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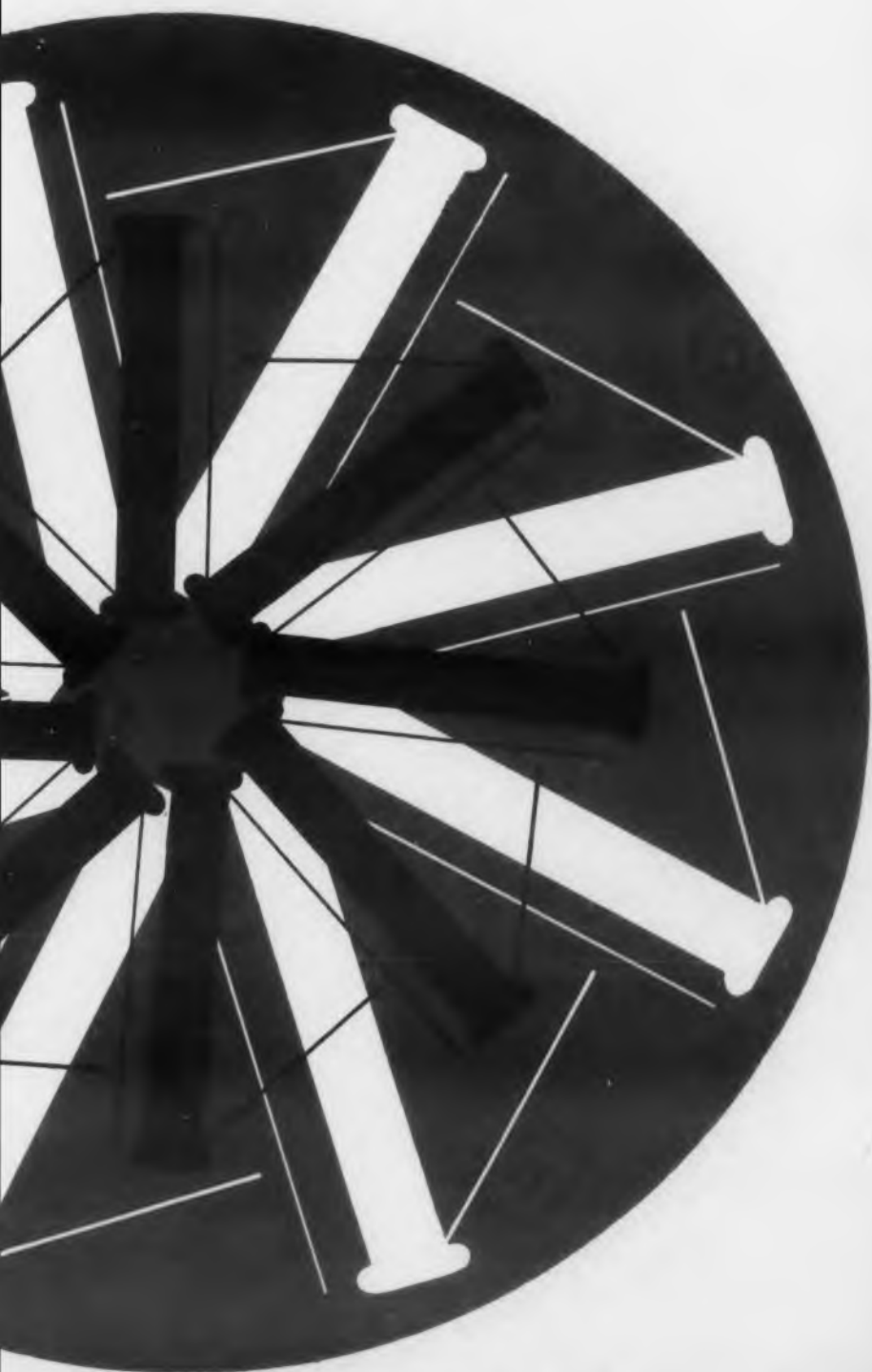


**THERMISTOR ISSUE**



# SONIC SIGN

APRIL 30, 1966



# FREED

offers for  
Immediate  
Delivery

## MAGNETIC AMPLIFIERS AND SATURABLE TRANSFORMERS

### FAST RESPONSE MAGNETIC AMPLIFIERS

2 response Phase reversible

Cat. No.	Supply Freq. C.P.S.	Power Out. Watts	Volt. Out. V. AC	AC or DC signal voltage req'd for full output.
MAF-1	60	13	110	1.0
MAF-4	400	5	57.5	Designed to be driven from vacuum tube or transistor preamplifier.
	400	10	57.5	
MAF-5	400	13	54	
MAF-6	400	5	57.5	1.2 0.4
	400	10	57.5	1.6 0.6
MAF-7	400	15	57.5	2.5 1.0

### SINGLE ENDED MAGNETIC AMPLIFIERS

Cat. No.	Supply Freq. C.P.S.	Power Out. Watts	Sig. req'd for full outp. MA-DC	Total res. contr. wdg. K $\Omega$	Lead res. ohms
MAO-1	60	4.5	3.0	.685	3800
MAO-2	60	20	1.8	1.3	700
MAO-4	60	400	9.0	10.0	25
MAO-5	60	575	6.0	10.0	25

### PUSH-PULL MAGNETIC AMPLIFIERS

Phase reversible

Cat. No.	Supply Freq. C.P.S.	Power Out. Watts	Volt. Out. V. AC	Sig. req'd for full outp. MA-DC	Total res. contr. wdg. K $\Omega$
MAP-1	60	5	115	1.2	1.24
MAP-2	60	15	115	1.6	2.4
MAP-3	60	50	115	2.0	0.5
MAP-3-A	60	50	115	7.0	2.9
MAP-4	60	175	115	8.0	6.0
MAP-7	400	15	115	0.5	8.8
MAP-8	400	50	115	1.75	0.5
MAP-11	400	10	115	.7	6.6

### SATURABLE TRANSFORMERS

Phase reversible

Cat. No.	Supply Freq. C.P.S.	Power Out. Watts	Volt. Out. V. AC	Sig. req'd for full outp. MA-DC	Total res. contr. wdg. K $\Omega$
MAS-1	60	15	115	6.0	27
MAS-2	400	6	115	4.0	10
MAS-5	400	2.7	26	4.0	3.3
MAS-6	400	30	115	4.0	8.0
MAS-7	400	40	115	5.5	8.0

All units designed for 115V-AC operation  
Write for detailed information on these and other components for military and commercial applications. Send for NEW 48 page TRANSFORMER CATALOG. Also ask for complete LABORATORY TEST INSTRUMENT CATALOG.

## MILITARY TRANSFORMERS BUILT TO MIL-T-27A SPECIFICATIONS

### AUDIO TRANSFORMERS — STANDARD

Freq. resp. 300 to 10000 c.p.s. = 2 db.

Cat. No. MGA	Type Designation TF1RX	IMPEDANCE LEVEL						Ratio	Max. Power DBM	Max. MA DC Unbal.
		Prim. K $\Omega$	Cl.	Split	Sec. $\Omega$	Cl.	Split			
-1	-15AJ	10.	✓		90K	✓	✓	1:3	+15	10
-2	-16AJ	.6	✓	✓	4, 8, 16	✓	✓	6.12:1	+33	0
-3	-10AJ	.6	✓		135K	✓	✓	1:15	+15	0
-4	-16AJ	.6	✓		600	✓	✓	1:1	+15	0
-5	-13AJ	7.6/4.8			600	✓	✓	3.56:1	+33	40
-6	-13AJ	7.6/4.8			4, 8, 16	✓	✓	21.8:1	+33	40
-7	-13AJ	15.	✓		600	✓	✓	5:1	+33	10
-8	-13AJ	24.	✓		600	✓	✓	6.32:1	+30	1
-9	-13AJ	60.	✓		600	✓	✓	10:1	+27	1

### POWER TRANSFORMERS — STANDARD

All primaries 105/115/125 v., 60 c.p.s.

Cat. No. MGP	Type Designation TF1RX	Hi V	V DC	A DC	Fil. #1		Fil. #2	
					V	A	V	A
-1	-03HA001	400/200	185	.07	5/6.3	2	6.3	3
-2	-03AB002	650oct	260	.07	5/6.3	2	6.3	4
-3	-03KB006	650oct	245	.15	6.3	5	5.	3
-4	-03LB003	800oct	318	.175	5.	3	6.3	8
-5	-03MB004	900oct	345	.25	5.	3	6.3	8
-6	-02KB001	700oct	255	.25	400 ~ single and 60 and 400 ~ three phase on special order			
-7	-02LB002	1,100oct	419	.25				
-8	-02NB003	1,600oct	640	.25				

### FILAMENT TRANSFORMERS — STANDARD

All primaries 105/115/125 v., 60 c.p.s.

Cat. No. MGF	Type Designation TF1RX01	V	I A	Test KV	Cat. No. MGF	Type Designation TF1RX01	V	I A	Test KV
-2	-GB003	2.5	10	2.5	-7	-JB008	6.3	10	2.5
-3	-FB004	5.	3	2.5	-8	-KB009	6.3	20	2.5
-4	-HB005	5.	10	2.5	-9	-JB012	2.5	10	10.
-5	-FB006	6.3	2	2.5	-10	-KB013	5.	10	10.

\*400 ~ single and 60 and 400 ~ 3 phase on special order

### FILTER REACTORS

Cat. No. MGC	L Hy.	I DC MA	R DC $\Omega$	Test KV	Case	Cat. No. MGC	L Hy.	I DC MA	R DC $\Omega$	Test KV	Case
-2	4.	50	230	1.	AJ	-18	7.	200	135.	2.	HB
-3	10.	50	325	1.	EB	-19	10.	200	125.	2.5	JA
-4	20.	50	475	1.5	FA	-20	2.5	300	50.	2.	GA
-5	30.	50	650	1.5	FA	-21*	4.	300	62.	2.5	HB
-6	3.	75	175	1.	AJ	-22	6.	300	85.	2.5	JB
-7	6.	75	235	1.5	EB	-23*	8.	300	65.	2.5	KB
-8	12.	75	265	1.5	FA	-24	10.	300	100.	2.5	LA
-9	3.5	100	145	1.	EB	-25*	2.	400	37.	2.5	HB
-10	8.	100	180	1.5	FA	-26	6.	400	60.	2.5	KB
-11	12.	100	190	2.	GA	-27*	2.	500	35.	2.5	JA
-12	2.	150	92	1.5	EB	-28	4.	500	45.	2.5	KB
-13	4.	150	115	1.5	FA	-29*	7.	500	50.	2.5	MB
-14	8.	150	125	2.	GA	-30*	2.	700	20.	2.5	LB
-15	11.	150	120	2.5	JB	-31*	1.75	1,000	12.5	2.5	MB
-16	2.5	200	70	1.5	FA	*Not stocked, available on short del.					

### PULSE TRANSFORMERS

Cat. No. MPT	Pulse Kilovolt	Duration Microsec.	Duty Rate	No. of Windings	Test KV	Z $\Omega$
-1	.25/.25/.25	0.2-1.0	.004	3	.7	250
-2	.25/.25	0.2-1.0	.004	2	.7	250
-3	.5/.5/.5	0.2-1.5	.002	3	1.	250
-4	.5/.5	0.2-1.5	.002	2	1.	250
-5	.5/.5/.5	0.5-2.0	.002	3	1.	500
-6	.5/.5	0.5-2.0	.002	2	1.	500
-7	.7/.7/.7	0.5-1.5	.002	3	1.5	200
-8	.7/.7	0.5-1.5	.002	2	1.5	200
-9	1./1./1.	0.7-3.5	.002	3	2.	200
-10	1./1.	0.7-3.5	.002	2	2.	200
-11	1./1./1.	1.0-5.0	.002	3	2.	500
-12	.15/.15/.3/3	0.2-1.0	.004	4	.7	700

## TELEMETERING COMPONENTS

BAND PASS FILTERS						DISCRIMINATORS				
Cat. No. Z $\Omega$ 500	Cat. No. Z $\Omega$ 2,500	3dB Bandwidth per cent of F $_c$	Center Frequency F $_c$ (KC)			Cat. No.	Per cent Deviation of F $_c$	Per cent Linearity	DST	
			FBP	FBP	9 3/4					19 1/2
-10	-34	✓	.4	✓	✓	-10	8 1/2	15.	0.5	1.0
-11	-35	✓	.56	✓	✓	-11				
-12	-36	✓	.73	✓	✓	-12				
-13	-37	✓	.96	✓	✓	-13				
-14	-38	✓	1.3	✓	✓	-14				
-15	-39	✓	1.7	✓	✓	-15				
-16	-40	✓	2.3	✓	✓	-16				
-17	-41	✓	3.0	✓	✓	-17				
-18	-42	✓	3.9	✓	✓	-18				
-19	-43	✓	5.4	✓	✓	-19				
-20	-44	✓	7.35	✓	✓	-20				
-21	-45	✓	10.5	✓	✓	-21				
-22	-46	✓	12.3	✓	✓	-22				
-23	-47	✓	14.5	✓	✓	-23				
-24	-48	✓	22.0	✓	✓	-24				
-25	-49	✓	22.0	✓	✓	-29				
-26	-50	✓	30.0	✓	✓	-25				
-27	-51	✓	30.0	✓	✓	-30				
-28	-52	✓	40.0	✓	✓	-26				
-29	-53	✓	40.0	✓	✓	-31				
-30	-54	✓	52.5	✓	✓	-27				
-31	-55	✓	52.5	✓	✓	-32				
-32	-56	✓	70.0	✓	✓	-28				
-33	-57	✓	70.0	✓	✓	-33				

### DISCRIMINATOR LOW PASS FILTERS

Cat. No.	Center Freq. F $_c$ (cps)	Cat. No.	Center Freq. F $_c$ (cps)	Cat. No.	Center Freq. F $_c$ (cps)	Attenuation
LPO -10	6	LPO -19	81	LPO -28	790	.05 DB at 9% F $_c$ 30 DB at 1 F $_c$ 20 DB to 2 F $_c$ 30 DB from 2.5 F $_c$ Harmonics
-11	8	-20	110	-29	900	
-12	11	-21	160	-30	1,050	
-13	14	-22	185	-31	1,200	
-14	20	-23	220	-32	1,600	
-15	25	-24	330	-33	2,100	
-16	35	-25	450	-34	7,200	
-17	45	-26	600	-35	10,000	
-18	60	-27	660			

Characteristic impedance of all—330 $\Omega$

### INPUT

LPI	Center Freq.	LPI	Center Freq.	LPI	Center Freq.
-10	400	-17	3,000	-23	14,500
-11	560	-18	3,900	-24	22,000
-12	730	-19	5,400	-25	30,000
-13	960	-20	7,350	-26	40,000
-14	1,300	-21	10,500	-27	52,500
-15	1,700	-22	12,300	-28	70,000
-16	2,300				

Characteristic impedance of LPI-10 thru 23—30,000 $\Omega$   
of LPI-24 thru 28—5,100 $\Omega$

### MINIATURE BAND PASS FILTERS

Cat. No.	Center Freq.	Band width $\pm$ 3% of CF $\leq$ 2 DB	40 DB att. at .5 and 2 times F $_c$
IBP-400	400	+3%</	

# ELECTRONIC DESIGN

DATA REQUEST PROCESS CARD  
Use Before June 11th, 1968



Name \_\_\_\_\_

Title \_\_\_\_\_

Company \_\_\_\_\_

Company Address \_\_\_\_\_

City \_\_\_\_\_

Zone \_\_\_\_\_

State \_\_\_\_\_

For Change of Address:  
Old Company Name \_\_\_\_\_

Old Company  
Address \_\_\_\_\_

10	20	30	40	100	110	120	130	140	200	210	220	230	240	300	310	320	330	340	400	410	420	430	440	500	510	520	530	540	
1	11	21	31	41	101	111	121	131	141	201	211	221	231	241	301	311	321	331	341	401	411	421	431	441	501	511	521	531	541
2	12	22	32	42	102	112	122	132	142	202	212	222	232	242	302	312	322	332	342	402	412	422	432	442	502	512	522	532	542
3	13	23	33	43	103	113	123	133	143	203	213	223	233	243	303	313	323	333	343	403	413	423	433	443	503	513	523	533	543
4	14	24	34	44	104	114	124	134	144	204	214	224	234	244	304	314	324	334	344	404	414	424	434	444	504	514	524	534	544
5	15	25	35	45	105	115	125	135	145	205	215	225	235	245	305	315	325	335	345	405	415	425	435	445	505	515	525	535	545
6	16	26	36	46	106	116	126	136	146	206	216	226	236	246	306	316	326	336	346	406	416	426	436	446	506	516	526	536	546
7	17	27	37	47	107	117	127	137	147	207	217	227	237	247	307	317	327	337	347	407	417	427	437	447	507	517	527	537	547
8	18	28	38	48	108	118	128	138	148	208	218	228	238	248	308	318	328	338	348	408	418	428	438	448	508	518	528	538	548
9	19	29	39	49	109	119	129	139	149	209	219	229	239	249	309	319	329	339	349	409	419	429	439	449	509	519	529	539	549
50	60	70	80	90	150	160	170	180	190	250	260	270	280	290	350	360	370	380	390	450	460	470	480	490	550	560	570	580	590
51	61	71	81	91	151	161	171	181	191	251	261	271	281	291	351	361	371	381	391	451	461	471	481	491	551	561	571	581	591
52	62	72	82	92	152	162	172	182	192	252	262	272	282	292	352	362	372	382	392	452	462	472	482	492	552	562	572	582	592
53	63	73	83	93	153	163	173	183	193	253	263	273	283	293	353	363	373	383	393	453	463	473	483	493	553	563	573	583	593
54	64	74	84	94	154	164	174	184	194	254	264	274	284	294	354	364	374	384	394	454	464	474	484	494	554	564	574	584	594
55	65	75	85	95	155	165	175	185	195	255	265	275	285	295	355	365	375	385	395	455	465	475	485	495	555	565	575	585	595
56	66	76	86	96	156	166	176	186	196	256	266	276	286	296	356	366	376	386	396	456	466	476	486	496	556	566	576	586	596
57	67	77	87	97	157	167	177	187	197	257	267	277	287	297	357	367	377	387	397	457	467	477	487	497	557	567	577	587	597
58	68	78	88	98	158	168	178	188	198	258	268	278	288	298	358	368	378	388	398	458	468	478	488	498	558	568	578	588	598
59	69	79	89	99	159	169	179	189	199	259	269	279	289	299	359	369	379	389	399	459	469	479	489	499	559	569	579	589	599

Home Address \_\_\_\_\_

City \_\_\_\_\_

Zone \_\_\_\_\_

State \_\_\_\_\_

For Personnel Ads Only  
(Nos. 550-599)

# ELECTRONIC DESIGN

DATA REQUEST PROCESS CARD  
Use Before June 11th, 1968



Name \_\_\_\_\_

Title \_\_\_\_\_

Company \_\_\_\_\_

Company Address \_\_\_\_\_

City \_\_\_\_\_

Zone \_\_\_\_\_

State \_\_\_\_\_

For Change of Address:  
Old Company Name \_\_\_\_\_

Old Company  
Address \_\_\_\_\_

10	20	30	40	100	110	120	130	140	200	210	220	230	240	300	310	320	330	340	400	410	420	430	440	500	510	520	530	540	
1	11	21	31	41	101	111	121	131	141	201	211	221	231	241	301	311	321	331	341	401	411	421	431	441	501	511	521	531	541
2	12	22	32	42	102	112	122	132	142	202	212	222	232	242	302	312	322	332	342	402	412	422	432	442	502	512	522	532	542
3	13	23	33	43	103	113	123	133	143	203	213	223	233	243	303	313	323	333	343	403	413	423	433	443	503	513	523	533	543
4	14	24	34	44	104	114	124	134	144	204	214	224	234	244	304	314	324	334	344	404	414	424	434	444	504	514	524	534	544
5	15	25	35	45	105	115	125	135	145	205	215	225	235	245	305	315	325	335	345	405	415	425	435	445	505	515	525	535	545
6	16	26	36	46	106	116	126	136	146	206	216	226	236	246	306	316	326	336	346	406	416	426	436	446	506	516	526	536	546
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50	60	70	80	90	150	160	170	180	190	250	260	270	280	290	350	360	370	380	390	450	460	470	480	490	550	560	570	580	590
51	61	71	81	91	151	161	171	181	191	251	261	271	281	291	351	361	371	381	391	451	461	471	481	491	551	561	571	581	591
52	62	72	82	92	152	162	172	182	192	252	262	272	282	292	352	362	372	382	392	452	462	472	482	492	552	562	572	582	592
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54	64	74	84	94	154	164	174	184	194	254	264	274	284	294	354	364	374	384	394	454	464	474	484	494	554	564	574	584	594
55	65	75	85	95	155	165	175	185	195	255	265	275	285	295	355	365	375	385	395	455	465	475	485	495	555	565	575	585	595
56	66	76	86	96	156	166	176	186	196	256	266	276	286	296	356	366	376	386	396	456	466	476	486	496	556	566	576	586	596
57	67	77	87	97	157	167	177	187	197	257	267	277	287	297	357	367	377	387	397	457	467	477	487	497	557	567	577	587	597
58	68	78	88	98	158	168	178	188	198	258	268	278	288	298	358	368	378	388	398	458	468	478	488	498	558	568	578	588	598
59	69	79	89	99	159	169	179	189	199	259	269	279	289	299	359	369	379	389	399	459	469	479	489	499	559	569	579	589	599

Home Address \_\_\_\_\_

City \_\_\_\_\_

Zone \_\_\_\_\_

State \_\_\_\_\_

For Personnel Ads Only  
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low-cost thermal  
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The sound design, sturdy construction and reliable operation long associated with G-V Hermetically Sealed Thermal Relays is available in a low-cost form, fully qualified for industrial control . . . light and inexpensive enough for electronic and communications circuits.

Delays of 2 seconds to 3 minutes • Energizing voltages - 6.3 to 230 AC or DC.

• **RUGGED STAINLESS STEEL MECHANISM**

Relay mechanism is of stainless steel, differential expansion type, used in all G-V Thermal Relays. All parts are welded into a single integral structure.

• **SHATTERPROOF—NO GLASS**

No glass is used in mechanism, encasing shell, or base. This avoids the danger of cracking or breakage in handling and use.

• **STEEL ENCASED HEATERS**

Heating elements are conservatively designed, wound with Ni-chrome wire on mica and encased in stainless steel, insuring long heater life even when energized continuously.

• **DUST TIGHT ENCLOSURE**

A dust tight metal shell completely enclosing the relay mechanism and contacts, crimped tightly to the base, provides complete protection for the structure.

• **TAMPER PROOF**

Time delay intervals are preset at the factory. Thus changes of delay interval in the field which might damage associated equipment are avoided.

• **DIRECTLY INTERCHANGEABLE**

Directly interchangeable with all other octal-size relays.



Available through Selected Distributors



**G-V CONTROLS INC.**  
18 Hollywood Plaza, East Orange, New Jersey

Write for Publication 131

U. S. PAT. 2,700,084 OTHER U. S. & FOREIGN PATENTS PENDING

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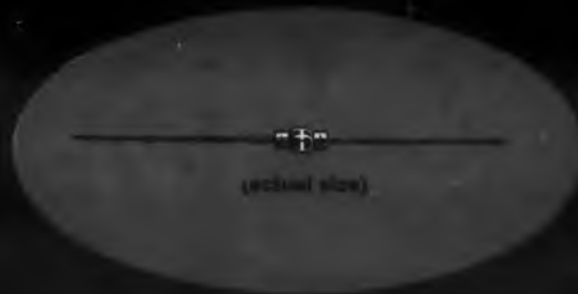
RAYTHEON

# DIFFUSED JUNCTION SILICON GLASS RECTIFIERS

400 MILLIAMPERES

225 TO 500 PEAK  
INVERSE VOLTS

-65°C TO +150°C TEMPERATURE RANGE



Type	Ave. Rectified Current		Peak Inverse Voltage		Reverse Current ( $\mu$ Adc) max. at indicated volts		
	25°C mA	150°C mA	-65° to +150°C	25°C	volts	at 25°C	at 100°C
<b>1N645</b>	400	150	225	275	225	0.2	15
<b>1N646</b>	400	150	300	360	300	0.2	15
<b>1N647</b>	400	150	400	480	400	0.2	20
<b>1N648</b>	400	150	500	600	500	0.2	20

**For all types**

Voltage Drop (400mA, 25°C)..... 1.0 V max.  
 Steady State Peak Forward Current (25°C)..... 1.25 A max.  
 Surge Current (1 sec. 25°C to 150°C)..... 3.0 A max.  
 Dissipation (25°C)..... 600 mW max.

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CIRCLE 3 ON READER-SERVICE CARD

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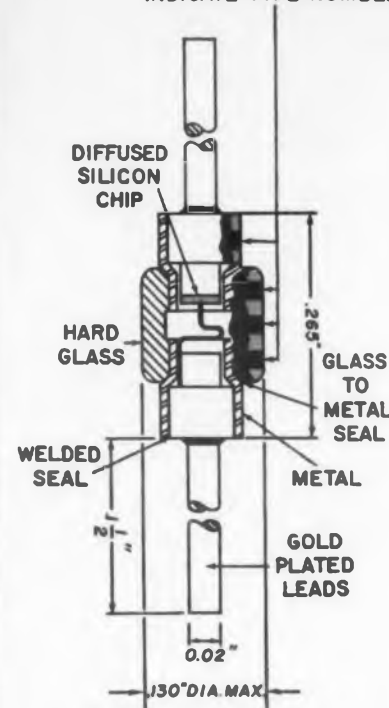
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## EDITORIAL

### Exploiting Thermistors In ELECTRONIC DESIGN

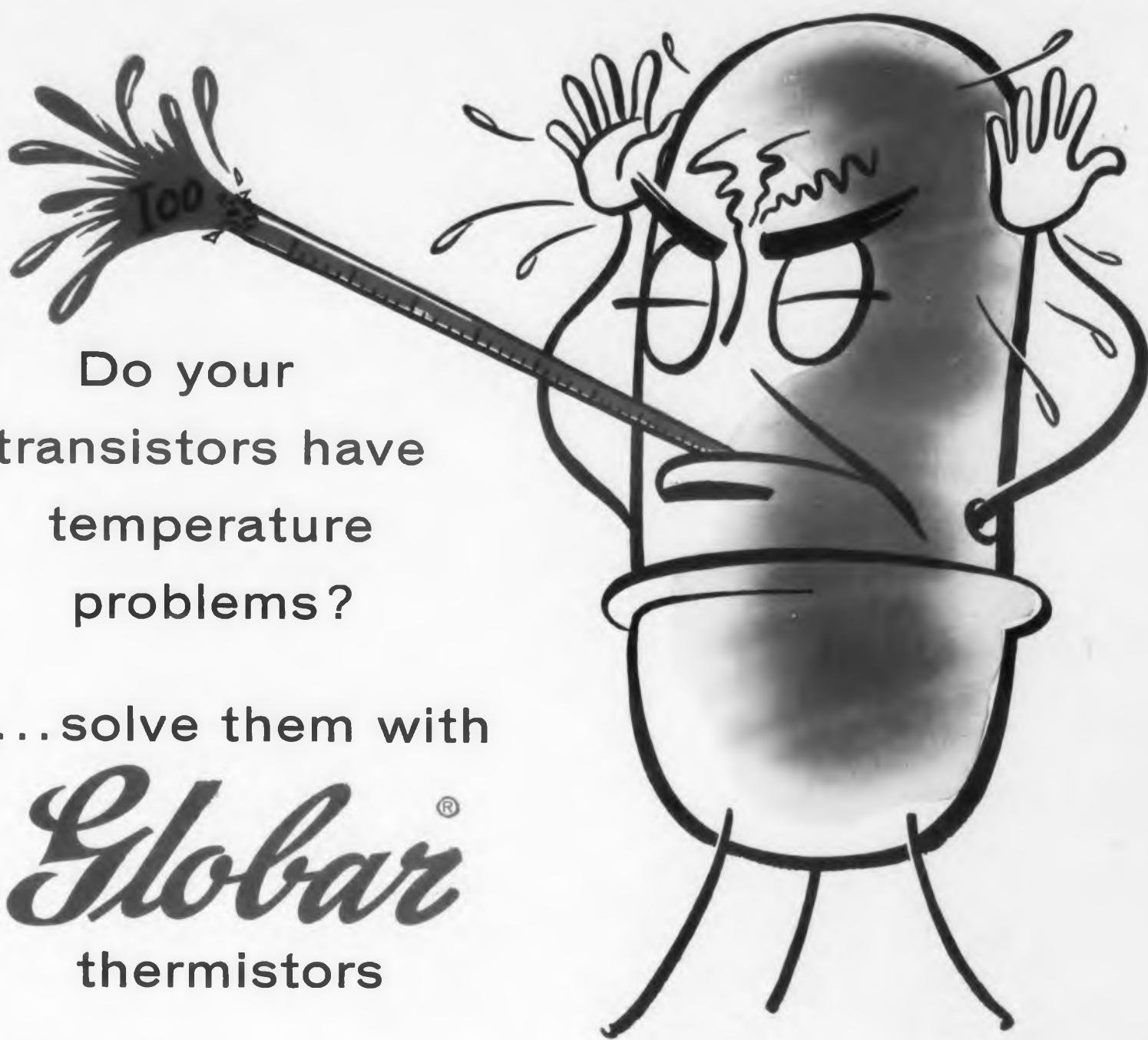
This is our third issue this month. The "extra" edition permits us space to bring you a special feature section devoted entirely to thermistors. Thermistors have been around for quite some time, but we expect you'll be working with them more in the near future. We expect units will be available with closer tolerances at no increase in cost.

A deterrent to the wholesale use of thermistors has been the wide tolerance to which they were made. It has been difficult to match a thermistor to a transistor to compensate for temperature change (some people will certainly take exception to this statement, but as a generalization there has to be much hand work in making or picking thermistors). There has been no specification on thermistors which a customer could specify to insure a constant quality. The "Specifying Military Thermistors" by Bernard Schwartz of RCA, page 34 should prove a helpful guide to the inexperienced buyer.

In gathering material for this issue, we are deeply appreciative of the efforts made by thermistor manufacturers to supply us with information that would be most helpful to designers. An abundance of design information exists in the manuals and data books put out by manufacturers. We have not warmed this over, but bring instead new approaches to designing with thermistors. More new design articles will appear in succeeding issues. We think you'll particularly appreciate Mr. Schwartz's design aids which boil the problem down to using curves and nomograms.

Thermistors can be used in the following applications: temperature measurement, temperature compensation, temperature control, liquid level gauges, time delays, surge suppression, switching, microwave power measurement, volume limiting, voltage regulation, compressors and expanders, age, overload protection, and oscillator amplitude stabilization. If you're not now using thermistors, you ought to look into them. If you've found them inadequate in the past, watch future developments closely.

*James A. Kipp*



Do your  
transistors have  
temperature  
problems?  
...solve them with  
**Globar**<sup>®</sup>  
thermistors



Minimize Ico variation and prevent thermal runaway by using Globar thermistors. They are available in a wide range of resistance values and temperature coefficients to meet most transistor circuit requirements.

Globar Thermistor Test Kits are available for general evaluation in transistor circuits. If you have a specific transistor temperature problem, submit details to GLOBAR Plant, The CARBORUNDUM Company, Dept. ED 87 - 711, Niagara Falls, New York. Ask for Technical Bulletin GR-3 . . . describes physical and electrical characteristics of GLOBAR Thermistors.

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by **CARBORUNDUM**  
REGISTERED TRADE MARK

Over 30 years' experience in the field of special ceramic resistance devices

CIRCLE 4 ON READER-SERVICE CARD

87-711 ■

# NEW—Raytheon Amplitron

Now—peak power 800 kw, bandwidths of 10% with efficiencies of 50-70% over entire band



**QK520 Amplitron**  
Typical Operation (Pulsed)

Anode Voltage . . . . . 40 kv  
Anode Current . . . . . 35 amps  
Peak Power Output . . . . . 800 kw  
Average Power Output . . . . . 1200 watts  
Efficiency . . . . . 55%  
Operating Band ( $\pm 1$  db) . . . . . 1225-1350 Mc  
Peak Power Input . . . . . 80 kw  
Phase Stability  
with Anode Current . . . . . 1°/amp

The Amplitron is a new type of tube capable of power amplification at microwave frequencies. Amplification is obtained over a broad range of frequencies without need of mechanical or electrical adjustments. The Amplitron is a derivative of the magnetron and retains many of its advantages—high operating efficiency, simple construction, small size, light weight, low operating voltage.

The Amplitron uses crossed electric and magnetic fields, a reentrant beam produced by a magnetron-type cathode, and a non-reentrant broadband circuit matched at either end to external circuits.

Variations in anode current or voltage have little effect upon the total phase shift. This results in very low phase pushing and excellent reproduction of the input spectrum even under pulse conditions with slow rise time and ripple. Because of low insertion loss, duplexing may be accomplished at the input rather than the output of the final rf amplifier.

A limited quantity of preliminary literature is now available. To be sure of your copy, write now. *Amplitrans in other frequency bands are currently in development. Inquiries are invited.*

**RAYTHEON MANUFACTURING COMPANY**

Microwave and Power Tube Operations, Section PT-24  
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Regional Sales Offices: 9501 W. Grand Avenue, Franklin Park, Illinois. 5236 Santa Monica Blvd., Los Angeles 29, California  
Raytheon makes: Magnetrons and Klystrons, Backward Wave Oscillators, Traveling Wave Tubes, Storage Tubes, Power Tubes, Miniature and Sub-Miniature Tubes, Semiconductor Products, Ceramics and Ceramic Assemblies



*Excellence in Electronics*

## ENGINEERING

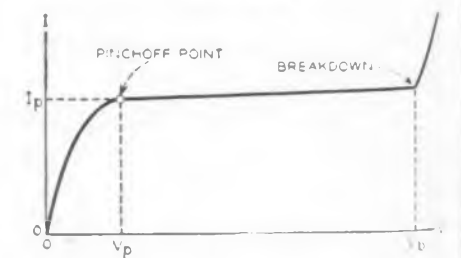
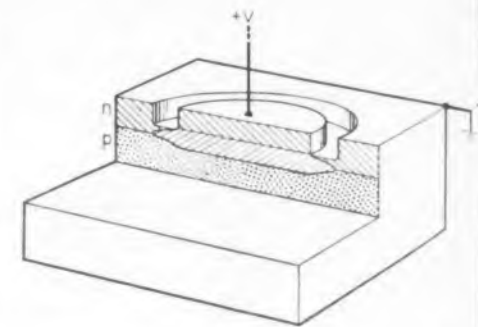
For more information on developments described, write directly to the address given in the individual item.

### Constant-Current Varistor Announced

A field effect varistor with a constant current feature has been announced by Bell Telephone Laboratories, New York City. The two-terminal passive semiconductor component is applicable as a current regulator where load or supply varies over 20 to 120 v.

Still in the experimental stage, the component has other applications as a current limiter or as a pulse shaper; with its high ac impedance, it can be used as a coupling choke or ac switch.

The field effect varistor is related to the field effect transistor. A single planar junction is made by diffusion. Current passing parallel through this junction goes through a constricted channel. As the voltage increases, the current increases and a depletion layer builds up to the entire thickness of the channel. At a "pinch-off" point, voltage increase does not produce any current increase. Before an avalanche breakdown point, and after the pinch-off point, current is essentially constant—and this is the region of primary interest.



**Varistor Cross-Section, (top), and a plot of varistor pinch-off and breakdown points.**

◀ CIRCLE 5 ON READER-SERVICE CARD

## REVIEW

Present varistors are produced in a precision process. Germanium or silicon diodes are heavily plated, on all surfaces, and circular trenches are then cut into diffused junctions, to within 0.1 mil of the junction.

In experiments, the trench was first cut by ultrasonic means and finished by etching. Leads were attached by thermocompression bonding or other convenient means.

Bell research engineers believe varistors which regulate current at any level between 10  $\mu$  a and 10 ma could be produced. With improvements in fabrication techniques, higher current levels will be feasible. Germanium units with 10 ma rating have 10 to 25 v range.

### Coded TV Pictures

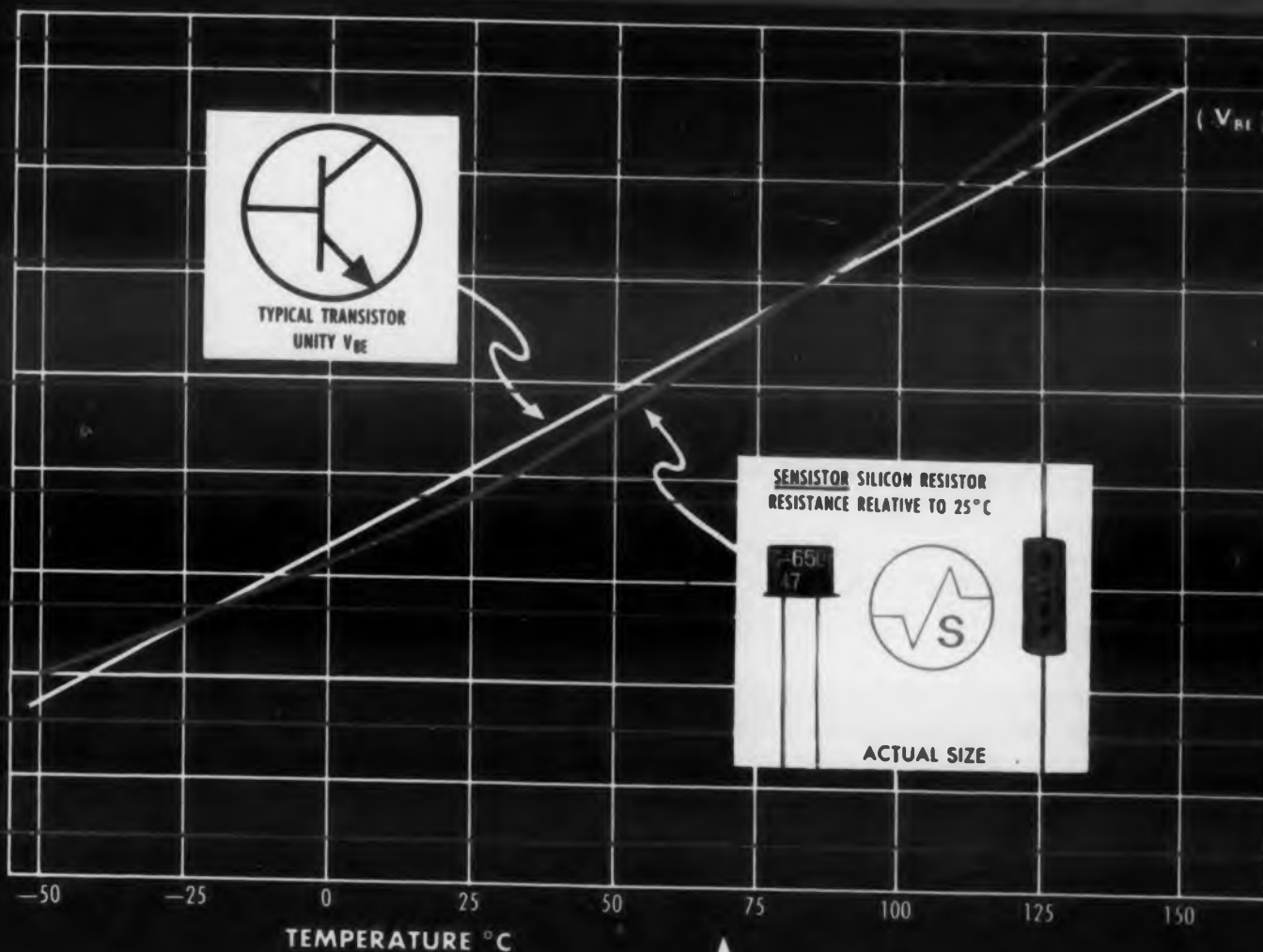
Techniques for improving the efficiency of long-distance television picture transmission were revealed by the Technicolor Corp., Burbank, Calif. Bandwidth reductions of as much as 4 to 1 were reported.

In the complete system a normal television camera output is fed into a small high-speed electronic computer which codes the video signal into a series of dots and spaces as in the Morse code before transmission to the receiver. There a similar computer translates the code before presenting the picture on a television tube. An essential feature of the device is the temporary retention of the coded signal in electrostatic storage tubes to average out the information rate. Laboratory equipment built so far handles pictures with just two levels of brightness, but additional circuitry to permit acceptance of a complete tone scale is approaching completion and will yield the same bandwidth reduction factor. Color TV signals may also be transmitted with only slightly greater bandwidth than for black and white pictures.

CIRCLE 6 ON READER-SERVICE CARD

# ANOTHER NEW SOLID STATE DEVICE from TEXAS INSTRUMENTS

SENSISTOR SILICON RESISTOR RESISTANCE RELATIVE TO 25°C



TRANSISTOR BASE-EMITTER VOLTAGE RELATIVE TO 25°C VALUE

# sensistor

SILICON RESISTOR

**Positive temperature coefficient of resistance (+0.7%/°C) plus a constant rate of change**

*Sensistor* silicon resistors further stabilize temperature-induced variations in transistor characteristics... compensate for base-emitter bias voltage vs. temperature characteristics of transistors.

*Sensistor* silicon resistors are ideally suited for your temperature sensing and for temperature compensating type applications in amplifiers... computer switching circuits... servos... power supplies.

For your next temperature compensating or sensing requirement, specify a *sensistor* silicon resistor, the resistor with a positive temperature coefficient of resistance plus a constant rate of change.

STANDARD AVAILABLE RESISTANCES\*\* AT 25°C: 100, 120, 150, 180, 220, 270, 330, 390, 470, 500, 560, 680, 820, and 1000 ohms.

electrical specifications	TM %	TC %	UNITS
wattage rating . . . . .	1/4	1/8	W
average temperature coefficient	+0.7	+0.7	%/°C
resistance tolerance . . . . .	10	10	%

\*\*Other resistance values and tolerances available on special order.

\*Trademark of Texas Instruments Incorporated

Available now! Ask your nearest TI sales office for Bulletin DL-C 860

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 INCORPORATED

# AMPLIFIERS

**Wide band, fast pulse amplifiers — 90 db in cascade —  
distortion-free amplification of pulses shorter than 0.01  $\mu$ sec!**

At moderate cost, -hp- 460A and 460B Amplifiers offer true amplification of millimicrosecond pulses at power levels sufficient to operate scalars, counting meters and cathode ray tubes.

Model 460A provides voltage gain of approximately 20 db while Model 460B is a 15 db terminal amplifier insuring maximum output. Since rise time is 0.0026  $\mu$ sec, and overshoot and ringing are negligible, distortion-free amplification of pulses faster than 0.01  $\mu$ sec is assured. The high gain, no distortion feature means the instruments, in cascade, serve as a 100 MC pre-amplifier



for standard oscilloscopes, and a x 10 sensitivity multiplier for voltmeters. Rack mount model only. -hp- 460AR, \$185.00. -hp- 460BR, \$225.00.

**General purpose amplifier — 20 or 40 db gain — high  
stability 10 cps to 1 MC — low priced at \$140.00**

-hp- 450A is an ideal, general duty amplifier for use wherever wide frequency coverage and stable gain are desired. Gain is  $40 \pm \frac{1}{8}$  db or  $20 \pm \frac{1}{8}$  db at 1,000 cps as selected at front panel switch. Frequency response is flat, stability is  $\pm 2\%$  on  $\pm 10$  volt changes in line power, input impedance is 1 megohm with approximately 15  $\mu$ mf shunt, distortion is less than 1%, output 10 volts maximum into 3,000 ohms. The instrument is resistance-coupled and has no peaking or compensating networks. Phase shift is negligible and there are no spurious resonances or oscillations. Hum is minimized by a dc filament supply to the two amplifier tubes. \$140.00.

*Data subject to change without notice.  
Prices f.o.b. factory*



**-hp- also offers 4 Traveling-Wave Tube Amplifiers  
covering frequencies 2 to 12.4 KMC! See your -hp-  
representative or write direct for details!**

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FIELD ENGINEERS IN ALL PRINCIPAL AREAS

## ENGINEERING REVIEW

### Mach 2 Bomber Control System Disclosed

The autopilot and flight control system that makes it possible to fly a Mach 2 bomber was revealed by the Eclipse-Pioneer Division of Bendix Aviation Corp., Teterboro, N.J.

The Convair B-58 Hustler control system continually senses and computes maximum control-surface movement permitted by the structural limitations of the supersonic jet over its entire range of speed. The control system also takes into account the constantly changing atmosphere conditions the plane encounters. In effect, the human pilot is prevented from putting the plane into any maneuver that could instantly destroy it.

Sensing units in the nose of the delta-wing jet pick up data on the plane's air environment—air speed, temperature, air density, and other vital information. This information is evaluated and compared in a central air data computer. Appropriate control information from the computer is then relayed through an amplifier computer to a complex electromechanical device, the power control linkage assembly (PCLA).

