

Rheostats

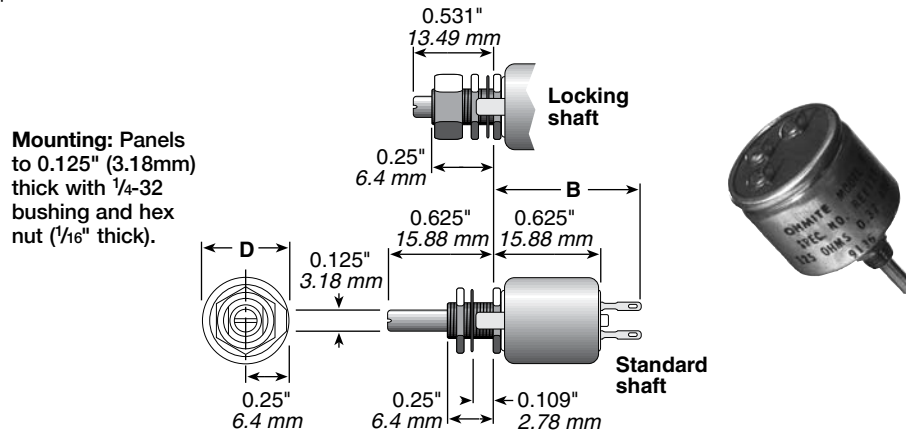
(Potentiometers) Wirewound



MODEL C

Model Type	Watts	Ohmic range	Core	Max. Voltage (RMS)*	Behind panel "B" (in./mm Ref.)	Diameter "D" (in./mm Ref.)	Dimension "C" (in./mm Ref.)	Shaft torque	Rotation (±5°)
C RCS/RCL	7.5	10.0-5K	enclosed	305	0.875/22.23	0.515/ 13.08	—	0.25-3 oz. in.	300°

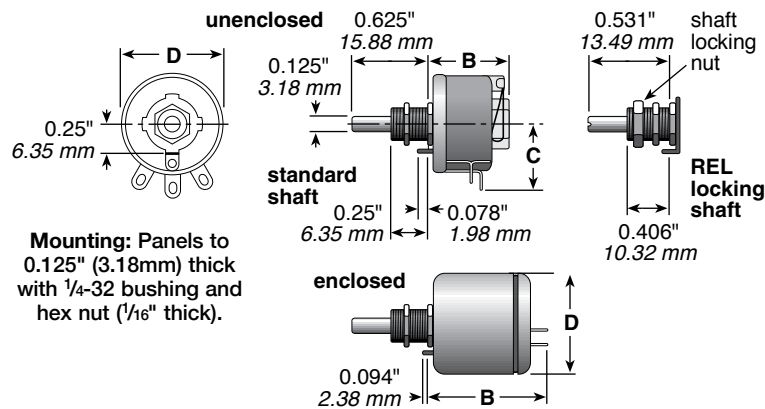
• See Catalog #203 for complete details.



MODEL E

Model Type	Watts	Ohmic range	Core	Max. Voltage (RMS)*	Behind panel "B" (in./mm Ref.)	Diameter "D" (in./mm Ref.)	Dimension "C" (in./mm Ref.)	Shaft torque	Rotation (±5°)
E RES/REL	12.5	1.0-15K	open	305	0.688/17.46	0.875/ 22.23	0.594/15.08	1-6 oz. in.	300°
E REE	12.5	1.0-15K	enclosed	305	1.219/30.96	1.047/ 26.59	—	1-6 oz. in.	300°

• See Catalog #203 for complete details.



Dimensions for reference only; consult factory for details.

Since all rheostats/potentiometers are electro-mechanical devices, they are subject to mechanical wear and, therefore, have a finite life.

Models H, J, K, L and N are listed under UL File No. E-10946 and CSA File No. 21309 unless noted otherwise.

All rheostats are 10% tolerance.

Rheostats

(Potentiometers) Wirewound

MODELS H, J, G, K, L

Model	Type	Watts	Ohmic range	Core	Max. Voltage (RMS)*	Behind panel "B" (in./mm Ref.)	Diameter "D" (in./mm Ref.)	Dimension "C" (in./mm Ref.)	Shaft torque	Rotation (±5°)
H	RHS/RHL	25	1.0-25K	open	500	1.375/34.93	1.560/ 39.62	0.940/23.88	0.25-0.5 lb. in.	300°
J	RJS	50	0.5-50K	open	750	1.375/34.93	2.31 / 58.67	1.56 /39.62	0.25-2 lb. in.	300°
G	RGS	75	0.5-50K	open	900	1.750/44.45	2.75 / 69.25	1.78 /45.21	0.5-2 lb. in.	300°
K	RKS	100	0.5-50K	open	1000	1.750/44.45	3.125/ 79.38	1.91 /48.51	0.5-2 lb. in.	300°
L	RLS	150	0.5-50K	open	1200	2.000 / 50.8	4.00 /101.60	2.28 /57.91	0.5-3 lb. in.	300°

- Models H, J, G, and K also available in enclosed versions.
- See Catalog #203 for complete details.

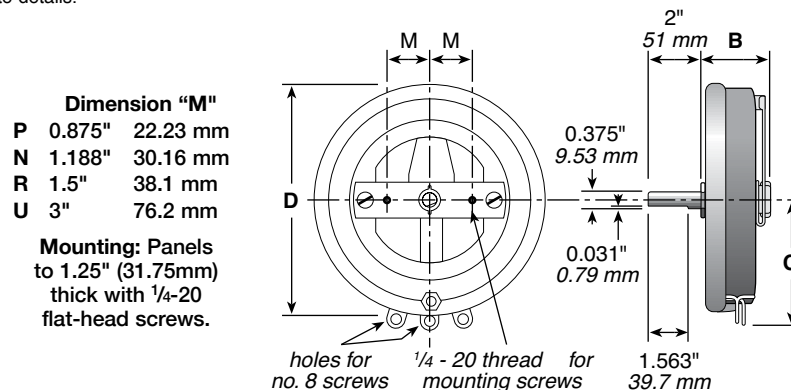


Mounting: Panels to 0.25" (6.35mm) thick with $\frac{3}{8}$ -32 bushing and hex nut ($\frac{3}{32}$ " thick) (or with 10-32 x 0.75 flat-head screws for model L only).

MODELS P, N, R, U

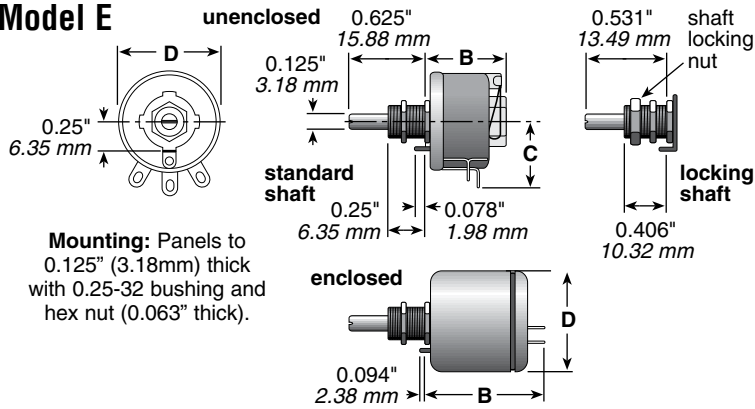
Model	Type	Watts	Ohmic range	Core	Max. Voltage (RMS)*	Behind panel "B" (in./mm Ref.)	Diameter "D" (in./mm Ref.)	Dimension "C" (in./mm Ref.)	Shaft torque	Rotation (±5°)
P	RPS	225	1.0-30K	open	1300	2.125/53.98	5.00 /127.00	2.97 /75.44	2.5-4 lb. in.	310°
N	RNS	300	1.0-50K	open	1225	2.375/60.33	6.00 /152.40	3.44 /87.38	2.5-5 lb. in.	320°
R	RRS	500	1.0-20K	open	1450	2.125/53.98	8.00 /203.20	4.31/109.47	4.5-7 lb. in.	325°
U	RUS	1000	1.0-20K	open	1600	3.000 / 76.2	12.00 /304.80	6.38/162.05	3.5-7 lb. in.	335°

- See Catalog #203 for complete details.



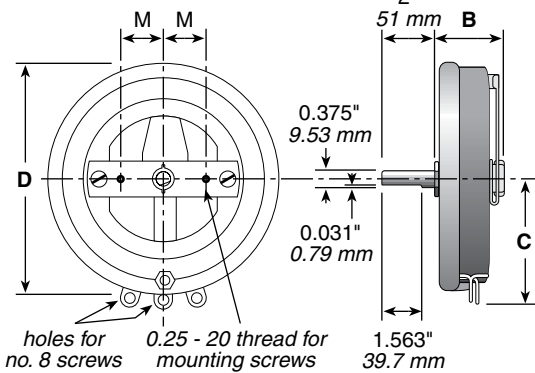
(continued)

Model E



Mounting: Panels to 0.125" (3.18mm) thick with 0.25-32 bushing and hex nut (0.063" thick).

Models P, N, R, U



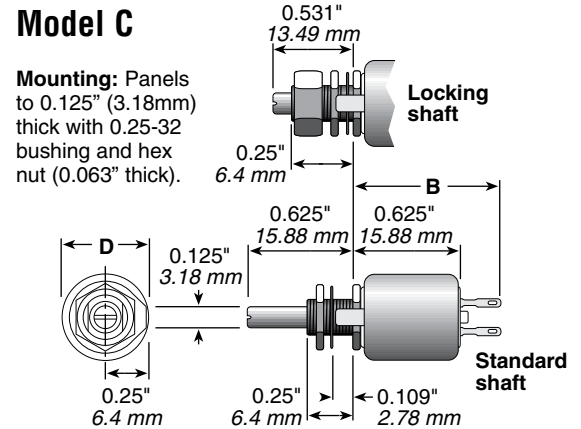
Dimension "M"

P	0.875"	22.23 mm
N	1.188"	30.16 mm
R	1.5"	38.1 mm
U	3"	76.2 mm

Mounting: Panels to 1.25" (31.75mm) thick with 0.25-20 flat-head screws.

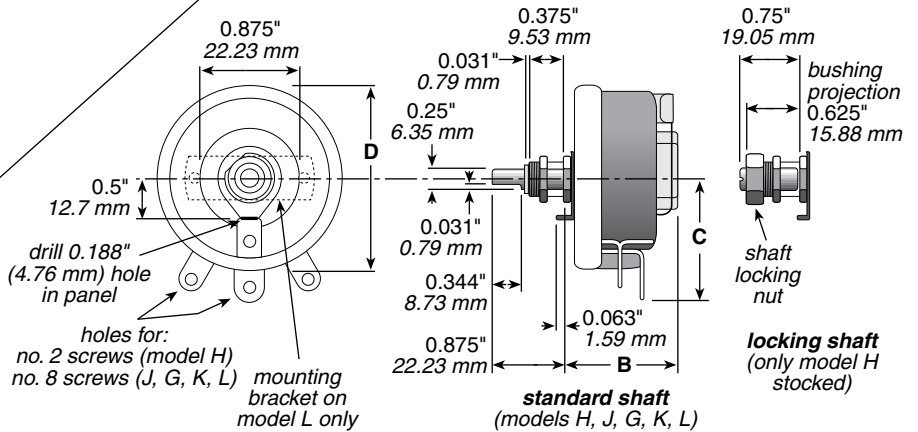
Rheostats (Potentiometers) Wirewound

Model C



Mounting: Panels to 0.125" (3.18mm) thick with 0.25-32 bushing and hex nut (0.063" thick).

Models H, J, G, K, L



Mounting: Panels to 0.25" (6.35mm) thick with 0.375-32 bushing and hex nut (0.094" thick) (or with 10-32 x 0.75 F.H. screws for model L only).

Dimensions for reference only; consult factory for details.

Since all rheostats/potentiometers are electro-mechanical devices, they are subject to mechanical wear and, therefore, have a finite life.

Models H, J, K, L and N are listed under UL Reexamination Service File No. E-10946 and CSA File No. 21309 unless noted otherwise.

See page 82 for knobs, dials, and other hardware

All rheostats are 10% tolerance.

ORDERING INFORMATION

Series: Rheostats, Wirewound, Potentiometers

E = RoHS compliant

RCSR50E

Code	Watts	Model	Shaft	Core	Resistance Value*
CL =	7.5	C	Locking	Enclosed	R50 = 0.50Ω
CS =	7.5	C	Standard	Enclosed	1R0 = 1Ω
EE =	12.5	E	Standard	Enclosed	7R5 = 7.5Ω
EL =	12.5	E	Locking	Open	250 = 250Ω
ES =	12.5	E	Standard	Open	1K0 = 1,000Ω
GS =	75	G	Standard	Open	1K75 = 1,750Ω
HL =	25	H	Locking	Open	4K5 = 4,500Ω
HS =	25	H	Standard	Open	50K = 50,000Ω
JS =	50	J	Standard	Open	
KS =	100	K	Standard	Open	
LS =	150	L	Standard	Open	
NS =	300	N	Standard	Open	
PS =	225	P	Standard	Open	
RS =	500	R	Standard	Open	
US =	1000	U	Standard	Open	

*Check Table for Standard Resistance Values and Maximum Current Values

Model	Type	Watts	Ohmic range	Core	Max. Voltage (RMS)*	Behind panel "B" (In./mm)	Diameter "D" (In./mm)	Dimension "C" (In./mm)	Shaft torque	Rotation (±5°)
E	RES/REL	12.5	1.0-15K	open	305	0.688/17.46	0.875/ 22.23	0.594/15.08	1-6 oz. in.	300°
H	RHS/RHL	25	1.0-25K	open	500	1.375/34.93	1.560/ 39.62	0.940/23.88	0.25-0.5 lb. in.	300°
J	RJS	50	0.5-50K	open	750	1.375/34.93	2.31 / 58.67	1.56 /39.62	0.25-2 lb. in.	300°
G	RGS	75	0.5-50K	open	900	1.750/44.45	2.75 / 69.25	1.78 /45.21	0.5-2 lb. in.	300°
K	RKS	100	0.5-50K	open	1000	1.750/44.45	3.125/ 79.38	1.91 /48.51	0.5-2 lb. in.	300°
L	RLS	150	0.5-50K	open	1200	2.000 / 50.8	4.00 /101.60	2.28 /57.91	0.5-3 lb. in.	300°
P	RPS	225	1.0-30K	open	1300	2.125/53.98	5.00 /127.00	2.97 /75.44	2.5-4 lb. in.	310°
N	RNS	300	1.0-50K	open	1225	2.375/60.33	6.00 /152.40	3.44 /87.38	2.5-5 lb. in.	320°
R	RRS	500	1.0-20K	open	1450	2.125/53.98	8.00 /203.20	4.31/109.47	4.5-7 lb. in.	325°
U	RUS	1000	1.0-20K	open	1600	3.000 / 76.2	12.00 /304.80	6.38/162.05	3.5-7 lb. in.	335°
C	RCS/RCL	7.5	10.0-5K	enclosed	305	0.875/22.23	0.515/ 13.08	—	0.25-3 oz. in.	300°
E	REE	12.5	1.0-15K	enclosed	305	1.219/30.96	1.047/ 26.59	—	1-6 oz. in.	300°

- Models H, J, G, and K also available in enclosed versions.
- See Catalog #203 for complete details.
- RoHS compliant product available. Add "E" suffix to part number to specify.
- Made-to-order rheostats available: Contact nearest Ohmite sales office.
- * Voltage rating dependent on resistance value.

