CQ·TV 79

THE BRITISH AMATEUR TELEVISION CLUB

AUG 1972

THE BRITISH AMATEUR TELEVISION CLUB

BATC

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Overseas members may have their copy of C Q - T V sent by airmail, for a surcharge depending on their country. Details are available from the Treasurer.

Members wishing to have material published in C Q - T V should send the manuscript and drawings to the Editor; articles are invited on all subjects of interest to amateurs and should be of about 1500 words; larger articles should be divided into convenient Parts for publication in consecutive issues of the journal.

COVER PHOTO G6AGT/T at Stourbridge as received by G6KQJ/T at Wolverhampton

EDITORIAL

The problems of an Editor are legion; almost every issue seems to be delayed by some most extraordinary reason completely out of anyone's control. The last issue was delayed by a squashed finger in the printing press, and another recent issue was late when I found myself working in Northern Ireland when all the C Q - T V material was in my home in Surrey. This time the magazine is late because of a sudden attack of appendicitis culminating in a painful stay in hospital! All is now well however, and here is C Q - T V 79. And I promise that my excuse for the late appearance of C Q - T V 80 will be bigger and better.

Have you filled in the registration form for the 1972 Convention printed in the last issue of this magazine? You can attend with no notice of course - but if you want to exhibit your gear, use the car park, read a paper on an amateur subject etc., you MUST fill in the form. Look out your copies of C Q - T V 78 and get writing.

As mentioned in the last issue, any member who has a Resolution to put to the Annual General Meeting must submit it in writing to the Honorary Secretary beforehand. Resolutions will then be place on an Agenda for the meeting, so that discussion and voting may take place. Only Resolutions accepted in this way will be admissable and it will be impossible to accept Resolutions during the Meeting. The A.G.M. takes place, of course, at three o'clock at the Convention; please attend.

It was recently announced by the Royal Television Society that the new Chairman of Council for 1972-3, is to be Neville Watson, at present the Chief Engineer of the BBC. But more important to us, Neville Watson was the Honorary President of B.A.T.C. from 1964-68, and we, the members of B.A.T.C., offer our congratulations on this appointment to one of our most distinguished past Presidents.

On page 5 you will find details of the first international amateur tv contest, organised by Germany, Belgium, and Great Britain. Note the dates and do your utmost to be on the air that weekend. Amateur television is essentially involved with transmitting and receiving pictures - and this is a great opportunity for the essence of ATV to be demonstrated both in this country and abroad; publicity we really need. One hears so much these days, from mis-informed sources, of the lack of 70cm activity by amateurs that it could be said to be essential that this contest is used to show just the opposite. The band should really be busy in September.

Sony recently announced that they intend to release a colour tube with a 114° deflection angle and narrow neck soon; an 18 inch first, but they say the same technology is applicable to larger tubes. Looks like amateurs building colour receivers themselves will soon be using cabinets smaller than their black and white sets! A big difference from those huge boxes we used at first.

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CONTENTS

AN INTRODUCTION TO SLOW SCAN TV.

By Gordon Sharpley G3LEE

At present the position of slow scan television is similar to that of single sideband in the early 1950s. Few stations are equipped for it, but it has vast possibilities. The additional dimension of a visual image gives a great deal more interest to long distance communication. About twenty amateurs in the UK, 400-500 in the USA, 50 in Italy, and a number in Australia and New Zealand with others scattered through about forty countries of the world, are equipped so far.

Cop Macdonald, WA2BCW, started it all with an article in QST, August 1958 (ref. 1). Things were slow at first, but in 1959 the Post Office (as it was then) licensed about half a dozen British stations, myself included, for SSTV transmission on 144MHz and upwards. About this time G3AST received WA2BCW on the first transatlantic SSTV contact on 14MHz. In 1961 WA2BCW developed the idea of frequency modulating the subcarrier (ref 2). Up to now amplitude modulation had been used, with severe QRM problems. Slow Scan then went dormant until about two years ago, when activity in the USA perked up again.

Basically, the picture is transmitted in the form of a frequency modulated subcarrier in the audio range. 1500Hz is black, 2300Hz white, whilst 1200Hz "blacker than black", is used for synchronising information. This signal will go through an amateur's transmitter and receiver (SSB or AM) without modification to either. The pictures can also be stored on a normal audio tape recorder.

The picture has 120 lines. American standards are based upon dividing the mains frequency by four, i.e. $60Hz \div 4 = 15Hz$ for the line rate. A picture takes 8 seconds. British Standards have to divide the mains (50Hz) by 3 giving a line rate of $16\frac{2}{3}$Hz (not far from 15Hz). The picture thus takes 7.2 seconds. In practice these two standards require only a slight adjustment of the monitor line speed control to change from one to the other. As the picture takes so long to complete a very long persistence phosphor is required on the monitor tube. Cathode ray tubes having the P7 phosphor are ideal, especially if an orange-yellow filter is used to cut out the initial blue trace. The 5FP7, 5JP7, 3FP7, surplus tubes are suitable.

The receiving monitor consists of the long persistence tube with its high voltage supply and suitable timebases. The audio subcarrier incoming from the station receiver is limited and fed to an FM demodulator working over 1500Hz to 2300Hz to brightness modulate the tube with video and a demodulator at 1200Hz to feed synchronising pulses to the timebases. Integration is used to separate the line and field pulses (5mS and 30mS long respectively) as in normal television technique.

Generation of pictures for direct transmission or recording onto tape is by either flying spot scanner or camera (ref 3,4). Camera systems can be quite complicated, so we will confine the description to flying spot.

The monitor can be used as the scanning source if it is fed with suitable synchronising pulses (ref 5). Fortunately the P7 phosphor has a bright blue initial trace of short persistence. A photo multiplier tube such as the 931A is sensitive to this, but blind to the yellow long afterglow. The transparency to be transmitted is either placed directly on the front of the C.R.T. or the raster can be imaged onto it by a lens system. The light passing through the transparency is gathered by the photomultiplier and the output of this fed, with the sychronising pulses, to a voltage controlled multivibrator. The multivibrator is set up to give the correct frequencies when modulated with the video signal. 1200Hz at sync. 1500Hz black, 2300Hz peak white. A filter follows the multivibrator to remove the high harmonics and restrict the bandwidth to 1200 - 2300Hz. This is then the slow scan signal.

Transmission of slow scan television in the UK requires permission from the M.P.T. (no additional licence fee). Bands from 7MHz to 432MHz can be used.

International calling frequencies for slow scanners have been established at 14230KHz, 21340KHz, 28680KHz (3845KHz and 7220KHz are internationally accepted, but British amateurs have settled on 3740KHz and 7040KHz for UK working). The characteristic warbling sound of slow scan is becoming more and more frequently heard on the bands.

References

1. A narrow band image system. Macdonald QST Aug. - Sept. 1958.
2. SSFM a new system for slow scan. Macdonald. QST Jan. - Feb. 1961.
3. A Slow Scan TV Camera. C.G. Dixon C Q - T V No. 55 1965.
4. Ham Radio Nov. 1971.
5. An I.C. Timing Generator for slow scan. J. Lawrence. C Q - T V No. 70. May 1970.
6. A Slow Scan Pulse Generator. Ake Backman C Q - T V No. 78 May 1972

SLOW SCAN NEWS

2nd World Slow Scan Contest

Here are the results of the contest, sponsored by "C Q Elettronica" magazine, held on 5th - 13th Febuary.

1.	W9NTP	scored	7.560
2.	PAØLAM	scored	6.750
3.	VE3GMT	scored	6.375
4.	i6CGE	scored	4.940
5.	W4MS	scored	4.770
6.	G5ZT	scored	4.715
7.	F6AXT	scored	4.095
8.	W5PPP	scored	4.000
9.	i2KBW	scored	3.900
10.	K9BTU	scored	3.150
11.	F9XY	scored	1.800
12.	15BNT	scored	1.800
13.	i5CW	scored	1.520
14.	SMØBUO	scored	1.445
15.	i1ROL	scored	1.360
16.	W1JKF	scored	1.215
17.	EA4DT	scored	1.200
18.	W5QKR	scored	1.120
19.	SV1CG	scored	825
20.	WB2MEX	scored	825
21.	K4TWJ	scored	810
22.	VK5MF	scored	800
23.	W7FEN	scored	750
24.	i5CG	scored	715
25.	WB6OMF	scored	625
26.	W1FUQ	scored	540
27.	W5GQV	scored	425
28.	EA4KJ	scored	400
29.	FO8DO	scored	320
30.	K61V	scored	300
31.	WB6ZYE	scored	300
32.	G3ZGO	scored	275
33.	OD5BV	scored	240
34.	OZ6PH	scored	225
35.	F9AC	scored	30

Short wave listeners;

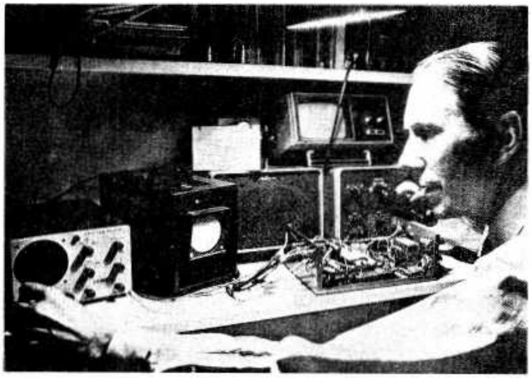
1.	i1BAY	scored	5.200
2.	ON4BX	scored	3.465
3.	WDX41KZ	scored	2.015
4.	i1RAR	scored	700

Slow Scan in South Africa

Radio hams should be seen as well heard, says Peter Towers ZS6PP who claims to be the first South African to send and receive slow scan pictures.

ZS6PP became interested in amateur tv when he picked up freak uhf commercial television pictures from Rome on a conventional tv receiver.

He started work on an oscilloscope, but turned it into a slow scan monitor, and built a convertor for slow scan reception. He uses the 10, 15 and 20m bands and finds them quite reliable, and since he received permission from the South African Post Office in January 1971 has worked Hawaii, Australia, U.S.A., Sweden, England, Holland, Wales and Belgium. One last ambition - to have worked all of the continents! The photograph shows Peter's shack at his home in Johannesburg.



Harold Jones G5ZT has sent us a copy of his log for the World SSTV Contest; with 41 QSO s it's much too big to print here, but it really is a log to be proud of. The countries 'ZT contacted were Italy, Sweden Spain, Sardinia, Hungary, Greece, Lebanon, Canary Isles, U.S.A., Canada, France, Holland, Guadeloupe, England, Denmark and Wales, a total of 16, and is a measure of the popularity of the mode of transmission worldwide today. Congratulations on coming sixth, Harold.

INTERNATIONAL ATV CONTEST 1972

Organised by A.G.A.F. A.T.A. B.A.T.C. & Amateurfunk Magazin.

DATE & TIMES

23/24 September and 30 September/1 October 1972

Saturday 1700 - 2200 Central European Time
Sunday 0900 - 1200 (= British Summer Time)

Contest duration 16 hours in total.

