1,3-DIPOLAR CYCLOADDITIONS OF AROMATIC NITRILE OXIDES AND NITRONES TO 1,1'-(METHYLENEDI-4,1-PHENYLENE)BISMALEIMIDE *

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Within the scope of our research aimed at utilization of 1,3-dipolar cycloaddition reactions to heterocycles as well as to pesticide programme we report the 1,3-dipolar cycloaddition of nitrile oxides *II*, *III* and nitrones *V* to bis-maleimide derivative *I*. Although *I* is a commercial product and some aspects of its chemistry have been investigated, its potential as a reactive dipolarophile has so far been neglected.

EXPERIMENTAL

The melting points are uncorrected, the ^1H and ^{13}C NMR spectra of deuteriochloroform solutions containing tetramethylsilane as an internal reference were measured on a Varian VXR 300 spectrometer.

Chlorides of benzenehydroximic acids were prepared by chlorination[1] of the corresponding benzaldoximes in chloroform, chlorides of methoxybenzenehydroximic acid were obtained by treatment of the oximes with nitrosyl chloride[2], 2,4,6-trimethylbenzonitrile oxide[3] was prepared as described and *I* was purchased as commercial product. C-Aryl-N-phenylnitrones were prepared from the respective benzaldehyde and phenylhydroxylamine according to ref.[4] and C-2,4-dichlorobenzoyl-N-phenylnitrone was prepared by the established procedure[5].

5,5'-(Methylenedi-4,1-phenylene)bis-3-aryl-4,6-dioxo-3a,4,6,6a-tetrahydropyrrolo[3,4-*d*]isoxazoles *IVa – IVs*

A solution of dry triethylamine (12 mmol) in ether (20 ml) was added dropwise at –5 to 0 °C to a stirred, cooled solution of the corresponding benzenehydroximic acid chloride (10 mmol) and *I* (1.8 g, 5 mmol) in dry ether (30 ml) over 0.5 h. Each mixture was stirred overnight at room temperature, filtered from triethylammonium chloride, and concentrated in vacuo. Column chromatography (chloroform) of each residue on

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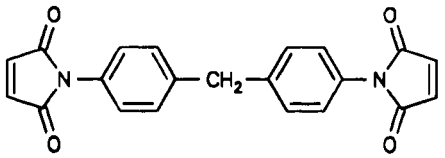
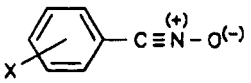
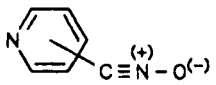


I



II



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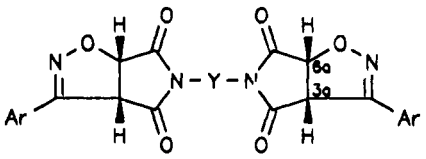
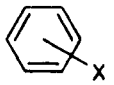
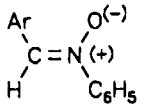


IV

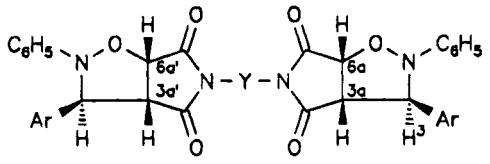
In formulae *II*, *IV*

a, X = 4-Cl	b, X = 2-Cl
c, X = 2-NO_2	d, X = 4-NO_2
e, X = 2,5-diOCH_3	f, X = 4-Br
g, X = 3-NO_2	h, X = 4-CH_3
i, X = 2,4-diCl	j, X = 2,4,6-tri-CH_3
k, X = H	l, X = 4-F
m, X = 2-Br	n, X = 2-F
o, X = 2,6-diCl	p, Ar = 2-pyridyl
r, Ar = 3-pyridyl	s, Ar = 4-pyridyl