STANDARD PART NUMBERS FOR RHEOSTATS

Ohmic value	Part No. Prefix □ Suffix □	7.5W Model C			12.5W Model E			25W Model H			50W Model J	75W Model G	100W Model K	150W Model L	225W Model P	300W Model N	500W Model R	1000W Model U
		Std. shaft RCS	Locking RCL	Amps max.	Std. shaft RES	Locking REL	Enclosed REE	Amps max.	Std. shaft RHS	Locking RHL	Amps max.	RJS Amps max.	RGS Amps max.	RKS Amps max.	RLS Amps max.	RPS Amps max.	RNS Amps max.	RRS Amps max.
0.5	R50										✓ 10.0	✓ 12.3	✓ 14.1	✓ 17.3				
1	1R0				✓	✓	✓ 3.53	✓	✓	5.00	✓ 7.07	✓ 8.66	✓ 10	✓ 12.3	✓ 15.0	✓ 17.32	✓ 22.3	✓ 31.6
1.5	1R5				✓	✓	✓ 3.53	✓	✓	5.00	✓ 7.07	✓ 8.66	✓ 10	✓ 12.3	✓ 15.0	✓ 17.32	✓ 22.3	✓ 31.6
2	2R0				✓	✓	✓ 2.50	✓	✓	3.54	✓ 5.00	✓ 6.12	✓ 7.07	✓ 8.65	✓ 10.6	✓ 12.24	✓ 15.8	✓ 22.4
2.5	2R5				✓	✓	✓ 2.24	✓	✓	2.04	✓ 2.88	✓ 3.16	✓ 3.65	✓ 4.47	✓ 5.49	✓ 6.32	✓ 7.90	✓ 11.2
3	3R0				✓	✓	✓ 2.04	✓	✓	2.88	✓ 3.53	✓ 5.00	✓ 5.75	✓ 7.07	✓ 8.66	✓ 10.00	✓ 12.9	✓ 18.3
4	4R0				✓	✓	✓ 1.58				✓ 2.88	✓ 3.88	✓ 4.47	✓ 5.48	✓ 6.71	✓ 7.75	✓ 11.2	✓ 15.8
5	5R0				✓	✓	✓ 1.44	✓	✓	2.04	✓ 2.88	✓ 3.16	✓ 3.65	✓ 4.47	✓ 5.49	✓ 6.32	✓ 7.90	✓ 11.2
6	6R0				✓	✓	✓ 1.44	✓	✓	2.04	✓ 2.88	✓ 3.16	✓ 3.65	✓ 4.47	✓ 5.49	✓ 6.32	✓ 7.90	✓ 11.2
7.5	7R5				✓	✓	✓ 1.25	✓	✓	1.77	✓ 2.50	✓ 2.74	✓ 3.16	✓ 3.88	✓ 4.74	✓ 5.48	✓ 7.90	✓ 11.2
8	8R0				✓	✓	✓ 1.12	✓	✓	1.58	✓ 2.04	✓ 2.74	✓ 3.16	✓ 3.88	✓ 4.74	✓ 5.48	✓ 7.90	✓ 11.2
10	10R	✓	✓	0.86	✓	✓	✓ 1.12	✓	✓	1.58	✓ 2.04	✓ 2.74	✓ 3.16	✓ 3.88	✓ 4.74	✓ 5.48	✓ 7.90	✓ 11.2
12	12R				✓	✓	✓ 0.91	✓	✓	1.29	✓ 1.76	✓ 2.17	✓ 2.50	✓ 3.163	✓ 3.87	✓ 4.47	✓ 6.30	✓ 8.95
12.5	12R5				✓	✓	✓ 0.91	✓	✓	1.29	✓ 1.76	✓ 2.17	✓ 2.50	✓ 3.163	✓ 3.87	✓ 4.47	✓ 6.30	✓ 8.95
15	15R	✓	✓	0.71	✓	✓	✓ 0.91	✓	✓	1.29	✓ 1.76	✓ 2.17	✓ 2.50	✓ 3.163	✓ 3.87	✓ 4.47	✓ 6.30	✓ 8.95
16	16R				✓	✓	✓ 0.71	✓	✓	1.00	✓ 1.76	✓ 2.17	✓ 2.50	✓ 3.163	✓ 3.87	✓ 4.47	✓ 6.30	✓ 8.95
22	22R				✓	✓	✓ 0.60	✓	✓	0.845	✓ 1.50	✓ 1.73	✓ 2.0	✓ 2.450	✓ 3.00	✓ 3.46	✓ 4.47	✓ 6.33
25	25R	✓	✓	0.55	✓	✓	✓ 0.71	✓	✓	1.00	✓ 1.76	✓ 2.17	✓ 2.50	✓ 3.163	✓ 3.87	✓ 4.47	✓ 6.30	✓ 8.95
35	35R	✓	✓	0.46	✓	✓	✓ 0.60	✓	✓	0.845	✓ 1.19	✓ 1.73	✓ 2.0	✓ 2.450	✓ 3.00	✓ 3.46	✓ 4.47	✓ 6.33
40	40R				✓	✓	✓ 0.60	✓	✓	0.845	✓ 1.19	✓ 1.73	✓ 2.0	✓ 2.450	✓ 3.00	✓ 3.46	✓ 4.47	✓ 6.33
50	50R	✓	✓	0.39	✓	✓	✓ 0.50	✓	✓	0.707	✓ 1.00	✓ 1.23	✓ 1.41	✓ 1.735	✓ 2.12	✓ 2.45	✓ 3.16	✓ 4.47
75	75R	✓	✓	0.32	✓	✓	✓ 0.40	✓	✓	0.575	✓ 1.00	✓ 1.00	✓ 1.15	✓ 1.415	✓ 1.73	✓ 2.00	✓ 3.16	✓ 4.47
80	80R				✓	✓	✓ 0.40	✓	✓	0.575	✓ 0.790	✓ 1.00	✓ 1.15	✓ 1.415	✓ 1.73	✓ 2.00	✓ 3.16	✓ 4.47
100	100R	✓	✓	0.27	✓	✓	✓ 0.36	✓	✓	0.500	✓ 0.790	✓ 0.866	✓ 1.00	✓ 1.225	✓ 1.50	✓ 1.73	✓ 2.52	✓ 3.65
125	125R	✓	✓	0.27	✓	✓	✓ 0.32	✓	✓	0.445	✓ 0.630	✓ 0.866	✓ 1.00	✓ 1.225	✓ 1.50	✓ 1.73	✓ 2.52	✓ 3.65
150	150R	✓	✓	0.22	✓	✓	✓ 0.29				✓ 0.575	✓ 0.866	✓ 1.00	✓ 1.225	✓ 1.50	✓ 1.73	✓ 2.52	✓ 3.65
160	160R				✓	✓	✓ 0.29				✓ 0.575	✓ 0.866	✓ 1.00	✓ 1.225	✓ 1.50	✓ 1.73	✓ 2.52	✓ 3.65
175	175R				✓	✓	✓ 0.27	✓	✓	0.375	✓ 0.630	✓ 0.866	✓ 1.00	✓ 1.225	✓ 1.50	✓ 1.73	✓ 2.52	✓ 3.65
200	200R	✓	✓	0.19	✓	✓	✓ 0.25				✓ 0.470	✓ 0.612	✓ 0.707	✓ 0.865	✓ 1.06	✓ 1.22	✓ 1.69	✓ 2.39
225	225R				✓	✓	✓ 0.25				✓ 0.470	✓ 0.612	✓ 0.707	✓ 0.865	✓ 1.06	✓ 1.22	✓ 1.69	✓ 2.39
250	250R	✓	✓	0.17	✓	✓	✓ 0.22	✓	✓	0.316	✓ 0.408	✓ 0.433	✓ 0.500	✓ 0.655	✓ 0.750	✓ 0.866	✓ 1.00	✓ 1.41
300	300R				✓	✓	✓ 0.22	✓	✓	0.316	✓ 0.408	✓ 0.433	✓ 0.500	✓ 0.655	✓ 0.750	✓ 0.866	✓ 1.00	✓ 1.41
325	325R				✓	✓	✓ 0.19	✓	✓	0.267	✓ 0.408	✓ 0.433	✓ 0.500	✓ 0.655	✓ 0.750	✓ 0.866	✓ 1.00	✓ 1.41
350	350R	✓	✓	0.15	✓	✓	✓ 0.19	✓	✓	0.267	✓ 0.408	✓ 0.433	✓ 0.500	✓ 0.655	✓ 0.750	✓ 0.866	✓ 1.00	✓ 1.41
400	400R				✓	✓	✓ 0.19	✓	✓	0.267	✓ 0.408	✓ 0.433	✓ 0.500	✓ 0.655	✓ 0.750	✓ 0.866	✓ 1.00	✓ 1.41
500	500R	✓	✓	0.12	✓	✓	✓ 0.16	✓	✓	0.222	✓ 0.316	✓ 0.388	✓ 0.447	✓ 0.548	✓ 0.657	✓ 0.655	✓ 0.817	✓ 1.15
600	600R				✓	✓	✓ 0.16	✓	✓	0.222	✓ 0.316	✓ 0.388	✓ 0.447	✓ 0.548	✓ 0.657	✓ 0.655	✓ 0.817	✓ 1.15
700	700R				✓	✓	✓ 0.13	✓	✓	0.182	✓ 0.250	✓ 0.316	✓ 0.365	✓ 0.447	✓ 0.548	✓ 0.657	✓ 0.655	✓ 0.817
750	750R	✓	✓	0.10	✓	✓	✓ 0.13	✓	✓	0.182	✓ 0.250	✓ 0.316	✓ 0.365	✓ 0.447	✓ 0.548	✓ 0.657	✓ 0.655	✓ 0.817
800	800R				✓	✓	✓ 0.13	✓	✓	0.182	✓ 0.250	✓ 0.316	✓ 0.365	✓ 0.447	✓ 0.548	✓ 0.657	✓ 0.655	✓ 0.817
900	900R				✓	✓	✓ 0.10	✓	✓	0.155	✓ 0.224	✓ 0.274	✓ 0.316	✓ 0.387	✓ 0.447	✓ 0.500	✓ 0.578	✓ 0.707
1000	1K0	✓	✓	0.086	✓	✓	✓ 0.10	✓	✓	0.155	✓ 0.224	✓ 0.274	✓ 0.316	✓ 0.387	✓ 0.447	✓ 0.500	✓ 0.578	✓ 0.707
1200	1K2				✓	✓	✓ 0.10	✓	✓	0.155	✓ 0.224	✓ 0.274	✓ 0.316	✓ 0.387	✓ 0.447	✓ 0.500	✓ 0.578	✓ 0.707
1250	1K25				✓	✓	✓ 0.090	✓	✓	0.129	✓ 0.176	✓ 0.224	✓ 0.258	✓ 0.316	✓ 0.387	✓ 0.447	✓ 0.500	✓ 0.707
1500	1K5	✓	✓	0.071	✓	✓	✓ 0.090	✓	✓	0.129	✓ 0.176	✓ 0.224	✓ 0.258	✓ 0.316	✓ 0.387	✓ 0.447	✓ 0.500	✓ 0.707
1600	1K6				✓	✓	✓ 0.071	✓	✓	0.129	✓ 0.176	✓ 0.224	✓ 0.258	✓ 0.316	✓ 0.387	✓ 0.447	✓ 0.500	✓ 0.707
1750	1K75				✓	✓	✓ 0.071	✓	✓	0.129	✓ 0.176	✓ 0.224	✓ 0.258	✓ 0.316	✓ 0.387	✓ 0.447	✓ 0.500	✓ 0.707
1800	1K8				✓	✓	✓ 0.071	✓	✓	0.129	✓ 0.176	✓ 0.224	✓ 0.258	✓ 0.316	✓ 0.387	✓ 0.447	✓ 0.500	✓ 0.707
2000	2K0				✓	✓	✓ 0.071	✓	✓	0.129	✓ 0.176	✓ 0.224	✓ 0.258	✓ 0.316	✓ 0.387	✓ 0.447	✓ 0.500	✓ 0.707
2250	2K25				✓	✓	✓ 0.071	✓	✓	0.129	✓ 0.176	✓ 0.224	✓ 0.258	✓ 0.316	✓ 0.387	✓ 0.447	✓ 0.500	✓ 0.707
2500	2K5	✓	✓	0.055	✓	✓	✓ 0.070	✓	✓	0.100	✓ 0.141	✓ 0.173	✓ 0.200	✓ 0.224	✓ 0.300	✓ 0.346	✓ 0.447	✓ 0.633
3000	3K0				✓	✓	✓ 0.070	✓	✓	0.100	✓ 0.141	✓ 0.173	✓ 0.200	✓ 0.224	✓ 0.300	✓ 0.346	✓ 0.447	✓ 0.633
3500	3K5	✓	✓	0.046	✓	✓	✓ 0.060	✓	✓	0.084	✓ 0.119	✓ 0.141	✓ 0.160	✓ 0.182	✓ 0.224	✓ 0.267	✓ 0.333	✓ 0.447
4500	4K5				✓	✓	✓ 0.060	✓	✓	0.084	✓ 0.119	✓ 0.141	✓ 0.160	✓ 0.182	✓ 0.224	✓ 0.267	✓ 0.333	✓ 0.447
5000	5K0	✓	✓	0.039	✓	✓	✓ 0.050	✓	✓	0.070	✓ 0.100	✓ 0.123	✓ 0.141	✓ 0.160	✓ 0.182	✓ 0.224	✓ 0.267	✓ 0.333
7500	7K5				✓	✓	✓ 0.041	✓	✓	0.058	✓ 0.079	✓ 0.100	✓ 0.115	✓ 0.141	✓ 0.160	✓ 0.182	✓ 0.224	✓ 0.333
8000	8K0				✓	✓	✓ 0.041	✓	✓	0.058	✓ 0.079	✓ 0.100	✓ 0.115	✓ 0.141	✓ 0.160	✓ 0.182	✓ 0.224	✓ 0.333
10000	10K				✓	✓	✓ 0.035	✓	✓	0.050	✓ 0.079	✓ 0.100	✓ 0.115	✓ 0.141	✓ 0.160	✓ 0.182	✓ 0.224	✓ 0.333
12500	12K5				✓	✓	✓ 0.031	✓	✓	0.041	✓ 0.058	✓ 0.079	✓ 0.100	✓ 0.115	✓ 0.141	✓ 0.160	✓ 0.182	✓ 0.224
15000	15K				✓	✓	✓ 0.029	✓	✓	0.041	✓ 0.058	✓ 0.079	✓ 0.100	✓ 0.115	✓ 0.141	✓ 0.160	✓ 0.182	✓ 0.224
20000	20K				✓	✓	✓ 0.035	✓	✓	0.050	✓ 0.079	✓ 0.100	✓ 0.115	✓ 0.141	✓ 0.160	✓ 0.182	✓ 0.224	✓ 0.333
25000	25K				✓	✓	✓ 0.032	✓	✓	0.045	✓ 0.058	✓ 0.079	✓ 0.100	✓ 0.115	✓ 0.141	✓ 0.160	✓ 0.182	✓ 0.224
30000	30K				✓	✓	✓ 0.032	✓	✓	0.045	✓ 0.058	✓ 0.079	✓ 0.100	✓ 0.115	✓ 0.141	✓ 0.160	✓ 0.182	✓ 0.224
40000	40K				✓	✓	✓ 0.032	✓	✓	0.045	✓ 0.058	✓ 0.079	✓ 0.100	✓ 0.115	✓ 0.141	✓ 0.160	✓ 0.182	✓ 0.224
50000	50K				✓	✓	✓ 0.032	✓	✓	0.045	✓ 0.058	✓ 0.079	✓ 0.100	✓ 0.115	✓ 0.141	✓ 0.160	✓ 0.182	✓ 0.224