In the PCLA the pilot's control-stick movements are translated into correct control-surface action by the power control part of the system. This control-surface action varies from a 20 deg movement under one set of conditions to eight-tenths of one degree under extreme-opposite conditions of speed and air environment. Yet, there is no difference in the "feel" of the controls, as far as the pilot is concerned, between the two



Control signals from the pilot or automatic guidance system of the Convair B-58 Hustler, pass through the power-control linkage assembly. This 267-pound electromechanical device, which contains an array of 17,000 parts, translates into linear motion, electronic signals from a computing system that senses aerodynamic forces.



**has six new oscilloscopes. Tested them?**

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extremes. The B-58 power control system can develop a maximum torque of 120 ton-foot.

Designed into this control system is a process called "mixing." The conventional airplane has both elevators for up or down movement and ailerons for banking. The delta-wing Hustler, however, has just one set of control surfaces, elevons, which "mixes" the work of both elevators and ailerons.



### Automatic Missile Launcher

This is a prototype of the automatic missile loading and launching equipment for firing a series of ground-to-air defense missiles of the Talos type. Designed and built by American Machine & Foundry Co., 261 Madison Ave., New York, N.Y., the equipment has been delivered to White Sands Proving Ground, New Mexico, where it is installed in the Talos Defense Unit.

On command from computers in the control station, the launcher turns toward the cell in the circular storage magazine which contains the desired type of missile for the tactical mission. A cart runs out to the automatically preselected cell, picks up a missile and returns to the launcher. The missile is then positioned in the launcher where it is elevated and rotated to firing position. When the firing signal is received, the missile is fired automatically and the launcher recycles for the next round. Unloading is also automatic.

### In Case You Wondered— HSD=Hoffman Electronics Corp.

We're sorry. In "Zener Diode Characteristics" (Mar. 19, 1958 ELECTRONIC DESIGN), the code HSD went unexplained. It stands for Hoffman Electronics Corp., Semiconductor Div., 930 Pittner Ave., Evanston, Ill.

We're sorry, too, that the following Hoffman types were not listed: IN465; IN466; IN467; IN468; IN469; and IN470. These types span the zener voltage range of 2.0 to 8.0 v at  $I_z = 5$  ma dc.

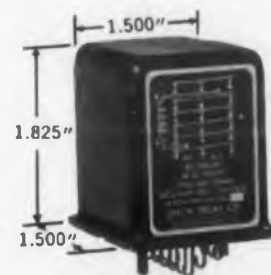
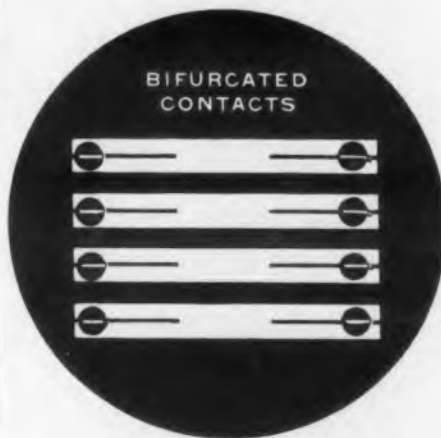


# LEACH

*balanced-armature relays  
solve environmental problems*

*... unique design gives high resistance  
to shock, acceleration, vibration*

Leach *Balanced Armature* relays are now solving the most exacting problems for systems designers. Exclusive balanced armature design eliminates faulty operation of contacts due to vibration and shock forces. Bifurcated contacts assure high reliability in contact-making circuits. You'll find these exceptional relays give optimum performance in resistance to shock, acceleration and vibration.



9226 . . . *Balanced Armature* relay. Square configuration with a variety of mounting and terminals available. Hermetic sealing is 100% tested by mass spectrometer.

### Typical Ratings

6 PDT  
Normal operating voltages—6-115 vdc—115 vac (400 cycle).  
Contact ratings @ 28 vdc or 115 vac, single phase  
Resistive—3 amp @ 125°C  
—5 amp @ 85°C (dc only)  
Inductive—1.5 amp @ 85°-125°C  
Motor Load—1.5 amp @ 85°-125°C  
Rated duty—continuous  
Minimum cycles—100,000  
Weight—0.3 lbs. max.  
Shock—50 G's  
Vibration—15C's—2000 cps  
Applicable specifications  
MIL-R-6106C  
Class A5, A8, B8  
Minimum current test applicable  
MIL-R-5757B  
Class A & B

*We invite other special requirements such as microamp switching, high vibration, and special mounting.*

# LEACH CORPORATION

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For fabricated parts—or for extruded strip, rod, tubing or special shapes—you'll find National a dependable primary source of Nylon. Costly molds and time delays may favor the delivery of 100% usable parts fabricated from National Nylon and timed to your production needs.

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Check him, also, for your other

basic materials needs—PHENOLITE® Laminated Plastic, Vulcanized Fibre, PHENOLITE Copper-clad. Many grades from the more than 100 available—including Nylon rod—are "in stock" for immediate shipment. For Nylon sizes, grades and properties, write Dept. E-4 for our Technical Data Folder.

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## ENGINEERING REVIEW

### Electrical Cable Guides Car

An automobile automatically steered by an electrical cable beneath a concrete surface cruised along a one-mile check road.

During the demonstration held at General Motors, Warren, Mich., the car rolled along the two-lane road and negotiated the banked turn-around loops at either end without the driver's hand on the steering wheel. To turn off the road or pass another vehicle, the driver switched back to manual steering.

Guidance was accomplished by a circular magnetic field created by the low frequency ac line. A pair of tuned pickup coils on the front bumper of the vehicle straddled the field. Any deviation or lateral motion of the car produced a difference in voltage from one pickup coil to the other. These voltage variations were fed into a small analog computer on the instrument panel. The computer was linked with a servo system that controlled the modified power steering unit.

The computer transmitted command signals to the servo mechanism which positioned the front wheels. Thus, if the car underwent any deviations from its straight-ahead course the automatic steering system brought it back into the straight-ahead path.



### Flammability Testing of Laminates

A flammability test unit is aiding research and development programs on flame-retardant laminates. Installed recently at Continental Diamond Corp., Bridgeport, Pa., test equipment provides detailed and specific information on flammability characteristics.

The specimen is placed within the unit's heating coil, which can heat the specimen to temperatures in excess of 860 C. Specially designed electrodes located immediately adjacent to the test specimen emit a constant stream of high-voltage sparks which ignite the gases arising from the heated specimen. After a burning period of 30 sec, all current is cut from the heating coil and spark electrodes, following which the time required for the flame to extinguish itself is measured.

# MEETINGS

## May 5-7: AIEE Great Lakes District Meeting

Michigan State University, East Lansing, Mich.  
Write to AIEE, 33 W. 39th St., N.Y. 18, N.Y.

## May 5-7: PGMT&T National Symposium

Stanford University, Calif. Write to Dr. K. Tomiyasu, GE Microwave Lab., 601 California Ave., Palo Alto, Calif.

## May 6-8: 12th Annual Frequency Control Symposium

Berkeley-Carteret Hotel, Asbury Park, N.J. Sponsored by the Frequency Control Division, U.S. Army Signal Engineering Labs. of Ft. Monmouth, N.J. Write to Dr. E. A. Gerber, Frequency Control Div., U.S. Army Signal Labs., Ft. Monmouth, N.J.

## May 6-9: Western Joint Computer Conference

Ambassador Hotel, Los Angeles, Calif. For more information write David Parry, 6363 Wilshire Blvd., Los Angeles 48, Calif.

## May 12-14: National Aeronautical and Navigational Electronics Conference

Biltmore Hotel, Dayton, Ohio. Contact Walter Fried, 1668 Wesleyan Rd., Dayton, Ohio.

## May 13-14: Spring Assembly Meeting of the Radio Technical Commission for Marine Services

Benjamin Franklin Hotel, Philadelphia, Pa. Write to R. T. Brown, Radio Technical Commission for Marine Services, c/o Federal Communications Commission, Washington 25, D.C.

## May 13-15: AIEE East Central District Meeting

Huntington, W. Va.

## May 21-23: Joint Electronic Components Conference, AIEE, IRE, RETMA, WCEMA

Los Angeles, Calif.

## May 26-27: Engineering Refresher (Electrical Engineering)

University of Wisconsin. Contact Mr. Robert A. Ratner, Director Engineering Institutes, University of Wisconsin Extension Div., Dept. of Engineering, Madison 6, Wis.

## May 27-28: Maintainability of Electronic Equipment, 2nd EIA Conference

University of Pennsylvania, Philadelphia, Pa. For more information write J. A. Caffiaux, 650 Salmon Tower, 11 W. 42nd St., New York 36, N.Y.

ALLEN-BRADLEY PRESENTS...

# NEW METAL GRID

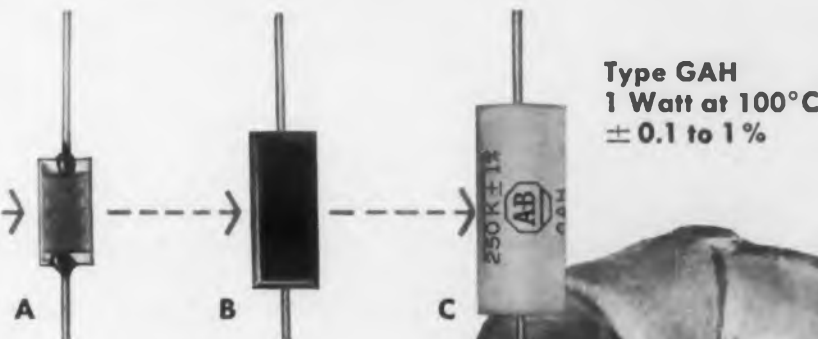
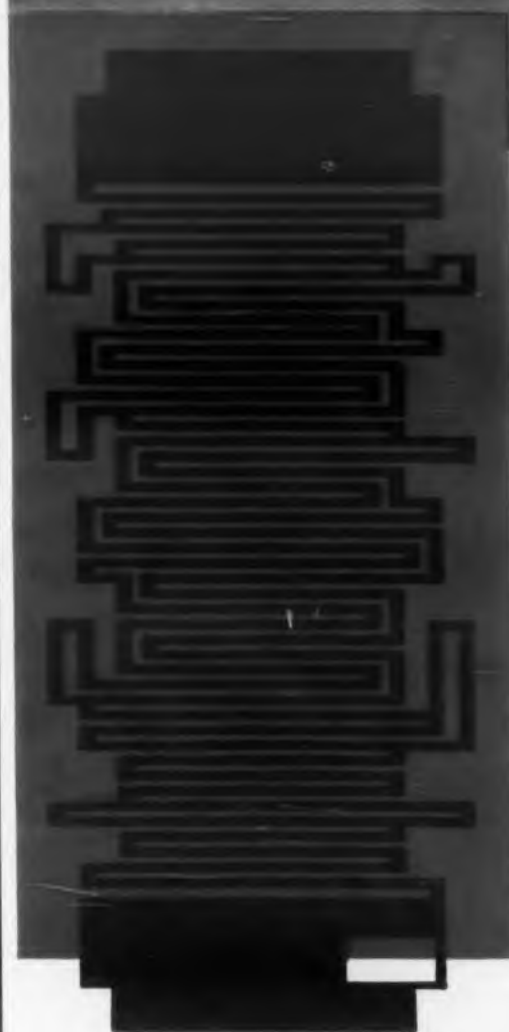
1/4, 1/2, and 1-WATT

PRECISION RESISTORS



## Far exceed MIL Specs for film and wire-wound resistors

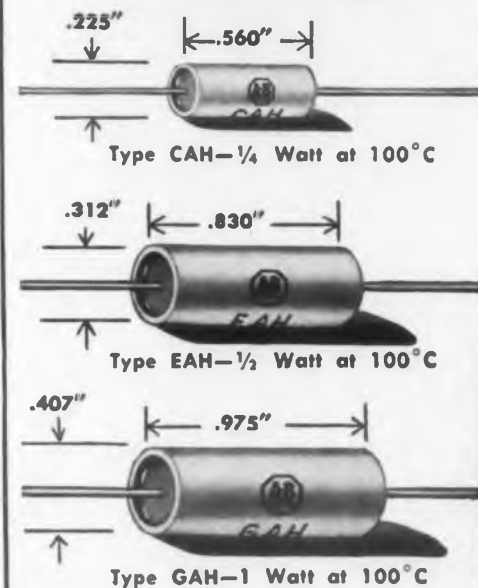
Allen-Bradley's new, truly accurate, metal grid resistors are now available in 1/4, 1/2, and 1-watt ratings, producing test results that are a substantial improvement over the MIL Specifications for wire-wound and film type precision resistors. They combine remarkable stability, under load and on the shelf, with an exceptionally low temperature coefficient. The metal alloy grid is noninductive, providing excellent high frequency characteristics. They also have an exceptionally low noise level... comparable to that of wire-wound units. Each unit is individually calibrated and marked with nominal resistance value, tolerance ( $\pm 0.1$  to 1%), and temperature coefficient. Provided with gold plated leads for flawless soldering. Considering their superior characteristics, these new resistors justly qualify under the Allen-Bradley trademark of *Quality*.



Type GAH  
1 Watt at 100°C  
 $\pm 0.1$  to 1%

The construction of the 1/4, 1/2, and 1-watt resistors is identical. At the upper left is an enlarged view of the metal alloy grid, mounted on glass, which forms the resistance element. (A) Actual size of 1-watt element, (B) encapsulating epoxy resin body, (C) finished unit hermetically sealed in ceramic tube.

Allen-Bradley Co.  
1344 S. Second St., Milwaukee 4, Wis.  
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.



# ALLEN-BRADLEY

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**PYRAMID MYLAR...**

**-30°C to +125°C...**

**SMALLEST FILM CAPACITORS MADE!**

Smallest film capacitors made... Pyramid Mylar capacitors have extremely high insulation resistance, high dielectric strength and resistance to moisture penetration.

Commercially available immediately, Pyramid Mylar capacitors have an operating range between -30° C to +125° C with voltage de-ratings above +85° C. Pyramid wrapped Mylar capacitors—Series No. :101, 103, 106 and 107 have the following characteristics:

Construction Styles:	Basic No.	Type Winding	Shape
	101	Inserted Tabs	Flat
	103	Extended Foil	Flat
	106	Inserted Tabs	Round
	107	Extended Foil	Round

**Tolerance:** The standard capacitance tolerance is ± 20%. Closer tolerances can be specified.

**Electrical Characteristics:** Operating range for Mylar capacitors—from -55° C to +85° C and to +125°C.with voltage de-rating.

**Dissipation Factor:** The dissipation factor is less than 1% when measured at 25° C and 1000 CPS or referred to 1000 CPS.

Insulation Resistance:	Temperature	IR x mfd	Maximum IR Requirements
	25° C	50,000	15,000 megohms
	85° C	1,000	6,000 "
	125° C	50	300 "

Pyramid Mylar capacitors are subject to the following tests:

**Test Voltage**—Mylar capacitors shall withstand 200% of rated D.C. voltage for 1 minute at 25° C.

**Life Test**—Mylar capacitors shall withstand an accelerated life test of 250 hours with 140% of the voltage rating for the test temperature. 1 failure out of 12 is permitted.

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# The Growing Thermistor Field

**A. J. Gizzi**

Manager, Specialty Resistor Project  
Magnetic Materials Section  
General Electric Co.  
Edmore, Mich.

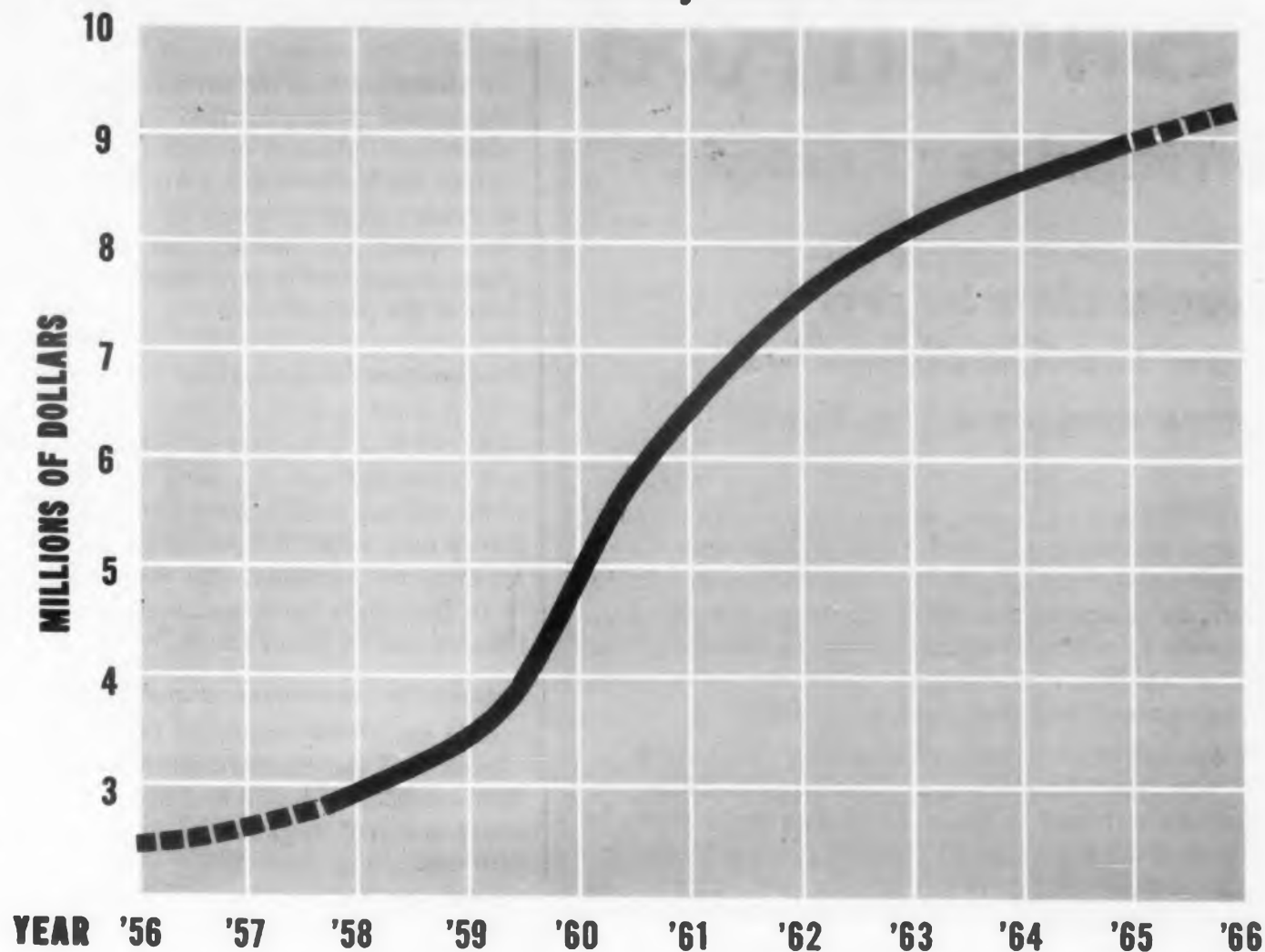


**T**HE THERMISTOR, born some two decades ago in the laboratories of Western Electric, is now assuming full stature as a design component. Its unusual properties—extreme sensitivity, negative temperature coefficient, and high reliability make it an ideal component for modern electronic equipment. It is only in the last few years that manufacturers have taken up the challenge of providing the design engineer with reliable, standard, thermistor types. The versatility of thermistors is already reflected in a wide variety of applications, from medical temperature probes to missile-fuel sensing elements. Temperature measurement and control for instrumentation has become a major area of thermistor use.

The use of thermistors in transistor circuitry should prove of the greatest interest to designers. Thermistors are a good design choice for compensating transistor-circuits because they are of extremely small size, are very sensitive to temperature change, have indefinite life, are economical, and have very stable and reproducible characteristics within their design limits.

Active research is still being carried on and new thermistor types are being developed, such as special bolometer thermistors and ultra-low temperature thermistors. Research is also increasing the accuracy and reproducibility of thermistor types. Most present manufacture is still on the batch system, and continuous controlled production is an important goal. The evolution of a complete set of standard thermistor types is making the thermistor an invaluable tool for the designer.

## Thermistor Industry Market Estimate



Past, present, and future markets for the thermistor.

**W**HILE the thermistor is not a new product, nor even a new development, its commercial history is comparatively recent. With the increasing demand for small rugged components like the thermistor, that fit the growing technical complexity of circuits, some planning for the future was a necessity. In the summer of 1957, as a result, an extensive market survey was carried out by the General Electric Co.

For clarification, and for better visualization of types of applications, we might indicate subdivisions of typical applications of the three major branches:

### Temperature compensation

Fluctuation in temperature will often affect many electrical and electronic systems or components, reflecting undesirable changes in resistance and general operating characteristics. In most cases a thermistor incorporated properly in the circuit will compensate for the expected tempera-

ture change. Some of the typical applications of this type of thermistor are:

- Vertical deflection yoke on 110 degree television cathode-ray tubes.
- Transistors and associated circuitry.
- Fuel flow, in relation to ambient temperature fluctuations in a fuel injection system.
- Delicate miniature or subminiature instrumentation, servomechanisms, missile components, or relays.

### Temperature measurement and control

Thermistors have a high temperature coefficient of resistance, and can be effectively used to measure and control reasonable changes in temperature. With high resistance in a small mass, both rapid and accurate measurements are easy to obtain, even when the thermistor itself is spotted remotely from the measuring circuit. Some typical applications:

- Indication of engine oil or water temperatures.
- Oven roast-food probe.
- Electric range surface and oven controls.
- Indoor/outdoor temperature controls for home and industrial heating systems.
- Indication and control of temperature in chemical reaction stills, kettles, or other industrial apparatus.
- Replacement of thermocouples for temperatures ranging up to 400 C.

### Time delay and inrush surge suppression

The thermistor's inherent thermal inertia delays current-rise through it, and through its associated circuitry. A thermistor prevents a large initial current surge caused by application of voltage to cold electrical components such as relays, tubes, transformers, or motors. Typical applications are:

- Protection for longer life of TV and radio tubes by limitation of inrush currents.
- Time delays required for many electrical or mechanical devices; one of these worth mentioning is the steadily growing adoption of home and industrial air-conditioning.

Major producers found it difficult to assess either present quantitative demand for thermistors or parameters for future potential. To efficiently predict trends or usage, and consequent effect upon production facilities, it was necessary to definitely determine the real areas of market growth.

To provide complete coverage, the survey was divided into two separate sections—a series of personal interviews and a direct-mail questionnaire. Based upon various informational sources, it is estimated that at least one-quarter of the total industry market was covered by the man-to-man interviews. Of the mailed question sheets, about 23 percent were filled out and returned to the checking source. Results of both surveys closely agreed, and it is felt that the voluminous data eventually compiled represents a good sampling of the thermistor market.

Over an extended period, based on final study of the paired surveys, the total industry market for all types of thermistors should be something like this:

1958	\$3,000,000
1959	\$3,500,000
1960	\$5,000,000
1961	\$6,500,000
1962	\$7,500,000
1965	\$9,000,000

These figures do not include "captive" industrial production.

Breaking down these totals into thermistor application areas, both for the known present and the expected future, we may expect:

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Sylvania supplies n-type germanium in the form of undoped single crystals and polycrystalline as-reduced or purified ingots. Resistivity of the purified material is greater than 40 ohm cm at 25° C. Both silicon and germanium are available in specially cut pieces to fit practically every type of crucible or boat for crystal growing.

Contact Sylvania's Chemical and Metallurgical Division for further information on the new small diameter cast silicon rods and other semiconductor materials.

Type of Application	1958	1965
Temperature compensation	40%	30%
Temperature measurement and control	40%	20%
Time delay, and inrush-suppression	20%	50%

Although in ratio the various types of uses may be expected to vary by 1965, its dollar value will increase as indicated in earlier pages. Although certain applications may narrow or widen, overall usage will grow. It may be of some interest to chart—using the survey results—some places where thermistors may be more broadly adopted than at the present time.

#### Temperature compensation

In general, both mechanical and electrical devices will tend to become more remotely operated and controlled, and also more automatic. In case of the military missile, more exact control is mandatory over wider temperature ranges. In these applications, certainly, the thermistor will be more frequently used, and more as a part of a planned system than as an individual item.

#### Temperature measurement and control

It is confidently expected that there will be extension of the effective temperature range of the thermistor. This will lead to a more simplified measurement of temperature, especially in remote locations.

Time, as a measurement of how food should be properly cooked, is being discarded in favor of using food temperature as a criterion. Already the thermistor is in use in this field, and recent design trends forecast an increasing growth.

Rigid control of home or industrial heating units, using thermistors, will provide a more uniform temperature. Individual-room control can be obtained, a special role for the thermistor.

#### Time delay, and initial-surge suppression

There is a large field for the thermistor in the protection of elaborate industrial lighting systems large inrush current. From a dollar viewpoint, this will increase lamp life and will reduce costly maintenance schedules.

Thermistors will be more widely used as a safeguard against faulty or erratic operation of relays or other control devices due to spurious currents.

As previously mentioned, the growing use of air-conditioning units, both domestic and industrial, will compound the problems of the utility companies. Initial inrush current to electric motors and sudden peak demand can be controlled by the thermistor. Of this last item, air-conditioning is only one of the fast-growing appliances that are appearing in the field of power consumption. The potential of this thermistor application prob-

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ably is the largest of all, because of the variety of the end-products involved.

No attempt was made to list all or even part of the present or future application of the thermistor; the foregoing items are only indications of General Electric's belief that the market will continue to enlarge. Many other applications, of course, will be conceived by the design engineer as he learns more, and is able to design into his mechanisms the full potential of the thermistor. In line with this thinking, part of the survey study was made of present attitudes and needs of both the manufacturer and the present and potential users. Various questions were asked, and the general trade requirements were weighed against product improvements requested by present customers. The final tabulation is interesting, in that it defines both present limitations of the thermistor and the much greater possibilities that lie ahead:

1. Closer electrical tolerances.
2. Improved thermistor stability.
3. Higher operating temperatures, up to 1000 C.
4. Availability of differing resistances in the same geometrical shape.
5. Expansion of the temperature coefficient range, both negative and positive.
6. Greater current carrying capacity.

In the past, these requirements have been deterrents to many possible thermistor applications. It seems to be generally appreciated that the manufacturers are recognizing these demands, and are moving in the needed direction. With these design standards accomplished, the thermistor is even now being used where it had been ruled out in the past; obviously, more complete utilization cannot help but follow newer developments.

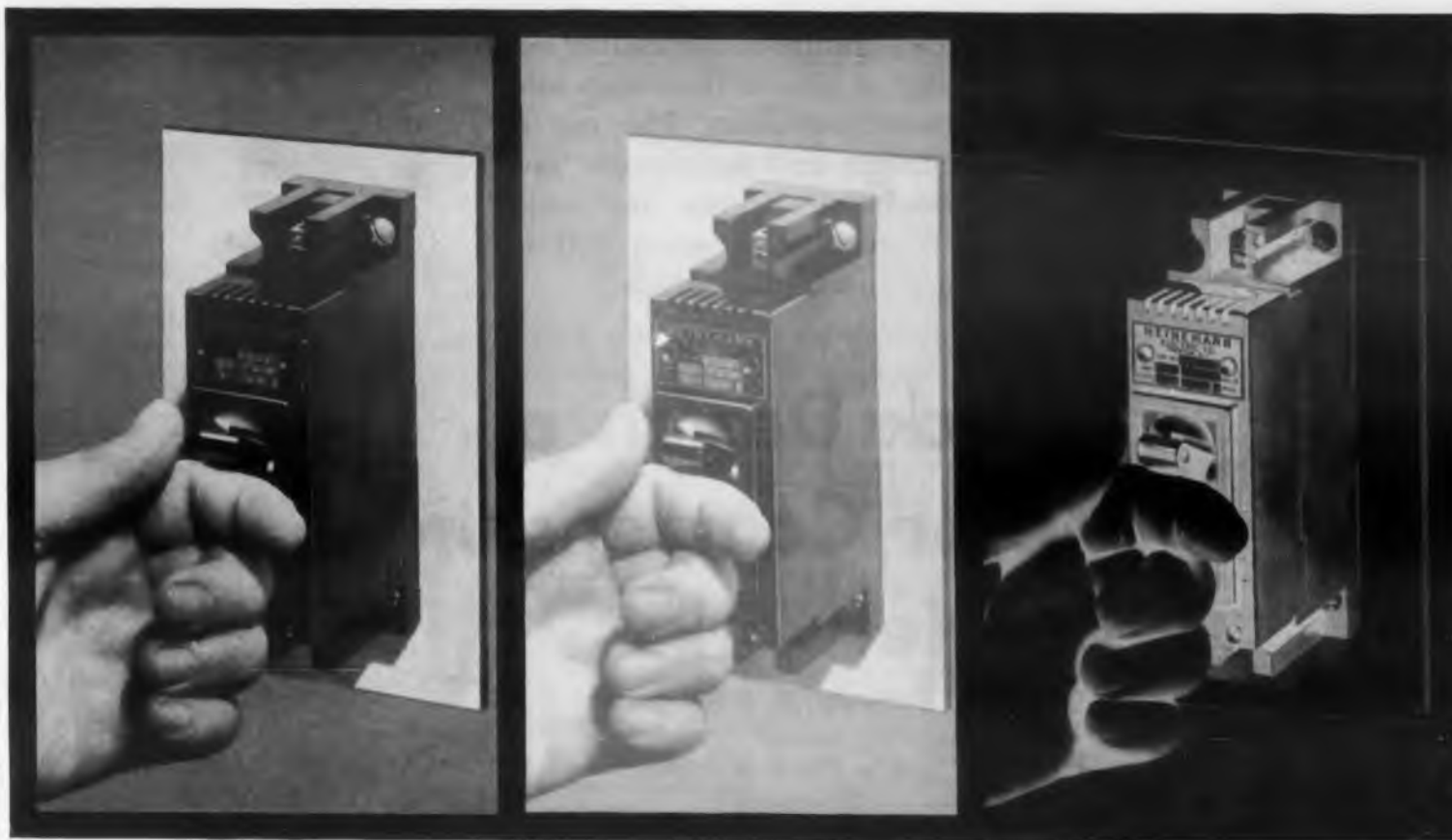
Although emphasis has traditionally been laid on refinement of volume production to provide the best attractive price, the survey points out that more and more basic studies are being conducted. Almost immediate technological advances should be forthcoming.

There is a definite need for standardization in the field. This includes both thermistor nomenclature, testing methods, and specifications in general. Lack of this basic standardization has led to confusion in the market. In many cases, the specifications for the thermistor are inadequate in that they improperly characterize the product itself.

In essence, the thermistor industry has just begun to grow. What has been a slow, steady pace should accelerate rapidly as the designers become fully aware of the thermistor's unique properties. With the development of even more advanced electrical and electronic equipment, the thermistor as an important component cannot be overlooked in system and circuit design.

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This fresh approach to the design of thermistor temperature-compensating networks develops a simple three-step solution to network problems. The use of normalized curves and nomograms save laborious calculations. Curves and nomograms for two-resistor networks will be presented in a succeeding article.

# Quick Design of Thermistor Compensation Networks

**Bernard R. Schwartz**  
Radio Corp. of America  
Defense Electronic Products  
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**T**HE USE of temperature compensating networks having thermistors as the active element has been steadily increasing the last few years. Among the many circuit applications which utilize such networks are those where transistors, deflection yokes, meters, and other components are to be exposed over a wide ambient temperature range. Other articles have indicated methods for the solution of these networks graphically (Refs. 1, 2) and for compensating copper-wound components (Ref. 3).

The approach taken here is that the designer has already made suitable tests to determine the resistance-temperature characteristic required. By selecting the desired performance from normalized temperature characteristic curves, a rapid solution of the circuit values is possible.

Temperature compensating networks (see Table I) involving one or two additional resistors together with a thermistor have been investigated. (Curves and nomograms for two-resistor networks will be presented in a succeeding article.) It was assumed that the resistors were temperature passive compared with the thermis-

tor, which exhibits a negative temperature characteristic approximated by:

$$r_t = r_{t25} e^{(\text{exp.}) - \beta \left( \frac{1}{T_t} - \frac{1}{298} \right)} \quad (1)$$

The solution of circuit equations using the indicated nomenclature is as follows:

Type I(a)

$$R_t = \frac{R_1 r_t}{R_1 + r_t} \quad (2)$$

$$F = \frac{R_t}{R_{t25}} = \frac{r_t}{r_{t25}} \left( \frac{R_1 + r_{t25}}{R_1 + r_t} \right) = f \left( \frac{k_1 + 1}{k_1 + f} \right) \quad (3)$$

Type I(b)

$$R_t = R_2 + r_t \quad (4)$$

$$F = \frac{R_t}{R_{t25}} = \left( \frac{R_2 + r_t}{R_2 + r_{t25}} \right) = \left( \frac{k_2 + f}{k_2 + 1} \right) \quad (5)$$

Type II(a)

$$R_t = \frac{R_3 (R_2 + r_t)}{R_3 + R_2 + r_t} \quad (6)$$

NOMENCLATURE	
$r_t$ :	dc resistance value of thermistor at temperature (t)°C; $r_{t25}$ is dc resistance value of thermistor at 25°C
$\beta$ :	thermistor material constant in exponential equation which approximates actual resistance-temperature response
$R_t$ :	dc resistance value of network at temperature (t)°C; $R_{t25}$ is dc resistance value of network at 25°C
$f = \frac{r_t}{r_{t25}}$ :	normalized thermistor dc resistance value at temperature (t)°C with respect to its 25°C value
$F = \frac{R_t}{R_{t25}}$ :	normalized network dc resistance value at temperature (t)°C with respect to its 25°C value
$k_n = \frac{R_n}{r_{t25}}$ :	ratio of dc resistance value of temperature-passive circuit resistor ( $R_n = R_1 \dots R_4$ ) with respect to the thermistor's dc resistance value at 25°C

$$F = \frac{R_t}{R_{t25}} = \left( \frac{R_2 + r_t}{R_2 + r_{t25}} \right) \left( \frac{R_3 + R_2 + r_{t25}}{R_3 + R_2 + r_t} \right) = \left( \frac{k_2 + f}{k_2 + 1} \right) \left( \frac{k_3 + k_2 + 1}{k_3 + k_2 + f} \right) \quad (7)$$

Type II(b)

$$R_t = \frac{R_4 (R_1 + r_t) + R_1 r_t}{R_1 + r_t} \quad (8)$$

$$F = \frac{R_t}{R_{t25}} = \left( \frac{R_1 + r_{t25}}{R_1 + r_t} \right) \left( \frac{R_4 (R_1 + r_t) + R_1 r_t}{R_4 (R_1 + r_{t25}) + R_1 r_{t25}} \right) = \left( \frac{k_1 + 1}{k_1 + f} \right) \left( \frac{k_4 (k_1 + f) + k_1 f}{k_4 (k_1 + 1) + k_1} \right) \quad (9)$$

These equations can be solved for  $F$  by the substitution of appropriate values for  $f$ ,  $k_1$ ,  $k_2$ ,  $k_3$  and  $k_4$ . The following "k" values were substituted for individual calculations: 0.01, 0.02, 0.05, 0.1, 0.2, 0.5, 1.0, 2.0, 5.0, 10, 20, and 50.

The values of "f" used in these equations correspond to the resistance-temperature response of a specific thermistor material. Table II shows the various normalized values for this constant. Material  $f_1$  was chosen as being the fastest response material available from most, if not all, of the thermistor sources. (Full sets of curves for another material,  $f_2$ , are not included in this article since such thermistors are available from only one manufacturer.)

The use of other materials for similar calculations would only require that their normalized

temperature response values be inserted in the equations. Little variation in the network temperature response was noticed for the different thermistor materials, especially for the Type II circuits. Apparently the temperature-passive resistors so completely modify the thermistor's response that only extreme differences between thermistors can display significantly different network responses.

#### Procedure

The designer selects the normalized dc resistance temperature response he desires from the various graphs. A particular curve is selected and the value of the "k" constant(s) noted. Interpolation between plotted curves is possible. With the noted "k" value(s), the appropriate nomogram quickly permits determination of the ohmic value(s) of the resistor(s) and the thermistor at 25 C. Note that the nomogram's scale for net-

work resistance value at 25 C has a multiplier at 10x. The appropriate value of the thermistor's resistance would then be scaled by the same 10x multiplier.

#### Example No. 1

A network is desired which has the following resistance-temperature response:

Resistance (ohms)	Temp. (°C)
15,000	-40
13,200	-20
10,800	0
9,000	10
6,000	25
3,900	40
2,400	50
1,380	65

#### Step 1:

The network resistance value variation is then normalized with respect to the 25 C value.

F (norm. network resist.)	Temp. (°C)
2.5	-40
2.2	-20
1.8	0
1.5	10
1.0	25
0.65	40
0.40	50
0.23	65

#### Step 2:

An examination of the above table shows:

- the required network should be fairly stabilized at the lower temperatures;
- the required network continues to drop rapidly at temperatures near the high end of the temperature range.

These characteristics are indicative of shunt networks (see Figs. 1 and 2). Series networks (see Figs. 4 and 5) have characteristics which change

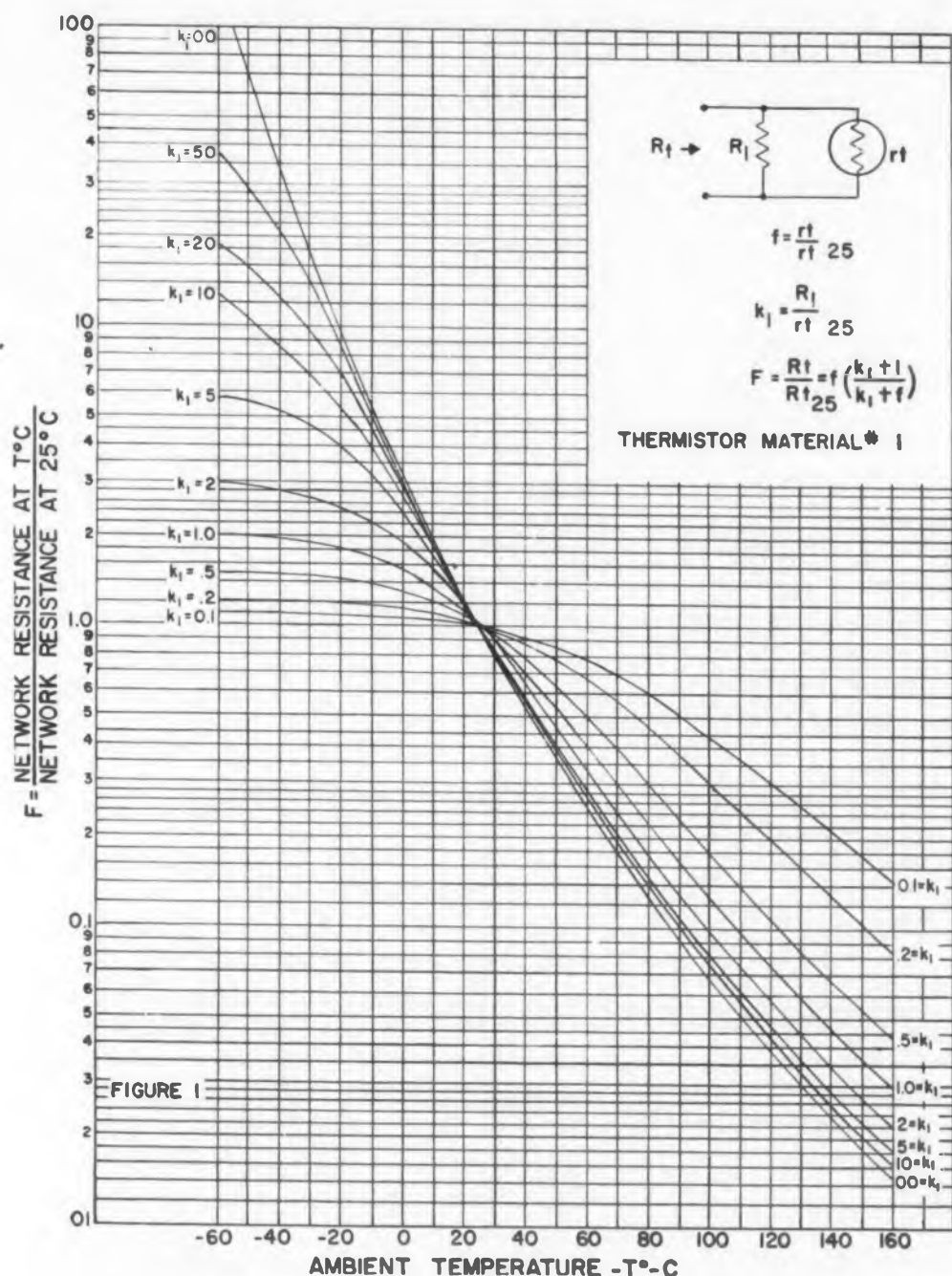


Fig. 1. Shunt network compensation circuit and characteristics for material No. 1 of Table II.

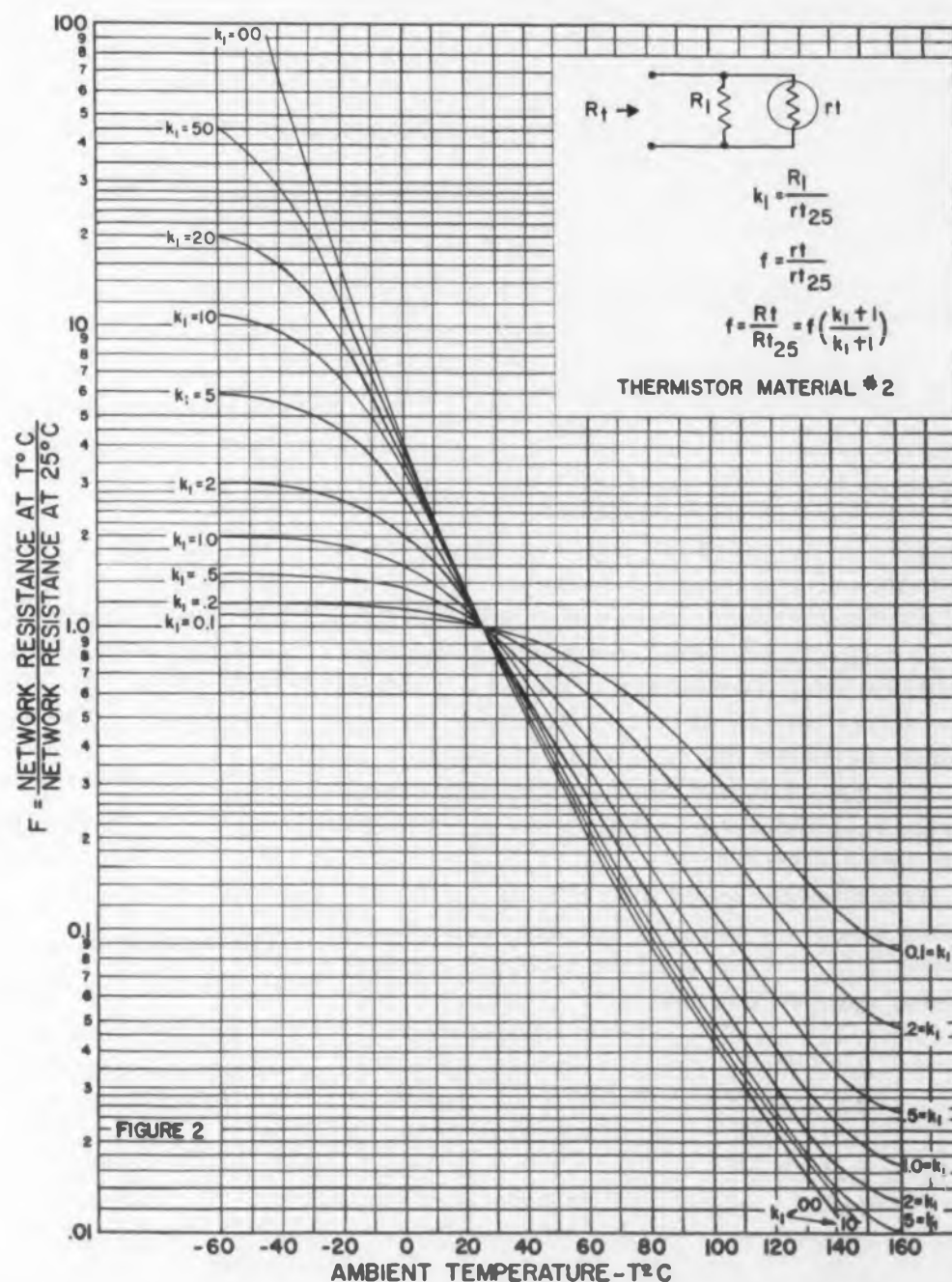


Fig. 2. Similar to shunt network compensation characteristics of Fig. 1 except material is Keystone Carbon type 150.