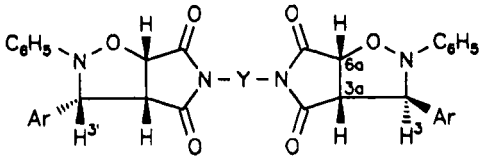
Ar = 



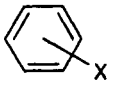
V



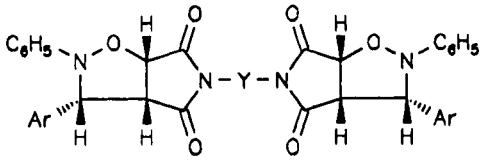
VI



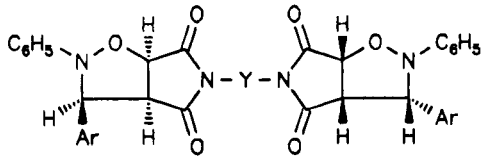
VII

In formulae *V–VII* Ar = 

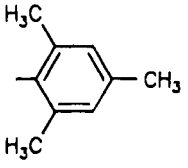
a, X = H *b*, X = 4-OCH_3 *c*, X = 3-NO_2
d, X = 4-CH_3 *e*, Ar = 2,4-$Cl_2C_6H_3CO$ *f*, Ar = 2-furyl



VIII



IX

In formulae *VIII*, *IX* Ar = 

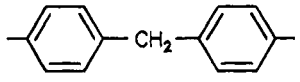
In formulae *IV*, *VI–IX* Y = 

TABLE I
Characteristic data for compounds *IV*

Compound	Formula (M. w.)	M. p., °C (Yield, %)	Calculated/Found		
			% C	% H	% N
IVa	$C_{35}H_{22}Cl_2N_4O_6$	140	63.17	3.30	8.42
	(665.3)	(88)	63.59	3.06	8.74
IVb	$C_{35}H_{22}Cl_2N_4O_6$	143	63.17	3.30	8.42
	(665.3)	(90)	63.51	3.40	8.36
IVc	$C_{35}H_{22}N_6O_{10}$	145	61.20	3.20	12.20
	(686.2)	(90)	61.15	3.68	12.63
IVd	$C_{35}H_{22}N_6O_{10}$	175	61.20	3.20	12.20
	(686.2)	(95)	60.98	2.89	12.61
IVe	$C_{39}H_{32}N_4O_{10}$	180	65.30	4.46	7.82
	(716.6)	(90)	65.69	4.05	8.17
IVf	$C_{35}H_{22}Br_2N_4O_6$	175	55.70	2.90	7.42
	(754.3)	(88)	55.40	3.05	6.97
IVg	$C_{35}H_{22}N_6O_{10}$	228	61.20	3.20	12.20
	(686.2)	(85)	61.24	3.33	12.60
IVh	$C_{37}H_{28}N_4O_6$	160	71.10	4.48	8.97
	(624.6)	(95)	71.02	4.55	8.52
IVi	$C_{35}H_{20}Cl_4N_4O_6$	135	57.20	2.69	7.62
	(734.3)	(90)	57.10	2.40	8.03
IVj	$C_{41}H_{36}N_4O_6$	195	72.35	5.29	8.23
	(680.7)	(80)	72.08	5.58	7.94
IVk	$C_{35}H_{24}N_4O_6$	170	70.46	4.00	9.39
	(596.5)	(95)	70.50	4.30	9.49
IVl	$C_{35}H_{22}F_2N_4O_6$	170	66.45	3.48	8.86
	(632.5)	(90)	66.41	3.75	8.35
IVm	$C_{35}H_{22}Br_2N_4O_6$	130	55.70	2.90	7.42
	(754.3)	(95)	55.53	2.61	7.65
IVn	$C_{35}H_{22}Br_2N_4O_6$	210	66.45	3.48	8.86
	(632.5)	(90)	66.65	3.37	8.91
IVo	$C_{35}H_{20}Cl_4N_4O_6$	190	57.20	2.69	7.62
	(734.3)	(88)	57.27	3.00	7.47
IVp	$C_{33}H_{22}N_6O_6$	150	66.22	3.67	14.04
	(598.5)	(88)	66.61	3.58	14.37
IVr	$C_{33}H_{22}N_6O_6$	160	66.22	3.67	14.04
	(598.5)	(85)	66.06	4.06	13.70
IVs	$C_{33}H_{22}N_6O_6$	155	66.22	3.67	14.04
	(598.5)	(93)	66.55	3.85	14.18

silica gel gave *IV*. The cycloaddition of 2,4,6-trimethylbenzonitrile oxide involved heating a mixture of the nitrile oxide (10 mmol) and *I* (1.8 g, 5 mmol) in dry benzene (40 ml) at 80 °C for 4 h. The mixture was then cooled and worked-up as described above. Characteristic data for compounds *IV* are listed in Tables I – III.