ELIGIBLE ENTRANTS

All european amateurs who are licenced to transmit and/or receive A.T.V.

MODES OF TRANSMISSION

A-5 with F-3 or A-3

All entrants must conform with their National Licence Conditions and Requirements.

FREQUENCIES

2 Meters Band	Sound Only
70 cm Band	Sound and Vision
23 cm Band	Sound and Vision

SECTIONS *

There will be three sections to the contest:

A. Those entrants who transmit sound and vision
B. Those who transmit sound only
C. Those entrants who only receive A.T.V.

OPERATING SITES

Stations may change their location and/or operate from portable sites if they wish.

CONTEST EXCHANGES

Contest Exchanges shall consist of:
1. The call sign of the station.
2. The video signal readability report.
3. The sound signal strength report.
4. The serial number of the contact (which shall commence at 001 and advance by one for each contact during the duration of the contest).
5. The Q.R.A. locator.

The Q.R.A. locator shall only be sent as a vision signal (i.e. A5 mode).

Each station may be contacted once each day, thus giving a maximum of four contacts with each station during the contest.

CONTEST ENTRIES

Contest entries must be submitted giving the following information for each contact:

1. Date.
2. Time
3. Call sign of station contacted or received
4. Readability report or vision signal
5. Strength report of sound signal
6. Serial number of the contact

(As received)

7. Readability report of vision signal
8. Strength report of sound signal
9. Serial number of the contact

(As sent)

10. Q.R.A. locator (As received)
11. Q.R.A. locator (As sent)
12. Distance in kilometers
12. Claimed score.

For reporting purposes, the readability of the vision signal should be reported on a scale of zero to five, whilst the strength of the sound signal should be reported on a scale of zero to nine by UK entrants.

*NOTE Only one section may be entered by each competitor.

SCORING

Each contact or station received shall be scored at one point per kilometer between station locations or at five points per kilometer if the vision signal is on 23 cm. (Parts of a kilometer shall count as being the next whole number above). If the Q.R.A. locator is received by vision signal then points for that contact are multiplied by 2.

Incorrect or incompleter log entries will be allowed at the Group Organisers' discretion.

ENTRIES

All entries should be post marked not later than 15th November 1972 and sent to:

Stations in France & Benelux to A.T.A.
Stations in Great Britain and Scandinavia to B.A.T.C.
Stations in Federal German Republic, West Berlin and all others to A.G.A.F.

All entries must be accompanied by a cover sheet giving:

- Name and address for correspondence
- Call sign used
- Claimed score
- All locations used during the contest in longitude and latitude with height above sea level in meters.
- Vision Transmitter P.A. Stage
  - Valve or transistor type number
  - Input power in watts
  - Antenna System used
- Vision Receiving System used.
- Vision source - camera, flying spot scanner scanner etc.

AWARDS

The winners of each section will receive a certificate plus the following prizes:

SECTION A

First prize - A brand new Vidicon TV camera donated by "Amateurfunk Magazin" 533 Konigswinter Winzerstr 82

Second prize - A 1" Vidicon tube.

SECTION B

First prize - A 1" vidicon tube.

SECTION C

First prize - A 1" vidicon tube.

Addresses for Contest entries:

B.A.T.C. Malcolm Sparrow G6KQJ/T
64 Showell Lane,
Penn,
Wolverhampton,
Staffordshire.
Great Britain.

A.T.A. Willy P. Everaert ON4WM
Park ten Hove 97,
B-9230 Melle,
Belgium.

A.G.A.F. Herman Hiltenkamp, DL8PO
D-5980 Werdohl,
Bahnhofstrasse 2
West Germany.

In addition to the International Contest, B.A.T.C. is running a National Contest with slight variations of the above rules. Entrants may change their operating sites, or operate in a portable mode if they so wish. Awards for this contest will consist of certificates issued by the Club.

POSTBAG

Ladislaw Vig in Switzerland has been using PIN diodes and I.Cs to modernise his FSS, but has had problems focussing the light onto the small area of the diode, which also proves to have the wrong spectral response! Not discouraged, current experiments are aimed at building a compact FSS for SSTV, using a DG-3 cathode ray tube and a CdS light dependant resistor. If this shows a long afterglow, an alternative is another system using a DB-3 (1½ inch tube) and a phototransistor, but Ladislaw believes that for SSTV, the first system will work. If anyone else has any experience, or ideas, along these lines Ladislaw would like to correspond, his address is 6030 Ebikon, A. Schindlerstr. 3, Switzerland.

Maitland Lane VK5AO of Henley Beach, South Australia writes of amateur activity in his area. Many people in Adelaide have colour tubes now and are starting to build receivers, and some have picked up Maitland's colour signals on 70cm. But the new development is the use of 1296, and VK5AO hopes that the exchange of his signals with VK5ZEF two miles away will not be hampered by the big tree right in the path! Current experiments are with a 4ZX250B, with a few problems at the moment. With VK5ZEF, VK5GG, VK5ZOF and VK5AO on the air regularly twice a week, Maitland still claims his area has the highest activity in Australia.

Frank E. Wood in Blackpool has just finished building an S.P.G. and camera based on Mike Cox's circuits. Frank had help from other B.A.T.C. members and enjoys reading C Q - T V. Hope to see you on the air soon Frank.

Doug Laver VK4ZDL/T from Queensland, Australia writes to tell us of his transmissions. He has a one inch vidicon camera and has completed his transmitter as well as the 70cm receiver. Up to the present a 13 element yagi has been used, but Doug has a 48 element collinear array under construction now - time permitting!

Joseph Tolbert Jr. from South Carolina U.S.A. tells of a group of amateurs in his area who are just starting ATV. There are three stations in North Augusto, two running 6V6 modulated oscillator transmitters and one with a G.E. 470MHz mobile transmitter strip driving a cavity that puts a measured 80 watts into a corner reflector. Eighty miles east in Colombia are two more stations, one gives 10 watts into a yagi, the other is just getting started. Fifty miles north Joseph is able to put 10 watts into a homebrew yagi from his own location. All the stations use modified tv sets as receivers with one inch vidicons as picture source. All random interlace, but one station has an S.P.G. under construction.

Ronald B. Cohen K3ZKO from Philadelphia U.S.A. has recently taken over A5 magazine and announces that from now on it will be upgraded. He tells us that on the Eastern side of U.S.A. amateurs are using crystal controlled transmitters and receivers, and sending video and audio on the same frequency of 439.25MHz. Apparently this works well with a narrow bandwidth.

Dr. K.M. Kelly is another member from Queensland, Australia and has told us something of the SSTV activity his way. Several people have used a type 101 radar unit for a start, this having a built-in transformer which can be used with a 2N3055 oscillator to provide the eht. The valves are replaced by diodes, and by using I.Cs and transistors the power supply needs only to be 15 volts dc for a SSTV receiver. One idea being followed up is re-phosphoring tv tubes with the correct phosphor for slow scan; a cheap and effective plan!

Raymond Foxwell VK5ZEF/T is another member of the South Australian Amateur Television Group and is looking forward to the arrival of colour tv in 1975. In preparation he has acquired a 63.120X colour tube and wonders if anyone has any deflection gear for this tube - none is available his way at a reasonable price. Using C Q - T V circuits, 'ZEF has built a crosshatch generator and a colour bar generator for setting up the receiver when completed.

DON'T FORGET THE 1972 B.A.T.C. CONVENTION ON SEPTEMBER 16th. FILL IN THE REGISTRATION FORM ON PAGE 6 OF C Q - T V 78 AND ENTER THE DATE IN YOUR DIARY. COME AND MEET ALL THE OTHER MEMBERS OF B.A.T.C., EXHIBIT YOUR OWN GEAR AND SEE OTHER PEOPLES AS WELL.

1972 BATC CONVENTION

FINAL ARRANGEMENTS

The final arrangements for the Convention remain as published in the last issue of CQ-TV, except for a few details which are printed here.

Firstly, due to lack of support, the idea of a Convention dinner has had to be dropped. This is unfortunate, but with only nine members expressing interest there really wasn't much point in running it. However, there is a licensed hostelry underneath the ITA Convention Suite - so perhaps we could assemble there in the evening!

The Provisional Agenda for the Annual General Meeting has been established, and here it is:-

1. Apologies for absence.
2. Minutes of previous meeting.
3. Chairman's report.
4. Treasurer's report.
5. Proposed Constitution changes.
6. Equipment Registry.
7. Resolutions received in writing.
8. Election of Officers.
9. Elected Treasurer's confirmation of subscription fee.
10. Any other business relevant to the old committee.
11. Announcement of Constitution of new committee.
12. Any other business relevant to the new committee.

Among the lectures to be delivered during the Convention will be one by Arthur Critchley on Integrated Circuits. Those of you who have been reading his articles in the magazine will, we hope, be keen to hear him speak on his pet subject. It is hoped that other lectures will be read as well.

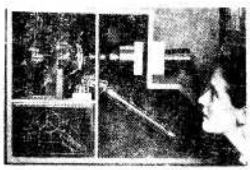
The ITA has been kind enough to allow B.A.T.C. access to their "Television Galley" during the Convention. This, as you probably know, is a permanent exhibition of the history of television, showing also how television programmes are made; there is also a section on how colour television works. We hope to have official guides available to show members round this unique display; an extra incentive to you to come up to London for the Convention! The photograph printed here is a QSL card issued by the ITA for the Television Galley, and gives further details.

Two cameras from the B.A.T.C. Outside Broadcast Van "Monoculus"

To ____________ Confirming Our Fone/CW ________ MHZ QSO

On ________ At ____________ UR R.S.T. ________

TX ________ RX ____________ ANT ____________



The Mark 1 Emitron Camera Tube. 1932.

INTERESTED IN ITA

The ITA Television Gallery is an exciting and unique permanent exhibition covering all aspects of television, past as well as present. Its history, how different kinds of programme are made, how colour works and much more is shown in the most unusual exhibition that you have seen.

Open to the public on weekdays by appointment.

ITA TELEVISION GALLERY
70 BROMPTON ROAD
SW3 01-584 7011

Parties of up to 30. Minimum age 16.

BATC at the 1972 vhf Convention.

B.A.T.C. was represtented at the vhf/uhf Convention at Whitton this year with emphasis on the fast growing slow scan method of Communication.

G3RHI, Mr. B.J. Arnold, kindly loaned the Club his slow scan monitor for the occasion. This was the American "Robot" type which is now commercially available in this country.* The picture is reproduced on a long persistance tube with the P7 phosphor, which is similar to the 5FP7. Malcolm Sparrow brought along his receiver, an SPDX-400, and a temporary 14MHz dipole was tied up outside the hall. This was only 12 feet high, unfortunately, as it was rigged as quickly as possible in order to avoid awkward questions from vhf men wondering why B.A.T.C. committee members were climbing up trees; especially as they were putting up l.f. band dipoles at a vhf Convention!