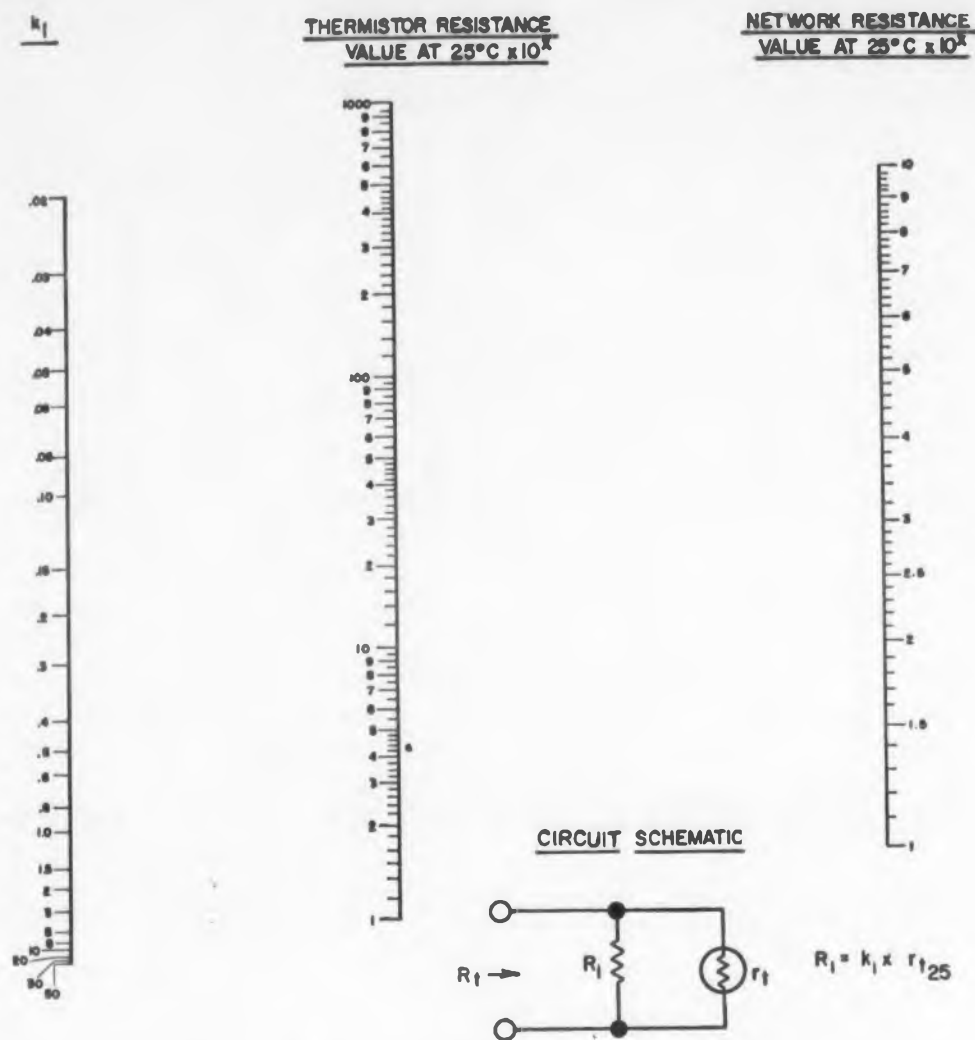


Fig. 3. Nomogram for solution of shunt circuit values.

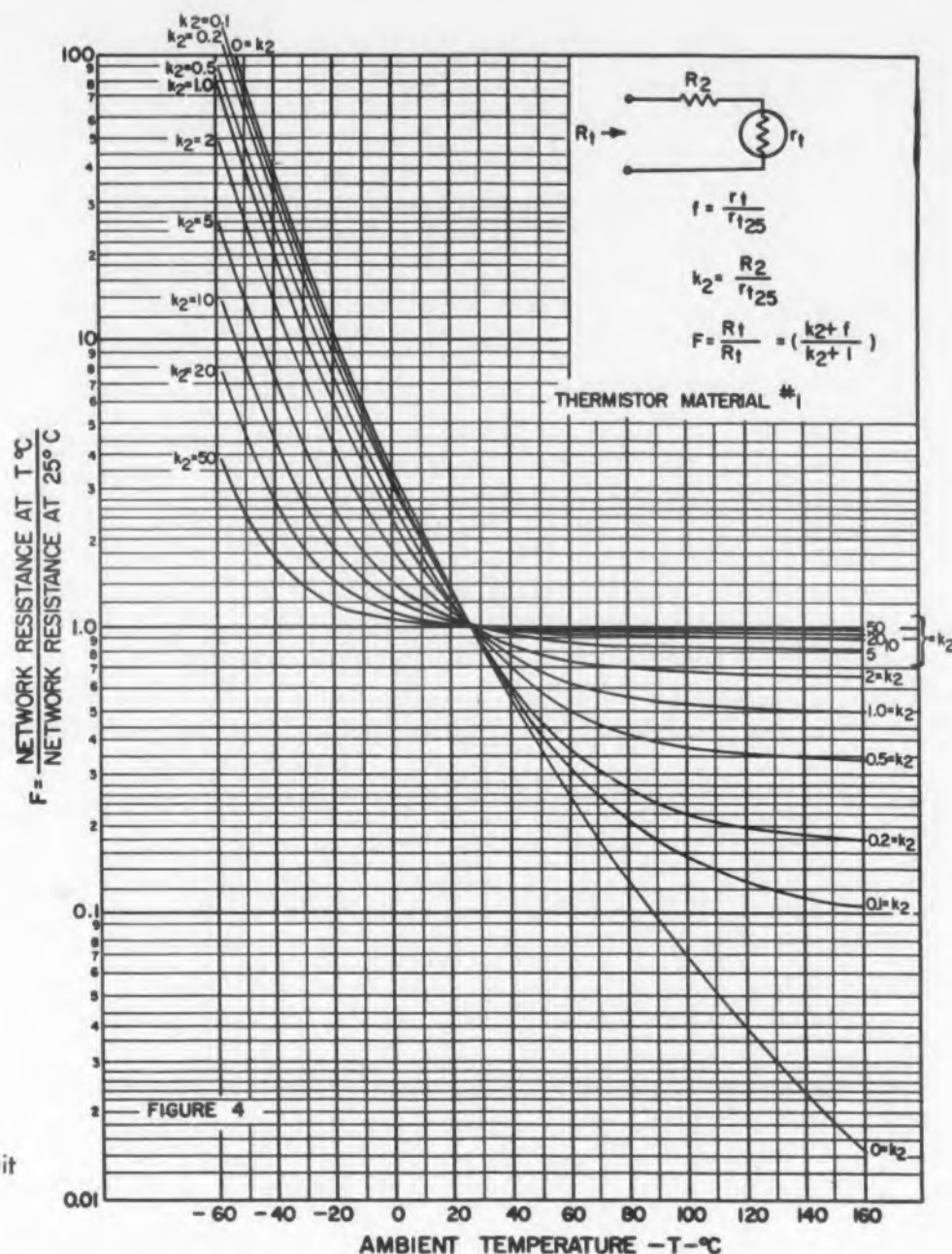


Fig. 4. Series network compensation circuit and characteristics, material No. 1.

rapidly or are relatively stable at the opposite extremes of this temperature range.

An examination of Figs. 1 and 2 will show that Fig. 2 has curves which more closely approximate the desired performance. If  $k_1 = 2$  is chosen the actual curve will be slightly higher at temperatures below 25 C. If an interpolation of  $k_1 = 1.5$  is attempted, the fit of the actual curve to the required curve will be better over the entire temperature range.

With no other application data available, this latter choice is made. When the interpolated curve of  $k_1 = 1.5$  is used the following network performance is indicated.

F	Temp. (°C)
2.4	-40
2.2	-20
1.78	0
1.44	10
0.62	40
0.44	50
0.255	65

**Step 3:**

The appropriate nomogram for the shunt network is Fig. 3. A straight line is then drawn between the 1.5 point on the  $k_1$  scale and the 6 on

the network resistance value scale. This line intersects the thermistor resistance value scale at 10. Since the network scale is in thousands the same multiplier is used for the thermistor value scale. Thus,  $R_1$  is equal to 1.5 times 10,000 or 15,000 ohms. The circuit appears as:



**Example No. 2**

A network is desired with the following resistance-temperature response within 5 per cent:

Resistance (ohms)	Temp. (°C)
19,500	-55
18,900	-25
18,500	0
16,000	25
11,100	50
7,700	80

**Step 1:**

Variation of network resistance value is first normalized with respect to its 25 C value:

F (Norm. network resistance)	Temp. (°C)
1.22	-55
1.18	-25
1.15	0
1.00	25
0.70	50
0.48	80

**Step 2:**

A brief examination of the above table shows that the desired response:

- a. does not change rapidly at temperature excursions below room ambient, and
- b. does fall rapidly between 50 C and 80 C.

An examination of the Fig. 1 shows that type I(a) circuits show this general trend, while type I(b) circuits, Fig. 4 show the opposite. That is, they tend to display rapid increases with temperature excursions below room ambient and do not fall rapidly at temperatures above room ambient.

Fig. 1 shows a curve having markedly similar response to the required one when  $k_1 = 0.2$ .

For  $k_1 = 0.2$ , the following network values are obtained: (These values meet the tolerance of the required response).

F	Temp. (°C)
1.20	-55
1.18	-25
1.14	0
1.00	25
.072	50
.046	80

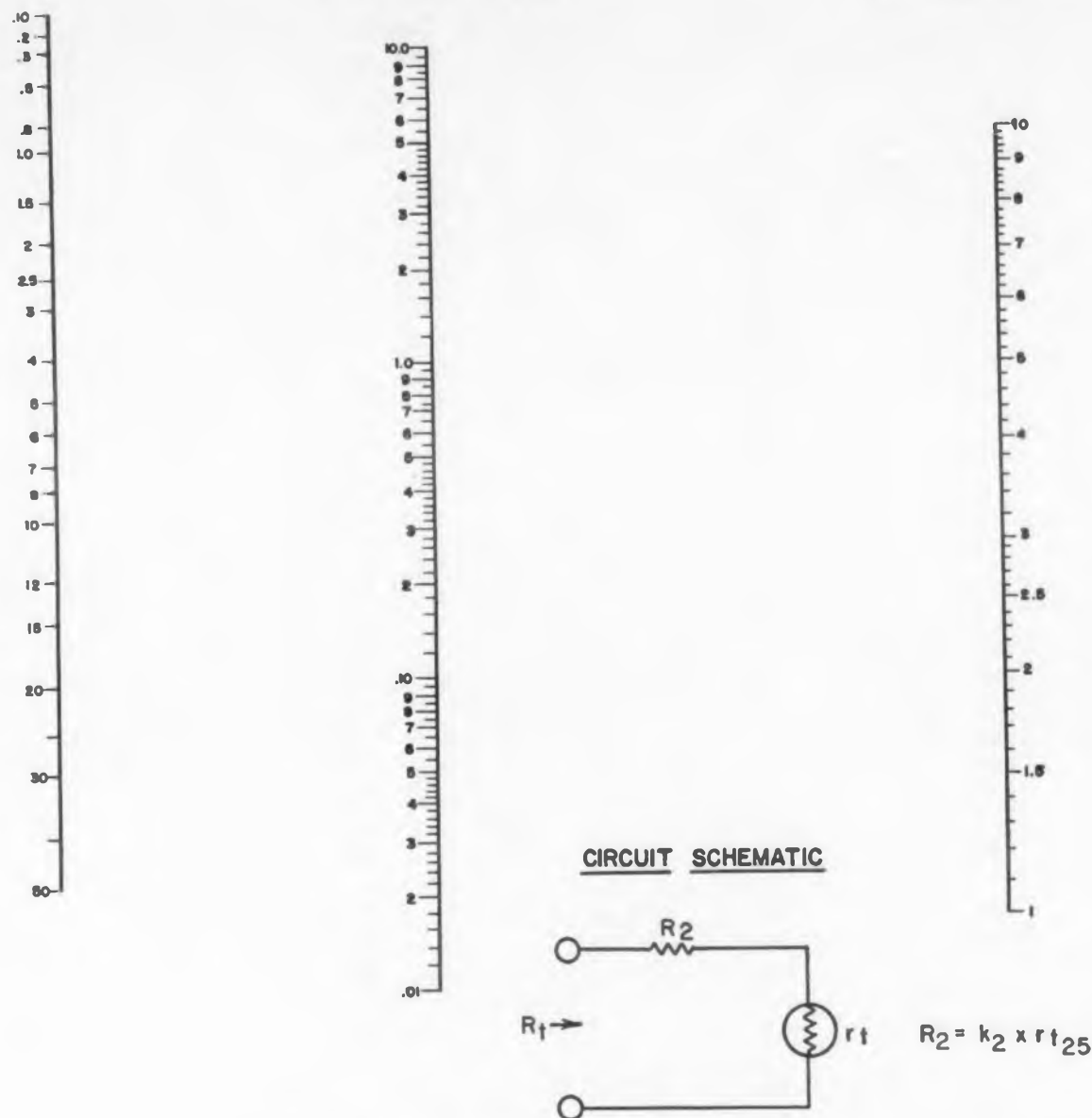


Fig. 5. Nomogram for solution of series circuit values.

Table I. Basic Temperature Compensation Networks

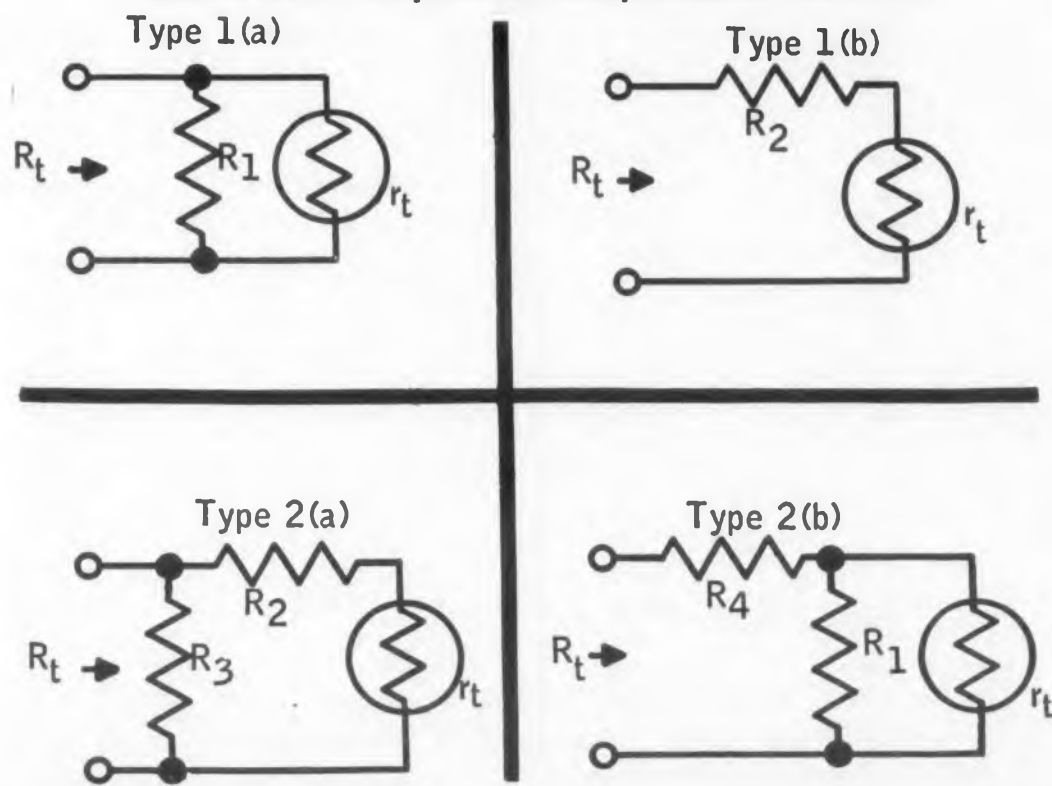
**Step 3:**

Fig. 3 is the appropriate nomogram for circuit type I(a). A line is then drawn on Fig. 3 between the 0.2 point on the  $k_1$  scale and the 1.6 point on the network resistance scale ( $16,000 \times 10^{-4}$ , the specified resistance at 25 C). This line intersects the thermistor resistance scale at 9.6.

**Step 4:**

Since the  $10^x$  scale factor of the network resistance value at 25 C scale is used, the same  $x = 4$  is used for the thermistor resistance value at 25 C scale. The required thermistor is then obtained as 96,000 ohms at 25 C.  $R_1$ , then, is equal to  $k_1$  (0.2) times 96,000 or 19,200 ohms. Beta is 3900 at  $\pm 55$  K.

For a reprint of this article turn to the Reader-Service card and circle 15.

**References**

1. Designing Thermistor Temperature Correcting Networks Graphically, F. A. Bennett, *Control Engineering*, Nov., 1955.
2. Shaping the Characteristics of Temperature-Sensitive Elements, E. Keonjian and J. S. Schaffner, *Electrical Engineering*, October, 1954.
3. Simplified Method for Selecting Thermistor Temperature Compensation Networks, *ELECTRONIC DESIGN*, December 15, 1956.

**Acknowledgements:** The author is indebted to Mr. J. Kimmel for his critical review and Mr. L. E. Harris for his efforts in the construction of the nomograms.

Table II.

Normalized Thermistor Resistance-Temperature Response Values

Temperature (°C)	Material #1	Material #2
-60	145.0	361.4
-40	34.3	64.3
-20	9.79	14.61
0	3.27	4.030
20	1.25	1.297
40	0.532	0.475
40	0.248	0.193
60	0.125	0.08561
80	0.0675	0.04103
100	0.0387	0.02092
120	0.0233	0.01128
140	0.0147	0.00843
160		
Vendors' Thermistor Material Type	Carborundum Corp.—Globar-type H; Fenwal Electronics-type No. 1; G. E.—Carboloy—Grade 1; Keystone Carbon—type 97; Thermistor Corp. of America (now Gulton)—type D; Victory Engrg. Corp.—type D	Keystone Carbon—type 150





# Thermistor Data Chart

**R**EPRESENTATIVE groups of thermistors made by major manufacturers are tabulated here. These are standard catalog items. Most manufacturers also produce special thermistors to customer specifications. Not included are the various thermistor assemblies produced for specific applications such as microwave power measurements, etc. Characteristics included in the table are described below.

## Cold Resistance

The cold resistance,  $R_0$ , is the resistance value of a thermistor at a specified temperature when measured with zero electrical power dissipated in it. (For practical purposes, the resistance of thermistors is measured with test current sufficiently small to limit the rise in temperature of the unit to less than 0.01 d C above test temperature.)

## Dissipation Constant

The dissipation constant,  $\delta$ , is a constant of proportionality between the power dissipated and the resultant temperature rise in a thermistor at a specified temperature. Practically, this constant is the number of milliwatts which when dissipated by the unit will raise its temperature one degree Centigrade above that of its surroundings. Since the temperature rise of a thermistor due to dissipated power depends on the rate at which heat is transferred away from the unit, the dissipation constant depends on the method of mounting the unit as well as the medium or environment in which it is located.

The dissipation constants of a typical 2 in. long glass probe, when supported by its leads in still air, in still oil, or in still water are approximately 1, 3.5, and 5 milliwatts per degree Centigrade respectively.

## Time Constant

The thermal time constant,  $\tau$ , is the time required for a thermistor to change 63 per cent of the difference between its initial temperature value and that of its surroundings when no electrical power is being dissipated in it. With a bead element mounted in a glass envelope or bulb, a disc mounted on a plate, or one or more washer element bolted in a pile-up, the thermal time constant applies to the complete mounted unit rather than the thermistor element alone. It is also assumed that the thermistor element of such a unit is in thermal equilibrium with the remaining components of the unit (i.e., the thermistor element is not in a self-heated condition prior to the introduction of the change in temperature).

*(Continued on page 25)*

## Thermistor Data Chart

Thermistor Number and Type		Resistance at 25°C	Temperature Coefficient %/°C	Dissipation Constant mw/°C	Time Constant (Seconds)
<b>Carborundum Co., Glebar Div. Niagara Falls, N. Y.</b>					
759	rod	2.0	0.25	no data available	
759	rod	3.5	0.25		
763	rod	5.0	0.25		
304	rod	10.0	0.28		
304	rod	100	0.35		
304	rod	1000	0.45		
304	rod	10000	0.49		
304	rod	100000	0.53		
997	rod	10	1.35		
997	rod	100	1.80		
997	rod	1000	2.00		
997	rod	10000	2.20		
997	rod	100000	2.25		
997	rod	1000K	2.35		
763	rod	4.5	1.25		
763	rod	10.0	1.60		
763	rod	25.0	1.70		
763	rod	50	1.80		
763	rod	100	1.90		
763	rod	500	2.05		
763	rod	1000	2.10		
763	rod	5000	2.15		
763	rod	10000	2.25		
763	rod	100000	2.40		
763	rod	1000K	2.50		
441	rod	10.0	1.70		
441	rod	100	2.00		
441	rod	1000	2.20		
441	rod	10000	2.25		
441	rod	100000	2.40		
763	rod	3150	3.40		
763	rod	5000	3.50		
763	rod	10000	3.90		
763	rod	50000	4.50		
763	rod	100000	4.75		
763	rod	500000	5.20		
763	rod	1000K	5.20		
416	disc	40	3.05		
416	disc	100	3.50		
416	disc	500	4.05		
416	disc	1000	4.40		
416	disc	10000	5.00		
479	disc	40	3.05		
479	disc	100	3.50		
479	disc	1000	4.40		
479	disc	10000	4.95		
343	washer	5.0	3.05		
343	washer	10	3.05		
343	washer	100	3.85		
343	washer	315	4.40		
343	washer	1500	5.20		

## Thermistor Data Chart (cont.)

Thermistor Number and Type		Resistance at 25° C	Temperature Coefficient %/°C <sup>2</sup>	Dissipation <sup>1</sup> Constant mw/°C	Time <sup>1</sup> Constant (Seconds)
<b>Fanwall Electronics, Inc., Framingham, Mass.</b>					
GA51J1	bead	100000	10.3	0.7	2
GA51L1	bead	100000	10.3	0.7	2
GA51P8	probe	100000	10.3	1.0	25
GB32J1	bead	2000	7.3	0.7	2
GB32P8	probe	2000	7.3	1.0	25
GC32A1	bead	2000	5.6	0.1	1
GC32A2	bead	2000	5.6	0.1	1
GC32A3	bead	2000	5.6	0.1	1
GC32A4	bead	2000	6.0	0.4	1
GC32J1	bead	2000	5.6	0.1	1
GC32L1	bead	2000	5.6	0.1	1
KA31L1	disc	1000	9.1	6	20
KA31W1	disc	1000	9.1	125	4
KA34W1	disc	4000	9.1	45	15
KB23L1	disc	268	6.95	6	20
LA23W1	disc	300	9.1	240	9
LA2751	disc	725	9.1	80	30
LA27W1	disc	700	9.1	105	20
LA2851	disc	760	9.1	70	35
LA31J1	disc	1000	9.1	9	135
LA31S1	disc	1351	9.1	60	40
LA31W1	disc	1000	9.1	85	30
LB21J1	disc	100	6.95	8	135
LB21W1	disc	100	6.95	160	15
MA22S1	disc	228	9.1	200	20
QA51J1	rod	100000	9.1	2.5	20
RA43L1	rod	31500	9.1	4.0	70
RA51L1	rod	100000	9.1	6.0	90
RB33L1	rod	3150	7.1	4.0	70
RB36L1	rod	6300	7.1	4.0	70
RB38L1	rod	8000	7.1	4.0	70
RB41L1	rod	10000	7.1	6.0	90
WA21W1	washer	100	9.1	800	13
WA23W1	washer	315	9.1	350	18
WB11W1	washer	10	6.95	860	12
WB13W1	washer	31.5	6.95	500	16

**General Electric Co., Carboly Dept.  
Detroit, Mich.**

D101	disc	10000	no data	5.0	14.6 <sup>3</sup>
D103	disc	5000	available	3.5	5
D201	disc	3000			
D203	disc	1000		7.0	4.2
D301	disc	3000		13.5	67
D303	disc	1000		8.0	11.7
D401	disc	1000		11.5	24
D403	disc	250		14.5	2.2
D501	disc	1000		19.0	64
D503	disc	500		16.0	14
D751	disc	250		25.5	
D753	disc	100		23.0	

1. Dissipation and time constants are based on units being suspended by their leads in still air.

2. Ratio  $R_{0} @ 0^{\circ}\text{C} / R_{0} @ 50^{\circ}\text{C}$

3. Time to reach 63% of applied voltage (seconds) for voltage of 48 v (for this Co.)

LOOKING  
FOR THE  
**SENSITIVE TYPE?**



TRY  
THIS  
NUMBER

**SV-1C/5000D**

The Advance type SV Sensitive Relay (shown at right) is 1 1/4" high x 2 1/4" long x 2 1/4" wide. Also available is the type SO Miniature Sensitive Type, 1 1/2" high x 1 1/4" long x 1 1/4" wide.



Advance type SV relays are ultra-sensitive, yet durable—dust-tight, yet fully adjustable. Contacts and all working parts are protected by a transparent molded plastic cover.

**SPECIFICATIONS**

**Coil resistance:** From .005 Ohms at .005 volts DC to 40,000 Ohms at 14.0 volts DC.

**Nominal power required:** Factory adjusted at .005 watts.

**Contact rating:** 1 amp resistive, .5 amps inductive at 115 volts AC or 26.5 volts DC.

**Contact arrangement:** SPDT only.

Sensitivity can be adjusted from the 5-milliwatt factory setting by turning the vernier screws. Use the type SV in any DC circuit where power consumption is limited to a few thousandths of a watt.

*Available from leading distributors*

**WRITE FOR COMPLETE DETAILS**

Data sheets on the SV Sensitive Relay and the SO Miniature Sensitive Relay will be sent promptly.



**ADVANCE RELAYS**



**A PRODUCT OF ELECTRONICS DIVISION  
ELGIN NATIONAL WATCH COMPANY**

Dept. G, 2435 N. Naomi St., Burbank, California

CIRCLE 16 ON READER-SERVICE CARD

# MINIATURE CAPACITORS

## miniature capacitors

Come to AEROVOX for the widest selection of case styles and constructions in paper, metallized-paper, mica, ceramic, electrolytic, tantalum, and film types in a complete range of miniature and microminiature sizes for every requirement. AEROVOX has the miniature capacitor for your application from low-voltage, long-life components for transistorized assemblies to microminiature units for those critical application requirements in guided missiles and airborne electronic equipment.

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Mass.

## miniature capacitors

### SRED - TNED

Miniature electrolytics for printed-wiring applications.



### TNE - SRE

Miniature electrolytics for transistorized applications.



### WT

Wire tantalum units for low voltage applications.



### P83CZK

Microminiature metallized-paper capacitors.



### P92ZN

Microminiature metallized-paper capacitor for elevated temperature operation.



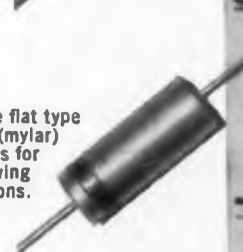
### V84

Miniature Aerofilm (mylar) units for general purpose applications.



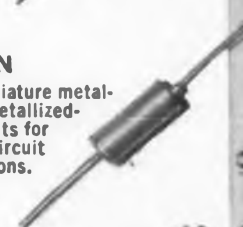
### V146

Miniature flat type Aerofilm (mylar) capacitors for space-saving applications.



### P123ZN

Microminiature metal-cased, metallized-paper units for critical circuit applications.



### P323S - V123

Metal-cased, hermetically-sealed, microminiature paper and Aerofilm capacitors.



### ADM

Plastic-coated, dipped mica capacitors for printed-wiring and automatic insertion applications.



CIRCLE 17 ON READER-SERVICE CARD

## Thermistor Data Chart (cont.)

Thermistor Number and Type		Resistance at 25° C	Temperature Coefficient %/°C	Dissipation Constant mw/°C	Time Constant <sup>1</sup> (Seconds)
<b>General Electric Co., Carboloy Dept. (Cont.)</b>					
D104	disc	500	no data available	4.0	0.7
D202	disc	300			
D204	disc	100		8.0	<0.5
D302	disc	300		11.0	6.8
D304	disc	100		8.0	1.0 <sup>1</sup>
D402	disc	100		13.0	
D404	disc	25		13.0	<0.5
D502	disc	100		17.5	4.6
D504	disc	50		22.5	1.2
D752	disc	25		22.5	
D754	disc	10		20.0	<0.5
D1002	disc	25		34.0	
D1004	disc	10		30.0	0.5
R051	rod	100000		4.5	
R111	rod	100000		14.0	
R113	rod	31500		7.5	
R171	rod	50000		24.5	
R173	rod	20000		11.0	
R052	rod	10000		4.0	11.4
R112	rod	10000		12.0	
R114	rod	4300		11.5	86
R116	rod	3150		10.0	32
R172	rod	5000		16.5	
R174	rod	2000		14.0	44
RF111	hi-temp rod	40000		7.5	
W751	washer	415		58	59
W753	washer	315		57	34
W755	washer	100		55	8.2
W752	washer	41.5		56	4.8
W754	washer	31.5		54	3.2
W756	washer	10.0		51	0.8
<b>Gulton Industries Metuchen, N. J.</b>					
11TE1	wafer	10	-3.9	7.9	23
12TE1	wafer	20	-3.9	4.7	16
15TE1	wafer	50	-3.9	3.2	11
21TE1	wafer	100	-3.9	2.5	7
21TD1	wafer	100	-4.4	7.8	16
22TD1	wafer	200	-4.4	4.0	12
25TD1	wafer	500	-4.4	3.0	7
31TD1	wafer	1000	-4.4	2.6	5
23TD1 1	wafer	270	-4.4	3.8	11
27MD1	wafer	725	-4.4	150 <sup>2</sup>	35
28MD1	wafer	760	-4.4	150 <sup>2</sup>	35
35TF1	wafer	5000	-4.9	4.3	12
45TG1	wafer	50K	-5.4	4.6	11
51TG1	wafer	100K	-5.4	4.2	7
61TM1	wafer	1 meg.	-6.8	5.3	13
36RR1	rod	6.3K	-3.9	4	70
36RR1	rod	6.3K	-3.9	4	70
41RR1	rod	10K	-3.9	6	95

1. Time to reach 63% of applied voltage (seconds) for voltage of 48 v (for this Co.)
2. With thermal sink

## Thermistor Data Chart (cont.)

Thermistor Number and Type		Resistance at 25°C	Temperature Coefficient %/°C	Dissipation Constant mw/°C
<b>Gulton Industries (Cont.)</b>				
<b>51RD2</b>	rod	100K	-4.4	2.5
<b>31CH1</b>	bead	1000	-3.4	0.5
<b>31CH2</b>	bead	1000	-3.4	0.5
<b>31CB1</b>	bead	1000	-3.9	0.7
<b>31CB2</b>	bead	2000	-3.4	0.1
<b>32CH1</b>	bead	2000	-3.4	0.1
<b>32CH3</b>	bead	2000	-3.4	0.1
<b>32CB1</b>	bead	2000	-3.9	0.7
<b>32CB2</b>	bead	2000	-3.9	.07
<b>32CB5<sup>1</sup></b>	bead	12000	-3.9	
<b>35CB1</b>	bead	5000	-3.9	0.7
<b>35CB2</b>	bead	5000	-3.9	0.7
<b>36CB2</b>	bead	5700	-3.9	0.3
<b>38CB2</b>	bead	8000	-3.9	0.1
<b>38CX2</b>	bead	8000	-4.2	0.4
<b>41CB1</b>	bead	10000	-3.9	0.7
<b>41CB2</b>	bead	10000	-3.9	0.7
<b>45CA1</b>	bead	50000	-4.6	0.7
<b>45CA2</b>	bead	50000	-4.6	0.7
<b>45CD3</b>	bead	47000	-4.4	0.1
<b>45CD5</b>	bead	50000	-4.4	0.1
<b>51CA1</b>	bead	100000	-4.6	0.7
<b>51CA2</b>	bead	100000	-4.6	0.7
<b>51CA3</b>	bead	100000	-4.6	0.1
<b>58CX2</b>	bead	800000	-5.1	0.7
<b>65CX2</b>	bead	5.3 meg	-4.6	0.1
<b>32PB1</b>	bead probe	2000	-3.9	1
<b>32PB2</b>	bead probe	2000	-3.9	1
<b>51PA1</b>	bead, bulb	100000	-4.6	1
<b>36BS1</b>	bead, bulb	5700	-3.9	
<b>65BS1</b>	bead, bulb	5.3 meg	-4.6	

**Keystone Carbon Co.  
St. Marys, Pa.**

<b>L0503-1500-88</b>	bead	2520	-4.1	no data available
<b>L0503-56K-125</b>	bead	100000	-4.9	
<b>L0903-200-70</b>	disc	316	-3.8	
<b>L0903-1100-95</b>	disc	1888	-4.3	
<b>L0903-25K-140</b>	disc	46700	-5.0	
<b>L1204-48K-145</b>	disc	89300	-5.1	
<b>L1215-800-73</b>	disc	1290	-3.9	
<b>L1215-7.5K-107</b>	disc	13400	-4.6	
<b>L1215-33K-123</b>	disc	60000	-4.8	
<b>L1215-75K-131</b>	disc	138000	-5.0	
<b>L2110-45K-151</b>	disc	85500	-5.2	
<b>L2003-62-73</b>	disc	99.6	-3.9	
<b>L2005-95-70</b>	disc	150	-3.8	
<b>L2005-112-73</b>	disc	180	-3.9	
<b>L2005-156-97</b>	disc	270	-4.4	
<b>L2004-577-97</b>	disc	1000	-4.4	
<b>L2005-2.2K-111</b>	disc	3800	-4.7	
<b>L2005-7.1K-131</b>	disc	13090	-5.0	
<b>L2005-32K-152</b>	disc	60600	-5.2	
<b>L3004-20-73</b>	disc	32.2	-3.9	

# DELAY LINES



## **BREW'S Complete Facilities** ★ **offer Reliable Product** **Performance & Economy with** **Quality Controlled Production!**

- ★ \* Competent and Experienced Engineering Personnel plus the Latest Testing Equipment guarantee designs to your specifications.
- \* Modern Assembly Line of Thoroughly Trained Production Personnel assures quality on short or long runs.
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**Founded in 1946 for design, development and manufacture of delay lines.**

Brew offers you the "one source" for Distributed Constant, Lumped Constant, and Ultrasonic Delay Lines. You and your product will benefit from Brew's modern and complete production facilities, pioneer experience, and complete cooperation from our personnel.



**Richard D. Brew and Company, Inc.**

Concord, New Hampshire

design • development • manufacture

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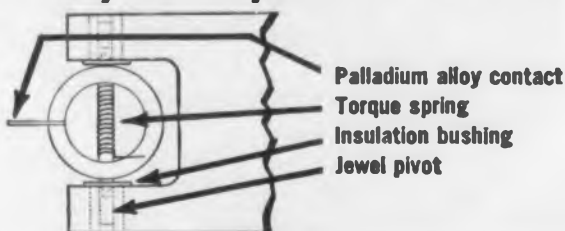
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# 5,000,000 CYCLE LIFE!



## another result of **dynamic** balance" \* precision potentiometers

Long life is achieved by minimizing wear. Wear results from pressures or forces between contact assembly and winding. Total force consists of a dynamic force  due to vibration, acceleration and shock; an inertial force  acting on the contact assembly; and a static force resulting from contact pressure. For proper operation, contact force must exceed the vector sum of the dynamic forces .

The Kintronic contact assembly is *dynamically balanced* about a pivot  and therefore vibration, acceleration and shock forces cancel out. Inertial force on the contact assembly is minimized by making its mass and size small as possible. Reduction of these dynamic forces enable use of very low contact pressure.

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\* Patent Pending

Operational Results: total wear producing force is extremely small. 5,000,000 cycle life is achieved at maximum speeds of 3,425 r.p.m., under 2,000 cycle 30g vibration!

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Division of  
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CIRCLE 19 ON READER-SERVICE CARD

## Thermistor Data Chart (cont.)

Thermistor Number and Type		Resistance at 25° C	Temperature Coefficient %/°C <sup>1</sup>	Dissipation Constant mw/°C	Time Constant (Seconds)
<b>Keystone Carbon Co. (Cont.)</b>					
L3006-50-73	disc	80.4	-3.9	no data available	44
L3006-120-89	disc	204	-4.2		44
L3006-450-97	disc	780	-4.4		44
L3006-1K-113	disc	1790	-4.7		44
L3006-10K-141	disc	18500	-5.0		44
L3804-30-73	disc	48.1	-3.9		50
L3806-100-81	disc	164	-4.1		64
L3806-1200-120	disc	2170	-4.8		64
L3806-4300-134	disc	8280	-5.0		64
L4010-577-97	disc	1000	-4.4		80
L4504-10-73	disc	16.8	-3.9		50
L4507-700-120	disc	1260	-4.8		78
L4507-10K-156	disc	19048	-5.2		78
L4715-100-79	disc	163	-4.0		110
L4715-300-97	disc	520	-4.4		110
L4715-1K-120	disc	1810	-4.8		110
L4715-5K-138	disc	9250	-5.0		110
L4715-20K-155	disc	38200	-5.2		110
L5505-3.3-59	disc	5.02	-3.5		90
L5507-100-100	disc	173.4	-4.4		96
L5507-500-120	disc	904	-4.8		96
L5507-2K-140	disc	3740	-5.0		96
L7606-15-85	disc	25.2	-4.1		
L8208-11-70	disc	17.39	-3.8		
L8212-150-108	disc	266	-4.6		
L10010-10-75 <sup>1</sup>	disc	16.07	-3.9		
L10015-100-97	disc	174	-4.4		
L10012-260-92	disc	437	-4.3		
L060637-400-85	rod	674	-4.1		
L060637-43K-103	rod	74780	-4.5		
L060637-375K-125	rod	670000	-4.9		
5713-W29-100-85	washer	168	-4.1		
5726-W29-200-85	washer	336	-4.1		
7611-W28-1K-133	washer	1850	-5.0		

**Victory Engineering Corp.**  
Union, N. J.

26A2	bead	528	5.6	0.5	3
31A3	bead	1000	7.3	0.7	2
32A1	bead probe	2000	7.3	1.0	25
32A5	bead	2000	5.6	0.1	1
32A11	bead	2000	7.3	1.0	25
32A16	bead	850	1.0	4.0	45
32A30	bead probe	2000	7.3	1.0	25
32A38	bead probe	2000	7.3	1.0	25
32A50	bead	2000	5.6	0.09	0.5
33C3	bead	3100	7.3	0.4	2
35A1	bead	5000	7.3	0.7	2
35A11	bead probe	5000	7.3	1.0	25
37A3	bead	7000	7.3		
41A2	bead	10000	7.5	0.7	2

1. Ratio  $R_{0°C} / R_{50°C}$

### Thermistor Data Chart (cont.)

Thermistor Number and Type		Resistance at 25° C	Temperature Coefficient %/°C <sup>1</sup>	Dissipation Constant mw/°C	Time Constant <sup>1</sup> (Seconds)
<b>Victory Engineering Corp. (Cont.)</b>					
43A4	bead	30000	7.3	0.7	2
44A1	bead	35000	4.5		
45A2	bead	50000	9.1	0.7	2
45B3	bead	50000	9.1	0.5	
46A2	bead	60500	4.5		
49A1	bead	85000	4.5		
51A10	bead	100000	10.3	0.6	2
51A22	bead	100000	10.3	0.09	0.5
55A2	bead	500000	11.5	0.7	2
61A1	bead probe	1000K	12.7	1.0	25
61A11	bead probe	1000K	12.7	1.0	25
71A2	bead rod	12000K	20.0	1.0	25
05E1	disc	5	6.95	12	200
21D1	disc	100	9.1	800	13
21E3	disc	100	6.95	8	140
23D2	disc	300	9.1	250	9
23E3	disc	310	6.95	6	20
25E2	disc	500	6.95	3	10
28D2	disc	760	9.1	100	25
31D2	disc	1000	9.1	100	4
31D7	disc	1200	9.1	6	20
31E1	disc	1000	6.95	30	2
33D4	disc	2500	9.1	20	4
35D1	disc	5000	9.1	130	2
11X1	washer	10	6.95	850	13
21W1	washer	100	9.1	800	13
22X1	washer	150	6.95	130	4
33S1	rod	3150	7.1	4.0	70
41S1	rod	10000	7.1	6.0	95

1. Ratio  $R_0 @ 0^\circ\text{C} / R_0 @ 50^\circ\text{C}$

Since the time required for the thermistor to change its temperature by a specified amount depends on the rate of heat transfer between the thermistor and its surroundings, the thermal time constant depends upon the method of mounting the unit as well as the medium of environment in which it is located. For example, the thermal time constants of a typical 0.4 in. diameter disc, when supported by its leads in still air, in moving air (1000 ft/min), still oil, or moving oil (200 ft/min), are approximately 100, 30, 20, and 5 seconds respectively.

The thermal time constants for a typical 2 in. long glass probe thermistor, when supported by its leads in still air, in still oil, or in still water are approximately 25, 2, and 1 second respectively.

The thermal time constants of a thermistor with leads is usually specified for

the unit supported by its leads in still air. For a thermistor which does not have leads, the thermal time constant is specified for the unit mounted in intimate contact with a good thermal sink.

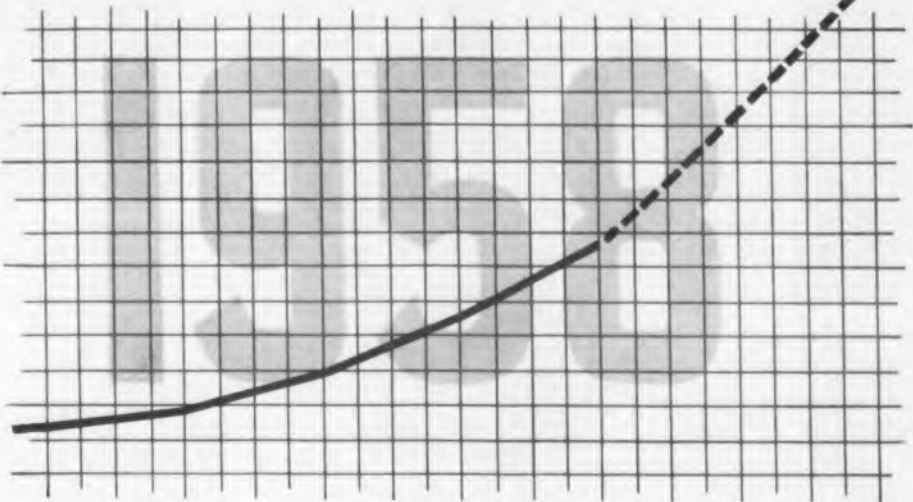
#### Temperature Coefficient

The temperature coefficient of resistance,  $\alpha$ , is the ratio of the rate of change of resistance with temperature to the resistance of the thermistor at a specified temperature. It is commonly specified in per cent per degree, or ohms/ohm/degree and may be expressed mathematically as:

$$\alpha(T) = [1/R_0(T)] [dR_0(T)/dT]$$

Since the resistance versus temperature characteristic of a thermistor is non-linear,  $\alpha$  varies with temperature. In general,  $\alpha$  increases as the temperature decreases and vice versa.

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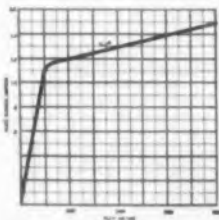


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# Microwave Applications

## of Thermistors



**Leonard I. Kent**

Chief Microwave Engineer  
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A thermal sensitive resistor, the thermistor, is finding wide application in measuring microwave power. Among the topics of importance are thermistor characteristics, thermistor mounts, dc characteristics, broadband mounts, and coaxial mounts. Part II will discuss waveguide thermistor mounts, and measuring techniques.

### Part I

**T**HERE ARE many devices which are sensitive, with varying degree, to thermal or temperature changes. The thermistor, a thermal sensitive resistor with a negative temperature coefficient of resistance, is one of the more sensitive devices. When a thermistor is subjected to a temperature change, as occurs when it is exposed to electromagnetic energy, it undergoes a very large change in resistance. If the thermistor is small compared to a wavelength, and its resistivity sufficiently great that high-frequency currents are forced to flow throughout the volume of the element, rather than on the surface; the temperature gradients within the volume of the element, and the exchange of heat with the surrounding area, will be almost identical for direct current, audio and microwave frequencies. Since this implies that equal quantities of dc, af, or rf power absorbed by the thermistor heat it to the same temperature and effect the same resistance change, this principle can be used to measure any of these powers by substitution methods. Of particular interest here is the measurement of rf or microwave power.