✓ = Standard values; check availability
 Rheostats are silicone-ceramic coated at and
 above the following ohmic values:
 Model C: all Model G: 5000
 Model E: 3500 Model K: 7500
 Model H: 7500 Model L: 7500
 Model J: 15,000

Check product availability at
www.ohmite.com

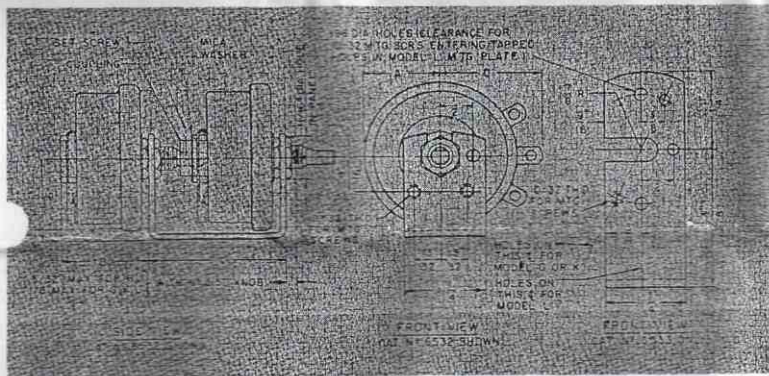
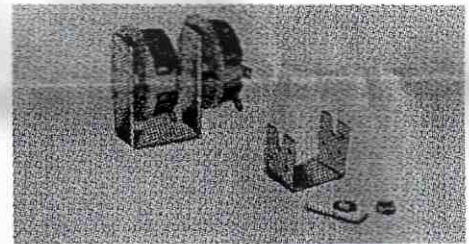
OHMITE**ASSEMBLY INSTRUCTIONS
RHEOSTAT TANDEM COUPLING KITS****Instructions for Tandem Kits No. 6532 or 6533 (Models H, J, G, K, L)**

Note: Kit 6532 will also accommodate G, K, or L in rear position; 6533 can also accommodate H or J in rear position.

(1) Assemble the front rheostat on the frame. See that the tip of the locating washer is in the hole provided (for Models H, J, G, and K) before tightening the mounting nut. Do not loosen the nut which is against the rheostat base. (For the Model L, see that the tapped holes in the rheostat mounting-plate, line up with the clearance holes in the frame; this assembly mounts the panel by means of these holes.) For the Model G, K, and L frame, the slot is open to left looking from panel end.

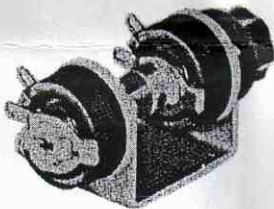
(2) Turn the shaft of both rheostats so the flat is up (toward open side of frame).

(3) Loosen the mounting nut of the second (rear) rheostat until it is held by only one turn. Put the coupling on the shaft with the set screw on the flat, but leave slightly loose. Put the mica washer on the coupling. Slide the rheostat into the frame and then push it forward so that the end of the shaft enters the back of the hub of the front rheostat. See that the locating washer is in the hole provided. Push the coupling forward firmly so that the projections are in the slots in the driving hub. (On Model L only, use the two hex head screws for fastening the rear rheostat to the bracket.) Tighten the mounting nut of the rheostat and tighten the set screw in the coupling.



Cat. No.	Rheo. Model	A	B	C	D
6532	H	2 ⁵ / ₃₂	1 ³ / ₈	2 ⁵ / ₃₂	1 ⁵ / ₁₆
	J	1 ⁵ / ₃₂	1 ³ / ₈	2 ⁵ / ₃₂	1 ⁷ / ₁₆
6533	G	1 ³ / ₈	1 ³ / ₄	2 ⁷ / ₁₆	1 ²⁵ / ₃₂
	K	1 ⁷ / ₁₆	1 ³ / ₄	2 ⁷ / ₁₆	1 ²⁵ / ₃₂
	L	2	2*	2 ⁷ / ₁₆	2 ⁷ / ₃₂

*2 inch overall depth of Rear Rheostat as measured to contact form.

Instructions for Tandem Kit No. 6591 (Model E)

(1) Place rear rheostat on frame with locating nib in hole provided. Leave mounting hex nut loose, approximately 1 to 2 turns.

(2) Position contact on upper lug. Place coupling on shaft.

(3) Place mica washer on coupling.

(4) Position contact on front rheostat same as rear rheostat. Place rheostat in frame and locate non-turn nib in hole provided.

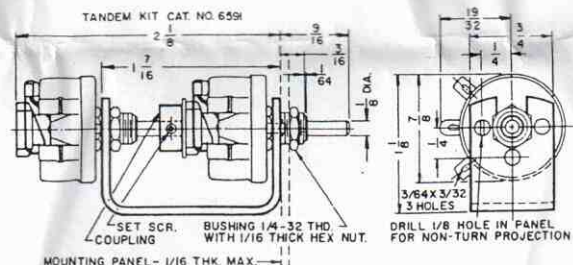
(5) Push coupling forward firmly so that projections definitely engage driving hub of front rheostat with mica washer between hub and coupling.

(6) Tighten set screw in coupling and hex nut of rear rheostat.

(7) Mount assembly on panel so that non-turn nib is located in the 1/8" diameter hole in the panel.

(8) Tighten hex nut.

(9) Check spring arm and contact alignment and retighten coupling as required.

**OHMITE**

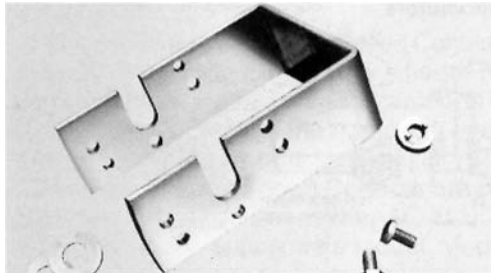
Ohmite Mfg. Co.
1600 Golf Road
Suite 850
Rolling Meadows, IL 60008

Ph 847-258-0300
Fax 847-574-7522
www.ohmite.com
info@ohmite.com

Rheostat and Tap Switch Hardware

Knobs, Dials, Mounting Fasteners

RHEOSTAT TANDEM COUPLING KITS



Ohmite coupling kits permit tandem mounting of two rheostat units. A coupling fastens to the shaft of the back unit; projections on the coupling engage the recesses in the driving hub of the front unit.

Each kit consists of a steel "U" frame, a coupling with set screw, mica washer, allen wrench and instructions.

Part No.	Front mount models	Rear mount models	Max. panel thickness
✓ 6532	H, J	H, J, G, K, L	5/32"
✓ 6533	G, K, L	H, J, G, K, L	1/8"
❖ 6591	E	E	1/16"

RHEOSTAT REPAIR KITS



Electrical contact replacement kit. Kit includes contact/slip ring assemblies (for round and ribbon wire rheostats), copper graphite washer, spring arm and hub. Instructions included.

Part No.	Rheostat model
✓ 7070	P
✓ 7071	N
✓ 7072	R
✓ 7074	U

EXTRA MOUNTING HARDWARE

Kit contains 25 each, nuts and lock washers for panel mounting units.

Part No.	For model
✓ 7090	E
✓ 7091	H, J, G, K, L, 111, 212, 711

- ✓ = Standard values
- ❖ = Non-standard values subject to minimum handling charge per item

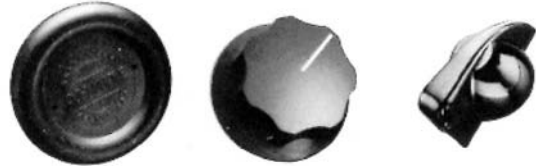
KNOB S



Finger grip with pointer

Finger grip without pointer

Handwheel with pointer



Handwheel without pointer

Finger grip

Bar knob, 1.5" long

Any knob can be used with any rheostat and tap switch model which has the corresponding shaft diameter. Knobs are fastened to shafts with slotted set screws.

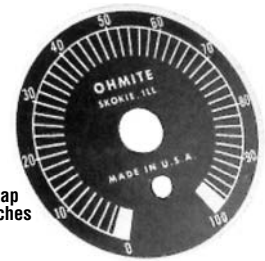
Slotted set screw	Hex socket set socket	Description	Knob dia.	Hole dia.	Fits model
❖ 5102	—	Bar knob, 2 1/4" long	—	1/4"	H, J, G, K, L
✓ 5103	✓ 5103A	Bar knob, 1 1/4" long	—	1/4"	H, J, G, K, L
✓ 5104	✓ 5104A	Handwheel with pointer	3 1/4"	3/8"	P, N, R, U
✓ 5105	—	Handwheel without pointer	3 1/4"	3/8"	P, N, R, U
✓ 5106	❖ 5106A	Handwheel with pointer	3 1/4"	1/4"	H, J, G, K, L
❖ 5107	—	Handwheel without pointer	3 1/4"	1/4"	H, J, G, K, L
✓ 5109	✓ 5109A	Finger-grip with pointer	1 5/8"	1/4"	H, J, G, K, L
✓ 5110	❖ 5110A	Finger-grip without pointer	1 5/8"	1/4"	H, J, G, K, L
✓ 5111	✓ 5111A	Finger-grip with pointer	1 1/4"	1/4"	H, J, G, K, L
❖ 5112	❖ 5112A	Finger-grip without pointer	2 3/8"	1/4"	H, J, G, K, L
✓ 5116	❖ 5116A	Bar knob, 1 1/2"	—	1/4"	H, J, G, K, L
✓ 5150	❖ 5150A	Finger-grip	1 1/2"	1/4"	H, J, G, K, L
✓ 5151	—	Finger-grip	3/4"	1/8"	C, E
—	✓ 5152A	Like 5104 (shorter pointer)	3 1/4"	1/4"	H, J, G, K, L

DIALS

Handsomely finished, black-enameled, aluminum dials for Ohmite rheostats and tap switches. Figures and lines are etched on a black background for contrast and ease of readability. On rheostat dials, divisions indicating approximate percentage of rheostat resistance in circuit are marked from 0 to 100. On tap switch dials, Number of dial positions are identical with number of switch positions.



For rheostats



For tap switches

Part No.	For model	For knob	Dial dia.
✓ 5007	C, E	5151	1 1/4"
✓ 5000	H, J, G, K, L	5150, 5116, 5103	2 3/16"
✓ 5001	P, N, R, U	5104, 5106	5 1/2"
✓ 5002-*	111, 212 (single), 312 (single)	5109, 5116, 5150	2 3/4"
✓ 5003-*	212 (tandem), 312 (tandem), 412	5111, 5152A	3 3/4"
✓ 5004-*	608	5104	5 1/2"

* Specify number of positions as suffix.

STEP 1 Determine Resistance and Watts

Ohm's Law

(a) $R = E/I$ or $I = E/R$ or $E = RI$

Ohm's Law, shown in formula form above, enables determination of the resistance when the required voltage and current are known. When the current and voltage are unknown, or the best values not decided on, at least two of the three terms in Ohm's Law must be measured in a trial circuit (see Engineering Manual Bulletin 1100).

Note that the maximum current to be determined is the current of the load before the rheostat resistance is inserted. On the other hand, the maximum resistance occurs with the minimum current.

(b) $W = I^2R$ or $W = EI$ or $W = E^2/R$

Power, in watts, can be determined from the formulas above, which stem from Ohm's Law.

Note that the rated wattage of a uniform wound rheostat is calculated using the maximum current and the total rheostat resistance. The Summation Watts are calculated instead for a taper wound rheostat as explained under "Tapered Rheostats," page 14.

Short Cut Method

Use an Ohmite Ohm's Law Calculator (convenient slide-chart) or use Ohm's Law Chart in the Engineering Manual, Bulletin 1100. Set known values as explained on the Calculator, or Chart, and read the sought for OHMS, WATTS (or other terms).

Calculation Method

Using the Ohm's Law formulas given above, and explained in greater detail in the Engineering Manual, calculate the unknown values. How to conduct tests when a trial must be made of the actual apparatus is explained in the Manual.

STEP 2 Power Rating or Physical Size of Rheostat

General: Rheostat watt ratings are based on the condition that the moving contact is set so that all of the winding is in the circuit. This makes the condition the same as that of a fixed resistor (assuming a uniform rheostat winding) and we may then say that a rheostat operated at a constant wattage will attain a steady temperature which is determined largely by the ratio between the size (surface area) and the wattage dissipated. The temperature stabilizes when the sum of the heat loss rates (by radiation, convection and conduction) equals the heat input rate (proportionage). The greater the rheostat area per watt to be dissipated, the greater the heat loss rate and therefore the lower the temperature rise.