Success came in the late afternoon when a three way QSO between an Italian, a Belgian and a Portuguese station was received and recorded. All produced really excellent slow scan pictures; the Italian station sent several pictures of himself and his family whilst the Portuguese man, CTILX, gave a very slick presentation of various captions. Later an American station was watched sending CQ in caption form.

These pictures, together with some recorded pictures which were shown earlier, gave many amateurs present their first sight of the potential of slow scan television for worldwide exchange of video.

Grant Dixon G6AEC/T bought along to the Convention his digital frequency meter. This was built to be as versatile as possible and with x18 and x54 circuits could be used for checking throughout many bands, including 70 cm. This was admired by many visitors to the stand.

Robert Skegg G3ZGO G6ADJ/T, came complete with a homebuilt microwave link, which he proceded to rig across the hall! This worked on 3 cm and was seen to produce a good video signal, which although the path was a little short, was a very commendable effort for an amateur. Also it may be a portent for the future, with our present 70 cm difficulties.

The B.A.T.C. effort at the Convention was the result of hard work by G6LEE/T Gordon Sharpley, G6KQJ/T Malcolm Sparrow, G6AEC/T Grant Dixon and G8CPJ, G3ZGO and G3RHI to whom our thanks for a splendid display must go.

*From G5ZT of Saltash Radio & Television Co. Ltd., 84 Fore Street, Saltash, Cornwall, PL12 6AB

21 YEARS AGO IN C Q - T V

"Grant Dixon has been trying colour television and will let us have more details later. He is using a 100c/s frame time base and a 20Kc/s line oscillator. This gives 33⅓ complete colour pictures per second, and gives negligible flicker compared with his previous 200 line 50 frame raster. A six sector rotating disc of Strand Electric gelatines is used and the three 931As all feed into the same amplifier. Grant would like to contact any other colour men".
(C Q - T V October 1951)
(Who said B.A.T.C. weren't first? ED.)

Ideas for Amateur Colour
Part 3

Nigel Walker
G6ADK'T

In this article a vision mixer suitable for handling colour signals will be described. You may think that such a device is rather over ambitious, when producing a single colour source is quite an achievement. Well, once you have one colour source - say colour bars - it is easier to duplicate the coder and produce a second source, synthesised captions for instance. Also you may like to inlay colour bars at the top of your monochrome test card, and there's no reason why you shouldn't mix several monochrome sources with your one or two colour sources. Lastly, a mixer which gives a good colour performance will undoubtably give an excellent monochrome performance.

DESIGN CONSIDERATIONS

Originally two alternatives were considered. Firstly one could copy the broadcasters and process the encoded video signals. This requires a separate coder for each colour source, and the circuits used must be carefully designed so as not to cause distortion to the signal. The other alternative is to mix the individual R,G and B signals, and have a single coder at the output of the mixer. The problem with this system is that the circuits have to be made in triplicate, and also have to match and track one another very accurately, otherwise errors in hue will result. It was therefore decided to follow convention and handle already encoded signals.

CIRCUIT DETAILS

This vision mixer is built up using three 'building blocks'. The complexity of the mixer and the facilities provided can be varied by rearranging the blocks.

Fig. 1 shows a simple mixer of the well known A/B format. One of four inputs is selected for each channel by the blocks marked 'SW'. The circuit of this block is shown in Fig. 2. This is a simple feedback pair amplifier which can be turned on and off with a TTL compatible input.

The switching logic is arranged so that only one amplifier per group is 'on' at any time, and that switching takes place during the field blanking period. In the 'off' condition the attenuation given is better than 60dB at subcarrier frequency.

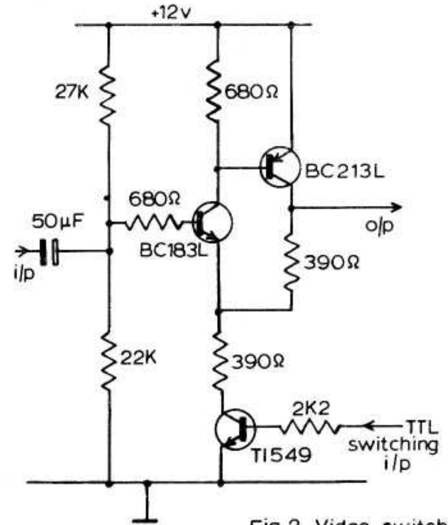


Fig.2 Video switch.

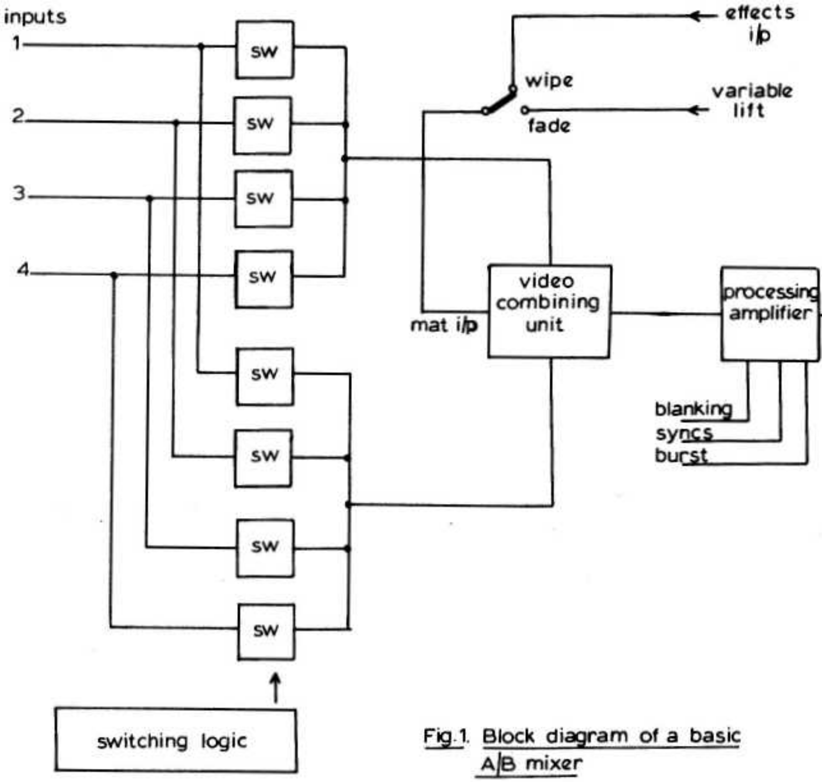


Fig.1. Block diagram of a basic A/B mixer

The heart of the mixer is the Video Combining Unit which is shown in Fig. 3. This unit combines the two vision sources selected in a variety of ways depending on the waveform at the 'mat' input.

The circuit is built around the 1596 balanced modulator I.C. that was used in the coder. In this application it is used as a linear multiplier. That is, it has two inputs, and the output is a product of the inputs. Fig. 4 shows the output obtained when one input is grille and the other sawtooth.

Referring to Fig. 3 again, it can be seen that each input has a clamp, so that the input d.c. component is always referred to the blanking level of the corresponding waveform. This means that a particular input can be faded by applying a variable lift waveform to the other input. It can also be seen that there are two such groups of circuits, one being fed with the inverse of the matting waveform supplied to the other. Thus a crossfade can be produced by applying the variable lift waveform, and inlays, wipes etc., can be achieved very simply by applying the app-

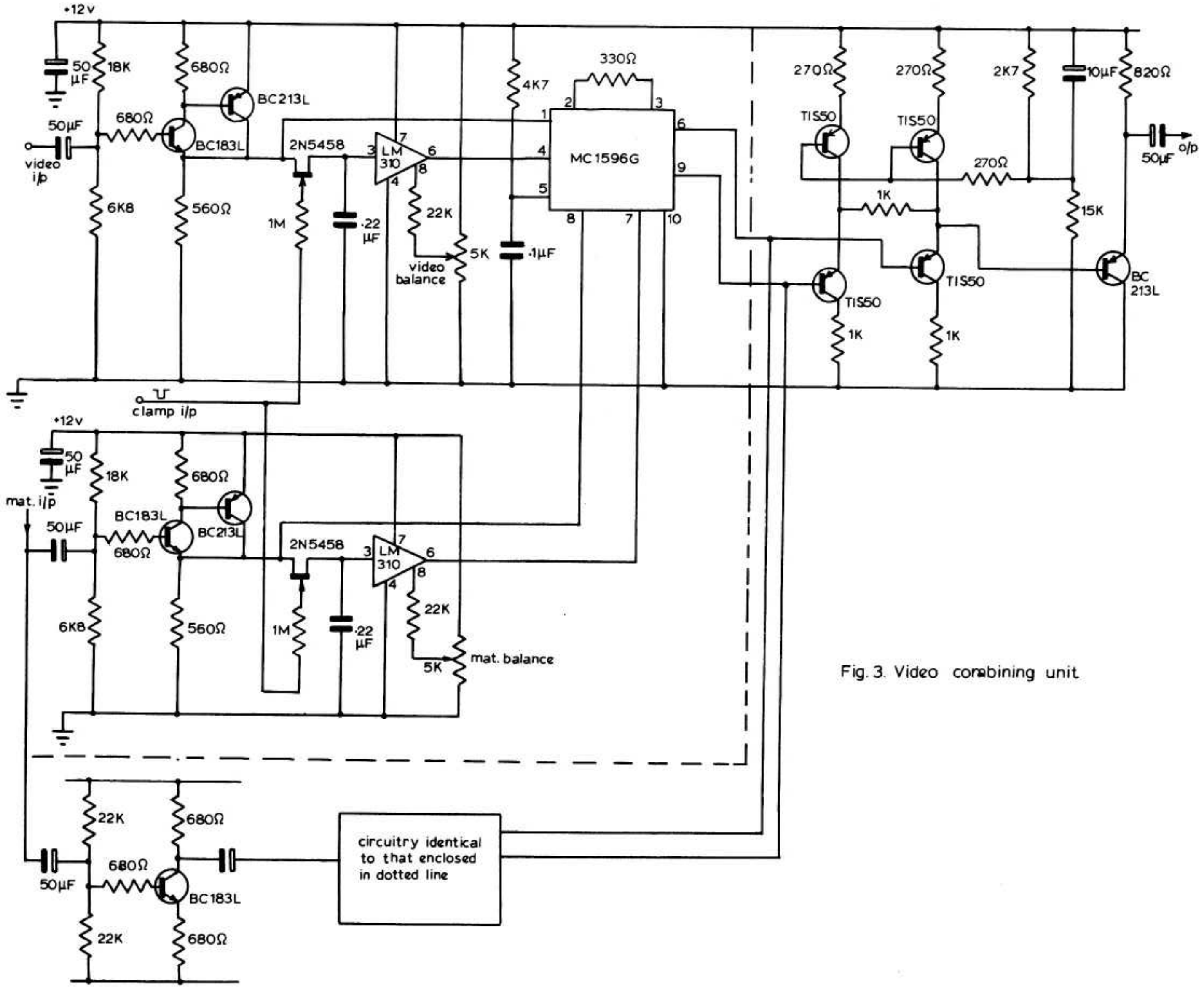


Fig. 3. Video combining unit

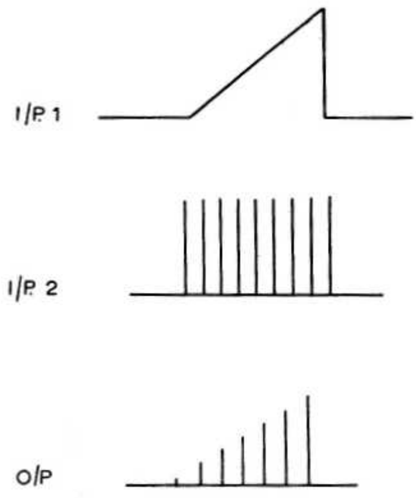


Fig. 4. Multiplier waveforms

ropriate 'schmitted' signal. Since the matting input has a linear transfer function it is very easy to produce 'soft wipes' (on verticles) by softening the matting waveform with a simple integrating network. This design has an excellent switching characteristic due to the balanced nature of the modulator and selecting a horizontal split with the same signal on both inputs produces no detectable switching transient or gap in the output.