Primary equipment needed for the measurement of microwave power are an efficient thermistor mount matched to the transmission line in which it will be used, and a Wheatstone bridge circuit, preferably one which is self-balancing. When a power substitution method is used, the



(a)

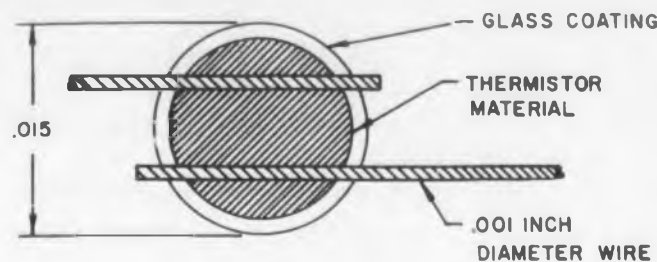
**Cartridge Type**

**Fig. 2. Thermistor Mounts.**



(b)

**Enlarged  
Miniature  
Cartridge**



**Fig. 1.** Thermistor bead construction. The finished bead is a hard ceramic material enveloped in a thin glass coating.

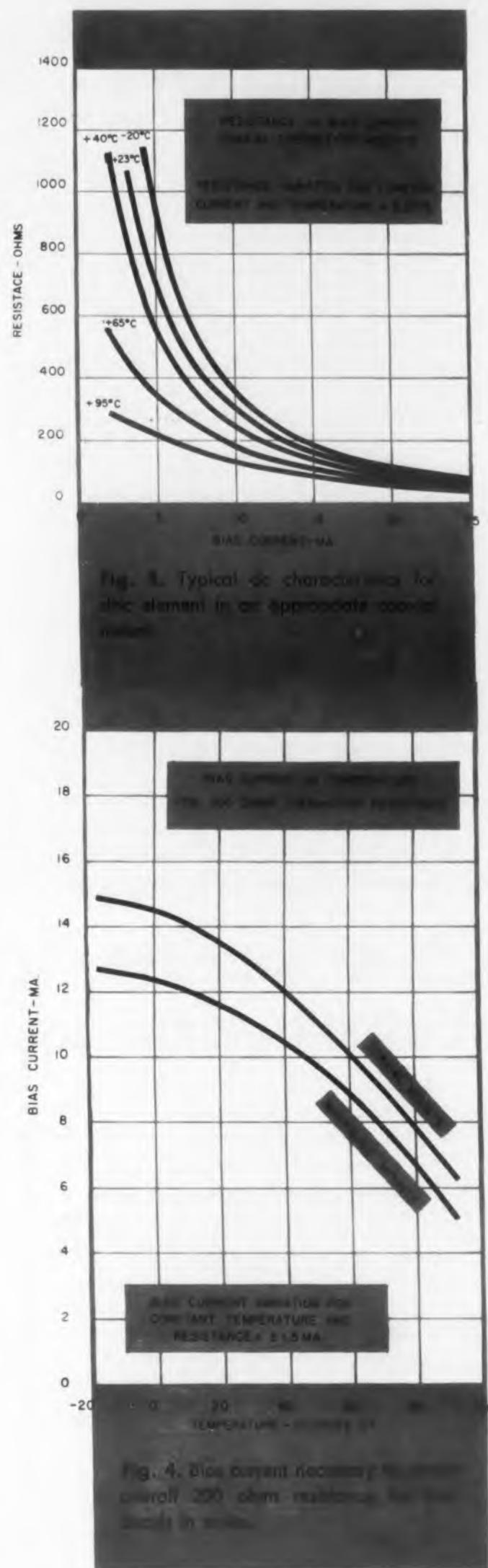
bridge should be capable of biasing the thermistor to at least the amount of power to be measured, and the thermistor must be capable of withstanding that amount of power. For the measurement of power greater than the element can handle, additional equipment can be used.

#### Characteristics of Thermistors

Thermistors used for microwave power measurements are ceramic semiconductor beads which consist of various mixtures of the oxides of manganese, nickel, cobalt, copper, uranium, iron, zinc, titanium, and magnesium.<sup>1</sup> The materials are mixed in proper proportion to obtain the required specific resistance and temperature coefficient of resistance. To form the bead, two taut platinum alloy wires, 0.001 inches in diameter, are stretched parallel to each other with an accurately controlled spacing between them. The thermistor material in paste form is placed across the gap. Surface tension molds the paste into an approximate sphere with a diameter of 0.015 inches. The sphere is air-dried and sintered under accurately controlled atmospheric and temperature conditions. The leads become embedded tightly in the material, making good electrical contact to it. The finished bead is a hard ceramic material which is enveloped in a thin glass coating protecting it from further oxidation at high temperatures. This coating also greatly aids in the ruggedness and electrical stability of the bead. Diagonally opposite lead wires are cut and the bead cross-section is then as shown in Fig. 1.

#### Preliminary Mounting of the Thermistors

The bare thermistor element can be placed in a mount to which its impedance is matched and then used for microwave power measurements. Although this would serve the purpose, it is not the easiest assembly task to achieve. The extremely small size of the element makes it necessary for a skilled technician to do the assembling. In addition, when the bead has to be replaced, the user must acquire another bead and endure the hardship of soldering the new bead in the mount, or else send the unit back to the manufacturer for the replacement of the thermistor. The



logical approach, then, is to put the thermistor element into a form which is conveniently replaceable.

Figs. 2(a), 2(b), & Fig. 5 show appropriate forms in which thermistors can be placed so that they can be easily handled and readily replaced. The element shown in Fig. 5 is a mica disc, upon which two thermistors are mounted. This unit is specifically designed for use in a mount which can be used to measure power in a coaxial transmission line. Fig. 2(a) shows a cartridge which is similar in shape to the body of a 1N21 and 1N23 crystal. One or two thermistor beads can be mounted in this unit, dependent upon its application. This element is primarily used in mounts which measure power in waveguide systems. Fig. 2(b) shows a miniature version of the Fig. 2(a) unit. This is used in waveguide mounts for the higher frequency ranges. Further details of the construction of these elements are discussed in subsequent paragraphs.

#### DC Characteristics

Typical curves of the dc characteristics of the thermistor units are shown in Fig. 3. This curve is typical for the disc element in an appropriate coaxial mount and the cartridge units in a representative waveguide mount. The data variation among elements or mounts stated in the curves are due primarily to two factors. One is the difference in characteristics among thermistor beads and the other is the difference in the immediate surroundings within the mounts in which the elements are placed. The length of the 0.001-inch diameter leads and the effect of conductive and convective heat losses affect the dc characteristics appreciably. By keeping the leads uniform in length for the particular types of elements, some of the variational effects are reduced. Each mount, though, will still present at least a slightly different environment to the element, so that the dc characteristic can not be absolutely uniform among mounts designed for various frequency ranges. The variations of the dc characteristics are particularly important if a self-balancing bridge circuit is not used for the power measurements.

Experience has shown that these thermistor elements should operate within the range of 100 to 300 ohms in order to obtain the optimum conditions of good bridge sensitivity, ease of impedance-matching the thermistor to the mount, and protection from overload or burnout of the beads.<sup>2</sup> Therefore, when a single-bead thermistor is used, it is usually biased to 200 ohms, and two beads in series are biased to 100 ohms each. The latter, of course, requires a larger bias current to obtain necessary resistance. This is advantageous in the substitution method of measuring microwave power, since a greater amount of rf power can now be substituted for the power that biases

the element than if a single bead were used. Fig. 4 shows the bias current as a function of temperature necessary to obtain the overall 200 ohms for the beads connected in series in waveguide and coaxial mounts.

#### Broadband Thermistor Mounts

One of the most important items required for microwave power measurements is a mount whose impedance is matched to the thermistor it houses, and is also matched to the transmission line in which it will be used. To be completely versatile, the thermistor mount should be well-matched over as large a frequency range as possible with no tuning necessary. It should also be able to maintain a good match with any of the same type of elements that may readily be placed in it. Not only would this mount need no adjustments by the user, but no factory adjustments would be required by the manufacturer.

By matching the thermistor mount to the transmission line over a broad frequency range, the error due to the loss of power by reflection is minimized. Another factor requiring attention, however, is inefficiencies in the mount. There must be no microwave power leaking from or into the mount, and no sources of power dissipation other than the thermistor beads must exist. Lossy tuning devices and defective electrical contacts must be completely avoided. With these points in mind, excellent coaxial and waveguide thermistor mounts can be designed.

In Fig. 5, the internal construction of a broadband coaxial thermistor mount is shown. Also shown is the construction of a mica disc thermistor element. The element contains sprayed silver electrodes upon which two thermistor beads are mounted. The principles by which the mount and element operate can be described with the aid of the equivalent circuit of Fig. 6. The two beads are placed in series for the external bias circuit and in shunt across a 50-ohm coaxial line. When the beads are biased to present a resistance of 200 ohms to the external bridge circuit, each bead is biased to 100 ohms. To the rf line, the two beads are in parallel, thereby presenting a thermistor rf resistance of 50 ohms. Bias connections are provided by one end of a thermistor bead being isolated from the outer coaxial conductor by means of an rf by-pass capacitor, and the end of the other bead connected to the outer conductor, which is ground for the external circuit. An rf blocking capacitor isolates the center point between the two beads from the center conductor of the rf coaxial line. Both capacitors are in the form of silvered circular electrodes on a thin mica insulator. The undercut of the center conductor of the mount in Fig. 5 provides a series inductance to match any reactance of the thermistor beads, as well as the fringing capacity caused by the sudden termination of the coaxial center conductor. The center conductor bead support shown in the figure has been designed to give negligible reflections over the operating range.

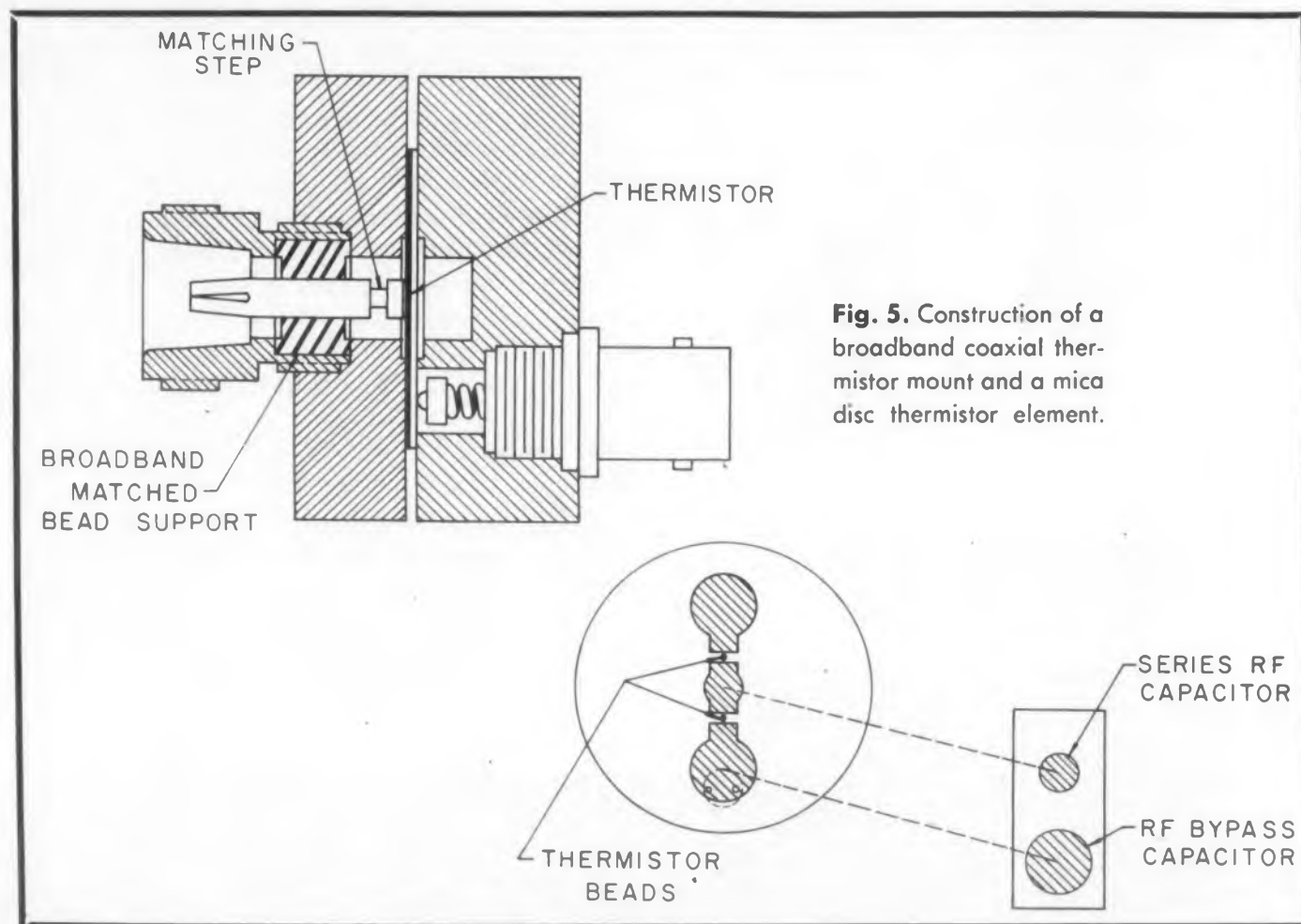


Fig. 5. Construction of a broadband coaxial thermistor mount and a mica disc thermistor element.

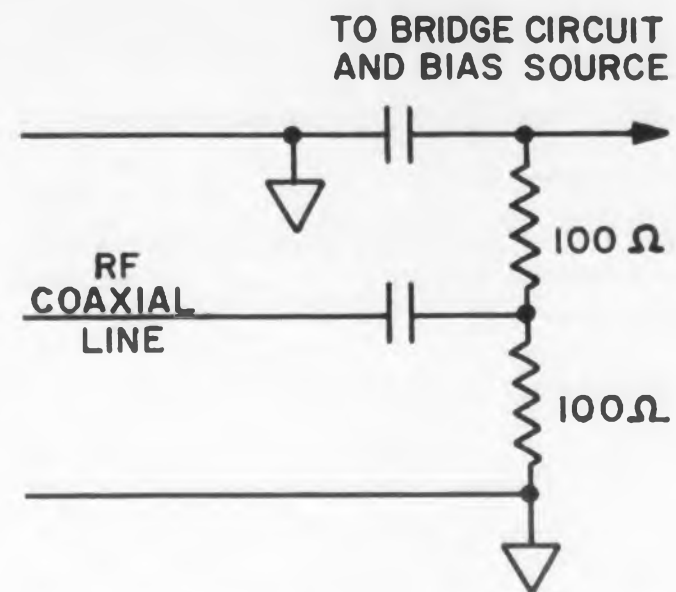


Fig. 6. Equivalent dc circuit of broadband coaxial thermistor mount.



Fig. 7. Photograph of coaxial mount opened to replace the element. It can be used with disc bolometer elements.



Fig. 8. Coaxial thermistor mount using two replaceable cartridge thermistor elements. Blocking capacitors are built into the mount.



The coaxial thermistor mount is designed to operate over the frequency range from 500 to 10,000 mc. The vswr of the mount over this range is always less than 1.50. This corresponds to a power reflection loss less than 0.2 db. Operation below the lowest frequency is limited by the blocking capacitor, while at the highest frequency, the coaxial connector limits the operation. The disc thermistor element is capable of measuring power levels from 0.01 to 10 mw. The design of this element embodies the considerations given it for ease of handling and replacement of a damaged element. Uniformity is maintained very closely in its manufacture so that the replacement of a thermistor element does not adversely affect the broadband characteristics of the mount. A photograph of the coaxial mount is shown in Fig. 7, and how it appears when opened to replace an element. As an incidental feature, besides being used as a thermistor mount, this unit can be used with various disc bolometer elements which are available. The principles of operation for bolometers in this mount are similar to those described for the thermistors. This mount offers a broadband match ( $vswr < 1.50$ ) to four types of bolometers that require bias currents of 4.5, 8.75, or 35 ma. The arrangement of the locating pin in the descriptive nameplate makes it possible to change elements rapidly, and to determine at a glance which type of element is in the mount and its bias requirements.

Another type of coaxial thermistor mount (see Fig. 8) can be briefly mentioned here. This fixed tuned mount makes use of two replaceable cartridge thermistor elements as shown in Fig. 2(b), each containing a single thermistor bead. As with the disc's thermistor beads for the 561 coaxial mount, the two cartridges are placed in series for dc, and in parallel for rf. The parallel combination is again similarly made to present a 50-ohm impedance to the input coaxial line. Necessary blocking capacitors are built into the mount. This coaxial mount can be used over the frequency range from 20 to 1500 mc with a vswr less than 1.20. Similar to the 561 thermistor mount, this mount can also give equal performance with the appropriate cartridge type 100-ohm bolometers which are available. (This is the first of two articles on Microwave Applications of Thermistors.)

#### References

1. Veco Thermistor Data Book, Victory Engineering Co., 1957
2. Technique of Microwave Measurements, Montgomery, Radiation Lab Series, Vol. 11, Page 98
3. Extremely Broadband Component Development, Final Report Contract No. DA 36-039-SC-42662, Signal Corps Engineering Labs, Fort Monmouth, N.J.
4. Broadband Ridged Waveguide Components, Final Report Contract No. AF 30(602)-1426, RADC, Griffiss Air Force Base, Rome, N.Y., Pages 24-25; 50-54



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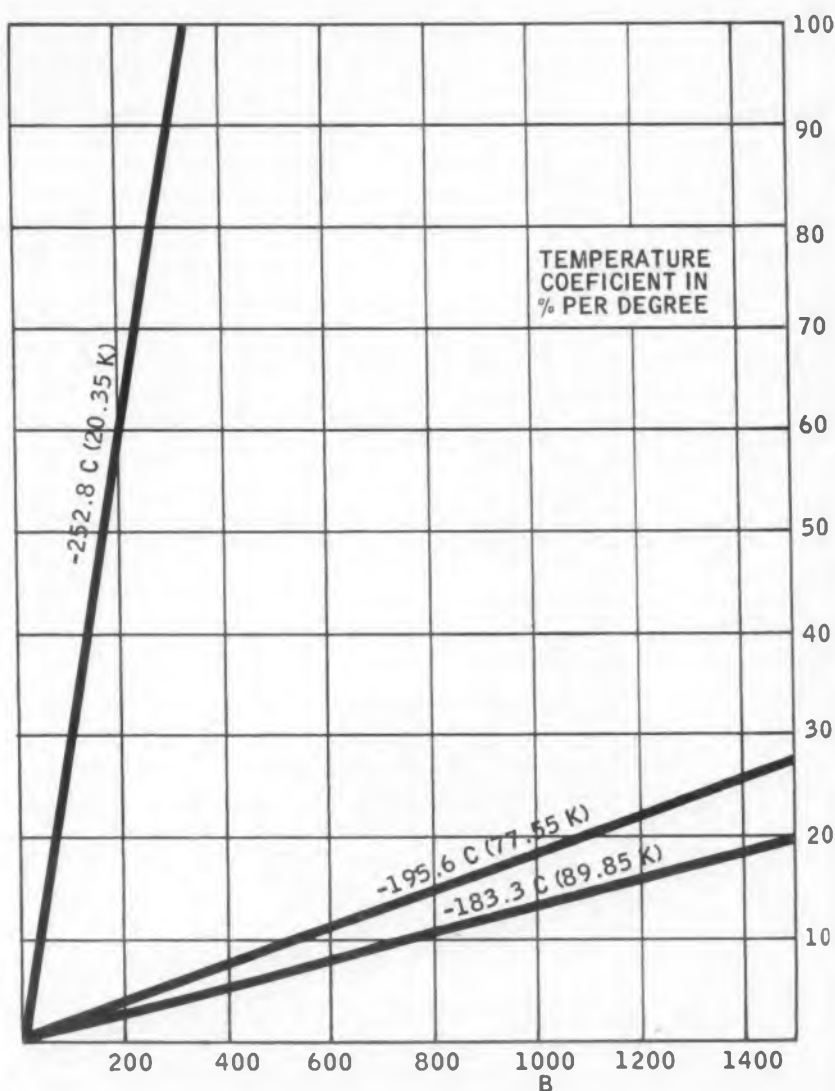


# Design Data for Ultra Low Temperature Thermistors

**Herbert B. Sachse**  
Keystone Carbon Co.  
St. Marys, Pa.

**L**OW-TEMPERATURE thermistors are very useful to measure temperatures of missile fuel components. New low-temperature types have been designed which work in liquid oxygen, nitrogen, and hydrogen. Thermistors are desirable replacements for helium gas and platinum resistance thermometers because they are less expensive, much less breakable, and much more sensitive. The gas thermometer has additional shortcomings in that it does not produce electrical signals directly and cannot be easily miniaturized.

**Fig. 1.** Temperature coefficient in % per degree C as a function of B for  $-183.3$ ,  $-195.6$ , and  $-252.8$  C. B is calculated from the resistance ratio:  $R_{-183.3 C} / R_{+20 C}$ .



The usual commercial thermistors with negative temperature coefficients between 2 and 8 per cent per degree at room temperature cannot be used for very low temperatures. In liquid oxygen ( $-183.3$  C) the resistance would be increased to values above 10 megohms, which are inconvenient for electronic circuitry. The new types of thermistors developed for applications at such low temperatures are described in this article.<sup>1,2</sup> Data on wattage rating, time constant, and reliability estimates are given.

#### Resistance

Various resistance materials have been developed to cover the temperature range between liquid oxygen and liquid hydrogen with resistance values which are practical for normal circuitry. "Large" temperature coefficient materials can only be used down to  $-220$  C, while "small" temperature coefficient materials were developed for applications down to  $-255$  C. The classification "large" and "small" temperature coefficient is arbitrary and refers to the behavior of the materials in liquid oxygen. At room temperature both materials have a very low temperature coefficient. On the other hand, in liquid hydrogen, the "low" temperature coefficient would increase to 50 to 75 per cent per degree. See Table 1.

Further variations, though only to a lesser degree, can be made by changing the geometrical dimensions of these units. By producing thermistor units either in disk or rod type, a resistance range of more than one decade can be covered by the same material. Simultaneously, the self-heating and wattage rating of these units, which are determined by the values of their mass and surface, can be varied within certain limits. The same holds true for their response to temperature changes (time constant).

The gap between "large" and "small" temperature coefficient thermistors is expected to be closed soon by new thermistor types.

The exponential increase of the resistivity of thermistors with decreasing temperature is expressed in first approximation by the formula:

$$\log \frac{\rho_1}{\rho_2} = \frac{B(T_2 - T_1)}{2.303 \cdot T_1 T_2}$$

in which  $\rho_1$  and  $\rho_2$  represent resistivities at the respective absolute temperatures  $T_1$  and  $T_2$  in degree Kelvin (degree K = degree C + 273.15). For a given temperature interval ( $T_2 - T_1$ ) the constant  $B$  is a linear function of the Briggs logarithm of the resistivity ratio between  $T_1$  and  $T_2$ . On the other hand,  $B$ , Fig. 1, is truly constant only for smaller temperature intervals. It has its own temperature dependence, which however is small and tends to decrease the  $B$  value itself and correspondingly the resistivity ratio, thus extending the application range of these thermistors to lower temperatures.

Table 1. Thermistor Resistance and Temperature Coefficient

Characteristic	Large temperature coefficient	Small temperature coefficient
TEMPERATURE RANGE	+20 to $-220$ C	+20 to $-255$ C
RESISTANCE RANGE (ohms)		
at $-183.3$ C (liquid oxygen)	240 to 30 K <sup>1</sup>	90 to 10 K <sup>1</sup>
at $-195.6$ C (liquid nitrogen)	1600 to 260 K <sup>1</sup>	150 to 20 K <sup>1</sup>
$-252.75$ (liquid hydrogen)		100 K to 100 Meg <sup>2</sup>
RESISTANCE RATIO		
$-183.3$ C/ $+20$ C	2500 to 14,000 <sup>1</sup>	18 to 300 <sup>1</sup>
$-195.6$ C/ $-183.3$ C	6.6 to 9.0 <sup>1</sup>	1.4 to 2.0 <sup>1</sup>
$-252$ C/ $-195.6$ C		850 to 100,000 <sup>2,3</sup>
TEMPERATURE COEFFICIENT		
in liquid oxygen	14 to 17% per deg C <sup>4</sup>	2.6 to 3.7% per deg C <sup>1</sup>
in liquid nitrogen	19 to 26% per deg C <sup>4</sup>	3.3 to 5.3% per deg C <sup>4</sup>
in liquid hydrogen		58 to 130% per deg C <sup>4</sup>

<sup>1</sup> in tolerance bands of  $\pm 10\%$

<sup>2</sup> no standardized tolerance.

<sup>3</sup> only values below 2000 are of practical interest because of high resistance values involved.

<sup>4</sup> depending on  $B$  or the ratio group: See Fig. 1.

Note that the range of possible resistance values at temperatures below  $-183.3$  C becomes larger.

This effect is most welcome for ultra low temperatures in the order of  $-253$  C (20 deg K) where it helps to shift the limit of application 3 to 4 degrees lower. For a truly constant  $B$  the resistivity would be a linear function of  $1/T$ , the reciprocal absolute temperature in degree Kelvin.

In Fig. 2 the resistivity versus temperature characteristics of various thermistor types are compared with that of carbon resistors which during the past few years have been recommended for temperature measurements below 4 deg K. From the illustration, four facts are evident.

- The resistivity of commercial thermistors is sky high in the liquid oxygen range.

- The practical low temperature limit for "large" temperature coefficient thermistors is of the order of  $-220$  C (53 deg K).
- The resistivity versus temperature slope tends to decrease with falling temperatures as mentioned before.
- Carbon resistors are impractical as a temperature sensing element above 20 deg K. Below this temperature they require individual calibration.

#### Wattage Rating, Time Constant

Wattage rating and time constants are mainly determined by the absolute values of mass and surface and their ratio. A second contributing

Table 2. Physical Data on Ultra Low Temperature Thermistors

Type	Code No.	Diameter in inch	Length in inch	Weight in milligram	Contact
MIDGET DISKS	L0904	.09 $\pm$ .01	.04 $\pm$ .004	20	Fine silver wire .007 in. dia., 2 in. long.
STANDARD DISKS	L2505	.245 $\pm$ .02	.048 $\pm$ .005	200	Fine silver wire .014 in. dia., 2 in. long.
MIDGET ROD	L050533	.052 $\pm$ .003 square	.33 $\pm$ .01	50	Tinned copper wire .01 in. dia., 1.75 in. long.
STANDARD ROD	L1440	.140 $\pm$ 0.04	.400 $\pm$ .020	380	Tinned copper wire .019 in. dia., 1.75 in. long.

This types listed above are not available in all materials and resistance values. Disk types are preferred for "small" temperature coefficient materials, but by no means restricted to them. On the other hand, standard rods are normally made of "large" temperature coefficient materials, as are also midget rods. The latter have played a minor role in electronic design till now.

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factor is the heat conduction of the lead wires. Economical considerations impose some restrictions on the variety of types with regard to the physical dimensions and the contact leads. Table 2 describes these features for the principal types.

**Wattage rating.** The wattage which can be applied to these thermistors without changing their value beyond certain limits by self-heating is influenced not only by their geometrical dimensions and their mass, but also by their temperature coefficient and the heat dissipation into the surrounding medium. Heat capacity, viscosity, and, for liquid gases, pressure and heat of evaporation, will determine the dissipation. Table 3 refers to thermistors immersed in liquid oxygen at its boiling temperature. The per cent resistance decrease for various thermistor wattage ratings is shown.

**Table 3. Reversible resistance decrease and wattage for disk and rod type thermistors.**

Type	5	10	30	100	300 mw
Midget disk	0.2	0.6	1	2	3%
Standard disk	0.1	0.3	0.6	1	2"
Standard rod	1	2	3	6	8"

**Table 4. Time constant of Various Thermistors (From +20 C in air to -183.3 C in liquid oxygen)**

Type	Time Constant
Midget disk	2 ± 0.2 sec.
Standard disk	6 ± 0.3 "
Midget rod	2.5 ± 0.5 "
Standard rod	9 ± 1 "

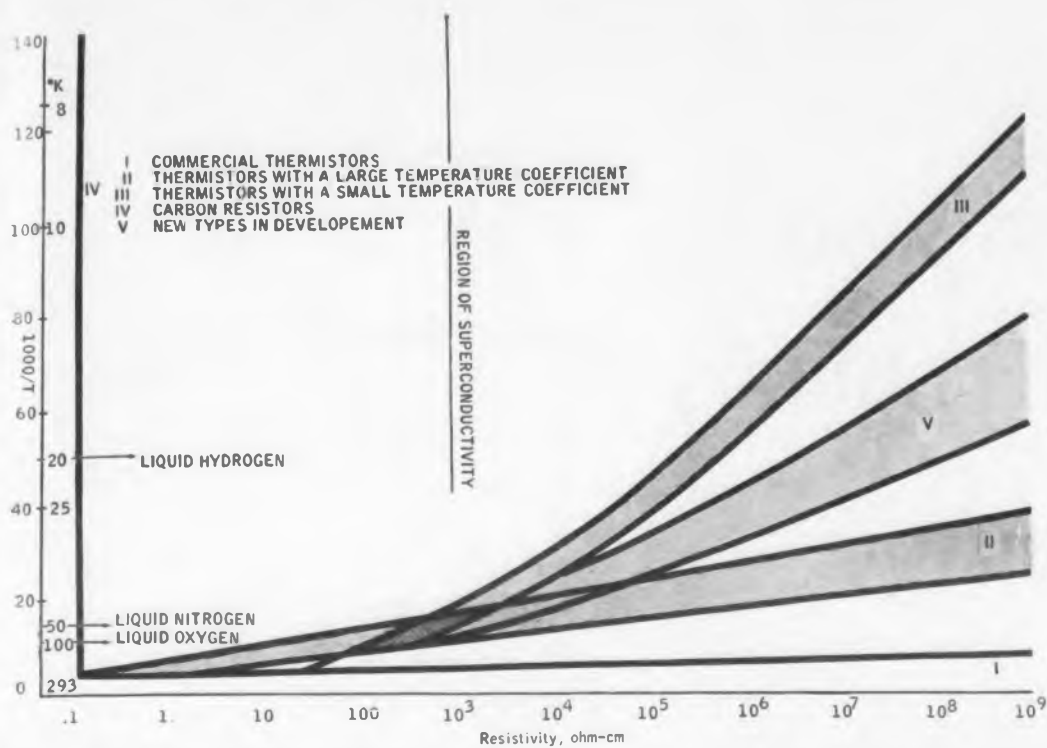
The relatively high resistance change for standard rods compared to disks shown in Table 3 evidently results from the large temperature coefficient material normally used for this type. The temperature increase for 100 mw corresponds to 0.5, 0.25, and 0.35 C, respectively.

**Time constant.** The time which is necessary to reach 63 per cent of the final value when submerging a thermistor of room temperature into liquid oxygen is listed for several types in Table 4.

Under equal cooling conditions the time constant should be in first approximation proportional to the heat capacity or the mass respectively of the unit. However, the data of Table 4, by no means, reflect the decrease in mass from standard to midget size.

The formation of gas bubbles, though only transient, during the dipping of the units into the boiling oxygen apparently distorts the cooling conditions and obscures the true time con-

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**Fig. 2.** Resistivity versus temperature characteristics for various thermistor types. Types III and V show up as best for extreme low temperatures. Two ordinate scales are shown. For plotting, the 1000/T scales are used. For reading, the direct reading absolute temperature scale is more convenient.

stant. A similar effect is observed when water is dropped onto a red hot steel plate. The water does not evaporate explosively, but a few water drops "swim" a few seconds on a heat insulating cushion of water vapor (Leidenfrost phenomenon). The true time constant of these units measured without formation of gas bubbles, e.g., non-evaporating media, will be smaller. In order to provide some data for the calculation of temperature adaptation processes, the approximate specific heat in cal/gram of these materials is given: +20 C = 0.15; -200 C = 0.08; -230 C = 0.04.

For temperatures below -230 C the specific heat will drop further at an increased rate, thus decreasing the time constant. This effect is most welcome insofar as it opens the possibility to apply larger and more rugged thermistors at very low temperatures (< 30 deg K). In other words, larger units behave as if they had a smaller mass.

**Reliability.** Life tests were carried out in two different ways.

**Long term life tests:** Consecutive cooling cycles from room temperature to -183.3 C and back were made with storage periods at ambient temperature between the cooling cycles;

**Short term life tests:** Repetitive cycles were made either between room temperature and liquid oxygen or between liquid oxygen and liquid nitrogen temperature.

Since resistance changes alone are not conclusive enough because of the different temperature coefficients for various types and ratio groups, it is more informative to express reliability data as possible temperature errors produced by resistance deviations with time.

Possible temperature error:

- in long term life tests (1000 hours and more)  $\pm 2$  C or better;

- in short term life tests  $\pm 0.2$  C.

It is obvious that the electrical stability of these thermistors is in some degree dependent upon the cooling rate. The life test cycles were always made by direct quenching in liquid gases and reheating in air of ambient temperature. The thermal shock during quenching in the liquid is exceptionally rough. It can be compared to the quenching of other electronic components from 200 C in air into ice water, a test which normally is not applied.

Since certain applications call for a better long term stability, higher quality grades can be obtained by proper classification and treatment. However, as usual, quality requirements and economy will have to be matched by the designer.

**Protective coatings.** The high insulation resistance of liquid gases and their chemical indifference makes it superfluous to apply insulating or protective coatings. Furthermore, many of the conventional coating materials such as plastic films become very brittle at low temperatures and do not withstand consecutive quenchings. Nevertheless, special coatings have been investigated which hold promise of being satisfactory in this temperature range.

**Acknowledgement:** The author wishes to thank Mr. G. W. Vollmer for his assistance and Keystone Carbon Co. for granting permission to publish this information.

#### References

First basic facts on low temperature thermistors were published in:

1. Low Resistance Thermistors As Ultra-Cold Thermometers by H. B. Sachse, *Tele Tech & Electronic Industries*, Jan., 1957, pp. 55.
2. Temperature measurements Near Absolute Zero by H. B. Sachse, *Tele Tech & Electronic Industries*, Sept. 1957, pp. 58.

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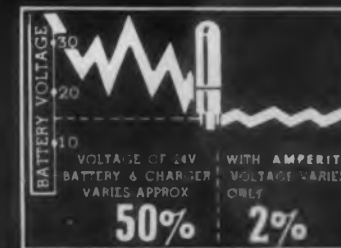


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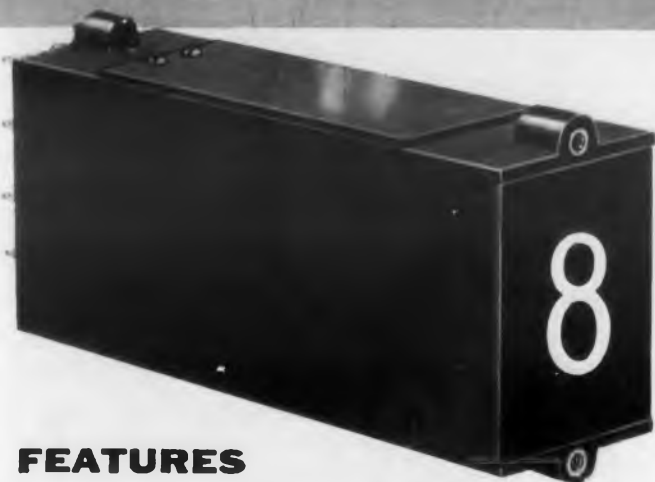
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# Specifying Military Thermistors

**Bernard R. Schwartz**  
Radio Corporation of America  
Defense Electronic Products  
Camden, N. J.

The increasing use of thermistors has made adequate military specifications a necessity. As yet no standardization efforts have been made by the Armed Services or by industry. This general specification for procurement of thermistors was prepared by R.C.A. for military airborne equipment. It has enabled the purchase of reliable thermistors for the past few years.

**T**HERMISTORS are being utilized in increasing numbers in new military equipments. The versatility of this part is evidenced by its many applications: temperature compensation of transistor circuitry and instruments; measurement of true air speeds; indication of liquid levels; control of cabin temperature; stabilization of oscillator frequency; and many other ingenious designs.

However, there remains the problem of specifying thermistors for military applications. There has been no standardization efforts for this part by the usual sources, the Electronic Industries Association, the Aircraft Industries Association, or any of the Armed Services. This article describes a general specification for procurement of thermistors prepared by Radio Corporation of America for military airborne equipments.

The most widely known characteristic of thermistors is its variation of dc resistance value with temperature. This property is not quite the same thing as "temperature coefficient of resistance" for resistors. The resistance-temperature characteristic can be closely described by:

$$R_t = R_o e^{-\beta \left( \frac{1}{T_t} - \frac{1}{T_o} \right)} \quad (1)$$

where:  $T_o$  and  $T_t$  are the references and test temperatures, respectively, in degrees Kelvin.  
 $\beta$ —material constant

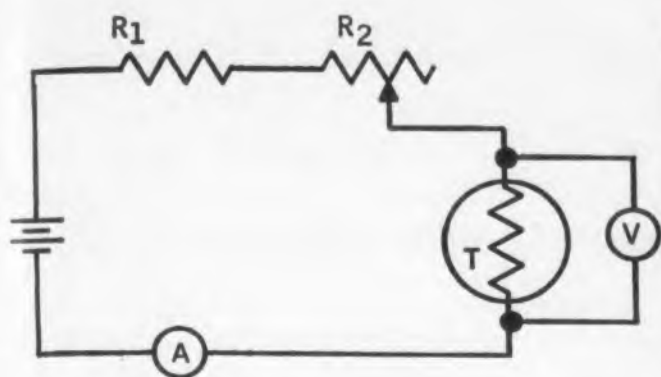
Since thermistors exhibit relatively large changes in dc resistance with small temperature swings, the specification should carefully indicate the test procedure for evaluation.

### Resistance-Temperature Characteristic

Thermistors should be mounted at least one inch apart on suitable mounting strips. Three temperature baths should be available to provide controlled temperature environment over an extended period of time. The temperatures should be controlled within  $\pm 0.05$  degrees C and should consist of one of the group options listed below:

OPTION I	OPTION II	OPTION III
0°C	-21.5°C	37.8°C
25°C	25.0°C	25.0°C
50°C	37.8°C	104.4°C

The thermistors should have their dc resistance value measured at the listed temperatures, in the order shown, with a Wheatstone bridge which is accurate to  $\pm 0.05$  per cent. The resistance values measured at the low and high temperatures shown above (0°C and 50°C, -21.5°C, and 37.8°C, or 37.8°C and 104.4°C, respectively) should be used to calculate the material constant (beta or "b") of each sample for comparison with subsequent measurements. The 25°C resistance measurements should be only to initially check



Schematic circuit for voltage-current characteristic test.

**Table I. Current Values for Voltage-Current Characteristic Test**

Sequence	Current Value (% nom. 25°C current rating)
(a)	10
(b)	25
(c)	50
(d)	100

**Table II. Qualification Test Procedure**

**Test Group I (All Specimens)**

Resistance-Temperature Characteristic

**Test Group II (Ten Specimens)**

Low Temperature Exposure

Temperature Cycling

Moisture Resistance

Terminal Strength (Applicable only to Rod Thermistors)

Effect of Soldering

Body Strength (Applicable only to Rod Thermistors)

**Test Group III (Ten Specimens)**

Load Life

**Test Group IV (Four Specimens)**

Voltage-Current Characteristic

Vibration

Shock

the commonly-specified 25°C resistance tolerance. The following formulas should be used in the material constant calculations with Options I, II, and III, respectively:

Material Constant = Beta =

$$4061 \log \frac{R_{0^{\circ}\text{C}}}{R_{50^{\circ}\text{C}}}; 3036 \log \frac{R_{-21.5^{\circ}\text{C}}}{R_{37.8^{\circ}\text{C}}}; \text{ or } 4056 \log \frac{R_{37.8^{\circ}\text{C}}}{R_{104.4^{\circ}\text{C}}}$$

**Voltage-Current Characteristic**

This characteristic is extremely important in many thermistor applications where self-heating is an integral part of the circuit design. Thus, the test procedure should be carefully stated so that the desired performance is indicated.

The thermistors should be mounted with the leads soldered 1-1/2 ± 1/8 inch (effective length)

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### Specifying Military Thermistors *continued*

from the body and in still air at 25°C. The test circuit should be that shown in Figure 1. The series-limiting resistors ( $R_1$  and  $R_2$ ) shall be such that initially the circuit current will not cause self-heating in the thermistor sample. The circuit current should then be increased in the sequence shown in Table I and the corresponding voltage measurements should be made. A stabilization period, not to exceed 15 minutes, should be allowed at each sequence prior to recording values. The nominal 25°C current rating should be calculated as:

$$I_{(\text{nom. } 25^\circ\text{C rating})} = \left( \frac{P_{(\text{nom. } 25^\circ\text{C rating})}}{R_{(\text{nom. } 150^\circ\text{C value})}} \right)^{\frac{1}{2}}$$

#### Qualification Tests

As a condition for granting engineering approval a group of specimens should be submitted to a qualification test procedure designed to determine whether they meet minimum acceptable quality levels. The determination of those limits should be the result of an initial study of thermistor performances when subjected to the usual military specification environmental tests. A study of this nature has been completed by the Radio Corporation of America, Camden, N.J. The qualification test procedure, as used by RCA, Defense Electronic Products, is in Table II.

Adequate precautions should be taken during tests to prevent moisture condensation on specimens, except during the Moisture Resistance and Temperature Cycling Tests.

Failure of a single thermistor in one or more tests of a test group should be charged as a single failure. One failure should be permitted in each test group but no more than two should be permitted for all test groups combined.

When thermistors as a group fail a specified average percent-change requirement, only one failure should be charged; however, a failure should be charged for each thermistor of the group which exceeds the maximum percent-change requirement, and these thermistors should not be considered in computing that average. It is intended to permit one average percent-change failure to be charged for the material constant requirement and an additional failure for the resistance change requirement.

The Resistance-Temperature and Voltage-Current Characteristic Tests have already been described.

#### Low Temperature Exposure

After a 24 hour exposure at  $-80^{\circ}\text{F}$  ( $+2^{\circ}\text{F}$ ,  $0^{\circ}\text{F}$ ) the resistance-temperature characteristic should again be performed.

The average change in the material constant for a group of specimens should not exceed  $\pm 0.5$  per cent, nor should an individual specimen have a material constant change greater than  $\pm 1.0$  per cent. The average change in the resistance value for a group of specimens at  $0^{\circ}\text{C}$ ,  $-21.5^{\circ}\text{C}$  or  $37.8^{\circ}\text{C}$  should not exceed  $\pm 3.0$  per cent, nor should any individual specimen have a resistance change (from initial  $37.8^{\circ}\text{C}$ ,  $0^{\circ}\text{C}$  or  $-21.5^{\circ}\text{C}$  value) greater than  $\pm 5.0$  per cent.

#### Temperature Cycling

Specimens should be subjected to the Method 102, MIL-STD-202, condition A test. No subsequent measurements should be required. Mounting should be as specified in the Resistance-Temperature Characteristic Test.

The specimens should be inspected for evidence of mechanical damage and discoloration of the color coding which renders it unrecognizable from the specimen background color.

#### Moisture Resistance

Specimens should be subjected to the Method 106, MIL-STD-202 test. Mounting should be as specified in the Resistance-Temperature Characteristic Test. No load or polarizing potential should be applied to the specimens during the test. Final measurements should be made after the 24 hour room ambient conditioning following the tenth cycle. The Resistance-Temperature Characteristic Test should be performed. Per cent change of resistance value at  $0^{\circ}\text{C}$ ,  $37.8^{\circ}\text{C}$ , or  $-21.5^{\circ}\text{C}$  and material constant ( $\beta$ ) should be calculated.

The average change in the material constant for a group of specimens should not exceed  $\pm 5.0$  per cent, nor should an individual specimen have a material constant change greater than  $\pm 10$  per cent. The average change in the resistance value for a group of specimens at  $0^{\circ}\text{C}$ ,  $-21.5^{\circ}\text{C}$  or  $37.8^{\circ}\text{C}$  should not exceed  $\pm 10$  per cent, nor should an individual specimen have a resistance change (from initial  $37.8^{\circ}\text{C}$ ,  $0^{\circ}\text{C}$  or  $-21.5^{\circ}\text{C}$  value) greater than  $\pm 12$  per cent. Evidence of galvanic action within a specimen should be considered as cause for rejection as a defective specimen.

