T14 and the secondary data bus for that MRTU supplying the error.

(h) If operation is satisfactory during the next MUX frame on the secondary data bus, the secondary data bus is designated the primary data bus for that MUX system component.

(i) If an error is received on the secondary data bus during the next MUX frame, control is switched back to the primary data bus.

(j) Switching of MUX system components between primary and secondary data buses continues until no errors are received.

(4) In backup mode of operation, during normal operation the FCC fail line is 5 VDC. If the FCC fails, the system enters backup mode. The FCC fail line goes to 0 V. When the BBC fail line goes to 0 V, the BBC waits until the MUX bus is quiet, and then assumes control of the MUX bus. The BBC sets the BBC IN CONTROL signal to 5 VDC. The BBC applies 28 VDC to the pilot and CPG caution/warning panels, turning on the pilot and CPG **PRI MUX** caution lights.

(a) The BBC assumes responsibility for bus control when commanded by a manual switch command from the CPG fire control panel (FCP).

(b) The BBC gives bus control back to the FCC if the FCC fail line goes high (5 VDC) and the **MUX PRI/SEC** switch is set to **PRI**.

(c) Setting the **MUX PRI/SEC** switch to **SEC** causes the BBC to turn off the **PRI MUX** caution lights.

(d) The BBC IN CONTROL signal of 5 VDC is sent to the BBC in control detector. The BBC in control detector removes the CDU from the data bus when the FCC fails (ADD).

b. MRTU Type I LH FAB.

(1) Interface. The MRTU Type I LH FAB is wired directly to the following units (fig. 14-4).

(a) DLTUs T19 and T20 to establish multiplex communication link.

(b) Electrical power distribution box for 26 VAC 400 Hz input operating voltage.

(c) TADS laser electronics unit (LEU) to provide laser range finder/designator (LRFD) temperature, power, and coolant status, as well as counter-countermeasures (CCM) first/last pulse selection.

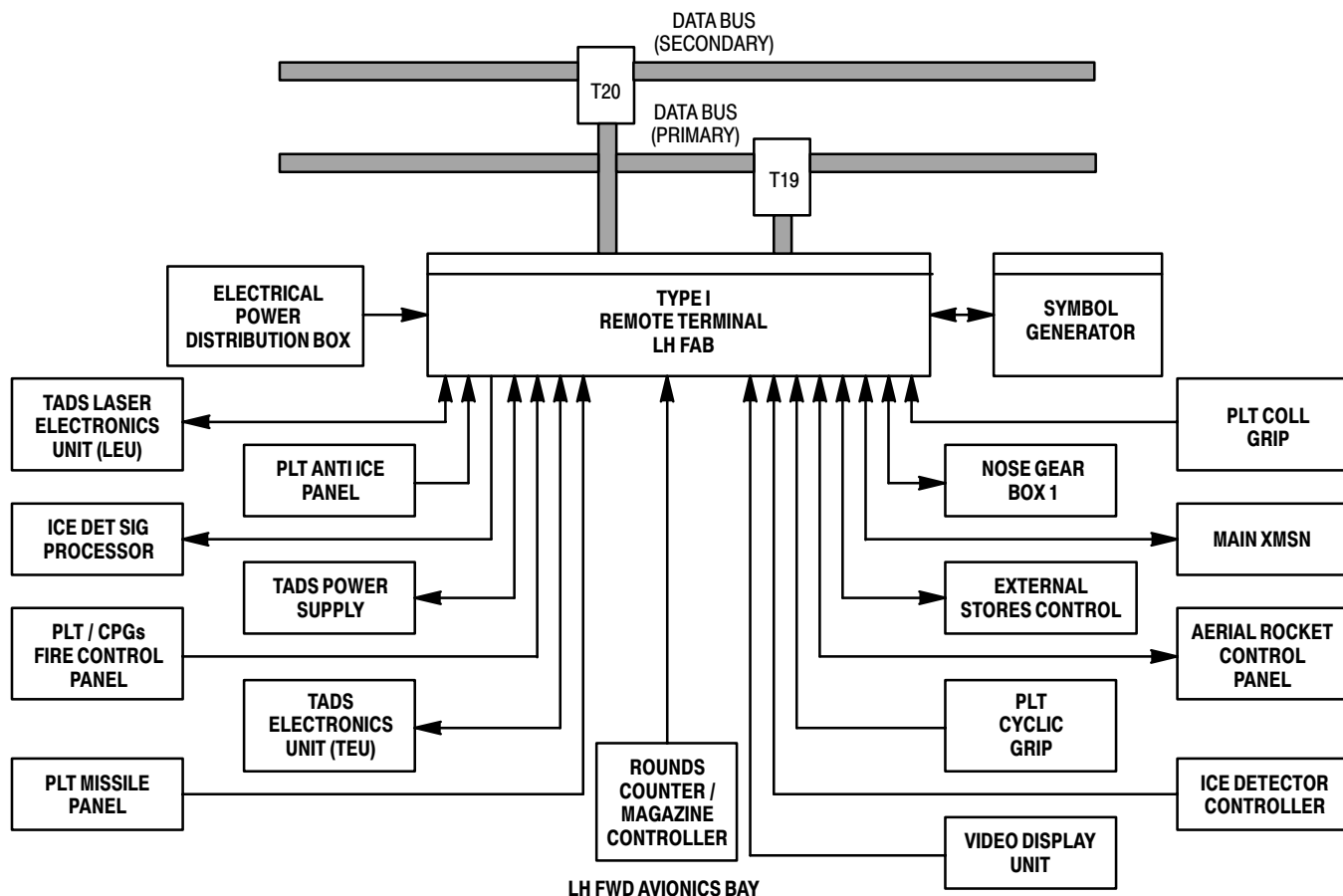
(d) Pilot's **ANTI ICE** panel for TADS anti-ice selection.

(e) Canopy temp controller for BIT monitoring.

(f) TADS power supply (TPS) to initiate TADS, TADS forward looking infrared radar (FLIR), PNVs standby/operating voltages and TADS/PNVs BIT monitoring.

14-3. THEORY OF OPERATION (cont)

14-3



M52-149

Figure 14-4. MRTU Type I LH FAB Interface

- (g) Pilot's and CPG FCPs for switch position, and BIT monitoring.
- (h) TEU for status, data, clock, symbol brightness interfaces.
- (i) Pilot's missile panel to monitor switch positions.
- (j) Rounds counter/magazine controller (RC/MC) for data and clock signal interface.
- (k) Symbol generator for pilot and CPG symbol intensity control.
- (l) Pilot's collective control stick to monitor switch positions.
- (m) Engine 1 nose gearbox for oil temperature and pressure monitoring.
- (n) Main transmission for L/H oil pressure monitoring.
- (o) External stores controller for 100 knot airspeed lockout, missile enable, elevation command and rate signals, as well as FD/LS monitoring.
- (p) Aerial rocket control panel for data, status, and fire enable circuit interface.
- (q) Pilot's cyclic control stick grip for switch position monitoring.

14-3. THEORY OF OPERATION (cont)

14-3

(r) Ice detector controller for FD/LS input.

(s) VDU for artificial horizontal pitch and roll adjustments.

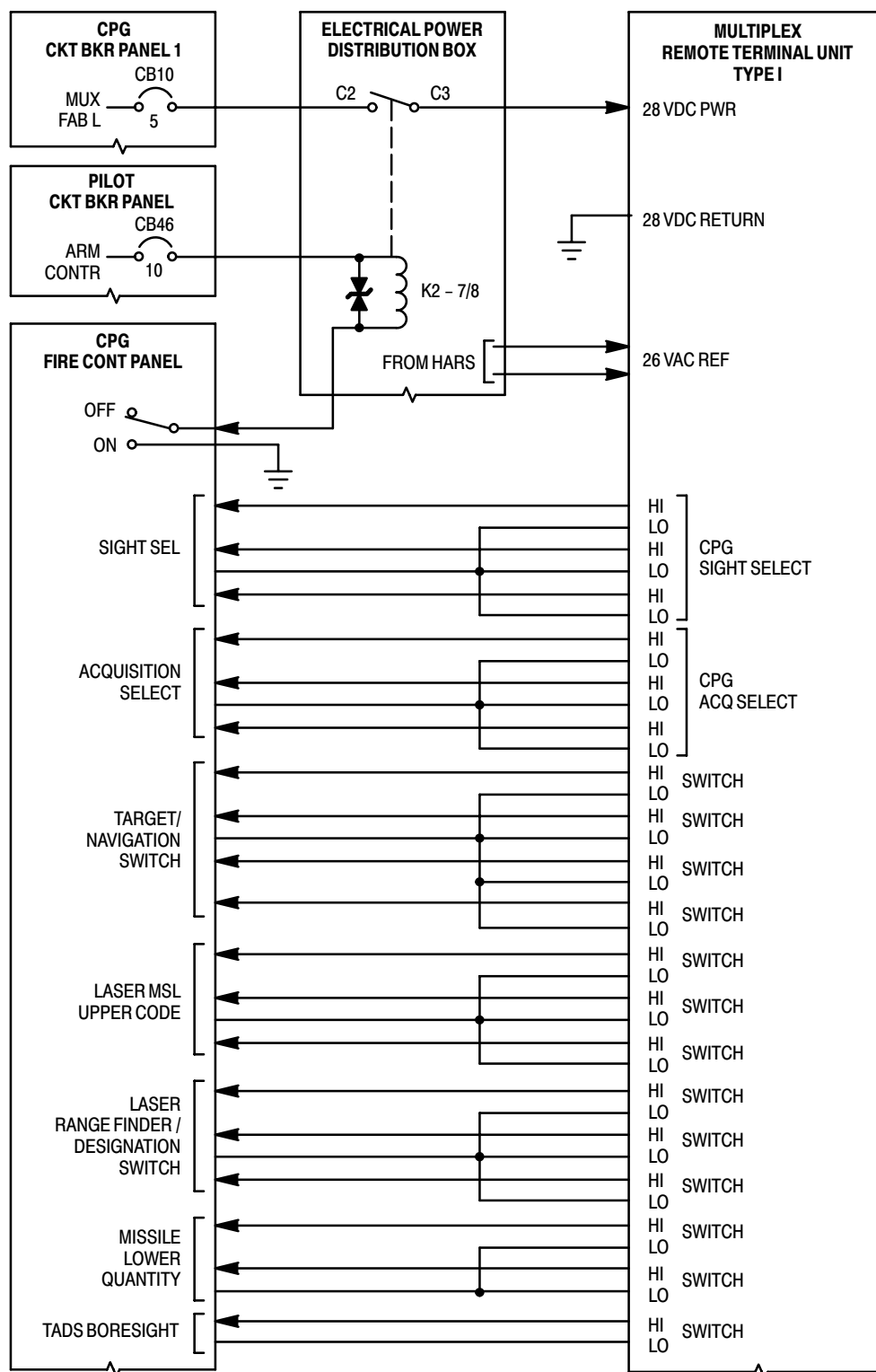
(2) **Power Input.** Circuit breaker **MUX FAB L** (CB10), on the CPG's circuit breaker panel, supplies 28 VDC through the C2 and C3 contacts of relay K2-7/8 to the MRTU Type I in the left forward avionics bay (FAB).

(a) Circuit breaker **ARM CONTR** CB46, on the pilot's circuit breaker panel, supplies 28 VDC to the coil of relay K2-7/8. The **FCC MUX** switch, when set to **OFF**, de-energizes the relay which removes power from the MRTU.

(b) Setting the **FCC MUX** switch to **ON** energizes relay K2-7/8, allowing 28 VDC operating power to be supplied to the MRTU Type I LH FAB.

14-3. THEORY OF OPERATION (cont)

14-3

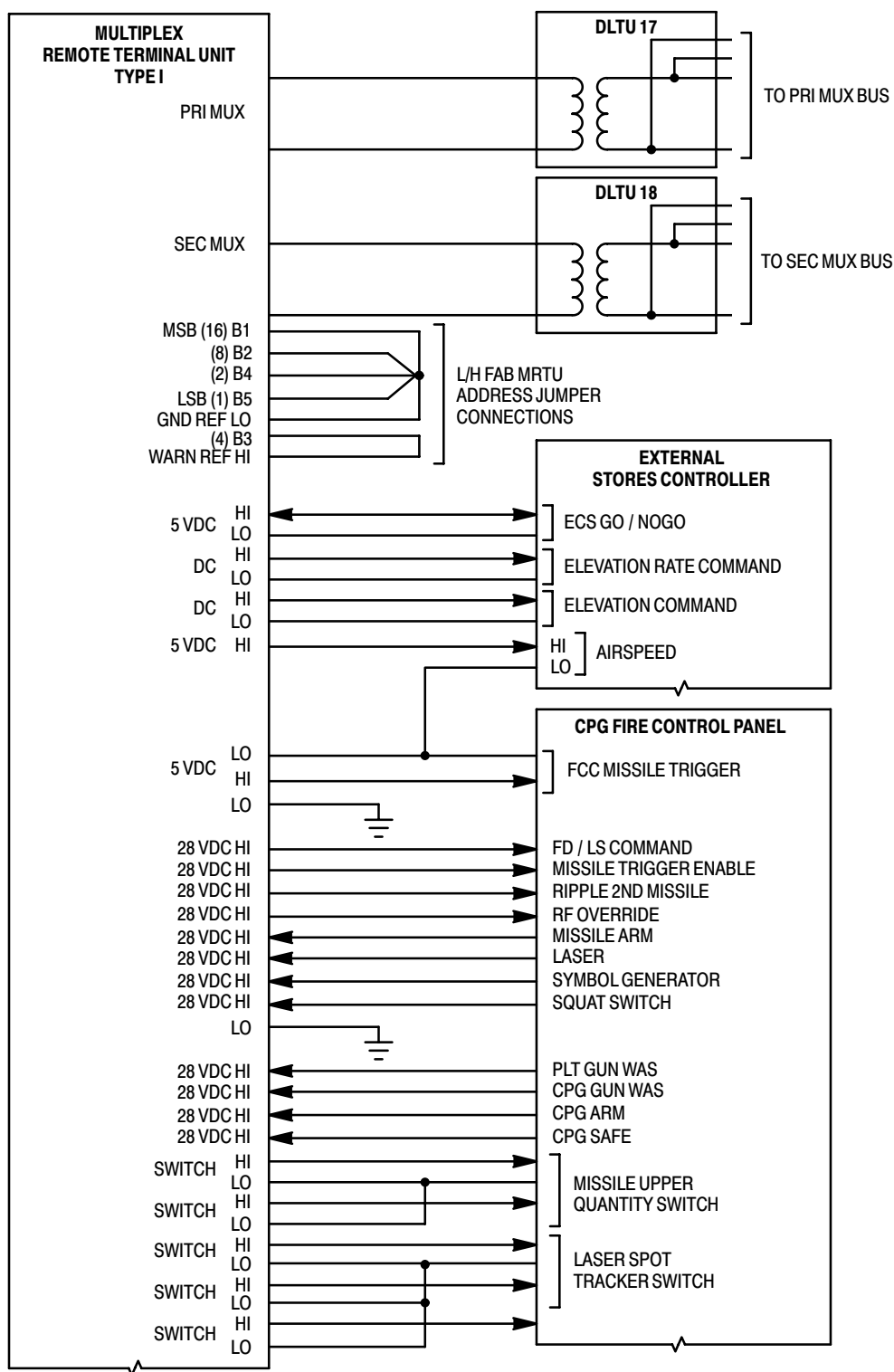


M52-150-1A

Figure 14-5. MRTU Type I LH FAB Operation (Sheet 1 of 6)

14-3. THEORY OF OPERATION (cont)

14-3

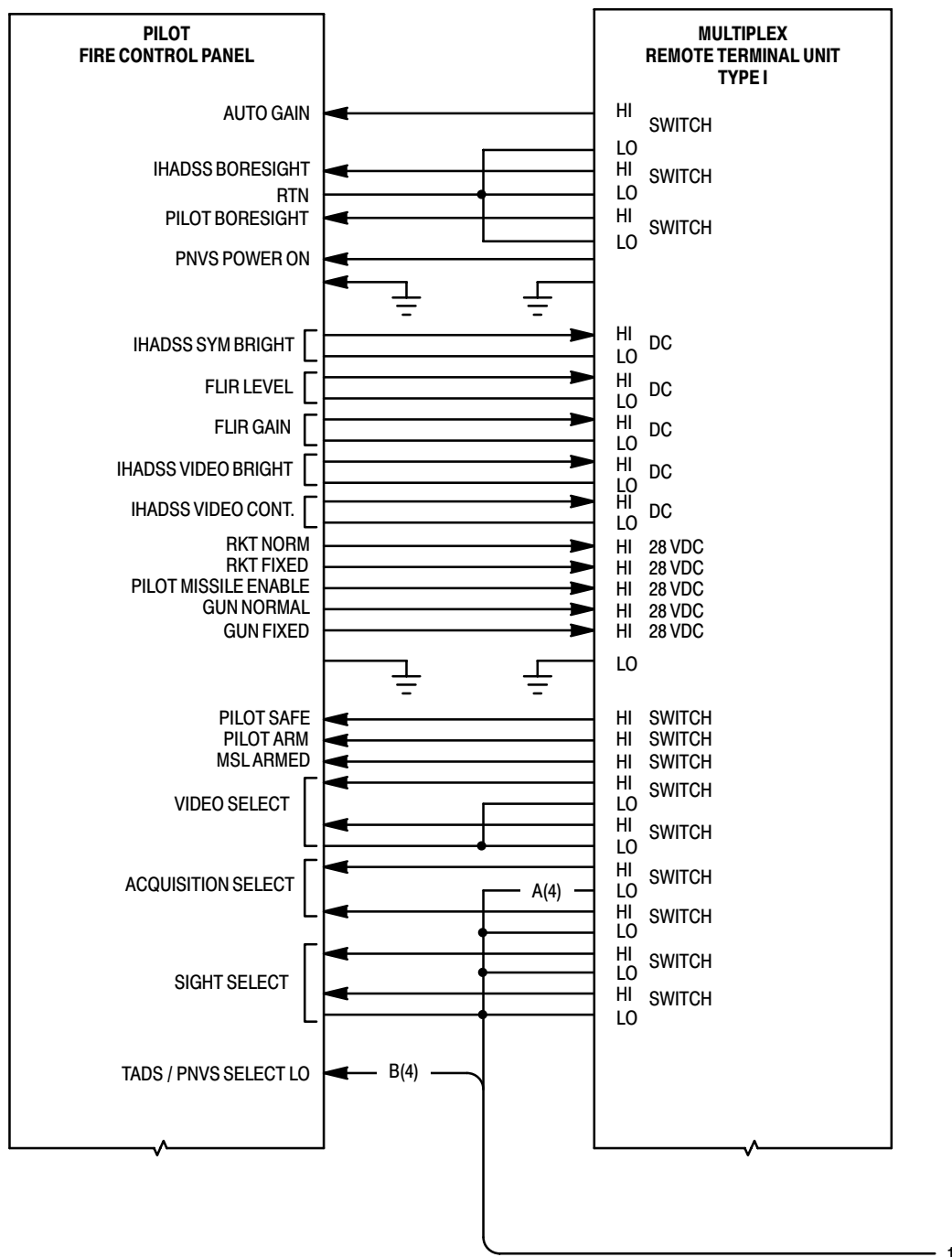


M52-150-2A

Figure 14-5. MRTU Type I LH FAB Operation (Sheet 2 of 6)

14-3. THEORY OF OPERATION (cont)

14-3

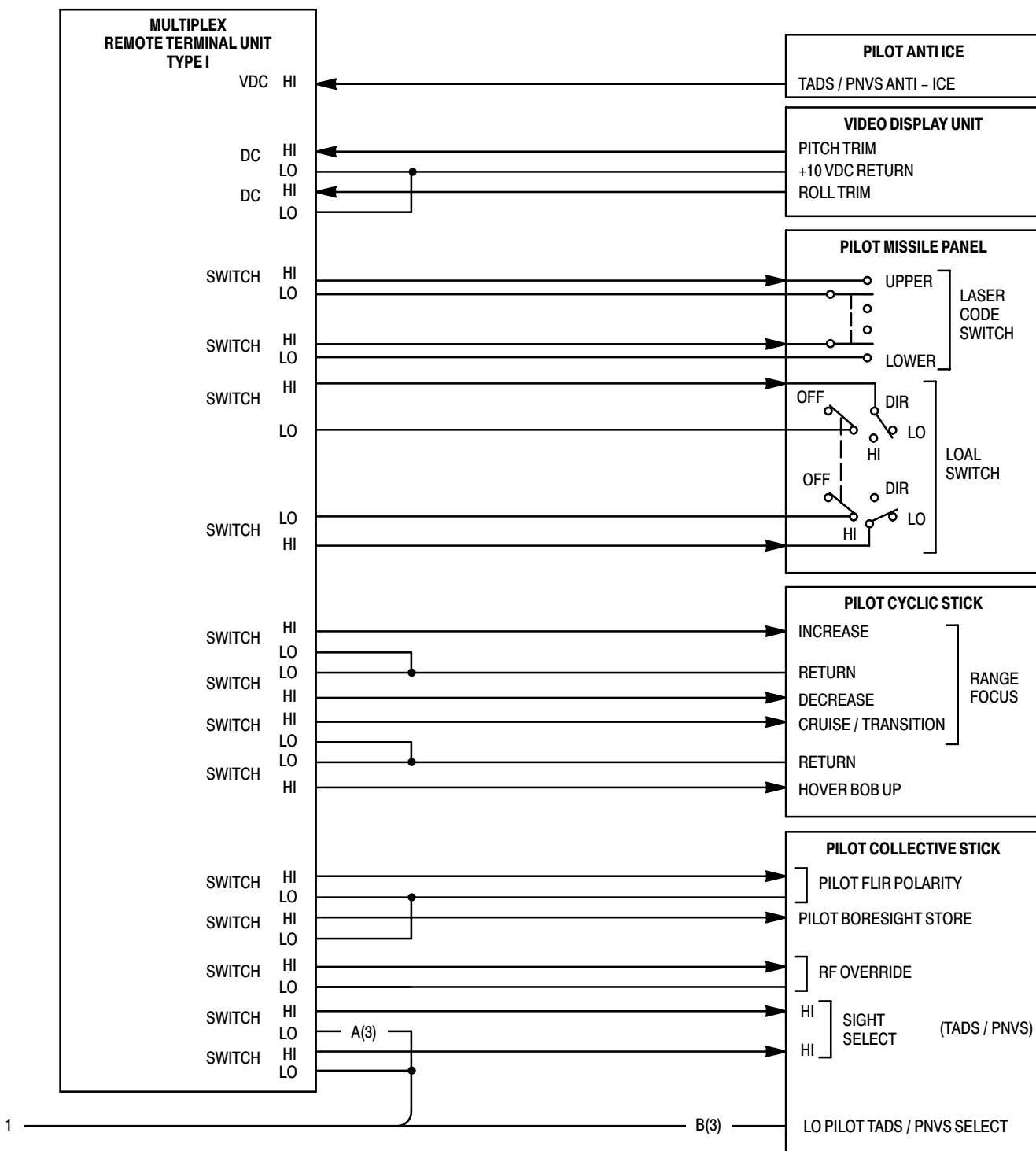


M52-150-3A

Figure 14-5. MRTU Type I LH FAB Operation (Sheet 3 of 6)

14-3. THEORY OF OPERATION (cont)

14-3

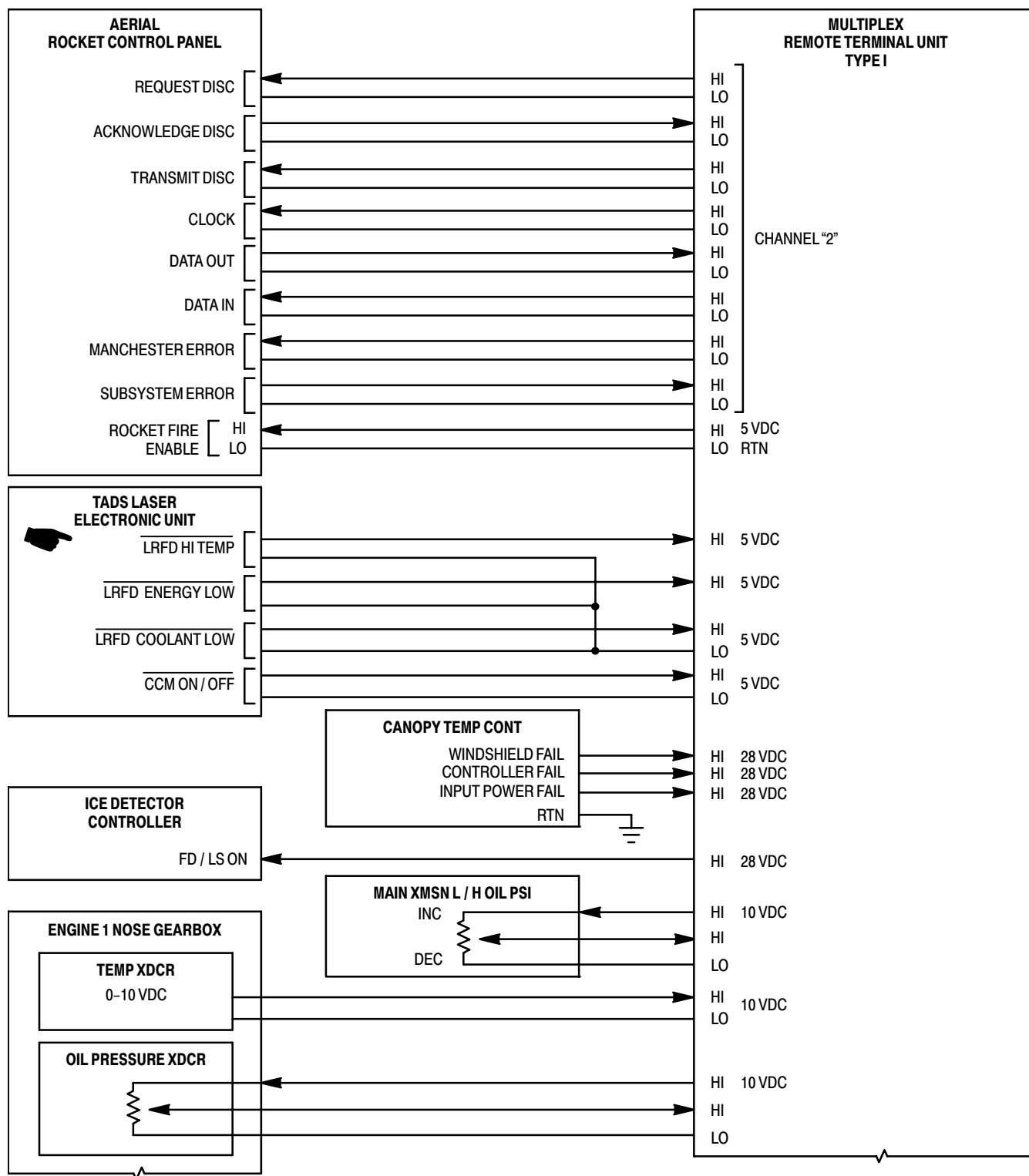


M52-150-4A

Figure 14-5. MRTU Type I LH FAB Operation (Sheet 4 of 6)

14-3. THEORY OF OPERATION (cont)

14-3

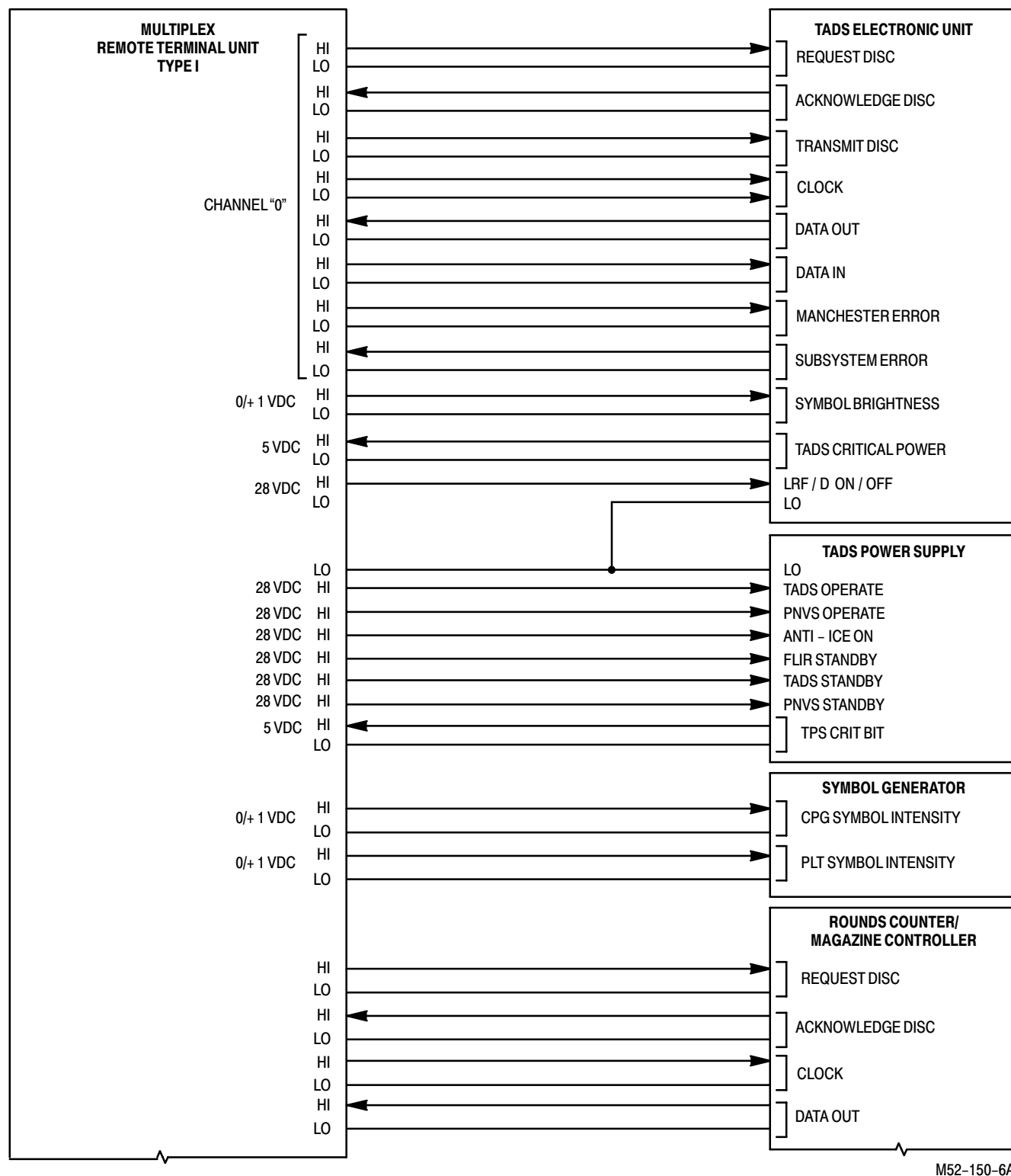


M52-150-5B

Figure 14-5. MRTU Type I LH FAB Operation (Sheet 5 of 6)

14-3. THEORY OF OPERATION (cont)

14-3



M52-150-6A

Figure 14-5. MRTU Type I LH FAB Operation (Sheet 6 of 6)

14-3. THEORY OF OPERATION (cont)

14-3**(3) Operation.**

(a) The LH FAB MRTU monitors the CPG's FCP for the following actions (fig. 14-5).

- Acquisition select switch.
- Target/Navigation switch.
- Laser missile upper code.
- Laser range finder/designator switch.
- Missile lower quantity switch.
- TADS boresight switch.
- Laser spot tracker switch.
- Missile upper quantity switch.
- CPG's safe switch.
- CPG's arm switch.
- CPG gun WAS.
- PLT gun WAS.
- Squat switch.
- Symbol generator switch
- Laser switch.
- Missile arm.

(b) The MRTU interfaces with the CPG's FCP to supply dc power for the following signals.

- RF override.
- Ripple 2nd missile.
- Missile trigger enable.
- FD/LS command.
- FCC missile trigger.

(c) The MRTU Type I LH FAB monitors the external stores controller for ECS GO/NO-GO.

(d) The MRTU Type I LH FAB interfaces with the external stores controller to provide dc power for the following outputs.

- Elevation rate command.
- Elevation command.
- Airspeed command.

14-3. THEORY OF OPERATION (cont)

14-3

(e) The MRTU Type I LH FAB monitors the pilot's FCP for the following actions.

- Auto gain.
- IHADSS boresight.
- Pilot boresight.
- PNVIS power on.
- IHADSS symbol brightness.
- FLIR level.
- FLIR gain.
- IHADSS video bright.
- IHADSS video contrast.
- Rocket normal.
- Rocket fixed.
- Pilot missile enable.
- Gun normal.
- Gun fixed.
- Pilot safe.
- Pilot arm.
- Missile armed.
- Video select.
- Acquisition select.

(f) The MRTU Type I LH FAB monitors the pilot's FCP and pilot collective stick sight select switch.

(g) The MRTU Type I LH FAB monitors the pilot collective stick for the following actions.

- RF override.
- Pilot boresight store.
- Pilot FLIR polarity

(h) The MRTU Type I LH FAB monitors the pilot's cyclic stick for the following actions.

- Range focus
- Cruise/transition switch.
- Hover/bobup switch.

(i) The MRTU Type I LH FAB monitors the pilot's missile panel for the following actions.

- Laser code switch
- Lock on after launch (**LOAL**) switch

14-3. THEORY OF OPERATION (cont)

14-3

- (j) The MRTU Type I LH FAB monitors the VDU for the following signals.
 - Pitch trim
 - Roll trim.
- (k) The MRTU Type I LH FAB monitors the pilot's **ANTI ICE** panel.
- (l) The MRTU Type I LH FAB interfaces with the aerial rocket control panel (ARCP) for serial digital data transfers.
- (m) The MRTU Type I LH FAB monitors the TADS LEU for the following signals.
 - Laser range finder/designator (LRFD) high temperature.
 - LRFD energy low
 - LRFD coolant low.
 - LRFD first/last command.
- (n) The MRTU Type I LH FAB monitors the canopy temp controller for the following signals.
 - Windshield fail.
 - Controller fail.
 - Input power failure.
- (o) The MRTU Type I LH FAB interfaces with the ice detector controller to provide a 28 VDC FD/LS ON signal.
- (p) The MRTU Type I LH FAB interfaces with the (L/H) main transmission for the following purposes.
 - Provide power to the oil pressure transducer.
 - Monitor the oil pressure transducer
- (q) The MRTU Type I LH FAB interfaces with engine 1 nose gearbox for the following purposes.
 - Monitors the temperature transducer.
 - Provides power to the oil pressure transducer.
 - Monitors the oil pressure transducer.
- (r) The MRTU Type I LH FAB interfaces with the TEU for serial digital transfer.
- (s) The MRTU Type I LH FAB interfaces with the TPS to provide dc power for the following signals.
 - TADS operate.
 - PNVs operate.
 - Anti-Ice on.
 - FLIR standby.
 - TADS standby.
 - PNVs standby.
- (t) The MRTU Type I LH FAB monitors the TPS for TADS critical signals.

14-3. THEORY OF OPERATION (cont)

14-3

(u) The MRTU Type I LH FAB interfaces with the symbol generator to provide the following signals.

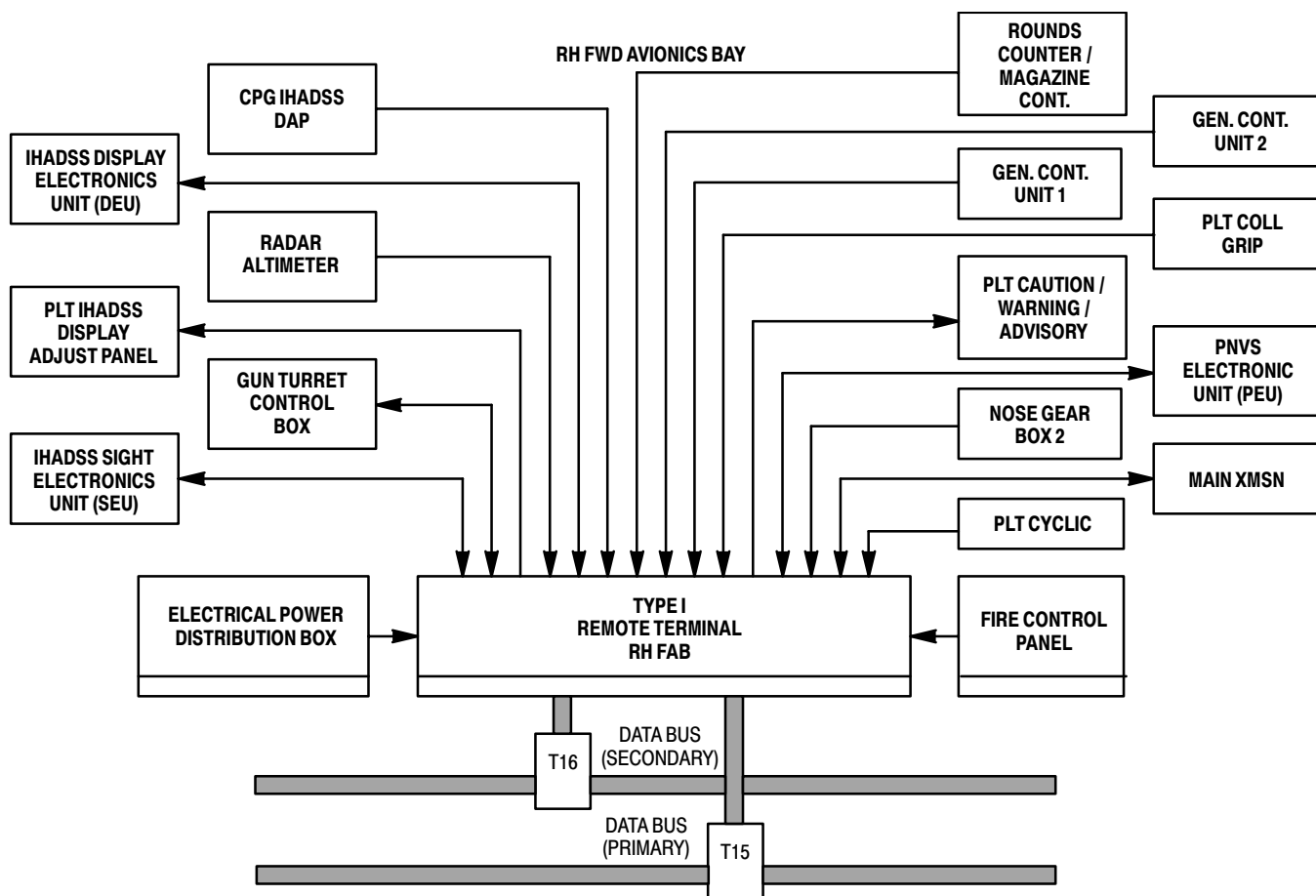
- CPG symbol intensity
- Pilot symbol intensity

(v) The MRTU Type I LH FAB interfaces with the RC/MC for serial digital data transfer.

c. **MRTU Type I RH FAB.**

(1) **Interface.** The MRTU Type I RH FAB is wired directly to the following units (fig. 14-6).

- (a) DLTUs T15 and T16 to establish multiplex communication link.
- (b) Electrical power distribution box for 28 VDC and 26 VAC reference input operating voltage.
- (c) IHADSS sight electronics unit (SEU) for serial digital data.



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Figure 14-6. MRTU Type I RH FAB Interface

14-3. THEORY OF OPERATION (cont)

14-3

(d) Gun turret control box for positioning 11.8 VAC reference, feedback, error, inhibit, boresight, FD/LS, and trigger signals.

(e) Gun control box for FD/LS.

(f) Pilot display adjust panel (DAP) for brightness and contrast adjustment.

(g) Radar altimeter for auxiliary altitude signal.

(h) IHADSS display electronics unit (DEU) pilot and CPG azimuth and elevation, and BIT signals.

(i) CPG DAP for brightness and contrast adjustment.

(j) RC/MC for FD/LS.

(k) Generator control unit 1 for FD/LS.

(l) Generator control unit 2 for FD/LS.

(m) Pilot collective grip for jettison switch.

(n) Pilot caution/warning panel for weapon system status.

(o) PNVIS electronics unit (PEU) for mode, anti-ice, and line of sight (LOS) signals.

(p) Nose gear box 2 for oil temperature and pressure monitoring.

(q) Main transmission (RH) for oil pressure monitoring.

(r) Pilot cyclic for 1st/2nd trigger detent.

(s) CPG's FCP for weapon action, missile enable, override and trigger signals.

(2) **Power Input.** Circuit breaker **RH FAB** (CB89), on the CPG's circuit breaker panel, supplies 28 VDC to contact B2 of relay K2-7/8 in the electrical power distribution box (fig. 14-7).

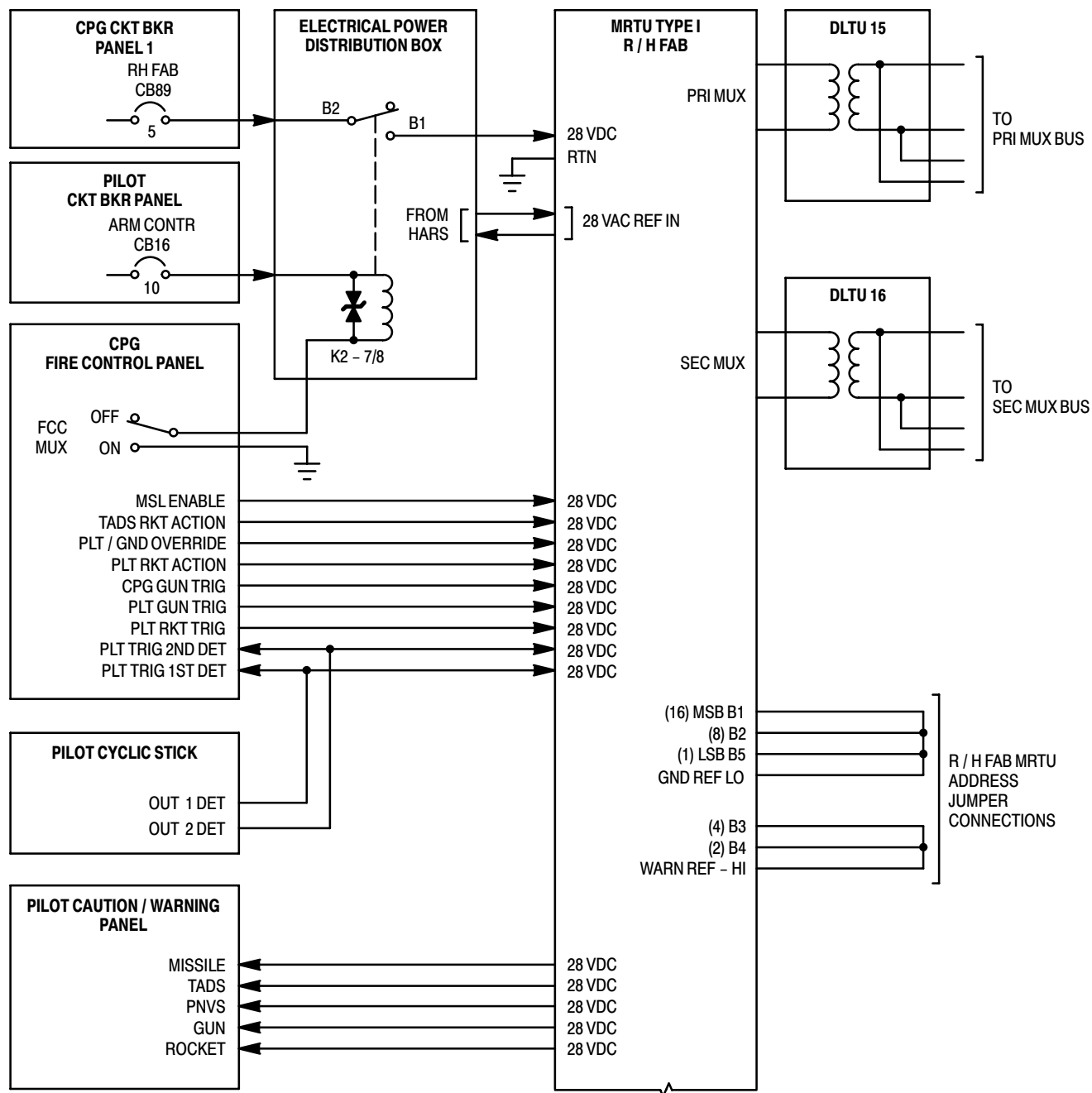
(a) Circuit breaker **ARM CONTR**, on the pilot's circuit breaker panel supplies 28 VDC to the coil of relay K1-3. The **FCC MUX** switch, when set to **OFF**, energizes the relay which removes power from the MRTU.

(b) Setting the **FCC MUX** switch to on de-energizes relay K1-3, allowing 28 VDC operating power to be supplied to the MRTU Type I RH FAB.

(c) The heading attitude reference set (HARS) supplies a 26 VAC 400 Hz, reference voltage through the electrical power distribution box to the MRTU Type I RH FAB.

14-3. THEORY OF OPERATION (cont)

14-3

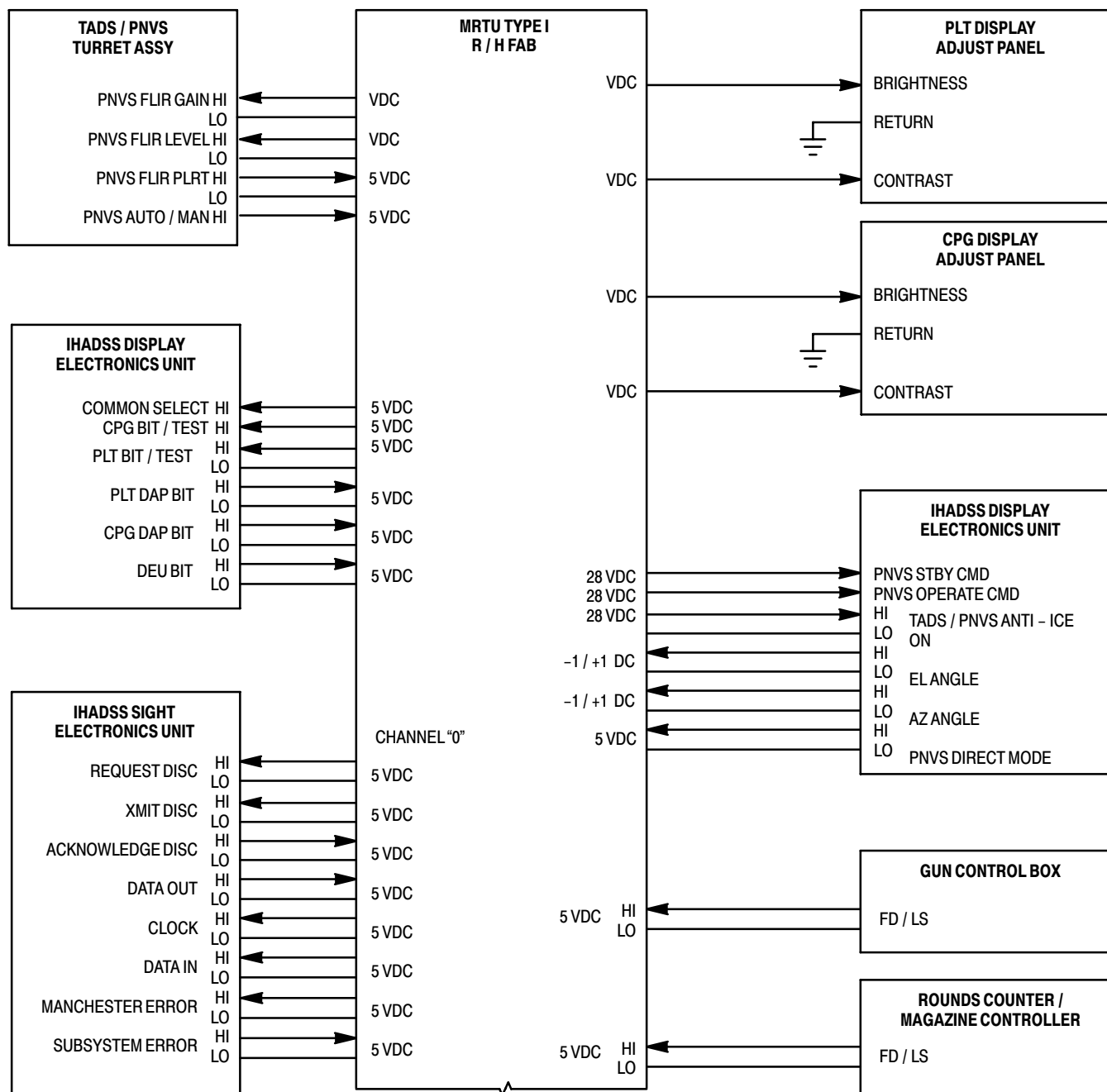


M52-152-1A

Figure 14-7. MRTU Type I RH FAB Operation (Sheet 1 of 3)

14-3. THEORY OF OPERATION (cont)

14-3

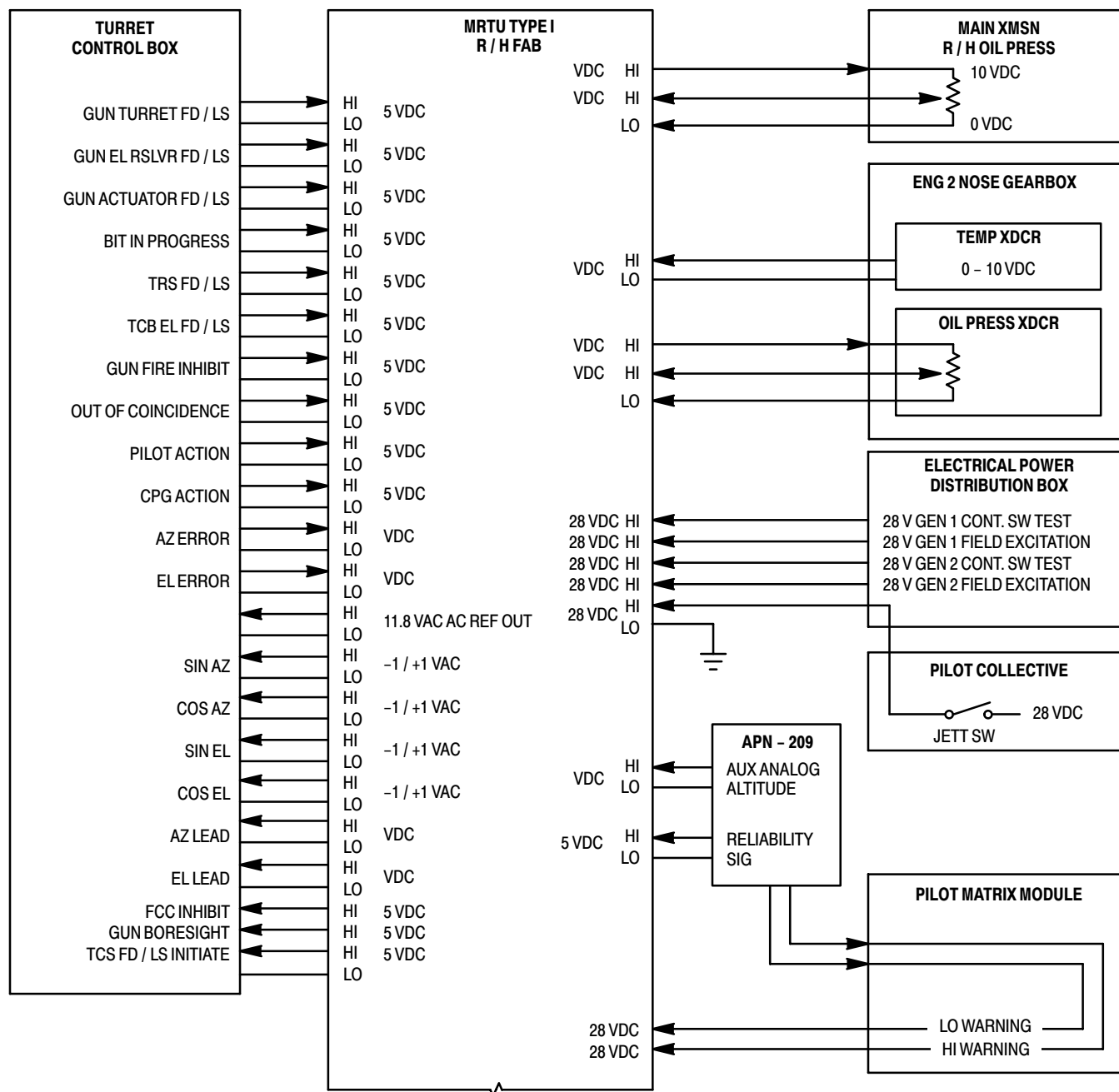


M52-152-2A

Figure 14-7. MRTU Type I RH FAB Operation (Sheet 2 of 3)

14-3. THEORY OF OPERATION (cont)

14-3



M52-152-3A

Figure 14-7. MRTU Type I RH FAB Operation (Sheet 3 of 3)

14-3. THEORY OF OPERATION (cont)

14-3

(3) Operation.

(a) The MRTU Type I RH FAB monitors the CPG's FCP for the following signals (fig. 14-7).

- Missile enable.
- Pilot rocket action.
- Pilot/ground override.
- Pilot rocket action.
- CPG gun trigger.
- Pilot gun trigger.
- Pilot rocket trigger.

(b) MRTU Type I RH FAB monitors the pilot cyclic stick for the following signals.

- Second detent.
- First detent.

(c) The MRTU Type I RH FAB interfaces with the pilot caution/warning panel to provide dc power for the following signals.

- Missile fail.
- TADS fail.
- PNVS fail.
- Gun fail.
- Rocket fail.

(d) The MRTU Type I RH FAB interfaces with the TADS/PNVS turret assembly to provide dc power for the following adjustable signals.

- PNVS FLIR **GAIN**.
- PNVS FLIR **LEVEL**.
- PNVS FLIR **PLRT**.
- PNVS **AUTO/MAN**.

(e) The MRTU Type I RH FAB interfaces with the IHADSS display electronics unit (DEU) to provide dc power for the following signals.

- Common select.
- CPG BIT/test.
- Pilot BIT/test.

(f) The MRTU Type I RH FAB monitors the IHADSS DEU for the following:

- Pilot DAP BIT.
- CPG DAP BIT.
- DEU BIT.

14-3. THEORY OF OPERATION (cont)

14-3

(g) The MRTU Type I RH FAB interfaces with the IHADSS sight electronics unit (SEU) for serial digital transfer.

(h) The MRTU Type I RH FAB interfaces with the pilot DAP to provide dc power for the following signals.

- Brightness.
- Contrast.

(i) The MRTU Type I RH FAB interfaces with the CPG DAP to provide power for the following signals.

- Brightness.
- Contrast.

(j) The MRTU Type I RH FAB interfaces with the PNVs to provide dc power for the following signals.

- PNVs standby.
- PNVs operate.
- TADS/PNVs anti-ice on.
- Elevation angle.
- Azimuth angle.
- PNVs direct mode.

(k) The MRTU Type I RH FAB monitors the gun control box (GCB) for a FD/LS signal.

(l) The MRTU Type I RH FAB monitors the RC/MC for a FD/LS signal.

(m) The MRTU Type I RH FAB monitors the turret control box for the following signals.

- Gun turret FD/LS.
- Gun elevation resolver FD/LS.
- Gun actuator FD/LS.
- Bit in progress.
- Train rate sensor.
- TCB.
- Gun fire inhibit.
- Out of coincidence.
- Pilot action.
- CPG action.
- Azimuth error.
- Elevation error.

14-3. THEORY OF OPERATION (cont)

14-3

(n) The MRTU Type I RH FAB interfaces with the turret control box to provide power for the following signals.

- Sine azimuth.
- Cosine azimuth.
- Sine elevation.
- Cosine elevation.
- Azimuth feed forward.
- Elevation feed forward.
- FCC inhibit.
- Gun boresight.
- TCS FD/LS initiate.

(o) MRTU Type I RH FAB interfaces with the (R/H) main transmission for the following purposes.

- Provides power to the oil pressure transducer.
- Monitors the oil pressure transducer.

(p) The MRTU Type I RH FAB interfaces with engine 2 nose gearbox for the following purposes.

- Monitors the temperature transducer.
- Provides power to the oil pressure transducer.
- Monitors the oil pressure transducer.

(q) The MRTU Type I RH FAB monitors the electrical power distribution box for the following purpose.

- Generator 1 controller test.
- Generator 1 field excitation.
- Generator 2 controller test.
- Generator 2 field excitation.
- Pilot collective jettison switch.

(r) The MRTU Type I RH FAB monitors AN/APN-209 radar altimeter for the following signals.

- Aux analog altitude.
- Reliability signal.
- Low warning.
- High warning.

14-3. THEORY OF OPERATION (cont)

14-3**d. RHE.**

(1) **Power Input.** Circuit breaker **MSL DC ELEC** (CB 17), on the CPG's circuit breaker panel, supplies 28 VDC to normally open contacts of relay K1-4 in the electrical power distribution box (fig. 14-8).

(a) The 28 VDC fire control (FC) enable signal from the CPG's FCP is routed through the pilot's FCP to the coil of relay K1-4.

(b) The RHE receives 28 VDC from the contacts of relay K1-4 operating power and interface adapter module (IAM) address power.

(2) **Operation.** The RHE interfaces with each missile launcher (4 ea) to provide the following signals.

(a) Laser coding.

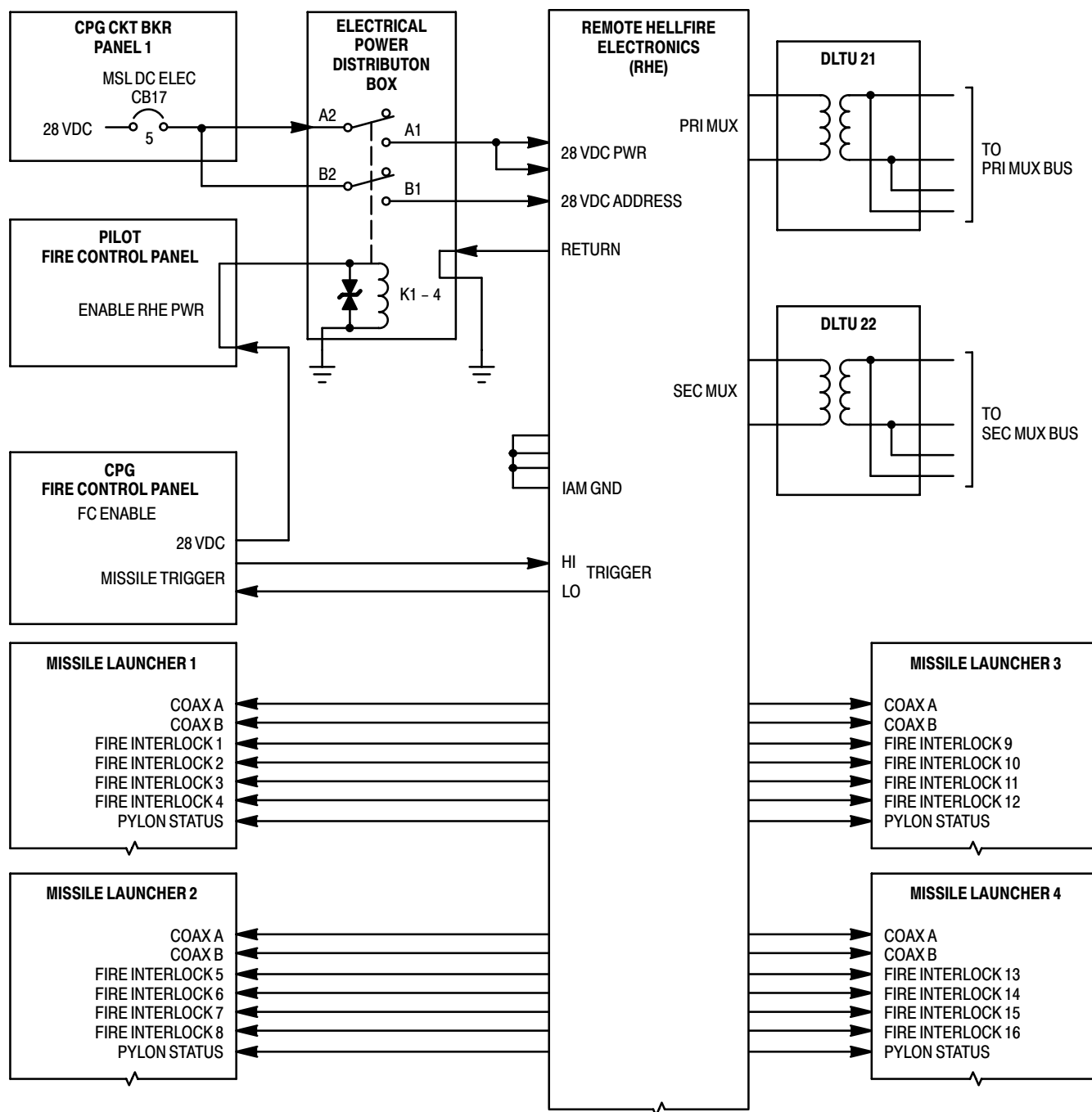
(b) Fire interlock.

(c) Pylon/launcher status.

(d) Video transfer (when missile available).

14-3. THEORY OF OPERATION (cont)

14-3



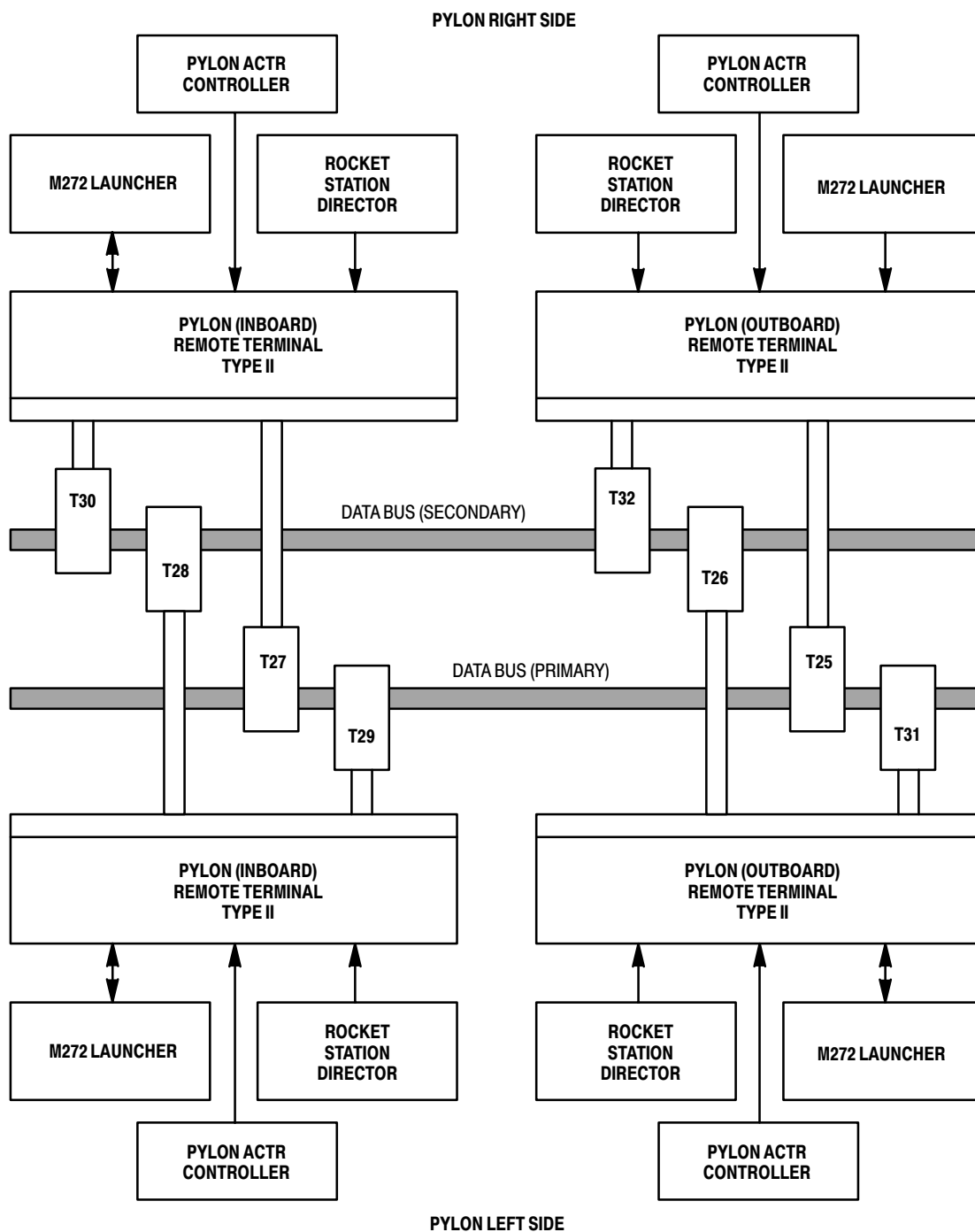
M52-153A

Figure 14-8. RHE Operation

14-3. THEORY OF OPERATION (cont)

14-3**e. MRTU Type II Pylon.**

- (1) **Interface.** Each MRTU Type II is wired directly to the following components (fig. 14-9).
 - (a) Two DLTUs for each MRTU Type II pylon to establish a multiplex communication link.
 - (b) M272 launcher to provide analog and digital interface for missile testing and guidance.
 - (c) Pylon actuator controller for status and pylon position monitoring inputs.
 - (d) Rocket station director for station director status monitoring.
- (2) **Power Input.** Circuit breaker **MUX L PYL OUTBD** (CB 25), on the CPG's circuit breaker panel, supplies 28 VDC to L/H outboard MRTU Type II (fig. 14-10).

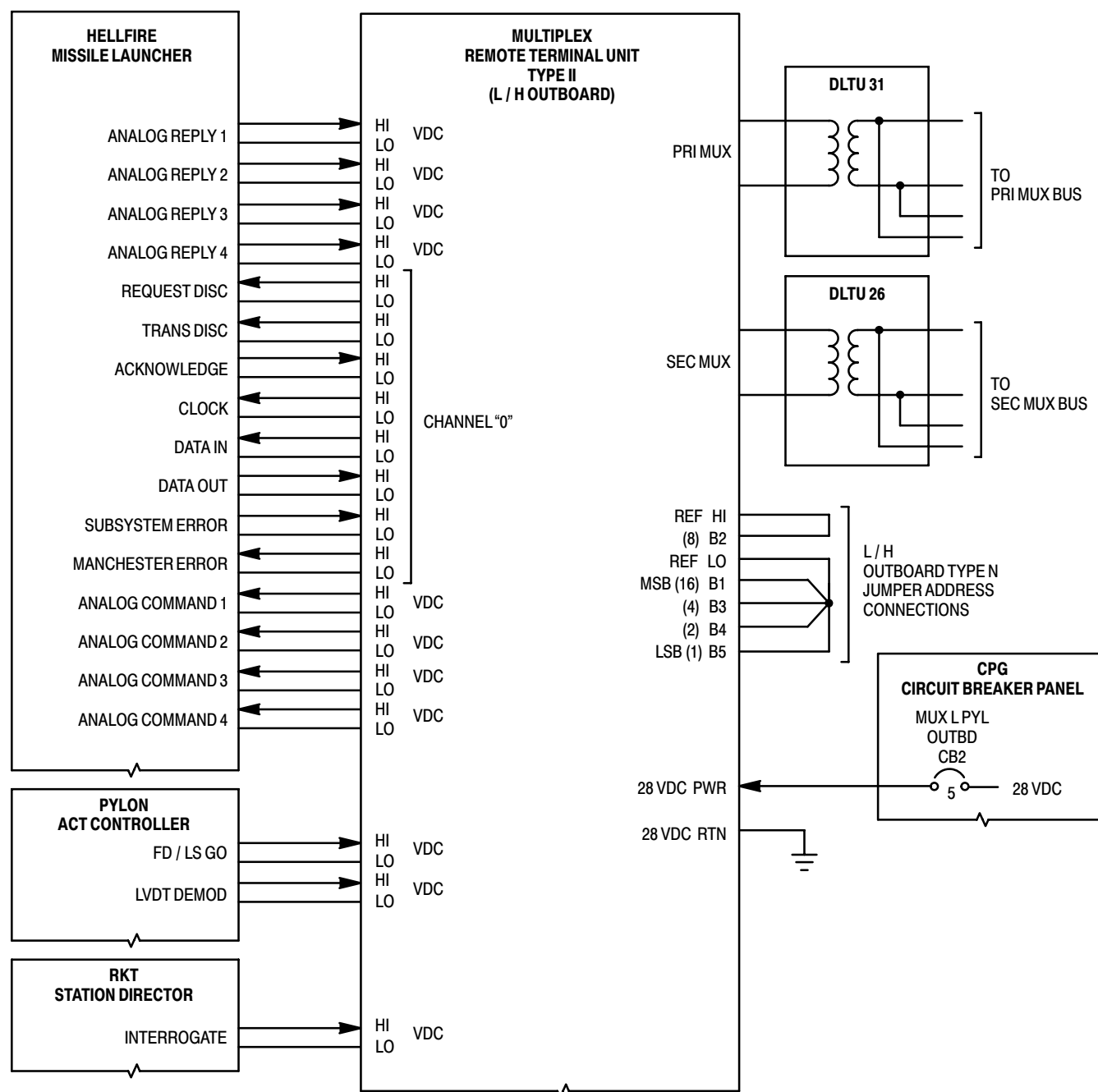


M52-154

Figure 14-9. MRTU Type II Pylon Interface

14-3. THEORY OF OPERATION (cont)

14-3

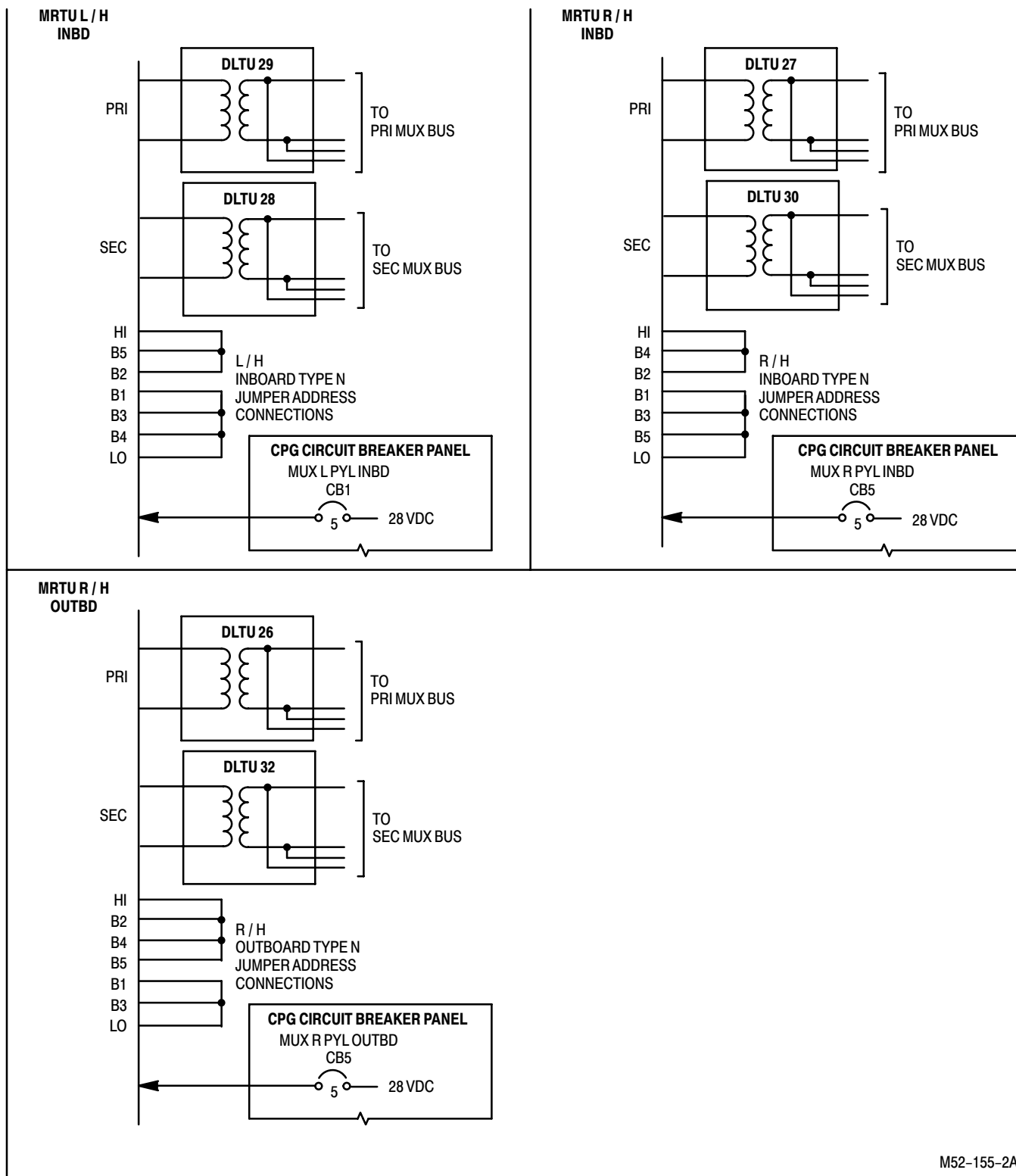


M52-155-1A

Figure 14-10. MRTU Type II Pylon Operation (Sheet 1 of 2)

14-3. THEORY OF OPERATION (cont)

14-3



M52-155-2A

Figure 14-10. MRTU Type II Pylon Operation (Sheet 2 of 2)

14-3. THEORY OF OPERATION (cont)

14-3**(3) Operation.**

(a) Pylon MRTU Type II interfaces with the HELLFIRE missile launcher to transfer analog and serial data.

(b) The MRTU Type II monitors the pylon actuator for the following signals.

- FD/LS GO.
- LVDT Demodulation.

(c) The MRTU Type II monitors the rocket station director interrogate FD/LS.

f. DASEC.

(1) **Interface.** The DASEC is wired directly to the following units (fig. 14-11).

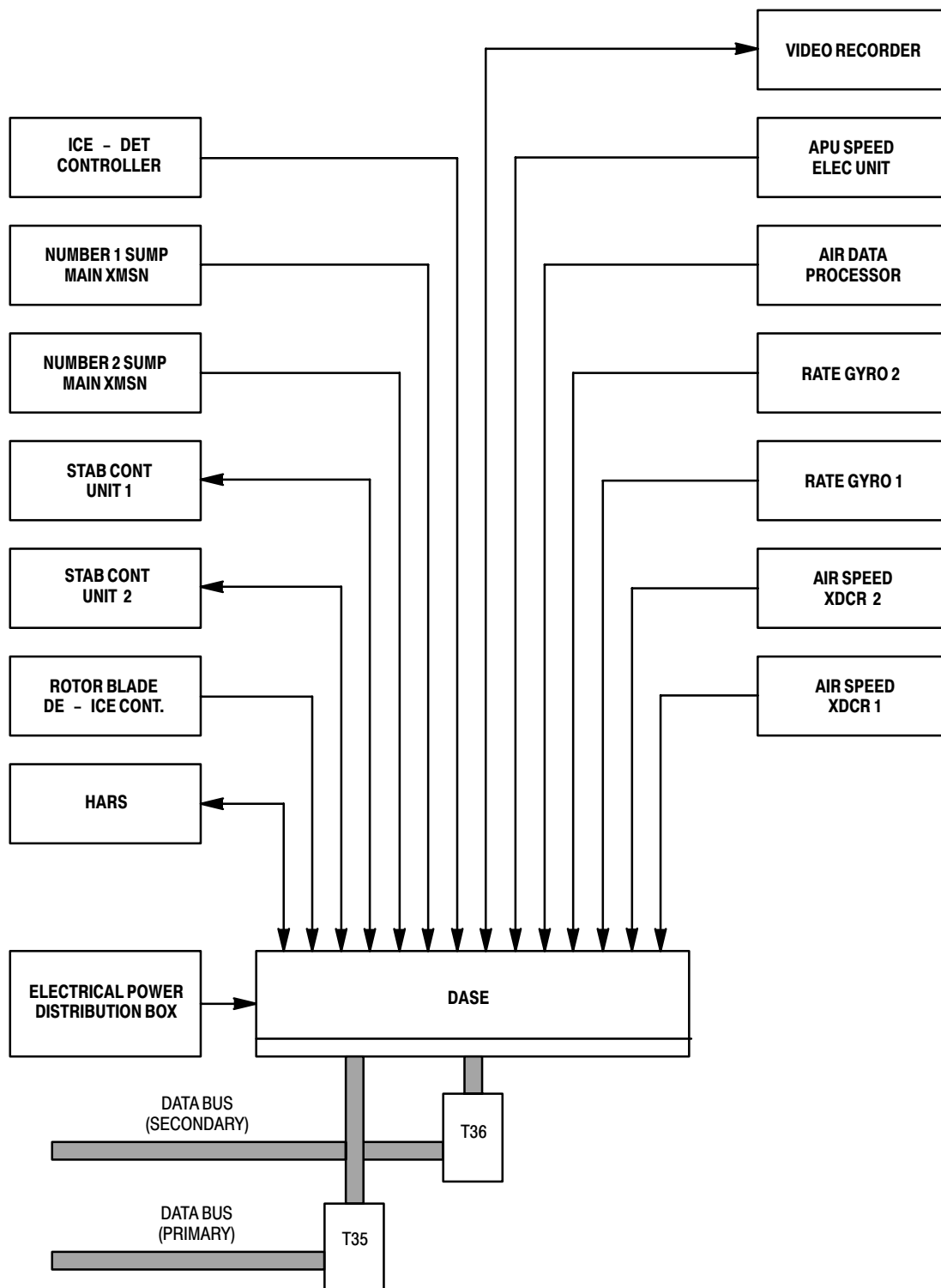
(a) DLTUs T35 and T36 to establish a multiplex communication link.

(b) Electrical power distribution box for 28 VDC input.

(c) HARS for data, clock, rate, and status circuit interface.

(d) Rotor blade de-ice control for FD/LS.

(e) Stabilator control units 1 and 2 for FD/LS.



M52-156

Figure 14-11. DASEC Interface

14-3. THEORY OF OPERATION (cont)

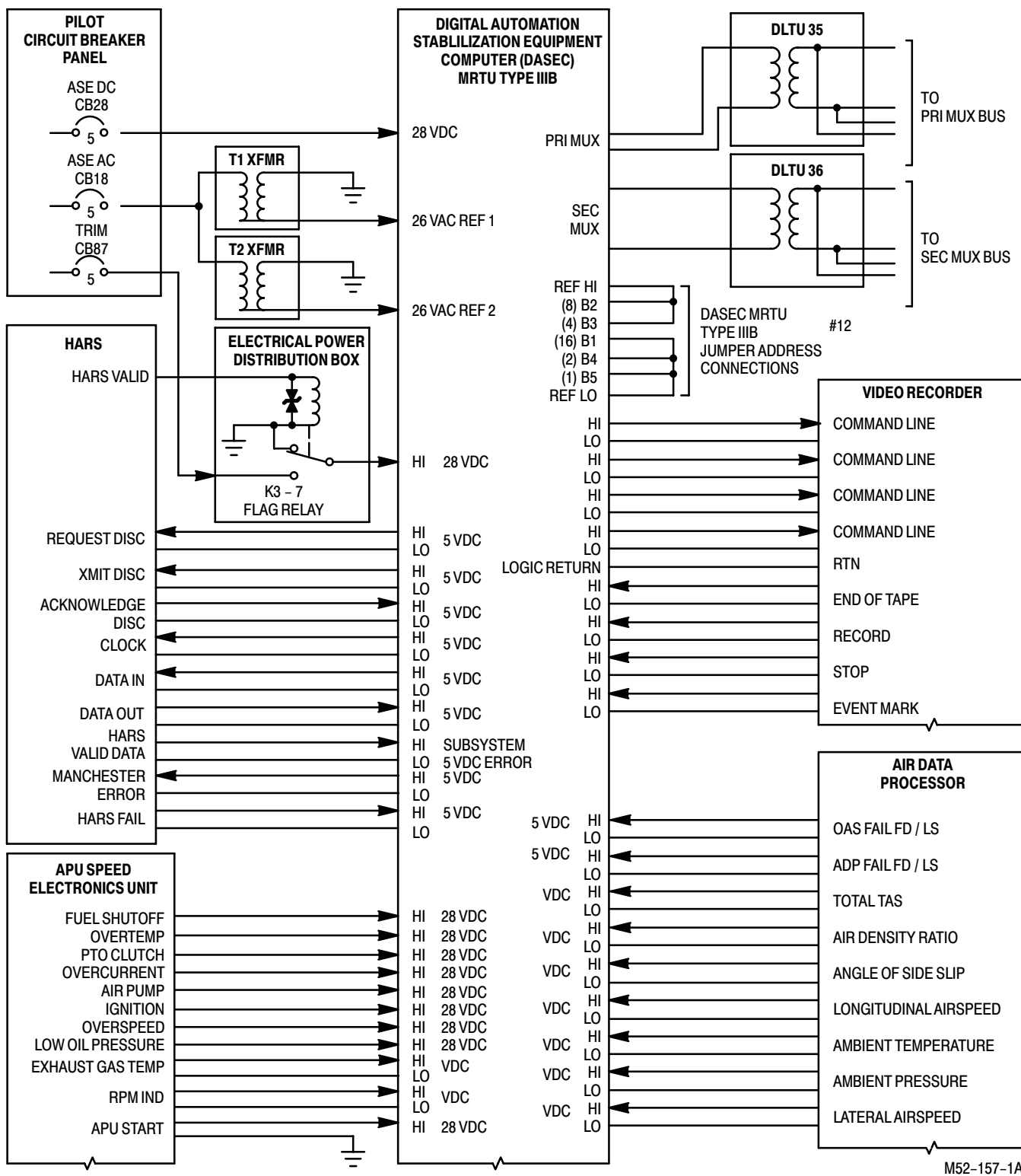
14-3

- (f) Number 1 sump, main transmission, oil temperature monitoring.
- (g) Number 2 sump, main transmission, oil temperature monitoring.
- (h) Ice detector signal processor for FD/LS.
- (i) Video recorder for record, play, mark, stop, and end of tape circuit.
- (j) APU speed electronics unit for FD/LS.
- (k) Air data processor (ADP) for FD/LS and airspeed data.
- (l) Rate gyro 2 for FD/LS.
- (m) Rate gyro 1 for FD/LS.
- (n) Airspeed transducer 2 for FD/LS.
- (o) Airspeed transducer 1 for FD/LS.

(2) **Power Input.** Circuit breaker **ASE DC** (CB28), on the pilot's circuit breaker panel, supplies 28 VDC to the DASEC (fig. 14-12). Circuit breaker **ASE AC** (CB18) supplies 115 VAC to T1 transformer and T2 transformer. Transformers T1 and T2 supply 26 VAC to the DASEC 26 VAC REF 1 and 2 respectively.

14-3. THEORY OF OPERATION (cont)

14-3

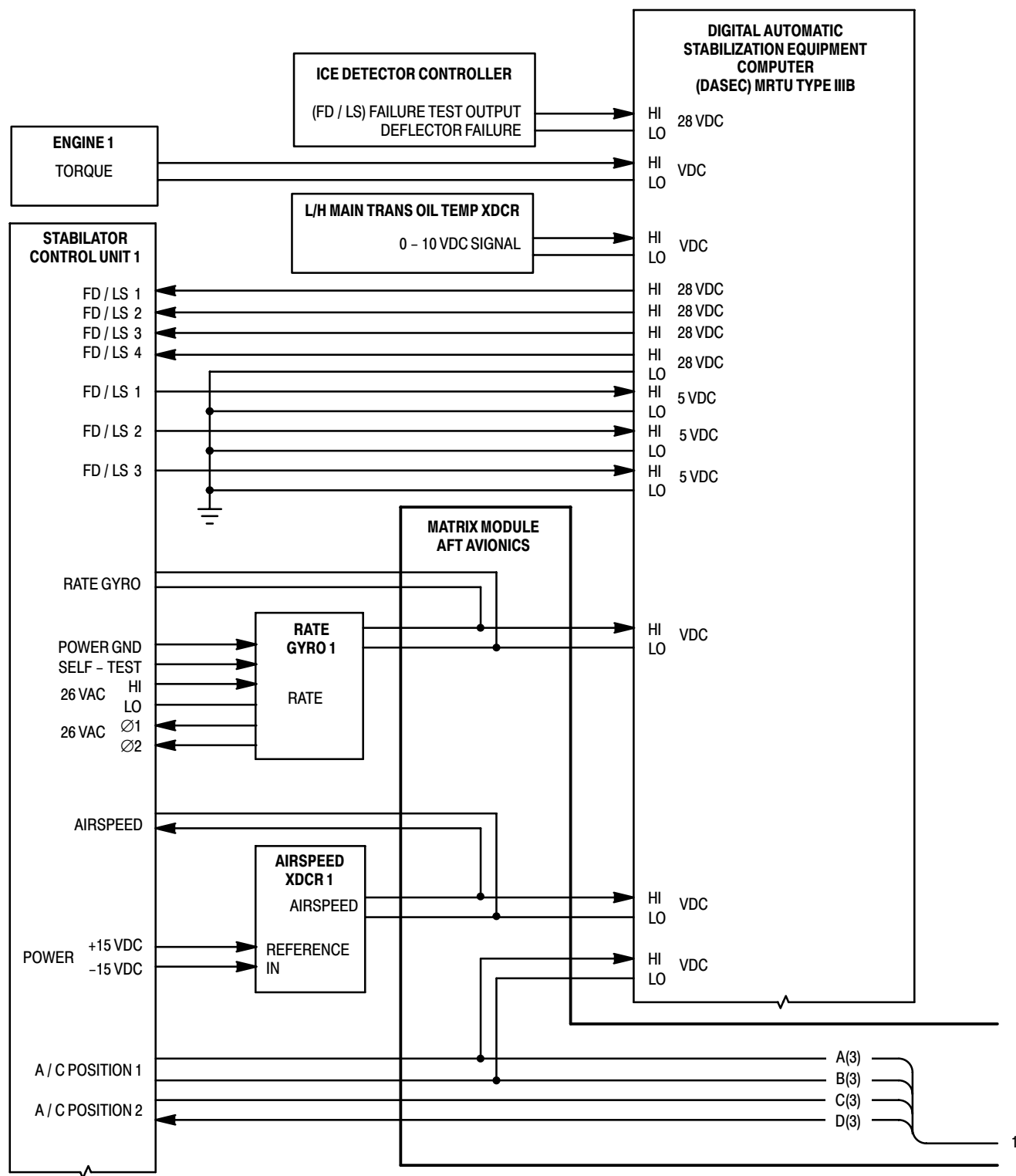


M52-157-1A

Figure 14-12. DASEC Operation (Sheet 1 of 3)

14-3. THEORY OF OPERATION (cont)

14-3



M52-157-2A

Figure 14-12. DASEC Operation (Sheet 2 of 3)



14-3. THEORY OF OPERATION (cont)

14-3**(3) Operation.**

(a) The DASEC monitors the electrical power distribution box for 28 VDC from relay K3-7 flag relay. K3-7 flag relay is energized when HARS is valid.

(b) The DASEC monitors HARS for HARS valid.

(c) The DASEC interfaces with HARS for serial digital transfer.

(d) The DASEC monitors the APU speed electronics unit for the following signals.

- Fuel shutoff.
- Overtemperature.
- PTO clutch.
- Overcurrent.
- Ignition.
- Overspeed.
- Low oil pressure.
- Exhaust gas temperature.
- RPM indicator.
- APU start.

(e) The DASEC interfaces with the video recorder to provide dc power for the command lines.

(f) The DASEC monitors the video recorder for the following signals.

- End of tape.
- Record.
- Stop.
- Event mark.

(g) The DASEC monitors the air data processor for the following signals.

- OAS fail FD/LS.
- ADP fail FD/LS.
- Total TAS.
- Air density ratio.
- Angle of sideslip.
- Longitudinal airspeed.
- Ambient temperature.
- Ambient pressure.
- Lateral airspeed.

14-3. THEORY OF OPERATION (cont)

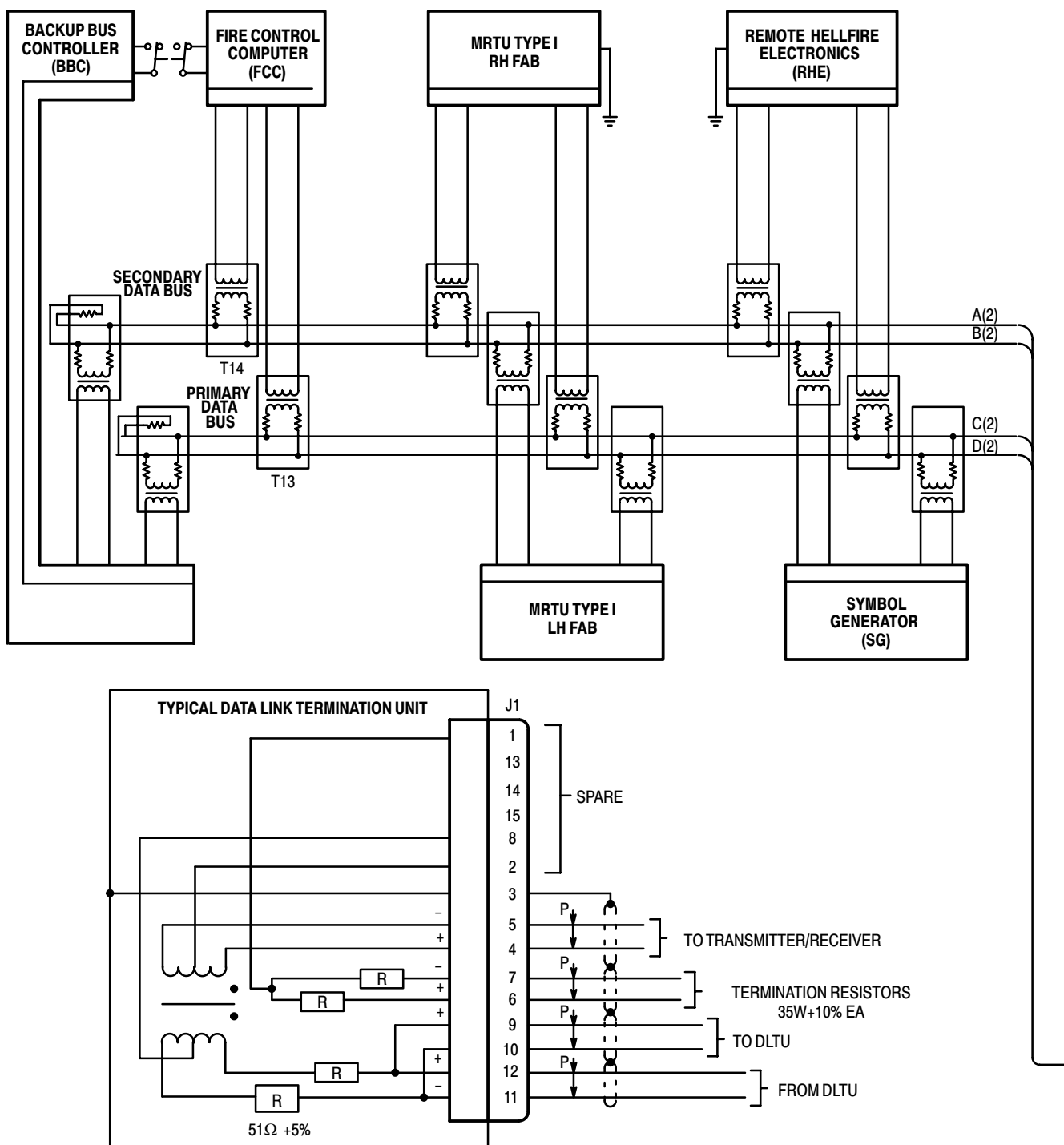
14-3

- (h) The DASEC monitors the ice detector controller for the following signals.
 - FD/LS failure test.
 - Detector failure.
- (i) The DASEC monitors engine 1 torque.
- (j) The DASEC monitors the main transmission L/H oil temperature transducer.
- (k) The DASEC interfaces with stabilator control unit 1 to provide dc power for SCU test codes.
- (l) The DASEC monitors stabilator control unit 1 for the following signals.
 - FD/LS status.
 - A/C position 1.
- (m) The DASEC monitors rate gyro 1.
- (n) The DASEC monitors airspeed transducer 1.
- (o) The DASEC monitors the rotor blade de-ice controller for the following signals.
 - Tail heater fail.
 - Main heater fail.
 - Distributor fail.
- (p) The DASEC monitors engine 2 torque.
- (q) The DASEC monitors main transmission R/H oil temperature transducer.
- (r) The DASEC interfaces with stabilator control unit 2 to provide dc power for SCU test codes.
- (s) The DASEC monitors stabilator control unit 2 for the following signals.
 - FD/LS status.
 - A/C position 2.
- (t) The DASEC monitors rate gyro 2.
- (u) The DASEC monitors airspeed transducer 2.

g. **DLTU.** The MUX system contains 22 DLTUs (ADC) or 30 DLTUs (ADD) (fig. 14-13). Each DLTU is impedance-matched to, and connected in series with, the data bus cable. The DLTU on each end of the primary and secondary buses has built-in termination resistors connected to the bus. This terminates the data bus to the proper impedance. This way, each bus is properly terminated if a break occurs anywhere in the chain. The remaining 18 DLTUs (ADC) or 26 DLTUs (ADD) in series configuration do not use termination resistors.

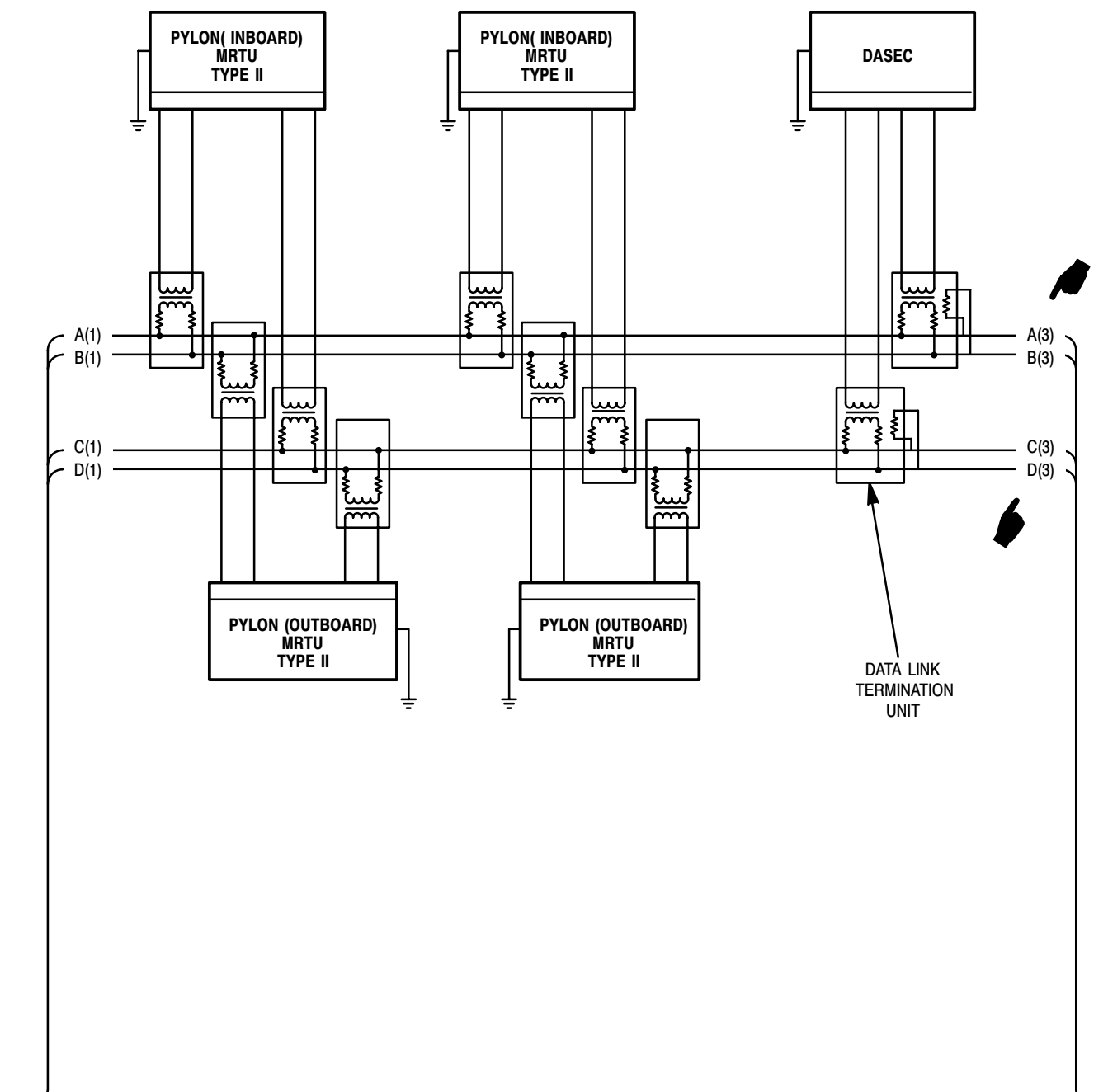
14-3. THEORY OF OPERATION (cont)

14-3



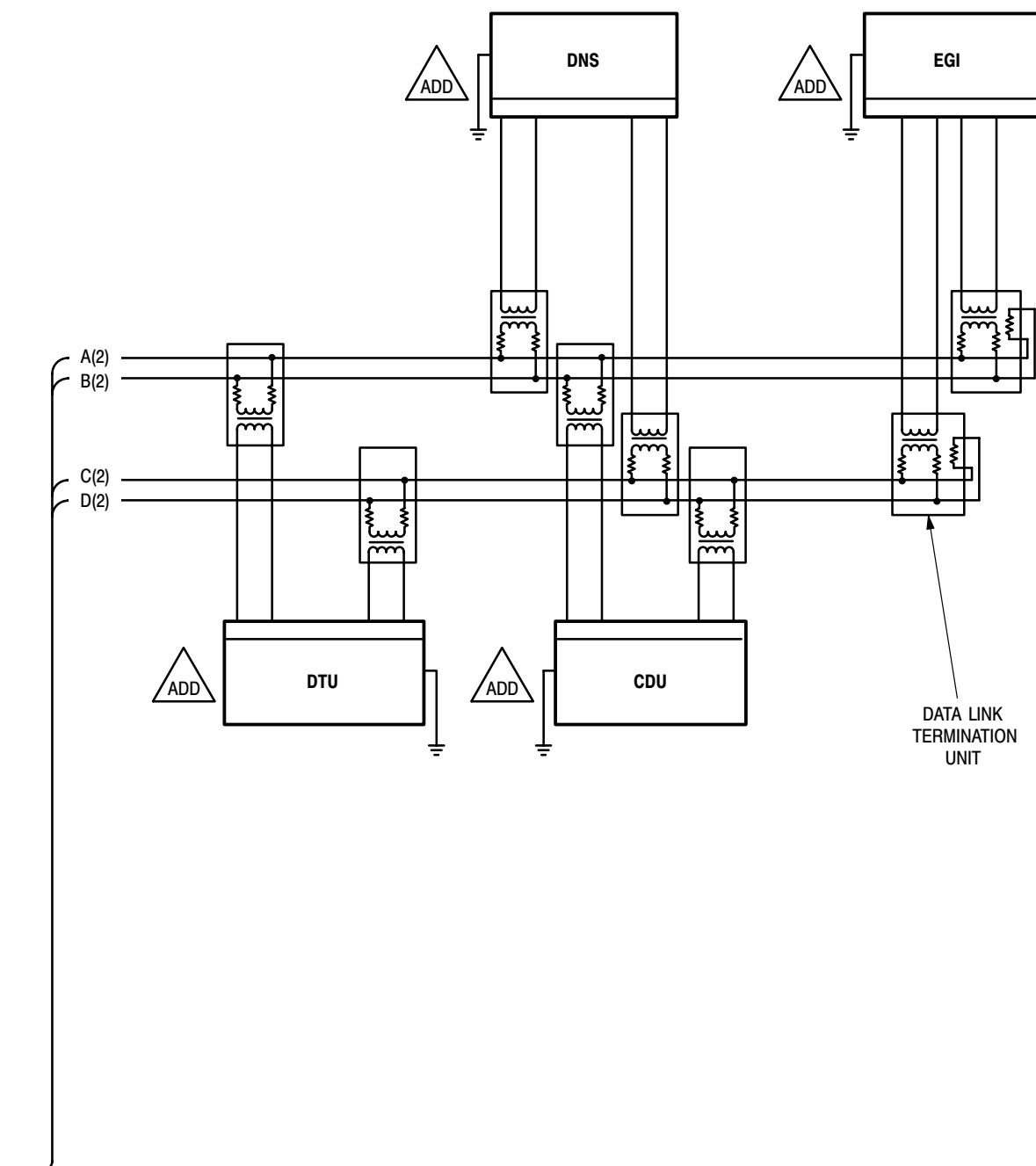
M52-158-1A

Figure 14-13. DLTU Interface (Sheet 1 of 3)



M52-158-2B

Figure 14-13. DLTU Interface (Sheet 2 of 3)



M52-158-3

Figure 14-13. DLTU Interface (Sheet 3 of 3)

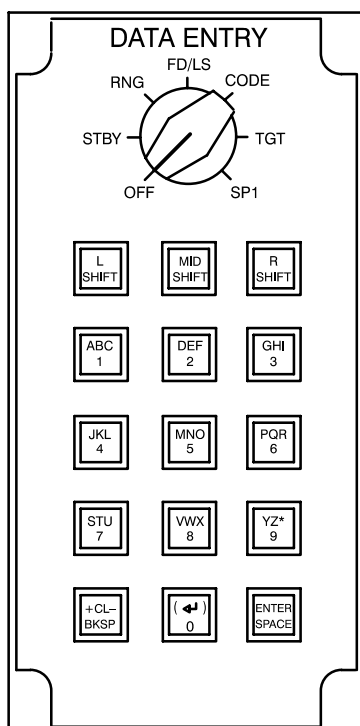
14-3. THEORY OF OPERATION (cont)

14-3

h. **DEK.** The DEK provides the CPG with the primary means of communicating with the FCC (ADC) and backup means of communicating with the FCC (ADD) via the BBC. The DEK (fig. 14-14) contains a keyboard unit with one rotary switch and 15 switches, with functions described below.

(1) **Rotary Switch Functions.**

- (a) **OFF.** In the **OFF** position, the DEK is off.
- (b) **STBY (Standby).** In the **STBY** position, power is applied and built-in self-test is initiated. The DEK performs a validity check for internal electrical functions.
- (c) **RNG (Range).** The **RNG** position provides the CPG with a means to manually input rate into the FCC or BBC. Input can be of any range value for mission requirements. Entering a "0" for range commands the FCC to compute automatically; that is, flat earth computations, range from aircraft attitude, and line of sight (LOS) depression angle with respect to the horizon.
- (d) **FD/LS.** The **FD/LS** position allows the CPG or ground maintenance personnel to interrogate failed system and identify failed line replaceable units (LRU) and their approximate location in the aircraft.
- (e) **CODE.** The **CODE** position allows the code of the day to be programmed into the FCC for upper/lower missile channels.
- (f) **TGT (Target).** The **TGT** position allows input of coordinate data for waypoint targeting.
- (g) **SP1.** The **SP1** position inputs preflight data to the FCC. When used with the keyboard keys **L SHIFT** and **I**, the AND is displayed on the HOD. When used with the keyboard keys **L SHIFT** and **R**, the memory location in the FCC can be accessed.



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Figure 14-14. DEK

14-3. THEORY OF OPERATION (cont)

14-3

(2) Key Functions.

(a) **L SHIFT** (left shift) key. The **L SHIFT** key allows the top left letter or symbol of each key to be selected.

(b) **MID SHIFT** (middle shift) key. The **MID SHIFT** key allows the top middle letter or symbol of each key to be selected.

(c) **R SHIFT** (right shift) key. The **R SHIFT** key allows the top right letter or symbol of each key to be selected.

(d) **ABC1** key. Pressing the **ABC1** key allows a one to be selected. Using the **L SHIFT** key allows an A to be selected. Using the **MID SHIFT** key allows a B to be selected. Using the **R SHIFT** key allows a B to be selected. Keys **DEF 2** through **VWX 8** operate the same.

(e) **YZ*9** (YZ asterisk 9) key. Pressing the **YZ*9** key allows a nine to be selected. Using the **L SHIFT** key allows a Y to be selected. Using the **MID SHIFT** key allows a Z to be selected. Using the **R SHIFT** key allows the asterisk to be selected (there is no use for the asterisk at this time).

(f) **+CL – BKSP** (plus clear minus backspace) key. Pressing the key selects the backspace and cause the cursor to move back one character position to the left. Using the **L SHIFT** key allows a plus symbol to be selected. Using the **MID SHIFT** key allows the clear to be selected; this clears the entire display. Using the **R SHIFT** key allows a minus symbol to be selected.

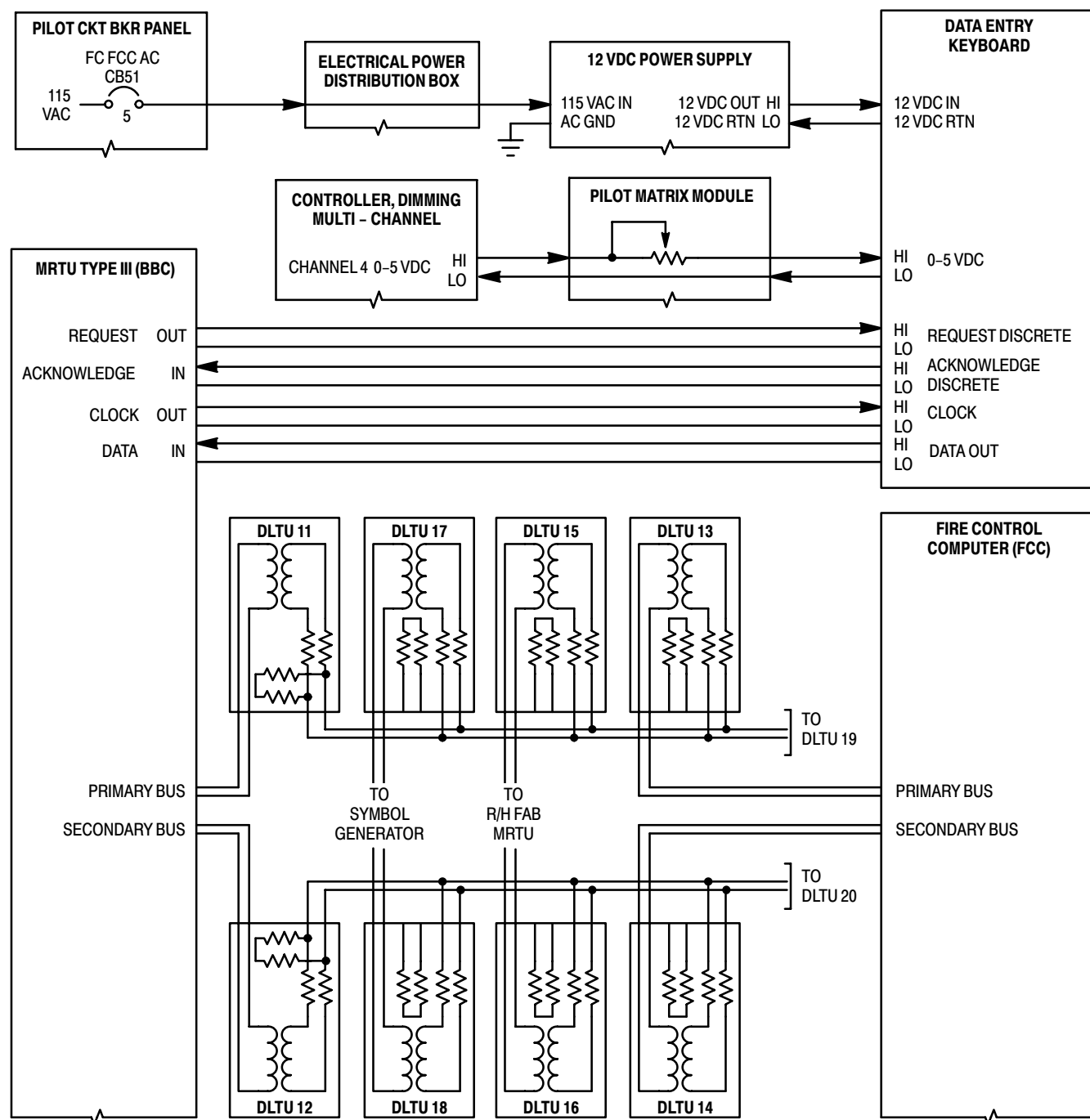
(g) **(0↵)0** (left parenthesis, carriage return, right parenthesis, o) key: Pressing the key allows a zero to be selected. Using the shift keys allows the parenthesis or carriage return to be selected. (Parenthesis and carriage return are not used.)

(h) **ENTER SPACE** key. Pressing the key selects the space and cause cursor to skip the next character position. Pressing a shift key and pressing the key selects the enter; this enters information into the computer. Pressing the key acknowledges the data or function to be correct.

(3) **Power Input.** Circuit breaker **FC AC** (CB51), on the pilot's circuit breaker panel, supplies 115 VAC through the electrical power distribution box to the 12 VDC power supply (fig. 14-15). The output from the 12 VDC power supply is routed to the DEK. The multi-channel dimming controller supplies 0 to +5 VDC through the pilot matrix module trim pot to the DEK lighting input.

14-3. THEORY OF OPERATION (cont)

14-3



M52-160A

Figure 14-15. DEK Interface

14-3. THEORY OF OPERATION (cont)

14-3

i. **Symbol Generator.**

(1) **Power Input.** Circuit breaker **MISSION SYM GEN** (CB45), on the pilot's circuit breaker panel, supplies 115 VAC through the electrical power distribution box to the **SYM GEN** switch on the CPG's FCP (fig. 14-16). Setting the switch to **ON** completes the following circuits.

- (a) 115 VAC to the symbol generator.
- (b) A ground for 115 VAC from the symbol generator to the electrical power distribution box.
- (c) 28 VDC from the CPG's FCP to the LH FAB MRTU Type I.

(2) **Operation.**

(a) The symbol generator receives CPG symbol intensity signals from the LH FAB MRTU Type I. The pilot's FCP provides a 0-10 VDC signal to the symbol generator to control pilot's symbol brightness.

(b) The symbol generator, on command from the bus controller, selects the following incoming videos to add symbology to.

- PNVs FLIR video from the PNVs electronic unit.
- TADS TV video from the TADS electronic unit.
- TADS FLIR video from the TADS electronic unit.
- Video recorder output from the video recorder.

(c) The symbol generator supplies video to the following units.

- CPG and pilot video to the IHADSS DEU.
- TADS or PNVs video to the ORT.
- CPG and pilot video to the VDU.
- CPG or pilot video to the video recorder.

j. **Transformer Rectifier.**

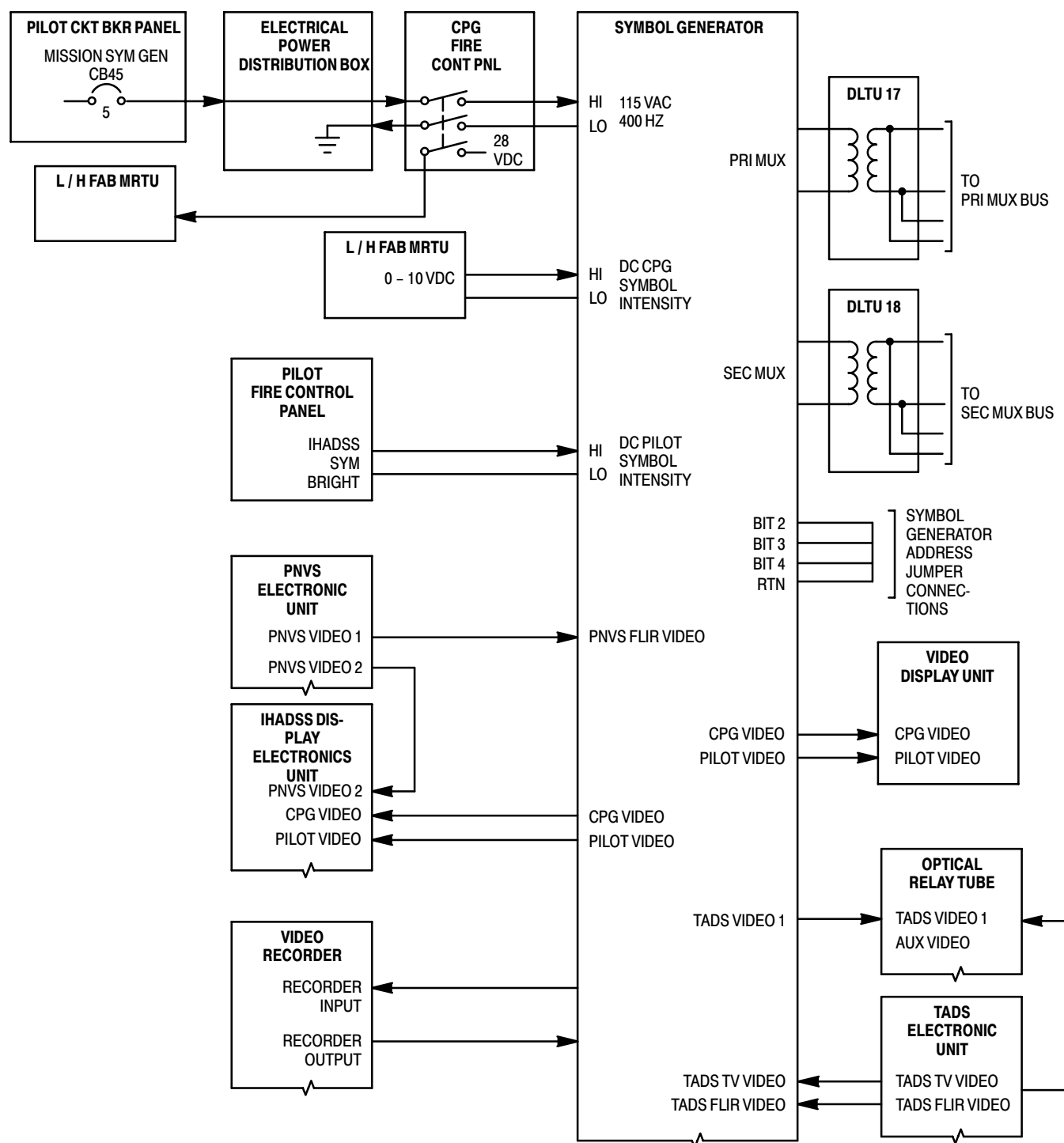
(1) **Power Input.** Circuit breaker **FC AC** (CB51), on the pilot's circuit breaker panel, supplies 115 VAC through the electrical power distribution box to the transformer rectifier (fig. 14-17). The transformer rectifier steps the 115 VAC down to 12 VAC and rectifies the ac voltage into 12 VDC.

(2) **Operation.** The unregulated output of the transformer rectifier is sent to the following units.

- (a) DEK.
- (b) CPG FCP.
- (c) Video recorder control panel.

14-3. THEORY OF OPERATION (cont)

14-3

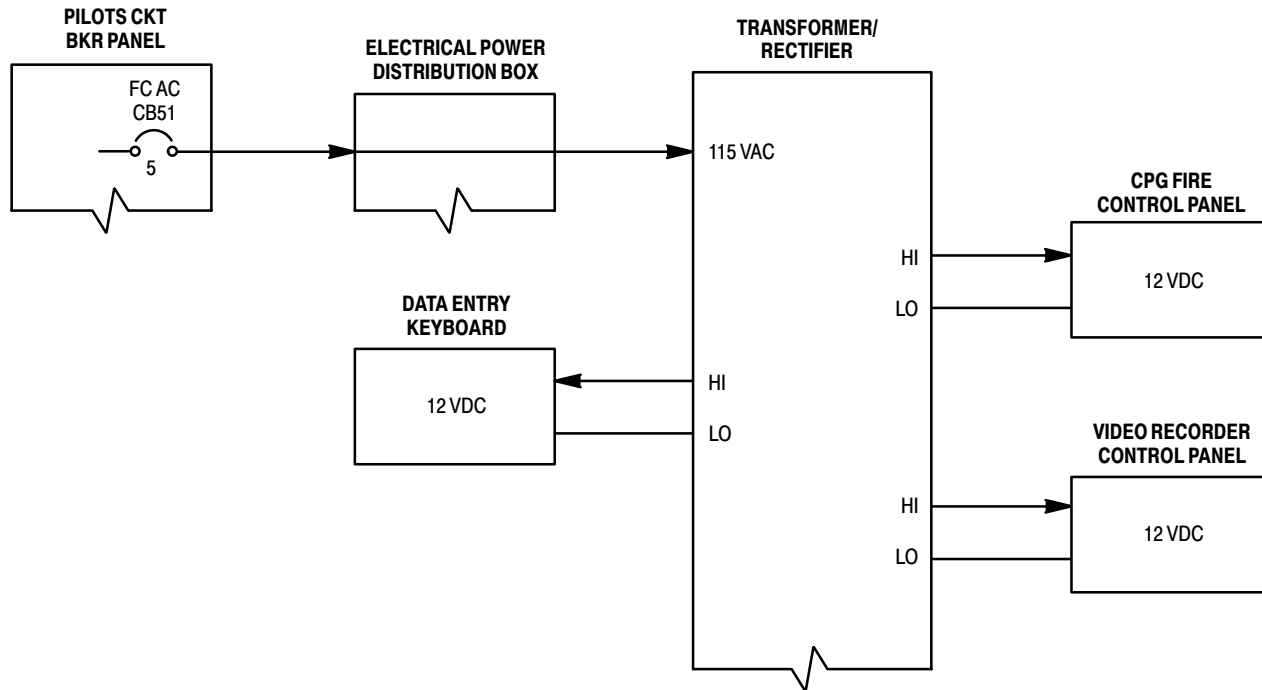


M52-161A

Figure 14-16. Symbol Generator Operation

14-3. THEORY OF OPERATION (cont)

14-3



M52-162

Figure 14-17. Transformer/Rectifier Operation

k. CPG MRTU Type III (Backup Bus Controller).

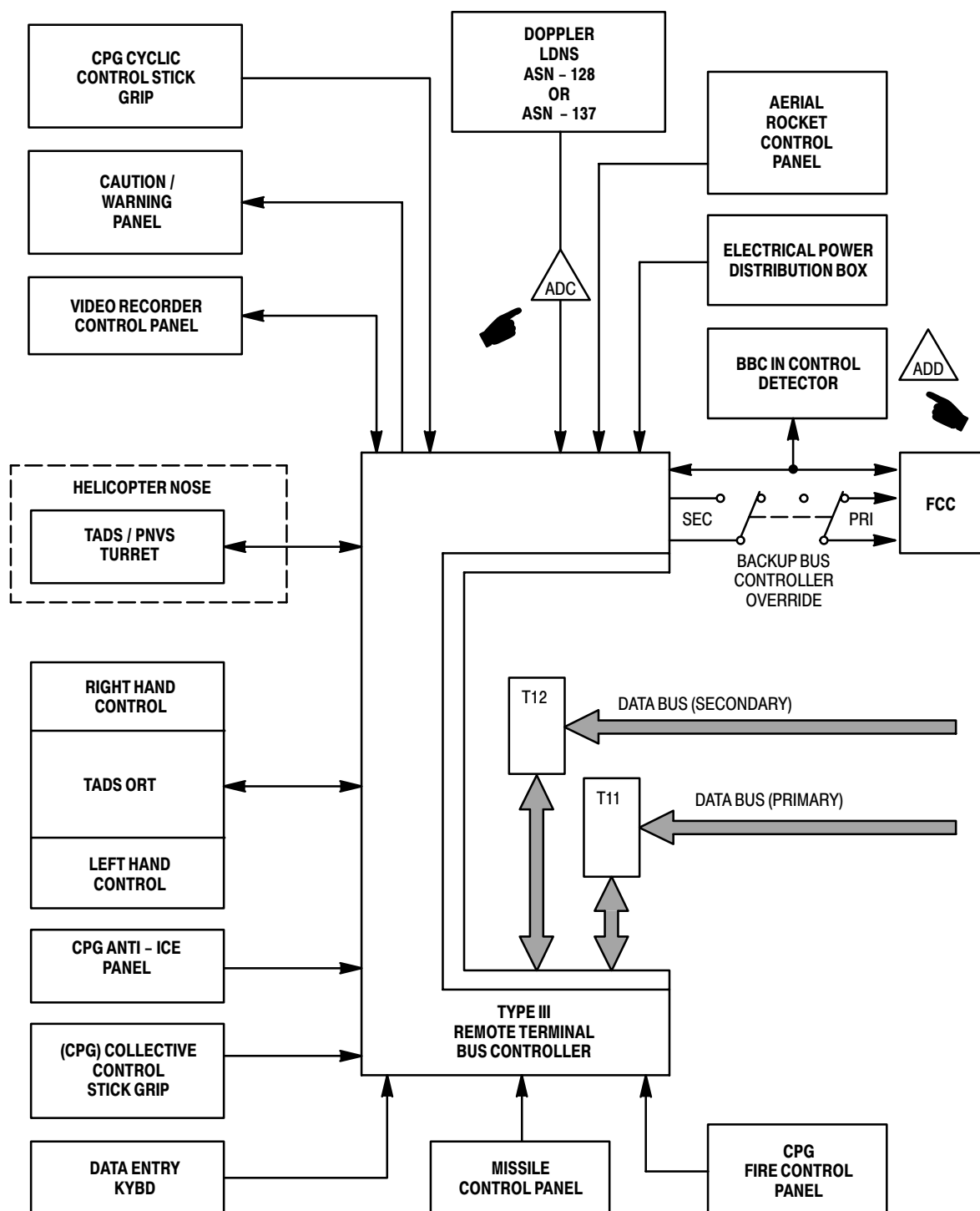
(1) **Interface.** The CPG MRTU Type III is wired directly to the following components (fig. 14-18).

- (a) DLTUs T11 and T12 for interface with the MUX system.
- (b) FCC for automatic selection of bus controller.
- (c) Electrical power distribution box to route 115 VAC from CB51 **FC AC** on the pilot's circuit breaker panel.
- (d) Lightweight doppler navigation system (LDNS) to interface doppler navigation ground references data to the bus controller (ADC).
- (e) CPG cyclic control grip to monitor switch positions.
- (f) Caution and warning panels.
- (g) Video recorder control panel to control the operation of the video recorder.
- (h) Target acquisition designation sight/pilot night vision sensor (TADS/PNVIS) turret to control movement selection, and control of the TADS/PNVIS turrets.
- (i) TADS optical relay tube (ORT) for interfacing selection and control functions of the ORT.
- (j) CPG's **ANTI ICE** panel to control anti-ice functions of the TADS/PNVIS.
- (k) CPG's collective control stick grip to monitor switch selections.
- (l) Data entry keyboard to provide alphanumeric code inputs into the bus controller.

14-3. THEORY OF OPERATION (cont)

14-3

- (m) CPG's missile control panel to monitor switch selections.
 - (n) CPG's FCP to provide weapon and sighting system switch selection data to the bus controller.
 - (o) FCC to provide direct and automatic control as bus controller if the FCC initiates an FCC fail signal.
 - (p) BBC in control detector to remove the CDU from the FCC bus and connect the CDU to the DNS when the FCC fails.
- (2) **Power Input.** Circuit breaker **MUX CPG** (CB15), on the CPG circuit breaker panel (fig. 14-19), supplies 28 VDC through contacts A2 and A3 of relay K1-3 in the electrical power distribution box to the BBC.
- (a) The **MISSION ARM CONTR** circuit breaker (CB46), on the pilot's circuit breaker panel, supplies 28 VDC to the coil of relay K1-3. The **FCC MUX** switch, when set to **OFF**, is de-energized, supplying 28 VDC operating power to the BBC.
 - (b) Setting the **FCC MUX** switch to **ON** energizes relay K1-3, removing 28 VDC operating power from K1-3 to the CPG MRTU Type III (BBC).
 - (c) HARS supplies a 26 VAC 400 Hz reference voltage through the electrical power distribution box to the BBC.
 - (d) The BBC in control line is 0 VDC (inactive).
 - (e) The FCC fail line is 5 VDC (inactive).

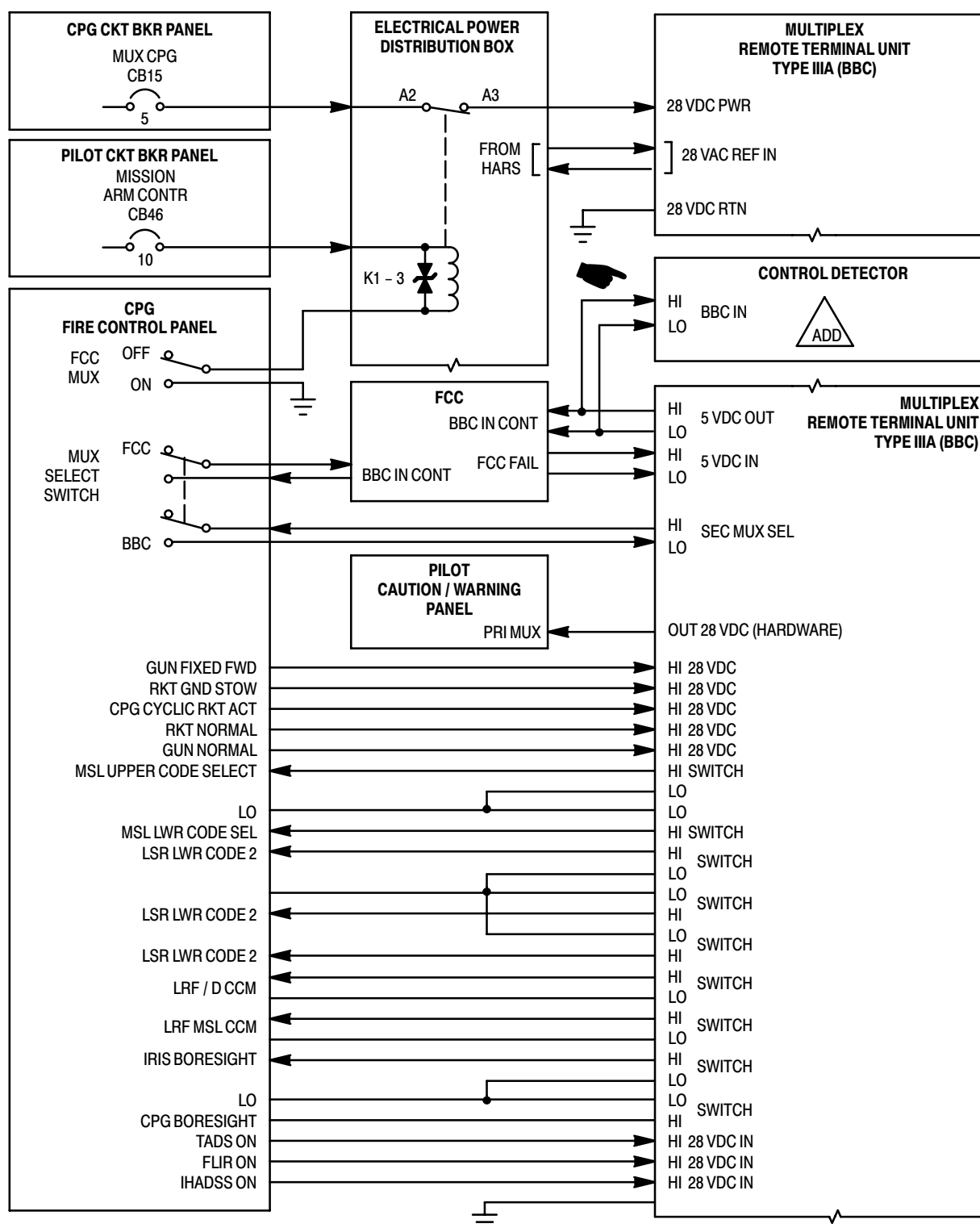


M52-163B

Figure 14-18. CPG MRTU Type III Interface

14-3. THEORY OF OPERATION (cont)

14-3

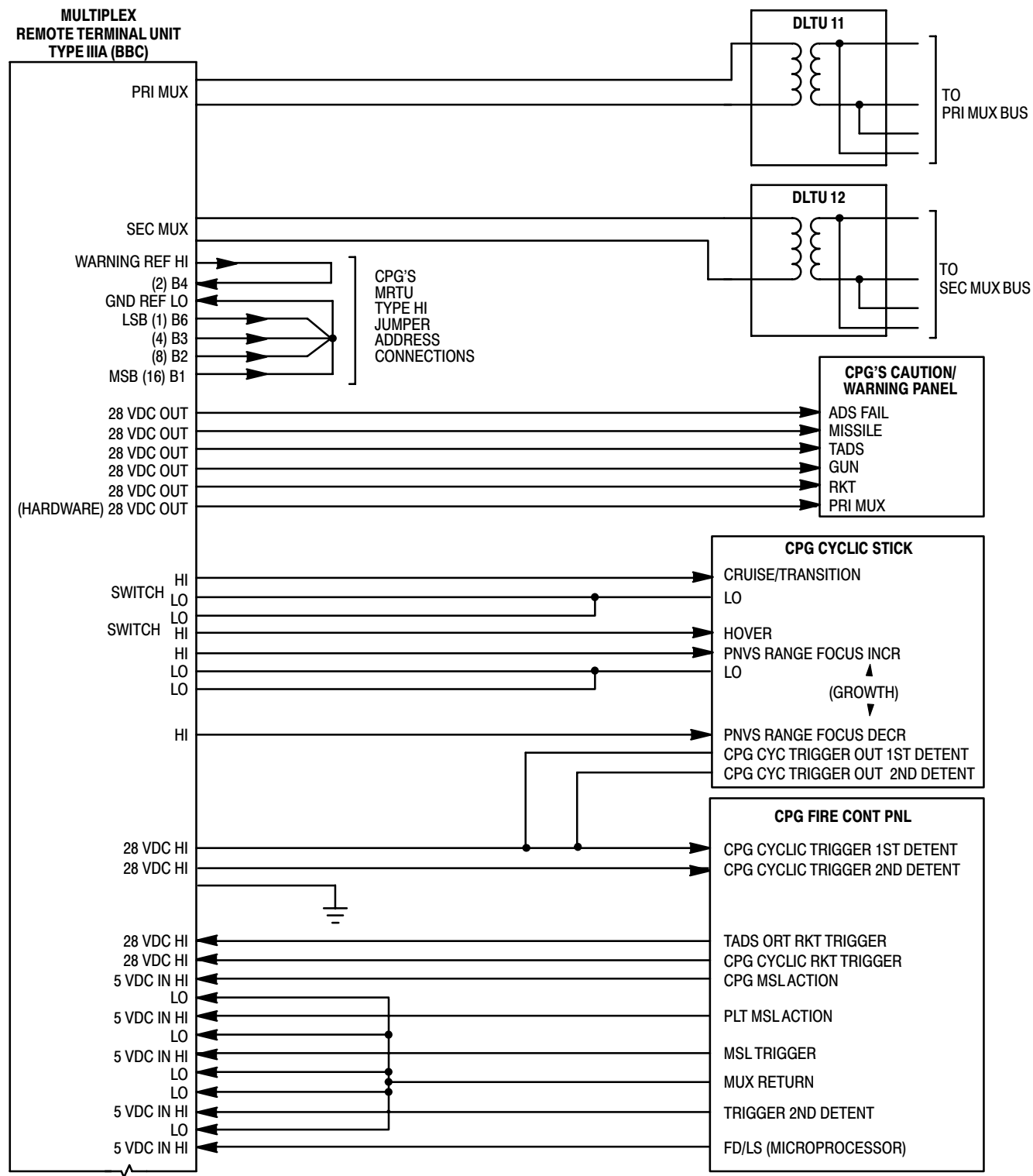


M52-164-1B

Figure 14-19. CPG MRTU Type III Operation (Sheet 1 of 5)

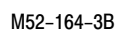
14-3. THEORY OF OPERATION (cont)

14-3



M52-164-2A

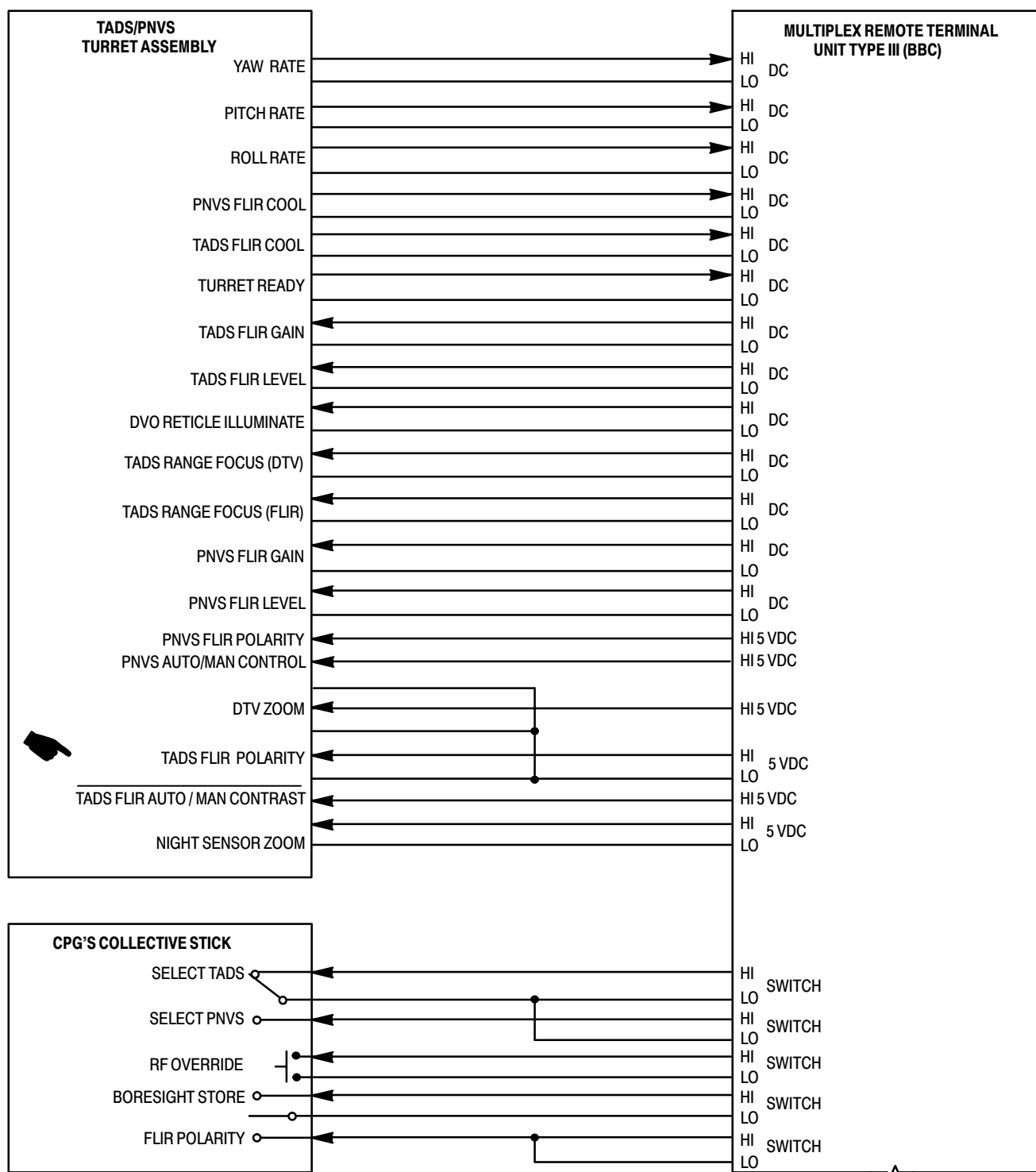
Figure 14-19. CPG MRTU Type III Operation (Sheet 2 of 5)



14-55

14-3. THEORY OF OPERATION (cont)

14-3

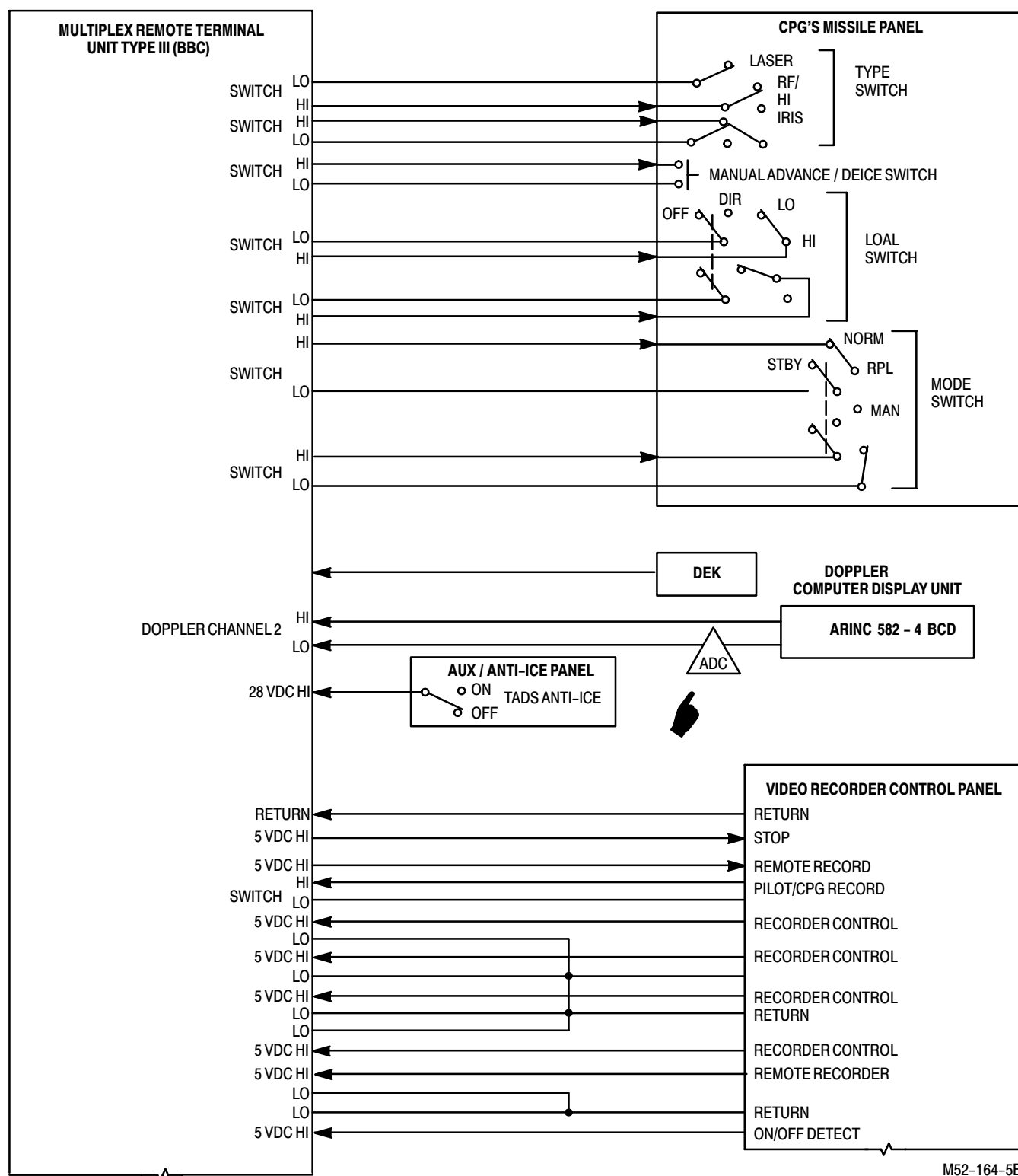


M52-164-4B

Figure 14-19. CPG MRTU Type III Operation (Sheet 4 of 5)

14-3. THEORY OF OPERATION (cont)

14-3



M52-164-5B

Figure 14-19. CPG MRTU Type III Operation (Sheet 5 of 5)

14-3. THEORY OF OPERATION (cont)

14-3

(3) Operation.