The processing amplifier blanks any syncs or bursts that may be present on the output of the VCU and adds new syncs and bursts from a colour black level generator. Circuits for the processing amplifier aren't included as they follow general practice.

A Pulse

D. M. Bridgen

It has occurred to me that during testing of SPGs, and indeed other digital circuits, it may sometimes be advantageous to temporarily replace the master oscillator with a source of pulses, the repetition rate and actual number of which could be selected as desired. This would enable a counter chain, say, to be clocked up to a particular point and held in that condition while logic levels throughout the circuit were investigated. Further pulses could be clocked in very slowly, or one at a time manually, thus allowing the changes of state with each pulse to be observed at leisure.

I have not constructed the circuit shown so it is therefore presented as "food for thought".

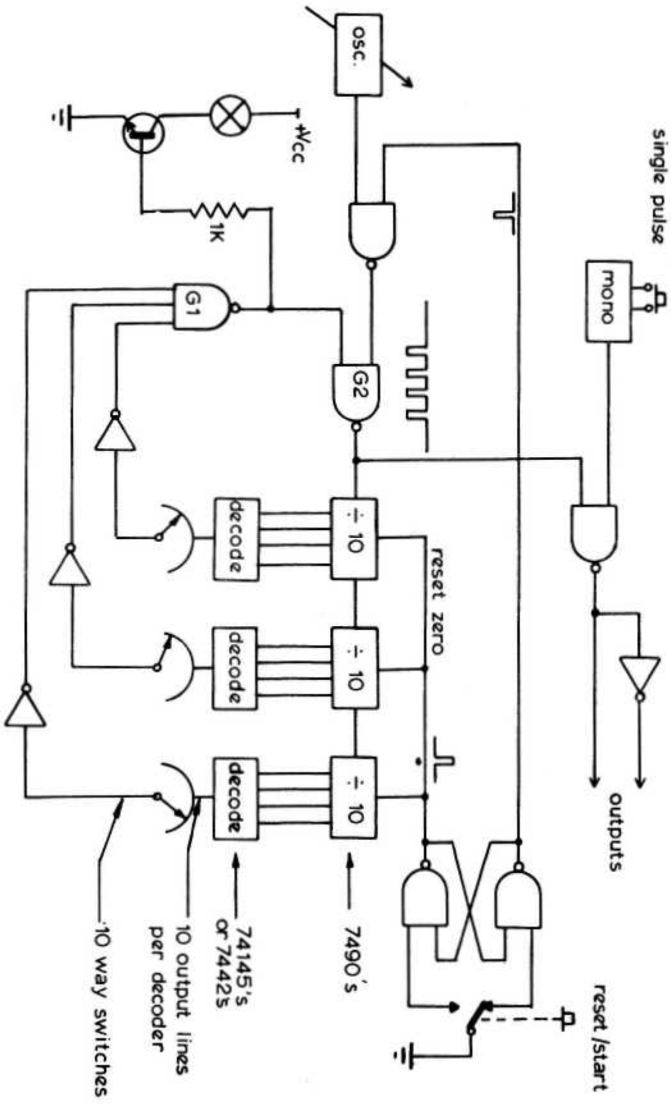
DESCRIPTION

A pulse generator of either switched or continuously variable repetition rate, which could well be an external source such as a sine/square generator, feeds a chain of decade counters. The BCD output of each counter is decoded such that each one of ten output lines from the decoder will be enabled sequentially. One of each set of output lines from the decoders is selected by a ten-way switch and thereby connected to an input of gate 1. When a particular count, as selected by switches, is reached, all inputs of gate 1 will be high and its output will go low. This output, feeding one input of gate 2, will keep the output of gate 2 high effectively inhibiting the clock pulses. The output of gate 2 therefore will be a train of a preselected number of pulses.

Depressing the reset/start button clears the counters, the output of gate 1 then going high, and at the same time temporarily inhibits the clock pulses from the input of gate 2, otherwise pulses would appear at the output before counting started. Releasing the button enables the counters and allows

continued on page 21

Counting Generator



THE BRITISH AMATEUR TELEVISION CLUB.

INCOME and EXPENDITURE ACCOUNT for the YEAR ended 31st DECEMBER, 1971.

TRADING ACCOUNT

	Year ended 31.12.71.		Year ended 31.12.70.	
Sales of Equipment		258.01		467
Less Cost: Purchases	332.77		476	
Stock at 1.1.71	133.03		123	
	465.80		599	
Stock at 31.12.71	221.26	244.54	133	466
SURPLUS for the Year		13.47		1

GENERAL ACCOUNT

INCOME				
Subscriptions: Current	587.08		222	
Arrears	6.00		8	
	593.08		230	
Interest from Building Society	17.12		23	
Advertising in C Q - T V	66.00		54	
Miscellaneous Income	25.32	701.53	39	346
EXPENDITURE				
4 Issues C Q - T V	381.31		313	
Postage thereon	135.53		103	
	516.84		416	
Printing, Postages & Stationary	116.47		104	
Convention & Exhibition Expenses	0.00		10	
Committee Expenses	1.05		7	
R.S.G.B. Affiliation Fee	0.50		1	
Bank Charges	5.00		1	
Depreciation of Equipment	13.00	652.86	16	555
SURPLUS/DEFICIT for the Year		48.67 (Surplus)		209 (Deficit)

RESOURCES of the CLUB

Accumulated Fund:

Balance at 1st January 1971		642.12		933
General Account Surplus (Deficit)	48.67		209	
Trading Account Surplus	13.47	62.14	1	208
		704.26		725
Less Deficit on CAT 70		0.00		83
Balance at 31st December 1971		704.26		642

Represented by-

Fixed Assets				
Office Equipment at 1st January 1971	64.00			
Less Depreciation	13.00	51.00		64
Current Assets				
Stocks: Trading	221.26		133	
C Q - T V Magazines	10.67		16	
CAT 70 Booklets	5.00		20	
Stationery	109.36		5	
	346.29		174	
Debtors	0.00		20	
Balance with Building Society	513.86		347	
Balance with Bankers	0.00		149	
	860.15		690	
Current Liabilities				
Creditors	22.98		0	
Subscriptions paid in Advance	118.20		112	
Lloyds Bank Ltd.	65.71		0	
	206.89		112	
Net Current Assets		653.26		578
		704.26		642

The above Balance Sheet at 31st December 1971, together with the Trading and General Accounts for the year ending on that date, are in accordance with the books of the Club as produced to me, and, to the best of my knowledge and belief, show a true and fair view of the position of the Club as at 31st December 1971 and of the results for the year.

BRIGG

April 17th 1972.

J.R. GREGORY

Chartered Accountant.

CIRCUIT NOTEBOOK No11

J. Lawrence GW6JGA'T

This edition of Circuit Notebook departs from the usual circuit items and describes a D-I-Y Quadrant Fader/Mixer. The mixer consists of two quadrant faders mounted side by side in a frame, one increasing upwards and one increasing downwards. Two input signals A and B, can then be faded up and down individually or by holding the two quadrant arms simultaneously, in effect ganging the two controls, a straight fade from A to B or B to A can be made. An example of the unit can be seen in the photograph on page 6 in C Q - T V 78.

CONSTRUCTION

The construction of the unit is very simple and consists of two side plates of 16 swg aluminium spaced by four 2 inch long pillars; screwed rod (studding) and nuts would do equally well.

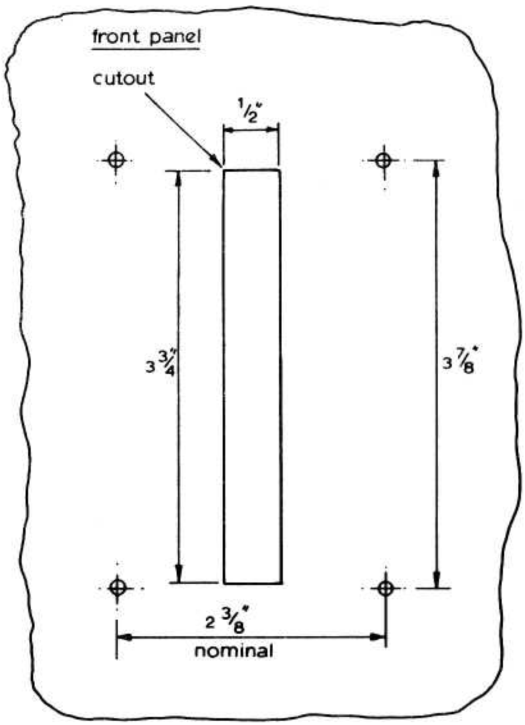
The quadrant arms consist of Radiospares perforated strip, 14 holes long. Each is fixed with 4BA bolts and nuts to a Meccano $3\frac{1}{2}$ inch gear wheel No. 27b, as shown in the drawing.

Each fader potentiometer is fixed to the side plate from the outside with the spindle protruding inside. Extra nuts or washers may be needed on the potentiometer bush to position correctly.

Two Meccano pinions No. 25 are drilled out to $\frac{1}{4}$ inch diameter and fit on each potentiometer spindle. The gears and pinions should work together smoothly and have very little backlash. It may be necessary to 'draw' the potentiometer fixing hole slightly and position the potentiometer critically for best operation.