Free Air Watt Rating

In general, for commercial rheostats, the relation of the "Free Air Watt Rating" of vitreous enameled rheostats to the physical size has been set at such a figure that: "When operated at their rated watts the temperature rise of the hottest spot shall not exceed 300°C (540°F) as measured by a thermo-couple, when the temperature of the surrounding air does not exceed 40°C (104°F). The temperature is to be measured at the hottest point on the embedding material of a rheostat mounted on a vertical metal panel in free, still air space with at least one foot of clearance to the nearest object, and with unrestricted circulation of air." This is in accordance with standards of the "National Electrical Manufacturers Association" (NEMA) and the "Underwriters' Laboratories."

Electronic Industries Association (formerly RETMA) standards provide for a maximum attained hot spot temperature of 340°C for rheostats of 100 watts or less and 300°C for rheostats of greater wattage. The reference ambient is 25°C.

Military Rheostat Specification MIL-R-22 provides for a maximum hot spot temperature attained (on the exposed winding) of 340°C for rheostats of 100 watts or less and 390°C for larger rheostats. The reference ambient is 25°C.

The temperature rise, with all resistance in the circuit, is not directly proportional to the wattage but follows the curves as shown in Fig. 1 and Fig. 2.

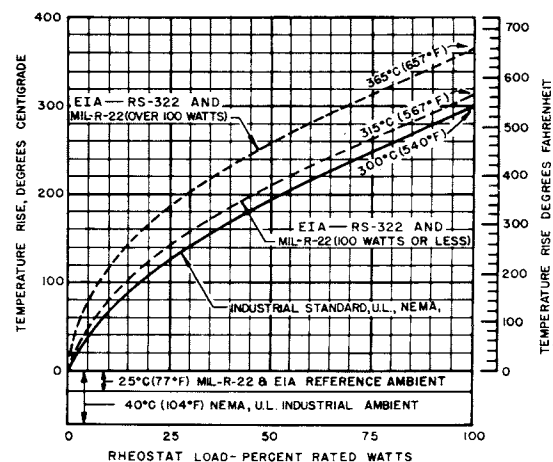


Fig. 1: Hot spot temperature rise of a rheostat for various specifications.

The temperature rise on a tapered rheostat does not exceed the rated maximum, but the location of the hot spot, for each position of the contact, depends on the taper design.

In the usual rheostat application, the current is reduced as the resistance is inserted in the circuit and so the operating temperature is much less than the maximum rated temperature. If the maximum current is actually carried as a constant value, the hot spot temperature builds up as the resistance is added and levels off at the maximum rated temperature starting at approximately 30% rotation.

Current Rating

When selecting a rheostat for a particular application, it is the current rating, rather than the wattage rating, which directly indicates the usability. For any given wattage size and resistance, the maximum current to be carried through any part of a uniform winding is determined from Ohm's Law, $I = \sqrt{W/R}$. The current values for all stock rheostat resistances are given in the stock tables.

The minimum current (occurring at maximum resistance) is a factor influencing the rheostat watt size required, as explained under "Tapered Rheostats."

When a rheostat is connected as a potentiometer, i.e., bridged across the line with the load connected between one end and the moving contact, the minimum current is the "bleeder" current (through the entire winding). The maximum potentiometer current is the sum of the bleeder current and the maximum load current.

Tapered Windings

A "tapered winding" consists of two or more smoothly joined sections wound with larger wire for the higher current sections. Characteristics of tapered windings are explained fully starting on page 14.

Application Modifications of Power Ratings

To allow for the differences between the actual service conditions and the "Free Air Watt Rating" it is sound engineering practice to operate the rheostats at modifications of nominal rating. The details by which such ratings can be estimated are given hereafter. Most thermal calculations, however, involve so many factors which are usually not accurately known, that at best they are only approximations.

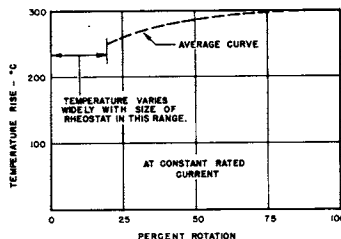


Fig. 2: Hot Spot temperature rise of a typical rheostat versus percentage of winding in circuit.

The factors which affect the temperature rise act nearly independently of each other and are summarized as follows:

- 1. Ambient Temperature:** As the maximum permissible operating temperature is a set amount, any increase in the ambient temperature subtracts from the permissible temperature rise and therefore reduces the permissible watt load.
- 2. Enclosure:** Enclosure limits the removal of heat by convection currents in the air and by radiation. The walls of the enclosure also introduce a thermal barrier between the air contacting the rheostat and the outside cooling

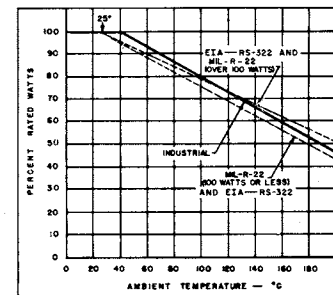
air. Hence, size, shape, orientation, amount of ventilating openings, wall thickness, material and finish, all affect the temperature rise of the enclosed rheostat. Reduction of rating is generally necessary only if the housing is only slightly larger than the rheostat, totally enclosed and where the ratio of I_{max} to I_{min} is less than two.

3. Grouping: Rheostats mounted in standard tandem frames do not require derating. Other conditions should be studied for possible effects.

4. Altitude: The amount of heat which air will absorb varies with the density, and therefore with the altitude above sea level. At altitudes above 100,000 feet, the air is so rare that the rheostat loses heat practically only by radiation (and conduction).

5. Pulse or Rotating Operation: This is not an environmental condition but a circuit condition. As a pulse of power (or the varying power in the rheostat as the contact is rotated) when averaged over the total on and off time results in less heat per unit time than for continuous duty, the temperature rise is affected. This may permit higher pulse power. The conditions must be expertly considered for conservative rating.

Fig. 3: Rheostat derating for ambient temperature for various specifications.



6. Cooling Air: Forced circulation of air over a rheostat removes more heat per unit time than natural convection does and therefore permits an increased watt dissipation. Liquid cooling also can increase the rating.

7. Limited Temperature Rise: It is sometimes desirable to operate a rheostat at a fraction of the Free Air Watt Rating in order to keep the temperature rise low. This may be to protect adjacent heat sensitive apparatus; to hold the resistance value very precisely both with changing load and over long periods of time and to insure maximum life.

8. Other Considerations: HIGH RESISTANCE. High resistance units, which require the use of very small diameter wire, generally should operate at reduced temperature and voltage for maximum reliability.

HIGH VOLTAGE. The total volts must be limited to a reasonable ratio with respect to the insulation breakdown values, etc.

MILITARY AND OTHER SPECIFICATIONS. The special physical operating and test requirements of the applicable industrial or military specification must be considered. Military specification rheostats should be ordered by their MIL numbers.

Temperature Coefficient of Resistance

The resistance alloys used for all except the lowest ohmic values show such little change with temperature that in most power circuits the resistance is considered constant with load.

For special applications which require very constant resistance, it may be desirable to specify the maximum permissible TC (temperature coefficient of resistance), and the range of temperature, and consequently to use only certain types of resistance alloys.

For low TC (and other) applications, Ohmite can provide rheostats with an "Ohmicone" (silicone-ceramic) coating. "Ohmicone" is processed at much lower temperatures than vitreous enamel and therefore makes control of TC and tolerance easier.

Data on the TC of various alloys is given in the Engineering Manual.

Determining the Power Rating

Short-Cut Method: Appropriate scales on the "Step 2 Short Cut Chart" in the Resistor Catalog can also be used for rheostats. Locate the known application modifications of Free Air Conditions, multiply the correction factors for ambient, altitude, etc, together with the rheostat Watts ($I^2_{max} \times R_{rheo.}$) to obtain the minimum Watt Size Required.

Calculation Method: Obtain derating factors from graphs in this catalog and the Engineering Manual and calculate necessary allowances.

STEP 3 Selecting the Rheostat Model and Mechanical Features

A uniformly wound rheostat can be chosen quite easily from the many models and resistances listed on pages 9 to 13. It is only necessary to select one with the desired resistance which has a current value not less than the maximum current of the circuit.

When the desired resistance falls between the standard values listed, use coded specification number to order.

Taper wound rheostats of the required resistance and with both maximum and minimum current ratings not less than those of your application may be selected from listings on pages 35 through 38.

Ohmite will be pleased to design a tapered rheostat for your application based on the required resistance, maximum and minimum current and nature of the load.

The minimum size model for a three-section taper can be determined with fair accuracy by the method given on page 15.

Additional Features—Mechanical and Electrical

The Rheostat Guide, pages 4 and 5, indicates the more commonly used additional features and the pages on which detailed information will be found. Mechanical features include such typical items as special mounting bushings and shafts, tandem mountings, and auxiliary switches. Electrical features include special winding angles, and tapers.

Special attention may be required for extra long rotation life, unusual vibration, resolution, linearity, etc. The possible combinations of additional features are great. In addition, special designs to meet customer requests can be created.

SUGGESTIONS FOR ORDERING

CODED SPECIFICATION NUMBER

Model	Ohms	Shaft Type	Max. Panel	Additional Feature
E, H, J, G, K, L, P, N, R, T, or U	As Required. Letter R used for decimal point	F=Flatted R=Round S=Screwdriver (standard for LO, LA, & LE) LO=Locking "SHALO" LA=Locking "SHALA" LE=Locking "SHALE"	Number of Eighths	352, etc., Off Pos. 375, etc., Toggle Sw. T2=Two in Tandem T3=Three in Tandem

*Substitute the shaft Type No. from pages 16 or 18 instead of max. panel thickness when one of these shafts is to be used.

Example 1: H-7R5 S2-T2

This is a Model H rheostat, 7.5 ohms, with screwdriver slotted shaft for 1/4" panel and mounted two in tandem.

Example 2: J-500-502B-352

This is a Model J rheostat, 500 ohms, with a catalog item special shaft (from table page 16)—and with Type 352 Off Position.

Rheostats with following features may be specified using code formula described above:

- Standard or Special Resistance
- Standard, round, screwdriver and locking shafts
- Catalogued special panel length bushing or shaft
- Off position or auxiliary switches
- Standard cages
- Tandem assemblies

Rheostats with following features may not be coded but are assigned a serial specification number at the factory:

- Tapered or special winding
- Combination of more than 2 "additional features"
- Customer designed special shafts and features

FOR STANDARD RHEOSTATS

1. Quantity.
2. Resistance.
3. Catalog Number.
4. Model and Watt Rating.
5. Itemize knobs and all other accessories separately.

FOR MADE-TO-ORDER RHEOSTATS

1. Quantity.
2. Resistance.
3. (a) Coded Specification Number and Resistance. (For Uniform Wound Rheostats where applicable.)
(b) Ohmite Specification Number and Resistance. On reorders of special rheostats, the use of this number will assure exact duplication.
(c) Catalog Number of standard Tapered Rheostats.
4. Model, Watt Rating and whether Tapered Winding is desired.
5. Maximum current.
6. Minimum current (for Tapered Winding).
7. Resistance Tolerance if other than standard $\pm 10\%$.
8. Give Catalog Number, Type Number or Code Word for all Additional Features plus description of special shafts, etc.
9. Itemize knobs and all other accessories separately.
10. MIL Rheostats should be ordered by MIL number.

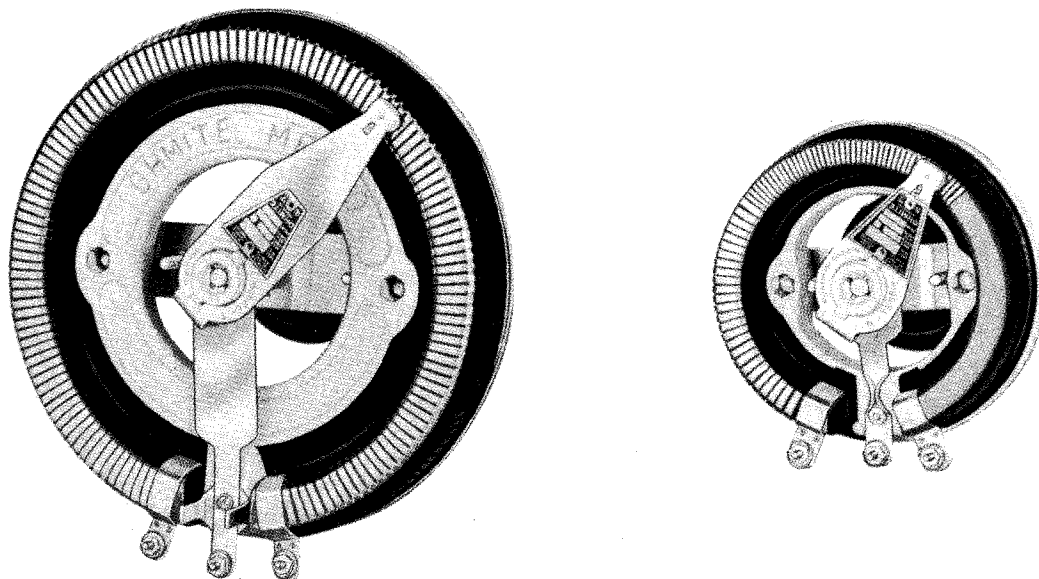


Fig. 28: Size comparison of uniform and tapered rheostats for a specific application.

Rheostat windings are sometimes tapered, i.e., wound in two to five (or more) sections of diminishing wire or ribbon sizes. These sections are so smoothly joined that only the change in wire size tells where the sections connect (see Fig. 28).

For a given application, the taper may accomplish one or more of the following:

1. Make possible the use of a smaller rheostat.
2. Provide more uniform control (i.e., more nearly linear control) at all positions of the contact arm.
3. Make possible special curves of resistance (or of the controlled effect) versus rotation.
4. Make possible the winding of higher resistance on a given size rheostat, for a given maximum amperage.

Because tapered windings involve extra manufacturing operations, tapered rheostats when ordered singly or in small quantities generally cost more than uniformly wound rheostats of the next larger size. Tapers are generally not suitable unless the ratio of maximum to minimum current is 1.5 or greater. When large quantities are involved (the necessary quantity depending upon the rheostat model and number of sections) the tapered unit generally becomes the more economical one. For convenience and economy in making preliminary tests to determine the resistance and current rating, a stock (linear) rheostat is frequently used.

How Size Is Reduced

When the moving contact of a rheostat is on the first turn of wire or ribbon, this turn must carry the maximum current. But as the resistance is put into the circuit, the

succeeding turns never have to carry more than a certain fraction of the maximum current, because the current tapers off from the maximum to some minimum value.

Hence, in a uniform, or linear winding, the latter portions of the winding operate at lower wattages (I^2R) per square inch than the rated values. The tapered winding, using smaller size wire for each section, proportioned for the current to be carried, increases the ohms per inch of winding in successive sections. This makes the watts dissipated per square inch of winding section more nearly approach the rated wattage value. As the core area required for a given wattage dissipation is less when operated at higher watts per square inch than for lower watts per square inch, the total core size is reduced.