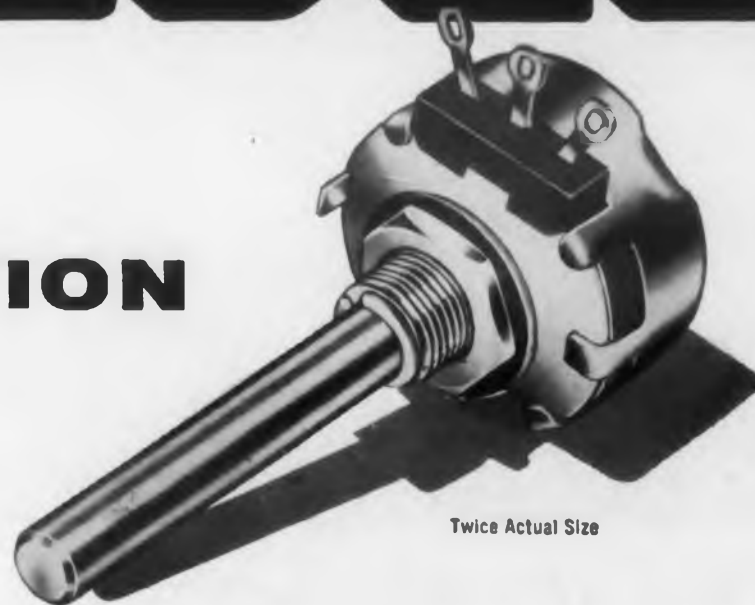
#### Terminal Strength (applicable to rod thermistors only)

Thermistors should be held by a terminal and tensile force should be gradually applied to the

# MOLDED

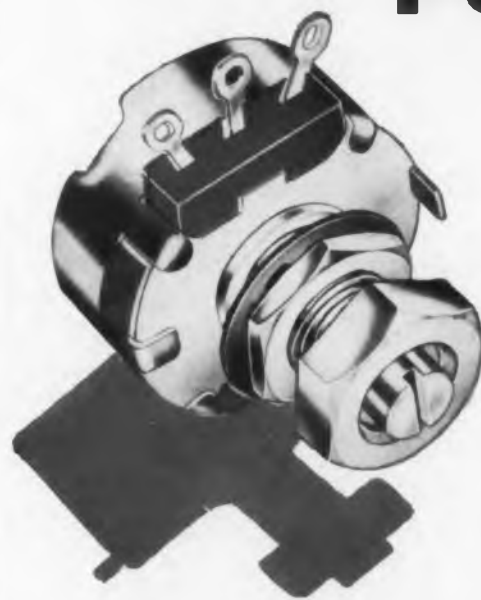
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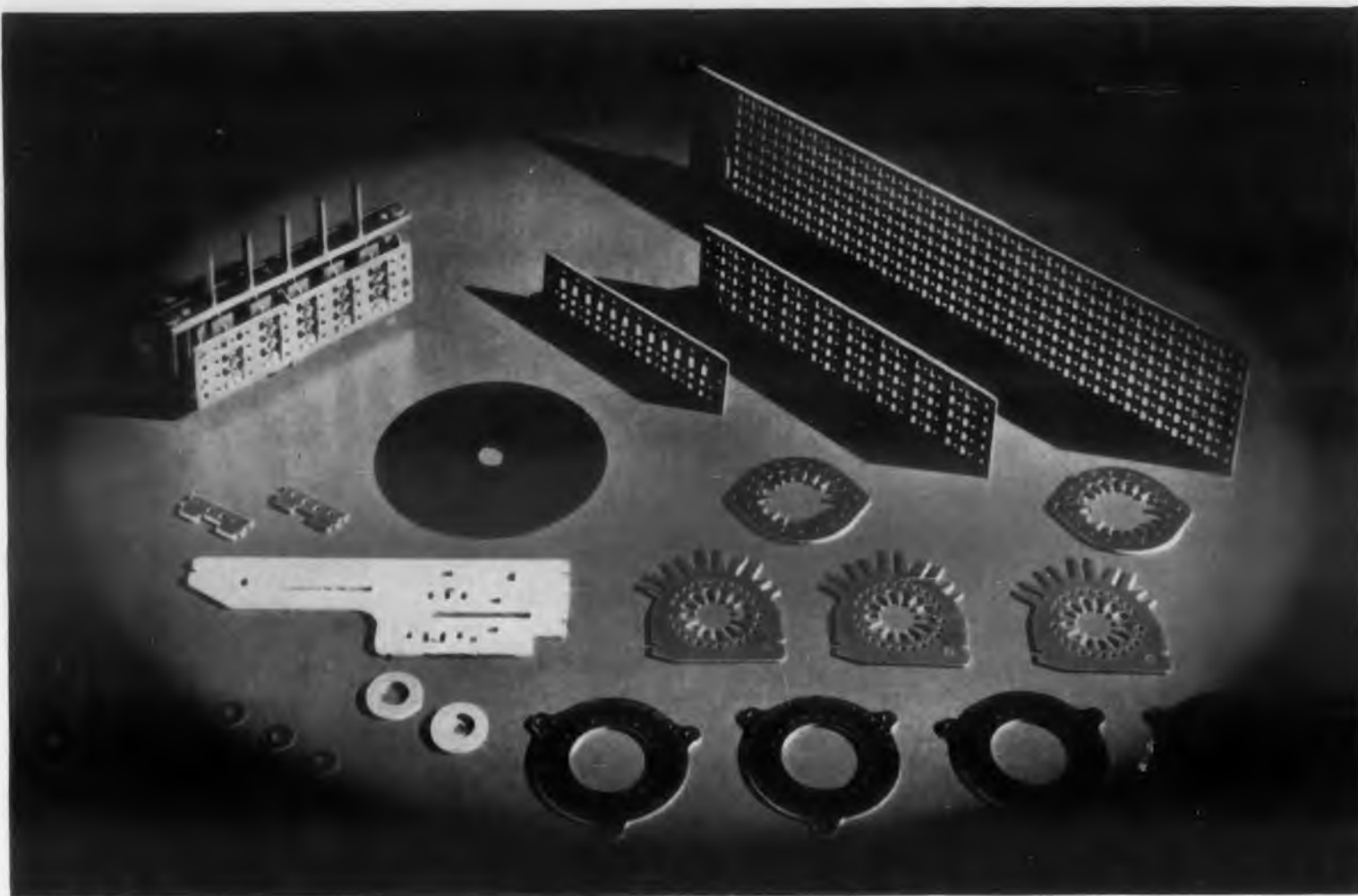
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T-812	24,500	620 vpm	1,000,000	225°F.
T-819	15,000	375 vpm	3,000,000	165°F.
T-827	25,000	320 vpm	170	225°F.
T-859	48,000	375 vpm	25,000	300°F.
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### Specifying Military Thermistors *continued*

other terminal in the direction of the longitudinal axis until the applied load reaches 3 pounds. Each wire lead should be bent through 90° at a point 0.25 inch from the body of the thermistor, and rotated through 360° in alternating directions for five cycles, at the rate of approximately 5 seconds for each complete cycle.

Terminals should withstand a direct pull of 3 pounds and the five twist cycles without evidence of mechanical failure.

#### Effects of Soldering

Thermistor terminals should be immersed individually for  $3 \pm 1/2$  seconds in a pot of molten solder at a temperature of  $350 \pm 10^\circ\text{C}$  to a point one-eighth to three-sixteenths inch from the thermistor body.

There should be no evidence of mechanical damage, loosening of terminals or discoloration of color coding beyond ability to distinguish from the specimen background body color.

#### Body Strength (applicable to rod thermistors only)

Specimens should be supported one-eighth inch from each end, and should then be subjected to a transverse load of not less than 4 pounds. The load should be applied at the center of the thermistor through a fulcrum having a radius of not less than 0.25 inch.

There should be no evidence of mechanical damage, breaking, or splitting of the specimen's body.

#### Load Life

The thermistors should be mounted on terminal strips with terminals spaced two inches apart, so that the effective lead length (including the height of the terminal post) is not greater than 1 inch.

Thermistors should be placed in an oven whose temperature is then brought to  $125^\circ\text{C} \pm 2^\circ\text{C}$  within two hours from room temperature. A current equivalent to 10 per cent of the nominal  $25^\circ\text{C}$  current value should be drawn by each thermistor for 1000 (+0, -8) hours. The power

supply should then be disconnected and the doors of the oven may be opened so as to allow the oven temperature to return to room conditions in not less than two hours. Final measurements of Resistance-Temperature Characteristic should be made and per cent change of resistance value at 0°C, 37.8°C or -21.5°C and material constant should be calculated.

The average change in the material constant for a group of specimens should not exceed  $\pm 1.0$  per cent, nor should individual specimen have a material constant change greater than  $\pm 3.0$  per cent. The average change in resistance value for a group of specimens at 37.8°C, 0°C or -21.5°C should not exceed  $\pm 3.0$  per cent, nor should any individual specimen have a resistance change (from initial 37.8°C, 0°C or -21.5°C value) greater than  $\pm 5.0$  per cent.

#### Vibration

With the component mounted rigidly as intended, vibrate according to the following information noting all resonant frequencies:

Frequency range: 5 to 500 cps. 5 to 500 and back to 5 in 15 minutes.

Repeat 8 times (2 hours) for modes 1, 2, and 3, below.

Total excursion or acceleration: 0.01 in. or  $\pm 5g$ , whichever is maximum.

Mode (1) Horizontal-parallel to major axis.

Mode (2) Horizontal-perpendicular to major axis.

Mode (3) Vertical.

Resonance running time: 30 minutes at each noted resonant frequency.

If any mounting bracket resonance occurs below or at 55 cps, run for 30 minutes at that frequency with total excursion of 0.60 inch.

There should be no evidence of, mechanical damage to the wire leads, breaking or splitting of the specimen's body.

#### Shock

Subject the part to 30 impact shocks which have an amplitude of 30 times the acceleration of gravity, each shock impulse having a time duration of  $11 \pm 1$  millisecond. The shocks should be applied in the following directions:

Horizontally, parallel to the major axis, five shocks in each direction.

Horizontally, perpendicular to the major axis, five shocks in each direction.

Vertically, five shocks in each direction.

There should be no evidence of mechanical damage to the wire leads, breaking or splitting of the specimen's body.

The procurement drawing covering the above tests and requirements has permitted RCA to buy reliable thermistors during the past few years. It is expected that a future evaluation of the qualification test results will permit reduction of allowable change levels.

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# BURNDY

CIRCLE 31 ON READER-SERVICE CARD



# Thermistor Bridges

**Marsden L. Miller**  
Chief Engineer  
Victory Engineering Corp.  
Union, N. J.

Significant advantages can be obtained from the relatively large outputs rendered by thermistor bridges. Temperature sensing circuits become quite involved because of the inherently low outputs from most transducers. A basic sensing circuit with a reasonably high output offers important savings and increased reliability. Three thermistor bridges with relatively large outputs are compared with those of several types of a more familiar device, the thermocouple.

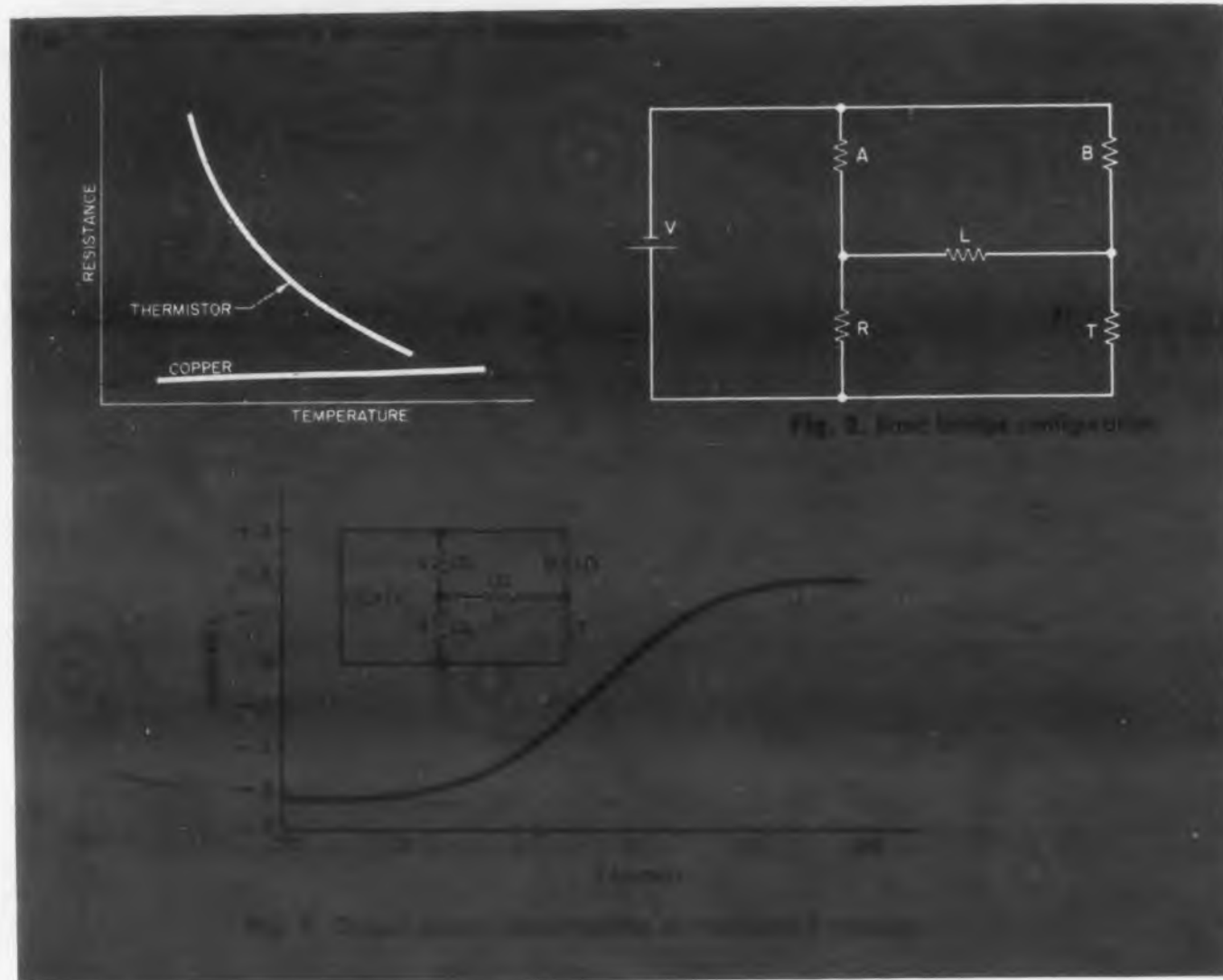


Fig. 2. Basic bridge configuration.

## Thermistor Self-Heating

Before proceeding directly to bridges there is one further item that must be thoroughly understood. Since thermistors are basically resistors, they will heat up appreciably if sufficient current is passed through them. The resultant temperature change should be accounted for.

For instance, suppose that it were required to measure the temperature of water flowing through a large pipe at a varying rate. Further, suppose the thermistor, which of course is the sensing element, is heated so that its temperature is three degrees above that of the water when the water is flowing slowly. When the water speeds up it will not draw off more heat from the thermistor than before. If it is assumed the increased flow cools the thermistor so that it is now only two degrees above the water temperature, a one degree temperature change has been introduced in the measurement, and the water, for all practical purposes, has not changed temperature at all.

How is this change eliminated? Simply keep the power dissipation in the thermistor low

## Fundamentals

Thermistors in general have very high negative temperature coefficients, that is, they drop drastically in resistance as the temperature rises and vice versa. This function is depicted graphically in Fig. 1.

Thermistors presently are available in resistance values from a matter of a few ohms to tens of megohms. Since they are very temperature sensitive, a reference point of 25 C (77 F) is usually assumed as the temperature at which they are measured. For instance, a thermistor which is purchased as a one thousand ohm unit has been tested to within its specified tolerance at exactly 25 C. For values of resistance at other temperatures there is a graph or table of values usually covering the range of about -50 to 300 C. For those who may wish to calculate the values, the following approximate formula may be applied:

$$R_1 = R_2 e^{\beta \left( \frac{1}{T_1} - \frac{1}{T_2} \right)} \quad (1)$$

where:

- $R_1$  = Thermistor resistance at temperature  $T_1$
- $R_2$  = Thermistor resistance at temperature  $T_2$
- $e$  = Napierian base . . . 2.713
- $\beta$  = Material Constant ( $^{\circ}K$ )
- $T_1$  = Reference temperature ( $^{\circ}K$ ) of thermistor
- $T_2$  = Another thermistor temperature ( $^{\circ}K$ )

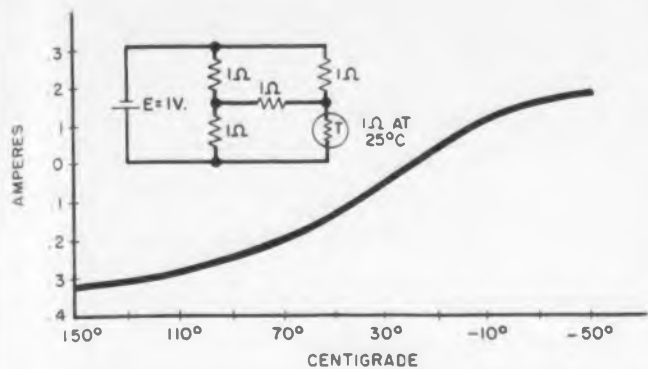


Fig. 4. Output current as a function of thermistor resistance change with temperature.

enough so that its temperature rise is less than the desired accuracy of measurement. For, if it is desired to measure a temperature accurately to one degree F, the thermistor temperature rise due to electrical current flow must be kept less than one degree.

Each unit's heating capacity is described as a dissipation constant which states the number of watts or milliwatts required to heat up a particular thermistor one degree Centigrade. If a unit were to have a dissipation constant of say two milliwatts per degree Centigrade, ten milliwatts of power would cause the thermistor to rise approximately five degrees above its surrounding medium. When the thermistor is dissipating a negligible (for the problem in question) amount of power, it is said to be non-self heated. In contradistinction, if the unit is heated appreciably above its medium, it is said to be self-heated. Incidentally, many applications require this latter condition.

#### Simple Bridge

Fig. 2 is the simplest bridge configuration possible. All further discussion will be based on use of this rather familiar circuit.

Assuming an equilateral bridge, one in which all legs are initially equal,  $A = B = R = T$ . The power source  $V$  may be in any form desired such as a battery, voltage regulator tube or transformer. Note that alternating currents may be applied as easily as direct currents.

If the only element in the bridge to vary is  $T$ , and the output load  $L$  is matched to the bridge for maximum power transfer; i.e.  $L = A = B = R$ , then the curve in Fig. 3 will describe the output current characteristics where all the aforementioned elements are one ohm and the applied potential is one volt.

If a thermistor is placed in position  $T$ , the curve of current output that will now be derived as the thermistor changes resistance with temperature is shown in Fig. 4.

Note the relatively wide range of temperature over which good linearity is obtained. This range runs from about 10 C to 60 C, or 50 F to 140 F, a span of room temperatures any section of

#### 2. PRECISION CALIBRATED SLIDING SHORTS.

Nine types — Short-circuiting, non-contact plunger has travel of more than half a wavelength in the 2.6 to 75 kmc/s range. Counter type readout 2.6 to 12.4 kmc, and micrometer readout 12.4 to 75 kmc.

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#### 5. LT COAXIAL SLOTTED SECTION.

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#### 6. BROADBAND CRYSTAL MOUNTS.

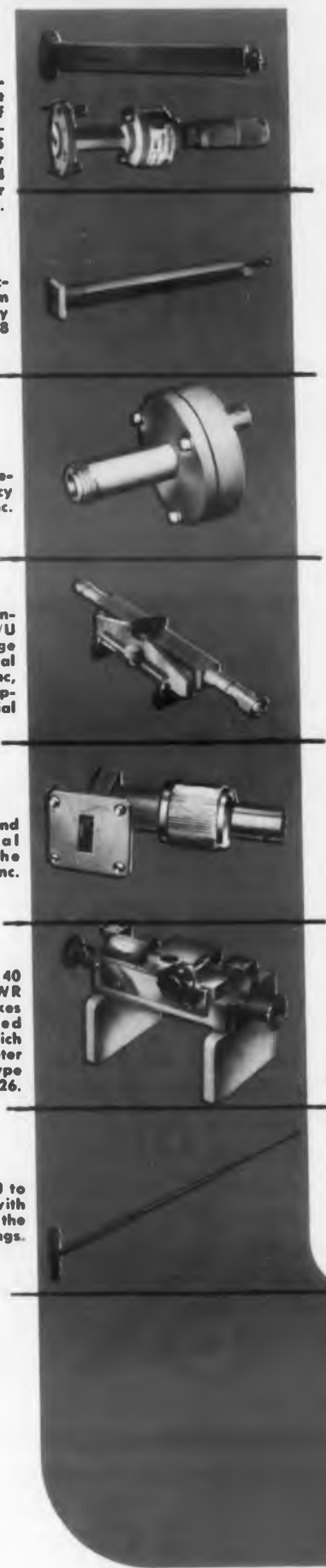
Fixed tuned, broadband waveguide crystal mounts covering the range 12.4 to 40 kmc.

#### 7. SLOTTED SECTIONS

Range from 12.4 to 40 kmc; residual VSWR less than 1.01. Takes broadband untuned probe, Type 253 which accepts PRD balometer Type 609, or PRD Type 608, or modified 1N26.

#### 8. COAXIAL E-H Tuner.

Frequency range 900 to 10,000 mc. Fitted with locking collets on the tuning plunger housings.



# new

## FREQUENCY METER EXTENDS THE PRD PACEMAKER LINE

Just announced as additions to the new PRD PACEMAKER integrated line of microwave test equipment are the TE<sub>111</sub> Mode direct-reading Frequency Meters. This series of ruggedized meters covers the frequency range from 3.95 to 40 kmc.

One of the outstanding features of this new line of frequency meters is the direct-reading accuracy of 0.08% for most ranges.

This high accuracy is provided by a continuous dial, 100 inches long. The dial scale is calibrated, helical fashion, around the drum that is seven inches in circumference. The ample space permits clear separation between all graduations. Full data on the Direct Reading Frequency Meters, and other members of the PACEMAKER line, is available through your PRD representative.

Call him for information, or write us directly.



POLYTECHNIC RESEARCH & DEVELOPMENT CO., INC.  
202 Tillary Street, Brooklyn 1, N. Y., UL 2-6800



1. FREQUENCY METER.  
Frequency range 8.2 to 12.4 kmc. Reaction type. Waveguide size 1 x 1/2". Accuracy ±0.08%. Seven models covering the frequency range from 3.95 to 40 KMC. (Model 535 is illustrated.)

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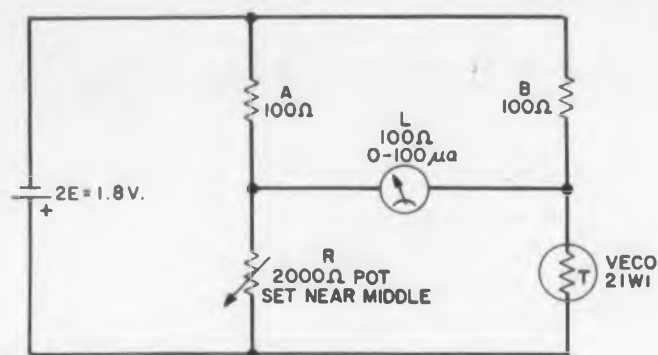


Fig. 5. Practical bridge for temperature measurement over one degree centigrade.

which will plot out on a meter scale as practically a linearly divided arc.

For a practical case, the problem of temperature measurement over only a one degree Centigrade span will be examined. Suppose that in particular a plate of copper is varying between 25 and 24 C. An approach to this rather difficult problem is to construct a bridge as shown in Fig. 5. From the meter's scale we wish to read off temperature divisions of .01 degrees C. Obviously this can be done only if the thermistor has the sensitivity to deflect the meter at least to full scale.

The thermistor indicated is a Veco washer type 21W1 and is approximately 0.77 in. in diameter by 0.048 in. in thickness. It has a convenient mounting hole with approximately a 0.28 in. diameter by which it may be screwed or bolted directly to the copper plate and is specified as 100 ohms  $\pm 10$  per cent at 25 C. Data from the Veco catalog indicates also that this unit has a dissipation constant of approximately 800 mw per degree C. If the requirements demand that the thermistor contribute no more than 0.01 degree C error, this means that no more than 8 milliwatts can be dissipated in the unit. Using formula (2),

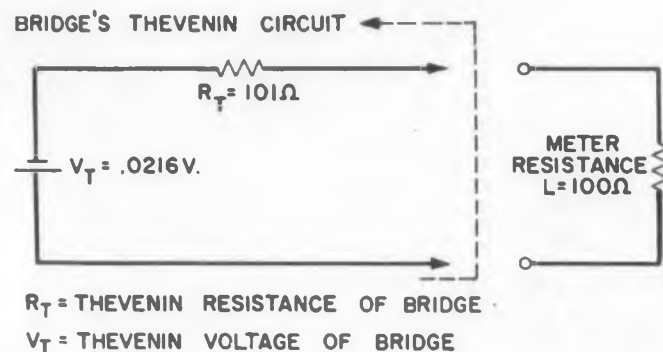


Fig. 7. Thevenin circuit for temperature bridge of Fig. 5.

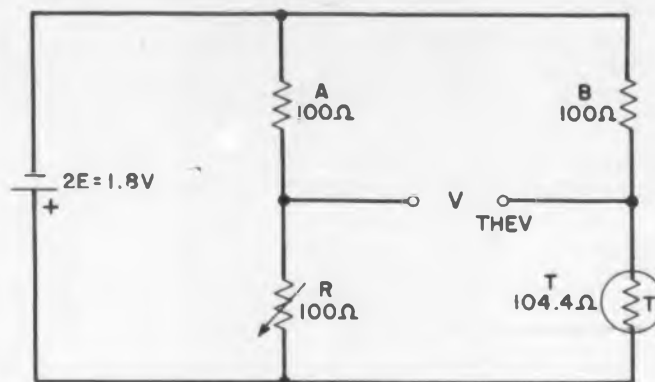


Fig. 6. Approximate output current is calculated from Thevenin's theorem. See Fig. 7.

$$E = \sqrt{PR} \quad (2)$$

where  $E = \text{Thermistor voltage}$   
 $P = \text{Power allowed in thermistor}$   
 $R = \text{Thermistor resistance}$

the required bridge voltage ( $2E$ ) is found to limit the thermistor to 8 milliwatts. The necessary bridge voltage is approximately 1.8 volts as shown in Fig. 5.

Data further reveals that the 21W1 thermistor changes about  $-4.4$  per cent/ $^{\circ}\text{C}$  at 25 C. With this knowledge, an approximation can be made of the output meter current. This shall be done by employing Thevenin's Theorem. With the meter out of the circuit the output bridge voltage is derived from divider relations in Fig. 6. This is now the Thevenin voltage of the circuit when the thermistor changes from 25 C to 24 C or 100 ohms to 104.4 ohms. Since the Thevenin resistance of the circuit is relatively unchanged by this small leg shift, we shall simply approximate it as 101 ohms. Therefore, the complete Thevenin circuit of our bridge is as shown in Fig. 7.

When the meter is connected into the bridge,

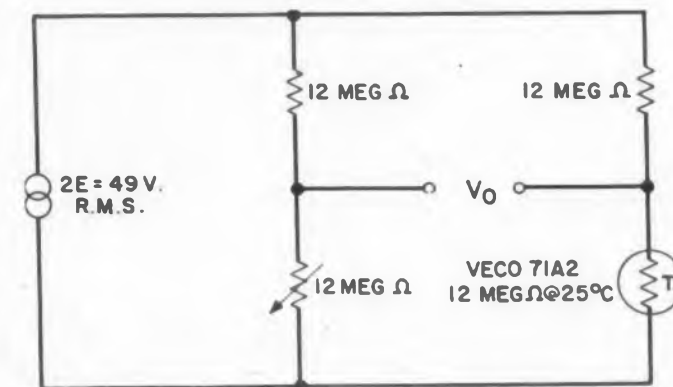


Fig. 8. Thermistor and bridge for high output voltage.

the calculation of its current is quite simple:

$$I_M = \frac{V_T}{R_T + L} = \frac{0.0216}{101 + 100} = 107 \mu a \quad (3)$$

It is seen that the meter can be driven well off scale by the small change in temperature of only one degree.

For the next bridge example, a relatively high resistance thermistor is utilized since the object will be to develop a high voltage output from the bridge. The unit employed will be the Veco type 71A2. It is a bead in a glass rod and has a shape very similar to a standard one watt size carbon resistor with axial leads. The ratings of the 71A2 are:

Resistance at 25 C	= 12 Megohms $\pm 20\%$
Dissipation Constant	= 5 mw/ $^{\circ}\text{C}$ in water
Maximum Power	= 0.1 watt
Temperature Coefficient	= $-5.8\%/^{\circ}\text{C}$ @ 25 $^{\circ}\text{C}$
Maximum Temperature	= Approx. 500 $^{\circ}\text{C}$

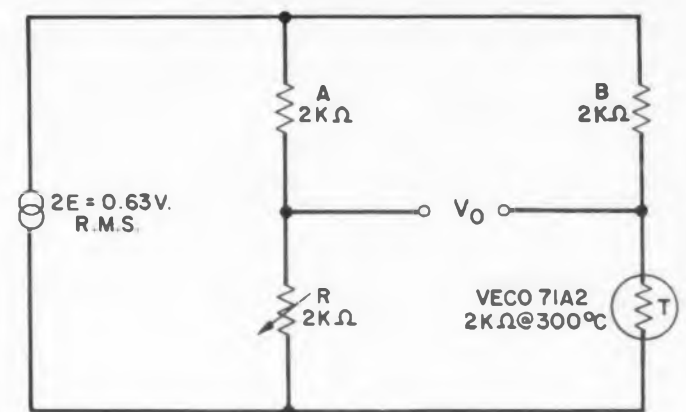


Fig. 9. Bridge for measurement in 300 C range.

Let us now construct another equilateral bridge using the 71A2 and check its output for a single degree change with less than 0.01 degree C self-heating. From formula (2) we find

$$E = (PR)^{\frac{1}{2}} = (0.00005 \times 12,000,000)^{\frac{1}{2}} = 24.5 \text{ volts across thermistor}$$

Therefore the bridge voltage ( $2E$ ) is 49 volts. If the 71A2 is changed to 24 C its resistance will rise to approximately 12.7 megohms. Using formula (4) we find the output ( $V_0$ ) to be:

$$V_0 = \left( \frac{T}{T+B} - \frac{1}{2} \right) (2E) = \left( \frac{12.7}{12.7+12.0} - \frac{1}{2} \right) 49 = 0.686 \text{ volts output} \quad (4)$$

Now by simply placing another 71A2 in leg A of the bridge, the output may be more than doubled, thus rendering a total output of over 1.4 volts for only a one degree change! Of course this bridge is unloaded and has a very

high Thevenin resistance. However, it does serve to demonstrate that large outputs can be approached by this type of circuit.

The examples given so far have been for room ambients. At elevated temperatures the outputs though less, are still extremely large compared to similarly used components such as thermocouples. The upper temperature limit of commercial thermistors in use today is approximately 500 C (932 F). Thermistors have been used at higher temperatures, but for good stability it is recommended that they be used below 500 C.

For use around 300 C the type 71A2 would be approximately 2000 ohms. Assume now construction of a 2000 ohm bridge using a 71A2 at 300 C.

At this temperature the thermistor's coefficient is about 1.5 per cent degree C. Using formula (2) again and keeping the allowable self-heating to 0.01 degrees C:

$$E = (PR)^{\frac{1}{2}} = (0.0005 \times 2000)^{\frac{1}{2}} \\ = 0.316 \text{ volt across thermistor}$$

Therefore the applied bridge voltage should be 0.63 volts (either ac or dc as the application may warrant). Using formula (4) to find the output:

$$V_a = \left( \frac{T}{T+B} - \frac{1}{2} \right) (2E) = \left( \frac{2030}{2030+2000} - \frac{1}{2} \right) 0.63 \\ = 2.52 \text{ mv}$$

Several added advantages are inherently present in thermistor bridges. For example, the thermistor may be located at remote distances from the bridge itself since extension lead resistance can be made negligible compared to the thermistor resistance. Some other advantages are the absences of cold junction compensation and polarity observation which are always present with the use of thermocouples.

A table will now be constructed showing comparative outputs of the thermistor bridges developed versus some of the more commonly used thermocouples.

Bridge or Thermocouple	Microvolt outputs per Degree Centigrade	
	at 25 C	at 300 C
Bridge Fig. 6	10,700	
Bridge Fig. 8	1,570,000	
Bridge Fig. 9		2520
Copper/Constantan	40	60
Iron/Constantan	50	55
Chromel/Alumel	40	40
Plat/Plat-10% Rhodium	6	9
Plat/Plat-13% Rhodium	6	10

The thermistor bridge outputs indicated are comparatively very high. However, the figures shown are perhaps even more impressive when it is recalled that they are drastically reduced by the severe restriction that was placed on them to achieve a readout accuracy of 0.01 degrees C.

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Model 706—0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 20 db  
Model 707—0, 3, 6, 9, 12, 15, 18, 21 INF db

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The unit is completely self contained, with built-in detector and indicating meter. A sensitivity control allows use with strong signals; for signals below 5 mw., the external meter jack may be connected to an amplifier or oscilloscope.

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1500-2400	2 mc	500	1.25	0.5 mw	806	375

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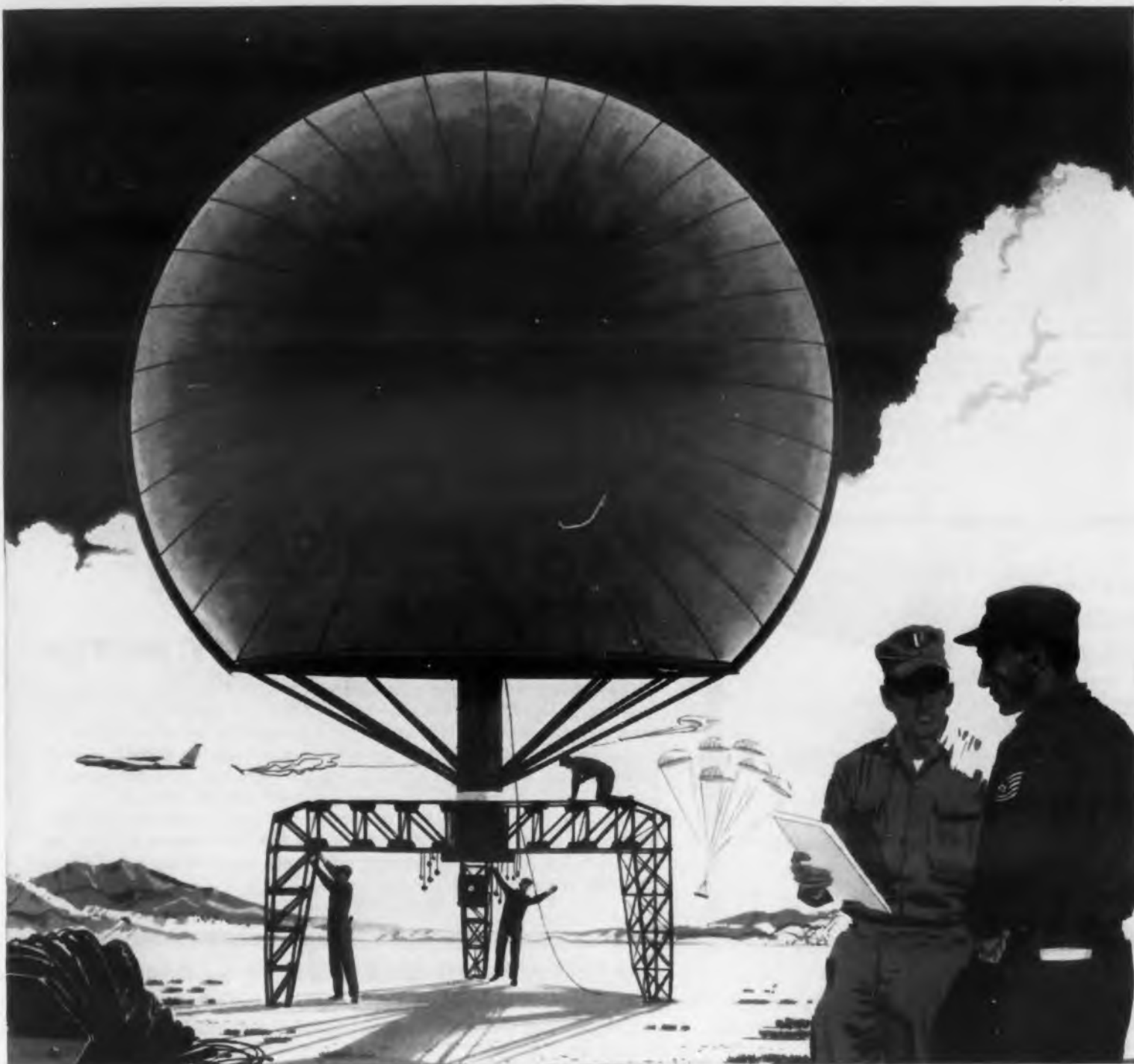
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The "Paraballoon" antenna is one of the many examples of how the high strength-to-weight ratio of magnesium pays off in terms of saved weight in electronic equipment. For more information on magnesium in electronics contact the nearest Dow Sales Office or write to THE DOW CHEMICAL COMPANY, Midland, Michigan, Department MA 1416M.

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**Beads are made** by placing exact drops of mix on two parallel platinum wires, above. Surface tension forms drops into little spheres which become beads when fired in a furnace, below. Mixture, shape of bead and spacing between beads determines characteristics.



DESIGN ACHIEVEMENTS WITH **SUPRAMICA\*** CERAMOPLASTICS



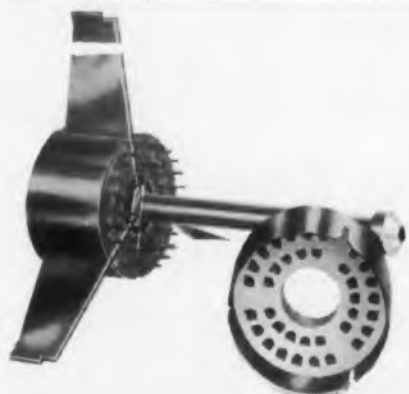
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# NEW PRODUCTS

To provide a complete coverage of ALL new products generally specified when designing electronic original equipment, the New Product section has been extended. To include the larger number of items, products which are best suited to a brief description have been noted at the end of the section.



## ACCELEROMETER

A fluid immersed sensing element moving precisely in a straight line makes possible the high accuracy of this accelerometer. Threshold sensitivity is better than  $10^{-5}$  g. This means that when the accelerometer (circled) is attached to the index table shown, it has the ability to detect the gravity force produced by tilting its sensitive axis as little as 2 seconds of arc.

Three small metal cylinders are the basic elements of the device. The smallest internal cylinder is the acceleration sensitive element. This is

immersed in a silicone fluid inside the next larger cylinder, which in turn is supported by bearings within the outer shell or case. The middle cylinder is caused to spin at 1000 rpm by a small external motor. This rotates the silicone fluid as well, and produces hydrostatic forces that exactly center the inner sensor away from adjoining walls, thus eliminating the need for bearings. Because no static friction is present, the slightest component of acceleration along the longitudinal axis is measured accurately.

Sperry Gyroscope Co., Dept. ED, Great Neck, N.Y.

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## THERMISTORS

Tapped resistance values give these thermistors added versatility. Called Tap-A-Therm, the thermistors are available in a variety of tapped values, and resemble standard types except for the addition of extra leads to permit in circuit design changes or adjustments. There are nine types, covering the range from 100 to 100,000 ohms. Each unit has from four to seven terminals providing 100 or 200 ohm steps.

Victory Engineering Corp., Dept. ED, P.O. Box 573, Union, N.J.

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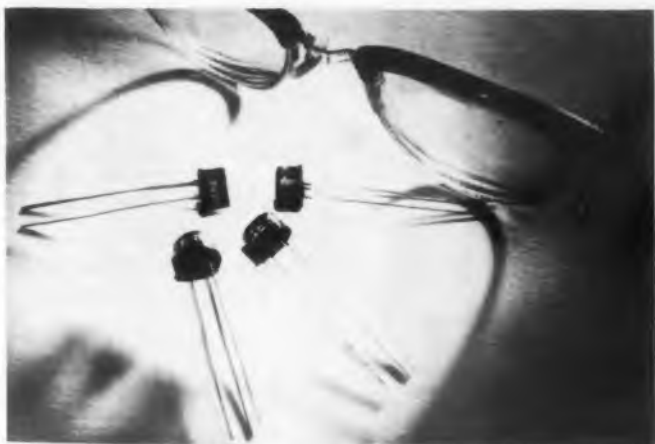


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Avco Manufacturing Corp., Research & Advanced Development Div., Dept. ED, 20 S. Union St., Lawrence, Mass.

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General Electric Co., Semiconductor Products Dept., Dept. ED, Syracuse, N.Y.

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Model SC-18-2-M

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**0.1%**  
REGULATION  
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\*Two units mounted in  
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SC-18-1	0-18	0-1	.02	.2	8 1/8"	4 1/8"	13 5/8"	250.00
SC-18-2	0-18	0-2	.01	.1	8 1/8"	4 1/8"	13 5/8"	295.00
SC-18-4	0-18	0-4	.005	.05	19"	3 1/2"	13"	395.00
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SC-1836-1	18-36	0-1	.04	.4	8 1/8"	4 1/8"	13 5/8"	295.00
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- **RECOVERY TIME** 50 microseconds
- **STABILITY** (for 8 hours) 0.1% or 0.003 Volts (whichever is greater)
- **TEMPERATURE COEFFICIENT** 0.05% per °C. Ambient operating temperature 50°C maximum. Over-temperature protection included. Unit turns off when over-temperature occurs.
- **SHORT CIRCUIT PROTECTION: NO FUSES CIRCUIT BREAKERS OR RELAYS!** Designed to operate continuously into a short circuit. Returns instantly to operating voltage when overload is removed. Ideal for lighting lamps and charging capacitive loads.
- **OVER CURRENT CONTROL** can be set from 0 to 120% of full load.
- **REMOTE PROGRAMMING** at 1000 ohms per volt.
- **REMOTE ERROR SIGNAL SENSING** to maintain stated regulation directly at load.
- Suitable for square wave pulsed loading.
- Continuously variable output voltage without switching.
- Either positive or negative can be grounded.
- Units can be series connected.
- Power requirements: 105-125 volts, 50-65 cycles. 400 cycle units available.
- Terminations on front and rear of unit.
- High efficiency. Low heat dissipation.
- Compact, light weight for bench or rack use.
- Color: grey hammertone.

**ORDERING INFORMATION:**

Units without meters use model numbers indicated in table. To include meters add M to the Model No. (e.g. SC-18-1-M) and add \$30.00 to price.

\*Rack adapter for mounting any two 8 1/8" x 4 1/8" units is available. Model No. RA2 is 5 1/4" h x 19" w, is \$15.00

# HIGH PRECISION

## CHANGE OF STATE CRYSTAL OVEN



AMBIENT VS. CAVITY TEMPERATURE CHANGE

### SPECIFICATIONS

**CAVITY TEMPERATURE:**  $\pm 0.01^\circ\text{C}$   
**TEMPERATURE CONTROL:**  
 Less than 0.005 ppm/deg  
 (temperature drift per degree ambient change)  
**STABILIZATION TIME:**  
 Approximately 30 minutes  
**AMBIENT TEMPERATURE RANGE:**  
 Operating  $0^\circ\text{ to }+50^\circ\text{C}$   
 Storage  $+85^\circ\text{C}$  maximum

### ELECTRICAL

**HEATER VOLTAGE:**  
 $3$  volts A.C. or D.C.  $\pm 5\%$   
**HEATER POWER:**  
 $1.5$  watts max. during warm-up  
 $0.7$  watts max. after warm-up  
**CAPACITY BETWEEN CRYSTALS:**  
 $6.7$  pfd  
**TEMPERATURE COEFFICIENT:** Proportional  
 $1.7/16" \times 1.7/8" \times 4.1/16"$   
 (case height)  
 Approximately  $0.6$  oz.

### APPLICATIONS

Applications requiring precise temperature control may be mounted within the oven cavity. Applications include: *Crystal Oscillator Modules* — exacting frequency control employed in communications, computers, frequency standards and marker circuits for radar and precision test equipment. *Temperature sensitive components* such as zener diodes, thermocouple reference junctions and transistorized oscillator circuits.

Complete information upon request. Ask for Technical Bulletin RF-584



Robertson-Fulton CONTROLS COMPANY

CIRCLE 41 ON READER-SERVICE CARD

# NEW PRODUCTS

## Coaxial TR Tubes

For low frequency high power use



Designed for low frequency high power transmit-receive purposes, the TR860 utilizes a large metal-to-ceramic seal. Measuring 9 in. diam, the coaxial TR tube is cylindrical in shape with smaller window and seal areas than previous low frequency waveguide TR's. The reduction in size of these areas, plus substitution of ceramic for glass in the window, is stated to result in a more rugged yet lighter and smaller tube than conventional types.

Sylvania Electric Products, Inc., Dept. ED, Woburn, Mass.

CIRCLE 42 ON READER-SERVICE CARD

## Bolometer-Thermistor Mounts

Instantly replaceable



Both bolometers and thermistors may be replaced instantly in this series of matched bolometer-thermistor mounts. Replacement elements, available from stock, simply plug in without the use of tools, and require no adjustments.