The spindle holding the two large gear wheels is a Meccano axle rod No. 16 and this is rigidly fixed at each end by a Meccano

FIGURE 1



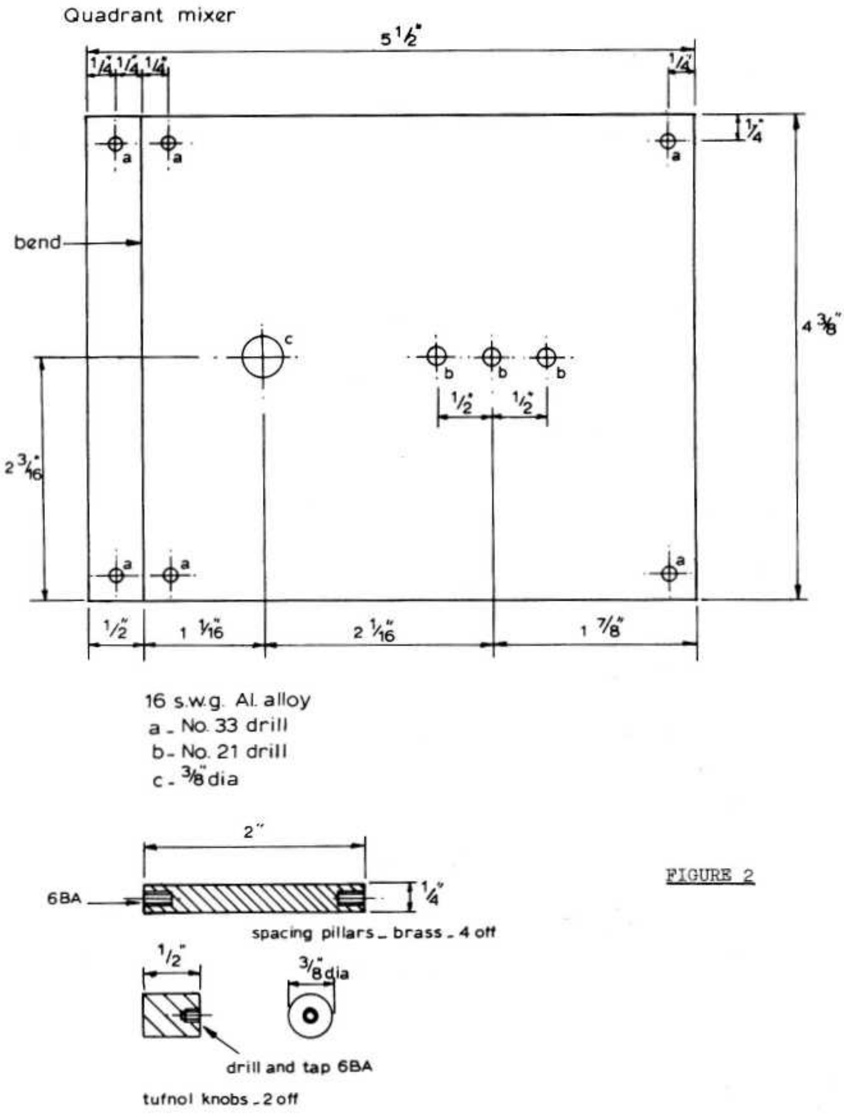
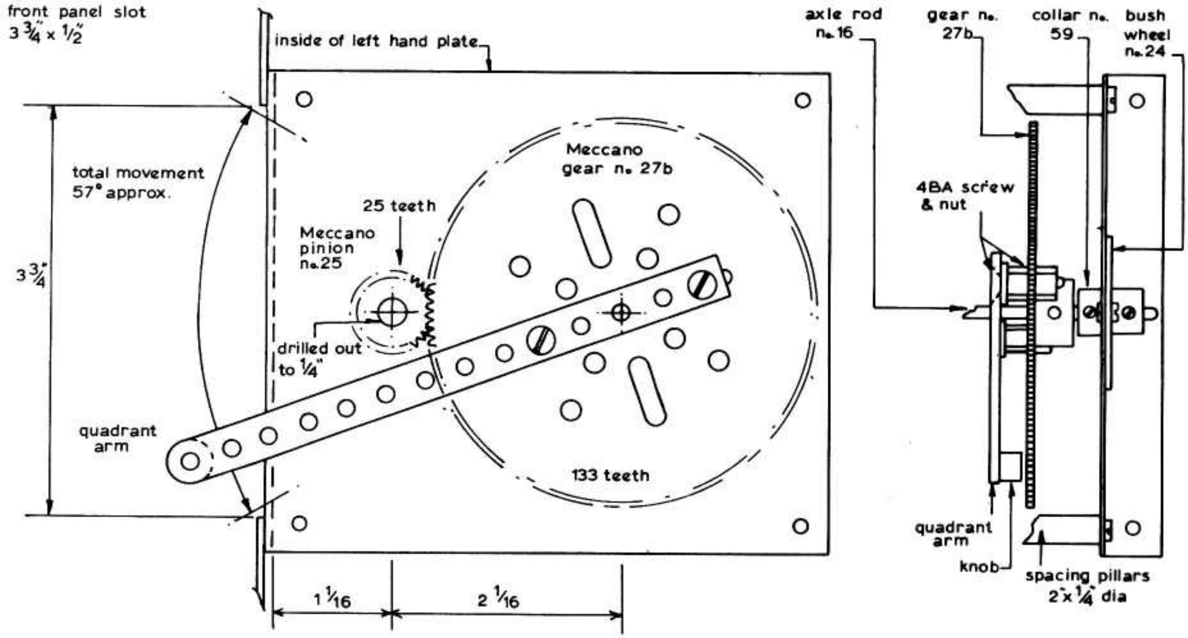

Quadrant mixer
5 1/2"
1/4" 1/4" 1/4"
1/4"
1/4"
4 3/8"
bend
a
b
c
2 3/16"
1/2"
1/2"
1/2"
1 1/16"
2 1/16"
1 7/8"
16 s.w.g. Al. alloy
a - No. 33 drill
b - No. 21 drill
c - 3/8" dia
2"
6BA
1/4"
spacing pillars - brass - 4 off
1/2"
3/8" dia
drill and tap 6BA
tufnol knobs - 2 off

FIGURE 2

Quadrant mixer

FIGURE 3



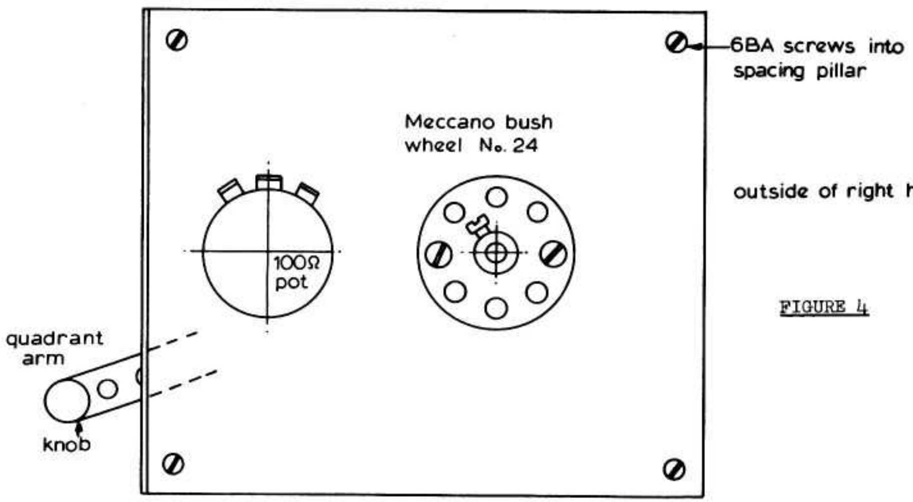


FIGURE 4

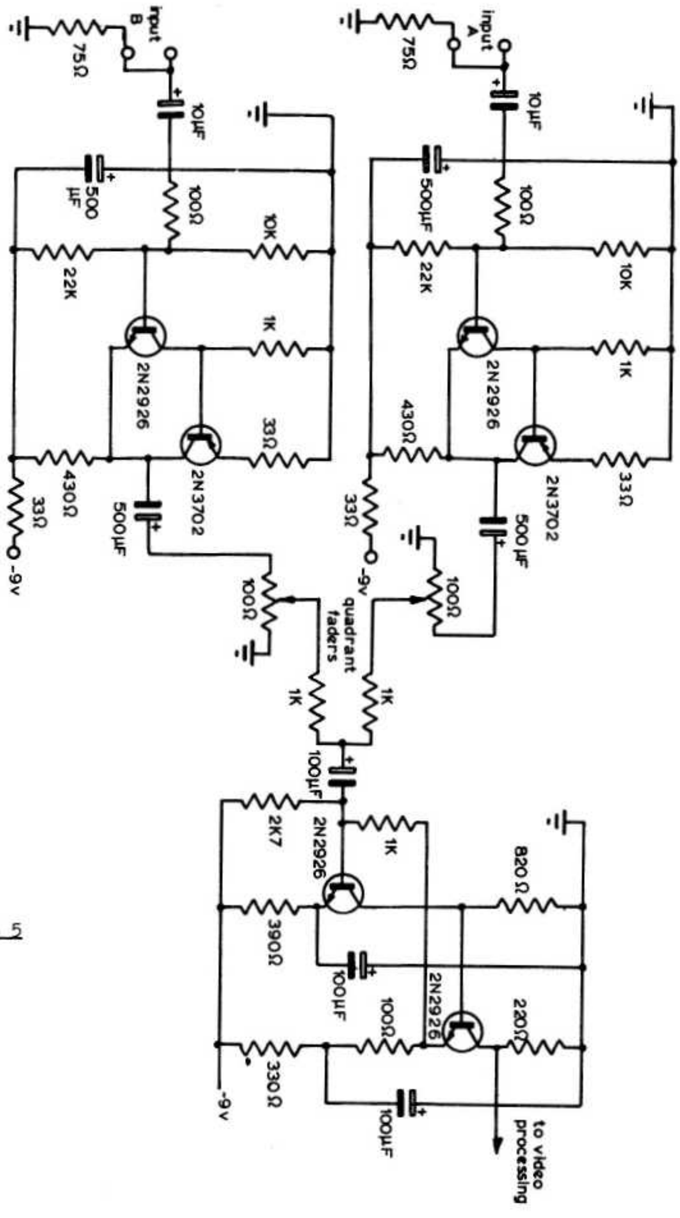

input A
75Ω
10µF
500µF
100Ω
10K
22K
1K
2N2926
430Ω
33Ω
2N3702
500µF
-9v
100Ω
input B
75Ω
10µF
500 µF
100Ω
10K
22K
1K
2N2926
33Ω
430Ω
2N3702
500µF
33Ω
-9v
100Ω
quadrant faders
1K
1K
100µF
2K7
2N2926
1K
820Ω
390Ω
100µF
2N2926
100Ω
220Ω
330Ω
-9v
100µF
to video processing

FIGURE 5

bush wheel No. 24. These are bolted on the outsides of the side plates.

The complete assembly is bolted to a front panel and the quadrant arms protrude through a slot in the panel and are fitted with small knobs, old terminal tops would be quite suitable.

CIRCUIT

For simple operation, signal inputs A and B could terminate in each potentiometer directly. The 100 ohm could be made 75 ohm by paralleling with a 330 ohm resistor.

The slider output from each potentiometer is taken through a resistor to the summing junction of a virtual earth amplifier.