5,5'-(Methylenedi-4,1-phenylene)bis-2-phenyl-3-aryl-4,6-dioxo-2,3,3a,4,6,6a-hexahydropyrrolo-[3,4-*d*]isoxazoles *VI* – *IX*

C-Aryl-N-phenylnitrones *V* (10 mmol) and *I* (1.8 g, 5 mmol) in dry toluene (50 ml), were heated under reflux for 2 – 4 h. The reaction mixture was then cooled and the solvent was evaporated under reduced pressure, the residue was purified on silica gel (chloroform) to give *VI* – *IX*. The cycloaddition of C-(2,4-dichlorobenzoyl)-N-phenylnitrone involved a stirring at room temperature for 24 h. Characteristic data for compounds *VI* – *IX* are presented in Tables IV – VIII.

TABLE II
^{1}H NMR data for compounds *IV*

Compound	δ, ppm; *J*, Hz					
	H-6a[a]	$J_{3a,6a}$	H-3a[a]	CH_2[b]	H_{arom}[c]	CH_3[b]
IVa	5.65	9.6	4.93	3.99	7.15 – 7.96	–
IVb	5.64	9.9	5.27	3.97	7.13 – 7.49	–
IVc	5.82	9.9	5.53	4.00	7.19 – 8.73	–
IVd	5.82	9.6	5.47	4.00	7.18 – 8.35	–
IVe	5.71	9.6	5.31	4.00	7.06 – 7.34	3.70, 3.79
IVf	5.73	9.6	5.37	4.06	7.16 – 7.87	–
IVg	5.80	9.6	5.50	4.00	7.18 – 8.73	–
IVh	5.69	9.6	5.32	3.98	7.14 – 7.81	2.32
IVi	5.80	9.3	5.30	3.98	7.17 – 7.76	–
IVj	5.79	9.3	4.93	4.01	6.92 – 7.39	2.10, 2.21
IVk	5.72	9.6	5.36	3.99	7.15 – 7.93	–
IVl	5.73	9.6	5.38	4.01	7.15 – 8.02	–
IVm	5.78	9.6	5.33	3.98	7.18 – 7.67	–
IVn	5.75	9.3	5.26	3.96	7.15 – 7.83	–
IVo	5.70	9.6	4.88	3.99	7.17 – 7.40	–
IVp	5.81	9.6	5.41	4.01	7.18 – 8.72	–
IVr	5.78	9.9	5.47	4.01	7.20 – 9.11	–
IVs	5.74	9.6	5.37	4.01	7.17 – 8.73	–

[a] Doublet; [b] singlet; [c] multiplet.

TABLE III
^{13}C NMR data for compounds *IV*

Compound	δ, ppm						
	C-3[a]	C-3a[b]	C-4[a]	C-6[a]	C-6a[b]	CH_2[c]	CH_3[d]
	(C_{arom})						
IVa	151.98	54.79	169.82	170.77	80.63	45.83	–
	(137.40, 129.81, 129.70, 129.32, 129.16, 129.01, 126.23, 125.22)						
IVb	152.74	56.26	169.30	171.06	80.08	41.00	–
	(141.37, 139.16, 131.90, 131.30, 131.22, 130.62, 129.81, 126.11)						
IVc	152.48	55.08	171.05	171.96	82.01	45.59	–
	(147.96, 141.84, 134.00, 130.60, 129.43, 128.97, 127.14)						
IVd	152.68	54.90	170.90	171.80	82.20	45.46	–
	(148.52, 141.73, 133.36, 129.65, 129.38, 129.21, 127.08, 123.91)						
IVe	152.99	55.67	170.64	172.58	80.58	45.54	56.49, 56.82
	(152.78, 151.85, 141.72, 129.70, 129.45, 129.30, 127.06, 127.01)						
IVf	152.99	55.17	171.06	172.06	81.61	45.83	–
	(141.78, 131.91, 129.94, 129.69, 129.45, 127.10, 126.47, 124.55)						
IVg	152.47	55.05	171.03	171.95	81.97	45.60	–
	(147.95, 141.83, 133.99, 136.61, 129.65, 129.41, 128.93, 127.13, 125.44)						
IVh	150.47	55.09	171.12	172.23	81.20	45.81	21.12
	(141.46, 141.04, 129.70, 129.64, 129.47, 127.95, 127.07, 124.31)						
IVi	152.25	57.79	170.66	172.55	81.18	46.02	–
	(142.22, 136.40, 133.66, 133.13, 130.20, 129.81, 128.24, 127.24, 125.46)						
IVj	154.15	58.80	170.69	173.12	80.46	40.49	19.64, 21.00
	(142.24, 139.63, 136.94, 130.01, 129.77, 128.86, 128.71, 127.06, 123.46)						