(a) The CPG MRTU Type III monitors the CPG's FCP for the following actions.

- Gun fixed fwd.
- Rocket ground stow.
- CPG cyclic rocket action.
- Rocket normal.
- Gun normal.
- Missile upper code select.
- Missile lower code select.
- Laser lower code 2 select
- Laser range finder/designator.
- Laser range finder/designator counter countermeasure.
- Infrared imaging seeker boresight.
- CPG boresight.
- TADS switch.
- TADS **FLIR ON** switch.
- IHADSS switch.
- Microprocessor FD/LS.
- Trigger second detent.
- Missile trigger.
- Pilot missile action.
- CPG missile action.
- CPG cyclic rocket trigger.
- TADS ORT **RKT** trigger.
- CPG's cyclic trigger second detent.
- CPG's cyclic trigger first detent.

(b) The CPG MRTU Type III monitors the CPG's cyclic stick for the following actions.

- Cruise/transition.
- Hover.
- PNVS range focus increase.
- PNVS range focus decrease.

14-3. THEORY OF OPERATION (cont)

14-3

(c) The CPG MRTU Type III supplies 28 VDC to the pilot's caution/warning panel, when commanded, for **PRI MUX** light illumination caused by internal latching.

(d) The CPG MRTU Type III supplies 28 VDC to the CPG's caution/warning panel, when commanded, for the following signals.

- ADS fail.
- Missile fail.
- TADS fail.
- GUN fail.
- RKT fail.
- PRI MUX.

(e) The CPG MRTU Type III monitors the optical relay tube, control panel, left hand grip, for the following signals.

- Image auto track (IAT) **MAN/AUTO TRACK** switch position.
- IAT offset.
- Store target.
- Update target.
- Linear motion compensation (LMC).
- Zoom field of view.
- Medium field of view.
- Wide field of view.
- Narrow field of view.
- Weapon trigger first detent.
- Weapon trigger second detent.
- FLIR sensor selector.
- TV sensor selector.
- Direct view optics (DVO) sensor selector.
- TADS video select.
- PNVIS video select.
- IRIS video select.
- Gray scale select.
- FLIR level.
- Gain level.
- Range focus.
- Elevation boresight adjust.
- Azimuth boresight adjust.
- Boresight enable.

14-3. THEORY OF OPERATION (cont)

14-3

- Laser tracker auto search.
- Laser tracker manual search.
- Turret manual azimuth rate.
- Turret manual elevation rate.
- Slave command.
- FLIR polarity.
- TADS image automatic tracking polarity black.
- TADS image automatic tracking polarity white.
- Record command.
- Heads out display/heads down display status.
- Laser trigger first detent.
- Laser trigger second detent.
- FLIR auto contrast.
- Symbol brightness.
- IHADSS display brightness.

(f) The CPG MRTU Type III interfaces with the optical relay tube's alphanumeric display (AND) for serial digital transfer output.

- IHADSS display contrast.

(g) The CPG MRTU Type III interfaces with the optical relay tube for independent HOD command.

(h) The CPG MRTU Type III monitors the TADS/PNVS turret for the following signals.

- Yaw rate.
- Pitch rate.
- Roll rate.
- TADS FLIR cool.
- TADS ready.

(i) The CPG MRTU Type III interfaces with the TADS/PNVS turret to supply dc power for the following signals.

- TADS FLIR gain.
- TADS FLIR level.
- DVO reticule illuminate.
- TADS range focus (DTV).
- TADS range focus (FLIR).
- PNVS FLIR gain.
- PNVS FLIR level.
- PNVS FLIR polarity.

14-3. THEORY OF OPERATION (cont)

14-3

- PNVS AUTO/MAN control.
- Day TV zoom.
- TADS FLIR polarity.
- TADS FLIR auto contrast.
- Night sensor zoom.

(j) The CPG MRTU Type III monitors the CPG's collective stick for the following signals.

- Select TADS.
- Select PNVS.
- RF override.
- Boresight store.
- FLIR polarity.

(k) The CPG MRTU Type III monitors the CPG's missile panel for the following signals.

- Type switch.
- Manual advance/de-ice switch.
- Lock on after launch (LOAL) switch.
- Mode switch.

(l) The CPG MRTU Type III interfaces with the DEK for serial digital transfer (ADC).

(m) The CPG MRTU Type III interfaces with the Doppler for ARINC 582-4 BCD consisting of the following signals (ADC).

- Distance to go.
- Cross track deviation.
- Desired track.
- Track angle error.
- Ground speed.
- Position Northing.
- Position Easting.
- Drift velocity.
- Vertical velocity.
- 100 Km square area identifier.
- Built-in test word.
- Heading velocity.

14-3. THEORY OF OPERATION (cont)

14-3

(n) The CPG MRTU Type III interfaces with the video recorder control panel to supply dc power for the following signals.

- Stop command.
- Remote record command.

(o) The CPG MRTU Type III monitors the video recorder control panel for the following signals.

- Pilot/CPG recorder control.
- Recorder control.
- Remote recorder.
- On/off detect.

I. **Primary and Secondary Data Buses.** The primary and secondary data buses provide a redundant electrical interface between the major components of the MUX system (fig. 14-20).

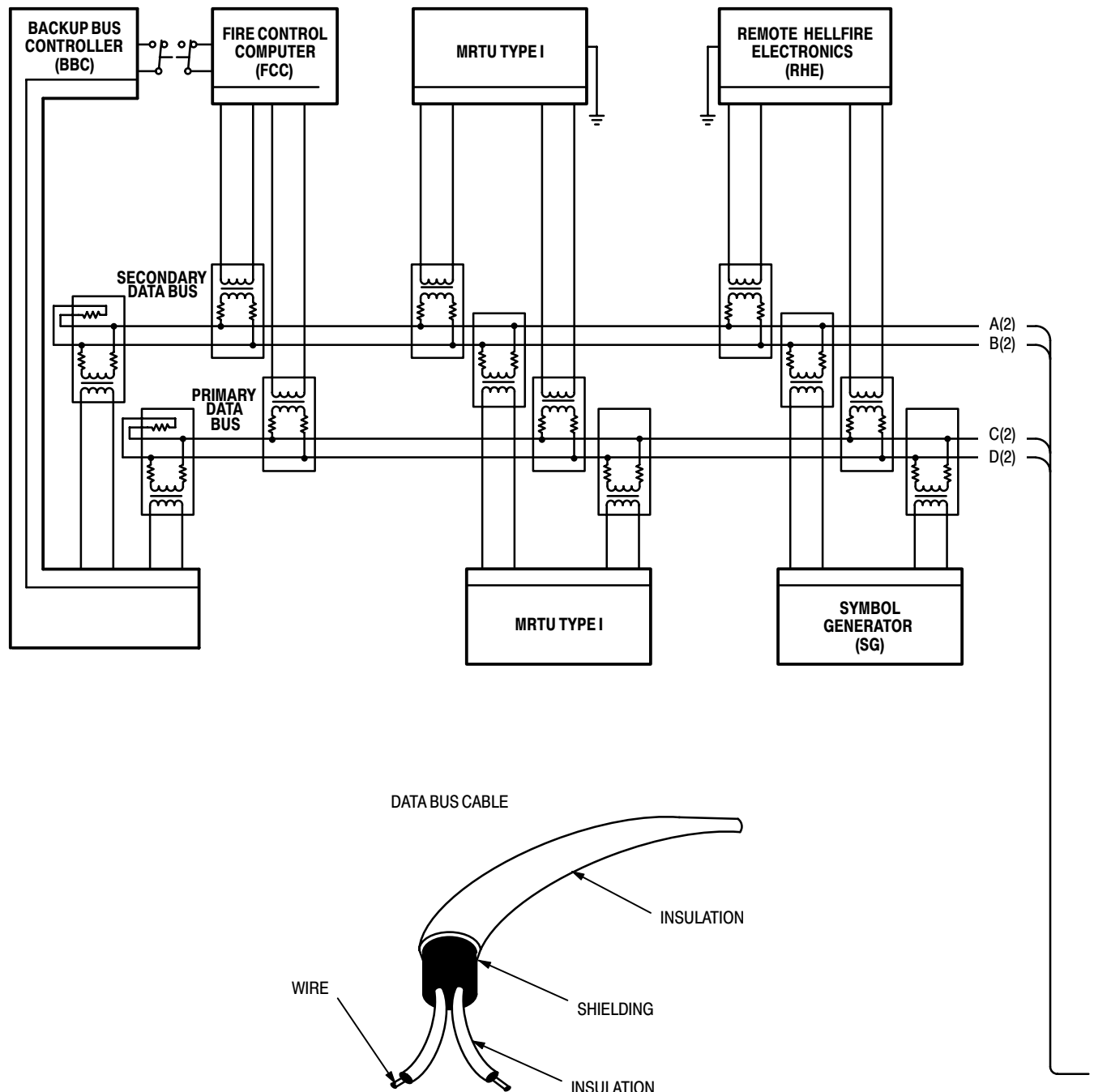
(1) The primary bus is routed on the left side of the aircraft. The secondary bus is routed on the right side of the aircraft.

(2) Each bus consists of a pair of twisted, shielded, Teflon-insulated wires (cable).

(3) The buses are monitored by the FCC. The FCC generates a FD/LS message for the primary (**LT**) or secondary (**RT**) bus and the appropriate LRU, when a failure occurs (ACZ).

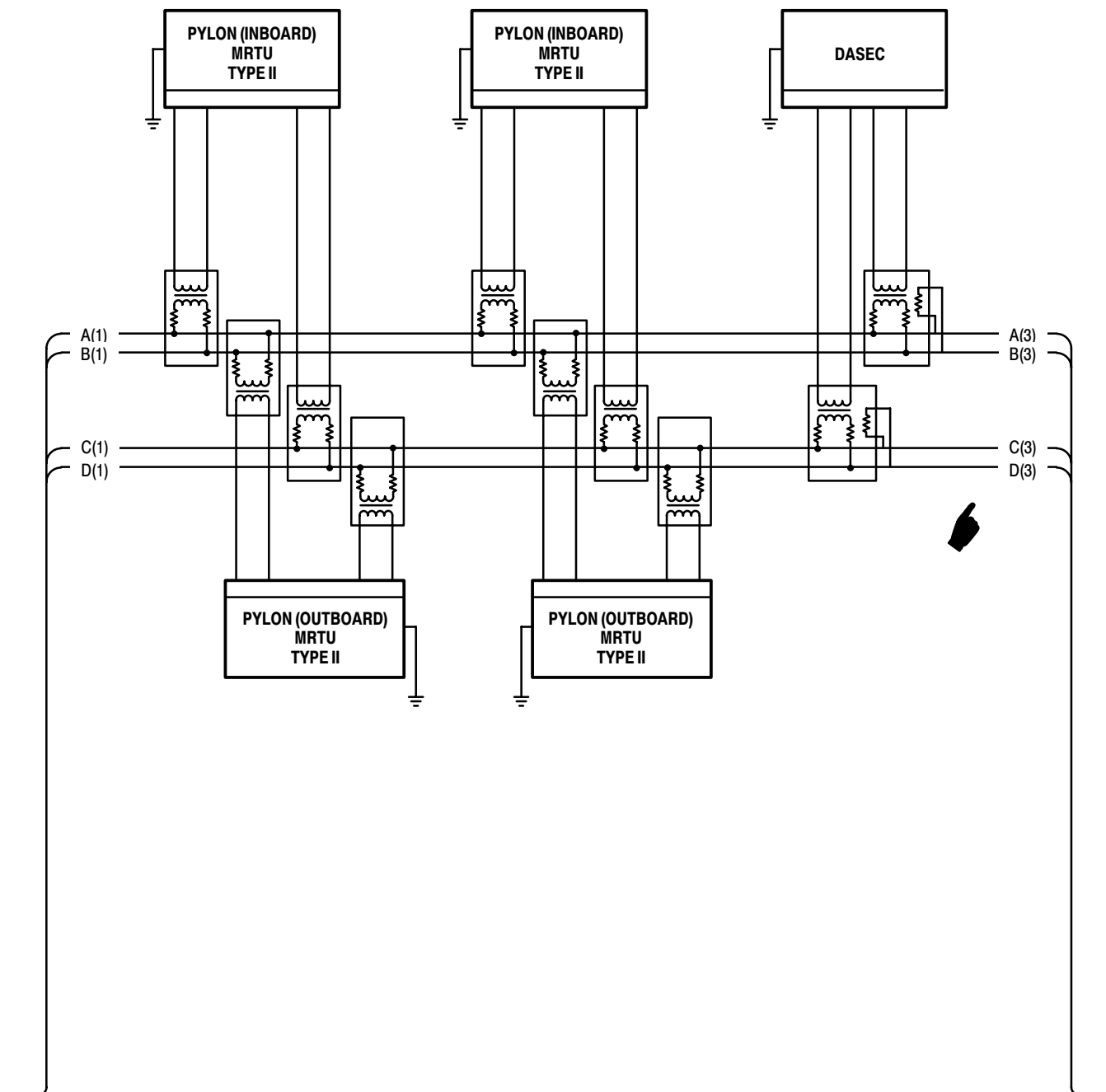
14-3. THEORY OF OPERATION (cont)

14-3



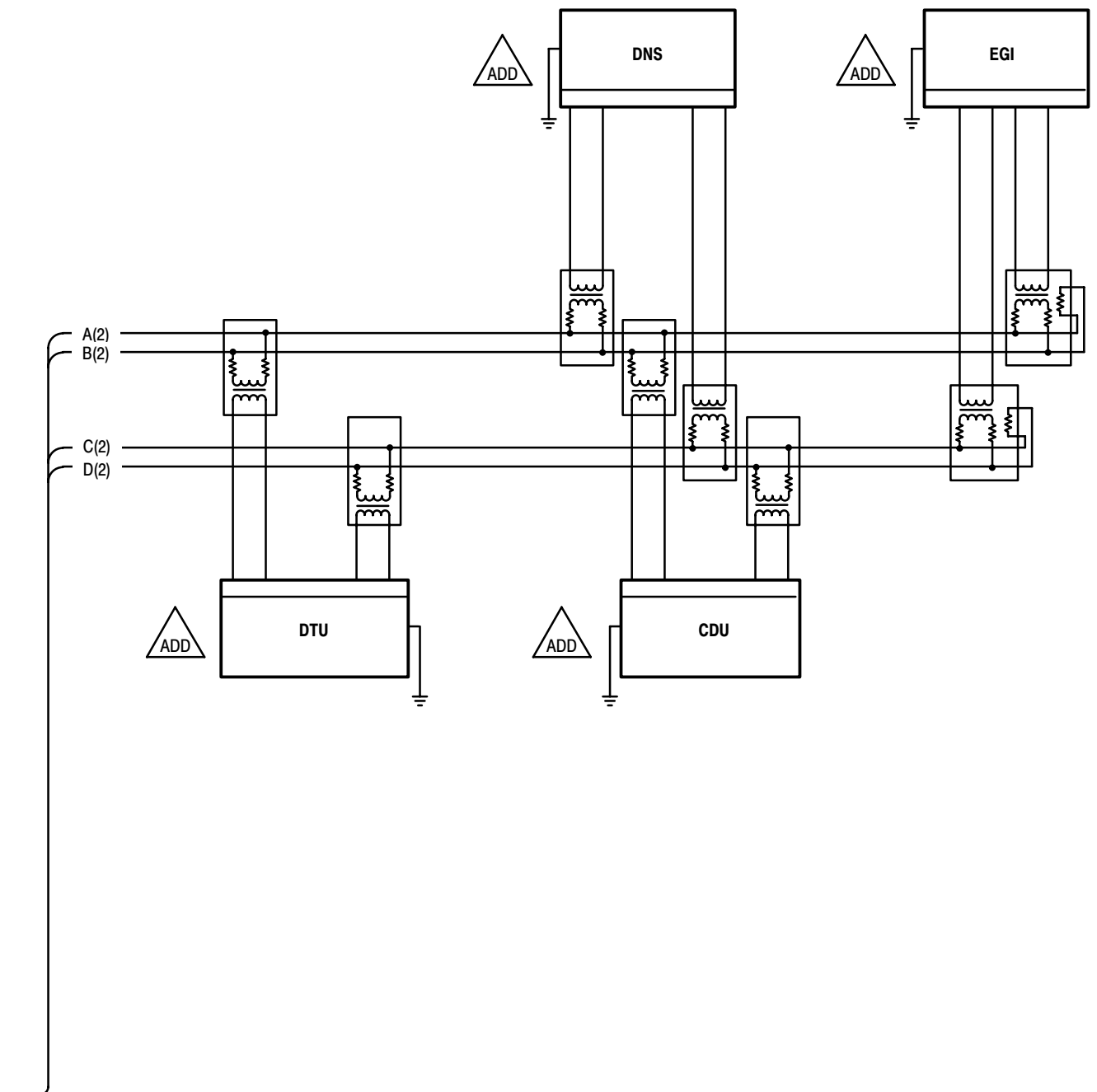
M52-165-1A

Figure 14-20. Data Bus Interface (Sheet 1 of 3)



M52-165-2B

Figure 14-20. Data Bus Interface (Sheet 2 of 3)



M52-165-3

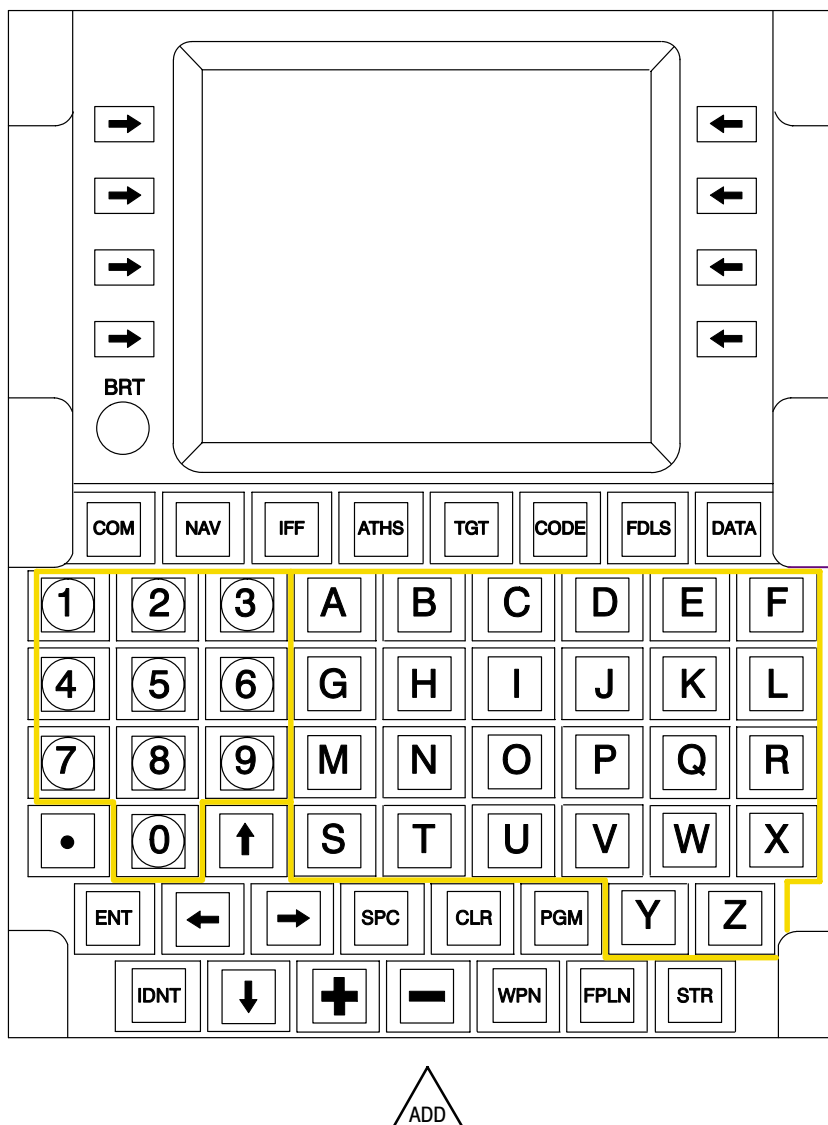
Figure 14-20. Data Bus Interface (Sheet 3 of 3)

14-3. THEORY OF OPERATION (cont)

14-3

m. **CDU (ADD).** The CDU provides the CPG with the primary means of communicating with the FCC via the MUX bus. Functions are described below.

- (1) **BRT Control Function.** The **BRT** function controls the brightness of the CRT.



M52-467

Figure 14-20.1. CDU (ADD)

14-3. THEORY OF OPERATION (cont)

14-3

(2) **CRT Functions.** The CRT (fig. 14-20.2) contains eight display lines. The lines are identified as lines one through eight. Lines one through seven are used to display data and provide legends for selection of functions. Line eight is scratchpad data. All eight lines are 22 characters long.

(3) **VAB Functions.** The VABs (fig. 14-20.2) select mode and display functions.

(4) **FAB Functions.** The FABs (fig. 14-20.2) are used to access the FCC top level function pages.

(a) **COM (Communication).** Not used.

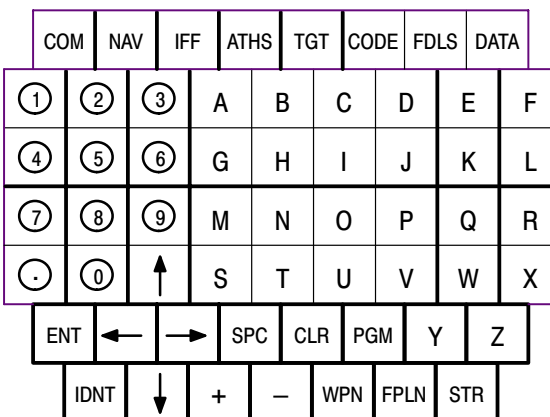
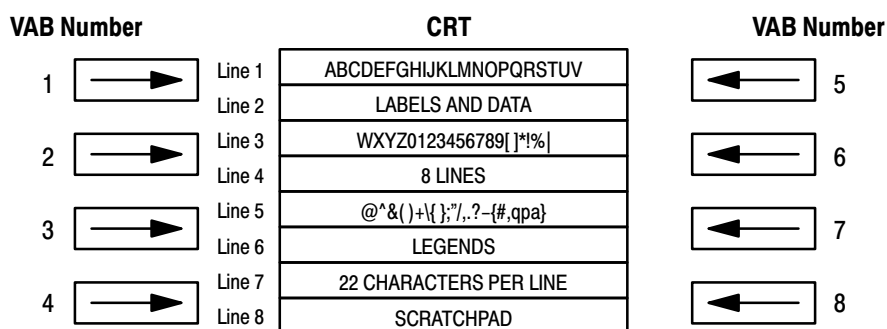
(b) **NAV (Navigation).** Provides access to **NAV** top level page. The **NAV** position allows input of present position data, viewing of fly to data and hover bias calibration mode (HBCM).

(c) **IFF (Identification Friend or Foe).** Not used.

(d) **ATHS (Automatic Target Handoff System).** Not used.

(e) **TGT (Target).** Provides access to target list pages. The **TGT** position allows input of coordinate data for 40 targets.

(f) **CODE.** Provides access to laser **CODE** page. The **CODE** position allows the code of the day to be programmed into the FCC for upper/lower missile channels.



Keyboard

M52-0466

Figure 14-20.2. CDU CRT and Keyboard (ADD)

14-3. THEORY OF OPERATION (cont)

14-3

(g) **FDLS (Fault Detection and Location System).** The **FD/LS** position allows the CPG or ground maintenance personnel to interrogate failed system and identify failed line replaceable units (LRU) and their approximate location in the aircraft.

(h) **DATA.** Provides access to data menu top level page. The **DATA** position allows selection of navigation status, GPS status, navigation sensor controls, DTU functions, zeroize function and HAVE QUICK radio function.

(i) **ENT (Enter).** Not used.

(j) **SPC (Space).** The space key is only used for entry of coordinate identification, FDLS and boresight operations.

(k) **CLR (Clear).** Freezes the invalid character string or clears the scratchpad.

(l) **PGM (Program).** Provides access to program top level page. The **PGM** position allows input of EGI boresight information, input of Area Weapon Subsystem (AWS) Harmonization corrections, access of multiplex read codes and display of AND on CDU.

(m) **IDNT (Identification).** Not used.

(n) **WPN (Weapon).** Provides access to weapon control page. The **WPN** position allows input of range data, selection of range source and target report data.

(o) **FPLN (Flight Plan).** Provides access to waypoint directory page. The **FPLN** position allows input of coordinate data for 40 waypoints.

(p) **STR (Store).** Stores present position information.

(5) **Key Functions.**

(a) **ALPHA** keys. The **ALPHA** keys allow the letter of each key to be selected.

(b) **NUMERIC** keys. The **NUMERIC** keys allow the number of each key to be selected.

(c) **+, -** keys. The **+, -** keys allow a plus or minus symbol to be selected.

(d) **ARROW** keys. When the **WPT COORD** or **TGT COORD** pages are displayed, the up and down arrow keys allow scrolling through the respective pages. When the **NAV** or **WPN** pages are displayed, the up and down arrow keys allow scrolling forward or backward through the flight plan or target lists to select another valid coordinate as the new active fly-to or target. The left and right arrow keys move the cursor one character respectively on the scratchpad line.

(6) **Power Input.** Circuit breaker **CDU** (CB6) (fig. 14-20.3), on the CPG circuit breaker panel, supplies 28 VDC through BBC in control detector to the CDU.

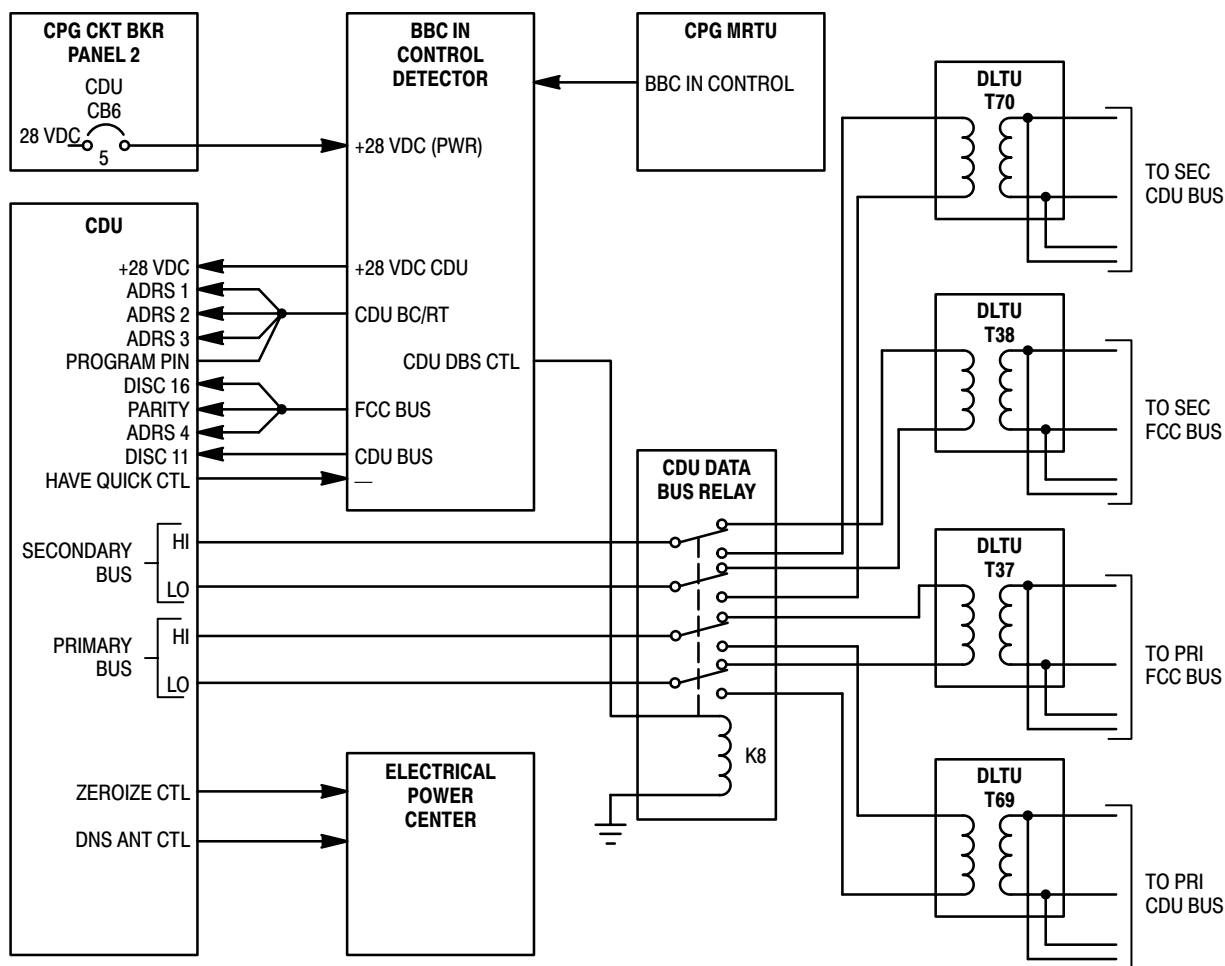
(7) **Operation.** The CDU operates normally with the FCC bus. If the FCC fails, a CDU bus is created and the CDU works in conjunction with the DNS.

(a) During normal operation (FCC in control), the CDU is interfaced to the primary and secondary FCC buses through CDU data bus relay K8 and DLTUs T37 and T38. The CDU's FCC bus address is 01 decimal. The CDU discrete HAVE QUICK CTL is interfaced to the BBC in control detector to enable loading of time of day (TOD) from the EGI to AN/ARC-164 UHF-FM radio. The CDU discrete ZEROIZE CTL is interfaced to the electrical power center to enable zeroizing of EGI, DNS and DTU. The CDU discrete DNS ANT CTL is interfaced to the electrical power center to select power on or off to the DNS antenna.

(b) When the FCC fails, the CPG MRTU TYPE III sends a BBC in control signal to the BBC in control detector. The BBC in control detector changes the address of the CDU to 17 decimal for the CDU bus and energizes the CDU data bus relay K8, interfacing the CDU with DLTUs T69 and T70.

14-3. THEORY OF OPERATION (cont)

14-3



M52-468

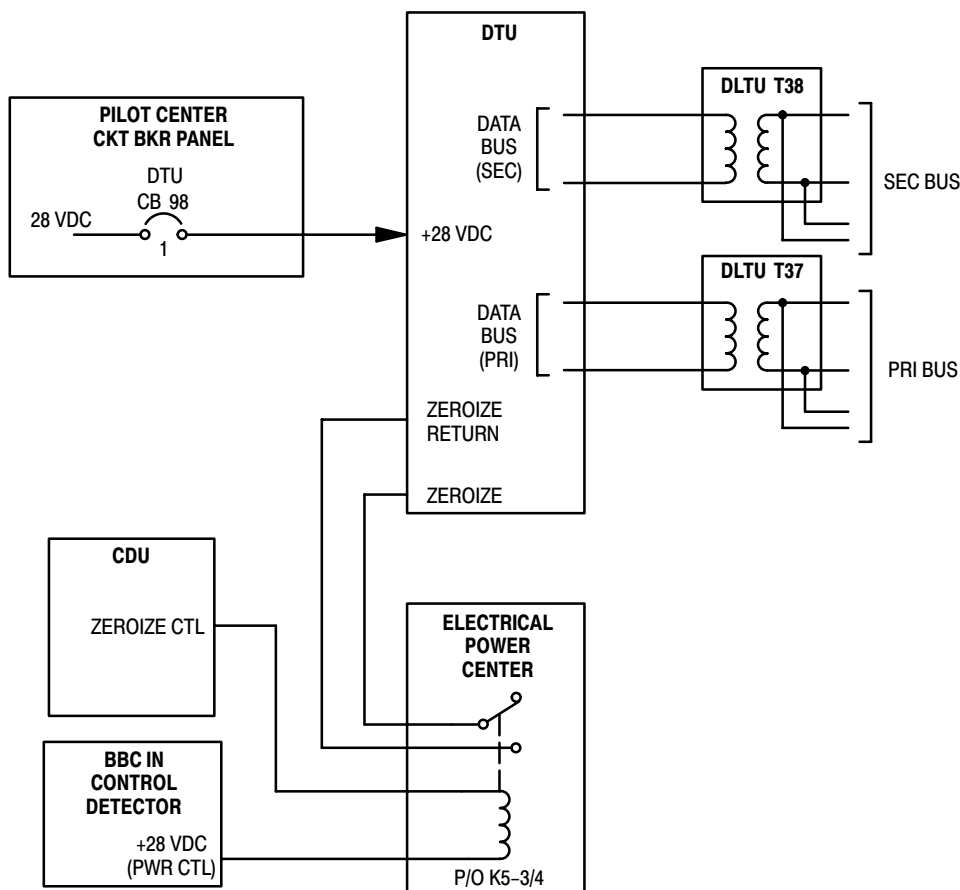
Figure 14-20.3. CDU Operation (ADD)

n. **DTU (ADD).** The DTU consists of a data transfer receptacle (DTR) and data transfer cartridge (DTC). The DTU provides the capability to transfer data to and receive data from the FCC.

(1) **Power Input.** Circuit breaker **DTU** (CB97) (fig. 14-20.4), on the pilots circuit breaker panel No. 2, supplies 28 VDC to the DTU.

14-3. THEORY OF OPERATION (cont)

14-3



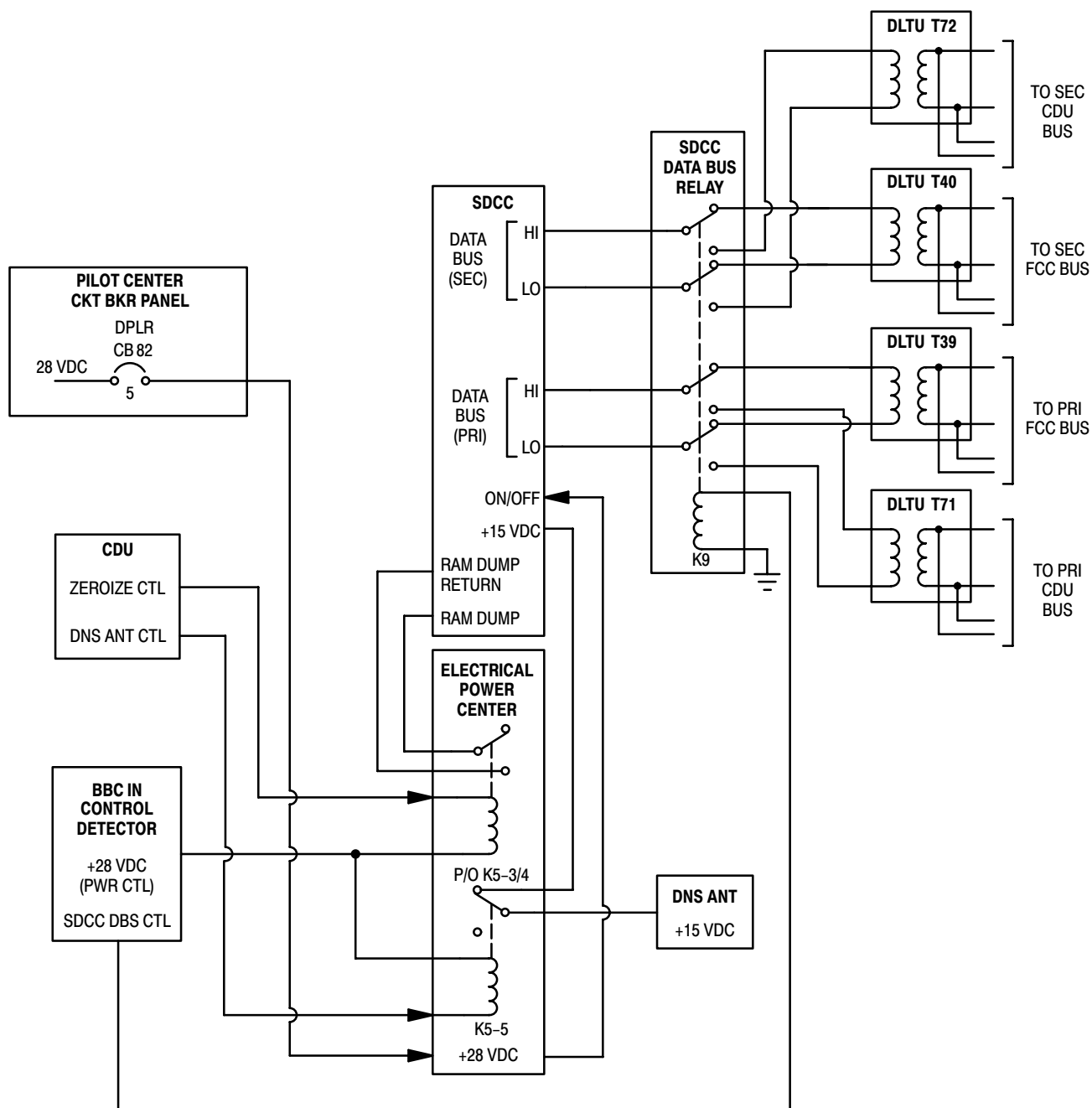
M52-465

Figure 14-20.4. DTU Operation (ADD)

(2) **Operation.** Control of the DTU is by the CDU DTU page. When the DTC is installed in the DTR, the DTR door is closed and latched, and power applied to the aircraft, the message **DTC READY** will appear on the DTU page. When selected, the data is uploaded to the FCC via DLTUs T37 and T38. The pre-mission data includes target and waypoint coordinates, startup present position, laser codes, boresight constants and Mean Sea Level (MSL) altitude. FD/LS failure codes can be downloaded to the DTC when **FCC SAVE** on CDU is selected. The CDU discrete ZEROIZE CTL is interfaced to the electrical power center to enable zeroizing of DTU through relay K5-3/4.

14-3. THEORY OF OPERATION (cont)

14-3



M52-464

Figure 14-20.5. DNS Operation (ADD)

o. **DNS (ADD).** The DNS provides the FCC with ground speed, track angle error, bearing-to-destination, time-to-destination, track angle and cross track distance navigation information.

(1) **Power Input.** Circuit breaker **DPLR** (CB97) (fig. 14-20.5), on the pilots circuit breaker panel No. 2, supplies 28 VDC through the electrical power center to the SDCC.

14-3. THEORY OF OPERATION (cont)

14-3

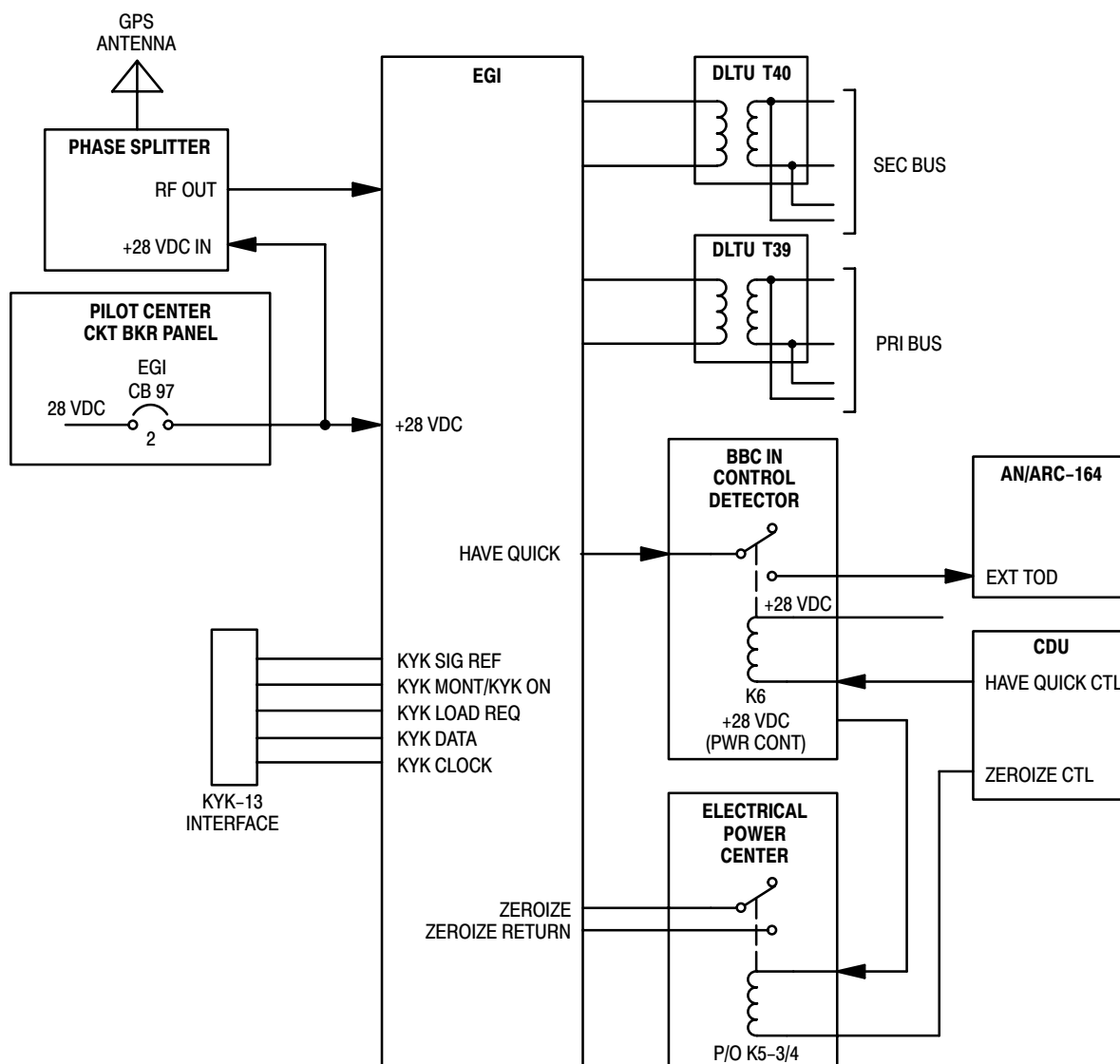
(2) **Operation.** The DNS operates normally with the FCC bus. If the FCC fails, a CDU bus is created and the CDU works in conjunction with the DNS.

(a) During normal operation (FCC in control), the SDCC is interfaced to the primary and secondary FCC buses through SDCC data bus relay K9 and DLTUs T39 and T40. The CDU discrete ZEROIZE CTL is interfaced to the electrical power center to enable zeroizing of DNS through relay K5-3/4. The CDU discrete DNS ANT CTL is interfaced to the electrical power center to select power on or off to the DNS antenna through relay K5-5.

(b) When the FCC fails, the CPG MRTU TYPE III sends a BBC in control signal to the BBC in control detector. The BBC in control detector energizes the SDCC data bus relay K9, interfacing the SDCC with the CDU bus DLTUs T71 and T72.

14-3. THEORY OF OPERATION (cont)

14-3



M52-463

Figure 14-20.6. EGI Operation (ADD)

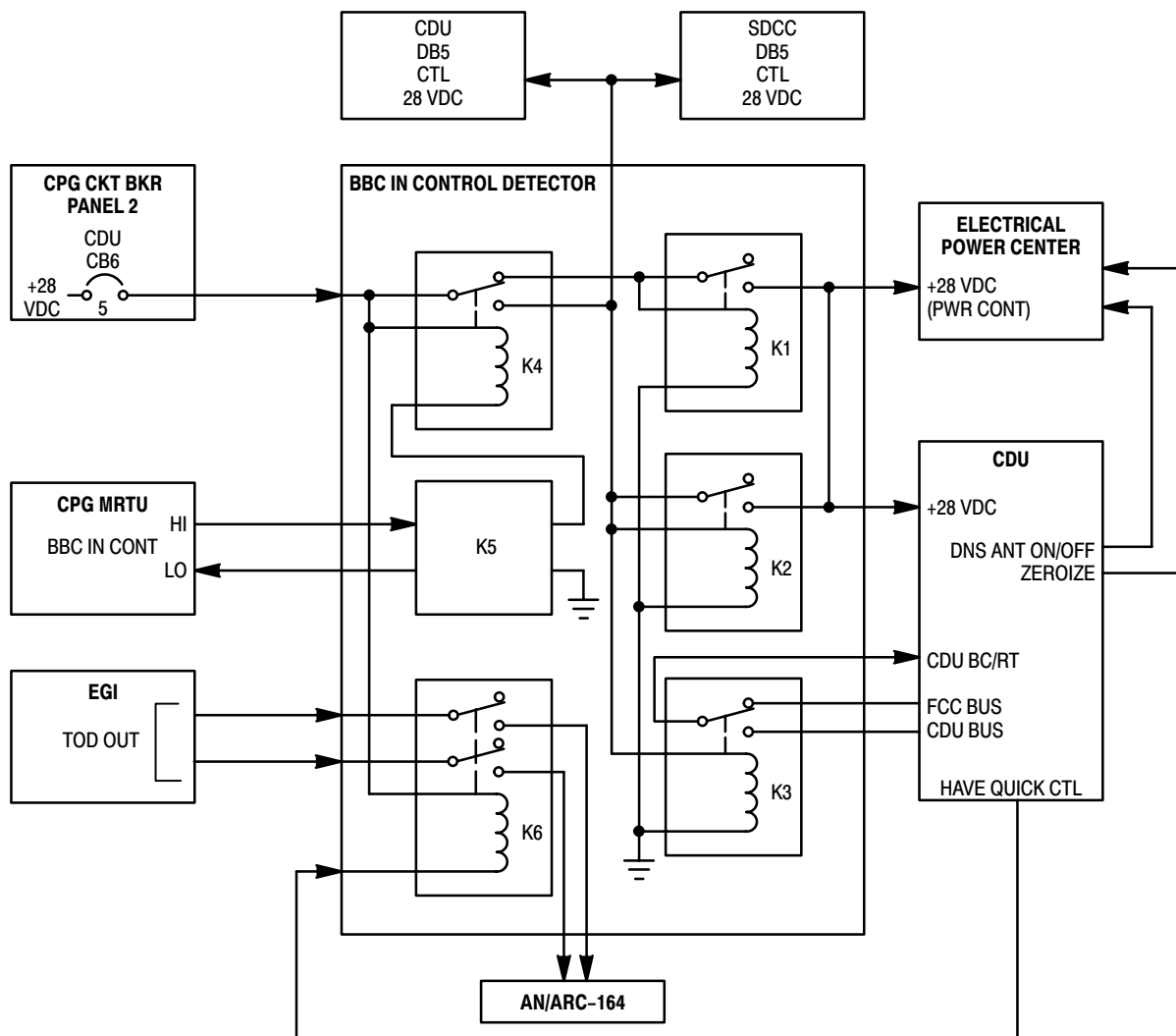
p. **EGI (ADD).** The EGI is the primary navigation and present position sensor. The EGI contains a global positioning system (GPS) and inertial navigation unit (INU). The EGI determines position from up to five space vehicles (SVs) simultaneously.

(1) **Power Input.** Circuit breaker **EGI** (CB97) (fig. 14-20.6), on the pilots circuit breaker panel No. 2, supplies 28 VDC to the GPS power splitter and and inertial – satellite signals navigation unit.

14-3. THEORY OF OPERATION (cont)

14-3

(2) **Operation.** RF satellite signals are received by the GPS fixed radiation position antenna (FRPA), attenuated by the phase splitter and fed to the EGI. The EGI outputs linear acceleration, angular acceleration, linear velocity, angular velocity, universal transverse mercator (UTM) coordinate of position, attitude (roll, pitch and platform azimuth), magnetic heading, true heading, altitude, body angular rates, time tags and universal time coordinated (UTC) synchronized time to the FCC through DLTUs T39 and T40. Selecting the HAVE QUICK function on the CDU enables relay K6. The output of K6 routes EGI time of day (TOD) directly to the AN/ARC-164. The CDU discrete ZEROIZE CTL is interfaced to the electrical power center to enable zeroizing of EGI through relay K5-3/4. The EGI has an external connector for the loading of KYK-13 crypto data.



M52-461

Figure 14-20.7. BBC In Control Detector Operation (ADD)

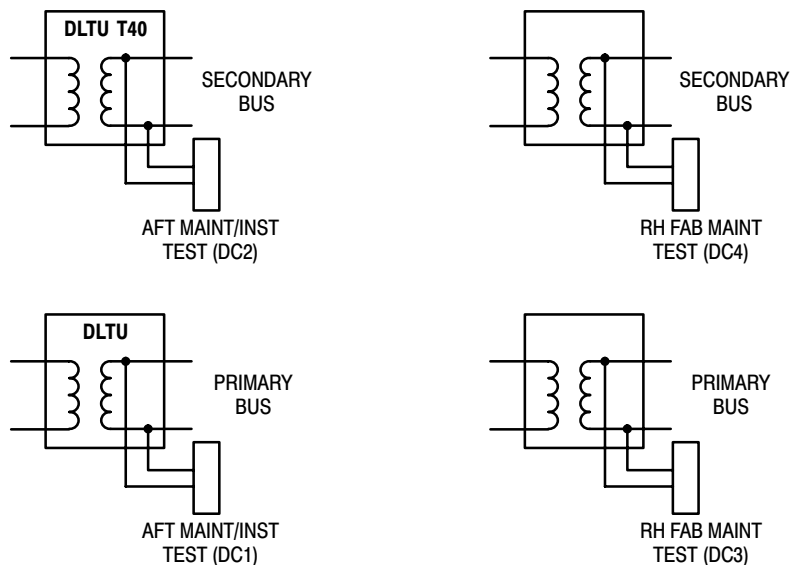
q. **BBC In Control Detector (ADD).** The BBC in control detector (fig. 14-20.7) supplies 28 VDC to the CDU, control voltage for zeroizing and DNS antenna on/off to the electrical power center, and contains a relay for HAVE QUICK operation. When the FCC fails, the BBC in control detector removes the CDU and SDCC from the FCC bus and creates a CDU bus.

14-3. THEORY OF OPERATION (cont)

14-3

(1) **Power Input.** Circuit breaker **CDU** (CB6) on the CPG circuit breaker panel No. 2, supplies 28 VDC through relay contacts of K4, enabling relay K1.

(2) **Operation.** The output of K1 provides 28 VDC to the CDU and control voltage to the electrical power center. Selecting the HAVE QUICK function on the CDU enables relay K6. The output of K6 routes EGI time of day (TOD) directly to the AN/ARC-164. Upon FCC failure, a 5 VDC signal is sent from the CPG MRTU, enabling relay K5. Relay K5 enables relay K4. Relay K4 enables the CDU and SDCC data bus relays (creating a CDU bus), relay K2 and relay K3. Relay K2 provides 28 VDC to the CDU and control voltage to the electrical power center. Relay K3 changes the CDU FCC address bus R/T number from 01 decimal to 17 decimal.



M52-462

Figure 14-20.8. Multiplex Test Connectors (ADD)

r. **Multiplex Test Connectors (ADD).** Four maintenance test connectors (fig. 14-20.8) are installed for future use. One primary (DC3) and one secondary bus test (DC4) connector is installed in the RH FAB. One primary (DC1) and one secondary bus test (DC2) connector is installed in the left hand catwalk area.

14-3. THEORY OF OPERATION (cont)

14-3

m. **FD/LS.** The FD/LS provides the AH-64A multiplex system with an overall test of all mission essential line replaceable units (LRUs) (fig. 14-21). The FD/LS software resides in the FCC. Executions of all FD/LS functions are done only under primary bus control (FCC). The BBC contains a limited version of system status faults detection.

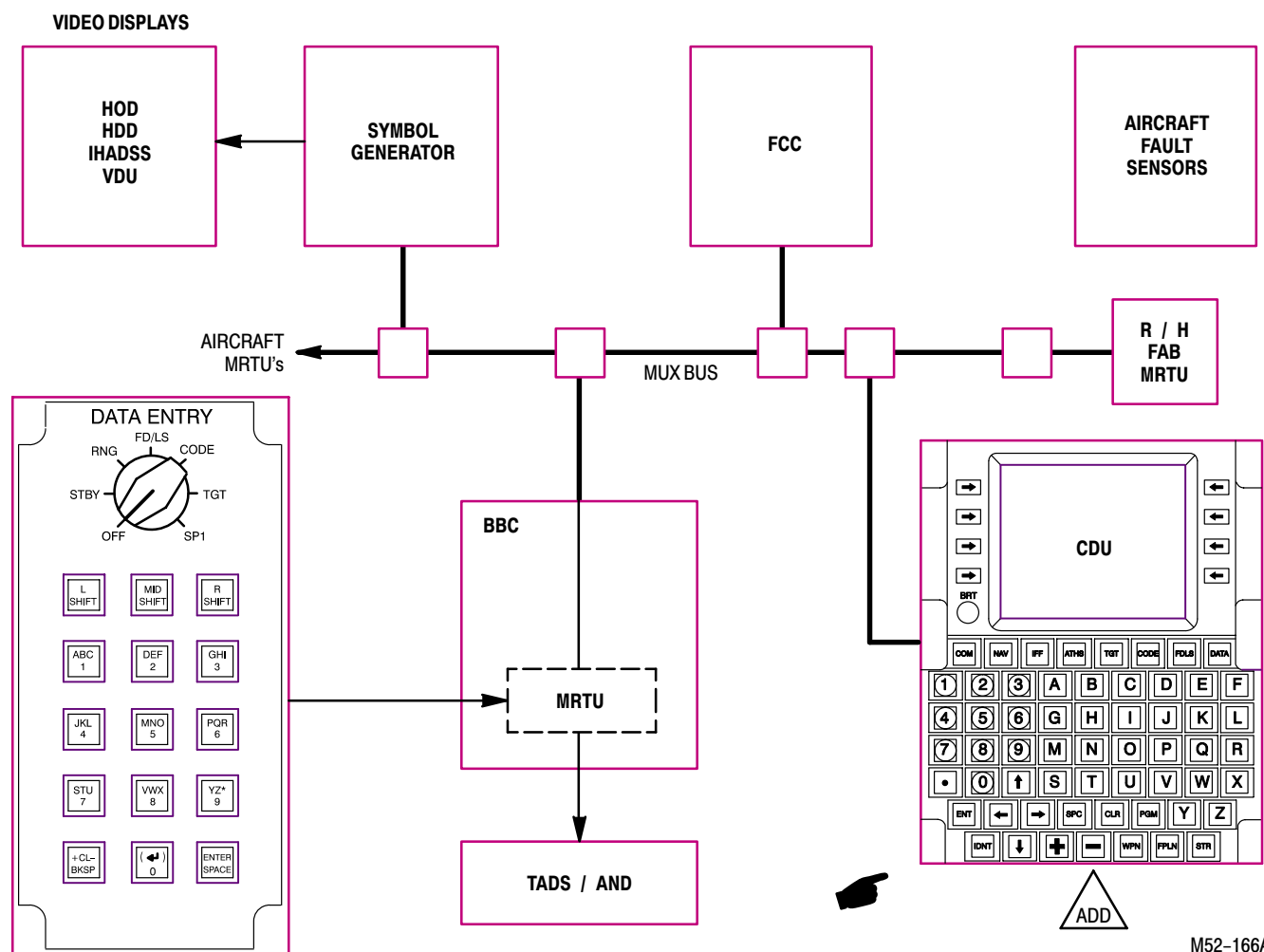


Figure 14-21. FD/LS Interface

(1) **Continuous test.** The continuous test mode is an ongoing test monitor of all subsystems which contain a continuous built-in test electronics (BITE) circuitry test output. The FD/LS continuous routine is called by the FCC executive on a time available for processing basis. The continuous test processor sequentially schedules and executes one of 15 (ADC) or 19 (ADD) subsystem test routines. At the completion of the subsystem test, the continuous processor calls for a MUX communication test. In this manner, a complete subsystem test and a MUX communication test are tested during one frame. The continuous test processing is executed until the DEK rotary switch is turned to the FD/LS position (ADC) or **FDLS** FAB on the CDU (ADD), at which time all continuous test monitoring is halted.

14-3. THEORY OF OPERATION (cont)

14-3

(a) Should any NO-GO failure occur during a continuous test, the no-go ID is stored in memory. This memory is called the auto status buffer, and a flag is set in the current aircraft status word. The aircraft status word is used for instantaneous automatic system status indication. Upon any single NO-GO, the crew stations are alerted that there is a current NO-GO on-board the aircraft, with either or both of the following methods.

- A flashing FD/LS message is displayed in the upper left corner of the CPG's video display.
- A flashing caution light appears on each crew station's caution and warning panel.
- A **✓FDLS** message on the CDU (ADD).

(b) When the FD/LS message appears, and the CPG turns the DEK rotary switch to the FD/LS position (ADC) or selects CDU FDLS FAB (ADD), the auto status buffer with all the current on-board system NO-GOs are displayed on the CPG's video. An asterisk is displayed to the left of the FD/LS message which activated the FD/LS flasher (ACZ). The LRU NO-GOs are formatted for four lines of status display, which is defined as a page. If two or more NO-GOs exist, the auto status display can be scrolled page by page by depressing the DEK space key (ADC) or CDU **SPC** key (ADD). When the end of list message, **ANY KEY FOR FD/LS MENU** is displayed, the operator has scrolled through the entire auto status buffer. The NO-GOs may be reviewed again by scrolling the screen.

(b) Once the DEK is placed in the FD/LS position (ADC) or the CDU FDLS FAB is selected (ADD), the FD/LS flasher is reset so that the flasher won't appear again until a new NO-GO is detected on-board the aircraft.

(d) The following list shows each continuously monitored system.

- FD/LS flasher.
- ADSS.
- DASE.
- De-ice system.
- AWS.
- HARS.
- IHADSS.
- Missile system.
- MUX communication.
- PNVs.
- Pylon articulation.
- Aerial rocket system.
- Automatic stabilator system.
- Symbol Generator.
- TADS.
- Utilities consisting of BBC, keyboard and integrated fire control panel.
- CDU (ADD)

14-3. THEORY OF OPERATION (cont)

14-3

- DNS (ADD)
- DTU (ADD)
- EGI (ADD)

(2) **Maintenance Test.** The maintenance test is an operator-initiated test of all the AH-64A systems' LRUs.

(a) When the DEK rotary switch is set to FD/LS (ADC) or CDU FDLS FAB is selected (ADD) and any numbered key is pressed, the maintenance test menu is displayed one page at a time.

(a) To scroll from page to page, the operator presses the DEK space key (ADC) or CDU **SPC** key (ADD). To execute a maintenance menu FD/LS test, the operator selects from the menu the desired test number and enters the test number via the DEK (ADC) or CDU (ADD). The test number is automatically entered. During the execution of a maintenance FD/LS test, the operator is sequenced through the test with a display of various aircraft moding prompts. The aircraft moding prompts, upon execution, mode the aircraft for the particular test being executed. When the maintenance test completes, all of the current LRU NO-GOs and their physical location on the aircraft are displayed. The NO-GOs may be scrolled page to page by pressing the DEK space key (ADC) or CDU **SPC** key (ADD), until the end of fail list is displayed.

(c) The end of fail list prompt indicates the end of all NO-GOs. The NO-GOs may be scrolled for review.

15-1. PURPOSE

15-1

CHAPTER 15 INSTRUMENT SYSTEMS

15-1. PURPOSE

- a. The instrument systems provide the pilot and CPG with engine and flight information.
- b. The instruments are located on instrument panels in the pilot and CPG stations.
- c. The instruments are the following main types.

(1) Engine. The engine instruments provide the crew with the means to monitor power turbine (N_P) speed, gas producer turbine (N_G) speed, oil pressure, turbine gas temperature (TGT), and torque of each engine plus fuel quantity and the main rotor rpm.

(2) Flight. The flight instruments measure and display helicopter performance (forward, up, and down), altitude, and gravity (g) forces. Not all flight instruments are common to both crew station.

(3) Flight Reference. The flight reference instruments provide visual displays of helicopter attitude and flight conditions. Flight reference instruments operate from power and flight data inputs.

(4) Navigation. The navigation instruments measure and display helicopter position, heading, and course with relation to the ground.

(5) Miscellaneous. The miscellaneous instruments display hydraulic pressure, fuel quantity, outside temperature, and time.

15-2. DESCRIPTION

a. **Engine Instruments.** The engine instruments (fig. 15-1) are self-contained, rectangular units with fixed numbered scales and colored columns of lamp segments that illuminate when a corresponding numeric value is reached. The lamp segments are divided into color coded zones. The colors are red (danger zone), amber (caution zone) and green (normal operating zone). Only one colored zone will be illuminated at a time. The bottom lamp segment of each scale is a blue segment that illuminates to indicate electrical power is applied to the instrument. Some instruments have three-digit digital displays that display values in numbers that are more accurate and easier to read than the vertical scales.

The following are pilot's instruments.

- (1) **ENG/RTR/RPM** indicator.

The N_P1 and N_P2 vertical scales are color coded as follows:

Red zone (upper)	104 to 120% (ACV).
Red zone (upper)	110 to 120% (ACW).
Amber zone (upper)	100 to 104% (transient operation only) (ACV).
Amber zone (upper)	104 to 110% (transient operation only) (ACW).
Green zone	98 to 100% (ACV).
Green zone	98 to 104% (ACW).
Amber zone (lower)	94 to 98% (transient operation only).
Red zone (lower)	0 to 94%.
Red dots (upper and lower) ..	Light at beginning of upper and lower red range (ACV).
Red dots (lower)	Light at beginning of lower red range (ACW).
Blue	Light when instrument power is applied

15-2. **DESCRIPTION (cont)**

15-2

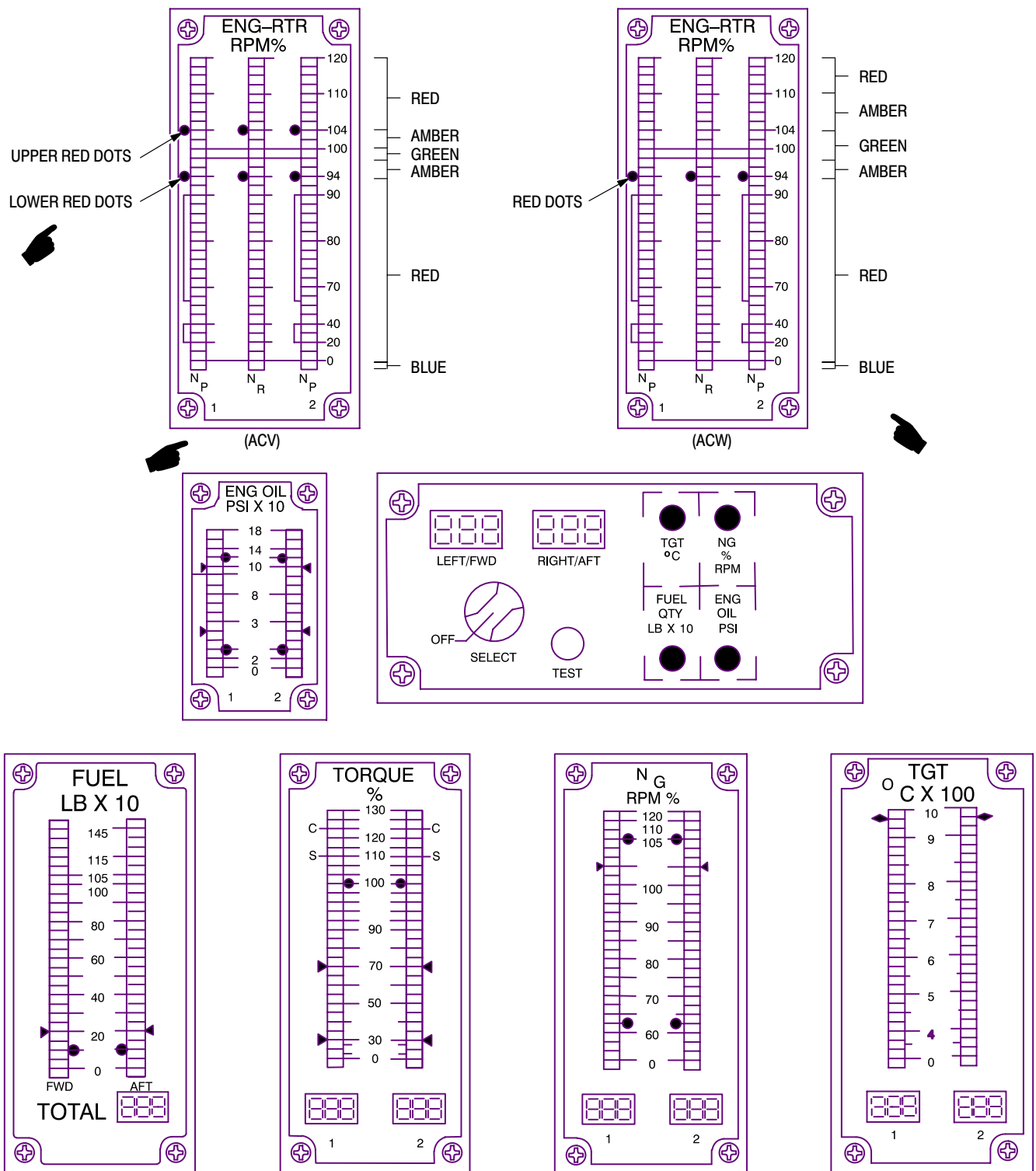
The N_R vertical scale is color coded as follows.

Red zone (upper)	104 to 110% (transient operation only) (ACV).
Red zone (upper)	110 to 120% (ACW).
Amber zone	104 to 110% (transient operation only) (ACW).
Green zone	94 to 104%.
Red zone (lower)	0 to 94%.
Red dots (upper and lower) ..	Light at begining of upper and lower red range (ACV).
Red dot (lower)	Lights at begining of lower red range (ACW).
Blue	Lights when instrument power is applied

- (2) **FUEL** quantity indicator (operation and description in miscellaneous instruments).
- (3) Engine **TORQUE** indicator.
- (4) **N_G RPM** indicator.
- (5) **ENG OIL PSI** indicator.
- (6) **TGT** indicator.

15-2. DESCRIPTION (cont)

15-2



M52-180A

Figure 15-1. Engine Instruments Functional Description

15-2. DESCRIPTION (cont)

15-2

The following are CPG's instruments.

- (7) **ENG/RTR/RPM** (identical and interchangeable with pilot's **ENG/RTR/RPM** indicator).
- (8) Engine **TORQUE** indicator (identical and interchangeable with the pilot's **TORQUE** indicator).
- (9) Selectable Digital Display (SDD).

b. **Flight Instruments.** The following flight instruments (fig. 15-2) are on pilot and CPG instrument panels.

(1) Pilot's Instruments.

- (a) Airspeed.
- (b) Vertical velocity.
- (c) Barometric altimeter.
- (d) Accelerometer.

(2) CPG's Instruments.

- (a) Airspeed.
- (b) Vertical velocity.
- (c) Barometric altimeter.

(3) Airspeed Indicators.

- (a) The airspeed indicators are on pilot and CPG instrument panels.
- (b) The airspeed indicators show helicopter airspeed in knots.
- (c) The calibrated airspeed dial reads from 20 to 250 knots.

(4) Vertical Velocity Indicator (VVI).

- (a) The vertical velocity indicators are on pilot and CPG instrument panels.
- (b) The vertical velocity indicators display vertical speed up or down.
- (c) Vertical speeds can be measured to a maximum rate of 6000 feet per minute.

(5) Barometric Altimeters. The barometric altimeters are on pilot and CPG instrument panels. The altimeters display aircraft altitude from -1000 to +50,000 feet.

(6) Accelerometer. The accelerometer is on the pilot instrument panel. The accelerometer shows positive and negative changes in gravity (g) forces caused by aircraft position changes. Positive gravity forces can be measured to +4g. Negative g forces can be measured to -2g.

15-2. DESCRIPTION (cont)

15-2

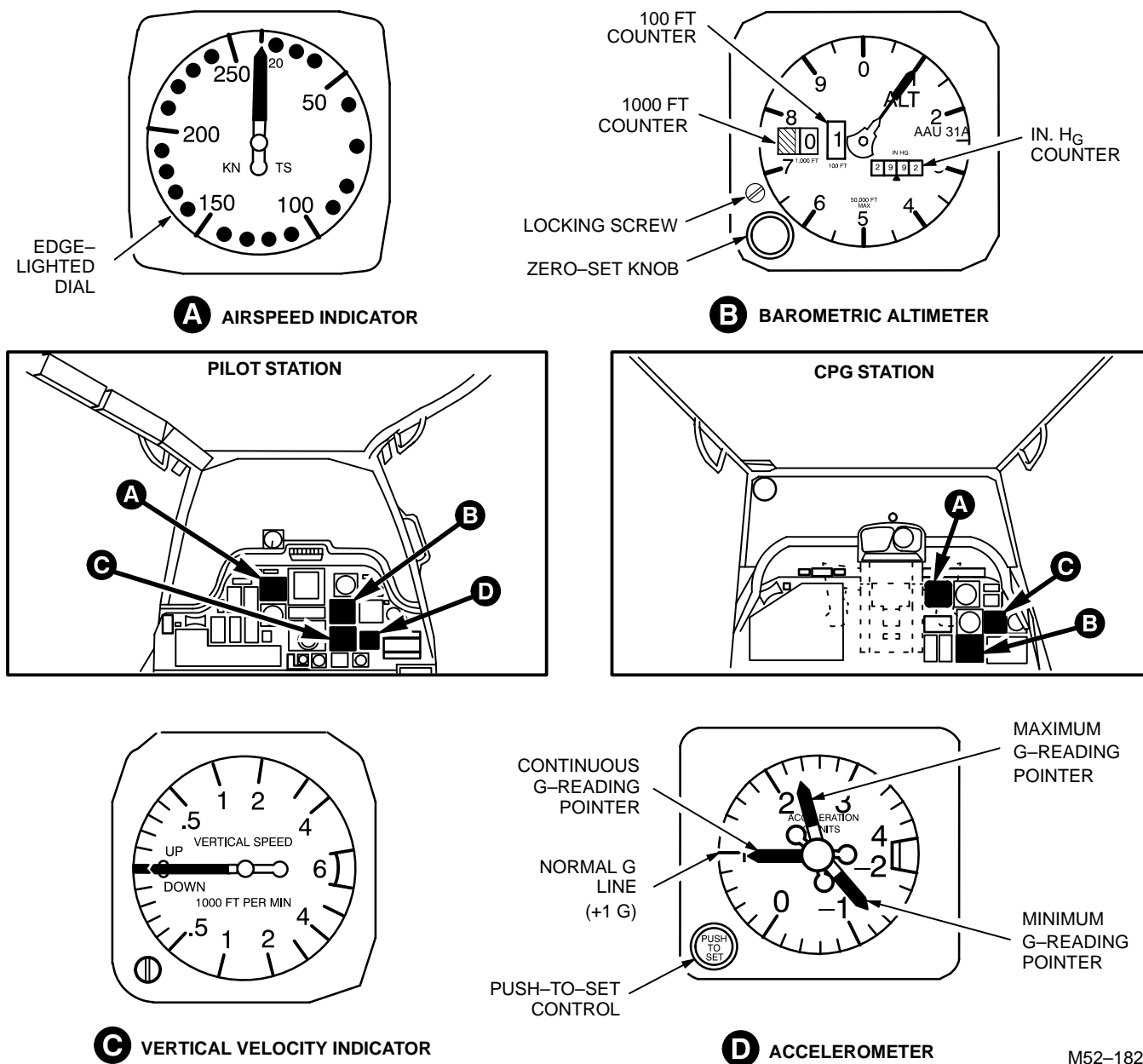


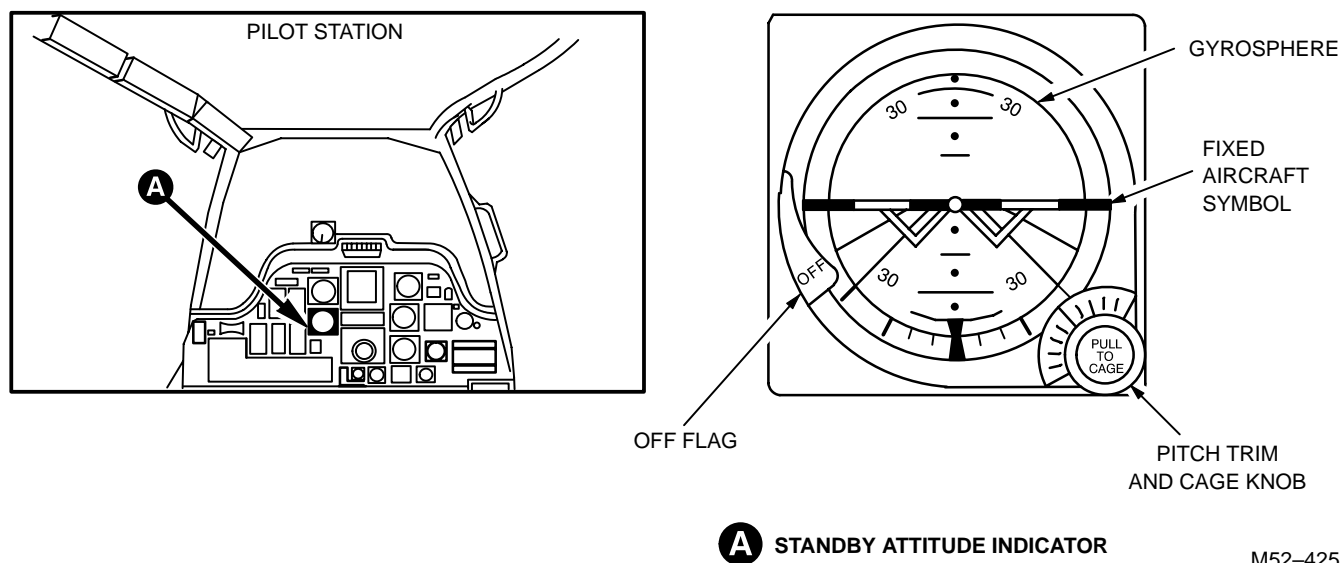
Figure 15-2. Flight Instruments

c. **Flight Reference Instruments.** Flight reference instruments provide a visual display of helicopter attitude. The following instruments are considered flight reference instruments.

(1) **Standby Attitude Indicator (SAI).** The SAI (fig. 15-3), located on the pilot instrument panel, provides the pilot with an independent, continuous backup display of helicopter attitude. The SAI can display 360° roll, 85° climb pitch, and 85° dive pitch.

15-2. DESCRIPTION (cont)

15-2



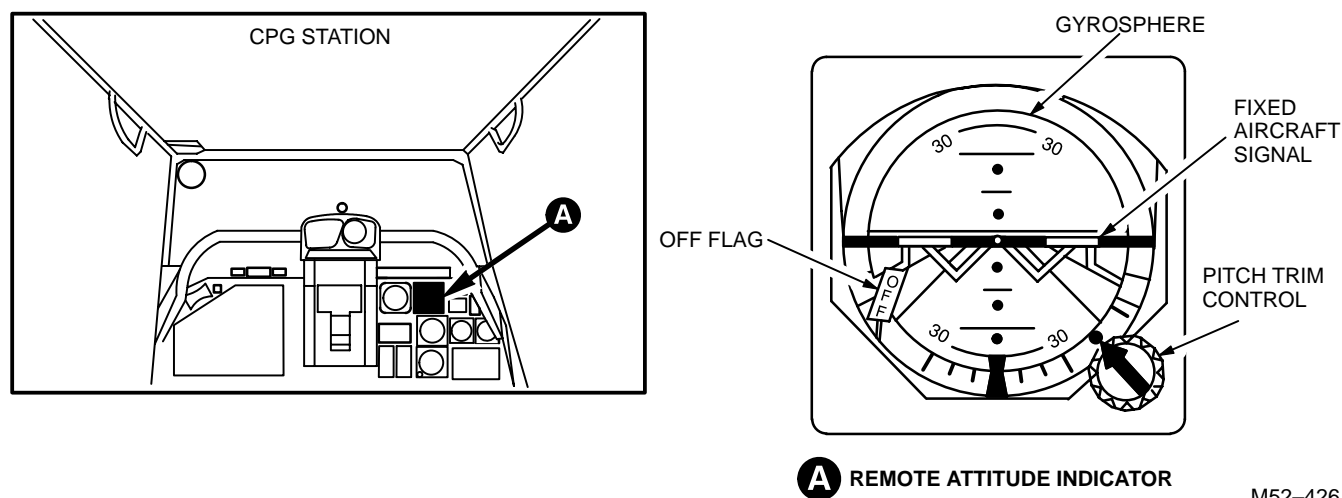
M52-425

Figure 15-3. Standby Attitude Indicator

(2) Remote Attitude Indicator (RAI). The RAI gyrosphere (fig. 15-4), located on the CPG instrument panel, can display 360° horizontal roll, 90° climb pitch, or 75° dive pitch. The RAI is hermetically sealed. When the pitch trim and cage knob is pulled, the background horizon line is 0° in pitch and roll.

(a) The two-color gyrosphere is divided in halves by a white horizon line. The upper (climb) half is grey; the lower (dive) half is black. Degree of pitch is scaled and numbered on both halves. Degree of roll is marked by white lines on the bottom half of the casing. The white markers are at the zero-, 10, 20, 30, 60, and 90° positions.

(b) Helicopter attitude is read by comparing the fixed helicopter symbol on the cover glass with the gyrosphere degree markings.



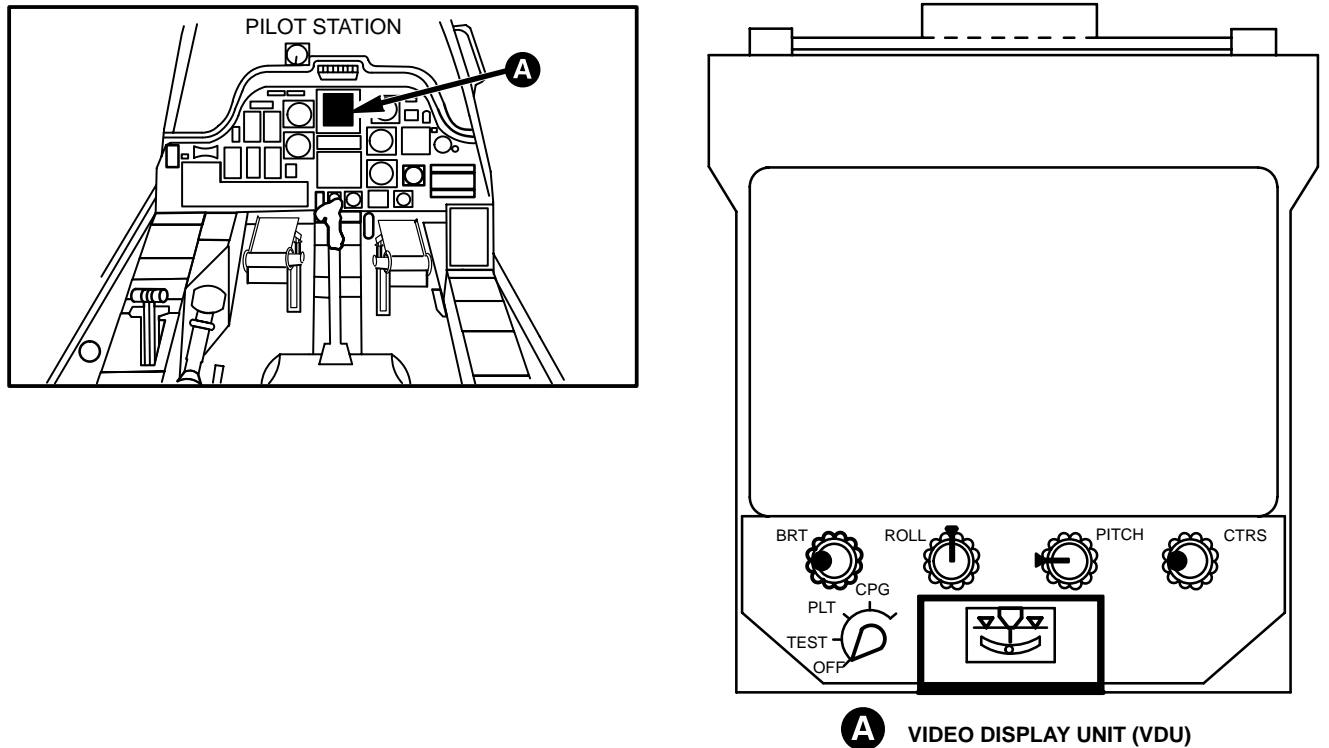
M52-426

Figure 15-4. Remote Attitude Indicator

15-2. DESCRIPTION (cont)

15-2

(3) Turn and Slip Indicator. The turn and slip indicator (fig. 15-5) is a combination of two instruments; a turn needle and a ball. The turn needle depends on gyroscopic precession for indications and the ball is actuated by gravity and centrifugal forces. The gyro has a horizontal spin axis with a restricted mounting and is only free to tilt. The tilting of the gyro is displayed to the pilot as a deflection of the turn needle. The deflection of the turn needle away from vertical or centered position indicates that the aircraft is turning in the direction of the deflection. The ball part of the turn and slip indicator consists of a sealed, curved glass tube containing kerosene and a black agate or steel ball bearing. The tube is curved so the ball seeks the lowest point at the tubes center.



M52-443

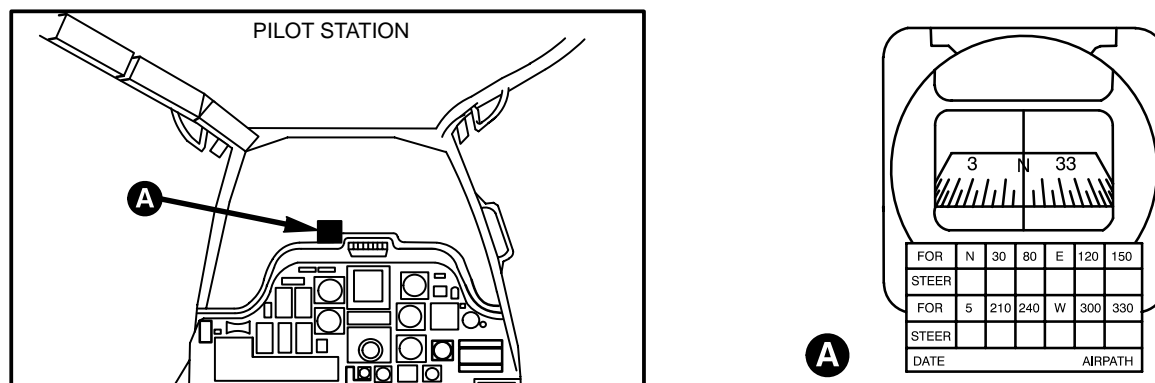
Figure 15-5. Turn and Slip Indicator

d. **Navigation Instruments.** Navigation Instruments provide a visual display of helicopter heading and course. The following instruments are considered navigation instruments.

(1) Magnetic Compass. The magnetic compass (fig. 15-6) is located on a panel in the pilot station. The magnetic compass displays the aircraft magnetic heading in relation to the North Pole. The magnetic compass displays headings from 0° thru 360°. The magnetic compass is liquid-filled to keep vibration from affecting operation.

15-2. DESCRIPTION (cont)

15-2



M52-429

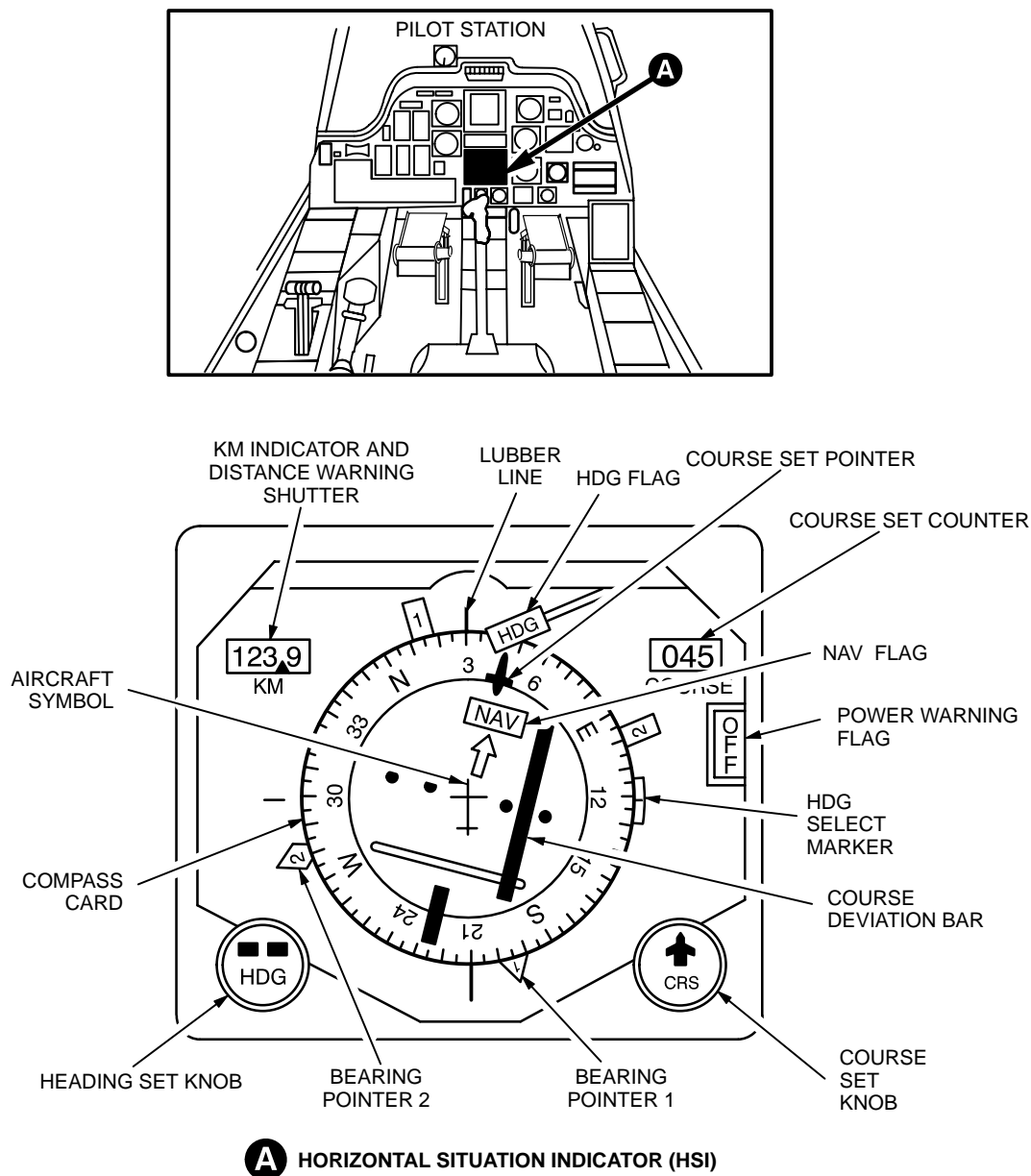
Figure 15-6. Magnetic Compass

(2) Horizontal Situation Indicator (HSI). The HSI (fig. 15-7) is located on the pilot instrument panel. The HSI is an electromechanical indicator that presents position information in relation to various navigation inputs. The HSI is hermetically sealed. The instrument face contains the following indicators and controls.

- (a) Compass card that can rotate 360°. The compass card displays heading obtained from HARS.
- (b) Lubber line at the top of the dial for compass heading reference.
- (c) Fixed aircraft symbol in center of the compass card and aligned with the lubber line.
- (d) Two bearing pointers that can rotate around the compass card. Pointer 1 operates in conjunction with the Doppler. Pointer 2 operates in conjunction with the ADF.
- (e) Course deviation bar that moves from side to side indicating deviation from selected Doppler course.
- (f) Kilometer (**KM**) indicator provides distance to destination set on Doppler **FLY-TO-DEST**.
- (g) Distance warning shutter that can move down to partially cover the **KM** indicator when the Doppler is unreliable.
- (h) Heading (**HDG**) select marker that is positioned around the compass card by the heading set knob.
- (i) Course set pointer that is positioned around the compass card by the course set knob.
- (j) Power warning flag to indicate failure of input power or internal power supply.
- (k) **NAV** flag is a retractable navigation warning indicator.
- (l) **HDG** flag is a retractable heading warning indicator.

15-2. DESCRIPTION (cont)

15-2



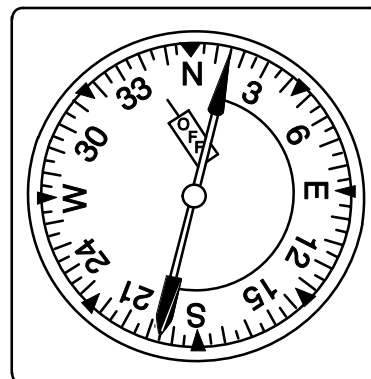
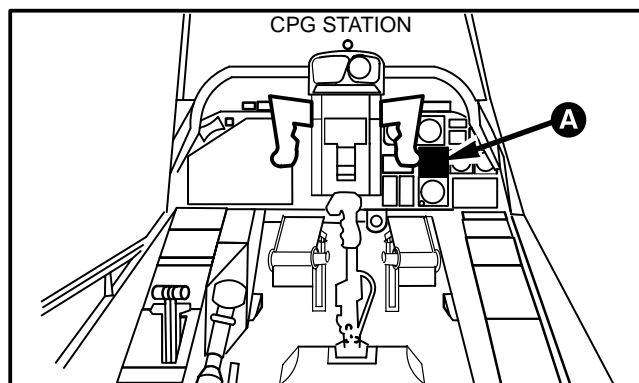
M52-427

Figure 15-7. Horizontal Situation Indicator

(3) Radio Magnetic Indicator (RMI). The RMI (fig 15-8) is on the CPG right instrument panel. The RMI has an electronic box mounted behind the front display panel. The electronic box contains a heading servo, warning relay, and bearing servo. The front display panel has a compass card, pointer, and a heading **OFF** warning flag.

15-2. DESCRIPTION (cont)

15-2



A CPG RADIO MAGNETIC INDICATOR (RMI)

M52-428

Figure 15-8. Radio Magnetic Indicator

e. **Miscellaneous instruments.** Miscellaneous instruments (fig. 15-9) are.

(1) Dual Hydraulic Pressure Indicator.

(a) Dual hydraulic pressure indicator is on the pilot instrument panel.

(b) The indicator displays primary and utility hydraulic pressure from 0 – 6000 psi.

(2) Emergency Hydraulic Pressure Indicator.

(a) The hydraulic pressure indicator is on the pilot instrument panel.

(b) The indicator displays hydraulic pressure from 0 – 5000 psi.

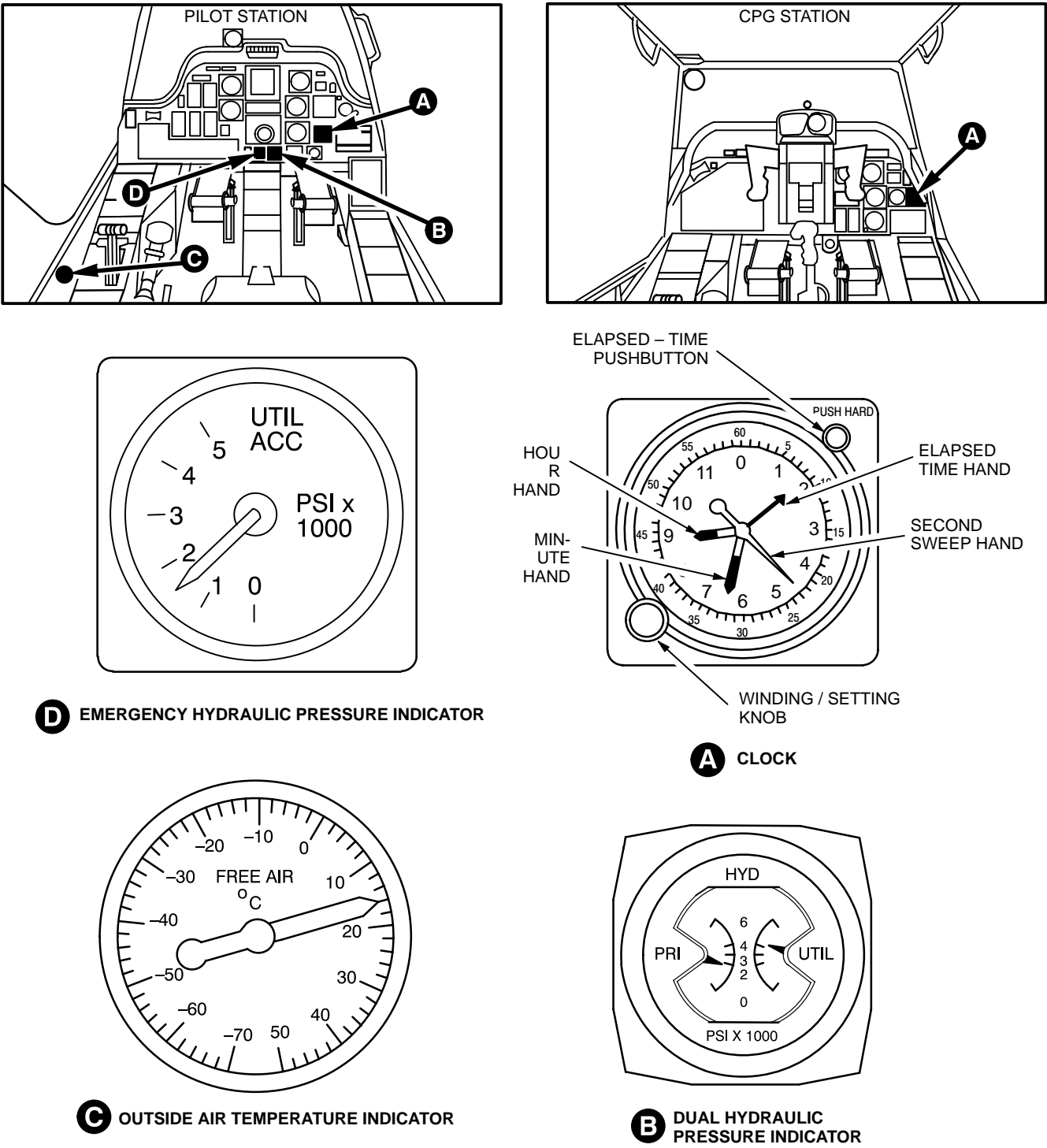
(3) Outside Air Temperature Indicator.

(a) The outside air temperature indicator is in the left side of the pilot station fuselage. The shielded sensing element extends through the fuselage to the outside air.

(b) A luminous dial shows temperature in degrees C above and below zero.

(4) Clock.

(a) The clocks, mounted on the pilot and CPG instrument panels, show time of day in hours, minutes, and seconds. The clock also shows elapsed time in minutes.



M52-430

Figure 15-9. Miscellaneous Instruments

15-3. THEORY OF OPERATION (cont)

15-3**15-3. THEORY OF OPERATION****a. Pilot ENG/ROTOR/RPM Indicator.**

- (1) The **ENG/ROTOR/RPM** indicator (fig. 15-10) receives inputs from:
 - (a) Signal data converter supplies operating and lamp supply voltages.
 - (b) Engine 1 rpm sensor.
 - (c) Engine 2 rpm sensor.
 - (d) Rotor rpm sensor.
 - (e) Pilot dim/test panel provides dim/bright control and testing for vertical scale lamp segments.
 - (f) Pilot instrument lights panel provides edge lighting.
 - (g) Signal data converter (SDC) provides operating voltages.
- (2) The **ENG/ROTOR/RPM** indicator operates as follows.
 - (a) The bottom segment of each vertical scale is a blue light that, when illuminated, indicates electrical power is applied to the indicator.
 - (b) As the Np or Nr increases, the lights illuminate progressively in sequence.
 - (c) As the rpm increases above one color range into the next, the lower color range segments extinguish and the higher color range starts to illuminate.
 - (d) As the rpm decreases from a higher color range to a lower color range, the higher color range extinguishes and the entire lower color range initially illuminates as the rpm drops into the lower range.

b. PILOT ENGINE TORQUE Indicator.

- (1) The engine **TORQUE** indicator receives inputs from:
 - (a) SDC supplies operating/lamp voltages.
 - (b) Torque 1 and 2 sensors.
 - (c) Pilot **DIM/TEST** panel provides automatic and manual dim/bright control.
 - (d) Instrument lights panel for edge lighting dim/bright.
- (2) Each vertical scale is color coded as follows.
 - (a) Red zone indicates 100 to 130%.
 - (b) Green zone indicates 0 to 100%.
- (3) Each vertical scale has a digital display. The digital displays indicate the torque developed by the engines in whole numbers.
- (4) Operation of the vertical scale lamp segments is the same as the **ENG/ROTOR/RPM** indicator.
- (5) Markings on the indicator are as follows.

15-3. THEORY OF OPERATION (cont)

15-3

- (a) **C** indicates single engine contingency power (2.5 minute limit).
- (b) **S** indicates single engine maximum continuous power.

c. **PILOT Ng RPM Indicator.**(1) The **Ng** indicator receives inputs from:

- SDC.
- Engine 1 and 2 Ng RPM sensors.
- Pilot's dim/test panel.
- Pilot's instrument lights panel.

(2) Each vertical scale display is color coded as follows.

- Red zone indicates 105 to 120%.
- Amber zone indicates 102 to 105%.
- Green zone indicates 62 to 102%.
- Red zone indicates 0 to 62%.

(3) The vertical scale light segment operation is the same as the **ENG/ROTOR/RPM** indicator.

(4) The digital displays are located under each vertical scale and each is a three-digit display with the last digit always indicating a tenth of a number. 83.6% Ng would appear as 83.6 and 100% Ng would appear as 00.0.

d. **TGT Indicator.**(1) The **TGT** indicator receives inputs from:

- Engine 1 and 2 temperature sensors via the SDC.
- Pilot dim/test panel.
- Pilot instrument panel.

(2) Each vertical scale display is color coded as follows.

- Red zone indicates 860 to 1000°C.
- Amber zone indicates 800 to 860°C.
- Green zone indicates 0 to 800°C.

(3) Vertical scale light segment operation is the same as the **ENG/ROTOR/RPM** indicator.

(4) The digital displays are located under each vertical scale. The digital displays show TGT in whole numbers only.

e. **ENGINE OIL PRESSURE Indicator.**(1) The engine oil pressure (**ENG OIL PSI**) indicator receives inputs from the following components.

- (a) SDC.
- (b) Engine 1 and 2 oil pressure sensor.

15-3. THEORY OF OPERATION (cont)

15-3

- (c) Pilot's dim/test panel.
- (d) Pilot's instrument lights panel.
- (2) Each vertical scale is color coded as follows.
 - (a) Red zone indicates 120 to 180 psi.
 - (b) Amber zone indicates 100 to 120 psi.
 - (c) Green zone indicates 27.5 to 100 psi.
 - (d) Amber zone indicates 22.5 to 27.5 psi.
 - (e) Red zone indicates 0 to 22.5 psi.
- (3) The vertical scale light segment operation is the same as the ENG/ROTOR/RPM indicator. There is no digital displays on the engine oil pressure indicator.

f. CPG ENG/ROTOR/RPM Indicator.

- (1) Operation of the CPG's **ENG/ROTOR/RPM** indicator is identical to the pilot's. The instruments are identical and interchangeable.
- (2) The CPG's **ENG/ROTOR/RPM** indicator receives inputs from the following components.
 - (a) Lamp power supply provides 0 to 5 VDC for manual dim/bright control of the lamp segments.
 - (b) Engine 1 rpm sensor.
 - (c) Engine 2 rpm sensor.
 - (d) Rotor rpm sensor.
 - (e) Pilot dim/test panel provides dim/bright control of vertical scale lamp segments.
 - (f) CPG SDD test switch provides vertical scale lamp segment test.
 - (g) CPG instruments lights panel provides edge lighting dim/bright.
 - (h) Signal data converter (SDC) provides operating voltages.

g. CPG ENGINE TORQUE Indicator Operation.

- (1) Operation and color coding of the lamp segments is identical to the pilot's engine torque indicator.
- (2) The CPG's engine torque indicator receives inputs from the following components.
 - (a) Lamp power supply provides 0 to 5 VDC for manual dim/bright control of the lamp segments.
 - (b) Engine 1 and 2 torque sensors.
 - (c) CPG dim/test panel provides manual dim/bright control and test of lamp segments and digital readouts.
 - (d) SDD test switch provides testing of lamp segments and digital readouts.
 - (e) CPG instrument lights panel provides dim/bright control of edge lighting.

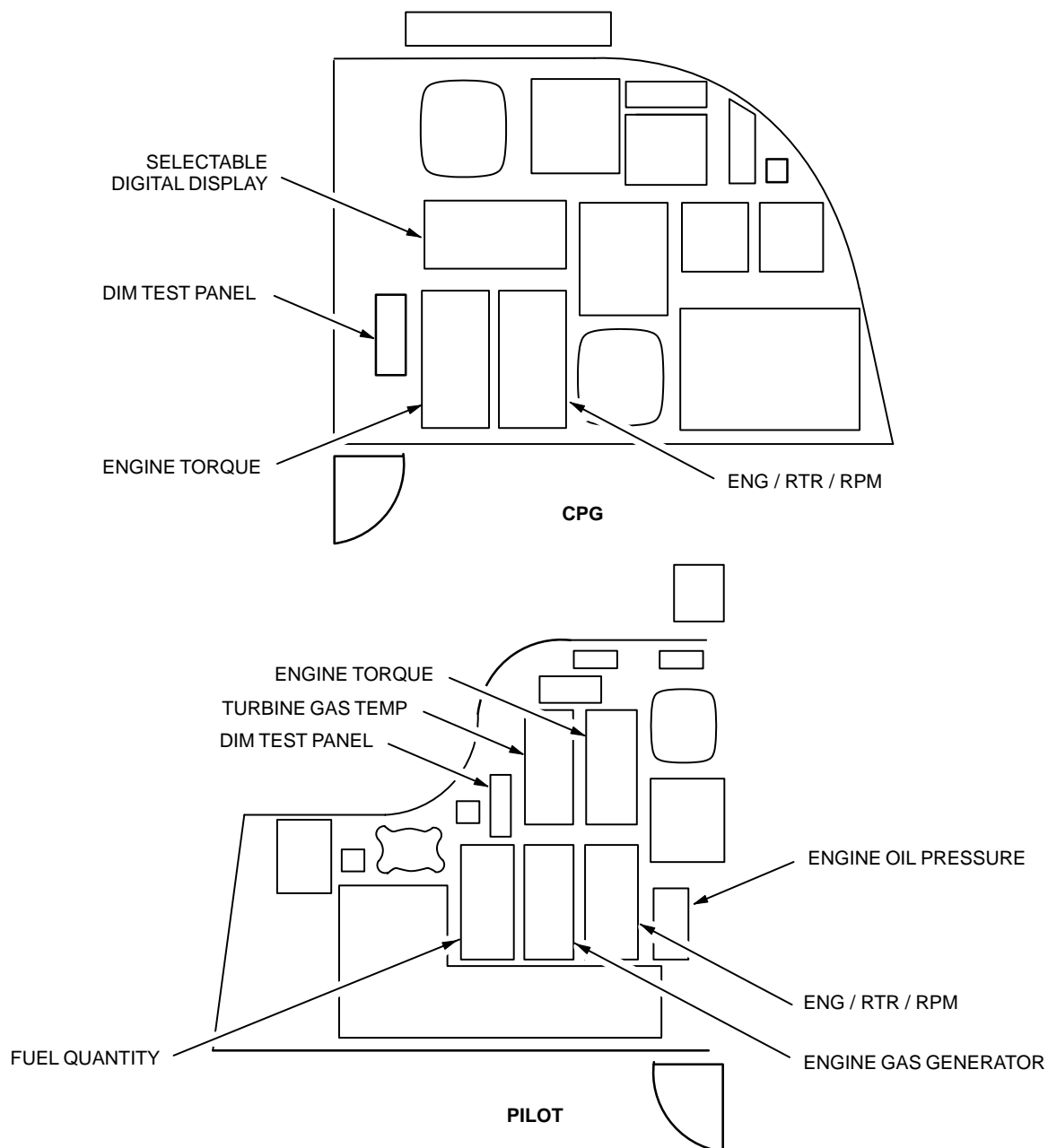
15-3. THEORY OF OPERATION (cont)

15-3

(f) SDC provides operating voltages.

h. **Selectable Digital Display (SDD).** The SDD receives inputs from:

- (1) Lamp power supply.
- (2) SDC.
- (3) Pilot's engine 1 and 2 oil pressure indicator.
- (4) Pilot's engine 1 and 2 **TGT** indicators.
- (5) Pilot's engine 1 and 2 **Ng RPM** indicators.
- (6) Pilot's fuel quantity indicator.
- (7) CPG's dim/test panel.
- (8) CPG's instrument lights panel.



M52-181

Figure 15-10. Engine Instruments Locations

15-3. THEORY OF OPERATION (cont)

15-3

i. Air Speed Indicators.

- (1) The airspeed indicators (fig. 15-11) are edge-lighted.
- (2) A diaphragm is inside the case. The case is connected to the static port which supplies the outside air pressure. The diaphragm connects to the pitot tube which receives ram air.
- (3) Air pressure through the pitot tube builds up inside the indicator as the helicopter moves forward.
- (4) The expanding diaphragm triggers the mechanical multiplier. The multiplier drives the instrument pointer to display airspeed on the calibrated indicator dial.

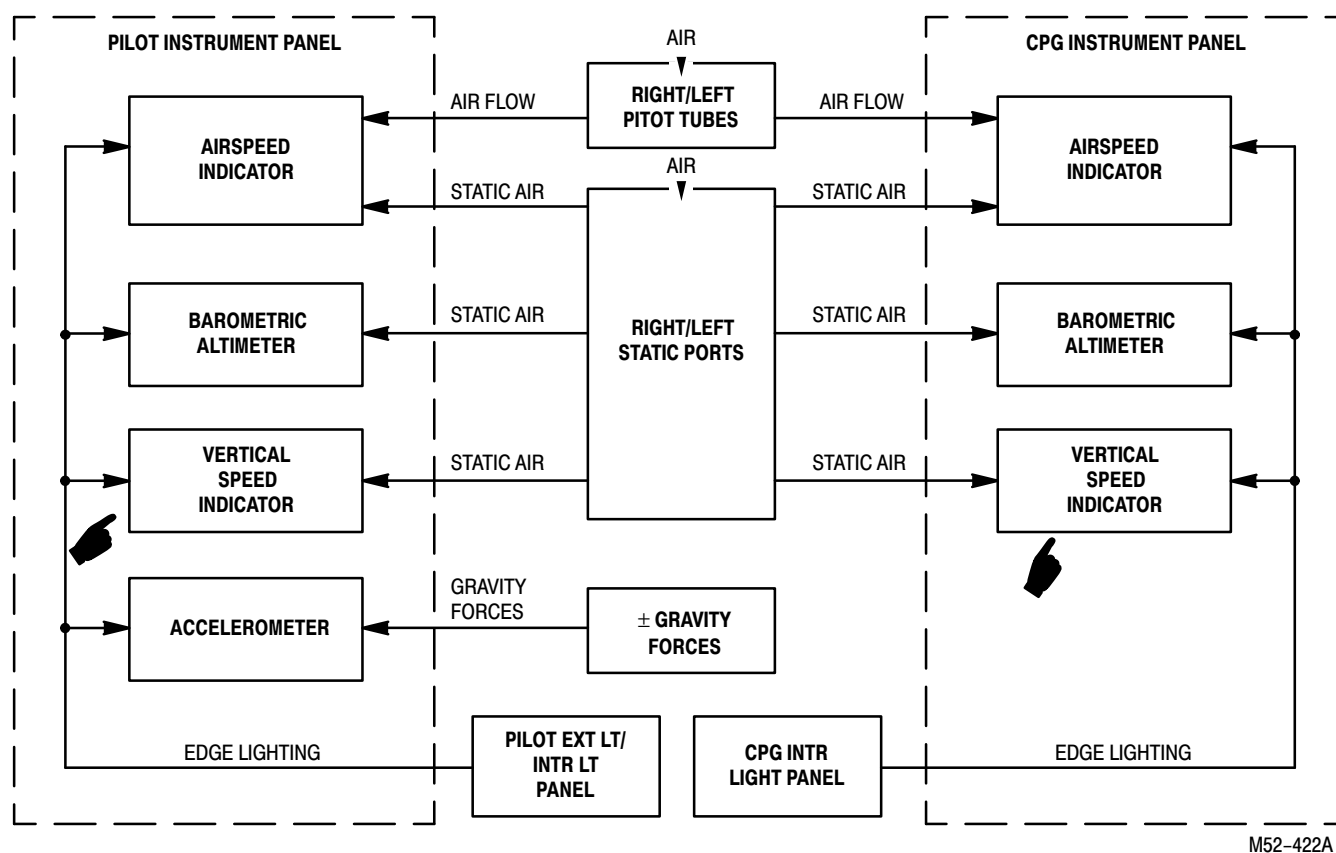


Figure 15-11. Flight Instruments Functional Operation

j. Vertical Speed Indicators.

- (1) The vertical speed indicators are edge-lighted.
- (2) The diaphragm is connected to the static port which provides static (outside) air pressure.
- (3) Air pressure inside and outside the helicopter are equal when the helicopter stays at the same altitude. The indicator pointer reads zero.

15-3. THEORY OF OPERATION (cont)
15-3

(4) Pressure outside the helicopter changes when the helicopter moves up or down. Changes are sensed by the indicator to move the pointer clockwise to indicate upward movement, and counterclockwise to indicate downward movement.

k. Barometric Altimeter.

- (1) The barometric altimeters are edge-lighted.
- (2) The **IN. HG** counter displays barometric pressure in inches of mercury. The pilot or CPG sets in sea level barometric pressure, using the zero-set locking screws.
- (3) The barometric zero-setting knob is used to set the altitude pointer to zero.
- (4) The altitude pointer indicates hundreds of feet and goes completely around every 1000 feet.
- (5) The 100 FT readout tracks the altitude pointer. The readout displays altitude from 0 to 999 feet and restarts at zero every 1000 feet.
- (6) The 1000 FT readout records the number of times the pointer goes around.
- (7) The altimeters operate from the action of outside air pressure.
- (8) Outside air pressure passes through the air pressure fitting into the sealed case. The air acts instantly on the two opposed aneroids inside the sealed case.
- (9) The aneroids expand or contract as air pressure changes, which causes the rocking shaft to rotate. The rotation is multiplied by the gear train, which moves the altitude pointer and counters.

l. Control. The airspeed, vertical velocity and barometric altimeters are controlled by input from the pitot static system.

(1) Pitot tubes. A pitot tube is on the leading edge of both wings of the helicopter. The pitot tube extends into the air stream in the direction of helicopter forward motion. The opposite end is connected to airtight tubing that connects to both airspeed instruments. The pitot tube has a heating element that keeps the pitot tube clear of moisture and ice. The heating element can operate from normal helicopter power or emergency battery power. The heating element is controlled by the pilot **ANTI ICE** panel **PITOT AD SNSR** switch.

(2) Static Ports. Static ports are at various points on the helicopter. The static ports provide for selection of suitable sources of static air.

- (a) The static ports are round plates with drilled holes.
- (b) Airtight tubing connects the static ports to the flight instruments in both crew stations. The holes allow outside air to pass through the airtight tubing to the flight instruments.

m. Accelerometer.

- (1) The accelerometer is edge-lighted from the pilot **EXT LT/INTR LT** panel.
- (2) The accelerometer has the following indications.
 - (a) Continuous-g pointer.
 - (b) Maximum-g pointer.
 - (c) Minimum-g pointer.

15-3. THEORY OF OPERATION (cont)

15-3

(3) Helicopter flight movements move the three pointers. The maximum-g pointer is moved if the aircraft is going up. The minimum-g pointer is moved if the aircraft is going down.

(4) The continuous g pointer shows actual g forces on the aircraft at all times.

(5) The maximum and minimum g pointers are connected to ratchets. These pointers follow the continuous pointer, but stop and stay at the largest reading reached. Pressing the **PUSH TO SET** control returns these pointers to +1 g.

n. **Standby Attitude Indicator (SAI).**

(1) The SAI has the following inputs:

- (a) 28 VDC or 24 VDC emergency battery power.
- (b) 0-5 VDC edge lighting from the pilot **EXT LT/INTR LT** panel.

(2) The SAI operates from 28 VDC from the helicopter emergency dc bus. If primary power is lost, the battery supplies 24 VDC to the SAI. An internal static converter changes incoming dc power to 26 VAC, 400 Hz

(3) The 26 VAC power runs the motor which spins the gyroscope. The spinning gyroscope produces visual indication of helicopter roll and pitch.

(4) The word **CLIMB** appears on the gyrosphere when helicopter upward pitch reaches +35°. The word **DIVE** appears on the gyrosphere when downward pitch reaches +35°.

(5) The elapsed-time meter keeps track of the total time the SAI operates.

(6) The pitch trim control adjusts the pitch of the gyrosphere horizon. The pitch trim control is also used to cage (stop) the gyroscope when not in use.

(7) The **OFF** warning flag is displayed if the gyroscope is caged or power is lost.

o. **Remote Attitude Indicator (RAI).**

(1) The RAI has the following inputs.

- (a) 115 VAC, 400 Hz power bus.
- (b) 0-5 VDC edge lighting from the copilot/gunner (CPG) **INTR LT** panel.
- (c) Roll and pitch synchro signals from the heading and attitude reference system (HARS).
- (d) A 28 VDC warning signal from the HARS if HARS failure occurs.

(2) The RAI operates from 115 VAC, single-phase, 400 Hz applied to the RAI pitch trim control and stepdown transformer T1. The pitch trim control changes the 115 VAC when the control knob is turned. The changing voltages cause the gyrosphere to adjust the horizon line up or down.

(3) The word **CLIMB** is visible on the gyrosphere when helicopter climb pitch reaches 35°. The word **DIVE** is visible on the gyrosphere when dive pitch reaches 35°.

(4) The transformer converts the 115 VAC to excitation voltages for the roll and pitch servo rotors.

(5) HARS roll data is applied as roll synchro signals to the RAI roll servo stator. The signals rotate the gyrosphere to a new degree-of-roll position.

15-3. THEORY OF OPERATION (cont)**15-3**

(6) HARS pitch data is applied as pitch synchro signals to the RAI pitch servo stator. The signals move the gyrosphere up or down to a new pitch position.

(7) A 28 VDC signal is sent to the RAI flag relay if the HARS fails. The signal displays the **OFF** flag.

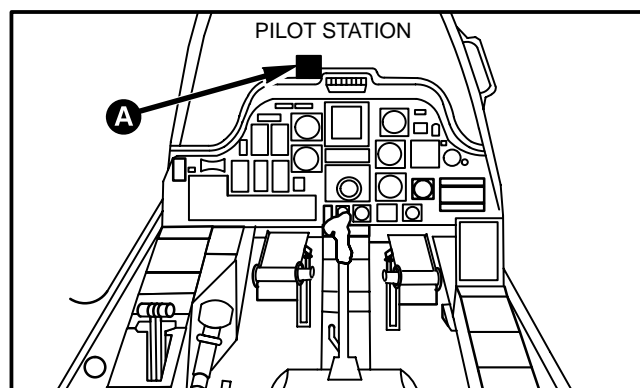
p. **Turn and Slip Indicator.** In straight flight, the force of gravity causes the ball to rest in the lowest part of the tube between the reference markers. In a balanced (or coordinated) turn, gravity and centrifugal forces are in balance and the ball remains between the reference markers.

q. **Magnetic Compass.**

(1) The offsetting magnets adjust the compass pointer to true magnetic north. The magnets correct the compass error caused by magnetic forces of the helicopter structure.

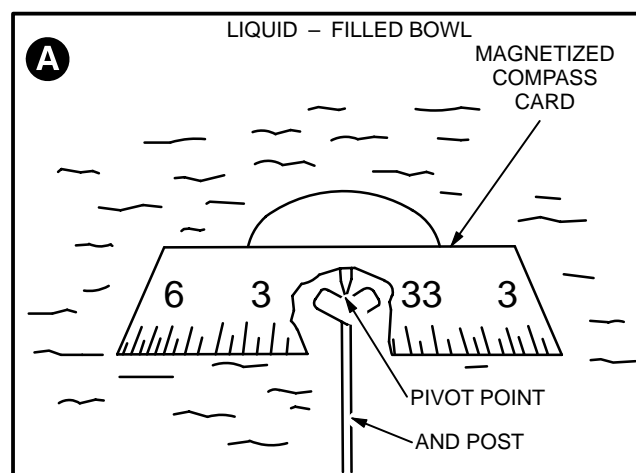
(2) A compass correction card (fig. 15-12) is provided to note compass errors that remain after magnet correction. The compass card rotates on the pivot point inside the liquid-filled and sealed compass bowl. The compass card lines up with earth's magnetic field.

(3) The instrument is edge-lighted.



FOR	STEER	FOR	STEER
N		S	
30		210	
60		240	
E		W	
120		300	
150		330	

COMPASS CORRECTION CARD



M52-432

Figure 15-12. Magnetic Compass Operation

r. **Horizontal Situation Indicator.**

(1) The hermetically sealed case contains electronic and electro-mechanical devices. The electronic and electro-mechanical devices change input signals and voltage into usable signals to drive the indicators.

(2) The HSI receives the following inputs (fig. 15-13).

15-3. THEORY OF OPERATION (cont)

15-3

- (a) 115 VAC from the essential AC bus.
- (b) 0-5 VDC edge-lighting from the pilot **EXT LT/INTR LT** panel.
- (c) Magnetic heading and 28 VDC heading warning from the heading and attitude reference system (HARS).
- (d) Bearing to an automatic direction finder (ADF) station from the ADF system.
- (e) Digital data from the lightweight Doppler navigation system (LDNS).

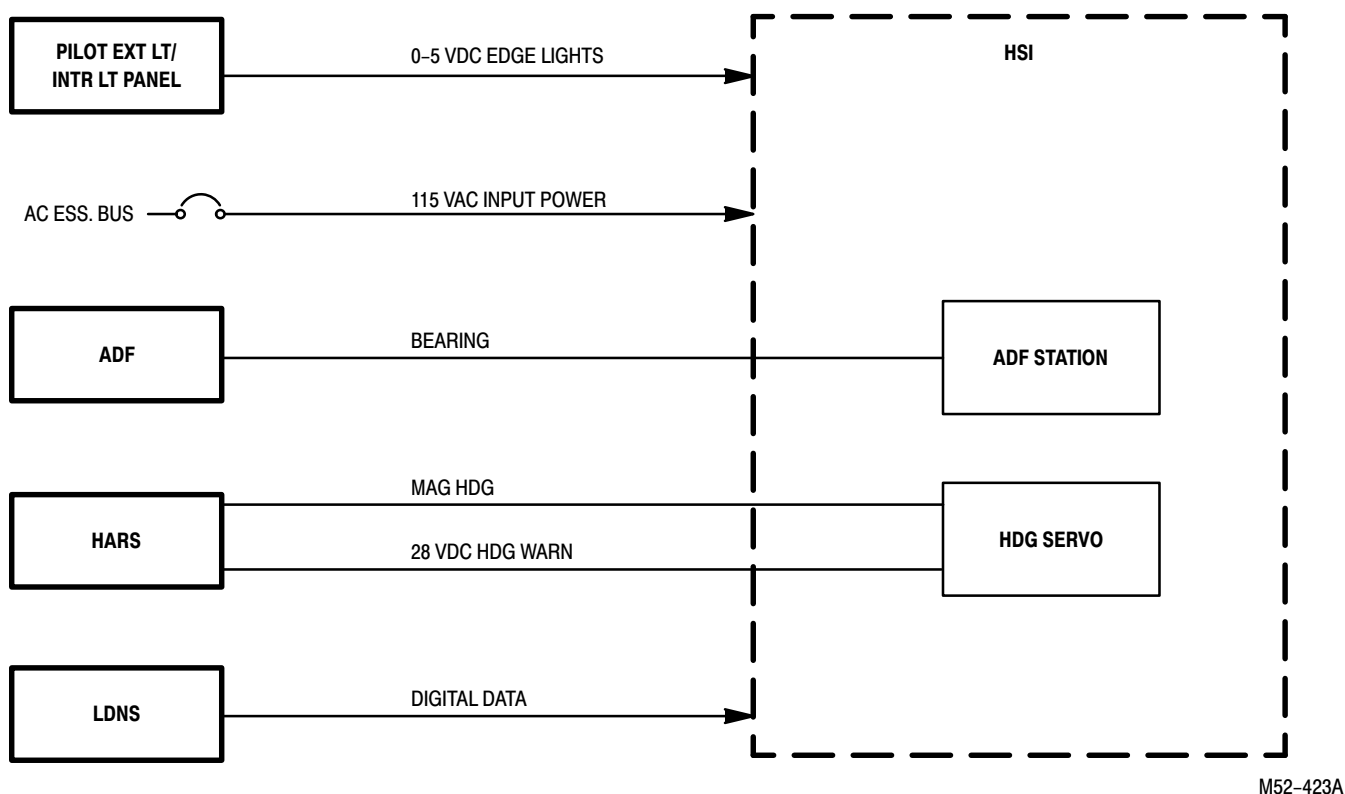


Figure 15-13. Horizontal Situation Indicator Operation

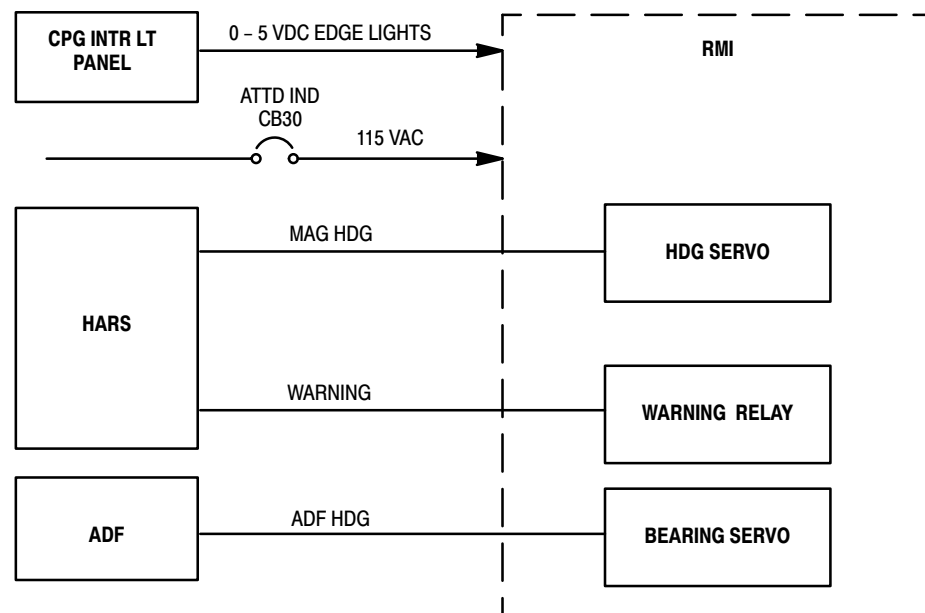
s. Radio Magnetic Indicator.

- (1) The radio magnetic indicator (fig. 15-14) receives the following inputs:
 - (a) Magnetic heading information from the heading and attitude reference system (HARS) on the rotating compass card.
 - (b) Direction to the station selected by the pilot on the automatic direction finder (ADF) pointer.
 - (c) Power to the servos from circuit breaker **ATTD IND** (CB 30).
 - (d) Edge lighting from the **CPG INTR LT** panel.
- (2) The **OFF** flag will be displayed when HARS heading information is unreliable.

15-3. THEORY OF OPERATION (cont)

15-3

(3) Operation is automatic when the **ATTD IND** circuit breaker on the CPG circuit breaker panel is closed and the helicopter has ac power.



M52-420

Figure 15-14. Radio Magnetic Indicator Operation

t. Dual Hydraulic Pressure Indicator.

- (1) The indicator is edge-lighted.
- (2) The indicator has a dual numbered, scaled dial with a pointer for each scale. Each pointer is connected to a meter movement.
- (3) The dial scales are numbered 0, 2, 3, 4, and 6. Each number equals hydraulic pressure in thousands of pounds per square inch.
- (4) Two transducers measure hydraulic pressure in the primary and utility hydraulic pressure systems. The transducers convert hydraulic pressure into 0 to 5 VDC signals.
- (5) The dc signals move the pointers across the dial. Pointer movement changes with changes in hydraulic pressure.

u. Emergency Hydraulic Pressure Indicator.

- (1) The indicator is edge-lighted.
- (2) The dial shows hydraulic pressure in thousands of pounds per square inch.
- (3) An emergency pressure transducer in the utility hydraulic system measures hydraulic pressure. The transducer converts the hydraulic pressure into a 0 to 5 VDC signal. Pointer movement changes with changes in hydraulic pressure.

15-3. THEORY OF OPERATION (cont)

15-3

v. **Fuel Quantity Indicator.**

- (1) The indicator is controlled at the pilot **DIM/TEST** panel **DGT OFF/NORM/TST** switch.
- (2) The indicator receives the following inputs.
 - (a) Operating and display lamp power from the signal data converter (SDC).
 - (b) Linear 0-5 VDC (converted from forward/aft fuel cell sensor data by the fuel signal conditioner).
 - (c) Lamp test, lamp dimming, and digital blanking signals from the pilot **DIM/TEST** panel.
 - (d) Edge-lighting power from the pilot **EXT LT/INTR LT** panel.

w. **Outside Air Temperature Indicator.**

The sensing element winds or unwinds as outside air temperature changes. This motion is multiplied and applied to the pointer. The amount of pointer movement changes as outside air temperature changes.

x. **Clock.**

- (1) The clocks are edge-lighted.
- (2) The mainspring drives the clock mechanism which drives the clock hands and the elapsed time hand.
- (3) To wind the mainspring, the winding/setting knob is pushed in and turned. Pulled out, the knob is used to set the hour and minute hands.
- (4) The elapsed-time pushbutton control has a three-stage action.
 - (a) First push. The elapsed-time hand and second sweep hand go to zero.
 - (b) Second push. The sweep-second hand and elapsed-time hand start keeping time.
 - (c) Third push. The sweep-second hand and elapsed-time hand stop.

CHAPTER 16 AVIONICS SYSTEMS

16-1. PURPOSE

a. **Intercommunication System.** The intercommunication system (ICS) selects, routes, and amplifies all audio signals throughout the helicopter. The ICS controls individual receivers, microphone inputs, and headset audios; provides alert and warning signals; and permits the pilot to change transmitter selection by use of a remote switch on the cyclic grip.

b. **VHF Radio.** The VHF AM-FM AN/ARC-186 (ADH) radio provides air-to-air and air-to-ground AM and FM communication. The VHF/FM AN/ARC-201A (ADI) SINCGARS (Single Channel Ground to Air Radio Subsystem) radio provides air-to-air and air-to-ground FM communication. The VHF AM-FM AN/ARC-186 (ADH), when used with the TSEC/KY-58 provides secure voice operation. The VHF/FM AN/ARC-201A (ADI), when used with the TSEC/KY-58 provides secure voice and frequency hopping operations.

c. **UHF Radio.** The AN/ARC-164 ultra high frequency (UHF) radio system provides air-to-air and air-to-ground line-of-sight military voice communications. **HAVE QUICK** capabilities are available with some models.

d. **ADF Navigation System.** The ADF navigation system provides bearing-to-station information to the pilot's horizontal situation indicator (HSI) and the CPG's radio magnetic indicator (RMI).

e. **Radar Altimeter.** The AN/APN-209A radar altimeter provides the pilot with visual indications of aircraft altitude above the ground (absolute altitude above ground level) (AGL).

f. **HARS System.** The heading attitude reference set (HARS) system provides pitch, roll, and magnetic heading for the helicopter.

g. **IFF Transponder.** The identification friend or foe (IFF) transponder system signal is issued by air traffic control (ATC) to distinguish between aircraft in the surrounding airspace. The system provides automatic identification when interrogated. The system also provides emergency identification when selected by the pilot. The IFF system has the ability to decode interrogations and to encode replies in the following modes.

- (1) Mode 1.
- (2) Mode 2.
- (3) Mode 3A.
- (4) Mode 4.
- (5) TEST.
- (6) MODE C.

h. **Doppler.** The Doppler navigation set AN/ASN-128 (AAK) or AN/ASN-137 (ABQ) is the helicopter's primary navigation system (ADC). The Doppler navigation set (DNS) AN/ASN-137 is the helicopter's secondary navigation system (ADD). The Doppler determines the three orthogonal components of aircraft velocity from measurements of the Doppler shift frequency, and computes present position and bearing, time, and distance to selected destinations. When provided with a synchro reference, pitch, roll, heading, and true airspeed information, the Doppler computes the following.

- (1) Helicopter present position or destination in **UTM** or **LAT/LONG** coordinates.
- (2) Ground speed in kilometers per hour.

16-1. PURPOSE (cont)

16-1

- (3) Track angle error in degrees.
- (4) Distance-to destination in kilometers and tenths of kilometers.
- (5) Bearing-to-destination in degrees.
- (6) Time-to-destination in minutes and tenths of minutes.
- (7) Track angle in degrees.
- (8) Cross track distance in kilometers.
- (9) Displays spheroid code of destination (entered manually).
- (10) Displays magnetic variation of destination (entered manually).

i. **Embedded GPS Inertial (EGI) (ADD).** The EGI is the primary navigation and present position sensor. The EGI contains a global positioning system (GPS) and inertial navigation unit (INU). The EGI determines position from up to five space vehicles simultaneously. The EGI has an external connector for the loading of KYK-13 crypto data. The EGI determines the three orthogonal components of aircraft velocity from INU measurements, and computes present position and bearing, time, and distance to selected destinations from GPS and manually entered FCC information. The EGI outputs the following to the FCC via the mux bus:

- (1) Helicopter present position or destination in **UTM** or **LAT/LONG** coordinates.
- (2) Linear acceleration.
- (3) Angular velocity.
- (4) Attitude (roll, pitch and platform azimuth).
- (5) Magnetic heading.
- (6) Altitude.
- (7) Body angular rates.
- (8) Time tags.
- (9) Universal Time Coordinated (UTC) synchronized time.

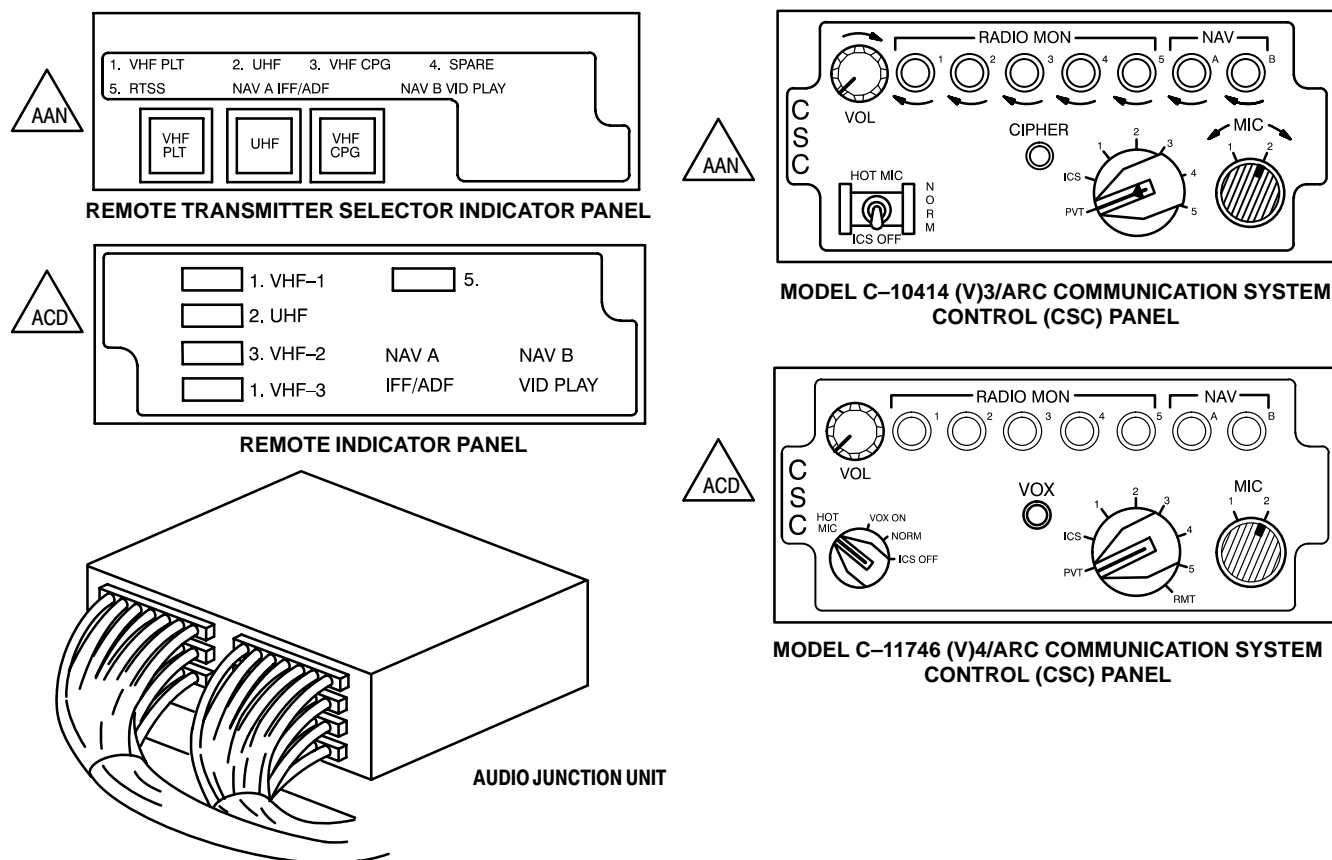
j. **Data Transfer Unit (DTU) (ADD).** The DTU provides a cartridge capability to load mission data and save FD/LS data to and from the FCC. The mission data includes:

- (1) Target coordinates.
- (2) Waypoint coordinates.
- (3) Present position coordinates.
- (4) Laser codes.

16-2. DESCRIPTION**16-2****16-2. DESCRIPTION**

a. **ICS.** Major components of the ICS are described below.

(1) CSC panel C-10414(V)3/ARC (fig. 16-1) or CSC panel C-11746(V)4/ARC panel are identical and interchangeable. The CSC panel switches are divided into two groups. The top half of the control panel switches are the controls for the radio receivers and the bottom half of the control panel houses the transmit switches.



M52-234A

Figure 16-1. ICS Major Components

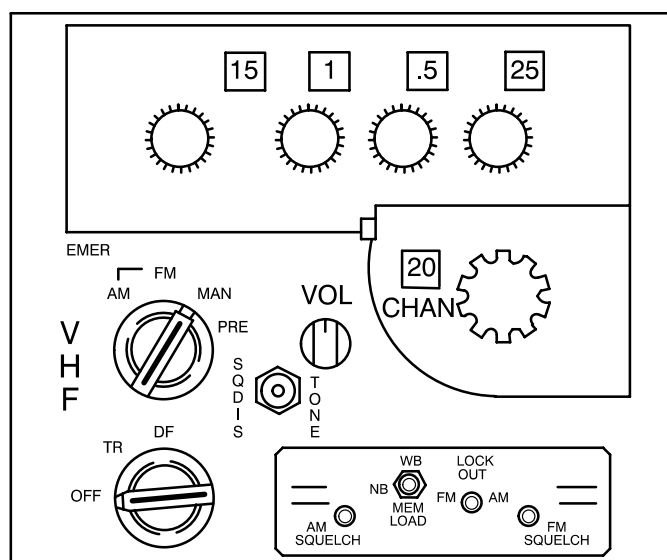
(2) Remote indicator panel or remote transmitter selector indicator panel provides the pilot with a visual indication of which radio has been selected for transmit.

(3) Audio junction unit is the central signal routing unit for the AH-64A communications systems.

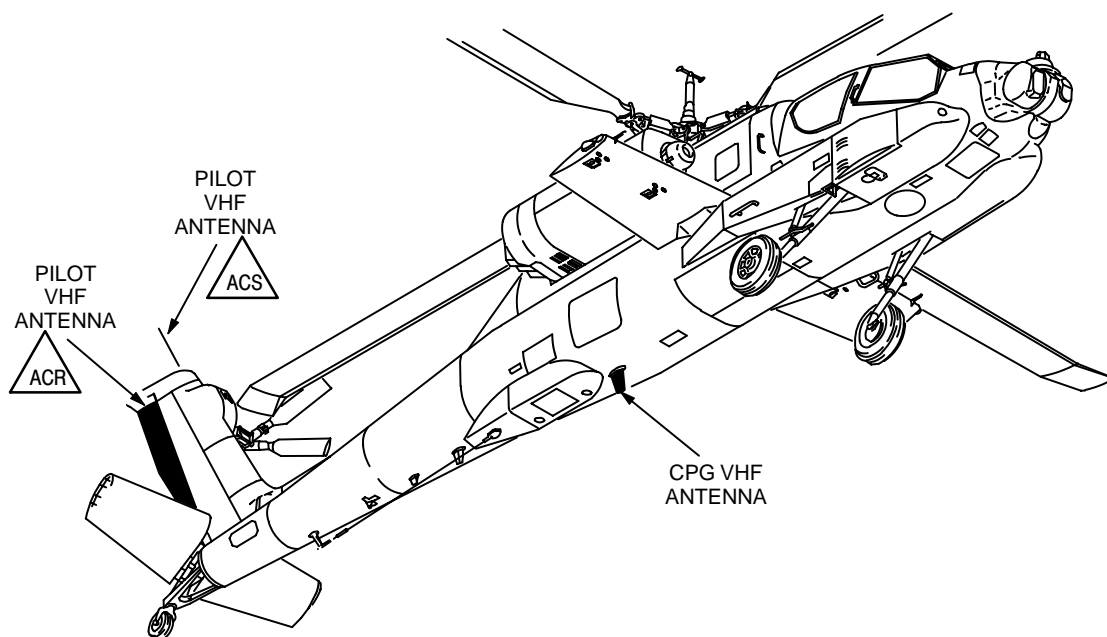
16-2. DESCRIPTION (cont)

16-2

b. **AN/ARC-186 VHF Radio System (ADH).** The VHF radio system major components (fig. 16-2) are listed below.



RT-1354/ARC-186



M52-240B

Figure 16-2. VHF AN/ARC-186 (ADH) Radio System Major Components

16-2. DESCRIPTION (cont)**16-2**

(1) RT-1354/ARC-186 1 and 2 provides VHF AM and FM clear voice communication. The front panel provides **ON/OFF** and tuning controls. The AN/ARC-186 provides two way AM, FM and X-mode (secure) voice communications. The transceiver contains two guard receivers with fixed frequencies of 40.500 Mhz (FM) and 121.500 Mhz (AM). The transceiver receives 108 to 115.975 Mhz in AM, transmits and receives on 116 to 151.975 Mhz in AM and transmits and receives on 30.000 to 87.975 Mhz in FM. The DF and retransmit functions are not used in this aircraft.

(2) The CPG VHF blade antenna is mounted on the bottom center fuselage, directly forward of the Doppler fairing.

(3) The pilot VHF antenna (ACR) is an integral part of the vertical stabilizer or a noise canceling antenna (ACS) mounted on the vertical stabilizer tip fairing.

b.1. **AN/ARC-186 VHF and AN/ARC-201A Radio System (ADI).** The VHF radio system major components (fig. 16-2A) are listed below.

(1) The CPG AN/ARC-186 provides two way AM, FM and X-mode (secure) voice communications. The transceiver contains two guard receivers with fixed frequencies of 40.500 Mhz (FM) and 121.500 Mhz (AM). The transceiver receives 108 to 115.975 Mhz in AM, transmits and receives on 116 to 151.975 Mhz in AM and transmits and receives on 30.000 to 87.975 Mhz in FM. The DF and retransmit functions are not used in this aircraft.