For 'bridging' inputs a separate amplifier is required for each potentiometer and the complete circuit incorporating input and summing amplifiers is shown in Fig. 5.

continued from page 14

pulses to pass through gate 2.

The monostable is included to allow single pulses to be generated manually. An inverter provides a complementary output.

The lamp, driven from gate 1 output, lights while counting is in progress and could be helpful when a low clock frequency and a high count are being used.

I would welcome comments on this circuit, either academic or from anyone who builds it, addressed to me c/o the Hon Editor of C Q - T V.

continued from page 2.

In the Schoenberg Memorial Lecture this year, Proffessor Walter Bruch spoke about the future of colour tubes as he saw it. Nothing significant will happen before 1980 he thought but with engineers working hard on the flat picture screen something should be available by 1990 or 2000. It's a long time to wait isn't it! The Proffessor predicted that the flat screen would be made from semiconductor laser elements, would be self-luminescent, and current day magnetic deflection techniques would be replaced by a sort of shift register system, the picture elements lighting up one after the other, each one excited by the preceding one. Rather like "shove ha'penny". If only all this could happen today.......

THE EDITOR.

Further Note on the CQ-TV SPG Genlock system.

The performance of the Genlock system with Helical scan Video-tape recorders is not always perfect. The symptoms are a ragged Genlock and poor field lock.

This is due to two causes. Firstly, Helical scan VTRs often have no decent field pulses and they generate noise spikes due to drop-out etc. The Genlock performance can be improved considerably by removing the output from the Equalising pulse detector so that the Superlock system works only from Broad pulses. This removes the effects due to the narrow spikes - narrower than Equalising pulses. It does mean that the SPG outputs are delayed by 2½ lines.

The ragged Genlock is due to the omission of line Sync pulses so that the Genlock bistable suddenly changes from line frequency to half line frequency with the consequent hiccup in the master oscillator control voltage. This hiccup may be in either direction because of the bistable action. Hence, the ragged effect.

There appears to be no simple solution to this problem short of a complete redesign. However, for most purposes the Genlock system is more than adequate. On the majority of Video-tape sources the performance is satisfactory. It is only when a particularly noisy tape is replayed that this happens.

INTEGRATED CIRCUITS

PART 9.

A.CRITCHLEY Dip El; C Eng; MIERE.

DIGITAL ENCODERS AND DECODERS

Encoders and decoders are expressions in common use which describe some process of conversion from one system of transmission to another. For example, a PAL encoder changes RGB TV signals into a more easily transmitted form. This is the basic reason for conversion - to make things easier. However, in this article we are concerned only with digital means of conversions and codes in particular.

Perhaps the most common form of digital coding occurs because there are' too many wires! This happens when a control or indication function has to be performed. Coding provides a means of reducing the number of wires and decoding recovers the information after transmission.

A frequent code is the binary code which we all know is based on powers of 2 because there are only two states in most electronic digital systems - on or off. (1 or 0). Unfortunately we count in tens and so to change from our decimal system to digital systems we have to encode, then perform the electronic business and finally decode for display purposes. The simplest method of conversion from decimal to binary is by means of a counter. Fig. 1 shows this. If the binary counter has four stages it is called a four-bit counter and has a maximum count of 16 before repeating itself ($2^4 = 16$). The states of the four bits are shown in table 1. Note that the first state is when all Q-outputs are low, or 0, and that the count finishes at 15

Table 1 The states of a 4-bit counter

Decimal	Binary DCBA
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
10	1010
11	1011
12	1100
13	1101
14	1110
15	1111
16	0000
17	0001
etc.	

The least-significant bit is A and the most-significant bit D (LSB & MSB).

For decimal counting purposes the count is limited to 10 and the sequence from 0000 to 1001 is known as the Binary Coded Decimal sequence - BCD.

A BCD counter is therefore a counter which counts in multiples of 10 and gives out this binary sequence from each part.

This type of a counter would be found in a frequency meter or a calculator. The problem of decoding each BCD section into a decimal display remains of course.

It is possible to calculate in normal binary code and then to decode the entire system in decimal outputs for display, but the amount of logic required would be unwieldy to say the least.

Fig. 1 Binary Counter

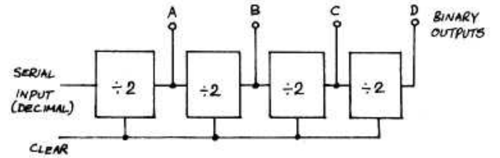
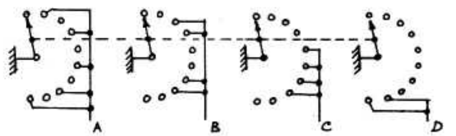


Fig. 2 Decimal-to-Binary Encoding with Switch



There is an IC, the 74185A, which will convert Binary to BCD and also another, the 74184, for converting BCD to Binary. Both will handle six bits but for more than this, can be inter-connected with other converters. However, the TV applications of these devices are virtually nil.

The BCD code is not the only 10-digit code that can be derived from four bits i.e. 10 from 16. There are many more possibilities with various advantages and disadvantages and table 2 shows three popular ones. Of these the Gray code is one in which only one bit changes at a time. This has applications in digital angular-position indicators. Compare this with BCD where all four bits change in ripple fashion when going from 7 to 8. A recognisable feature of a Gray code is that it is a reflective type of code. i.e. the second half is a mirror-image of the first half except for the MSB.

Table 2 Common 4-bit codes

Decimal	BCD (8-4-2-1)	2-4-2-1	Excess-3	Excess-3 Gray
0	0000	0000	0011	0010
1	0001	0001	0100	0110
2	0010	0010	0101	0111
3	0011	0011	0110	0101
4	0100	0100	0111	0100
5	0101	1011	1000	1100
6	0110	1100	1001	1101
7	0111	1101	1010	1111
8	1000	1110	1011	1110
9	1001	1111	1100	1010

Features of these codes are that the 2-4-2-1 code consists of the first five and the last five states of the sixteen possible. The Excess-3 code has the centre ten.

Both 2-4-2-1 and Excess-3 are weighted codes in that they can be converted directly into their decimal analogue form. Weighting means giving a value to each bit. Thus to decode BCD, D is given a weighting of 8, C 4, B 2 and A 1. Hence decimal 7 = 0111 = (0 x 8) + (1 x 4) + (1 x 2) + (1 x 1). The total is 7.

Again in 2-4-2-1. D=2, C=4, B=2 and A=1. Decimal 8 is 1110 which is 1.2 + 1.4 + 1.2 + 0.1 = 8.

The Excess-3 code is rather different. The excess-3 refers to the value being the BCD equivalent minus 3. Thus decimal 6 = 1001 = 1.8 + 0.4 + 0.2 +1.1 - 3 = 9 - 3 = 6.

The method of converting digital numbers to analogue values will be described in the next issue of CQ-TV.

It is not essential to stick to four bits when forming a code. For example, there are several well known five-bit codes.

The unweighted code is perhaps the most common as it is generated by a twisted-ring or Johnson counter (see CQ-TV 73 page 14 for description). The decoding of this into decimal is achieved by means of ten, two-input AND-gates each fed from adjacent bistables. Incidentally, it can also represent Morse Code numerals for those who are trying to make automatic Call-sign devices.

Table 3 Five-bit codes.

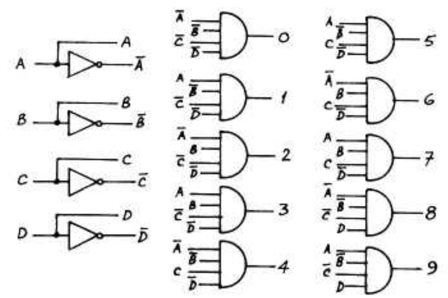
Decimal	5-1-1-1-1	8-6-4-2-1	Unweighted
0	00000	00000	00000
1	00001	00001	10000
2	00011	00010	11000
3	00111	00011	11100
4	01111	00100	11110
5	10000	00101	11111
6	11000	01000	01111
7	11100	01001	00111
8	11110	10000	00011
9	11111	10001	00001

Decoding Binary to Decimal

This is more difficult than its counterpart as we require some system which will provide one of ten outputs from any of four inputs

Straight logic can do this without any clocking or counting. For example, to decode the binary equivalent of 5 (0101) a four-input AND gate is required. In fact, a four-input gate is required for each of the ten states. Fig. 3 shows the system.

Fig. 3 Binary-to-Decimal Decoding (7442)



Boolean Algebra terms are shown, A = A at 1

$\bar{A}$ = A at 0

This system can be simplified somewhat since it is not always necessary to have all four inputs to define a particular number. For example, the 8 and 9 can be detected by the presence of a 1 in D and a 0 or a 1 in C. It is not necessary to have A and B. Fig. 4 shows the simplified system. If the input source has more than the ten possible states of the four variables then false answers will be obtained with this simplified system.

The decoding of four-bit binary to decimal is often called 4-line to 10-line decoding and there is a special IC for doing this - the 7442. This is of the un-simplified logic and contains ten, four-input gates and eight invertors. This does not make much difference to us as it is all inside a single package and all we are concerned with is what it does. The 7442 does in fact convert TTL BCD to TTL decimal, but there is another type of decoder which can drive lamps or Nixie tubes (7445, 74145 etc). This merely ends up in some sort of open-collector transistor arrangement suitable for driving the indicators.

Fig.4 Binary-to-Decimal Decoder (Simplified)

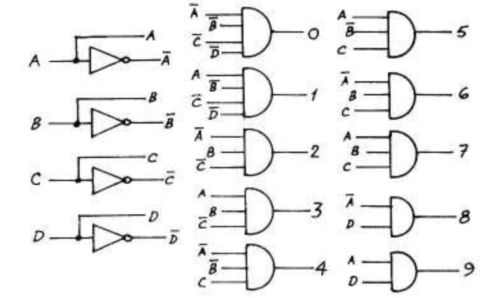
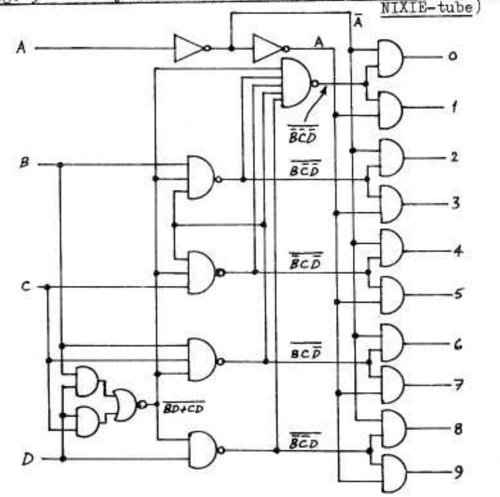


Fig. 5 Binary-to-Decimal Decoder (System for driving a NIXIE-tube)



The 7441 and its improved version the 74141, are for driving the Nixie tubes. The internal logic is entirely different too in that the output transistors act as AND gates. This arrangement is very complicated and really requires the use of Boolean Algebra to understand it. Suffice to say it works.