TABLE III
(*Continued*)

Compound	δ, ppm						
	C-3[a]	C-3a[b]	C-4[a]	C-6[a]	C-6a[b]	CH_2[c]	CH_3[d]
	(C_{arom})						
IVk	153.87	55.59	171.35	172.43	81.64	45.93	–
	(142.04, 131.29, 129.96, 129.73, 129.13, 128.25, 127.40, 127.35)						
IVl	152.60	55.26	170.99	172.00	81.37	45.30	–
	(141.82, 141.60, 134.63, 130.41, 130.29, 129.62, 126.98, 126.87)						
IVm	153.70	56.95	169.51	171.42	80.43	45.87	–
	(133.67, 131.88, 131.37, 129.69, 129.24, 128.00, 127.75, 126.28, 122.27)						
IVn	150.22	55.98	169.78	171.27	80.43	45.90	–
	(141.39, 132.95, 132.83, 130.32, 130.30, 129.69, 126.34, 124.67, 124.62)						
IVo	149.96	56.66	168.87	171.63	79.90	45.64	–
	(141.28, 132.03, 129.76, 129.69, 128.95, 128.23, 125.98, 125.18)						
IVp	154.64	55.15	170.24	171.66	81.77	45.00	–
	(149.66, 146.72, 141.53, 137.12, 129.71, 129.29, 126.98, 125.27, 123.06)						
IVr	151.73	55.01	170.90	171.90	81.40	45.33	–
	(151.36, 148.55, 141.61, 135.09, 129.61, 129.30, 129.14, 127.01, 123.77)						
IVs	152.50	54.68	170.74	171.69	82.00	45.35	–
	(150.21, 141.66, 134.47, 129.57, 129.29, 127.01, 121.72)						

[a] Singlet; [b] doublet; [c] triplet; [d] quartet.

TABLE IV
Characteristic data for compounds *VI – IX*

Compound	Formula (m. w.)	M. p., °C (Yield, %)	Calculated/Found		
			% C	% H	% N
VIa	$C_{47}H_{36}N_4O_6$	138 – 140	74.99	4.82	7.44
	(752.7)	(70)	75.30	5.06	7.39
VIb	$C_{49}H_{40}N_4O_8$	140 – 142	72.40	4.96	6.89
	(812.8)	(76)	72.36	4.70	6.77
VIc	$C_{47}H_{34}N_6O_{10}$	135	66.98	4.06	9.97
	(842.7)	(70)	67.24	4.10	9.69
VId	$C_{49}H_{40}N_4O_6$	175	75.37	5.16	7.17
	(780.8)	(72)	75.58	5.45	6.82
VIe	$C_{49}H_{32}Cl_4N_4O_8$	160 – 162	62.16	3.40	5.91
	(946.6)	(84)	62.46	3.60	6.04
VIf	$C_{43}H_{32}N_4O_8$	130 – 140	70.48	4.40	7.64
	(732.7)	(60)	70.51	4.70	7.37
VIIa	$C_{47}H_{36}N_4O_6$	135	74.99	4.82	7.44
	(752.7)	(25)	74.80	4.73	7.50
VIIb	$C_{49}H_{40}N_4O_8$	150	72.40	4.96	6.89
	(812.8)	(20)	72.44	4.80	6.95
VIIc	$C_{47}H_{34}N_6O_{10}$	145	66.98	4.06	9.97
	(842.7)	(28)	66.64	4.20	9.69
VIId	$C_{49}H_{40}N_4O_6$	138 – 140	75.37	5.16	7.17
	(780.8)	(26)	75.50	5.33	6.88
VIIf	$C_{43}H_{32}N_4O_8$	168 – 170	70.48	4.40	7.64
	(732.7)	(30)	70.33	4.55	7.34
VIII	$C_{53}H_{48}N_4O_6$	113 – 115	76.05	5.78	6.69
	(836.9)	(60)	76.28	5.50	6.74
IX	$C_{53}H_{48}N_4O_6$	135	76.05	5.78	6.69
	(836.9)	(31)	76.33	5.34	6.50