(2) The pilot AN/ARC-201A (SINCGARS) (Single Channel Ground to Air Radio Subsystem) provides two way FM, X-mode (secure) and FH (Frequency Hopping) voice communications. The transceiver transmits and receives on 30.000 to 87.975 Mhz in FM, in 25 kHz steps. The DF and retransmit functions are not used in this aircraft.

(3) The battery box CY-8515/ARC-201 provides memory voltage to the AN/ARC-201A.

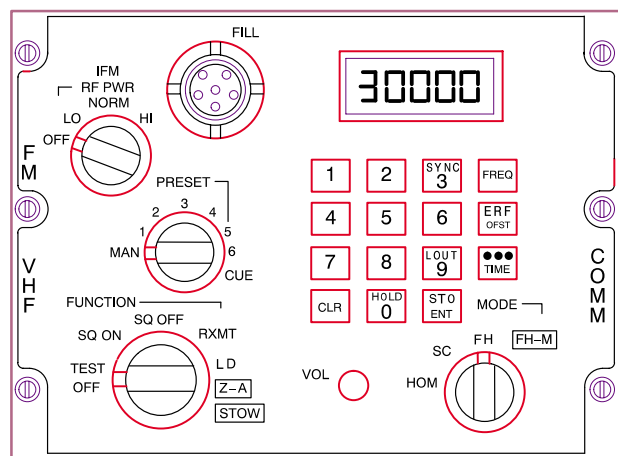
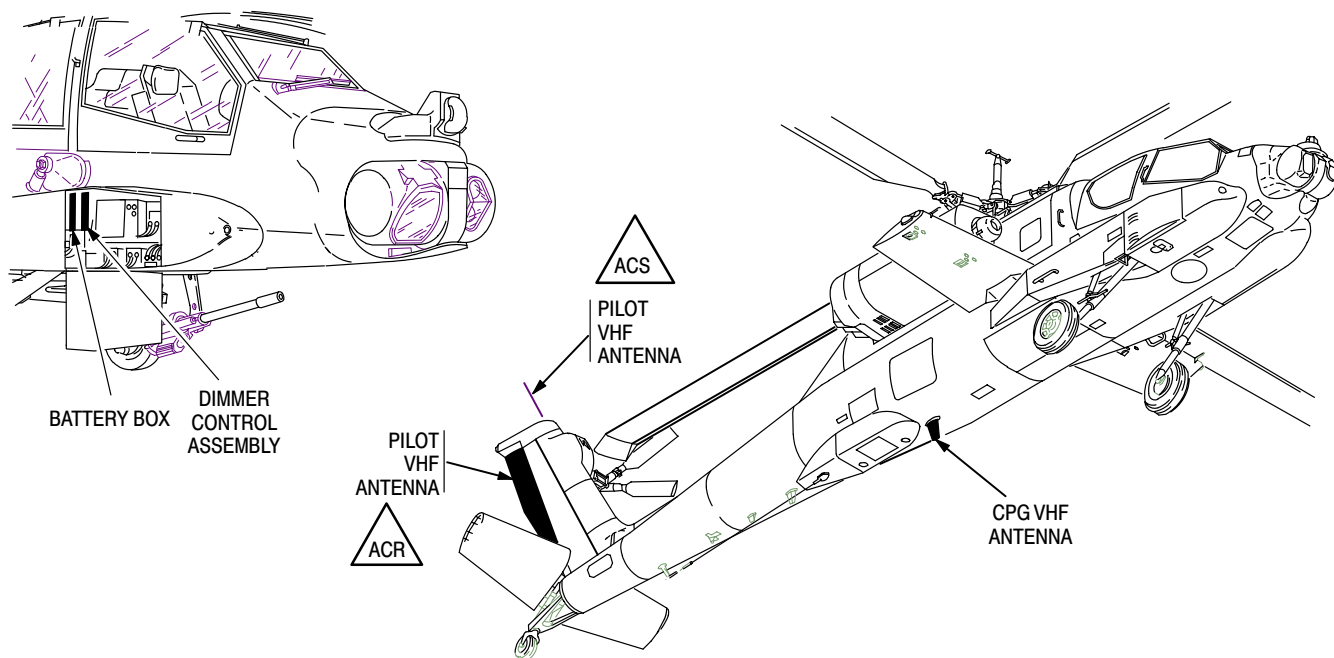
(4) The dimmer control assembly provides light panel voltage to the AN/ARC-201A.

(5) The CPG VHF blade antenna is mounted on the bottom center fuselage, directly forward of the Doppler fairing.

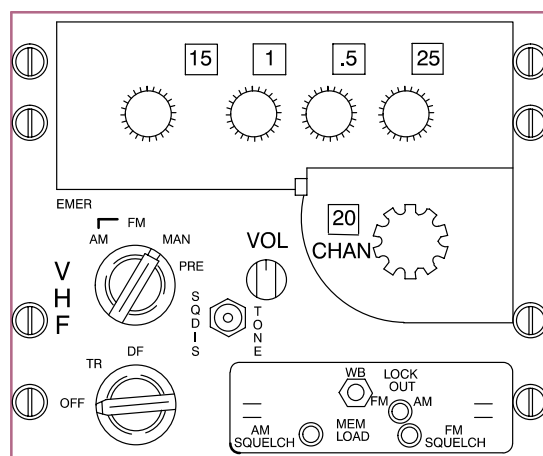
(6) The pilot VHF antenna (ACR) is an integral part of the vertical stabilizer or a noise canceling antenna (ACS) mounted on the vertical stablizer tip fairing.

16-2. DESCRIPTION (cont)

16-2



VHF / FM RECEIVER / TRANSMITTER AN/ARC-201A



VHF AM-FM RECEIVER / TRANSMITTER AN/ARC-186

M52-474

Figure 16-2A. VHF AN/ARC-186 and AN/ARC-201A (ADI) Radio System Major Components

16-2. DESCRIPTION (cont)

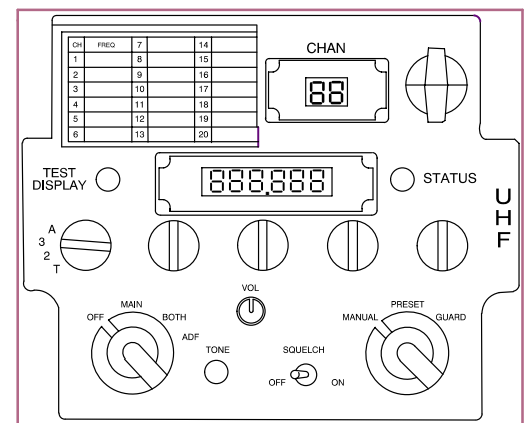
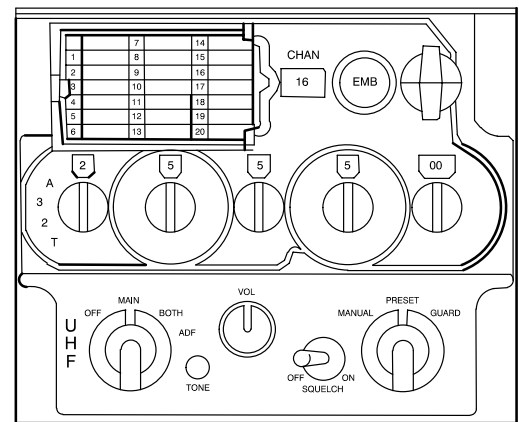
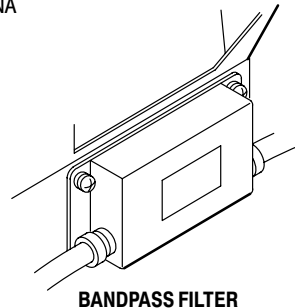
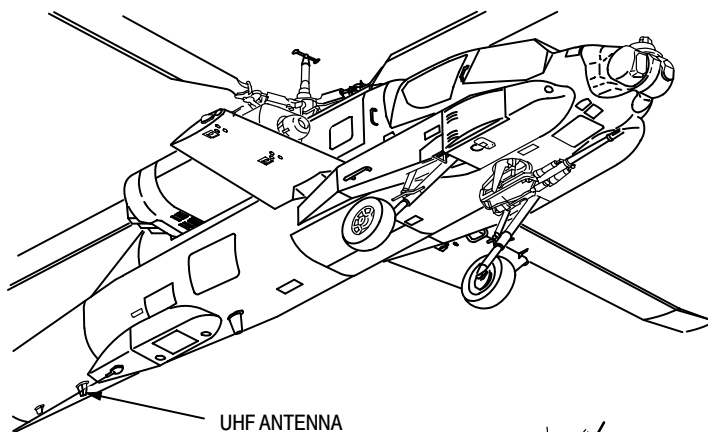
16-2

c. **UHF Radio System.** The UHF radio system major components are listed below.

(1) The bandpass filter (fig. 16-3) allows UHF radio signals to pass while rejecting IFF signals that are transmitted from the same antenna.

(2) The RT-1167/ARC-164 provides two-way AM wide or narrowband voice communication on any one of 7000 frequencies spaced in 0.025 MHz increments in the 225.000 to 399.750 UHF military band. The guard receiver is tunable from 238.000 to 248.000 MHz (usually 243.000 MHz). The ADF function is not used. RT-1167C/ARC-164 and RT-1518/ARC-164 provide **HAVE QUICK** operations capability.

(3) The UHF antenna allows UHF transmission and reception.



M52-247B

Figure 16-3. UHF Radio System Components

16-2. DESCRIPTION (cont)**16-2**

d. **AN/ARN-89 ADF Set (ACK).** The AN/ARN-89 ADF set is an airborne low frequency automatic direction finder radio. The AN/ARN-89 actually consists of three versions; AN/ARN-89, AN/ARN-89A, and AN/ARN-89B. The AH-64A helicopter uses the AN/ARN-89B system. The major components (fig. NO TAG) of the ADF navigation system are listed below.

(1) ADF antenna AS-2108 or AS-2108A provides directional information to the ADF receiver. The AH-64A helicopter uses the AS-2108A.

(2) **ADF RCVR** control panel C-7392/ARN-89 or C-7392A/ARN-89 provides complete control of the ADF system. The AH-64A helicopter uses the C-7392A/ARN-89.

(3) ADF sense preamplifier AM-4859/ARN-89 or AM-4859A/ARN-89 amplifies the incoming omnidirectional signal. The AH-64A helicopter uses the AM-4859A/ARN-89.

(4) ADF sense antenna provides the ADF receiver with an omnidirectional RF signal via the sense preamplifier.

(5) ADF receiver R-1496/ARN-89 or R-1496A/ARN-89 processes loop antenna and sense antenna inputs to provide bearing-to-station information and audio outputs. The AH-64A helicopter uses the R-1496A/ARN-89.

d.1. **AN/ARN-149 (V) ADF Set (ACJ).** The AN/ARN-149 ADF set is an airborne low frequency automatic direction finder radio. The major components (fig. 16-3.1) of the ADF navigation system are listed below.

(1) ADF loop antenna AS-3933/ARN-149(V) is a combination loop and sense antenna. The antenna provides directional information and information to the ADF receiver.

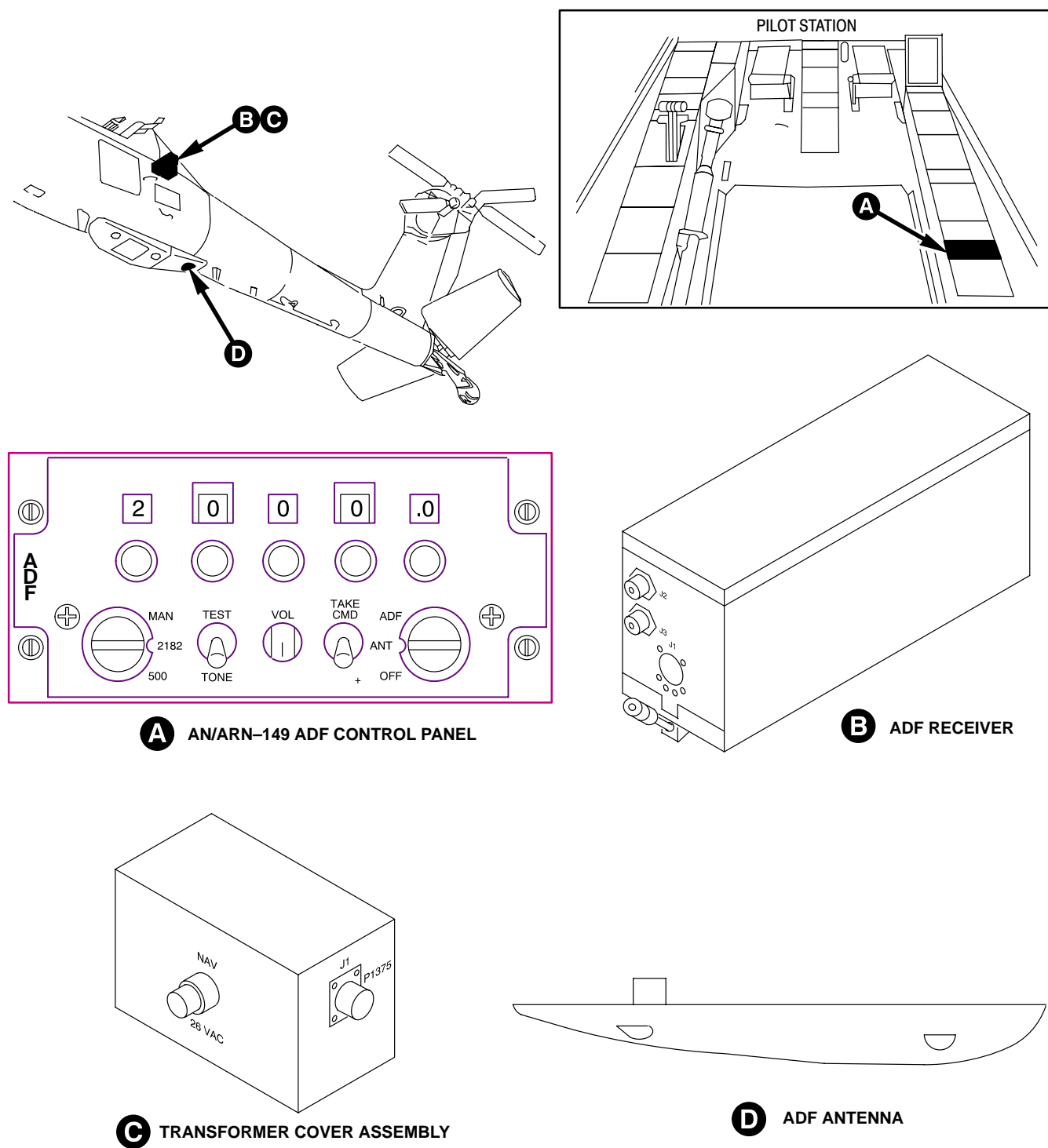
(2) **ADF** control panel 12192/ARN-149(V) provides complete control of the ADF system.

(3) ADF receiver R-2382 ARN-149(V) processes antenna inputs to provide bearing-to-station information and audio outputs.

(4) The transformer cover assembly provides 26 VAC 400 Hz reference voltage for the AN/ARN-149 ADF set.

16-2. DESCRIPTION (cont)

16-2



M52-458

Figure 16-3.1. ARN-149 ADF System Components

16-2. DESCRIPTION (cont)

16-2

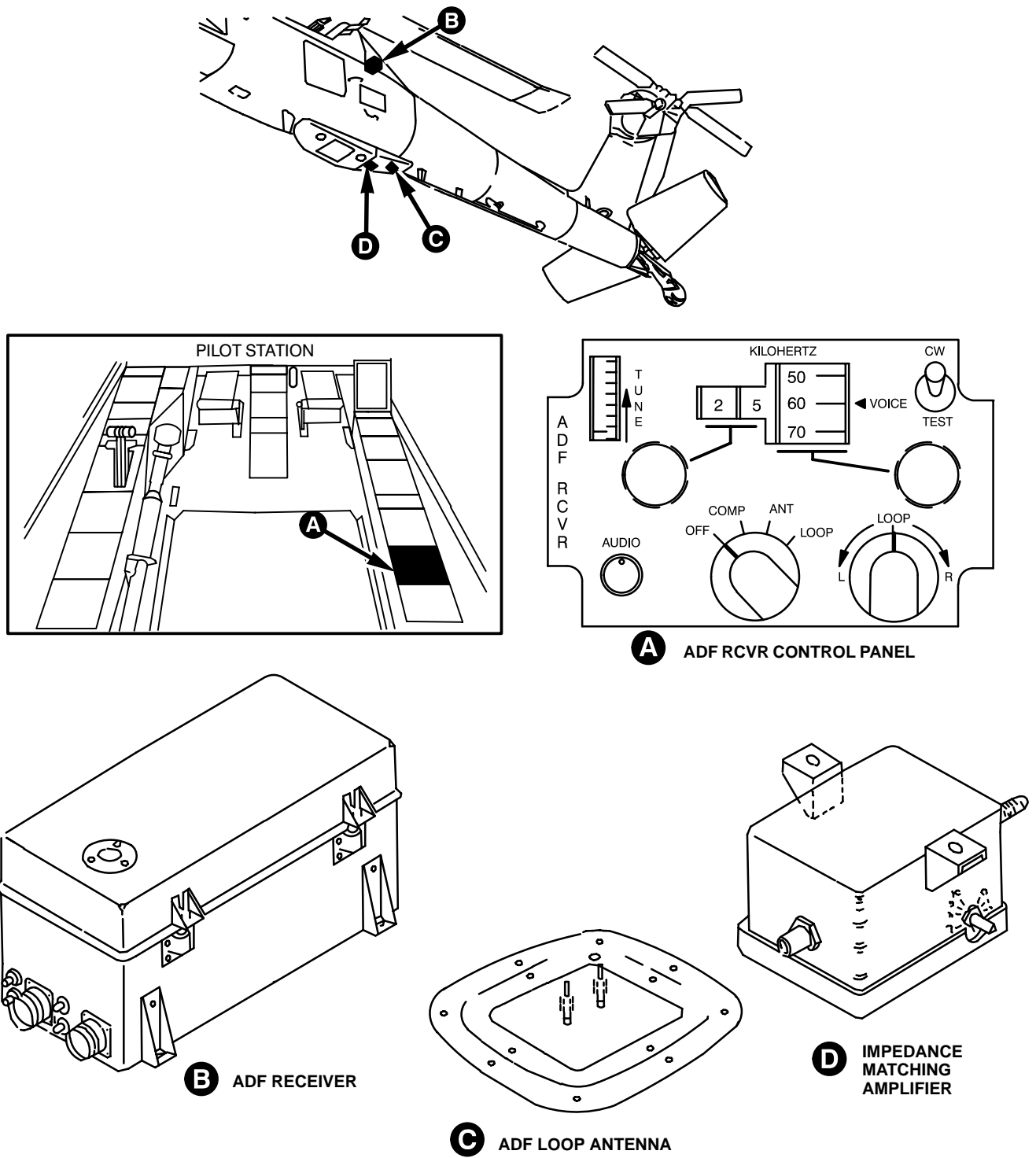


Figure 16-4. ADF System Major Components

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16-2. DESCRIPTION (cont)**16-2**

e. **Radar Altimeter.** Major components of the radar altimeter are listed below.

(1) RT-1411/APN-209A Receiver/Transmitter. The receiver/transmitter (fig. 16-5) transmits, receives, and processes radar signals to provide analog and digital output signals of the helicopter's absolute height above the terrain.

(2) ID-1917/APN-209A Indicator. The indicator provides the pilot with analog and digital displays of the helicopter altitude.

(3) AS-2595/APN-209A Antenna. The antenna radiates RF pulses from the receiver/transmitter to the earth. Also collects the reflected RF pulses and routes them to the receiver/transmitter for conversion to altitude display signals. The receive and transmit antennas are identical.

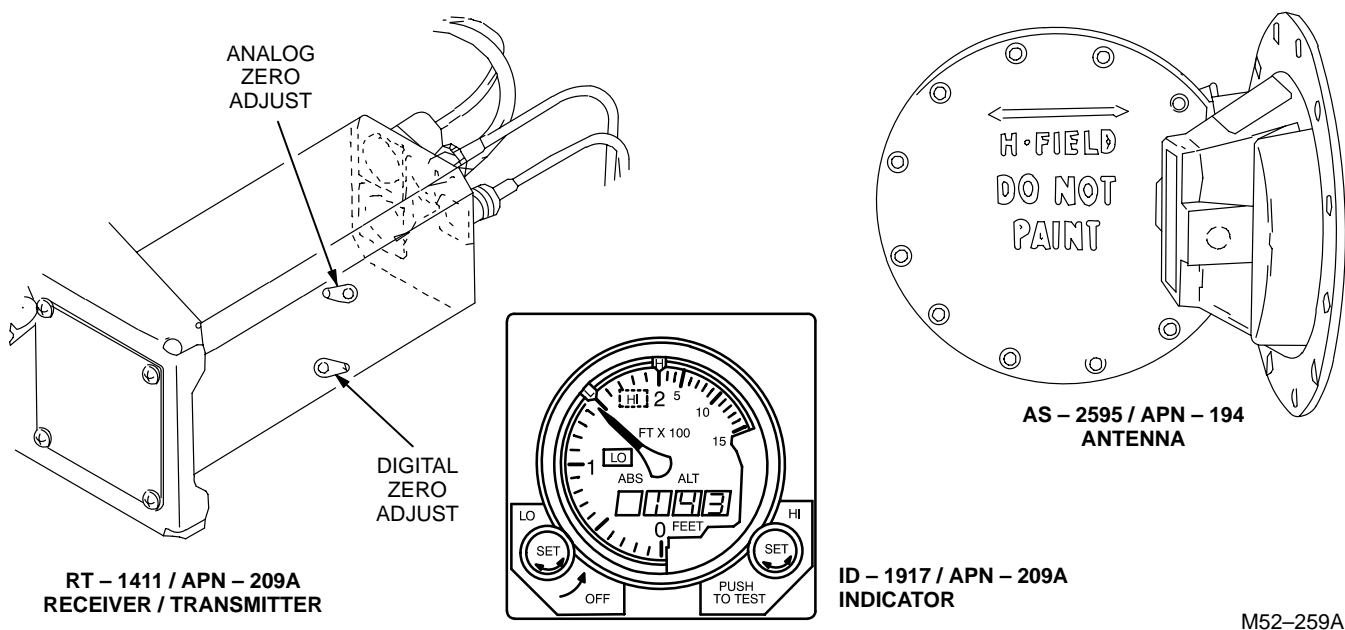


Figure 16-5. Radar Altimeter Major Components

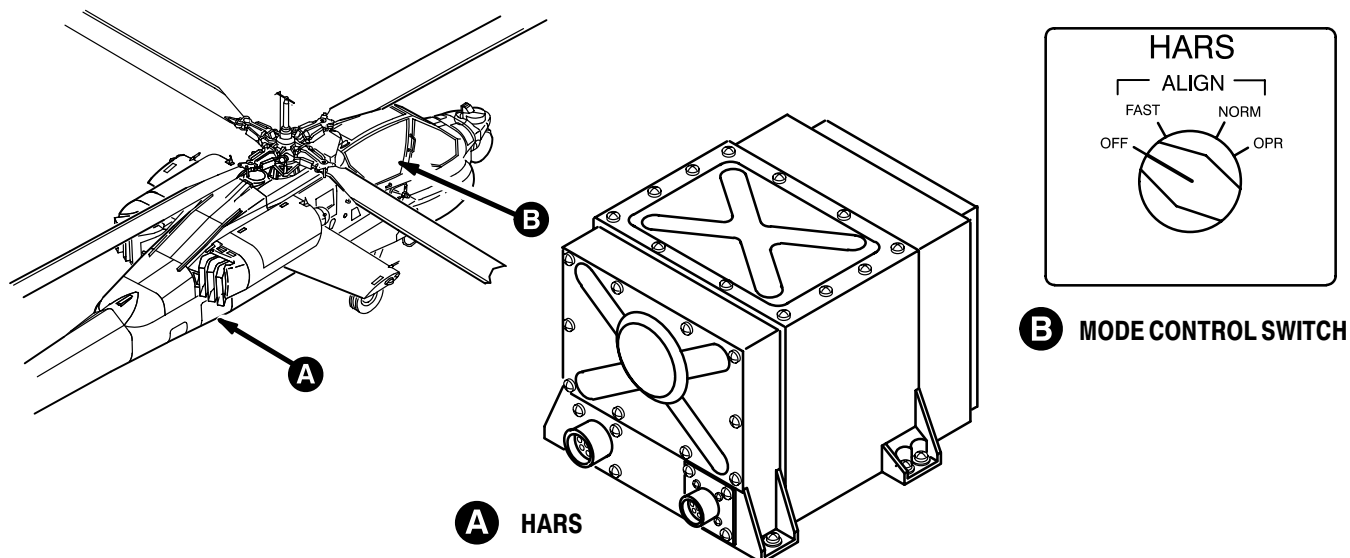
f. **HARS.** Major components of HARS are listed below.

(1) The AN/ASN-143 HARS (fig. 16-6) provides outputs that are proportional to pitch, roll, and magnetic heading of the helicopter.

(2) The HARS mode control panel gives the pilot on-off control of the HARS and the ability to select the alignment mode.

16-2. DESCRIPTION (cont)

16-2



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Figure 16-6. HARS Major Components

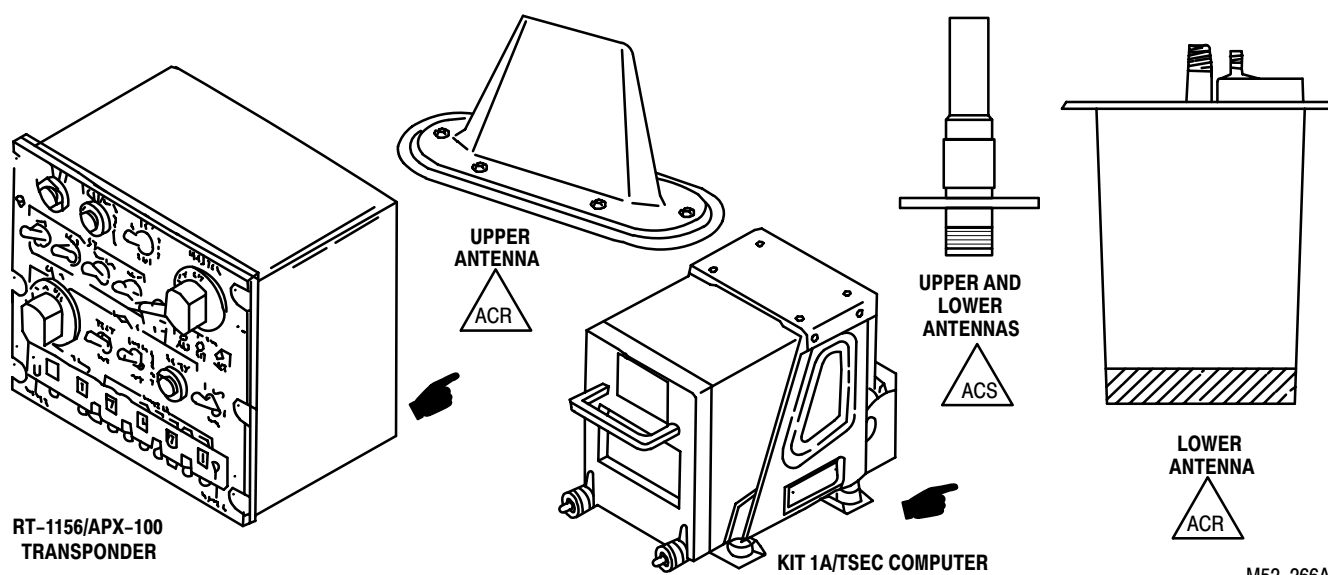
g. **IFF.** IFF major components are listed below.

(1) The upper antenna (fig 16-7) is located on top of the cabin section, aft of the canopy (ACR) or on the doghouse fairing work platform forward of the main rotor mast (ACS).

(2) The lower antenna is the aft half of the blade antenna (ACR) (the forward half is the UHF antenna) located on the bottom of the tail boom behind the Doppler fairing or a dipole antenna located aft of the jack pad (ACS).

(3) KIT 1A/TSEC computer provides a secure Mode 4.

(4) RT-1156/APX-100 transponder provides for reception and decoding of interrogations and also provides for encoding and transmission of replies. The controls required for operation are on the front panel.



M52-266A

Figure 16-7. IFF System Major Components

16-2. DESCRIPTION (cont)**16-2**

h. **AN/ASN-128 and AN/ASN-137 Dopplers.** The Doppler major components (fig. 16-8) are listed below.

(1) The computer display unit (CDU) CP-1252(XE-2)/ASN-128 (AAK) or IP-1552/G (ABQ) is located in the CPG right-hand console.

(a) The CDU CP-1252(XE-2)/ASN-128 (AAK) contains all navigation set operating controls, indicators, and displays on the front panel. The CDU also contains a keyboard to permit entry of alpha and numeric characters into memory. Two electrical connectors located at the rear of the unit provide an interface with the signal data converter (SDC) and receiver/transmitter antenna (RTA). An elapsed time indicator located on the back of the CDU, indicates the cumulative operating time of the navigation set. A dry-cell battery prevents the loss of data from the computer memory when the navigation set is turned off. The battery can be removed by removing the protective battery cover and releasing the snap-on terminal connector.

(b) The CDU IP-1552/G (ABQ) contains all eight variable action buttons (VABs) and five fixed action buttons (FABs). A brightness (**BRT**) control located on the front panel of the CDU controls display brightness. The CDU also contains a keyboard to permit entry of alpha and numeric characters into memory. Two electrical connectors located at the rear of the unit provide an interface with the SDC and receiver/transmitter antenna (RTA). An elapsed time indicator located on the back of the CDU, indicates the cumulative operating time of the navigation set.

(2) The SDC (ADC) or SDCC (ADD) is located on the aft transmission deck left of the catwalk. The SDC (ADC) or (SDCC (ADD) provides filtering and frequency tracking of the Doppler signal and converts inputs from the air data subsystem (ADSS) and HARS to serial data words.

(3) The Doppler RTA is located in the fairing on the bottom of the fuselage. The RTA is a combined antenna/radome and receiver/transmitter. A radiating grid array is printed in the radome material. The antenna radiates and receives four non-coplanar switched beams. The signals are processed by the CDU to present navigational information.

(4) Data bus switch (K8) switches the SDCC address when the FCC fails (ADD).

(5) Data bus switch (K9) switches the SDCC from the data bus to the CDU bus when the FCC fails (ADD).

j. **Embedded GPS Inertial (EGI) (ADD).** The EGI major components are listed below.

(1) The EGI (fig. 16-8.1) is located the R/H FAB extension. Six electrical connectors are located on the front of the unit. The connectors provide an interface for power, system input output (I/O), test, 1553 bus, GPS (Global Positioning System) KYK and GPS antenna. One battery prevents the loss of data from the EGI memory when the navigation set is turned off.

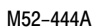
(2) The attenuator power splitter is located the R/H FAB extension. Five connectors are located on the power splitter of which three are used. The connectors provide power, RF input and RF output.

(3) The GPS antenna is located on the vertical stabilizer tip fairing. The antenna is a fixed reception pattern antenna (FRPA) used to receive satellite transmissions.

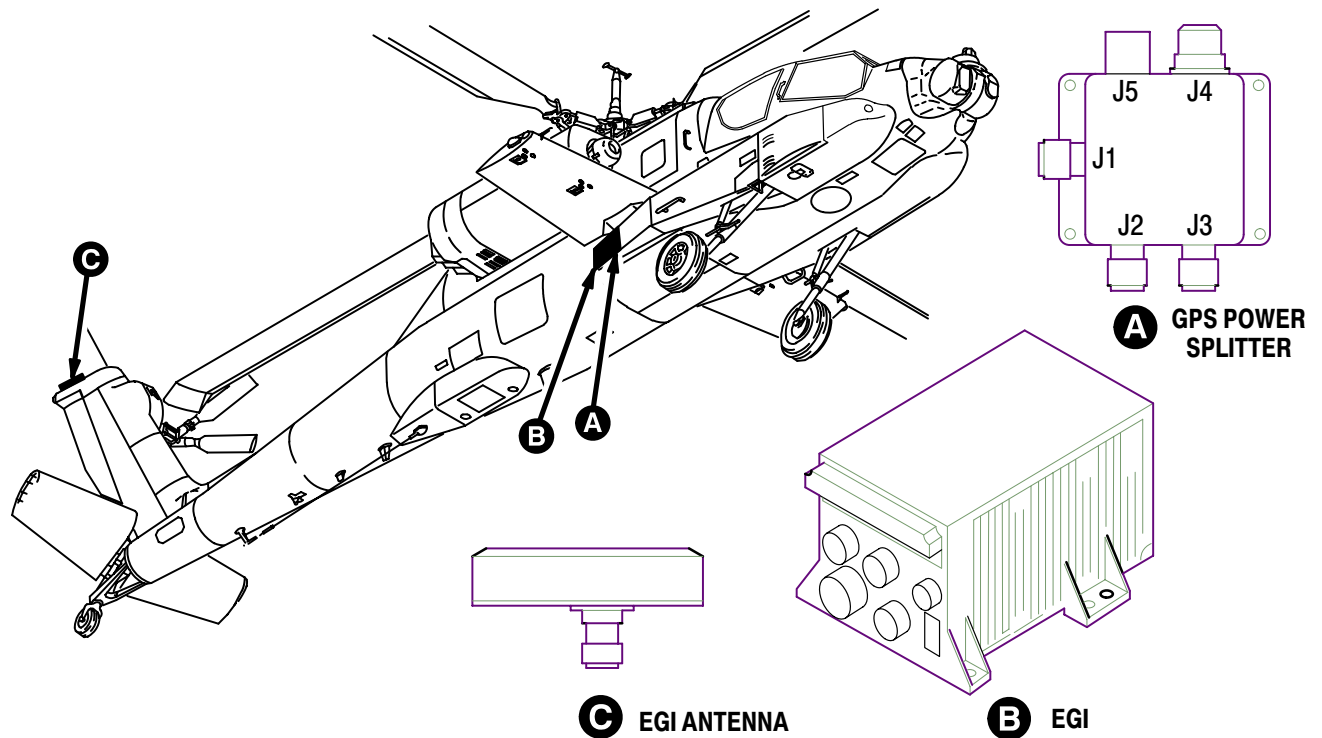
k. **Data Transfer Unit (DTU) (ADD).** The DTU (fig. 16-8.2) major components are listed below.

(1) The data transfer receptacle (DTR) is located in the CPG station. The DTR has two connectors. The connectors are for power and bus interface. The DTR supplies power to the data transfer cartridge.

(2) The data transfer cartridge (DTC) is programmed by the automated mission planning station (AMPS). Data is uploaded to the FCC and downloaded from the FCC (saved) to the cartridge.

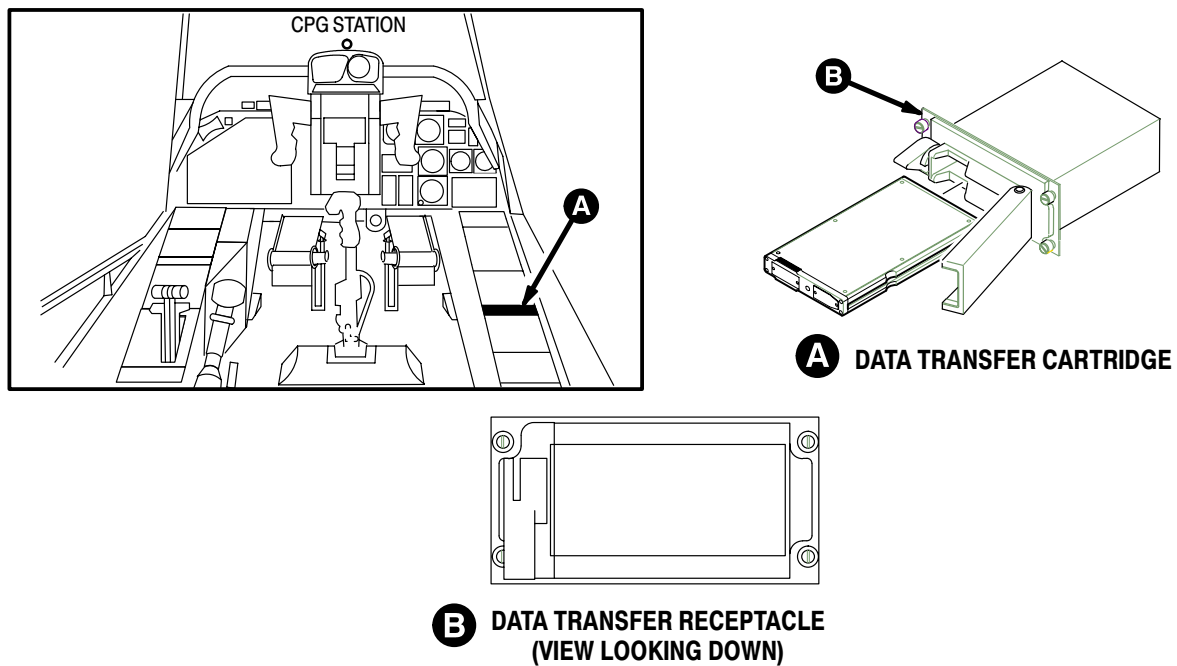


16-8.1/(16-8.2 blank)



M52-470

Figure 16-8.1. EGI Major Components (ADD)



M52-469

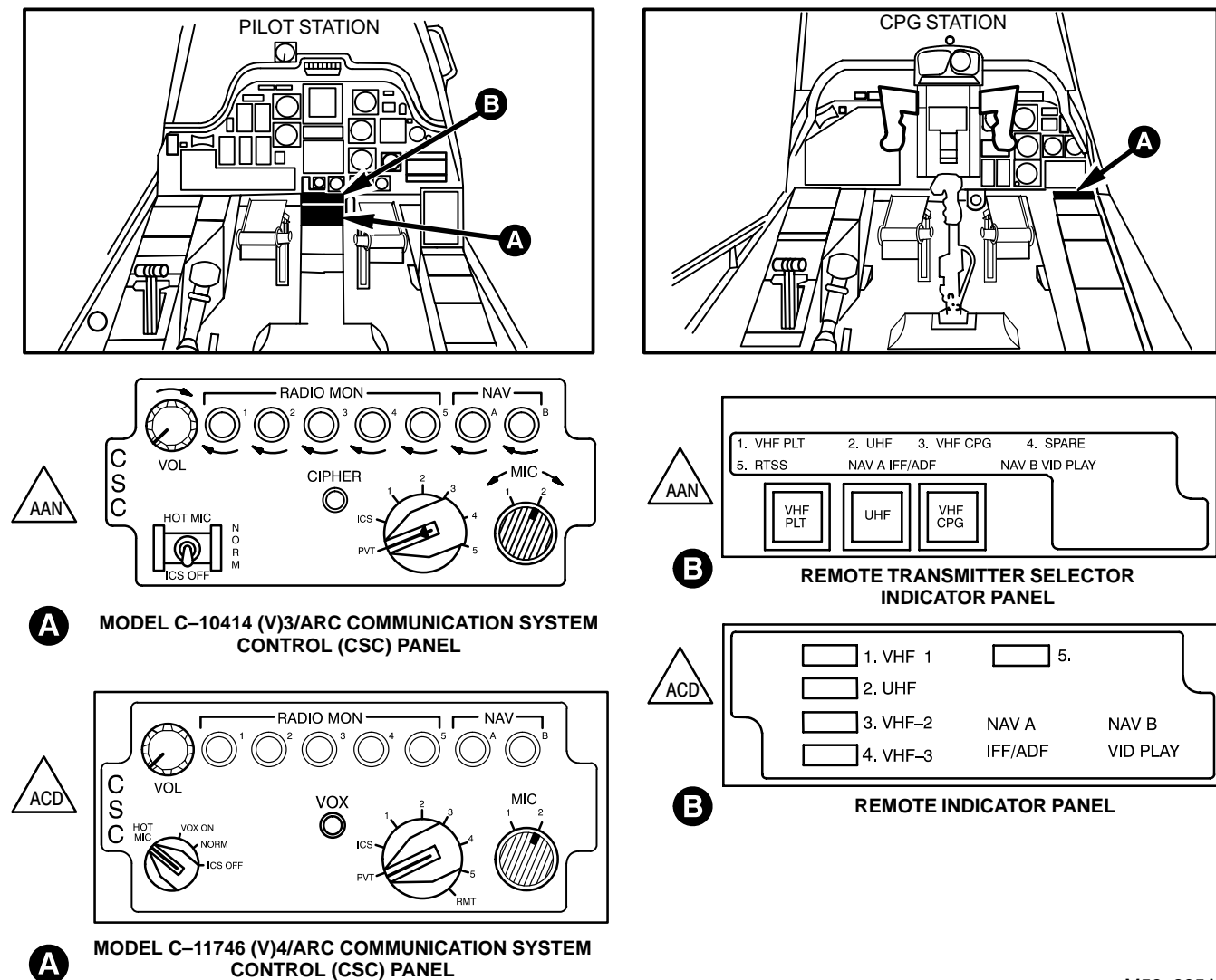
Figure 16-8.2. DTU Major Components (ADD)

16-3. THEORY OF OPERATION

16-3

16-3. THEORY OF OPERATION

- a. **CSC Panel.** Switches and inputs on the CSC panel perform the following functions (fig. 16-9).



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Figure 16-9. CSC and Indicator Panels

- (1) **VOL** switch/potentiometer: master volume control for all receive monitor switch/potentiometers.
- (2) **RADIO MON** switches: push on, pull off switch/potentiometers. Functions are as follows.
 - (a) **RADIO MON 1** provides on/off and volume control for the (pilot's) VHF receiver 1.
 - (b) **RADIO MON 2** provides on/off and volume control for the UHF receiver.
 - (c) **RADIO MON 3** provides on/off and volume control for the (CPG's) VHF receiver 2.
 - (d) **RADIO MON 4** is not used.

16-3. THEORY OF OPERATION (cont)

16-3

- (e) **RADIO MON 5** is a spare.
 - (3) **NAV** switches are push on, pull off switch/potentiometers. Functions are as follows.
 - (a) **NAV A** provides on/off and volume control for ADF (ARN-89) and IFF (APX-100) audio.
 - (b) **NAV B** provides on/off and volume control for video recorder and audio playback.
 - (4) **HOT MIC/VOX ON/NORM/ICS OFF** switch provides control of the internal microphone amplifier. Positions are as follows.
 - (a) **HOT MIC** allows interphone transmit functions at all times.
 - (b) **VOX ON** allows use of voice operate transmit function.
 - (c) **NORM** disables the microphone amplifier.
 - (5) Transmit Select switch: positions are as follows.
 - (a) **PVT** is not used.
 - (b) **ICS** allows intercommunication.
 - (c) **1** allows transmission on the VHF 1.
 - (d) **2** allows transmission on the UHF.
 - (e) **3** allows transmission on the VHF 2.
 - (f) **4** is not used.
 - (g) **5** is not used.
 - (h) Remote (**RMT**) in pilot's station, enables remote transmit select operation. Not used in CPG's station.
 - (6) **MIC** select switch positions are as follows.
 - (a) **1** is used with dynamic microphones.
 - (b) **2** is used with carbon microphones.
 - (7) Hardwired inputs into the CSC control panel provide audio for the following warning functions.
 - (a) Stabilator control system automatic mode operation failure.
 - (b) Engine out.
 - (c) Low rotor rpm.
 - (d) Radar.
- b. **Remote Indicator Panel.** The remote indicator panel (fig. 16-9) contains indicators for the following functions.
- (1) **VHF-1.**
 - (2) **UHF.**

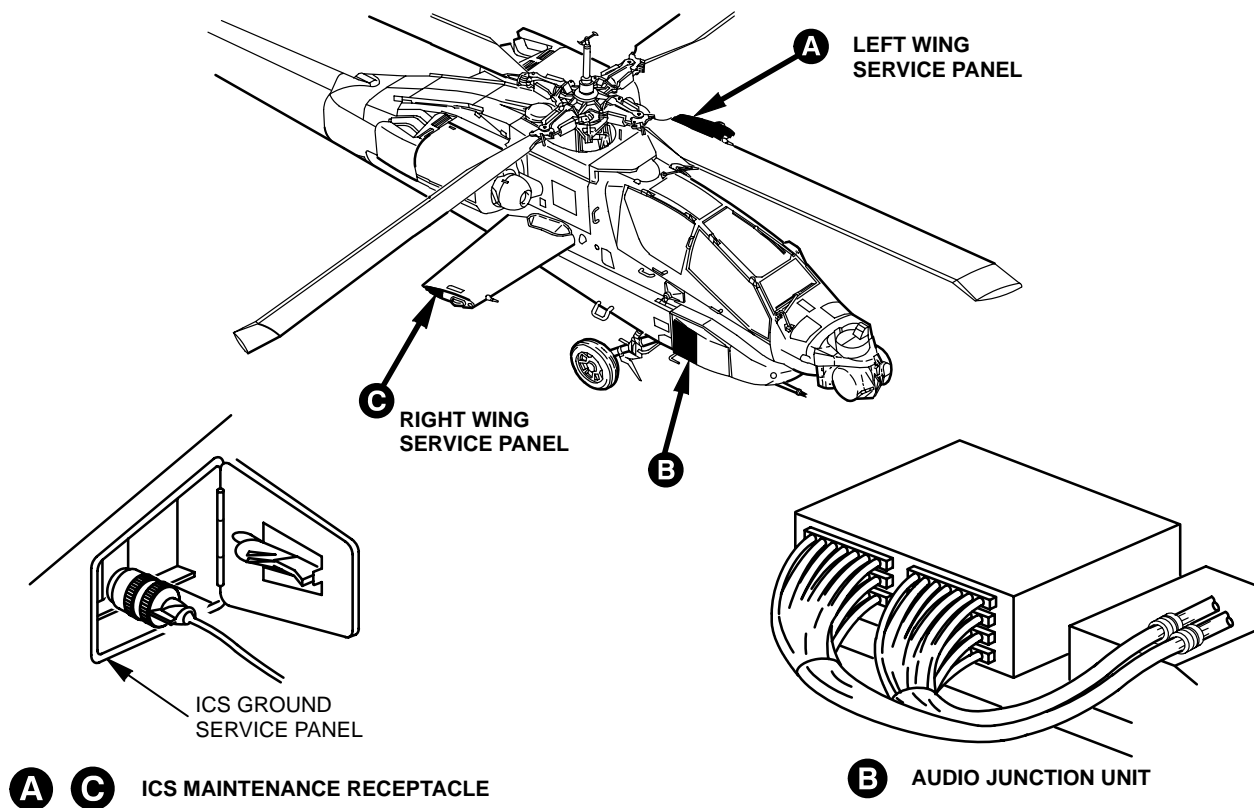
16-3. THEORY OF OPERATION (cont)

16-3

(3) VHF-2.

(4) VHF-3.

(5) Spare.



M52-236

Figure 16-10. Maintenance ICS Receptacle

- c. **Audio Junction Unit).** The audio junction unit (fig. 16-10) connector functions are as follows.
- (1) J1 connects inputs and outputs to the pilot's ICS (receiver side).
 - (2) J2 connects inputs and outputs to the pilot's ICS (transmitter side).
 - (3) J3 connects inputs and outputs to CPG ICS (receiver side).
 - (4) J4 connects inputs and outputs to CPG ICS (transmitter side).
 - (5) J5 connects inputs from aircraft radios and integrated audio warning system. The connector also connects audio to and from the video recorder
 - (6) J6 outputs audio to the aircraft radio transmitters.
 - (7) J7 connects discrete inputs and outputs from aircraft switches, relays and circuit breakers.

d. **Maintenance ICS Receptacle.** The maintenance ICS receptacle (fig. 16-10) allows maintenance personnel to communicate with the pilot and CPG crew stations during ground operations. A single ICS receptacle is mounted on each wing tip near the trailing edge, behind an access door.

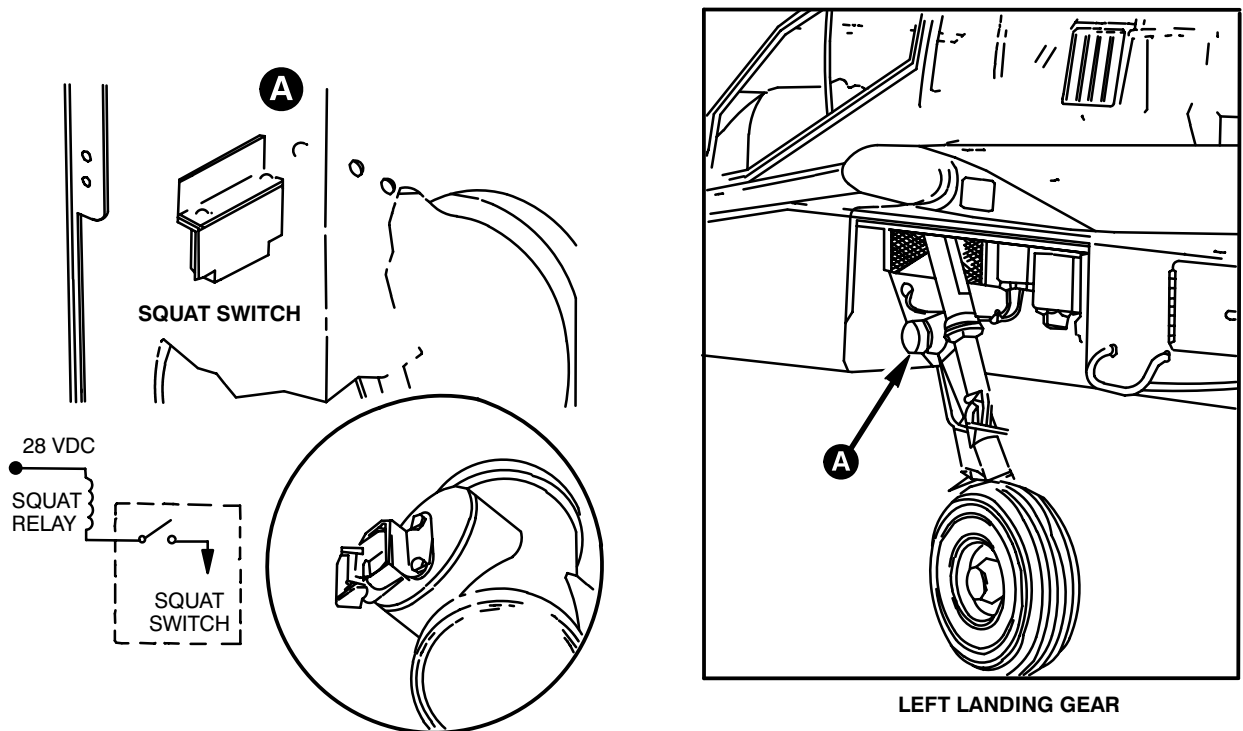
16-3. THEORY OF OPERATION (cont)

16-3

e. **Squat Switch.** The squat switch (fig. 16-11) provides a ground for the squat relay when the helicopter is in the air.

(1) When the aircraft is on the ground, the switch is open and the ground is removed from the return side of the squat relay.

(2) When the aircraft is in the air, the switch is closed and a ground is supplied to the return side of the squat relay coil.



M52-237

Figure 16-11. Squat Switch

f. **Squat Relay.** The squat relay (fig. 16-12) disconnects the maintenance receptacles from the ICS system when the helicopter is in flight.

(1) The relay receives power from the emergency dc bus via the IFF circuit breaker.

(2) When the aircraft is on the ground, the squat switch is open and the squat relay is de-energized.

(3) The squat relay provides a ground (when de-energized) to two relays in the audio junction unit. When the two relays in the audio junction unit are energized, the maintenance receptacles are connected to the ICS system.

g. **ICS Circuit Breakers.** Two circuit breakers (fig. 16-13) provide circuit protection for the ICS system.

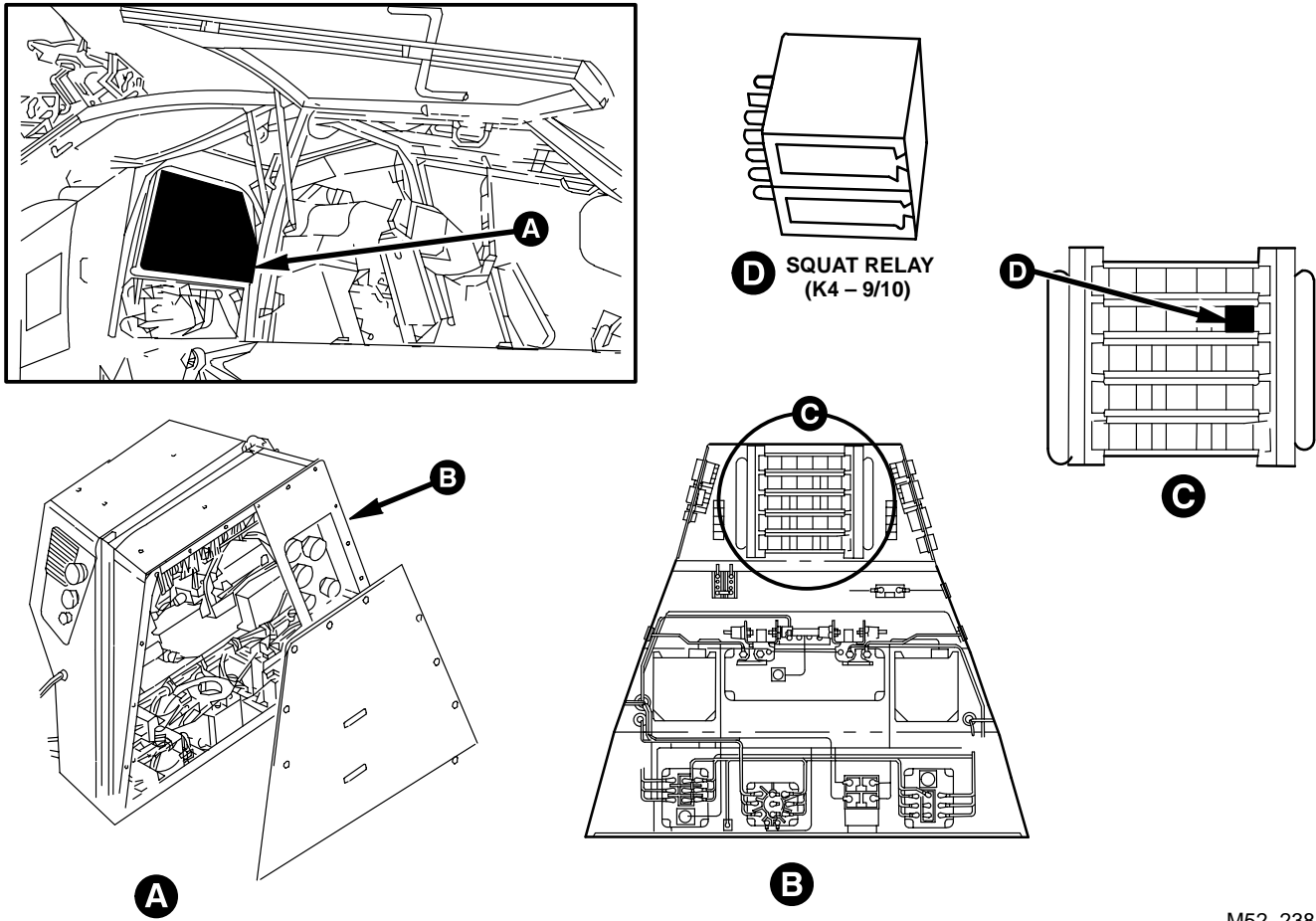
(1) The pilot's **ICS** circuit breaker is mounted on the center overhead circuit breaker panel.

(2) The CPG's **ICS** circuit breaker is mounted on the circuit breaker panel 1 in the left console.

16-3. THEORY OF OPERATION (cont)

16-3

(3) The **ICS** circuit breakers receive 28 VDC from the emergency dc bus. Each circuit breaker is rated at 5 amperes.

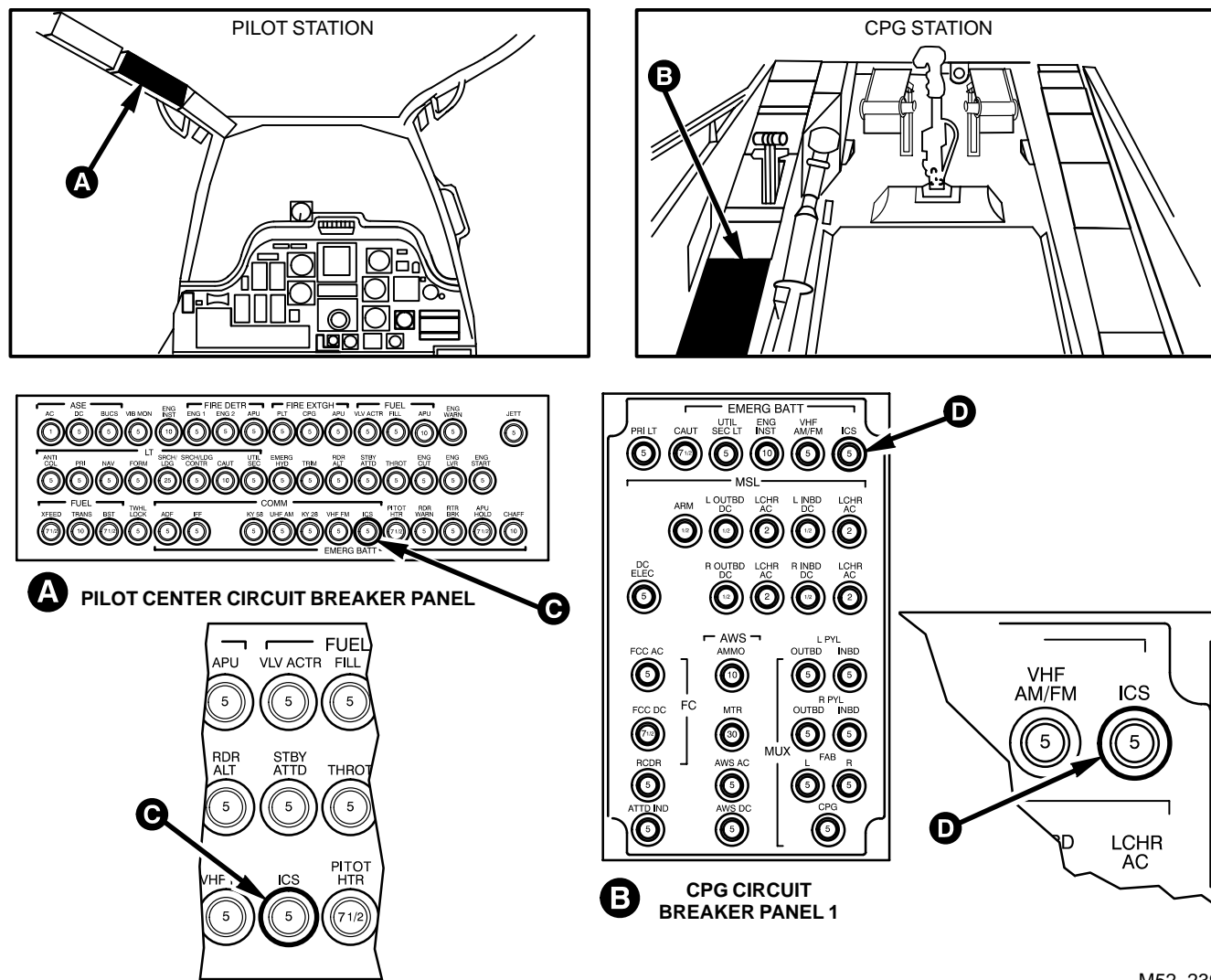


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Figure 16-12. Squat Relay

16-3. THEORY OF OPERATION (cont)

16-3



M52-239

Figure 16-13. ICS Circuit Breakers

h. ICS Warning Signals (fig. 16-14).

(1) When the engine out warning unit senses an engine failure, a signal is applied at J5, pins A1 and A2 and:

(a) The signal is applied to the primary of T7, and exiting the audio junction unit at pins A1 and A2 of J1 and pins A1 and A2 of J3.

(b) The signal from J1 is applied to the pilot's CSC panel at pins q and r of J2.

(c) The signal is amplified and sent to the pilot's headset via the audio junction unit.

(d) The signal from J3 is applied to the CPG's CSC panel at pins q and r of J2.

(e) The signal is amplified and sent to the CPG's headset via the audio junction unit.

16-3. THEORY OF OPERATION (cont)

16-3

(2) Operation of all warning signals is the same. The volume of the warning signals cannot be adjusted.

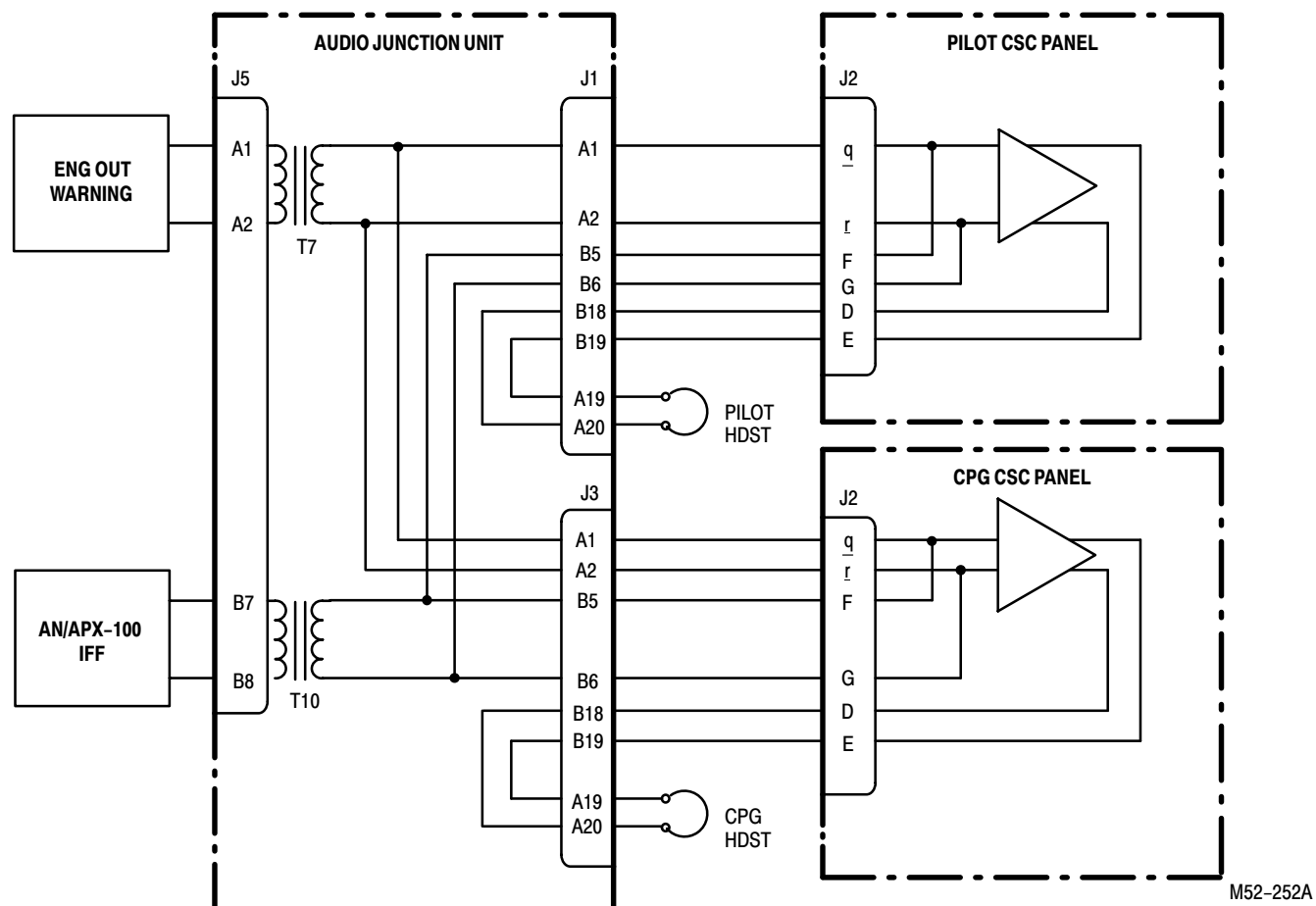


Figure 16-14. ICS Warning Signal Block Diagram

i. RT-1354/ARC-186.

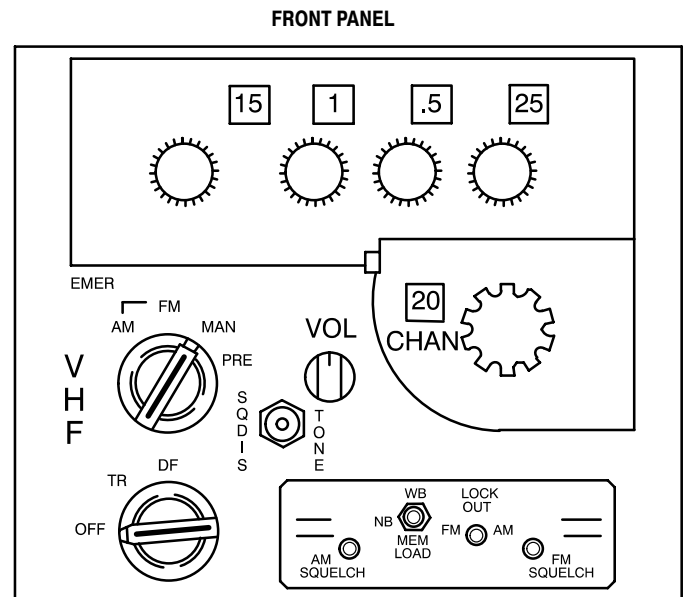
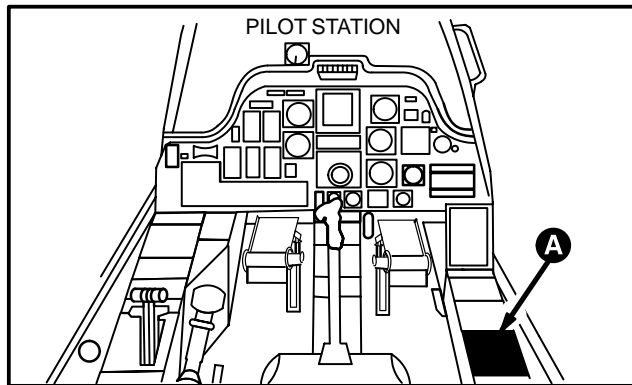
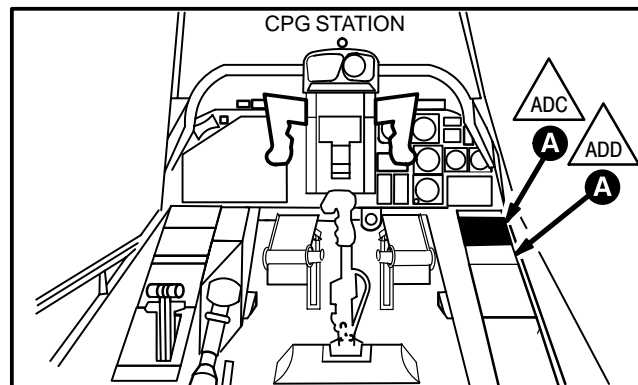
(1) Each radio operates in a frequency range of 116.000 to 151.975 MHz in the AM mode, and 30.000 to 87.975 MHz in the FM mode. Frequency selection is in 25 KHz Steps (fig. 16-15).

(2) Transmit power is 16 watts in the AM mode and 10 watts in the FM mode

- (a) The back panel (fig. 16-15) contains the following items.
- (b) Fuse F1 (located under the fuse cover).
- (c) J1 and J2 (electrical connectors).
- (d) J3 (FM antenna connector).
- (e) J4 (AM antenna connector).

16-3. THEORY OF OPERATION (cont)

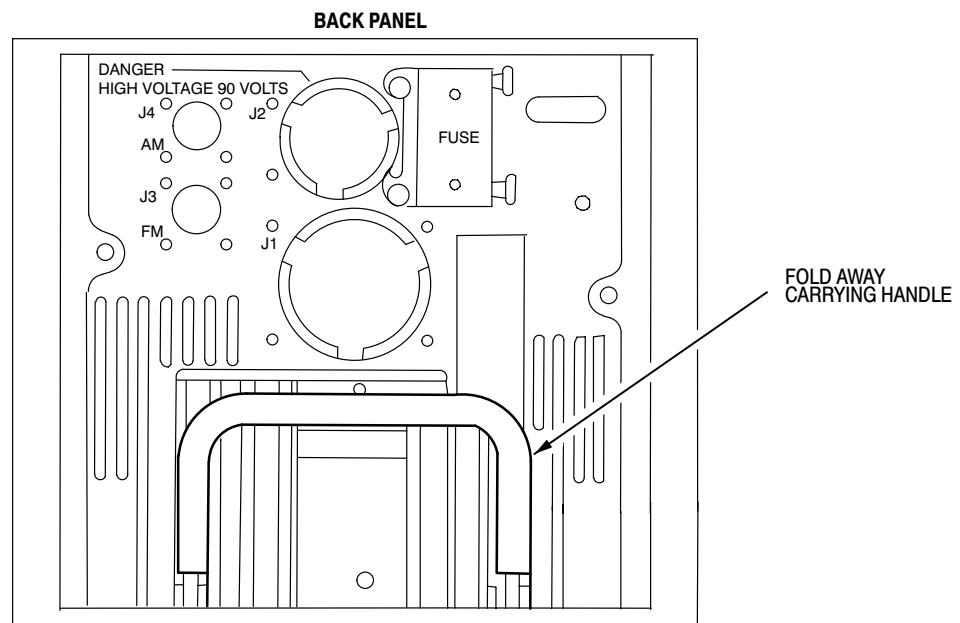
16-3



1	6	11	16
2	7	12	17
3	8	13	18
4	9	14	19
5	10	15	20

SNAP - ON COVER

A PLT / CPG AN / ARC-186 VHF AM - FM RADIO CONTROL PANEL



M52-241A

Figure 16-15. VHF RT-1354/ARC-186

16-3. THEORY OF OPERATION (cont)

16-3

j. RT-1476A/ARC-201A.

(1) The VHF/FM transceiver AN/ARC-201A SINCGARS (Single Channel Ground to Air Radio Subsystem) (fig. 16-15A) frequency range is 30.000 to 87.975 MHz in 25 KHz steps. A frequency offset tuning capability of -10KHz, -5KHz, +5KHz and +10KHz is provided for transmitting and receiving in non-secure mode only. An Electronics Counter Counter-Measure (ECCM) mode provides jam resistant capabilities. When used with the T/SEC KY-58, the radio is capable of clear or cipher mode communications. There are no re-transmission or homing capabilities in this configuration.

(2) The ECCM operation provides a jam resistant capability through a frequency hopping technique. Frequency hopping is a technique in which the frequency being used for a given channel is automatically changed at some rate common to the receiver and transmitter. The standard, single frequency VHF/FM voice mode of operation is referred to as **SC** (Single-Channel). The frequency hopping VHF/FM mode of operation is referred to as **FH** or **FH-M** (Frequency Hopping or Frequency Hopping-Master). In the FH mode, the following parameters are necessary for successful operation.

(a) Loading ECCM Parameters. To use the ECCM function, TRANSEC (Transmission Security) variables and hopsets or lockouts are loaded into the transceiver by external devices connected to the **FILL** connector.

(b) Time synchronization. Time synchronization is provided by a clock inside the transceiver. The operation of the frequency hopping net is accuracy time dependant. A relative standard or master must be established to prevent gradual time creepage during normal communications. One radio set will be designated as master. The time differences will be accommodated in the other radios, not the master radio. The net control station or master, is designated as the time standard for all radios in the net.

(c) ECCM Radio Signalling. An operator with a non-ECCM radio attempting a contact within an ECCM net places the **PRESET** switch to **CUE**. The non-ECCM radio must be keyed for at least four seconds in order to ensure reception by the ECCM radio. The ECCM radio displays **CUE** for seven seconds and a two second tone is heard in headset each time a non-ECCM radio is keyed. The ECCM radio is then switched to the single channel **CUE** frequency or some other predetermined frequency.

(3) Display. The LCD (Liquid Crystal Display) provides operator interface depending on switch positions and keyboard entry. The LCD displays manual frequencies, preset frequencies, offset frequencies, CUE frequency, time, and transceiver status during test.

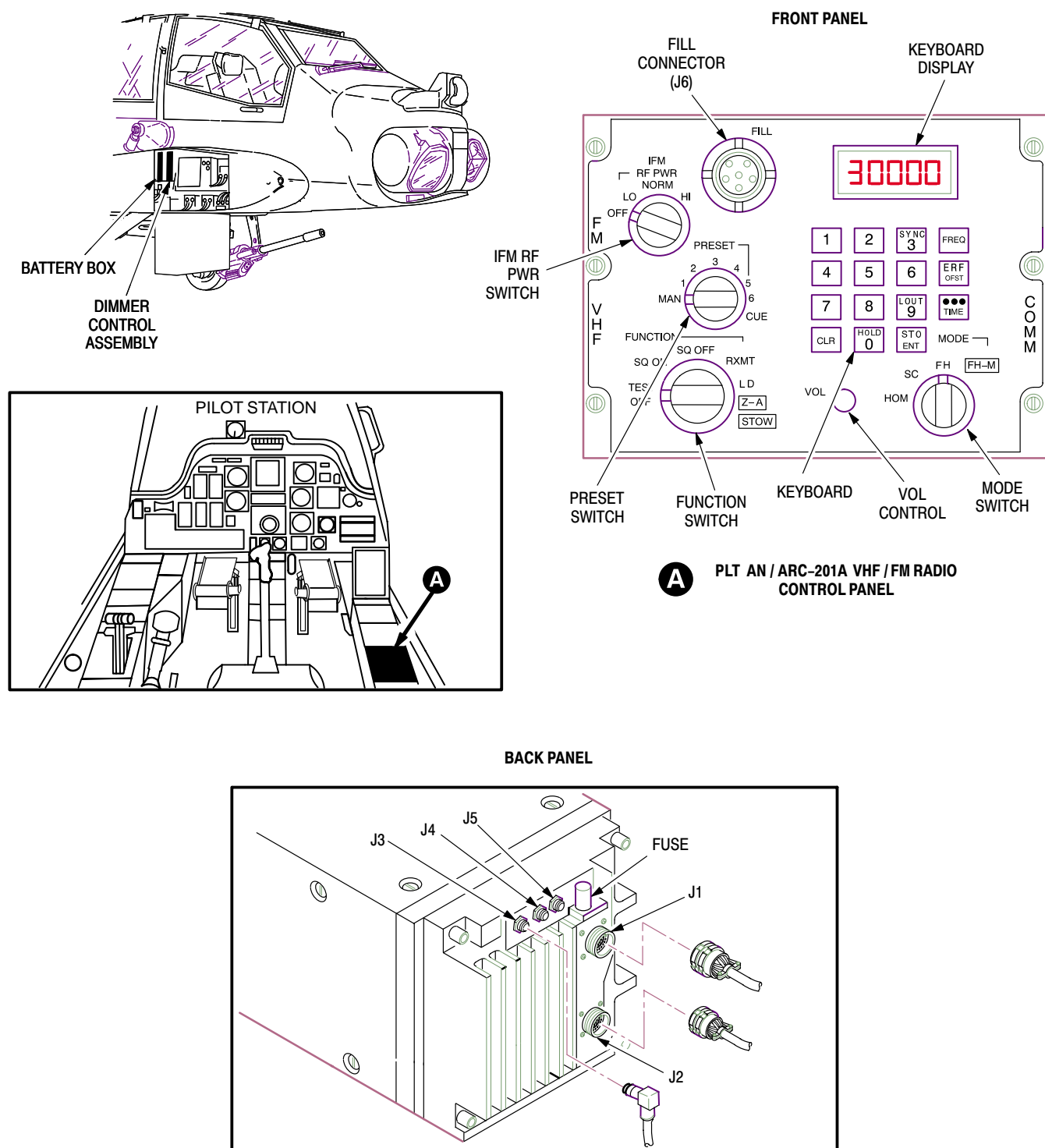
(4) Entering Data. Data is entered through a nine digit keyboard. Entry of information is normally displayed digit by digit left to right. Inputted valid data is registered on the display when the **STO** key is depressed. Acceptance of valid data is signaled by a momentary blink of the display. Operation of the transceiver is then changed. Illegal entries will not register on the display. Incomplete entries will not be accepted when the **STO** key is pressed. Partial or erroneous data can be erased at any time by pressing the **CLR** key.

(5) Preset Channels. Seven preset channels are available (**PRESET** positions **1** through **6** and **CUE**). The channels select preset frequencies in the non-ECCM and ECCM modes. In the normal single-channel mode (**MODE** to **SC**) either manual or **PRESET** channels are selected. In the ECCM mode (**MODE** to **FH** or **FH-M**), frequency hopping nets are selected according to preloaded data. When a frequency hopping net is selected the display will indicate **FH** followed by a corresponding number. The **CUE** frequency can serve as a seventh preset channel in single-channel operation or a special signaling frequency in frequency hopping.

(6) Frequency Offset Tuning. A single-channel operating frequency, either manually or preset selected, can be offset by -10KHz, -5KHz, +5KHz and +10KHz. The offset is displayed on the right two digits of the LCD.

16-3. THEORY OF OPERATION (cont)

16-3



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Figure 16-15A. VHF/FM AN/ARC-201A

16-3. THEORY OF OPERATION (cont)

16-3

(7) Warning Tones and Indications. The following tests are performed with the results of the test being audible or visible.

(a) **FUNCTION** switch to **TEST**. Display show **E** (shows dash if ECCM module not installed). After three seconds, the display changes to all **8**'s. After eight seconds, the display will indicate **GOOD** or **FAIL** with a number.

1. **1** indicates failure of transceiver.
2. **3** Indicates failure of ECCM module.
3. **7** Indicates failure of interface to transceiver.
4. **8** Indicates internal failure of control panel.

(b) VSWR (Voltage Standing Wave Ratio) Test. This test is performed each time the transmitter is keyed. If VSWR test exceeds 5 to 1 the sidetone is inhibited.

(c) Secure Mode Test. A continuous tone will be heard in the intercom each time the transmitter is keyed, if the KY-58 is present and the operation is faulty. A short beep will be heard each time the transmitter is keyed, if the KY-58 is present and operation is satisfactory.

(d) ECCM Test. While in the **FH** operating mode, changing the **PRESET** switch causes examination of the fill data. If valid hopset data is present, **FXXX** will be displayed. If no hopset or invalid hopset data is present, **FILLn** will be displayed.

(8) The front panel contains the following items.

(a) **FILL** connector (J6). Enters ECCM variables from an external fill device.

(b) Liquid Crystal Display (LCD). Displays data depending on key switch actuation and the positions of **MODE** and **FUNCTION** switches.

(c) Keyboard. Enters Data.

1. Number **1** through **9**. Keys in frequency, time and offset information.
2. **SYNC**. Synchronizes to a net already in progress.
3. **FREQ**. Displays the current operating single-channel manual or preset frequency. Used in loading manual and preset frequencies.
4. **ERF/OFST**. Initiates an **ERF** (ECCM Remote Fill) transmission if the **FH-M** mode. **OFST** (offset) modifies single-channel operating frequency manually or preset by -10KHz, -5KHz, +5KHz and +10KHz.
5. **TIME**. Displays or modifies the time setting within the receiver.
6. **LOUT**. **LOUT** (Lock Out) stores or retrieves a lockout set.
7. **STO**. **STO** (store) initiates entry of all valid completed entries by keyboard. Stores a received hopset or lockout set held in holding memory.
8. **0/LOAD**. **0** enters zeros. **LOAD** initiates transfer of ECCM parameters to transceiver.
9. **CLR**. **CLR** (clear) clears partial or erroneous entries.

(d) **MODE** switch. Selects operational mode.

1. **HOM**. Homing. Not used.

16-3. THEORY OF OPERATION (cont)

16-3

2. **SC. SC** (Single Channel) selects single-channel mode of operation. Operating frequency is selected by **PRESET** or keyboard entry.
 3. **FH. FH** (Frequency Hopping) selects frequency hopping mode of operation. Operating frequency is selected by **PRESET 1** through **6** frequency hopping parameters.
 4. **FH-M. FH-M** (Frequency Hopping-Master) is a pull and turn switch which designates control station as the time standard for all radios within a net.
- (e) **VOL** control. Adjusts receiver volume.
- (f) **FUNCTION** switch. Selects basic operational function of transceiver.
1. **OFF**. Primary power is off. Memory holding battery power is on.
 2. **TEST**. Self test of transceiver and ECCM functions.
 3. **SQ ON**. Power is applied to the transceiver and squelch is enabled.
 4. **SQ OFF**. Power is applied to the transceiver and squelch is disabled.
 5. **RXMT**. Remote transmit. Not used.
 6. **LD**. Loads TRANSEC variable into the transceiver.
 7. **Z-A. Z-A** (Zero All) is a pull and turn switch which zeros ECCM variables.
 8. **STOW**. Is a pull and turn switch which removes aircraft and battery power from transceiver.
- (g) **PRESET** switch. Selects specific predetermined operating conditions.
1. **MAN**. In **SC** mode, selects any operating frequency in 25KHz increments. Inoperative in **FH** modes.
 2. **1** through **6**. In the **SC** mode, preset frequencies are selector loaded. In **FH** mode frequency hopping net parameters are selected.
 3. **CUE**. Used by non-ECCM radio to signal an ECCM radio. Used as seventh frequency in **SC** mode.
- (h) **IFM RF PWR** switch. Not used. Always set to **OFF**.
- (9) The back panel contains the following items.
- (a) J1 System electrical connector.
 - (b) J2 auxiliary connector.
 - (c) J3 antenna connector.
 - (d) J4 homing connector. Not used.
 - (e) J5 homing connector. Not used.
 - (f) Fuse F1.
- (10) Memory Holding. A battery box provides voltage to retain stored FH parameters, preset frequencies and time when power is removed from the transceiver.
- (11) Light Panel. A dimmer controller assembly provides voltage for light panel illumination.

16-3. THEORY OF OPERATION (cont)

16-3

(12) Antennas. The antennas used are the same as the AN/ARC-186.

16-3. THEORY OF OPERATION (cont)

16-3

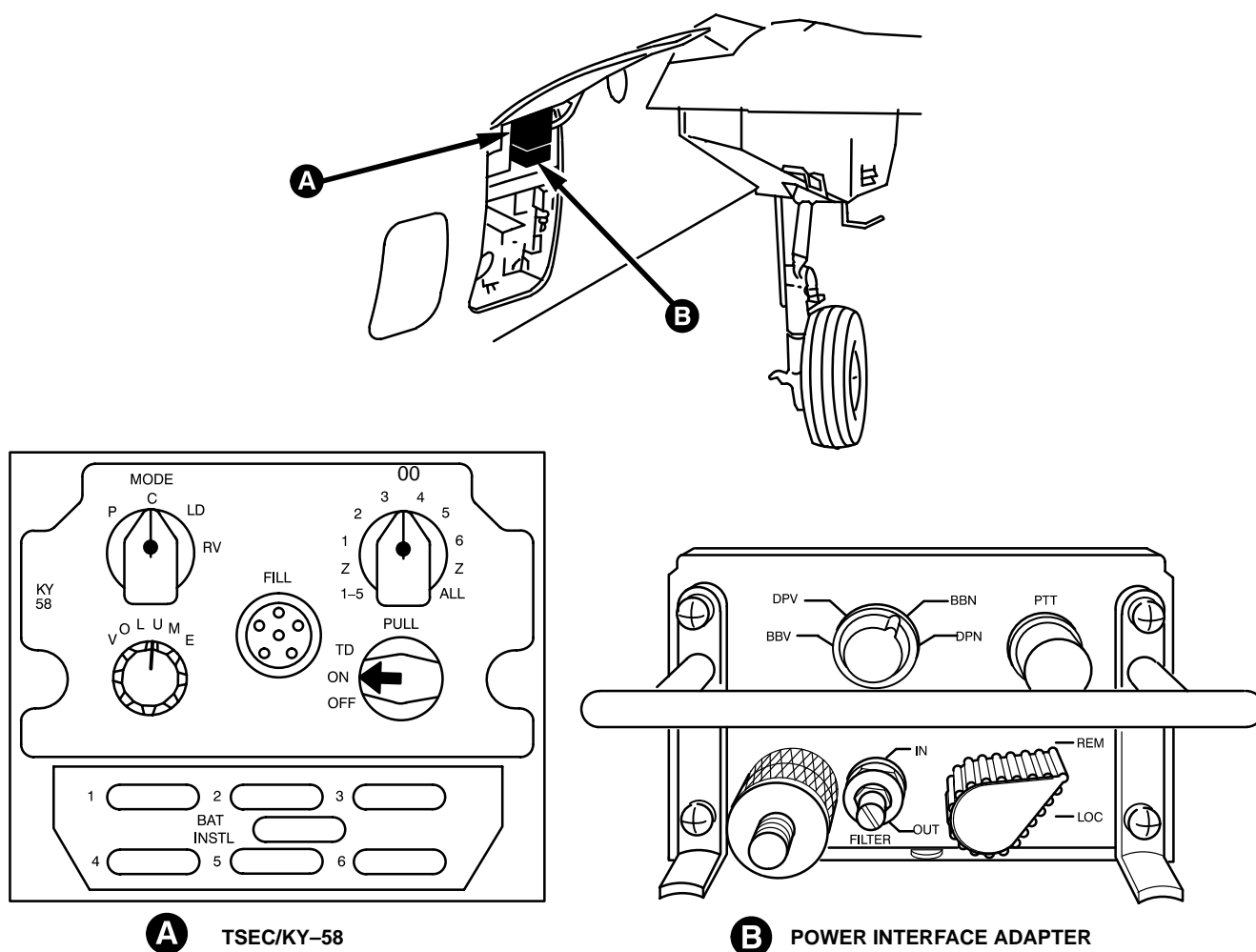
k. **TSEC/KY-58 Secure Voice Set.** The secure voice set provides cipher (secure) voice communications for all classifications of traffic in a tactical environment. The pilot VHF AM-FM 1 (ADH) or VHF/FM (ADI) is the only radio/transmitter using secure voice transmission and reception.

(1) The pilot has a KY-58 set available.

(2) A **VOICE CIPHER** indicator on the CPG caution/warning panel illuminates when the set is in use.

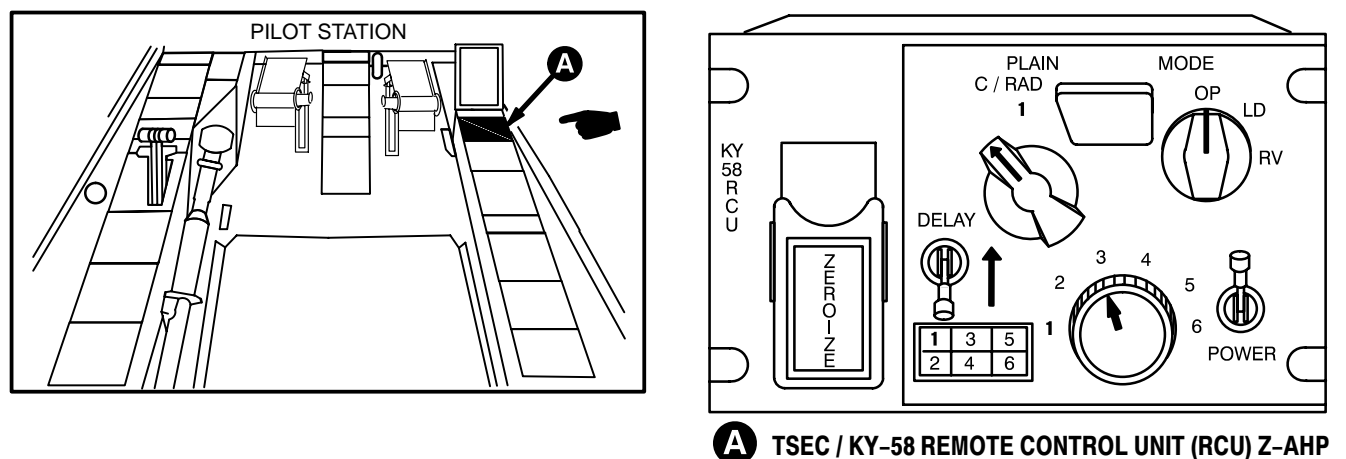
(a) The KY-58 secure voice set is a remote unit which fits in the mounting area in the aft avionics bay. The KY-58 secure voice set (fig. 16-16) consists of the set and power interface adapter (Z-AHQ) and mounts in the aft avionics bay KY-28 rack.

(b) The KY-58 remote control unit (RCU) Z-AHP (fig. 16-16.1) is console mounted as a single unit. The console mounted units control power, radio re-transmission, zeroizing, crypto-net variable (CNV) and operational mode of the security equipment.



M52-449A

Figure 16-16. TSEC/KY-58 and Power interface Adapter Z-AHQ Locations



M52-243B

Figure 16-16.1. C-8157/ARC CIPHONY Control-Indicator and TSEC/KY-58 Remote Control Unit Z-AHP Locations

I. **TSEC/KY-58 Remote Control Unit Z-AHP.** The TSEC/KY-58 remote control unit Z-AHP allows the pilot to select TSEC/KY-58 secure voice operation. The front face of the TSEC/KY-58 remote control unit Z-AHP has the following controls (fig. 16-16.1).

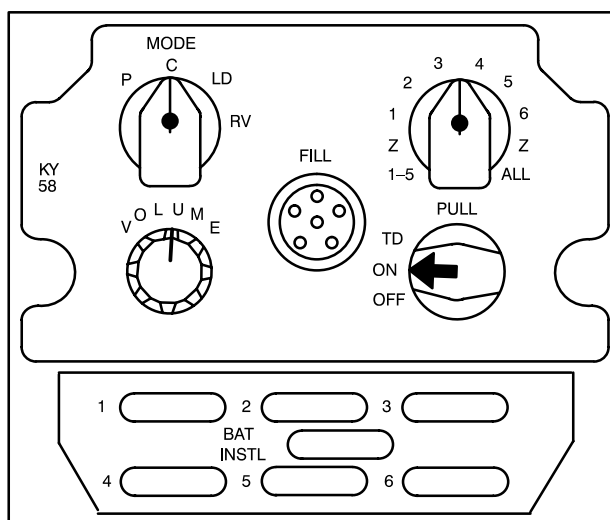
- (1) **POWER** switch is used to turn set on and off.
- (2) Fill rotary switch is used to select one of six crypto-net variables (CNVs).
- (3) **ZEROIZE** toggle switch is housed under a spring cover. The switch is used in an emergency to zero all CNVs from in the TSEC/KY-58 registers. The TSEC/KY-58 is unusable until new variables are loaded.
- (4) **C/RAD 1/PLAIN** switch positions are as follows.
 - (a) **PLAIN** selects clear VHF AM-FM (ADH) or VHF/FM (ADI) communications.
 - (b) **C/RAD 1** selects secure voice VHF AM-FM (ADH) or VHF/FM (ADI) communications.
- (5) **MODE** switch positions are as follows.
 - (a) **OP** enables pilot VHF AM-FM (ADH) or VHF/FM (ADI) receiver/transmitter in either **C/RAD 1** or **PLAIN** mode.
 - (b) **LD** allows the installation of CNVs into the TSEC/KY-58.
 - (c) **RV** enables manual remote keying.
- (6) **DELAY** is not used.

16-3. THEORY OF OPERATION (cont)

16-3

I.1. **TSEC/KY-58.** The TSEC/KY-58 contains external access and storage area for six crypto-net variables. These variables are used during the cipher mode. The unit contains a battery for maintaining memory. The TSEC/KY-58 has the following controls (fig. 16-16.2).

- (1) **VOLUME** variable control adjusts the audio level to pilot VHF AM-FM (ADH) or VHF/FM (ADI) receiver/transmitter.
- (2) **MODE** rotary switch positions are as follows.
 - (a) **P** selects clear operation of VHF AM-FM (ADH) or VHF/FM (ADI) communications.
 - (b) **C** selects secure voice VHF AM-FM (ADH) or VHF/FM (ADI) communications.
 - (c) **LD** allows installation of CNVs into the TSEC/KY-58.
 - (d) **RV** allows manual remote keying.
- (3) **FILL** connector allows loading of the CNVs into the TSEC/KY-58 registers.
- (4) Fill rotary switch positions are as follows.
 - (a) **Z1-5** zeroizes (deletes) CNVs in TSEC/KY-58 registers 1-5.
 - (b) **1, 2, 3, 4, or 5** selects desired CNV.
 - (c) **Z-ALL** zeroizes CNVs in all (1-6) TSEC/KY-58 registers. Zeroizing all registers renders the TSEC/KY-58 unusable.
- (5) Power rotary switch positions are as follows.
 - (a) **OFF** turns off TSEC/KY-58 and pilot VHF AM-FM (ADH or VHF/FM (ADI) receiver transmitter.
 - (b) **ON** turns on TSEC/KY-58 and pilot VHF AM-FM (ADH) or VHF/FM (ADI) receiver transmitter.
 - (c) **TD** is not used.



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Figure 16-16.2. TSEC/KY-58

16-3. THEORY OF OPERATION (cont)

16-3

I.2. **Power Interface Adapter Z-AHQ.** The power interface adapter Z-AHQ adapts existing aircraft wiring from TSEC/KY-28 for use with TSEC/KY-58 communication security unit. The Z-AHQ selects frequency range and modulation mode. The Z-AHQ has the following controls (fig. 16-16.3).

(1) **FILTER IN/OUT** selector toggle switch positions are as follows.

(a) **IN** prevents adjacent channel interference when using radios with channel spacing of 25 KHz. The switch must be set to **IN** for pilot VHF AM-FM (ADH) or VHF/FM (ADI) receiver transmitter.

(b) **OUT** disables the filter.

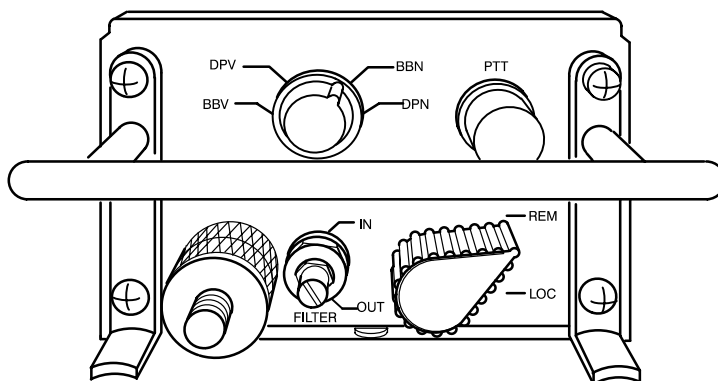
(2) **BBV, DPV, BBN, DPN** rotary switch selects the type of radio being secured. The switch must be set to **BBV** for pilot VHF AM-FM (ADH) or VHF/FM (ADI) receiver transmitter.

(3) **PTT** (push-to-talk) button clears the crypto alarm which occurs on power up.

(4) **REM** (remote)/**LOC** (local) rotary switch positions are as follows.

(a) **REM** allows remote keying of **PTT** button.

(b) **LOC** sets power interface adapter to local mode. The switch returns to **REM** position when released, but equipment remains in local mode until any **PTT** is keyed.



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Figure 16-16.3. Power Interface Adapter Z-AHQ

16-3. THEORY OF OPERATION (cont)

16-3

NOTE

The KY-58 secure voice set (VHF-FM 1) is installed in the aft avionics bay only when required. When a set is not required, a jumper cable is installed.

m. Circuit Protection.

(1) Circuit breakers **VHF FM** (CB64) and **KY 28** (CB30), located in the pilot's center circuit breaker panel (fig. 16-17), provide circuit protection for the VHF 1 system.

(2) Circuit breaker **VHF AM/FM** (CB32), located in the CPG's circuit breaker panel, provides circuit protection for the VHF 2 system.

n. VHF Transmitter/Receive Operation (fig. 16-18). The VHF AN/ARC-186 (ADH) transmitters/receivers are simultaneously tuned to the same frequency by selector knobs on the front panel. The VHF AN/ARC-186 (ADI) transmitter/receiver is tuned by selector knobs on the front panel and the VHF/FM AN/ARC-201A is tuned by a keyboard.

(1) The VHF 1 receive RF signal is routed from the antenna directly to the radio set and converted to audio.

(2) The audio signal is sent to the audio junction unit and audio is applied to the primary of audio transformer T3, which induces a signal into the two secondary windings. One set of windings couple the signal to the pilot's CSC panel. The CSC provides amplification, volume control, and sends the signal back to the audio junction unit where the signal is jumpered to the pilot's headset. The other set of secondary windings couple the audio signal to the CPG's CSC panel. The CSC panel provides amplification, volume control, and sends the signal back to the audio junction unit where the signal is jumpered to the CPG's headset.

(3) The VHF 2 receive operation is identical to VHF 1, except audio transformer T1 is used. Both crew members can monitor both VHF radios by setting monitor switch/potentiometers **1** and **3** to on and adjusting the volume.

o. VHF Transmit Operation (fig. 16-19). Either crew member can transmit on either VHF radio (ADH) by placing the transmit select switch on the respective CSC panel to position **1** to transmit on the VHF 1, or position **3** to transmit on the VHF 2. The VHF AN/ARC-186 communications are available to the CPG but not to the pilot when the AN/ARC-201A is installed (ADI).

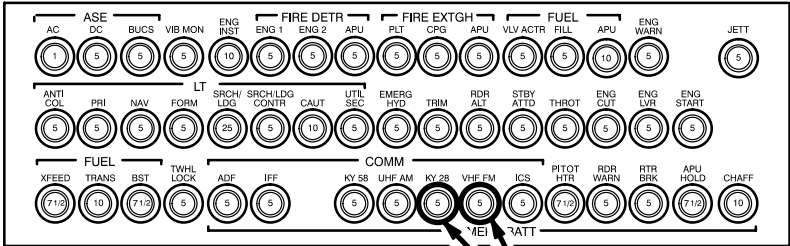
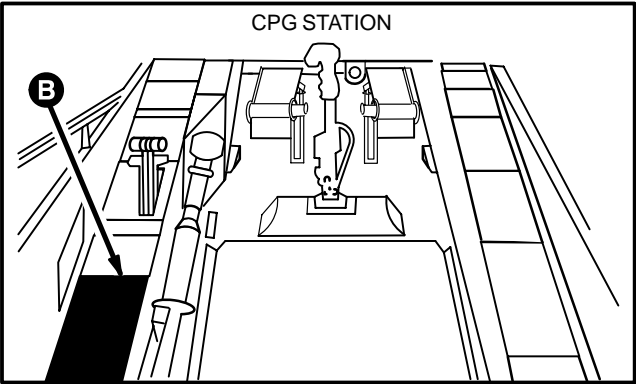
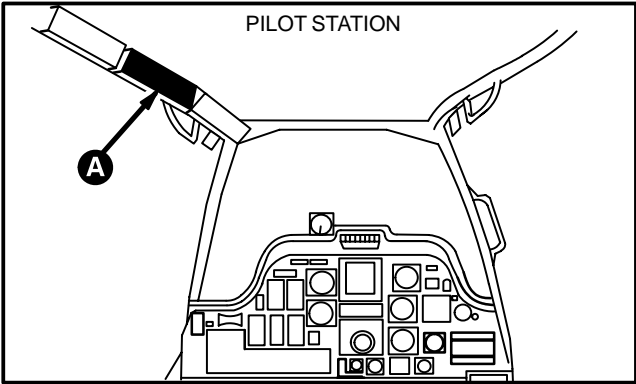
(1) **Pilot Transmission 2.** The pilot must select position **3** on the CSC panel transmit select switch, or set the transmit select switch to **RMT** and use the **RTSS** switch to select CPG VHF as indicated on the RTS panel.

(a) Transmit side tone is generated by the VHF and sent back to the headsets via the same path as receiver audio.

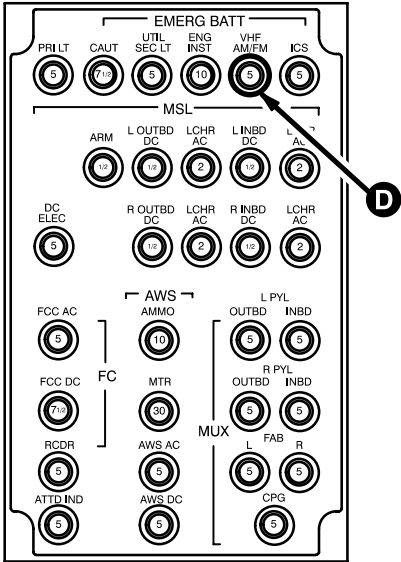
(b) When the pilot presses the PTT switch and speaks into the microphone, an audio signal is developed and sent through the RTS panel to the pilot's CSC panel.

(c) The CSC panel amplifies the signal and sends the signal back through the RTS panel.

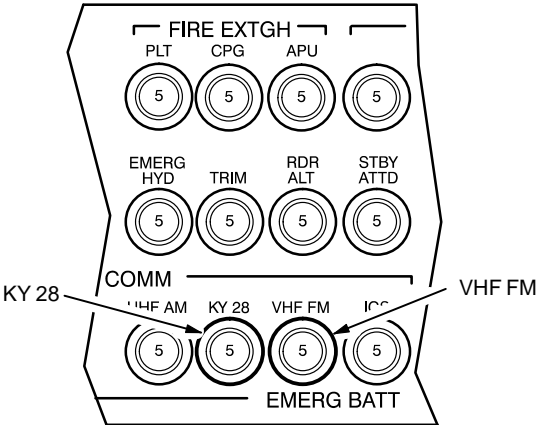
(d) The signal is routed from J2 to the primary winding of T4.



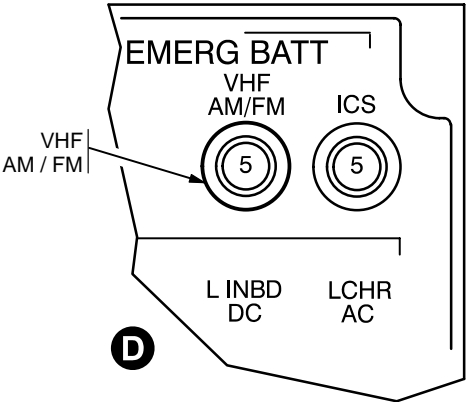
A PILOT CENTER CIRCUIT BREAKER PANEL



B CPG CIRCUIT BREAKER PANEL 1



C



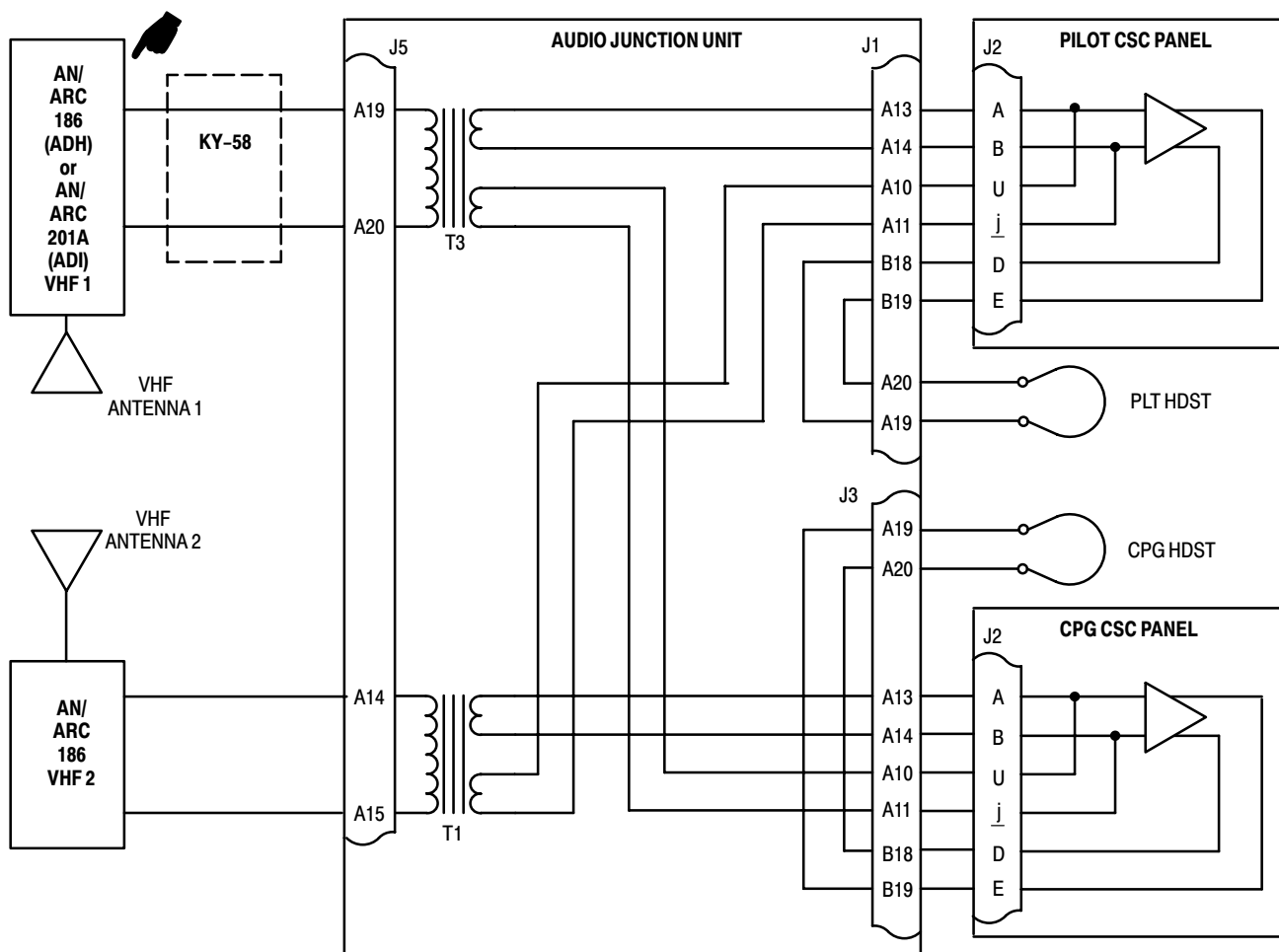
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M52-244A

Figure 16-17. VHF Circuit Breakers

16-3. THEORY OF OPERATION (cont)

16-3



M52-245B

Figure 16-18. VHF Receive Block Diagram

(e) The signal is induced into the secondary winding and is sent to the CPG's VHF radio.

(f) The VHF radio processes the audio signal and converts the audio to an RF signal.

(2) **CPG Transmission 2.** When the CPG presses either radio PTT switch and speaks into the microphone, an audio signal is generated and coupled through the audio junction unit to the CPG CSC panel.

(a) The signal is amplified by the CSC panel and applied back to the audio junction unit to the primary of audio transformer T4.

(b) The secondary of T4 supplies the audio signal to the VHF transmitter.

(c) The transmitter processes the audio signal and converts audio to an RF signal.

(d) The RF signal is broadcast out through the antenna.

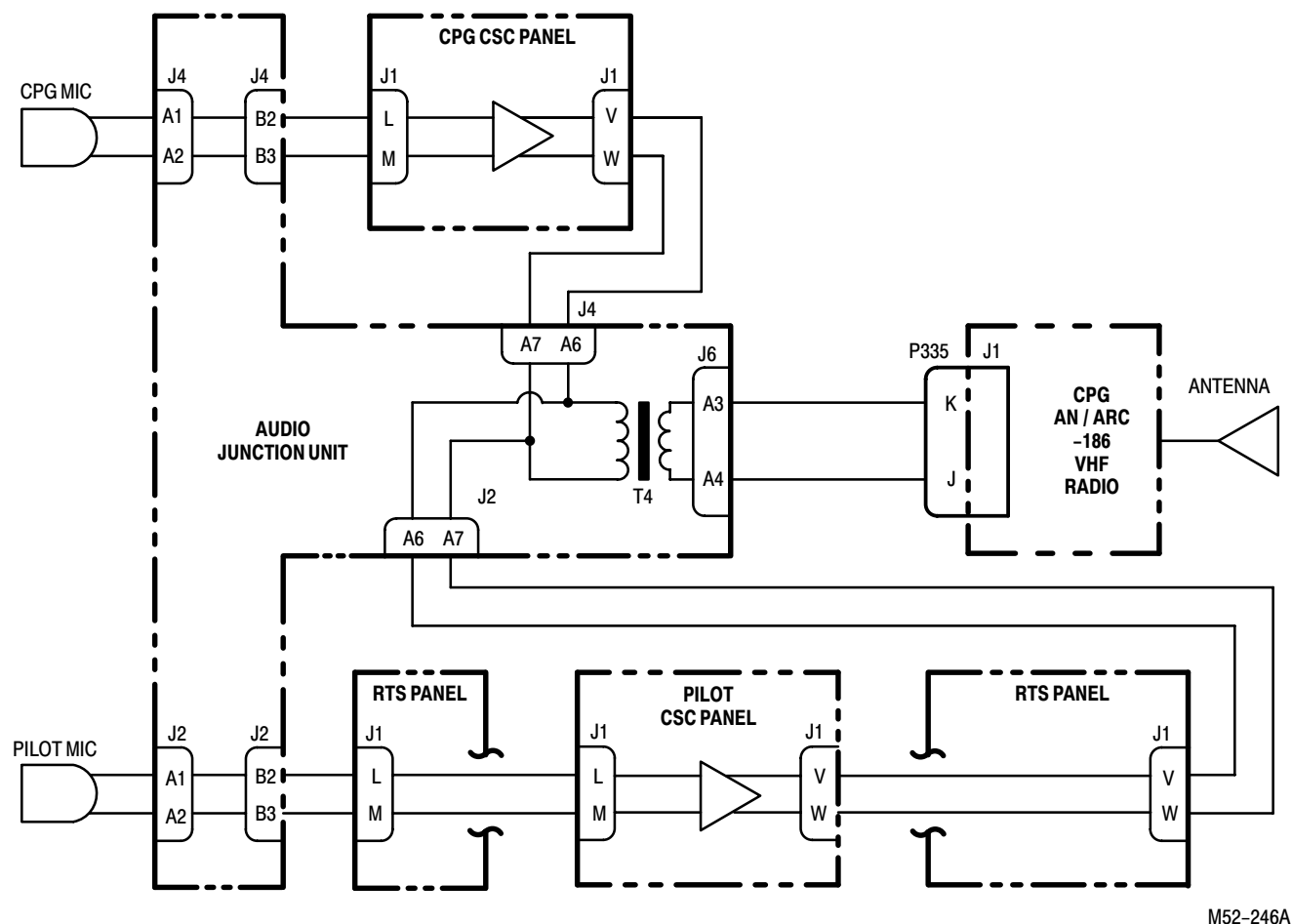


Figure 16-19. VHF Transmit Block Diagram

p. RT-1167/ARC-164, RT-1167C/ARC-164 and RT-1518/ARC-164.

(1) The UHF AM transceivers (fig. 16-19.1) frequency range is 225.000 to 399.975 MHz in 25 KHz steps with constant monitoring of the guard/emergency frequency of 243.000 MHz. RT-1167C/ARC-164 and RT-1518/ARC-164 have the same capabilities as RT-1167/ARC-164 plus a **HAVE QUICK** anti-jamming mode. Transmit power is a nominal 10 watts in wide or narrowband operation.

(2) The **HAVE QUICK** operation provides a jam resistant capability through a frequency hopping technique. Frequency hopping is a technique in which the frequency being used for a given channel is automatically changed at some rate common to the receiver and transmitter. The standard, single frequency UHF voice mode of operation is referred to as the normal mode. The frequency hopping UHF mode of operation is referred to as the anti-jam (AJ) mode. In the AJ mode, the following parameters are necessary for successful operation.

- (a) Common frequency. The common frequencies have been programmed into all AJ radios.

16-3. THEORY OF OPERATION (cont)

16-3

(b) Time synchronization. Time synchronization is provided via UHF radio or EGI. Universal Time Coordinated (UTC) is supplied by EGI. A time-of-day (TOD) signal must be initiated each time the radio is turned on. TOD transmission and reception is possible in both normal and AJ modes. The radio accepts the TOD message initiated after the radio is turned on and the word-of-day (WOD) is transferred. Subsequent messages are ignored unless the **T** position is selected with the **A-3-2-T** knob and returned to a normal channel for normal operation or **A** for AJ operation. The radio then accepts the next TOD update, provided the TOD update arrives within 60 seconds of selection. Transmission of timing information in flight is accomplished by momentarily pressing the **STONE** button. A time transmission allows a time update if one radio has drifted out of synchronization. A tone is heard in the headset if TOD was not initially received.

(c) Common hopping rate and pattern. Common hopping rate and pattern are determined by operator inserted WOD. The WOD is a multi-digit code, common world-wide to all **HAVE QUICK** users. WOD is entered by selecting one or more of six preset channels 20 through 15. Entering a new WOD is accomplished by starting at channel 20 and using the same method as entering preset frequencies in the normal mode with the frequency select knobs and the **PRESET** button. After each entry, a single beep is heard until channel 15 entry; a double beep is heard indicating the radio has accepted all six WOD entries. A tone is heard in the headset if WOD was not entered.

(d) Common net number. Common net number is a communications channel instead of a signal frequency. After TOD and WOD are entered, any valid net number can be selected by use of the manual frequency knobs.

(3) The front panel contains the following items.

(a) Frequency selector switch 1 (**A-3-2-T**). Manual frequency select switch for 100's digit of frequency (2 or 3) MHz in the normal mode or the 100's digit of the WOD in the AJ mode. The **A** position selects the AJ mode. The **T** position (spring-loaded) allows the radio to receive a new TOD or for emergency clock start.

(b) Frequency selector switch 2. Manual frequency select switch for 10's digit of frequency (0 through 9) MHz in the normal mode, and the second digit of the WOD or net number in the AJ mode.

(c) Frequency selector switch 3. Manual frequency select switch for unit's digit of frequency (0 through 9) MHz in the normal mode, and the third digit of the WOD or net number in the AJ mode.

(d) Frequency selector switch 4. Manual frequency select switch for tenths digit of frequency (0 through 9) MHz in the normal mode, and the fourth digit of the WOD or net number in the AJ mode.

(e) Frequency selector switch 5. Manual frequency select switch for hundredths and thousandths digits of frequency (00, 25, 50, or 75) MHz in the normal mode, and the fifth digit of the WOD or net number in the AJ mode.

(f) Frequency indicators (frequency/status indicator RT-1518/ARC-164). The frequency indicators display the frequency selector switch settings. The frequency/status indicator displays the following status messages when the **STATUS** switch is pressed.

- **M-LOAD.** Indicates control is in multiple WOD load mode.
- **FMT.CNG.** Indicates control is in frequency management training change mode. This mode is used for training and maintenance.
- **ERASE.** Indicates multiple WOD erase mode.

16-3. THEORY OF OPERATION (cont)

16-3

- **FILL.** Indicates that a fill device is connected to the front panel.
- **BAD.** Indicates that an invalid WOD has been received or that WOD was not successfully received.
- **WOD OK.** Indicate that a WOD has been successfully received.

(g) Preset channel selector switch. The preset channel selector switch is used to store and select one of 20 preset channels in the normal mode. Stores and selects channels 20 through 15 for WOD in the AJ mode.

(h) **CHAN** indicator. Indicates selected preset channel.

(i) **STATUS** switch (RT-1518/ARC-164). When pressed, the frequency/status indicator display status messages.

(j) **MANUAL-PRESET-GUARD (MNL-PRESET-GRD** RT-1518/ARC-164) selector switch. Selects method of frequency selection. Positions are as follows.

- **MANUAL** position allows selection of any of 7000 frequencies using the five frequency selector switches.
- **PRESET** position allows use of the preset channel selector switch to select any one of 20 preset channels as indicated on the **CHAN** indicator.
- **GUARD** position automatically tunes the main receiver and transmitter to the guard frequency. The **GUARD** position blocks out any frequency set either manually or preset.

(k) **SQUELCH ON-OFF** switch. Turns squelch of main receiver on or off.

(l) **VOL** control. Controls the audio volume.

(m) **TONE** switch. Enables transmission and headset monitoring of a 1020 Hz tone on selected frequency for maintenance checks in the normal mode. Transmits TOD followed by 1020 HZ tone and is used with the **A-3-2-T** switch for emergency clock start in the AJ mode.

(n) **MODE SELECTOR** switch positions are as follows.

- **OFF** position turns power off.
- **MAIN** position enables the transceiver.
- **BOTH** position enables transceiver and guard receiver. If AJ mode is selected, any guard transmission takes precedence over the AJ mode.
- **ADF** position is not used.

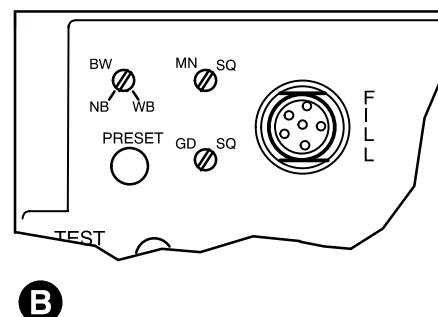
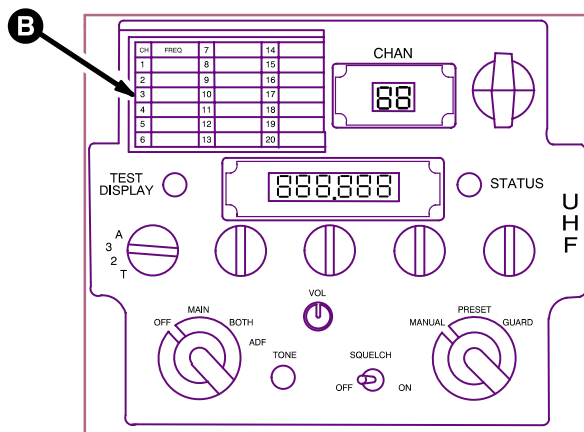
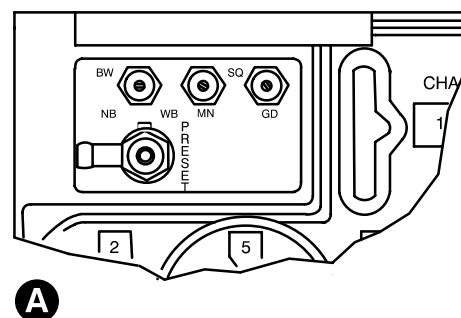
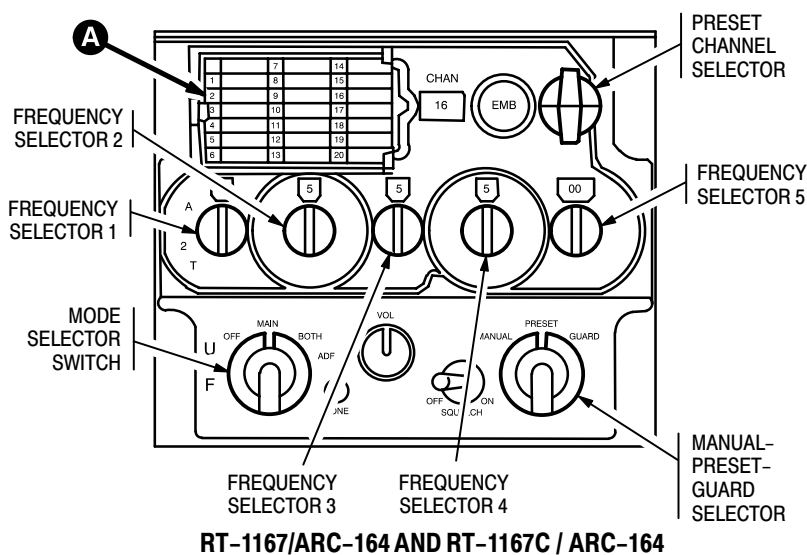
(o) **TEST DISPLAY** switch (RT-1518/ARC-164). When pressed, lights all segments of the frequency/status and **CHAN** indicators.

(p) Snap-on cover is used to cover the **PRESET** switch, bandwidth select switch, main squelch adjust, guard squelch adjust and **FILL** connector (RT-1518/ARC-164).

- **PRESET** switch is used to load the 20 preset channels.
- Bandwidth select switch (**BW** RT-1518/ARC-164) selects wideband (**WB**) or narrowband (**NB**) main receiver operation.
- Main squelch (**MN SQ**) adjusts sets the squelch level of the main receiver.

16-3. THEORY OF OPERATION (cont)

16-3



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Figure 16-19.1. UHF Transceivers

- Guard squelch (**GD SQ**) adjusts sets the squelch level of the guard receiver.
 - **FILL** (RT-1518/ARC-164) connector provides an interconnection for a fill device, allowing semi-automatic loading of multiple WOD.
- (4) The back panel contains the following items.
- (a) J1 electrical connector.
 - (b) J3 auxiliary connector.

16-3. THEORY OF OPERATION (cont)

16-3

(c) J2 antenna connector.

(d) Fuse F1

(e) Fuse F2 (not used).

q. **UHF Antenna.** The UHF antenna is a blade/fin antenna with two connectors. One connector provides the UHF with transmission and reception; the other is used for IFF(ACS).

r. Deleted.

s. Deleted.

t. **UHF-AM Circuit Breaker.** Circuit breaker **UHF AM** (CB24) provides circuit protection for the UHF radio (fig. 16-20).

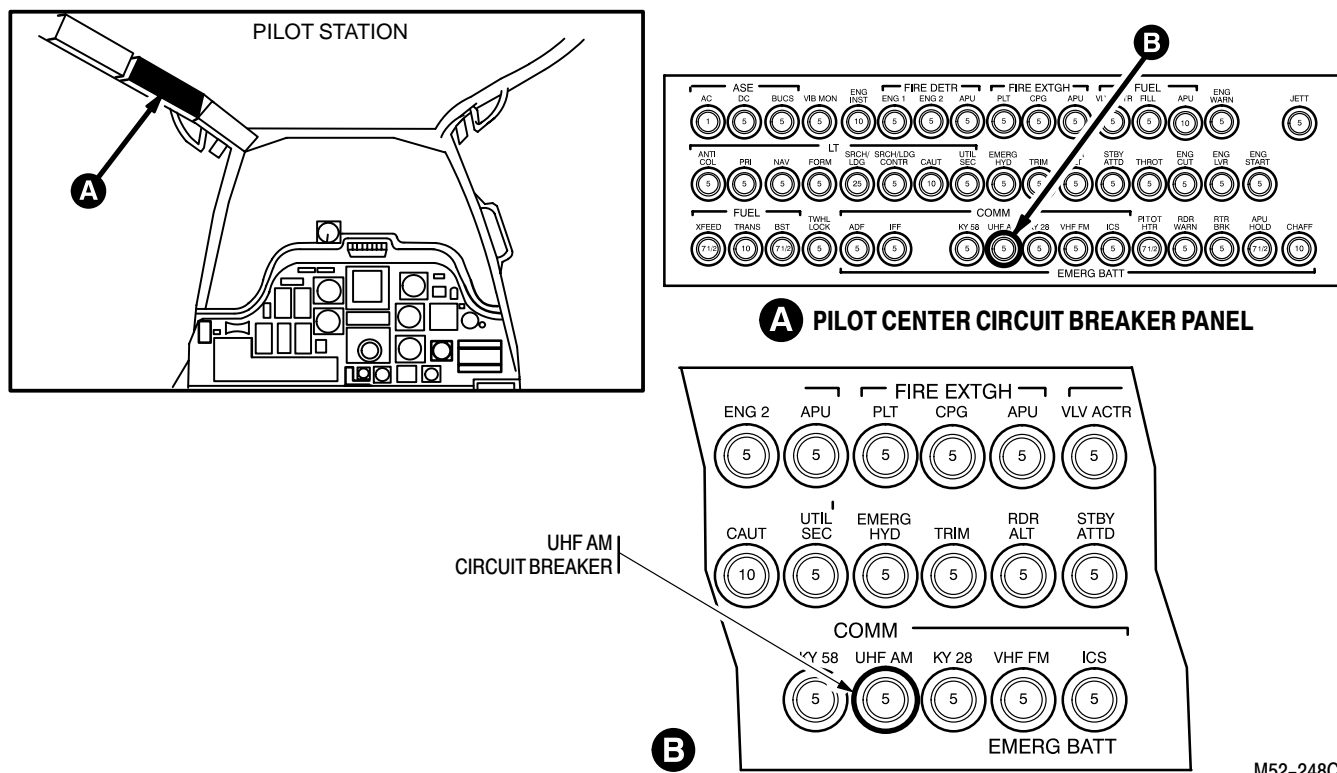


Figure 16-20. UHF Circuit Breaker

u. **UHF Transmit ICS Operation** (fig. 16-21). All transmit and receive operations of the UHF radio are controlled by the ICS.

(1) If the CPG wants to transmit on the UHF, the CPG CSC panel transmit select switch must be in position 2.

(a) When the radio PTT switch is pressed and the CPG speaks into the microphone, an audio signal is developed and sent to the CPG CSC panel via the audio junction unit.

16-3. THEORY OF OPERATION (cont)

16-3

(b) The CSC panel amplifies the signal and applies the signal to the primary of audio junction unit audio transformer T5.

(c) The output of the secondary of T5 is applied to the UHF R/T unit, then to the antenna via the bandpass filter.

(2) For UHF transmission from the pilot's station, the pilot's CSC transmit select switch must be in position **2** or **RMT**. **RMT** enables the RTSS.

(a) When the pilot presses the PTT switch and speaks into the microphone, an audio signal is developed and applied to the pilot's CSC panel via the RTS panel.

(b) The CSC panel amplifies the signal and sends the signal back through the RTS panel.

(c) The RTS panel couples the signal to the audio junction unit where the signal is applied to the primary of audio transformer T5.

16-3. THEORY OF OPERATION (cont)

16-3

(d) A signal is induced into the secondary of T5 and sent to the UHF R/T unit.

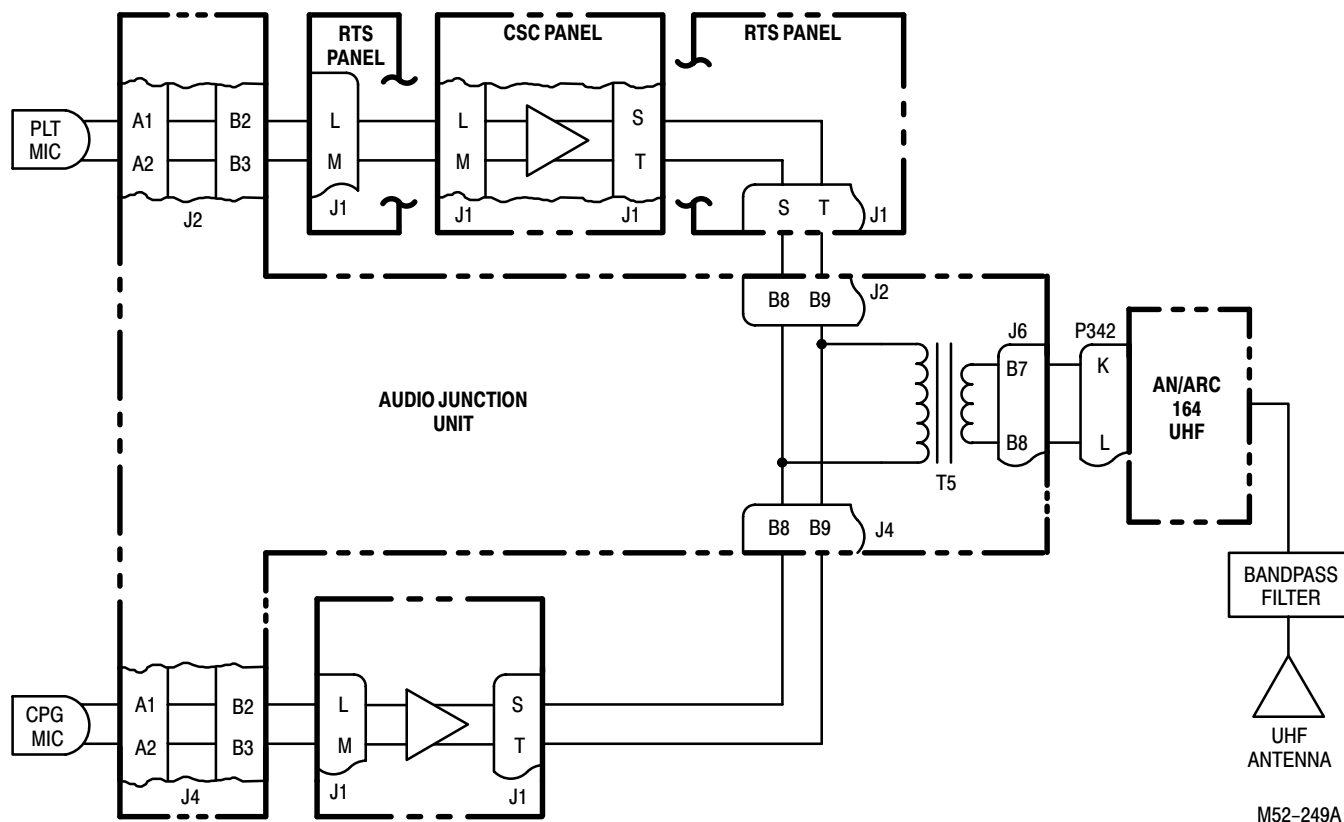


Figure 16-21. UHF Transmit Block Diagram

v. **UHF Receive ICS Operation** (fig. 16-22). The UHF antenna receives the RF signal and sends the signal to the R/T unit.

- (1) The R/T processes the RF signal and converts the RF signal to an audio signal.
- (2) The audio signal is applied to the primary of audio transformer T2.
- (3) One secondary of T2 is applied to the pilot's CSC panel and one secondary of T2 is applied to the CPG's CSC panel.
- (4) The CSC panels amplify the signals, and connect them to the respective headsets via the audio junction unit.

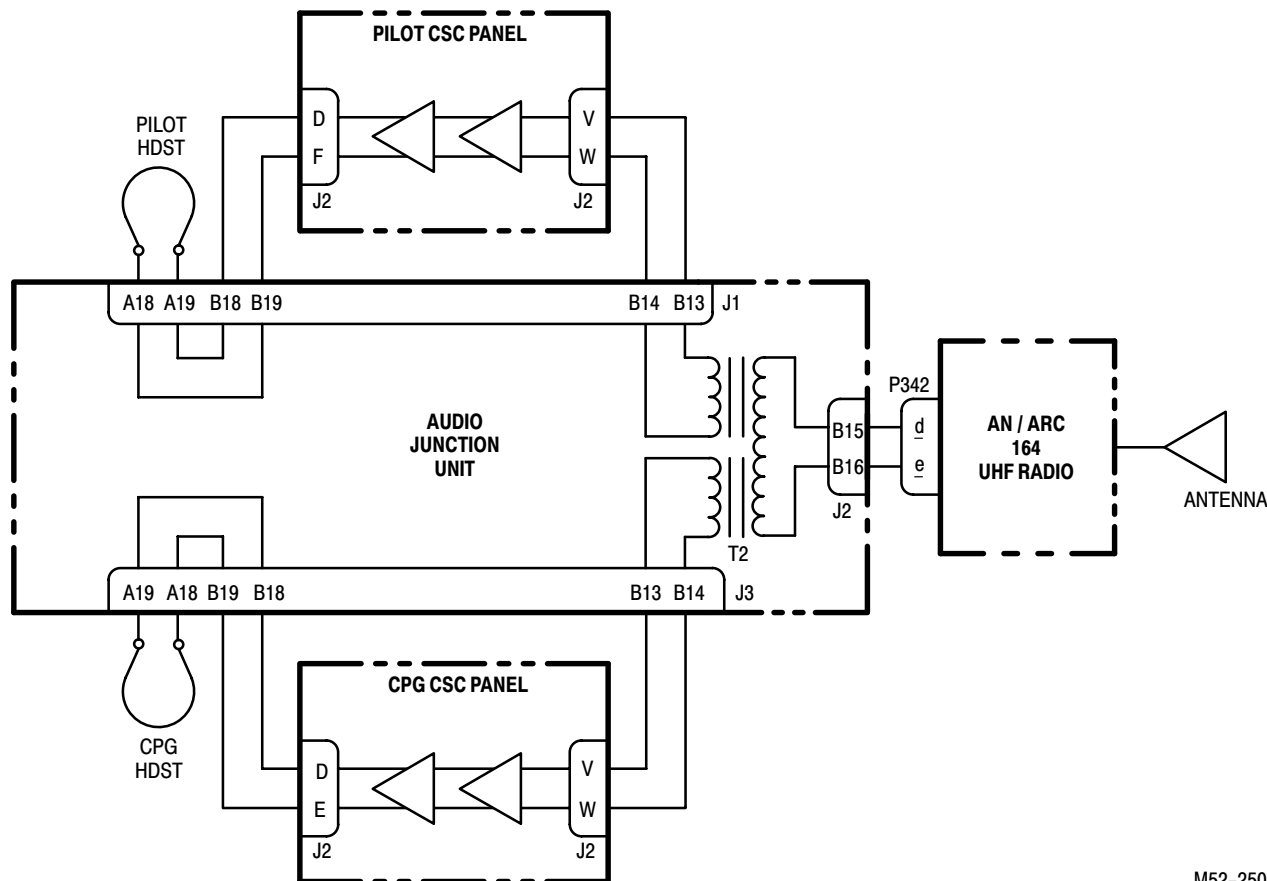


Figure 16-22. UHF Receive Block Diagram

w. **AN/ARN-89 (ACK) ADF.** The AN/ARN-89 ADF system provides an automatic or manual compass bearing on any radio signal within the frequency range of 100 to 3000 KHz. The ADF displays helicopter bearing relative to a selected radio station and has three modes of operation.

- (1) Continuous wave automatic direction finder.
- (2) Continuous wave manual direction finder.
- (3) AM broadcast receiver.

w.1. **AN/ARN-149 (ACJ) ADF.** The AN/ARN-149 ADF system provides an automatic compass bearing on any amplitude modulated (AM) or continuous wave (CW) radio signal within the frequency range of 100 to 2199.5 KHz. The ADF displays helicopter bearing relative to a selected radio station and has two modes of operation.

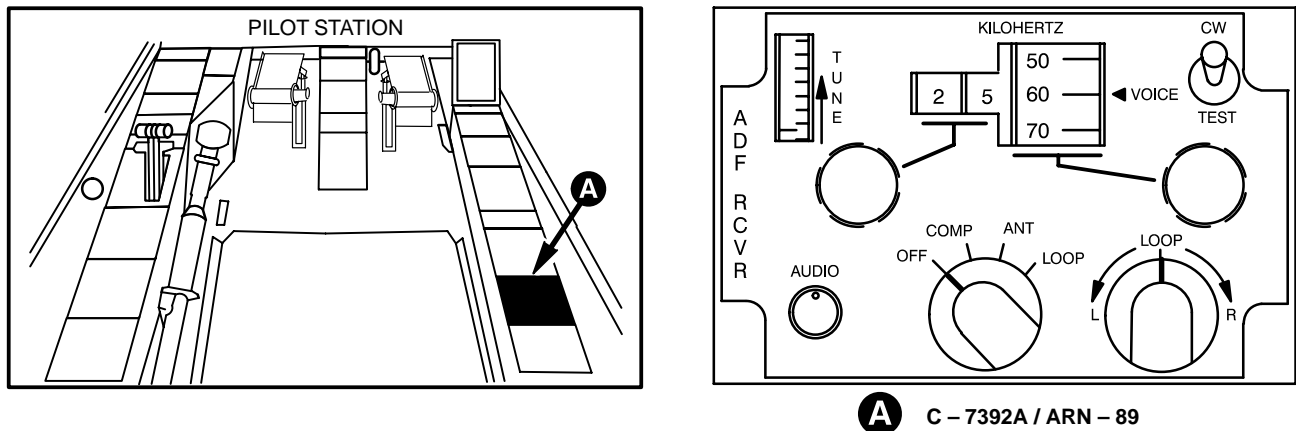
- (1) Continuous wave automatic direction finder.
- (2) AM and CW broadcast receiver.

x. **ADF RCVR Control Panel (ACK).** The switches and connectors on the ADF control panel perform the following functions (fig. 16-23).

16-3. THEORY OF OPERATION (cont)

16-3

- (1) Mode selector switch positions are as follows:
 - (a) **OFF** removes power from the set.
 - (b) **COMP** provides for operation as an ADF.
 - (c) **ANT** provides for operation as an AM receiver using the sense antenna.
 - (d) **LOOP** provides for receiver operation as a manual direction finder using only the loop antenna.



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Figure 16-23. ADF RCVR Control Panel (ACK)

- (2) **TUNE** Indicator indicates relative signal strength while tuning the set to a specific radio signal.
- (3) Coarse Tune Control tunes the receiver in 100-KHz steps as indicated by first two digits of the **KILOHERTZ** indicator.
- (4) Fine Tune Control tunes the receiver in 10 KHz steps as indicated by last two digits of the **KILOHERTZ** indicator.
- (5) **CW/VOICE/TEST** switch positions are as follows:
 - (a) **CW** has two modes of operation. **CW** in **COMP** mode enables the tone oscillator to provide an audible tone for tuning to a continuous wave (CW) station when the mode selector switch is in the **COMP** position. **CW** in **ANT** or **LOOP** mode enables the beat frequency oscillator to permit tuning to a CW station when the mode select switch is in the **ANT** or **LOOP** position.
 - (b) **VOICE** permits low frequency receiver to operate as a receiver when the mode selector switch is in any position.
 - (c) **TEST** (used in the **COMP** mode only) provides for slewing of the loop through 180° to check operation of the receiver in the **COMP** mode. The **TEST** position is inoperative in **LOOP** and **ANT** modes.
- (6) **LOOP L-R** control provides for manual left and right control of the loop when the mode selector is in the **LOOP** position.
- (7) **AUDIO** control adjusts audio volume.

16-3. THEORY OF OPERATION (cont)

16-3

x.1. **AN/ARN-149 ADF Control Panel (ACJ).** The switches and connectors on the **ADF** control panel perform the following functions (fig. 16-23.1).

(1) **ADF/ANT/OFF** selector switch positions are as follows:

- (a) **ADF** provides for operation as an ADF.
- (b) **ANT** provides for operation as an AM receiver.
- (c) **OFF** removes power from the set.

Figure 16-23.1. ADF Control Panel (ACJ)

(2) **TAKE CMD.** Not used.

(3) **VOL.** Adjusts the volume in 12 discrete steps.

(4) **TEST/TONE** switch positions are as follows.

- (a) **TEST.** Selects test submode. RMI pointer momentarily shifts 90° as an indication of self test.
- (b) **TONE.** Selects a 1000 Hz tone for CW use.