There are several types of decoders available in TTL packages. These are shown in Table 4. (Decoders are also known as de-multiplexers)

Seven-Segment Decoders

These are becoming more common and several versions are available to drive either TTL or Lamps of various voltages. The displays are cheaper than decimal systems.

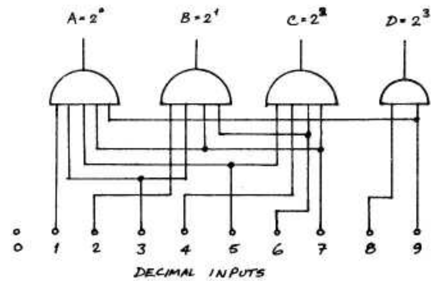
The next issue will describe seven-segment indicators and decoders and will give circuit details for their use. Also it is hoped to describe a system to display seven-segment numerals on an oscilloscope trace.

Table 4 Decoders (De-multiplexers)

Function	Type No.	No. Pins	Commments
BCD - Dec	7442	16	TTL outputs } Same pins
XS3 - Dec	7443	16	TTL outputs } Same pins
Gray- Dec	7444	16	TTL outputs } Same pins
4 to 16	74154	24	TTL outputs, 2 strobes
Dual 2-4	74155	16	TTL outputs
Dual 2-4	74156	16	TTL outputs (open coll)
BCD - Dec	7445	16	Lamp Drivers 30V, 80 mA
BCD - Dec	74145	16	Lamp Drivers 15V, 80 mA
BCD - Dec	7441	16	NIXIE-tube Drivers.
BCD - Dec	74141	16	NIXIE-tube Drivers (improved).
BCD - 7 seg	7446	16	Lamp Drivers 30V, 40 mA
BCD - 7 seg	7447	16	Lamp Drivers 15V, 40 mA
BCD - 7 seg	7448	16	TTL outputs (non-active)
BCD - 7 seg	7449	14	TTL outputs (open coll)

So much for Decimal-to-binary and vice-versa. Incidentally, there is now a package, 74147 which converts decimal to binary in logic form in a manner somewhat as shown in Fig. 6 . It has some extra logic which gives priority to the highest number if more than one input is selected. This is called a 10-line to 4-line Priority Encoder.

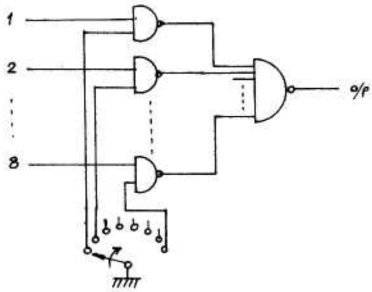
Fig. 6 Decimal-to-Binary Decoder



Single Line Encoding

This is the ultimate - putting all the information onto one wire. It is probably the most useful system for TV purposes and a common requirement is to select one of several sources for routing to one destination. This is analagous to an n-way, single-pole switch.

Fig. 7 8-input, Single-wire Encoder



The basic arrangement is shown in Fig. 7 and consists of, say eight, AND-gates and an OR-gate. The AND-gates are controlled by the switches. This is expensive and so a special IC has been made. The 74151 is an 8-line to 1-line encoder but the eight switching inputs have been replaced by three binary-coded inputs since this saves on pins. ($2^3 = 8$). There are only eight possible ways of selecting three inputs so the eight sources cannot be selected in parallel at all. The device is therefore indeed an eight-way switch.with a very high possible rate of rotation. Normally, the three selection inputs would probably be fed from a three-bit counter. See Fig. 8.

Fig. 8 74151, 8-line to 1-line Encoder

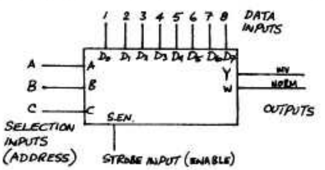
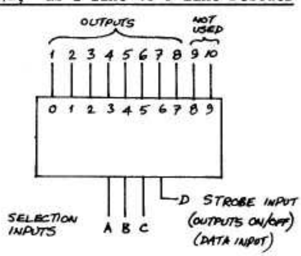


Fig. 9 7442, as 1-line to 8-line Decoder



The converse device is a 7442 1-line to 8-lines decoder which is effectively eight single-pole switches. This also has a three-bit selection input system.

Actually, the 7442 is a 1-line to ten-lines decoder as we have just seen but it can be used to select any number less than ten. In the above application it selects eight and the fourth selection input acts as a strobe input. This is shown in Fig. 10 which depicts the whole encoding and decoding system for eight bits. Note that the two eight-bit counters have to be kept in step at all times.

Fig.10 8-input Coder/Decoder System

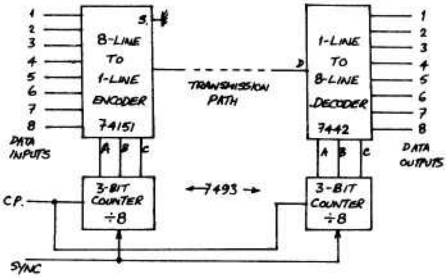


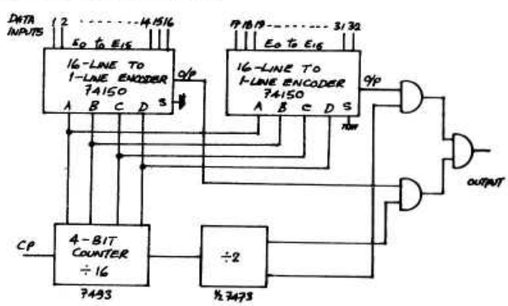
Table 5 Encoders (also known as Multiplexers or Data Selectors)

Function	type No.	No. Pins.	Strobe	Comments
Dec - BCD	74147	16	No	Priority type
16 - 1	74150	24	Yes	
8 - 1	74151	16	Yes	As 74152 but for strobe and o/p inv
8 - 1	74152	14	No	
Dual 4 - 1	74153	16	Yes	Two strobes and common address.
8 - 3	74148	16	Yes	Priority type

Strobe inputs are used to turn the outputs on or off independantly of the addressing code - usually during code changing intervals to avoid the problems of ripple counters.

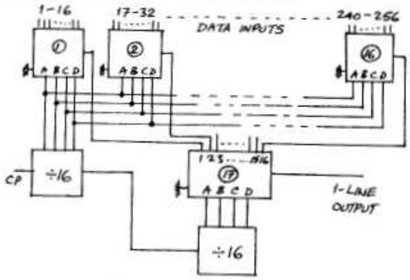
Sixteen-line systems are also available for the encoder in the form of the 74150. Suppose we want more than sixteen? A second encoder can be used to double the number of inputs and one more bit added to the counter. This is shown in Fig. 11 and in more complex form in Fig.12.

Fig.11 Using two Encoders



This shows a 256-line encoder using seventeen such devices. The first sixteen select groups of sixteen inputs and the seventeenth one selects the outputs from the other sixteen. Eight bits are reqired in the counter ($2^8 = 256$). This system could be even further extended.

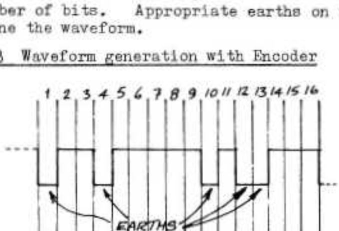
Fig. 12 256-line Encoder with 74154's



Here we have the basis of a TV character generator. The 256 inputs can be arranged to fit a portion of the raster by splitting the counts between line and field. (See CQ-TV 78 page 16 for a typical system for this) To form the characters the 256 inputs are earthed, or left open-circuit as required as each represents one dot in the matrix. No diodes are necessary. Mind you, there are a lot of ICs, and the system would have to be tidied-up considerably. Nevertheless, it would work.

Another use for encoder ICs is to generate pulse-type waveforms. e.g. Syncs. To do this the waveform is divided into convenient sections and the repetition rate arranged to fit the number of bits. Appropriate earths on the inputs will then define the waveform.

Fig. 13 Waveform generation with Encoder

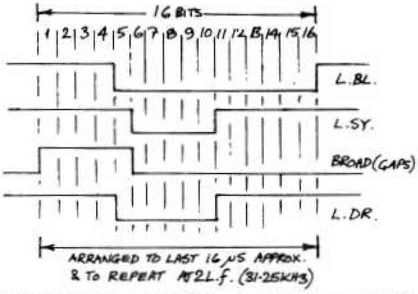


For use in an SPG a more complex approach is used. The Line Blanking period is arranged to fit the number of bits, say 16 to cover the time from the end of Broad Pulses to the end of Blanking (nearly 16 µs). Blanking is then the last 12 of these pulse-periods, Sync 6 to 10, and so on. Generally each type of pulse could be generated by a different encoder, but it is possible to reduce the number by sharing. This can be done for Syncs, Equalising and Broad Pulses.

A similar system could be used for Field-rate pulses - in particular those for generating the gating pulses for the Equalising pulses and Brüch Blanking (for PAL Burst Gate).

The advantage of the use of encoders is of course that the waveforms can easily be retimed merely by altering a few earth connections.

Fig. 14 Line-rate pulses generation.



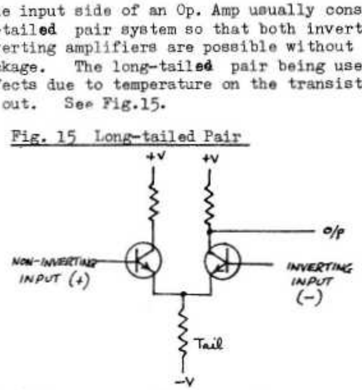
LINEAR INTEGRATED CIRCUITS - OPERATIONAL AMPLIFIERS

A Linear IC is by definition an IC which has a linear transfer characteristic - that is, the output is a replica of the input; unlike a digital IC whose output is either high or low. Being an IC it contains several transistors and can therefore be arranged to have a high gain.

There are really two types of IC loosely called Operational Amplifiers (Op. Amps for short) and these are Op. Amps and Video Amplifiers. In this article we are concerned only with the Op. Amps since the principles apply equally well to both types. The main difference between the two is the signal handling range. Op. Amps are principally intended for analogue computer applications but have now been found to be very useful devices in all kinds of fields.

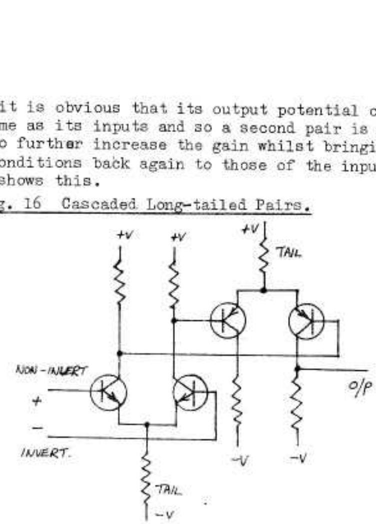
The input side of an Op. Amp usually consists of a long-tailed pair system so that both inverting and non-inverting amplifiers are possible without changing the package. The long-tailed pair being used because the effects due to temperature on the transistors largely cancel out. See Fig.15.