TABLE V
^{1}H NMR data for compounds *VI*, *VIII*

Compound	δ, ppm; *J*, Hz						
	H-3[a]	H-6a[b]	$J_{3a,6a}$	H-3a[b]	CH_2[a]	H_{arom}[c]	CH_3[a]
VIa	5.74	5.07	7.2	3.99	3.89	6.50 – 7.57	–
VIb	5.68	5.06	7.2	3.94	3.89	6.52 – 7.46	3.80
VIc	5.85	5.11	7.5	4.03	3.90	6.48 – 8.45	–
VId	5.71	5.08	7.8	3.98	3.90	6.52 – 7.45	2.36
VIe	6.10	5.04	7.5	4.77	3.85	6.28 – 7.45	–
VIf	5.68	5.18	7.2	4.17	3.91	6.32 – 7.39	–
VIII	5.27[d]	5.17	7.2	4.03[e]	4.00	6.91 – 7.25	2.30, 2.48

[a] Singlet; [b] doublet; [c] multiplet; [d] doublet; [e] doublet of doublets with $J_{3,3a}$ = 5.7 Hz.

TABLE VI
^{13}C NMR data for compounds *VI*, *VIII*

Compound	δ, ppm						
	C-3[b]	C-3a[b]	C-4[a]	C-6[a]	C-6a[b]	CH_2[c]	CH_3[d]
	(C_{arom})						
VIa	69.92	57.29	174.19	172.70	77.25	41.03	–
	(148.84, 141.15, 138.62, 129.73, 129.61, 129.41, 129.09, 126.51, 126.24, 122.98, 114.31)						
VIb	69.52	57.22	174.25	172.77	77.23	40.99	55.32
	(159.33, 148.73, 141.11, 129.58, 129.33, 128.81, 127.79, 126.30, 126.21, 114.42, 114.29, 114.20)						
VIc	68.97	57.03	173.53	172.20	77.23	41.03	–
	(148.61, 148.16, 141.29, 140.55, 132.77, 130.09, 129.65, 129.60, 129.92, 126.17, 123.53, 121.81, 114.29)						
VId	69.76	57.29	174.22	172.73	77.22	41.03	21.10
	(148.85, 141.12, 137.94, 135.62, 129.58, 129.37, 129.09, 126.42, 126.22, 122.90, 114.33)						
VIe[e]	72.01	58.24	174.47	172.80	78.39	39.45	–
	(147.68, 141.16, 138.09, 134.70, 131.65, 130.10, 129.69, 129.54, 129.32, 127.64, 126.10, 123.90, 111.23)						
VIf	64.25	53.60	173.82	172.75	77.04	41.03	–
	(150.28, 147.61, 142.83, 129.64, 129.24, 129.13, 126.25, 123.40, 115.14, 110.68, 108.42)						
VIII	69.91	56.79	174.38	170.78	76.83	41.07	20.82, 21.2
	(149.12, 141.20, 138.02, 137.04, 130.88, 130.18, 129.75, 129.32, 128.81, 126.30, 126.15, 123.77, 116.47)						

[a] Singlet; [b] doublet; [c] triplet; [d] quartet; [e] (s, C=O).

TABLE VII
^{1}H NMR data for compounds *VII*, *IX*

Parameter	δ, ppm; *J*, Hz					
	VIIa	*VIIb*	*VIIc*	*VIId*	*VIIf*	*IX*
H-3, s	5.74	5.67	5.85	5.72	5.67	5.25[a]
H-6a, d	5.04	5.04	5.10	5.07	5.15	5.17
$J_{3a, 6a}$	7.5	7.5	7.5	7.5	7.5	7.2
H-3a, d	3.97	3.94	4.01	3.97	4.14	4.04[b]
CH_2, s	3.91	3.91	3.92	3.92	3.94	3.99
H-3', d	5.22	5.17	5.27	5.23	5.21	5.11
$J_{3'a, 6'a}$	9.3	9.0	9.0	9.0	9.0	8.7
H-3a', dd	4.12	3.90	4.12	4.00	3.96	4.01
H_{arom}	6.50 – 7.56	6.54 – 7.45	6.47 – 8.45	6.51 – 7.43	6.35 – 7.42	6.92 – 7.27
CH_3, s	–	3.79, 3.76	–	2.35, 2.32	–	2.49, 2.30

[a] Doublet with $J_{3, 3a}$ = 6.0 Hz; [b] doublet of doublets.