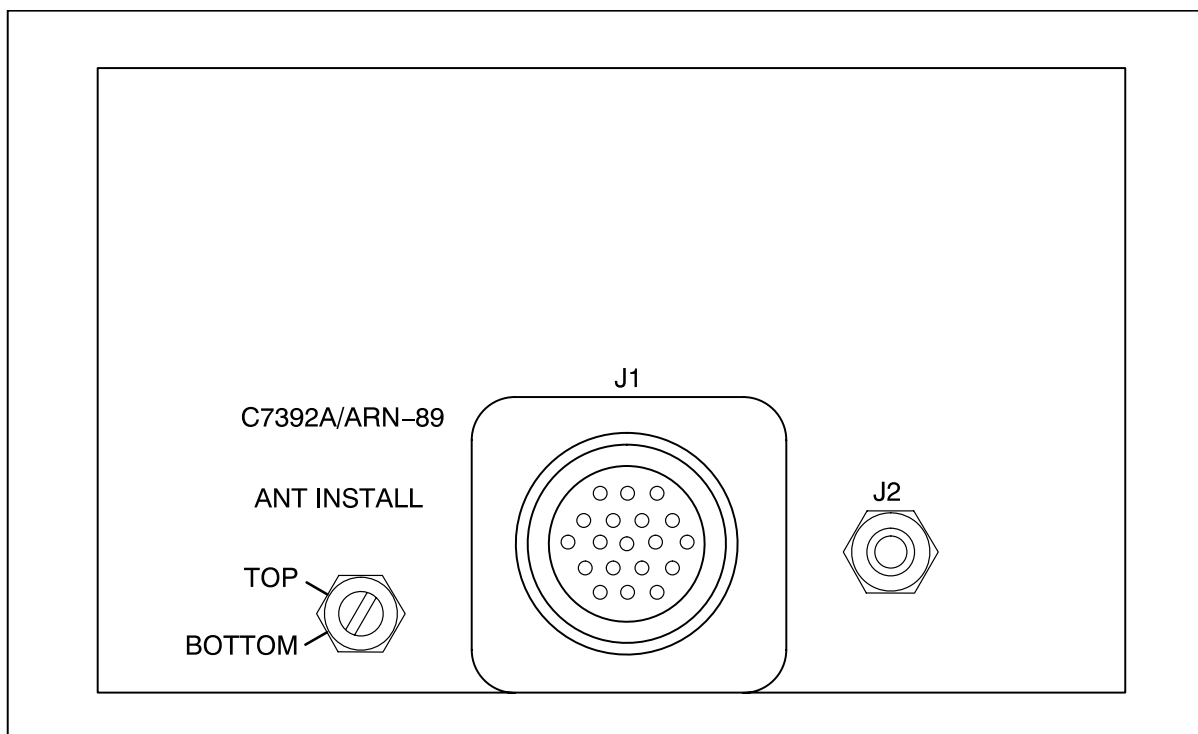
(5) **MAN/2182/500** switch positions are as follows.

- (a) **MAN.** Enables manual controls and indicators.
- (b) **2182.** Selects 2182 KHz emergency frequency.
- (c) **500.** Selects 500 KHz emergency frequency.

y. **ADF RCVR Control Rear Panel (ACK)** (fig. 16-24). The rear panel provides for the following items .

- (1) **ANT INSTALL** switch selects top or bottom antenna (the AH-64A uses the **BOTTOM** antenna).
- (2) J1 provides connection for signal and control.
- (3) J2 provides antenna connection.

y.1. **ADF Control Rear Panel (ACJ).** The rear panel provides one connector (J1) for system interfacing.



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Figure 16-24. ADF RCVR Control Rear Panel (ACK)

z. **ADF Receiver (ACK).** The receiver has two signal and power connectors (J1 and J2), and four coaxial connectors (J3 through J6). A circular goniometer indicator window in the top cover of the case shows the angle of the antenna position.

z.1. **ADF Receiver (ACJ).** The receiver contains one connector for system interfacing.

aa. **Sense Preamplifier (ACK).** The sense preamplifier provides amplification of signals picked up by the sense antenna and impedance matches the antenna to the receiver.

ab. **Pilot ADF controls and indicators** (fig. 16-25).

(1) The **ADF** circuit breaker is 28 VDC, 5 amp thermal circuit breaker located on the pilot's overhead center circuit breaker panel.

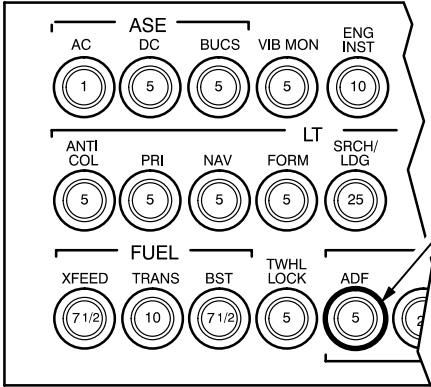
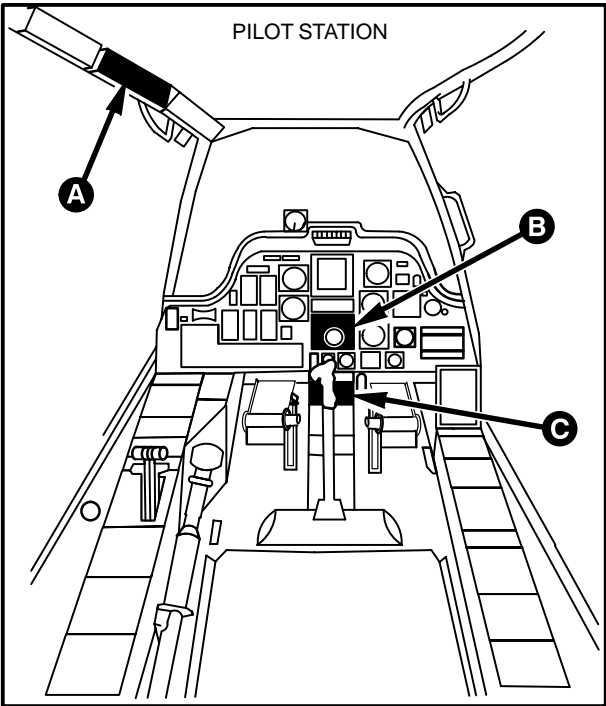
(2) HSI needle 2 indicates bearing to the station tuned into the ADF receiver.

(3) CSC panel **NAV A MON** switch/rheostat controls ADF receive volume to the headset.

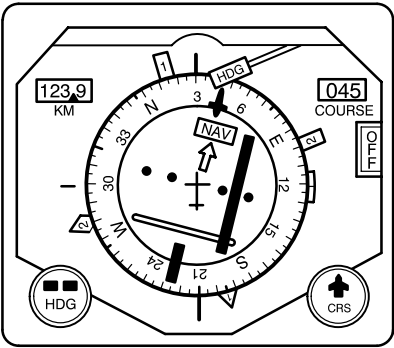
ac. **CPG ADF controls and indicators** (fig. 16-26).

(1) RMI bearing pointer is driven by the ADF.

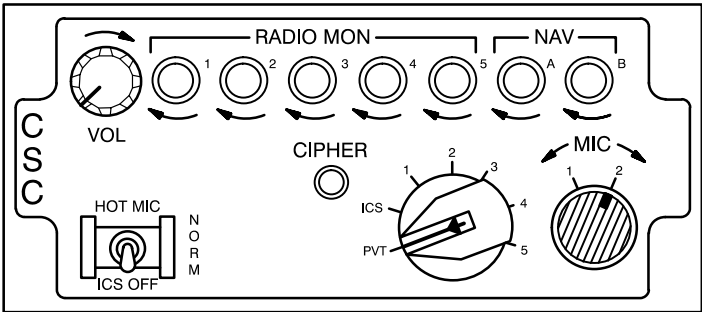
(2) CSC panel **NAV A MON** switch/rheostat controls ADF receive volume to the headset.



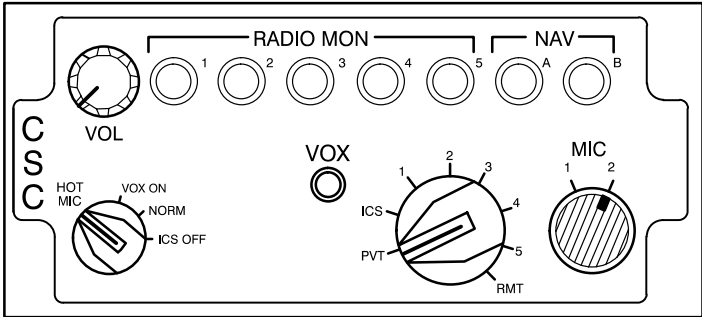
A PILOT CENTER CIRCUIT BREAKER PANEL



B HSI



MODEL C-10414 (V)3/ARC COMMUNICATION SYSTEM CONTROL (CSC) PANEL



C MODEL C-11746 (V)4/ARC COMMUNICATION SYSTEM CONTROL (CSC) PANEL

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Figure 16-25. Pilot ADF Controls and Indicators

16-3. THEORY OF OPERATION (cont)

16-3

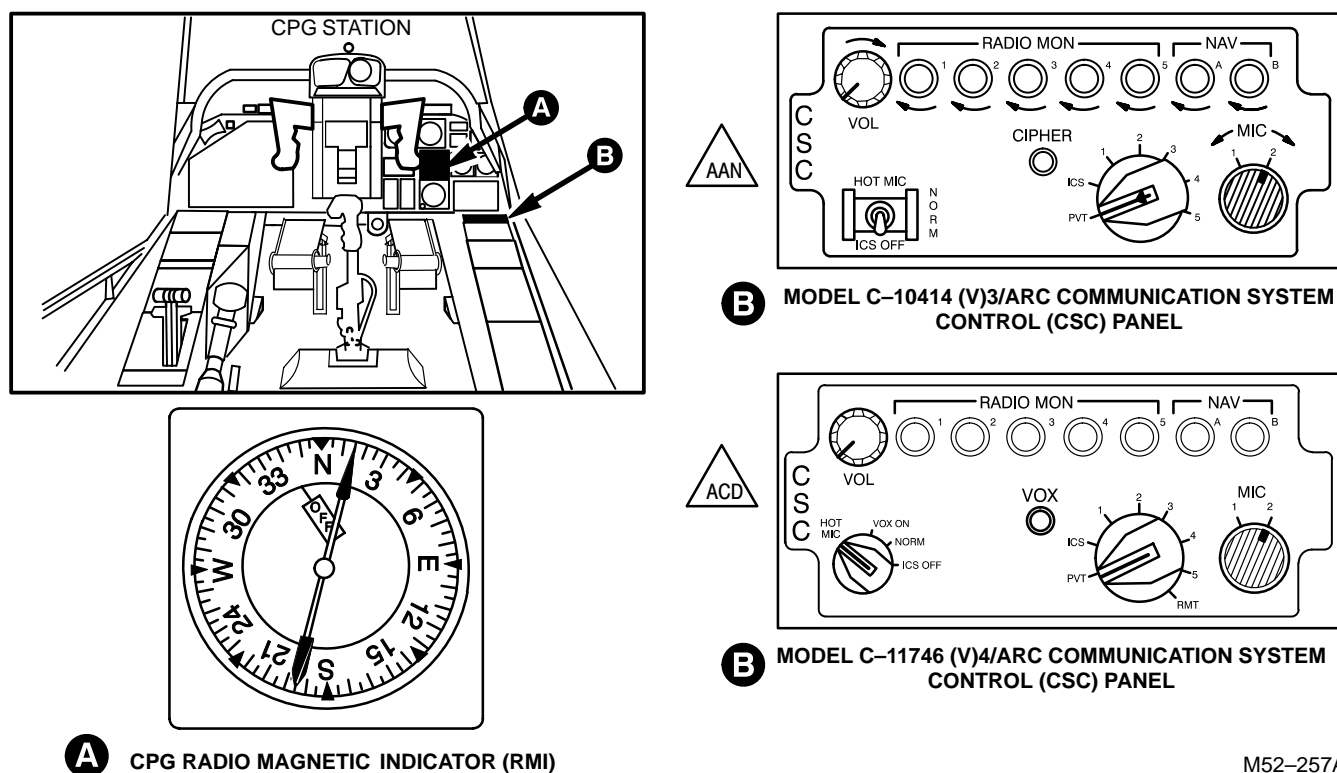


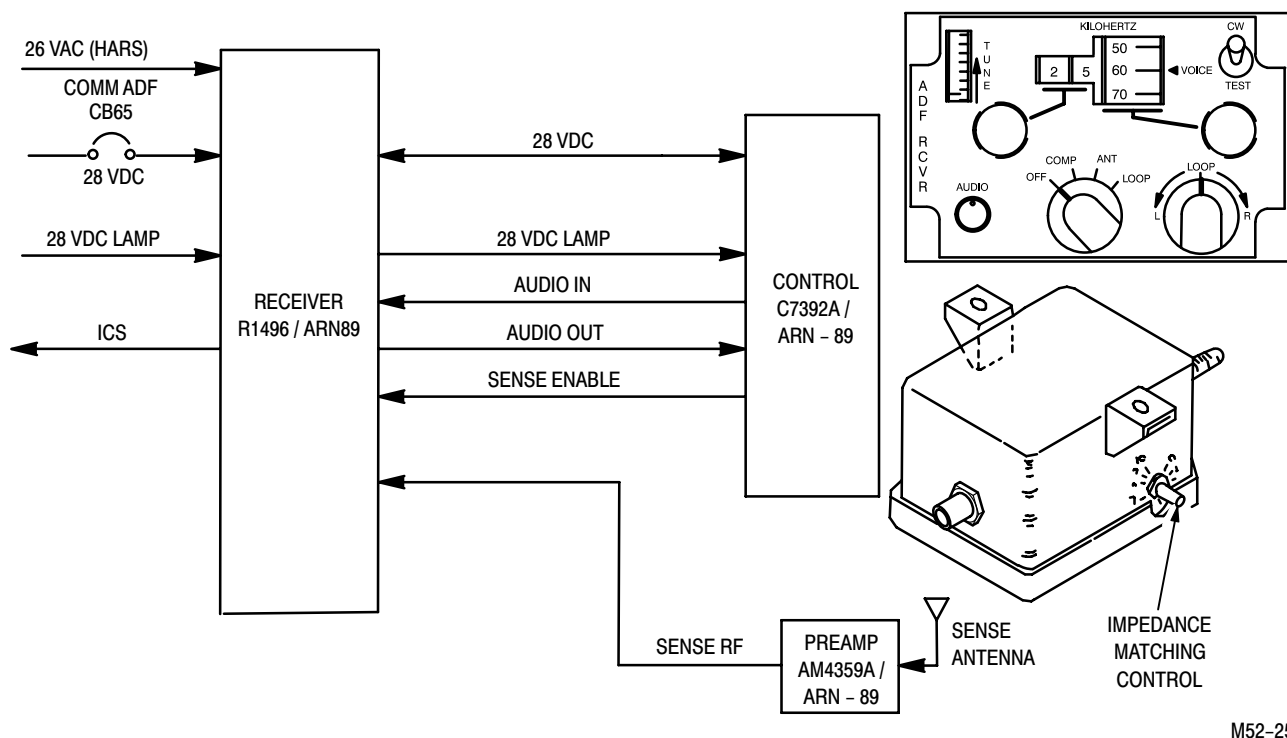
Figure 16-26. CPG ADF Controls and Indicators

ad. ADF Antenna Mode Operation (ACK) (fig. 16-27).

- (1) Power inputs are as follows.
 - (a) 28 VDC is applied to the ADF receiver from the dc emergency bus.
 - (b) 26 VAC synchro-reference voltage is supplied by the HARS.
 - (c) 28 VDC lamp voltage is supplied by the multichannel dimmer.
- (2) Antenna (**ANT**) mode operation (ACK).
 - (a) When mode select switch is placed in the **ANT** position, the sense antenna is enabled.
 - (b) The **CW/VOICE/TEST** switch must be placed in the **CW** or **VOICE** position.
 - (c) The sense antenna receives the AM signal and routes the signal to the preamplifier.
 - (d) The preamplifier matches the high sense antenna impedance to the low ADF receiver impedance, amplifies the RF signal, and applies the signal to the ADF receiver.
 - (e) The ADF receiver processes the RF signal and routes the audio portion of the signal to the tune indicator on the control panel, allowing the operator to fine-tune to the transmitting station frequency.
 - (f) The audio signal is routed back to the receiver for amplification and routing to the ICS.

16-3. THEORY OF OPERATION (cont)

16-3



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Figure 16-27. ADF Antenna Mode Block Diagram (ACK)

ae. ADF COMP and LOOP Mode Operation (ACK).

(1) Sense preamplifier impedance matching. The sense preamplifier has an impedance matching control which is manually adjusted for equal RF signal strength in the **LOOP** and **ANT** modes.

(a) Tune the ADF to a known station in the **LOOP** mode by peaking the **TUNE** indicator on the ADF control panel utilizing the **LOOP L/R** switch.

(b) After a peak is attained, place the mode select in the **ANT** position and duplicate the **LOOP** peak by adjusting the impedance matching control on the sense preamplifier.

(2) **LOOP** mode operation. The **LOOP** mode is the manual direction finding mode of operation.

(a) The mode selector switch is placed to **LOOP**, enabling both the sense antenna and the loop antenna.

(b) The rotor vane remains stationary until the **LOOP/L/R** switch is operated. As the **LOOP/L/R** switch is activated, the rotor vane moves.

(c) The operator detects the nulls by listening to the ADF or by observing the **TUNE** indicator.

(d) The direction information is displayed on the HSI and RMI.

(e) The **LOOP** mode audio processing is identical to the **ANT** mode.

(3) Compass (**COMP**) Mode Operation. The **COMP** mode is the automatic direction finding mode of operation. The **COMP** mode combines the loop antenna inputs with the sense antenna input to produce automatic and continuous bearing-station indications as well as audio.

16-3. THEORY OF OPERATION (cont)

16-3

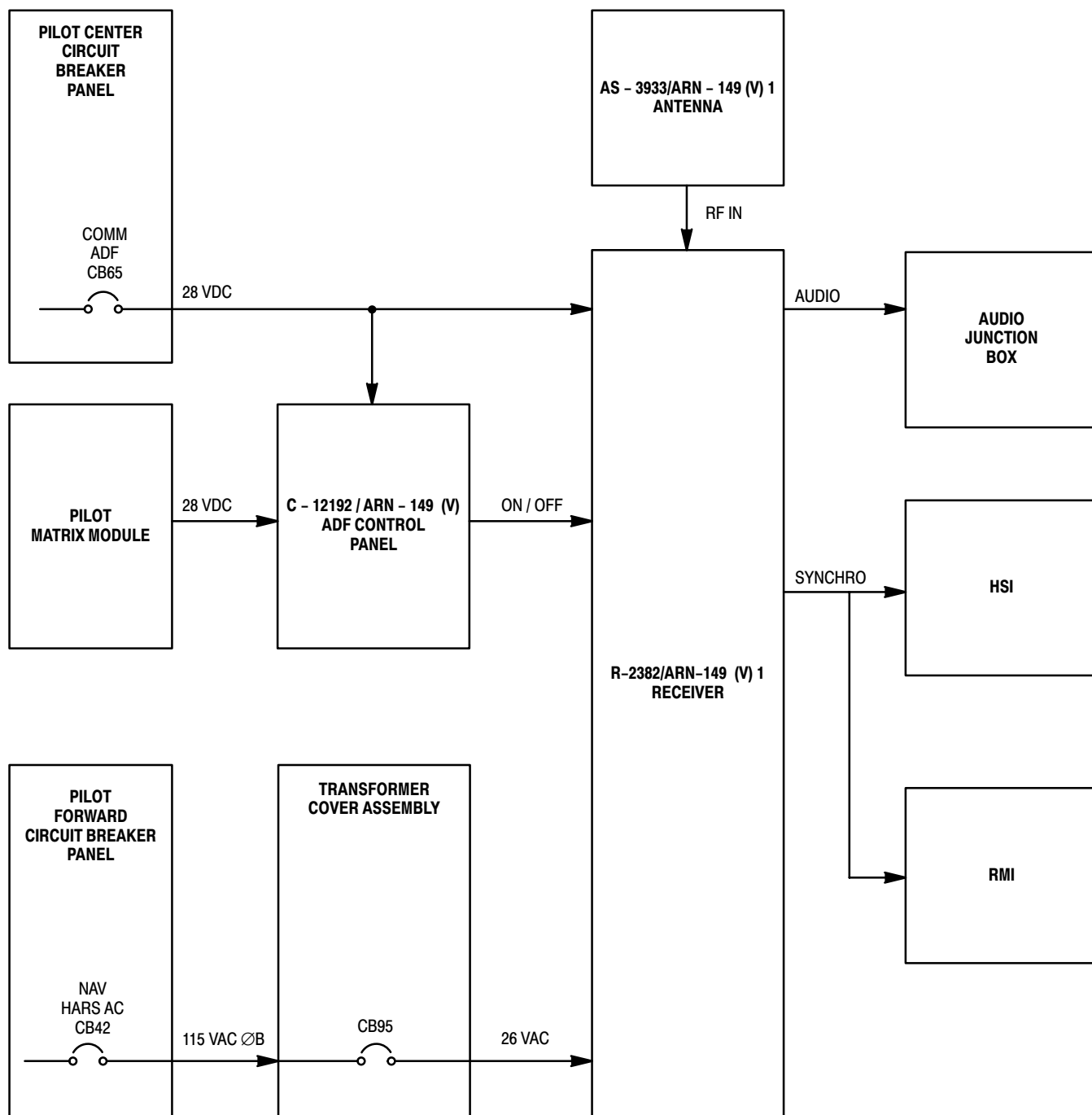
- (a) The **COMP** position of the mode selector switch enables both the sense and loop antennas.
- (b) The **CW/VOICE/TEST** switch must be selected to **CW** or **VOICE**.
- (c) The two loops in the loop antenna pick up the selected station's RF signal. The RF energy in each loop is amplified separately by preamps in the antenna assembly.
- (d) The loop input signals are then applied to the ADF receiver.
- (e) A loop difference signal is produced in the ADF receiver where the signal is combined with the sense antenna input.
- (f) The combined signal is processed through the ADF receiver and sent to mechanically position the goniometer to mechanically position the rotor vanes until the loop difference signal is nulled.
- (g) With no loop difference, the signal is inhibited which prevents further movement of the rotor vane.
- (h) The rotor vane is mechanically ganged to the rotor of a synchro transmitter.
- (i) The 3-wire stator output of the synchro transmitter is the bearing-to-station signal that drives the HSI and RMI.
- (j) The **TEST** position of the **CW/VOICE/TEST** switch is also used in the **COMP** mode, as follows.
 - Tune to a known station.
 - Hold the switch in the **TEST** position; the needle should rotate 180° to the right to the false null position.
 - When the test switch is released, the needle should return to the correct null.

ae.1. **AN/ARN-149 Operation (ACJ)** (fig. 16-27.1).

- (1) The **COMM ADF** circuit breaker (CB65) supplies 28 VDC to the **ADF** control panel and receiver.
- (2) The pilot matrix module supplies 28 VDC to the **ADF** control panel for edge lighting.
- (3) The **NAV HARS AC** circuit breaker supplies 115 VAC to the transformer cover assembly.
- (4) The transformer cover assembly steps down 115 VAC to 26 VAC.
- (5) The **NAV 26 VAC** circuit breaker (CB95) supplies 26 VAC to the receiver for reference voltage.
- (6) When **ANT** is selected, rf in from the antenna is processed and audio is outputted to the audio junction box.
- (7) When **ADF** is selected, rf in from the antenna is processed.
 - (a) Audio is outputted to the audio junction box.
 - (b) Synchro signals are outputted to the HSI and RMI providing heading information.

16-3. THEORY OF OPERATION (cont)

16-3



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Figure 16-27.1. ARN-149 ADF Block Diagram (ACJ)

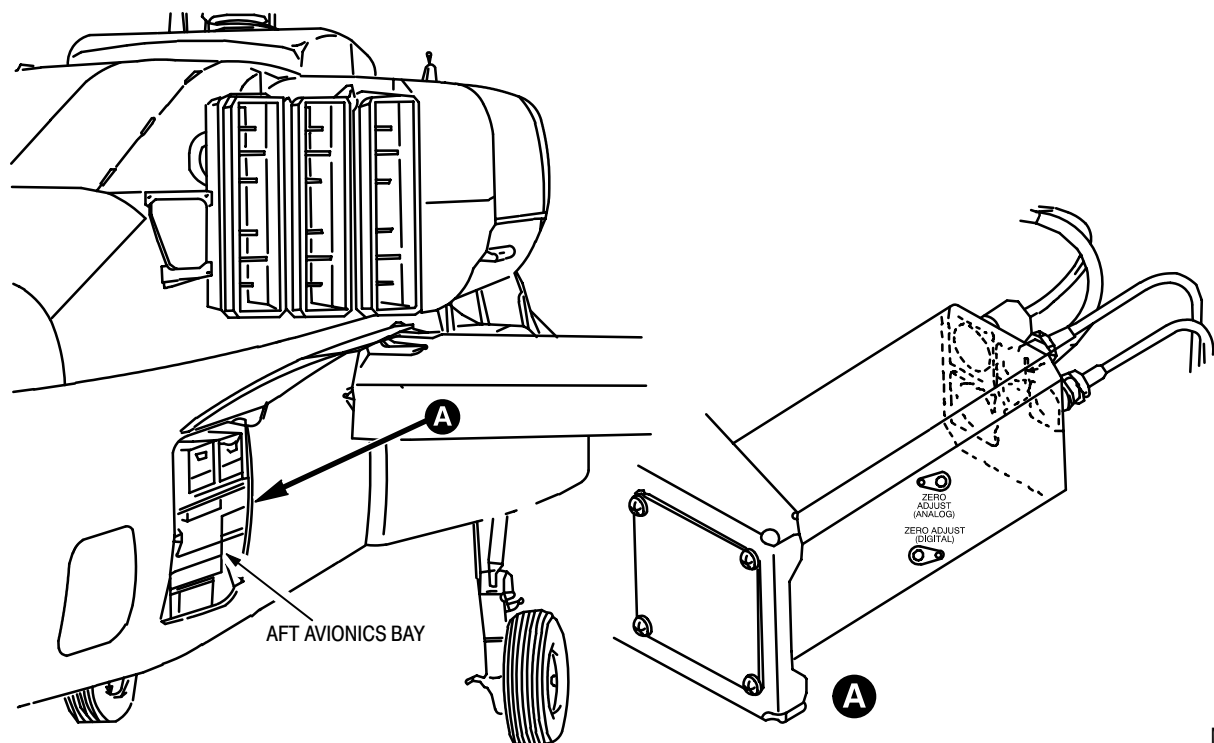
16-3. THEORY OF OPERATION (cont)

16-3

af. **AN/APN-209A.** The AN/APN-209A electronic altimeter set measures and displays the height of the aircraft above the ground or nearest terrain obstacle, from zero to 1500 feet. The system will operate at any airspeed within the capability of Army aircraft and at pitch and roll attitudes up to 45°.

ag. **RT-1411/APN-209A Receiver/Transmitter.** Functions of connectors and adjustments on the receiver/transmitter are as follows (fig. 16-28).

- (1) J1 is a signal and power connector.
- (2) J2 is a signal and power connector.
- (3) J3 is a receive coaxial connector.
- (4) J4 is a transmit coaxial connector.
- (5) Analog zero adjust is adjusted to 0 ± 3 feet.
- (6) Digital zero adjust is adjusted to 0 ± 3 feet.

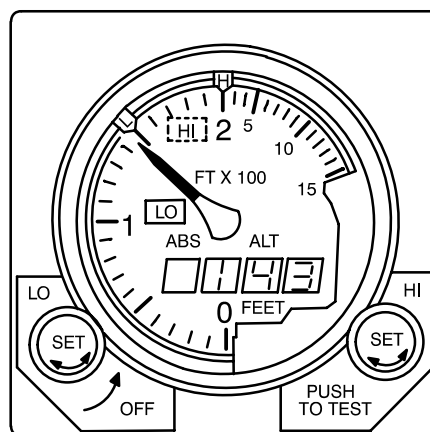
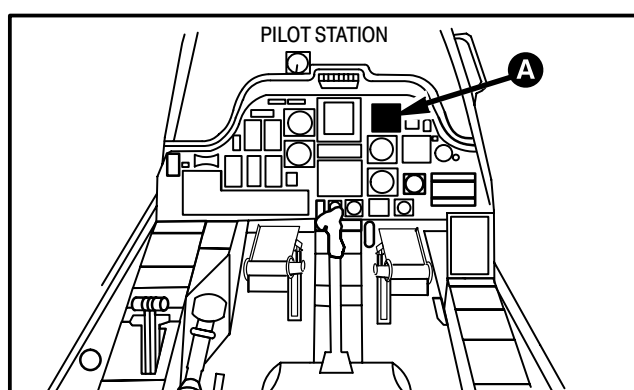


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Figure 16-28. RT-1411/APN-209A Receiver/Transmitter

ah. **ID-1917/APN-209A Indicator** (fig. 16-29). Functions of controls and indicators are as follows.

- (1) **LO** set knob sets position of **LO** index and provides on-off function.
- (2) **LO** set index sets trip point for **LO** warning lamp.
- (3) **HI** set knob sets position of **HI** index and initiates self-test function.
- (4) **HI** set index sets trip point for **HI** warning lamp.
- (5) Dial pointer provides analog indications of altitude (0 to 200 ft, 10 foot increments and 200 to 1500 feet, 100 foot increments).
- (6) Digital readout provides a direct-reading four-digit indications of the absolute altitude from 0 to 1500 feet.
- (7) **LO** warning lamp illuminates whenever the dial pointer goes below the setting of the **LO** set index.
- (8) **HI** warning lamp illuminates whenever the dial pointer goes above the setting of the **HI** set index.
- (9) **OFF** flag moves into view whenever unreliable operation is detected, or loss of primary power is detected.



A PILOT RADAR ALTIMETER

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Figure 16-29. ID-1917/APN-209A Indicator

ai. System Operation (fig. 16-30). Power to operate the AN/APN-209A is supplied from the dc emergency bus via a 5 amp circuit breaker on the pilot's center circuit breaker panel.

(1) The receiver/transmitter generates radar pulses which are radiated toward the earth through the transmit antenna. These pulses reflect from the terrain to the receive antenna. The receiver/transmitter computes the time from transmission to reception and translates this into auxiliary, digital, and pointer altitude signals.

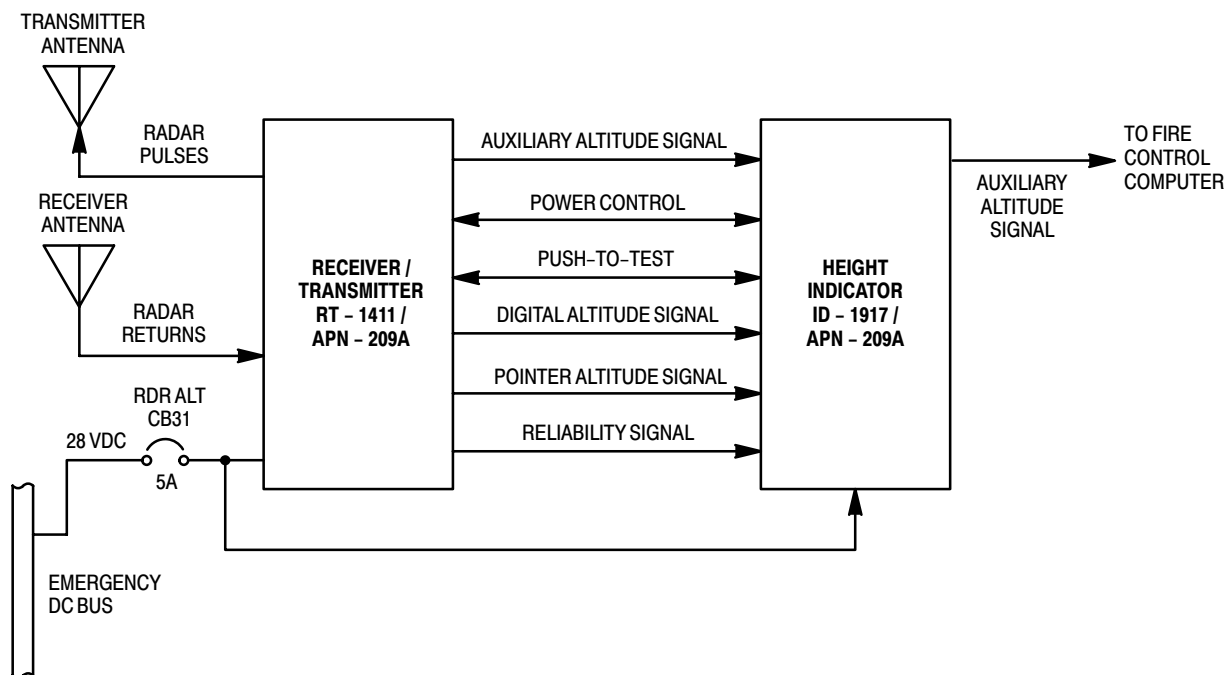
(2) The digital and pointer signals are used to produce altitude displays on the height indicator and the auxiliary altitude signal is relayed to the fire control computer. The altitude information is required by the fire control computer for ballistic/trajectory computation during weapons delivery. Altitude information from the auxiliary signal will also be used to develop symbology to be displayed on the VDU.

(3) The receiver/transmitter produces a reliability signal which enables all system displays as long as altitude data is valid. Unreliable data causes the **OFF** flag to appear. If the **HI** or **LO** altitude limits are exceeded, the **HI** or **LO** warning lamp will light.

(4) When self-test is initiated, the pointer and digital display will indicate 1000 ± 100 feet. The **OFF** flag will not be present. The **HI** and **LO** warning lamps will be lit, depending upon the **HI** and **LO** index settings.

16-3. THEORY OF OPERATION (cont)

16-3



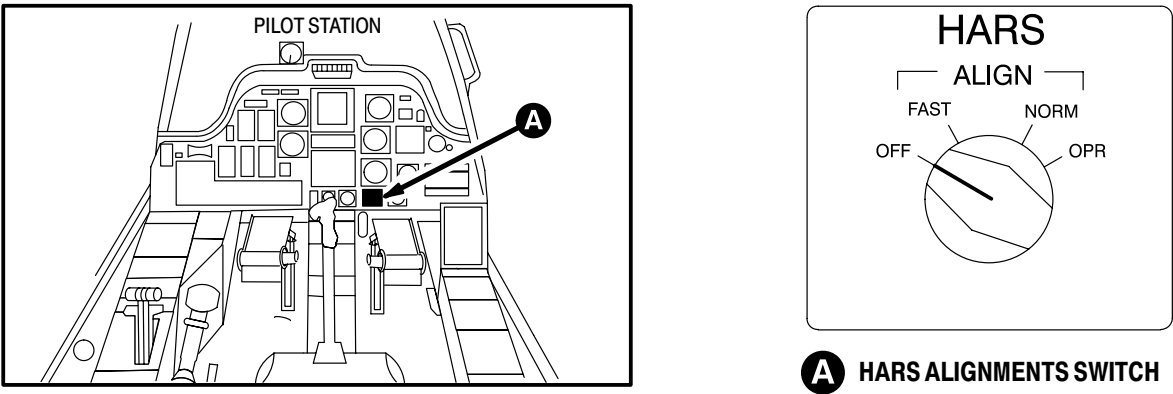
M52-262

Figure 16-30. Radar Altimeter System Block Diagram

aj. **HARS Mode Control Panel.** The panel contains one switch, labeled **HARS** (fig. 16-31). Functions are as follows.

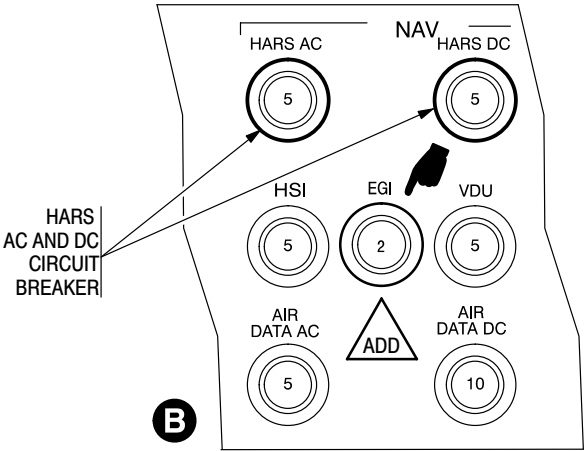
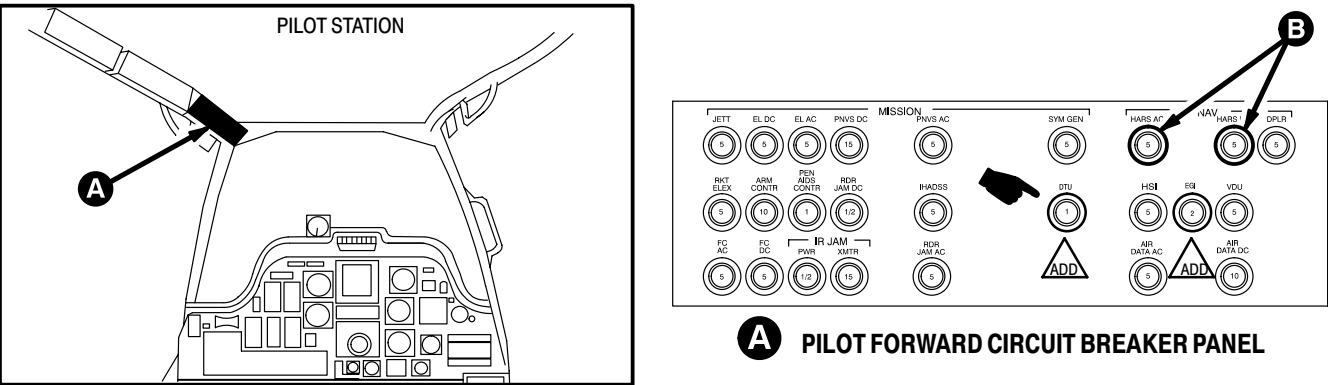
- (1) **OFF.** In the **OFF** position, the system is de-energized.
- (2) **FAST ALIGN.** The **FAST ALIGN** position provides rapid, single-position gyrocompass alignment. Alignment time is four to six minutes. Accuracy is degraded in this mode.
- (3) **NORM ALIGN.** A two position gyrocompass alignment. Most accurate if performed prior to engine start. Six to nine minutes alignment time.
- (4) **OPR.** Selected after the alignment has been accomplished. This is the normal operating mode, all outputs from the HARS are available.

ak. **HARS and HSI Circuit Breakers.** The HARS (**AC, DC**) and **HSI** circuit breakers (fig. 16-32) provide circuit protection for the HARS.



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Figure 16-31. HARS Mode Control Panel

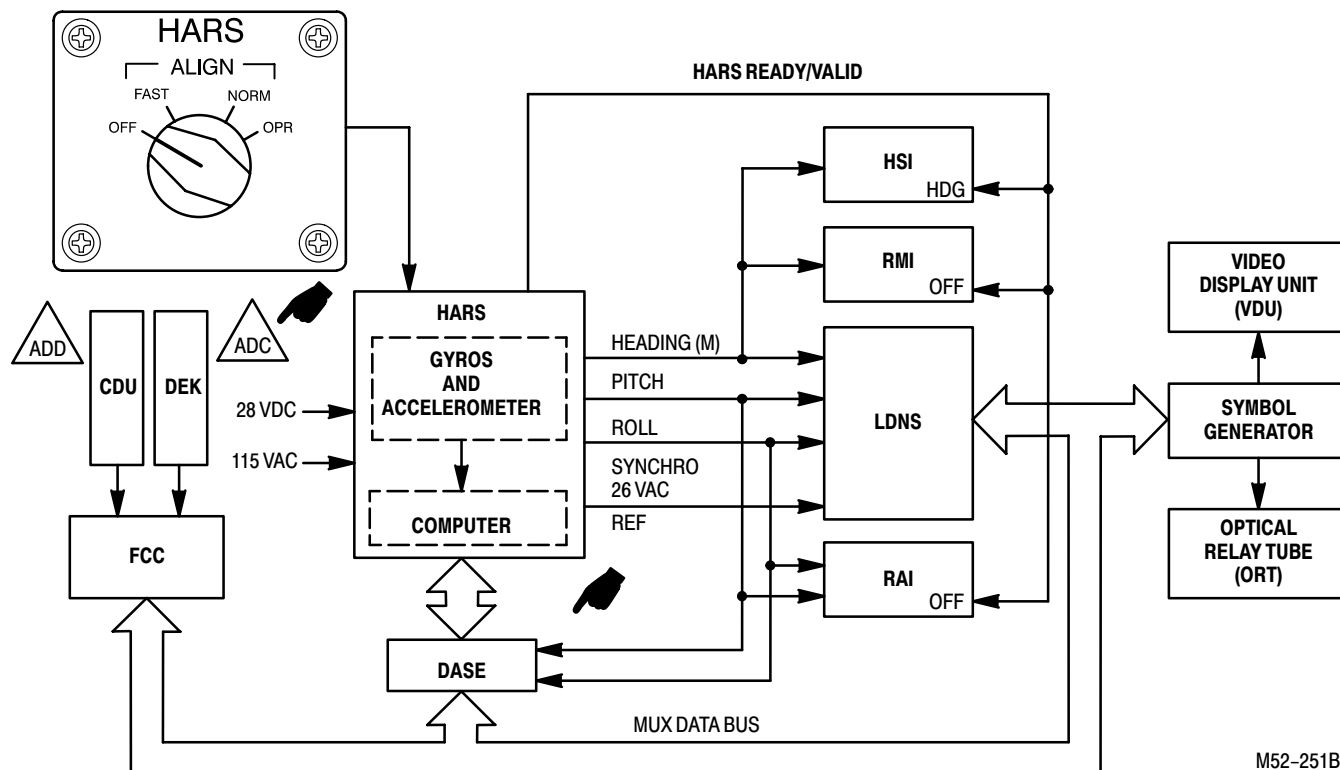


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Figure 16-32. HARS Circuit Breakers

16-3. THEORY OF OPERATION (cont)

16-3

al. **System Operation** (fig. 16-33).**Figure 16-33. HARS System Block Diagram**

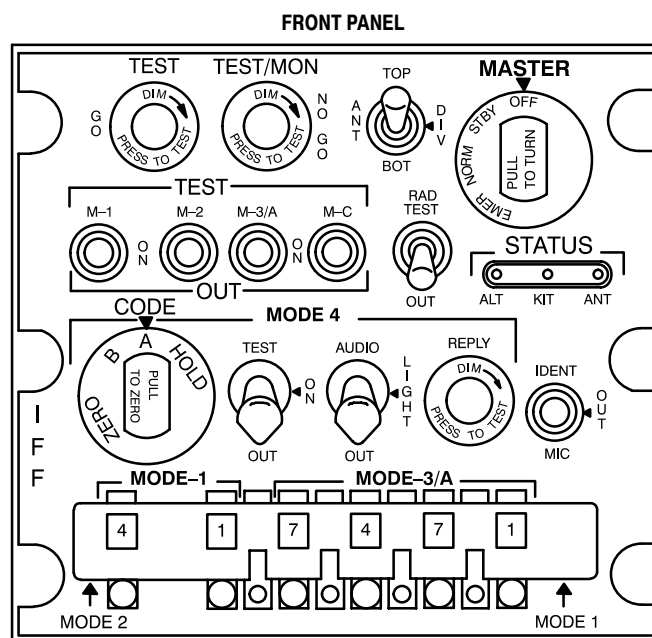
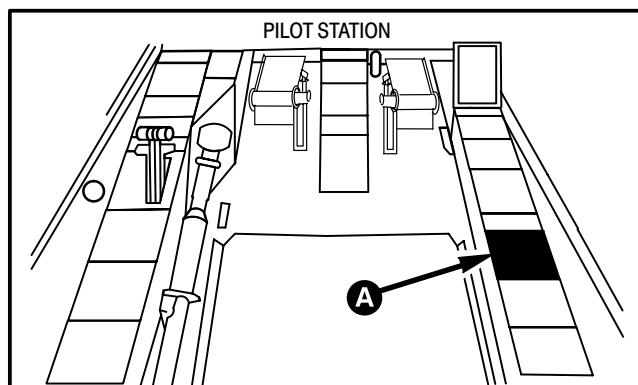
- (1) The HARS internal gyros sense changes in helicopter attitude, and internal accelerometers sense changes in helicopter movement. The sensors feed directly into the HARS computer.
- (2) The HARS computer outputs the following analog signals.
 - (a) Pitch.
 - (b) Roll.
 - (c) Heading.
- (3) The HARS computer outputs the following digital signals.
 - (a) Pitch.
 - (b) Roll.
 - (c) Heading.
 - (d) Angular rates, angular accelerations, linear rates, linear velocities and hover display data.
- (4) The computer outputs a synchro reference 26V ac signal used by the LDNS.
- (5) HARS computer outputs feed directly to the following units.
 - (a) Horizontal situation indicator (HSI). Provides heading information.

16-3. THEORY OF OPERATION (cont)**16-3**

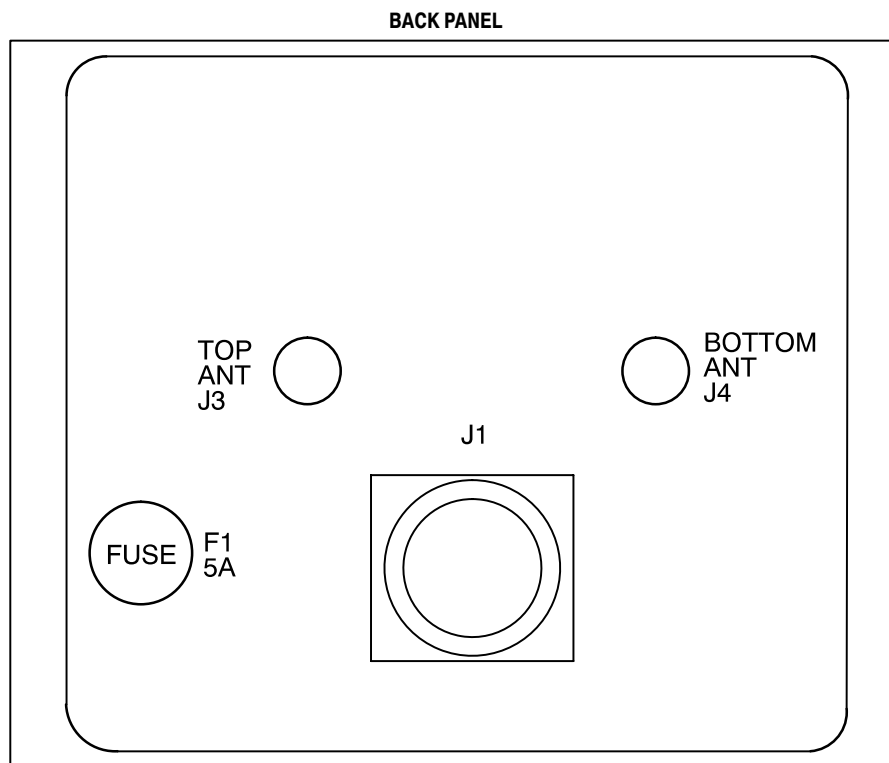
- (b) Remote attitude indicator (RAI). Provides pitch and roll information.
- (c) Remote magnetic indicator (RMI). Provides heading information.
- (d) Lightweight Doppler navigation system (LDNS). Provides heading, pitch, roll, and synchro voltage reference information.
- (e) Digital automatic stabilization equipment. Provides pitch and roll information.
- (6) The HARS ready/valid signal has the following functions.
 - (a) The gyros are aligned and the pitch, roll, and heading outputs are valid.
 - (b) The read/valid signal will be 28 VDC in a good condition.
 - (c) Controls the heading flag (**HDG**) on the HSI and the **OFF** flag on the RMI and RAI.
- (7) The HARS provides flight reference symbology for the video display unit (VDU) and the optical relay tube (ORT) via the symbol generator (ADC). The HARS provides backup flight reference symbology for the video displays (ADD).
 - am. **Upper and Lower IFF Antennas.** The upper and lower antennas receive the incoming interrogation signals and radiate the outgoing replies.
 - an. **KIT-1A/TSEC Security Computer.** The KIT-1A/TSEC processes the MODE 4 challenge signals from the transponder and supplies a secure MODE 4 reply. Visual and audio warnings are provided to the crew when the transponder is interrogated but does not reply in MODE 4.
 - ao. **RT-1296/APX-100(V) and RT-1557/APX-100(V) Transponder** (fig. 16-34).
 - (1) The RT-1296/APX-100(V) and RT-1557/APX-100(V) transponder has the ability to be interrogated and to reply in six modes. The modes are:
 - (a) **MODE 1** is used for aircraft control number. Total of 32 different codes.
 - (b) **MODE 2** is used for military identification. Total of 4096 different codes.
 - (c) **MODE 3A** is used for special and/or variable purposes. Total of 4096 different codes.
 - (d) **MODE 4** is used as the secure mode.
 - (e) **TEST** is an internally generated test mode.
 - (f) **MODE C** is used to report altitude.
 - (2) The transponder uses space diversity to insure strong reliable transmission and reception.
 - (3) The transponder also has a built-in-test (BIT) feature.
 - (4) The rear panel contains the following items (fig. 16-34).
 - (a) J1 is a 66-pin power and signal connector.
 - (b) J3 is the top antenna connection.
 - (c) J4 is the bottom antenna connection.
 - (d) F1 is a 5 amp fuse.

16-3. THEORY OF OPERATION (cont)

16-3



A PILOT AN / APX - 100 IFF TRANSPONDER CONTROL PANEL



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Figure 16-34. RT-1296/APX-100(V) and RT-1557/APX-100(V) Transponder

16-3. THEORY OF OPERATION (cont)

16-3

(5) **System Operation** (fig. 16-35).

(6) The transponder receives 28 VDC from a 5-amp, emergency bus circuit breaker, located on the pilot's center overhead circuit breaker panel.

(7) The interrogation processing is essentially the same for **MODES 1, 2, and 3A**. If the interrogation mode coincides with the preset **MODE** selected by the pilot, the transponder replies in the same mode as the interrogation. The reply contains specific coded information that has been selected by the controls for each of the three modes. Due to high transmit power (approximately 500 watts), a blanking output pulse is produced by the transponder to prevent false missile threats in the radar warning system.

(8) Mode C capability is available starting with aircraft serial number 87-0475 and subsequent. The barometric pressure altitude is digitized by the encoding altimeter and made available to the transponder over the data transfer wires. When the IFF is interrogated with **Mode C** selected, the transponder responds with the altitude information being supplied by the encoding altimeter.

(9) Identification of Position (I/P) – The pilot “squawks I/P” through the ICS.

(10) For Mode 4 processing, **MODE 4** must be selected on the transponder so the mode 4 interrogation signal can be routed to the KIT-1A computer. The interrogation pulse contains the following codes.

(a) The mode identification code (trigger).

(b) Special information coding (challenge video).

(11) The KIT-1A computer compares the mode 4 challenge video with the code of the day. If the codes are the same, the KIT-1A encodes the mode 4 reply, which is sent to the transponder for transmission. If the codes differ, the KIT-1A sends a disparity signal to the transponder, which triggers the mode 4 alarms.

(12) Mode 4 alarms occur when mode 4 is interrogated but does not reply, due to an improper interrogation or if the KIT-1A fails. Three alarm indications exist, as follows.

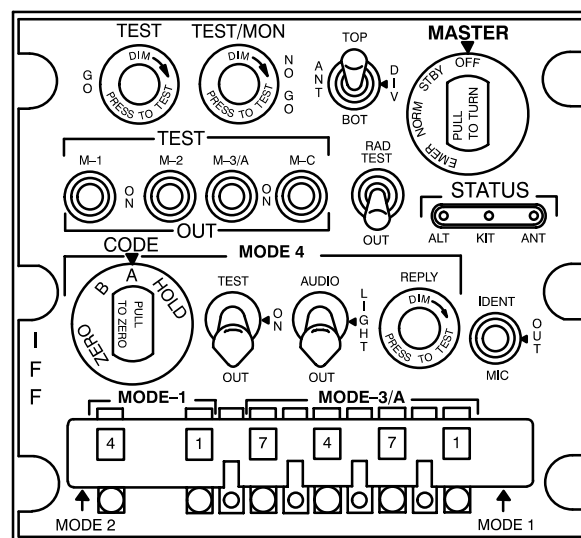
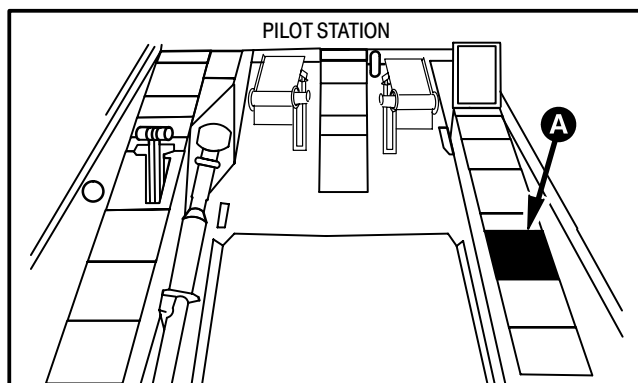
(a) Caution lights illuminate on the pilot and CPG caution/warning panels.

(b) Combination of the two caution lights and the **TEST/MON NO GO** lamp will light.

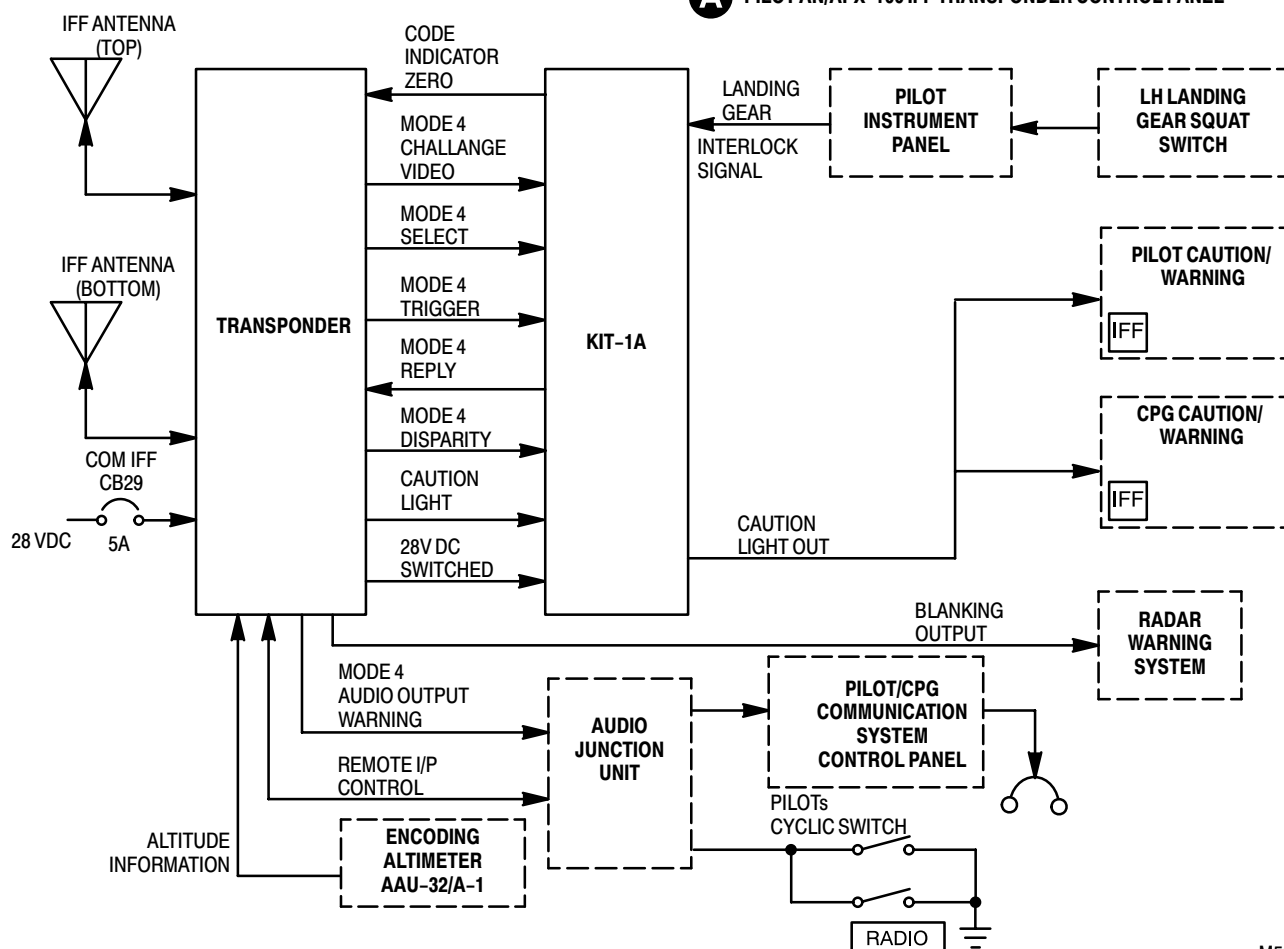
(c) Combination of the two caution lights and an audio warning in both helmets.

16-3. THEORY OF OPERATION (cont)

16-3



A PILOT AN/APX-100 IFF TRANSPONDER CONTROL PANEL



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Figure 16-35. IFF System Block Diagram

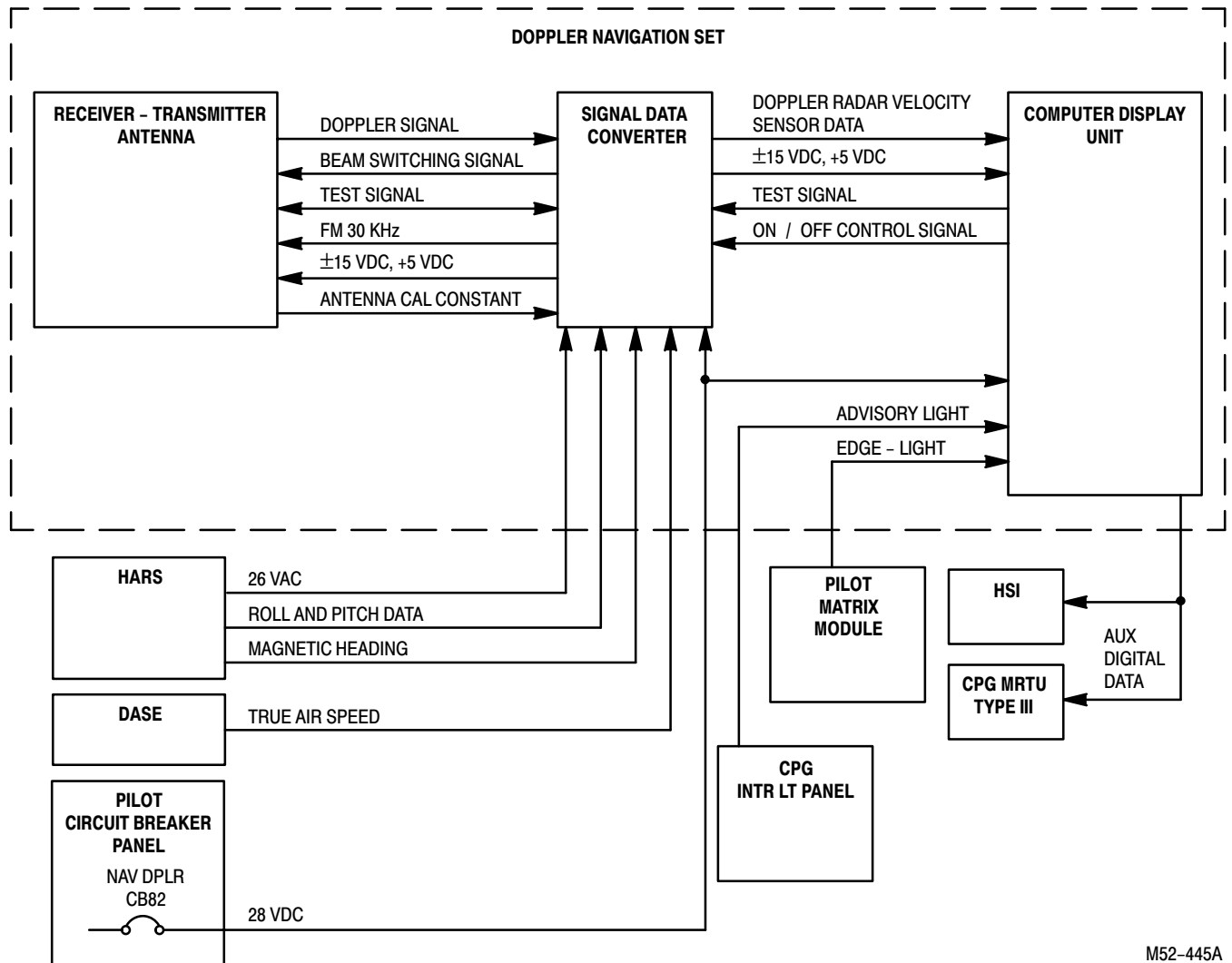
16-3. THEORY OF OPERATION (cont)

16-3

- ap. **Doppler System Operation (ADC)** (fig. 16-36). Power to the Doppler is provided by the aircraft electrical system **NAV DPLR** circuit breaker CB82. When the **NAV DPLR** circuit breaker is closed, 28 VDC is supplied to the SDC and RTA. The DASE provides true airspeed from the ADSS to the SDC. The HARS provides 26V ac reference voltage, pitch and roll data, and magnetic heading to the SDC. The **CPG INTR LT** panel provides 28 VDC for **MEM** and **MAL** indicators advisory lighting. The pilot matrix module provides 5 VDC for CDU edge-lighting. The HSI receives serial data from the CDU. The CPG MRTU Type III provides a multiplex bus interface between the fire control computer (FCC) and outputted serial data of the CDU.
- aq. **Doppler System Operation (ADD)** (fig. 16-37). Power to the Doppler is provided by the aircraft electrical system **NAV DPLR** circuit breaker CB82. When the **NAV DPLR** circuit breaker is closed, HARS is turned on and finds vertical reference, 28 VDC is supplied from the **NAV HARS DC** circuit breaker to the Doppler on/off relay. The HARS provides 26V ac reference voltage, pitch and roll data, and magnetic heading to the SDCC. The pilot matrix module provides 5 VDC for CDU edge-lighting. The HSI receives serial data from the SDCC. The SDCC and CDU are interfaced to the MUX bus. The SDCC supplies HARS and doppler secondary data to the FCC. The CDU displays and control discretes that control the SDCC power on control relay and the RTA power on control relay are controlled by the FCC.
- ar. **SDC (ADC)**. The SDC supplies +15 VDC, -15 VDC and +5 VDC to the RTA and CDU when the on control discrete is supplied by the CDU. The SDC supplies a beam switching signal and 30 KHz frequency modulation signal to the RTA. The Doppler signal is received, processed and sent to the CDU for display.
- as. **SDCC (ADD)**. The SDCC supplies +15 VDC, -15 VDC and +5 VDC to the RTA power control relay when the SDCC power on discrete is supplied via the CDU. The SDCC supplies a beam switching signal and 30 KHz frequency modulation signal to the RTA. The SDCC is interfaced to the primary and secondary FCC buses through a SDCC data bus relay. The Doppler signal is received, processed and used by the FCC. In event of FCC failure, the SDCC is interfaced to the CDU creating a CDU bus.
- at. **RTA**. The RTA generates a microwave carrier frequency of 13.325 GHz modulated by 30 Khz from the SDC (ADC)/SDCC (ADD). The beam switching signal is a timing signal used to create four separate beams. Reflected rf energy is received by the RTA and sent to the SDC (ADC)/SDCC (ADD). The antenna calibration constant is fed to the SDC (ADC)/SDCC (ADD) for monitoring by the SDC (ADC)/SDCC (ADD) in conjunction with the test signal for continuous built-in-test (BIT).
- au. **CDU (ADC)**. The CDU supplies the on/off discrete signal and initiates BIT. The CDU displays Doppler radar velocity sensor data and provides controls to insert, change, and recall position, aircraft steering and other navigational data. The keyboard allows the operator to enter wind speed, direction, destination, present position, variation and spheroid codes for the selected area.
- av. **CDU (ADD)**. Power to the CDU is provided by the aircraft electrical system **CDU** circuit breaker CB6 through the BBC in control detector. The CDU displays and control discretes are controlled by the FCC. During normal operation (FCC in control), the CDU is interfaced to the primary and secondary FCC buses through a CDU data bus relay. The CDU discrete HAVE QUICK CTL is interfaced to the HAVE QUICK relay within the BBC in control detector to enable loading of time of day (TOD) from the EGI to AN/ARC-164 UHF-FM radio. The CDU discrete ZEROIZE CTL is interfaced to the ZEROIZE relay within the electrical power center to enable zeroizing of EGI, DNS and DTU. The CDU discrete DNS ANT CTL is interfaced to the DNS RTA relay within the electrical power center to select power on or off to the DNS antenna. In event of FCC failure or manual selection of the BBC for bus control, the CDU has 28 VDC removed for one second via the BBC in control detector to allow re-configuration as the CDU bus controller. The CDU is interfaced to the SDCC creating a CDU bus. The CDU provides controls to insert, change, and recall position, aircraft steering and other navigational data. The keyboard allows the operator to enter wind speed, direction, destination, present position, variation and datums for the selected area.

16-3. THEORY OF OPERATION (cont)

16-3

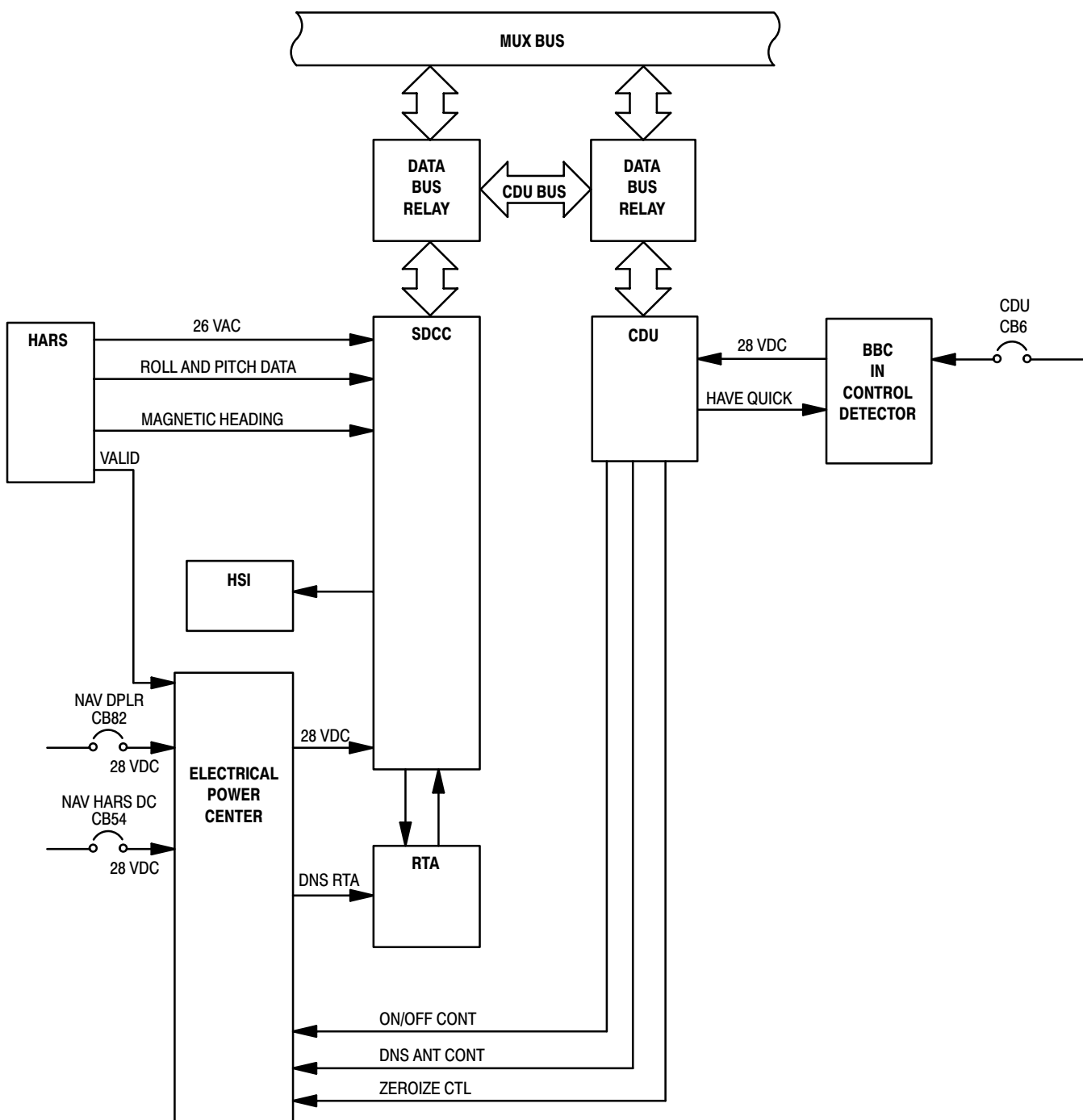


M52-445A

Figure 16-36. Doppler Navigation Set Block Diagram (ADC)

16-3. THEORY OF OPERATION (cont)

16-3



M52-472

Figure 16-37. Doppler Navigation Set Block Diagram (ADD)

16-3. THEORY OF OPERATION (cont)

16-3

aw. **DTU (ADD).** The DTU consists of a data transfer receptacle (DTR) and data transfer cartridge (DTC).

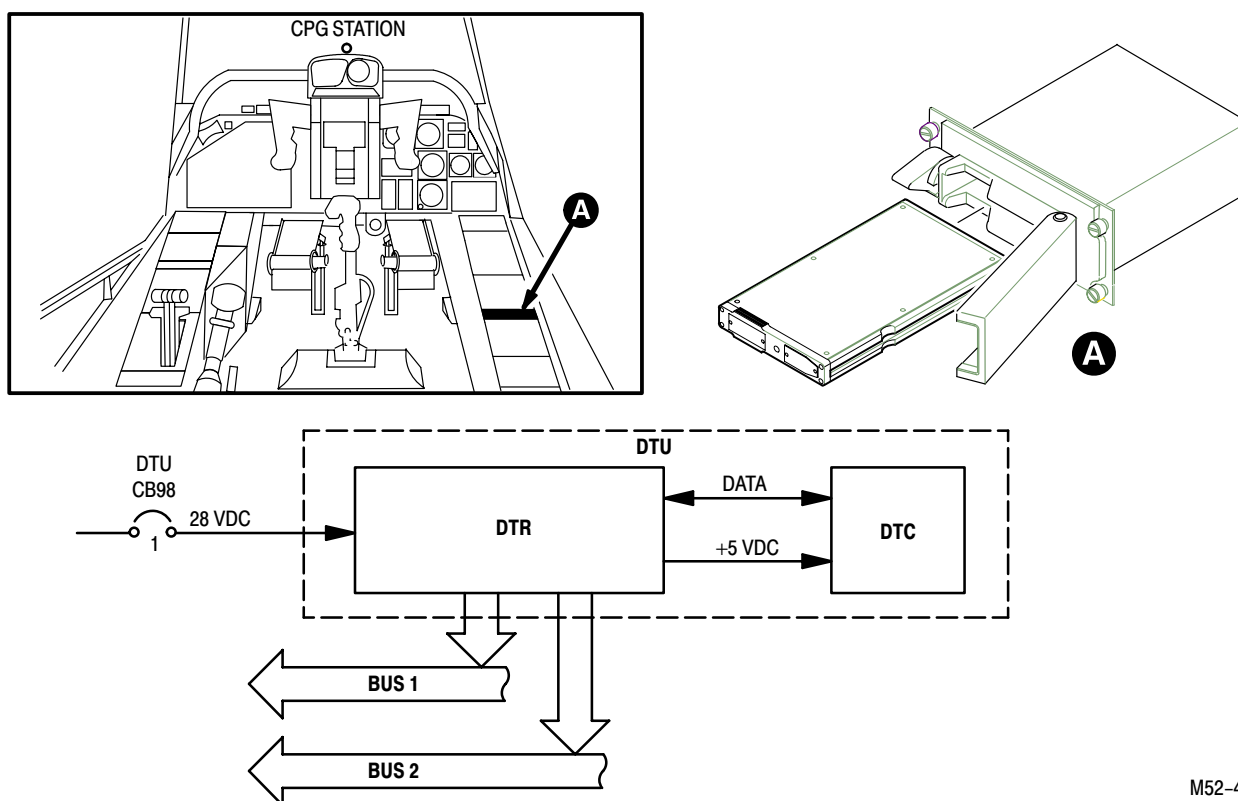
(1) The DTR transfers data to and retrieves data from the DTC. The DTR supplies power to the DTC when the DTC is installed in the DTR. The DTR contains three connectors.

(a) J1 is a power, 1553 bus interface, zeroizing and fault connector.

(b) J2 is bus 1 interface connector.

(c) J3 is bus 2 interface connector.

(2) The DTC contains two 1.5 volt AAA alkaline batteries for maintaining 128K of EPROM memory of pre-mission data. The DTC is programmed using the automated mission planning station (AMPS).



M52-471

Figure 16-38. DTU Block Diagram (ADD)

ax. **System Operation.** Circuit breaker **DTU (CB97)** (fig. 16-38) supplies 28 VDC to the DTU. Control of the DTU is via the multiplex bus by the CDU DTU page. When the DTC is installed in the DTR and power applied to the aircraft, the message **DTC READY** will appear on the CDU DTU page. When selected, the mission data is uploaded to the FCC or FD/LS failure codes can be downloaded to the DTC.

16-3. THEORY OF OPERATION (cont)

16-3

ay. **EGI (ADD).** The EGI is the primary navigation and present position sensor. The EGI system consists of an antenna, phase splitter and inertial – satellite signals navigation unit.

(1) The EGI outputs linear acceleration, angular acceleration, linear velocity, angular velocity, universal transverse mercator (UTM) coordinate of position, attitude (roll, pitch and platform azimuth), magnetic heading, true heading, altitude, body angular rates, time tags and universal time coordinated (UTC) synchronized time to the FCC via the MUX bus. The EGI contains six connectors.

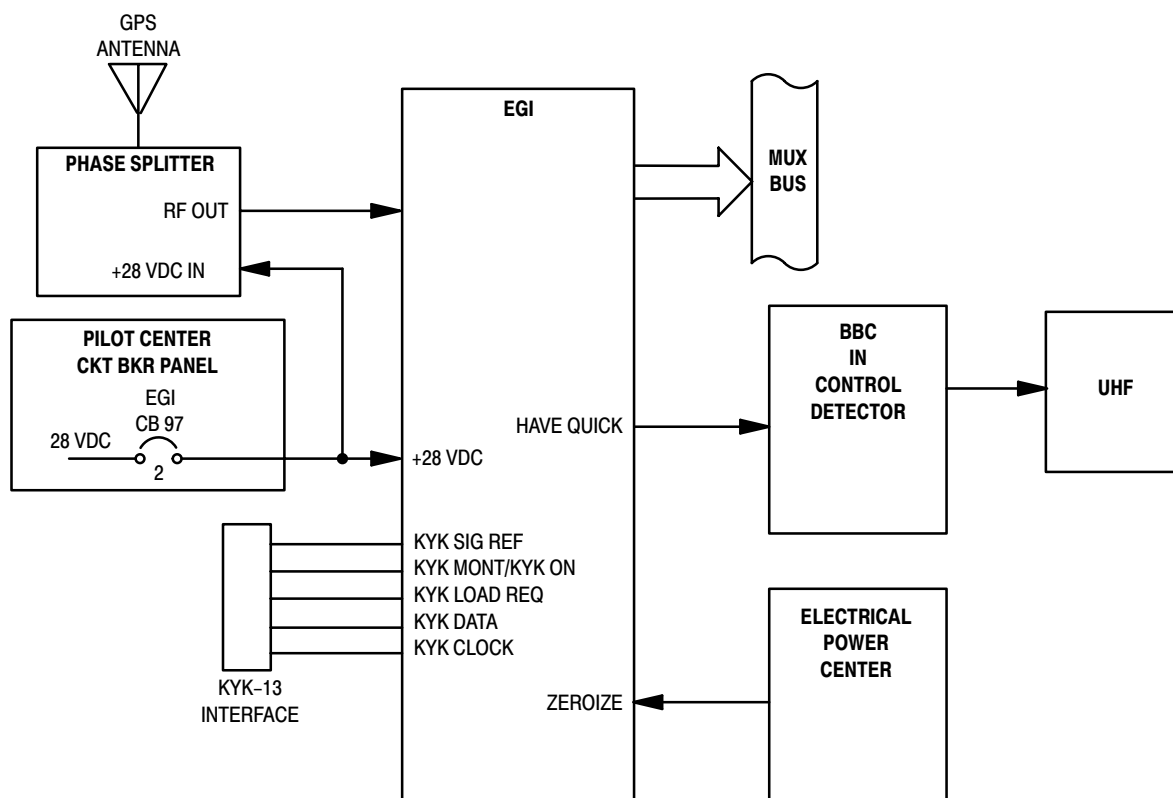
- (a) J1 is a power connector.
- (b) J2 is Input/Output (I/O) connector.
- (c) J3 is test connector.
- (d) J4 is a dual 1553 bus connector.
- (e) J5 is a GPS KYK connector.
- (f) J6 is GPS antenna connector.

(2) The EGI contains a 6 volt lithium batteries for maintaining EEPROM memory.

(2) **System Operation.** Circuit breaker **EGI** (CB97) (fig. 16-39) supplies 28 VDC to the GPS power splitter and and inertial – satellite signals navigation unit. RF satellite signals are received by the GPS fixed radiation position antenna (FRPA), attenuated by the phase splitter and inputted to the EGI. The EGI outputs navigation data to the FCC. KYK-13 crypto data can be loaded externally through a KYK-13 interface. The EGI provides time of day for HAVE QUICK operation through the BBC in control detector to the UHF transceiver. The EGI is zeroized via the electrical power center.

16-3. THEORY OF OPERATION (cont)

16-3



M52-473

Figure 16-39. EGI Block Diagram (ADD)

17-1. PURPOSE

17-1

CHAPTER 17 DIGITAL AUTOMATIC STABILIZATION EQUIPMENT SYSTEM

17-1. PURPOSE

The digital automatic stabilization equipment (DASE) system is an electrically activated system that assists the flight control system to stabilize the helicopter.

17-2. DESCRIPTION

a. The DASE system major components (fig. 17-1) are described below.

(1) Digital automatic stabilization equipment computer (DASEC) receives and transmits flight reference signals for control and stability of the helicopter.

(2) Excitation transformers and transformer filter box assembly step down 115 VAC to 26 VAC for DASE operations.

(3) ASE control panel controls DASE functions.

(4) Collective and cyclic control sticks provide mountings for the **ASE** release switch, force trim release switch, and **BUCS** select switch.

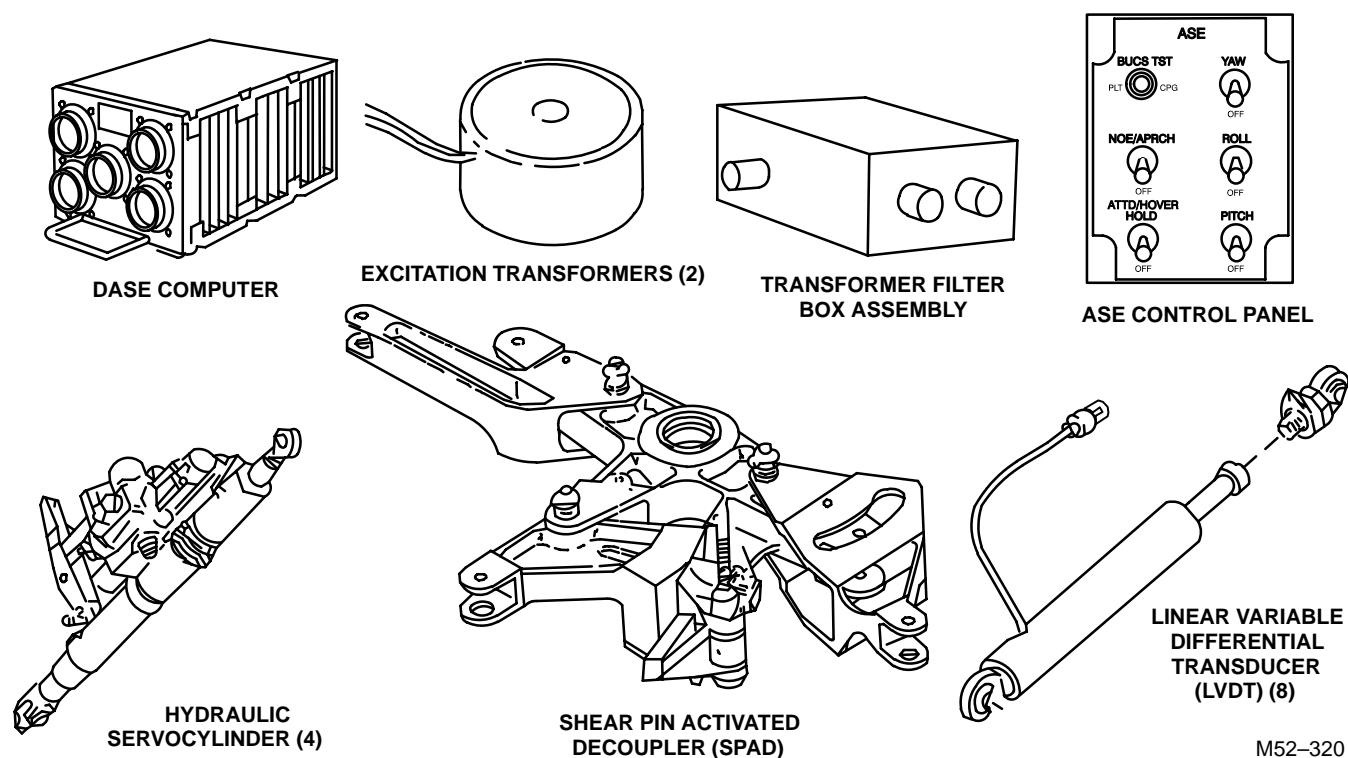


Figure 17-1. DASE System Major Components

17-2. DESCRIPTION (cont)

17-2

(5) Hydraulic servocylinders move the upper flight controls which control the pitch of the main and tail rotor blades (part of rotor system), as directed by the pilot, CPG, or DASE system. The servocylinders (ACB) are grounded to prevent electro-magnetic interference (EMI).

(6) Shear pin activated decoupler (SPAD) assemblies disconnect the collective and cyclic control sticks, and the directional pedals (part of flight control system) from the respective mechanical control linkages when the linkages are jammed.

(7) Linear variable differential transducers (LVDT) assemblies develop signals that are proportional to the position of the flight controls. The LVDTs (ACB) are grounded to prevent EMI.

17-3. THEORY OF OPERATION

a. **DASE System Operation.** The theory of operation of the DASE system components is described in the following subparagraphs.

(1) The DASEC (fig. 17-2) is mounted in the aft avionics bay. The DASEC is a solid-state LRU that receives and transmits flight reference signals.

(2) The DASEC (fig. 17-3) is energized by 115 VAC and 28 VDC for DASE operations. The following systems and components interface with the DASEC.

(a) **ASE** control panel provides mounting for the **PITCH, ROLL, YAW, ATT/HOVER HOLD**, and **BUCS TST** switches that control DASE system operations.

(b) Squat switch disengages YAW CAS when the helicopter is on the ground.

(c) Longitudinal, lateral, directional, and collective hydraulic servocylinders perform ASE and BUCS operations while providing signals proportional to cylinder movements.

(d) Pilot and CPG SPAD assemblies activate BUCS when the flight controls are jammed.

(e) Video display unit (VDU) provides monitoring of rate-of-turn.

(f) Force trim system engages for attitude/hover hold operation.

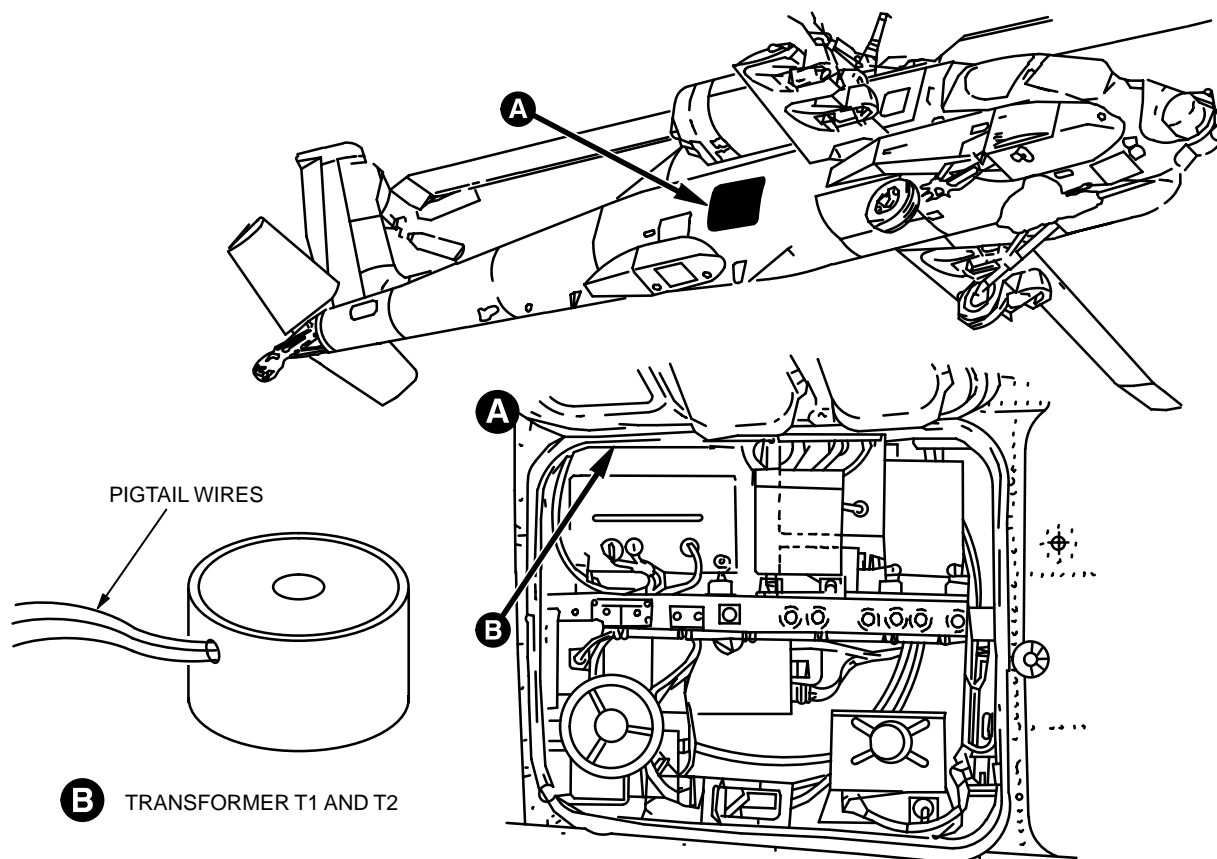
(g) Heading attitude reference set (HARS) provides rate, attitude, and heading signal data.

(h) Air data subsystem (ADSS) provides airspeed and sideslip information.

(i) Pilot and CPG collective, cyclic, and directional LVDT assemblies provide signals proportional to control stick and directional pedals movements.

(j) Tracer wires provide signals to the DASEC to monitor wire severance for BUCS operation.

(k) Pilot and CPG caution/warning panel provides mountings for caution/warning lights for BUCS operation, ASE operation, and BUCS failure.



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Figure 17-2. DASEC Component Location

(3) The excitation transformers and transformer filter box assembly (fig. 17-2) are located in the aft avionics bay. They step down 115 VAC to 26 VAC for DASE operations.

(a) The two excitation transformers (fig. 17-2) are used on non-hardened electro-magnetic interference (EMI) helicopters (ACA). Transformer T1 supplies 26 VAC to the DASEC, CPG collective, cyclic, and directional LVDT assemblies, and the hydraulic servocylinder BUCS LVDT assemblies. Transformer T2 supplies 26 VAC to the DASEC, pilot collective, cyclic, and directional LVDT assemblies, hydraulic servocylinder BUCS LVDT assemblies, and each hydraulic cylinder SAS LVDT assembly.

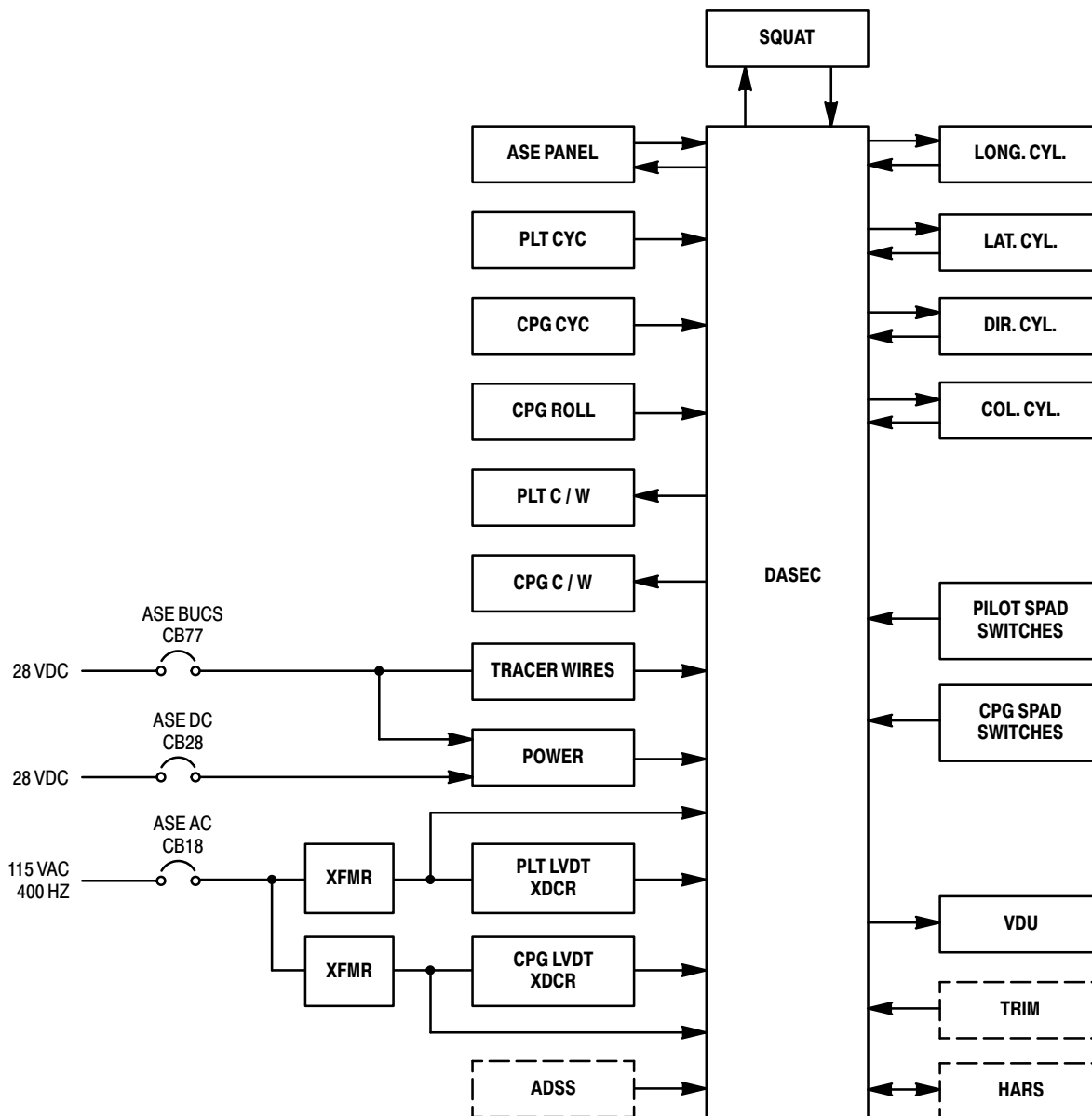
(b) The transformer filter box assembly (ACB) is an LRU that houses two step down transformers and four filters for EMI hardening.

(c) The assembly supplies 26 VAC from transformer T1 to the DASEC, CPG collective, cyclic, and directional LVDT assemblies, and the hydraulic servocylinder BUCS LVDT assemblies. Transformer T2 supplies 26 VAC to the DASEC, pilot collective, cyclic, and directional LVDT assemblies, hydraulic servocylinder BUCS LVDT assemblies, and each hydraulic cylinder SAS LVDT assembly.

17-3. THEORY OF OPERATION (cont)

17-3

(4) The **ASE** control panel (fig. 17-4) is mounted on the top, inboard portion of the pilot left console. The **ASE** control panel contains five switches for control of the DASE system. The **PITCH**, **ROLL**, **YAW**, and **ATTD/HOVER HOLD** switches are spring-loaded **OFF** toggle switches that are electromagnetically latched when placed to the on position. The **BUCS TST** switch is a single-pole, double-throw, center off switch used for testing BUCS operation.



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Figure 17-3. DASEC Block Diagram

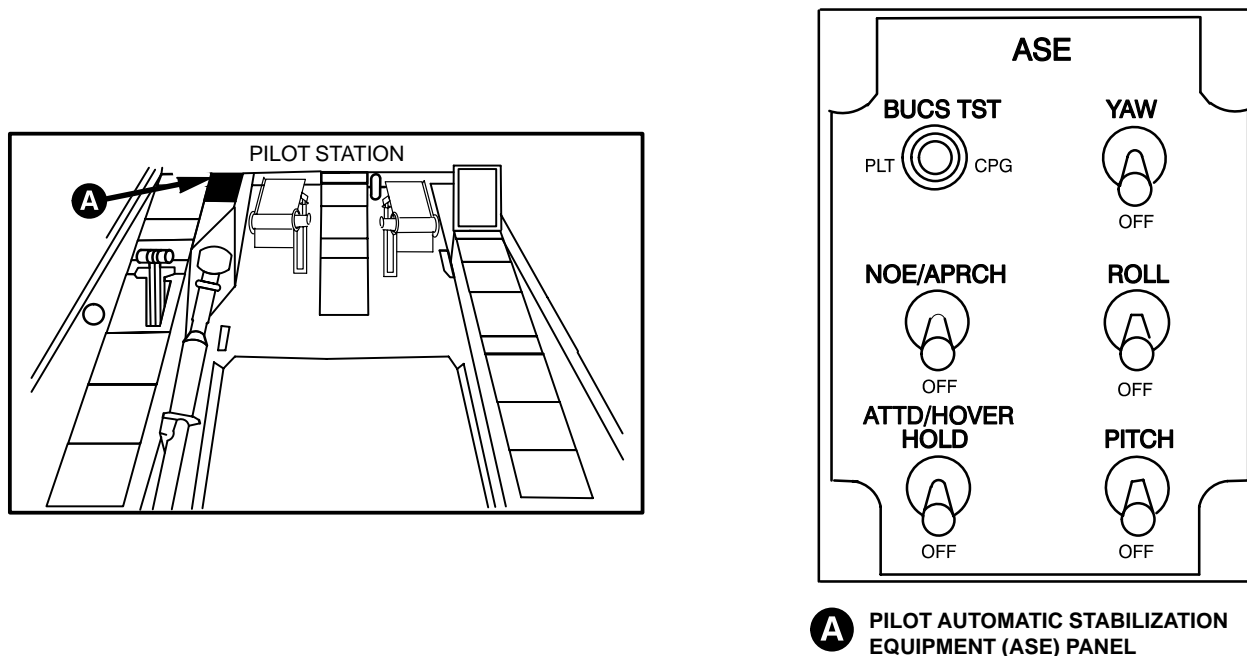


Figure 17-4. ASE Control Panel

(5) The pilot and CPG collective and cyclic control sticks (fig. 17-5) provide mountings for the **BUCS SELECT**, **ASE RELEASE**, and **TRIM RELEASE** switches.

(a) The **BUCS** select switch (ACB) is a sealed single-throw, momentary contact, guard protected trigger-switch. The switch is used during BUCS operation to transfer control from the pilot collective, cyclic, and direction LVDT assemblies to the CPG collective, cyclic, and directional LVDT assemblies. The switch is also pressed during ground operations to test BUCS operation.

(b) The **ASE** release switches are mounted on each cyclic control stick. They are momentary contact, button-type switches spring-loaded to the ON position. When the switch is released, a ground circuit is provided to magnetically latch the **PITCH**, **ROLL**, **YAW**, and **ATTD/HOVER HOLD** switches to the on position. When the switch is pressed, the circuit is opened and the **PITCH**, **ROLL**, **YAW**, and **ATTD/HOVER HOLD** switches simultaneously move to the **OFF** position.

(c) The force trim release switches are located on each cyclic control stick. The pilot force trim release switch is a three-position, thumb-actuated switch that is marked **OFF**, **ON**, and **FORCE TRIM REL**.

(d) The off position is a permanent position that turns off the force trim system. The on position is a permanent position that engages the force trim system, to the force trim setting. The release position is a momentary-contact position, spring-loaded to the on position. This position is used to release the force trim system during maneuvering of the helicopter, or to establish a new force trim setting.

17-3. THEORY OF OPERATION (cont)

17-3

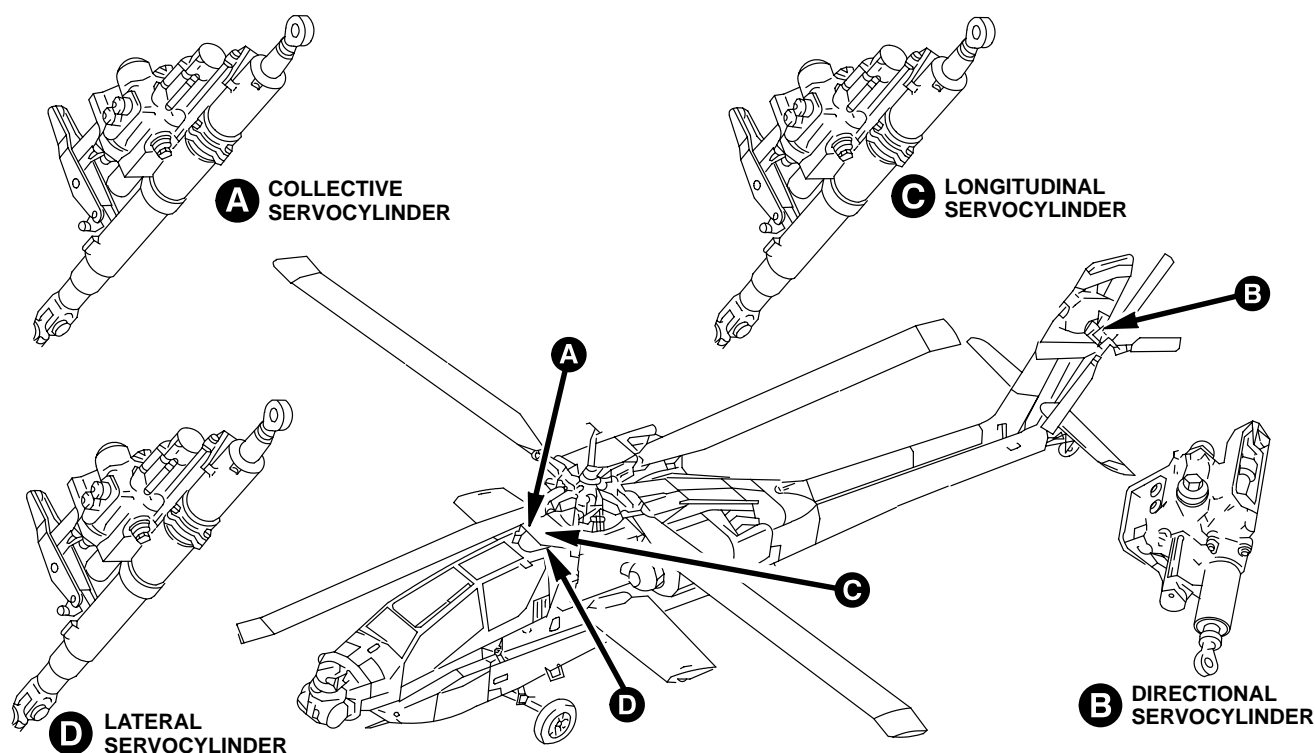
(e) The CPG force trim release switch is a two-position, momentary contact button-type switch, spring-loaded to the on position. When the switch is released the force trim system is engaged. When the switch is pressed, the force trim system is released which permits the CPG to establish a new force trim setting, or maneuver the helicopter.

(6) The collective, longitudinal, and lateral hydraulic servocylinders (fig. 17-6) are located in the main transmission area, forward of the main transmission (part of drive system). The directional hydraulic servocylinder is mounted on the tail rotor gearbox (part of drive system). The hydraulic servocylinders control the movement of the upper flight controls as directed by mechanical or electrical inputs from the pilot, CPG, or DASEC.

(a) When the **ASE** control panel **PITCH, ROLL, YAW, and ATTD/HOVER HOLD** switches are positioned on, the SAS solenoid valve is energized open. The open SAS valve ports pressurized hydraulic fluid through the primary pressure port to the two-stage electrohydraulic valve (EHV). The EHV is a flapper valve that is controlled electrically by the DASEC. When the EHV is centered, hydraulic pressure is equal on both sides of the SAS cylinder.

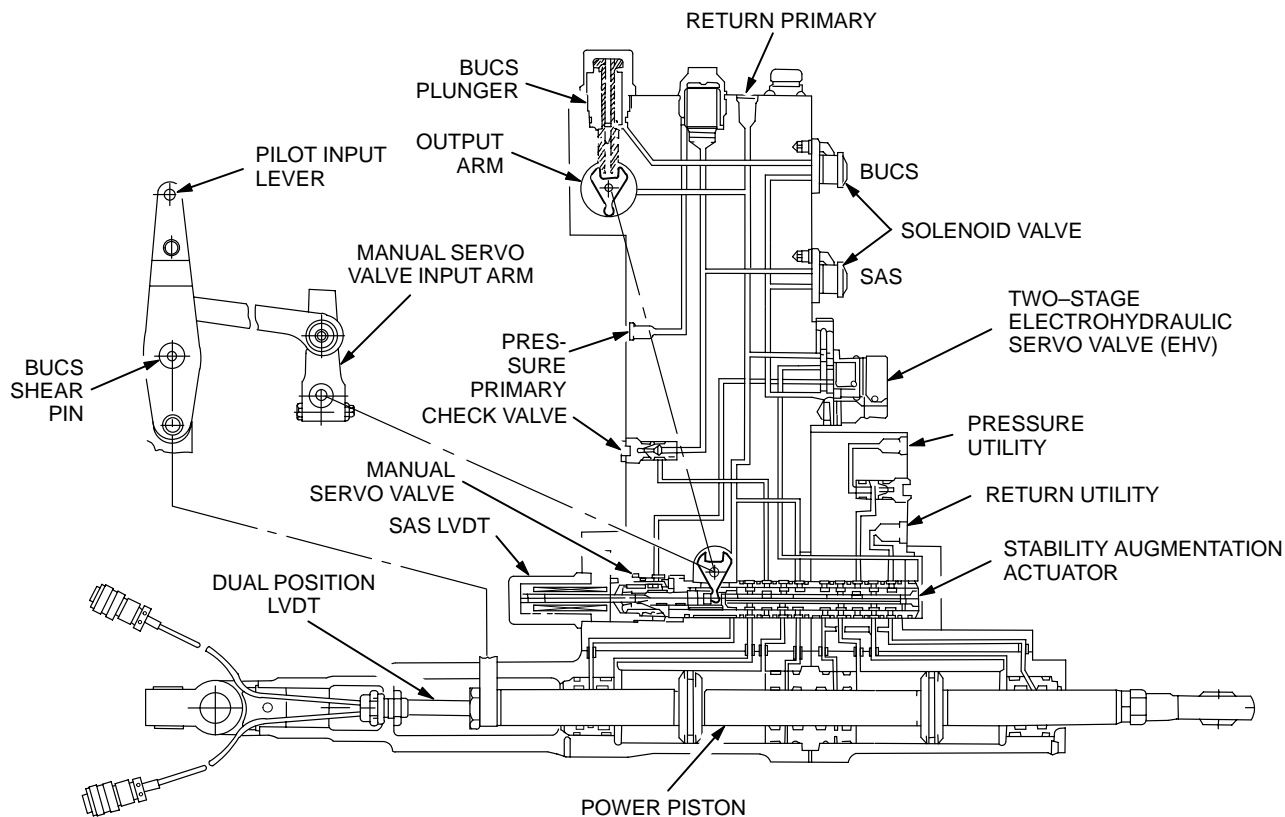
(b) When the helicopter deviates from the reference attitude, a rate signal is developed by the HARS and sent to the DASEC. The DASEC develops a command signal and sends the signal to the EHV. The EHV moves, causing hydraulic pressure to move the SAS cylinder. Movement of the SAS cylinder opens ports to allow hydraulic pressure to extend or retract the power piston. The SAS LVDT provides a feedback signal to the DASEC, to prevent overcorrections and washout DASEC command signals.

(c) When the DASEC command signals are washed-out the EHV returns to the centered position. This equalizes the pressure on the SAS cylinder and power piston movement stops.



M52-325-1

Figure 17-6. Hydraulic Servocylinders (Sheet 1 of 2)



M52-325-2A

Figure 17-7. 17-6. Hydraulic Servocylinders (Sheet 2 of 2)

(7) The collective SPAD assemblies (fig. 17-7) are attached to the pilot and CPG collective control sticks. The longitudinal, and lateral SPAD assemblies are located under the floor in both the pilot and CPG crew stations. The longitudinal, and lateral SPAD assemblies are attached to the cyclic control stick. The directional SPAD assemblies are located under the floor in both the pilot and CPG crew station. The directional SPAD assemblies are attached to the directional pedals.

(a) The SPAD assemblies used on helicopters (ACA) have shear pins replaced by steel pins. The SPAD assemblies equipped with steel pins function as bellcranks only.

(b) The SPAD assemblies used on helicopters (ACB) have shear pins installed. When a flight control becomes jammed, the respective SPAD shear pin must be broken to free the crew station flight controls and activate BUCS. The force required to break the respective SPAD shear pins is listed in Table 17-1.

(c) When a mechanical linkage (part of flight control system) becomes jammed, force applied to the respective control stick or directional pedal by the pilot or CPG breaks the shear pin of the respective SPAD assembly. The breaking of the shear pin assembly frees the linkage jam and causes the cam lever to rotate contacting the switch assembly. The switch assembly engages and provides a signal to the DASEC to energize BUCS.

17-3. THEORY OF OPERATION (cont)

17-3

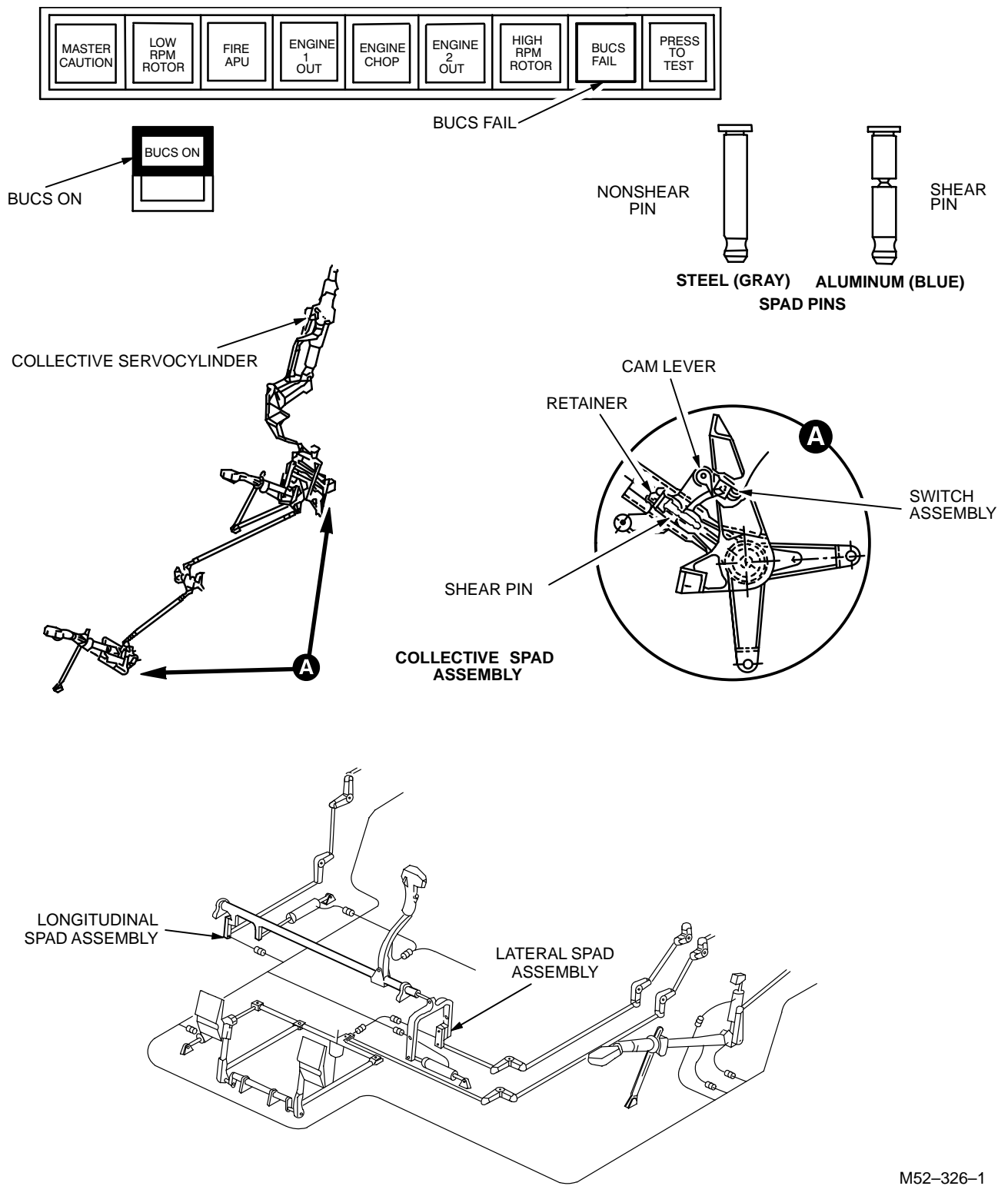
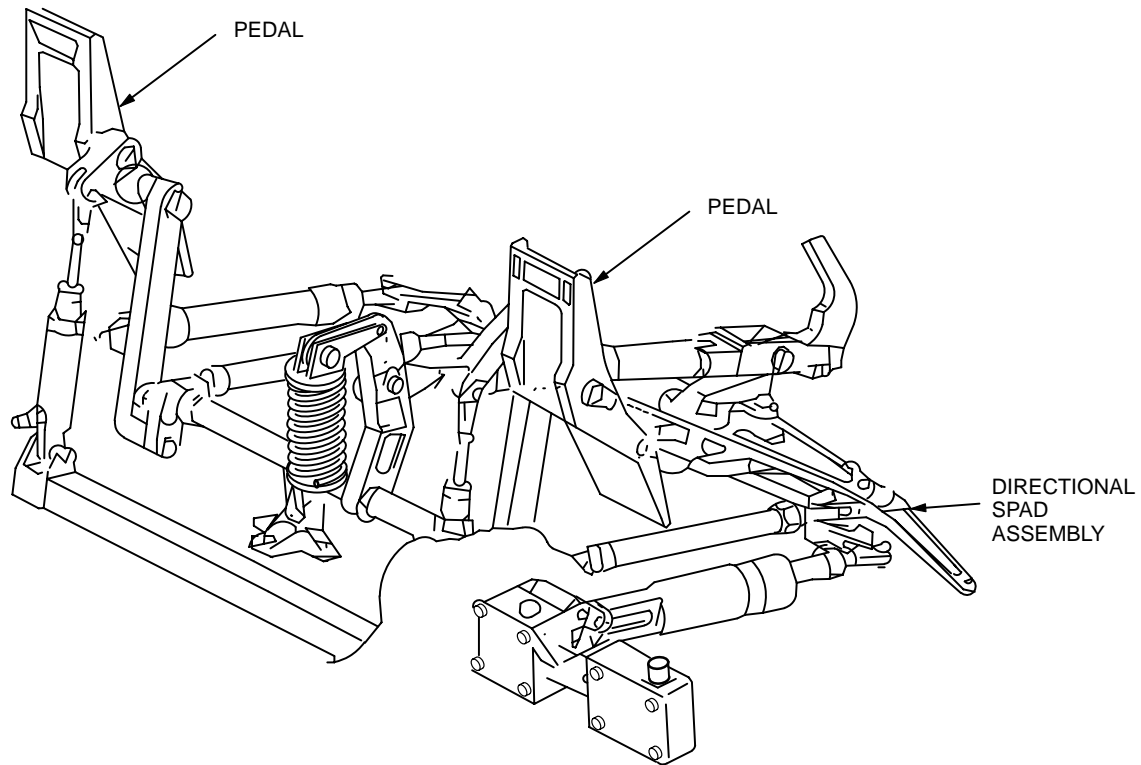


Figure 17-7. SPAD Assemblies (Sheet 1 of 2)

M52-326-1



M52-326-2

Figure 17-7. SPAD Assemblies (Sheet 2 of 2)

Table 17-1. SPAD Shear Pin Force Requirements

SPAD Assembly	Nominal Force (Pounds)
Pilot Collective	38
CPG Collective	45
Pilot Longitudinal	43
CPG Longitudinal	50
Pilot Lateral	26
CPG Lateral	30
Pilot Directional	77
CPG Directional	90

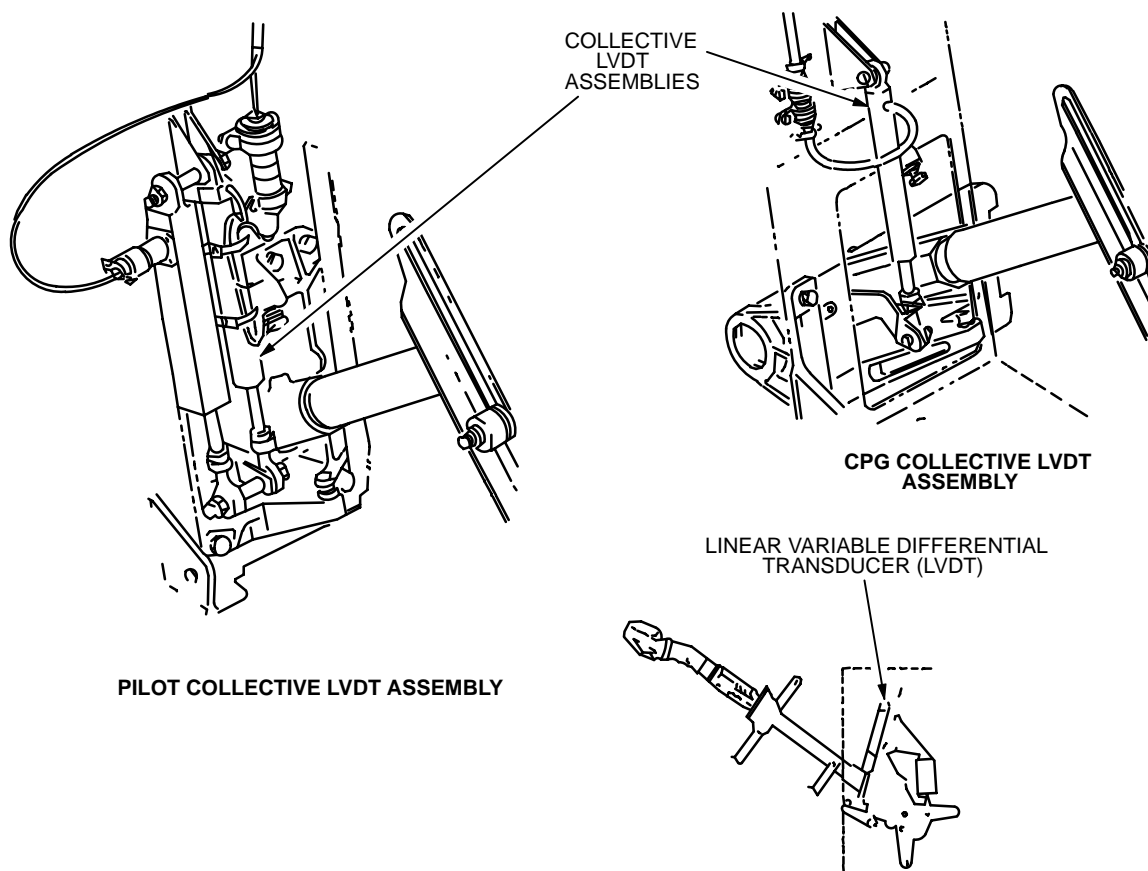
17-3. THEORY OF OPERATION (cont)

17-3

(8) The LVDT assemblies (fig. 17-8) develop signals that are proportional to the collective and cyclic control sticks, and directional foot pedals positions. The LVDT assemblies are located under the floor. The collective LVDT assemblies are attached to the pilot and CPG collective sticks. The longitudinal and lateral LVDT assemblies are attached to the pilot and CPG cyclic control sticks. The directional LVDT assembly is attached to the pilot and CPG directional pedals.

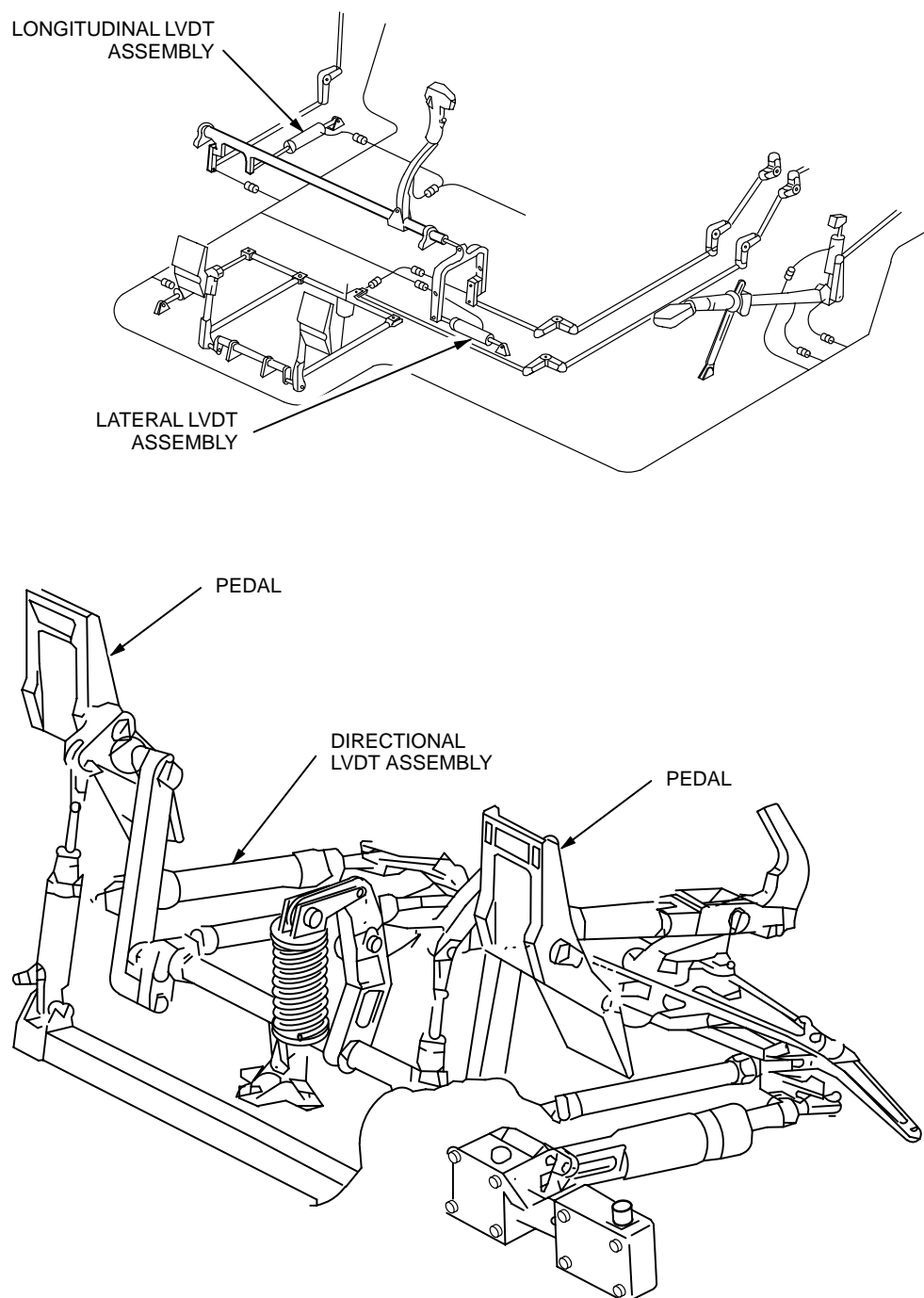
(a) The pilot LVDT assemblies are activated by 26 VAC from the T2 transformer. The CPG LVDT assemblies are activated by 26 VAC from the T1 transformer. When the control sticks or directional pedals are moved, the moveable core of the LVDT assembly moves, causing a signal to develop which is supplied to the DASEC.

(b) On helicopters (ACA), the signal supplied to the DASEC is used for CAS operation. On helicopters (ACB), the LVDT assemblies signals are supplied to the DASEC for CAS operation, BUCS operation, and monitoring of flight control wire severance.



M52-327-1

Figure 17-8. LVDT Assemblies (Sheet 1 of 2)



M52-327-2

Figure 17-8. LVDT Assemblies (Sheet 2 of 2)

17-3. THEORY OF OPERATION (cont)
17-3

b. **DASE System Functions.** The DASE system components operate to achieve system functions that stabilize the helicopter. These functions are described below.

(1) Stability augmentation system (SAS) is an automatic function that corrects flight deviations corresponding to the direction and rate of deviation.

(2) Command augmentation system (CAS) is commanded by pilot or CPG control stick movements to increase flight control response while not affecting SAS operation.

(3) Attitude hold reduces aircrew workload by maintaining the desired pitch and roll attitude above airspeeds of 60 knots.

(4) Turn coordination is provided through SAS using air data subsystem (ADSS) information.

(5) Hover augmentation system (HAS) reduces aircrew workload by maintaining the desired position and attitude during hover and low airspeeds.

(6) Heading hold reduces aircrew workload by maintaining the desired heading.

(7) Force trim system holds the control sticks and directional control pedals in a neutral position selected by the pilot or CPG to allow limited hands-off flying.

(8) Back-up control system (BUCS) is a non-redundant, emergency fly-by-wire back-up control system that controls the hydraulic servocylinders based on pilot or CPG control stick and directional pedals movements.

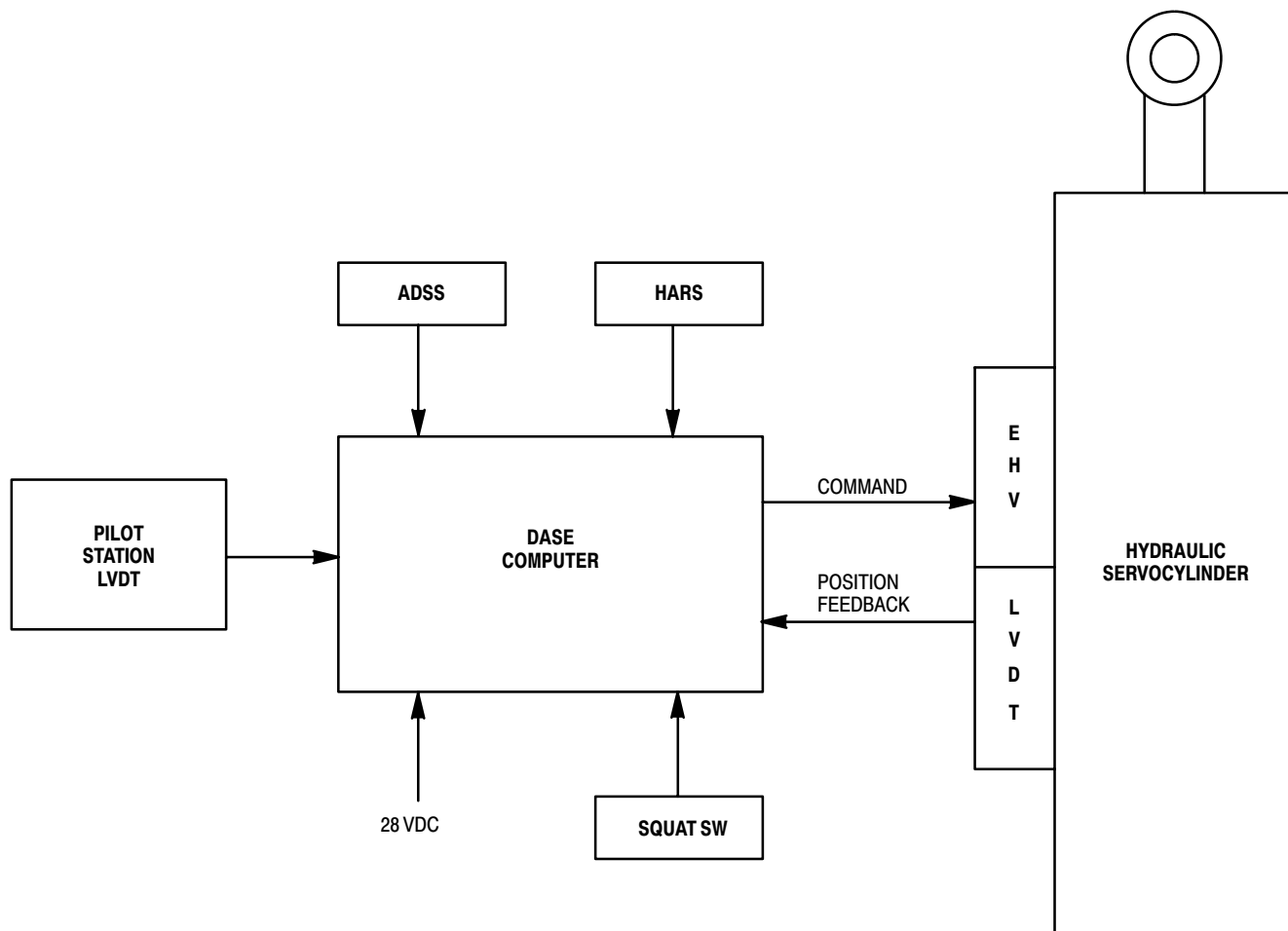
The functions of the DASE system are described in the following paragraphs to aid in understanding how the DASE system components interface.

(9) The SAS/CAS (fig. 17-9) are functions of helicopter deviations in flight and helicopter movement commanded by the pilot or CPG.

(a) SAS operates when a deviation in flight attitude occurs. The HARS and ADSS provide rate and direction of deviation signals to the DASEC. The DASEC computes a command signal and sends the signal to the EHV. The EHV causes the hydraulic servocylinder to move the upper flight controls and rotor system to correct the deviation. The servocylinder SAS LVDT provides a position feedback signal to the DASEC which washes-out EHV signals and prevents over correction.

(b) CAS operates when the control sticks or directional pedals are moved by the pilot or CPG. The CAS function assists the mechanical linkages to move the hydraulic servocylinders to increase flight control response while not affecting SAS operation. When the control sticks or directional pedals are moved the respective LVDT assemblies in the pilot or CPG crew station develop a signal proportional to the direction and amount of control sticks or directional pedals movements. The LVDT assemblies signals are sent to the DASEC.

(c) The DASEC uses the LVDT assemblies signals to compute a command signal proportional to control sticks or directional pedals movements. The DASEC sends the command signal to the hydraulic servocylinder EHV. The EHV assists the mechanical linkages to move the servocylinder. The hydraulic servocylinder BUCS LVDT assemblies send signals to the DASEC proportional to servocylinder movement.



M52-328-1A

Figure 17–9. SAS/CAS Operation (Sheet 1 of 4)

(d) The DASEC sums the BUCS LVDT assemblies signal with the control sticks or directional pedals LVDT assemblies, to equal the signal sums by computing command signals to the EHV. When the LVDT assemblies sums equal the EHV returns to the centered position.

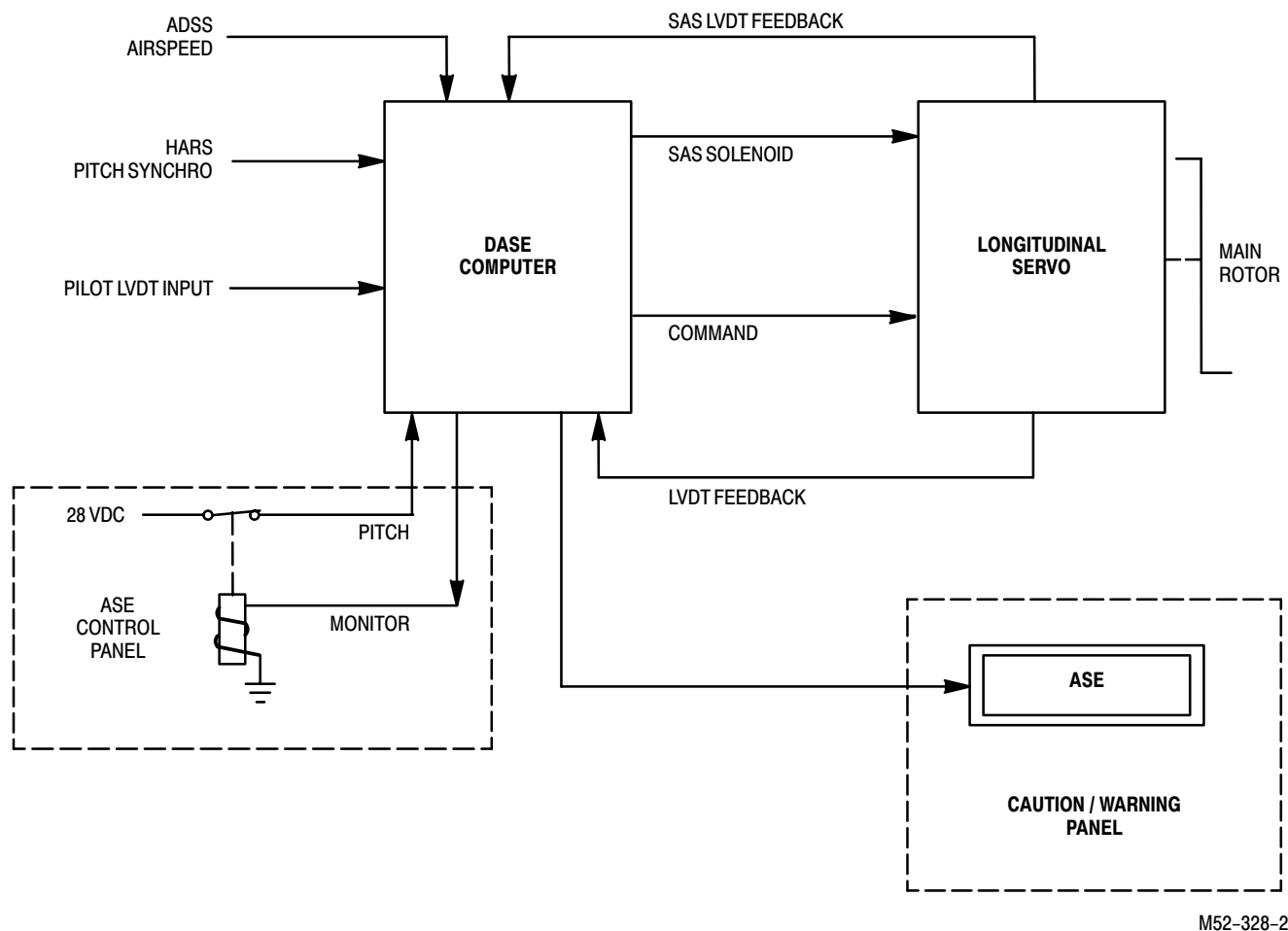
(e) The SAS/CAS operation combines to form the pitch, roll, and yaw stability command augmentation system (SCAS).

(f) The pitch SCAS operates when the **PITCH** switch on the **ASE** control panel is positioned on, and outside forces act upon the helicopter in the lateral axis. The HARS senses the deviation and supplies a rate signal to the DASEC. The DASEC sends a pitch rate signal to the longitudinal servocylinder EHV. The EHV moves the SAS cylinder which moves the servocylinder. The rate signal is summed with the CAS signal by the DASEC.

(g) The CAS signal is computed by the DASEC and sent to the EHV when the pilot or CPG moves the cyclic stick to compensate the outside force acting upon the helicopter lateral axis. The EHV assists the mechanical linkage to move the servocylinder while overriding pitch rate signals sent to the EHV. The CAS signal is lagged after initial flight controls response rate is achieved, to generate the desired response rate when summed with the pitch rate signal.

17-3. THEORY OF OPERATION (cont)

17-3



M52-328-2A

Figure 17-9. SAS/CAS Operation (Sheet 2 of 4)

(h) Roll SCAS operates when the **ROLL** switch on the **ASE** control panel is positioned on, and outside forces act upon the helicopter longitudinal axis. Roll SCAS functions are similar to pitch SCAS functions. Rate, attitude, and cyclic stick lateral movements are received by the DASEC. Roll SCAS moves the lateral servocylinder.

(i) Yaw SCAS operates when the **YAW** switch on the **ASE** control panel is positioned on, and outside forces act upon the helicopter vertical axis. Yaw SCAS functions are similar to pitch SCAS functions. Rate, attitude, and directional pedals movements are received by the DASEC. Yaw SCAS moves the directional servocylinder.

17-3. THEORY OF OPERATION (cont)

17-3

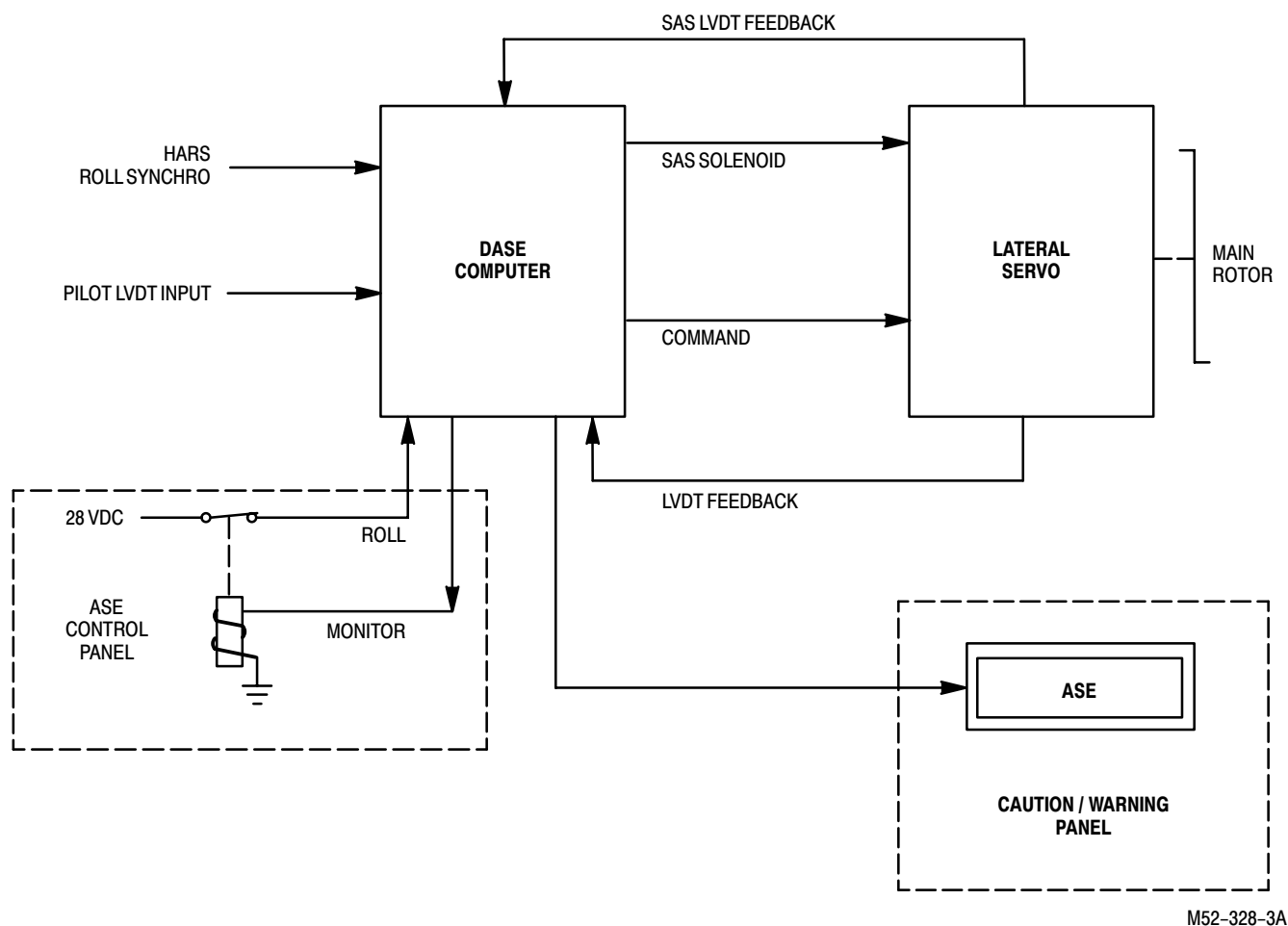
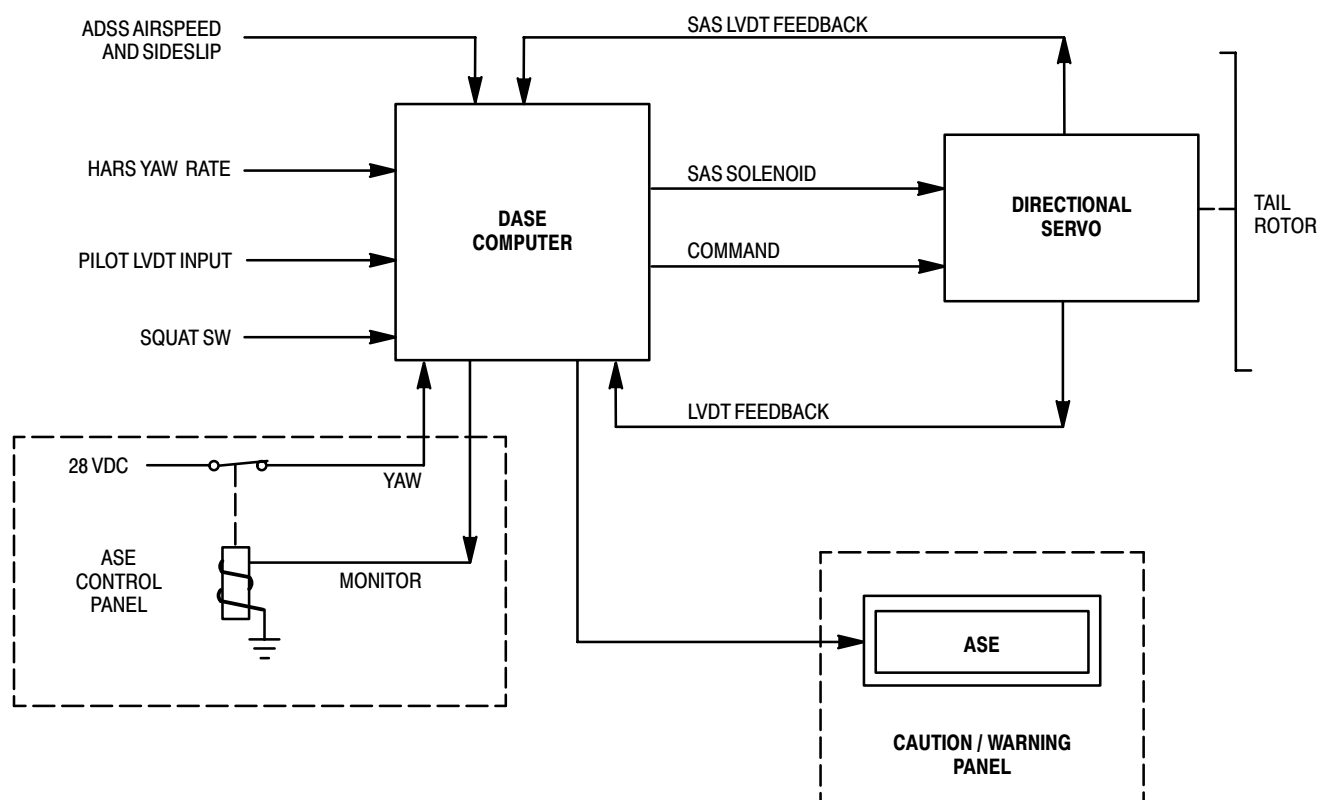


Figure 17-9. SAS/CAS Operation (Sheet 3 of 4)

17-3. THEORY OF OPERATION (cont)

17-3



M52-328-4A

Figure 17-9. SAS/CAS Operation (Sheet 4 of 4)

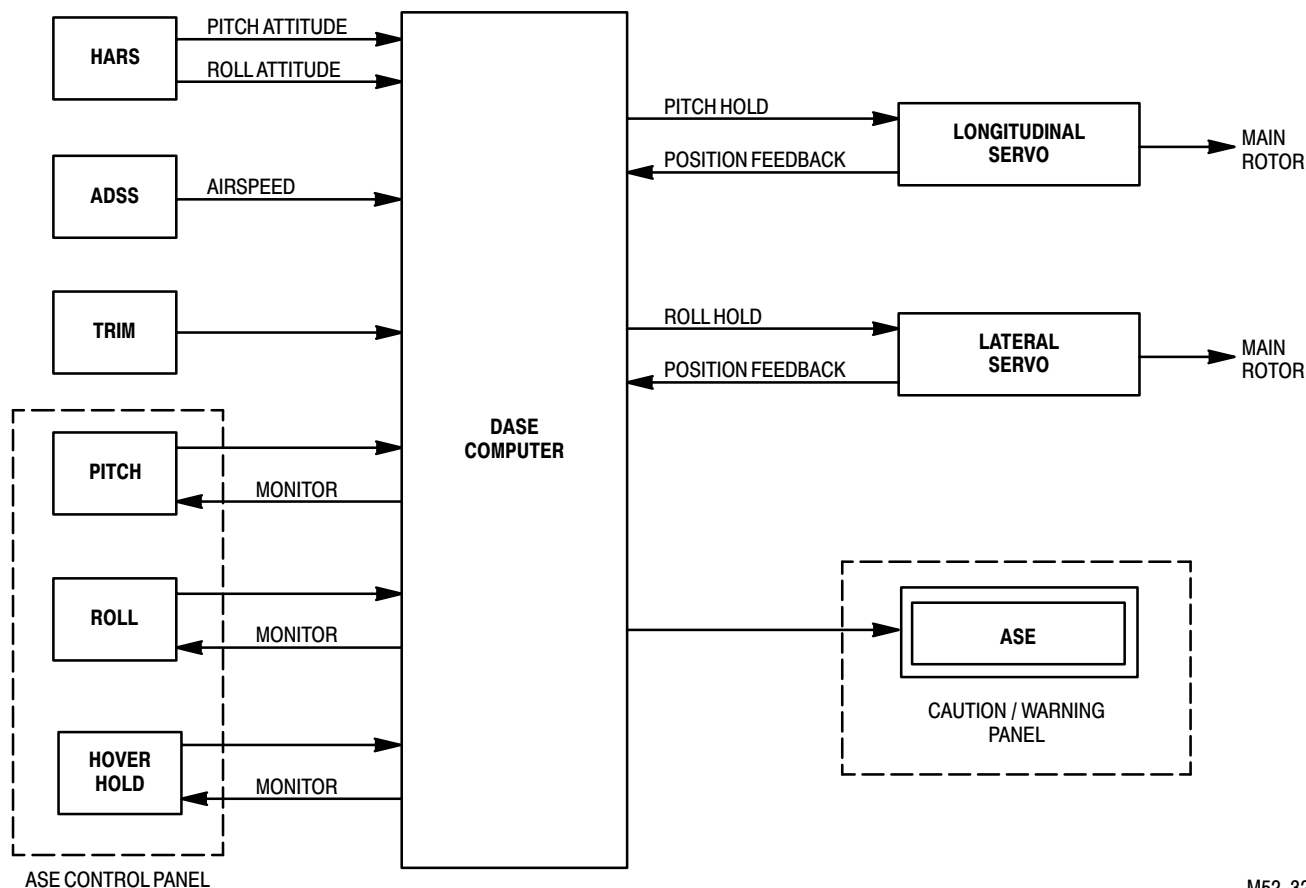
(10) Attitude hold (fig. 17-10) operates when the **PITCH**, **ROLL**, and **ATTD/HOVER HOLD** switches on the **ASE** control panel are positioned on; and the ADSS airspeed is above 60 knots. Attitude hold allows hands-off flying and CAS is inoperable while attitude hold is operating.