Ohmite taper designs use the largest wire practicable for each section so that great durability is maintained.

How Better Control Is Produced

Fig. 29 shows how the current varies (in a typical case) with the percent rotation of the rheostat contact. Because a uniformly wound rheostat adds a constant number of ohms per degree of rotation to a constantly increasing number of ohms, the current changes ever more slowly as the resistance is increased (curve "A" Fig. 29). A tapered winding (curves "B" and "C") by increasing the number of ohms per degree of rotation as the total ohms in circuit increases, makes the current curve more nearly linear.

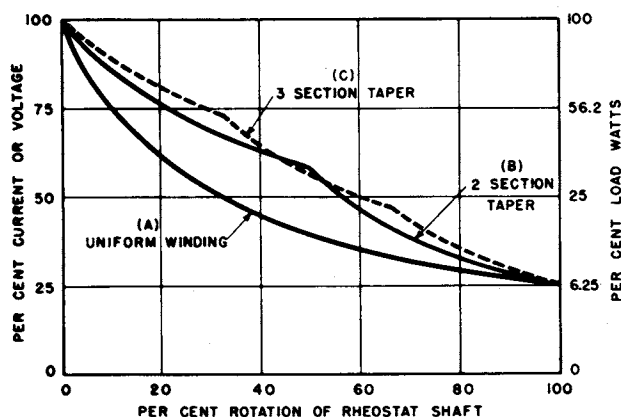


Fig. 29: Typical curves of load variation with shaft rotation for uniform and taper-wound rheostats.

Selecting a Tapered Rheostat

Tapers depend, among other factors, on the ratio of the maximum to the minimum current and upon the way in which the current varies between these end points. Tapers, therefore, are designed for specific circuits.

For any given set of rheostat conditions (resistance, maximum and minimum current) it is generally possible to design more than one size of tapered rheostat. That is, any of the various Ohmite rheostats can be used the wattage rating of which is sufficiently greater than the required Summation Watts ($\Sigma W = I_{max} \times I_{min} \times R_{theo.}$)—the smaller rheostat generally having more sections than the larger. The choice between the models will depend upon the space requirements, mounting conditions, and upon the quantity ordered. In small quantities the larger rheostat of fewer sections sometimes costs less than the smaller rheostat of greater number of sections.

Approximate Size of Tapered Rheostat

Method I. The approximate size of a tapered rheostat, for specified conditions, having an average number of sections (3) can be determined as follows:

1. Determine Summation Watts—
 $\Sigma W = I_{max} \times I_{min} \times R$
2. Determine $K = \frac{I_{max}}{I_{min}}$ Round off the figure to the next highest number in Col. K, Fig. 30.
3. Select Factor F from Table Fig. 30.
(Note: For greater accuracy, the exact value of K can be used and F found by interpolation in the Table.)

4. Determine Rheostat Model (Watt Size). Multiply ΣW by F and choose smallest rheostat having a watt rating equal to or greater than this product.

Example:

Rheostat Ohms = 20

$I_{max} = 12.6$ amps.

$I_{min} = 1.27$ amps.

1. $\Sigma W = 12.6 \times 1.27 \times 20 = 321$ watts
2. $K = \frac{12.6}{1.27} = 9.9$ Round off to 10.
3. $F = 2.13$ (from table Fig. 30)
4. $\Sigma W \times F = 321 \times 2.13 = 684$ Model T = 750 which is greater than product 684 and therefore 3 section Model T can be used.

K	F	K	F
1.5	1.15	5	1.70
2	1.26	7.5	1.93
3	1.45	10	2.13
4	1.60		

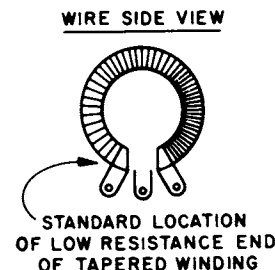
Fig. 30: Table of factor F for tapered rheostat selection (three sections).

The Ohmite Engineering Department will be glad to recommend the most economical unit and to design the taper upon receipt of full information (see page 8 "How To Order").

Standard Taper Rheostats. The rheostats listed on pages 35 to 39 include taper-wound units which can be used for field control or other purposes, such as the control of heating elements or other loads of constant resistance.

Method II. An alternate design method sometimes can be used which results in a rheostat of smaller size and/or fewer number of taper sections than that provided by the Method I design. Method II specifies a rheostat, the wattage size of which is equal to (or sometimes less than) the calculated Summation Watts. Such designs operate at higher hot spot temperatures than the Method I designs.

Direction of Taper. To indicate the direction of taper, a sketch, similar to Fig. 31 or a statement, should be included when ordering. The direction of taper shown is standard and will be supplied unless otherwise ordered. It is described as "counterclockwise increase in resistance when viewed from the knob side."



Bushings and Shafts for Small Rheostats

(Models C, E, H, J, G, K, L)

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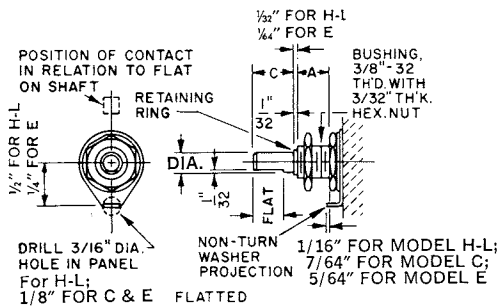


Fig. 32: Flatted shaft for 1/8" and 1/4" diameter

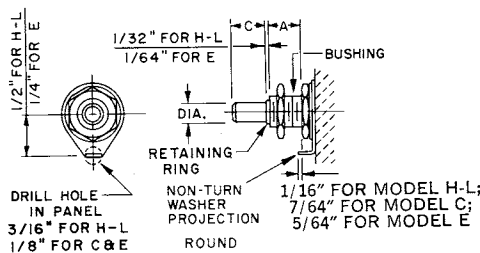


Fig. 33: Round shaft for 1/8" and 1/4" diameter

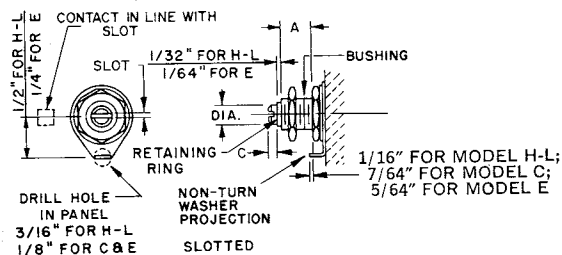


Fig. 34: Slotted (Screwdriver) shaft for 1/8" and 1/4" diameter

Standard shafts for Models C and E rheostats are round with a 1/4"-32 bushing for mounting on panels to 1/8" thick; for Models H, J, G, K and L rheostats, standard shafts have a flat and a 3/8"-32 threaded bushing—long enough for mounting on panels up to 1/4" thick. Shafts without a flat, with a screwdriver slot, or with screwdriver slot and

STANDARD SHAFT VARIATIONS FOR MODEL C' AND E (1/8" Dia. Shaft)													
MAX. PANEL	BUSHING PROJ. "A"	'SHAFT PROJECTION (C) FROM RETAINING RING—SHAFT CODES AND TYPE NUMBERS											
		SCREWDRIVER SLOT											
		FLATTED		ROUND		Non-Locking Shaft				Locking Shaft			
		REG.	LOCK.	STD.	LONG	STD.	LONG		STD.	SPECIAL			
		23/64	23/64	11/64	1/4	23/64	11/64	13/64	21/64	1/4	1/4	23/64	
1/16	3/16	11/32	F1	R1	572A	S1	573A	573B	573C	573D	*1	—	
1/8	1/4	1/32	F1	R1	577A	S1	577A	577B	577C	577D	*1	+578C	
		1/2	—	—	—	—	—	—	—	—	—	+579B	+579C
1/4	3/8	17/32	F2	R2	581A	S2	582A	582B	582C	582D	*2	+583B	+583C
			Proj. from Mtg. Surface to end of shaft for 1/8" panel (2)										
			5/8"	3/4"	1 1/2"	3/8"	5/8"	1 1/2"	2"	2 1/2"	1 1/32"	5/8"	7/8"

- Add 1/4" to obtain projection from front of bushing to end of shaft.
 - For PFMS (projection from mounting surface to end of shaft); for panels other than 1/8" add difference between the chosen bushing projection and 1/4" to projection shown.
 - Flat length; 3/8" for all.
 - Model C limited at present to 577A, 578C, 579B, and 579C. No. 577A is standard on Model C and used instead of S1.
- *Prefix consisting of code for type of locknut must be added as in L01, LA1, LE1. For other than the standard shaft with screwdriver slot, indicate with additional prefix letter such as FL01, or RL01.
 †Prefix consisting of code for type of locknut must be added as in LE579B (LA is not applicable).
 ‡Standard.

slotted bushing for a locking device are also available with bushings to accommodate various panel thicknesses. They can be obtained with different projections beyond the retaining ring to accommodate special knobs, or auxiliary devices, etc.

Where appearance requires that the knob be close to the panel or space is limited, and the panel is thin, the 1/8" panel bushing is used. Bushings for a 1/16" panel can be made also.

Shafts with Flat

The standard flat is always located so that a perpendicular to the flat is in line with the rheostat contact and on the opposite side of the shaft. This agrees with the normal location of a set screw on a knob and results in the arrow-head or pointer, if any, pointing to the location of the contact. Symbol "F" describes this type of shaft in the rheostat coded designation (for standard front projection only).

Shafts without Flat (Round)

A plain round end is sometimes preferred when it is desired to be able to line up the knob with certain panel calibration marks, to fit a coupling gear, etc. Rheostat code symbol is "R" (for standard front projection only).

STANDARD SHAFT VARIATIONS FOR MODELS H, J, G, K AND L (1/8" Dia. Shaft)																							
Max. Panel	Bushing Proj. "A"	'Shaft Projection (C) from Retaining Ring—Type Nos.										Max. Panel	Bushing Proj. "A"	'Shaft Projection (C) from Retaining Ring—Type Nos.									
		Flatted ³					Round							Screwdriver Slot									
		Regular Type		Long			Short			Non-Locking Shaft				Locking Shaft									
		Std.	Long	Short	Std.	Long	Short	Std.	Med.	Long				Std.	Long								
1/8	1/8	1 1/2"	2"	2 1/2"	3"	1 1/2"	2"	2 1/2"	3"	1 1/2"	1 1/2"	2"	2 1/2"	3"	*1	+562F	+562E						
1/4	3/8	F1	502A	502B	502C	R1	512A	512B	512C	512D	1 1/2"	1 1/2"	2"	S1	552E	552A	552B	552C	*1	+562F	+562E		
1/2	1/2	F2	503A	503B	503C	R2	513A	513B	513C	513D	2"	2"	S2	553E	553A	553B	553C	*2	+563F	+563E			
3/4	3/4	F4	504A	504B	504C	R4	514A	514B	514C	514D	2 1/2"	2 1/2"	S4	554E	554A	554B	554C	*4	+564F	+564E			
1"	1"	F6	505A	505B	505C	R6	515A	515B	515C	515D	3"	3"	S6	555E	555A	555B	555C	*6	+565F	+565E			
1 1/4	1 1/4	F8	506A	506B	506C	R8	516A	516B	516C	516D	3 1/2"	3 1/2"	S8	556E	556A	556B	556C	*8	+566F	+566E			
1 1/2	1 1/2	F12	507A	507B	507C	R12	517A	517B	517C	517D	4"	4"	S12	557E	557A	557B	557C	*12	+567F	+567E			
2"	2"	F16	508A	508B	508C	R16	518A	518B	518C	518D	4 1/2"	4 1/2"	S16	558E	558A	558B	558C	*16	+568F	+568E			
			Projection From Mtg. Surface To End of Shaft For 1/8" Panel (2)																				
			7/8"	1 1/2"	2"	2 1/2"	3"	3 1/2"	4"	4 1/2"	5"	1 1/2"	1 1/2"	2"	2 1/2"	3"	3 1/2"	4"	4 1/2"	5"	5 1/2"	6"	6 1/2"

- Add 1/2" to obtain projection from front of bushing to end of shaft.
 - For PFMS (projection from mounting surface) for panels other than 1/8" add difference between the desired bushing projection and 3/8" the PFMS shown.
 - Flat length; 1 1/2" for all.
- *Prefix consisting of code for type of locknut must be added as in L01, LA1, or LE1 (see page 17). For other than the standard shaft with screwdriver slot, indicate with additional prefix letter such as FL01, or RL01.
 †Prefix consisting of code for type of locknut must be added as in L0562F or LE562F (LA is not applicable—see page 17).
 ‡Standard

Bushings and Shafts for Small Rheostats

(Models C, E, H, J, G, K, L)

Shafts with Screw-Driver Slot

This type of shaft is used to permit operation by a screw-driver instead of a knob when the rheostat is to be adjusted infrequently or when possibility of tampering with the setting must be minimized. Symbol "S" is used in the code (for standard front projection only).

Locking Type Screw Driver Shafts

A slotted bushing for use with special nuts as described below can be supplied. Rheostat code shaft and bushing symbols are "LO," "LA," or "LE" depending on the type of locking nut.

Special Shafts

Commercial shafts for Models E, H, J, G, K and L are ordinarily of zinc-plated steel. Stainless steel is standard on Model C. Bushings are unplated brass, but can be supplied zinc or nickel-plated at extra cost. All shafts listed in military specification MIL-R-22 are available also.

For special shafts made to order, supply a drawing or complete dimensions. Specify dimension "A," which is the projection of the bushing beyond the rheostat assembly nut. The retaining ring is not included in this dimension. Dimension "A" is (nominally) the sum of the given maximum panel thickness plus the thickness of the mounting nut and an allowance for manufacturing tolerance. The bushing should be another $\frac{1}{16}$ " longer if a lock-washer (see page 26) is to be used. See page 26 for "Shoulder Nuts" which are used with screwdriver shafts ($\frac{3}{8}$ "-32 bushing) when it is desired to keep the end of the shaft protected in a recess. Use shoulder nut No. 6057 for bushing lengths over $\frac{1}{4}$ ".

Heavy Duty Stop and $\frac{3}{8}$ " Dia. Shaft

Rheostat Models H, J, G, K and L can be provided with a $\frac{3}{8}$ " diameter shaft sleeve with a special heavy duty stop for use on industrial applications, especially where large diameter knobs are used. The stop can safely withstand stopping torques of 80 pound-inches. As the stationary stop is part of the special mounting bracket and the moving stop is a part of the $\frac{3}{8}$ " diameter sleeve, the stopping torque is not transmitted into the rheostat.