TABLE VIII
^{13}C NMR data for compounds *VII*, *IX*

Parameter	δ, ppm					
	VIIa[a]	*VIIb*[b]	*VIIc*[c]	*VIId*[d]	*VIIf*[e]	*IX*[f]
C-3, d	69.91	69.51	68.95	69.75	64.23	69.91
C-3a, d	57.26	57.18	57.00	57.29	53.62	56.78
C-4, s	174.21	174.29	173.50	174.22	173.86	174.45
C-6, s	172.72	172.81	172.18	172.74	172.80	171.57
C-6a, d	77.29	77.28	77.24	77.23	77.08	76.86
C-3', d	71.42	71.12	70.57	71.37	66.67	68.97
C-3'a, d	54.60	54.52	54.33	54.63	52.68	51.52
C-4', s	173.52	173.81	173.25	173.69	173.36	174.28
C-6', s	171.43	171.65	171.34	171.55	171.59	170.85
C-6'a, d	77.08	77.12	77.04	77.03	77.08	77.06
CH_2, t	41.02	41.00	41.04	41.04	41.06	41.06
CH_3, q	–	55.33	–	21.27	–	21.82[g]
		55.23		21.10		21.24

[a] 148.87, 147.39, 141.25, 141.15, 140.88, 138.53, 134.53, 129.74, 129.58, 129.41, 128.95, 128.14, 127.52, 126.52, 126.24, 126.03, 124.77, 122.99, 118.76, 114.30 (C-arom).
[b] 159.78, 159.33, 148.76, 147.35, 141.25, 140.86, 136.65, 129.75, 129.56, 129.35, 129.14, 128.75, 128.70, 127.83, 126.24, 126.19, 124.79, 122.92, 119.07, 114.43, 114.39, 114.22 (C-arom).
[c] 148.61, 148.46, 148.16, 146.05, 141.36, 141.23, 140.69, 136.68, 133.62, 132.79, 130.12, 129.92, 129.62, 129.03, 126.17, 126.08, 123.55, 123.25, 122.66, 121.81, 119.95, 114.27 (C-arom).
[d] 148.86, 147.32, 141.25, 140.85, 138.70, 137.93, 131.30, 129.75, 129.58, 129.37, 128.74, 126.42, 124.77, 122.92, 119.00, 114.33 (C-arom).
[e] 150.34, 150.32, 147.65, 147.00, 146.77, 143.42, 142.82, 141.32, 140.99, 129.79, 129.65, 129.59, 129.26, 129.15, 128.81, 126.40, 126.82, 123.41, 118.75, 115.13, 110.91, 110.80, 110.69, 108.41 (C-arom).
[f] 149.13, 147.29, 141.30, 140.78, 138.02, 137.64, 137.00, 136.89, 135.56, 134.14, 131.86, 130.89, 130.89, 130.21, 129.86, 129.80, 129.73, 129.66, 128.74, 126.75, 125.83, 124.84, 119.08, 116.48 (C-arom).
[g] 21.35 and 20.84.

REFERENCES

1. Werner A., Buss H.: Ber. Dtsch. Chem. Ges. *27*, 2193 (1894).
2. Rheinboldt H., Dewald M., Jansen F., Schmitz-Dumont O.: Justus Liebigs Ann. Chem. *451*, 161 (1927).
3. Grundmann C., Dean J. M.: J. Org. Chem. *30*, 2809 (1965).
4. Black D. S. C., Croiser R. F., Davis V. Ch.: Synthesis *1975*, 205.
5. Huisgen R., Hauck H., Seidl H., Burger M.: Chem. Ber. *102*, 1117 (1969).