(a) Pitch and roll attitude signals are sent to the DASEC from the HARS. The actual attitude signals are compared to the reference attitude, and the DASEC computes a command signal to the longitudinal or lateral servocylinder EHVs. The EHVs move the SAS cylinders which move the servocylinders, correcting attitude deviations while providing rate damping. The servocylinders SAS LVDT assemblies send position signals to the DASEC. The DASEC sums the command signals and the LVDT assemblies position signals to wash out command signals. This returns the SAS cylinders to a centered position which stops servocylinders movements.

(b) Momentary release of the force trim switch resynchronizes the rate signal with the force trim system, and establishes a new reference attitude.

17-3. THEORY OF OPERATION (cont)

17-3



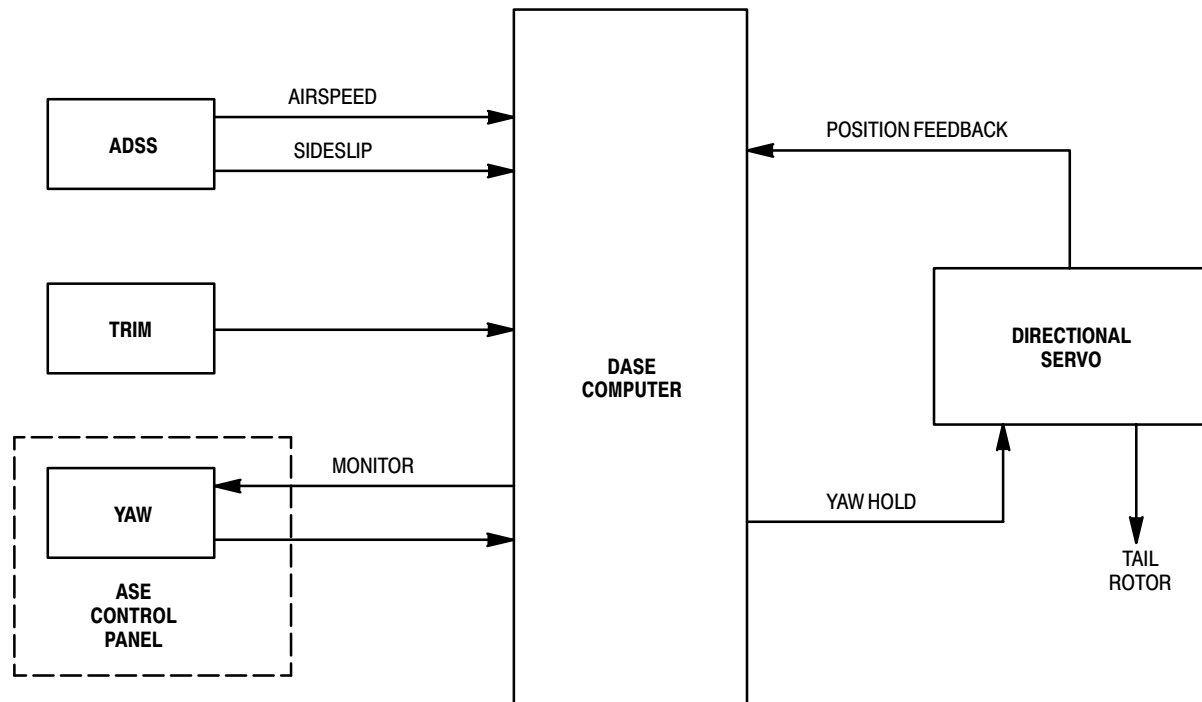
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Figure 17-10. Attitude Hold Operation

(11) Turn coordination (fig. 17-11) is automatic during Yaw SCAS operation when the force trim system is operating and ADSS airspeed is above 60 knots. Yaw CAS is inoperable during turn coordination operation. Sideslip signals from the ADSS are sent to the DASEC. The actual sideslip signals are compared to the reference sideslip, and the DASEC computes a command signal to the directional servocylinder EHV. The EHV moves the SAS cylinder which moves the servocylinder, correcting sideslip deviations while providing rate damping. The servocylinder SAS LVDT assembly sends position signals to the DASEC. The DASEC sums the command signals and the LVDT assembly position signals to wash out command signals. This returns the SAS cylinder to a centered position which stops servocylinder movements.

17-3. THEORY OF OPERATION (cont)

17-3



M52-330

Figure 17-11. Turn Coordination Operation

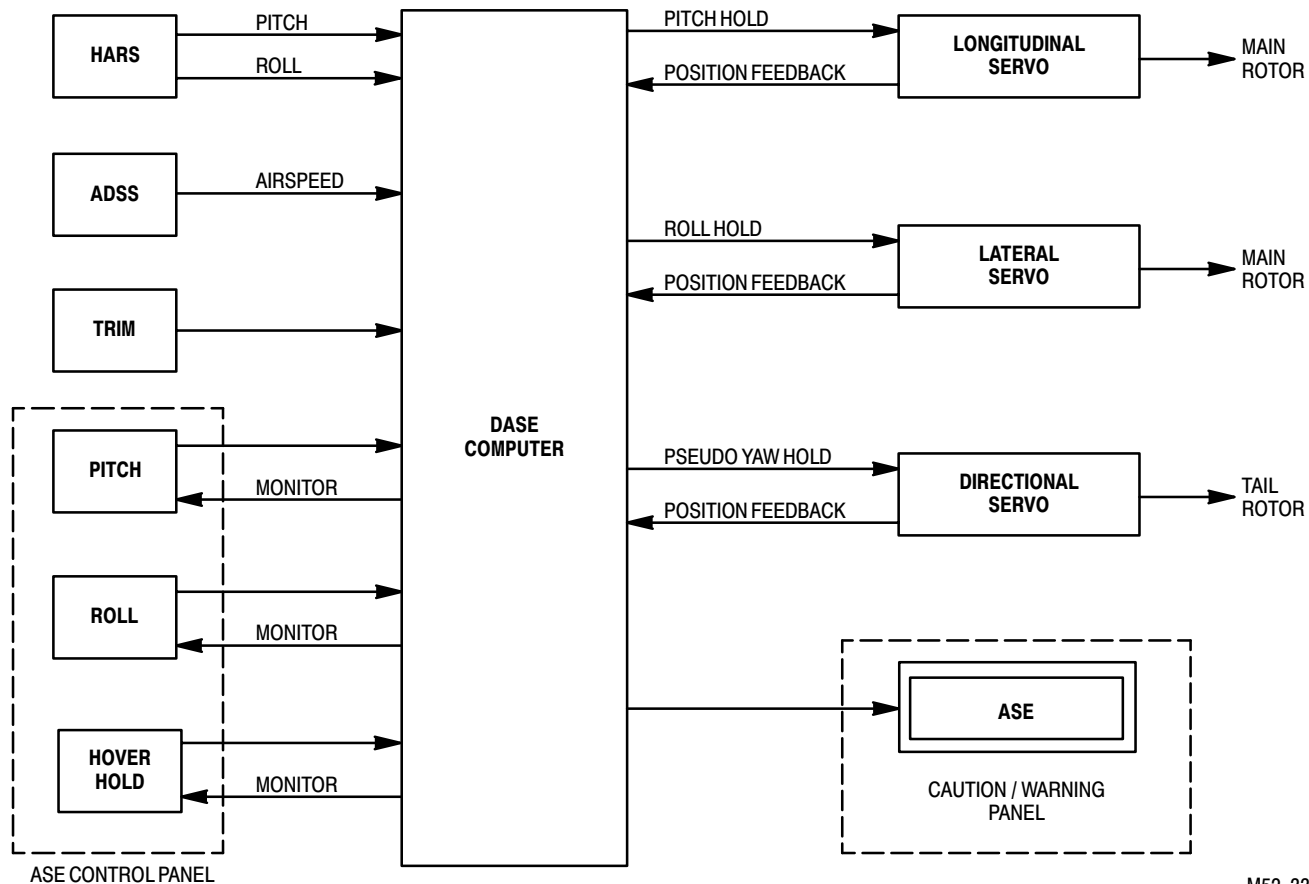
(12) The hover augmentation system (fig. 17-12) operates automatically during pitch and roll SCAS operation, when the force trim system is operating, ADSS airspeed is below 50 knots, and ADSS ground speed is below 15 knots. The hover augmentation system holds the helicopter in a 12-foot radius circle for 20 seconds in a 5 to 10 mph wind, while slow ascent or descent from 200 feet above ground level can be executed.

(a) Pitch and roll attitude signals are sent to the DASEC from the HARS. The actual attitude signals are compared to the reference attitude, and the DASEC computes a command signal to the longitudinal or lateral servocylinder EHVs. The EHVs move the SAS cylinders which moves the servocylinders, correcting attitude deviations while providing rate damping. The servocylinders SAS LVDT assemblies send position signals to the DASEC. The DASEC sums the command signals and the LVDT assemblies position signals to wash out command signals. This returns the SAS cylinders to a centered position which stops servocylinders movements.

(b) Momentary release of the force trim switch resynchronizes the rate signal with the force trim system, and establishes a new reference attitude.

17-3. THEORY OF OPERATION (cont)

17-3



M52-331A

Figure 17-12. Hover Augmentation System Operation

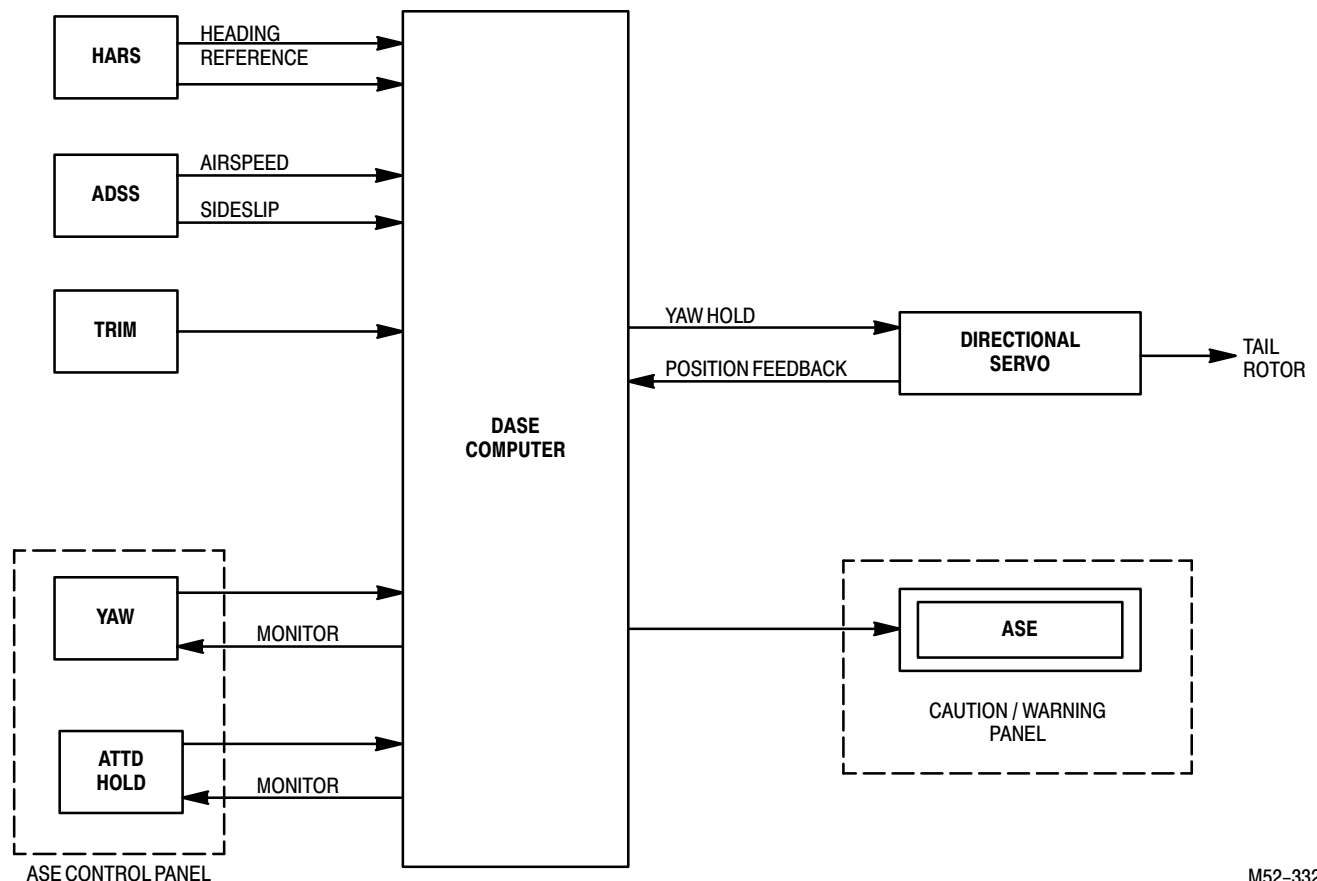
(13) Heading hold (fig. 17-13) operates automatically during yaw SCAS operation when the force trim system is operating, and ADSS airspeed is below 50 knots. Heading hold maintains a one degree heading in a 10 to 50 mph wind.

(a) Heading signals from the HARS are sent to the DASEC. The actual heading signals are compared to the reference heading, and the DASEC computes a command signal to the directional servocylinder EHV. The EHV moves the SAS cylinder which moves the servocylinder, correcting heading deviations while providing rate dampening. The servocylinder SAS LVDT assembly sends position signals to the DASEC. The DASEC sums the command signals and the LVDT assembly position signals to wash-out command signals. This returns the SAS cylinder to a centered position which stops servocylinder movements.

(b) Momentary release of the force trim switch resynchronizes the heading signal with the force trim system, and establishes a new reference heading.

17-3. THEORY OF OPERATION (cont)

17-3



M52-332A

Figure 17-13. Heading Hold Operation

(14) The force trim system (fig. 17-14) must be operating for the DASE system to be fully operational. When the force trim release switch is positioned off, power is removed from the magnetic brakes (part of flight controls system). The pilot and CPG are in full control of the cyclic control sticks and directional foot pedals.

(a) When the pilot trim release switch is positioned on, the magnetic brakes are energized and the cyclic control sticks and directional foot pedals are held in the position selected by the pilot. If the pilot or CPG move the cyclic control sticks or directional control pedals during force trim system operation the feel spring assembly (part of flight control system) is compressed.

(b) The feel spring assembly allows force trim to be overridden without resetting force trim. When the control sticks or pedals are released the feel spring assemblies return the control sticks or pedals to the force trim setting.

(c) When the force trim release switch is positioned to release, power is momentarily removed from the magnetic brakes (part of flight controls system). The pilot and CPG are in full control of the cyclic control sticks and directional foot pedals. When the switch is released, the switch automatically returns to the on position and establishes a new force trim setting.

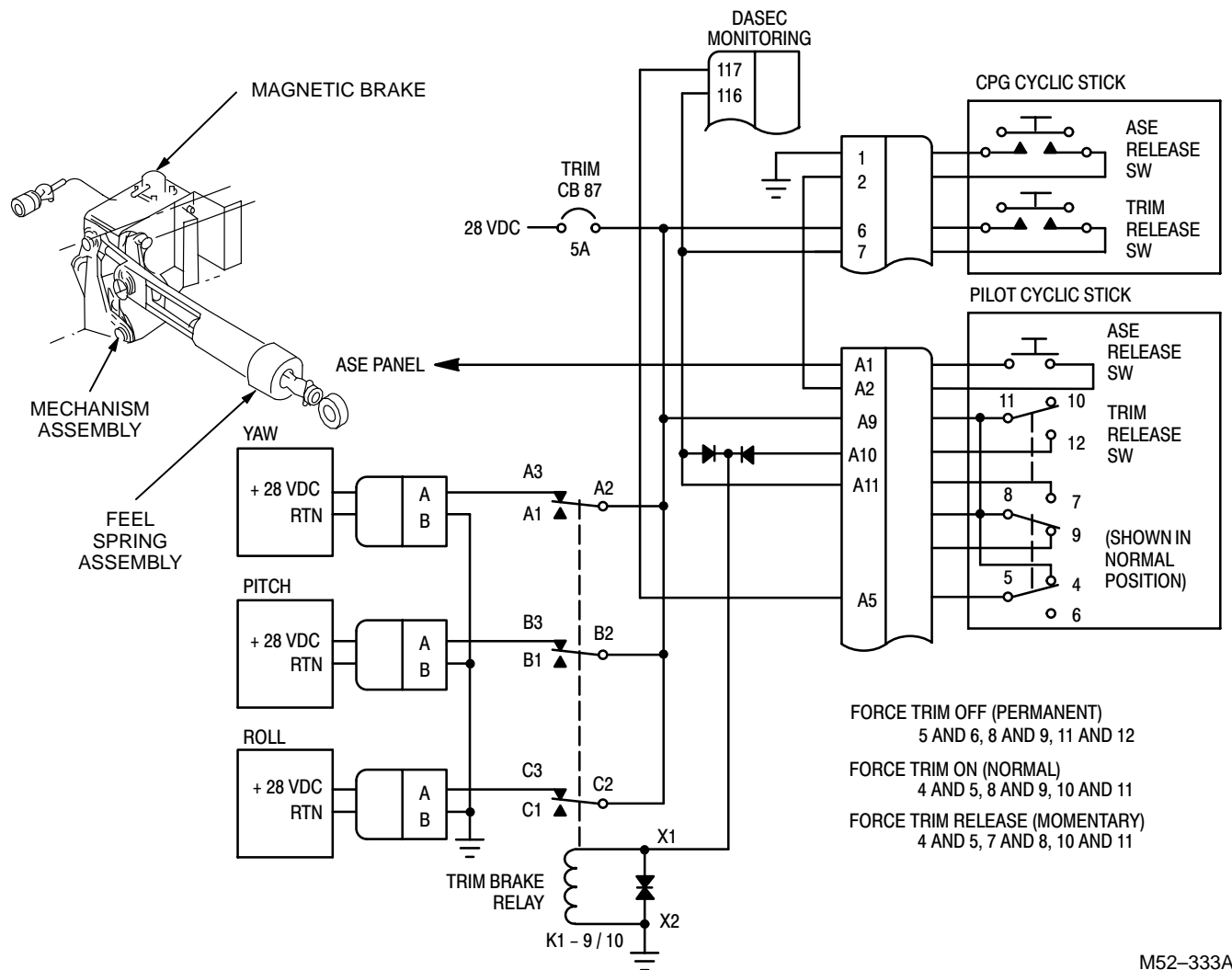


Figure 17-14. Force Trim System Operation

(15) The BUCS (ACB) (fig. 17-15) engages in any one flight axis or all flight axes. The SPAD assemblies disengage mechanical linkages operation and send a signal to the DASEC initiating BUCS operation in the affected axis. The DASEC disengages ASE operation and has total control of the hydraulic servocylinders.

(a) When the SPAD assemblies signal BUCS operation, the DASEC signals the hydraulic servocylinder SAS and BUCS solenoid valves. The solenoid valves apply hydraulic pressure to the affected servocylinder, and lock out manual control of the servocylinder. With the manual control locked out the EHV controls the servocylinder in the BUCS engaged axis.

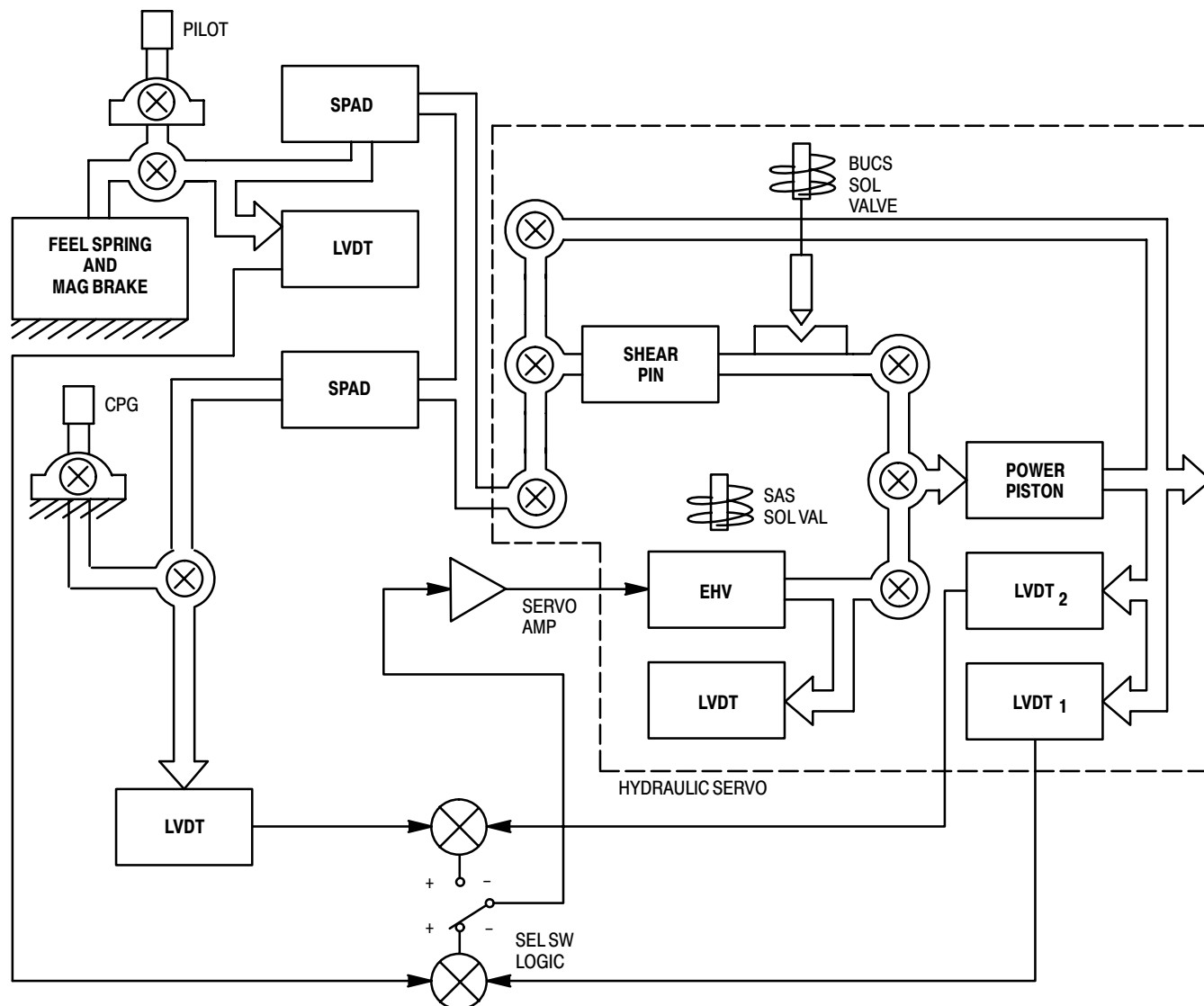
(b) When the pilot moves the control sticks or directional pedals the LVDT assembly in the affected axis sends a position signal to the DASEC. The DASEC computes a command signal and sends the signal to the EHV. The EHV ports pressurized hydraulic fluid through the primary pressure port and SAS cylinder to move the power piston. The power piston moves to generate upper flight controls and rotor system movement.

17-3. THEORY OF OPERATION (cont)

17-3

(c) The servocylinder BUCS LVDT assemblies develop a position signal which is sent to the DASEC. The DASEC sums the position signals and the command signal to wash out the command signal. The EHV returns to the centered position and servocylinder movement stops. The cylinder is hydraulically locked into position until the pilot moves the control sticks or directional pedals in the affected axis.

(d) BUCS control can be switched from the pilot LVDT assemblies to the CPG LVDT assemblies by pressing the **BUCS** select switch on the CPG collective control stick. When the **BUCS** select switch is pressed control of the LVDT assemblies cannot be transferred back to the pilot.



M52-334

Figure 17-15. BUCS Operation

18-1. PURPOSE

18-1

CHAPTER 18 AIRCRAFT SURVIVABILITY EQUIPMENT

18-1. PURPOSE

The active and passive aircraft survivability equipment (ASE) enhances helicopter radar, infrared (IR), and wire strike survivability.

18-2. DESCRIPTION

The ASE consists of the following major subsystems (fig. 18-1).

- a. **Radar Countermeasures System (AN/ALQ-136).** The radar countermeasures system provides the capability to jam the operation of radar systems and radar-guided weapons.
- b. **IR Countermeasures System (AN/ALQ-144).** The IR countermeasures system provides the capability to jam the operation of IR systems and IR-guided weapons.
- c. **Radar Warning System (AN/APR-39) (ADN).** The radar warning system detects radar signals and provides visual and aural warning.
- d. **Radar Warning System (AN/APR-39A) (ADO).** The radar warning system detects radar signals and provides visual and audio (synthetic voice) warning.
- e. **Laser Detecting Set (AN/AVR-2A) (ADP).** The laser detecting set works in conjunction with the Radar Warning System (AN/APR-39A(V) (ADO) to detect tracking laser signals and provides visual and audio (synthetic voice) warning.
- f. **Chaff Dispenser System (M130).** The chaff dispenser system dispenses chaff to decoy radar systems and radar-guided weapons away from the helicopter.
- g. **Wire Strike Protection System (WSPS).** The wire strike protection system provides a means of deflecting and/or cutting electrical or communication transmission wires encountered during low-level flight.

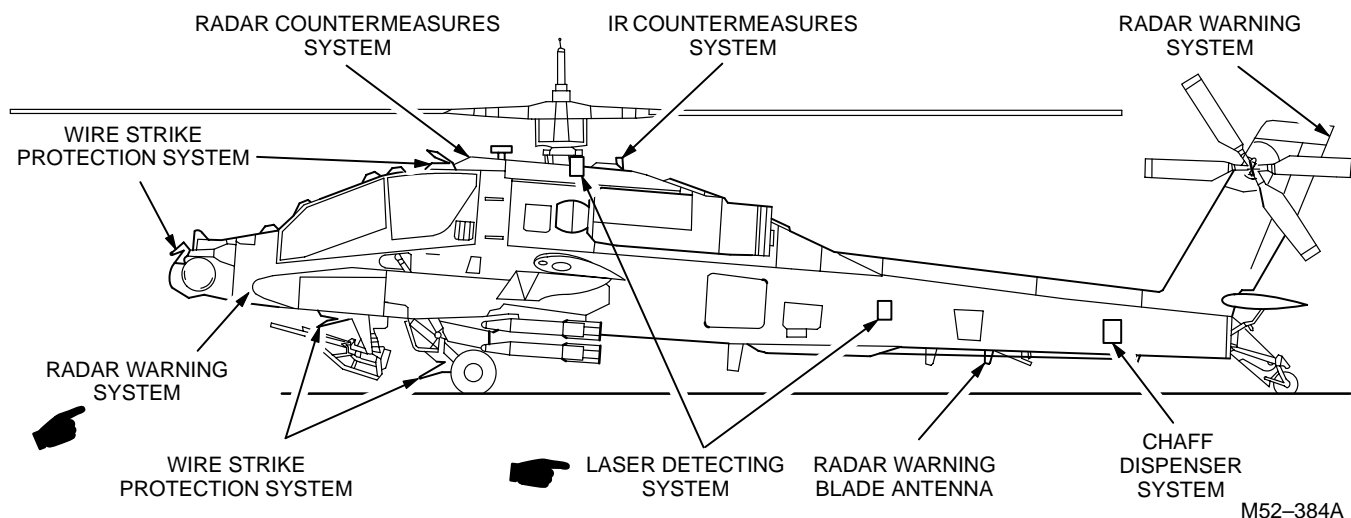


Figure 18-1. ASE Major Subsystems

18-3. THEORY OF OPERATION

18-3

18-3. THEORY OF OPERATION

a. **Radar Countermeasures System (AN/ALQ-136).** The radar countermeasures system major components (fig. 18-2) are described in the following subparagraphs.

(1) The radar/IR jammer control panel is located on the pilot upper right console. The control panel provides a mounting for the **RDRCM** switch. The **RDRCM** switch is a three-position switch that turns the radar jamming system on, off, or to standby.

(2) Receive antenna. The receive antenna is mounted on top of the fuselage in front of the rotor mast on the doghouse fairing assembly. The receive antenna receives unfriendly fire control radar threat signals and sends them to the receiver/transmitter.

(3) Transmit antenna. The transmit antenna is mounted on top of the target acquisition designation sight (TADS) and pilot night vision sensor (PNVS) turret. The transmit antenna transmits modulated jamming signals back to unfriendly fire control radar.

(4) The radar jammer receiver/transmitter is located in the pilot left forward avionics bay. The receiver/transmitter receives 115 VAC from the essential bus 1, and 28 VDC from the essential bus 1. The receiver/transmitter receives RF signals from the receiver antenna. The receiver/transmitter operates in the standby and on modes. When the **RDRCM** switch on the radar/IR jammer control panel is set to **ON**, the receiver transmitter operates in the on mode.

(5) In the **ON** mode, the radar jammer automatically provides jamming signals to the transmit antenna upon receipt of radar-guided missile signals after an initial one minute warm-up period. When the **RDRCM** switch is positioned to **STBY**, the receiver/transmitter does not send RF signals to the transmit antenna. Standby mode operation negates the need for **ON** mode warm-up after operating one minute.

(6) The radar jammer indicator light assembly is located on the pilot upper right console. The **JAM** light illuminates when the radar jammer transmitter/receiver provides jamming signals to the transmit antenna.

(7) When the **TEST** light is pressed, the light illuminates and signals the receiver/transmitter to perform a confidence test of the radar jammer components. When the confidence test is performed the **GO** or **NO GO** light illuminates to inform the radar jammer system status.

b. **IR Countermeasures System (AN/ALQ-144).** The IR countermeasures system major components (fig. 18-3) are described in the following subparagraphs.

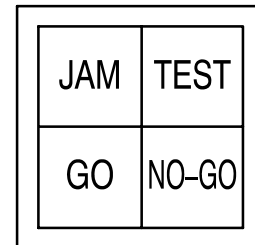
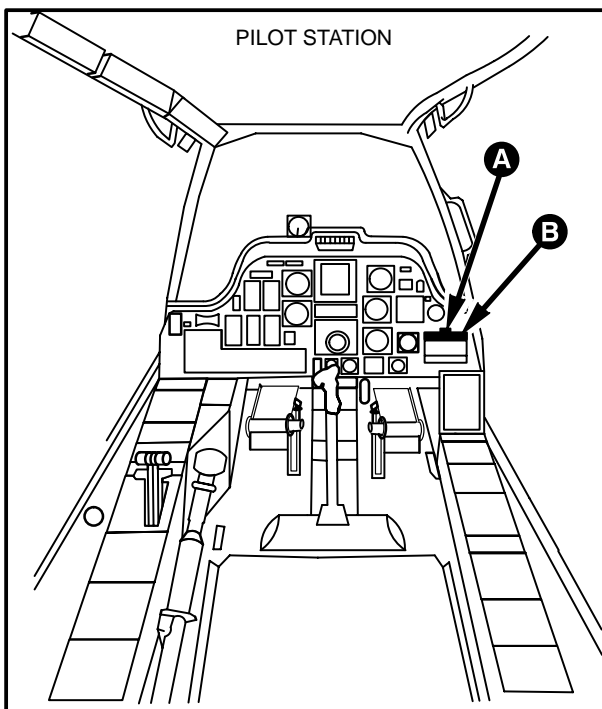
(1) The radar/IR jammer control panel is located on the pilot upper right console. The control panel provides mounting for the **IRCM** switch. The **IRCM** switch is a two position switch that turns the IR jammer system on or off.

(2) The IR jammer is located in the fairing aft of the main rotor on the upper center portion of the center fuselage section. The IR jammer receives 28 VDC from the essential bus 2. When the **IRCM** switch is set to **ON**, the IR jammer transmits mechanically modulated radiation at high and low frequencies to decoy IR-guided missiles, after a 30 second warm-up period. A built-in test function monitors system failures and illuminates the IR **JAM** light on the pilot caution/warning panel.

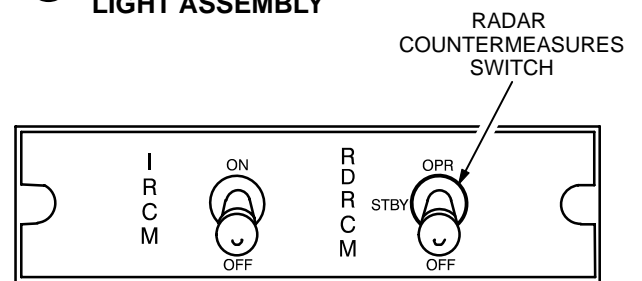
(3) When the **IRCM** switch is set to **OFF**, the IR jammer no longer transmits radiation, but operates the IR jammer for a cool down period. During the cool down period the IR **JAM** light on the pilot caution/warning panel is illuminated.

18-3. THEORY OF OPERATION (cont)

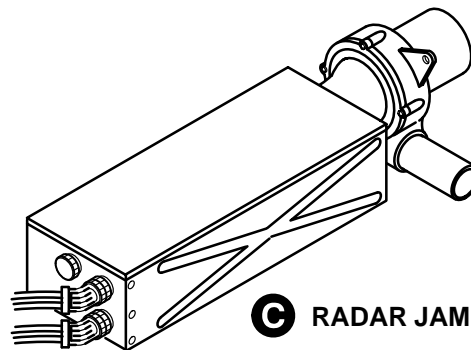
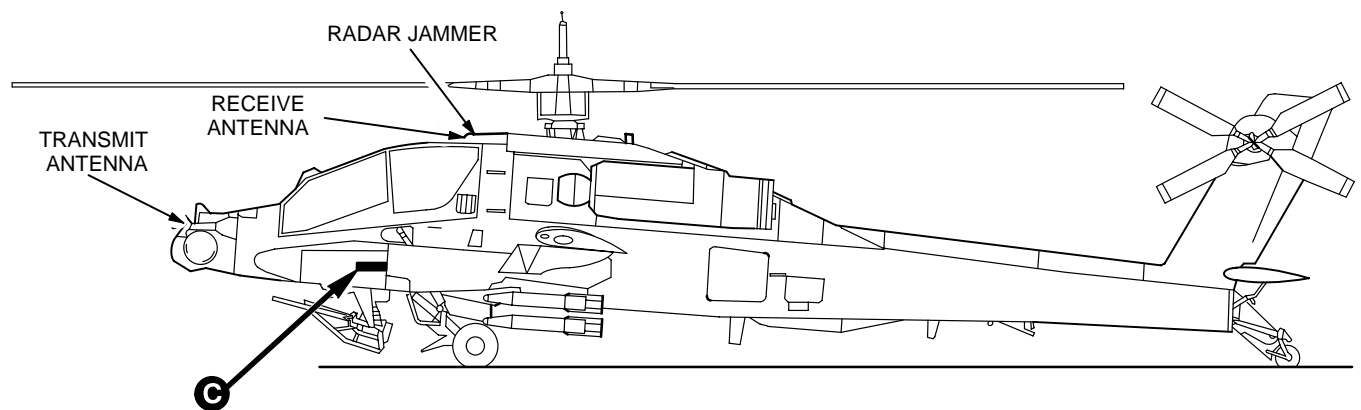
18-3



A RADAR JAMMER INDICATOR LIGHT ASSEMBLY



B RADAR/IR JAMMER CONTROL PANEL



C RADAR JAMMER RECEIVER/TRANSMITTER

M52-385B

Figure 18-2. Radar Countermeasures System (AN/ALQ-136) Major Components

18-3. THEORY OF OPERATION (cont)

18-3

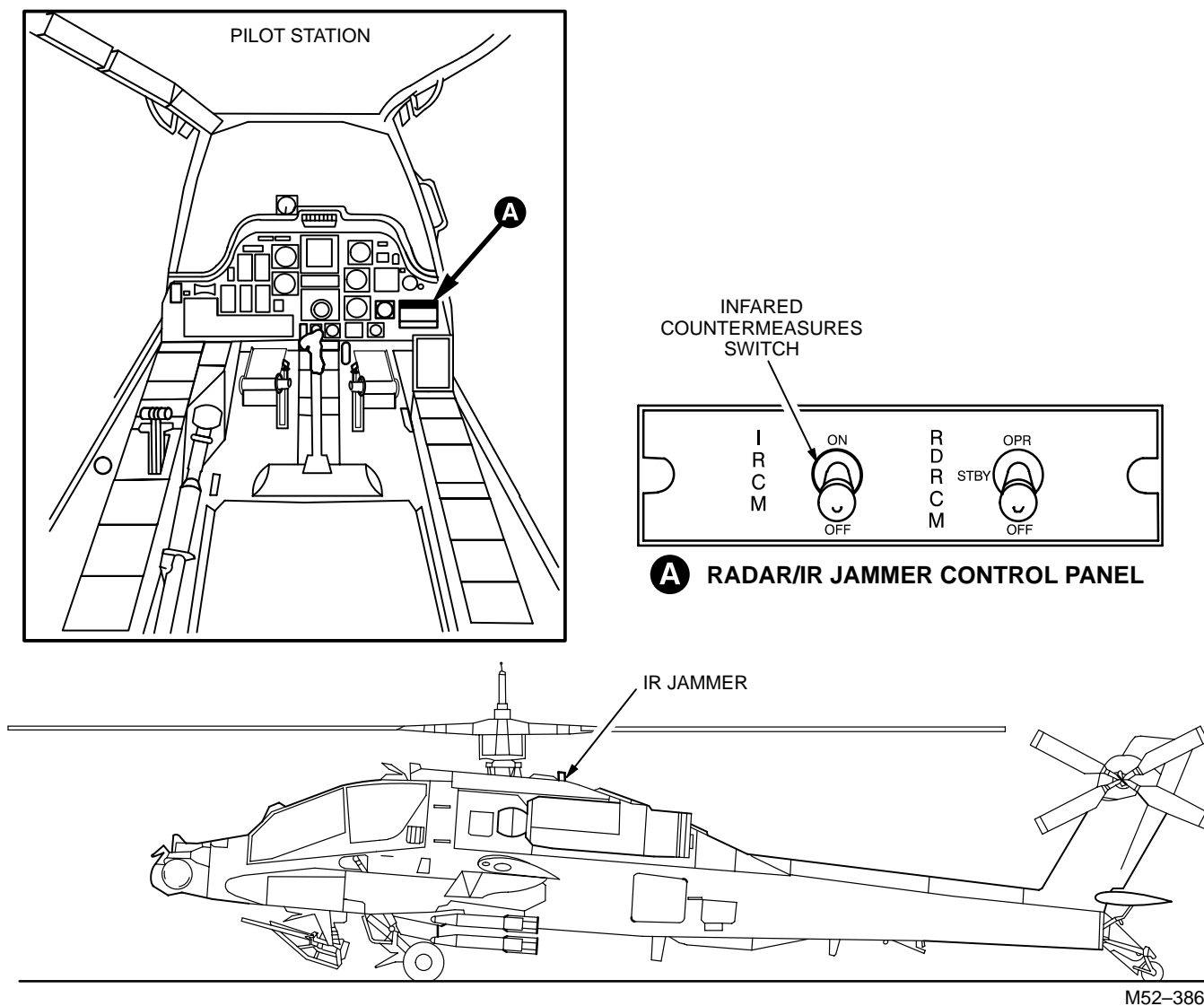


Figure 18-3. The IR Countermeasures System (AN/ALQ-144) Major Components

c. **Radar Warning (RW) System (AN/APR-39) (ADN).** The RW system (fig. 18-4) major components are described in the following subparagraphs. See paragraph c1. for RW system AN/APR-39A (ADO).

(1) The forward and aft radar warning receivers are solid state LRUs that convert RF signals, supplied by the forward and aft spiral antennas, into video signals. There is one forward and one aft radar warning receiver. The forward radar warning receiver is located in the left forward avionics bay (part of airframe). The aft radar warning receiver is located in the upper forward section of the vertical stabilizer (part of airframe).

(2) The radar warning comparator is located under fairing T355. The comparator is a solid state, sealed LRU that receives power from the emergency dc bus. The comparator receives radio frequency (RF) signals from the blade and spiral antennas. The comparator has a one minute warm up period prior to operation. During operation, the comparator translates RF signals into video signals that are then sent to the radar warning display unit.

18-3. THEORY OF OPERATION (cont)

18-3

(a) The radar warning comparator operates in the discriminator ON and OFF modes, and the SELF-TEST mode. In the discriminator OFF mode, the **DSCRM** switch is positioned **OFF**. In this mode, all high band radar signals with amplitude greater than a predetermine threshold level are displayed on the radar warning display unit. In the discriminator ON mode, the **DSCRM** switch is positioned **ON**. In this mode only, the radar signals that meet the following criteria are displayed on the radar warning display unit.

- The signal level must be greater than the minimum threshold level.
- The pulse width must be less than the maximum pulse width.
- The pulse repetition frequencies (PRF) must be greater than the minimum pulses per second.
- The pulse train must exit with not less than the minimum pulse train persistence.

(b) In the self test mode the **SELF-TEST** switch is pressed. The radar warning comparator confidence checks all radar warning system components with the exception of antennas.

(3) The forward and aft spiral antennas are airframe surface mounted antennas. There are two forward and two aft antennas. The forward antennas are located on the forward left and right lower sections of the forward fuselage section. The aft spiral antennas are located on the upper aft section of the vertical stabilizer. The spiral antennas receive radio frequency (RF) signals from land-based and airborne radar transmitters.

(4) The blade antenna is located on the center bottom section of the aft fuselage and tail boom section (part of airframe). The antenna receives RF signals from land-based and airborne radar transmitters.

(5) The radar warning display is a solid state cathode ray tube (CRT) display that receives video signals from the radar warning comparator. The radar warning display displays the total radar environment when the radar warning comparator is operating in the discriminator on mode. Each radial strobe display represents a line of bearing to an active radar transmission.

(a) When a radar signal represents a threat, (low band radar signals correlate with high band radar signals; such as radar-guided missiles) an audio signal is sent to the radar control panel and an audio alarm is sounded in the pilot's helmet (part of avionics system). The audio alarm frequency represents the relative strength of the intercepted radar signals.

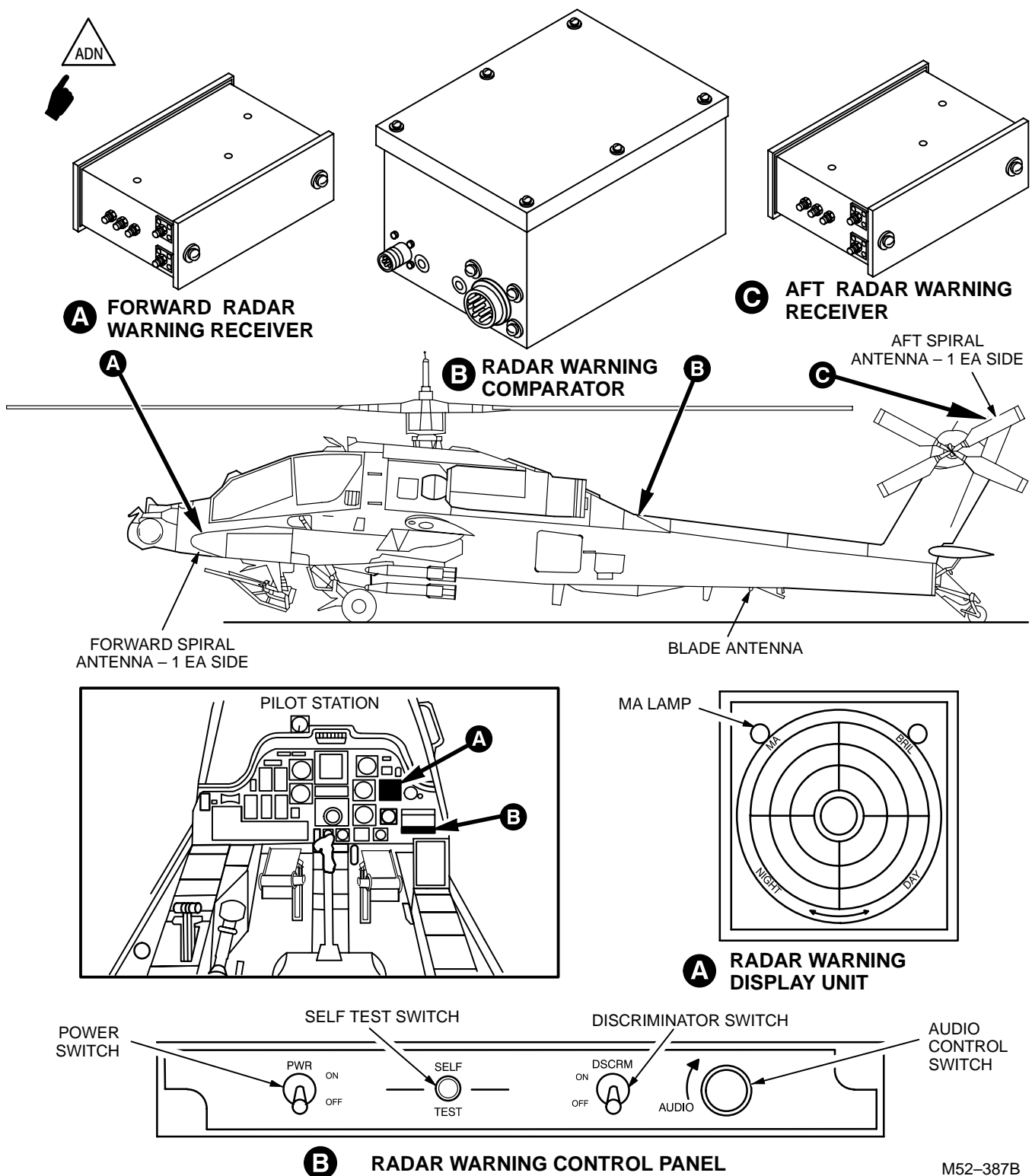
(b) During radar signal threats, the radar warning display missile alert (**MA**) lamp is illuminated. The **MA** lamp flashes to represent the relative strength of the intercepted radar signals.

(6) The radar warning control panel is located on the pilot lower right instrument panel. The radar warning control panel provides mounting for the following control switches.

- **PWR** switch is a two position switch that turns the radar warning system **ON** and **OFF**.
- **DSCRM** switch is a two position switch that activates or deactivates the discriminator mode.
- **SELF-TEST** switch is a button type switch that is pressed to initiate a self-test confidence check of the radar warning system components.
- **AUDIO** control knob is a rheostat switch that is rotated to adjust the volume level radar warning audio tones.

18-3. THEORY OF OPERATION (cont)

18-3



M52-387B

Figure 18-4. Radar Warning System (AN/APR-39) (ADN) Major Components

18-3. THEORY OF OPERATION (cont)

18-3

c1. **Radar Warning (RW) System (AN/APR-39A) (ADO).** The RW system (fig. 18-4.1) major components are described in the following subparagraphs. See paragraph c. for RW system AN/APR-39 (ADN).

(1) The forward and aft RW receivers are solid state LRUs that convert RF signals, supplied by the forward and aft antenna-detectors, into video signals which are sent to the RW digital processor. There is one forward and one aft RW receiver. The forward RW receiver is located in the left forward avionics bay (part of airframe). The aft RW is located in the upper forward section of the vertical stabilizer (part of airframe).

(2) The RW digital processor is located in the aft left avionics bay (part of airframe). The digital processor is a solid state, sealed LRU that receives power from the emergency dc bus. The digital processor receives RF signals from the blade antenna and video signals from the RW receivers. The digital processor has a one minute warm up period prior to operation. During operation, the digital processor processes and prioritizes input signals and sends video signals to the RW indicator. The processor also generates an audio (synthetic voice) message for each displayed threat. The audio message is routed to the intercommunications system through the RW control panel.

(a) The RW digital processor operates automatically when power is applied and a mode is selected. Power is applied and modes are selected on the RW control panel. The modes control message format and are **MODE 1** (full) and **MODE 2** (terse). There are no operator or maintenance controls. All functions are controlled through the RW control panel.

(3) The forward and aft antenna-detectors are airframe surface mounted antennas. There are two forward and two aft antennas. The forward antennas are located on left and right lower sections of the forward fuselage section (part of airframe). The aft antennas are located on the upper aft section of the vertical stabilizer (part of airframe). The antennas receive RF signals from land-based and airborne radar transmitters.

(4) The blade antenna is located on the center bottom section of the aft fuselage and tail boom section (part of airframe). The antenna receives RF signals from land-based and airborne radar transmitters.

(5) The RW indicator is a solid-state CRT display that receives video signals from the RW digital processor. The indicator displays the seven highest priority threats on a clock position line of bearing relative to the aircraft position.

(a) The display contains a BRIL (brilliance) control which varies the intensity of the alpha-numeric symbology. The **MA** lamp and the **NIGHT/DAY** filter control toggle switch are not used in the AN/APR-39A (ADO) Radar Warning System.

(6) The RW control panel is located on the lower right pilot instrument panel. The RW control panel provides mounting for the following control switches.

- **PWR** switch is a two position locking toggle switch that turns the RW system **ON** and **OFF**.
- **MODE** switch is a two position switch that toggles the message format between full (**MODE 1**) and terse (**MODE 2**).
- **TEST** switch is a button type switch that is pressed to initiate a self-test confidence check of the RW system,
- **AUDIO** control knob is a rheostat switch that is rotated to adjust the volume of the synthetic voice warning message, generated when a radar or missile threat is received.

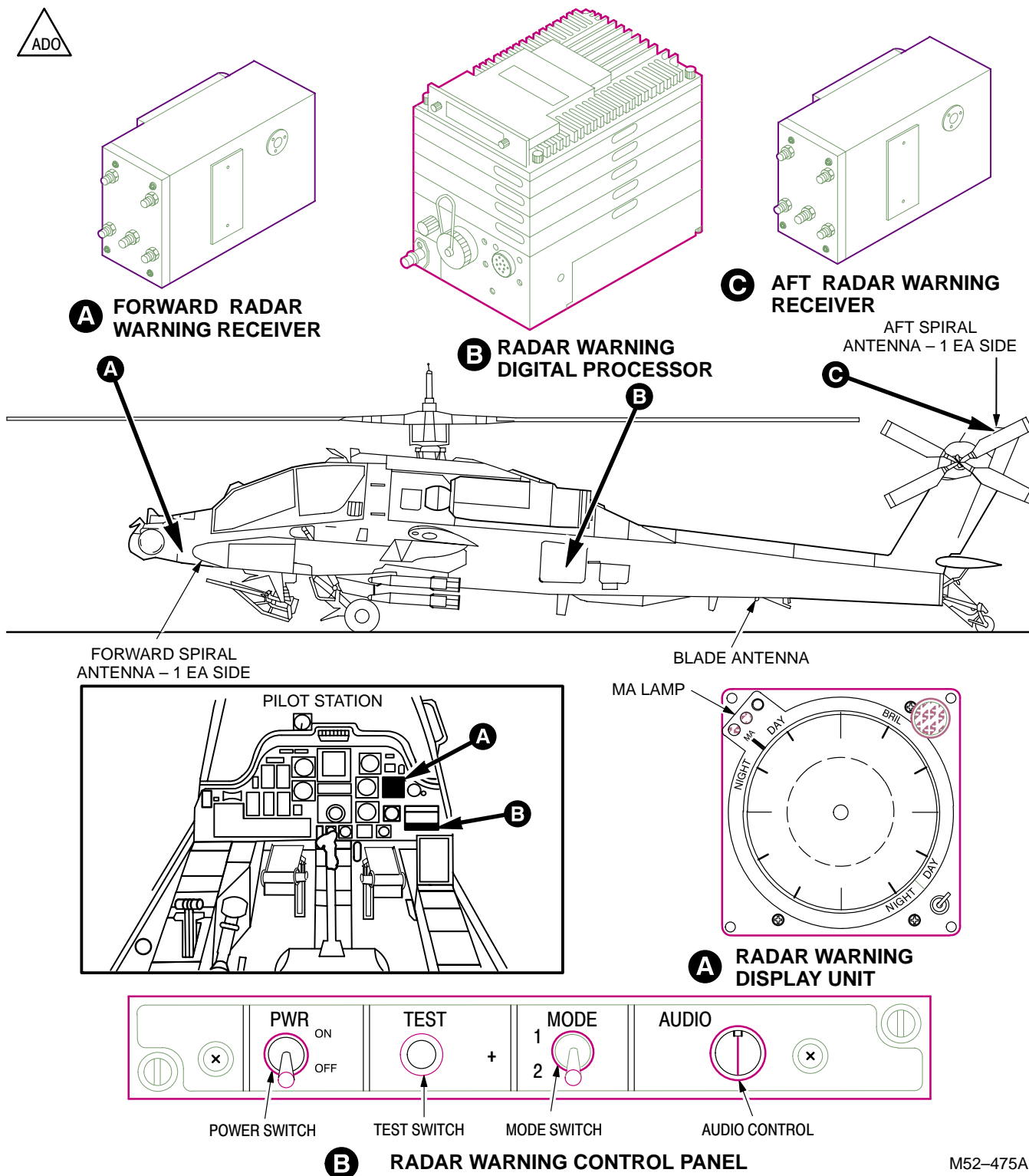


Figure 18-4.1. Radar Warning System (AN/APR-39A) (ADO) Major Components

18-3. THEORY OF OPERATION (cont)

18-3

c2. **Laser Detecting Set (AN/AVR-2A) (ADP).** The Laser Detecting Set (LDS) consists of an Interface Unit Comparator (IFU) and four sensor units. The laser detecting set works in conjunction with the Radar Warning (RW) System (AN/APR-39A) (ADO) and uses the RW indicator, control panel, and processor (fig 18-4.2).

(1) The LDS IFU is a solid-state LRU located in the aft left avionics bay (part of airframe) and receives power from the essential dc bus 2. The comparator receives validated laser threat signals from the sensor units, prioritizes the threats, and sends display information to the RW processor. The processor generates display video which is displayed on the RW indicator. The RW processor also generates an audio (synthetic voice) warning message which is sent through the RW control panel to the aircraft intercommunications system.

(a) Power to the IFU and self-test initiation are controlled by the power switch and **TEST** button on the RW control panel.

(2) The sensor units are located on the left and right sides of the main rotor fairings and the left and right sides of the aft fuselage at approximately FS 378. The sensor units receive laser threats in three designated bands (Band I, II, and III).

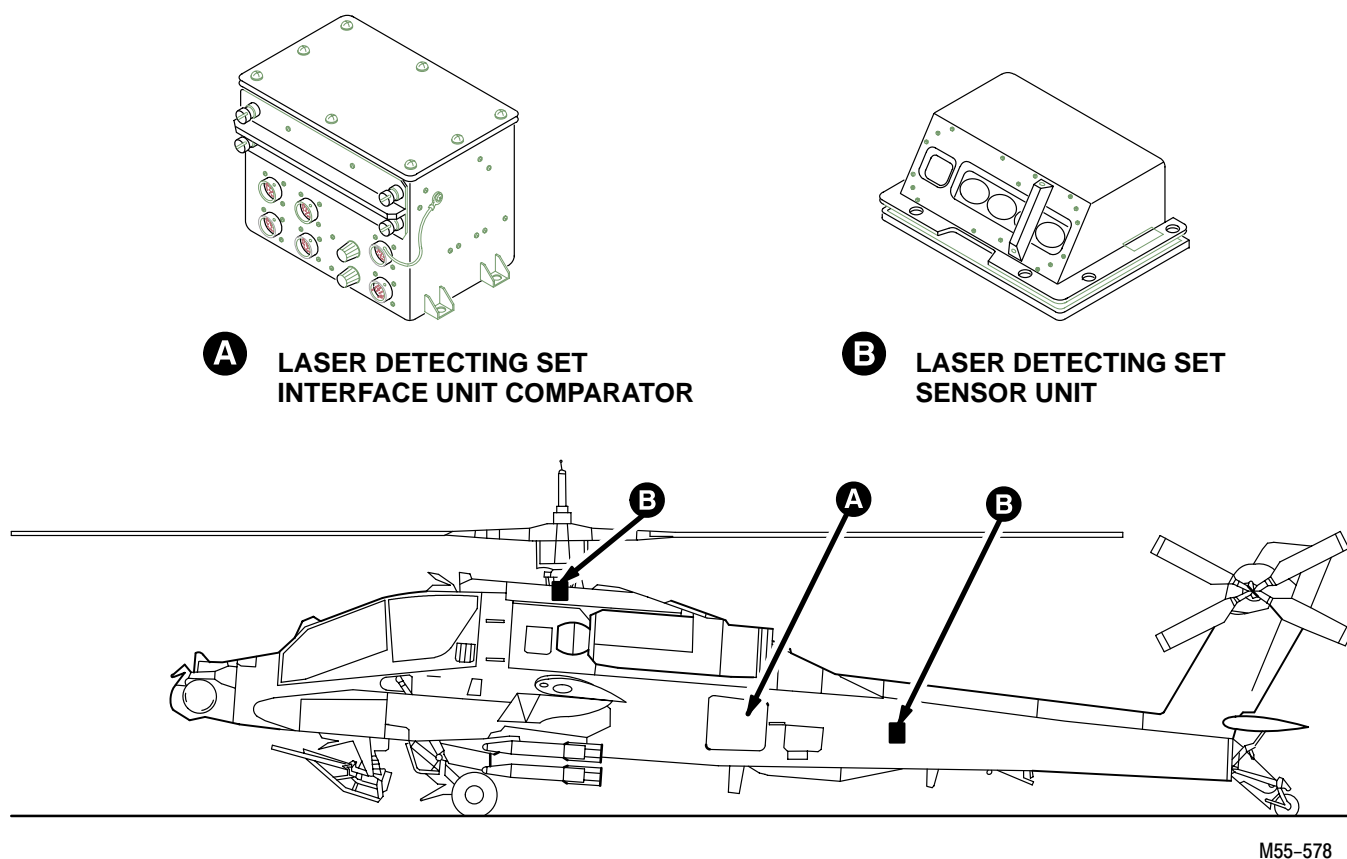


Figure 18-4.2. Laser Detecting Set (AN/AVR-2A) (ADP) Major Components

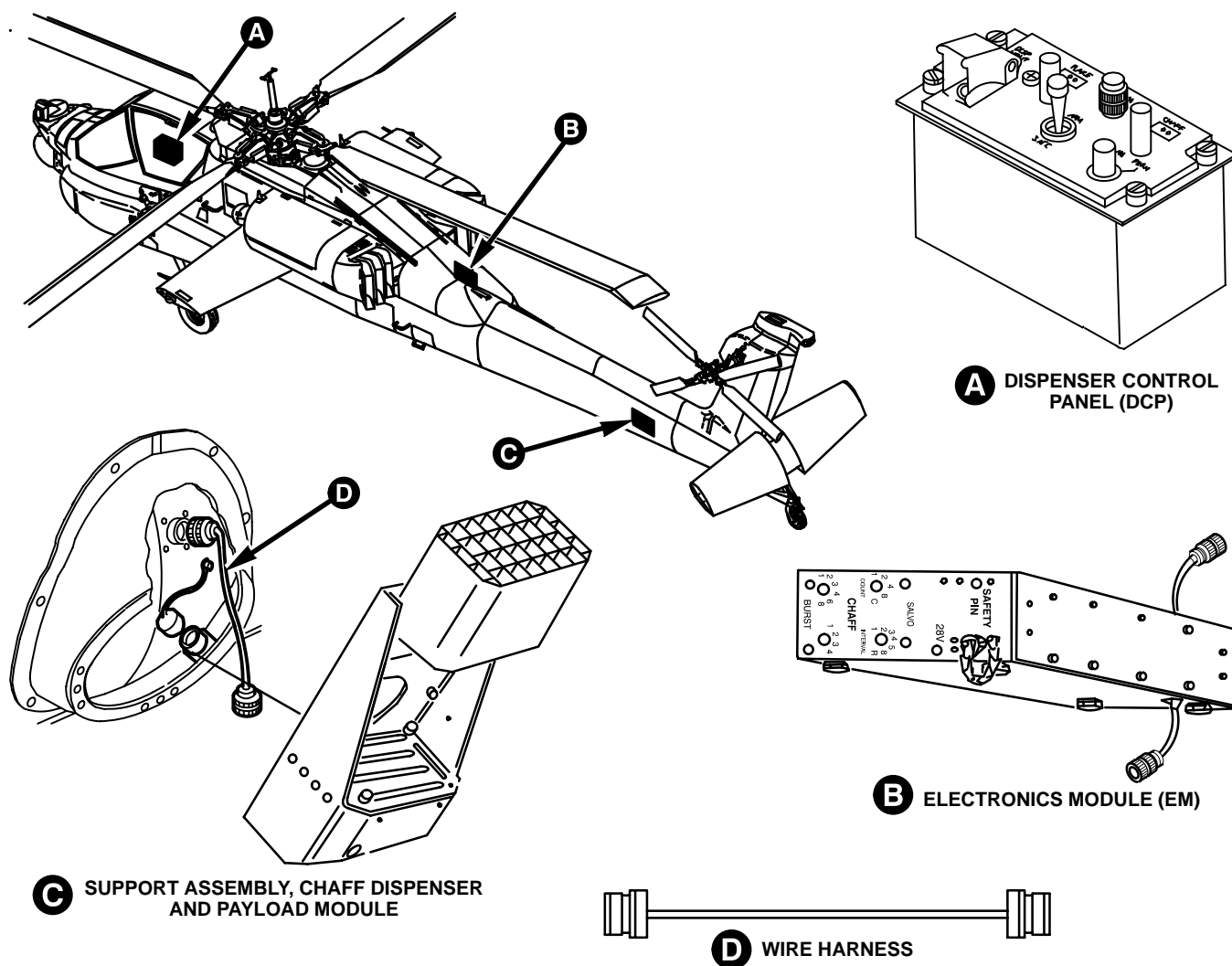
18-3. THEORY OF OPERATION (cont)

18-3

d. **Chaff Dispenser System (M130).** The chaff dispenser system major components (fig. 18-5) are described in the following subparagraphs.

(1) The support assembly is located on the left side of the aft fuselage section and tailboom assembly. The support assembly is an adapter that provides mounting for the chaff dispenser.

(2) The wire harness is located inside the support assembly behind the chaff dispenser. The wire harness provides an electrical connection between the aircraft connector on the aft fuselage section and tailboom assembly and the chaff dispenser aircraft connector.

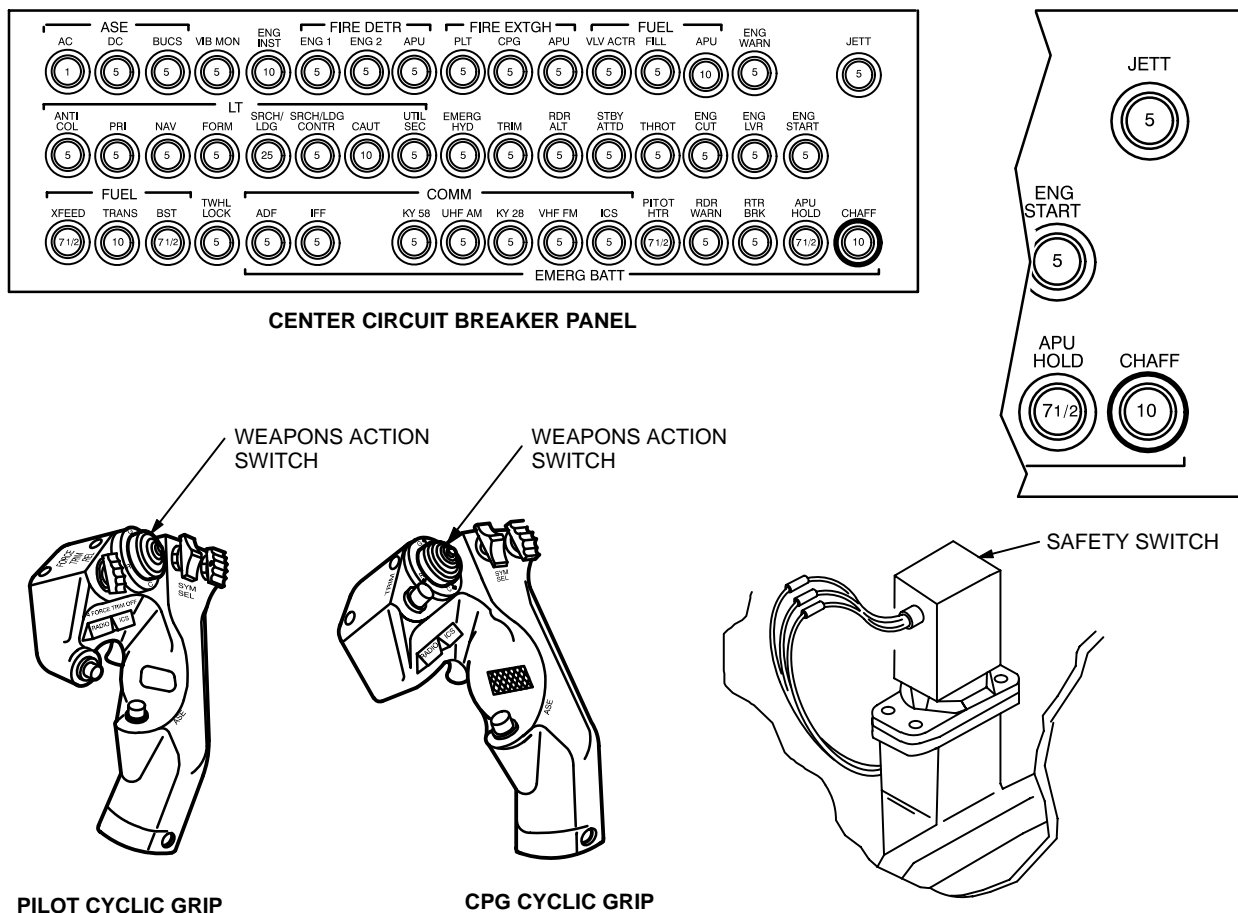


M52-388-1

Figure 18-5. Chaff Dispenser System (M130) Major Components (Sheet 1 of 2)

18-3. THEORY OF OPERATION (cont)

18-3



M52-388-2

Figure 18-5. Chaff Dispenser System (M130) Major Components (Sheet 2 of 2)

(3) The electronics module (EM) (fig. 18-6) is located in the right aft avionics bay. The EM is a solid state LRU that provides signals to fire 30 chaff cartridges (inert bundles of fiberglass dipoles coated with aluminum), and energize the chaff counter. The following switches are used to preset automatic firing of the chaff dispenser.

- (a) The **BURST COUNT** switch is a rotary switch adjusted to select the number of chaff cartridges in a burst.
- (b) The **SALVO COUNT** switch is a rotary switch adjusted to select amount of bursts to be fired.
- (c) The **BURST INTERVAL** switch is a rotary switch adjusted to select a time interval between each burst.
- (d) The **SALVO INTERVAL** switch is a rotary switch that adjusted to select the time interval between the energizing of each salvo switch.

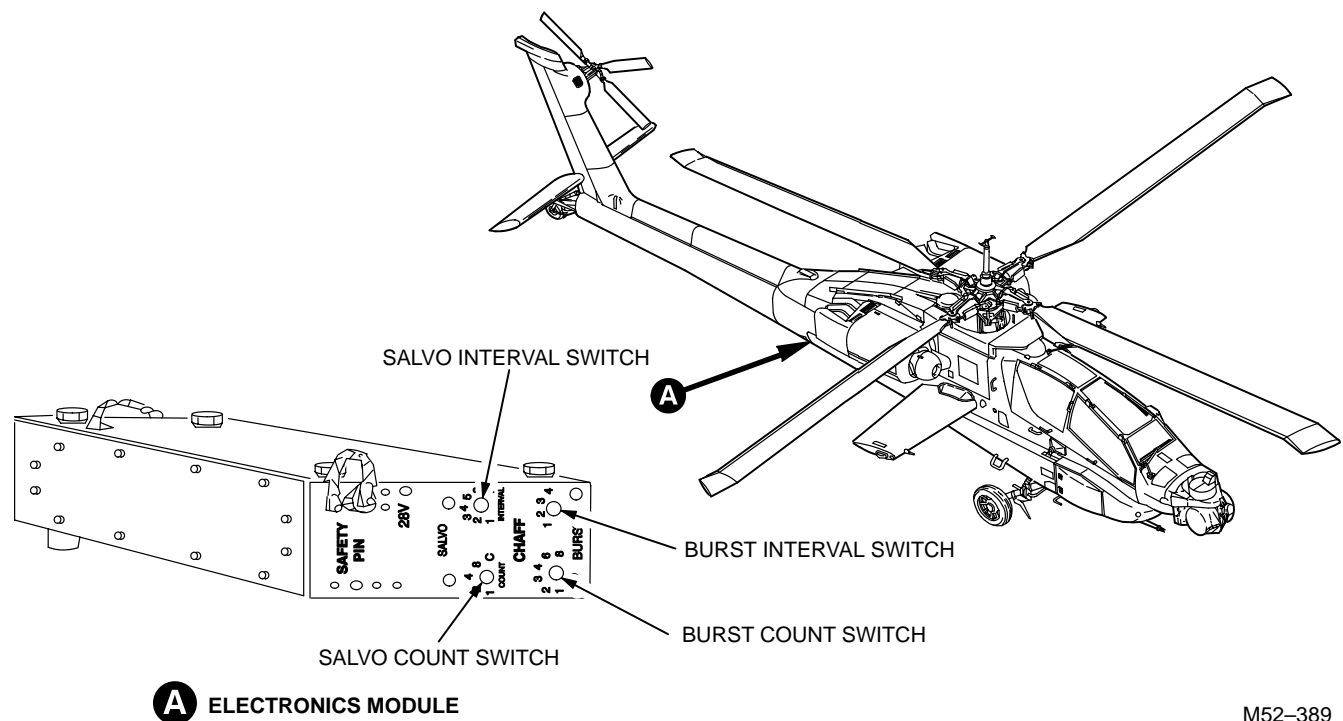


Figure 18-6. Electronics Module

(4) The dispenser control panel (DCP) (fig. 18-7) is located on the pilot upper control panel. The DCP monitors the number of chaff cartridges in the dispenser and arms the dispenser for firing. The DCP provides mountings for the following switches.

- **ARM/SAFE** switch is a two position toggle switch that arms or safes the chaff dispenser system.
- Chaff/push reset knob is used to clear the **CHAFF** counter indicator.
- **MAN/PRGM** switch is a two position rotary switch that provides one of two chaff dispensing system firing modes.
- **ARM** lamp illuminates when the chaff dispenser is armed.
- **CHAFF** counter indicator displays the number of chaff cartridges left in the payload module.

(5) The chaff dispenser is mounted on the support assembly and houses the payload module. The chaff dispenser is U-shaped and closed at one end to provide firing pulses to the chaff cartridges. The firing pulses electrically fire impulse cartridges that expel bursts of chaff cartridges from the dispenser into the environment. This forms a chaff cloud, a silver colored cloud made up of thousands of aluminum coated fiberglass particles.

(a) When the **MAN/PRGM** switch on the DCP is set to **MAN**, the firing command is routed directly from the switch to the dispenser to manually fire the chaff cartridges.

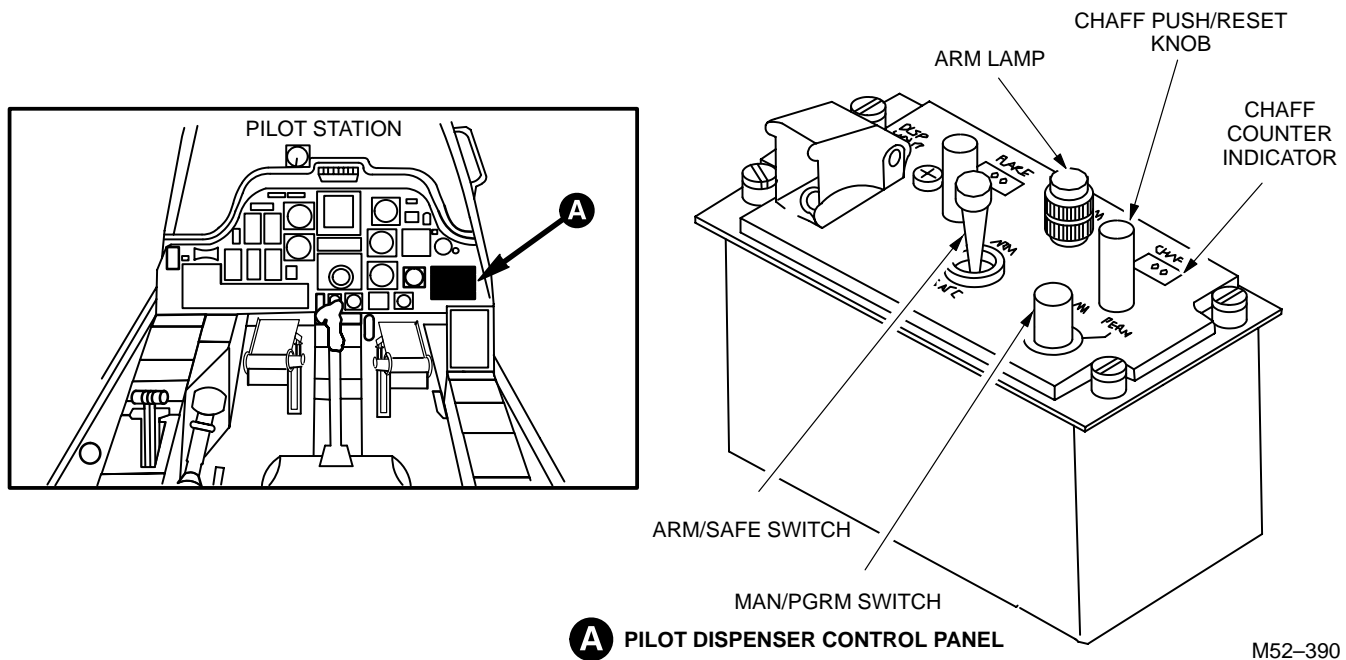


Figure 18-7. Dispenser Control Panel

(b) When the **MAN/PRGM** switch is positioned to **PRGM**, the firing command is routed from the EM to the dispenser to automatically fire the cartridges to the EM presets.

(c) The EM sends a signal to the DCP **CHAFF** counter which cycles to show the number of unfired cartridges remaining in the payload module.

(6) The payload module is mounted in the chaff dispenser. The payload module is rectangular in shape and stores 30 chaff cartridges.

(7) The chaff circuit breaker is located on the pilot center circuit breaker panel. The circuit breaker is rated at 28 VDC and 10 amperes to provide chaff dispenser system circuit protection.

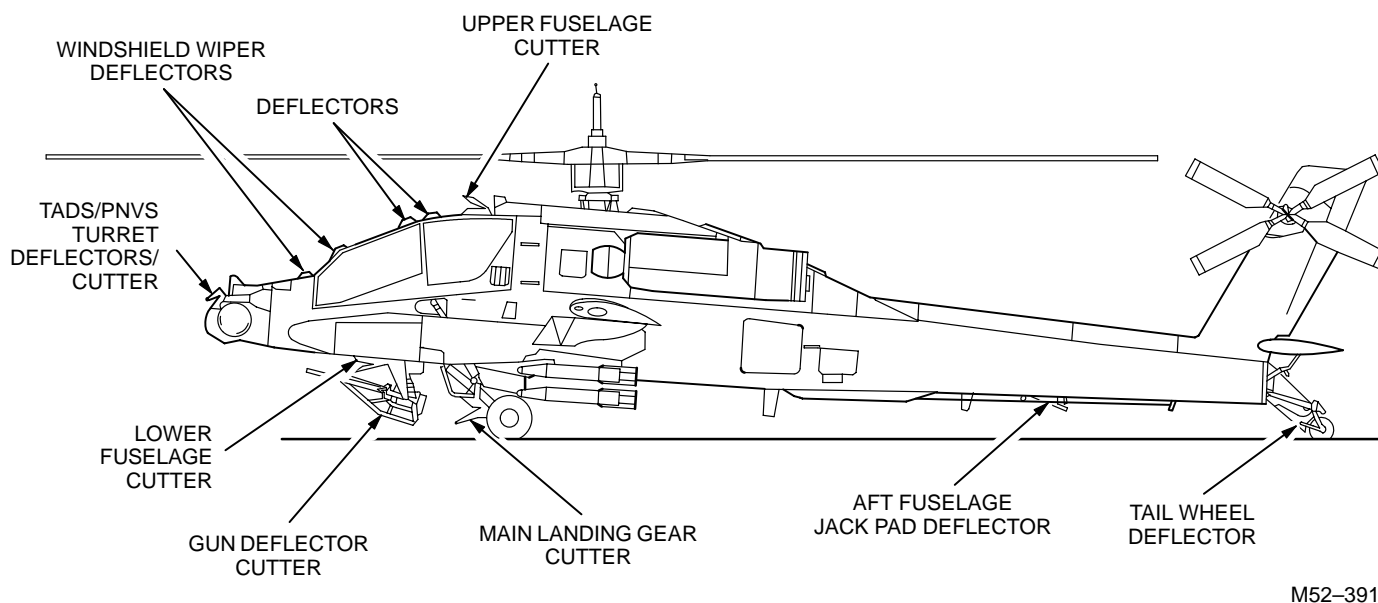
(8) The pilot and CPG cyclic control sticks provide mounts for the weapons action switch. The weapons action switch is a spring-loaded off, four-position switch. When the switch is positioned to **C**, a signal is sent to the EM and chaff dispenser to fire.

(9) The safety switch is located inside the aft fuselage section and tailboom assembly. The safety switch safes and grounds the chaff dispenser system when the ground safety pin is installed. The safety switch is a double-pole, double-throw switch mounted in an aluminum housing. When the safety pin is installed the safety switch prevents 28 VDC firing voltage from energizing the EM and chaff dispenser.

18-3. THEORY OF OPERATION (cont)

18-3

e. **Wire Strike Protection System (WSPS).** The WSPS major components (fig. 18-8) are described in the following subparagraphs.



M52-391

Figure 18-8. WSPS Major Components

(1) The deflectors are aluminum plates mounted on the helicopter at various locations. The deflectors provide a means to deflect electrical and/or communication transmission wires encountered during low level flight operations. Deflectors are located on the following components.

- (a) Windshield wipers.
- (b) Access doors.
- (c) Tail wheel.
- (d) Aft fuselage jack pad.
- (e) M230 chain gun.
- (f) TADS/PNVS turret.

(2) The cutters are steel blades attached to aluminum frames that mount on the helicopter. The cutters provide a means to cut electrical and/or communication transmission wires encountered during low-level flight operations. The cutters are located on the following components.

- (a) Upper fairing.
- (b) Main landing gear.
- (c) M230 chain gun.
- (d) Lower forward fuselage.
- (e) TADS/PNVS turret.

19-1. PURPOSE

19-1

CHAPTER 19 AIR DATA SUBSYSTEM

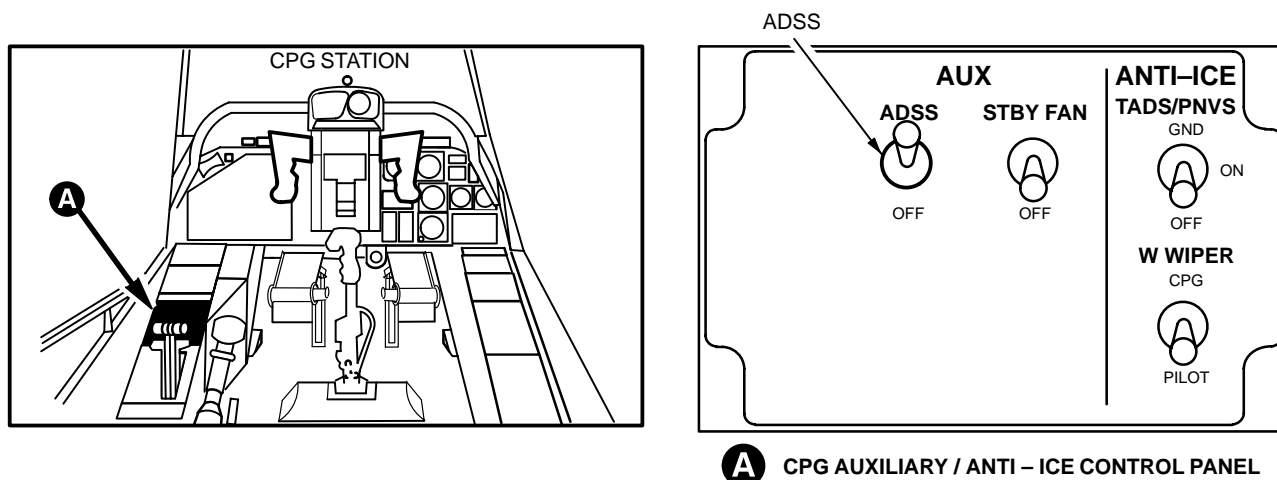
19-1. PURPOSE

The air data subsystem (ADSS) measures and provides airspeed information, static (ambient) pressure, and air temperature for use by fire control equipment, digital automatic stabilization equipment (DASE), display systems, and navigation systems.

19-2. DESCRIPTION

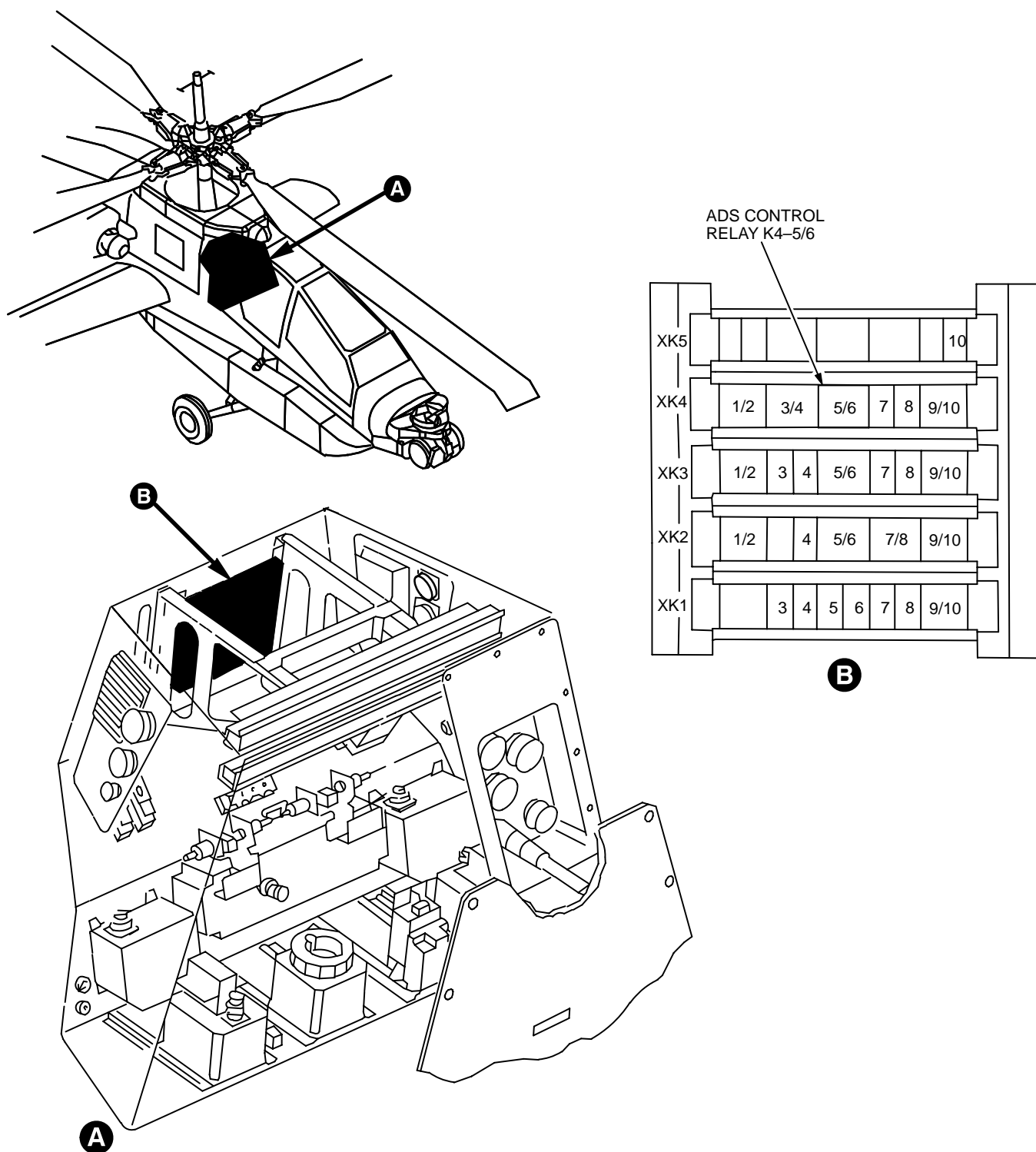
The ADSS provides omnidirectional air data between zero and 210 knots-true-air-speed (KTAS) to the helicopter systems. The ADSS includes the following components (fig. 19-1).

- a. **ADSS Control Switch.** The ADSS control switch controls operation of the ADSS.
- b. **ADS Control Relay K4-5/6.** The ADS control relay supplies power to the omnidirectional airspeed sensor (OAS) and air data processor (ADP).
- c. **Omnidirectional Airspeed Sensor (OAS).** The OAS provides airspeed data by sensing airspeed magnitude, sideslip angle, and free-stream air temperature. The outputted signals are sent to the ADP for processing.
- d. **Air Data Processor (ADP).** The ADP converts inputted signals into various air data outputs using an internal static-pressure transducer as a reference. The ADP provides built-in-test (BIT), the ability to compensate for installed position errors, and conditions the signal output for transmission to the data bus.



M52-101-1

Figure 19-1. ADSS Major Components (Sheet 1 of 3)



M52-101-2

Figure 19-1. ADSS Major Components (Sheet 2 of 3)

19-2. DESCRIPTION (cont)

19-2

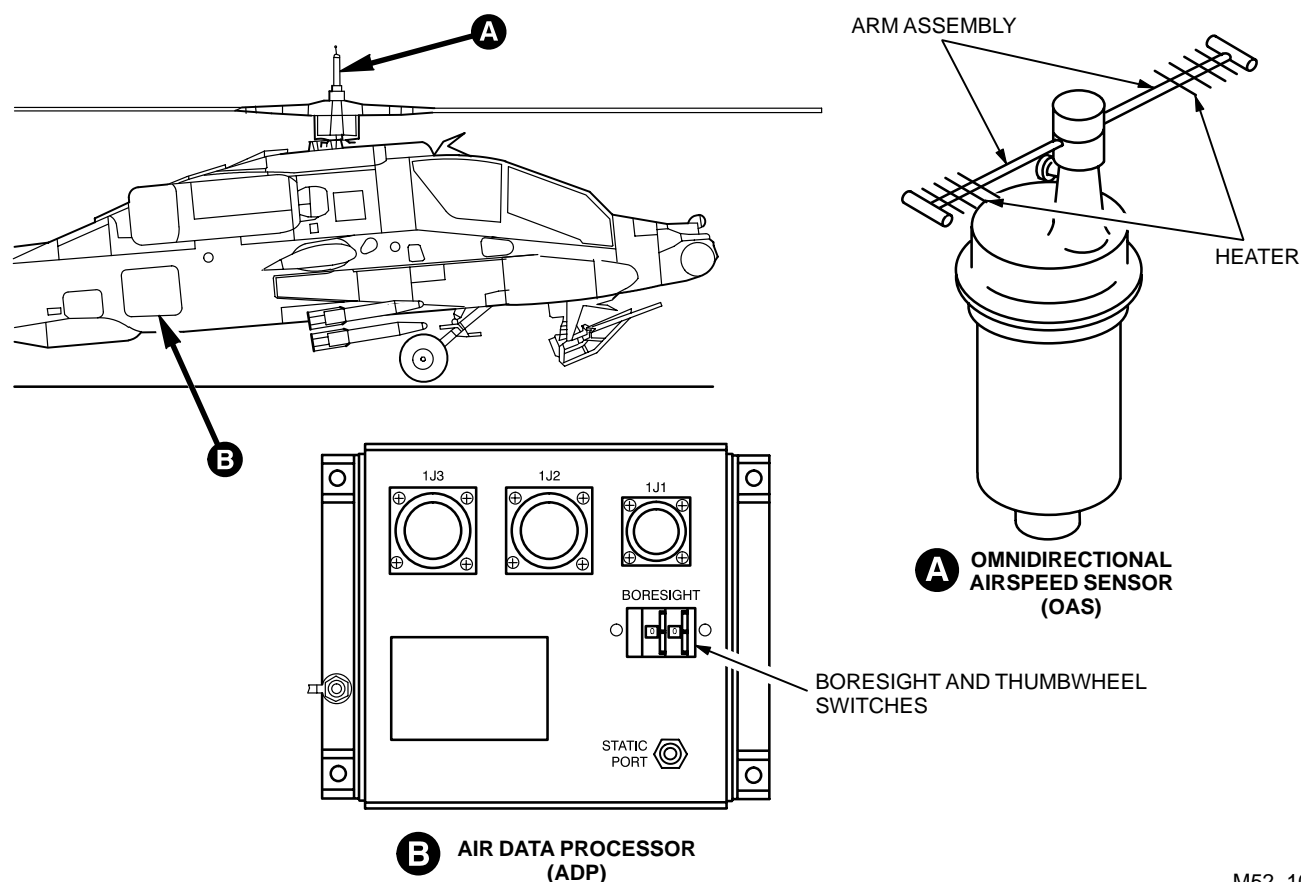


Figure 19-1. ADSS Major Components (Sheet 3 of 3)

19-3. THEORY OF OPERATION

a. **ADSS Control Switch.** The ADSS control switch allows the CPG to control ADSS operation. The switch has two positions.

- (1) **ADSS** position provides a ground to the return side of ADS control relay K4-5/6 coil.
- (2) **OFF** position removes the ground from the coil of K4-5/6.

b. **ADS Control Relay K4-5/6.** The ADS control relay supplies power to the OAS and the ADP. When the CPG sets the **ADSS** control switch to **ADSS**, the relay energizes and completes the following three circuits.

- (1) Three-phase, 115/200 VAC from **AIR DATA AC** circuit breaker CB84 to the OAS motor.
- (2) Single-phase 115 VAC from **AIR DATA AC** circuit breaker CB84 to the OAS heater control relay.
- (3) 28 VDC from **AIR DATA DC** circuit breaker CB69 to the ADP.

c. **OAS.** The OAS senses airspeed, sideslip angle, and ambient temperature.

19-3. THEORY OF OPERATION (cont)

19-3

(1) To measure airspeed, the OAS uses two sensors mounted on venturis at opposite ends of two spinning arms, with a differential pressure transducer between them. The arms rotate at 720 rpm. The transducer measures differences in pressure between the sensors.

(a) During a no-wind condition, the air flow through both venturis is equal and no pressure difference exists between the two sensors. With equal pressure in both arms, the differential pressure transducer output is 0 V.

(b) When wind is introduced into the plane of rotation, the wind adds to the tip speed of the advancing venturi and subtracts from the tip speed of the retreating venturi. This makes the pressure lower in the advancing arm than in the retreating arm. The transducer develops a dc output proportional to the difference in pressure. The OAS sends this data to the ADP.

(2) To measure temperature, a sensor on the OAS provides outside air temperature (OAT) data to the ADP.

(3) The spinning arms contain heating elements to provide anti-ice capabilities.

d. **ADP.** The ADP processes static system and inputs from the OAS for use by the fire control system, DASE, display systems, and navigation systems.

(1) The ADP converts input signals into digital data, and sends the data to the internal computer module. The internal computer module then routes the following outputs to the DASEC.

(a) Total true airspeed. -50 to 210 KTAS.

(d) Ambient temperature. -65° F (-53.89° C) to 131° F (55° C).

(e) Static pressure. 5 to 19 psi.

(f) Angle of sideslip. 25° (left sideslip) to +25° (right sideslip).

(g) ADP fail.

(h) OAS fail.

(i) Air density ratio.

(j) ADS slideslip.

(k) ADS longitudinal airspeed.

(2) Boresight thumbwheel switches on the ADP are used to electrically adjust the ADSS for mechanical errors in the OAS alignment.

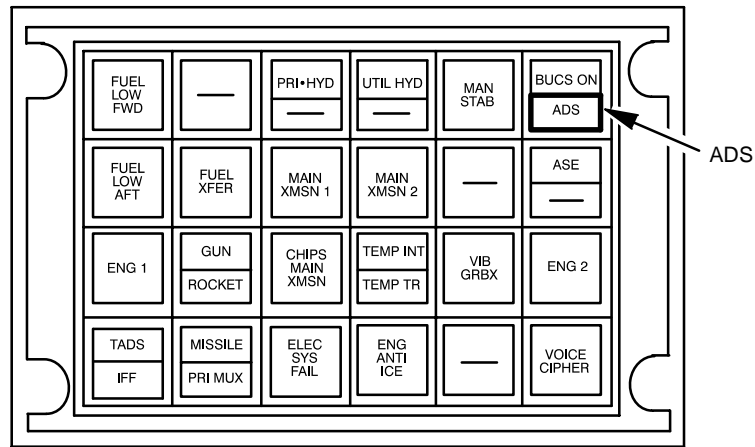
e. **ADSS Caution Lights.** The following caution lights are used.

(1) **ADS** amber light on the CPG caution/warning panel (fig. 19-2) turns on when either the OAS or the ADP fails.

(2) **ADS** amber light on the pilot caution/warning panel (fig. 19-3) turns on when either the OAS or the ADP fails.

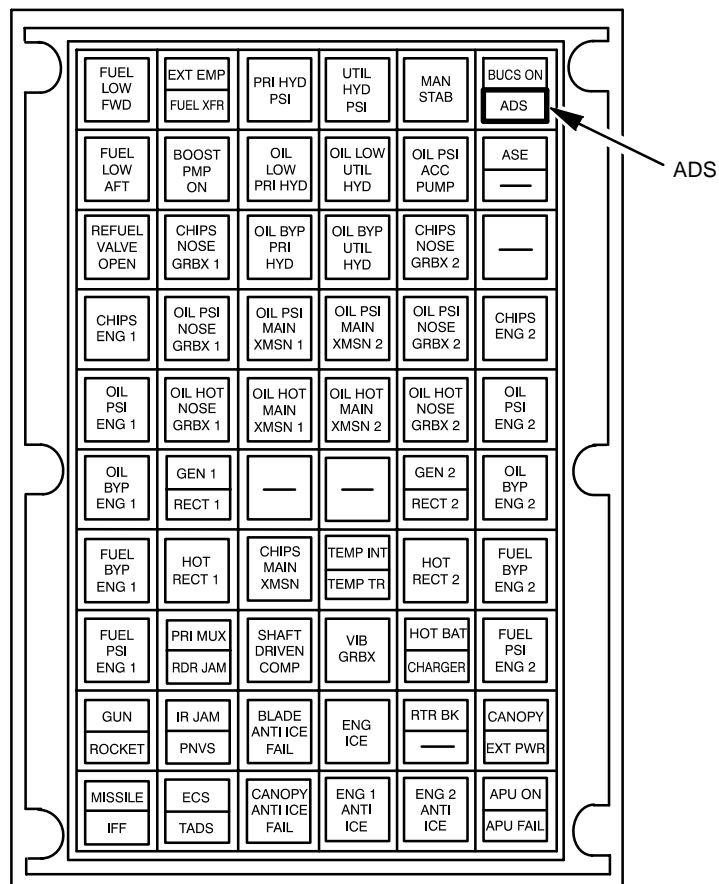
19-3. THEORY OF OPERATION (cont)

19-3



M52-102

Figure 19-2. CPG Caution/Warning Panel



M52-103

Figure 19-3. Pilot Caution/Warning Panel

19-3. THEORY OF OPERATION (cont)

19-3

f. **System Operation.** The ADSS operates as follows (fig. 19-4).

(1) Power Application. Circuit breaker **AIR DATA DC** (CB69) supplies 28 VDC to ADS control relay K4-5/6, in the electrical power distribution box. Circuit breaker **AIR DATA AC** (CB84) supplies 115 VAC to the ADS control relay. When the **ADSS** control switch is set to **ADS**, a ground is supplied to the ADS control relay, energizing the relay. The ADS control relay energizes and completes two circuits.

(a) 28 VDC from CB69 to the ADP.

(b) 115/200 VAC from CB84 to the OAS.

(2) OAS Operation. The OAS contains five functional areas. The functional areas are described below.

(a) Motor drive is a three-phase induction motor which drives the OAS at 720 RPM. The motor drives whenever the **ADSS** control switch is set to **ADS**.

(b) Anti-icing circuit prevents ice from forming on the rotating arms. Refer to Chapter 22 for information.

(c) Photo interrupter is mounted on the drive shaft, and rotates with the arms.

- Once per revolution, the photo interrupter sends a phase reference pulse to the ADP. The ADP uses this pulse to resolve the wind/airspeed into longitudinal (X) and lateral (Y) components.
- The photo interrupter operates on 5 VDC supplied by the ADP power module.

(d) Pressure transducer develops a sinusoidal wave form.

- The magnitude of the wave form is proportional to airspeed. Phasing of the wave form is relative to wind direction. The OAS sends this information as differential pressure to the ADP.
- The pressure transducer operates on +15 VDC and -15 VDC supplied by the ADP power module.

(e) Temperature sensor is mounted on the rear of the OAS body.

- The temperature sensor develops a signal that is proportional to the free ambient temperature.
- The temperature sensor operates on +15 VDC and -15 VDC supplied by the ADP power module.

(3) ADP Operation. The ADP contains three functional areas. The functional areas are described below.

(a) Power module operates on 28 VDC from the ADS control relay. The power module produces the following voltages for the OAS.

- +15 VDC.
- -15 VDC.
- +5 VDC.

(b) Input/output (I/O) module receives inputs from the OAS sensors, and generates the following outputs to the computer module.

- Total airspeed.
- Longitudinal airspeed (x).
- Lateral airspeed (y).
- Ambient temp.

19-3. THEORY OF OPERATION (cont)

19-3

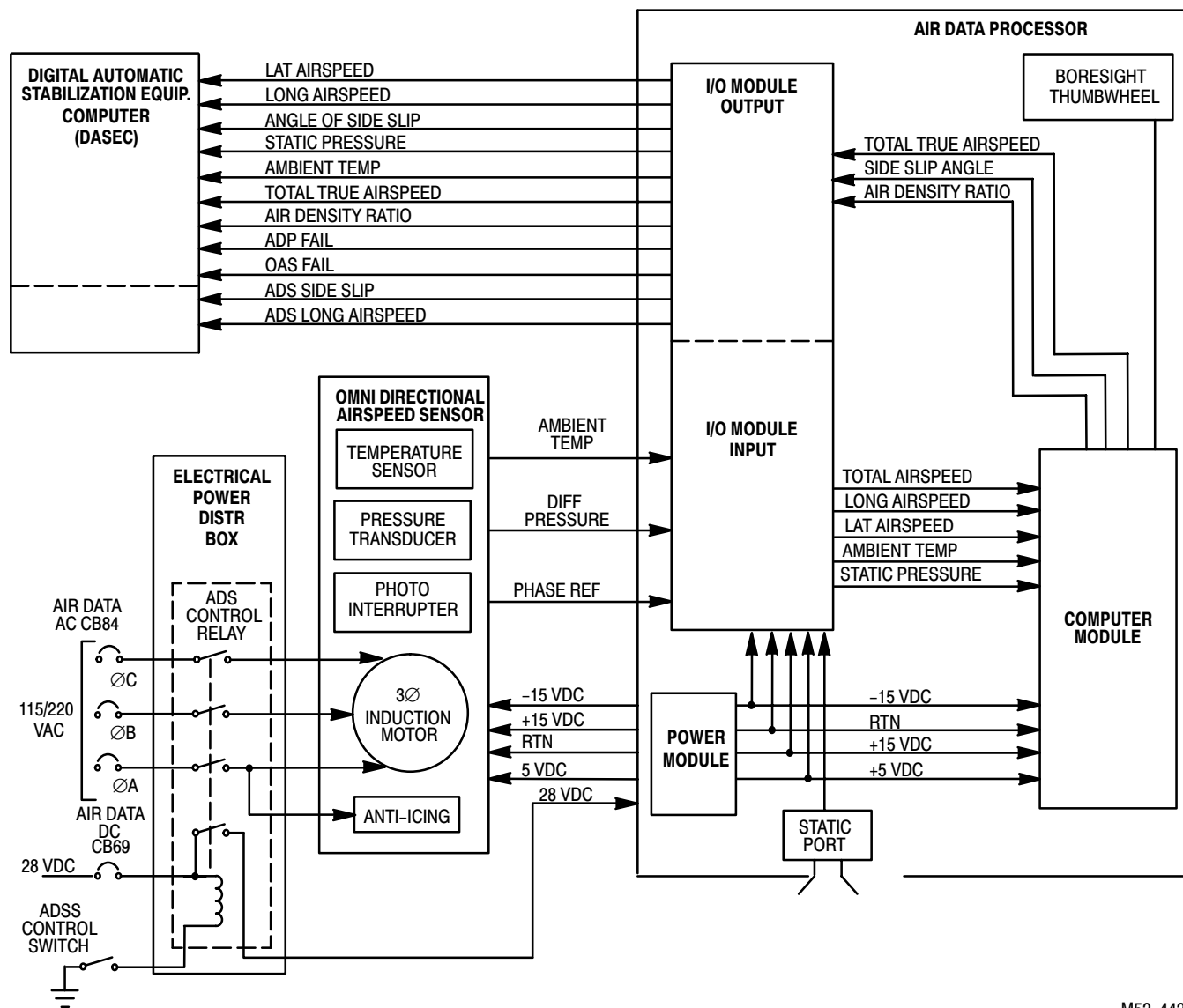
- Static pressure.

(c) The I/O module outputs the following signals to the DASEC.

- Angle of side slip.
- Static pressure.
- Ambient temp.
- Total true airspeed.
- Air density ratio.
- ADP fail.
- OAS fail.
- ADS side slip.
- ADS longitudinal airspeed.

(d) Computer module performs calculations using inputs from the I/O module, and returns the following signals to the I/O module.

- Air density ratio is derived from calculations of static pressure and ambient temperature.
- Side slip angle is the direction from which the wind is coming in relation to the OAS. Side slip angle is derived from calculations of lateral airspeed and total airspeed, or longitudinal airspeed and total airspeed.
- Total true airspeed is derived by dividing the air density ratio into true airspeed.



M52-442

Figure 19-4. ADS System Block Diagram

CHAPTER 20 ARMAMENT SYSTEMS

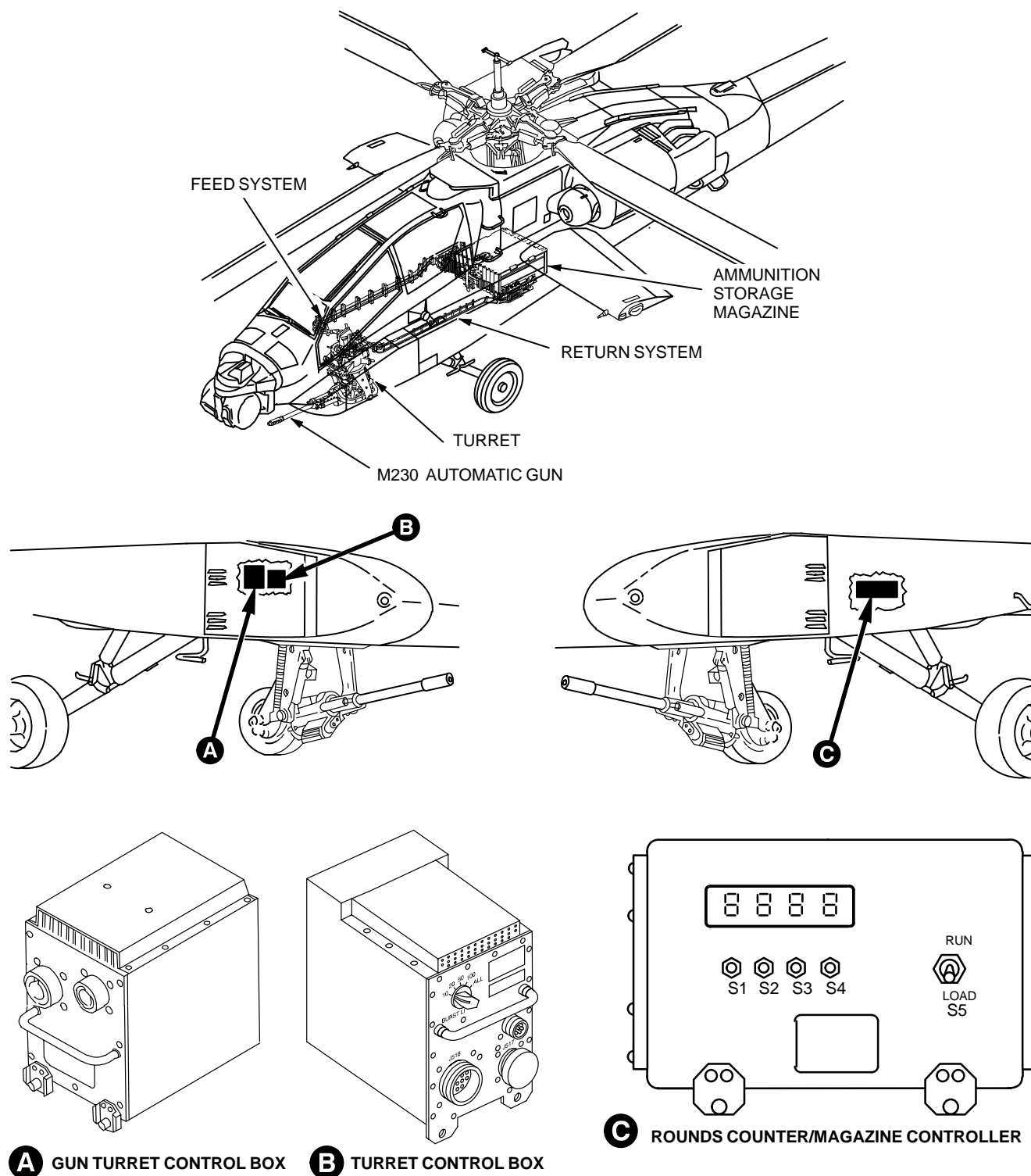
20-1. PURPOSE

The armament systems provide quick-response helicopter weapon systems selection, programming and firing for close-in, medium and long-range targets. Armament systems include following systems.

- a. **Area Weapons System (AWS) (M230 30 mm automatic gun).** AWS provides the AH-64A aircrew with an accurate quick-response weapon for close-in, medium-range, and long-range suppressive fire on soft-or medium-type targets.
- b. **Point Target Weapon System (PTWS) (HELLFIRE missile system).** PTWS is the helicopter's primary weapons system for the destruction of armor and other hardened targets.
- c. **Aerial Rocket Control System (ARCS) (folding fin aerial rocket).** ARCS provides carriage, selection, programming, and firing for the 2.75-inch/70mm folding fin aerial rockets (FFAR).
- d. **External Stores.** The external stores system provides the mounting and positional control of the external stores. The system provides the means to jettison any or all stores.

20-2. DESCRIPTION

- a. The AWS has the following features.
 - (1) Externally powered, chain-driven, automatic 30 mm gun.
 - (2) Electrically controlled, hydraulically driven, fully articulated turret.
 - (3) Electrically controlled, hydraulically driven, link-less ammunition feed system.
 - (4) Total integration with the fire control system.
- b. Major components of the AWS (fig. 20-1) are as follows.
 - (1) The M230 30 mm automatic gun provides the means of firing electrically primed 30 mm ammunition.
 - (2) The turret provides a flexible mount, in both azimuth and elevation, for the M230 automatic gun.
 - (3) The ammunition storage magazine receives and stores 30 mm linkless ammunition. The storage magazine delivers ammunition to the 30 mm automatic gun on demand.
 - (4) The turret control box (TCB) provides fire enable signals to the gun turret control box (GTCB). The TCB provides decrement signals to the rounds counter/magazine controller (RC/MC), azimuth positioning signals to the turret azimuth drive motor, elevation signals to the turret elevation actuator, solenoid actuation signal to the turret hydraulic solenoid and burst selection.
 - (5) The gun turret control box (GTCB) provides three-phase, 115 VAC, 400 Hz drive signal, gun fire pulses, and gun brake signal to the M230 automatic gun. The GTCB also provides bolt pulse signal to the turret control box.



M52-270

Figure 20-1. AWS Major Components

20-2. DESCRIPTION (cont)**20-2**

(6) The rounds counter/magazine controller (RC/MC) provides rounds remaining indication to FCC and ground crew. The RC/MC controls direction and speed of the carrier drive.

c. The PTWS manages up to 16 HELLFIRE missiles on four missile launchers.

(1) Warheads can penetrate any armor known today.

(2) High probability of first round hit and kill.

(3) Total integration with the helicopter's fire control, armament, acquisition designation sight and display systems.

(4) Conducts built-in-test (BIT) of the PTWS in conjunction with the FD/LS system.

(5) Allows day or night operation.

(6) Can employ three types of missile seekers; laser, RF/IR (not used), and IRIS (not used).

(7) Seeker is compatible with tri-service laser designators.

(8) Employs single, rapid, or ripple firing techniques.

(9) Can launch missiles directly at targets in the line of sight, or indirectly at targets concealed by terrain or landscape.

(10) Can lock on the target before or after launch from the AH-64A.

(11) Can employ either autonomous or remote laser designation modes.

d. The PTWS system major components (fig. 20-2) are listed below.

(1) HELLFIRE missile acquires and destroys targets.

(2) Dome cover provides a one-shot de-ice capability for the HELLFIRE seeker dome.

(3) M272 launcher provides a stable structure for carriage, control, and release of HELLFIRE missiles.

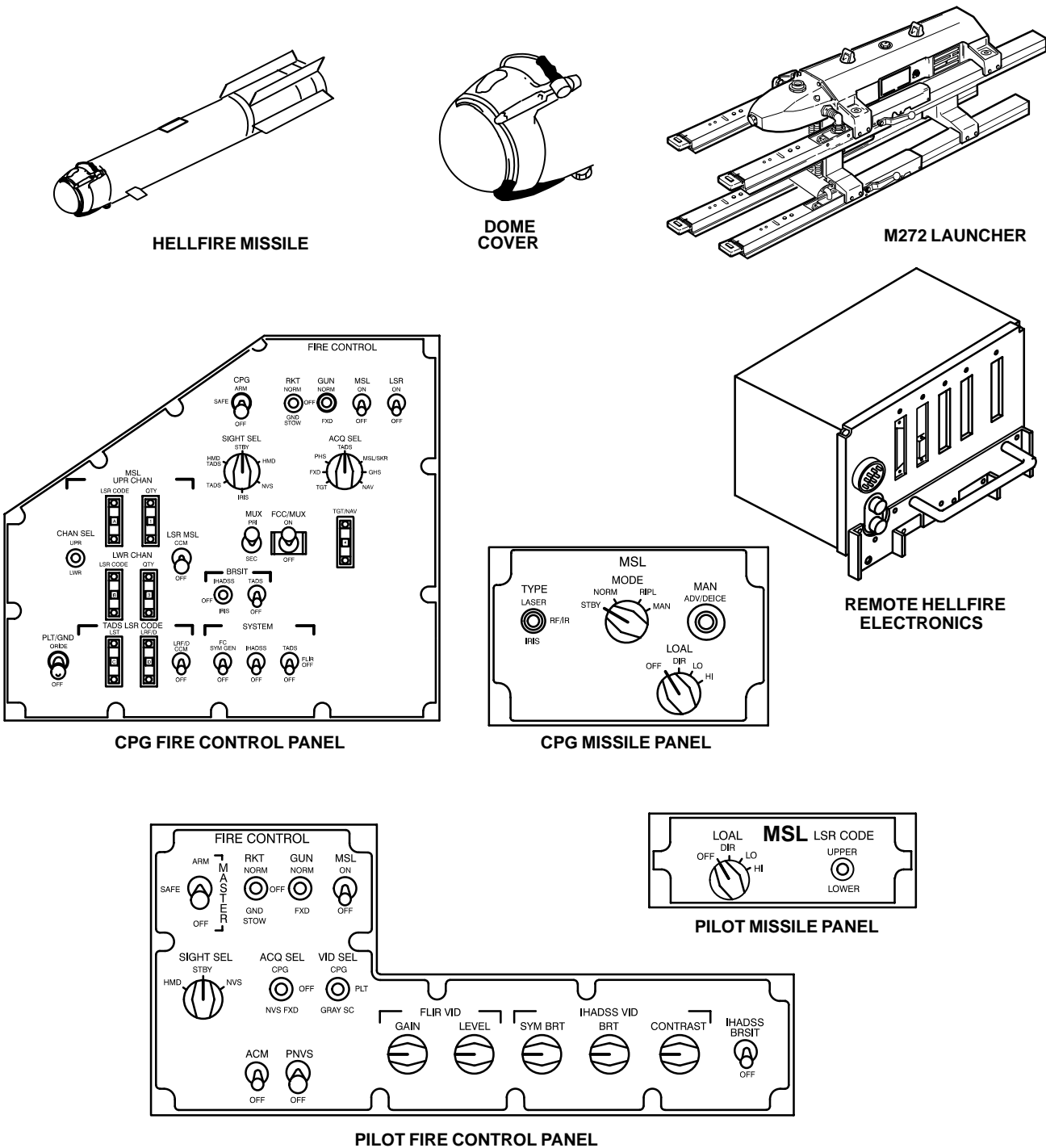
(4) Remote HELLFIRE Electronics (RHE) performs logic, processing, and control functions required to ensure operation of the PTWS. The RHE controls BIT of RHE, launchers, and missiles. The RHE provides inputs to crew station for missile status, inventory, lock-on, and ready to launch displays.

(5) CPG missile panel provides the CPG with the means to direct missile firing against designated targets. The missile panel enables all PTWS circuitry except firing circuits.

(6) CPG fire control panel provides the CPG with means to enable the PTWS, select missile quantities and codes, priority channel, laser counter-countermeasures, and fire RF missiles.

(7) Pilot missile panel provides the pilot with the means to direct missile firing against remotely designated targets.

(8) Pilot fire control panel provides the pilot with the means to enable the PTWS, and to fire RF missiles.



M52-279

Figure 20-2. PTWS Major Components

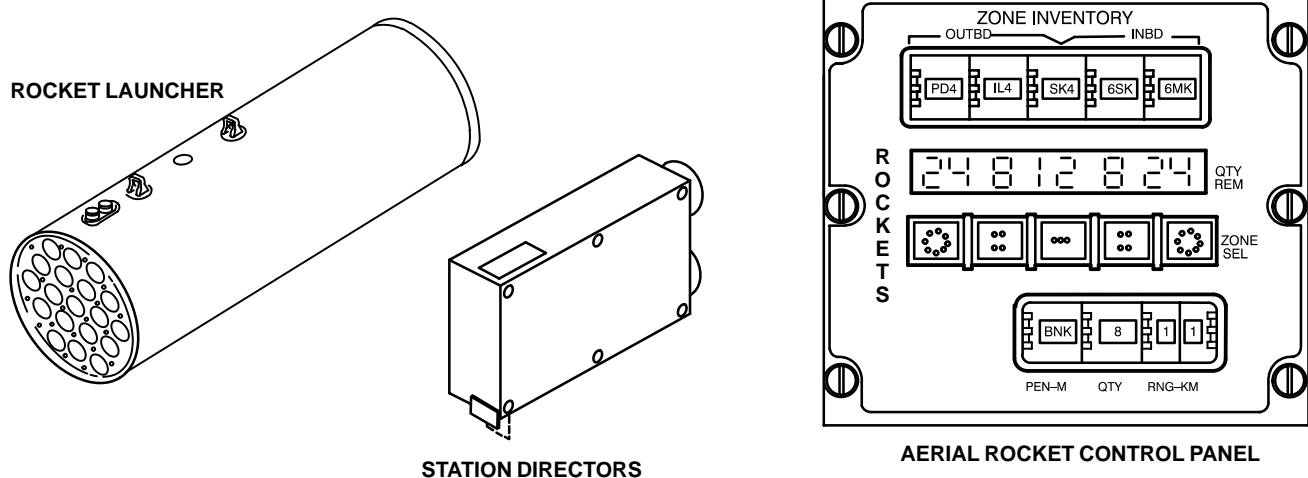
20-2. DESCRIPTION (cont)**20-2**

e. Major components of the ARCS (fig. 20-3) are listed below.

(1) The aerial rocket control panel (ARCP) provides fuzing information to the FCC. The aerial rocket control panel controls the quantity and location of rockets to be launched. The aerial rocket control panel displays quantities of rockets remaining.

(2) The station directors (four each) monitor rocket inventory and supply the information to the ARCP. The station directors select the order in which the rocket pod fires rockets provides the fuzing and firing signal to the rockets.

(3) The M261 rocket launchers carry and fire the rockets.



M52-343

Figure 20-3. ARCS Major Components

f. The external stores system (fig. 20-4) can accommodate up to four stores in any symmetrical combination of the following components.

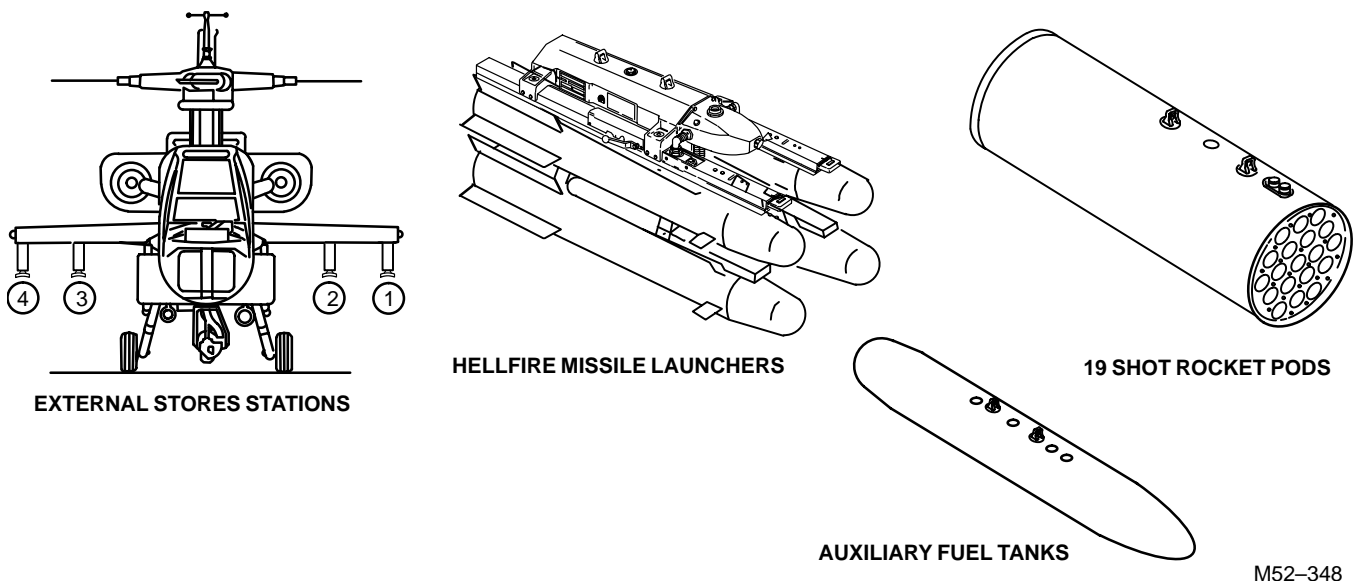
- (1) HELLFIRE missile launchers.
- (2) 2.75-inch folding fin aerial rockets (FFAR) launchers.
- (3) Auxiliary fuel tanks.

g. The external stores system can position the external stores (except fuel tanks) to any position within the following limits.

- (1) +4° up elevation (flight stow).
- (2) -5° down elevation (ground stow).
- (3) -15° down elevation (travel limit).

20-2. DESCRIPTION (cont)

20-2

**Figure 20-4. External Stores System**

h. The major components of the external stores system (fig. 20-5) are listed below.

(1) The rack assemblies attach external stores to the aircraft and provides the means to jettison unwanted external stores.

(2) The pylon assemblies provide the mounting interconnection between the rack assembly and the aircraft wing and provide the pivot point for rack articulation.

(3) The external stores controller controls the operation of the four pylon actuator controllers (PAC).

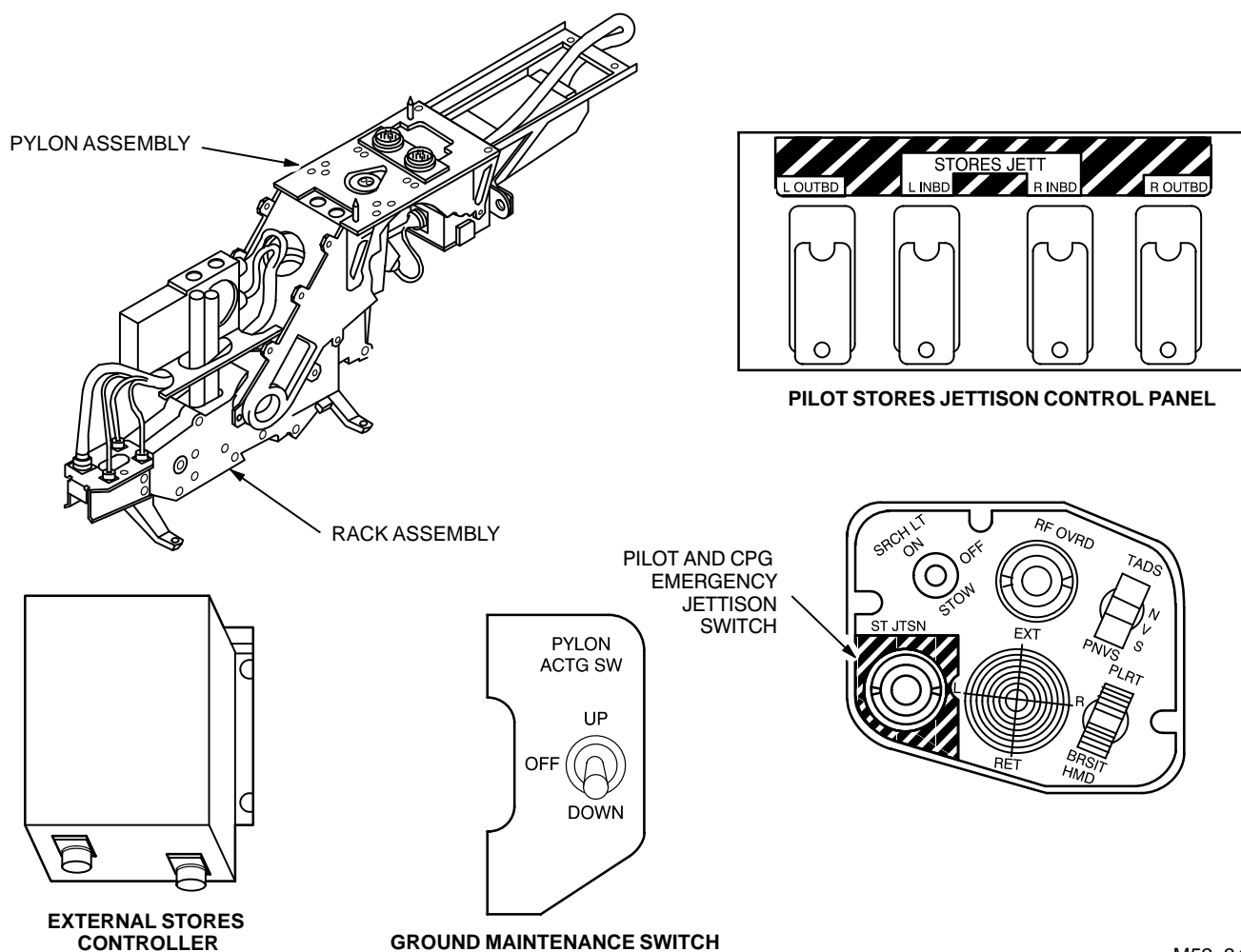
(4) The stores jettison control panel provides the pilot with the means to individually select any one, or combination of stores to jettison.

(5) The pilot and CPG emergency jettison switches provide the means to jettison all stores at the same time.

(6) The ground maintenance switch supplies a position command to the external stores controller.

20-2. DESCRIPTION

20-2



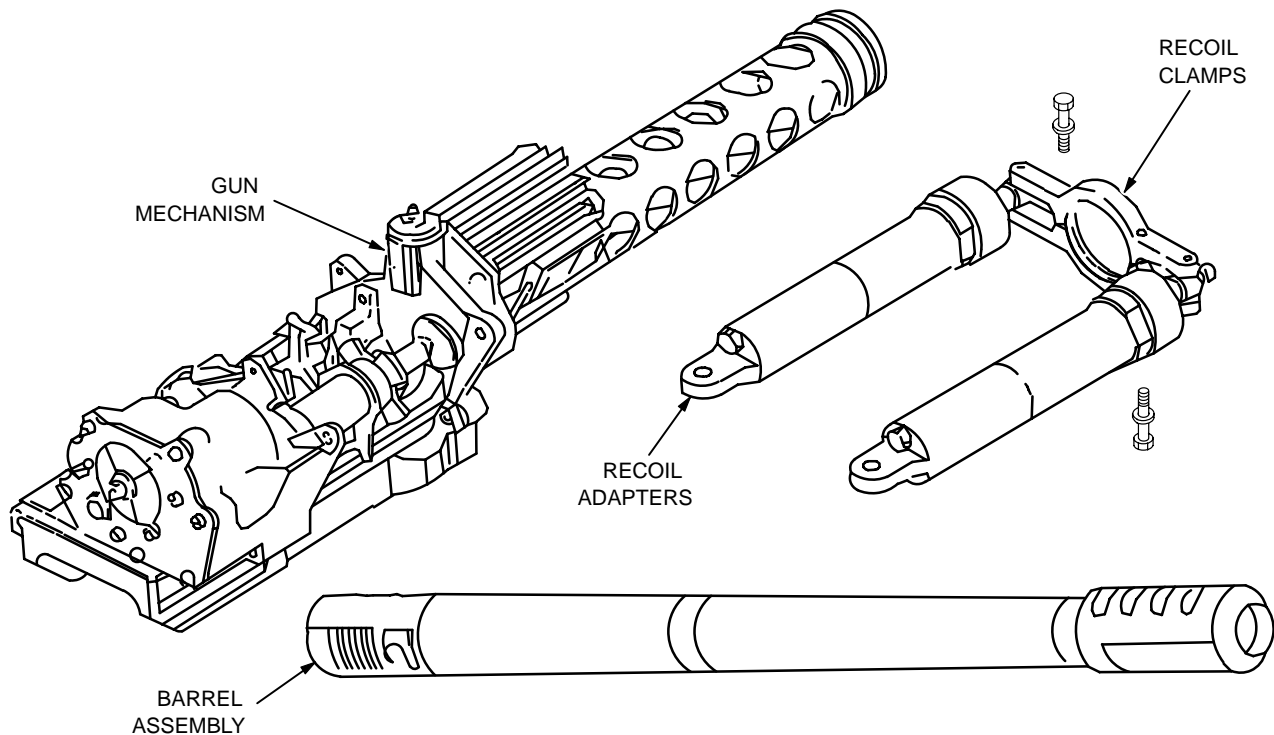
M52-349

Figure 20-5. External Stores System Major Components

20-3. THEORY OF OPERATION

a. **M230 30mm Automatic Gun.** Major components of the gun are as follows (fig. 20-6).

- (1) The barrel assembly provides directional control and stability of 30 mm projectiles, flash suppression, and assists with recoil dampening.
- (2) The recoil clamps (two each) provide the means of securing the recoil adapters to the gun.
- (3) The recoil adapters (two each) provide coil damping during firing and a mounting location for the gun to the turret cradle.
- (4) The gun mechanism is the main portion of the gun. The gun mechanism provides the round handling, carriage, firing, and extraction of the 30 mm ammunition.



M52-271

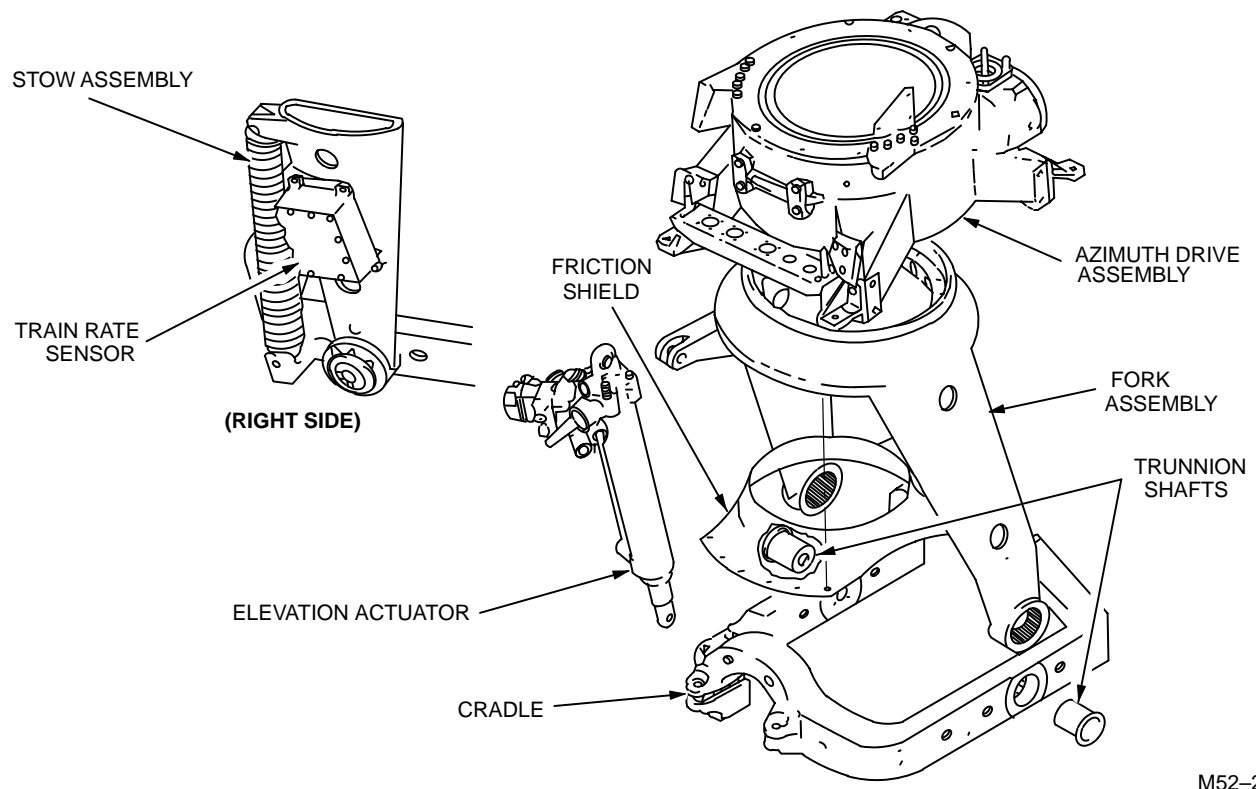
Figure 20-6. M230 Automatic Gun

b. **Turret.** Major components of the turret are as follows (fig. 20-7).

- (1) The stow assembly positions the automatic cannon to +11° elevation (EL) when either hydraulic or electrical power fails, thereby preventing the barrel from digging into the ground during landing.
- (2) The azimuth (AZ) drive assembly positions the M230 automatic gun throughout azimuth positioning limits.
- (3) The fork assembly provides the mounting location for the cradle, stow spring assembly, elevation actuator, and train rate sensor. The fork assembly works in conjunction with the cradle to provide elevation movement for the M230 automatic gun.
- (4) Trunnion shafts mount the cradle to the fork assembly and provides a bearing surface for elevation movements.
- (5) The cradle provides mounting location and the elevation movement for the gun.
- (6) The elevation actuator provides the drive force to position the automatic cannon in elevation.
- (7) The friction shield provides protection for the upper fork area, forward flex chute, and flexible hydraulic lines to the elevation actuator.
- (8) The train rate sensor senses the displacement speed of the turret in all firing positions. The train rate sensor supplies this displacement data to the turret control box (TCB).

20-3. THEORY OF OPERATION (cont)

20-3



M52-272

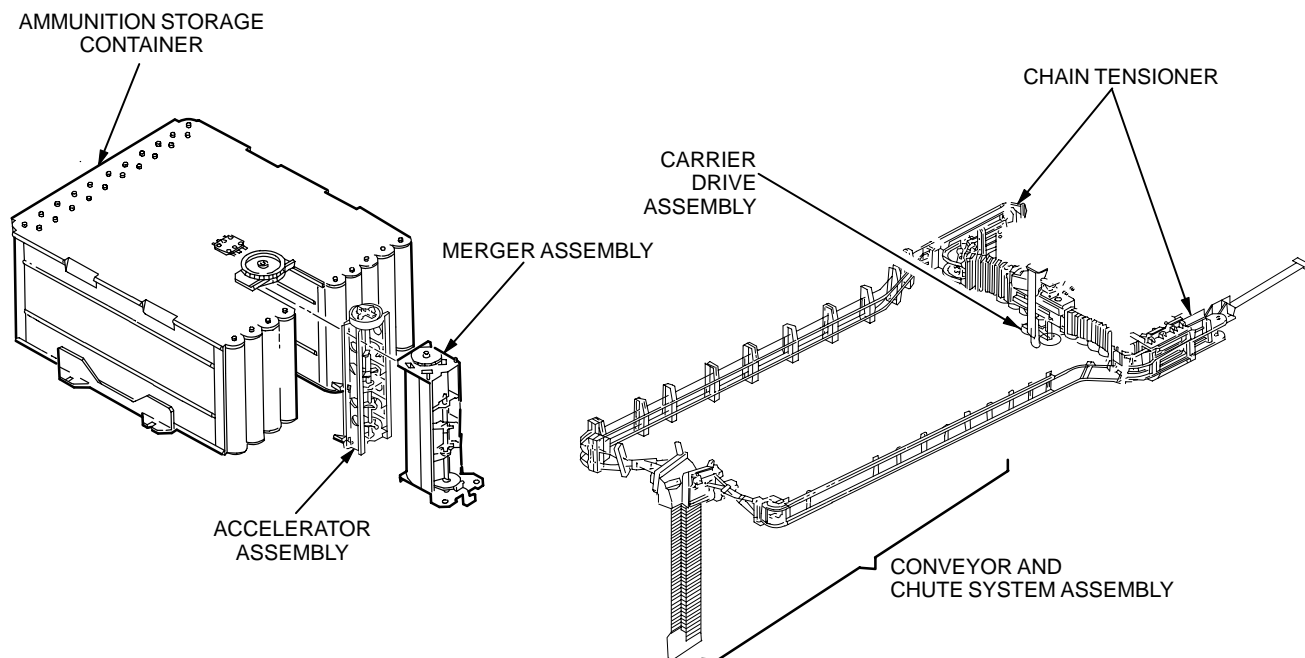
Figure 20-7. Turret Major Components

c. **Ammunition Handling System.** Major components of the ammunition handling system are as follows (fig. 20-8).

- (1) The ammunition storage container provides for the storage of 1110 rounds of 30 mm linkless ammunition.
- (2) The accelerator assembly transfers rotational drive from the merger assembly to the terminal sprocket drive gear. The accelerator assembly provides acceleration and round spacing used by the merger assembly.
- (3) The merger assembly provides the means to converge the upper and lower rows of ammunition into a single row during firing and downloading. The merger assembly alternately places rounds of ammunition into the upper and lower rotors of the accelerator during loading.
- (4) The carrier drive assembly provides rotational drive for the ammunition magazine and assists in driving the conveyor assembly. The carrier drive assembly provides interfacing between the merger assembly and conveyor assembly.
- (5) The chain tensioners keep conveyor assembly stretched out with preloaded spring during firing, loading or downloading modes. The chain tensioners provide tension data to the RC/MC.
- (6) The conveyer and chute assembly provides the means to transport uploaded linked, loose, and bulk ammo strip (BAS) 30 mm ammunition between the ammo storage magazine and M230 gun. The return chute assembly returns empty ammo carriers to the ammo storage magazine.