The mounts feature low vswr of 1.5, without tuning, over the full waveguide band. Models 533 and 536 cover C to L band frequencies and may be used with both bolometers and thermistors. For frequencies from 5.4 to 10.0 kmc, models 531 and 532 are designed for use with bolometers, and models 541 and 542 for thermistors.

Narda Microwave Corp., Dept. ED, Mineola, N.Y.

CIRCLE 43 ON READER-SERVICE CARD



# H-H

"Gray Line"

## COMPONENTS

Designed with Reliability in Mind...

### "Gray Line" Rheostats

- Resistance Element Ceramic-Protected
- Shock Resistant, Rugged Construction
- Positive, Permanent Electrical Contact
- Available in MIL Types

Hardwick, Hindle "Gray Line" Rheostats provide smooth long-life action with positive electrical contact. Super-rugged construction insures maximum shock resistance; resistance element is ceramic-protected.



### "Gray Line" Resistors

- Non-Crazing, High Temperature Enamel
- Stronger, More Rugged Core
- All-Welded Wire Connections
- MIL Types Available

Hardwick, Hindle "Gray Line" Resistors are designed to provide dependable performance in grueling environments. High temperature enamel is non-crazing; welded wire connections and stronger core assures high shock resistance.

Catalog on Request



# HARDWICK HINDLE • INC

40 Hermon St., Newark 5, N. J., U.S.A.

The Mark of Quality since 1924

Sold Thru Authorized Distributors Coast-to-Coast

CIRCLE 44 ON READER-SERVICE CARD

## Control Cable

Features high flexibility



This 42 conductor, no. 24 gauge, vinyl insulated cable is color coded and has a nylon braided jacket. In meeting a flexibility test in which a four foot sample had to be pulled through a 4-in. ring with a pulling load of no more than 4 lb, this cable passed with average pull being between 3/4 to 1-1/4 lb.

Rex Corp., Dept. ED, W. Acton, Mass.

CIRCLE 45 ON READER-SERVICE CARD

## Connectors

Provide true hermetic sealing



Designed to give hermetic sealing against high g forces, heat and cold extremes, pressure and atmospheric variations, vibration and corrosion, these two series of miniature electrical receptacles are designated DM5600 and DM 5606.

The units withstand mechanical shock of 100 g, thermal shock from -100 deg to 500 deg F, temperatures up to 1000 deg F, operating pressures up to 100 psi, and high potentials over 2000 v.

The hermetic seal is obtained when special alloy conductor pins are fused in a furnace with compression glass insulation into a specially designed steel shell.

The Deutsch Co., Dept. ED, 7000 Avalon Blvd., Los Angeles 3, Calif.

CIRCLE 46 ON READER-SERVICE CARD  
CIRCLE 47 ON READER-SERVICE CARD

# The INCREDIBLE SHRINKING RESISTOR...

Daven has always been the leader in the miniaturization of precision wire wound resistors. Now, due to further advances in resistor manufacture, Daven is able to offer higher resistance values in smaller sizes than ever before. Typical miniature units, with their new maximum values, are tabulated here.

For guided missiles, airborne radar, telemetering, and for any application where extremely small size

and dependability are of prime importance, specify Daven miniature wire wounds.

TYPE	DIAM	LENGTH	MAX WATTS	MAX OHMS
1250	1/4	1/2	.33	1 Megohm
1274	3/16	3/8	.25	250 K
1284	1/4	27/64	.25	1 Megohm

THE **DAVEN** co.



LIVINGSTON, NEW JERSEY

TODAY, MORE THAN EVER, THE DAVEN <sup>®</sup> STANDS FOR DEPENDABILITY!

# UAP COOLS

## THE BRAIN THAT GUIDES THE **ARROW**



Canada's Avro CF-105 Arrow, an all-weather, day-and-night jet fighter, is designed for supersonic missions. Armed with air-to-air missiles, its role will be long-range interception in the North American Defense Command.

The Arrow's electronic system, which combines automatic flight, weapon fire control, communication and navigation functions, is specially designed by RCA in the U.S. A vital component in this electronic brain is UAP's Hydraulic and Electronic Cooling System.

At Arrow's supersonic speeds, on the threshold of the "Thermal Thicket," this UAP designed-and-developed cooling system maintains safe operating temperature for Arrow's electronic equipment.

Get complete information on UAP electronic cooling systems... or submit your application problem today for UAP design study! Call the nearest UAP Contractual Engineering Office: Burbank, California VI 9-4236; New York, N. Y. MU-7-1283; Dayton, Ohio BA-4-3841; Montreal, Canada Elwood 4131.

*a famous family of aircraft essentials since 1929*

**UNITED AIRCRAFT PRODUCTS, INC.**

1116 BOLANDER AVENUE, DAYTON, OHIO



DESIGN PERFORMANCE CHARACTERISTICS  
OF U-520878-1 HYDRAULIC  
AND ELECTRONIC COOLING SYSTEM

Components: Pump and Accessories Unit (Reservoir Pressure Relief Valve, Thermal Bypass Valve)  
23" x 6" x 6", wet wt. 17.5 lbs., pump motor power 208 v.a.c., 3-phase, 4 wire, 400 cycle.  
Heat Exchangers, 20" x 9.5" dia., wet wt. 11.5 lbs.  
Max. Heat Loads: 2500 watts (Hydraulic)  
5150 watts (Electronic)  
Required Air Flow: only 75 lbs./min.  
Max. Pressure Drop: 6" H<sub>2</sub>O at 122 lbs./min.  
Operative Altitude Range: to 70,000 ft.

## NEW PRODUCTS

### Component Solver

Lightweight computer device



From inputs in polar coordinate form, this component solver produces outputs in X and Y cartesian coordinates. All inputs and outputs are in the form of shaft rotations. The mechanism, which weighs 3 lbs, is designed for use in lightweight electro-mechanical and mechanical analog computers.

Belock Instrument Corp., Dept. ED, 111-01 14th Ave., College Point, N.Y.

CIRCLE 49 ON READER-SERVICE CARD

### 4PDT Relay

High resistance to shock



The CH-12D relay features a balanced armature and contact section affording higher resistance to shock and vibration. Specifications are as follows: contact rating of 10 amp resistive, 8 amp inductive, at 29 v dc or 115 v ac 400 cps; vibration of 5 to 55 cps at 0.5 in. double amplitude, 55 to 2000 cps at 30 g units; shock of 100 g; temperature range of -65 to +125 C; weight of 5.3 oz; dielectric of 1500 v rms at sea level; and contact resistance of 0.1 ohm max initial.

Allied Control Co., Inc., Dept. ED, 2 East End Ave., New York 21, N.Y.

CIRCLE 50 ON READER-SERVICE CARD



## Binary Counter

Uses magnetic core transformers



The Model 301-D binary counter has plug-in type magnetic cores which may be replaced easily, if necessary. Designed primarily for use with television synchronizing generators, the unit measures 7-3/4 x 3-1/4 x 3-7/8 in. An entire synchronizing generator, model 1005-A2, is also available mounted in a portable carrying case which may also be rack mounted.

Telechrome Mfg. Corp., Dept. ED, 28 Ranick Dr., Amityville, N.Y.  
CIRCLE 51 ON READER-SERVICE CARD

## Discriminator

Switch controlled



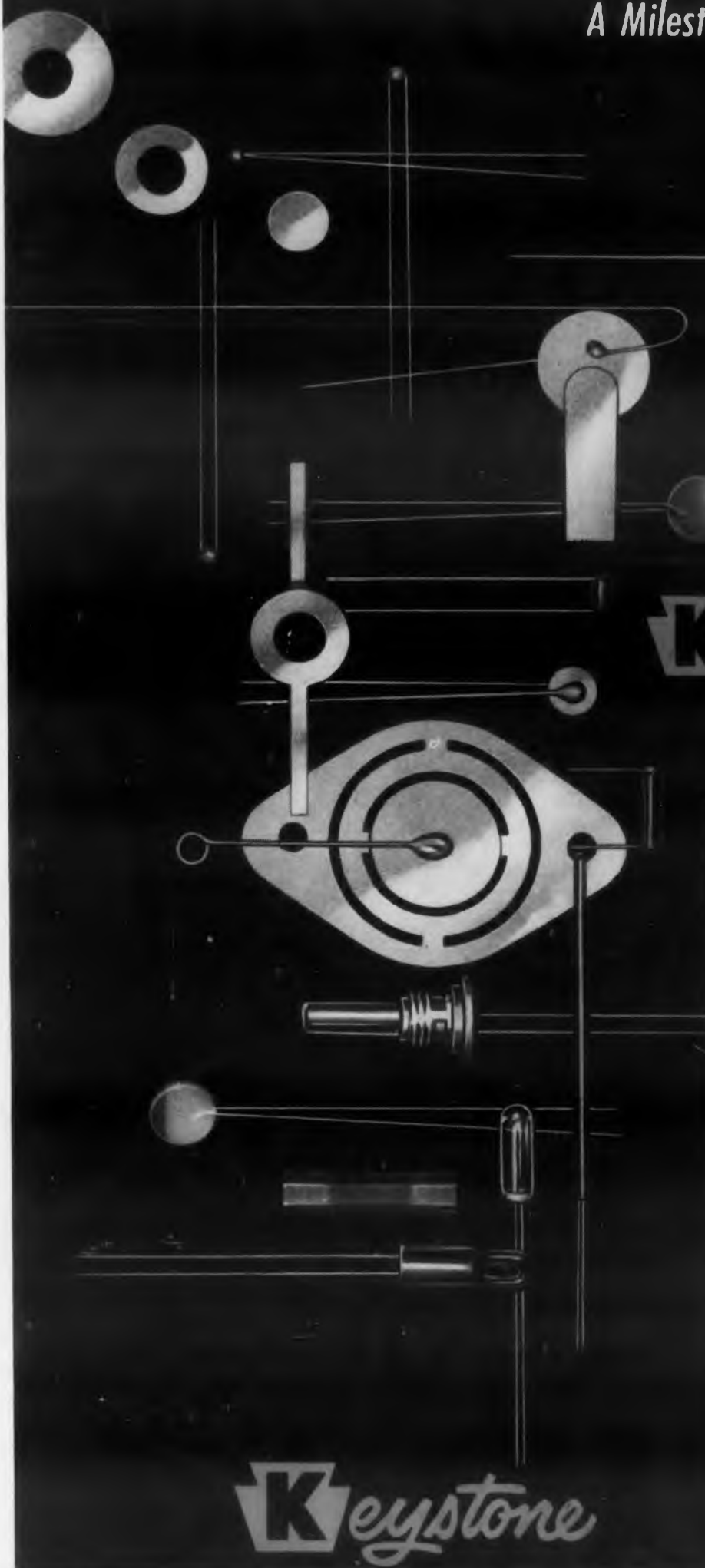
Model GMD-1, switchable discriminator for use in fm/fm telemetry data systems, is a compact 20-channel ground-based subcarrier assembly. Individual push buttons actuate a solenoid-operated 20-position rotary switch which selects all bandpass and output filter components to tune the discriminator to any standard IRIG telemetry channel.

Selector switches permit monitoring of either input or output signals and feed output connectors for driving a counter, voltmeter, penmotor, or galvanometer.

Data-Control Systems, Inc., Dept. ED, 39 Rose St., Danbury, Conn.  
CIRCLE 52 ON READER-SERVICE CARD

CIRCLE 53 ON READER-SERVICE CARD >

A Milestone in Electronics 1938 • 1958



20 YEARS OF  
**Keystone THERMISTOR**  
RESEARCH and PRODUCTION

Within the brief span of two decades, Keystone Carbon Company pioneered the development and commercial introduction of \*negative temperature coefficient resistance thermistors, and has become the principal supplier of these remarkable units to American industry, in the widest variety of forms.

It is an historic fact that the first thermistor shipment from Keystone, totalling 5000 units, occurred early in 1941 after three years of laboratory and pilot work. These units were for bomber intervalometers—a temperature compensation application. Later that year, 125,000 thermistors were supplied as sensing units for tank engine water temperatures—and the production flood began.

Since then, Keystone Thermistors have been supplied to the great names in American manufacturing for many measurement, control, and temperature compensation applications, including such uses as automobile temperature gauges, in meat probes for modern ovens, clinical thermometers, aircraft liquid fuel level indicators, and surge reducers in radio and TV circuits.

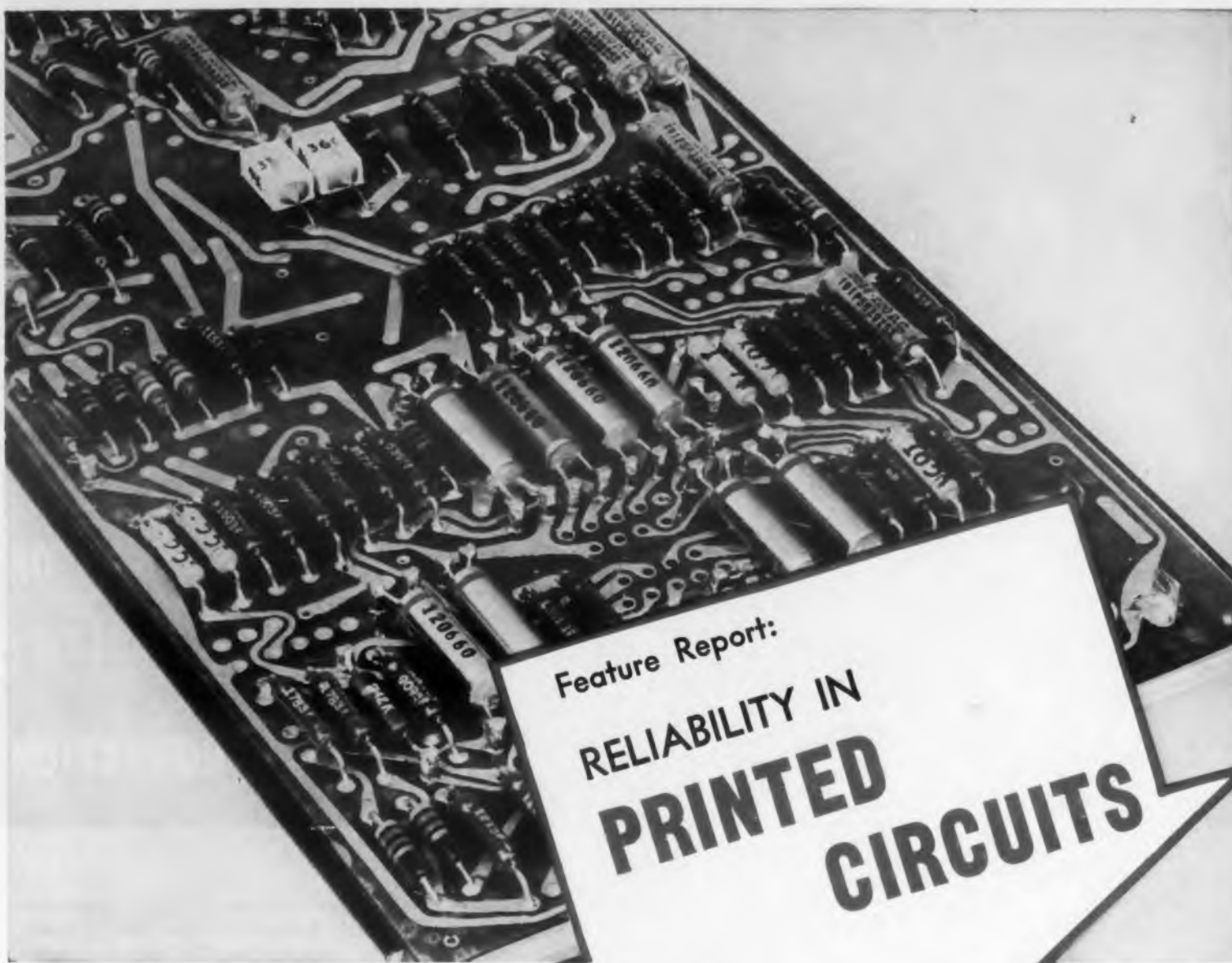
Today, some of the most interesting and promising new applications for Keystone Thermistors are in the very low temperature ranges, where stability and workable resistance values as low as  $-250^{\circ}\text{C}$  are necessary.

Let us suggest that you bring your temperature sensing and compensation problems to **KEYSTONE**—thermistor headquarters for 20 years. Our full cooperation is always available.

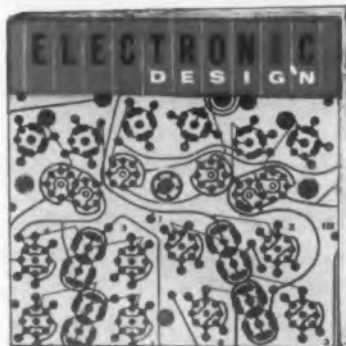
**Keystone**

**CARBON COMPANY**

ST. MARYS, PA.



- PLUG-IN COMPONENTS
- BOARD LAYOUT
- CONNECTORS
- INSULATION
- TEST AND CHECKOUT
- PRODUCTION EQUIPMENT



■ HAYDEN publication

### OPPORTUNITY FOR ADVERTISERS

Design and production of reliable, economical printed circuits will be featured June 11th in *Electronic Design's* Printed Circuits Issue. If you have a product with high reliability characteristics, or if your components, or services can assist the designer with printed circuit problems, or reduce the restrictions placed upon him, you must be represented in this issue.

In more than 4,000 OEM plants, 28,000 electronic design, development, and research engineers will be on the lookout for printed circuit ideas. Be sure to schedule this important issue now—then tie in your ad for extra readership.

PUBLISHED: JUNE 11  
CLOSING: MAY 12

830 Third Avenue, New York 22, N. Y. • PLaza 1-5530

## NEW PRODUCTS

### Digital-Voltage Converter

Accuracies to 0.01 per cent available



Series D high-speed transistorized Multiverter generate a voltage that is the product of a digital number and a fixed or varying reference voltage. If the reference is a fixed voltage, the d units operate as conventional digital to voltage converters. Accuracies up to 0.01 per cent are available and, by sacrificing accuracy, conversion speeds up to 0.5  $\mu$ sec are possible.

Packard-Bell Computer Corp., Dept. ED, 11766 W. Pico Blvd., Los Angeles 64, Calif.

CIRCLE 55 ON READER-SERVICE CARD

### TWT Amplifier

For C band application



Model 506 traveling wave tube amplifier has a power output of 1/2 watt or more from 4 to 8 k mc, and 1 w from 3.5 to 7.5 k mc. This amplifier is particularly suitable for antenna range work. Small signal gain is 32 db or more. By optimizing helix voltage, gain may be increased to 35 db over a substantial part of the frequency range. All r-f connections are made with type N connectors.

Alfred Electronics, Dept. ED, 897 Commercial St., Palo Alto, Calif.

CIRCLE 56 ON READER-SERVICE CARD

### Wirewound Resistors

Bobbinless construction

Designed for printed circuit boards, and sub-miniature assemblies for airborne and missile applications, these resistors, style R-2, have a resistance range of 0.1 ohms to 750 kilohms. The

units have a max length of 26/64 in., max diam of 17/64 in., and a lead length of 1 in. max.

Operating voltage is 250 v dc, and the bobbinless construction eliminates strain and stress on wire under extreme environmental conditions.

General Transistor Corp., Dept. ED, 91-27 138th Place, Jamaica 35, N.Y.

CIRCLE 57 ON READER-SERVICE CARD

### Silicon Diode Series

750 ma at 50 C, with up to 400 piv



Comprised of types 1N536 through 1N540, this series is rated at 750 ma at 50 C, and 250 ma at 150 C ambient, with piv ratings of 50, 100, 200, 300, and 400 v respectively. Maximum full load average voltage drop is 0.5 v. Maximum leakage current is 0.4 ma.

International Rectifier Corp., Dept. ED, 1521 Grand Ave., El Segundo, Calif.

CIRCLE 58 ON READER-SERVICE CARD

### PC Coil Forms

Are not threaded internally



This line of ceramic printed circuit coil forms (types 2525, 2530, 2540, 2550) are available with four terminals for printed circuit mounting. Made completely of class H materials, the units are equipped with the Perma-Torq locking device. The forms are not internally threaded. Instead, the tuning core is affixed to the form through a brass housing at one end; a design which results in a more precise element and finer tuning.

Cambridge Thermionic Corp., Dept. ED, 445 Concord Ave., Cambridge 38, Mass.

CIRCLE 59 ON READER-SERVICE CARD

## Specialists in special purpose tubes

**THYRATRONS**—An extensive line of thyratrons for use as grid control rectifiers, relays and noise generators. Inverse voltage ranges from 100 to 5,000 volts. Sizes from subminiatures to ST 16 bulbs. Filamentary as well as hot and cold cathode types are available.

**RECTIFIERS**—Both vacuum and gas filled tubes with peak inverse voltage ratings from 200 to 15,000 volts. Included are tubes with special features such as fast warm-up, cold cathodes, clippers, serviceratings and rugged construction.



**VOLTAGE REGULATOR AND REFERENCE TUBES**—Gas filled tubes designed to specific voltages for regulating small currents. Also used to make available stable reference voltages for high current supplies. Sizes from subminiatures to bantams, including many reliable, ruggedized types.

**TWIN POWER TRIODES**—The most complete line of high current twin power triodes developed especially for regulated power supply usage. Current and power ranges up to 800 milliamperes and 60 watts respectively. Included are rugged types in both low and medium mu construction.

**TELEPHONE TYPES**—A highly specialized line of vacuum and gas filled types in both the 300 and 400 series.

**HYDROGEN THYRATRONS**—Used primarily as switching tubes in line type radar modulators, these tubes permit accurate control of high energy pulses. Sizes from miniatures to the VC 1257. Peak pulse power ranges from 10 kilowatts to 33 megawatts.



Chatham research and development has produced many new tube types that have become industry standards. If you have a special purpose tube problem, Chatham experience can help you find the solution.

# CHATHAM

**CHATHAM ELECTRONICS** Division of **TUNG-SOL ELECTRIC INC.**

General Office and Plant: Livingston, New Jersey  
SALES OFFICES: CHICAGO, DALLAS, LIVINGSTON, LOS ANGELES

CIRCLE 60 ON READER-SERVICE CARD



### TPC-2 Specifications

Input Voltage:	12 vdc nominal
Input Current:	6.2 a full load, 0.8 a no load
Maximum Rated Output:	400 ma @ 150 vdc or 200 ma @ 300 vdc
Efficiency:	Better than 80% at full load
Load Regulation:	Less than 15%, No Load to Full Load Less than 8%, One-Half Load to Full Load
Ambient Temperature:	-40° F. to + 150° F.
Ripple:	0.5% full load, RMS basis
Dimensions:	3 3/4" H x 3 3/2" L x 2 3/4" W
Weight:	1 1/4 lbs.
Price:	\$125.00 (F.O.B. Houston, Texas)

There's an  
**SIE Power Supply**  
to meet  
any application

DC to DC  
DC to AC  
AC to DC

New circuit developments now enable SIE to offer transistorized power supplies to cover all possible applications: DC to DC, DC to AC and AC to DC; regulated and unregulated, high and low voltage and current ratings, for laboratory, industrial and military installations.

Especially significant is SIE's new circuit which permits operation from DC input voltages above 30 volts without requiring special transistors.

In the 60 watt TPC-2, an ingenious case design permits it to be used in free air without a heat sink, or attached to a heat sink in a confined space.

Check these specifications. They will suggest many new applications for these latest SIE contributions to *Electronic Instrumentation for Industrial Progress*.



### SOUTHWESTERN INDUSTRIAL ELECTRONICS COMPANY

2831 POST OAK ROAD • P O BOX 13058 • HOUSTON, TEXAS

CIRCLE 61 ON READER-SERVICE CARD

## Announcing a new ALLISON FILTER with

### CONTINUOUSLY VARIABLE PASSIVE NETWORK AUDIO FREQUENCY FILTER—MODEL 420P

A new Allison High Pass-Low Pass Filter permits *direct reading of the frequency dial!* The new filter, Model 420P, has separate High Pass-Low Pass Continuously Variable sections, allowing you to set up any band width within the range of 20 cycles to 20,000 cycles. For rapid, accurate analysis of noise, *specify Allison Filters!*



Write for Engineering  
Bulletin with complete  
technical data.



### Allison Laboratories, Inc.

14185 E. SKYLINE DRIVE • LA PUENTE, CALIFORNIA

CIRCLE 62 ON READER-SERVICE CARD

## DIRECT READING DIAL

### ALLISON 420P FILTER FEATURES

- Continuously variable frequency range from 20 cycles to 20,000 cycles
- 20 db attenuation in first octave
- Passive network • No power supply
- No vacuum tubes
- Dynamic range 140 db
- Designed for 600 ohms impedance
- Plug-in input-output transformers for other impedances
- Maximum input 2 volts
- Low loss—Approximately 2 db in pass band
- Low Pass Signals from d-c to cut-off frequency
- Minimum band width approximately one-half octave

## NEW PRODUCTS

### Power Supply

High resolution and stability permits use as standard



Two mv resolution and directly calibrated controls enable model 407 power supply to calibrate panel meters and multimeters. Regulation of model 407 against line or load changes is 0.01 per cent. Long term stability is better than 0.05 per cent. In addition to the 0-555 v dc 300 ma range, two 6.3 v ac 5 amp filament windings, two variable bias outputs (0-25 v dc and 0-225 v dc are available).

John Fluke Mfg. Co., Inc., Dept. ED, 1111 W. Nickerson St., Seattle 99, Wash.

CIRCLE 63 ON READER-SERVICE CARD

### Transistor Test Set

Tests basic characteristics



Model 210-A ascertains the basic characteristics of all types of small transistors. With the addition of a laboratory oscillator and a-c voltmeter, the a-c operated and completely self-contained test set can make alpha cut-off, beta cut-off, collector capacitance and other high frequency measurements. The performance of any given circuit can then be predicted with respect to voltage and power gain, matching impedances, and frequency response.

The instrument operates on a frequency of 1.5 kc with emitter supply impedance of approximately 200 K and collector supply impedance of approximately 5 ohms. Weighing 18 lb, Model 210-A measures 15 x 13 x 4 in.

Owen Lab., Inc., Dept. ED, 55 Beacon Pl., Pasadena, Calif.

CIRCLE 64 ON READER-SERVICE CARD

## Potentiometer

Linearity of  $\pm 0.3$  per cent in production quantities



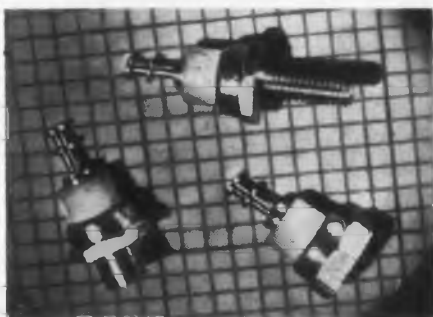
Model 087 size 9 potentiometers are available with linearity accuracies to  $\pm 0.3$  per cent in production quantities. Non-linear functions can be furnished. Specifications include a resistance range of 20 K, resistance tolerance of 2 per cent, and a standard electrical angle of 340 deg  $\pm 2$  deg.

George Rattray Co., Dept. ED, 116-08 Myrtle Ave., Richmond Hill 18, N.Y.

CIRCLE 65 ON READER-SERVICE CARD

## Printed Circuit Connectors

Bifurcation provides larger contact surface



The Bellows Action contact for printed circuit connectors provides a redundant circuit, with two independent spring leaf contact actions for greater reliability. Coil spring action grip of the bifurcated contact clasps the printed circuit board over its entire contact area. A gold plated phosphor bronze spring retains tension when used with either undersized or oversized tolerance boards. The contact resistance is rated at less than 20 mv at 5 amp.

Wiring styles include eyelet lug for soldering, solderless wire wrap lug, taper tab solderless wiring, and contacts for dip soldering.

Dejur-Amsco Corp., Electronic Sales Div., Dept. ED, 45-01 Northern Blvd., Long Island City 1, N.Y.

CIRCLE 66 ON READER-SERVICE CARD

CIRCLE 67 ON READER-SERVICE CARD



## MINIATURIZED SEALED RELAYS



## VIBRATION...yet normal operation

No—we don't use paint mixers to measure the vibration resistance of General Electric miniaturized sealed relays. But, it is a dramatic illustration of the punishment G-E hermetically sealed relays can—and do—withstand.

The best of laboratory equipment is used to measure this vibration resistance, and the results prove—General Electric voltage-calibrated Micro-miniature relays withstand vibration of 20 G's acceleration from 55 to 2000 cycles (.125 inch excursion from 10 to 55 cycles).

Excellent vibration resistance is just one of the many "plus" features—such as high- and low-temperature operation, high shock resistance, and rugged construction—you get with *all* Miniature, Sub-miniature, and Micro-miniature G-E sealed relays. Today, General Electric relays are proving their reliability on a variety of military and industrial electronics applications.

What's more, you get all of General Electric's complete line of standard-listed relays on *only 3-week shipment from*

*receipt of order—plus—immediate service on samples and prototypes.*

For further information, contact your G-E Apparatus Sales Office—or—write to General Electric Co., Sect. 792-7, Schenectady 5, N. Y., for complete relay data. *Specialty Control Dept., Waynesboro, Va.*

*Progress Is Our Most Important Product*

**GENERAL  ELECTRIC**

## NEW PRODUCTS

### Recorder Amplifiers

Isolated differential input



DC  $\mu\text{v}$  signals as low as 20  $\mu\text{v}$  can produce full scale deflection of a high speed 12 in. chart potentiometer in 1/4 sec or less with the Model 2HLA-7 preamplifier. This preamplifier has an isolated differential input, 20 cps frequency response, 1  $\mu\text{v}$  recorded noise and drift, and gains as high as 100,000.

Applications for the preamplifier-recorder combination include low level thermocouple and differential thermocouple measurements, strain gage analysis, measurement of low output photocells, other processes where low level signals could be traced on a recording potentiometer.

Minneapolis-Honeywell, Boston Div., Dept. ED, 1400 Soldiers Field Rd., Boston, Mass.

CIRCLE 68 ON READER-SERVICE CARD

### Differential Transformer

Explosion-proof model for 500 F use

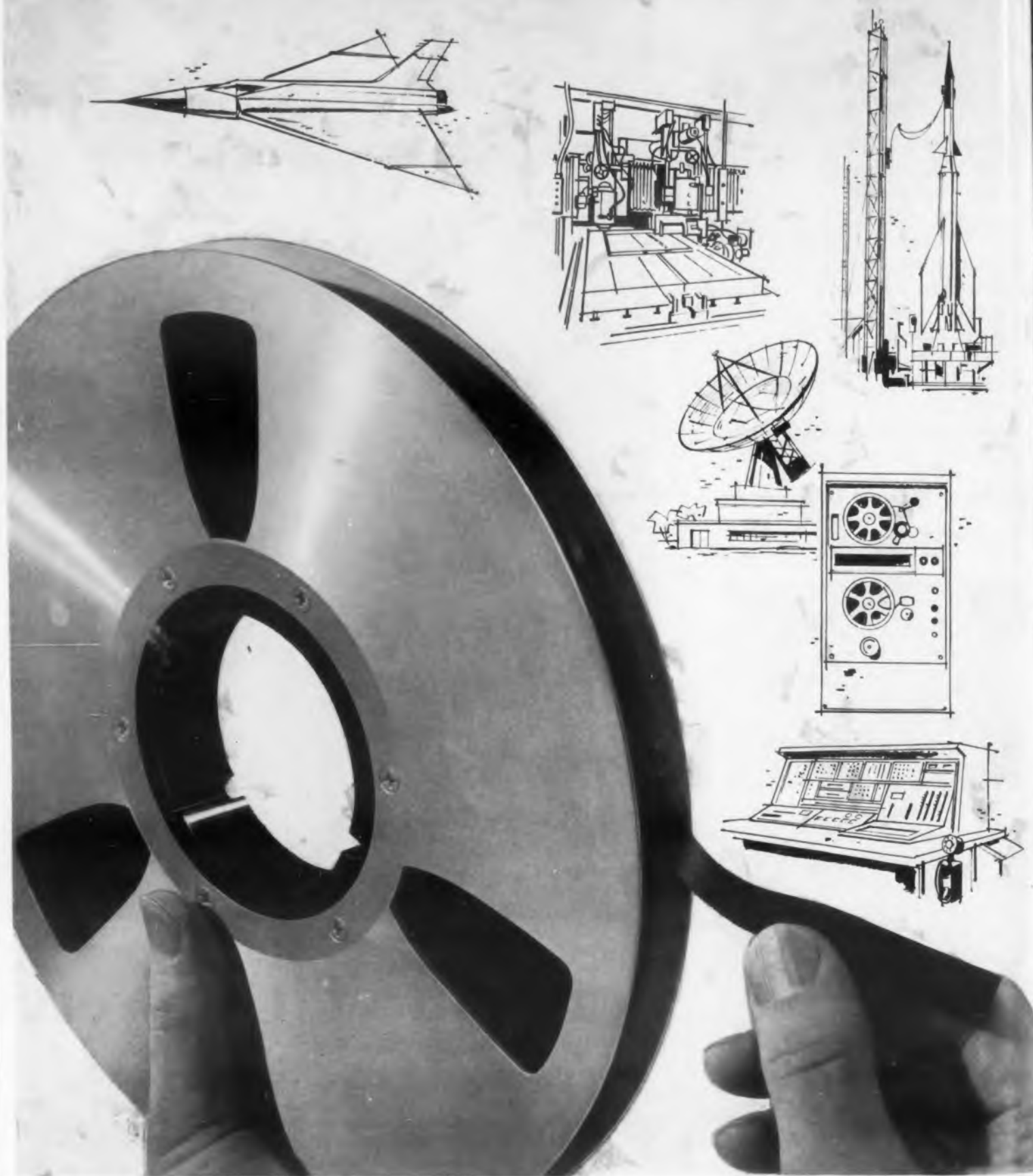


This Atcotran differential transformer is explosion-proof and permits operation in temperatures up to 500 F. The unit measures 2-1/8 in. long by 1-1/4 in. od. Range is  $\pm 0.15$  in. with a sensitivity of 0.5 mv output per 0.001 in. displacement per volt input at 400 cps. For a 20 v 400 cps input, the output is 0.001 amp to 500 ohm load for 0.05 in. armature motion.

Automatic Timing & Controls, Inc., Dept. ED, King of Prussia, Pa.

CIRCLE 69 ON READER-SERVICE CARD

# TAPES YOU CAN



**MINNESOTA MINING AND MANUFACTURING COMPANY**

... WHERE RESEARCH IS THE KEY TO TOMORROW



The term "SCOTCH" is a registered trademark of 3M Company, St. Paul 6, Minn. Export: 99 Park Avenue, New York. Canada: London, Ontario.

# TRUST because only **SCOTCH** Instrumentation Tapes assure absolute dependability inch after inch...reel after reel

You can't afford to compromise with accuracy, reliability and uniformity in critical recording work — instrumentation, computers, machine tool control and other technical applications. You need a magnetic tape of proven instrumentation quality, "SCOTCH" Brand Magnetic Tape.

These are precision tapes — engineered in the world's leading tape laboratories to meet your specific needs. You can trust "SCOTCH" Brand Instrumentation Tapes because they're made of only flaw-free materials and every reel put to more than 100 rigid quality control tests.

## PHYSICAL AND MAGNETIC PROPERTIES OF "SCOTCH" BRAND MAGNETIC TAPES — INSTRUMENTATION QUALITY



Tape Number Description	108 Std. Instrumentation	109 Std. Instrumentation	128 Hi-Output Instrumentation	159 Extra Play Instrumentation
<b>Physical Properties</b>				
Backing Material	Polyester	Acetate	Polyester	Polyester
Thickness in mils				
Backing	1.45	1.42	1.45	.92
Coating	.55	.55	.65	.35
Ultimate Tensile Strength 1/4" Wide —				
Room Condition	9#	5.8#	9#	7#
Yield Strength 5% Stretch in 1/4" Width	5.4#	4.5#	5.4#	3.8#
Elongation at Break	100%	25%	100%	100%
Coefficient of Friction	0.33	0.33	0.30	0.33
Residual Elongation	0.5%	1.5%	0.5%	0.5%
Slitting Tolerances	+ .000 ins. - .004 ins.	+ 0.0% - 0.8%	+ .000 ins. - .004 ins.	+ .000 ins. - .004 ins.
Toughness				
Tear — grams	26	3	26	12
Impact — Kc — cms	100	20	100	70
Coefficient of Expansion* Humidity (units per % RH change)	1.1 x 10 <sup>-5</sup>	15 x 10 <sup>-5</sup>	1.1 x 10 <sup>-5</sup>	1.1 x 10 <sup>-5</sup>
Temperature (units per °F.)	2 x 10 <sup>-5</sup>	3 x 10 <sup>-5</sup>	2 x 10 <sup>-5</sup>	2 x 10 <sup>-5</sup>
Temperature Limits for Safe Use				
Low	-40°F.	-40°F.	-40°F.	-40°F.
High	+140°F.	+140°F.	+185°F.	+140°F.
†Relative Wear Ability	100%	100%	250%	100%
<b>Magnetic Properties</b>				
Intrinsic Coercivity (Hci)	250	250	240	240
Oersted's Retentivity (Brs) Gauss	700	700	1100	1100
Remanence (Flux lines/ 1/4" tape)	0.6	0.6	1.2	0.6
Relative Output in db at 1% distortion** 15 mil Wave Length	0	0	+6	0
Relative Sensitivity in db** 15 Mil Wave Length	0	0	+3.5	+1.5
1 Mil Wave Length	0	0	0	+3.5
Erasing Field	1000	1000	900	800
Uniformity at 15 Mil Wave Length				
Within a Roll	±3%	±3%	±3%	±3%
Roll to Roll	±10%	±10%	±10%	±10%
Dropout Count** Errors/1 Roll	1	1	1	1

\*These coefficients are unitless and represent the change per % RH or degree Fahrenheit over the following ranges:  
Humidity: 20% RH to 80% RH  
Temperature: -30°F. to +130°F.

\*\*At optimum bias for each tape type.

\*\*\*Measured by recording 200 non-return pulses per inch on a 0.035" track. A reduction to less than 50% normal signal amplitude constitutes a signal error. Zero errors are measured by saturating the tape unidirectionally. Each spurious signal greater than 10% of normal signal amplitude constitutes a zero error. Errors per roll based on recording 7 tracks on rolls 1/2" x 2500'.

†Relative wear ability is considered as 100% for 109 Tape. Relative output is established by 109 which is designated as zero. All other tapes are expressed as gradations from this reference point.

**FREE BOOKLET!** Get all the facts about America's most complete line of instrumentation quality tapes. Mail this coupon for your free specification catalogue.

Minnesota Mining & Mfg. Co., Instrumentation Tape Div.  
900 Bush Avenue, St. Paul 6, Minnesota  
Please send me a free copy of your instrumentation booklet.

NAME \_\_\_\_\_  
POSITION \_\_\_\_\_  
COMPANY \_\_\_\_\_  
ADDRESS \_\_\_\_\_  
CITY \_\_\_\_\_ ZONE \_\_\_\_\_ STATE \_\_\_\_\_

CIRCLE 70 ON READER-SERVICE CARD

## Rate Meter Fast quantitative analysis



Model 412, a premium log and linear multi-range rate meter, is extremely useful for fast quantitative analysis. Applicable in high-speed scintillation and proportional counting systems, the unit simultaneously provides logarithmic and precision linear displays.

The five-decade logarithmic scale allows continuous accurate monitoring of activity levels varying over the widest ranges normally encountered.

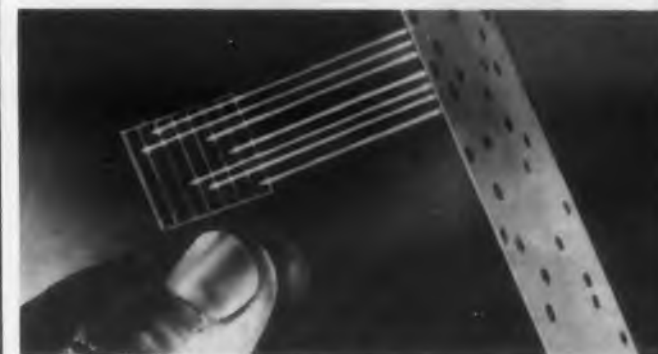
Model 412 will drive any standard potentiometer or galvanometer-type recorders from both linear and log scales. Selectable by a ten-position front panel switch, the linear scale has ranges of 0 to 30 cpm and 0 to 1,000,000 cpm. A special five-cycle log scale provides a logarithmic range of 10 to 1,000,000 cpm.

Baird-Atomic, Inc., Dept. ED, 33 University Rd., Cambridge 38, Mass.

CIRCLE 71 ON READER-SERVICE CARD

## Photo-Voltaic Cells

Silicon types with 20 μsec response



This series of silicon photo-voltaic cells has a response time of less than 20 μsec and very high lifetime expectancy. The cells operate, with no appreciable loss in efficiency, through a temperature range from -65 to +175 C, with an effective spectral response range from 3000 to 8000 angstroms. Applications include punched tape and card readouts, programming controls, pin-hole detection, remote switching controls, infrared sensing, and automatic counting.

Hoffman Electronics Corp., Semiconductor Div., Dept. ED, 930 Pitner Ave., Evanston, Ill.

CIRCLE 72 ON READER-SERVICE CARD

Light as a Feather



**Hoffman**  
Zener Reference Elements  
Designed Specifically for  
**PRINTED CIRCUITS**

EIA No.		ELECTRICAL CHARACTERISTICS			
		Operating Voltage @ 10mA and 25°C (Volts)	Maximum Change in operating voltage -55 to + 100°C (Volts)	Maximum Dynamic Impedance @ 10mA (Ohms)	
ACTUAL	SIZE	INI530	8.4 ± 5%	.014	15
		INI530A	8.4 ± 5%	.007	15

Operating and Storage Temperature Range: -65°C to + 150°C

**Lightweight and rugged for airborne applications**

Hoffman . . . leader in silicon semiconductor devices . . . now offers this new line of sub-miniature ZENER REFERENCE ELEMENTS, specifically designed to maintain a constant DC voltage level under extreme Temperature, Shock and Vibration conditions. This new light weight . . . 8 grams . . . "Circuit commander" is ideal for use in applications demanding a stable and reliable voltage reference . . . in a case designed for miniaturized and printed circuit mounting.

Types INI530 and INI530A are available from stock to specifications per the chart above.

Write for complete information, Technical Bulletin TIB 28-58.

**Hoffman Electronics CORPORATION**  
SEMICONDUCTOR DIVISION  
930 Pitner Avenue • Evanston, Ill.  
UNiversity 9-9850



**LEADER IN DIFFUSED JUNCTION SILICON SEMICONDUCTORS**



Silicon Zener Power Regulators



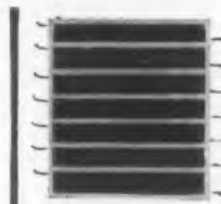
Silicon Junction Diodes



Silicon Medium Power Rectifiers



Silicon Micro-Miniature (Glass) Diodes



Silicon Photo-Voltaic Cell Assemblies

CIRCLE 73 ON READER-SERVICE CARD

**NEW PRODUCTS**

**Temperature Control**

Utilizes magnetic amplifiers

Use of bi-stable magnetic amplifiers in place of relays in this temperature control extends operational life. Potting is used to bond together the entire unit. Proportional pulse modulation permits small deadbands in a high response system with good stability. When an error is detected at the edge of the deadband, short duration, full power pulses are applied to an actuator or valve motor. As the magnitude of the error increases, the power pulses are of longer duration until finally power is applied to the actuator continuously.

The Garrett Corp., Dept. ED, 9851 Sepulveda Blvd., Los Angeles 45, Calif.

CIRCLE 74 ON READER-SERVICE CARD

**Heat Dissipator**

Press fitted over transistor



Designed to fit the JETEC-30 package, this device permits efficient heat dissipation for transistors. The finned jacket is made of black anodized aluminum alloy and can be press fitted over the transistor case without interfering with operation or servicing. Type 3AL-635 maintains a dissipation coefficient of Kr 0.28°C/mw.

The Birtcher Corp., Dept. ED, 4371 Valley Blvd., Los Angeles 32, Calif.

CIRCLE 75 ON READER-SERVICE CARD

**Coaxial Cable**

Highly stable to 200 C



Teflon jacketed, this low capacity, high temperature, miniature coaxial cable has a capacitance stability of 2 per cent from -65 to 200 C. Nominal outside diameter of the cable is 0.185 in.



The cable has a capacity of 10  $\mu$ f per ft at 1 mc with 125 ohms at 1 mc characteristic impedance. Velocity of propagation is 81 per cent. Other electrical properties show attenuation of 10 db per 100 ft at 250 mc, and 16.5 db per 100 ft at 400 mc.

The Rex Corp., Dept. ED, Hayward Rd., West Acton, Mass.