Shaft projection, special drilling, etc., can be varied.

Heavy Duty Stop, $\frac{3}{8}$ " Dia. Shaft and Tapped Mounting Bracket

Code Word
SHABS

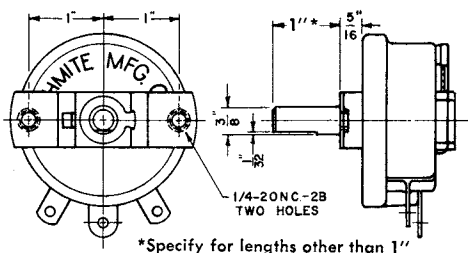


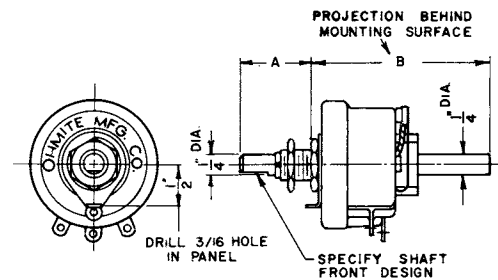
Fig. 35: Heavy duty stop for small rheostats.

Shafts with Rear Extension

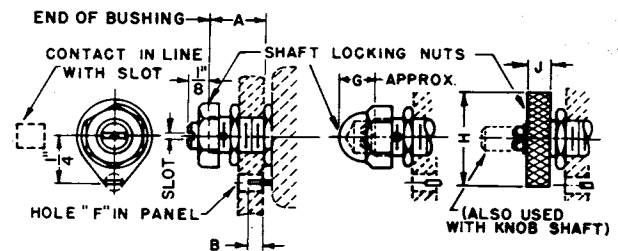
Special shafts with an extension on the rheostat wire side can be provided, so that other apparatus can be coupled to enable operation by the rheostat knob. Valves and switches are examples of items frequently coupled.

For Shaft Extensions on Wire Side, $\frac{1}{4}$ " Diam. Advise desired length

Distance from mounting surface to end of shaft must be given. Provide a sketch for special drilling, etc.



Shaft Locking Devices for Models C, E, H, J, G, K, L



Shaft Dia.	Max. Panel	A	B	Slot	F	G	H	J
$\frac{1}{8}$	See p. 16	See p. 16	$\frac{5}{64}$ (E) $\frac{7}{64}$ (C)	$\frac{1}{32}$ W $\frac{3}{64}$ D	$\frac{1}{8}$	$\frac{3}{32}$	$\frac{5}{8}$	$\frac{3}{32}$
$\frac{1}{4}$	See p. 16	See p. 16	$\frac{1}{16}$	$\frac{3}{64}$ W $\frac{1}{16}$ D	$\frac{3}{16}$	$1\frac{1}{32}$	1	$\frac{1}{4}$

Fig. 37: Shaft locking devices.

Shaft clamping or "locking" devices which discourage or prevent tampering with a rheostat setting, consist of a special nut on a split and tapered bushing (Fig. 37). The lock nut has a matching internal taper which forces the segments of the bushing against the shaft. Several types of nuts are available as shown. The knurled edge disc type is for tightening with the fingers and is sometimes employed with a knob-type shaft. The standard shaft end is normally slotted for screwdriver unless otherwise ordered. To order the shaft-lock feature, state panel thickness and proper code word shown below and/or specify bushing and shaft assembly when possible by the type numbers shown on page 16.

Code Word*

- Hexagon Nut Locking Device SHALO
- Cap Nut Locking Device SHALA
- Knurled Round Nut Locking Device SHALE

*"LO, LA or LE" are used in coded specification.

Shafts for Large Rheostats

(Models P, N, R, T, U)

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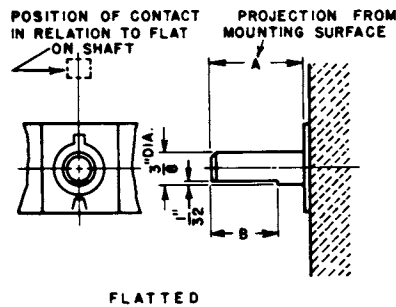


Fig. 38: Flatted shaft.

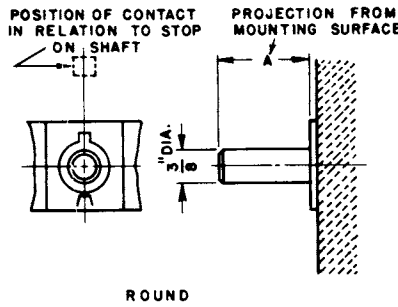


Fig. 39: Round shaft.

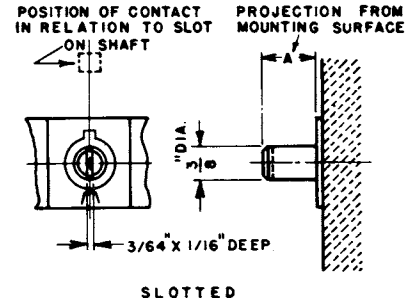


Fig. 40 Slotted (screwdriver) shaft.

Special Shafts

Standard rheostat shaft assemblies, as illustrated on stock units, have a shaft with a flat for the set screw of a knob, and are long enough for mounting on panels up to 1/4" thick (when used with knob Cat. No. 5104 or 5105). Shafts without a flat, or with a screw-driver slot are also available. While the standard shaft is generally used on thin panels as well as on panels up to the maximum, shorter shafts are available and are frequently used when it is desired to have the knob and pointer close to the dial, or panel. Standard shafts are zinc plated steel. Stainless steel, Type 416 or 303, is available at extra cost.

Shafts in all lengths per MIL-R-22 are also available. Special length shafts or shafts with special drilling etc., can be supplied. Please submit a drawing.

Shafts with Rear Extension

Special shafts with an extension on the rheostat wireside can be provided. Rheostats can also be made with the normal front end cut off and the rear extended for operation from the wire side only.

For Shaft Extension on Wire Side, 11/16" Dia Advise desired length

Distance from mounting surface to end of shaft must be given. Provide a sketch if any special drilling, etc., is required.

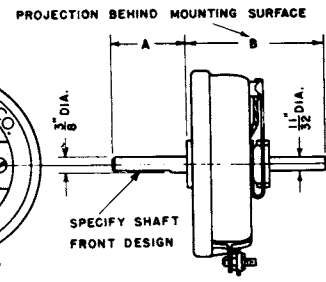


Fig. 42: Shaft with rear extension.

PANEL THICKNESS	FLATTED			ROUND		SCREW-DRIVER SLOT	
	A Proj. from Mfg. Surface	B Lgth. of Flat	Code Symbol	Proj. from Mfg. Surface	Code Symbol	Proj. from Mfg. Surface	Code Symbol
1/16" to 3/4"	1 1/32"	1"	F3 2	1 1/32"	R3	3/4"	S6 1
1/4" x 1 1/4"	2"	1 1/32"	F10 3 (Std.)	2"	R10	1 1/4"	S10
1 1/8" to 2 1/4"	3"	1 1/32"	4	3"	R18	2"	S16 1

(1) 3/4" Panel max. for S6 and 2" for S16.
 (2) Only F3 can be supplied for this range of panel thicknesses.
 (3) Only F10 can be supplied for this range of panel thicknesses.
 (4) Available in 1/8" increments from F11 to F18.

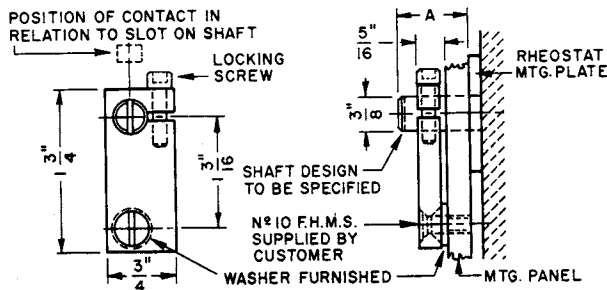


Fig. 41: Shaft locking device.

Screw Clamp Locks

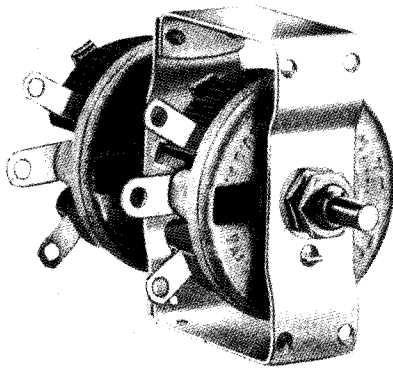
The locking device for rheostats with 3/8" shafts takes the form of a split arm fastened to the mounting panel as shown in Fig. 41. When the hex socket cap screw is tightened, the split arm is clamped to the shaft, preventing rotation. The shaft is slotted for screw-driver operation.

Screw Clamp Locking Device Code Word: SHALL

Specify shaft selected from following table or give projection from mounting surface for other panels.

Panel Thickness	Shaft Projection From Mounting Surface	Shaft Type No.
1/16" to 3/8" incl.	3/4"	S6
1/2" to 1 1/8" incl.	1 1/4"	S10

Fig. 43:
Standard
assembly of
two Model J
rheostats



Standard Tandem Assemblies

Ohmite rheostats can be supplied mounted two, three, or more in tandem for simultaneous control of several circuits, or phases of a circuit, by means of a single knob, as shown in Figs. 43 to 50. The rheostats are spaced to permit their operation at the same ratings as when individually mounted. Tandem rheostats are frequently connected in series (and sometimes in parallel) to obtain increased wattage dissipation over that of a single rheostat for a given panel space, or because the wattage required exceeds that of a single rheostat.

Frames consist of plated steel strip, as illustrated, with mounting holes for panel or shelf mounting. Two, three, or four rheostats are generally connected by Ohmite-made universal joints which provide smooth action with a minimum of backlash. Greater numbers of rheostats are connected by a single through-shaft, which may be supplied also for 2 to 4 rheostats at option of Ohmite or the customer. As many as ten rheostats can be arranged in tandem on special frames; details supplied on request.

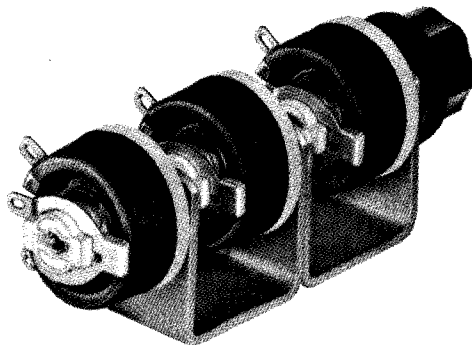
Mixed Models: Tandem assemblies of different model rheostats can be ordered, but such rheostats are specially made to make the angle of rotation of all of the rheostats the same as that of the smallest rheostat. The largest rheostat is mounted next to the panel and mounting dimensions for that size apply to the mixed assembly.

Ordering Information: Give Tandem Mounting Catalog Number and specify rheostats completely. When the rheostats are not identical, their location with respect to the panel should be given. Shaft lengths are as indicated in Figs. 44 to 46. Specify panel thickness or shaft length if other than standard is desired.

Shaft Diameter P, N, R, T & U: Model P, N, R, T, and U tandem assemblies can be supplied with 1/2" diameter through-shafts instead of 3/8" diameter. All large tandems of more than 4 rheostats in tandem are supplied with 1/2" diameter shafts as standard.

Location of Flat on Tandem Shafts: The standard location of the flat on a tandem shaft has been selected so that when the tandem frame is mounted on a panel with the frame vertical, the pointer on a knob will rotate symmetrically about the vertical center-line. Note that both the rheostat and the flat have been rotated 90° from the normal mounting position with the center-lead vertical and down. If the user intends to mount the rheostats per this latter method, the tandem assembly can be ordered with the flat on the shaft the same as on an individual rheostat, i.e., the perpendicular to the flat is 180° from the contact. Specify on order: "Flat on shaft to be 180° from contact."

Factory Assembled Tandem Rheostat Assemblies Model E



Model E-T3 Tandem

Rheostat Model	Watts Each	2-in-tandem Cat. No.	Weight (lbs.)	3-in-tandem Cat. No.	Weight (lbs.)
E	12 1/2"	6640	.080	6641	.164

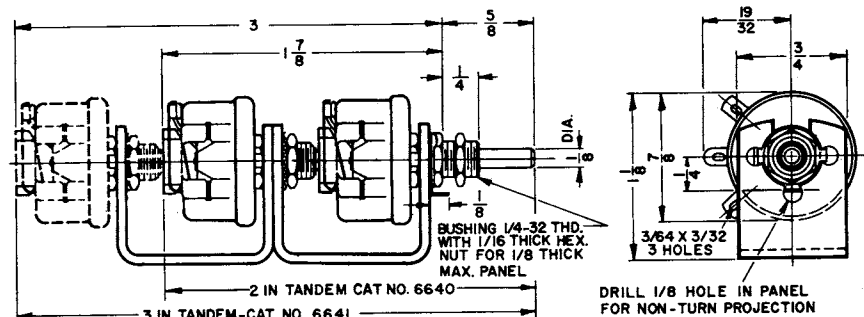
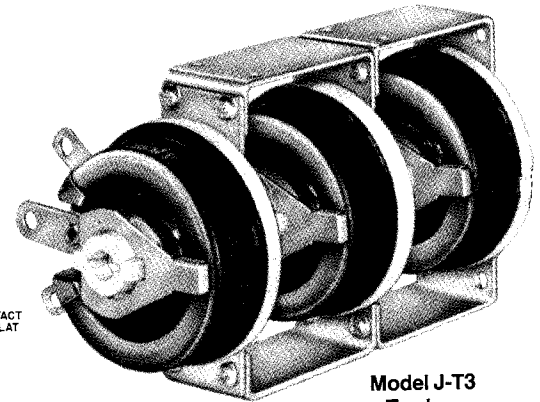


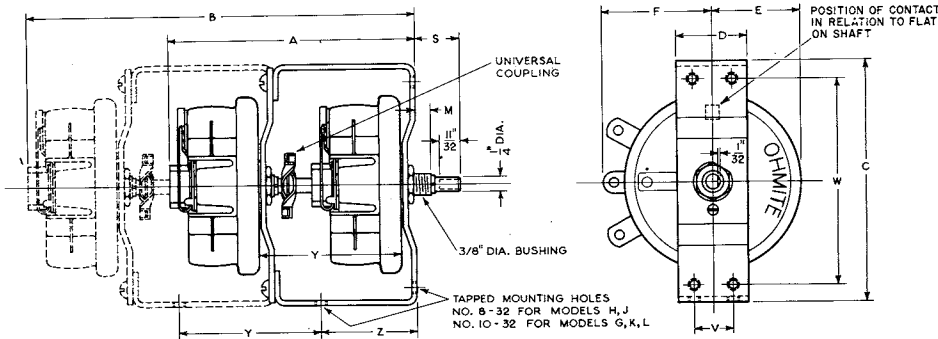
Fig. 44: Dimensions for Model E tandem assemblies

Factory Assembled Tandem Rheostat Assemblies

Models H, J, G, K, L



Model J-T3
Tandem



Max. Panel		M	S
Code	In.		
F2*	Std.	3/32"	25/32"
F4	1/2"	5/8"	1 1/8"
F6	3/4"	7/8"	1 3/8"
F8	1"	1 1/8"	1 7/8"
F12	1 1/2"	1 5/8"	2 1/8"
F16	2"	2 1/8"	2 5/8"

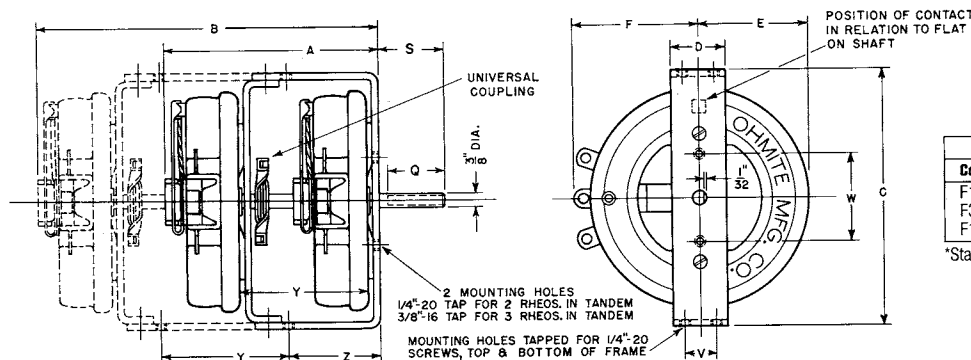
*Will fit 3/16" max. panel with panel nut; 1/4" max. panel without panel nut.