20-3. THEORY OF OPERATION (cont)

20-3



M52-273

Figure 20-8. Ammunition Handling System**d. Turret Control Box (TCB)** (fig. 20-9).

(1) The TCB contains the **BURST LIMIT** switch. Positions and functions are as follows.

- (a) **10**. 10 rounds can be fired.
- (b) **20**. 20 rounds can be fired.
- (c) **50**. 50 rounds can be fired.
- (d) **100**. 100 rounds can be fired.
- (e) **ALL**. all rounds can be fired.

(2) Circuit breaker **AWS DC**, on the CPG circuit breaker panel, supplies 28 VDC.

(3) Circuit breaker **AWS AC**, on the CPG circuit breaker panel, supplies 115 VAC.

e. Gun Turret Control Box (GTCB).

(1) Circuit breaker **MTR**, on the CPG circuit breaker panel 1, supplies 115 VAC to the drive motor.

(2) Circuit breaker **AWS AC**, on the CPG circuit breaker panel 1, supplies 115 VAC operating power to the GTCB.

(3) Circuit breaker **AWS DC**, on the CPG circuit breaker panel 1, supplies 28 VDC.

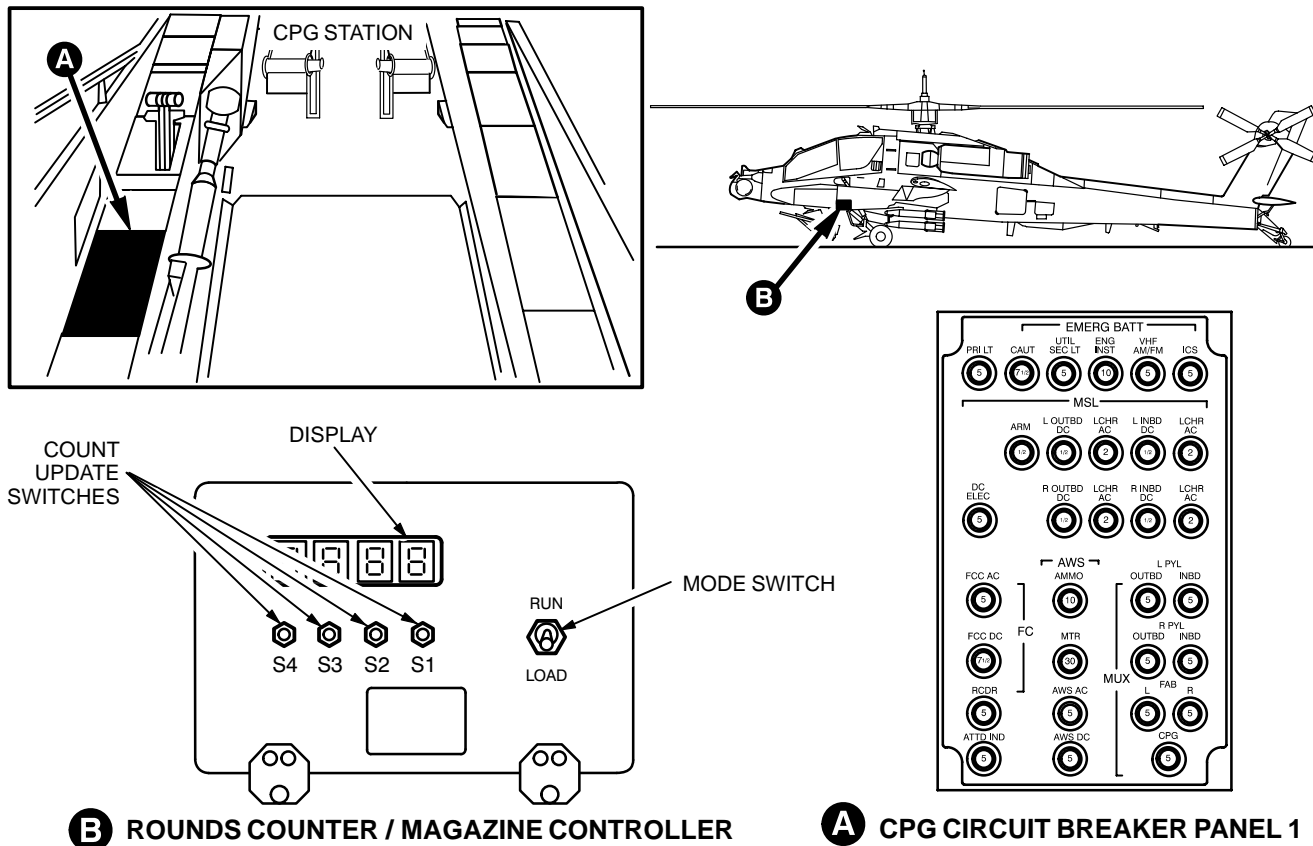
f. Rounds Counter/Magazine Controller (RC/MC).

(1) The RC/MC contains switches and displays. Positions and functions are as follows (fig. 20-10).

- (a) Mode switch positions are as follows.

20-3. THEORY OF OPERATION (cont)

20-3



M52-275

Figure 20-10. RC/MC

g. Pilot AWS Controls and Indicators (fig. 20-11).

(1) Pilot Fire Control Panel (FCP).

(a) **MASTER ARM/SAFE/OFF** switch positions are as follows.

- **OFF.** All weapon systems are de-energized.
- **SAFE.** Weapons are in standby mode. Weapon inventory and status can be monitored.
- **ARM.** Selected weapon system can be fired.

(b) **GUN** switch positions are as follows.

- **NORM.** Enables pilot arm/safe power to the AWS and slaves the gun turret to the pilot's line of sight when actioned. Gun movement is limited to: $\pm 100^\circ$ in azimuth (software stop), $\pm 110^\circ$ (mechanical stop) (ACY); $\pm 86^\circ$ in azimuth (software stop), $\pm 89.8^\circ$ (mechanical stop) (ACZ). Gun movement is limited to $+10$ to -60° in elevation. Gun movement rate is limited to 120° per second.
- **OFF.** Disables pilot arm/safe power to the AWS. Sets gun position to stow position. Gun movement is limited to 0° in azimuth and $+11^\circ$ in elevation. Gun movement rate is limited to 25° per second.

20-3. THEORY OF OPERATION (cont)

20-3

- **FXD.** Enables pilot arm/safe power to the AWS and positions the gun in a fixed forward position. Gun movement is limited to 0 ° in azimuth and +6° in elevation. Gun movement rate is limited to 120° per second.
- (2) Pilot Cyclic Stick.
- (a) Weapons action switch positions are as follows.
- Center normal position. No weapon selected.
 - **G.** M230 gun selected.
 - **M.** HELLFIRE missile selected.
 - **C.** Fires chaff.
 - **R.** 2.75 inch/70mm FFAR selected.
- (b) Guarded trigger switch positions are as follows.
- First detent is used for normal weapon firing.
 - Second detent overrides selected weapon performance inhibits but does not override safety inhibits to fire the selected weapon.
- (3) Pilot Caution/Warning Panel. **GUN** light illuminates when AWS fails.
- h. **CPG AWS Controls** (fig. 20-12).
- (1) CPG FCP.
- (a) **PLT/GND ORIDE** switch positions are as follows.
- **OFF.** No effect; system operates normally.
 - **GND ORIDE.** When airborne, overrides pilot **MASTER ARM** switch. On ground, overrides squat switch, allowing gun to fire.
- (b) **ARM/SAFE** switch positions are as follows.
- **OFF.** All weapons systems de-energized.
 - **SAFE.** Weapons systems are in standby mode. Weapon inventory and status can be inventoried. Receives operating voltage from the pilot **MASTER ARM** or **PLT/GND ORIDE** switch.
 - **ARM.** Selected weapon system can be fired. Receives operating voltage from the pilot **MASTER ARM** or **PLT/GND ORIDE** switch.
- (c) **GUN NORM/FXD** switch positions are as follows.
- **NORM.** Enables pilot arm/safe power to the AWS and slaves the gun turret to the CPG's line of sight when actioned. Gun movement is limited to: ± 100° in azimuth (software stop), ± 110° (mechanical stop) (ACY); ± 86° in azimuth (software stop), ± 89.8° (mechanical stop) (ACZ). Gun movement is limited to +10 to -60° in elevation. Gun movement rate is limited to 120° per second.
 - **OFF.** Disables pilot arm/safe power to the AWS. Sets gun position to stow position. Gun movement is limited to 0 ° in azimuth and +11° in elevation. Gun movement rate is limited to 25° per second.
 - **FXD.** Enables pilot arm/safe power to the AWS and positions the gun in a fixed forward position. Gun movement is limited to 0 ° in azimuth and +6° in elevation. Gun movement rate is limited to 120° per second.

20-3. THEORY OF OPERATION (cont)

20-3

(2) ORT.

(a) ORT weapons action switch positions are as follows.

- Center. Normal position; no weapon selected.
- **GUN.** M230 gun selected.
- **MSL.** HELLFIRE missile selected.
- Blank. Not used.
- **RKT.** 2.75 inch/70mm FFAR selected.

(b) Guarded trigger switch positions are as follows.

- First detent is used for normal weapon firing.
- Second detent overrides selected weapon performance inhibits but does not override safety inhibits to fire the selected weapon.

(3) CPG Cyclic Stick.

(a) Weapons action switch positions are as follows.

- Center. Normal position; no weapon selected.
- **G.** M230 gun selected.
- **M.** HELLFIRE missile selected.
- **C.** Fires chaff.
- **R.** 2.75 inch/70mm FFAR selected.

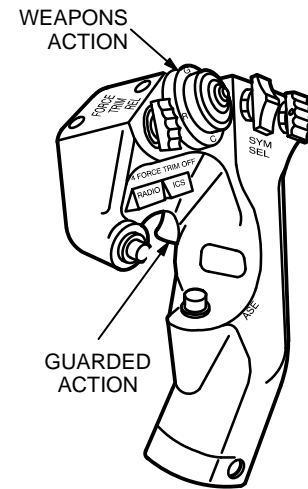
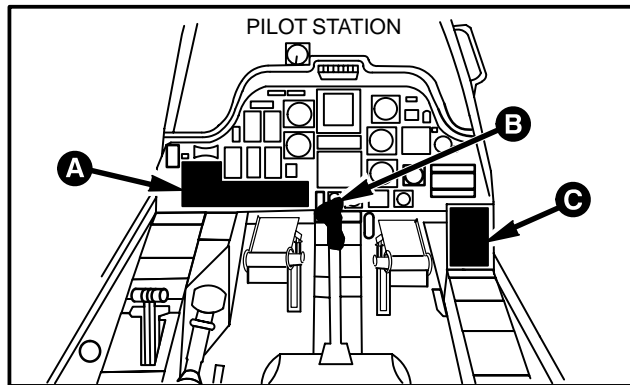
(b) Guarded trigger switch positions are as follows.

- First detent is used for normal weapon firing.
- Second detent overrides selected weapon performance inhibits but does not override safety inhibits to fire the selected weapon.

(4) CPG Caution/Warning Panel. **GUN** light illuminates when AWS fails.

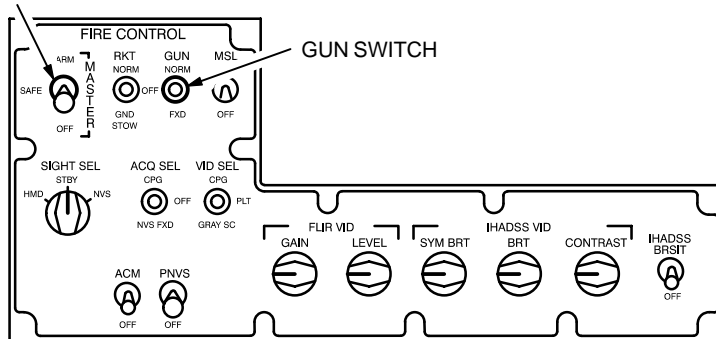
20-3. THEORY OF OPERATION (cont)

20-3



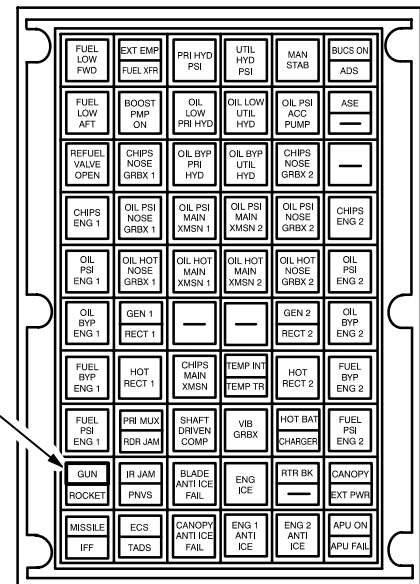
B CYCLIC CONTROL STICK

MASTER ARM/
SAFE/OFF
SWITCH



A FIRE CONTROL PANEL

GUN



C PILOT CAUTION / WARNING PANEL

M52-276A

Figure 20-11. Pilot AWS Controls and Indicators

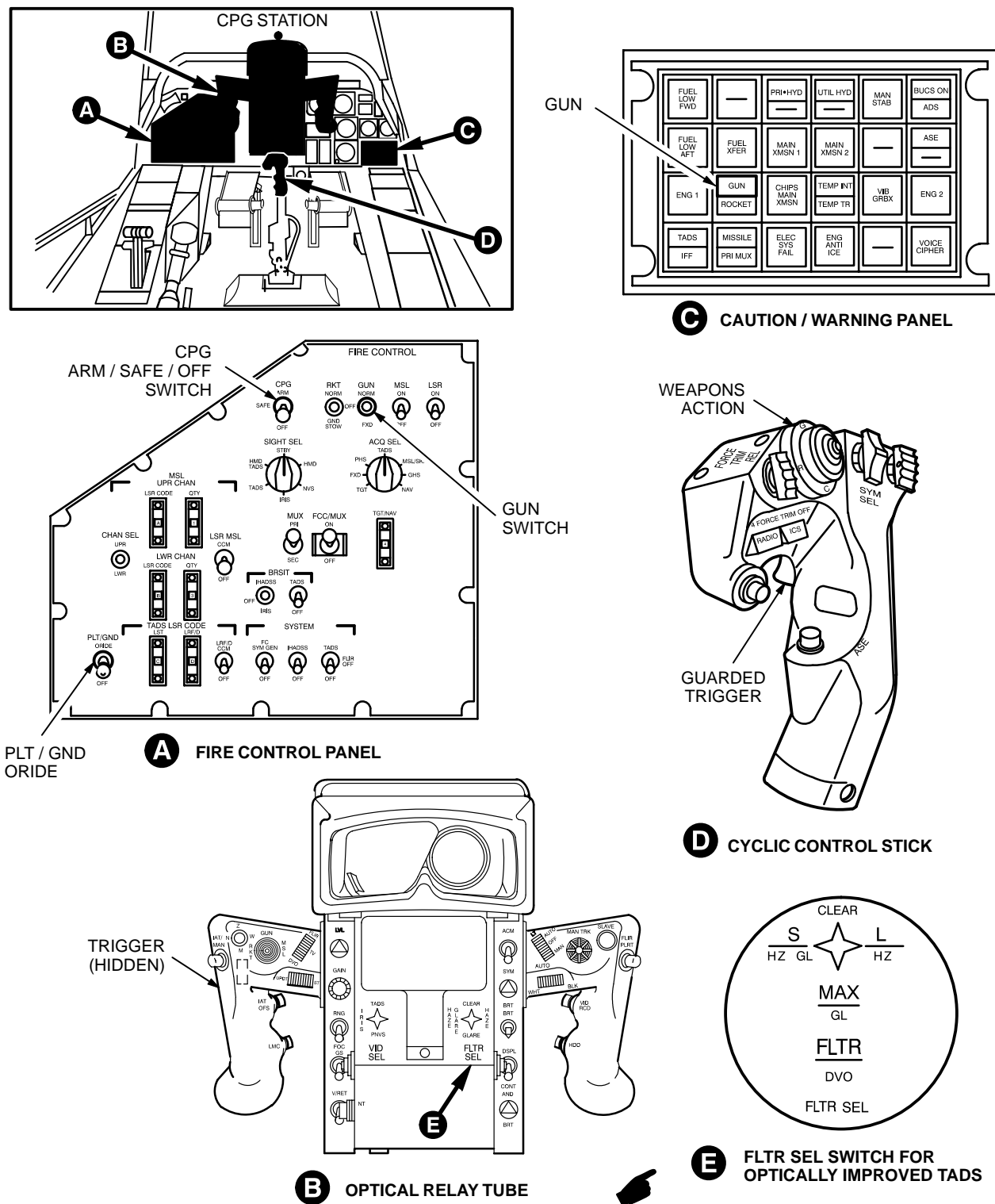


Figure 20–12. CPG AWS Controls

20-3. THEORY OF OPERATION (cont)

20-3**i. AWS Operation.**

- (1) Under command of the FCC, the MRTU Type I RH FAB supplies the following signals to the TCB (fig. 20-13).
 - (a) 11.8 VAC, 400 Hz reference voltage.
 - (b) 5 VDC causing the turret control system (TCS) to run BIT (FD/LS).
 - (c) 5 VDC inhibit signal from the FCC.
 - (d) 5 VDC causing the TCS to enter boresight mode (turret AZ and EL rates are 5 degrees/second).
 - (e) Positioning commands as follows.
 - AZ sin and cos.
 - AZ feed forward command.
 - EL sin and cos.
 - EL feed forward command.
 - (f) 28 VDC pilot gun trigger.
 - (g) 28 VDC CPG gun trigger.
- (2) The TCB supplies the following signals to MRTU Type I RH FAB.
 - (a) 5 VDC signal if the AWS is in the process of BIT.
 - (b) 5 VDC signal if the TCB fails FD/LS.
 - (c) 5 VDC signal if the turret AZ resolver fails FD/LS.
 - (d) 5 VDC signal if the gun elevation actuator fails FD/LS.
 - (e) 5 VDC signal if the train rate sensor fails FD/LS.
 - (f) 5 VDC signal if gun fire is inhibited.
 - (g) 5 VDC signal if the turret elevation resolver fails FD/LS.
 - (h) 5 VDC signal if the turret is out of coincidence.
 - (i) AZ error.
 - (j) EL error.
 - (k) 5 VDC if the pilot is actioned.
 - (l) 5 VDC if the CPG is actioned.
- (3) The TCB supplies the following signals to the train rate sensor (TRS).
 - (a) 26 VAC power to the TRS.
 - (b) Regulated rate sensor ± 15 VDC.
 - (c) Unregulated ± 15 VDC.

20-3. THEORY OF OPERATION (cont)

20-3

- (4) The TCB supplies 11.7 VAC excitation to the AZ resolver.
 - (a) A stimulus voltage during FD/LS.
 - (b) Stimulus enable.
 - (c) Washout bypass.
- (5) The TCB receives the following signals from the train rate sensor.
 - (a) Rate sensor.
 - (b) Acceleration sensor.
 - (c) TRS valid.
- (6) The TCB receives feedback signals relative to the turret AZ position.
- (7) The TCB supplies 11.7 VAC excitation to the EL resolver.
- (8) The TCB receives feedback signals relative to the turret EL position.
- (9) The TCB supplies the following signals to the elevation actuator servo valve.
 - (a) ± 15 VDC reference voltage.
 - (b) Elevation drive signal.
- (10) The TCB supplies azimuth drive signal to the AZ servo valve.
- (11) The TCB supplies an unlock signal to the solenoid valve.
- (12) The TCB supplies the following signals to the GTCB.
 - (a) ± 15 VDC reference voltage.
 - (b) +5 VDC reference voltage.
 - (c) Gun control box armed.
 - (d) Fire enable.
 - (e) Trigger.
- (13) The TCB receives a bolt pulse signal from the GTCB.
- (14) Under command of the TCB, the GTCB supplies the following signals to the gun.
 - (a) 115 VAC gun motor drive signal or 28 VDC to the motor drive for gun brake signal.
 - (b) 163 VAC primer fire voltage.
- (15) The GTCB receives a bolt position sensor signal from the gun contact box assembly.
- (16) The TCB supplies a rounds decrease signal to the RC/MC each time the TCB receives a bolt pulse signal from the gun.
- (17) The RC/MC receives operating power from the CPG circuit breaker **AWS DC**.

20-3. THEORY OF OPERATION (cont)

20-3

- (18) The MRTU Type I LH FAB sends a request command to the RC/MC.
- (19) The RC/MC responds with an acknowledge command.
- (20) The MRTU Type I LH FAB supplies the RC/MC with a 16-pulse clock pulse.
- (21) The RC/MC supplies the data out to the MRTU Type I LH FAB (rounds remaining).
- (22) The RC/MC supplies a 0 to +10 VDC signal to the MRTU Type I RH FAB for FD/LS.
- (23) The RC/MC supplies a +10 VDC signal to the carrier drive.
- (24) The RC/MC receives an upload signal (5 VDC) from J1058 during loading only.
- (25) The RC/MC receives rounds count signals when rounds are loaded or downloaded, causing the RC/MC to count up or down.
- (26) The RC/MC supplies a +120 VDC signal to each tensioner. The RC/MC receives return signals from the LH and RH tensioners.
- (27) The RC/MC receives a rounds decrease signal from the TCB.
- (28) The gunfire control logic determines the conditions necessary for proper gunfiring conditions. The gun can only be fired by the crewmember who actioned the gun last in the **NORM** or **FXD** mode. When both crewmembers action the gun at the same time, the pilot receives precedence. The gun will fire a maximum number of rounds as determined by the **BURST LIMIT** switch. To allow continued firing the trigger must be released for 30 msec.
- (29) A FD/LS failure or out-of-coincidence error will move the gun to the stow position and inhibit firing. Out-of-coincidence errors are errors greater than 2.865° in azimuth and elevation from the input command signal.

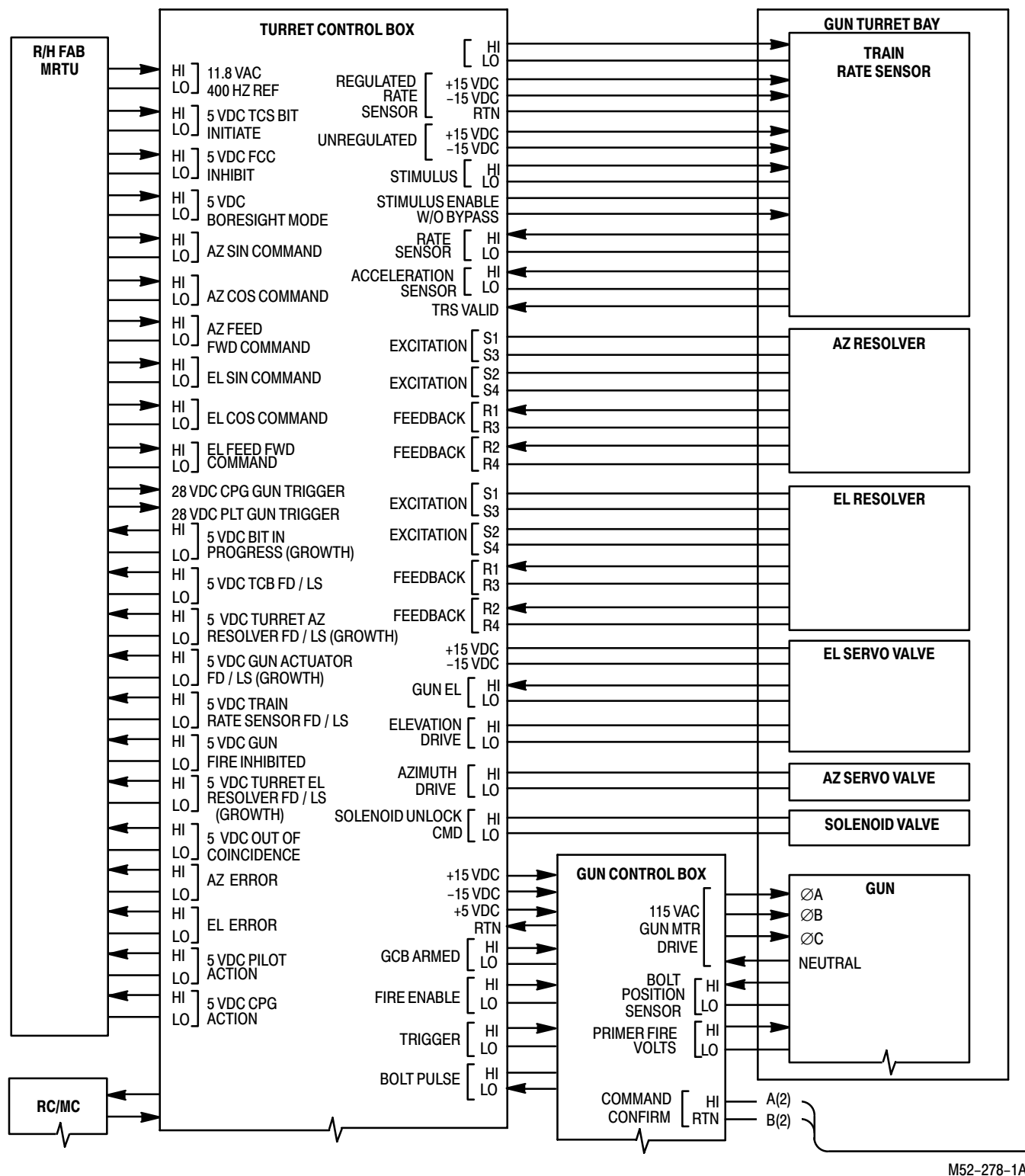
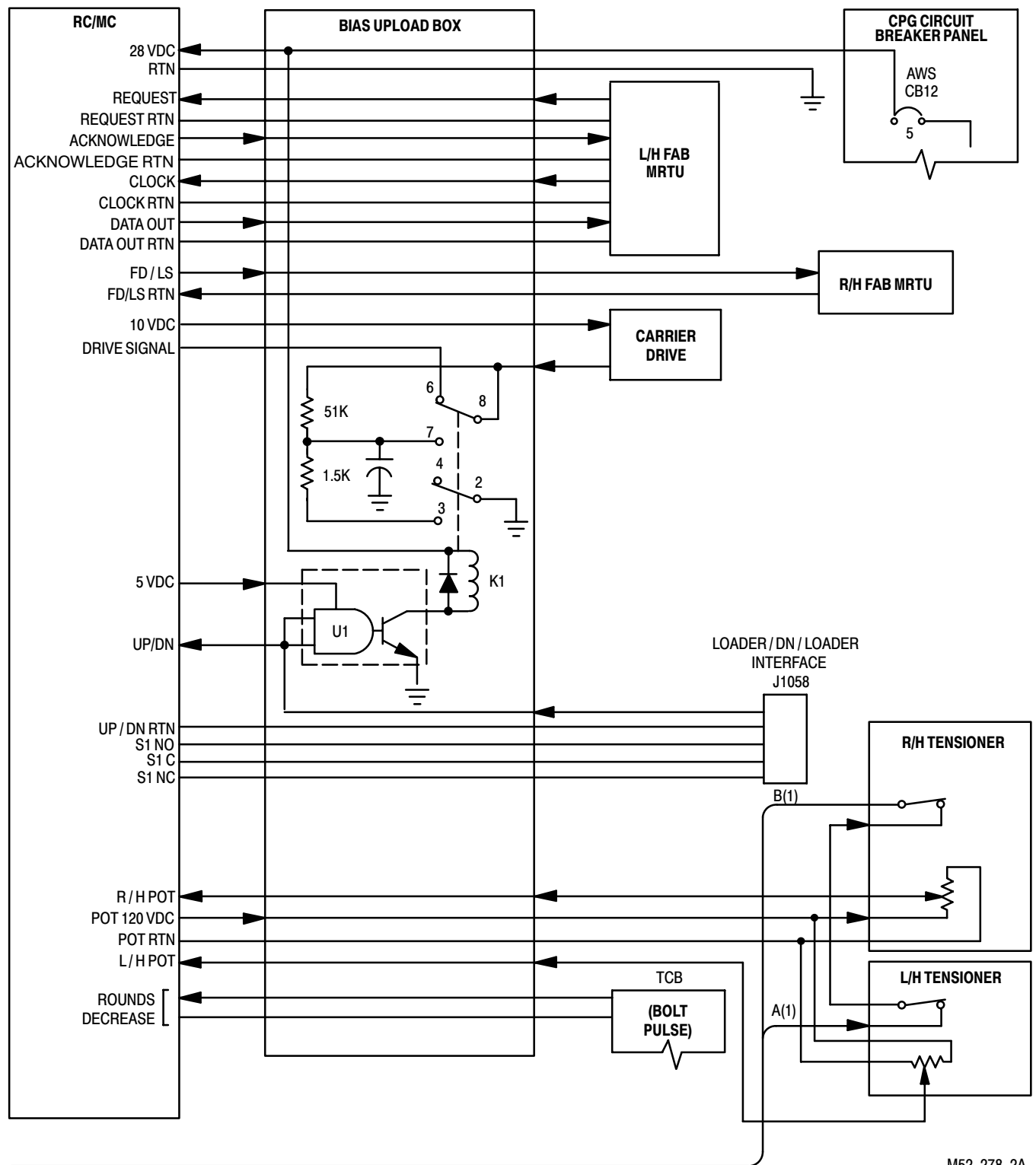


Figure 20–13. AWS Operational Block Diagram (Sheet 1 of 2)

20-3. THEORY OF OPERATION (cont)

20-3



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Figure 20-13. AWS Operational Block Diagram (Sheet 2 of 2)

20-3. THEORY OF OPERATION (cont)

20-3

j. **HELLFIRE missile.** Major components of the HELLFIRE missile are listed below (fig. 20-14).

(1) Seeker section searches for a target illuminated by a properly coded laser spot and guides the missile to that point of impact.

(2) Warhead section destroys the target.

(3) Guidance section receives target tracking commands from the laser seeker; provides stabilization and steering commands to the missile control section.

(4) Propulsion section generates the thrust to separate the missile from the launch rail, provides the acceleration profile necessary to arm the warhead fuze at a safe separation distance, and allows missile launch outside the target's gun defense range with minimum flight time to target.

(5) Control section provides guidance to the missile.

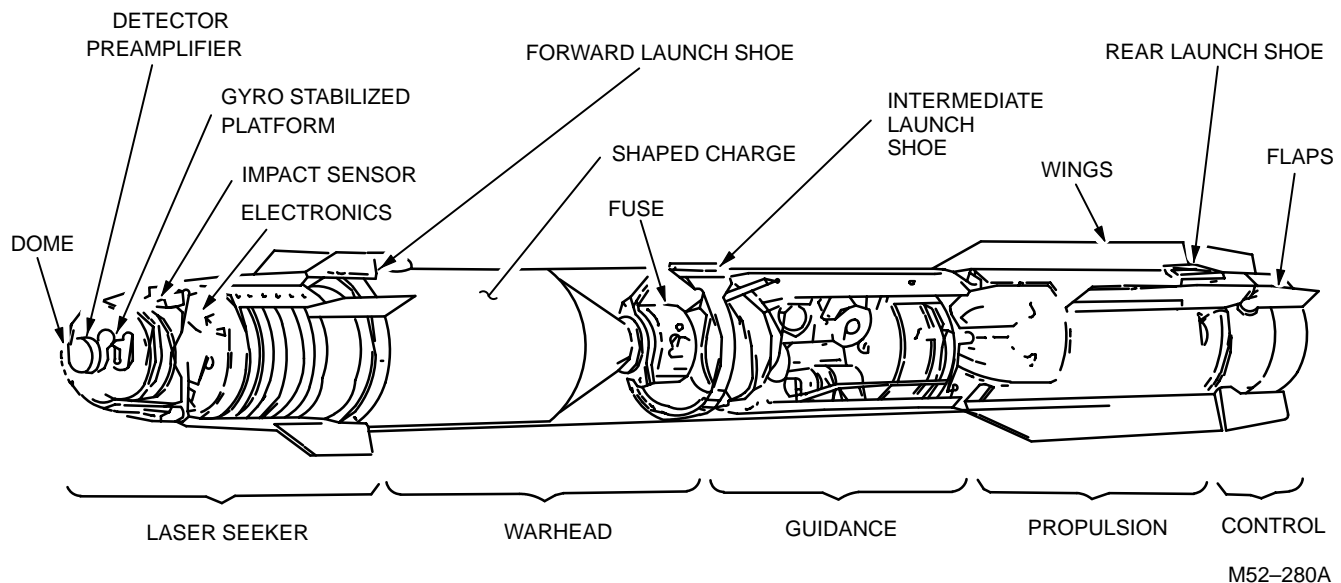


Figure 20-14. HELLFIRE Missile

k. **M272 Launcher.** Major components of the M272 Launcher and their functions are listed below (fig. 20-15).

(1) Launcher hardback provides the interface between the pylon rack and the launcher components.

(2) Electronic command signals programmer (ECSP) provides switching, transfer, and control functions for signals between the aircraft and the missile.

(3) Lower rail support assembly provides the attaching point for the two lower launcher rails. Provides attaching points for the wiring harness.

(4) Wiring harness provides the electrical interface between the ECSP and the rails.

(5) Launcher rail assembly (4 ea) provides the carriage and launch of one HELLFIRE missile.

(6) The hoist receptacle provides for a hoist adapter between lugs for launcher loading.

20-3. THEORY OF OPERATION (cont)**20-3**

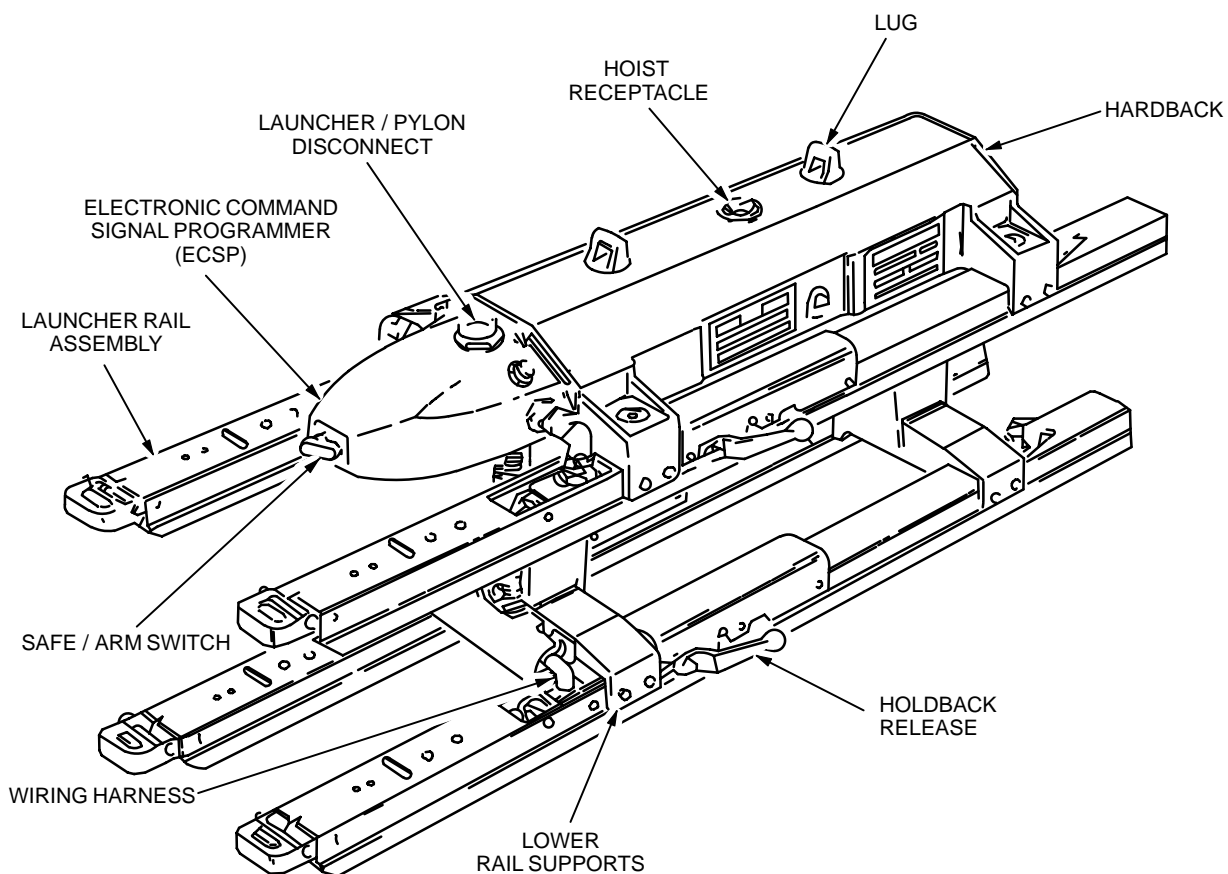
(7) The launcher pylon disconnect provides switching, transfer and control functions between the helicopter and launcher.

(8) The lugs (two each) provide attachment points for the helicopter and a means to jettison the external stores.

(9) The safe/arm switch provides the following functions.

- (a) Squib firing circuit interrupt.
- (b) Arm (power), safe (ground), or no launcher present.
- (c) Can be manually set to safe or arm on ground.
- (d) Can be electrically actuated from safe to arm from the crews station.

(10) Holdback release provides a means for locking or unlocking a missile from the rail.



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Figure 20-15. M272 Launcher

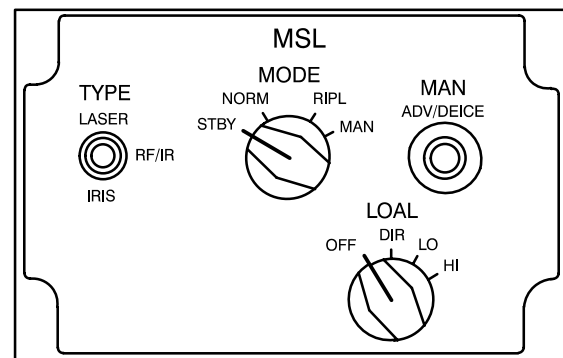
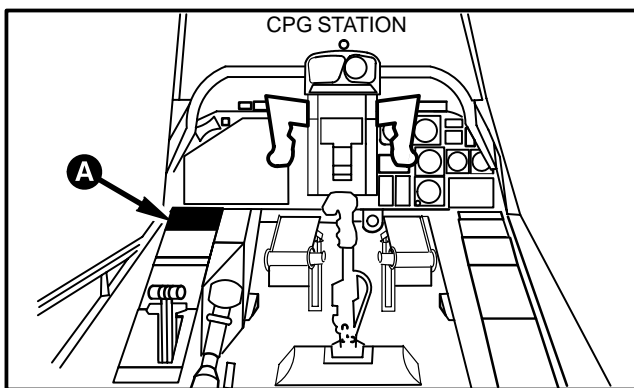
I. **CPG Missile Control Panel.** The CPG missile control panel (fig. 20-16) contains the following controls.

(1) **TYPE** switch positions are as follows.

20-3. THEORY OF OPERATION (cont)

20-3

- (a) **LASER**. The only position currently used.
- (b) **RF/IR**. Not used.
- (c) **IRIS**. Not used.
- (2) **MODE** switch selects the operating mode of the HELLFIRE system. Positions are as follows.
 - (a) **STBY**. All missiles are deselected. BIT can be performed.
 - (b) **NORM**. Activates a missile of the type selected.
 - (c) **RIPL**. Automatically switches the laser priority code for successive missile launches. Automatically codes the next selectable missile to replace the launched missile.
 - (d) **MAN**. provides for manual missile selection.
- (3) **MAN ADV/DEICE** switch allows manual selection and activation of any individual missile from any missile station. The switch is enabled when **MODE** switch is set to **MAN**. The **MAN ADV/DEICE** switch provides the ability to de-ice the missile laser dome if de-ice option is installed.
- (4) **LOAL** positions are as follows.
 - (a) **OFF**. Laser missiles to be launched in **LOBL** mode.
 - (b) **DIR**. Allows laser missile to be launched in **LOAL** mode: enables laser/HELLFIRE missile direct trajectory program.
 - (c) **LO**. Allows laser missile to be launched in **LOAL** mode; enables laser/HELLFIRE missile low altitude pitch and scan program.
 - (d) **HI**. Allows laser missile to be launched in **LOAL** mode; enables laser/HELLFIRE missile high altitude pitch and scan program.



A MISSILE CONTROL PANEL

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Figure 20-16. CPG Missile Control Panel

m. **CPG PTWS Controls**. The CPG FCP and collective stick switchbox (fig. 20-17) contain the following controls and indicators.

- (1) **MSL** switch enables missile circuits. Positions are **ON** and **OFF**.
- (2) **CHAN SEL** switch positions are as follows.

20-3. THEORY OF OPERATION (cont)

20-3

(a) **UPR**. Establishes upper channel as the priority channel. Commands the RHE to validate and execute the missile system switch positions.

(b) **LWR**. Establishes lower channel as the priority channel. Commands the RHE to validate and execute the missile system switch positions.

(3) **UPR CHAN, LWR CHAN LSR CODE** selects the laser code indexers which specify the alphabetic laser code designator assigned to that channel setup.

(4) **UPR CHAN, LWR CHAN QTY** selects the quantity indexers which specify the number of missiles per channel that are to be encoded and brought to a ready state at one time.

NOTE

The laser code and quantity indexers are selected by pressing either the top or bottom button on each indexer, causing the display to rotate up or down.

(5) **LSR MSL CCM** switch enables the counter-countermeasures function of the laser seeker.

(6) **RF ORIDE** switch is used to fire an RF missile when installed.

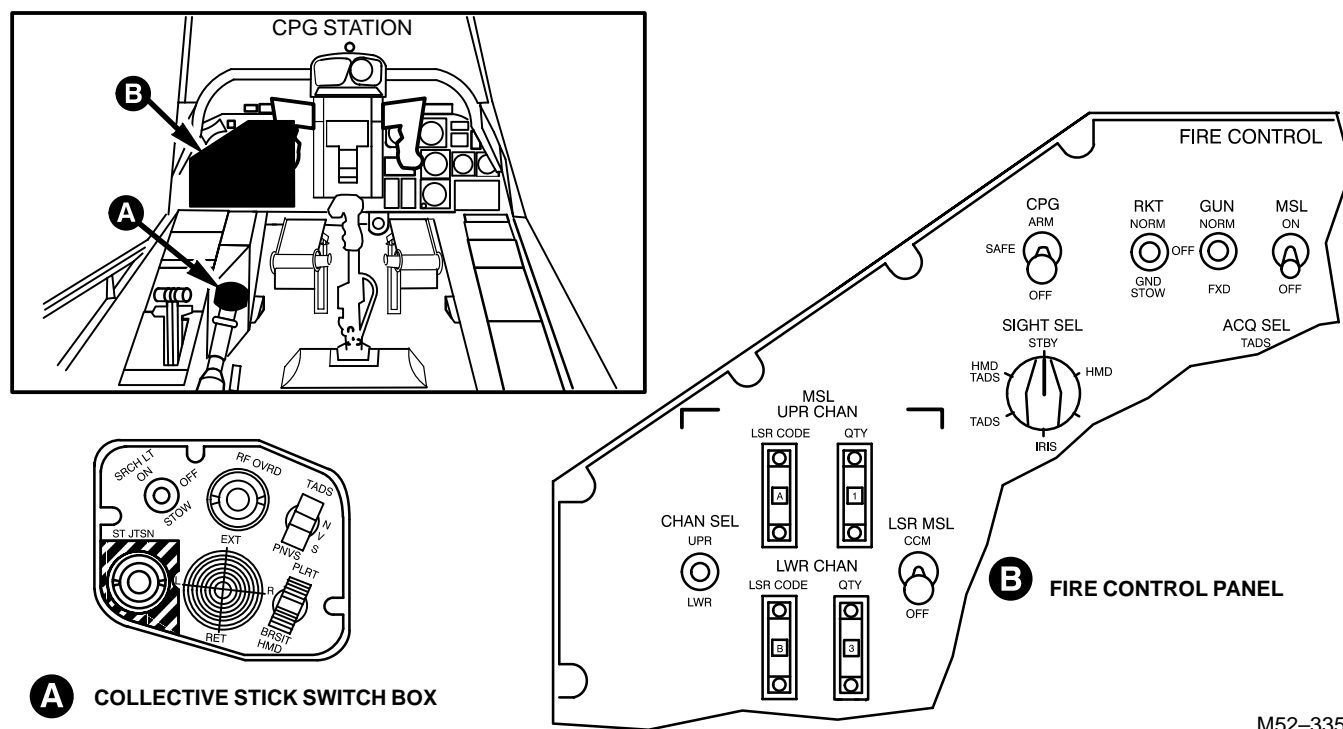


Figure 20-17. CPG FCP and Collective Stick Switchbox

n. **Pilot Missile Control Panel.** The pilot missile control panel (fig. 20-18) contains the following controls.

(1) **LOAL**. Positions are as follows.

(a) **OFF**. Laser missiles to be launched in **LOBL** mode.

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20-3. THEORY OF OPERATION (cont)

20-3

(b) **DIR**. Allows laser missile to be launched in **LOAL** mode; enables laser/HELLFIRE missile direct trajectory program.

(c) **LO**. Allows laser missile to be launched in **LOAL** mode; enables laser/HELLFIRE missile low altitude pitch and scan program.

(d) **HI**. Allows laser missile to be launched in **LOAL** mode; enables laser/HELLFIRE missile high altitude pitch and scan program.

(2) **LSR CODE**. Positions are as follows.

(a) **UPPER**. Selects the upper coded channel that has been selected on the CPG's FCP.

(b) **LOWER**. Selects the lower coded channel that has been selected on the CPG's FCP.

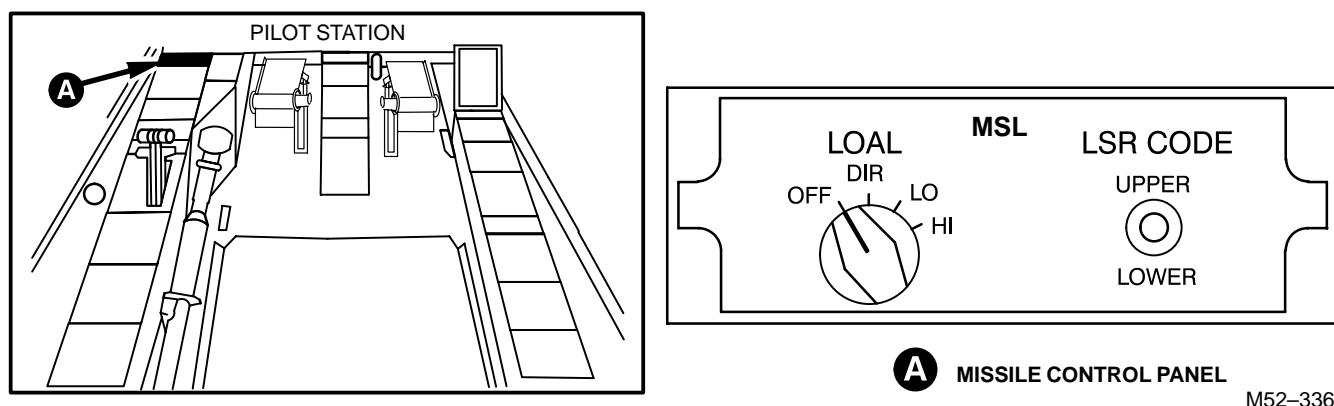
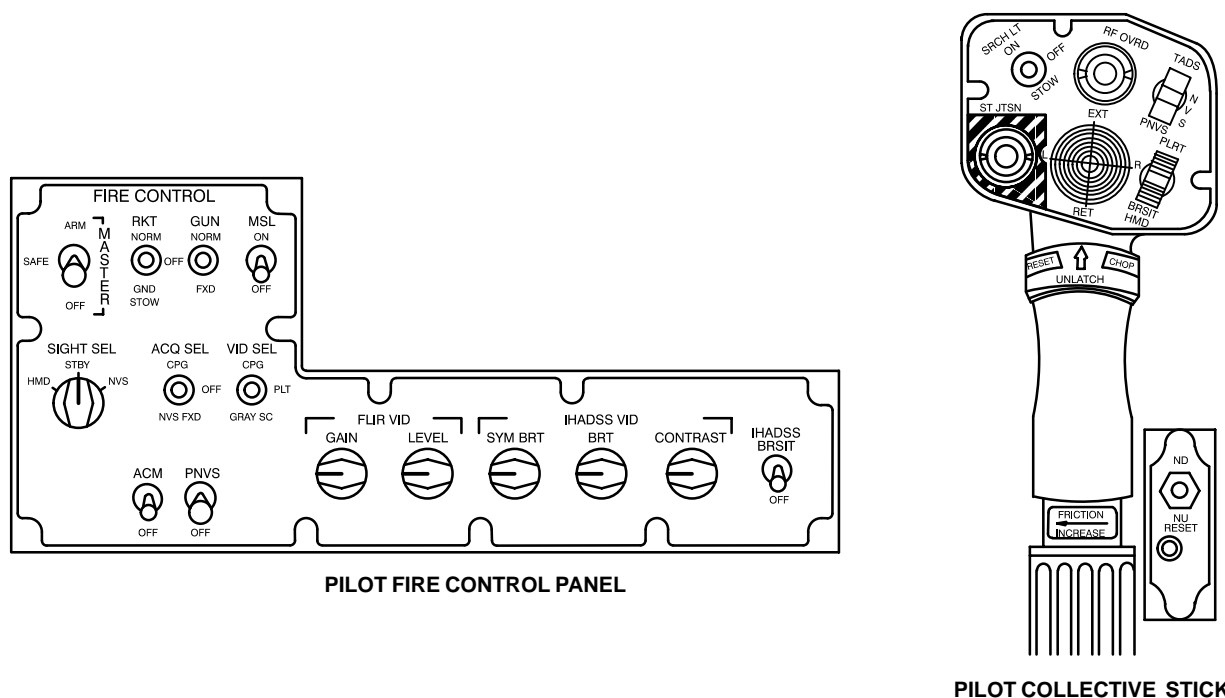


Figure 20-18. Pilot Missile Control Panel

o. **Pilot PTWS Controls.** The pilot FCP and collective stick switchbox (fig. 20-19) contain the following controls.

(1) **MSL switch**. Positions are **ON** and **OFF**.

(2) **RF ORIDE**. Used to fire an RF missile when installed.



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Figure 20-19. Pilot FCP and Collective Switchbox

p. **PTWS Symbology.** The missile constraints (fig. 20-20) indicate when the missile is within launch constraints for the selected lock-on option. The symbol may be located at any X and Y axes location within the display limits of the HOD, HDD, or HDU and VDU.

(1) The missile constraints symbol is a square. The size of the constraints square depends on the lock-on option selected, either lock-on-after-launch direct (**LOAL-DIR**), **LOAL-LO** or **LOAL-HI**, or lock-on-before-launch (**LOBL**).

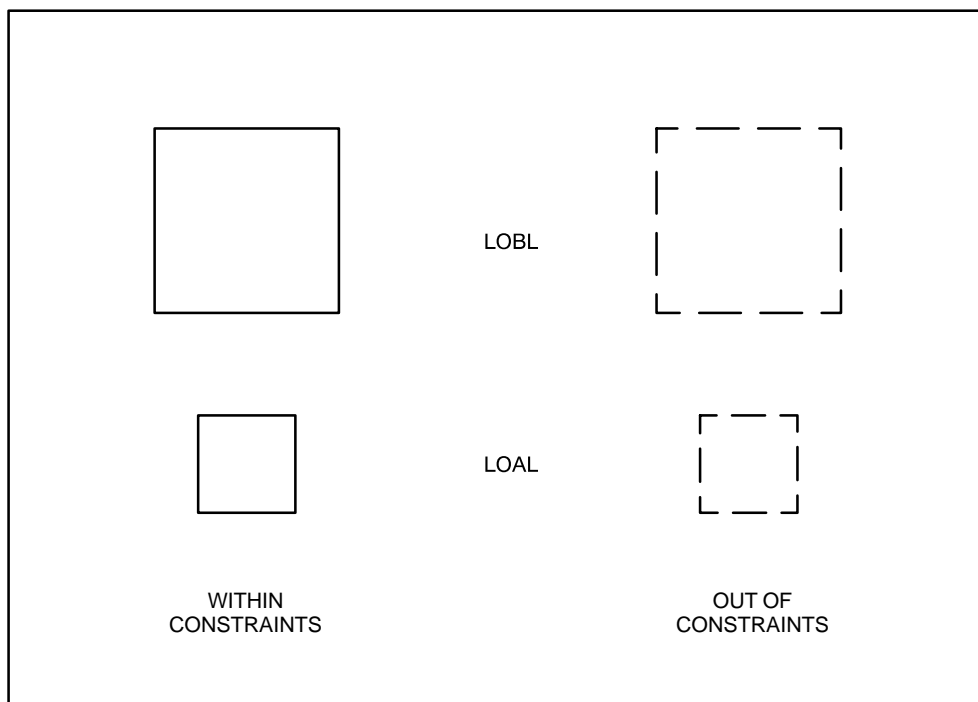
(2) The **LOBL** symbol represents 20° in X or Y axis. The **LOAL** symbol represents +7.5° in X and Y (X is horizontal; Y is vertical) axis.

(3) The line structure of either constraints symbol is dashed when the missile is not within launch constraints. When the missile is within launch constraints, the line structure of the square is solid.

(4) When launch constraints are satisfied, the missile may be fired.

(5) The constraints are displayed to both crew members any time the following conditions exist.

- (a) **MSL** switch is set to **ON**.
- (b) Either the **CPG** or **MASTER** switch is set to **SAFE** or **ARM**.
- (c) The weapon action switch (WAS) is set to **M** or **MSL**.



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Figure 20-20. Missile Constraints Symbols

q. **High Action Display.** The high action display (fig. 20-21) shows weapon system failures and status for use by the aircrew. The high action message is displayed on the TADS HOD and HDD, and on the IHADSS HDU or VDU. If the PTWS is selected for missile engagement, the following information is provided. Each crew member receives the same information.

(1) Weapon Control Section. **CMSL** or **PMSL** informs one crew member that the other crew member has actioned the PTWS

(2) Weapon Status Section. Weapon status section messages are as follows.

- (a) **WEAPON?**. The weapons trigger has been pulled without actioning a weapon.
- (b) **CPG MSL**. The CPG is in a missile engagement. Blinks at a 2-Hz rate.
- (c) **PLT MSL**. The pilot has actioned the missile system and outprioritized the CPG's rocket system action.
- (d) **RHE FAIL**. Indicates RHE failure.
- (e) **MSL FAIL**. Indicates missile system has been actioned but the missile has been detected as NO-GO.
- (f) **LAUNCHERS...FAILED**. Indicates all four launchers have failed BIT. Sequenced at 0.5 Hz rate.
- (g) **INVALID...COMMAND**. Indicates the aircrew has selected a command that the missile system cannot perform.

20-3. THEORY OF OPERATION (cont)

20-3

- (h) **BIT IN...PROGRESS**. Indicates the RHE is performing BIT.
 - (i) **HANGFIRE**. Indicates the missile fire signal was sent, but umbilical separation did not occur at the predicted time.
 - (j) **MSL LNCH**. Indicates the missile system is functioning properly and the weapons trigger has been pulled.
 - (k) **TOF = TT**. Time of flight in seconds to missile impact, decrementing.
 - (l) **FIRE...MISSILE**. Indicates a subsequent missile may be fired.
 - (m) **SIM LNCH**. Displayed when training missiles are being used.
 - (n) **RF OVRIDE**. Growth position for RF/IR missile seekers.
 - (o) **2 CHNLS...TRACKING**. Missiles selected on each channel have locked onto and are tracking reflected laser energy of two different PRF codes.
 - (p) **PRI CHAN...TRACKING**. Missiles selected on the priority channel have locked onto and are tracking laser energy.
 - (q) **ALT CHAN...TRACKING**. Missiles have been actioned, but no missiles have been selected.
 - (r) **MSL SEL?**. Missiles selected on the alternate channel have locked onto and are tracking laser energy.
 - (s) If no channels are tracking, the weapon status contains the lock-on option and the firing delivery mode. The lock-on option messages are **HI**, **LO**, **DIR**, **LOBL**. The firing delivery messages are **NORM**, **STBY**, **MANL**, and **RIPL**.
 - (t) **LASE...TARGET**, **LASE 2ND...TARGET** or **LASE 3RD...TARGET**. Appears only during certain missile engagements.
- (3) Sight Status Section.

NOTE

The only PTWS-related message in this section is displayed only to the CPG during PTWS engagements.

- **LASE... TARGET**, **LASE 2ND...TARGET** or **LASE 3RD...TARGET**. Appears only during certain missile engagements.

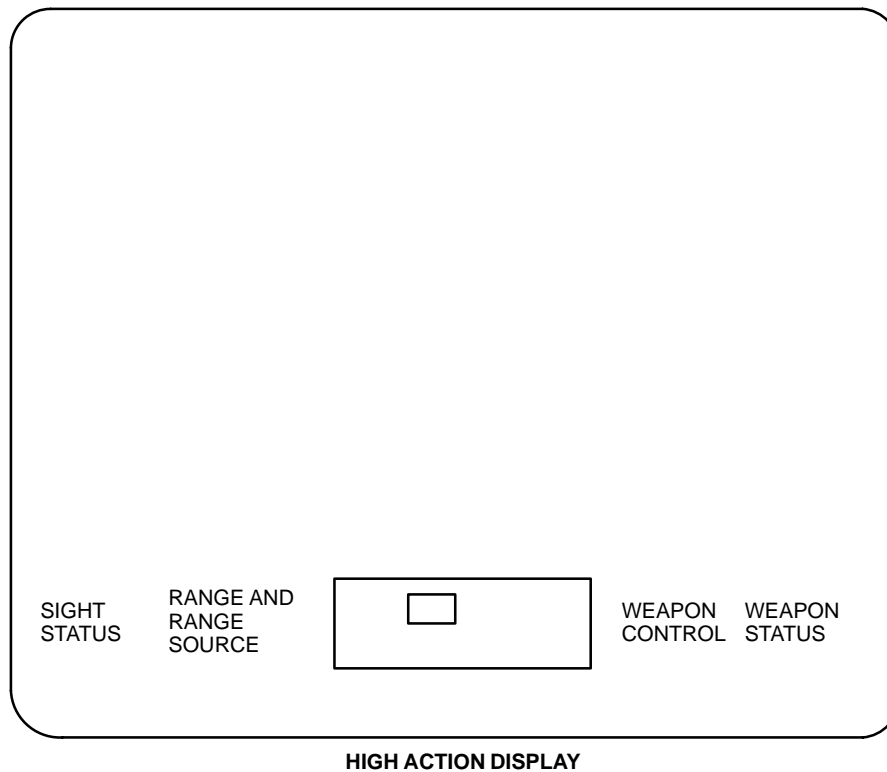


Figure 20-21. High Action Display

r. **Alphanumeric Display.** The alphanumeric display (AND) displays information as follows (fig. 20-22). Message/status sections use a 4 X 16 character layout in the center of the AND. The missile inventory and status sections use 4 X 4 layouts at both ends of the AND. The message/status sections indicate information as follows.

- (1) Weapon Status Section. Refer to subparagraph q. (2), for message definitions.
 - (a) **WEAPON?**.
 - (b) **RHE FAIL.**
 - (c) **LAUNCHERS...FAILED.**
 - (d) **INVALID...COMMAND.**
 - (e) **BIT IN...PROGRESS.**
 - (f) **PLT MSL.**
 - (g) **HANGFIRE.**
 - (h) **MISSILE...FAILURE.**
 - (i) **LAUNCH N...PROGRESS.**
 - (j) **FIRE...MISSILE.**
 - (k) **SIMULATED...LAUNCH.**

20-3. THEORY OF OPERATION (cont)

20-3

- (l) **TOF=TT.**
- (m) **RF OVRIDE.**
- (n) **2 CHANLS...TRACKING.**
- (o) **PRI...TRACKING.**
- (p) **ALT CHAN...TRACKING.**
- (2) Enhancement Display.
 - (a) **UP = A** through **H.** Displays after code channels are prioritized for upper code channel.
 - (b) **LOW = A** through **H.** Same as above.
 - (c) **PRI.** Displays prioritized code channel.

MISSILE INVENTORY AND STATUS	SIGHT STATUS	WEAPON STATUS	MISSILE INVENTORY AND STATUS
	TRACKER STATUS		
	LRF/D AND LST CODE STATUS		
	ENHANCEMENT DISPLAY		

MESSAGE STATUS SECTIONS

	LCHR 1 OTBD INBD MSL MSL		LCHR 2 T																		LCHR 3 T		LCHR 4 T	
UPR MSL	[Hatched Box]																							
LWR MSL																								

4 BY 24 CHARACTER LAYOUT

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Figure 20-22. AND

(3) Missile Inventory and Status Sections. The missile inventory and status section reserves two adjacent vertical columns of four blocks for each launcher and two blocks for each missile. Launchers are numbered from left to right, 1 through 4 (fig. 20-23). Looking forward, the missiles are numbered as shown in the illustration.

s. **RHE built-in test message.** When the CPG **MSL MODE** switch is set to **STBY** and the **MSL** switch on either FCP is set to **ON** (all ships power available, **MSL** switch enabled), the AND initially displays **BIT IN...PROGRESS** (fig. 20-24). This indicates the RHE is performing BIT, and is displayed during RHE, launcher, and missile BIT.

(1) When the RHE successfully completes BIT, the RHE performs launcher BIT, and displays the results in the missile status and inventory section of the AND. When launcher BIT is complete, the RHE performs missile BIT on each missile present. Missile BIT results are also displayed on the AND.

20-3. THEORY OF OPERATION (cont)

20-3

(2) If at least one launch station (launcher electronics and pylon MRTU) is GO, the following status may be displayed in the appropriate section of the AND 4 X 4 section for all launch stations.

(a) **FAIL**. Indicates the launcher electronics has failed BIT, or the serial/digital data link between the pylon MRTU and the launcher electronics has failed.

(b) **SAFE**. Indicates the launcher **ARM/SAFE** switch is set to **SAFE**. Launchers may be armed by setting either FCP to **ARM**, or by manually setting the switch to **ARM**.

(3) If the **SAFE/ARM** switch is set to **ARM**, the following missile status and inventory characters may be displayed in the 4 X 4 section of the AND.

(a) No display (blank). Launcher is not present, or the launcher status is GO and no missiles are loaded on that launcher.

(b) **L**. Laser missile loaded in this position.

(c) **A** through **H**. Code of the laser missile in place of the **L** indication.

(d) **I**. IRIS missile loaded in this position.

(e) **R**. RF/IR missile loaded in this position.

(f) **S**. Missile has been selected manually or by the RHE automatic selection process.

(g) **R** (steady). The missile is encoded and ready for employment.

(h) **R** (flashing). The LOAL priority channel missile that will be the next launched missile.

(i) **T** (steady). Missile seeker is locked on an appropriately coded laser spot and is tracking.

(j) **T** (flashing). The LOBL priority channel missile that will be the next launched missile.

(4) The status of all missiles is continuously displayed on the AND. The following missile failures prevent the missile from being launched.

(a) **M**
U. The missile is unlatched on the launcher.

(b) **M**
F. The missile has failed BIT or has been detected as failed subsequent to BIT.

(c) **S**
F. The missile launch station in that launcher has been detected as failed.

(d) **T**
F. The pylon MRTU cannot communicate with the selected missile. Once detected for one missile on a launcher, all missiles on that launcher reflect this status. This fault is cleared by cycling the MODE switch to STBY, then back to the desired position.

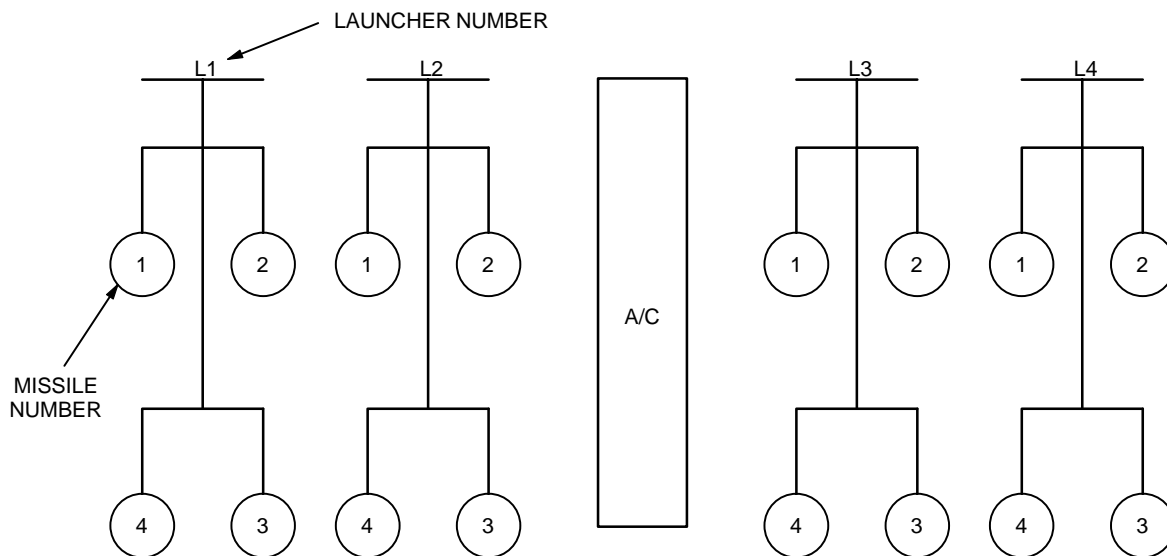
(e) **N**
A. Missile has been detected as not available, low coolant, or hangfire in progress.

(f) **M**
A. Battery failed or missile has misfired.

20-3. THEORY OF OPERATION (cont)

20-3

- (g) **M**
H. Missile is in the process of hangfire.



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Figure 20-23. Missile and Launcher Numbering System

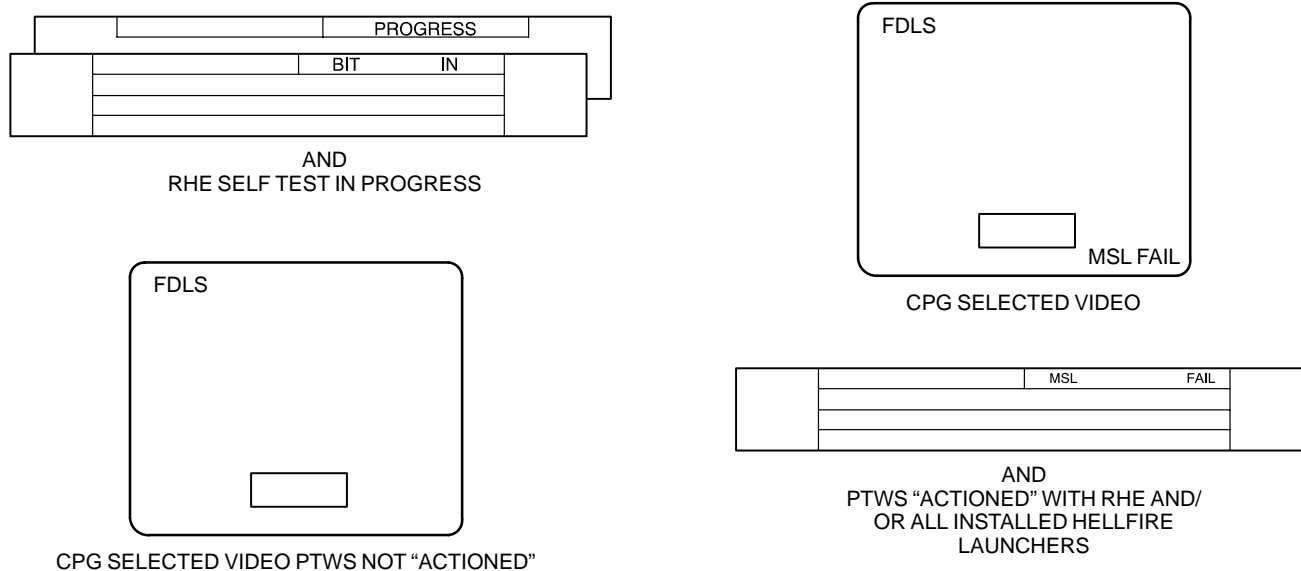


Figure 20-24. RHE Built-in Test Message Display

- t. **ARCP.** The ARCP contains four rows of switches and displays (fig. 20-25).

(1) The **ZONE INVENTORY** five thumbwheel switches display the type of rocket loaded in each pod zone. The switches each have the following settings and functions.

20-3. THEORY OF OPERATION (cont)

20-3

- (a) **PD4**. Point detonate; Mark 40 motor.
- (b) **RC4** Remote set fuze; Mark 40 motor.
- (c) **DP4**. Dual purpose; Mark 40 motor.
- (d) **WP4**. White phosphorus; Mark 40 motor.
- (e) **IL4**. Illumination; Mark 40 motor.
- (f) **SK4**. Smoke; Mark 40 motor.
- (g) **6PD**. Point detonate; Mark 66 motor.
- (h) **6RC**. Remote set fuze; Mark 66 motor.
- (i) **6IL**. Illumination; Mark 66 motor.
- (j) **6SK**. Smoke; Mark 66 motor.
- (k) **6MP**. Multipurpose; Mark 66 motor.

(2) **QTY REM** indicator provides the pilot with the total number of rockets remaining, or loaded in each zone.

(3) **ZONE SEL** switches enable the pilot to select the zone, or zones, to be fired. Each button corresponds to a zone in the M261 rocket launcher.

(4) **PEN-M** switch permits the pilot to select tree height burst detonation, or bunker detonation for the fuze. Positions are as follows.

- **10** through **45** in 5-meter increments: used for tree height burst detonation.
- **BNK**: used to defeat bunkers. Penetrates logs and dirt up to three meters thick.
- **SQ**: used to detonate when the fuze makes contact with any object.

(5) **QTY** switches permit the pilot to select the number of rockets to be fired in each volley. Positions are as follows.

- (a) **ALL**. Sustained or continuous fire of rockets in the selected zones.
- (b) **24**. 24 rockets to be fired.
- (c) **12**. 12 rockets to be fired.
- (d) **8**. 8 rockets to be fired.
- (e) **4**. 4 rockets to be fired.
- (f) **2**. 2 rockets to be fired.
- (g) **1**. 1 rocket to be fired.

(6) **RNG-KM** switches set the range at which the rocket fuze detonates. Functions are as follows.

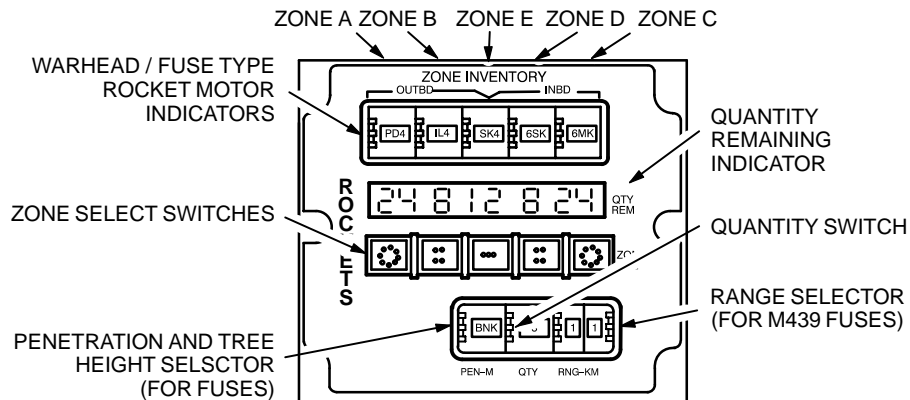
- (a) Left thumbwheel sets the range from 0 through 8 in 1000-meter increments.
- (b) Right thumbwheel sets the range from 0 through 9 in 100-meter increments.

20-3. THEORY OF OPERATION (cont)

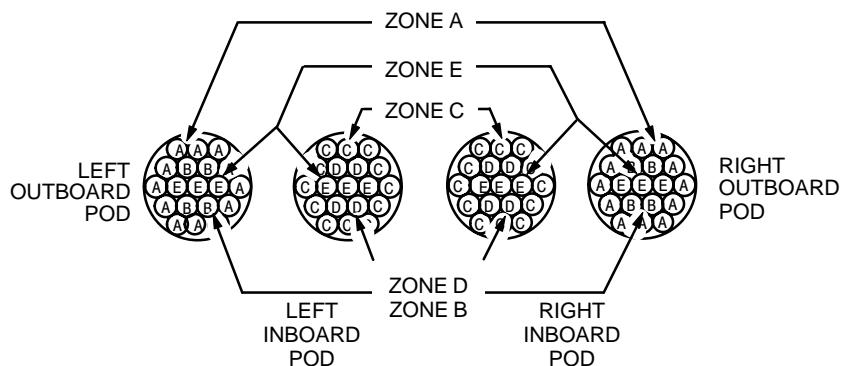
20-3

u. **Station Director.** The station director contains two connectors. Functions are as follows.

- (1) J1 provides arming and firing interconnection.
- (2) J2 provides power, trigger, fuzing, and FD/LS circuits.



IDENT CODE	TYPE	ROCKET MOTOR
PD4	POINT DETONATE	MARK 40
RC4	REMOTE SET FUSE (PENETRATION)	MARK 40
DP4	DUAL PURPOSE	MARK 40
WP4	WHITE PHOSPHOROUS	MARK 40
IL4	ILLUMINATION	MARK 40
SK4	SMOKE	MARK 40
6PD	POINT DETONATE	MARK 66
6RC	REMOTE SET FUSE	MARK 66
6IL	ILLUMINATION	MARK 66
6SK	SMOKE	MARK 66
6MP	MULTIPURPOSE	MARK 66



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Figure 20-25. ARCP

v. **M261 Rocket Launcher.**

- (1) The M261 rocket launcher contains two connectors (fig. 20-26). Functions are as follows.
 - (a) J1 provides firing circuits.

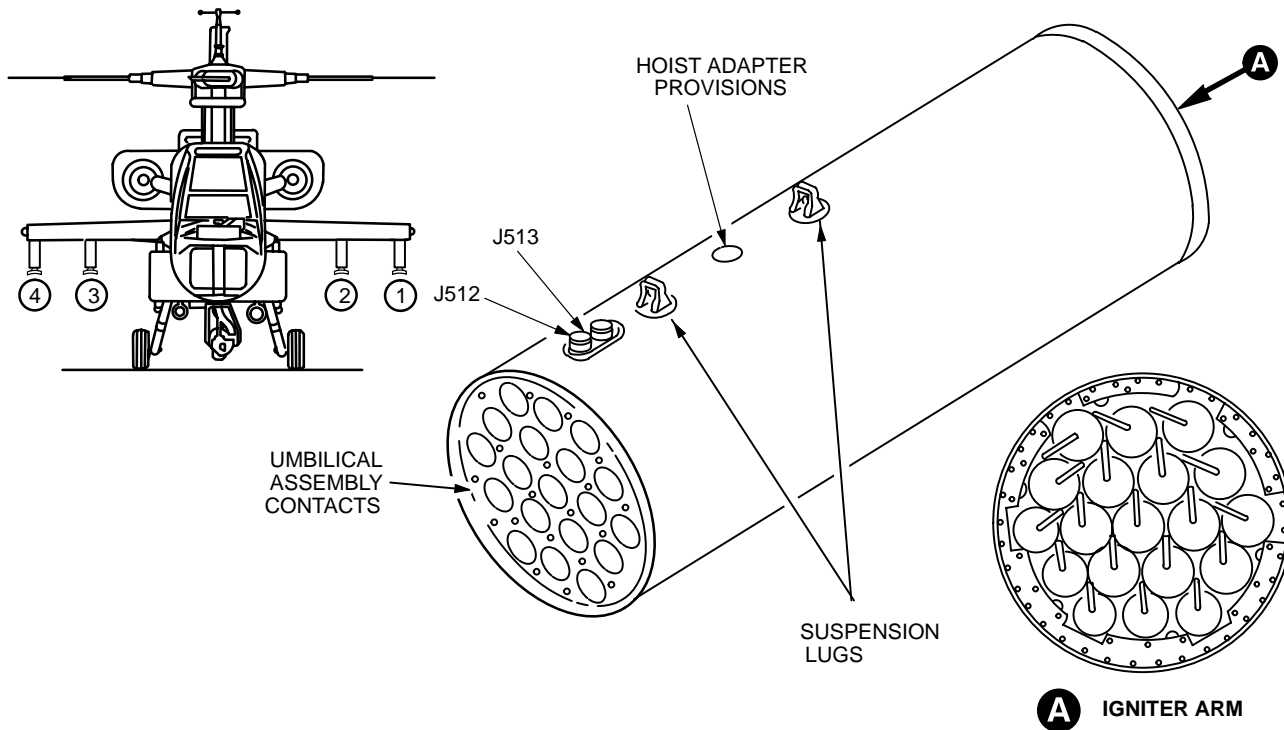
20-3. THEORY OF OPERATION (cont)

20-3

(b) J2 provides fuzing circuits.

(2) The front of the launcher has 19 umbilical assembly sockets used to interconnect the fusable warhead to the launcher.

(3) The rear of the launcher has 19 igniter arms which apply the firing signal to the rocket motors.



M52-345

Figure 20-26. M261 Rocket Launcher

w. **Pilot ARCS Controls.** The pilot's station contains the following controls for ARCS (fig. 20-27).

(1) **MASTER ARM/SAFE/OFF** switch controls the arm/safe status of all weapon systems. Positions are as follows.

- (a) **OFF.** All weapons systems are de-energized.
- (b) **SAFE.** Weapons systems are in standby mode. Weapon inventory and status can be monitored.
- (c) **ARM.** Selected weapon system can be fired.

(2) **RKT** switch controls power to the ARCS and positioning of the external stores. Positions are as follows.

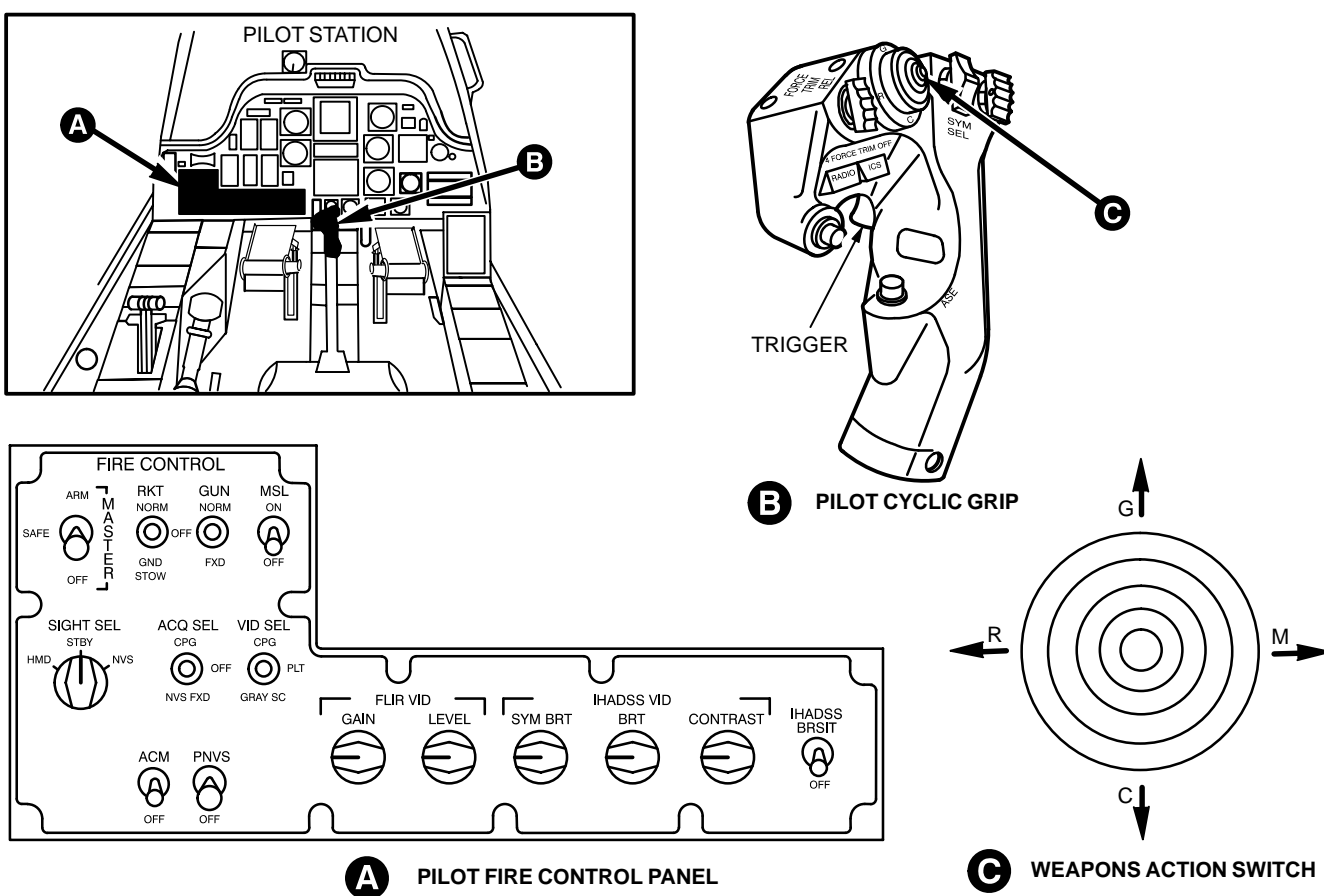
- (a) **NORM.** Rocket system electrical power can be applied.
- (b) **OFF.** No power can be applied to the rocket system.
- (c) **GND STOW.** Places the external stores in a ground stow position.

(3) Weapons action switch selects the weapon to be used by the pilot. Positions are as follows.

20-3. THEORY OF OPERATION (cont)

20-3

- (a) Center. Off.
 - (b) **G**. Actions the AWS.
 - (c) **R**. Actions the ARCS.
 - (d) **M**. Actions the PTWS.
 - (e) **C**. Fires the chaff.
- (4) Trigger switch fires the selected weapon. Positions are as follows.
- (a) First detent is normal weapon firing.
 - (b) Second detent overrides performance inhibits but does not override safety inhibits to fire weapon.



M52-346

Figure 20-27. Pilot ARCS Controls

x. **CPG ARCS Controls.** The CPG's station contains the following controls for ARCS (fig. 20-28).

- (1) **PLT/GND** switch overrides the squat switch and the pilot's **MASTER ARM/SAFE/OFF** switch for all weapon systems. Positions are as follows.

20-3. THEORY OF OPERATION (cont)

20-3

(a) **ORIDE**. Squat switch is overridden. Enables the CPG switch to control electrical power to the weapons.

(b) **OFF**. Squat switch inhibits arm/safe power if on the ground.

(2) CPG **ARM/SAFE/OFF** switch controls the arm/safe status of all weapons. Positions are as follows.

(a) **ARM**. Enables arm power to the CPG's firing circuits if the pilot's **MASTER ARM/SAFE/OFF** switch is set to **ARM** or if the **PLT/GND** switch is set to **ORIDE**.

(b) **SAFE**. Enables safe power to the CPG's weapon switches if the pilot's **MASTER ARM/SAFE/OFF** switch is set to **SAFE** or **ARM**, or if the **PLT/GND** switch is set to **ORIDE**.

(c) **OFF**. Disables all weapon control/firing circuits for the CPG.

(3) **RKT** switch controls power to the ARCS and positioning of the external stores. Positions are as follows.

(a) **NORM**. Rocket system electrical power can be applied.

(b) **OFF**. No power can be applied to the rocket system.

(c) **GND STOW**. Places the external stores in a ground stow position.

(4) Weapons action switch selects the weapon to be used by the CPG. Positions are as follows.

(a) Center. Off.

(b) **G**. Actions the AWS.

(c) **R**. Actions the ARCS.

(d) **M**. Actions the PTWS.

(e) **C**. Fires the chaff.

(5) ORT weapons action switch selects the weapon to be used by the CPG. Positions are as follows.

(a) Center. Off.

(b) **GUN**. Actions the AWS.

(c) **RKT**. Actions the ARCS.

(d) **MSL**. Actions the PTWS.

(e) Blank. Not used.

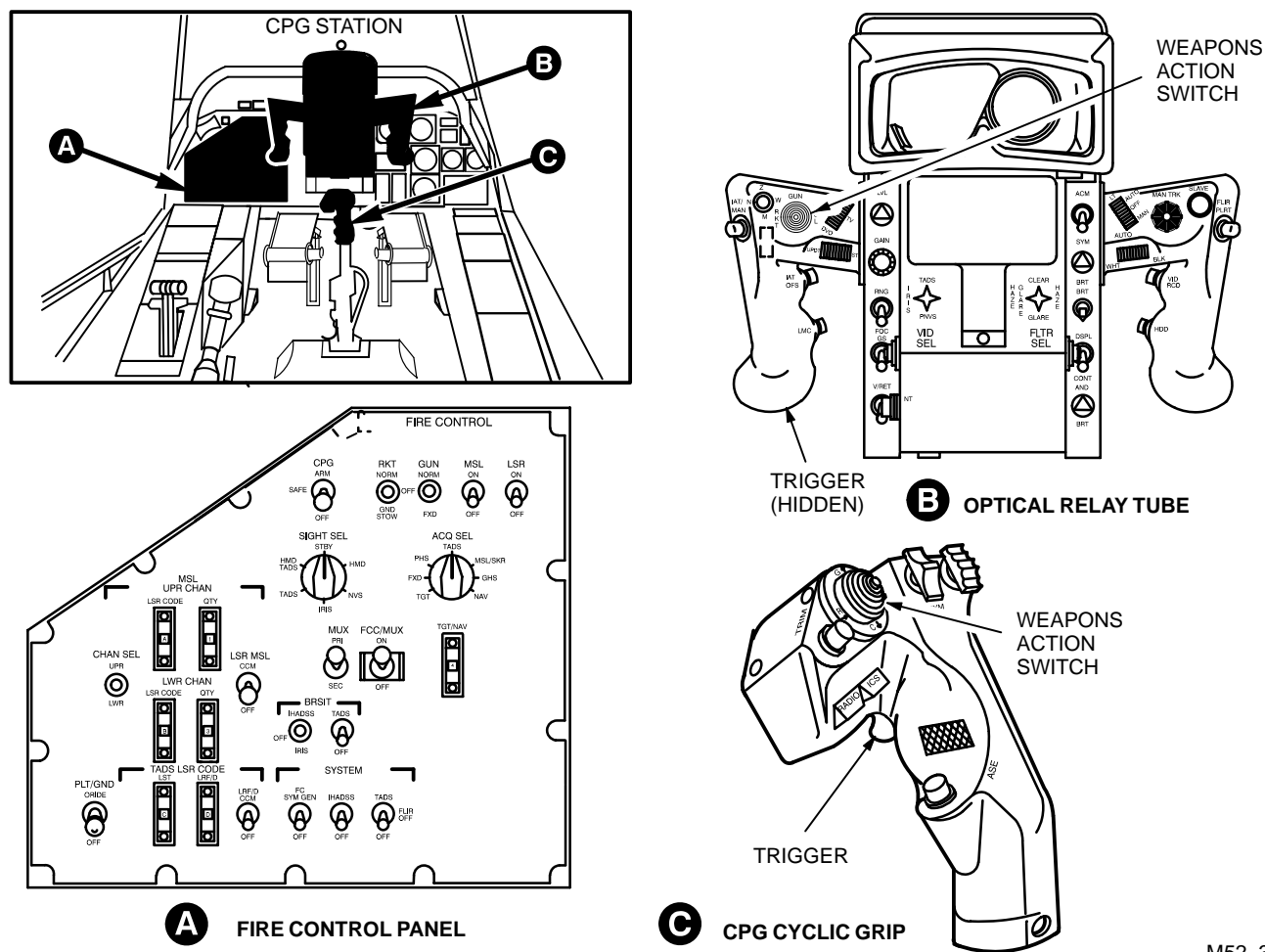
(6) Trigger switch (one in cyclic grip; one in ORT LH grip) fires the selected weapon. Positions are as follows.

(a) First detent is normal weapon firing.

(b) Second detent overrides performance inhibits but does not override safety inhibits to fire weapon.

20-3. THEORY OF OPERATION (cont)

20-3

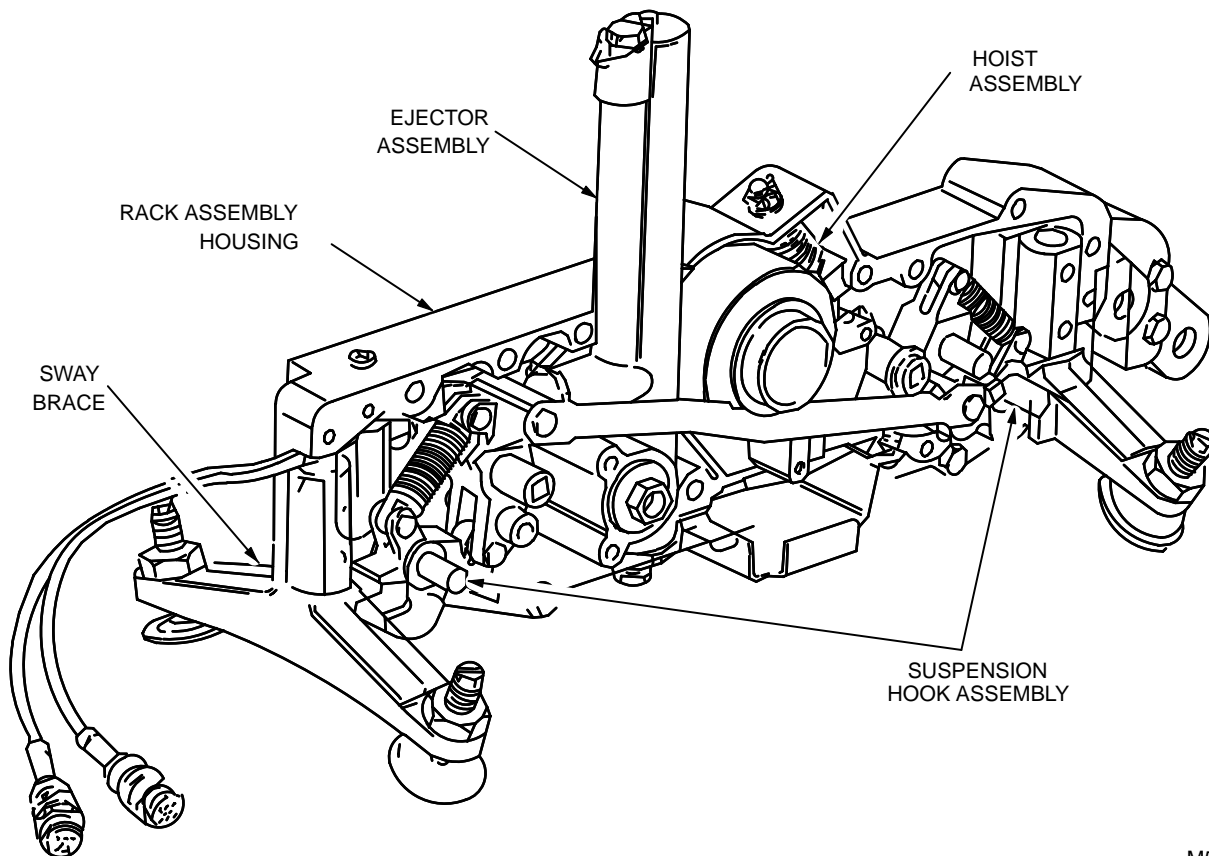


M52-347A

Figure 20-28. CPG ARCS Controls

y. **External Stores Rack Assembly.** Components of the rack assembly, and their functions, are listed below (fig. 20-29).

- (1) Rack assembly housing provides the mounting provisions for the rack assembly components.
- (2) Sway braces stabilize the stores load.
- (3) Suspension hook assembly holds and locks the stores to the rack. The suspension hook assembly opens automatically during jettison to allow the stores to be pushed away from the rack.
- (4) Ejector assembly provides the means of unlocking the suspension hooks and pushing the selected stores away from the aircraft.
- (5) Hoist assembly provides the means to lift and lower the stores.



M52-350

Figure 20-29. Rack Assembly

z. **Pylon Assembly.** Components of the pylon assembly, and their functions, are listed below (fig. 20-30).

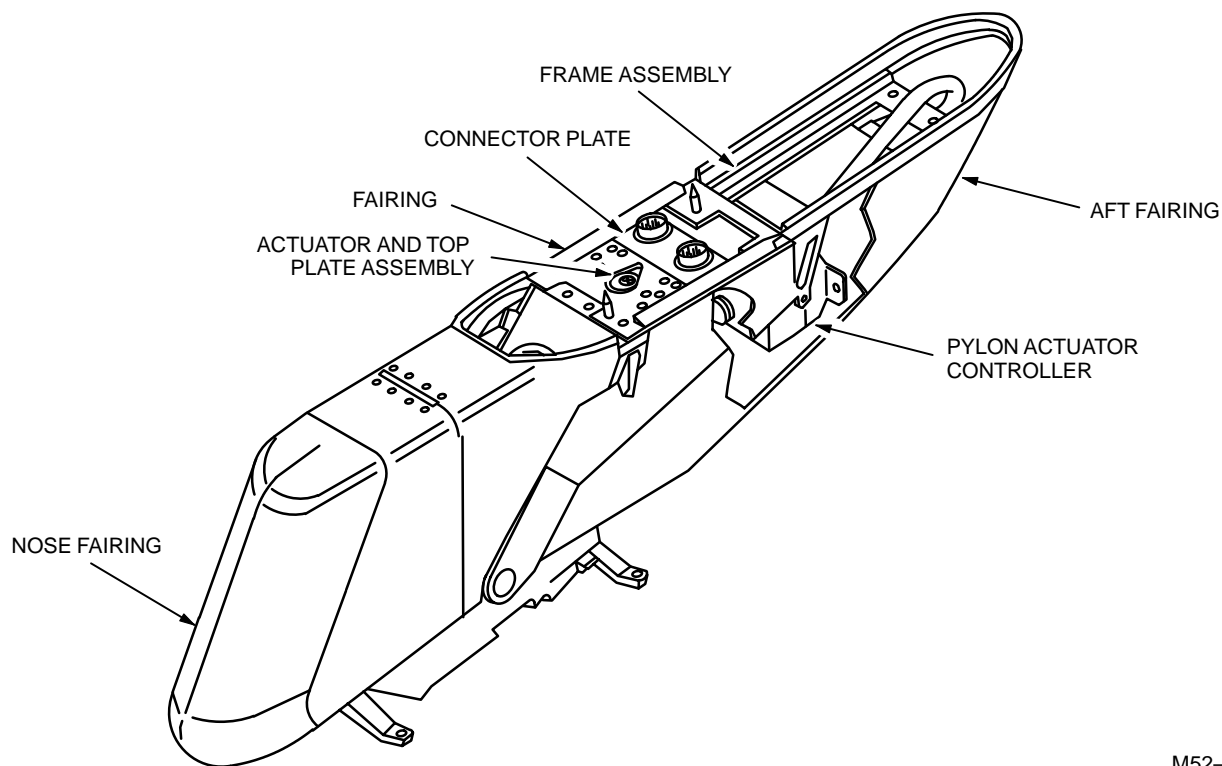
(1) Frame assembly provides an attaching point for pylon components. The frame assembly provides the pivot point for the rack.

(2) Connector plate provides the mounting location for the two quick disconnect electrical connectors on the pylon.

(3) Pylon actuator controller controls and monitors the position of the pylon actuator.

(4) Actuator and top plate provide the means for elevation positioning of the rack and the angular position information to the pylon actuator controller (PAC).

(5) Fairings provide protection for the pylon component for a smoother airflow around the pylon during flight.



M52-351

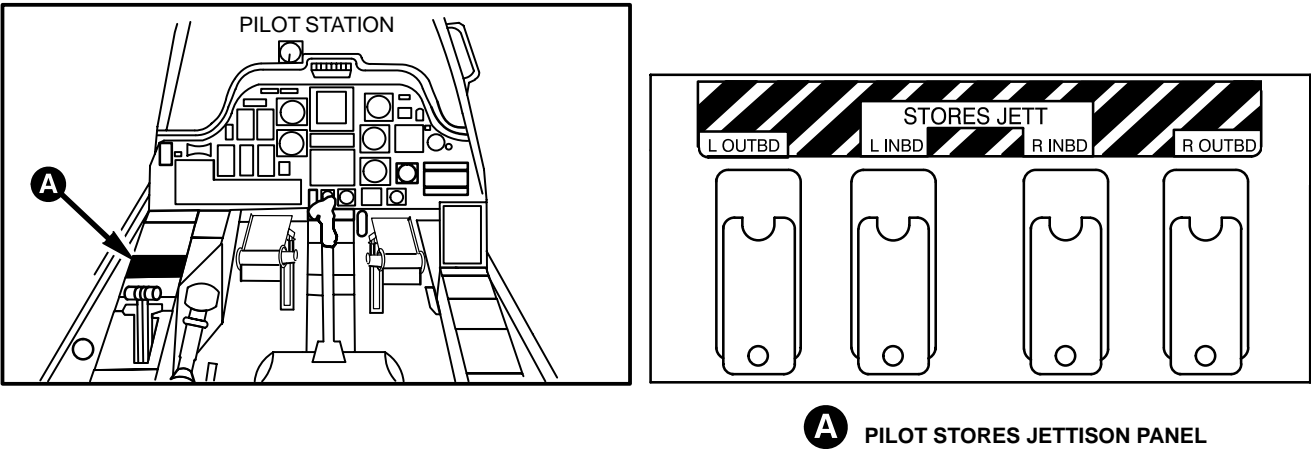
Figure 20-30. Pylon Assembly

aa. **Stores Jettison Control Panel.** The **STORES JETT** panel (fig. 20-31) allows selection of any external stores or combination of external stores to be jettisoned. When the pilot lifts the guard and engages the selected switches, 28 VDC is applied through a resistor assembly firing the selected squibs.

ab. **Pilot's and CPG's Emergency Jettison Switches.** The **ST JTSN** switch (fig. 20-32) supplies 28 VDC to all jettison cartridges at the same time.

ac. **Ground Maintenance Switch.** The ground maintenance switch (fig. 20-33) allows maintenance personnel to cycle the pylons. Positions and functions are as follows.

- (1) **UP.** Positions all pylons to flight stow position.
- (2) **OFF.** Normal position; no effect.
- (3) **DOWN.** Positions all pylons to ground stow position.



M52-352

Figure 20-31. Pilot's Stores Jettison Panel

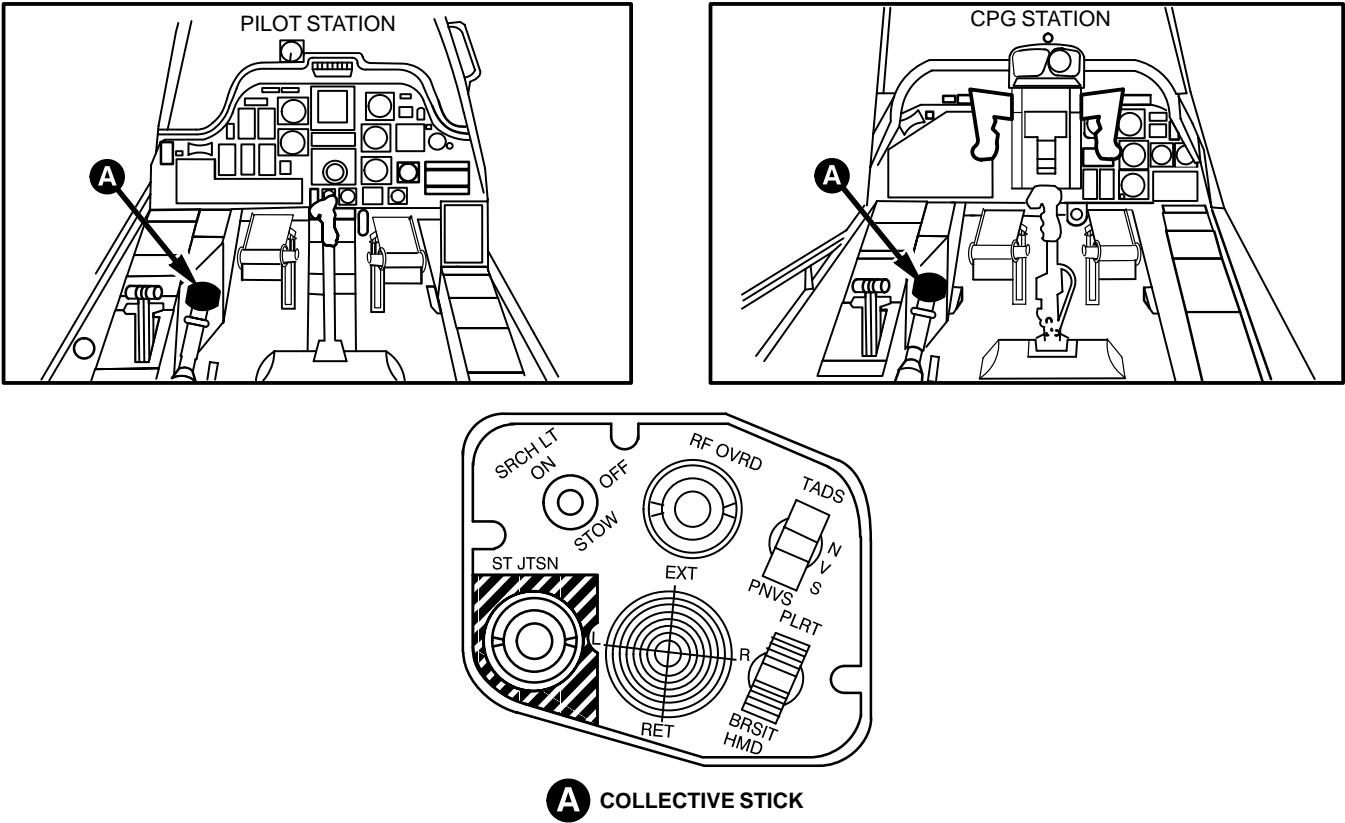
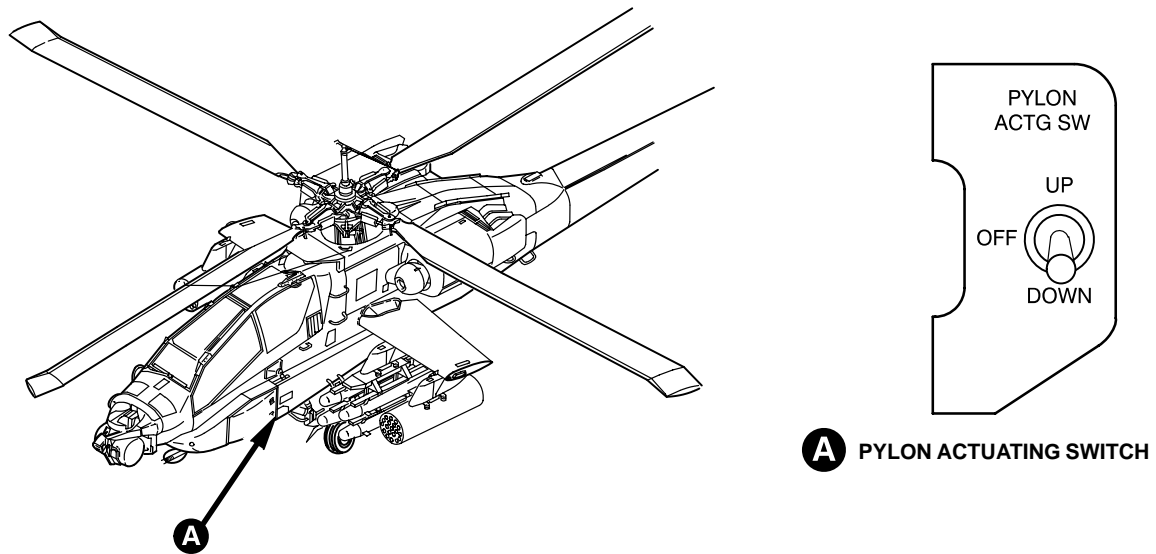


Figure 20-32. Emergency Jettison Switches



M52-354

Figure 20-33. Ground Maintenance Switch

CHAPTER 21 SIGHTING/DISPLAY SYSTEM

21-1. PURPOSE

The sighting and display systems provide the pilot and CPG with day and night visual target, navigation and replay capabilities.

a. **Target Acquisition Display Sight (TADS).** The TADS assembly provides day, night, and limited adverse weather target information, as well as night navigation capabilities. TADS provides the CPG with search, detection, recognition, and designation by means of direct view optics, television, and forward-looking infrared radar (FLIR) sighting systems that may be used singly or in combinations.

b. **Pilot Night Vision Sensor (PNVS).** PNVS provides thermal imaging that permits nap-of-the-earth (NOE) flight to, from, and within the battle area.

c. **Integrated Helmet and Display Sight System (IHADSS).** The integrated helmet and display sight system (IHADSS) establishes crew member line of sight for the following uses and displays.

- (1) Sensor pointing (TADS/PNVS).
- (2) Weapon aiming (gun and pylons).
- (3) Opposite crew member line of sight cueing.
- (4) Sensor video images (TADS/PNVS).
- (5) Flight, navigation, and weapons symbology.
- (6) The helmet provides for mounting of communications equipment and protection of crew member's head.

d. **Video Recorder.** The video recorder is a remote controlled airborne video cassette recorder which provides the pilot and CPG with the means of onboard playback of real time damage assessment and reconnaissance.

e. **Video Display Unit (VDU).** The VDU provides navigational and weapons display information from selected video sensors to the pilot.

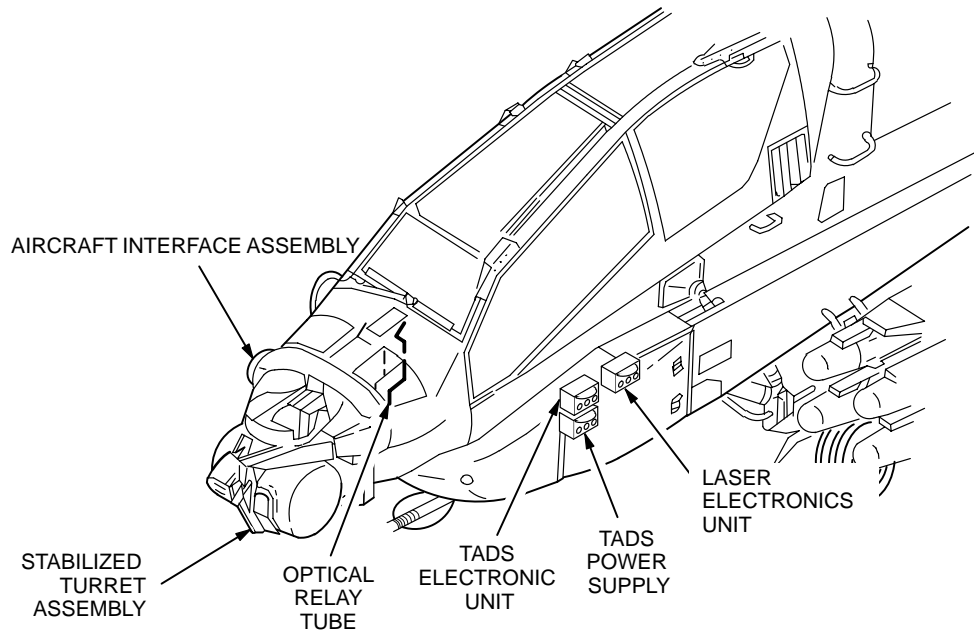
21-2. DESCRIPTION

a. The TADS has the following features and capabilities.

- (1) Allows sensor-to-sensor boresighting on the ground or in flight.
- (2) Contains automatic de-icing and temperature control.
- (3) Uses FLIR for night vision.
- (4) Provides four field-of-view options.
 - (a) Wide.
 - (b) Medium.

21-2. DESCRIPTION (cont)**21-2**

- (c) Narrow.
 - (d) Zoom.
 - (5) Displays video to pilot and CPG.
 - (6) Contains built-in test circuits.
 - (7) Can track targets automatically or manually using FLIR or day television (DTV). FLIR tracks laser-designated targets automatically.
 - (8) Direct view optics (DVO) allows the CPG to manually track targets visually.
 - (9) Laser allows the CPG to designate and range targets.
- b. The TADS assembly (fig. 21-1) includes the following components.
- (1) Aircraft interface assembly (AIA).
 - (2) Laser electronics unit (LEU).
 - (3) TADS power supply (TPS).
 - (4) TADS electronic unit (TEU).
 - (5) Optical relay tube (ORT).
 - (6) Stabilized turret assembly.



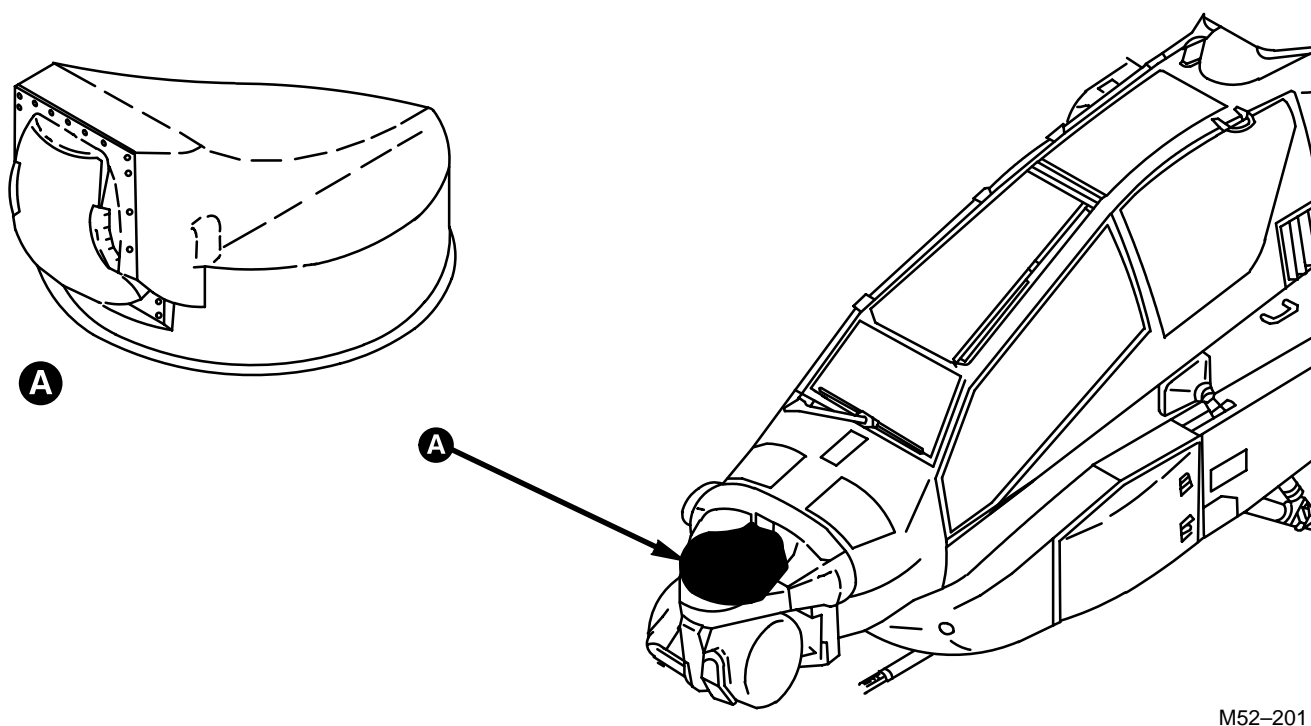
M52-188

Figure 21-1. TADS Major Components

- c. The PNVS has the following features and capabilities.
- (1) Operates independently of TADS.
 - (2) Contains anti-ice and de-ice circuits.

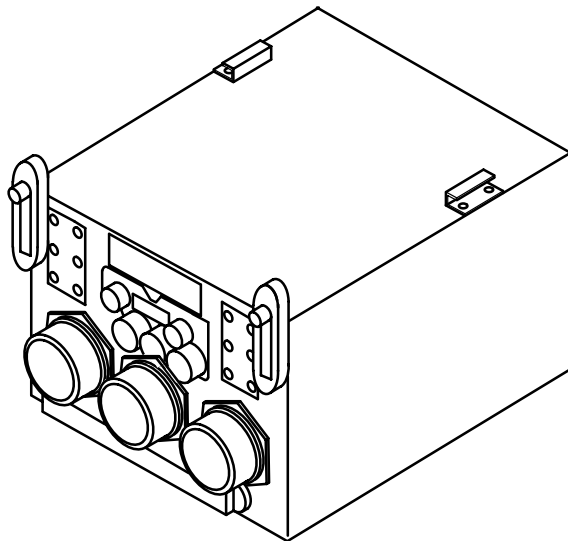
21-2. DESCRIPTION (cont)**21-2**

- (3) Contains a controlled environment.
 - (4) Contains built-in test circuits.
 - (5) Allows nap-of-the-earth navigation by the pilot.
 - (6) Allows night navigation.
- d. The PNVS assembly (fig. 21-2) includes the following components (fig. 21-3).
- (1) PNVS electronic unit (PEU).
 - (2) PNVS stabilized turret.
- e. The IHADSS has the following features and capabilities.
- (1) Uses line replaceable units.
 - (2) Continuously monitored by FD/LS.
 - (3) Pilot and CPG IHADSS operate independently.
 - (4) Crew members can view data while watching target.
 - (5) Allows rapid in-flight boresighting.
 - (6) Provides clarity of terrain image at night equal to day image clarity.

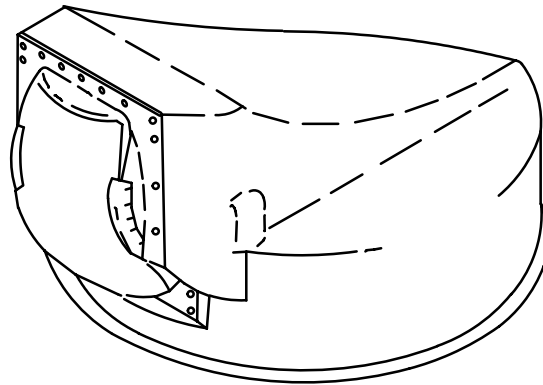


M52-201

Figure 21-2. PNVS Assembly



PNVS ELECTRONIC UNIT



PNVS STABILIZED TURRET

M52-202A

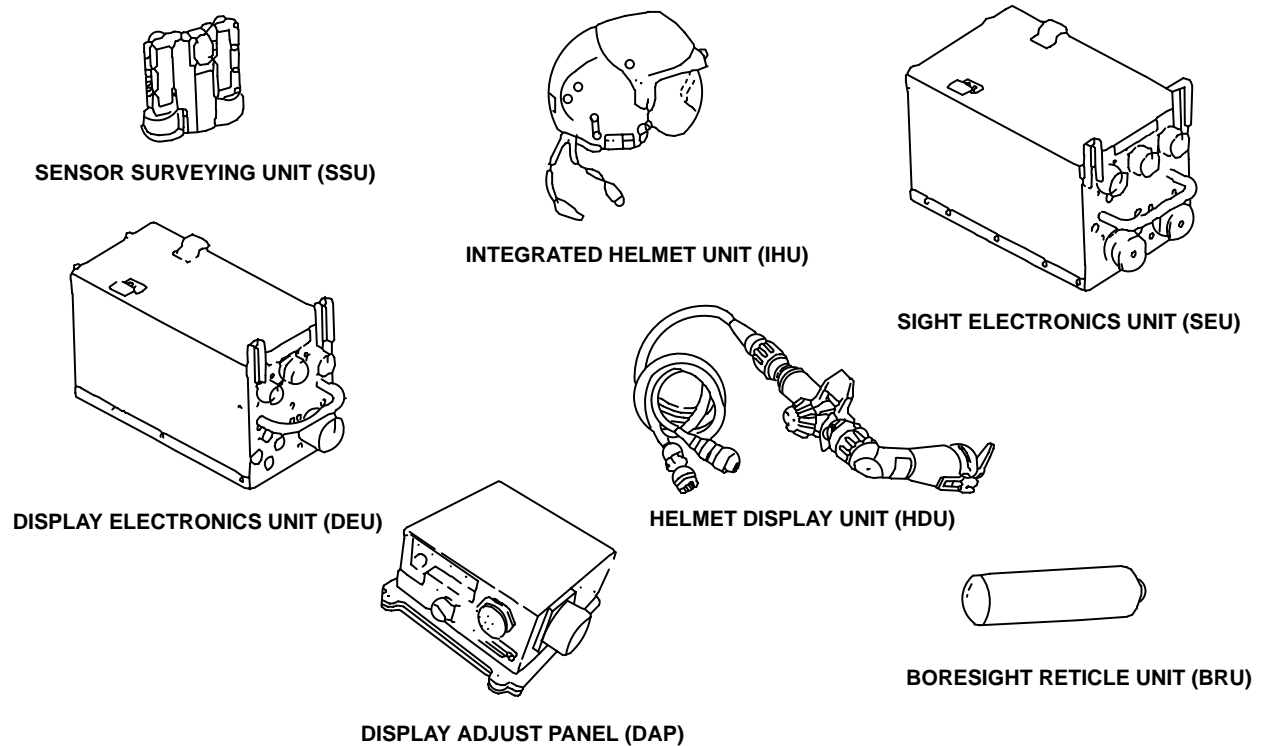
Figure 21-3. PNVS Major Components

f. The IHADSS includes the following major components (fig. 21-4).

- (1) Sensor surveying units (SSU).
- (2) Integrated helmet unit (IHU).
- (3) Sight electronics unit (SEU).
- (4) Boresight reticle unit (BRU).
- (5) Helmet display unit (HDU).
- (6) Display adjust panel (DAP).
- (7) Display electronics unit (DEU).

21-2. DESCRIPTION (cont)

21-2

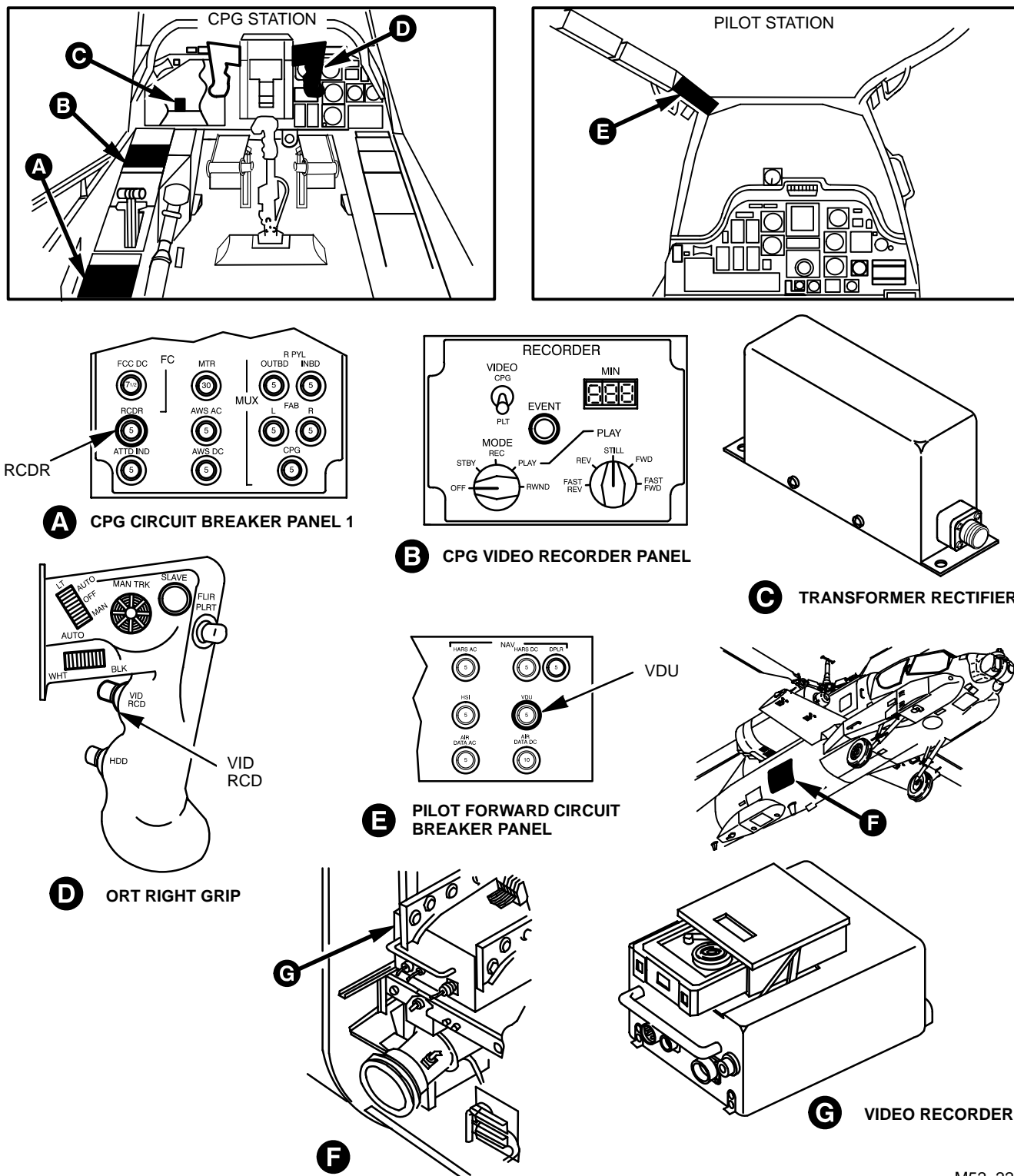


M52-218

Figure 21-4. IHADSS Major Components

g. The video recorder system includes the following major components (fig. 21-5).

- (1) Video display unit (**VDU**) circuit breaker.
- (2) Video recorder panel.
- (3) Video recorder.
- (4) Video recorder (**RCDR**) circuit breaker.
- (5) CPG ORT **VID RCD** switch.
- (6) Transformer rectifier.



M52-229

Figure 21-5. Video Recorder System Major Components

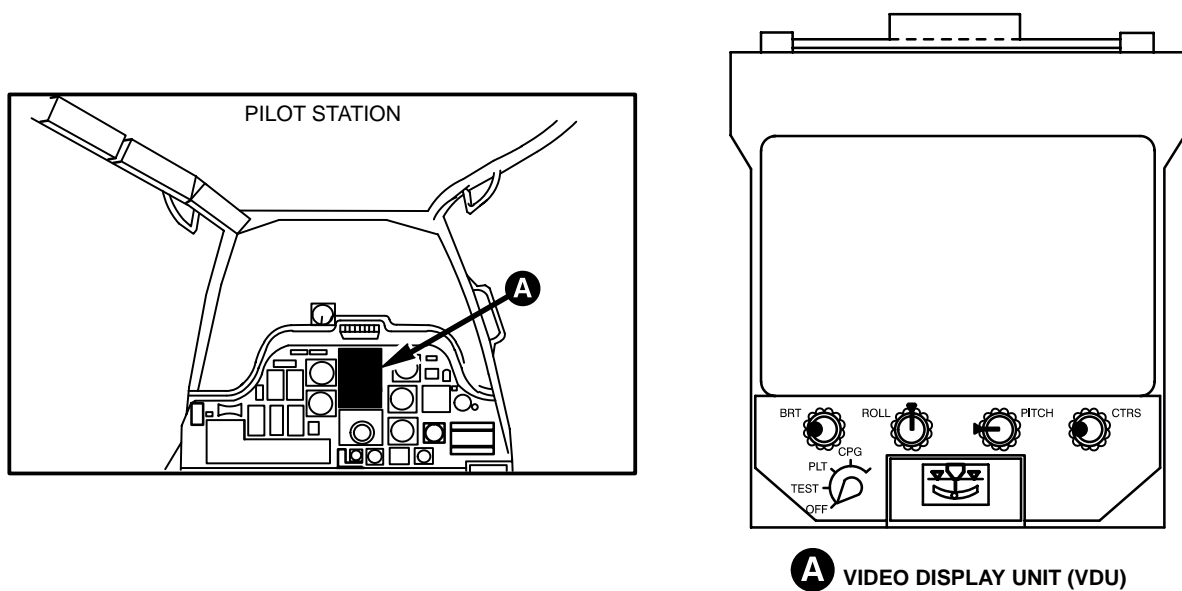
21-2. DESCRIPTION (cont)

21-2

h. The VDU includes the following major components.

(1) **VDU** circuit breaker. The **VDU** circuit breaker provides protection and 28 VDC for the VDU.

(2) **VDU**. The VDU (fig. 21-6) can display pilot PNVS or CPG TADS video independent of the integrated helmet display and sight system (IHADSS). This permits the pilot to have a simultaneous display of the PNVS video on the helmet mounted display (HMD) and CPG video on the VDU. In the event of pilot helmet display unit (HDU) failure, a limited night terrain flight capability is available by selecting pilot video on the VDU and placing the **PNVS** in the **NVS FXD** position. The VDU provides the following flight symbology (table 21-1 and fig. 21-7).



A VIDEO DISPLAY UNIT (VDU)

M52-453

Figure 21-6. VDU

Table 21-1. VIDEO DISPLAY UNIT SYMBOLOGY

Flight Symbology Displays (fig. 21-7)			
FIG. 21-7 INDEX NO.	SWITCH/ INDICATOR	POSITION	FUNCTION
1	LOS reticle		Represents line-of-sight of crew member selected sight. Reticle flashes when selected sight LOS is invalid or has failed. Reticle flashes when "ACTIONED" weapon is in a NO-GO state.
2	Alternate sensor bearing		Indicates other crew member's sensor relative bearing in reference to helicopter center line.
3	Lubber line		Indicates helicopter magnetic heading.

21-2. DESCRIPTION (cont)

21-2

Table 21-1. VIDEO DISPLAY UNIT SYMBOLOGY (cont)

Flight Symbology Displays (fig. 21-7) (cont)			
FIG. 21-7 INDEX NO.	SWITCH/ INDICATOR	POSITION	FUNCTION
4	Cueing dots		Indicates cued direction for target acquisition. Four dots present and flashing indicate IHADSS boresight is required.
5	Command heading		Indicates heading to fly to next navigation waypoint designated by Doppler navigation system if bob-up mode of flight symbology is not selected.
6	Acceleration cue		Displays vectors of helicopter longitudinal and lateral acceleration. Flashes when HARS inertial platform is in free inertial mode.
7	Velocity vector		Displays vectors of helicopter longitudinal and lateral ground velocities; in hover mode, maximum scale is 6 knots ground speed; in transition mode 60 knots ground speed. Flashes when HARS inertial platform is in free inertial mode.
8	Heading scale		Indicates helicopter magnetic heading scale.
9	Cued LOS reticle		Indicates cued LOS to appropriate crew member. Used with cueing dots.
10	Missile constraints		Indicates required orientation to align helicopter into constraints for Hellfire missile engagements.
11	Radar altitude		Displays digital radar altitude. Displays in 1-foot increments to 50 feet and in 10-foot increments above 50 feet.
12	Rate of climb		Displays analog rate of climb to left of vertical scale. Tick marks designate 500 and 1000 FPM rates of climb or descent.
13	Radar altitude vertical scale		Displays analog vertical scale of radar altitude. Tick marks designate 10-foot increments from 0 to 50 feet, and 50-foot increments from 50 to 200 feet. Scale is blanked when radar altitude is greater than 200 feet.
14	Radar altitude vertical tape		Displays analog radar altitude moving within the vertical scale. Scale is blanked above 200 feet.
15	Skid/Slip lubber line		Displays limits for 'ball centered' flight.
16	Skid/Slip ball		Indicates amount of skid or slip helicopter is experiencing.

21-2. DESCRIPTION (cont)

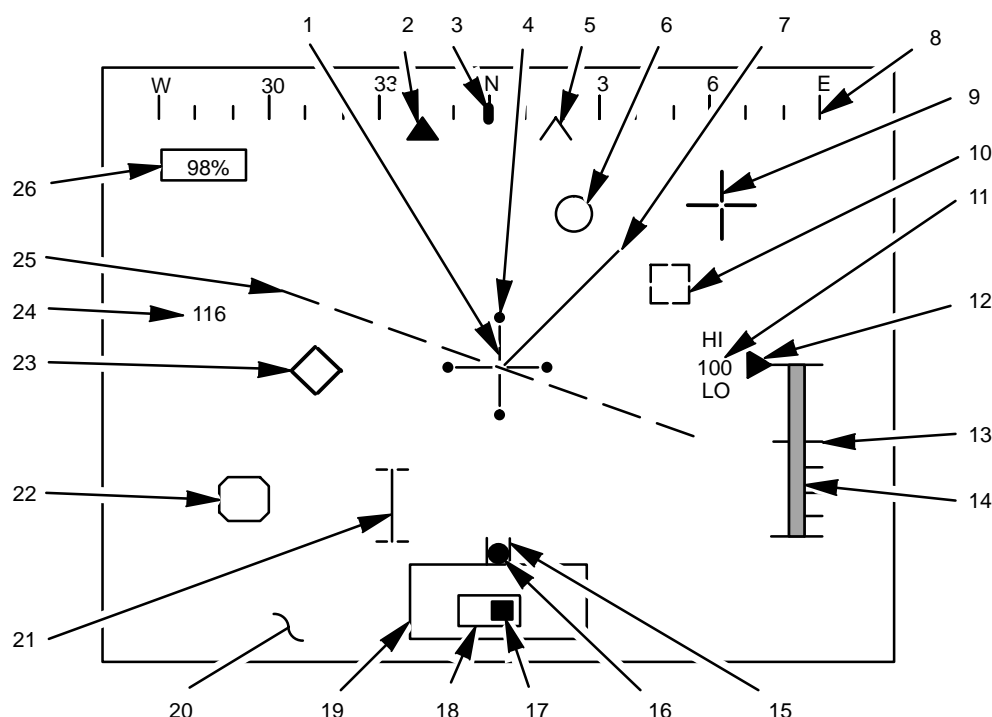
21-2

Table 21-1. VIDEO DISPLAY UNIT SYMBOLOGY (cont)

Flight Symbology Displays (fig. 21-7) (cont)			
FIG. 21-7 INDEX NO.	SWITCH/ INDICATOR	POSITION	FUNCTION
17	Cued LOS dot		Indicates cued LOS location within field of regard. Flashes when HARS inertial platform is in free inertial mode.
18	Field of view		Represents instantaneous FOV of crew member sensor within field of regard.
19	Sensor field of regard		Represents total gimbal limits possible for respective crew member sensor.
20	High action display		Displays sight status, range and range source, weapon status, and opposite crew station weapon control used to operate mission equipment.
21	Rocket steering cursor		Indicates required orientation to align helicopter into constraints for 2.75 inch FFAR rocket engagements. Broken 'I' beam appears during fixed or flight stow rocket delivery.
22	Hover position box		Displays helicopter relative position when bob-up mode is selected. Box size represents an 8 foot square, maximum displacement is 48 feet laterally or longitudinally.
23	Head tracker		Indicates pilot head position relative to helicopter center line. Range of display is 30 degrees vertically and 40 degrees horizontally relative to the nose of the helicopter.
24	Airspeed		Displays digital true airspeed when ADSS is on and not failed. If off or failed, ground speed knots is displayed from Doppler navigation system. Range is 0 to 200 knots, omnidirectional.
25	Horizon line		Indicates pitch and roll attitude of helicopter.
26	Engine torque		Indicates engine torque (magnitude is the larger of the two engine torque values). Display torque value flashes if 12 % torque split occurs between engines. At 98 % or higher a box flashes to indicate an impending engine torque limit. Symbolic torque value maximum is 120 %.

21-2. DESCRIPTION (cont)

21-2



M52-454

Figure 21-7. VDU Symbolism Displays

21-3. THEORY OF OPERATION

a. **Aircraft Interface Assembly.** The aircraft interface assembly (fig. 21-8) provides for mounting the TADS/PNVS assemblies to the aircraft. The interface also provides for environmental control of the equipment. The assembly includes the following components.

(1) The environmental control assembly (fig. 21-9) operates the turret blower and PNVS fan whenever TADS power is applied. The environmental control assembly blows conditioned air directly from the aircraft environmental control system into the aft part of the interface assembly.

(a) The turret blower pushes the conditioned air into the forward part of the interface assembly. The PNVS fan circulates part of this air through the PNVS.

(b) The conditioned air is then circulated through the stabilized turret, day sensor, and night sensor. From there, the conditioned air exits through the lower support arm, and is routed to the servo electronics and torquer amplifier.

(c) The conditioned air is routed throughout the servo electronics and torquer amplifier. The air is then dumped overboard.

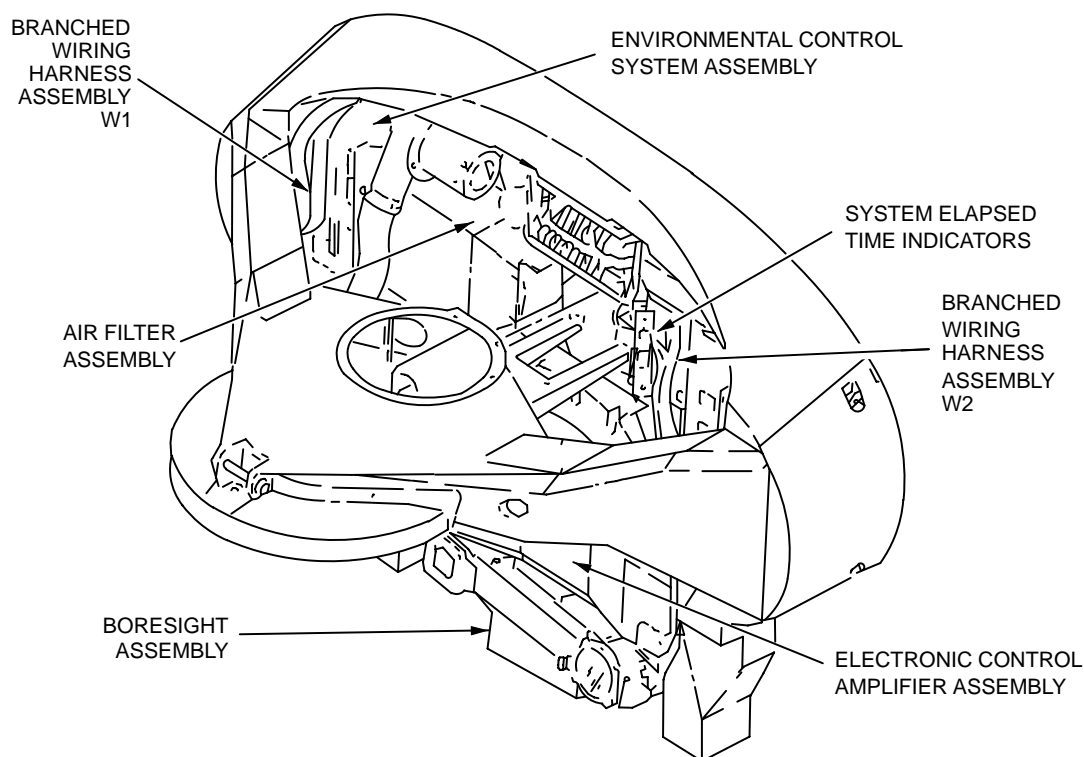
(2) The elapsed time indicator tracks system operating time to establish component warranty and time change items.

(3) Branched wiring assembly W2 carries power and electronic signals to and from the TADS/PNVS assemblies.

21-3. THEORY OF OPERATION (cont)**21-3**

(4) The electronic control amplifier assembly controls the azimuth and elevation drive motors and the yaw and pitch torquers.

(5) The boresight module (fig. 21-10) input lens receives the output from the laser. The assembly attenuates the signal, and detects the exact center of the laser. The boresight assembly projects the signal, through prisms and optics, to an output lens. The output enters the TADS night sensor to be used for sensor-to-sensor boresighting.



M52-189

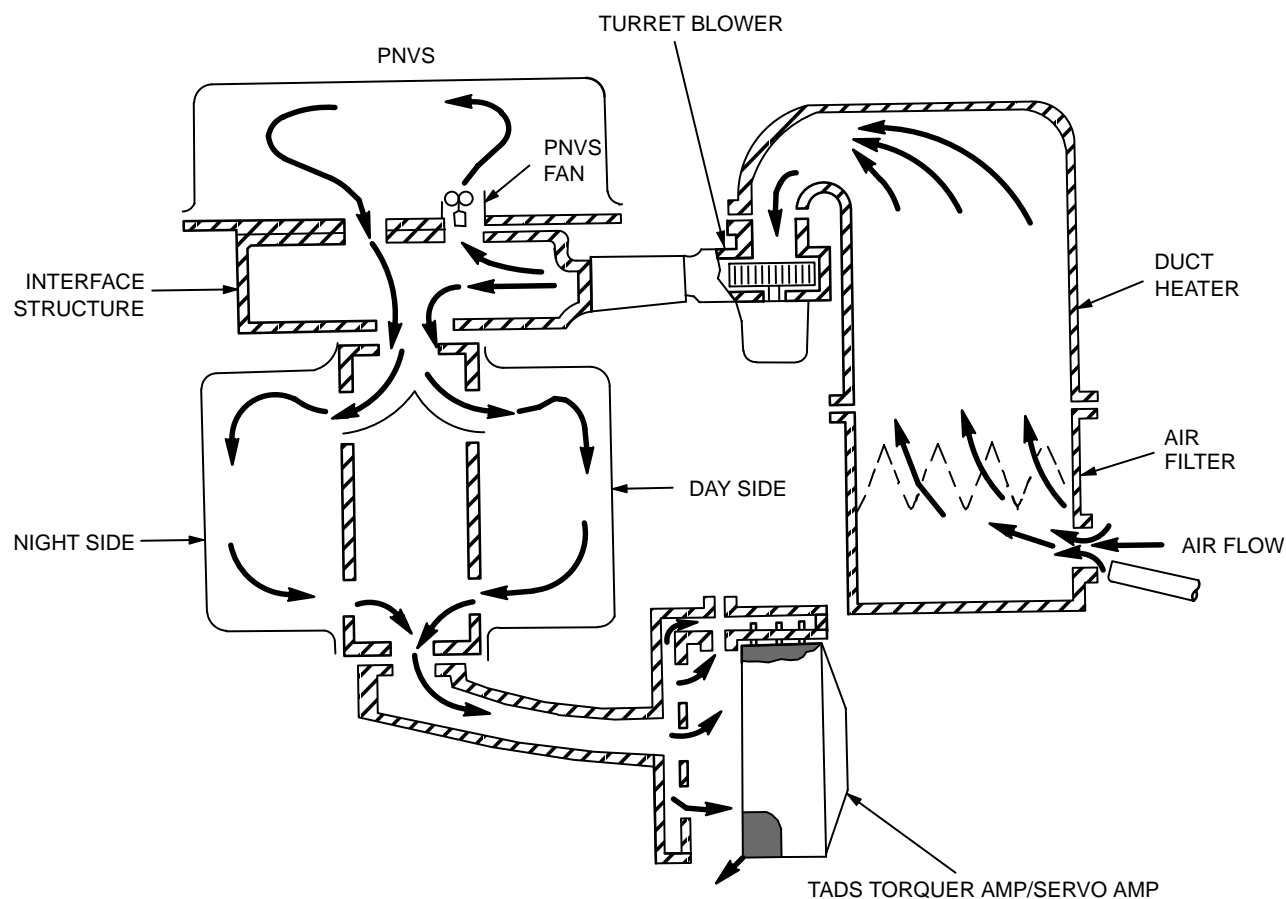
Figure 21-8. Aircraft Interface Assembly

(6) The air filter assembly cleans intake air from the cabin, for use in environmental control of turret-mounted assemblies.

(7) Branched wiring assembly W1 carries power and electronic signals to and from the TADS/PNVS assemblies.