Fig. 15 Long-tailed Pair



Op. Amps are generally arranged to have the inputs and output(s) normally at the same d.c. potential. For convenience this is usually zero volts. (Video Amps often do not) The voltage handling range is typically ±10 volts with a supply of ±12 volts or more. Zero-voltage reference of course demands the use of two supply rails which is a disadvantage for amateurs but it is possible to operate the ICs with only one supply rail. This is a tricky business though and generally it is best to use two rails. But, to return to the long-tailed pair, it is obvious that its output potential cannot be the same as its inputs and so a second pair is often used to further increase the gain whilst bringing the d.c. conditions back again to those of the inputs. Fig 16 shows this.

Fig. 16 Cascaded Long-tailed Pairs.



This is basis of many Op. Amps but some other refinements are also incorporated. These may take the form of constant-current sources for the tails of the pairs, voltage-regulators for the rails and output emitter-followers for low-impedance outputs. In order to reduce differential-gain problems (i.e. h.f. gain changing with l.f. signal levels) the output stages may be of totem-pole or complementary construction. There are also internal feedback loops to stabilise the gain as well as arrangements for very high input-impedances.

The problem of high-frequency stability with very high gain is a very real one and nearly all Op. Amps have at least two terminals which can be used to give high-frequency roll-off of the gain (and phase) by adding a capacitor/resistor combination. See fig.17. For the moment, though, this problem will be overlooked and an ideal Op. Amp considered.

Fig. 17 Compensation

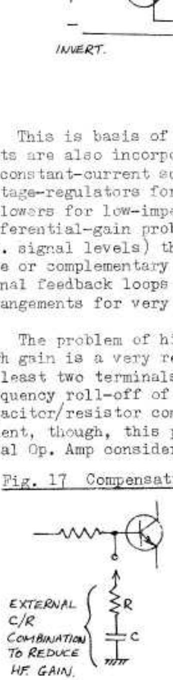
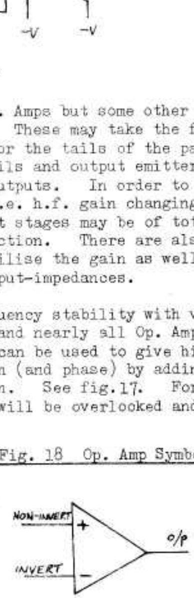


Fig. 18 Op. Amp Symbol



In general we are not interested in what is inside the package and so the Op. Amp can be represented be the symbol shown in Fig.18.

The gain would be typically 10,000 or more - this is called the open-loop gain - and for most purposes is excessive since this amount of gain is usually available only in the mid-band frequencies. To take advantage of the lower gain at high frequencies negative feedback is applied to reduce the gain to a more useful level. This effectively widens the bandwidth - as in figs 19 & 20.

Since the Op. Amp handles voltages, the adding of negative feedback is simply a matter of applying some portion of the output back to the inverting input.

Fig. 19 Open-loop Bandwidth

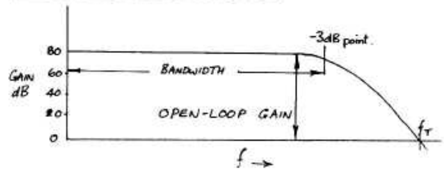
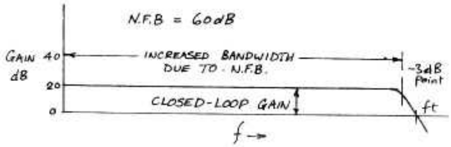


Fig. 20 Closed-loop Bandwidth



This can be a d.c. connection because of the similar potentials and so the d.c. conditions are stabilised as well as the gain.

Suppose we connect the output directly to the input? What will happen? Well, the feedback is 100% and so the gain, by the well known formula for gain with feedback, is :-

$$G = \frac{A}{1 + AB}$$

where A is the Open-loop gain and B is the feedback fraction.

However, since A is so high, the 1 can be ignored. (This sort of thing is common in Electronics theory - all kinds of things can be ignored at times - the secret is in knowing which and when). The gain is now :-

$$G = \frac{A}{AB} = \frac{1}{B} = 1$$

In this case B is 1 so the gain is also unity.

What then, is the advantage of such a circuit? The NFB modifies the input and output impedances to such an extent that the input impedance is now effectively many megohms whilst the output impedance is only a few ohms. This, then, is a kind of Super emitter-follower and is in fact known as a voltage-follower (or buffer).

Fig. 21 Voltage-follower (100% NFB)

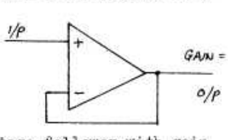
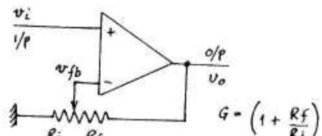


Fig. 22 Voltage-follower with gain



If we require some gain then the voltage fed back has to be less than 100% and a potentiometer is a convenient way to do this - as in figure 22. The voltage fed back is V_{fb}.

$$V_{fb} = \frac{v_o \cdot R_i}{R_i + R_f} \quad \text{i.e.} \quad B = \frac{R_i}{R_i + R_f}$$

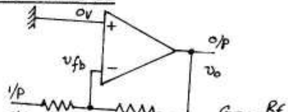
So the gain is, $$G = \frac{1}{B} = \frac{R_i + R_f}{R_i} = 1 + \frac{R_f}{R_i}$$

This is independant of the IC and has a range of from unity to A. The voltage fed back to the inverting input is proportional to :-

$$V_{fb} = \frac{v_i \cdot G}{B} = v_i$$

Thus the two inputs to the Op. Amp have the same voltage on them and hence no difference between them. In other words, the IC has balanced the voltages. This is the principle of the 'virtual-earth' of which more later.

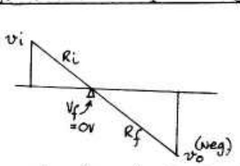
Fig. 23 Invertor



Suppose we now swop over the input and earth potentials as in Fig. 23 ? We know that the inputs must have the same voltage on them and that this must be 0v, or earth. For a balance then, the output voltage must be of negative polarity. We could draw a see-saw to represent this as in Fig. 24 . The gain is now seen to be simply :-

$$G = -\frac{V_o}{V_i} = -\frac{R_f}{R_i}$$

Fig. 24 See-saw representing gain

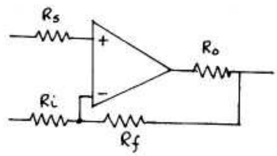


This expression for gain is even simpler than that for the voltage-follower. By changing the values of R_f and R_i the gain can be varied from zero to A.

The negative-feedback modifies the input and output impedances as previously mentioned. For the purposes of explanation, series resistances are assumed in the output and the non-inverting input (source resistance). See Fig.25 For the voltage-follower the voltage at the inverting terminal is an exact replica of the source voltage and so the source resistance has the same voltage at both its ends and hence no current flows in it. In other words it is of infinite resistance. In practise it is effectively a very high resistance; in fact R_s magnified by A/G. i.e. $A.R_s$.

The output voltage changes less than it would have done with no feedback (when the gain would have been A). This is equivalent to a lower output series resistance and is in fact very low indeed, being equal to $R_o/A.B = R_o/A$.

Fig. 25 Source Resistances



For the invertor similar reasoning applies but this time the input resistance is found to be equal to the input resistance R_i since the inverting input will always have 0v on it. (V_i appears across R_i - if R_s is low). The output impedance is virtually as for the voltage-follower - very low.

Incidentally, the gain stability and distortion are also improved by the same factors.

Unfortunately, Op Amps are not perfect devices and the input transistors have to draw base current from some place. This has to be the source and so the base current has to come through the input resistances which means that to keep a d.c. balance the two d.c. source resistances must be equal at all times. The effective resistance on each input is equal to all the resistances on the input in parallel. In the two cases mentioned this is R_i in parallel with R_f. So both inputs must have this effective resistance present as in fig. 26 .

Fig. 26 Input resistances

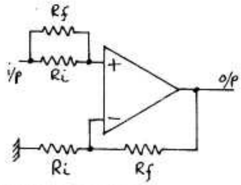
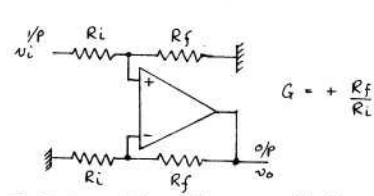


Fig. 27 Voltage-follower



This leads to an interesting case with the voltage-follower arrangement as in Fig. 27 . Here the extra R_f is earthed instead of being paralleled. The d.c. Resistance is the same but the voltage is now reduced to :-

$$V \cdot \frac{R_f}{R_i + R_f} \quad \text{The gain is therefore } G \cdot \frac{R_f}{R_i + R_f}$$

$$\text{or} \quad \frac{R_i + R_f}{R_i} \cdot \frac{R_f}{R_i + R_f} = \frac{R_f}{R_i}$$ i.e. the same as for the invertor. (but Positive)

So we now have a common arrangement for both types and the resistances must be kept in these proportions at all times. This is the basic system for the use of an Op.Amp.

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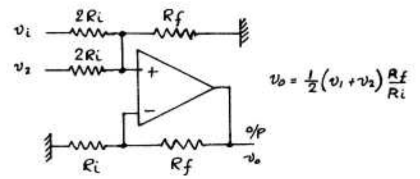
continued from page 28

Uses of Op.Amps

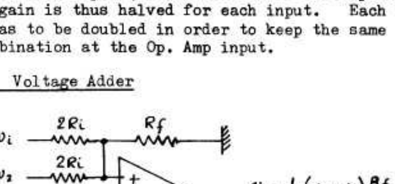
If the input resistor is split into two equal resistors a simple adder can be made. With the voltage-follower the effect is that the input network has a two-to-one attenuation on each input (if each source is low-impedance). The overall gain is thus halved for each input. Each input resistance has to be doubled in order to keep the same parallel combination at the Op. Amp input.

Fig. 28 Voltage Adder



If the same system is applied to the invertor we get a different state of affairs because the non-inverting input always has 0v on it - this is the so-called 'virtual earth' Each input signal remains unaffected by the other and so there is no extra attenuation.- the total output being the sum of the two input voltages. The principle can be extended to several inputs but all must be of low impedance sources. This is a much more useful system.

Fig. 29 Voltage Adder using Virtual-earth technique



The uses of the Op Amp will be continued in the next issue of CQ-TV which will give several practical uses for a basic Op. Amp. The 72741 is a nice, easy one to play with whilst finding out the problems. It is virtually short-circuit proof and requires no compensation. It is also cheap and easily obtained.

Next Issue

The next issue will describe Digital-to-Analogue Convertors, Seven-Segment Decoders and Indicators, Binary-Rate-Multipliers and will continue with Op. Amps.

Acknowledgements

The author wishes to thank the Directors of EMI Sound and Vision Equipment Division, Ltd. for permission to publish these articles.

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