Fig. 45: Dimensions for Model H, J, G, K or L tandem assemblies

RHEOSTAT		DIMENSIONS									
Model	Watts Each	A	B	C	D	E	F	V	W	Y	Z
H	25	3 1/2"	5 1/2"	2 5/8"	1"	2 5/32"	1 15/16"	1 1/16"	1 7/8"	2"	1 11/16"
J	50	3 1/2"	5 1/2"	3"	1"	1 15/32"	1 9/16"	1 1/16"	2 1/2"	2"	1 11/8"
G	75	4 3/8"	6 7/8"	4 1/4"	1 1/4"	1 3/8"	1 23/32"	1 1/16"	3 3/8"	2 1/2"	1 11/4"
K	100	4 3/8"	6 7/8"	4 1/4"	1 1/4"	1 3/8"	1 23/32"	1 1/16"	3 3/8"	2 1/2"	1 11/8"
L	150	4 3/4"	7 1/4"	5"	1 1/4"	2"	2 3/32"	1 1/16"	4 1/4"	2 1/2"	1 15/16"

NOTE: Catalog Numbers for 4 rheostats in Tandem are: H = 6620, J = 6621, G = 6622, K = 6623, L = 6624

Models P, N, R, T, U



Max. Panel		S	Flat Length Q
Code	In.		
F10*	1/2" to 1 1/4"	2"	1 9/16"
F3	1/8" to 3/8"	1 15/32"	1 7/16"
F18	1 1/2" to 2 1/4"	3"	1 9/16"

*Standard

Fig. 46: Dimensions for Model P, N, R, T or U tandem assemblies

RHEOSTAT		DIMENSIONS									
Model	Watts Each	A	B	C	D	E	F	V	W	Y	Z
P	225	5 1/16"	9 5/16"	7"	1 1/2"	2 1/2"	2 31/32"	7/8"	1 3/4"	3 1/2"	2 1/2"
N	300	6 1/4"	9 3/8"	7"	1 1/2"	3"	3 1/16"	7/8"	2 3/8"	3 1/2"	2 1/2"
R	500	5 1/16"	9 7/16"	8 3/4"	1 1/2"	4"	4 5/16"	7/8"	3"	3 1/2"	2 1/2"
T	750	7 1/16"	11 3/16"	13"	1 1/2"	5"	5 9/16"	7/8"	3 3/4"	4"	3"
U	1000	7 1/8"	11 3/8"	13"	1 1/2"	6"	6 7/8"	7/8"	6"	4"	3"

NOTE: Catalog Numbers for 4 rheostats in Tandem are: P = 6625, N = 6626, R = 6627, T = 6628, U = 6629

Sequence Coupled Rheostats

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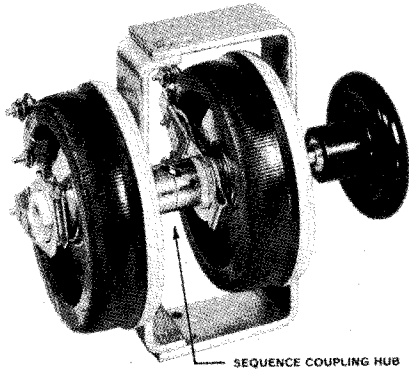


Fig. 51: Sequence-couple rheostats

“Sequence Coupling” is a method (Pat. No. 3,127,582) of coupling two rheostats in tandem so that they can be rotated by a single knob, in succession (or “sequence”) rather than together as in conventional ganged devices. Either the “front” or “back” rheostat can be arranged to rotate first. Sequence coupling is obtained by means of a special hub which links the two rheostats.

Advantages of this feature are:

(1) *The physical size of tandem rheostat assemblies used for motor speed control can be reduced considerably.* Where conventional tandem rheostats are used in combined motor-armature, motor-field or combined motor-field, generator-field control, opposite halves of the two rheostats must be “zero” resistance to permit full current to be maintained in one circuit while the current is varied in the other circuit (Fig. 52). With sequence-coupled rheostats, however, each rheostat controls its circuit in turn while the other remains fixed at the maximum current position. Hence, the zero resistance halves are not required (Fig. 53) and rheostat size may be approximately halved.

(2) *Resolution of adjustment is significantly increased* because control is possible over approximately 650 degrees of rotation.

(3) *Sequence-coupled rheostats can be wound to provide, in combination, a taper, which permits a higher ratio of maximum to minimum current combined with high total resistance, than is otherwise feasible.*

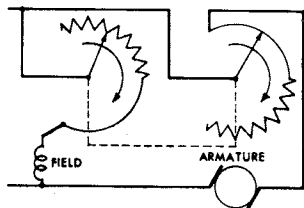


Fig. 52: Conventional tandem rheostat in field and armature circuit of motor.

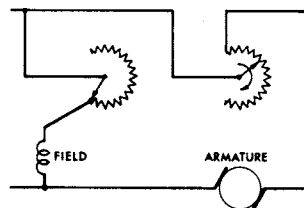


Fig. 53: Sequence-coupled rheostat in field and armature circuit of motor.

Rheostat Sizes: Sequence-coupled rheostats can be supplied in the following sizes:

Front Position (Adjacent to Knob End)—Models P, N, R, T, U (respectively 225, 300, 500, 750, 1000 watts).

Back Position—Models J, G, K, L, P, N, R, T, U (50, 75, 100, 150, 225, 300, 500, 750 and 1000 watts).

Note: The “front” or “back” rheostat actually can con-

sist of more than one rheostat, conventionally ganged, so that one group of rheostats is, in effect, sequence-coupled to another group.

Sequence: One of the following sequences of operation should be specified.

Sequence “A” Operation (Code Word: SECOA): When the knob is turned clockwise from the extreme counter-clockwise position, the “front” rheostat (closest to the knob) turns through its full rotation before the “back” one does. When the knob is turned in a CCW direction from the extreme CW position, then the back rheostat turns first.

Sequence “B” Operation (Code Word: SECOB): When the knob is rotated clockwise from the extreme CCW position, the back rheostat turns first.

Panel Thickness: Standard assembly accommodates up to 1¹/₁₆” panel; specify greater thicknesses.

Mounting Considerations: A tandem frame is normally arranged to mount on a panel in horizontal position. If the Sequence Coupling Dial is desired, and the frame must be mounted vertically on the panel, then the rheostat mounting screws must be countersunk in the panel.

Dimensions of sequence-coupled tandem assemblies are approximately the same as shown on page 20.* However, the frames are tapped for ¼–20 mounting screws only, even where there are three or more rheostats in tandem. An end support may therefore be required. Motor Drives can be supplied. Submit requirements.

*The “W” dimension for Model U rheostat changes to 3³/₄” and the “A” dimension to 7³/₁₆” in a sequence coupling arrangement.

Sequence Coupling Dials

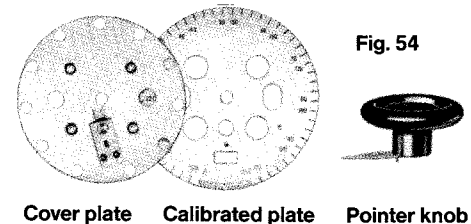


Fig. 54

Cover plate Calibrated plate Pointer knob

A “sequence-coupling” dial and knob are available which provide a specific reading for every setting of the knob throughout its double (approximately 650 degree) rotation. Between the points where one rheostat stops and the other begins its rotation, the movable (calibrated) plate is tripped by a pin on the knob pointer. This plate shifts to expose one of two sets of numbers (0-100, or 100-200) through holes in the cover plate.

The sequence coupling dial assembly is held on the panel by four-self-tapping screws. A choice of dials is available to accommodate the screws used in mounting the rheostat.

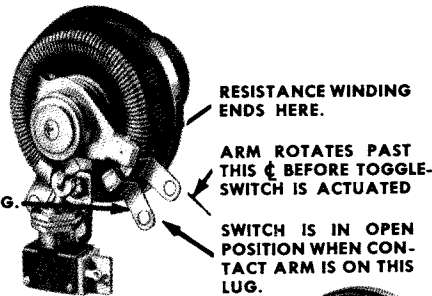
Sequence Coupling Dial and Knob Kits

Front Rheostat*	Rheostat Mounting Screws	Dial-Knob Kit Cat. No.	Requires Rheostat †Frame
P to U	Flat Hd.	5020	Hor. or Vert.
P	Round Head	5021	Horiz. Only
N		5022	
R		5023	
T or U		5024	

*Next to panel. †See “Mounting Considerations” above.

Toggle Switches

Fig. 56: Model J with toggle switch and extra lug



ARM ROTATES PAST THIS POINT BEFORE TOGGLE SWITCH IS ACTUATED.
SWITCH IS IN OPEN POSITION WHEN CONTACT ARM IS ON THIS LUG.

Fig. 57: Model P with dwell operation toggle switch

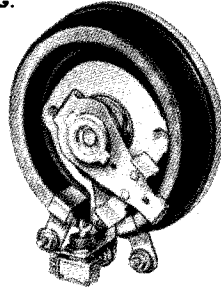


Fig. 55: Model J with toggle switch

Description: The toggle switch is operated with a positive snap after the rheostat arm has been rotated through from 30° (Model H) to 5° (Model U) approximately. The operation takes place while the rheostat contact is on the end lug only on Model P rheostats or larger. Depth of rheostat is increased approximately 1/2" except on Model R, it is 3/8". Two switches can be mounted on the same rheostat, to operate at opposite ends of rotation.

Application: When an auxiliary switch must be operated with a minimum amount of rheostat shaft rotation, or operation of the switch must occur at a closely specified angular location, regardless of direction of rotation, a sensitive, snap action switch (such as a "Micro-Switch") is required. Functions are otherwise the same as for a toggle-switch. These switches are also used when certain MIL specifications must be met. Depth of rheostat behind panel is increased 3/4" approximately.

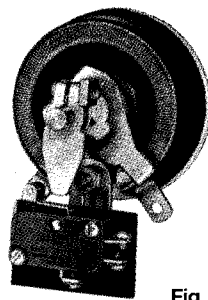


Fig. 58: Rheostat with sensitive switch

Standard Lugs: Toggle switch opens the rheostat circuit or switches an independent circuit. Recommended for 115V service on all models.

Extra Lug: Enables switching of rheostat and an independent circuit. Also used on Models H, J, G, K and L when the operation of the switch must occur outside the limits of resistance change. For all models.

Dwell Operation: Switch is operated at either end of rotation and remains in same state when direction of shaft rotation is reversed, until the other end of the rotation, where the switch is re-set. Action accomplished by double-pronged operating lever which pushes, but cannot pull, the toggle switch lever at both ends of rotation. Used to extend range of rheostat by alternately adding or removing a series resistor; also for motor reversal. Available on any model rheostat.

Toggle Switch Rating 125V. AC or DC	Type Numbers					
	With Std. Lugs		With Extra Lug		Dwell Oper.	
	*C.C. End	*C. End	*C.C. End	*C. End	*C.C. End	*C. End
SPST-N.O., † 6A	355	455	357	457	355D	375D
SPST-N.C., † 6A	375	475	377	477	375D	355D
DPDT, 6A	360	460	363	463	360D	360D
SPDT, 3A	346	446	348	448	346D	346D
SPDT, 12A	346A	446A	348A	448A	346AD	346AD
DPDT, 15A, AC	360A	460A	363A	463A	360AD	360AD

*Rotation observed from knob end of shaft, clockwise or counter-clockwise.
†Switch position when rheostat arm is on lug.

Sensitive Switches

Description: A basic size, or a small size, sensitive switch and actuator are mounted by means of a bracket and operated by a lever or cam attached to the rheostat shaft or contact arm. Available on any model. As listed in the table, the mechanism can be arranged to operate the switch at either end of rotation, or at any intermediate point. When ordering the latter type, the point of operation (and tolerance on location) must be specified in degrees, as well as the type of switch.

Switch Rating Notes: For tungsten filament lamp loads the size B switch rating is 30A. inrush and normal 3A. A size BA switch is also available rated at 20A. and lamp load of 75A. inrush, 10A. normal; ordered by adding A to the Type No. Special SPDT switches for 125V. DC with rating of 10A., non-inductive circuit, can be specified by adding MT to Type No. 381 or 481.

Sensitive Switch				Type Number	
Contact Form	Rating	Size	Rheostat Model	Counter-clockwise End*	Clockwise End*
SPDT	15A. 125/250 VAC	V	E, H, J, G, K, L	380	480
SPDT	15A† 125/250/480 VAC	B	K, L, N, P, R, T, U	381	481
SPDT	5A. 125/250 VAC	SM	E	379	479
DPDT	10A. 125/250 VAC	DT	P, N, R, T, U	385	485
DPDT	10A. 125/250 VAC	D	H to U	386	486

†20A rating available for dwell operation in which switch remains actuated thruout desired angle of rotation.