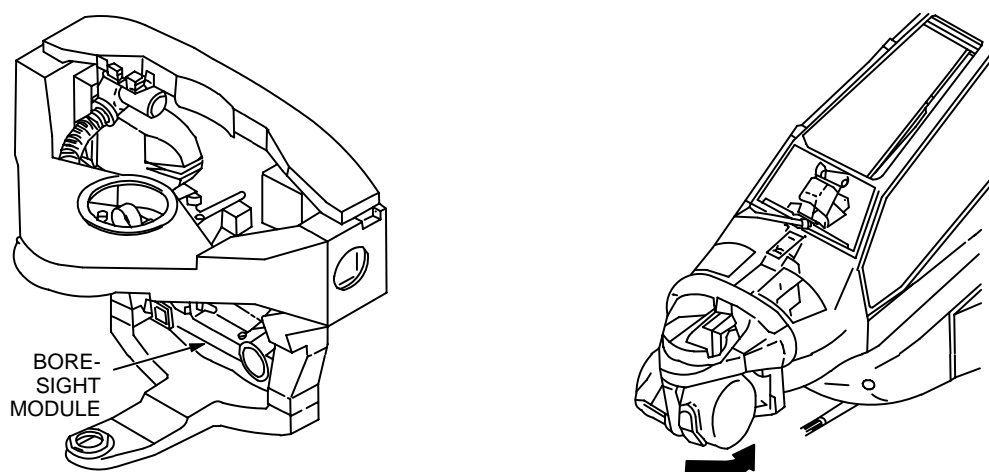
21-3. THEORY OF OPERATION (cont)

21-3



M52-190

Figure 21-9. Environmental Control Assembly



M52-191

Figure 21-10. Boresight Module

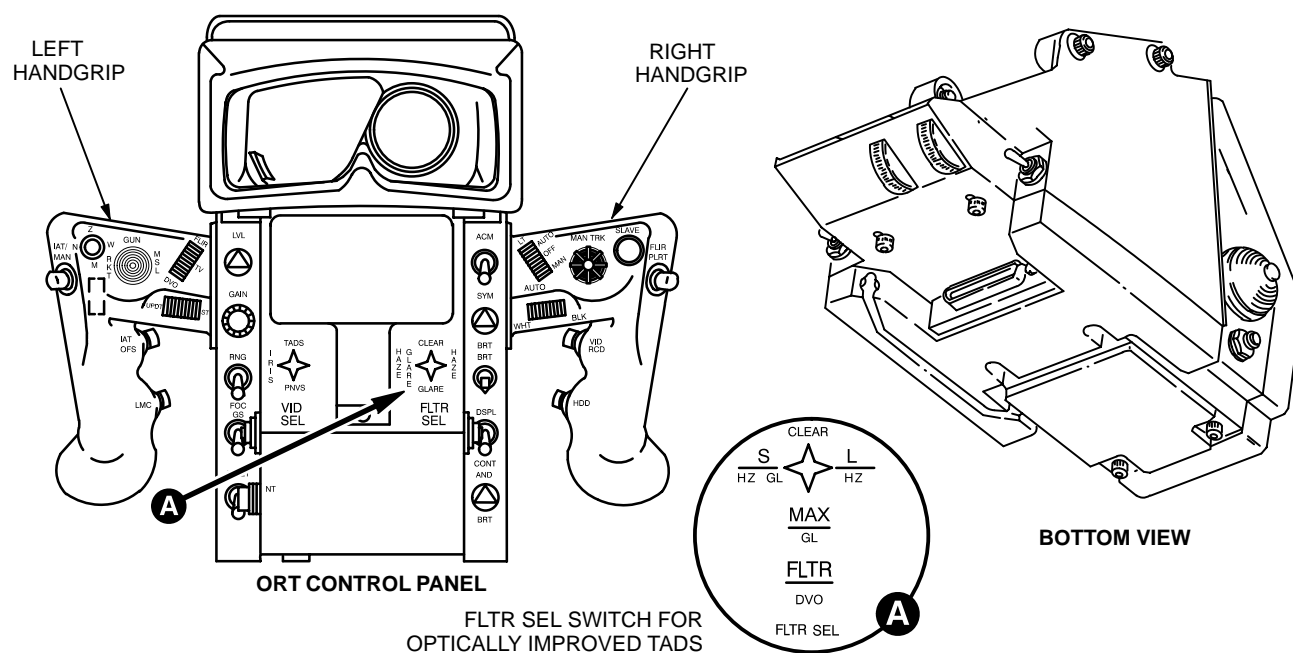
b. **LEU**. The LEU contains circuitry for laser tracking, laser ranging, and laser designation (coded information).

21-3. THEORY OF OPERATION (cont)

21-3

- c. **TPS.** The TPS provides power for the TADS assembly.
- d. **TEU.** The TEU provides an interface for signals sent between the TADS assembly and the helicopter.
- e. **ORT.** The ORT (fig. 21-11) provides the CPG with a visual display of the selected sensor. The ORT contains controls for fire control and sensors. The ORT contains the following components and operates as follows.

- (1) The left and right hand grip assemblies contain viewing, tracking, field-of-view switching, priority change, and laser functional switches.
- (2) ORT column assembly contains DVO and mounting for the ORT components.
- (3) Indirect view display/electronics assembly contains CRT and control electronics.
- (4) Alpha numeric display (AND) assembly displays status of weapon, sighting, and laser system.
- (5) Control panel assembly contains CRT and controls for TADS/PNVS operation.



M52-192A

Figure 21-11. ORT

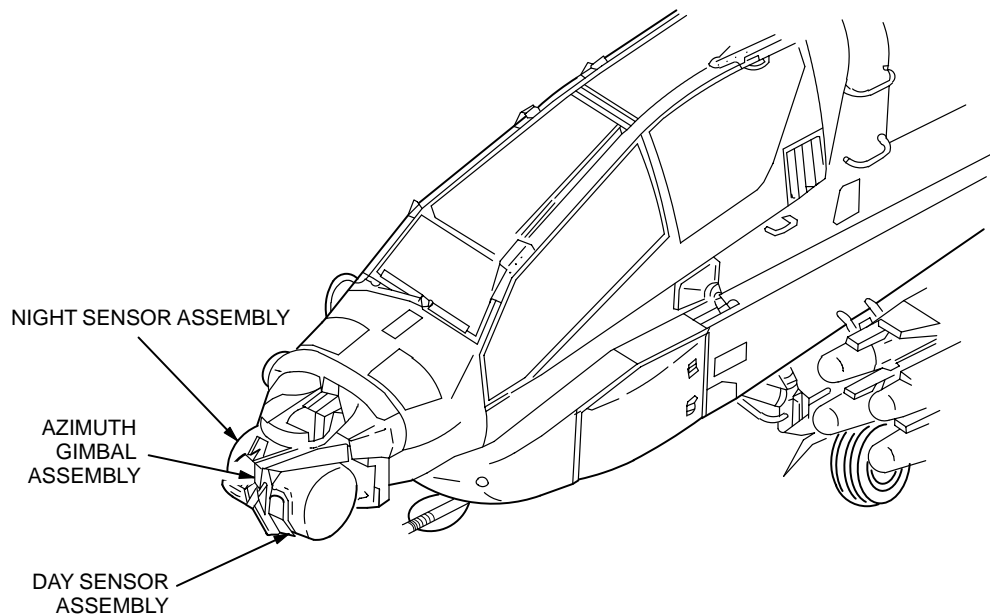
- (6) The ORT contains two types of viewing.
 - (a) When DVO is selected, the real world image from the day side sensor enters the forward portion of the ORT. The image bypasses a trip mirror and is routed by mirrors and prisms to the eyepiece.
 - (b) Indirect viewing is performed in either head down display or head out display mode.
 - In head down mode, a TV in the indirect view/electronics assembly displays the video image as detected by the TADS day side sensor DTV, night side sensor FLIR, or PNVIS. The image is projected onto the trip mirror and follows the same optical path as DVO.
 - In head out mode, a TV in the center of the control panel displays the video image as detected by the TADS DTV, night side sensor FLIR, or PNVIS.

21-3. THEORY OF OPERATION (cont)

21-3

f. **TADS Stabilized Turret Assembly.** The TADS stabilized turret assembly (fig. 21-12) provides azimuth and elevation movement. The turret assembly also provides for mounting of the sensors. Components of the assembly are as follows.

- (1) The night sensor assembly provides night viewing capabilities.
- (2) The day sensor assembly provides the CPG with a direct magnified view of the target. The day sensor provides a means to observe and track targets using TV or laser.
- (3) The azimuth gimbal assembly provides azimuth and elevation movement for the sensors, and provides stabilization for the sensors.



M52-193

Figure 21-12. TADS Stabilized Turret Assembly

g. **TADS/PNVS Switches and Controls.** The following switches and controls affect TADS/PNVS operation.

NOTE

TADS and PNVS controls are listed together because they are common in many areas.

- (1) **CPG Fire Control Panel (FCP)** (fig. 21-13).
 - (a) **SYSTEM TADS.** Controls power to TADS. Positions are as follows.
 - **OFF.** Disables TADS power.
 - **FLIR OFF.** Provides power to TADS but does not cool FLIR.
 - **TADS.** Provides power to all TADS sensor assemblies.
 - (b) **SIGHT SEL.** Permits the CPG to select a sight. Positions are as follows.
 - **STBY.** Deselects all LOS; stows sensors.
 - **HMD TADS.** Selects HMD as the reference LOS; permits TADS slaving to the HMD LOS.

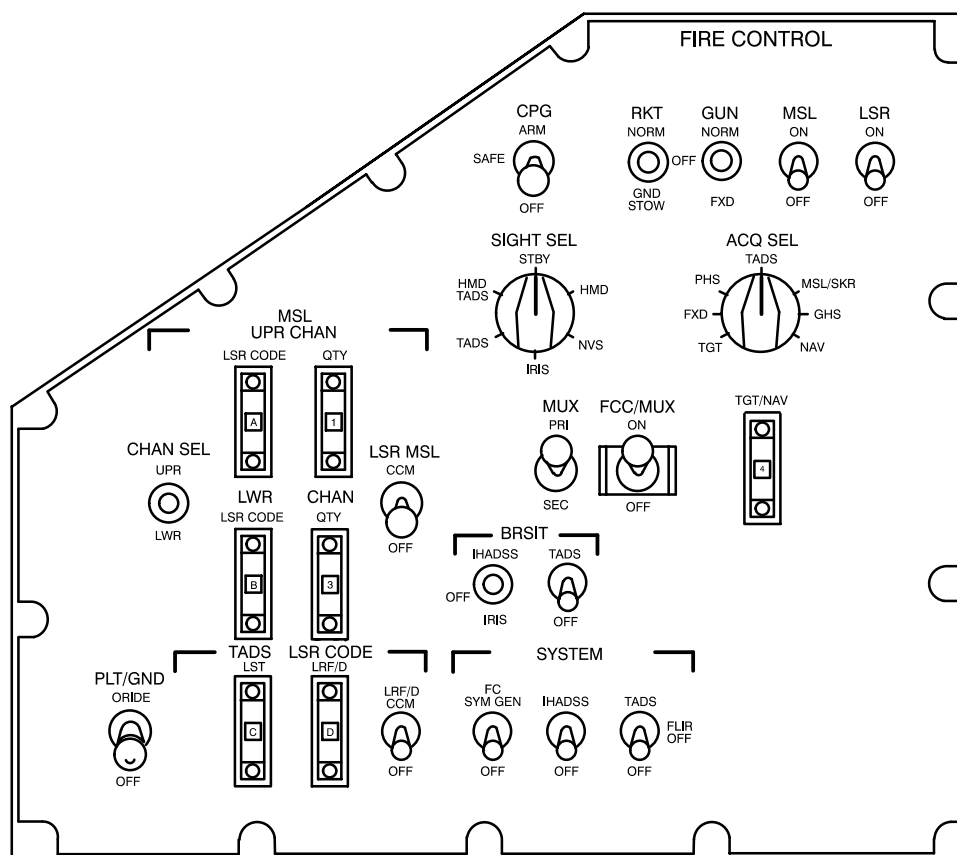
21-3. THEORY OF OPERATION (cont)

21-3

- **TADS.** Selects TADS as the reference LOS.
- **IRIS.** Selects IRIS missile as the reference LOS (not active).
- **NVS.** Activates the NVS select switch on the CPG collective switchbox.
- **HMD.** Selects the HMD as the reference LOS. TADS may be slaved to the helmet; however, the imagery is not displayed.

(c) **ACQ SEL** enables cueing or slaving to selected LOS when ORT slave button is activated. Only TADS may be slaved to a selected acquisition LOS; all others receive cueing.

- **FXD.** Defines the fixed forward position.
- **TGT.** Defines the waypoint/targeting routine as the acquisition source.
- **NAV.** Same as TGT position.
- **GHS.** CPG helmet LOS is defined as the acquisition source.
- **MSL/SKR.** The HELLFIRE missile seeker angles define the acquisition LOS.
- **TADS.** The TADS LOS is defined as the acquisition LOS (inactive if TADS sight is selected).
- **PHS.** The pilot helmet LOS is defined as the acquisition LOS.



M52-194

Figure 21-13. CPG FCP

21-3. THEORY OF OPERATION (cont)

21-3

(2) **ORT Control Panel** (fig. 21-14).

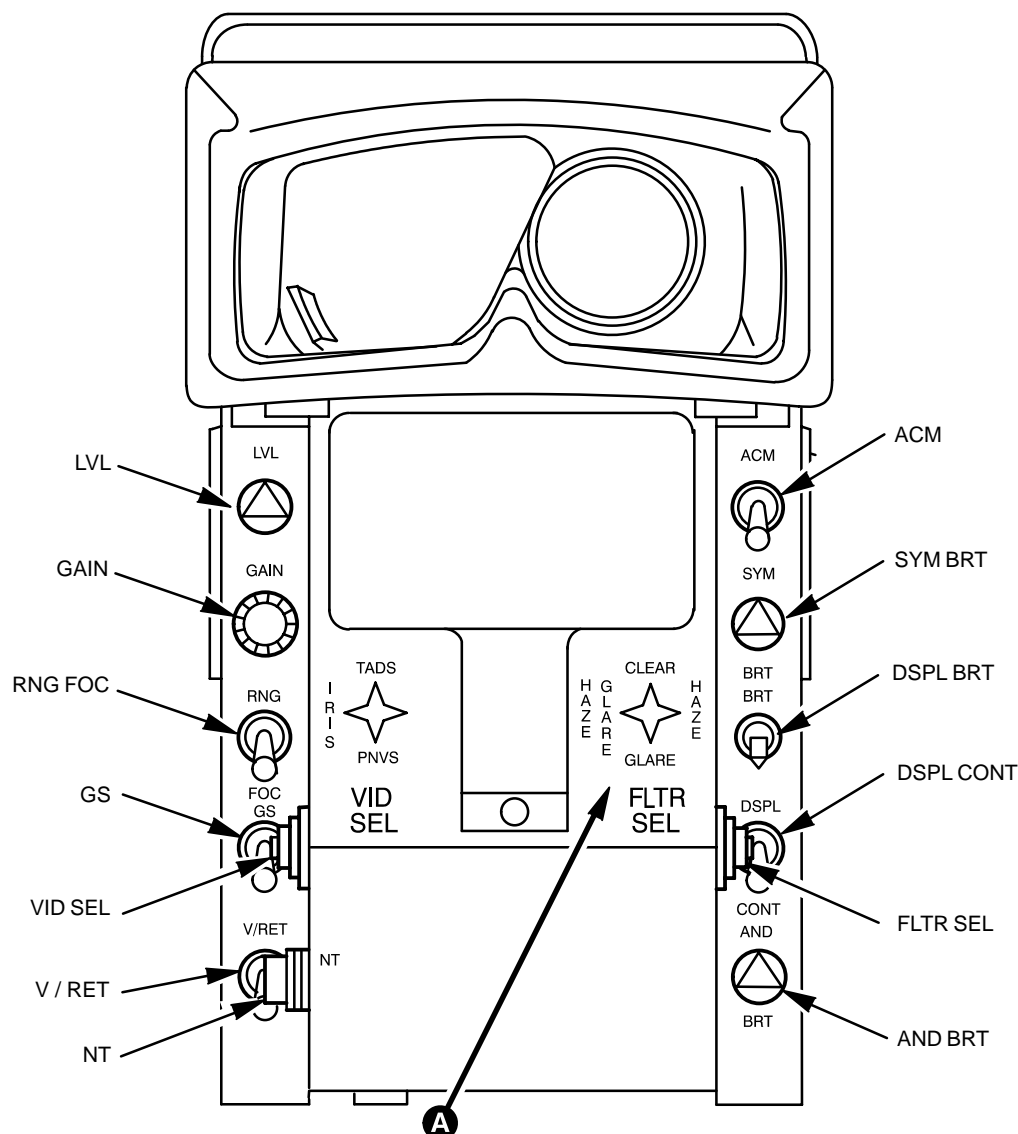
- (a) **LVL.** Adjusts FLIR level.
- (b) **GAIN.** Adjusts FLIR gain.
- (c) **RNG FOC.** Adjusts the narrow FOV on DTV or FLIR.
- (d) **GS.** Displays a 10-shade gray scale used to calibrate brightness and contrast.
- (e) **VID SEL.** Selects the video source for CPG display. Positions are as follows.
 - **TADS.** Displays video from the CPG-selected sight.
 - **PNVS.** Displays video from PNVS.
 - **IRIS.** Displays video from the IRIS missile (not currently available). Currently modes the ORT display for 525-line video format.
- (f) **VRET.** Visor retract is currently not used.
- (g) **NT.** Activates the heads down display red night filter.
- (h) **ACM.** Automatically maintains optimum gain and level settings as a result of varying thermal scene content or when switching FLIR polarities.
- (i) **SYM BRT.** Adjusts symbology brightness. Range is bright white through black.
- (j) **DSPL BRT.** Adjusts the display brightness for heads out, heads down or IHADSS. When **IHADSS** is selected on the **SIGHT SEL** switch, this control adjusts HDU brightness.
- (k) **DSPL CONT.** Adjusts the selected display contrast. When **IHADSS** is selected on the **SIGHT SEL** switch, this control adjusts HDU contrast.
- (l) **FLTR SEL.** Selects various DVO filters to compensate for atmospheric conditions. In the optically improved TADS, filter selection can also be made when the sensor select is **FLIR**. The FLIR filters provide laser threat protection. Selections are as follows.
 - Sensor select is **DVO** and **FLTR SEL** switch is **CLEAR/CLEAR**. Selects a clear filter for DVO.
 - Sensor select is **DVO** and **FLTR SEL** switch is **HAZE GLARE/HZ-GZ**. Selects a haze glare filter for DVO.
 - Sensor select is **DVO** and **FLTR SEL** switch is **HAZE/HZ**. Selects a haze filter for DVO.
 - Sensor select is **DVO** and **FLTR SEL** switch is **GLARE/GZ**. Selects a glare filter for DVO.
 - Sensor select is **FLIR** and **FLTR SEL** switch is **CLEAR**. Selects a clear filter for FLIR.
 - Sensor select is **FLIR** and **FLTR SEL** switch is **S**. Selects a laser protection filter for FLIR against short wavelength laser.
 - Sensor select is **FLIR** and **FLTR SEL** switch is **L**. Selects a laser protection filter for FLIR against long wavelength laser.

21-3. THEORY OF OPERATION (cont)

21-3

- Sensor select is **FLIR** and **FLTR SEL** switch is **MAX**. Selects maximum (short and long wavelength) laser protection filter for FLIR.

(m) **AND BRT**. Adjusts AND brightness.



FLTR SEL SWITCH FOR
OPTICALLY IMPROVED
TADS

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Figure 21-14. ORT Control Panel

(3) ORT Panel (Bottom Side) (fig. 21-15).

(a) **BRISIT ENABLE**. Brings FLIR/TV/DVO into coincidence with the laser spot during internal boresighting. Positions are as follows.

- Up. Used to align FLIR and TV.
- Center. Off.
- Down. Used to align DVO.

21-3. THEORY OF OPERATION (cont)

21-3

(b) **DVO BRSIT ADJUST.** Used with **BRSIT ENABLE** switch down position to adjust DVO into coincidence. Positions are as follows.

- Up. Starts DVO reticle scan.
- Center. Off.
- Down. Starts DVO reticle scan in the reverse (clockwise) direction of up position.

(c) **AZ ADJUST, EL ADJUST.** Used during outfront boresighting to bring the FLIR reticle into coincidence with the TV reticle.

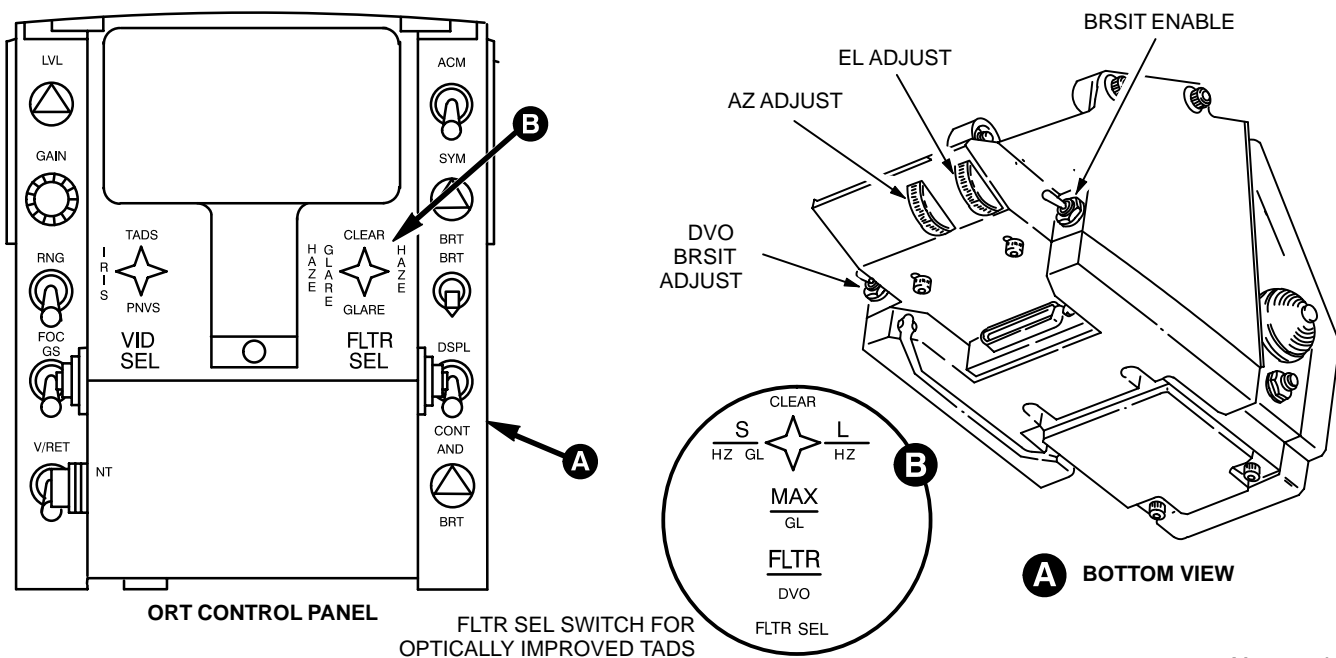


Figure 21-15. ORT Control Panel

(4) Left Hand Grip (fig. 21-16).

(a) **IAT/MAN.** Engages or disengages the image autotracker. On disengagement, the TADS is placed in manual track.

(b) **Field of View Select.** Selects the desired view. Positions are W (wide), M (medium), N (narrow), Z (zoom) and Neutral.

(c) **RKT/GUN/MSL Weapon Action Switch (WAS).** Actions the selected armament. Also deselects the weapon by selecting the same weapon again, or by selecting another weapon.

(d) **Sensor Select.** Selects the desired sensor for TADS. Positions are **DVO**, **DTV**, and **FLIR**.

(e) **UPDT/ST.** Signals the FCC to either store target or position information, or update position data used in waypoint/targeting. Used with the DEK to update or store new (correction) data into FCC.

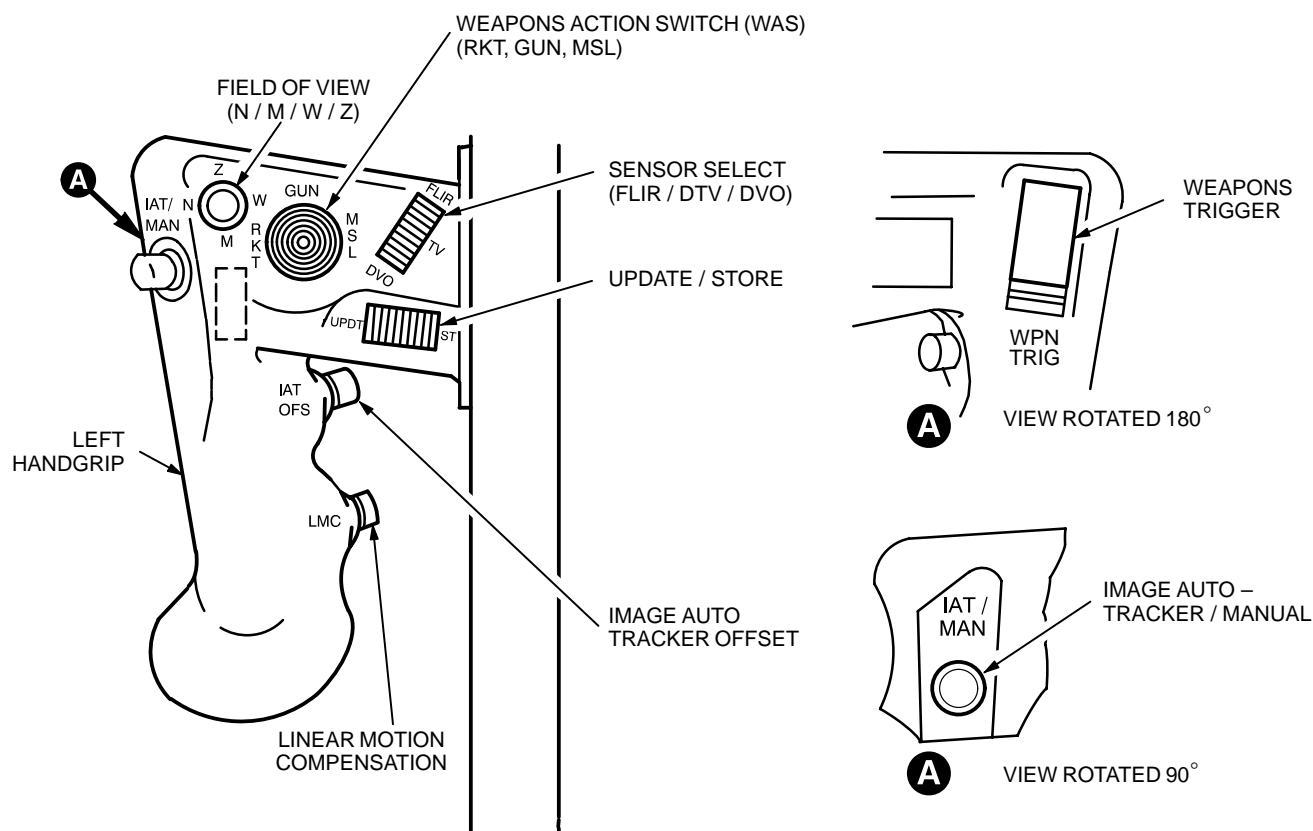
(f) **IAT OFS.** Engages the IAT offset track mode to enable the CPG to track multiple targets, or fire the laser spot indirectly at a target to avoid detection until missile launch.

(g) **LMC.** Turns on linear motion compensation and rate integrator tracking aids used with IAT to assist during limited visibility.

21-3. THEORY OF OPERATION (cont)

21-3

(h) Weapons Trigger. Enables the selected weapons firing. The first detent is for normal firing; the second detent overrides performance inhibits, but not safety inhibits at the selected weapon.



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Figure 21-16. ORT Left Hand Grip

(5) Right Hand Grip (fig. 21-17).

(a) **LT.** Selects the mode of search for a laser spot. Positions are as follows.

- **AUTO.** Arms the laser spot tracker; places the TADS turret into a scan for a designated laser spot.
- **OFF.** Disarms the laser spot tracker.
- **MAN.** Arms the laser spot tracker; leaves the turret in manual track mode.

(b) **IAT Polarity.** Selects the contrast for the IAT. Positions are as follows.

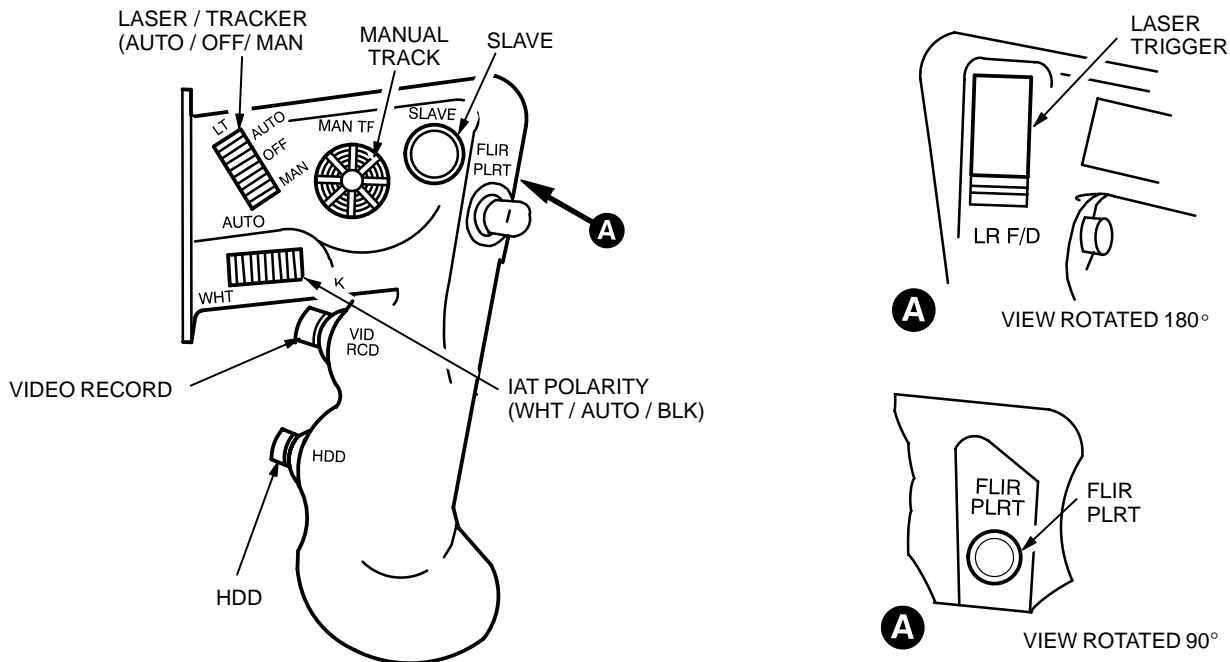
- **WHT.** Selects white on black contrast polarity.
- **AUTO.** Permits the tracker to automatically select the contrast polarity.
- **BLK.** Selects black on white.

(c) **MAN TRK.** Controls slewing the turret in manual track mode.

21-3. THEORY OF OPERATION (cont)

21-3

- (d) **SLAVE.** Activates the slave latch to slave or cue the selected sight to an acquisition LOS.
- (e) **FLIR PLRT.** Allows switching of the FLIR polarities, black or white hot.
- (f) **VID RCD.** Starts or stops the video recorder when the recorder in REC or PLAY mode.
- (g) **HDD.** Directs video to either heads out or heads down display.
- (h) **LRF/D trigger.** First detent fires a three pulse ranging burst. Second detent is used for continuous ranging or laser designation. An asterisk is displayed to the left of the four digit range during second detent use (ACZ). The asterisk flashes for multiple laser returns.



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Figure 21-17. ORT Right Hand Grip

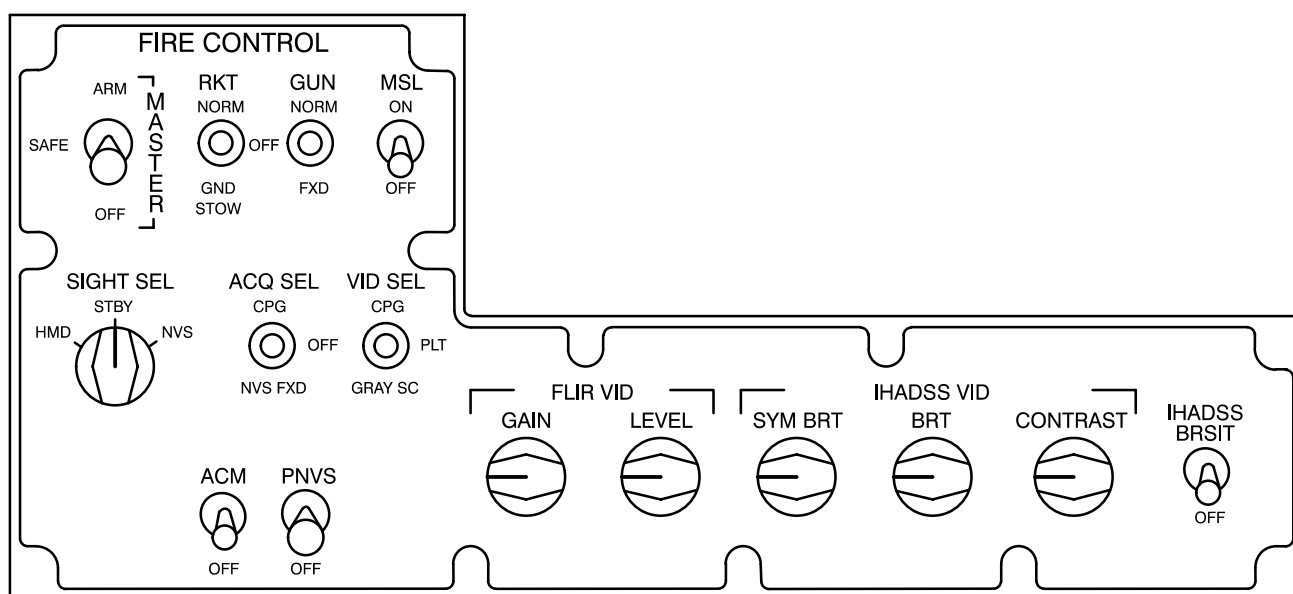
(6) Pilot FCP (fig. 21-18).

- (a) **SIGHT SEL.** Selects the sight/sensor to be used as the reference LOS. Positions are as follows.
 - **STBY.** Deselects all LOS; stows PNVs turret.
 - **HMD.** Selects the HMD as the pilot reference LOS.
 - **NVS.** Activates the **NVS** select switch on the collective switchbox. The HDU displays the selected night vision sensor (FLIR) video with flight symbology. This position slaves the PNVs or TADS (wide FOV) FLIR to the pilot HDU.
- (b) **ACQ SEL.** Controls display of cueing symbology; places night sensor to fixed forward position. Positions are as follows.
 - **CPG.** Pilot receives cueing symbology to the CPG-selected sight LOS.
 - **OFF.** No cueing symbology displayed to the pilot.

21-3. THEORY OF OPERATION (cont)

21-3

- **NVS FXD.** The pilot-selected sensor is slaved to the fixed forward position.
- (c) **VID SEL.** Selects video to be displayed on pilot's HDU. Positions are as follows.
 - **CPG.** Displays CPG-selected video.
 - **PLT.** Displays pilot video.
 - **GRAY SC.** Displays a 10-shade gray scale used to calibrate HMD brightness and contrast.
- (d) **ACM** (auto control module). Maintains optimum gain and level settings of the selected night vision sensor during varying thermal scene content or when switching FLIR polarity.
- (e) **PNVS.** Provides power to PNVS. Positions are as follows.
 - **OFF.** Disables all power to PNVS.
 - **PNVS.** Enables power to PNVS; begins cool-down of FLIR.
- (f) **FLIR VID GAIN, LEVEL.** Adjust the video presentation of FLIR by varying the gain and level.



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Figure 21-18. Pilot FCP

(7) Collective Stick Switchbox (fig. 21-19). NVS selects TADS FLIR or PNVS (**SIGHT SEL** switch must be set to **NVS**).

h. **Anti-Ice.** See chapter 22, Utility Systems.

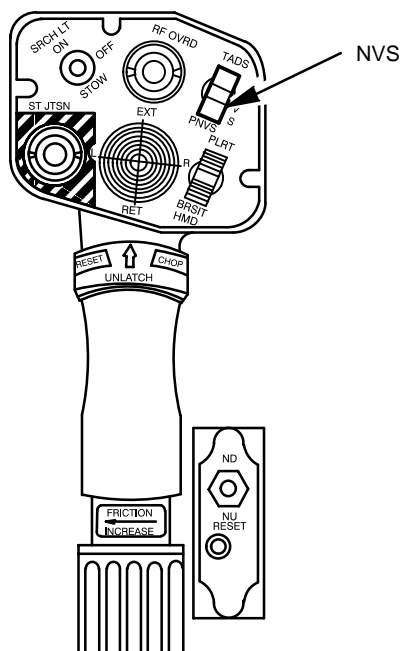
i. **PEU.** The PEU provides PNVS electronic control.

j. **PNVS Stabilized Turret.** The PNVS stabilized turret provides mounting to the interface structure assembly, and provides azimuth/elevation movement independent of TADS. The stabilized turret includes the following components (fig. 21-20).

- (1) PNVS shroud provides environmental protection for PNVS equipment.
- (2) Azimuth gimbal assembly controls azimuth movement.
- (3) Elevation mirror assembly reflects infrared energy into the optics.

21-3. THEORY OF OPERATION (cont)**21-3**

- (4) Power supply provides operating voltages for FLIR electronic modules.
- (5) FLIR electronic modules converts infrared into video.

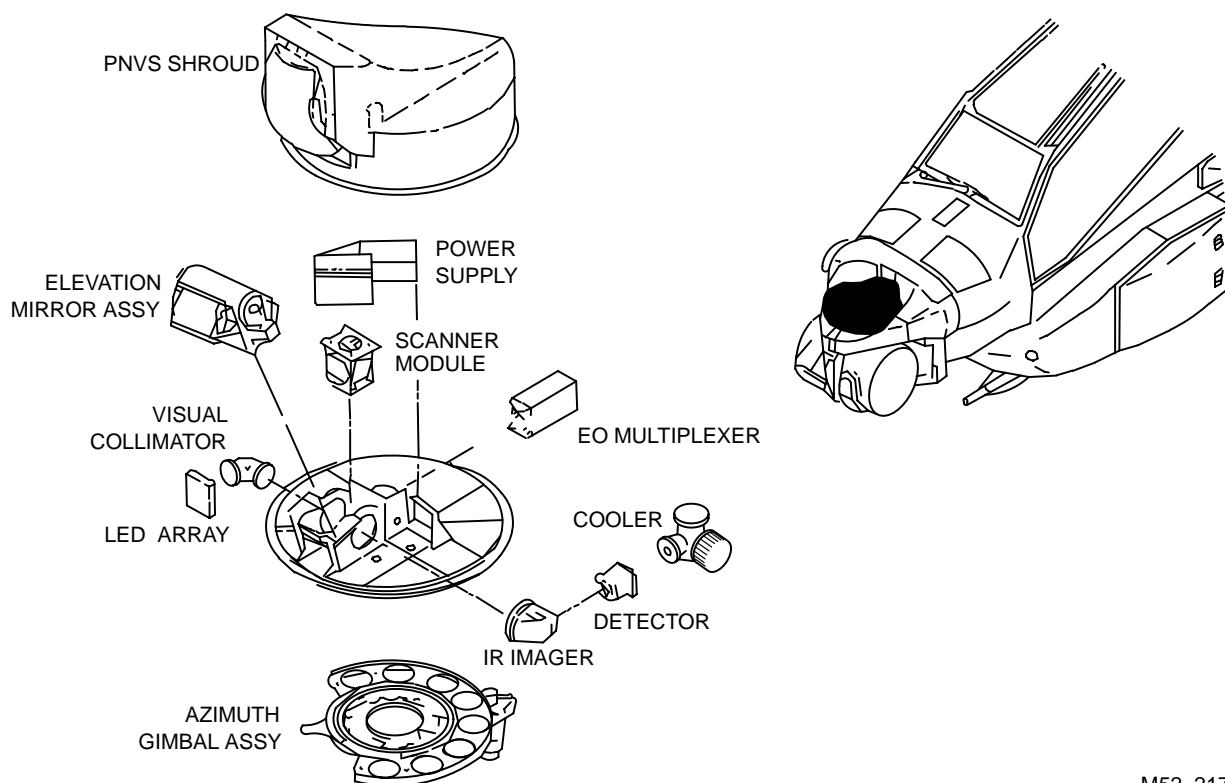


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Figure 21-19. Collective Stick Switchbox

21-3. THEORY OF OPERATION (cont)

21-3



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Figure 21-20. PNVS Stabilized Turret

k. **PNVS Switches and Controls.** TADS and PNVS controls are listed together because they are common in many areas. See paragraph 21-3 g.

l. **Anti-Ice.** See chapter 22, Utility Systems.

m. **SSU.** The SSU generates a pair of infrared light beams (fig. 21-21). When these beams contact the IHU sensors, signals are produced that measure LOS. The SSU contains a built-in sensor which provides the SEU with necessary reference timing pulse data.

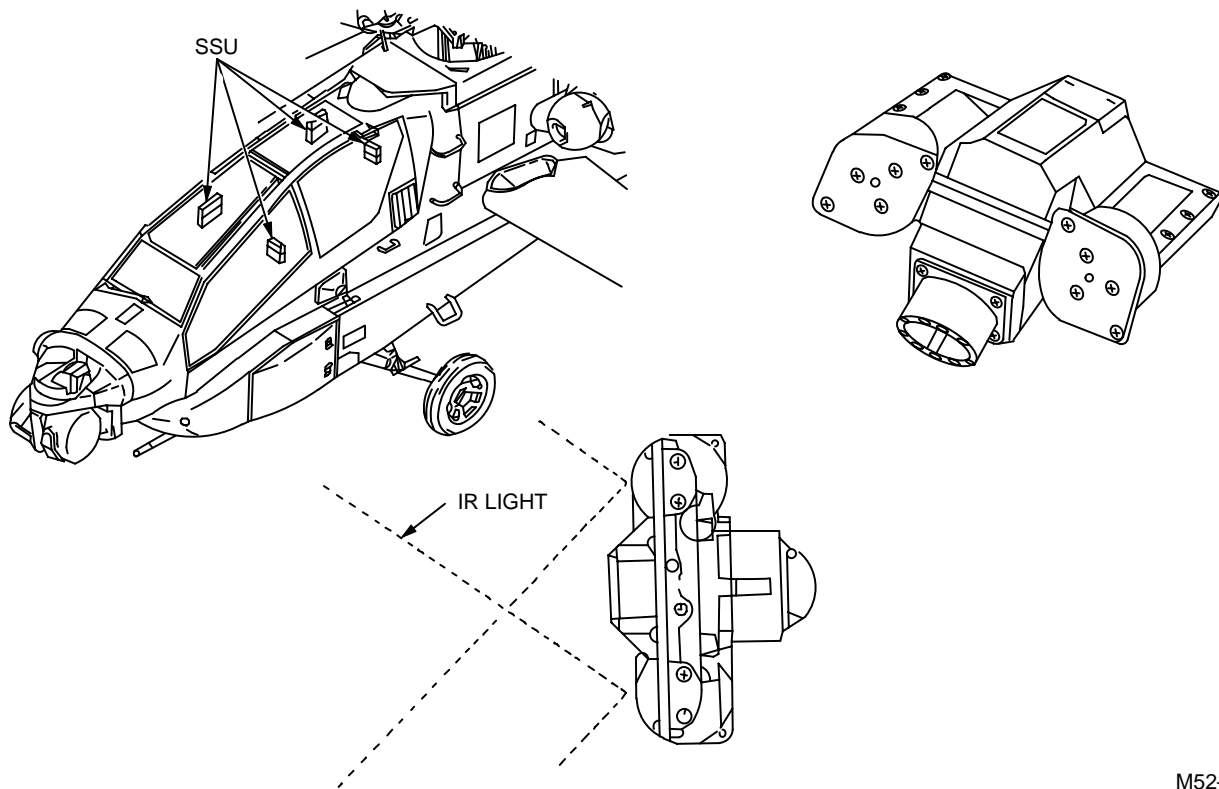
(1) There are two SSUs for the pilot. The SSUs mount above and behind the pilot's seat, one SSU on each side.

(2) There are two SSUs for the CPG. The SSUs mount above and behind the CPG's seat, one SSU on each side.

(3) Harness assembly infrared detectors detect infrared light beams generated by the SSUs, sending electronic pulses to the SEU.

(4) Microphone and boom assembly transmits audio signals from aircraft's intercommunication system (ICS).

(5) Headset assembly receives audio signals from aircraft's ICS.



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Figure 21-21. SSU

n. **IHU.** The IHU provides protection against head, face, and eye injury. The IHU is available in medium, large, and extra large sizes. Each unit weighs 3.5 pounds.

The following list shows IHU major components (fig. 21-22).

- (1) Helmet shell assembly provides the mounting location for the various helmet components.
- (2) Receiver assembly provides for mounting and alignment of the HDU.
- (3) Energy liner provides shock absorption.
- (4) Suspension and communication system provides for fitting the helmet and for padding, as well as the communication microphone and headphones.

21-3. THEORY OF OPERATION (cont)

21-3

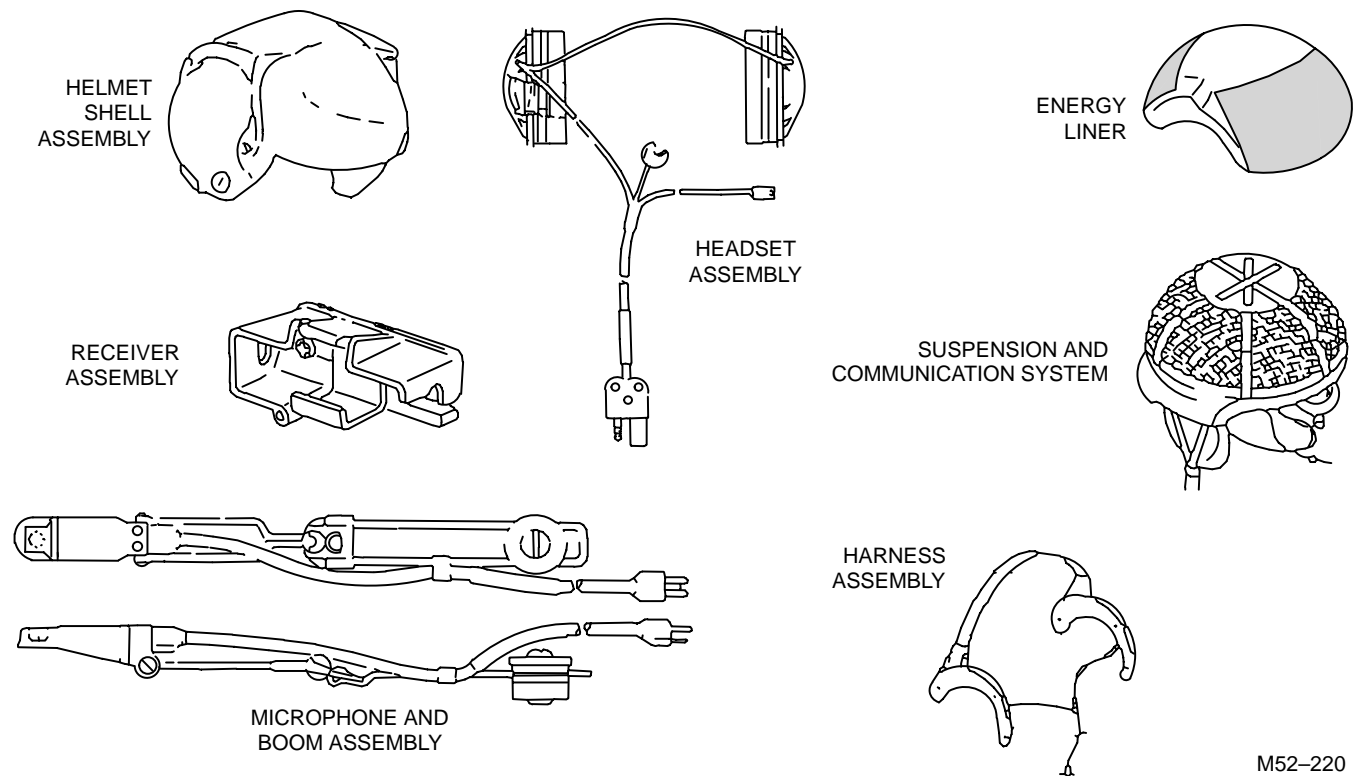


Figure 21-22. IHU Major Components

o. **SEU.** The SEU, using IHU position and SSU reference pulses, computes the IHU Line of Sight (LOS) for use by the Fire Control Computer (FCC). The SEU stores and uses IHADSS boresight data to monitor LOS accuracy.

p. **DEU.** The DEU processes incoming video signals from the symbol generator and pilot's night vision sensor (PNVS). The DEU supplies video information to the DAP.

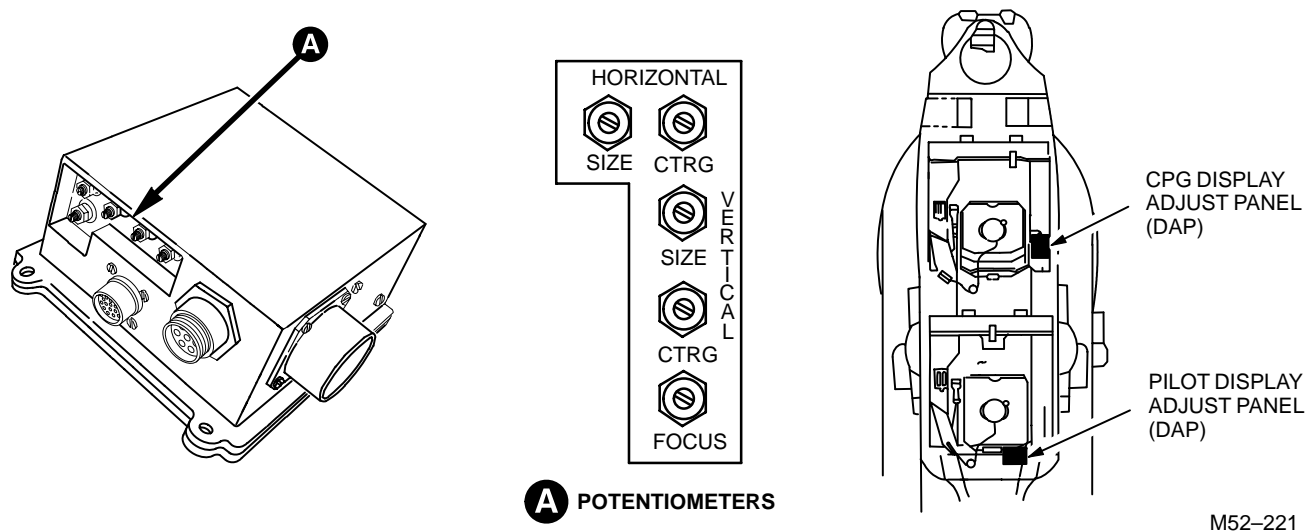
q. **DAP.** The DAP provides amplified video signals from the DEU to the HDU.

(1) The DAP (fig. 21-23) contains potentiometers for AVUM level image adjustment of size, centering, and focus. The adjustments are used to obtain the clearest picture on the HDU display.

(2) There are two DAPs. The pilot's is mounted on the bulkhead behind the right side of the seat. The CPG's is mounted to the right console beside the seat.

r. **HDU.** The HDU allows video/symbols to be displayed in front of the operator's eye, permitting viewing of the video and outside world images at the same time.

(1) The HDU attaches to the receiver on the IHU. When not in use, the HDU is stowed in a holster attached to the cockpit right side console.



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Figure 21-23. DAP

- (2) The HDU includes the following components (fig. 21-24).
- (a) Plastic housing provides protection for the cathode ray tube (CRT).
 - (b) CRT assembly group displays video and symbology.
 - (c) Image rotation collar adjusts display images by rotating the CRT.
 - (d) HDU rotational stop allows alignment of combiner lens with operator's eye.
 - (e) Stabilizing spring stabilizes the image rotation collar.
 - (f) Infinity focus collar moves the CRT closer to and further from the internal focusing lenses.
 - (g) Cable assembly and electrical connectors provides for the low and high voltage interface between the CRT and the DAP.
 - (h) HDU rotational collar provides image rotation.
 - (i) Sliding clip provides combiner adjustment.

21-3. THEORY OF OPERATION (cont)

21-3

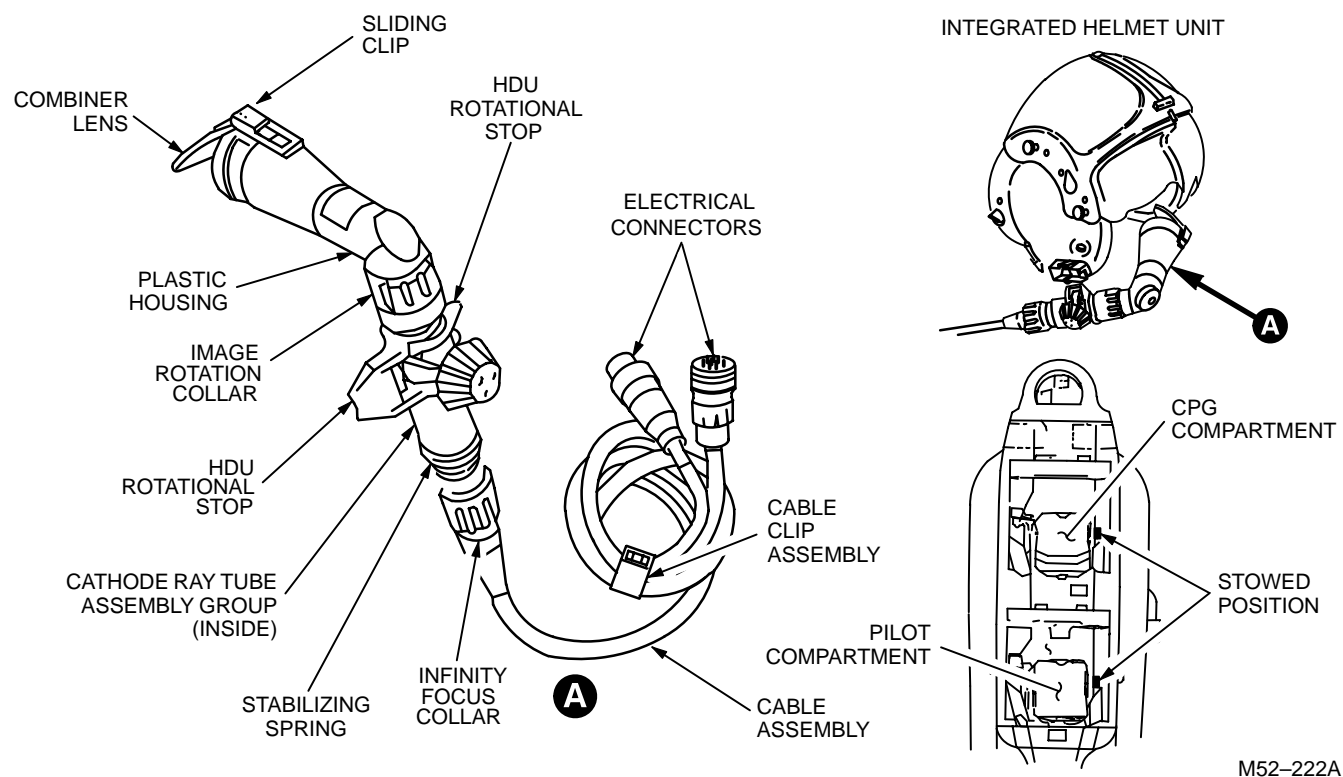


Figure 21-24. HDU Major Components

s. **BRU.** The BRU is an electro-optical device that is aligned to the helicopter armament datum line. The BRU provides a collimated sighting target (fig. 21-25) which is used by the crew members as a reference to align their IHU to the helicopter during boresighting mode. The BRU is turned on and off by SEU command.

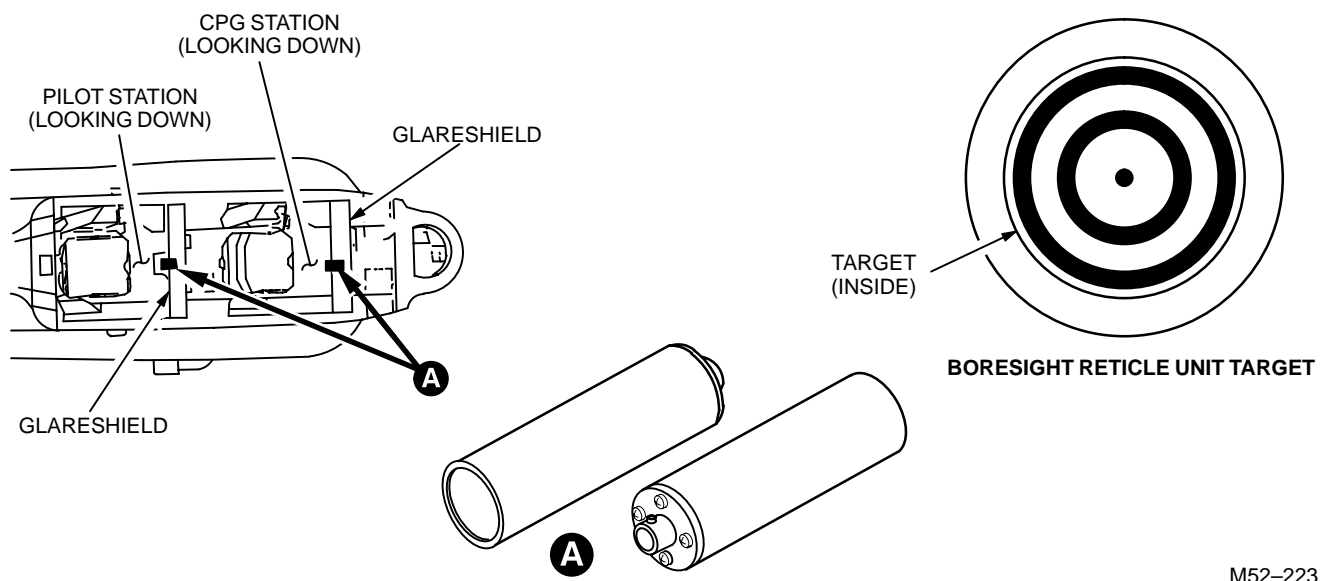


Figure 21-25. BRU

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21-3. THEORY OF OPERATION (cont)

21-3

t. **CPG's IHADSS Controls.** The following subparagraphs explain the CPG's IHADSS controls.

(1) CPG's FCP (fig. 21-26).

(a) **SIGHT SELECT** switch. Provides multiple sighting and/or video selections for target acquisition and recognition. Positions are as follows.

- **STBY.** Deselects any LOS (line of sight) and stows the TADS; however, symbology may be displayed on the HDU, VDU, and HOD.
- **HMD.** IHADSS provides position commands to the FCC. The TADS will be stowed. Symbology may be displayed on the HDU.
- **NVS.** Flight symbology which is normally controlled by the pilot is transferred to the CPG. Sight and weapon status section of the CPG's action displays are blanked. Video is FLIR wide field of view (WFOV); and the cueing functions are inhibited. Used in conjunction with the CPG's night vision sensor (NVS) switch on the collective control stick for either TADS or PNVS.
- **IRIS.** Not used.
- **TADS.** TADS is used as the sole source for sight LOS and video, but TADS may be slaved to all of the ACQ SEL switch positions except TADS.
- **HMD/TADS.** TADS is the sight LOS. The TADS can be slaved to follow the IHADSS sight LOS, utilizing the slave button. Symbology and TADS video is provided to the HDU.
- **OFF.** IHADSS boresight electronics are disabled.

(b) **BRSIT IHADSS/OFF/IRIS** switch. Enables the CPG IHADSS boresight electronics for IHADSS LOS alignment with the BRU. Positions are as follows.

- **IRIS.** Used in conjunction with IRIS sight select, slave button, and ORT slew control, enables boresighting of the IRIS missile selected by the MAN mode (not used at this time).
- **IHADSS.** The BRU is turned on, and the boresight circuits are enabled.

(c) **SYSTEM FC/SYM GEN/OFF** switch. Provides power to the symbol generator. Positions are **FC SYM GEN** and **OFF**.

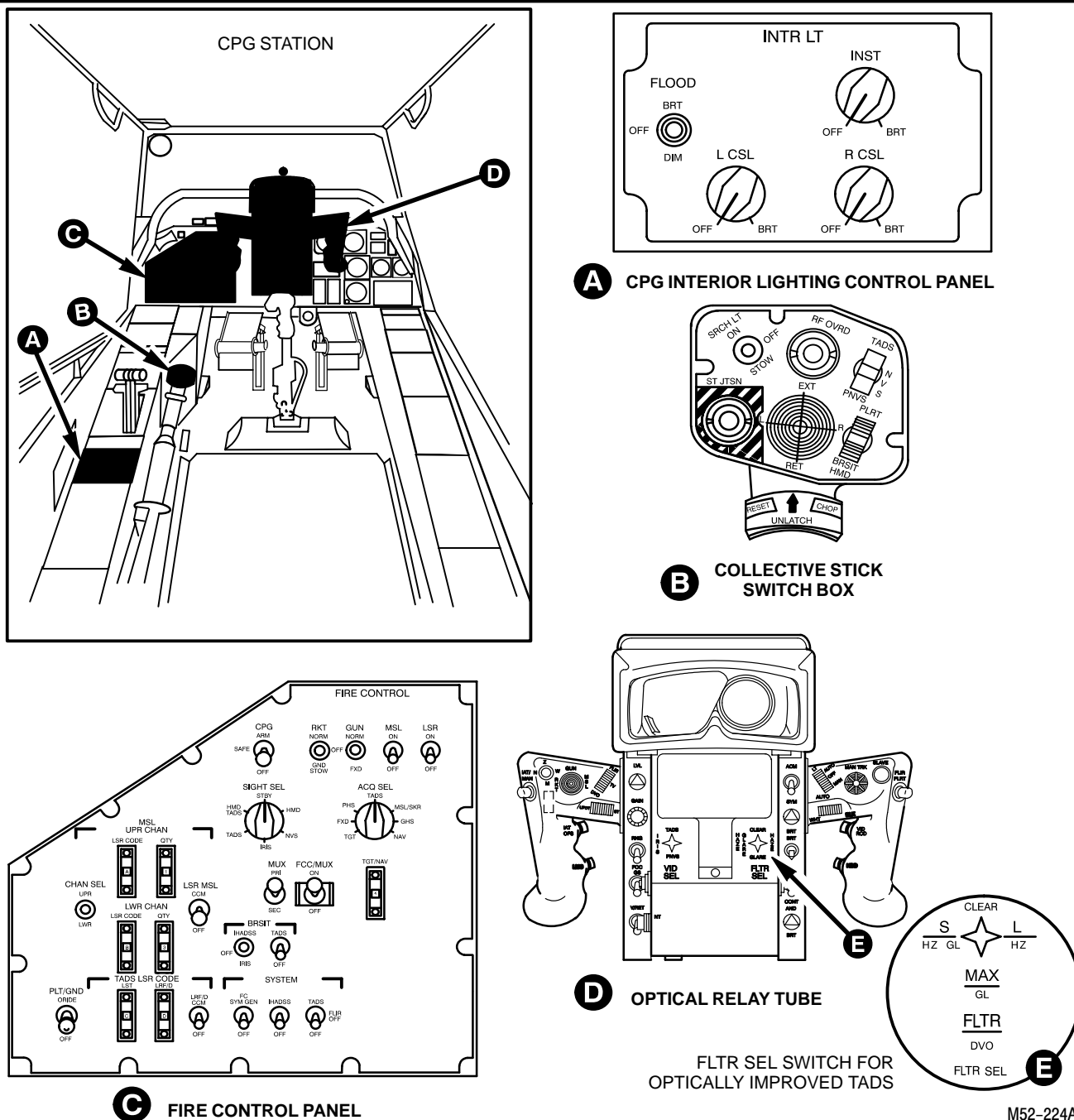
(d) **SYSTEM IHADSS/OFF** switch. Controls power to the DEU and SEU. Positions are **IHADSS** and **OFF**.

(e) **TADS/FLIR/OFF** switch. Controls power for the TADS and FLIR. Positions are as follows.

- **OFF.** No power applied to TADS.
- **FLIR OFF.** TADS has power applied; however, FLIR is disabled.
- **TADS.** Both TADS and FLIR have power applied.

21-3. THEORY OF OPERATION (cont)

21-3



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Figure 21-26. CPG IHADSS Controls

(2) ORT (fig. 21-26).

(a) **SYM/BRT** switch. Controls the brightness of the HDU symbols. Positions are as follows.

- Up. Increases the brightness of the HDU symbols.
- Center. No brightness control.
- Down. Decreases the brightness of the HDU symbols.

(b) **BRT/DSPL** switch. Controls the brightness of the HDU display. Positions are as follows.

21-3. THEORY OF OPERATION (cont)

21-3

- Up. Increases the brightness of the HDU display.
- Center. No brightness control.
- Down. Decreases the brightness of the HDU display.

(c) **DSPL/CONT** switch. Controls the contrast of the HDU display. Positions are as follows.

- Up. Increases the contrast of the HDU display.
- Center. No contrast control.
- Down. Decreases the contrast of the HDU display.

(d) **GS** switch. Signals the symbol generator to generate 10 distinct shades of gray for video adjustment. Positions are as follows.

- **GS**. Enables gray scales for display adjustment.
- Off. Normal operation.

(3) CPG's collective stick switch box (fig. 21-26).

(a) **NVS** switch. Selects the night vision sensor to be used by the CPG's IHADSS. Positions are as follows.

- **TADS**. Selects TADS as the display to be presented on the CPG's HDU if NVS is selected on the CPG's **SIGHT SEL** switch.
- **PNVS**. Selects pilot's night vision sensor (PNVS) as the display to be presented on the CPG's HDU if NVS is selected on the CPG's **SIGHT SEL** switch.

(b) **PLRT/BRISIT HMD** switch. Positions are as follows.

- **PLRT**. Reverses the polarity of the HDU display.
- Center. No selection actioned.
- **BRISIT HMD**. Actions the SEU to store the IHU line of sight (LOS) during boresighting mode.

u. **Pilot's IHADSS Controls**. The following subparagraphs explain the pilot's IHADSS controls (fig. 21-27).

(1) Pilot's FCP.

(a) **SIGHT SEL**. Provides multiple sighting and/or video selections for target acquisition and recognition. Positions are as follows.

- **HMD**. IHADSS supplies sighting LOS information to the FCC.
- **STBY**. The standby position commands the PNVS to stow and de-selects the IHADSS sight and any video source for the pilot; however, the symbology may still be displayed.
- **NVS**. The PNVS or TADS turret may be slaved to the pilot's IHADSS LOS. Video is projected on the HDU. All other HDU capabilities are still functional. When the sight select switch is moved from this position, the selected turret, after a short delay, goes to the stow position. Used in conjunction with the pilot's NVS switch on the collective control stick switch box.

(b) **VID SEL** switch. Provides the means of selecting the video source for the pilot's HDU. Positions are as follows.

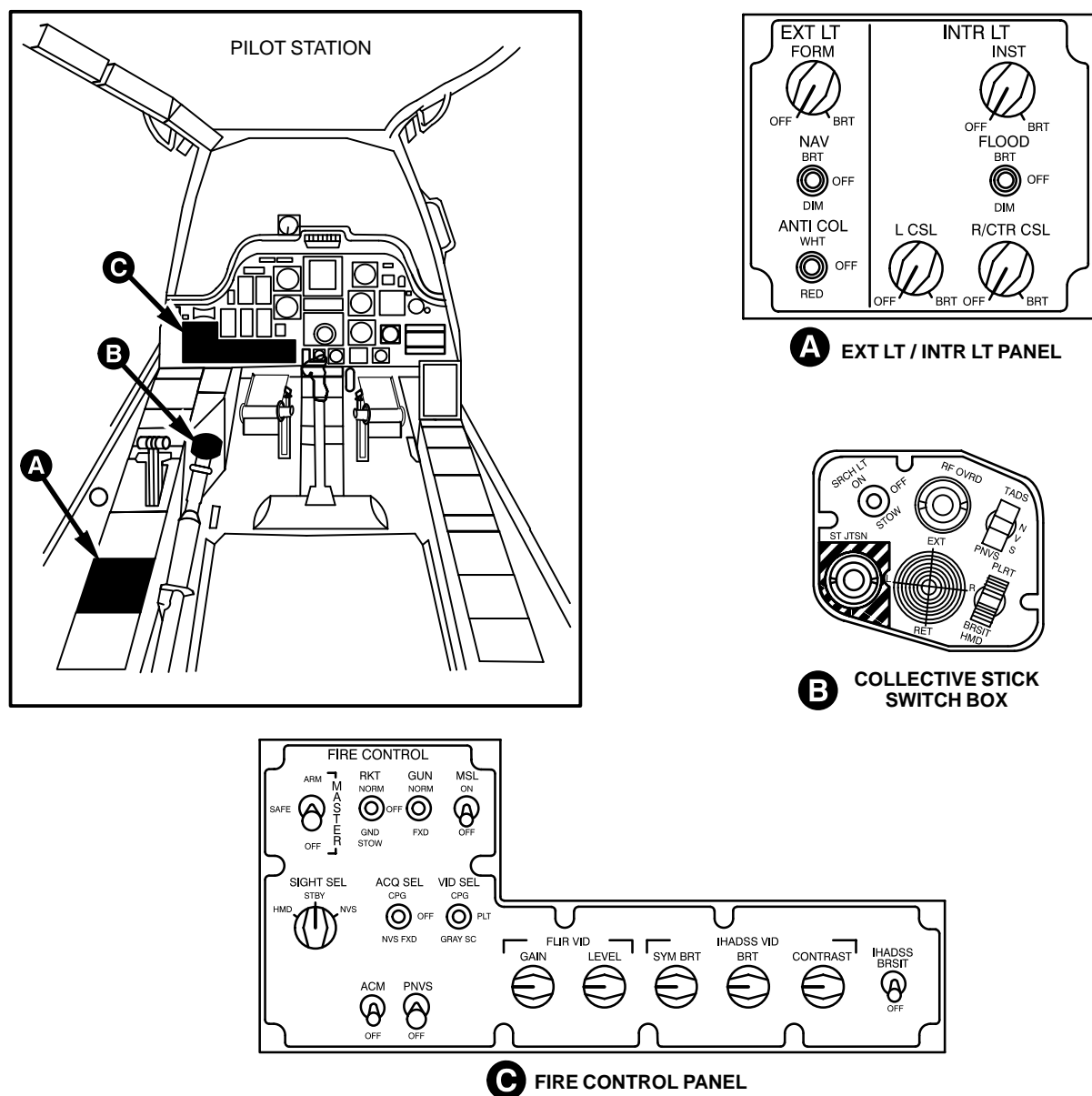
21-3. THEORY OF OPERATION (cont)

21-3

- **CPG.** The video presented on the pilot's HDU is the DTV or FLIR.
 - **PLT.** The video presented on the pilot's HDU is that video selected on the pilot's sight select switch, and the pilot's collective control stick NVS switch.
 - **GRAY SC.** A gray scale test pattern consisting of 10 bars (shades) of gray is presented on the pilot's HDU for display adjustments (part of components BIT test).
- (c) **IHADSS VID/SYM BRT** switch. Adjusts the brightness of the HDU symbols.
- (d) **IHADSS BRT** switch. Adjusts the brightness of the HDU video.
- (e) **IHADSS CONTRAST** switch. Adjusts the contrast of the HDU video.
- (f) **IHADSS BRSIT/OFF** (boresight). Enables the pilot's IHADSS boresight electronics for IHADSS LOS alignment with the BRU. Positions are as follows.
- **ON.** Enables pilot boresight mode.
 - **OFF.** Normal operation.
- (2) Pilot's collective control stick switch box.
- (a) **NVS.** Selects the night vision sensor used by the pilot's IHADSS. Positions are as follows.
- **TADS.** Selects TADS as the display to be presented on the pilot's HDU if NVS is selected on the pilot's sight select switch.
 - **PNVS.** Selects PNVs as the display to be presented on the pilot's HDU if NVS is selected on the pilot's sight select switch.
- (b) **PLRT/BRSIT HMD** switch. Selects the polarity of the display; enables boresight LOS computations. Positions are as follows.
- **PLRT.** Reverses the polarity of the HDU display (black/white to white/black).
 - **Center.** No action.
 - **BRSIT HMD.** Stores a new boresight value in the SEU.

21-3. THEORY OF OPERATION (cont)

21-3



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Figure 21-27. Pilot IHADSS Controls

v. **Display Sight System Operation.** The following subparagraphs describe the pilot's sight system. The CPG's sight system operations are identical.

(1) Circuit breaker **IHADSS** (CB41) on the pilot's circuit breaker panel, supplies three phase 115 VAC through the electrical power distribution box to the DEU (fig. 21-28).

(2) Circuit breaker **FC DC** (CB50), on the pilot's circuit breaker panel, supplies 28 VDC through the electrical power distribution box and filter FLT 1 in the pilot's FCP, to the **IHADSS BRSIT** switch on the CPG's FCP. Setting the **IHADSS BRSIT** switch to **ON** routes 28 VDC to the following places.

21-3. THEORY OF OPERATION (cont)

21-3

- (a) The DEU, causing the DEU to operate.
- (b) The CPG multiplex remote terminal unit (MRTU) Type III, creating status messages to the FCC. MRTUs interface the multiplex system with helicopter subsystems and components.
- (3) The symbol generator supplies both pilot (PNVS) and CPG (TADS) video, and fire control symbology to the DEU.
- (4) The PNVS supplies video 2 directly to the DEU.
- (5) The MRTU Type I RH FAB supplies the following data to the DEU.
 - (a) 5 VDC common select if the symbol generator video output fails.
 - (b) 5 VDC pilot BIT test.
 - (c) 5 VDC CPG BIT test.
- (6) The DEU supplies the following data to the MRTU Type I RH FAB, creating status messages to the FCC.
 - (a) 5 VDC pilot DAP BIT.
 - (b) 5 VDC CPG DAP BIT.
 - (c) 5 VDC DEU BIT.
- (7) The DEU supplies the pilot DAP with the following data.
 - (a) Video.
 - (b) Blanking signal.
 - (c) Sync pulses.
 - (d) BIT enable signal.
 - (e) A 5 VDC signal (shutdown) to the DAP to enable the DAP power supply.
- (8) The DEU supplies horizontal and vertical deflection signals to the DAP.
- (9) The DEU supplies the following power supply voltages to the DAP.
 - (a) +5 VDC.
 - (b) +15 VDC.
 - (c) -15 VDC.
 - (d) -60 VDC.
- (10) The pilot's DAP supplies the following data to the DEU.
 - (a) BIT status.
 - (b) Horizontal size and position signal.
 - (c) Vertical size and position signal.

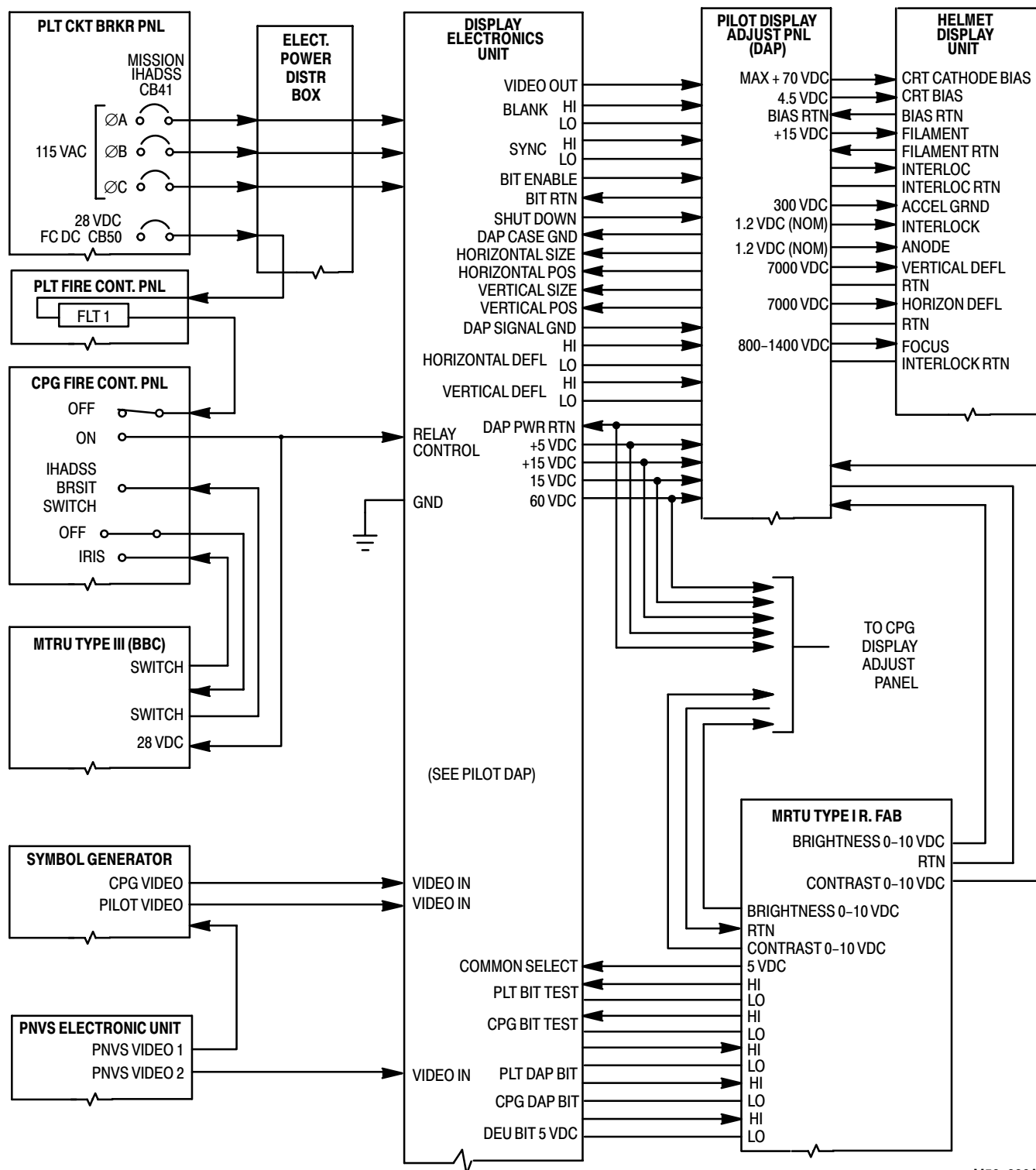
21-3. THEORY OF OPERATION (cont)

21-3

- (11) The MRTU Type I RH FAB supplies 0 to 10 VDC brightness and contrast signals to the DAP.
- (12) The DAP supplies the following data to the HDU.
 - (a) Up to 70 VDC CRT cathode bias.
 - (b) 4.5 VDC CRT bias.
 - (c) +15 VDC filament voltage.
 - (d) Interlock signal to the HDU.
 - (e) A 300 VDC accelerator grid voltage.
 - (f) A 1.2 VDC (nominal) interlock signal.
 - (g) A 1.2 VDC (nominal) anode signal.
 - (h) A 7000 VDC vertical deflection signal.
 - (i) A 7000 VDC horizontal deflection signal.
 - (j) A 800 to 1400 VDC focus signal.

21-3. THEORY OF OPERATION (cont)

21-3



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Figure 21-28. IHADSS Display Sight System Block Diagram

w. **Sighting System Operation:**

(1) Circuit breaker **IHADSS** (CB1), on the CPG's circuit breaker panel, supplies three phase 115 VAC to the SEU (fig. 21-29).

(2) Circuit breaker **FC DC** (CB50), on the pilot's circuit breaker panel, supplies 28 VDC through the electrical power distribution box and filter FLT 1 in the pilot's FCP, to the **IHADSS** switch on the CPG's FCP.

(3) Setting the IHADSS switch to **ON** routes 28 VDC to the following places.

- (a) The SEU, causing the SEU to operate.
- (b) The CPG MRTU Type III, creating status messages to the FCC.

(4) The SEU supplies the following signals to the SSUs.

- (a) 8 VAC, 146-Hz signal to the motor 1 and motor 2 drive.
- (b) 6 VDC lamp power signal to the SSUs.
- (c) +25 VDC.
- (d) +5 VDC.
- (e) +5 VDC load signal.
- (f) A clock signal.

(5) The SSUs supply the following data to the SEU.

- (a) A Pri 1 pulse each time motor 1 reflects the light.
- (b) A Pri 2 pulse each time motor 2 reflects the light.

(c) A calibration word following a load command. The calibration word tells the SSU the exact distance between the mirrors. The calibration word is transferred only one time during power up.

(6) The SSUs put out two fan-shaped patterns of IR light to the crew station.

(7) The SEU supplies each helmet with 100 VDC sensor voltage.

(8) The SEU supplies each helmet with +28 VDC operating power.

(9) The helmet detects the IR light from the SSUs, combines the two front and two rear pulses, and supplies the following signals to the SEU.

- (a) Front pulse.
- (b) Rear pulse.

(10) The MRTU Type I RH FAB sends a request discrete, or a request and transmit discrete, signal to the SEU.

(11) The SEU sends an acknowledge signal to the MRTU Type I RH FAB.

(12) The MRTU Type I RH FAB sends the clock pulses to the SEU.

(13) The SEU supplies the data out to the MRTU or receives data from the MRTU.

21-3. THEORY OF OPERATION (cont)

21-3

(14) The MRTU Type I RH FAB sends a manchester error to the SEU if an error is detected in the message.

(15) The SEU sends a subsystem error signal to the MRTU Type I RH FAB if the SEU detects an error in the message to the SEU.

(16) When the **BRSIT** switch is set to **IHADSS**, the CPG MRTU Type III creates status messages to the FCC.

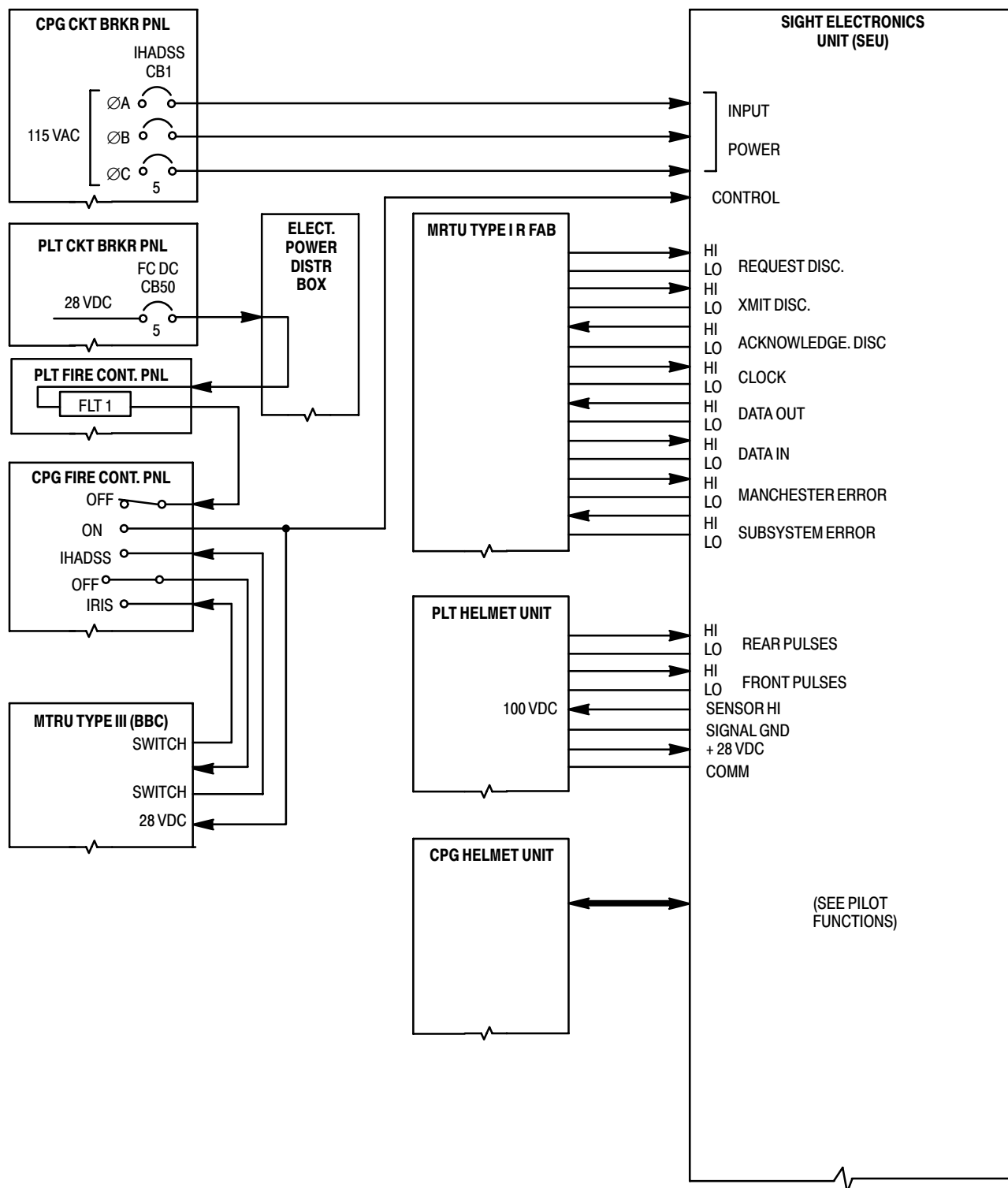
(17) When the **BRSIT** switch is set to **IRIS** (growth position), the MRTU Type I creates status messages to the FCC.

(18) The helmet contains a headset assembly and microphone/boom assembly for aircraft communication.

(19) Boresight reticle units (BRU) are used to provide a calibrated line of sight (LOS) reference.

21-3. THEORY OF OPERATION (cont)

21-3

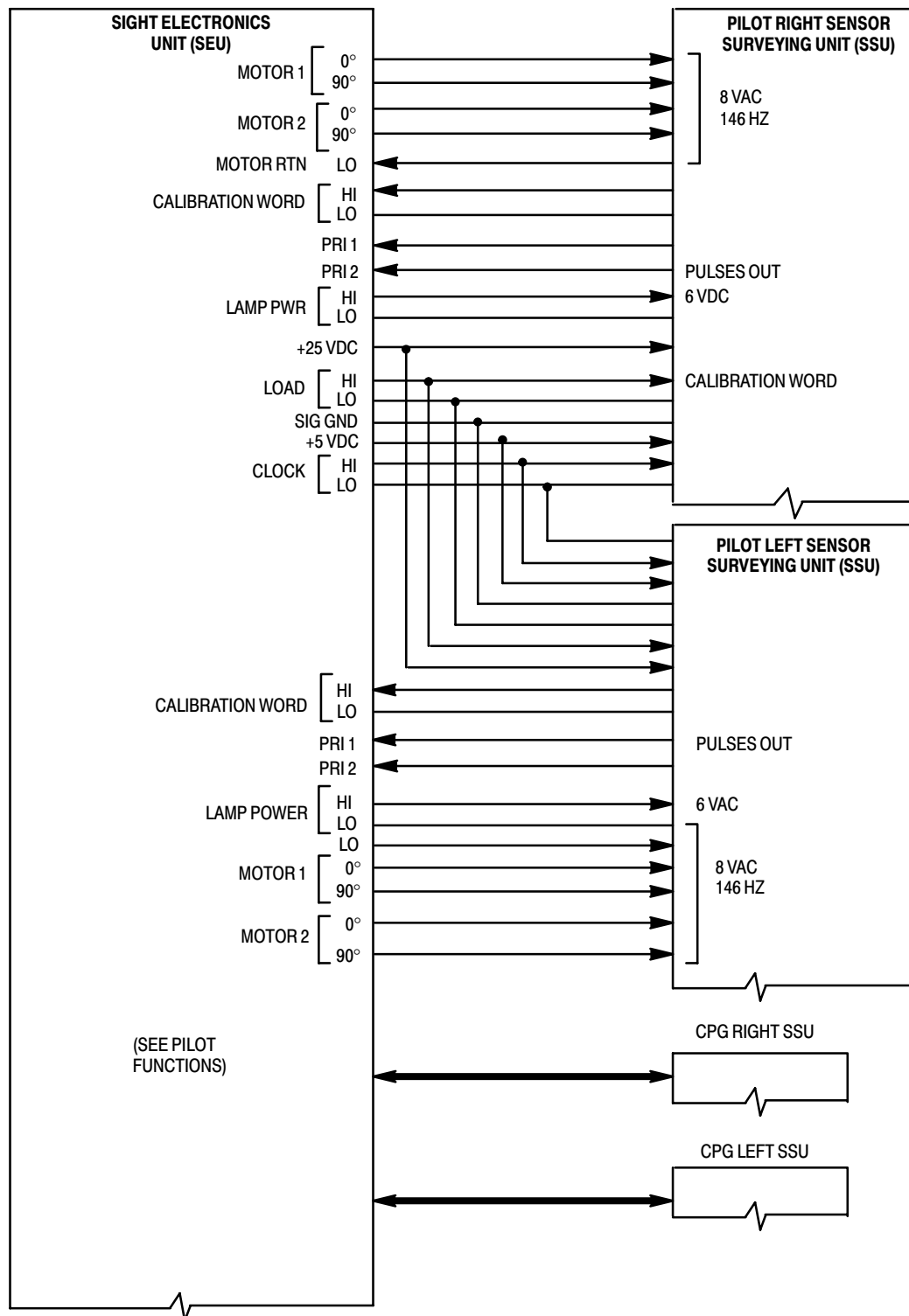


M52-227-1A

Figure 21-29. Sighting System Block Diagram (Sheet 1 of 2)

21-3. THEORY OF OPERATION (cont)

21-3



M52-227-2A

Figure 21-29. Sighting System Block Diagram (Sheet 2 of 2)

21-3. THEORY OF OPERATION (cont)

21-3

x. **Video Display Unit Circuit Breaker (VDU).** Circuit breaker **NAV VDU** (CB91), on the pilot's circuit breaker panel, provides 28 VDC and circuit protection for the video recorder panel **MIN** indicator.

y. **Video Recorder Panel.** The video recorder panel (fig. 21-30) provides remote control of the video recorder. The following switches and controls affect video recorder operation.

(1) **MODE** switch positions are as follows.

(a) **OFF.** Disables video recorder. Commands video recorder to disengage the video tape from video recorder head.

(b) **STBY.** Enables power to video recorder. Commands the video recorder to thread the tape.

(c) **REC.** Places video recorder in record mode. Actual recording starts when **VID RCD** switch on ORT is pressed. **REC** records the selected video (pilot or CPG) from the symbol generator and all audio on the communications line from the audio junction unit.

(d) **PLAY.** Places video recorder in play mode. Activates play switch on panel. Automatically commands the symbol generator to display the video recorder video on the CPG's displays.

(e) **RWND.** Commands the video recorder to rewind. The video recorder completely rewinds the tape if any further commands or detect an event mark are not received.

(2) **VIDEO** switch. Selects video to be recorded. Positions are as follows.

(a) **CPG.** Selects CPG's video to be sent to the recorder.

(b) **PLT.** Selects the pilot's video to be sent to the recorder.

(3) **PLAY** switch. Only activated when the **MODE** switch is set to **PLAY**. Positions are as follows.

(a) **FAST REV.** Commands recorder to fast reverse to preceding event mark (EMK). If no EMK is present, tape rewinds to beginning. **FAST REV** allows fast scanning to the general area desired.

(b) **REV.** Commands the video recorder to playback video in reverse until EMK is encountered. Playback is at normal speed.

(c) **STILL.** Commands video recorder to freeze video image for detailed analysis.

(d) **FWD.** Commands video recorder to playback the video until event mark (EMK) is encountered. Playback is at normal speed.

(e) **FAST FORWARD.** Commands video recorder to fast forward until EMK is encountered. If no EMK is encountered, video recorder continues to end of tape. Usable video is displayed at high speed.

(4) **EVENT** switch. Places an EMK on the video tape.

(5) **MIN** display. Displays tape remaining. The display is a relative tape remaining indicator, from 00.0 to 99.9.

z. **Video Recorder.** The video recorder provides recording and playback of video.

(1) Functions of video recorder connectors are as follows.

21-3. THEORY OF OPERATION (cont)

21-3

(a) J1 connector provides interface between the video control panel and the video recorder, via the power control lines. J1 also receives the command functions for the video recorder through the DASE/MUX system.

(b) J2 connector receives the 115 VAC to power the video recorder.

(c) J3 connector provides interfacing of the ICS and video input/output to the symbol generator.

(2) Functions of video recorder controls are as follows.

(a) Cassette release button releases the video tape from the video recorder.

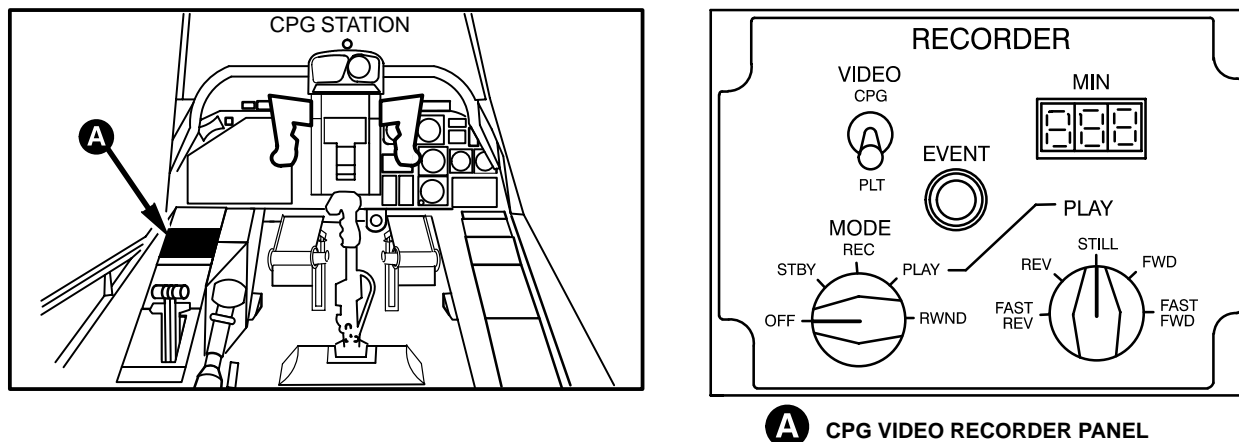
(b) Time indicator indicates approximate hours of video recorder operation, 0 to 1000 hour scale.

aa. **Video Recorder Circuit Breaker.** Circuit breaker **FC RCDR** (CB8), on the CPG's circuit breaker panel, provides circuit protection for the video recorder.

ab. **CPG ORT VID RCD Switch.** This switch, on the ORT right hand grip (fig. 21-17), provides a remote signal (through the CPG MRTU Type III to the FCC. The FCC processes the information and sends function commands to the video recorder via the DASEC. This switch works with the **MODE** switch on the video recorder panel.

ac. **Transformer Rectifier.** The transformer rectifier is a 115 VAC to 12 VDC solid state rectifier. The power supply provides 12 VDC input to the following components.

- (1) Video control panel.
- (2) Data entry keyboard (DEK).
- (3) CPG FCP.



A CPG VIDEO RECORDER PANEL

M52-457

Figure 21-30. Video Recorder Panel

ad. **Operation.** The video recorder system (fig. 21-31) operates as follows.

- (1) Circuit breaker **FC RCDR** (CB8) supplies 115 VAC operating power to the video recorder.
- (2) The video recorder supplies a +18 V signal to the contacts of **MODE** switch S1 wafer C.

21-3. THEORY OF OPERATION (cont)21-3

(3) Circuit breaker **FC AC** (CB51), on the pilot's circuit breaker panel, supplies 115 VAC power through the electrical power distribution box to the 12 VDC power supply.

(4) The 12 VDC power supply supplies 12 VDC unregulated power to the video recorder control panel power supply (VR-1).

(5) VR-1 develops a regulated 5 VDC output that is routed through resistor R1 to the **OFF** position of **MODE** switch S1 wafer A and then to ground if the **MODE** switch is off.

(6) When **MODE** switch S1 is set to **STBY**, the following occurs.

(a) The 5 VDC output from VR-1 is no longer shorted to ground and is routed to video recorder panel circuitry, and to the CPG MRTU for **ON/OFF** detect.

(b) The multichannel dimmer supplies 14 VDC (dim) or 28 VDC (bright) through **MODE** switch S1 wafer B to the MIN display for bright/dim control.

(c) **MODE** switch S1 wafer C sends 18 VDC back to the recorder, causing the video recorder to operate.

(7) When **MODE** switch S1 is set to **REC**, a ground is applied to the A3 logic board.

(8) When **MODE** switch S1 is set to **PLAY**, a ground is routed through wafer A to **PLAY** switch S2. This supplies a ground to one of the following functions of the A3 logic board:

(a) **F REV** (Fast Reverse).

(b) **REV** (Reverse).

(c) **STILL**.

(d) **FWD** (Forward).

(e) **F FWD** (Fast Forward).

(9) The CPG MRTU Type III monitors the ORT right hand grip for video record switch closure.

(10) Under command of the FCC, data is transferred between the DASEC MRTU and the CPG MRTU Type III.

(11) The DASEC supplies the video recorder with the command functions of play, record, still, fast forward, event, and fast reverse.

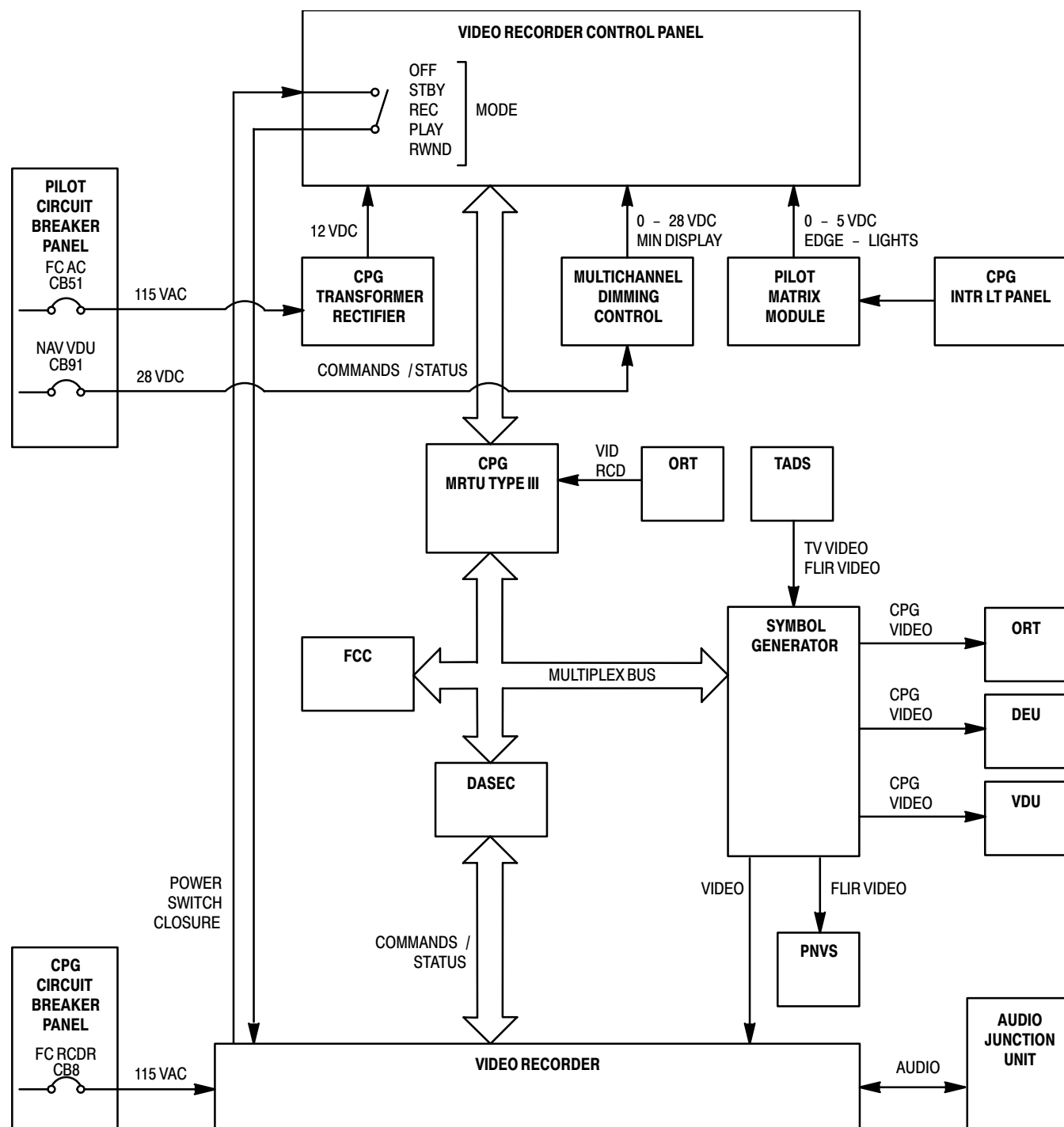
(12) The video recorder receives audio record in signal if in the record mode, or supplies audio playback out signal to the audio junction unit if in the playback mode.

(13) The video recorder receives the selected video (pilot or CPG) from the symbol generator, in the record mode.

(14) The video recorder supplies video to the symbol generator. The symbol generator supplies the video to the following places if in playback mode.

21-3. THEORY OF OPERATION (cont)

21-3



M52-230

Figure 21-31. Video Recorder System Block Diagram

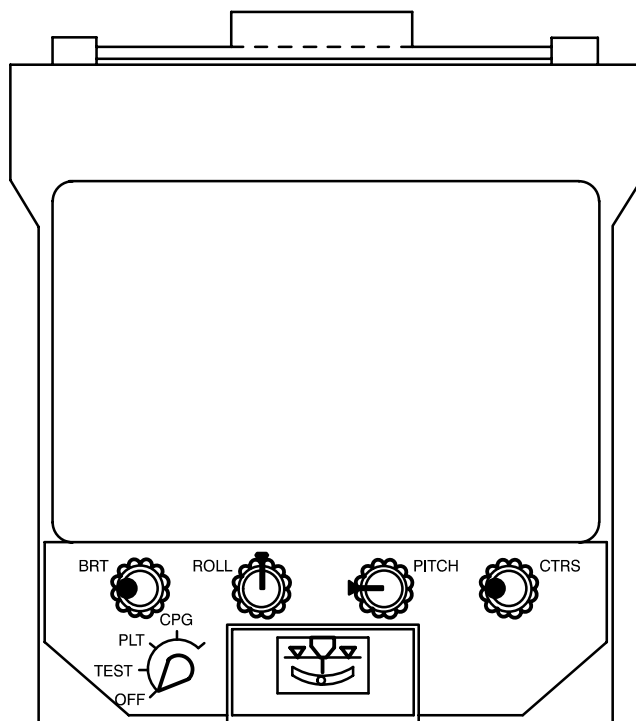
21-3. THEORY OF OPERATION (cont)

21-3

- (a) DEU for IHADSS viewing.
- (b) VDU for pilot viewing.
- (c) ORT for CPG viewing.

(15) The video recorder supplies the following 5 VDC status information to the DASEC, creating status messages to the FCC.

- (a) End of tape (**EOT**).
- (b) Record (**RECORDER**).
- (c) Beginning of tape (**BOT**).
- (d) Video recorder NO-GO (**RCDRFAIL**).



M52-455

Figure 21-32. VDU

ae. **Video Display Unit Controls and Indicators.** The VDU (fig. 21-32) displays pilot and CPG flight, navigation and weapon data to the pilot. The following subparagraphs describe the VDU controls and indicators.

- (1) The rotary selector switch performs the following functions.
 - (a) **OFF** disables all power to the VDU.
 - (b) **TEST** displays a vertically oriented test pattern on the cathode ray tube (CRT).
 - (c) **PLT** displays pilot selected video.
 - (d) **CPG** displays CPG selected video.

21-3. THEORY OF OPERATION (cont)
21-3

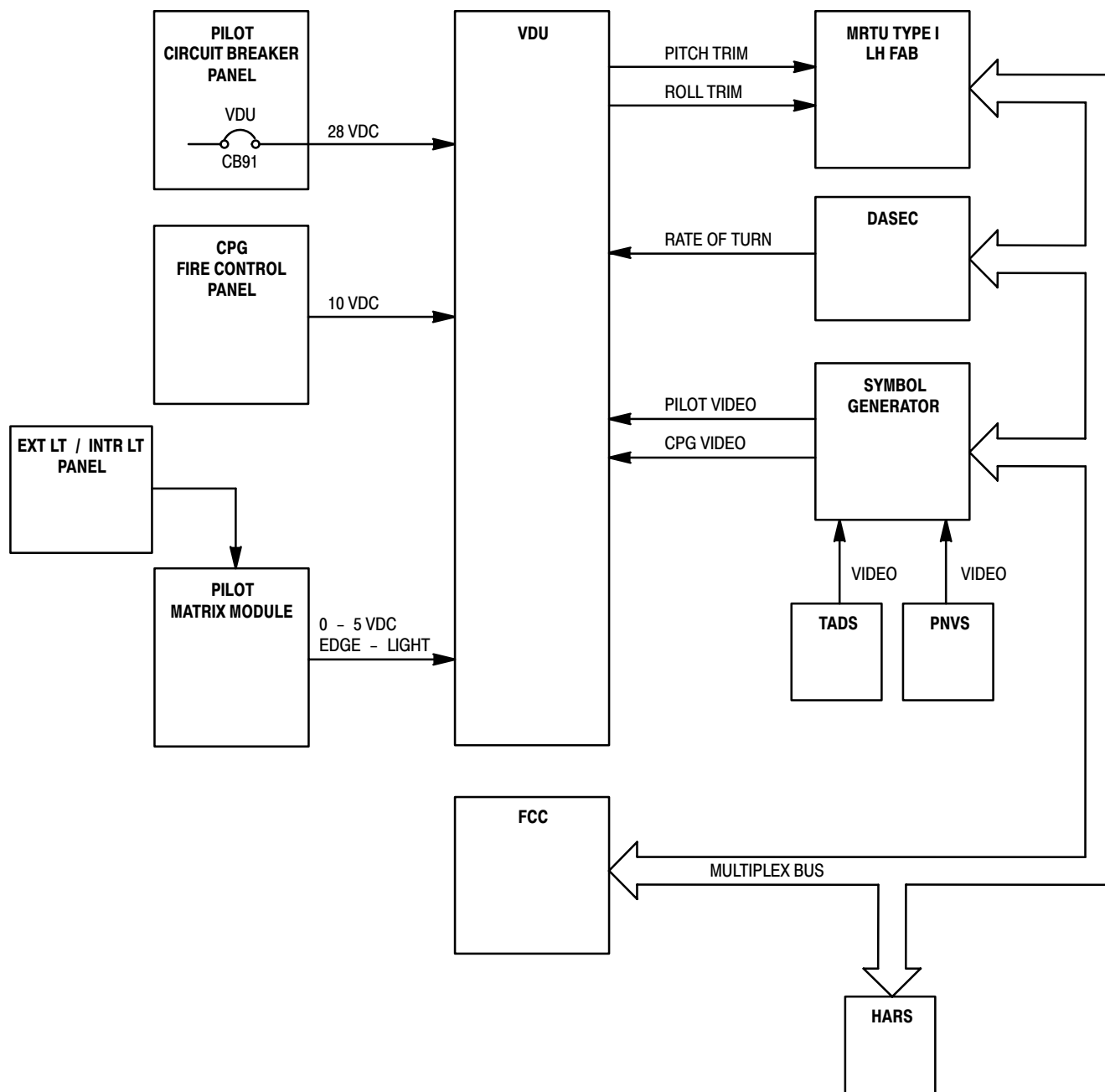
-
- (2) **BRT** variable control. The **BRT** variable control adjusts display brightness.
 - (3) **ROLL** variable control. The **ROLL** variable control adjusts roll trim on the symbolic horizon, displayed in transition and cruise modes of flight symbology.
 - (4) **PITCH** variable control. The **PITCH** variable control adjusts roll trim on the symbolic horizon, displayed in transition and cruise modes of flight symbology.
 - (5) **CTRS** variable control. The **CTRS** variable control adjusts display contrast in **PLT/CPG** mode.
 - (6) Turn and Slip indicator. The turn and slip indicator displays turn and slip information from heading attitude reference set (HARS).

af. VDU Operation.

- (1) **EXT LT/INTR LT** Panel. The **EXT LT/INTR LT** panel supplies 0 to 5 VDC through the pilot matrix module for edge-light panel lighting.
- (2) Target Acquisition and Designation Sight (TADS) Assembly. The TADS provides CPG video.
- (3) Pilot Night Vision Sensor (PNVS). The PNVS provides pilot video.
- (4) Symbol Generator. The symbol generator sends the selected pilot (PNVS) or CPG (TADS and video recorder) video to the VDU.
- (5) Digital Automatic Stabilization Equipment Computer (DASEC). The DASEC provides a multiplex bus interface between the fire control computer (FCC) and VDU for rate-of-turn information.
- (6) Multiplex Remote Terminal Unit (MRTU) Type I Left-Hand (LH) Forward Avionics Bay (FAB). The MRTU Type I provides a multiplex bus interface between the FCC and VDU for pitch and roll trim information.
- (7) Fire Control Computer (FCC). The FCC serves as the primary bus controller for the multiplex system and controls all communication on the data bus. The FCC generates command words and transmits and receives status words.
- (8) Heading Attitude Reference System (HARS). The HARS provides rate-of-turn information.
- (9) CPG **FIRE CONTROL** Panel. The CPG **FIRE CONTROL** panel supplies 10 VDC for pitch and roll trim excitation.

21-3. THEORY OF OPERATION (cont)

21-3



M52-456

Figure 21-33. VDU System Block Diagram

22-1. PURPOSE

22-1

CHAPTER 22 UTILITY SYSTEM

22-1. PURPOSE

The systems which comprise the utility system are described below.

- a. **Windshield Wiper System.** The windshield wiper system provides a means of removing moisture from the pilot's and copilot/gunner's windshields.
- b. **Anti-ice/De-ice Systems.** The anti-ice systems are described in the following subparagraphs.
 - (1) The canopy anti-ice system heats the canopy panels to prevent ice build up.
 - (2) The engine anti-ice system prevents ice build-up on the nose gearbox (NGB) fairings, engine guide vanes, swirl vanes, and deswirl vanes.
 - (3) The rotor blade de-ice system provides controlled ice removal from the main and tail rotor blades in trace to moderate icing conditions.
 - (4) The pitot and air data anti-ice system prevents ice from forming on the pitot tubes and air data sensor.
 - (5) The TADS/PNVS anti-ice system prevents the formation of ice on the pilot's night vision sensor (PNVS) window. The anti-ice system also prevents the formation of ice on the target acquisition designation sight (TADS) system day, night, and boresight module windows.
- c. **Canopy Defog System.** The canopy defog system removes fog from the inside of the crew members' canopies.
- d. **Fire Detection and Extinguishing Systems.** The engine fire detection and extinguishing systems detect and extinguish fires in the engine and APU compartments.
- e. **Canopy Jettison System.** The canopy jettison system provides rapid egress paths when the helicopter is downed and access doors are jammed or blocked. The system is pyrotechnically operated. The system operates by instantly severing and blowing out the four acrylic side panels.

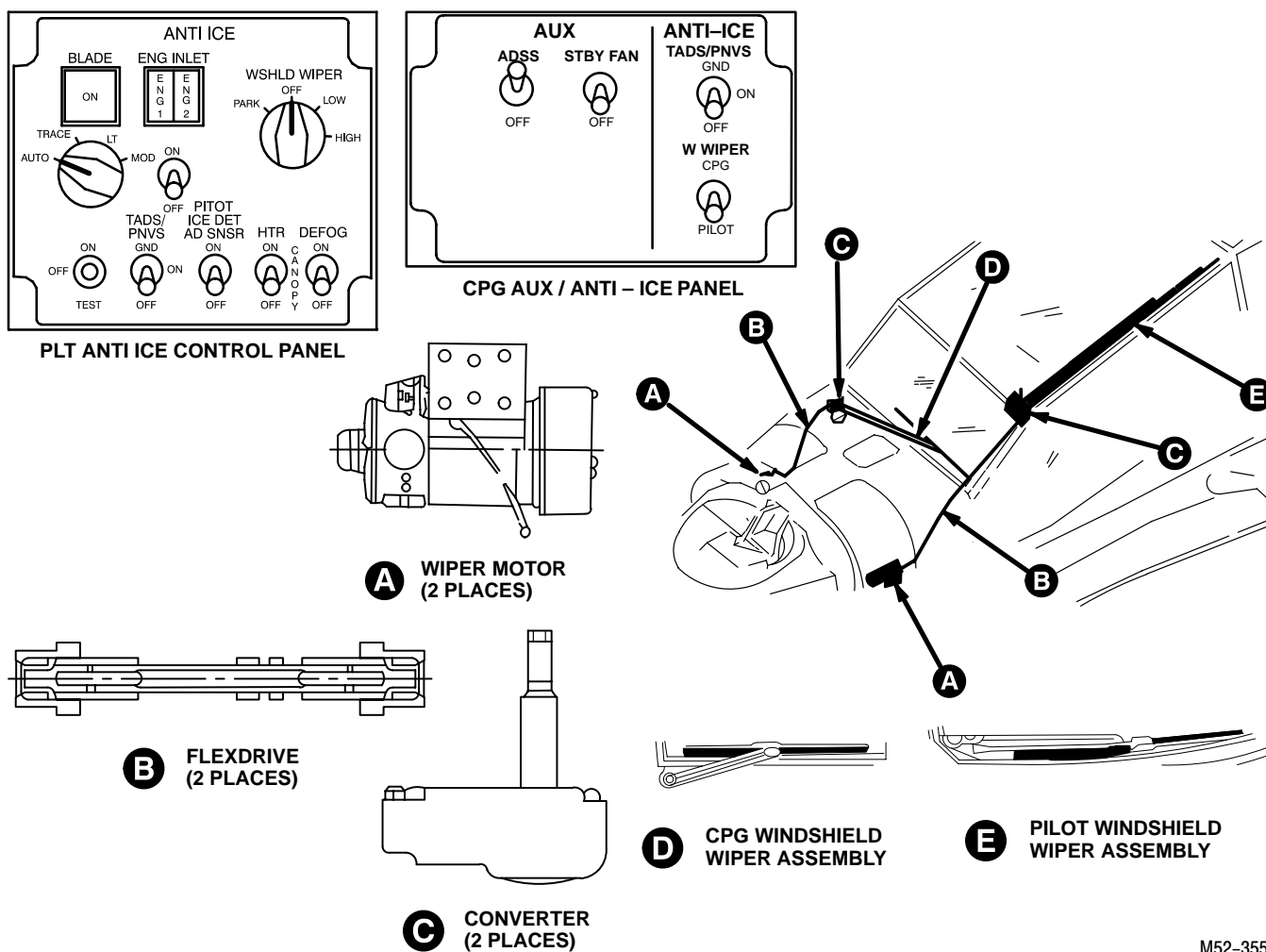
22-2. DESCRIPTION

- a. **Windshield Wipers.** The windshield wipers can operate at two speeds: low and high. The windshield wipers can clear the windshield in heavy rain conditions of up to 1.6 inches per hour at airspeeds up to 204 knots per hour. Major components of the system are listed below (fig. 22-1).
 - (1) Pilot **ANTI ICE** panel provides the pilot full control of the pilot station and limited control of the CPG station windshield wiper motor.
 - (2) CPG **AUX/ANTI-ICE** panel allows the CPG to select low speed windshield wiper operation regardless of the pilot's **WSHLD WIPER** switch position.
 - (3) Motors convert electrical energy to mechanical energy to drive the windshield wipers.
 - (4) Windshield wiper assemblies provides moisture removal from the pilot's and CPG's windshields.
 - (5) Flexible driveshafts transmit rotary output of each motor to the converter.

22-2. DESCRIPTION (cont)

22-2

(6) Converters reduce the wiper motor input speed to the wiper assemblies, and convert rotary motion to oscillating motion.



M52-355

Figure 22-1. Windshield Wiper System Major Components

b. **Canopy Anti-Ice.** Major components of the canopy anti-ice system are listed below (fig. 22-2).

(1) Canopy temperature sensor monitors canopy temperature and provides a corresponding signal to the canopy Anti-ice temperature control unit.

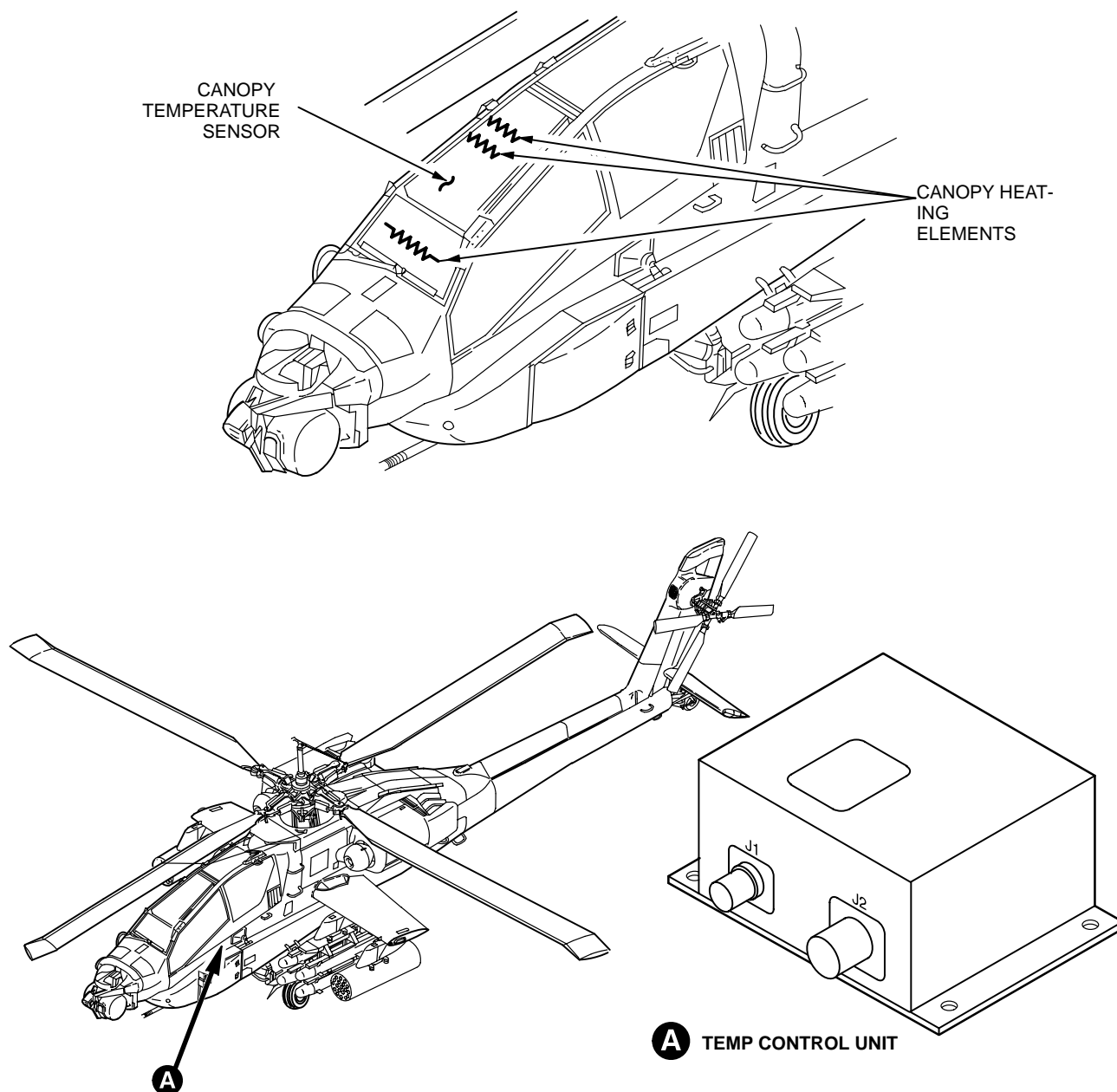
(2) Canopy heating elements prevent ice formation on the pilot and CPG's station windshields.

(3) Temp control unit monitors and controls canopy temperature.

(4) Pilot **ANTI ICE** panel **HTR** Switch (fig. 22-1) allows the pilot to control operation of the canopy anti-ice system.

22-2. DESCRIPTION (cont)

22-2



M52-359

Figure 22-2. Canopy Anti-ice System Major Components

c. **Engine Anti-Ice.** Major components of the engine anti-ice system are listed below (fig. 22-3).

(1) Engine anti-ice control switch is located on the pilot **ANTI ICE** panel. The switch gives the pilot a means of turning the engine anti-ice system on and off.

(2) NGB heater blanket is an integral part of the NGB fairing. The heater blanket prevents ice buildup around the NGB fairing.

(3) Control unit is an integral part of the NGB fairing. The control unit controls operation of the heater blanket.

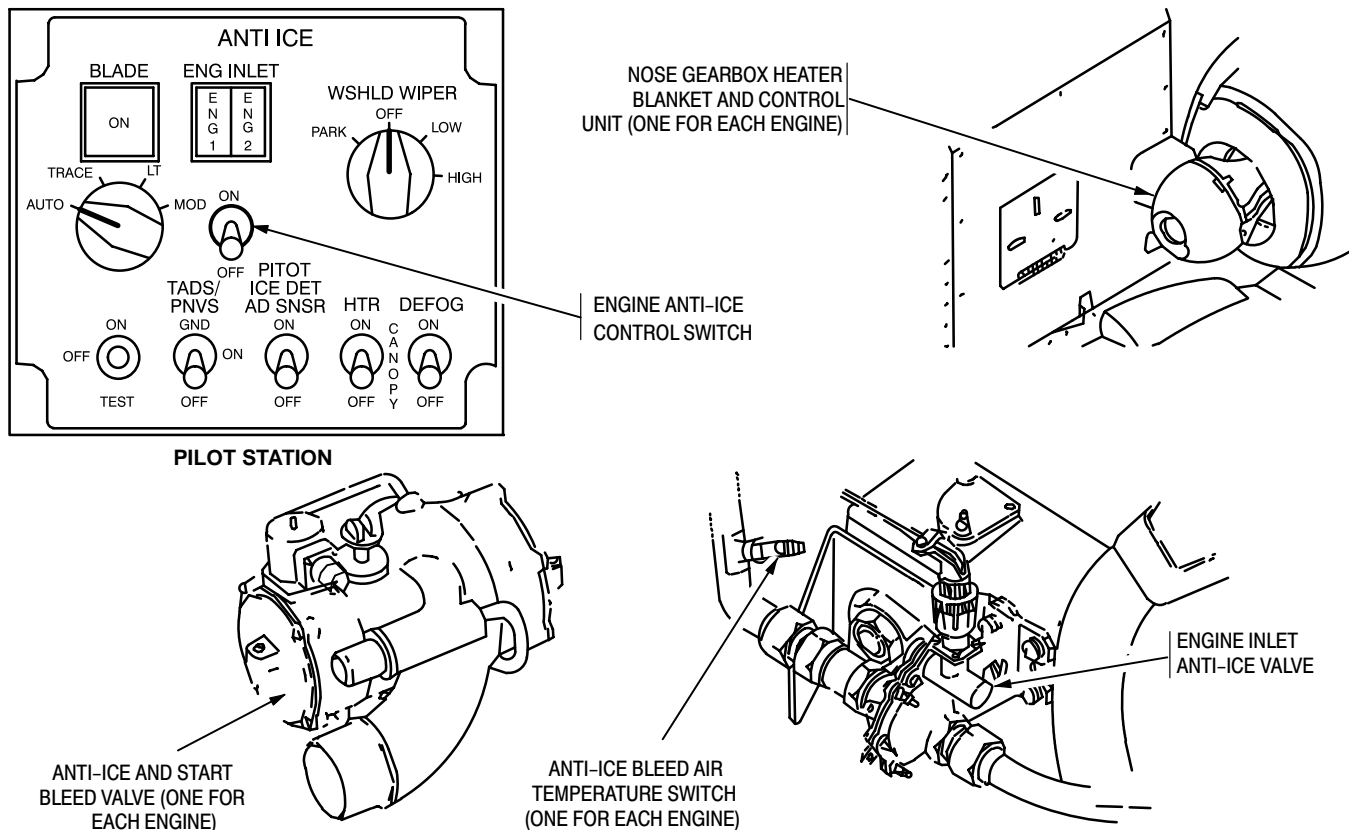
22-2. DESCRIPTION (cont)

22-2

(4) Anti-ice and start bleed valve is mounted on the compressor stator (cold seat module), lower left side (outboard on engine 1; inboard on engine 2). The engine inlet anti-ice valve controls anti-icing airflow to the engine inlet fairing; bleeds air from the compressor during start and low engine speeds.

(5) Anti-ice bleed air temperature switch is mounted in the bleed air tube between the inlet anti-ice valve and the engine inlet fairing. The anti-ice bleed air temperature switch senses the temperature of the air going from the anti-ice valve to the inlet fairing.

(6) Engine inlet anti-ice valve is located on the outboard side of the engines on the main frame cold section. The anti-ice and start bleed valve controls anti-icing airflow to the engine or air inlet section.



M52-375

Figure 22-3. Engine Anti-ice System Major Components

d. **Rotor Blade De-ice.** The main and tail rotor blades can be de-iced automatically or manually. The system can be functionally tested under full load conditions. Major components of the system are listed below (fig. 22-4).

(1) The rotor blade de-ice control switch allows the pilot to turn the rotor blade de-ice system **ON**, **OFF**, or **TEST** the system.

(2) The ice detector manual override switch allows the pilot to select automatic or manual rotor blade de-icing.

22-2. DESCRIPTION (cont)

22-2

(3) The **PITOT ICE DET AD SNSR** anti-ice control switch controls operation of the ice detector sensor 115 VAC anti-ice heater. Controls PAS air to the ice detector sensor.

(4) Blade de-ice contactor (K-3) connects 3-phase, 115 VAC to the rotor blade de-ice controller. The blade de-ice contactor provides overcurrent protection for the rotor blade de-ice controller ac input circuitry.

(5) Outside air temperature (OAT) sensor provides OAT information to the blade de-ice controller to control main and tail rotor heater "on" times.

(6) Blade de-ice contactor relay (K1-6) controls operation of the blade de-ice contactor.

(7) The ice detector sensor provides a signal to the ice detector signal processor proportional to the amount of ice detected.

(8) The ice detector sensor air shutoff valve controls PAS airflow to the ice detector sensor housing.

(9) Ice detector relay (K5-10) opens the ice detector sensor air shutoff valve and connects single- phase, 115 VAC from the **ICE DET HTR** circuit breaker to the anti-ice heater in the ice detector sensor housing.

(10) The ice detector signal processor provides a signal to the rotor blade de-ice controller which corresponds to the degree and rate of icing. Illuminates the pilot's caution/warning panel **ENG ICE** light when ice is detected by the ice detector sensor. Provides operating and control power for the icing severity indicator.

(11) The icing severity indicator provides the pilot with a visual indication of the degree of icing.

(12) The rotor blade de-ice controller determines main and tail rotor heater operating times.

(13) The distributor assembly supplies ± 134 VDC to the main rotor blade de-ice blankets.

(14) The main rotor slip ring assembly connects ± 134 VDC from the blade de-ice controller to the main rotor distributor assembly.

(15) The de-ice blankets provide uniform de-icing of the main and tail rotor blades.

(16) The tail rotor slip ring assembly provides ± 134 VDC from the blade de-ice controller to the tail rotor blade de-ice blankets.

22-2. DESCRIPTION (cont)

22-2

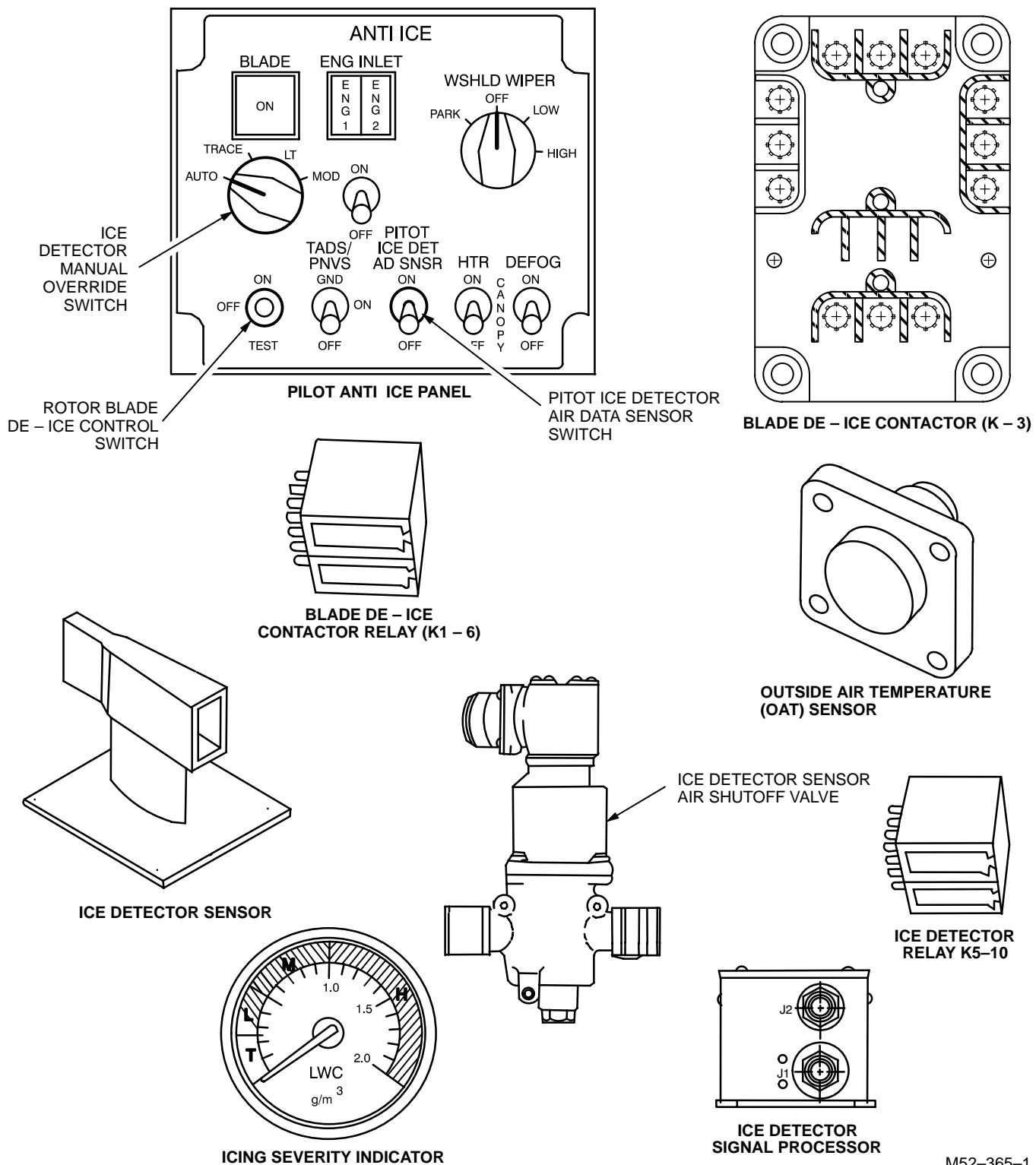


Figure 22-4. Rotor Blade De-ice System Major Components (Sheet 1 of 2)

22-2. DESCRIPTION (cont)

22-2

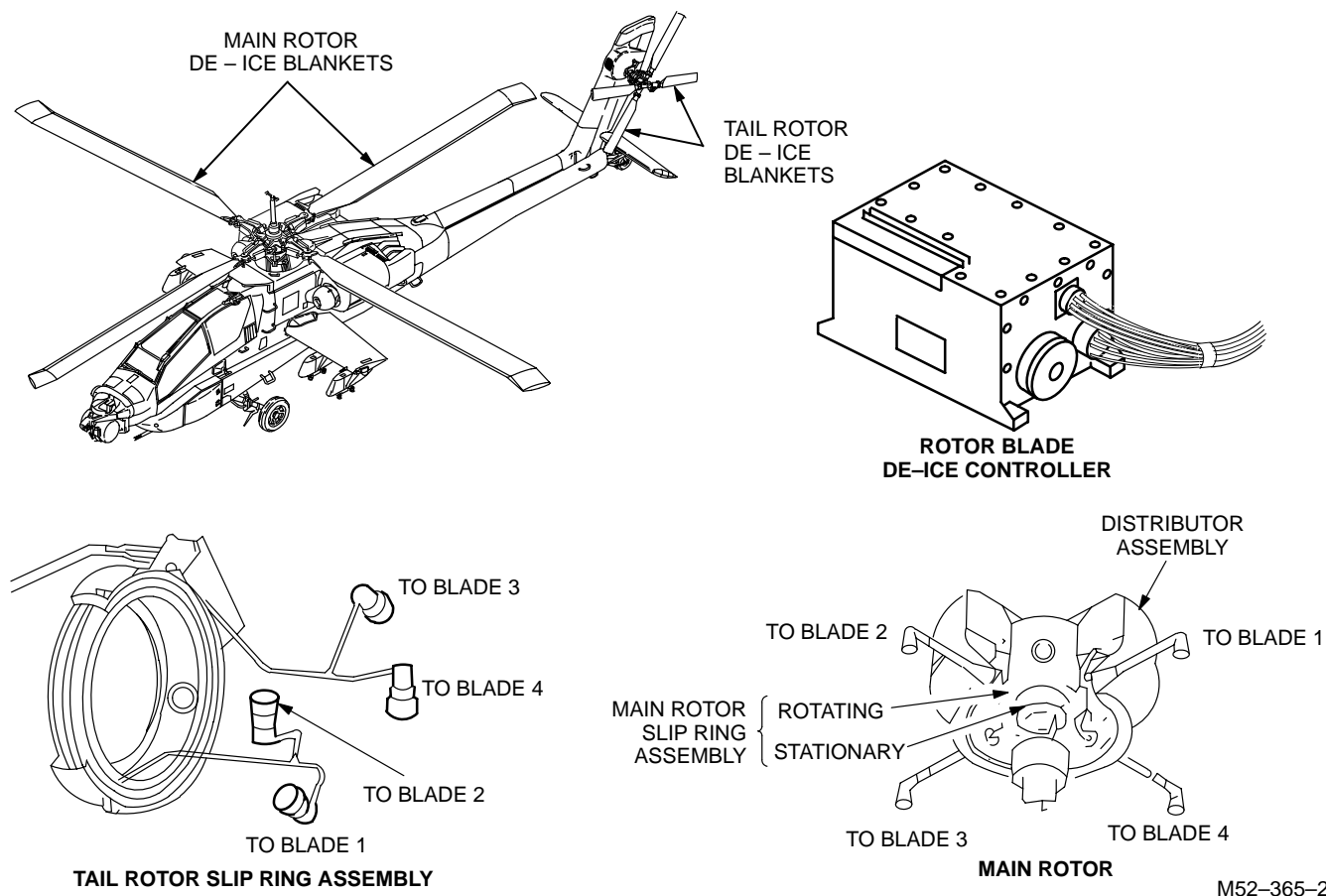


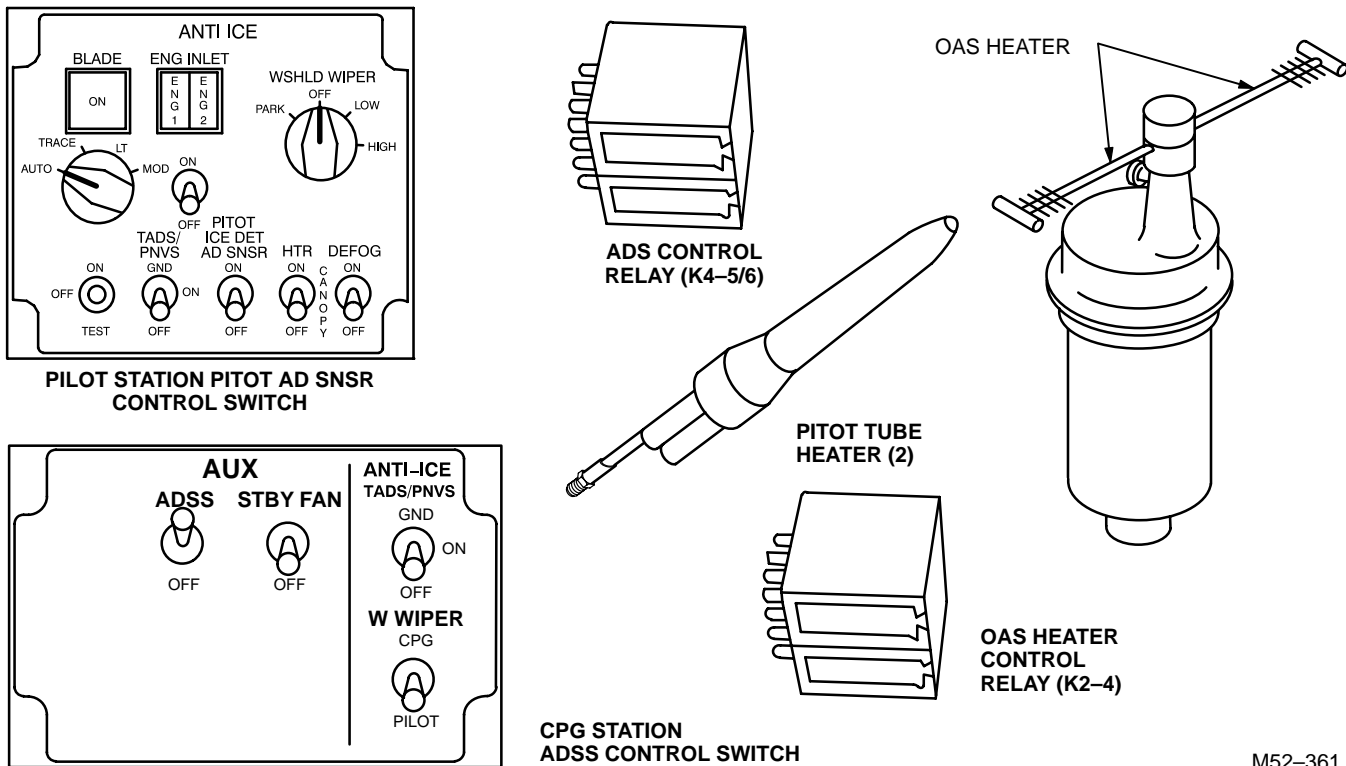
Figure 22-4. Rotor Blade De-ice System Major Components (Sheet 2 of 2)

e. **Pitot and Air Data Anti-Ice.** Major components of the pitot and air data sensor anti-ice systems are listed below (fig. 22-5).

- (1) The **PITOT ICE DET AD SNSR** control switch allows the pilot to control left and right pitot heater operation.
- (2) The **ADSS** control switch controls operation of the ADS control relay.
- (3) The OAS heater control relay controls single-phase, 115 VAC power to the OAS heater (fig. 22-6).
- (4) The OAS heater prevents ice from forming on the omnidirectional airspeed sensor (OAS).
- (5) The pitot tube heaters (two each) prevent ice from forming on the right (pilot) and left (CPG) pitot tubes.
- (6) The ADS control relay (K4-5/6) controls 28 VDC power to the air data processor. The relay also controls 3-phase, 115/200 VAC, 400 hertz motor drive power to the OAS sensor and single-phase, 115 VAC, 400 Hz OAS heater power to the OAS heater control relay.

22-2. DESCRIPTION (cont)

22-2



M52-361

Figure 22-5. Pitot and Air Data Sensor Anti-ice System Major Components

f. **TADS/PNVS Anti-Ice.** Major components of the TADS/PNVS anti-ice system (fig. 22-7) are listed below.