CIRCLE 76 ON READER-SERVICE CARD

## Galvanometer Amplifier

60 ma output



System D is a 4-channel galvanometer amplifier package including power supply. It is suited for use with wire strain gages and other transducers, and will drive low-sensitivity, high frequency galvanometers. Features include a balanced input, high output of  $\pm 60$  ma, phase sensitivity, high stability, low noise level, overload indicator and protector, and no operational delay when overloaded.

Allegany Instrument Co., Inc., Dept. ED, 1091 Willis Mountain, Cumberland, Md.

CIRCLE 77 ON READER-SERVICE CARD

## Potentiometers

High resolution



Designed in 1-7/16 in. and 1-3/4 in. sizes, these potentiometers feature the availability of a wide range of special electrical features. Standard resolution for Model 1437 (1-7/16 in.) is 3900 wires, with a resistance range from 100 to 160,000 ohms. Model 1750 (1-3/4 in.) is available with resolution to 5000 wires, and with resistance ranging from 100 to 300,000 ohms. The standard linearity range for both units is 0.5 per cent to 0.1 per cent.

G. M. Giannini & Co., Inc., Dept. ED, Pasadena, Calif.

CIRCLE 78 ON READER-SERVICE CARD



# 18 Years of Progress at E-I

## 1940

... specialists in glass to metal seals for over 18 years. Research, development and manufacture devoted exclusively to the production of sealed terminations.

## 1951

... pioneered the production of compression type glass-to-metal seals. E-I developed and made a practical reality of the first compression seal, now the standard of the industry.

## 1957

... expanded research paces industry's varied needs. Universal acceptance of super-durable E-I hermetic seals made necessary expansion of research, engineering and production facilities.

## 1958

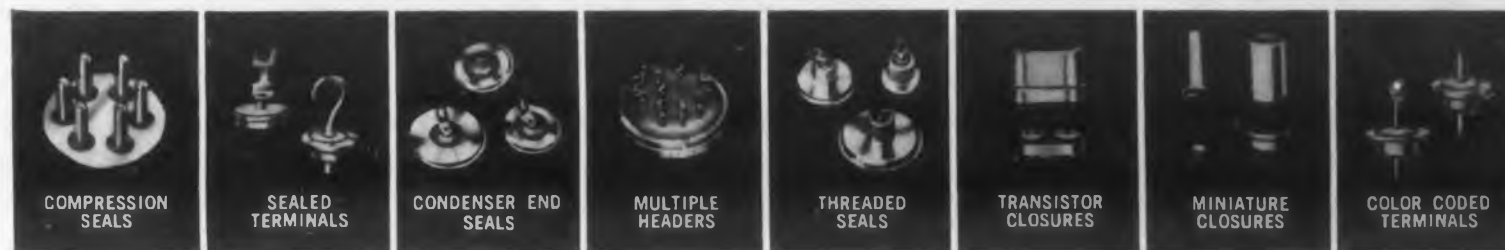
— and offering designers in industry's most complete standard line!

# GLASS-TO-METAL SEALS\*

E-I glass-to-metal seals are available in hundreds of economical types of standardized designs. The complete line ranges from single lead terminals to miniature closures and color coded terminals. Specify E-I super-rugged compression type seals for critical military and commercial appli-

cations. Save time and eliminate custom sealing costs by using application-proven, standardized seals that meet practically every hermetic sealing requirement. Complete engineering data on the E-I Standard Line is contained in one helpful handbook. Write for your copy now.

Select your seals from the complete E-I Standard Line ...



## ELECTRICAL INDUSTRIES

A Division of Philips Electronics, Inc. • MURRAY HILL, N. J.



\* MANUFACTURED UNDER CANADIAN PATENT 523,390. UNITED KINGDOM PATENT 734,583 AND LICENSED UNDER U.S. PATENT 2561520  
CIRCLE 79 ON READER-SERVICE CARD

Power supply users benefit from  
outstanding record of field performance

# LAMBDA GUARANTEES POWER SUPPLIES FOR FIVE YEARS

## DEPENDABILITY IS VITAL



Lambda power supplies are components of IBM's SAGE computer, the world's largest electronic digital computer.

Lambda Com-Pak supplies, with front panel modifications, used by Western Electric to power United States continental air defense system tests.



Standard Lambda power supplies specified by Stromberg-Carlson for multi-million dollar Air Force Digital Computer Intervention and Display System.

## Retroactive to all Lambda Power Supplies purchased since 1953

Now Lambda gives you the strongest proof of consistent trouble-free power supply performance ever offered.

The unprecedented five-year guarantee is based on the excellent experience owners of Lambda power supplies have had with their equipment under the most grueling, heavy-duty service.

You are covered not only on new Lambda supplies, but also on all Lambda equipment you have purchased since 1953.

### See new Lambda Transistorized Power Supplies at I.R.E. Show

They will be on display in Booths 2436 and 2438. You'll also want a close-up view of Lambda's Com-Pak series, for all needs up to 1.5 amperes. The Com-Pak models are real space savers. They need only 5 1/4" to 8 3/4" of front panel height, depending on the model.

### Send for latest catalog

Your request, on your company letterhead, brings you complete data on all Lambda power supplies—rack, bench and portable.



**LAMBDA Electronics Corp.**

11-11 131 STREET • COLLEGE POINT 56, NEW YORK

INDEPENDENCE 1-8500 Cable Address: Lambdatron, New York

## NEW PRODUCTS

### High Power Loads

Both coaxial and waveguide types



This line of high power loads in both coaxial line and waveguide is stated to take more than 75 per cent of the full power capabilities of the line size used. Examples of power handling capabilities offered as follows: X-band 900 w average power, overall length 9 in.; 1-5/8-in. coaxial line size, 1000 w average power, 12-1/2 in. length, and a 7/8-in. line size, 1000 w average power, 18 in. overall length.

Douglas Microwave Co., Inc., Dept. ED, 252 E. Third St., Mount Vernon, N.Y.

CIRCLE 81 ON READER-SERVICE CARD

### Scaler

Counts pulses from nuclear instruments



Model 762 high speed scaler consists of an input pulse height discriminator, a fast scale of 10, three slow-speed counter decades and a six-digit electromechanical register. The fast scale uses a Burroughs beam switching tube capable of counts in excess of 1 million counts per sec. Slow-speed decades are dekatron counter tubes capable of 5000 counts per sec.

The scaler permits counting pulses from nuclear instruments at high rates with low coincidence loss.

Victoreen Instrument Co., Dept. ED, 5806 Hough Ave., Cleveland 3, Ohio.

CIRCLE 82 ON READER-SERVICE CARD

← CIRCLE 80 ON READER-SERVICE CARD

## Stepping Motor

Provides high accuracy



The stepping motor is designed to rotate an external shaft and connected load through any specified angle up to 36 deg in response to a pulsed electric input signal. The unit will accept consecutive command pulses from either of two independent sources in any order. Resulting successive shaft steps may be continuously clockwise or counter-clockwise, or any random combination of the two directions.

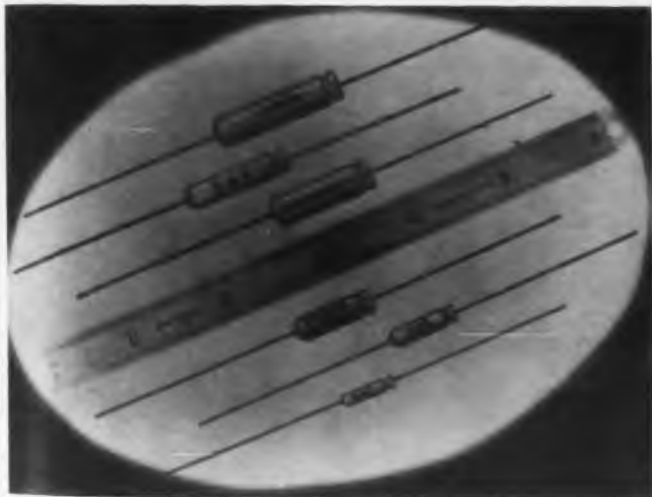
Designed for standard servo mounting, size 15, the stepping motor will operate at any altitude and at temperatures ranging from  $-65$  to  $+160$  F.

Clary Dynamics, Dept. ED, 408 Junipero St., San Gabriel, Calif.

CIRCLE 83 ON READER-SERVICE CARD

## Tantalum Capacitors

Ratings up to 150 wvdc



These low voltage tantalum foil capacitors consist of 15 sizes of both etched and plain foil tantalums, 0.125 od x 5/16 in. long to 0.375 od x 2-12/16 in. long. Voltage ratings are available from 3 wvdc to 150 wvdc and capacities from less than one  $\mu$ f to 6000 at 3 wvdc.

The units operate in the temperature range of  $-55$  to  $+125$  C. Featuring a solid cathode end construction, the capacitors are cased in silver or silver plate.

International Electronics Industries, Inc., Dept. ED, Nashville, Tenn.

CIRCLE 84 ON READER-SERVICE CARD



## CONTROL is first! Now—one step static control with switching reactors

No wonder Nikita looks worried. CONTROL has taken the strain off American industry's pocketbook by cutting the cost of static control.

American engineers who want to make free use of power switching guided by digital logic can now take over, because CONTROL's standard line of switching reactors give freedom of design and economy never before available.

First, one-step static control with switching reactors is so easy to operate it can be put to work in everyday sequencing and switching problems involving either a-c or d-c loads. Auxiliary equipment is eliminated by the basketful. Gone are all the preamplifiers, special power supplies, information-sorting single purpose logic units, and power switching relays. CONTROL's one-step switching reactor does most of the job by itself.

Second, these units, in four nominal volt-ampere ratings of 15, 75, 150 and 300, have no relay contacts or moving parts to replace. Switching is by impedance change. Install them and forget them—no wear, no maintenance.

Third, each CONTROL reactor performs all logic functions—AND, OR, NOT, MEMORY and TIME DELAY—through its multi-purpose control coils. Signal source is derived typically from limit switches, push buttons, or photo-cells.

Fourth, each unit has a 10,000:1 switching ratio under nominal supply voltage conditions. High inrush currents are handled without difficulty.

To learn how CONTROL reactors work, and how they'll fit your need for completely dependable, low-cost, versatile static control, write—and see why Nikita looks worried. CONTROL, Dept. ED-46, Butler, Pa. U. S. A.

Reliability begins with **CONTROL**



A DIVISION OF MAGNETICS, INC.

\*Expurgated translation. Heavens-to-Betsy!

CIRCLE 85 ON READER-SERVICE CARD

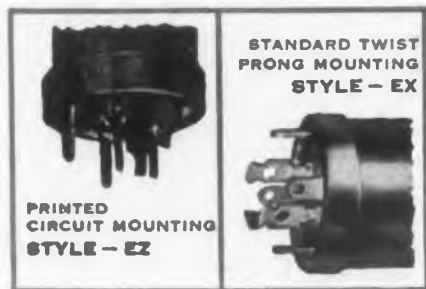


ASTRON 'SAFETY MARGIN' \*  
ELECTROLYTIC CAPACITORS

## for transistorized and printed circuits

### IMPORTANT DESIGN ADVANTAGES OF ASTRON EZ AND EX ELECTROLYTICS

- \* MINIATURIZED SIZE—LIGHT IN WEIGHT
- \* DESIGNED FOR MINIMUM LOSSES —  
LOW DRAIN
- \* LONG "SHELF" AND OPERATING LIFE
- \* HERMETICALLY SEALED
- \* RUGGEDLY CONSTRUCTED



\*Trade-Mark

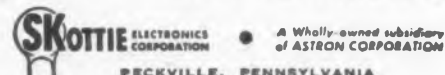
Today's low-voltage transistorized and printed circuits demand capacitors with absolute minimum leakage and impedance. To meet these exacting needs, Astron Engineers developed new miniaturized EZ and EX Electrolytics for ambient operation up to 85° C.

99.99% pure aluminum foil is specially anodized by an exclusive process . . . power drain is cut to a minimum. They are constructed to withstand extreme temperature changes and give reliable operation after periods of "long idleness."

Each electrolyte formula is scientifically compounded of special chemicals, selected for their high purity. Assembly steps are kept meticulously clean . . . the result: Safety Margin Construction, famous for its ability to withstand ripple currents, vibration, shock and wide temperature fluctuations. These hermetically sealed units are available in a broad selection of capacitance and voltage ratings.

Send today for further technical information . . . please describe your application; it helps us offer proper assistance to you . . . when special conditions require, we will design a prototype to meet your specifications.

**ASTRON**  
CORPORATION  
255 GRANT AVENUE EAST NEWARK, N. J.



A Wholly-owned subsidiary  
of ASTRON CORPORATION

PECKVILLE, PENNSYLVANIA

WEST COAST WAREHOUSE, 9041 WEST PICO BLVD., LOS ANGELES—EXPORT DIVISION, ROCKE INTERNATIONAL CORP., 13 EAST 40TH ST., N. Y., N. Y.—IN CANADA, CHARLES W. POINTON, 6 ALCINA AVE., TORONTO, ONTARIO

CIRCLE 86 ON READER-SERVICE CARD

## NEW PRODUCTS

### VSWR Amplifier

Battery-powered, transistorized unit



Battery-operated Model 441 is completely independent of line voltage deviations, and provides complete portability.

The unit features full sensitivity over the expanded vswr scale and eliminates the need for switching attenuation range when going from normal to expanded scale. The noise level, less than 0.02  $\mu$ v equivalent, and amplifier gain remain the same in the expanded position. Sensitivity is 0.1  $\mu$ v at 200 ohms, over the full scale.

Narda Microwave Corp., Dept. ED, Mineola, N.Y.

CIRCLE 87 ON READER-SERVICE CARD

### Vibration Test Accessory

Pinpoints cause of failure



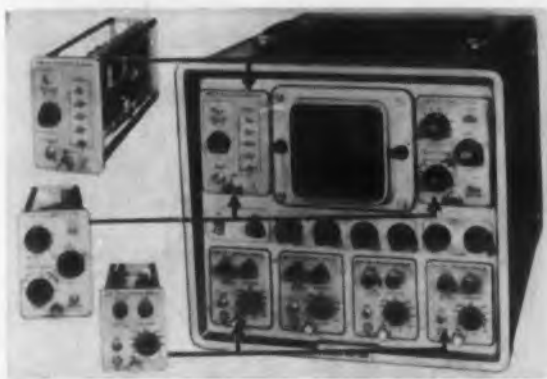
Designated Slip-Sync, this vibration test accessory automatically adjusts the flashing rate of stroboscopic lights to match the frequency of electromagnetic shakers in aircraft and missile testing. The vibrating component is watched in still or slow motion as it vibrates through the various frequencies to which it is subjected.

Chadwick-Helmuth Co., Dept. ED, Monrovia, Calif.

CIRCLE 88 ON READER-SERVICE CARD

## Oscilloscope

Plug-in 4-channel instrument



Through the use of plug-in features for individual pre-amplifiers, sweep generators, and marker-calibrator, this wide-band oscilloscope combines the advantages of true four-channel oscillography. Known as ETC Model K-470, the instrument handles oscilloscope applications from dc to 5 mc.

Five pre-amplifiers form an integral part of the instrument and may be used in any combination on each of the four channels. The ETC Model K-470 is one of the first scopes to use a special square face, four-gun cathode ray tube.

Electronic Tube Corp., Dept. ED, 1200 E. Mermaid Lane, Philadelphia 18, Pa.

CIRCLE 89 ON READER-SERVICE CARD

## Pulsed Oscillator

Stable high power output



Model PG-650 is a variable frequency pulse modulated r-f source for applications requiring high power output as well as stability. The principal use is in measuring various parameters of ultrasonic delay lines, whose high initial insertion loss and operation at low impedance levels usually present difficulties.

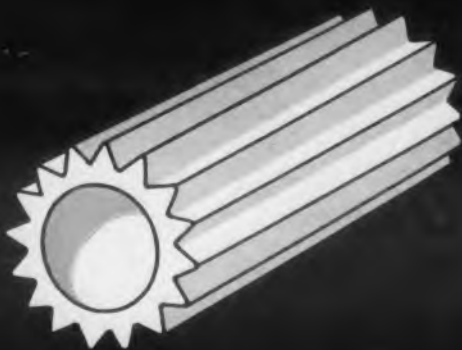
The output of a delay line (60 db into 50 ohms) can be shown at r-f using only the vertical amplifier of an oscilloscope. A second feature is that it can cascade two delay lines without an intermediate amplifier.

Arenberg Ultrasonic Lab., Inc., Dept. ED, 94 Green St., Jamaica Plain 30, Mass.

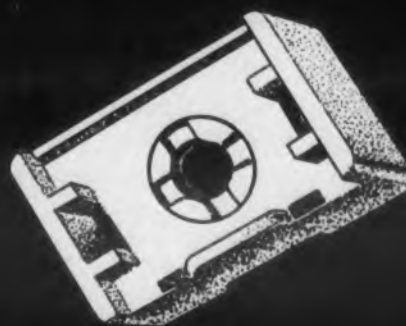
CIRCLE 90 ON READER-SERVICE CARD

an outstanding RI achievement . . .

**UNIFORM** plating on **ALL** surfaces exposed to solution . . .



Uniformly coats any surface regardless of how irregular or complex.

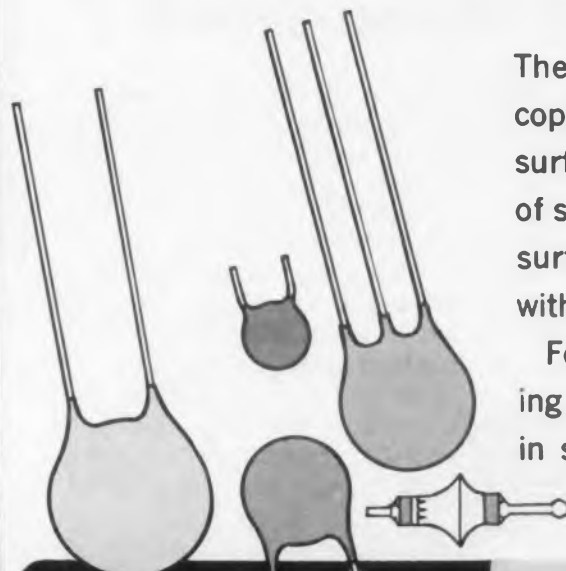


Uniformly coats the entire inside surface of a tube or knockout.



the new **KEMETAL** electro-less process of copperplating

**forms a close, tightly adhering chemical bond**



**NEW**  
**SWEDGE LEADS**

held to accurate dimensions for printed circuit insertion.

Samples on request.

The KEMETAL process deposits copper on ceramic (or any other) surface UNIFORMLY, directly out of solution. Complex or irregular surfaces are never a problem as with ordinary electroplating.

Forming a close, tightly adhering chemical bond that is not lost in soldering, the process elimi-

nates critical soldering time and temperature worries.

The copper, as applied in this process, has 100 times less migration activity between electrodes than silver in electronic circuit applications, assuring a longer life of high dielectric effectiveness.

the KEMETAL process is now used in the manufacture of RI-caps . . . CERAMIC DISC CAPACITORS and FEED-THRUS.

**RADIO INDUSTRIES, INC.**

5225 n. ravenwood ave. • chicago 40, ill.



CIRCLE 91 ON READER-SERVICE CARD



## 50 MIL O.D. Memory Cores for Transistorized High Speed Memories

These new 50 mil O.D. cores are now available in General Ceramics S-4, the material that has proven so successful in such vitally important systems as the SAGE computer. Switching time is less than one microsecond with 550 ma full drive. At recommended operating conditions, the "ONE" output voltage is greater than 60 millivolts; the "ZERO" output voltage is less than 6 millivolts. Cores are provided in two quality levels, to .015 AQL and to 6.5 AQL. Dimensions are .050" O.D., .030" I.D.

and .015" in height, all with tolerances of  $\pm .002$ ". General Ceramics has designed and built special equipment for core testing to insure that each unit meets established electrical properties. 50 mil O.D. cores are supplied in production quantities in two quality levels. Parts are shipped according to MIL Specification 105A to 0.015 AQL or 6.50 AQL. For complete information on this core write General Ceramics Corporation, Keasbey, New Jersey, for Bulletin 326; address Dept. ED.

### GENERAL CERAMICS

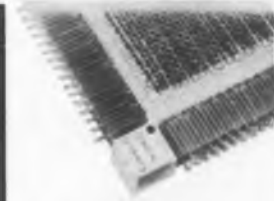
Industrial Ceramics for Industrial Progress... Since 1906



FERRAMIC CORES



PRECISION  
STEATITES



"MAGNETIC  
MEMORY PLANES



"ADVAC" HIGH  
TEMPERATURE SEALS



SOLDERSEAL  
TERMINALS

CIRCLE 92 ON READER-SERVICE CARD

## NEW PRODUCTS

### Hydrogen Thyratrons

High reliability, long life



For radar and other high-power pulse modulators, Genalex hydrogen thyratrons offer more reliable operation and greatly increased life through a new replenisher system, controlled by an integral barretter and thermistor. The replenisher generates hydrogen by means of a heater surrounding titanium hydride pellets, and prevents tube failure due to gas clean-up.

A barretter in series with the replenisher heater keeps the gas pressure constant. A thermistor in parallel with the heater maintains constant replenisher temperature over an ambient range of  $-25$  deg C to  $+70$  deg C and reduces warm-up time and anode delay time drift.

British Industries Corp., Dept. ED, Port Washington, N.Y.

CIRCLE 93 ON READER-SERVICE CARD

### Pulsed Oscillator

Miniature high power unit



The A-12 miniaturized high power 2 kw output pulsed oscillator cavity is designed for aircraft, beacon, and missile applications. The unit measures 5.75 in. in the tunable model and only 4.9 in. in the fixed frequency version while only 1.75 in. in diameter.

Designed to sustain rugged treatment utilizing the GL 6442 ceramic triode, the A-12 can be tuned in excess of 200 mc in the S band.

Atomitron, Inc., Dept. ED, 168-25 Hillside Ave., Jamaica, N.Y.

CIRCLE 94 ON READER-SERVICE CARD

## Microwave Circulator

Compact broadband unit



Model RX 810 C is a broadband, compact, four port circulator utilizing the principle of Faraday rotation of the plane of polarization of microwave energy.

The unit is 4-15/16 in. long and operates over the band 8.4-10.2 kmc with a minimum of 13 db isolation and 0.35 db insertion loss. The circulator can be pressurized to 30 psig.

Rantec Corp., Dept. ED, Calabasas, Calif.

CIRCLE 95 ON READER-SERVICE CARD

## Chokes

Encapsulated types for 125 C use

A family of epoxy encapsulated chokes, covering a range of inductances from .01  $\mu$ h to 200 mh is available in various configurations. One popular type features a flat side for mounting on printed wiring boards with axial leads. Additional leads are provided for mechanically securing heavier components.

Waters Mfg., Inc., Dept. ED, Boston Post Rd., Wayland, Mass.

CIRCLE 96 ON READER-SERVICE CARD

## Word Generator

PRF of up to 250 kc



This equipment is designed to create a selected 16 bit word for testing digital recording techniques and circuits. The word formed may be set up by the sixteen switches on the front panel. A trigger input establishes the pulse repetition frequency which may be as high as 250 kc.

Systems Research Labs., Dept. ED, 300 Woods Dr., Dayton 32, Ohio.

CIRCLE 200 ON READER-SERVICE CARD

# GO-NO-GO



*For production testing and process control*

**CMC** announces the Model 620A

## ELECTRONIC GO-NO-GO GAUGE

Here's an interesting new instrument from CMC with a host of applications in production testing and process control.

The Electronic Go-No-Go Gauge monitors any control or limiting situation which can be stated in terms of frequency. For instance, in the electronics industry relatively unskilled workers can tune oscillator circuits, filter networks, etc. with great accuracy. Frequency stability and comparison checks can be made quickly and easily. In mills and factories producing a continuous flow of goods such as steel, rubber, paper, the device can be used as a material flow controller keeping the output in tune with the input, preventing line buckle and stretch-out. In chemical and petroleum processing, the Model 620A can serve as a pressure or liquid flow regulating indicating system. Wherever motor speed control is a problem, the Model 620A will hold the speed within preselected limits.

### How it Works

In operation, the unknown frequency generated by either the unit under test or one of the many types of transducers on the market is applied at the input. Upper and lower frequency limits are selected by setting the control knobs on the front panel. If the unknown frequency falls

below the lower limit, a red "low" lamp lights. Equal to or above the higher limit, a red "high" lamp lights. Within either limit, a green "in limits" lamp lights. Relay contact closure for external control occurs at each lamp condition.

Actual input frequency is displayed on decades. Remote visual monitoring can be obtained with CMC's new Inline-Inplane Readable Readout. Use of CMC's new fast printer provides a permanent printed record.

Like all CMC instruments, the new Model 620A features unitized construction for structural strength and low weight.

### KEY SPECIFICATIONS

FREQUENCY RANGE	1 - 40,000 cps
INPUT REQUIREMENTS	.05v rms: 10 - 40,000 cps .07v rms: 1 - 10 cps Positive Pulse Rise Time: 1/2 volt or more/sec.
ACCURACY	$\pm 1$ count $\pm$ stability
STABILITY	0.1% (Normal power line stability) Crystal time base optional.
TIME BASES	0.1 sec. and 1 sec. (10 sec. optional)
READOUT	4 digits (5 digits optional)
DISPLAY TIME	Automatic: Continuously variable 0.1 to 10 seconds. Manual: Until reset
INPUT IMPEDANCE	0.5 megohm and 50 mmfd
PRICE	\$1120.00 f.o.b. factory

For more information, contact your nearest CMC engineering representative or write to us directly for complete specifications and applications data. Please address Department 194

Subsidiary of  
Hancock  
Manufacturing  
Company



**Computer-Measurements Corporation**

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CIRCLE 97 ON READER-SERVICE CARD

Now...

## DIALCO Pilot Lights

with **Built-in Resistor** (18,000 ohms)  
(a patented DIALCO feature)

and the **NEW High Brightness Neon Glow Lamp NE-51H**



### A New Advance in Pilot Light Design by DIALCO:

Three basic advantages are incorporated in this series of DIALCO assemblies: (1) *Built-in resistor* for direct use on 125 to 250 volt circuits... (2) *New plastic lens* designed to give attractive "halo" effect...

(3) *New High Brightness Neon Glow Lamp NE-51H*. This lamp may be operated at about 3 times the level of current that may be applied to the standard lamp, and it will produce 8 times as much light—with long life! Very low power is required, less than 1 watt on 250 volt circuit. Recommended for AC service only.

In the DIALCO assembly, the built-in current limiting (ballast) resistor (18,000 ohms) is *completely insulated in moulded bakelite* and sealed in metal (U. S. Patent No. 2,421,321)... Small space required—units are available for mounting in 9/16" or 11/16" clearance holes... A wide choice of optional features includes lens styles, shapes, and colors; terminal types; metal finishes, etc... Meet applicable MIL Spec and UL and CSA requirements.

**All Assemblies Are Available Complete with Lamp SAMPLES ON REQUEST—AT ONCE—NO CHARGE**

DIALIGHT CORP., 46 Stewart Ave., Brooklyn 37, N. Y.

Send brochures on Pilot Lights:  for NE-51H Neon lamp  Sub-Miniatures  Oil-Tight

Name \_\_\_\_\_ Position \_\_\_\_\_

Company \_\_\_\_\_

Address \_\_\_\_\_

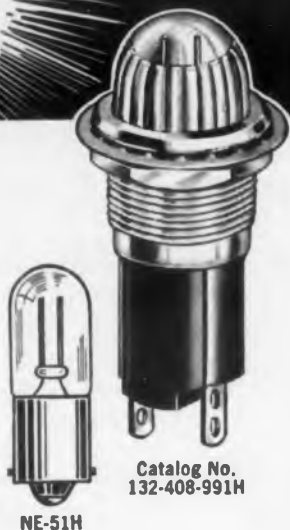
Foremost Manufacturer of Pilot Lights

# DIALIGHT

CORPORATION

46 STEWART AVE., BROOKLYN 37, N. Y. • HYacinth 7-7600

CIRCLE 98 ON READER-SERVICE CARD



NE-51H

Catalog No. 132-408-991H

## NEW PRODUCTS

### Waveguides

Thin walled



This process for producing irregular thin walled waveguide shapes features weight reduction, close tolerances, and smooth inner surfaces at reduced cost.

The method makes possible hollow, seamless one piece configurations in aluminum, silver, copper and other metals which usually require casting or electroforming.

Gorham Mfg. Co., Dept. ED, Providence 7, R. I.

CIRCLE 99 ON READER-SERVICE CARD

**Send for Your FREE Copy...**

**DECIMAL EQUIVALENT WALL CHART**

**Color Coded**  
**Uniform Number Size**  
**4-Place Carry**  
**Extremely Legible**  
**Large 16" x 23" Wall Size**

**Ideal for Designers and Engineers. Write for your FREE copy today!**

John Hassall, Inc., P. O. Box 2202  
Westbury, Long Island, N. Y.

MANUFACTURERS SINCE 1850



# Hassall

NAILS, RIVETS, SCREWS AND OTHER COLD-HEADED FASTENERS AND SPECIALTIES

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## HIGH POWER from a Little

# Variac®

The Type W5L VARIAC auto-transformer is designed for many applications in which output voltages not in excess of line are all that are needed. Through modifications of the popular Type W5 units, the power rating of the Type W5L is increased to 1265 va. As with all VARIACS the output voltage is continuously adjustable from zero. Other VARIAC features included are Duratrak brush construction for extra-long life... excellent regulation... low losses... linear output. The Type W5L VARIAC is moderately priced at \$17.50.

Write for the Variac Bulletin for Complete Data

**GENERAL RADIO Company**

275 Massachusetts Avenue, Cambridge 39, Massachusetts, U. S. A.

Broad Avenue at Linden, Ridgefield, N. J. NEW YORK AREA 1000 N. Seward St. LOS ANGELES 24  
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1182 Los Altos Ave., Los Altos Calif. SAN FRANCISCO 6605 W. North Ave., Oak Park, Ill. CHICAGO

In CANADA: 99 Floral Parkway TORONTO 15

CIRCLE 207 ON READER-SERVICE CARD

**NEW!** The lowest-cost ultrasonic cleaning and chemical processing unit available anywhere.

## narda SONBLASTER

**\$175**



Generator G-201

Tank NT-201

Now, no one need put off buying ultrasonic equipment because of cost! Narda's mass production techniques have done it again—this time, a 35-watt unit, complete with stainless steel transducerized tank with tremendous activity, at the lowest price in the industry—and with a 2-year warranty!

Hot lab apparatus, medical instruments, electronic components, optical and technical glassware, timing mechanisms—the Narda SonBlaster cleans 'most any mechanical, electrical or horological part or assembly you can think of—and cleans faster, better and cheaper. It's perfect, too, for brightening, polishing, decontaminating, sterilizing, pickling, deburring, and plating; emulsifying, mixing, impregnating, degassing, and other chemical process applications.

What's more, two tank sizes are available, and there's a duty cycle timer at only \$10 additional. For more information, write to Dept. ED-4.

### SPECIFICATIONS

Generator Model No.	Tank Model No.	Interior tank size (in.)	Tank Capacity	Price
G-201	NT-201	4-5/8 deep x 3-5/16 diam.	1/8 gal.	\$175
G-201	NT-202	6-1/2 deep x 4-7/8 diam.	3/8 gal.	\$210

Model G-202 Generator (same as G-201, but with duty cycle timer) available with either tank above, \$10 additional.

The SonBlaster catalog line of ultrasonic cleaning equipment ranges from 35 watts to 2.5 Kw, and includes transducerized tanks as well as immersible transducers which can be adapted to any size or shape tank you may now be using.

the narda ultrasonics corporation  
118-160 HERRICKS ROAD • MINEOLA, L. I., NEW YORK



Subsidiary of The Narda Microwave Corporation

CIRCLE 208 ON READER-SERVICE CARD

ELECTRONIC DESIGN • April 30, 1958



## Flat Cable

Can be solder dipped

A lightweight, flexible, multi-conductor flat cable called Polystrip is available. Insulation is a polyester which can be quickly stripped and the cable solder dipped. The cable is rated at 85 C continuously, and is available in widths up to 51 conductors. Each conductor is conservatively rated at 1 amp in free air at 25 C.

International Resistance Co., Dept. ED, 401 North Broad St., Philadelphia 8, Pa.

CIRCLE 101 ON READER-SERVICE CARD

## Remote Control System

Combines accuracy with high torque



The Electrolink model 60 is a closed-loop remote positioner designed specifically for industrial applications requiring fast response, high output torque, and high accuracy. The unit consists of a combined controller-amplifier and a servo drive.

The output shaft, driven by the high-response powder clutch, follows movement of the manual control with accuracies better than 0.25 deg. At maximum excitation, servo output torque is 250 in. lb. High gain and low-inertia drive permit the system to reach maximum speed in 0.020 sec.

Installation problems are simplified by modular construction, permitting the control to be panel-mounted away from the amplifier.

Lear, Inc., Dept. ED, P.O. Box 688, Grand Rapids, Mich.

CIRCLE 102 ON READER-SERVICE CARD

## High-Pot Programmer

Applies voltages at controlled rate

The function of model 1102 is to program the line voltage fed to a high-pot tester, thus producing a system in which test voltages are applied to components under test at a uniform controlled rate. The programmer prevents equipment damage due to accidental output surges, and assures that each component is given an identical, precisely controlled test.

Jackson Electronic and Mfg. Co., Dept. ED, 695 Johnston St., Akron 6, Ohio.

CIRCLE 209 ON READER-SERVICE CARD

# in volume production . . .

backed by 10 years' know-how and over 15,000 units in service



PRECISION GYROS by Reeves  
SINGLE AXIS, VISCOUS DAMPED

No manufacturer can show a matching record of precision engineering achievement in this most exacting department . . . or better our record of PROVED service in the field. Reeves was one of the first to achieve quantity production to high precision standards of the HIG-5 Gyro . . . the "work-horse" of the gyro field.

Now Reeves has stepped up volume on the new HIG-4 to meet both military and commercial needs . . . with these exceptional features:

**EXTREMELY LOW DRIFT:** Trimmed drift rate less than 3° per hour.

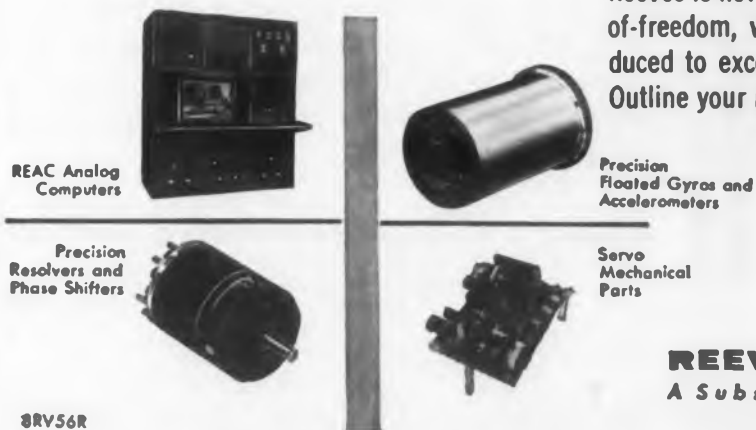
**FULLY FLOATED:** Will withstand over 100 G's shock.

**MASS UNBALANCE:** Less than 0.5 dyne-cm.

**WIDE RANGE:** Signal generator sensitivity and torque generator sensitivity.

**EXTREMELY COMPACT:** Only 2" dia. x 3" long.

Reeves is now ready to meet your requirements with a full range of single-degree-of-freedom, viscous damped integrating gyros and accelerometers, volume produced to exceptional standards in one of the finest gyro facilities in the world. Outline your needs for our recommendations.



REAC Analog Computers

Precision Floated Gyros and Accelerometers

Precision Resolvers and Phase Shifters

Servo Mechanical Parts

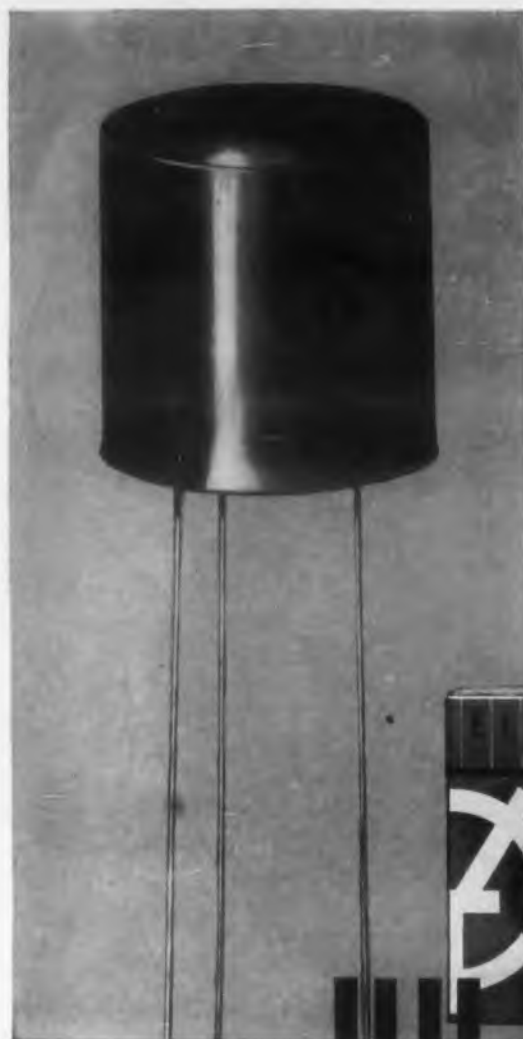
8RV56R



**REEVES INSTRUMENT CORPORATION**  
A Subsidiary of Dynamics Corporation of America

Roosevelt Field, Garden City, N.Y.

CIRCLE 103 ON READER-SERVICE CARD



**JULY 9th**

## SCHEDULE THESE TWO IMPORTANT ISSUES NOW

### 1. TRANSISTORS

- Transistors
- Materials for Transistors
- Components for Transistors
- Test Equipment for Transistors

Circuit and equipment designers will be on the lookout for *Electronic Design's* 6th Annual Transistor Data Issue—complete with the *Transistor Data Chart*, only complete transistor data source of its kind in the industry. This issue is read, and re-read, then filed for reference. You can depend on new highs in readership, greater response to your advertisements (last year 5,632 engineers responded), higher return for your advertising dollar. Be sure your company takes advantage of this once-a-year opportunity in the TRANSISTOR DATA ISSUE. Forms close June 13th.

*Transistor Issue—Closing Date June 13th*



**JULY 23rd**

### 2. DIODES

Semiconductor diodes, their increasing importance, application, and use will be the subject of *Electronic Design's* second feature issue in July. For the first time, manufacturers of diodes and their associated components, materials, and hardware, test equipment, etc. will be spotlighted. Special editorial surveys, data charts, characteristic curves, and availability lists will add to the regular editorial packaged in this issue. It's an issue you will want to include in planning your 1958 insertions.

*Diodes—Feature Report—Closing Date June 27th*



a HAYDEN publication • 830 Third Avenue, New York 22, N.Y., Telephone PLaza 1-5530

## NEW PRODUCTS

### Nylon Jack

Self-locking into chassis



The Pushlock molded nylon-tip jack requires no threads, nuts or lock washers. When the fluted nylon body is pushed through a 1/4 in. chassis hole, the flutes compress, then expand to provide positive holding action that requires approximately a 50-lb pull to release. Contact pressure and low resistance are provided by a heat-treated, silver-plated beryllium copper contact.

Whitso, Inc., Dept. ED, 9330 Byron St., Schiller Park, Ill.

CIRCLE 104 ON READER-SERVICE CARD

### Relay

Rotary action



The HG-2SMP series relay is a plug-in unit with an asbestos filled melamine socket designed specifically for performance exceeding standard socket units. Rotary action and rugged construction make this relay suitable for reliability and rapid interchangeability.

Contacts are rated up to 5 a and 250 v with coil operating voltages of 6 to 115 v ac or dc. Contact arrangement is 1 or 2 pole double throw.

Sockets are available with several types of gold plated terminals to mount above or below the chassis.

Hi-G, Inc., Dept. ED, Bradley Field, Windsor Locks, Conn.

CIRCLE 105 ON READER-SERVICE CARD

## Ferrite Isolator

Rated at 5 megawatts



Rated at 5 megawatts for large S-band radars, this air-cooled ferrite isolator is six in. long, or half the length of previous watercooled designs of lesser power rating.

By effecting a minimum 10 db one-way isolation in the transmission waveguide, the isolator protects high-power tubes from load impedances.

Sperry Gyroscope Co., Microwave Electronics Div., Dept. ED, Great Neck, N. Y.

CIRCLE 106 ON READER-SERVICE CARD

## Silicon Rectifiers

Reverse polarity types

Reverse polarity types in a variety of ratings and mounting styles are the features of these hermetically sealed, all-welded units. The series is rated at 45 to 150 amp (half-wave) with peak ratings from 50 to 800 v. Reverse polarity types are offered in each rating and mounting style.

International Rectifier Corp., Dept. ED, 1521 E. Grand Ave., El Segundo, Calif.

CIRCLE 107 ON READER-SERVICE CARD

## Strip Recorder

Amplifiers have 2 mv/mm sensitivity



The ER-20 two channel recorder features direct-coupled amplifiers which give a sensitivity of 2 mv/mm. Stylus deflection on each channel is 40 mm, with an accuracy of 2 per cent. Electro-sensitive paper eliminates the need for any inking system. Easy paper loading and an electrically controlled two-speed chart drive make operation simple.

Mandrel Industrial Instruments, Dept. ED, 134 Glenmont Dr., Houston, Tex.

CIRCLE 210 ON READER-SERVICE CARD

New GENISCO  
flight control  
accelerometer permits  
check out of system  
reliability prior to, or  
during, flight operations

This newest Genisco instrument is a modified version of the unusually rugged, military certified Model DDL Accelerometer. The Model DDL was developed specifically to withstand severe vibration and stress in high-speed aircraft, guided missile and fire control system applications. It is now in use on many of the nation's fastest operational jet fighter aircraft.

In the new Model DDT two miniaturized solenoids have been added to the basic design of the Model DDL. When actuated, these solenoids displace the mass through its full range permitting rapid, functional tests of system reliability prior to, or during, flight operation.

Only brief specifications of the Model DDT are given below. Copies of Technical Data Sheets giving complete specifications will be sent upon request.

Because most parts of the new Model DDT are interchangeable with the Model DDL now in high-quantity production, price and delivery are particularly good.

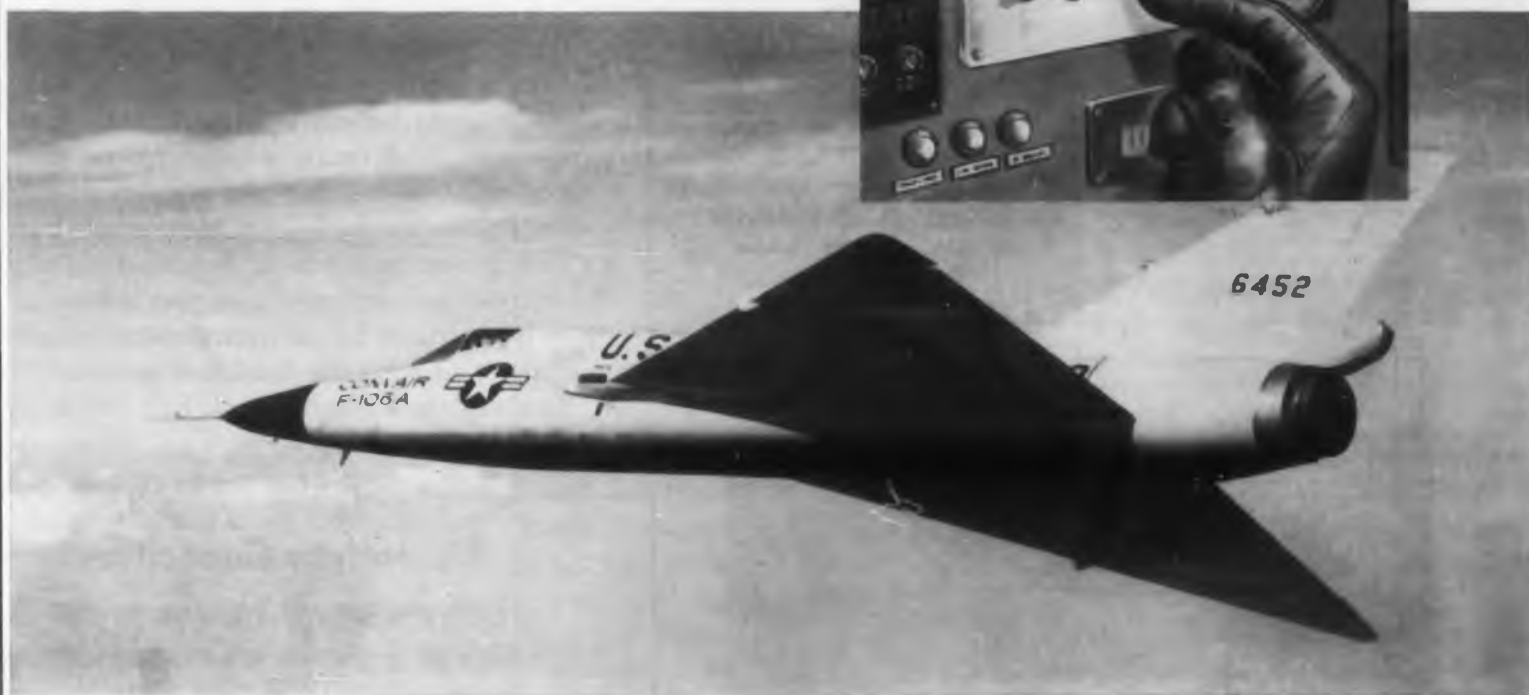


Photo courtesy Convair, San Diego



MODEL DDT



2233 FEDERAL AVENUE • LOS ANGELES 64 • CALIFORNIA

### BRIEF SPECIFICATIONS

- Range:  $\pm 0.1$  G to  $\pm 7.5$  G's.
- Natural Frequency: 5 cps to 27 cps.
- Linearity:  $\pm 1\%$  of full scale for balanced range instruments.
- Damping: Nominally 0.7 of critical at  $+75^\circ\text{F}$ .
- Temperature: Operates to specifications between  $-65^\circ\text{F}$ . to  $+275^\circ\text{F}$ .
- Vibration: 10 G's at 10 to 1500 cps on any axis.
- Shock: 40 G's of 7 ms duration on non-sensitive axes; 100% overload of 7 ms duration on sensitive axis.
- Pressure: Operates to specifications at any altitude.
- Size:  $3\frac{1}{2}'' \times 2\frac{1}{2}'' \times 4''$ , approx.
- Weight: 3.2 lbs.

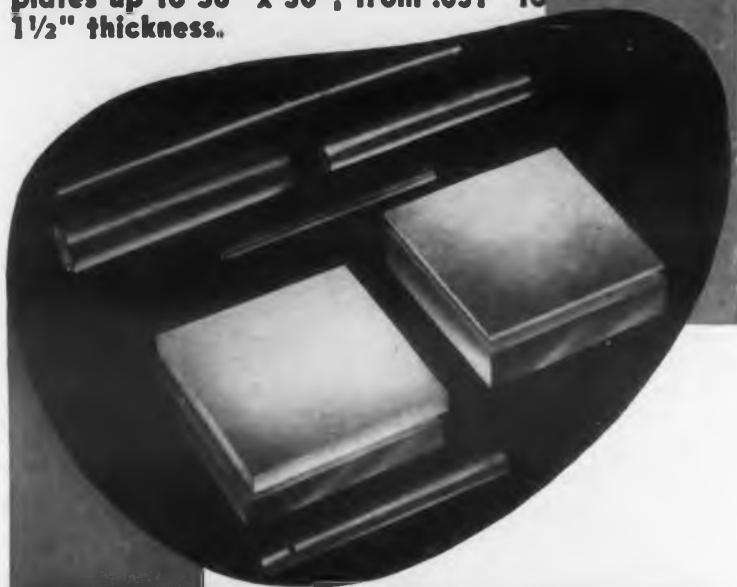
Inquiries to determine possible variations welcomed.

CIRCLE 108 ON READER-SERVICE CARD

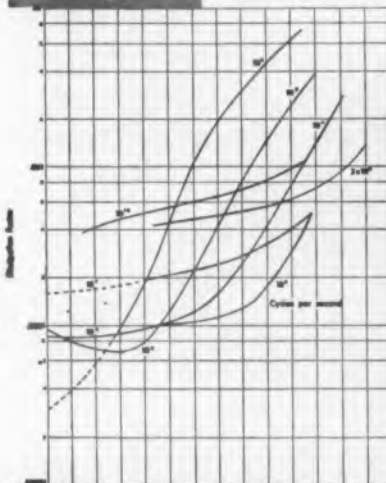
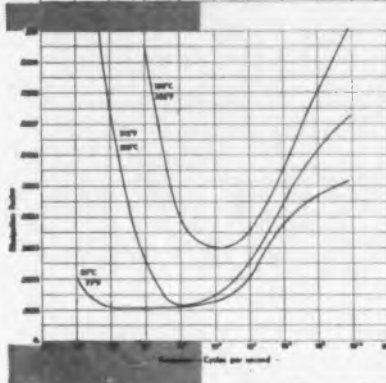
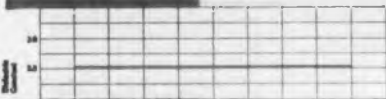
*For Ultra High Frequency Insulation*

## REXOLITE 1422

In cast rods of diameters to 6" and plates up to 36" x 36", from .031" to 1 1/2" thickness.



### REXOLITE 1422 CHARACTERISTICS



- Withstands high temperatures — to 400° F.
- Does not exhibit cold flow.
- Has low dielectric constant and power factor.
- Specific gravity of 1.045-1.050.
- Is strong and rigid with good tensile and impact strengths.
- Unusual chemical inertness permits its use where others fail.
- Readily machinable to close tolerances.

### WHERE PERFORMANCE PLUS PRICE IS A FACTOR REXOLITE 2200

UHF insulation in thermosetting sheets 36" x 36", .031"-.125" thick

- Has good punching properties.
- High impact strength.
- Good machinability.
- Dielectric constant 10-10,000mc, 2.77.

Send for complete technical data and samples

*The* **REX CORPORATION**  
Electronics Division

210 Hayward Rd.

West Acton, Mass.

CIRCLE 109 ON READER-SERVICE CARD

## NEW PRODUCTS

### Bondable Wire

For high temperatures

Wires and cables insulated with Teflon are available with the surface of the insulation treated so that it can be bonded to various impregnants. Magnet wire, lead wire, and cable jackets treated in this manner can be supplied. Individual wires inside cables can also be provided with a bondable surface.

American Super-Temperature Wires, Inc., Dept. ED, Winooski, Vt.

CIRCLE 110 ON READER-SERVICE CARD

### Power Meter

Calorimetric type for low r-f



A calorimetric power meter for low r-f power measurements between dc to 10 kmc has been announced. Full scale measurements range is 5 w. Resolution is 50 mw per division on 4-1/2 in. meter.

This power meter is a simplified calorimeter which uses an accurate metering pump of the gear type driven by an over powered synchronous motor to keep the fluid flow constant.

Electro Impulse Lab., Dept. ED, 208 River St., Red Bank, N.J.

CIRCLE 111 ON READER-SERVICE CARD

### Electrolytic Capacitors

High voltage and capacity ratings

For high  $\mu\text{f}$  applications such as bulk capacitance requirements, these Alumalytic capacitors are rated from 30,000  $\mu\text{f}$  at 10 v dc to 1000  $\mu\text{f}$  at 450 v dc and will operate from  $-20$  to  $+65$  C. The capacitors are manufactured with diameters of 1, 1-3/8, 2, and 3 in., and with a length of 4-1/8 in. The 1 and 1-3/8 in. diameter units are available in case lengths of 2, 2-1/2, 3, 3-1/2 in.

The principal construction feature of this capacitor is the use of 99.99 per cent pure aluminum foil anodes in every rating. This type of pure aluminum permits increased shelf and operating life and reduces leakage current.

General Electric Co., Dept. ED, Schenectady 5, N.Y.

CIRCLE 211 ON READER-SERVICE CARD

# DESIGN ENGINEER AVAILABLE

*...His name is  
American Rectifier-*

**A**LTHOUGH he is not human he can absorb your design, development and manufacturing costs, if need be.

American Rectifier Power Supplies are employed by numerous firms . . . They can go to work for you to save you time and money.



CUSTOM  
ENGINEERING  
and  
STANDARD  
RECTIFIER  
POWER  
SUPPLIES  
AVAILABLE  
TO MEET  
YOUR  
SPECIFIC  
REQUIREMENTS  
up to 500 KW



### COMPARE THESE FEATURES-

- Either silicon, selenium or germanium stacks as desired.
- Heavy duty, dependable rectifier.
- Magnetically or electrically regulated.
- Virtually no maintenance.



Write for Details!

## AMERICAN RECTIFIER CORPORATION

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CIRCLE 112 ON READER-SERVICE CARD

Technic Gold  
is in orbit  
with  
"Explorer"



Certain component parts of "Explorer", the first American satellite, required gold plating. Logical choice was Technic 24 karat INDUSTRIAL GOLD — the first and purest soluble 24 karat gold in the world. Or out of it!

**UNIQUE PROPERTIES  
SOLVE UNIQUE PROBLEMS**

Precious metals are finding extraordinary applications in industry and the laboratory. Electroplating offers an efficient method of exploring and exploiting such characteristics as the unique and diverse properties of gold — not found in combination in any other form.

**TECHNIC SERVICE**

If you have requirements for electroplated gold, other precious metals, or alloys — consult Technic. We equip you with controlled electroplating apparatus and/or solutions that eliminate variables, assure precise performance reproducible as often as required. Find out how Technic Service assures quality with economy.

Phone, wire, TWX or write . . .

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Chicago Office - 7001

North Clark Street



THE LARGEST ENTERPRISE OF ITS KIND IN THE WORLD

CIRCLE 113 ON READER-SERVICE CARD

**CLUTCH-BRAKE.**—Added to the company's line of miniature units, Model MBB duplex clutch-brake is a standard line of 4 sizes in 3 shaft alternates featuring zero back lash, zero end play, no slip rings, fast response, and maximum efficiency per unit size.

Autotronics Inc., Dept. ED, Box 812, Rt. 1, Florissant, Mo.

CIRCLE 114 ON READER-SERVICE CARD

**COAXIAL COMPONENTS.**—Consist of attenuators with a precision of  $\pm 0.5$  db, and impedance matching pads having a low loss. Dimensions of both are  $\frac{3}{8}$  in. diam x 2 in. length.

Electro-Physics Labs., Dept. ED, 2065 Huntington Dr., San Marino, Calif.

CIRCLE 115 ON READER-SERVICE CARD

**TRANSFORMER.**—This 25 w, 400 cycle transformer is available in voltage ratings up to 1000 v. Small size and low heat rise are featured.

Advance Industries, Inc., Dept. ED, Cambridge, Mass.

CIRCLE 116 ON READER-SERVICE CARD

**DELAY LINE.**—Smaller and lighter than previous units, these are especially designed for radar and computer applications for which a nominal repetition frequency of 360 cps is required.

Andersen Laboratories, Inc., Dept. ED, 501 New Park Ave., West Hartford, Conn.

CIRCLE 117 ON READER-SERVICE CARD

**RELAY.**—Having a hydrogen annealed magnetic structure and more contact pressure, Series AA telephone-type relays offers increased efficiency of operation.

Automation Controls Corp., Dept. ED, 5737 West 98th St., Los Angeles 45, Calif.

CIRCLE 195 ON READER-SERVICE CARD

**MOTOR-GENERATOR.**—The generator portion produces an exact frequency of 400 cps. Single phase and rated at 1100 w, the unit is self-regulated with voltage change kept within 5 per cent from no load to full load.

Kato Engineering Co., Dept. ED, Mankato, Minn.

CIRCLE 196 ON READER-SERVICE CARD

**TERMINAL KIT.**—Contains eight basic types of stand-off and feed thru terminals insulated with Teflon in a complete range of sizes.

Taurus Corp., Dept., ED, 8 Coryell St., Lambertville, N. J.

CIRCLE 197 ON READER-SERVICE CARD

**CONNECTORS.**—Identical to models DM9606-197 P/S and DM9700-197 P/S, except that the grommet is designed for four No. 12 or No. 14 wires and three No. 20 or No. 24 wires.

The Deutsch Co., Dept. ED, 7000 Avalon Blvd., Los Angeles 3, Calif.

CIRCLE 198 ON READER-SERVICE CARD



## AHEAD AGAIN...

### *U. S. Radium's Newest Instrument Dial*

A current problem in integral instrument lighting is that of obtaining, at reasonable cost, a dial for a particular unit which will light within the brightness ratio spec of MIL-L-25467A. Since different instruments will have different lighting systems and will require different dial configurations and indicia, the dial contractor must be able to vary the opacity of his dials in order that the finished instrument assemblies will light to MIL spec, regardless of the internal light levels and the number and position of the lights.

U. S. Radium's new production process for MIL-L-25467A dials permits the variation of the opacity factors of the background and indicia within wide limits, to provide a compatible instrument-dial assembly. It also allows piece-to-piece uniformity which excels conventional methods for meeting this spec, and at lower unit cost. These advantages, plus the availability of U. S. Radium's light engineering service during the formative stages of light housing design, provide a foolproof working method for eliminating light engineering headaches, cutting costs and speeding delivery.

For information, contact Department D4



## UNITED STATES RADIUM CORPORATION

MORRISTOWN, N. J. | Offices: Chicago, Illinois and No. Hollywood, Calif. Affiliates: Radelin-Kirk, Ltd., Toronto, Canada and United States Radium Corp. (Europe), Geneva, Switzerland

CIRCLE 199 ON READER-SERVICE CARD

# Magnet Calibration



MODEL 1295  
DIRECT READING

**Gaussmeter**  
measures  
magnetic flux  
density  
**ACCURATELY**

This stable, all transistorized Gaussmeter operates on the Hall effect and provides a conservative accuracy of  $\pm 3\%$  over nine full-scale ranges: 0-100, 200, 500, 1 K, 2 K, 5 K, 10 K, 20 K and 20 K + gaussses, using a single probe. Two standard Alnico V reference magnets having  $\frac{3}{4}\%$  accuracy are supplied. Unit is housed in an aluminum case, weighs 12 lbs. and operates from 115-volt, 50-400 cps line. Price \$420.



MODEL 889A

## Magnetreater<sup>®</sup>

Model 889A de-magnetizes saturated magnets to any desired level of flux. Provides a precisely controlled method for rapidly treating permanent magnets, including the new core-type instrument mechanisms. Used with Model 206A Booster Unit or Model 107A Magnet Charger. Over-all size is 8" x 10" x 7". Weight 24 lbs. Price \$163.



STANDARD MAGNETS

## Standard Magnets

Laboratory standard fixed gap reference magnets having flux densities from 100 to as high as 20,000 gaussses are now available. These units are fully stabilized magnetically, mechanically and thermally and are used to calibrate fluxmeters and gaussmeters for engineering or production testing. Certification supplied for each magnet.

*Performance of all models is rigidly guaranteed. Prices are net f.o.b. Boonton, N.J. and subject to change without notice.*



13 years' magnet charging experience is yours for the asking—send for illustrated data sheets.



**Radio Frequency**  
LABORATORIES, INC.  
Boonton, New Jersey, U. S. A.

CIRCLE 118 ON READER-SERVICE CARD



## NEW LITERATURE

### Slip Ring Assemblies

119

"Design Considerations for Miniature Slip Ring and Brush Assemblies" is a 32-page pamphlet. Photographs and drawings are included. Poly-Scientific Corp., Blacksburg, Va.

### Coaxial Terminations

120

This illustrated bulletin sheet describes a line of coaxial terminations with type BNC or TNC, male or female connectors. Stoddart Aircraft Radio Co., Inc., 6644 Santa Monica Blvd., Hollywood 38, Calif.

### Wirewound Resistors

121

Bulletin CB-3 describes and illustrates a line of axial, radial, and lug type precision wirewound resistors. Winding techniques, wattage range and temperature range are included. Kelvin Electric Co., 5907 Noble Ave., Van Nuys, Calif.

### Microwave Components

122

This 48-page catalog describes over 300 different types of microwave waveguide components, test equipment, and pressure windows. Designated Catalog 58CP, it includes operating characteristics, performance curves, application data, outline drawings, dimensions, and prices of components in the 1.12 kmc to 90.0 kmc frequency range. Photographs of each product type are included. Microwave Associates, Inc., Burlington, Mass.

### Aircraft and Missile Testers

123

This catalog describes a line of aeronautical and missile testing equipment. Featured in addition to a line of hydraulic system testers are many electrical devices. These include power supplies, generator testers, panel meters, and other equipment to test almost any electrical assembly that flies. Sun Electric Corp., Harlem and Avondale, Chicago 31, Ill.

### Synchros

124

This catalog sheet presents the salient characteristics of synchros, servomotors, resolvers, motor tachometers, and tachometer generators in production. The information is arranged for easy reference, and forms a useful key to the more detailed information contained in the sheet. Muirhead Instruments Inc., 677 Fifth Ave., New York, N.Y.



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OF THIS  
DATA BOOK



CIRCLE 125 ON READER-SERVICE CARD

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## Five constant voltage transformer types answer most stabilizing needs

**1. Plate-Filament\*** transformers (as shown above) are available as a manufacturer's component, providing regulated plate and filament voltages for electronic power supplies. Outputs are stabilized within  $\pm 3\%$  with line input between 100-130 volts. Windings are combined on a single, compact core for chassis mounting



### 2. Standard\*

Static-magnetic stabilizers for line voltage regulation . . . output voltage is constant within  $\pm 1\%$  with input variations up to  $\pm 15\%$



### 3. Harmonic-Free\*

Line voltage regulation of  $\pm 1\%$  with less than 3% total rms harmonic content, regardless of input fluctuations as great as  $\pm 15\%$ .



### 4. Filament\*

Regulated  $\pm 1\%$ , 6.3 volt output for operating large numbers of electron tube filaments . . . stock units for outputs up to 25 amps.



### 5. Adjustable Output

Adjustable from 0-130v . . . less than 3% harmonics . . . output regulated  $\pm 1\%$  with input variations to  $\pm 15\%$ .

\*Stock or custom designs

Send for circular 31D-CV-170.

Sola Electric Co., 4633 W. 16th St., Chicago 50, Ill.

# SOLA

Constant Voltage Transformers  
Regulated DC Power Supplies  
Mercury Lamp Transformers  
Fluorescent Lamp Ballasts

CIRCLE 126 ON READER-SERVICE CARD

## R-F Filters

127

This 4-page catalog lists custom r-f filters. Variations in size, shape, voltage, and current ratings are allowed without extra cost for this custom order service. All-Tronics, Inc., 45 Bond St., Westbury, N.Y.

## Impregnated Fibre

128

Bulletin V-58 is a 4-page folder describing a low-cost intermediate insulation material made of resin impregnated vulcanized fibre for use in many electrical and bearing applications. Typical applications are given for the material, which is available in the larger 43 x 76 in. sheet size. Tables and charts give mechanical and dielectric strength compared with those of other materials normally used for high-volume electrical and structural applications, together with physical properties. Continental-Diamond Fibre Corp., a subsidiary of the Budd Co., Newark, Del.

## Circuit Analysis

129

This brochure titled "Modern Testing Methods" describes how this company's analyzing equipment can be utilized by various manufacturers to test wiring systems in all phases of production. It points out how this same testing system, as used by the manufacturer, may be passed on to the military as support equipment to test electrical systems of aircraft, missiles, etc., at maintenance and overhaul bases, thus allowing the manufacturer and the military to standardize on like test equipment. DIT-MCO, Inc., 911 Broadway, Kansas City, Mo.

## Film Capacitors

130

Polystyrene, polyethylene, teflon, and Mylar dielectric capacitors appear in a 6-page illustrated catalog. The folder also lists a line of high voltage packaged power supplies. Electrical characteristic data, physical specifications, related part numbers, and prices are shown for all types listed. Film Capacitors, Inc., 3400 Park Ave., New York 56, N.Y.

## Digital Voltmeter

131

The operation, features, and specifications of a dc digital voltmeter are discussed in the four pages of Bulletin 19-2. Also described are accessories that may be added to permit the measurement of ac, ohms, and ratios, to allow scanning multiple inputs, or to drive typewriter and punched tape units. Kin Tel, Div. of Cohu Electronics, Inc., 5725 Kearny Villa Rd., San Diego 11, Calif.

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*For additional information, please write for Bulletins 85111 and 85151.*

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Shaft Diameter . . . . . Microtorque, 0.031 in.,  
Minitorque, 0.125 in.

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CIRCLE 134 ON READER-SERVICE CARD

## NEW LITERATURE

### Ceramics and Ferrites

135

A 6-page bulletin describes industrial ceramics, ferrites, and custom services. Covered are services for producing precision, electronic, and metallized ceramics and ceramic-to-metal assemblies. Among the ferrites discussed are low loss ferrites for frequencies up to 100 mc, microwave ferrites, and square hysteresis loop ferrites for computer applications. Thermo Materials, Inc., 4040 Campbell Ave., Menlo Park, Calif.

### Accelerometers

136

Now available is a 32-page catalog which describes a line of more than 40 accelerometers, high temperature strain gages and associated electronic equipment. A series of engineering drawings, tables and graphs are employed to give specifications and performance characteristics in terms of sensitivities, natural frequencies, acceleration and temperature ranges for the accelerometers along with the gage factors, resistances, drift rates, temperature ranges and card sizes of the strain gages. Columbia Research Labs., MacDade Blvd. and Bullens Lane, Woodlyn, Pa.

### Residual Stresses

201

"Residual Stresses in Cold Finished Steel Bars and Their Effect on Manufactured Parts" is an illustrated condensation of a paper which E. S. Nachtman presented at a semi-annual meeting of the ASME. Available as Data Book 16, a pocket-size booklet of 32 pages, the article covers specific subjects ranging from residual stresses in cold drawn, ground turned, and heat treated steels to discussions of fatigue cracking, machinability, tolerances, and corrosion. LaSalle Steel Co., 1420 150th St., Hammond, Ind.

### Coil Winder

202

An automatic coil winder with wire guides at the rear is featured in a one page illustrated catalog sheet. Dimensions, types of windings, maximum coil OD and width, and wire sizes are listed along with other details. Geo. Stevens Mfg. Co., Inc., Pulaski Rd. at Peterson, Chicago 30, Ill.

### Flight Simulator

203

A description of a three-dimensional flight simulator system and its applications are included in this 24-page illustrated bulletin. Bendix Aviation Corp., Bendix Computer Div., 5630 Arbor Vitae St., Los Angeles 45, Calif.



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Exacting physical requirements such as fatigue resistance, tensile strength and drawing properties are easily met by SOMERS, where complete facilities include a modern laboratory equipped for chemical, electrical and performance testing of all SOMERS THINSTRIP—both in process and before shipping.

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ELECTRONIC DESIGN • April 30, 1958

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GENERATORS — 1 KW; 2½ KW;  
5 KW; 10 KW; 20 KW; 30 KW; 50 KW;  
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CIRCLE 140 ON READER-SERVICE CARD

### Printed Circuit Etching

141

In Bulletin 90 a process for etching printed circuits with a solution of ammonium persulfate is described. The 7-page text outlines the advantages of the persulfate bath over ferric chloride and gives instructions for preparing the solution, processing, after-treatment, and disposing of the waste solution. Food Machinery and Chemical Corp., Becco Chemical Div., Station B, Buffalo 7, N.Y.

### Plug-In Servo Systems

142

Plug-in servo repeater systems and subminiature servo amplifiers are among the "Micromation" products appearing in a recent file folder. In addition to specification sheets, the folder contains a discussion of "Micromation": Waldorf Instrument Co., Huntington Station, N.Y.

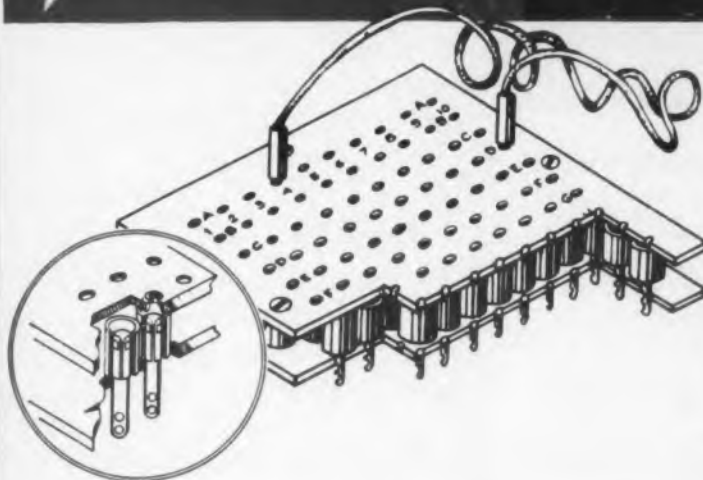
### Capacitors

143

A 2-page engineering bulletin on microminiature molded thermoplastic metallized-paper capacitors has been issued. It contains complete specifications, size and capacitance tables, and insulation resistance tables. Photographs illustrate the bulletin. Aerovox Corp., Application Engineering Dept., New Bedford, Mass.

## Vector PATCH BOARDS

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CONNECTIONS  
WHERE SMALL  
SIZE AND  
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Vector Patch-Boards provide simple, economical units for multiple-connection, single conductor patching. Useful for low cost computers, test boards and a multitude of connecting applications. Receptacles are 0.265" on centers and take .087-.091 diameter plugs. Patch cords also available. Standard boards available or readily made to size required.

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### SEALED ELAPSED TIME INDICATORS

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Glass-to-metal sealed ELAPSED TIME indicators. Compact, low cost, tamper-proof. Standard ASA/MIL dimensions, 2¼" and 3¼" sizes. Easy to read standard size counter registers 1/10 hour steps to 9999.9 or hour steps to 99999. Hermetically sealed. Shielded. Starts, operates continuously from -55°C to +85°C. For 110-125 or 220-250 volts 60 cycle A.C. Bulletin on request. Marlon Electrical Instrument Co., Manchester, N. H., U. S. A.

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marion  
"WHERE ELECTRONICS MEETS THE EYE"  
meters

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## SILICON

### RECTIFIER POWER SUPPLY



0-32 V.D.C.  
40 Amps  
½% Ripple  
Model KM93B

- Vacuum Varnish Impregnated Magnetic Components
- Short Circuit and Overload Protection
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- BUDGET PRICED

#### Additional Specifications

Regulation: 12% from 1/10 load to full load at 32v. output  
Overload Capacity: 125% of rated current continuously (50 Amps.) at 45°C ambient  
Polarity: Pos/Neg terminals are above ground and isolated from AC input.  
Input: 115 volts AC 60 cycles single phase  
Controls: Switch, fuse, load circuit breaker, voltage control, pilot light.  
Terminals: DC output — panel binding posts and terminal board at rear.  
AC input — barrier type terminal board at rear.  
Dimensions: 22"L x 14"H x 15"D Weight: 160 lbs.

Also available without cabinet for mounting in standard 19" rack. Panel height only 12¼" inches. Specify Model KM93

Opad

Bulletin No. 102 On Request

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Continuous electroplating methods permit coating of many metals on to wire (or ribbon) in specified thicknesses of plate . . . This very flexible operation makes it possible to designate a desirable base or precious metal with a coating of another metal for its own particular characteristics. In our laboratory Tungsten wire as small as .00015" has been electroplated with Gold. . . New combinations of plating on wire are being developed by our research staff from time to time. Your inquiry is invited.

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## NEW LITERATURE

### Precision Potentiometer Table 148

A handy precision potentiometers table in 8-1/2 x 11 in. page size to fit the data file or loose-leaf binder, is available. The table lists seven single-turn and one multi-turn types, with dimensions, resistance values, tolerances, resolution, ratings, rotation, tandem groupings, torque, taps, weight, bearings, and other data. At a glance the designer or engineer can select the precision potentiometer that best meets his particular requirements. Clarostat Mfg. Co., Inc., Dover, N.H.

### Digital Pulse Decoder 149

A 12-page engineering manual has been issued to describe a digital pulse decoder and its several applications. With diagrams, the text explains the use of the selector in both ac and dc circuits. It specifically discusses remote supervisory control, telephone, telegraph printer, and mobile radio applications. Photographs and a list of specifications round out a description of the instrument itself; and operation, code settings, and installation are separately discussed. Electrical Communications, Inc., 765 Clementina St., San Francisco 3, Calif.

### Time Rate Indicator 204

Bulletin 501A-B discusses the applications of a 10 mc time-rate indicator which measures frequency, the interval between pulses and period or averaging period, determines the ratio between two frequencies, and counts pulses per unit time. The 4-page illustrated brochure explains the features, functions, and advantages of the unit as it is used in various types of electronic circuits. Laboratory for Electronics, Inc., 75 Pitts St., Boston 14, Mass.

### Batteries 205

This 20-page three color catalog illustrates and presents information on all types of a company's dry cell batteries. Specification charts list each type of battery on separate pages. Also included, on fold-out page, is a cross reference chart of "Comparative and Interchangeable Numbers by Brands." Marathon Battery Co., Wausau, Wis.

### Potentiometer 206

Details of the series 7600 precision potentiometer are covered in Data Sheet 1273. In addition to dimensional drawings and descriptive text about the 10-turn, 1-13/16 in. diam potentiometer, the four-page data sheet now includes a table of coil characteristics for resistance values ranging from 350 to 450,000 ohms. Beckman/Helipot Corp., Newport Beach, Calif.



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...fast!

**Johnson pilot lights  
immediately available  
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in-the-field replacement!**

Save valuable specification time by selecting your panel indicators from Johnson's "preferred" line. This group contains over 47 separate assemblies carefully selected from Johnson's standard line by many of the nation's top design and development personnel. Available in a wide variety of types, these "preferred" units are immediately available at parts distributors throughout the country, for original equipment or in-the-field replacement. Write for your free copy of Johnson's newest pilot light specification catalog—see how easy it is to select the *right* pilot light... fast!

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New pilot light catalog — contains complete specifications, prices and technical data... everything you need to select the proper unit for original equipment or in-the-field replacement.



Available types include: continuous indication neon types; models for high and low voltage incandescent bulbs; standard or wide angle glass and lucite jewels in clear, red, green, amber, blue or opal. Specials, including those meeting military specifications are also available in quantities.



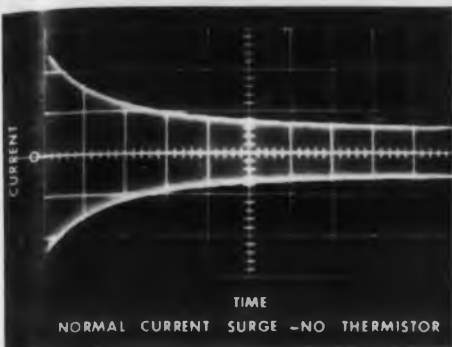
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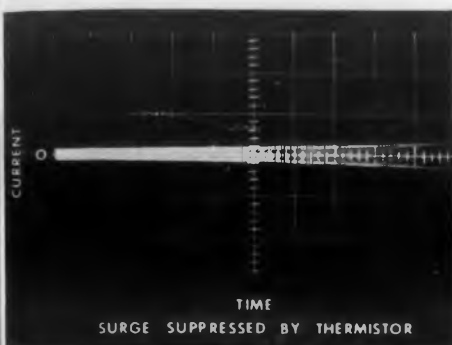
CIRCLE 151 ON READER-SERVICE CARD  
ELECTRONIC DESIGN • April 30, 1958



# THERMISTORS



## SUPPRESS INITIAL SURGE CURRENTS...



## PROTECT FILAMENTS

Application of voltage to tubes in receivers, transmitters, computers, and other electronic equipment subjects their filaments to initial current surges (top oscillogram).

These surges cause premature failure or unsatisfactory service life. Bottom oscillogram shows how a G-E thermistor can suppress the surge and protect the tube filaments.

The thermistor has a large negative temperature coefficient of resistance. The high resistance holds surge current to a low value during initial application of voltage. As the cold filament gradually heats up — raising its resistance to normal level — the thermistor's resistance lowers to a negligible value, permitting full current to flow after a brief period.

G-E thermistors can also be used to prevent surges from operating relays, or disturbing sensitive apparatus. They can provide time delay, control warning circuits, sequence switching.

For more information, or thermistor test kits, write: *Magnetic Materials Section, General Electric Company, 7820 N. Neff Street, Edmore, Michigan.*

### THERMISTOR TEST KITS \$12.50 each



- Kit A: 12 DISKS (10-500 OHMS), 6 SIZES.
- Kit B: 12 DISKS (1000-100,000 OHMS), 6 SIZES, 2 GRADES.
- Kit C: 12 WASHERS AND RODS (10-410 OHMS), 8 SIZES, 1 GRADE.
- Kit D: 10 DISKS (1000 OHMS), 5 SIZES, 2 GRADES.

*Progress Is Our Most Important Product*

**GENERAL ELECTRIC**

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## Research Activities

153

The activities and fundamental research program are described in a 12 page booklet just released. Subjects covered include the SAGE system, heavy radar, memory devices, transistorized digital computers, scatter communications, AEW, and systems analysis. M.I.T. Lincoln Laboratory, Box 24, Lexington, Mass.

## Polyethylene Sheath

154

The bulletin, describes the advantages of polyethylene sheathing compound, its specifications, and applications. Rating, scope of use, conductor construction, insulations, and shielding of available sheathed cables are detailed. The sheathing material passed industry (IPCEA) tests for ac and dc voltage and corona level.

Tables show the insulation and sheath thicknesses for 5001-9000 v (single conductor, grounded neutral), 3001-5000 v (single conductor, grounded or ungrounded), 5000-9000 v (single conductor, ungrounded neutral), and 15,000 v (single conductor, ungrounded neutral). AWG or MCM wire size, standing and nominal od in inches are also given in each table.

The four page bulletin, 8-1/2 by 11 in., is punched for notebook insertion. Rome Cable Corp., Rome, N.Y.



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Custom designed for use in electrical and electronic applications. Made from all metals to specific mechanical and electrical requirements. Special coatings where desired. Automatic equipment to produce varieties of shapes economically. Write for handy "Picture Book of Springs."

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**Associated Spring Corporation**

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Bristol, Connecticut

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Bristol, Connecticut

# Machlett ML-6544

A New Forced-Air Cooled Triode

For Use As Switch Tube in Hard-Tube Pulse Modulators

For Radar Applications



Machlett Laboratories, Inc. offers the designer a new forced-air-cooled, shielded grid triode designed primarily to operate as a switch tube in hard-tube pulse modulators in radar applications. Ruggedly constructed electrodes of the ML-6544 are of such a design as to provide electron beaming essential in keeping grid current to a minimum. This, in addition to the increased heat dissipation capabilities of the rugged control-grid structure, reduces grid emission to a negligible quantity.

The following tentative ratings apply:

*Electrical Characteristics*

Filament Voltage	6.0 Volts
Filament Current	60 Amps

*Maximum Ratings*

Peak Plate Voltage	25 kv
D-C Plate Voltage	20 kv
D-C Grid Voltage	-600 Volts
Peak Positive Grid Voltage	1500 Volts
Peak Cathode Current	75 Amps
D.C. Plate Current	100 mA
Grid Dissipation	45 watts*
Plate Dissipation	1000 watts

(150 cfm @ 0.8" water)

\*Sufficient air cooling must be provided to keep glass seal temperatures no more than 175°C under all conditions of operation.

For full technical data on this or any other Machlett tube type, write:

Machlett Laboratories, Inc., 1063 Hope Street, Springdale, Connecticut

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## TELEMETERING TEST OSCILLATOR



MODEL TO-258

\$42500

### PUSH-BUTTON SELECTION OF FREQUENCY

Standard model provides accurate and convenient calibration for telemetering systems. Also ideal for production testing and other applications. Models can be supplied with any 20 frequencies from 20 cycles to 100 KC.

Standard FM/FM frequencies from 400 cycles to 70 KC. Calibrated deviation control  $\pm 15\%$  of center frequency. Distortion less than 1% to 21 ma. rms. Less than 1% frequency error.

Full size module of TLI Modular Instrumentation System.



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## NEW AUTOMATIC CIRCUIT TESTING BRIDGE



# ROTOBRIDGE

• 99 test positions • one test per second • tolerances of 5, 10 and 20% • wide component range • stabilized circuitry and simple, tamper proof operation.

**AUTOMATIC,  
SEQUENTIAL,  
CIRCUIT TESTING  
BRIDGE FOR  
CIRCUITRY AND  
COMPONENTS  
WITH EASILY  
PROGRAMMED  
INTERNAL  
STANDARDS**



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**FEATURING:**

1. A quality switch with more than a decade of telephone industry development.
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3. Stabilized circuits to insure accuracy of measurements.
4. Audible and visual alarms for rejects or end of testing cycle.
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**COMMUNICATION MEASUREMENTS LABORATORY, INC.**  
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## **NEW at Monitor!**

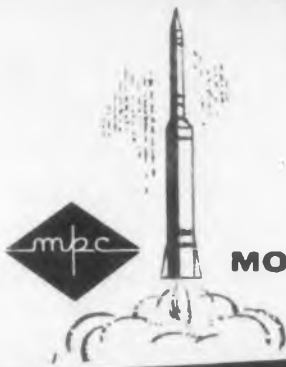
**Low Frequency  
crystals to  
meet high  
vibration  
requirements**

Monitor's modern facilities and techniques insures the quality of all units.

Fully tested from 2 to 2,000 CPS vibration. Acceleration of 15 to 30 G's. Frequency range 16 to 100 kc — typical tolerance  $\pm .012\%$  from  $-40^{\circ}\text{C}$  to  $+70^{\circ}\text{C}$ . Lower frequencies down to 400 cycles available in other Monitor types with less rigid requirements.



Small size  
MC-13/U



*If you have a special crystal problem,  
call, wire or write.*

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**MONITOR PRODUCTS COMPANY**

815 Fremont Ave., South Pasadena, Calif.

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CIRCLE 159 ON READER-SERVICE CARD

## NEW LITERATURE

### Coaxial Components 160

Coaxial components are cataloged in a 28-page booklet. Attenuators, filters, terminations, power dividers, crystal mounts, stub tuners, and miniaturized components are among the items listed. The catalog covers the operation theory of each product. It also presents application and performance data and mechanical and electrical specifications. Microlab, 71 Okner Pkwy., Livingston, N.J.

### Insulating Tubing 161

A selector card for insulating tubing and sleeving has been issued. It has a size gage and more than 40 tubing samples. Technical data on the 8-1/2 x 11 in. card includes dielectric strengths; temperature ratings; applicable NEMA, ASTM, and MIL specifications; flammability; oil resistance; flexibility; abrasion resistance; and resistance to potting. Suflex Corp., 33-38 57th St., Woodside 77, N.Y.

### Meters 162

An illustrated catalog features a full line of electrical indicating instruments. Covered are dc microammeters, dc milliammeters, dc ammeters, dc voltmeters, thermocouple rm ammeters, db, vu, and rectifier type ac instruments. Ruggedized types, commercial types, and types that conform to MIL-M-10304 are described. Sun Electric Corp., Harlem and Avondale, Chicago 31, Ill.

### Precision Resistors and Networks 163

A fact-packed 8-page catalog covering a complete line of custom-made precision wire-wound, encapsulated resistors and rugged, hermetically sealed resistor networks is now available. In this comprehensive, compact catalog are several easy-to-read charts and graphs, and many illustrations, drawing, and specifications pertinent to the life-tested resistors and networks. General Resistance, Inc., 577 E. 156th St., New York 55, N.Y.

### Epoxy Pumps 164

The operation of automatic epoxy pumps which mix, meter, and dispense two-part resins is explained in a recent brochure. Specifications and performance data are given for ten pump models. A technical advisory service which includes custom compounding is described in the same brochure. H. V. Hardman Co., 571 Cortlandt St., Belleville 9, N.J.



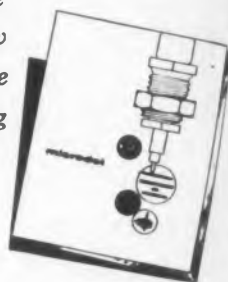
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**Epoxy Thinner**

**167**

Expanded data sheets on the properties and applications of epoxy resin flexibilizer NC 513 are available. The flexibilizer is used for epoxy coatings, encapsulation of electrical components and electrical potting compounds, tooling resins and plastic forming molds, epoxy resin adhesives, patching and splining compounds, and glass-reinforced epoxy resins. Minnesota Mining and Mfg. Co., 500 Doremus Ave., Newark 5, N.J.

**High Temperature Wire**

**168**

"Kulgrid 28, Nickel Clad Copper Wire" describes the chemical composition, mechanical properties, conductivity, and resistivity of a wire developed for high temperature use in electrical and electronic equipment. The technical bulletin also contains the results of comparative laboratory tests made on the resistivity of the wire at elevated temperatures. Sylvania Electric Products Inc., Warren, Pa.

**Nonlinear Pots**

**169**

With graphs, Technical Bulletin 10 shows the magnitude of resulting error due to external loads on several nonlinear potentiometer functions. The 4-page brochure also indicates a unique approach to nonlinear design and explains compensated winding procedure for any nonlinear functions. Technology Instrument Corporation of California, 7229 Atoll Ave., North Hollywood, Calif.

**Miniature Pulse Transformer**

**170**

Information about the ES-3, a subminiature pulse transformer for use in transistor circuits, is presented in a 1-page bulletin. The model is a spherical form encapsulated in epoxy resin to a maximum diameter of 3/8 in. for simplified mounting on printed circuit boards. The text covers the unit's features, construction, and ratings. A photograph shows its actual size. Pulse Engineering, Inc., 2657 Spring St., Redwood City, Calif.

**Vacuum Systems**

A 16-page product summary and price list shows a complete line of standard and custom high vacuum components, equipment, and systems. Mechanical and diffusion pumps, gauges, valves, analytical apparatus, furnaces, freeze drying equipment, and leak detectors are among the items listed. *For a copy of this catalog write on company letterhead directly to NRC Equipment Corp., 160 Charlemont St., Newton 61, Mass.*



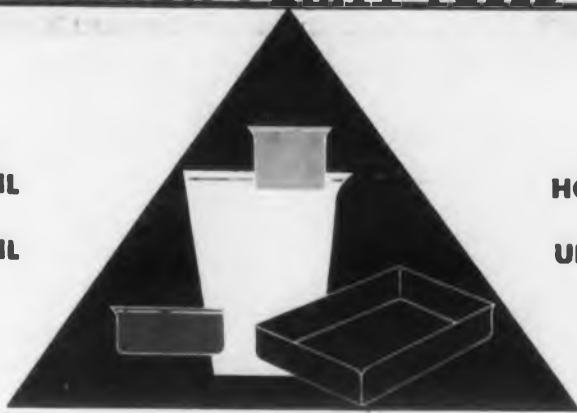
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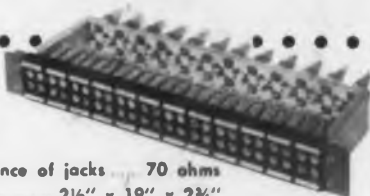
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## NEW LITERATURE

### Miniature Relays

174

Over 325 subminiature relays are described in a 12-page booklet. Designed for missile, airborne, and industrial equipment, the relays meet and surpass Mil-5757A, B, and C and Mil-R-25018 (USAF). Complete descriptions of the units include contact and vibration ratings. Photographs and diagrams illustrate the booklet. Radio Corporation of America, Commercial Electronic Products, Camden 2, N.J.

### Batteries for Aircraft

175

A line of production batteries for unmanned aircraft and missiles, and 11 for manned aircraft, are described in this recently published bulletin. The bulletin covers nominal capacity, open circuit voltage, normal discharge voltage, maximum charging voltage, charging rate, maximum current conditions at 70 deg F, weight, battery dimensions, and case material. Yardney Electric Corp., 40-50 Leonard St., New York 13, N.Y.

### Thyratron Grid Control

176

Bulletin 101-L features a packaged thyratron grid control for motor and generator controls, regulated power supplies, servo systems, and process control. The 4-page pamphlet presents circuit details, mechanical features, and typical applications. It is illustrated with graphs, schematics, and photographs. VecTrol Engineering, Inc., P.O. Box 1089, Stamford, Conn.

### Electronic Parts Catalog

177

Listing over 27,000 items, this 404 page catalog describes a line of electronic parts and equipment. The catalog features 192 pages in rotogravure and 4-color covers.

The catalog emphasizes equipment for industrial maintenance, research, and production requirements. There are detailed listings of standard and special purpose electronic tubes, test instruments, voltage stabilizers, transformers, resistors, capacitors, printed circuit components, new transistors, rheostats, relays, switches, rectifiers, fuses, tools, wire, cable, photo-electric components, two-way radio telephones, sound powered telephones, counters, program clocks, timers, batteries, sockets, generators, power supplies, and a wide variety of other electronic components.

Also included in the bulletin are audio equipment and test equipment kits. Allied Radio Corp., 100 N. Western Ave., Chicago, 80, Ill.

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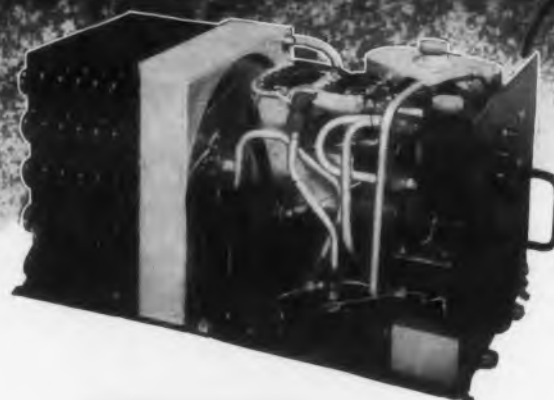
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