(1) The pilot **ANTI ICE** panel allows the pilot to engage the respective TADS/PNVS anti-ice system. The panel allows the system to be ground tested.

(2) The CPG **AUX/ANTI-ICE** panel allows the CPG to engage the respective TADS/PNVS anti-ice system. The panel allows the system to be ground tested.

(3) The squat switch controls operation of the squat relay.

(4) The squat relay controls 28 VDC from the dc bus 1 to the **ON** contacts of the respective pilot's and CPG's **TADS/PNVS** control switches. The squat relay de-energizes the TADS/PNVS anti-ice system upon touch down to protect maintenance personnel from a possible shock hazard if they should come in contact with a damaged germanium coated heater on the TADS/PNVS windows.

22-2. DESCRIPTION (cont)

22-2

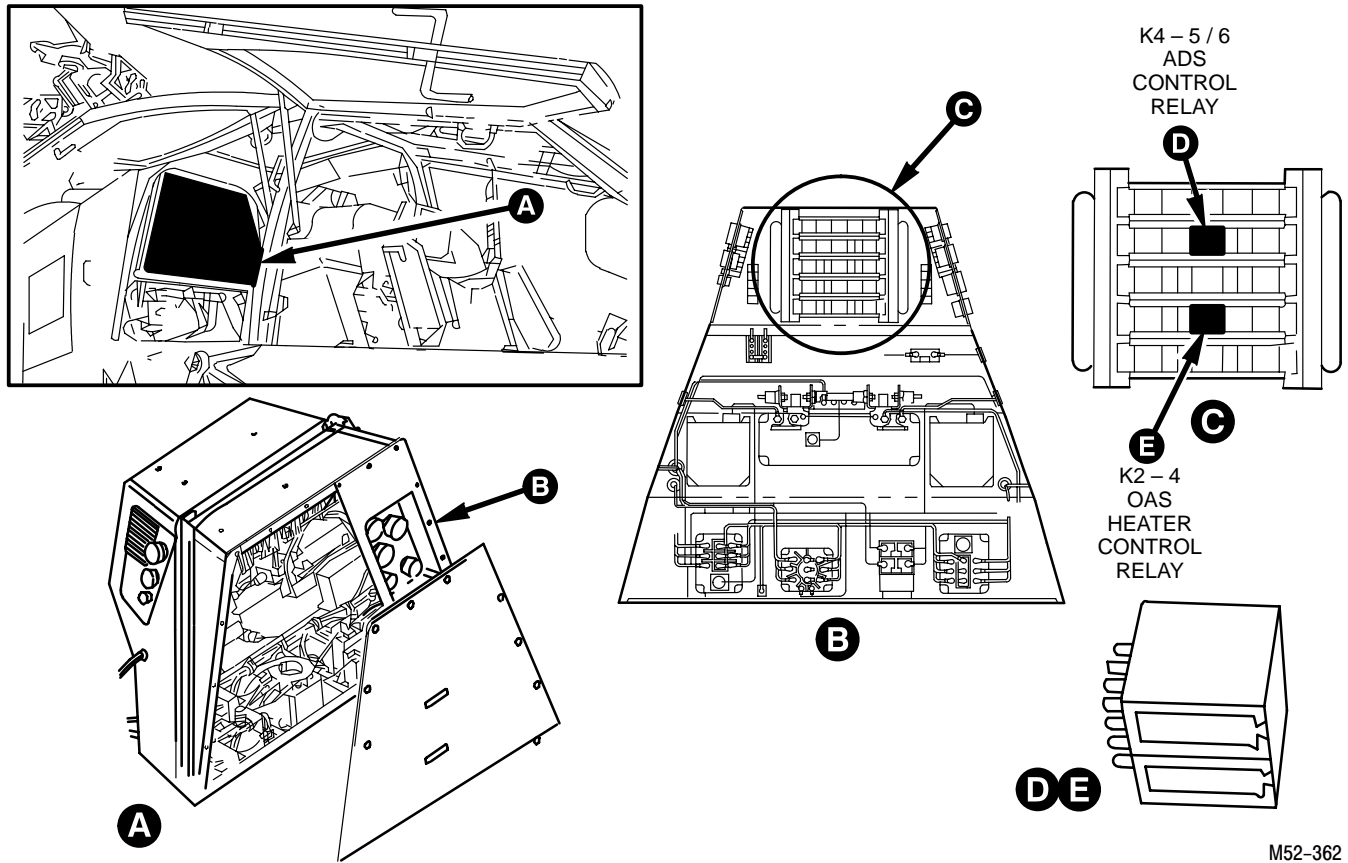
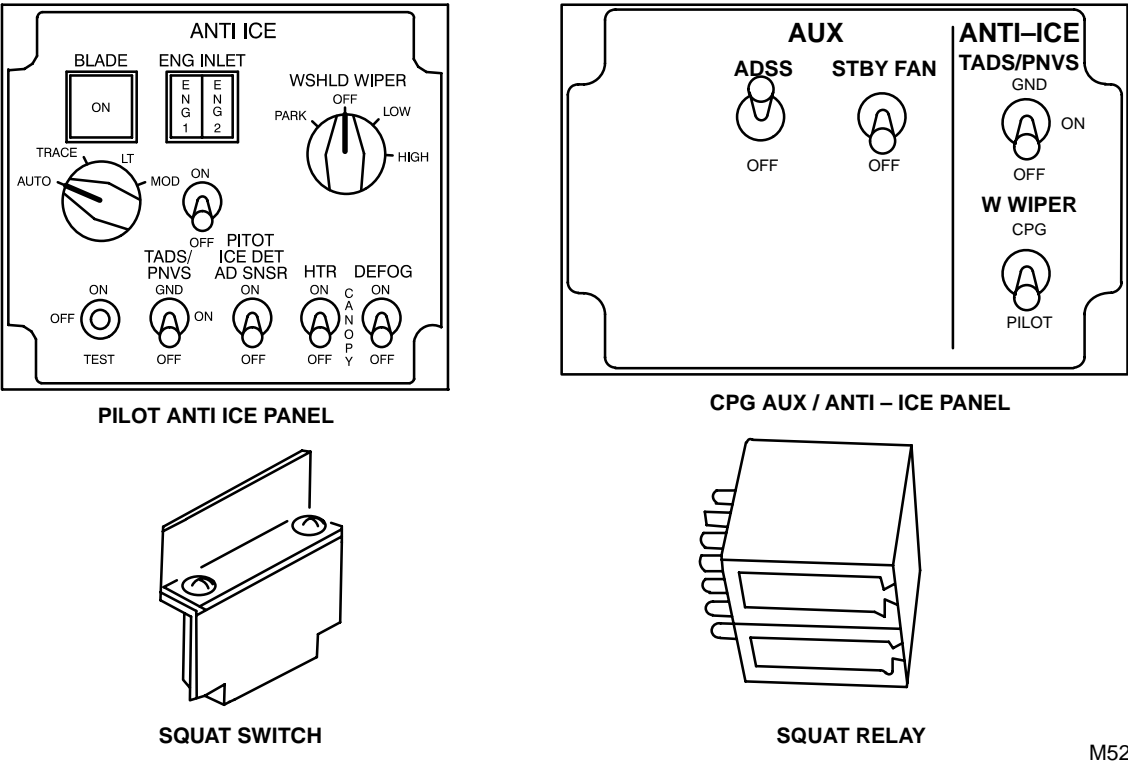


Figure 22-6. OAS Heater and ADS Control Relays



M52-371A

Figure 22-7. TADS/PNVS Anti-ice System Major Components

- g. **Canopy Defog.** Major components of the canopy defog system are listed below (fig. 22-8).
- (1) The **CANOPY DEFOG** control switch allows the pilot to control the opening and closing of the defog shutoff valve.
 - (2) The canopy defog shutoff valve allows hot air to flow through the mixers.

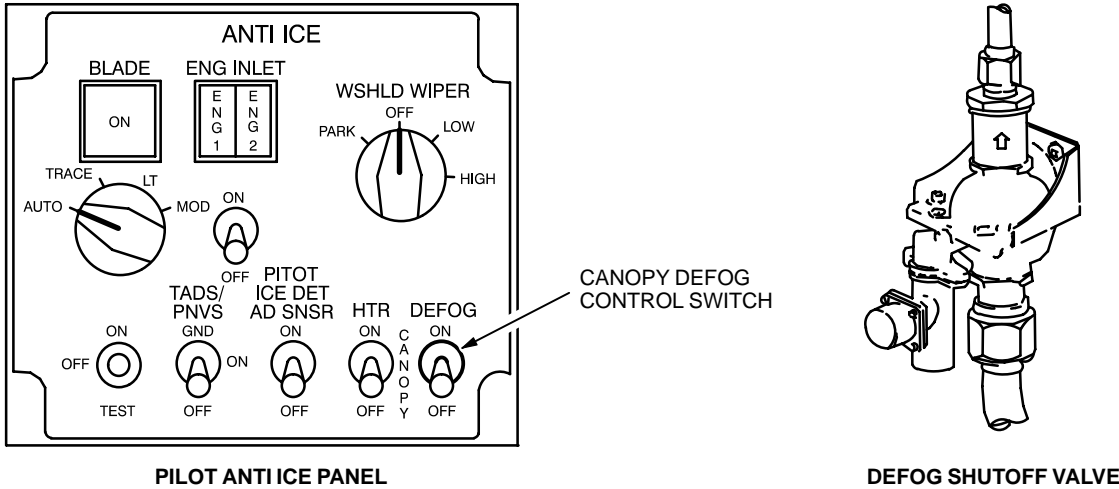


Figure 22-8. Canopy Defog System Major Components

22-2. DESCRIPTION (cont)**22-2**

h. **Fire Detection and Extinguishing.** The major components of the fire detection and extinguishing systems are listed in the following subparagraphs.

(1) The **FIRE PULL** handles (fig. 22-9) are located on the upper left portion of both instrument panels. When illuminated red, warn the crew that a fire exists in the corresponding engine compartment. When pulled, arms the **FIRE BTL** select switch, energizes the ENCU relay to remove PAS air from the ENCU, closes the respective engine nacelle louvers, and shuts off fuel to the respective engine. The pilot **APU FIRE PULL** handle is located on the upper left portion of the instrument panel. The **CPG APU FIRE PULL** handle is located on the **APU** fire panel assembly. When illuminated red, warn the crew that a fire exists in the APU/SDC area of the aft equipment bay. When pulled, arms the **FIRE BTL** select switch and energizes the APU fuel shutoff valve, shutting off fuel to the APU.

(2) Fire bottle assemblies (2 ea) (fig. 22-10) are located in the aft equipment bay, mounted on the left firewall. The fire bottles provide a source of pressurized chemical fire extinguishing agent for the engine and APU compartments.

(3) The fire bottle select switches (fig. 22-9) when armed, allow the flight crew to discharge the primary or reserve fire bottle into a selected engine or APU compartment.

(4) The engine flame detectors are located in the lower forward outboard position and the upper aft inboard position of each engine compartment. The APU flame detectors are located in the upper forward and lower aft sections of the APU shroud. The fire overheat detector is located under the main deck and on the left and right engine firewall louvers. The flame detectors are optical sensing devices which use hermetically sealed and balanced photocells to produce an electrical signal when a flame is detected. The fire/overheat and flame detectors generate a signal when a flame is detected in the respective engine compartment or the APU/SDC area of the aft equipment bay.

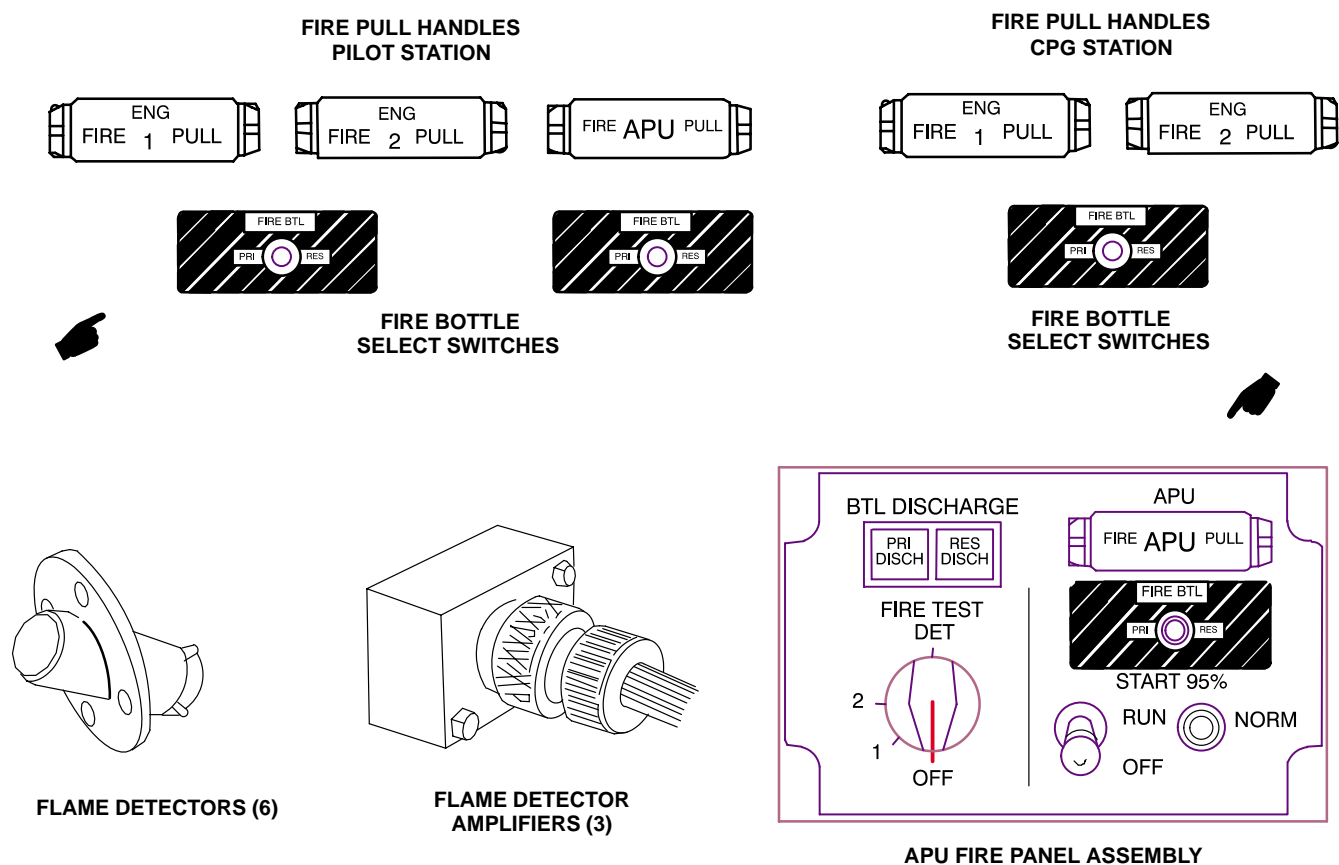
(5) There are three flame detector amplifiers. Flame detector amplifier 1 is mounted on the inboard side of the engine 1 firewall in the aft equipment bay, above the fire bottles. Flame detector amplifier 2 is mounted on the inboard side of the engine 2 firewall in the aft equipment bay, above the APU enclosure and forward of the APU flame detector amplifier. Flame detector 3 (APU) is located above the APU shroud in the aft equipment bay. The flame detector amplifier amplifies the flame detector warning signal to control the **FIRE PULL** handle lamps.

(6) The **BTL DISCHARGE/APU** control panel is located on the pilot's right console. The **FIRE TEST DET** switch allows the pilot to perform an operational test of the engine fire detection circuitry and components. The **BTL DISCHARGE** indicators light when the selected fire bottle is discharged.

(7) The fire bottle thermal discharge indicator is located on the left side of the fuselage beneath the engine compartment. The fire bottle thermal discharge indicator gives a visual indication of fire bottle discharge due to excessive temperature. The fire bottle thermal discharge indicator is discarded when the temperature in either fire bottle reaches 215° to 226°F (101.67° to 107.78°C)

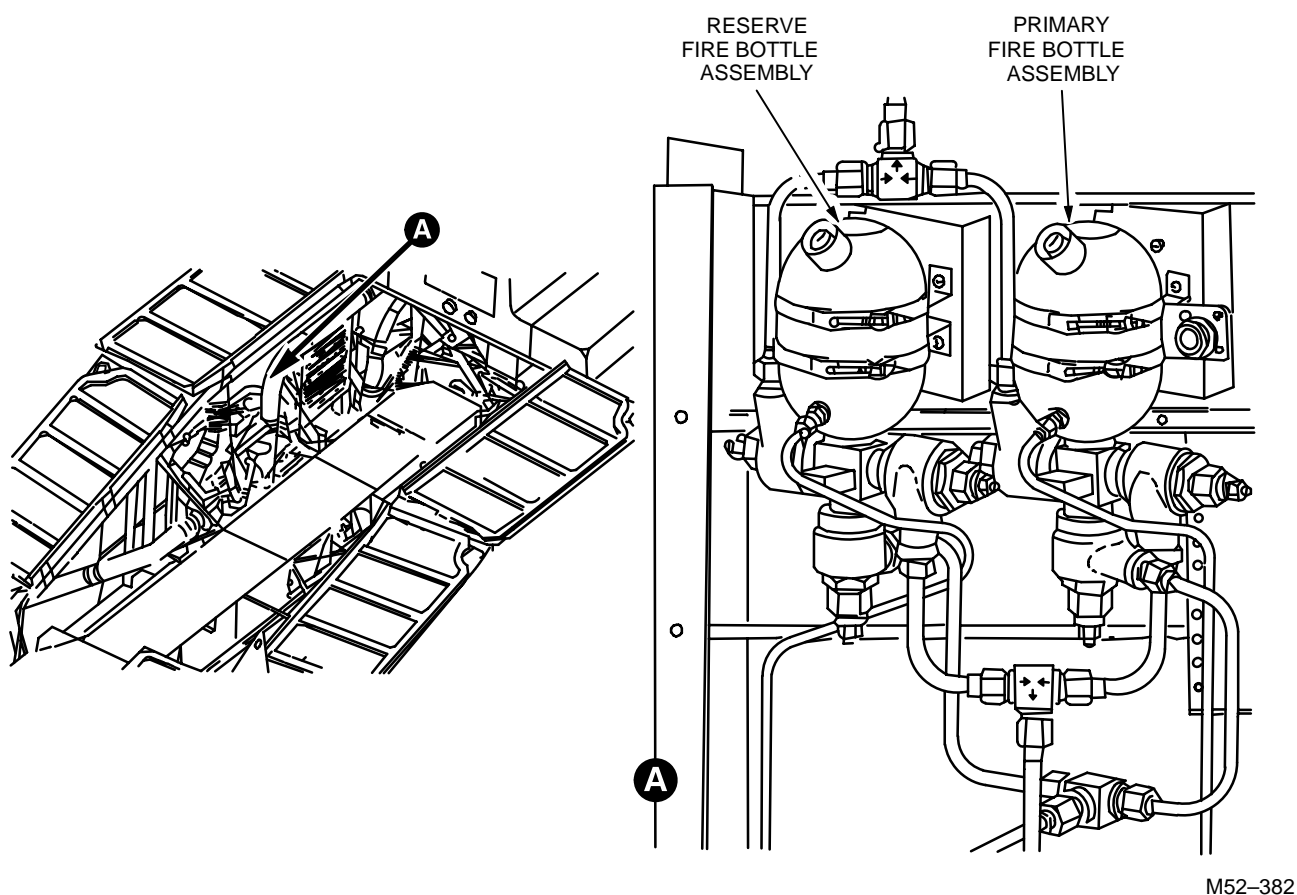
22-2. DESCRIPTION (cont)

22-2



M52-381A

Figure 22-9. Fire Detection and Extinguishing System Major Components



M52-382

Figure 22-10. Fire Bottle Assemblies

i. **Canopy Jettison.** Major components of the canopy jettison system(fig. 22-11) are listed below.

- (1) **CANOPY JETTISON** handles (3 ea) provide initiation of the canopy jettison system. Handles are located on the upper left side of the pilot and CPG instrument panels. A third handle is located under access door T-50.
- (2) Flexible confined detonating cord (FCDC) transmits detonation to the four acrylic side panels.
- (3) The interconnection union provides connection of the SMDC to FCDC at the crew station access doors.
- (4) The interconnect tees provide system interface.
- (5) The interconnect elbow connects the external handle and CPG handle to an interconnect tee.
- (6) Shielded mild detonation cord (SMDC) transmits detonation to the four acrylic side panels.
- (7) Detonation cord (X-cord) is installed around the periphery of each of the four acrylic side panels.

22-2. DESCRIPTION (cont)

22-2

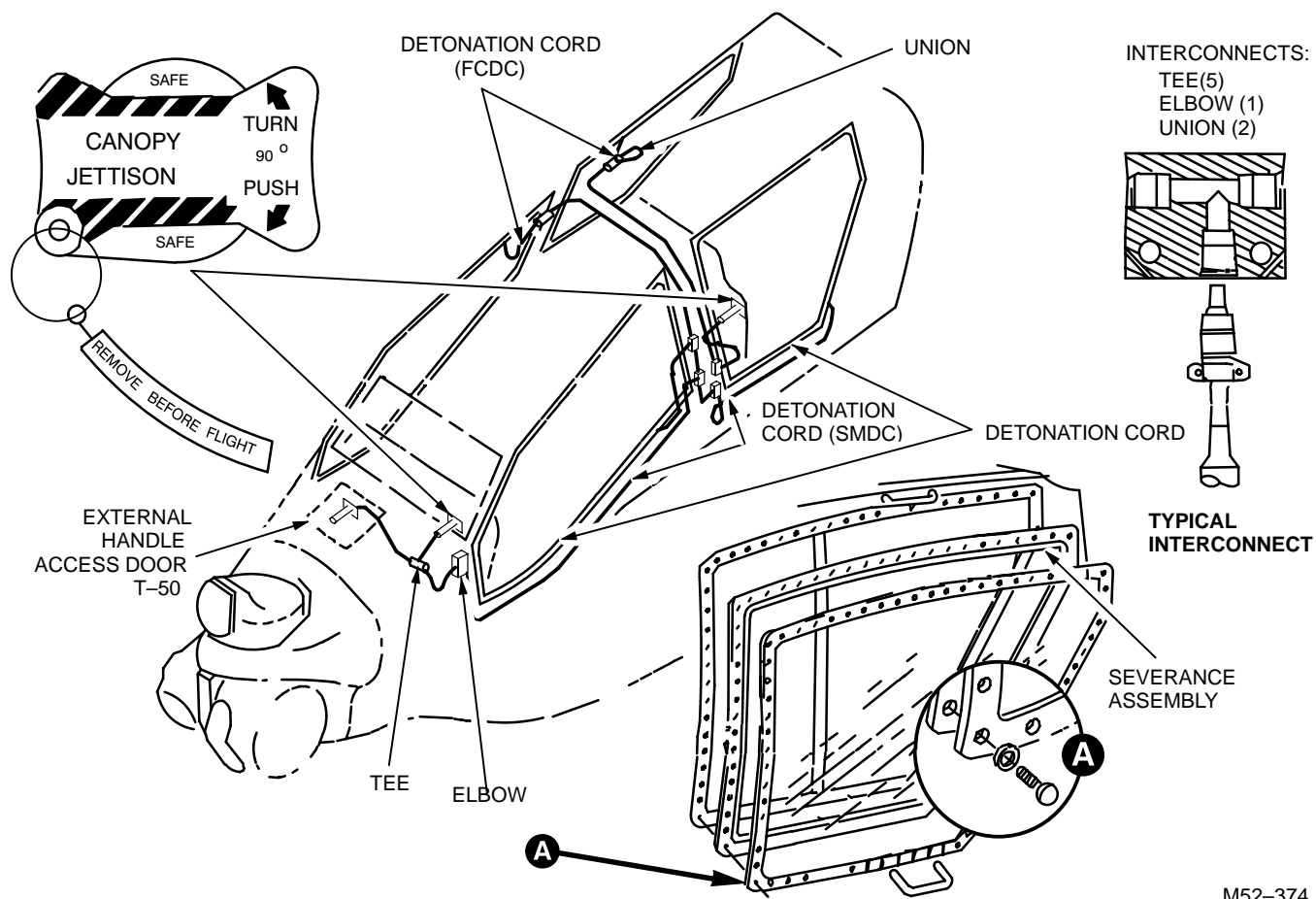


Figure 22-11. Canopy Jettison System Major Components

22-3. THEORY OF OPERATION

a. **Pilot ANTI ICE Panel.** The panel contains the **WSHLD WIPER** switch to control the wipers. Positions and functions are as follows.

- (1) **OFF.** Windshield wipers off.
- (2) **LOW.** Windshield wipers operate at low speed.
- (3) **HIGH.** Windshield wipers operate at high speed.
- (4) **PARK.** Windshield wipers go to stowed position. (This position is spring-loaded to the off position.)

b. **CPG AUX/ANTI-ICE Panel.** The panel contains the **W WIPER** switch to control the wipers. Positions and functions are as follows.

- (1) **PLT** position gives the pilot control of the windshield wiper system.
- (2) **CPG** position allows the CPG to select low speed operation for the CPG windshield wiper regardless of the pilot's **WSHLD WIPER** switch position.

22-3. THEORY OF OPERATION (cont)

22-3

c. **Flexible Driveshafts (Flexdrives).** One flexdrive is connected between each wiper motor and converter. Each flexdrive consists of a flexible cable that rotates at the speed of the wiper motor. The flexdrive drives the converter.

d. **Windshield Wiper Motors.** The motors are located in the left (pilot) and right (CPG) nose equipment bays. Each motor contains an internal limit switch for the park position.

e. **Windshield Wiper Assemblies.** The windshield wiper assemblies consist of the wiper arm, the link, and the wiper blade.

f. **Canopy Temperature Sensors.** The sensors are bonded between the outer and inner plies of the pilot's windshield. Each temperature sensor is monitored by the control unit. As windshield temperature rises, resistance rises. As windshield temperature decreases, resistance decreases.

g. **Heating Elements.** Two heating elements are bonded between the inner and outer plies of the pilot's windshield. One heating element is bonded between the inner and outer plies of the CPG windshield.

(1) All three metallic heating elements are joined together in a 3-phase, 115/200 VAC delta connection.

(2) The heating elements are placed so as to provide uniform windshield heating.

h. **Temp Control Unit.**

(1) The temp control unit receives 28 VDC control power from the dc bus 1 via the **HTR ON-OFF** switch, and three-phase, 115/200 VAC heating element power from the ac bus 2.

(2) With both ac and dc power applied, the control unit monitors the canopy temperature sensor resistance and control the application of three-phase, 115/200 VAC heater power to maintain canopy temperature between 65° and 85° F (18.3° and 29.4° C). If the canopy overheats or the temperature sensor fails, the control unit disconnects ac power from the heaters. Power may be reconnected by cycling the **HTR** control switch **OFF** and **ON**.

(3) The unit illuminates the **CANOPY ANTI-ICE FAIL** light on the pilot's caution/warning panel if one of the following failures occurs.

(a) Heating element (open or short).

(b) Temperature sensor (open or short).

(c) Input power failure (ac or dc).

(d) Canopy anti-ice temperature control unit failure.

(e) Canopy overtemperature above 95° F (35° C).

i. **Pilot HTR Switch.** Positions and functions of the switch are as follows.

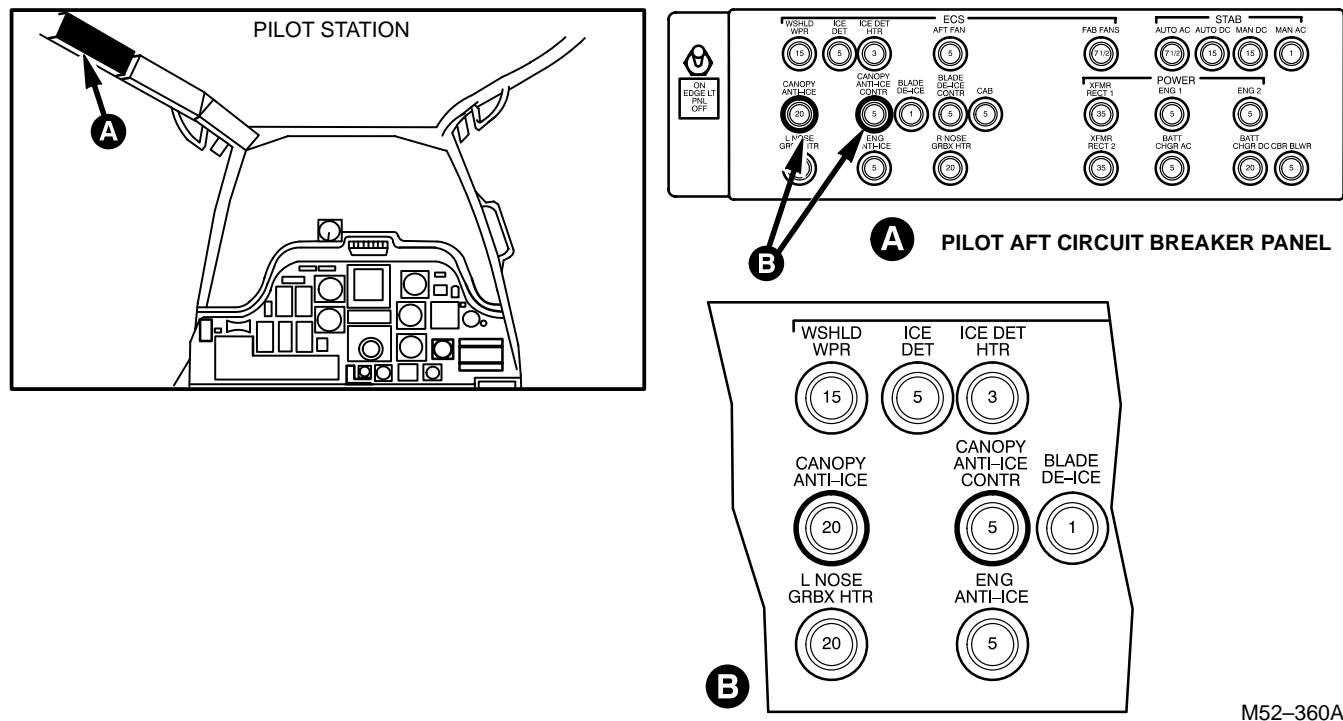
(1) **ON.** Applies 28 VDC control power to the canopy anti-ice temperature control unit and energizes the canopy anti-ice system.

(2) **OFF.** Removes 28 VDC from the canopy anti-ice control unit and de-energizes the canopy anti-ice system.

22-3. THEORY OF OPERATION (cont)

22-3

j. **Circuit Protection.** Circuit breaker **CANOPY ANTI-ICE CONTR** (CB70) (fig. 22-12) supplies 28 VDC to the temp control unit. Circuit breaker **CANOPY ANTI-ICE** (CB 78) supplies 115 VAC heater power for the canopy anti-ice system.



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Figure 22-12. Canopy Anti-ice System Circuit Breakers

k. **Engine Anti-ice Control Switch.** Positions and functions of the switch are as follows.

(1) **OFF.** Closes the engine anti-ice and start bleed valve, and the engine inlet anti-ice valve.

(2) **ON.** Opens the engine anti-ice and start bleed valve, and the engine inlet anti-ice valve. Controls voltage to the heater control unit.

l. **Engine NGB Heater.** The control unit is energized by the engine anti-ice control switch. When energized, the control unit controls the application of three-phase 115 V to the heaters to maintain the temperature of NGB fairing (fig. 22-13) between 225° and 235° F (107.2° and 112.7° C).

(1) If the fairing overheats, the safety sensor causes warning lights on the pilot and CPG caution/warning panels to illuminate, and deactivates the heaters.

(2) If the control sensor or the safety sensor become shorted, the control unit deactivates the heaters and illuminates the warning lights.

22-3. THEORY OF OPERATION (cont)

22-3

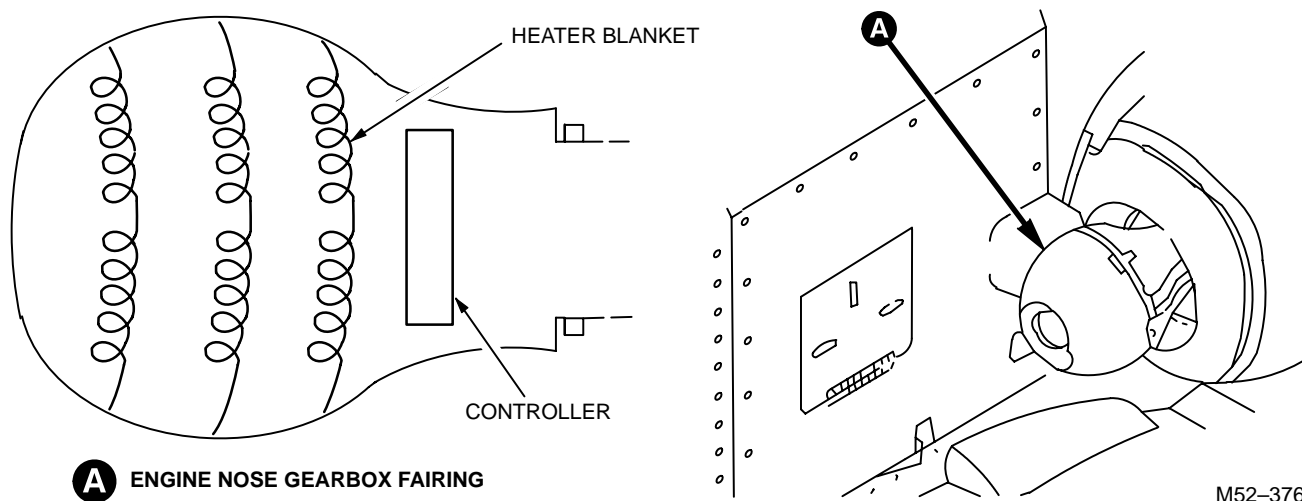


Figure 22-13. Engine NGB Fairing Anti-ice

m. **Anti-Ice and Start Bleed Valve.** The valve is controlled mechanically and electrically (fig. 22-14).

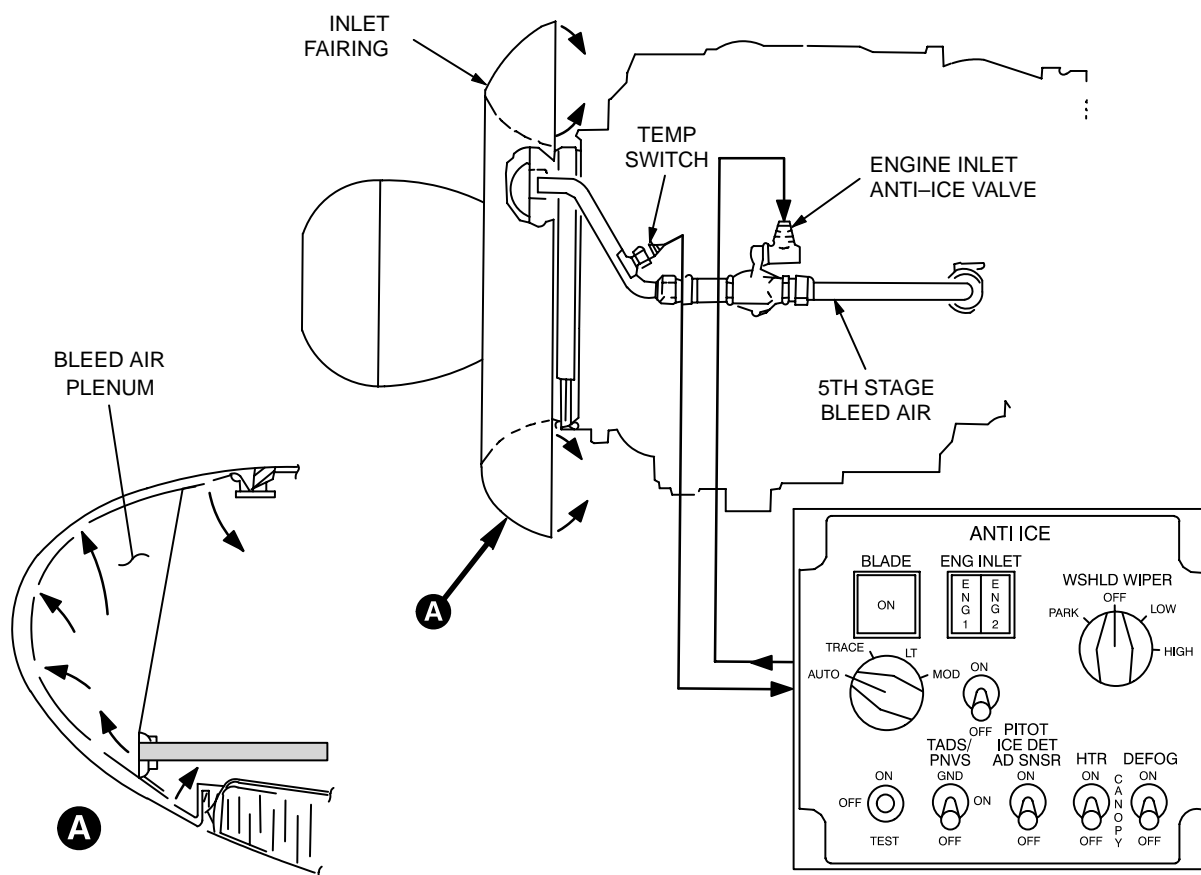
(1) The valve is controlled mechanically during start or at low engine rpm. The HMU positions a cam plate to mechanically open the metering valve, and then allows closure above 91 % Ng rpm or 60 % torque, whichever occurs first.

(2) The valve is controlled electrically by a solenoid. The solenoid, when energized, opens to allow fifth stage air to enter the servo and close the metering valve against servo spring pressure.

(3) De-energizing the solenoid closes off fifth stage air and vents the servo, allowing servo spring to open the metering valve.

(4) The valve opens if electrical power is lost.

(5) If the metering valve remains open when de-energized, the metering valve shaft moves off the sensing switch, which illuminates the pilot's **ENGINE 1** or **ENGINE 2 ANTI-ICE** and CPG's **ENGINE ANTI-ICE** lights.



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Figure 22-14. Anti-ice and Start Bleed Valve Operation

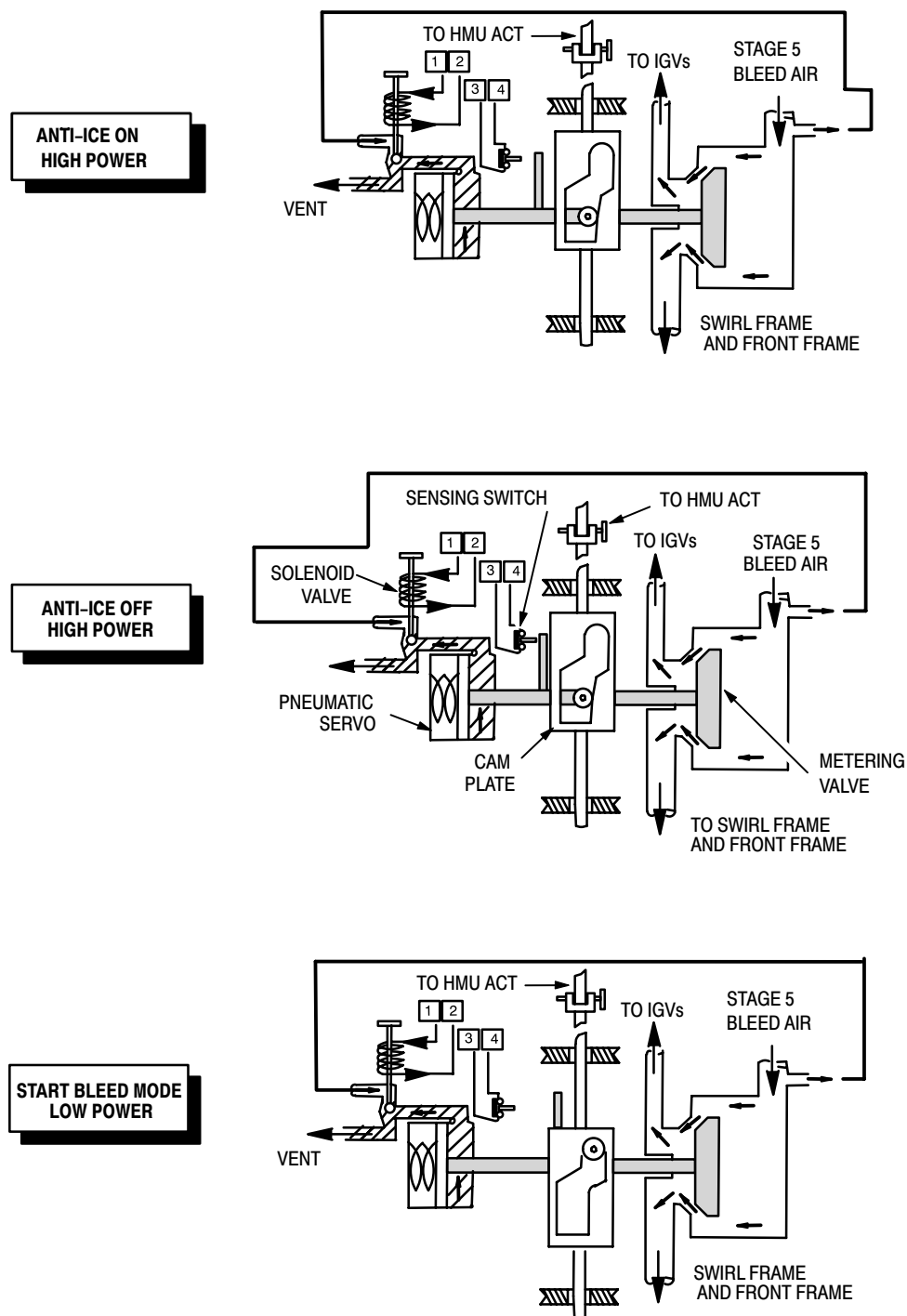
n. **Engine Inlet Anti-ice Valve.** Setting the engine anti-ice control switch to **OFF** applies 28 VDC to the coil of the valve (fig. 22-15), energizing the valve closed. Setting the switch to **ON** removes power from the coil, allowing the valve to open and supply air to the inlet fairing.

o. **Circuit Protection.** Circuit breaker **ENG ANTI-ICE** (CB67) (fig. 22-16) supplies dc power to the anti-ice system. Circuit breaker **NOSE GRBX HTR** (CB38) supplies ac power to NGB heater blankets

p. **Operating Indicators.** The **ANTI-ICE** panel contains two advisory lights. The **ENG INLET ENG 1** and **ENG 2** lights illuminate green when the engine and NGB anti-icing system is operating properly.

22-3. THEORY OF OPERATION (cont)

22-3

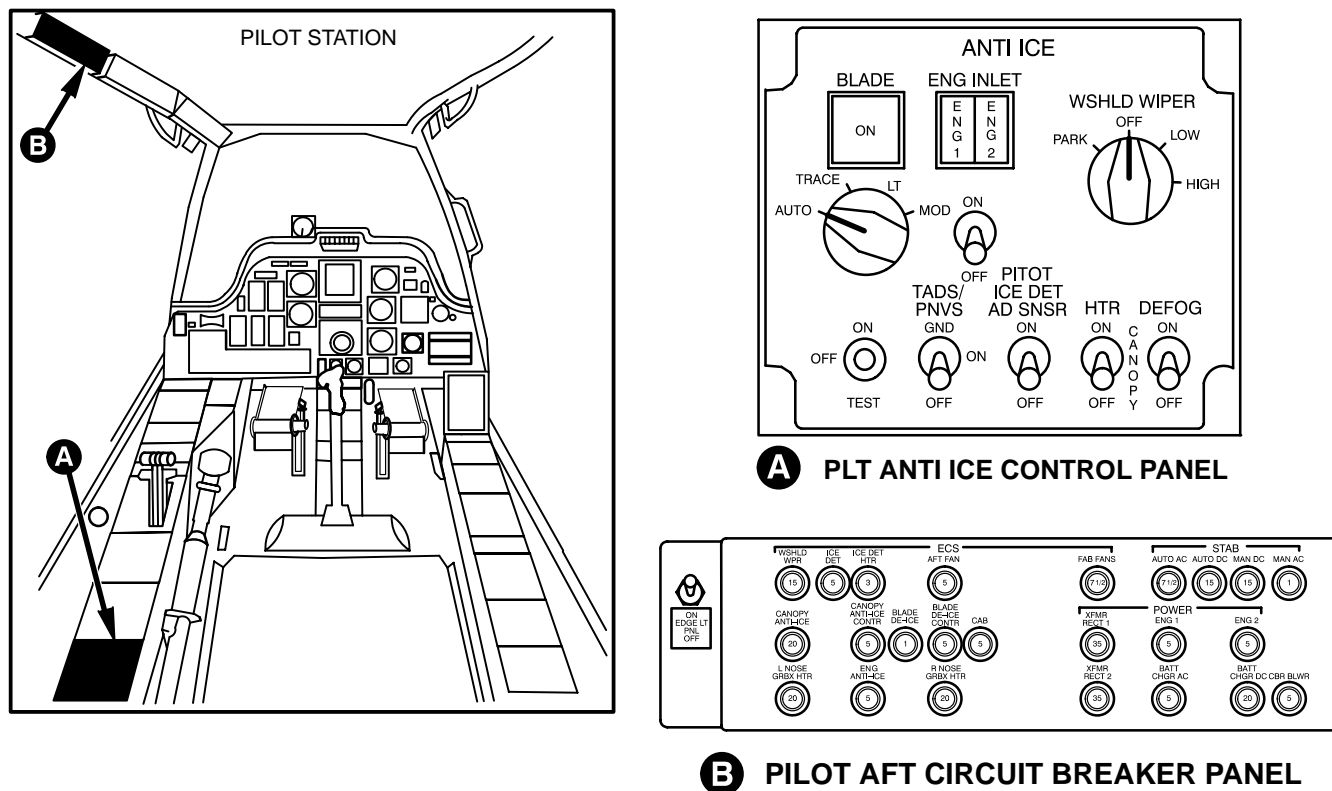


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Figure 22-15. Engine Inlet Anti-ice

22-3. THEORY OF OPERATION (cont)

22-3



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Figure 22-16. Engine Anti-ice Circuit Breakers and Indicators

q. **Warning Indicators.** The pilot and CPG caution/warning panels (fig. 22-17) contain the following indicators.

(1) Pilot Station.

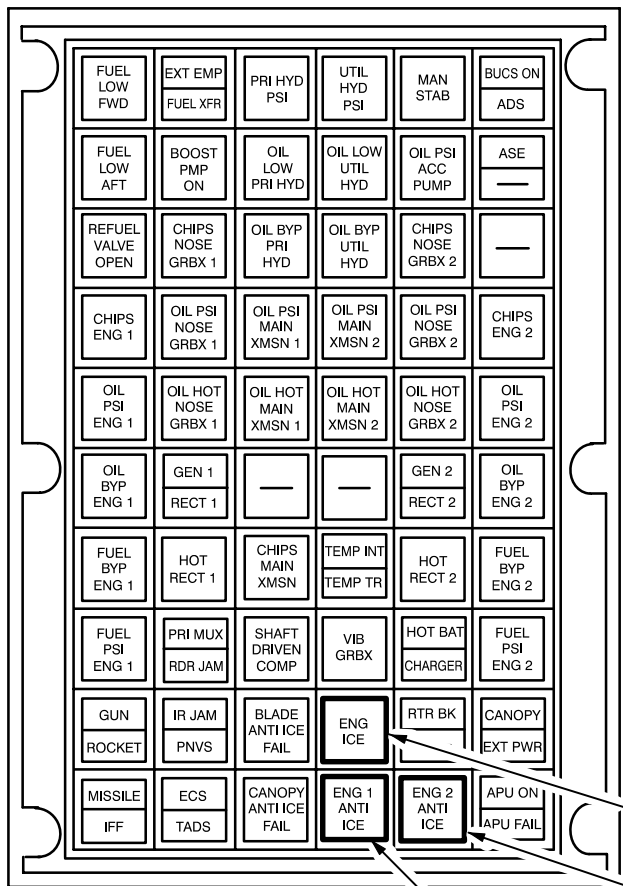
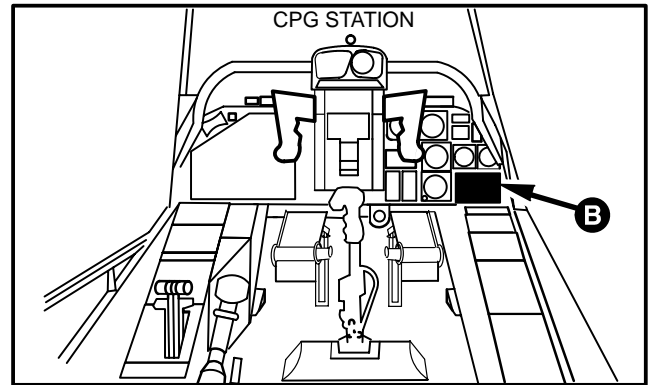
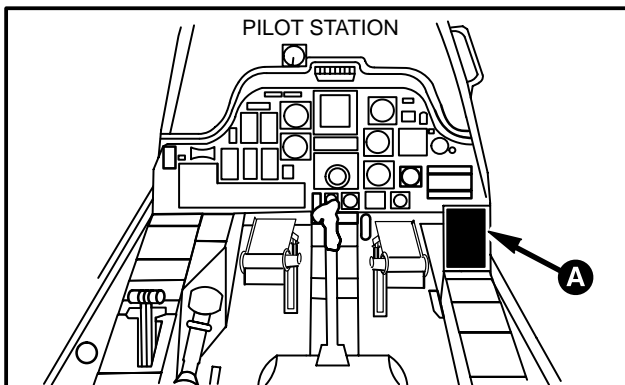
(a) **ENG ICE.** Illuminates when the ice detecting sensing head, located on the fairing above and aft of the pilots cockpit, senses ice.

(b) **ENG 1 ANTI-ICE, ENG 2 ANTI-ICE.** Illuminate when the anti-ice switch is set to **ON** until the respective anti-ice bleed air temperature switch senses 150 °F (66 °C). When the anti-ice system is on, the indicators monitor the temperature of the NGB heater blankets and the temperature of inlet bleed air. When heater blanket temperature falls below 205 °F (96 °C), or rises above 250 °F (121 °C), the respective light illuminates. When bleed air tube temperature falls to 150 °F (66 °C), the respective light illuminates.

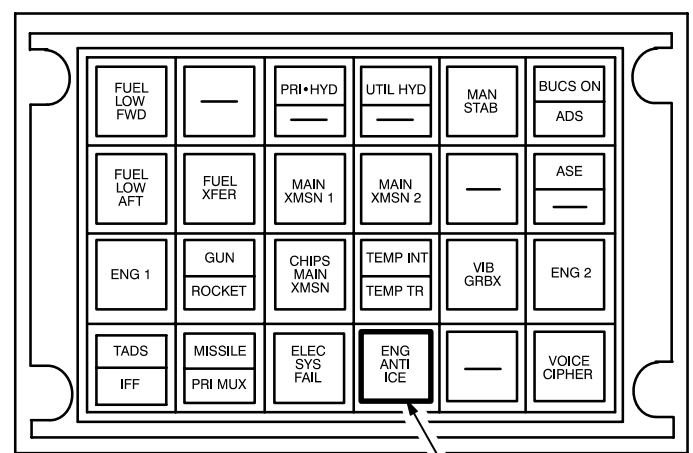
(2) CPG Station. The **ENG ANTI-ICE** caution light illuminates whenever the pilot's **ENG 1 ANTI-ICE** or **ENG 2 ANTI-ICE** lights are on.

22-3. THEORY OF OPERATION (cont)

22-3



A PILOT CAUTION / WARNING PANEL



ENG ANTI ICE

B CPG CAUTION / WARNING PANEL

ENG ICE

ENG 2 ANTI ICE

ENG 1 ANTI ICE

Figure 22-17. Engine Anti-ice Warning Indicators

r. **Pilot ANTI ICE Panel.** The panel contains the following controls.

(1) Rotor Blade De-ice Control Switch. The rotor blade de-ice control switch positions and functions are as follows.

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22-3. THEORY OF OPERATION (cont)

22-3

- (a) **OFF.** Turns off the rotor blade de-ice system.
- (b) **ON.** Turns system on.
- (c) **TEST.** Allows the system to be functionally tested under full load conditions.

(2) Ice Detector Manual Override Switch. The ice detector manual override switch positions and functions are as follows.

- (a) **AUTO.** Permits automatic blade deicing.
- (b) **TRACE.** Manual mode for trace icing conditions.
- (c) **LT.** Manual mode for light icing conditions.
- (d) **MOD.** Manual mode for moderate icing conditions.

(3) **PITOT ICE DET AD SNSR** switch positions and their functions are as follows.

- (4) **ON.** Energizes the ice detector relay.
- (5) **OFF.** No effect.

s. **Blade De-ice Contactor (K3).** Control coil power (28 VDC) and return are supplied by the **BLADE DE-ICE** circuit breaker (CB85) and the blade de-ice contactor relay (K1-6) respectively.

- (1) The contactor is directly connected to both ac generator contactors.
- (2) Each ac generator contactor supplies three-phase, 115 VAC to K3.
- (3) The contactor contains a solid state current sensing and time delay circuit which has two functions.

(a) Disconnect three-phase, 115/200 VAC from the blade de-ice controller if input load current exceeds 60 amperes for more than two seconds.

(b) Trip the **BLADE DE-ICE** circuit breaker (CB85) and de-energize the blade de-ice contactor within two seconds after ac power is disconnected from the controller.

(4) Automatic switching ensures power for rotor blade de-ice operation if only one ac electrical power system is operational.

t. **Blade De-ice Contactor Relay (K1-6).** The relay is energized by 28 VDC from the blade de-ice controller. When energized, the relay provides a ground to energize the blade de-ice contactor.

u. **Outside Air Temperature Sensor.** As temperature decreases, resistance of the outside air temperature sensor decreases. As temperature increases, sensor resistance increases. Changes in sensor resistance are input to the rotor blade de-ice controller. This causes the main and tail rotor heater "on" time to vary from 0 to 22 seconds.

v. **Ice Detector Sensor.** The ice detector sensor (fig. 22-18) is supplied 5 VAC operating voltage from the ice detector signal processor any time dc power is applied to the helicopter. This causes the sensor to vibrate at a specific frequency. The frequency of the sensor is applied back to the ice detector signal processor where the frequency is compared to a reference signal.

22-3. THEORY OF OPERATION (cont)

22-3

(1) When the **PITOT ICE DET AD SNSR** switch is placed in the **ON** position, the ice detector relay is energized. The ice detector relay has two functions.

- (a) Connects 115 VAC to the ice detector sensor housing for anti-icing of the housing.
- (b) Applies 28 VDC to energize the ice detector sensor air shutoff valve open.

(2) When the ice detector sensor air shutoff valve is open, PAS air flows through the housing of the ice detector sensor.

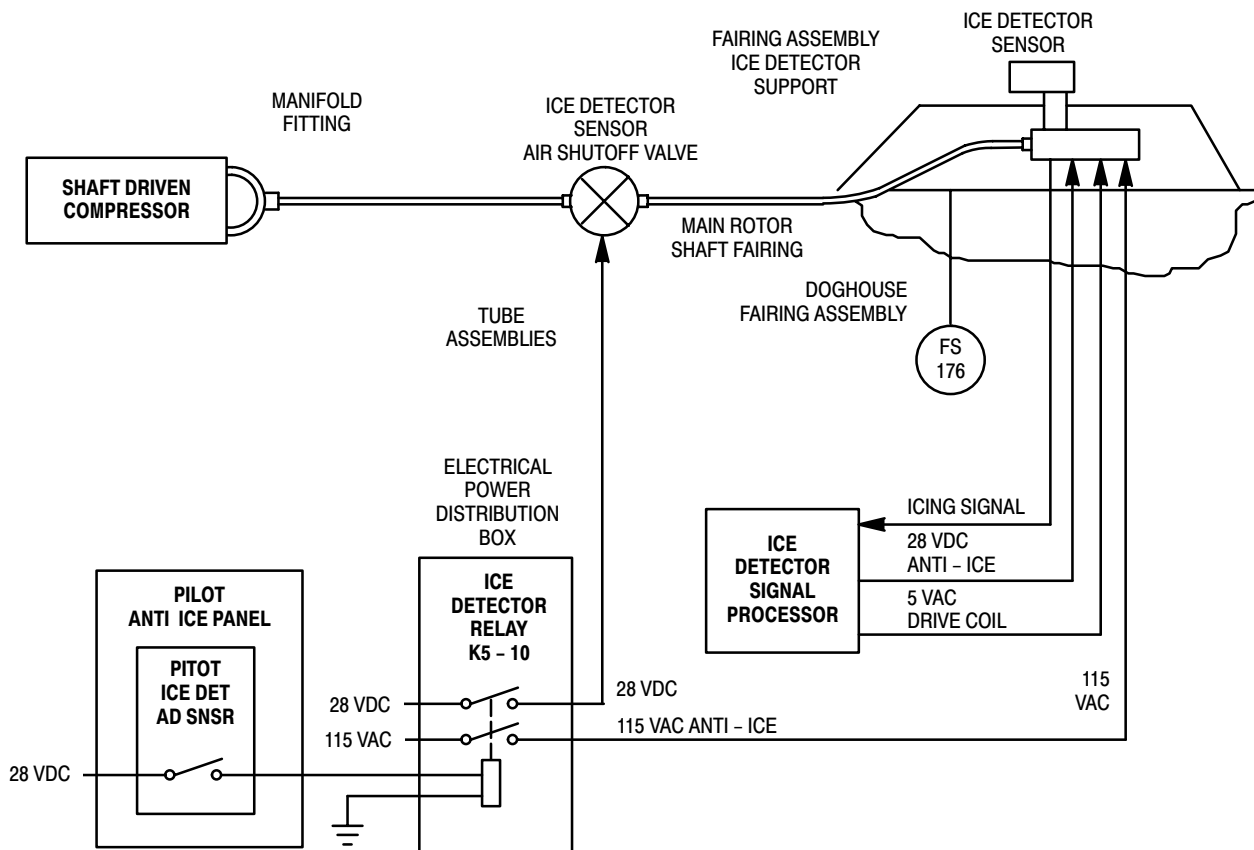
(3) The PAS air creates a venturi which draws outside air into the housing and across the ice detector sensor. This ensures a constant ambient air flow across the sensor at all airspeeds.

(4) As ice forms on the sensor, the frequency of the sensor decreases due to the weight of the ice. The frequency is compared to the reference frequency by the ice detector signal processor.

(5) If 0.005 to 0.015 inches of ice forms on the sensor, the frequency decreases and causes the ice detector signal processor to initiate the blade de-ice sequence.

(6) When the ice detector signal processor determines that 0.015 inch of ice has formed on the sensor, the processor provides 28 VDC to de-ice the sensor.

(7) As soon as the sensor is de-iced, the processor removes the de-ice power and the sensor is able to detect ice buildup again.



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Figure 22-18. Ice Detector Sensor Block Diagram

22-3. THEORY OF OPERATION (cont)

22-3

w. **Icing Severity Indicator.** The icing severity indicator is controlled by the ice detector signal processor.

(1) The analog indicator is divided into four sections which indicate the degree of icing severity in liquid water content (LWC) as follows.

- (a) **T.** (0.00 to 0.25 LWC gram per cubic meter).
- (b) **L.** (0.25 to 0.50 LWC gram per cubic meter).
- (c) **M.** (0.5 to 1.0 LWC gram per cubic meter).
- (d) **H.** (1.0 to 2.0 LWC grams per cubic meter).

(2) A press-to-test switch is mounted next to the indicator. When the test switch is pressed, the indicator needle is driven to the 1.5 mark (approximately 3/4 scale needle deflection).

x. **Ice Detector Signal Processor.** With dc operating power applied, the ice detector signal processor is activated and supplies 5 ± 1 VAC operating power to the ice detector sensor vibrating probe.

(1) The sensor probe activates and provides a frequency comparison signal to the ice detector signal processor.

(2) The ice detector signal processor contains a frequency comparison circuit which compares the input signal frequency to an internally generated preset reference frequency.

(3) Under no ice conditions the difference between the comparison and reference frequency is 200 ± 30 Hz.

(4) When ice (0.005 to 0.015 inch) is detected by the sensor, the frequency of the comparison signal decreases. This causes the frequency difference between the comparison signal and the reference signal to increase and trigger the ice detector signal processor.

(5) When triggered, the signal processor provides the following functions.

- (a) Provides 28 VDC to illuminate the **ENG ICE** light.
- (b) Provides a signal to the icing severity indicator which corresponds to the degree of icing.
- (c) Provides 28 VDC to cycle the ice detector sensor vibrating probe heater.
- (d) Measures the frequency of heater cycling.
- (e) Compares the frequency of heater cycling to the comparison circuit difference frequency.

Provides a signal (0 to 10 VDC) to the rotor blade de-ice controller (via the ice detector manual override switch) which corresponds to the degree and rate of icing.

(f) Maintains the degree and rate of icing signal for 60 seconds after the sensing head has been de-iced or until 0.005 inch of new ice has formed, whichever is less.

y. **Rotor Blade De-ice Controller.**

(1) The controller compares the following inputs to determine main and tail rotor heater operating times.

- (a) OAT sensor.

22-3. THEORY OF OPERATION (cont)

22-3

(b) Ice detector manual override switch provides automatic mode (input from ice detector signal processor); **TR**, **LT**, or **MOD** (input generated by the de-ice controller).

(c) Main and tail rotor blade heating element current. By monitoring the current, the resistance can be determined. Maximum normal current for the main rotor heaters (opposing blades) is 43 amps. Maximum normal current for the tail rotor heaters (all 4 blades) is 28 amps.

(2) The controller rectifies 115/200 VAC input power to ± 134 VDC in timed pulses to the respective main and tail rotor heating elements. The controller provides pulsed voltages to the main rotor distributor assembly to control sequential power application to the individual main rotor heating elements.

(3) The controller provides a ground to illuminate the pilot's caution/warning panel **BLADE ANTI-ICE FAIL** light if one of the following components should fail.

- (a) Main rotor distributor assembly.
- (b) Main rotor blade heater (open or short).
- (c) Tail rotor blade heater (open or short).
- (d) Rotor blade de-ice controller.

(4) The controller is powered by 28 VDC from the dc bus 3 via the **BLADE DE-ICE CONT** circuit breaker, and 3-phase 115/200 VAC from generator 1 or 2.

(5) The controller contains five adjustment modules (fig. 22-19) used to set the reference resistance for each blade heater zone into the controller.

(6) The controller uses the reference resistance and the amount of current required for each heater zone to determine the temperature of the blade.

(a) The heater elements have a positive temperature coefficient. (If temperature increases, resistance increases.)

(b) The controller determines the temperature of the blade by comparing the reference resistance of each heater zone to the amount of current used by the heater.

(7) The modules are labeled as follows.

- (a) P10 is used for the tail rotor.
- (b) P11 is used for the main rotor blade 1.
- (c) P12 is used for the main rotor blade 2.
- (d) P13 is used for the main rotor blade 3.
- (e) P14 is used for the main rotor blade 4.

(8) Each module has five variable resistors, one for each heater zone on the blade. The tail rotor module has five variable resistors, but only four are used, one for each blade.

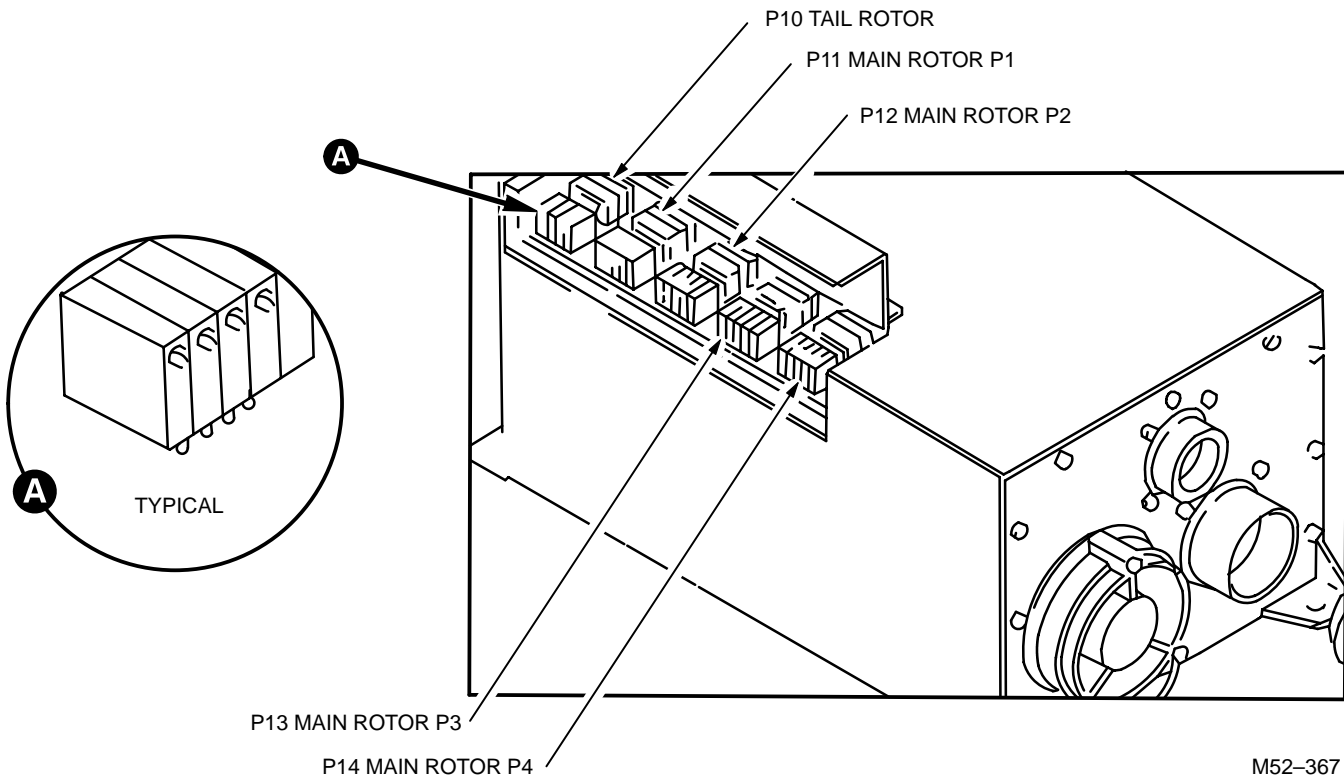


Figure 22-19. De-Ice Controller Adjustment Modules

z. Rotor Blade De-ice Controller Interconnect.

(1) With the rotor blade de-ice control switch in the **ON** position, 28 VDC activates the rotor blade de-ice controller.

(2) The rotor blade de-ice controller provides a 28 VDC output signal which energizes the blade de-ice contactor relay.

(3) This causes the blade de-ice contactor (K3) to energize and apply three phase 115/200 VAC to the rotor blade de-ice controller.

(4) The de-ice controller rectifies the 115/200 VAC input to ± 134 VDC heater voltage.

(5) Heater voltage **ON** (application) time is controlled by two independent control circuits.

(a) Time control. Controls heater "on" time over a range of 0 to 22 seconds in response to input data from the OAT sensor.

(b) Temperature control. Monitors the current and resistance of the blade heating elements and terminates heating as soon as a preset value of resistance is reached.

(6) Main and tail rotor heater voltage application is synchronized by the rotor blade de-ice controller to prevent both systems from operating at the same time and creating an over current condition.

(7) Main rotor heater voltage application is further controlled by sequential switching signals from the rotor blade de-ice controller to the main rotor distributor stepper switch.

22-3. THEORY OF OPERATION (cont)

22-3

(8) The main rotor distributor stepper switch signals cause power to be applied sequentially to the individual main rotor blade heating elements.

(9) Blade heater "off" time is determined by the controller as a function of the ice detector signal processor inputs and the ice detector manual override switch position.

(a) With the ice detector manual override switch in the **AUTO** position, the controller input is 0 to 10 VDC as determined by the ice detector signal processor.

(b) With the ice detector manual override switch in the manual positions trace, light, or moderate (**TR**, **LT**, or **MOD**), the ice detector input is a fixed level generated by the controller.

aa. Distributor and Slip Ring Assemblies.

(1) The main slip ring assembly consists of a stationary ring, two rotating slip rings, and carbon brushes. Carbon brushes transfer electrical power from the stationary ring to the rotating slip rings. The rotating slip rings connect power to the main rotor distributor assembly. The main rotor distributor assembly supplies dc voltage to the main rotor blade de-ice blankets.

(2) The tail rotor slip ring assembly consists of a stationary housing assembly, two rotating slip rings, and carbon brushes.

(a) Carbon brushes transfer power from the stationary housing assembly to the rotating slip rings.

(b) The rotating slip rings transfer electrical power to the tail rotor blade de-ice blankets.

ab. Main and Tail Rotor Blade De-ice Blankets. The blankets are thermally conductive composite blankets which contain etched foil heating elements. The heating elements have a positive temperature coefficient.

(1) The main rotor blades utilize two de-ice blankets on each blade. The forward blanket is internally bonded to the top and bottom of the leading edge and contains four heating elements. The aft blanket is internally bonded to the bottom, just aft of the leading edge blanket, and contains two heating elements. The aft and forward blankets together provide heater coverage to the 10 % chord on the upper surface and the 26 % chord on the lower surface.

(2) The tail rotor blades have only one blanket on each blade. The blanket is bonded to the top and bottom of the leading edge and contains a single heating element. The heater coverage extends to the 10 % chord on the upper surface and the 24 % chord on the lower surface.

(3) The main and tail rotor blankets are bonded to the blades so that all areas are uniformly heated.

ac. Caution/Warning Rotor Blade De-ice Caution Lights (fig. 22-20).

(1) **ENG ICE** caution light alerts the pilot that ice has been sensed by the ice detector sensor.

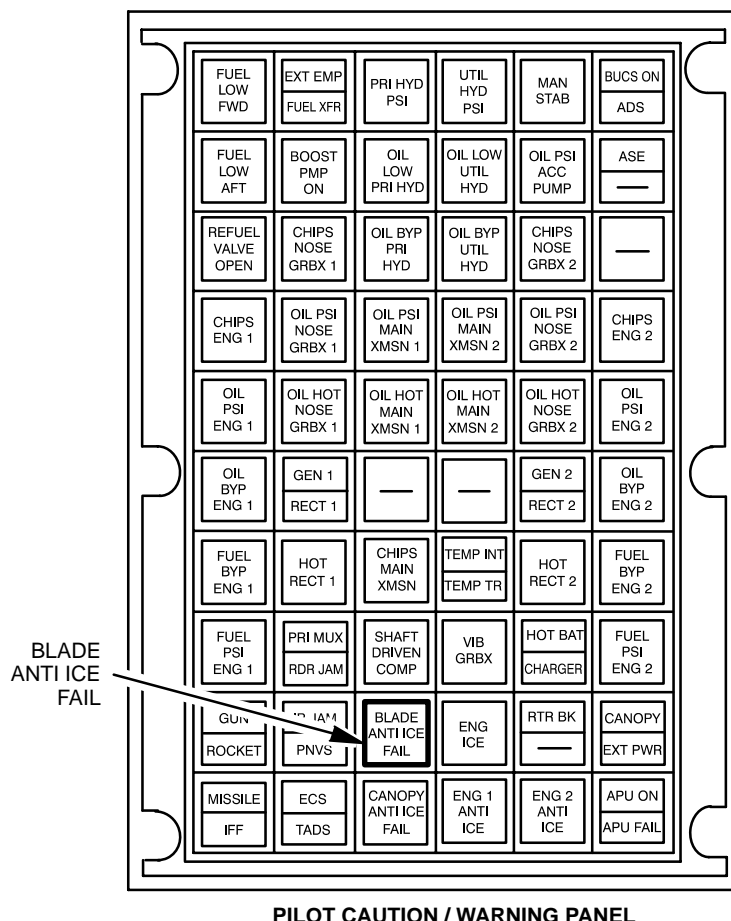
(2) **BLADE ANTI-ICE FAIL** caution light alerts the pilot to a failure of the rotor blade de-ice system. Illuminates when any of the following failures occur.

(a) Rotor blade de-ice controller.

(b) Main rotor distributor assembly.

(c) Main rotor blade heater (open or short).

(d) Tail rotor blade heater (open or short).



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Figure 22-20. Rotor Blade De-ice Caution Lights

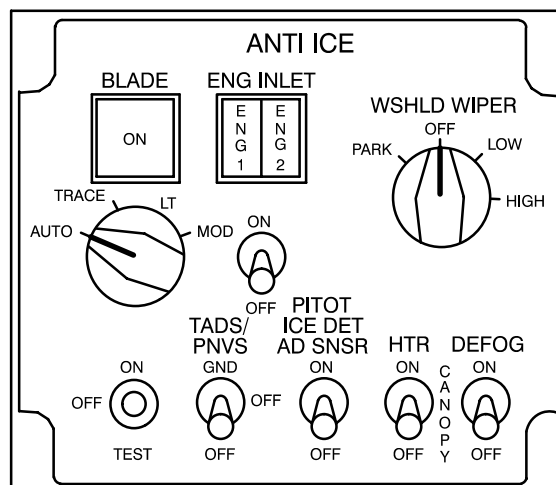
ad. **Pilot's ANTI ICE BLADE ON Panel Light** (fig. 22-21). The **BLADE ON** advisory light advises the pilot that the rotor blade de-ice system is operating.

ae. **Blade Anti-ice Circuit Protection** (fig. 22-22).

- (1) **BLADE DE-ICE** circuit breaker provides circuit protection for the blade de-ice contactor circuitry.
- (2) **ICE DET** circuit breaker provides circuit protection for the ice detector signal processor circuitry.
- (3) **BLADE DE-ICE CONTR** circuit breaker provides circuit protection for the rotor blade de-ice controller circuitry.
- (4) **ICE DET HTR** circuit breaker provides circuit protection for the ice detector sensor shroud anti-ice heater.

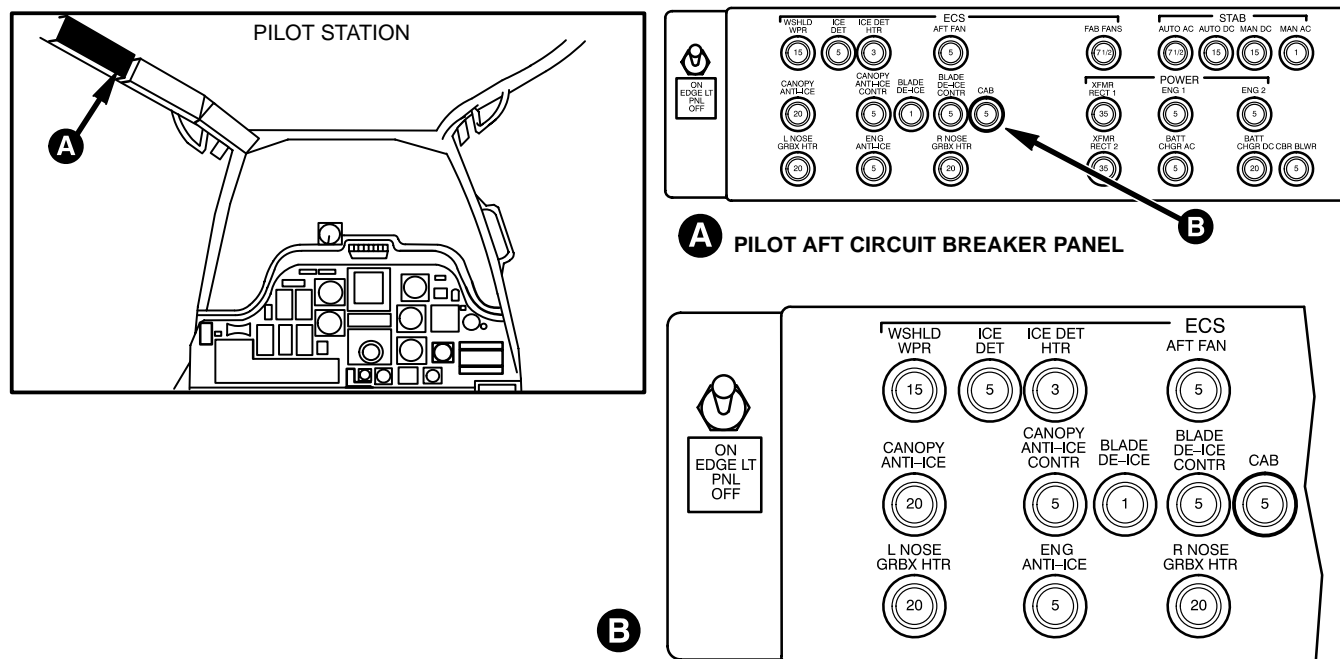
22-3. THEORY OF OPERATION (cont)

22-3



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Figure 22-21. Pilot ANTI ICE Panel



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Figure 22-22. Rotor Blade De-ice System Circuit Breakers

af. Pitot System Operation.

(1) With the pilot's **PITOT ICE DET AD SNSR** switch placed in the **ON** position, 28 VDC is supplied as follows (fig. 22-23).

(a) From the **PITOT HTR** circuit breaker through contacts 2 and 3 of the **PITOT ICE DET AD SNSR** switch to the pilot's pitot tube heater.

22-3. THEORY OF OPERATION (cont)

22-3

(b) From the **AIR DATA DC** circuit breaker through contacts 5 and 6 to the CPG's pitot tube heater and the coil of the OAS heater control relay via the **PITOT ICE DET AD SNSR** switch.

(2) This causes both pitot tube heaters to heat and the OAS Heater Control Relay to energize.

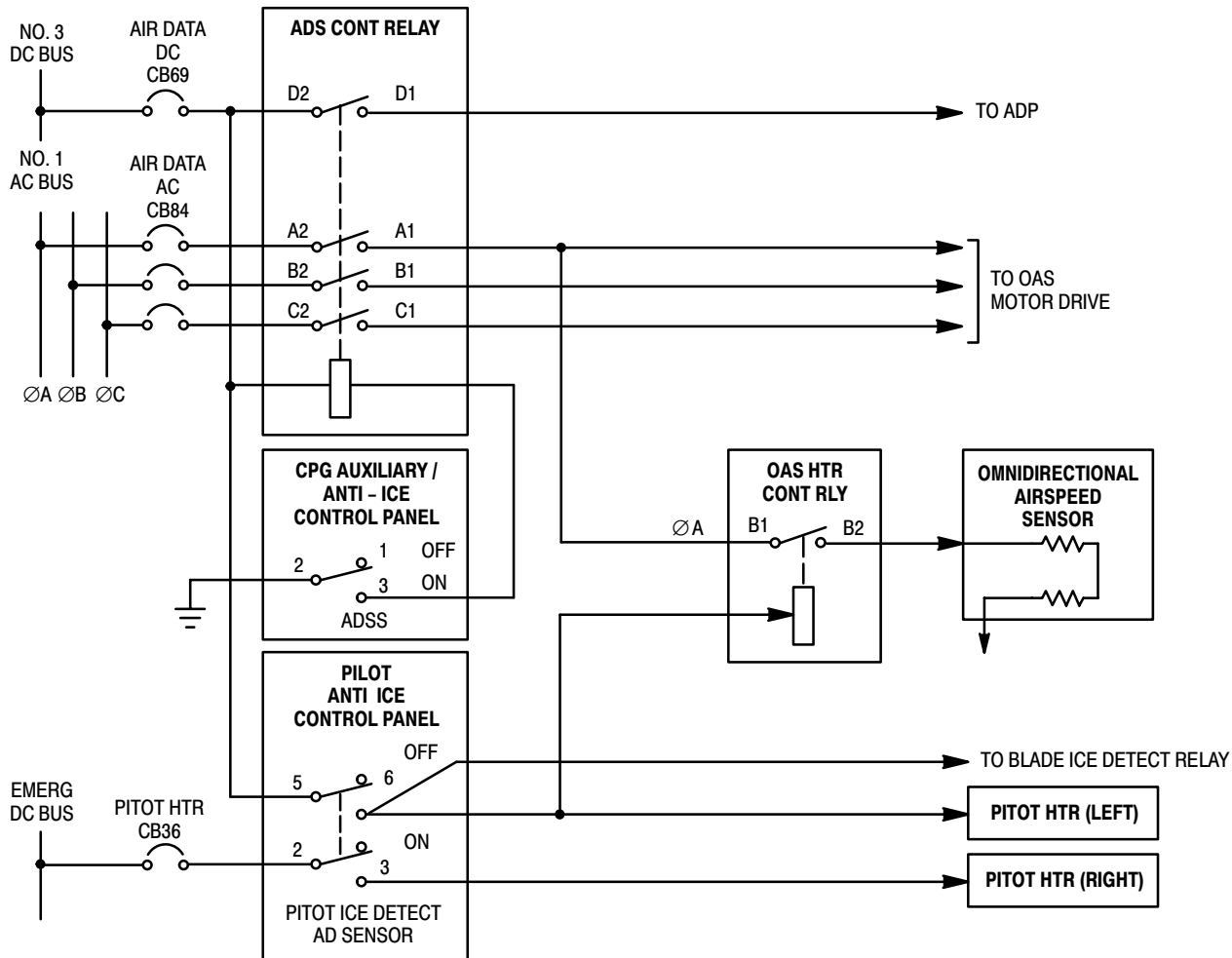
NOTE

In order to apply AC heater power to the OAS, the ADS control relay must be energized.

(3) With the CPG's **ADSS** control switch placed in the **ON** position, the ADS control relay energizes.

(4) The OAS heater control relay routes the ac power to the OAS heater.

(5) System heater power is applied as long as both the **PITOT ICE DET AD SNSR** and **ADSS** switch are in the **ON** position.



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Figure 22-23. Pitot and Air Data Sensor System Block Diagram

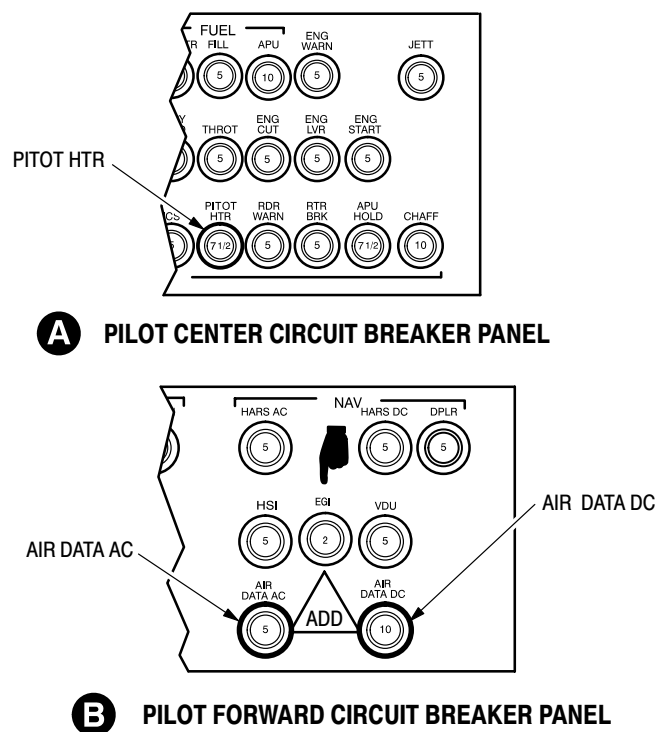
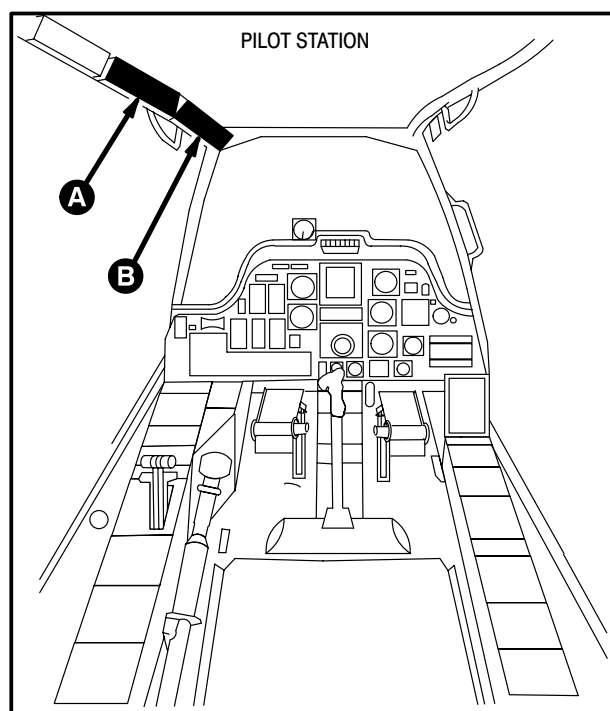
22-3. THEORY OF OPERATION (cont)

22-3

(6) In the event of a dc electrical system failure, only the pilot's pitot tube heater receives emergency dc bus power.

ag. **Pitot and Air Data Circuit Protection.** Circuit breaker **PITOT HTR** (fig. 22-24) supplies 28 VDC to the pilot's pitot tube heater.

- (1) Circuit breaker **AIR DATA DC** supplies 28 VDC to the following components.
 - (a) Air data processor.
 - (b) CPG's pitot tube heater.
 - (c) ADS control relay.
 - (d) OAS heater control relay.
- (2) Circuit breaker **AIR DATA AC** supplies 115 VAC to the OAS heater and motor drive circuits.



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Figure 22-24. Pitot and Air Data Sensor Heater Circuit Breakers

ah. **TADS/PNVS Anti-Ice.**

- (1) Pilot **ANTI-ICE** Panel. The panel contains a **TADS/PNVS** switch. Positions and functions are as follows.
- (a) **GND.** The **GND** position is used to functionally check the system on the ground.
 - (b) **ON.** The **ON** position applies 28 VDC through the squat relay to the anti-ice system. Operates only when airborne.
 - (c) **OFF.** The **OFF** position de-energizes the TADS/PNVS anti-ice system.

22-3. THEORY OF OPERATION (cont)

22-3

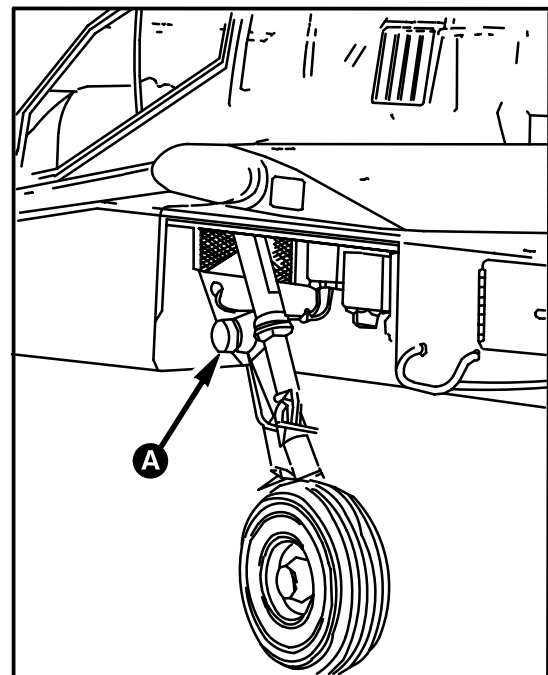
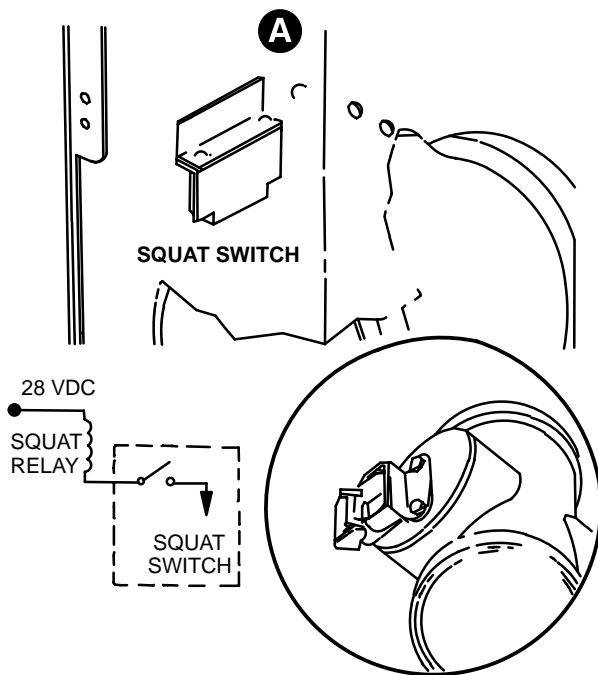
(2) CPG **AUX/ANTI-ICE** Panel. The panel contains a **TADS/PNVS** switch. Positions and functions are identical to the pilot's switch.

(3) Squat Switch. With the aircraft on the ground, the switch is open and the ground is removed from the return side of the squat relay coil (fig. 22-25). With the aircraft in the air, the switch is closed and a ground is supplied to the return side of the squat relay coil.

(4) Squat Relay. The coil is powered by 28 VDC from the emergency dc bus via the **IFF** circuit breaker. The return side ground is controlled by the squat switch.

(a) With the aircraft on the ground, the squat switch is open and the squat relay is de-energized.

(b) With the aircraft in the air, the squat switch is closed and a ground is provided to the return side of the squat relay. This causes the squat relay to energize.



LEFT LANDING GEAR

M52-372

Figure 22-25. Squat Switch

ai. **TADS/PNVS Anti-ice Circuit Protection.**

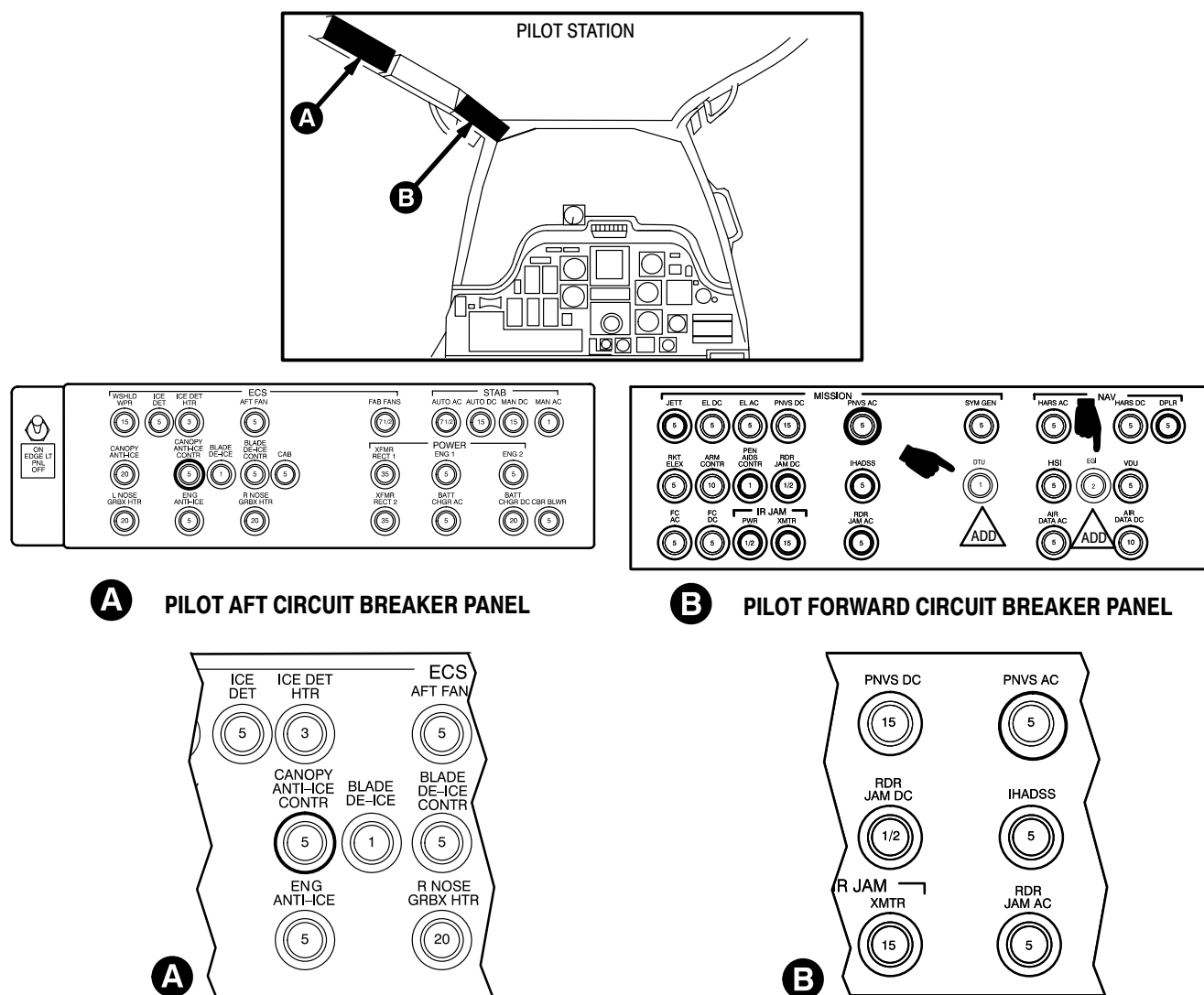
(1) Circuit breaker **CANOPY ANTI-ICE CONTR** (CB70) (fig. 22-26) provides circuit protection for the 28 VDC TADS/PNVS heater control circuitry.

(2) Circuit breaker **PNVS AC** (CB81) provides circuit protection for the 115 VAC PNVS heater circuitry.

(3) Circuit breaker **TADS AC** (CB3) provides circuit protection for the 115 VAC TADS heater circuitry.

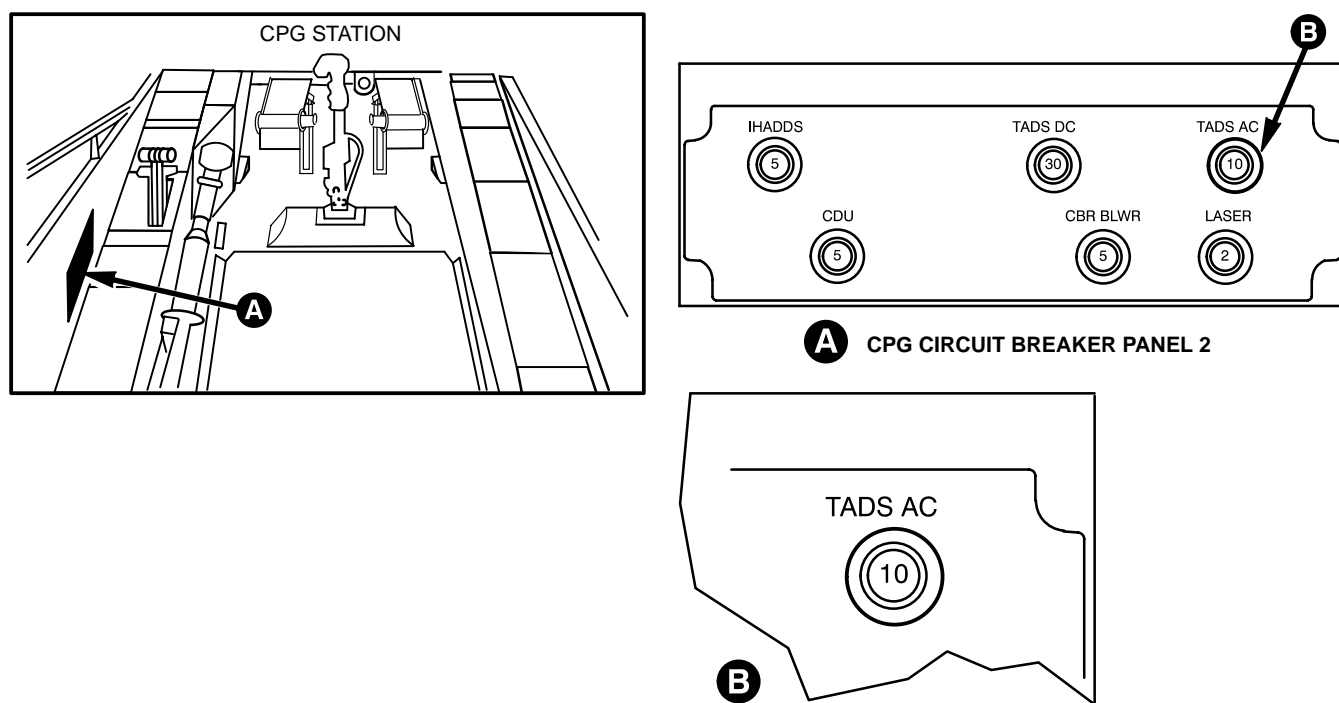
22-3. THEORY OF OPERATION (cont)

22-3



M52-373-1A

Figure 22-26. TADS/PNVS Anti-ice Circuit Breakers (Sheet 1 of 2)



M52-373-2

Figure 22-26. TADS/PNVS Anti-ice Circuit Breakers (Sheet 2 of 2)

aj. **Canopy Defog System Operation.** Circuit breaker **CANOPY ANTI-ICE CONTR** (CB70) (fig. 22-27) provides circuit protection for the 28 VDC canopy defog system. When energized, the three-way valve shuts off inlet air and vents chamber pressure. Inlet pressure acting on the poppet valve overcomes spring pressure and opens the valve.

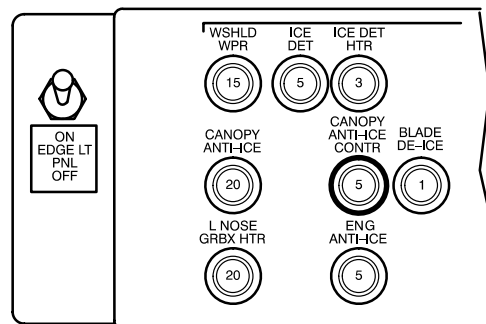
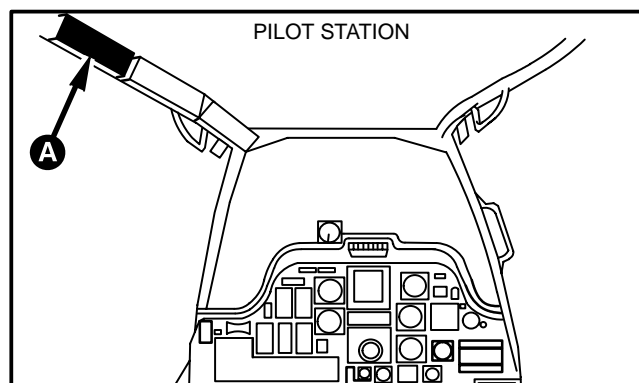
(1) When the **CANOPY DEFOG** (fig. 22-23) control switch is placed in the **ON** position, contacts 2 and 3 close (fig. 22-28). 28 VDC is routed from the dc bus 2 via CB70 to the defog shutoff valve.

(2) The defog shutoff valve is energized open. When energized, the three-way valve shuts off inlet air and vents chamber pressure. Inlet pressure acting on the poppet valve overcomes spring pressure and opens the valve. Hot air flows through the defog valve to the air mixers.

(3) The hot pressurized air mixes with crew station conditioned air in the air mixers. The partially cooled air is directed against the canopy side panels, defogging them.

22-3. THEORY OF OPERATION (cont)

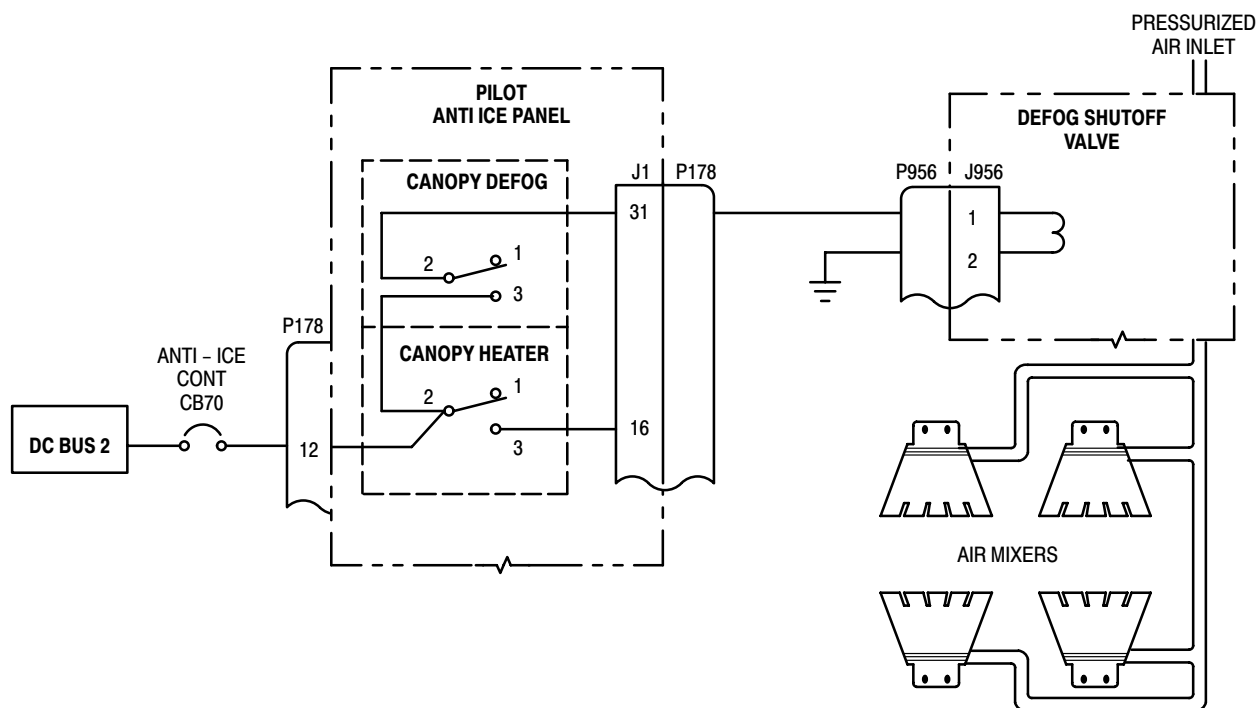
22-3



A PILOT AFT CIRCUIT BREAKER PANEL

M52-357A

Figure 22-27. Canopy Defog System Circuit Breaker



M52-358B

Figure 22-28. Canopy Defog System Block Diagram

ak. Engine Fire Detection and Extinguishing.

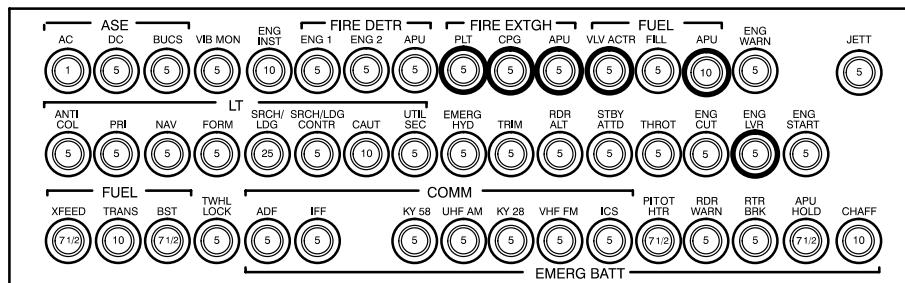
(1) **BTL DISCHARGE/APU** Control Panel. The panel contains the **FIRE TEST DET** switch. Positions and functions are as follows.

- (a) **OFF**. No operation.
 - (b) **1**. Tests the upper detector circuits and components.
 - (c) **2**. Tests the lower detector circuits and components.
- (2) **FIRE PULL** Handles. When pulled, the handles perform the following functions.

22-3. THEORY OF OPERATION (cont)

22-3

- (a) The handle energizes the respective fuel crossfeed valve to shut off fuel to the engine.
- (b) The handle energizes the respective louver actuator shutoff valves to close the engine louvers and limit engine compartment airflow.
- (c) The handle energizes the ENCU relay to close the ENCU shutoff valve. This ensures maximum pressurized air for the engine louver system.
- (3) **FIRE BTL Select Switches.** The switches have the following positions and functions.
- (a) **PRI.** Selects primary fire bottle.
- (b) **OFF.** No operation.
- (c) **RES.** Selects reserve fire bottle.
- (4) **Fire Bottle Assemblies.** Each fire bottle contains an electrically actuated explosive device (squib cartridge) used to release the extinguishing agent into the respective plumbing system. When the bottle discharges, a fire bottle discharge lamp sensor in the bottle causes the respective **BTL DISCHARGE** lamp to illuminate.
- (5) **Fire Bottle Thermal Discharge Indicator.** When the temperature in either fire bottle reaches 215° to 226° F (101.67° to 107.78° C), the respective pressure relief valve is forced open. The bottle discharges through the plumbing and ejects the indicator.
- (6) **Fire Extinguishing System Circuit Protection.**
- (a) Circuit breaker **FIRE EXTGH PLT** (CB25) supplies 28 VDC to the pilot's engine **FIRE BLT** select switch (fig. 22-29).
- (b) Circuit breaker **FIRE EXTGH CPG** (CB15) supplies 28 VDC to the CPG's engine **FIRE BLT** select switch.
- (c) Circuit breaker **FIRE EXTGH APU** (CB26) supplies 24/28 VDC to the **APU FIRE BLT** select switch.
- (d) Circuit breaker **FUEL APU** (CB9) supplies 28 VDC to the APU fuel shutoff valve.
- (e) Circuit breaker **FUEL VLV ACTR** (CB14) supplies 28 VDC to the left and right fuel crossfeed valves.
- (f) Circuit breaker **ENG LVR** (CB16) supplies 28 VDC to the left and right engine louver actuator shutoff valves.



PILOT CENTER OVERHEAD CB PANEL

M52-383A

Figure 22-29. Fire Extinguishing System Circuit Breakers

22-3. THEORY OF OPERATION (cont)

22-3

(7) Fire Detection System Circuit Protection.

(a) Circuit breaker **FIRE DETR APU** (CB11) supplies 28 VDC to the following components.

- APU forward and aft flame detectors.
- APU flame detector amplifier.
- APU **FIRE PULL** handle warning lamps.

(b) Circuit breaker **FIRE DETR ENG 1** (CB12) supplies 28 VDC to the following components.

- Fire detector test switch.
- Engine 1 flame detectors.
- Engine 1 flame detector amplifiers.
- Multichannel dimming controller.

(c) Circuit breaker **FIRE DETR ENG 2** (CB13) supplies 28 VDC to the following components.

- Fire detector test switch.
- Engine 2 flame detectors.
- Engine 2 flame detector amplifiers.
- Multichannel dimming controller.

al. **APU Fire Detection and Extinguishing.** The fire overheat detectors and the APU flame detectors generate a signal to the APU flame detector amplifier when a flame or overheat condition exists in the APU/SDC area of the aft equipment bay. The flame detector amplifier amplifies the detected signal and lights the **APU FIRE PULL** handle. When the **APU FIRE PULL** handle is pulled, the selected fire bottle is discharged and the APU fuel shutoff valve is energized, shutting off fuel to the APU.

am. **Canopy Jettison.**

(1) For normal system safing, a quick-release safety pin is used to hold the **CANOPY JETTISON** handles in the **SAFE** position. Safety pins are removed before flight. After flight, each handle is resafetied with the quick-release pin. Verification of a safed or armed position is indicated by the **ARMED** (uncovered by the handle) to either side of the handle, or **SAFE** at top and bottom of canopy jettison.

(2) To arm the system, a **CANOPY JETTISON** handle is rotated 90° left or right.

(3) To activate the system, the rotated **CANOPY JETTISON** handle is pushed in, detonating an explosive cartridge (The handle consists of a spring-loaded firing pin striking a primer/initiator subassembly).

(4) Cartridge ignites the SMDC, which burns to the FCDC.

(5) The detonation cord ignites and burns around the periphery of the canopy. The burning action cuts a line around the canopy, severing the canopy from the fuselage.

23-1. PURPOSE

23-1

CHAPTER 23 EXTERIOR LIGHTING SYSTEM

23-1. PURPOSE

The aircraft exterior lighting system consists of formation lights, navigation lights, anti-collision lights, and a search/landing light.

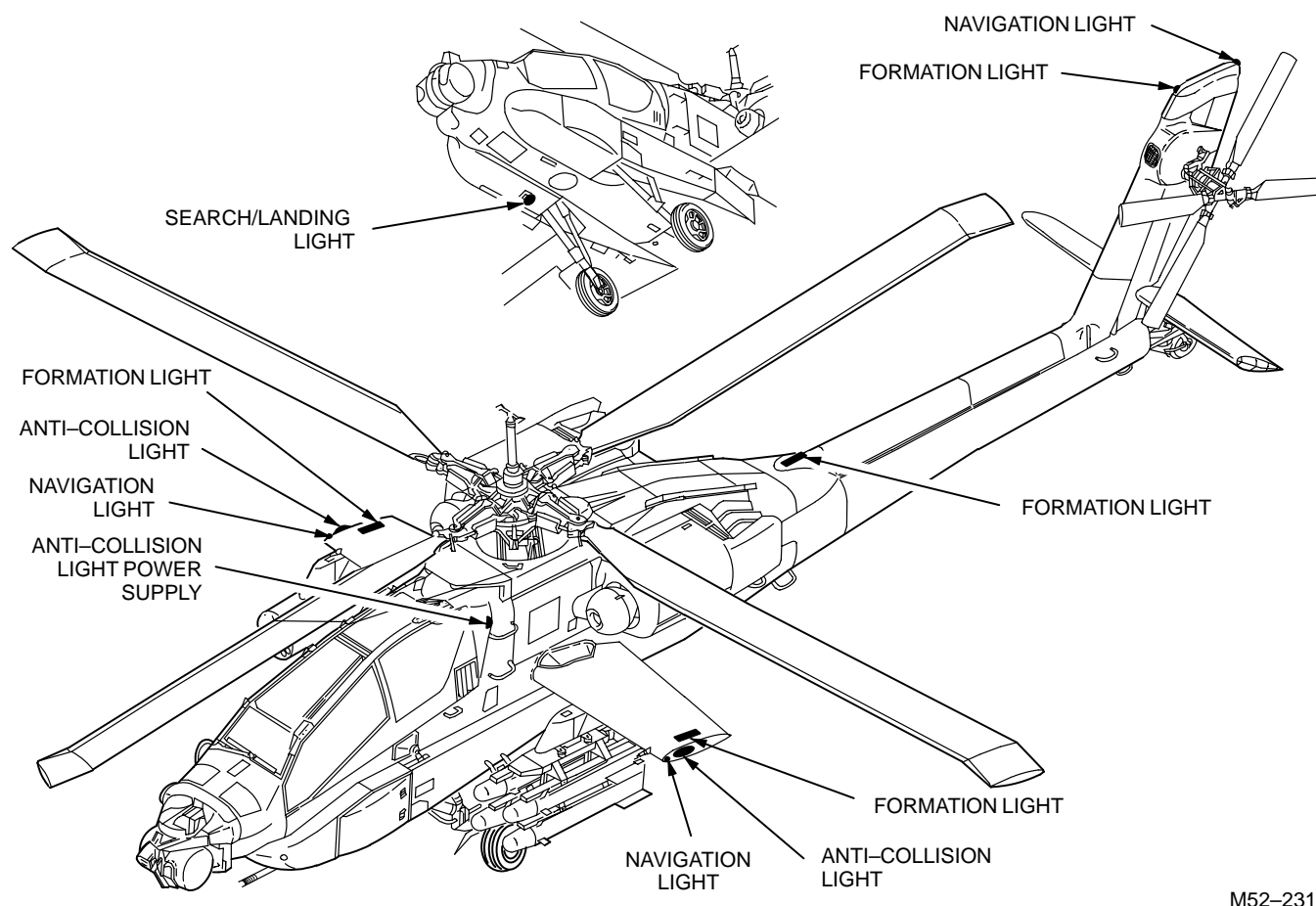
- a. The formation lights provide a visual indication of formation position during flight.
- b. The navigation lights indicate aircraft position and direction to other aircraft during flight.
- c. The anti-collision lights provide a visual anti-collision warning (white or red) during take-off and landing.
- d. The search/landing light provides omnidirectional landing and search visibility during low-visibility conditions.

23-2. DESCRIPTION

- a. Green formation lights (fig. 23-1) are located as follows.
 - (1) On the upper surface of each wing.
 - (2) On the upper center line on the aft fuselage.
 - (3) On the upper surface of the vertical stabilizer.
- b. Navigation lights (fig. 23-1) are located as follows.
 - (1) A green navigation light on the right wing tip.
 - (2) A red navigation light on the left wing tip.
 - (3) A white navigation light on the aft side of the vertical stabilizer.
- c. Anti-collision lights (fig. 23-1) are high-intensity strobe lights located on each wing tip.
- d. The searchlight (fig. 23-1) is located in a fairing under the forward end of the forward avionics bay just forward of the landing gear attachment.

23-2. DESCRIPTION (cont)

23-2



M52-231

Figure 23-1. Exterior Lighting

23-3. THEORY OF OPERATION

a. Power Input.

(1) Circuit breaker **FORM LT** (CB90), on the pilot's circuit breaker panel, supplies 115 VAC to the pilot's **EXT LT/INT LT** panel (fig. 23-2).

(2) Circuit breaker **NAV LT** (CB73), on the pilot's circuit breaker panel, supplies 28 VDC to the pilot's **EXT LT/INT LT** panel.

(3) Circuit breaker **ANTI COL LT** (CB40), on the pilot's circuit breaker panel, supplies 115 VAC to the pilot's **EXT LT/INT LT** panel, and to the anti-collision light power supply.

(4) Circuit breaker **SRCH/LDG CONTR** (CB80), on the pilot's circuit breaker panel, supplies 28 VDC to the pilot's and CPG's collective stick **SRCH LT** switches (fig. 23-3). Circuit breaker **SRCH/LDG LT** (CB22) supplies 28 VDC through the electrical power distribution box to the search/landing light relay K1-1/2.

b. Control.

(1) Moving the **FORM** rotary control away from **OFF** supplies 115 VAC through the electrical power center to the formation lights

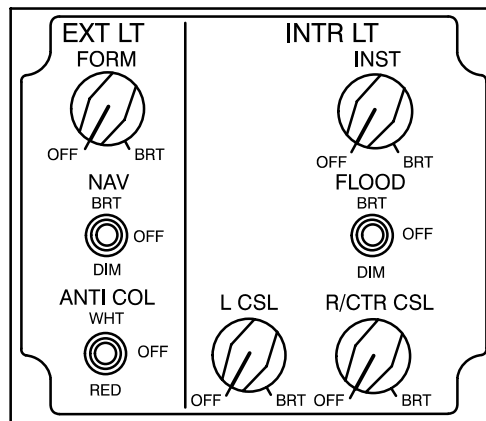
23-3. THEORY OF OPERATION?? (cont)

23-3

(2) Setting the **NAV** switch from **OFF** to **BRT** or **DIM** supplies 28 VDC directly to the right and left navigation lights, and through the electrical power distribution box to the aft light.

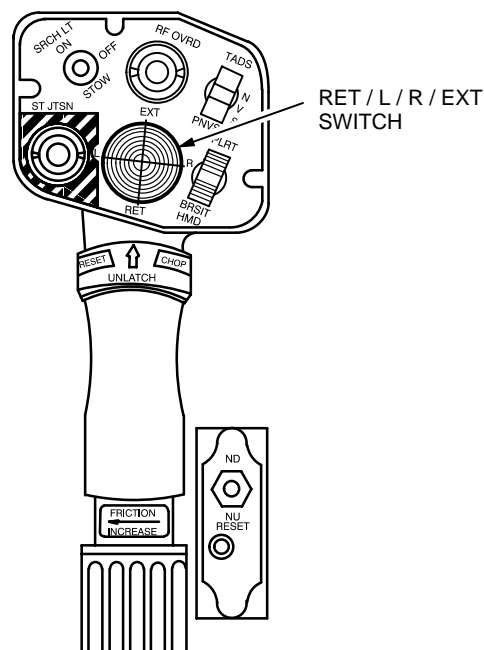
(3) Setting the **ANTI COL** switch from **OFF** to **WHT** or **RED** causes the anti-collision light power supply to provide 200 VDC trigger voltage and 400 VDC anode voltage to the white or red strobe lights.

(4) Setting either **SRCH LT** switch from **OFF** to **ON** supplies 28 VDC to turn on search/landing light. Directional control of the light is through the **RET/L/R/EXT** (retract/left/right/extend) switch.



M52-415

Figure 23-2. Pilot EXT LT/INTR LT Panel



M52-416

Figure 23-3. Collective Stick Switchbox

APPENDIX A REFERENCES

A-1. GENERAL

This appendix contains a list of all official publications referenced in this technical manual.

A-2. REFERENCES

- DA PAM 738-751 The Army Maintenance Management System – Aircraft
- FM 1-511 Army Aircraft Quality Control and Inspection
- FM 10-68 Aircraft Refueling
- SF 368 Quality Deficiency Report
- TM 1-1270-476-20 Aviation Unit Maintenance Manual, Target Acquisition Designation Sight (TADS) Assembly AN/ASQ-170 AH-64A Attack Helicopter
- TM 1-1270-476-T Aviation Unit Troubleshooting Manual, Target Acquisition Designation Sight (TADS) Assembly AN/ASQ-170 AH-64A Attack Helicopter
- TM 1-1520-238-10 AH-64A Helicopter Operator's Manual
- TM 1-1500-204-23 AH-64A Helicopter Manual
- TM 1-1520-238-CL Operator's Checklist
- TM 1-1520-238-L AH-64A Helicopter List of Applicable Publications
- TM 1-1520-238-MTF Maintenance Test Flight Manual: AH-64A Helicopter
- TM 1-1520-238-T-1 Aviation Unit Maintenance Manual for Army AH-64A Helicopter Fault Detection/Location System
- TM 1-1520-238-T-2 Aviation Unit Maintenance Manual for Army AH-64A Helicopter Integrated Troubleshooting Manual
- TM 1-1520-238-T-3 Aviation Unit Maintenance Manual for Army AH-64A Helicopter Multiplex Read Codes
- TM 1-1520-238-T-4 AVUM/AVIM Troubleshooting; Introduction; Airframe; Landing Gear System; Power Plants; Rotors; Drive System
- TM 1-1520-238-T-5 AVUM/AVIM Troubleshooting; Hydraulic and Pneumatic Systems; Instruments
- TM 1-1520-238-T-6 AVUM/AVIM Troubleshooting Electrical System
- TM 1-1520-238-T-7 AVUM/AVIM Troubleshooting Fuel System; Flight Controls
- TM 1-1520-238-T-8 AVUM/AVIM Troubleshooting Utilities System; Environmental System; Hoists and Winches; Auxiliary Power Unit; Mission Equipment
- TM 1-1520-238-T-10 Aviation Unit Maintenance for Army AH-64A Helicopter Wiring Diagrams
- TM 1-5855-265-20 Aviation Unit Maintenance Manual, Pilot Night Vision Sensor (PNVS) Assembly AN/AAQ-11
- TM 1-5855-265-T Aviation Unit Troubleshooting Manual, Pilot Night Vision Sensor (PNVS) Assembly AN/AAQ-11
- TM 3-4240-312-12&P Mask, Chemical – Biological Aircraft, M43
- TM 9-1090-208-23-2 Aviation Unit and Intermediate Maintenance Manual for Armament Subsystem, Helicopter: M139 Gun, Automatic, 30-Millimeter: M230 Rocket Management Subsystem, Inventory-Deployment: M140
- TM 9-1230-476-20-1 Aviation Unit Maintenance Manual for Army AH-64A Helicopter Fire Control System

A-2. REFERENCES (cont)

- TM 9-1230-476-20-2 Aviation Unit Troubleshooting Manual for Army AH-64A Helicopter Fire Control System
- TM 9-1270-221-23 Aviation Unit and Intermediate Maintenance Manual for Fire Control Subsystem, Helmet Directed: M142 (Used with M139 Helicopter Armament Subsystem)
- TM 9-1427-475-20 Aviation Unit Maintenance Manual for Army AH-64A Helicopter HELLFIRE Missile Equipment (Point Target Weapon System) and AH-64A Helicopter Launcher Interface (Launcher, Guided Missile, Aircraft, M272)
- TM 11-1520-238-23-2 Aviation Unit and Intermediate Troubleshooting Manual, Army Model AH-64A Helicopter, Avionics Configuration
- TM 11-5895-1184-23 Aviation Unit Maintenance Manual: Symbol Generator MX-10465/ASQ
- TM 11-6605-300-23 Aviation Unit Maintenance Manual: Attitude Heading Reference System AN/ASM-143
- TM 11-6625-3085-12 Operator and Aviation Unit Maintenance: Electronic Test Equipment Facility QQ-290(V)2/MSM
- TM 55-1500-323-24 Organizational Depot Maintenance Manual of Aeronautical Electrical and Electronic Installation Procedures
- TM 55-2840-248-23 Aviation Unit and Intermediate Maintenance Instructions: Engine, Aircraft, Turboshift Models T700-GE-701, T700-GE-701
- TM 55-4920-402-13&P Operating Instructions Aviation Unit and Aviation Intermediate Maintenance Manual (Including Repair Parts and Special Tools List) Vibrex Balancing Kit
- TM 750-244-1-5 Procedures for Destruction of Aircraft and Associated Equipment to prevent Enemy Use

GLOSSARY

ABBREVIATIONS AND ACRONYMS

AC	.....	Alternating Current/ Aircraft
ACC	.....	Accessory Accumulator
ACM	.....	Automatic Control Module
ADSS	.....	Air Data Subsystem
ACQ	.....	Acquisition
ACT	.....	Action
ACTR	.....	Actuator
ACTS	.....	Actuator
ADF	.....	Automatic Direction Finder
ADS	.....	Air Data System
AD	.....	Air Data
AH-64A	.....	Attack Helicopter Model AH-64A
AIA	.....	Aircraft Interface Assembly
AJ	.....	Anti-Jam
ALT	.....	Altimeter
AM	.....	Amplitude Modulation
AMMO	.....	Ammunition
AMP	.....	Ampere
AMPS	.....	Automated Mission Planning Station
AND	.....	Alphanumeric Display
ANT	.....	Antenna
APU	.....	Auxiliary Power Unit
APR	.....	Approximate
APRCH	.....	Approach
ARCP	.....	Aerial Rocket Control Panel
ARCS	.....	Aerial Rocket Control System

ABBREVIATIONS AND ACRONYMS (cont)

ASE	Aircraft Survivability Equipment
ASE	Automatic Stabilization Equipment
ASN	Aircraft Special Navigation Aid
ASSY	Assembly
ATTD	Attitude
ATC	Air Traffic Control
ATHS	Automatic Target Handoff System
AUTO	Automatic
AUX	Auxiliary
AVIM	Aviation Intermediate Maintenance
AVUM	Aviation Unit Maintenance
AWS	Area Weapon (Sub)System
AZ	Azimuth
BATT	Battery
BAS	Bulk Ammo Strip
BAT	Battery
BBC	Backup Bus Controller
BIT	Built-in-test
BITE	Built-In-Test Electronics
BK	Break
BLWR	Blower
BOT	Bottom, Beginning Of Tape
BRK	Break
BRKR	Breaker
BRSIT	Boresight
BRT	Bright
BRU	Boresight Reticle Unit
BST	Boost/Boresight
BTL	Bottle

ABBREVIATIONS AND ACRONYMS (cont)

BUCS	Backup Control System
BW	Bandwidth
BYP	Bypass
C	Celsius
CAB	Cabin
cal	Caliber
CAS	Command Augmentation System
CB	Circuit Breaker
CBR	Circuit Battery Charger
CCM	Counter Counter Measures
CDU	Computer Display Unit, Control Display Unit
CH	Channel
CHAN	Channel
CHAR	Character
CHGR	Charger
CHIPS	Metal Particles
CKT	Circuit
CLR	Clear
CMD	Command
CNTR	Counter
CNV	Crypto-Net Variable
COLL	Collective
COM	Communication
COMM	Communication/Common
COMP	Compressor
COMPL	Complete
CONT	Control
CONTR	Controller
CPG	Copilot Gunner
CPU	Central Processing Unit

ABBREVIATIONS AND ACRONYMS (cont)

CRKT	Copilot Rocket
CRT	Cathode Ray Tube
CTRS	Contrast
CSC	Communication System Control
CSL	Console
CTL	Control
CUT	Cut Out
CW	Continuous Wave
C/W/A	Caution Warning Advisory Panel
DA	Department of Army
DAP	Display Adjust Panel
DASE	Digital Automatic Stabilization Equipment
DASEC	Digital Automatic Stabilization Equipment Computer
DBS	Data Bus Switch
DC	Direct Current
DCPLR	Decoupler
DECU	Digital Engine Control Unit
DEG	Degree
DEK	Data Entry Keyboard
DES	Designation
DET	Decent/Detector
DETR	Detector
DEU	Display Electronics Unit
DETR	Detector
DF	Direction Finding
DGT	Dim/Test Panel Engine Instruments
DIR	Direct/Direction
DIR COS	Direct Cosine
DISP	Display
DISCH	Discharge
DISTRB	Distribution

ABBREVIATIONS AND ACRONYMS (cont)

DLTU	Data Link Terminal Unit, Data Link Termination Unit
DMA	Direct Memory Access
DNS	Doppler Navigation System
DOD	Department of Defense
DPLR	Doppler
DR	Deficiency Report
DSA	Day Sensor Assembly
DSCRM	Discriminate
DTC	Data Transfer Cartridge
DTR	Data Transfer Receptacle
DTU	Data Transfer Unit
DTV	Day TV
DVO	Direct View Optics
E	Empty
ECA	Electronic Control Amplifier
ECCM	Electronic Counter Counter-Measures
ECS	Environmental Control System
ECSP	Electronic Command Signal Programmer
ECU	Engine Control Unit
EED	Electronic Explosive Devices
EGI	Embedded GPS/INS
EGT	Exhaust Gas Temperature
EL	Elevation
ELEC	Electronic
EM	Emergency
EMERG	Emergency
EMK	Event Mark
EMP	Empty
ENG	Engine
ENT	Enter
EOT	End Of Test, End Of Tape
ERF	ECCM Remote Fill
EPROM	Erasable Programmable Read Only Memory
EXT	External
EXST	External Stores
EXTGH	Extinguisher

ABBREVIATIONS AND ACRONYMS (cont)

F	Fahrenheit
FAB	Forward Avionics Bay, Fixed Action Button
FC	Fire Control
FCC	Fire Control Computer
FCP	Fire Control Panel
FD/LS	Fault Detection and Location System
FFAR	Folding Fin Aerial Rockets
FH	Frequency Hopping
FH-M	Frequency Hopping –Master
FIP	Fault Isolation Procedure
FLIR	Forward Looking Infrared
FLT	Flight
FM	Frequency Modulation
FMT	Frequency Management Training
FORM	Formation
FOV	Field of View
FPLN	Flight Plan
FR	Front
FREQ	Frequency
FRPA	Fixed Radiation Pattern Antenna
FWD	Forward
FXD	Fixed
g	Grams
GCB	Gun Control Box
GCU	Generator Control Unit
GD	Guard
GEN	Generator
GL	Glare
gpm	Gallons per minute
GPS	Global Positioning System
GPU	Ground Power Unit
GND	Ground
GRD	Guard
GRBX	Gear Box
GSE	Ground service equipment

ABBREVIATIONS AND ACRONYMS (cont)

GTCB	Gun Turret Control Box
GYRO	Gyroscope
HARS	Heading Attitude Reference System
HAS	Hover Augmentation System
HDD	Heads Down Display
HDG	Heading
HDST	Headset
HDU	Helmet Display Unit
HI	High
HMD	Helmet Mounted Display
HME	HELLFIRE Missile Electronics
HMU	Hydro Mechanical Unit
HOD	Heads Out Display
HOM	Homing
HSE	Helmet Sensor Equipment
HSI	Horizontal Situation Indicator
HTR	Heater
HYD	Hydraulic
Hz	Haze
Hz	Hertz
IAM	Interface Adapter Module
IAT	Image Auto Track
ICS	Intercommunication System
ID	Identification
IDNT	Identification
IFF	Identification Friend or Foe
IFU	Interface Unit Comparator
IGB	Intermediate Gearbox
IGN	Ignition
IHADSS	Integrated Helmet and Display Sight System
IHU	Integrated Helmet Unit

ABBREVIATIONS AND ACRONYMS (cont)

IMC	Instrument Meteorological Condition
INBD	Inboard
IND	Indicate
INS	Inertial Navigation System
INT	Internal / Interior
INTR	Internal / Interior
INU	Inertial Navigation Unit
INST	Instrument
IR	Infrared
IRCM	Infrared Counter Measures
ITS	Integrated Trouble Shooting
IVD	Indirect View Display
I/O	Input/Output
JAM	Jammer
JETT	Jettison
JTSN	Jettison
KNTS	Knots
KTAS	Knots-True-Airspeed
KTS	Knots
KYBD	Keyboard
L	Left
LAT	Lateral
LB	Pound
LCD	Liquid Crystal Display
LCF	Low Cycle Fatigue
LCHR	Launcher
LD	Load
LDG	Landing
LDNS	Lightweight Doppler Navigation System
LDS	Laser Detecting Set
LDS	Load Demand Spindle
LED	Light Emitting Diode
LEU	Laser Electronics Unit

ABBREVIATIONS AND ACRONYMS (cont)

LH	Left-Hand
LIT	Light
LMC	Linear Motion Compensation
LO	Low
LOAL	Lock-On After Launch
LOBL	Lock-On Before Launch
LONG	Longitude
LOP	Low Oil Pressure
LOS	Line Of Sight
LOUT	Lockout
LRFD	Laser Range Finder/Designator
LRU	Laser Receiver Unit
LS	Laser Missile Select
LT	Laser Tracker/ Light
LTRU	Laser Tracker Receiver Unit
LTU	Laser Transceiver Unit
LVDT	Linear Variable Differential Transducer
LVL	Level
LVR	Lever
M	Meter
MA	Missile Alert
MF	Missile Fail
MAINT	Maintenance
MAL	Malfunction
MAN	Manual
MEM	Memory
MFOV	Medium Field of View
MH	Missile Hangfire
MIC	Microphone

ABBREVIATIONS AND ACRONYMS (cont)

MLG	Main Landing Gear
MN	Manual
MNL	Manual
mm	Millimeter
MOC	Maintenance Operational Check
MON	Monitor
MRTU	Multiplex Remote Terminal Unit
MTR	Motor/Meter
MSL	Missile, Mean Sea Level
MU	Missile Unlatched
MUX	Multiplex
NA	Not Applicable
NAV	Navigation
NB	Narrow Band
ND	Nose Down
NF	No Fire
NFOV	Narrow Field Of View
Ng	Turbine Speed
NGB	Nose Gearbox
NIU	Nitrogen Inerting Unit
Nr	Rotor Torque
NOE	Nap of the Earth
NOM	Nominal
NORM	Normal
Np	Engine Torque
NSA	Night Sensor Assembly
NU	Nose Up
NVS FXD	Night Vision Sensor Fixed

ABBREVIATIONS AND ACRONYMS (cont)

PTT	Press to Talk
PYL	Pylon
OAS	Outside Air Sensor
ODV	Overspeed Drain Valve
OFST	Offset
ORT	Optical Relay Tube
ORIDE	Override
OUTBD	Outboard
OVERTEMP	Over Temperature
OVRD	Override
OVSP	Overspeed
PAC	Pylon Actuator Controller
PAM	Pamphlet
PAS	Pressurized Air System, Power Available Spindle
PEN	Penetration
PEU	PNVS Electronic Unit
PGM	Program
PLRT	Polarity
PLT	Pilot
PMP	Pump
PMSL	Pilot Missile
PNL	Panel
PNVS	Pilot Night Vision Sensor
POS	Position
PRF	Pulse Repetition Frequency
PRI	Primary
PRKT	Pilot Rocket
PROG	Program
psi	Pounds Per Square Inch
psig	Pounds Square Inch of Gage

ABBREVIATIONS AND ACRONYMS (cont)

PTO	Power Take Off
PTT	Push To Talk
PTWS	Point Target Weapons System
PWR	Power
PYL	Pylon
PYLN	Pylon
QTY	Quantity
R	Right
RADALT	Radar Altimeter
RAI	Remote Altitude Indicator
RAM	Random Access Memory
RCCB	Remote Control Circuit Breaker
RC/MC	Rounds Counter/Magazine Controller
RCD	Record
RCP	Rocket Control Panel
RDR	Radar
REC	Record
RECT	Rectifier
REF	Reference
REM	Remaining
RES	Reservoir
RCDR	Recorder
RCVR	Receiver
RH	Right-Hand
RHE	Remote HELLFIRE Electronics
RHI	Remote Heading Indicator
RICE	Rotor Anti-ice
RIPL	Ripple

ABBREVIATIONS AND ACRONYMS (cont)

RKT	Rocket
RMI	Remote Magnetic Indicator
RNDS	Rounds
rpm	Revolutions Per Minute
RT	Right
R/T	Receive/Transmit
RTA	Receiver/Transmit Antenna
RTCL	Reticle
RTR	Rotor
RW	Radar Warning
RXMT	Remote Transmit
SAS	Stability Augmentation System
SC	Single Channel
SCU	Stabilization Control Unit
SDC	Signal Data Converter, Shaft Driven Compressor
SDCC	Signal Data Converter Computer
SDD	Selectable Digital Data
SEC	Secondary
SEL	Select
SEU	Sight Electronics Unit
SF	Station Fail
SHP	Shaft Horse Power
SIM	Simulated
SINCGARS	Single Channel Ground to Air Radio Subsystem
SNSR	Sensor
SOL	Solenoid
SPAD	Shear Pin Activated Decoupler
SPC	Space
SPD	Speed
SQ	Squelch
SRCH	Search
SSU	Sight Surveying Unit
ST	Store Target

ABBREVIATIONS AND ACRONYMS (cont)

STAB	Stabilator
STAT	Status
STBY	Standby
STO	Store
STR	Store
SW	Switch
SYM	Symbol
SYNC	Synchronize
SYMGEN	Symbol Generator
TADS	Target Acquisition Designation Sight
TBD	To Be Determined
TCB	Turret Control Box
TEMP	Temperature
TEU	TADS Electronics Unit
TF	Tracker Fail
TGB	Tail Rotor Gear Box
TGT	Turbine Gas Temperature, Target
THROT	Throttle
TK	Tank
TLG	Tail Landing Gear
TM	Technical Manual
TNK	Tank
TOD	Time of Day
TOF	Time of Flight
TPS	TADS Power Supply
TR	Transformer Rectifier/ Tailrotor
TRAN	Transmission
TRANS	Transfer
■ TRANSEC	Transmission Security
TRG	Tail Rotor Gearbox
TRIG	Trigger
TSEC	Time Second

ABBREVIATIONS AND ACRONYMS (cont)

TST	Test
TK	Talk/Tank
TV	Television
TWHL	Tail Wheel
UHF	Ultra High Frequency
UTC	Universal Time Constant
UTIL	Utility
UTM	Universal Transverse Mercator
UPDT	Update
VAB	Variable Action Button
VAC	Volts Alternating Current
VDC	Volts Direct Current
VDU	Video Display Unit
VEL	Velocity
VHF	Very High Frequency
VIB	Vibration
VID	Video
VLV	Valve
VOL	Volume
VSI	Vertical Situation Indicator
VSWR	Voltage Standing Wave Ratio
VVI	Vertical Velocity Indicator
WARN	Warning
WAS	Weapon Action Switch
WB	Wideband
WFOV	Wide Field of View
WHT	White
WOD	Word-of-Day
WPN	Weapon
WPR	Wiper

ABBREVIATIONS AND ACRONYMS (cont)

WPT	Waypoint
WRN	Warning
WSHLD	Windshield
WSPS	Wire Strike Protection System
XDCR	Transducer
XFEED	Crossfeed
XFER	Transfer
XFMR	Transformer
XMN	Transmission
XMSN	Transmission
XMTR	Transmitter
Z-A	Zero All
ZFOV	Zoom Field of View

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Z

By Order of the Secretary of the Army:

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14. Submitter Mname: T
15. **Submitter Lname:** Smith
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19. Paragraph: 3
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20 October 1990

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TM 55-1520-238-T-9

PUBLICATION DATE

22 April 1992

PUBLICATION TITLE

Preparation for Shipment FOR Army
Model AH-64A Helicopters

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2-60	2-26, 151		
2-68		2-30	

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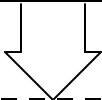
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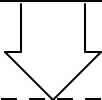
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TEAR ALONG PERFORATED LINE

The Metric System and Equivalents

Linear Measure

1 centimeter = 10 millimeters = .39 inch
 1 decimeter = 10 centimeters = 3.94 inches
 1 meter = 10 decimeters = 39.37 inches
 1 dekameter = 10 meters = 32.8 feet
 1 hectometer = 10 dekameters = 328.08 feet
 1 kilometer = 10 hectometers = 3,280.8 feet

Weights

1 centigram = 10 milligrams = .15 grain
 1 decigram = 10 centigrams = 1.54 grains
 1 gram = 10 decigrams = .035 ounce
 1 dekagram = 10 grams = .35 ounce
 1 hectogram = 10 dekagrams = 3.52 ounces
 1 kilogram = 10 hectograms = 2.2 pounds
 1 quintal = 100 kilograms = 220.46 pounds
 1 metric ton = 10 quintals = 1.1 short tons

Liquid Measure

1 centiliter = 10 milliliters = .34 fl. ounces
 1 deciliter = 10 centiliters = 3.38 fl. ounces
 1 liter = 10 deciliters = 33.81 fl. ounces
 1 dekaliter = 10 liters = 2.64 gallons
 1 hectoliter = 10 dekaliters = 26.42 gallons
 1 kiloliter = 10 hectoliters = 264.18 gallons

Square Measure

1 sq. centimeter = 100 sq. millimeters = .155 sq. inch
 1 sq. decimeter = 100 sq. centimeters = 15.5 sq. inches
 1 sq. meter (centare) = 100 sq. decimeters = 10.76 sq. feet
 1 sq. dekameter (are) = 100 sq. meters = 1,076.4 sq. feet
 1 sq. hectometer (hectare) = 100 sq. dekameters = 2.47 acres
 1 sq. kilometer = 100 sq. hectometers = .386 sq. mile

Cubic Measure

1 cu. centimeter = 1000 cu. millimeters = .06 cu. inch
 1 cu. decimeter = 1000 cu. centimeters = 61.02 cu. inches
 1 cu. meter = 1000 cu. decimeters = 35.31 cu. feet

Approximate Conversion Factors

<i>To change</i>	<i>To</i>	<i>Multiply by</i>	<i>To change</i>	<i>To</i>	<i>Multiply by</i>
inches	centimeters	2.540	ounce-inches	newton-meters	.007062
feet	meters	.305	centimeters	inches	.394
yards	meters	.914	meters	feet	3.280
miles	kilometers	1.609	meters	yards	1.094
square inches	square centimeters	6.452	kilometers	miles	.621
square feet	square meters	.093	square centimeters	square inches	.155
square yards	square meters	.836	square meters	square feet	10.764
square miles	square kilometers	2.590	square meters	square yards	1.196
acres	square hectometers	.405	square kilometers	square miles	.386
cubic feet	cubic meters	.028	square hectometers	acres	2.471
cubic yards	cubic meters	.765	cubic meters	cubic feet	35.315
fluid ounces	milliliters	29.573	cubic meters	cubic yards	1.308
pints	liters	.473	milliliters	fluid ounces	.034
quarts	liters	.946	liters	pints	2.113
gallons	liters	3.785	liters	quarts	1.057
ounces	grams	28.349	liters	gallons	.264
pounds	kilograms	.454	grams	ounces	.035
short tons	metric tons	.907	kilograms	pounds	2.205
pound-feet	newton-meters	1.356	metric tons	short tons	1.102
pound-inches	newton-meters	.11296			

Temperature (Exact)

° F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	° C
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