*Rotation observed from knob end of shaft

Switch Description			
Size	Dimensions	Terminals	Trade Name or Equiv.
B	1 1/16" x 2 7/32" x 1 1/16"	Solder lugs, std.	Micro Switch Basic
V	1 3/32" x 5 5/8" x 1 3/32"	Screws, std.	Micro Switch V-3
DT	1 3/16" x 1 1/4" x 1 1/16"	Screws, std.	Micro Switch DT-2R
D	1 1/4" x 7/16" x 1/2"	Solder lugs, std.	Licon 22-104
SM	2 5/32" x 2 3/64" x 1/4"	Solder lugs, std.	Micro Switch 1SM1

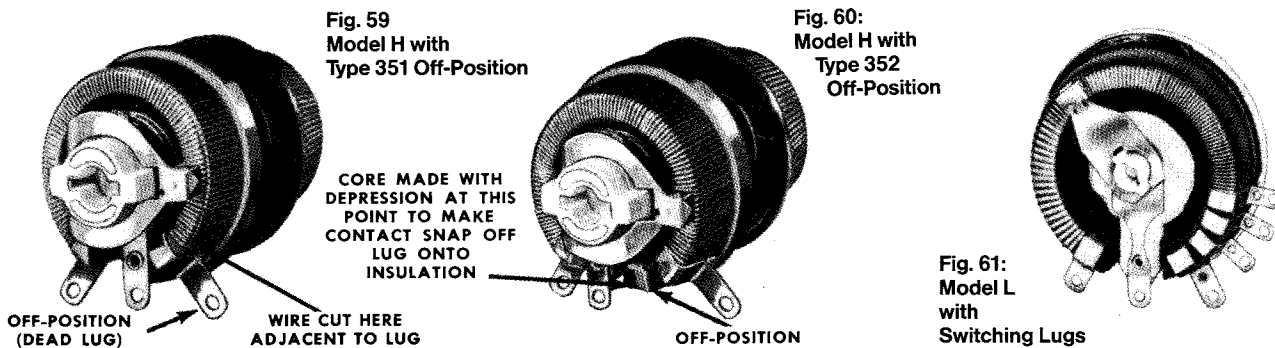


Fig. 59
Model H with
Type 351 Off-Position

Fig. 60:
Model H with
Type 352
Off-Position

Fig. 61:
Model L
with
Switching Lugs

CORE MADE WITH
DEPRESSION AT THIS
POINT TO MAKE
CONTACT SNAP OFF
LUG ONTO
INSULATION

OFF-POSITION
(DEAD LUG)

WIRE CUT HERE
ADJACENT TO LUG

OFF-POSITION

Dead-Lug Off-Position

Application: To open the rheostat circuit at the high resistance position. For light-duty and medium resistance values.

Description: The resistance winding is disconnected at one lug so that the circuit is opened as the contact passes onto the lug. This is the simplest construction. For fine wire rheostats, or units for heavy current or frequent adjustment, Type 353 (this page) is recommended.

Clockwise End Position (as illustrated) Type No. 351
Counterclockwise End Position Type No. 451

Snap-Action Off-Position

Application: The most popular form for general service. Opens the rheostat circuit at either the high or low resistance end.

Description: The circuit is opened as the contact brush snaps into an insulated notch next to the lug. Provides definite indexing action.

Additional Detent: The lug at the off-position end of the winding can be provided with an embossed ridge which provides a detent effect on the rotation to signal the operator (by sense of feel) the approach to the off position.

Cut-Off Lug: The projecting part of the lug at the off-position can be omitted on any style off-position when specified on order. Add "COL" suffix to Type Number.

Location (From Wire Side View)	Std. Type No.	With Detent
Clockwise End	352	352A
Counter-clockwise End	452	452A

Dead-Section Off-Position

Application: To open the rheostat circuit at either the high or low resistance position. Used mostly for medium duty apparatus type applications where no indicated off-position is desired.

Description: The circuit is opened as the contact brush passes off the lug onto an insulated section at the same level—otherwise similar to Fig. 60.

Position at Right (Standard) Type No. 353
Position at Left (Opposite) Type No. 453

Off-Position Ratings

Toggle switches should be used generally for line voltage applications and direct current use above 20 volts. The exact current and voltage rating of an off-position depends on the specific circuit in which it is used. The use of a capacitor for spark suppression is generally helpful on direct current.

Switching Lugs

Application: The addition of switching lugs to a rheostat is not for the purpose of an off-position but rather to add a tap switch action at the end of the rheostat winding so as to achieve the effect of a special tapered winding of a type not otherwise possible.

Description: As shown in Fig. 61, several insulated lugs, to the number desired, are located near the end of the rheostat rotation. They are to be connected to external resistances which are switched into the circuit by the rheostat contact brush. If Switching Lugs are required, advise quantity and placement.

BRIDGED GAP AND 360° WINDINGS FOR UNLIMITED ROTATION

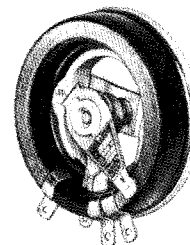


Fig. 62:
Model N with
bridge for un-
limited rotation

Switching Lugs Code Word: ZAPIN
Rheostats can be constructed without stops and with a track between the ends of the winding to provide for unlimited rotation. Rheostats can also be made with 360° cores and continuous winding, with taps as required.

Bridged Gap Feature Code Word: BRIGA
360° Winding Feature Code Word: CIRWI

Rheostat Additional Features

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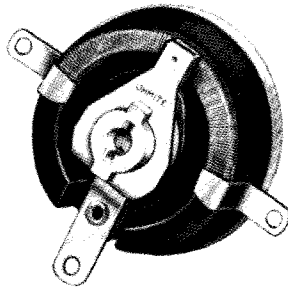


Fig. 63
Rheostat with less than
standard winding angle

Rheostats can be supplied with winding spaces and angles of rotation less than standard. The wattage rating of such rheostats is reduced approximately in proportion. For example, a Model J rheostat, 50 watts rating, when provided with a winding of 180° from center of lug to center of lug, would be reduced to 180/300 x 50, or 30 watts rating. The rotation specified is from stop to stop, which is approximately 15° more (varying with the model) than the degrees occupied by the winding alone, because of the width of the terminal lugs.

Less than Standard Rotation and Winding Feature **Code Word: LESWI**

Special Stops

Rheostats can be supplied with a fixed or an adjustable stop limiting the angle of rotation to any desired part of the total possible rotation. Generally, such rheostats are used where it is desired to leave a certain amount of resistance in the circuit at all times. However, a standard rheostat and separate resistor are often to be recommended. An adjustable stop increases the projection behind the panel by approximately 1/2".

Fixed Minimum Stop Feature, All Models **Advise Placement**
Adjustable Stop Feature, Back of Panel—All Models **Advise placement**
For Adjustable Stop Feature, Front of Panel—Models P to U only **Advise placement**

Tapped Windings

Rheostats can be supplied with taps at any point or points on the winding. The tap is usually a lug of the same dimensions as the regular terminals. An adjustable tap can be provided, also.

Rheostats with lower than normal torque are sometimes wanted when they are to be remotely controlled and operated by very small motors. Low torque is accomplished by eliminating friction at the center-lead by omitting the compression spring and using a flexible shunt connection to the contact (see Flexible Shunt). The torque for any given rheostat model will be somewhat greater on low resistance units than on high resistance units.

Low Torque Feature **Code Word: LOTOR**

REDUCED TORQUE RHEOSTATS

Rheostat Model	Approx. Torque	Rheostat Model	Approx. Torque
H	1.5-3 oz. in.	P	1.25-2.25 lb. in.
J	2-3.5 oz. in.	N	1.25-2.25 lb. in.
G	2-4 oz. in.	R	1.25-2.25 lb. in.
K	3-5 oz. in.	T	1.25-2.25 lb. in.
L	3-6 oz. in.	U	1.25-2.25 lb. in.

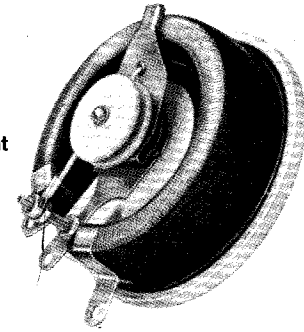


Fig. 64: Rheostat with flexible shunt and low torque

Flexible Shunts

Rheostats can be equipped with a flexible shunt directly connecting the moving contact and the center-lead. This is sometimes called for when the circuit requires that even minute variations in slip-ring to center-lead resistance be eliminated.

Flexible Shunt (5 Amps. Max.) For H, J, G, K, L **Type No. 204**
Flexible Shunt (Over 5 Amps.) J, G, K, L, P, N, R, T, U **203**

Quick-Connect Terminals

Terminals to receive standard female "quick-connectors" or "push-on" connectors can be provided on most rheostats. In addition to single terminals, a double or twin terminal permitting two connections at one terminus is also available.

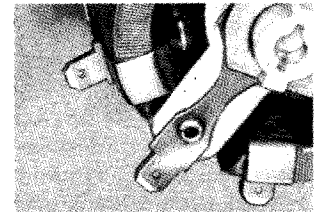


Fig. 65: Typical rheostat with terminals for push-on connection

Terminal†		For Rheostats
Width	Number	
3/16"	53-18B	H
1/4"	53-25D*	H, J, G, K, L, P, N, R, T, U
1/4" (Twin)	53-25DT	H, J, G, K, L, P, N, R, T, U

*53-25B and 53-25BT also available. Three-way type--accepts standard 1/4" female quick connector, 6-32 screw and nut or soldering.
 †Provided at all three rheostat connections unless otherwise specified.

Other Terminals

Model H rheostats can be provided with special size terminals with .156" diameter holes to receive No. 6 screws, maximum.

Terminals for No.6 Screw on Model H **Type 56**

Welded Nuts on Terminals

Rheostats can be provided with nuts welded to the terminals to permit screwdriver fastening of connections. Screws are not provided unless specified. Positions are specified from wire-side view. Nuts are No. 6-32 on Model H and No. 8-32 on larger models.

Clockwise lug and center lead **Type 55A**
Counter-clockwise lug and center lead **Type 55B**
All three terminals **Type 55C**

Terminal Bolts

Description	Cat. No.
For Model H-3 sets each consisting of: 1 No. 2-56 x 1/2" screw, 2 hex. nuts and 1 lockwasher	5075
For Models J, G, K or L-3 sets each consisting of: 1 No. 8-32 x 1/2" screw, 2 hex. nuts, 1 each flat, cup and lock washers	5077
For Models P, N, R, T, U-3 sets each consisting of: 1 No. 8-32 x 3/8" screw, 2 hex. nuts, 1 each flat, cup and lock washers	5079

Rheostat Knobs, Dials, Brackets

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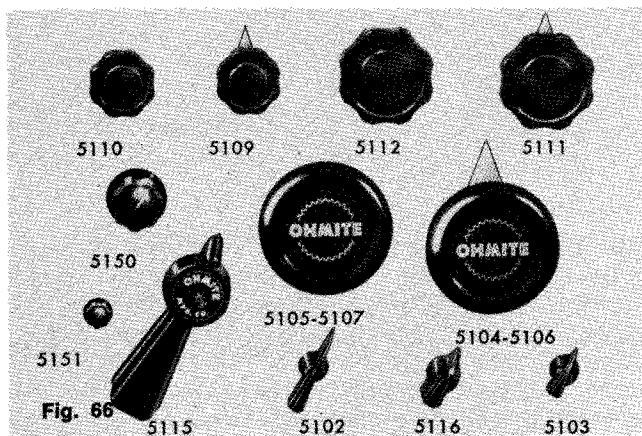


Fig. 66

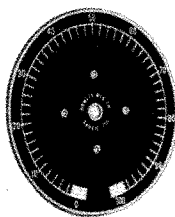
Rheostat Knobs

Knobs are made of black plastic and fasten by means of two screwdriver slotted set screws (except No. 5102, 5103, 5150 and 5151 which have one screw). Knobs can be ordered with hexagon socket set screws by adding suffix -A to catalog number. Indicating lines are white filled; pointers are bright plated. Any knob can be used with any model of rheostat having the corresponding shaft diameter. Knob No. 5116 is recommended for general use where a small bar type knob is wanted. Knobs must be specified on order, when desired.

Description	Knob Dia.	Hole Dia.	Pointer Radius	Cat. No.
Bar Knob, 2 1/4" long	—	1/4"	1 1/8"	5102
Bar Knob, 1 1/4" long	—	1/4"	5/8"	5103
Handwheel with Pointer	3 1/4"	3/8"	2 3/32"	5104
Handwheel without Pointer	3 1/4"	3/8"	—	5105
Handwheel with Pointer	3 1/4"	1/4"	2 3/32"	5106
Handwheel without Pointer	3 1/4"	1/4"	—	5107
Finger-Grip with Pointer	1 1/8"	1/4"	1 3/32"	5109
Finger-Grip without Pointer	1 1/8"	1/4"	—	5110
Finger-Grip with Pointer	2 3/8"	1/4"	1 1/32"	5111
Finger-Grip without Pointer	2 3/8"	1/4"	—	5112
Bar Knob, 4 1/4" long—Requires cross-pin and tapped hole in shaft	—	3/8"	1 1/8"	5115
Bar Knob, 1 1/2" long	—	1/4"	3/4"	5116
Finger-Grip without Pointer	2 3/8"	3/8"	—	5124
Finger-Grip with Pointer	2 3/8"	3/8"	1 1/32"	5130
Bar Knob, 1 1/2" long, AN-3220-3 Military Style—Dull Finish	—	1/4"	3/4"	5136
Finger-Grip	1 1/2"	1/4"	—	5150
Finger-Grip	3/4"	1/8"	—	5151

*"D"-Shaped hole to fit 1/32" deep flat.

Fig. 67: Typical rheostat dial



Standard Dials For Rheostat	Dial Diam.	Catalog No.
H, J, G, K, L	2 1/8"	5000
P, N, R, T, U	5 1/2"	5001
C, E	1 1/4"	5007

Rheostat Dials

Dials are made of aluminum with the figures and lines natural aluminum on an etched black background. Dials are calibrated to indicate the approximate percentage of resistance in the circuit (clockwise increase). Dials No. 5000 and 5007 are secured by the rheostat mounting nut. Dial No. 5001 is separately fastened by means of No. 6 screws, or it can be held by the rheostat mounting screws.

Mounting Nuts

Standard Nut: 3/8"-32 threaded hexagonal 3/16" across flats by 3/32" thick, zinc plated steel Cat. No. 6500

Rheostat Mounting Brackets

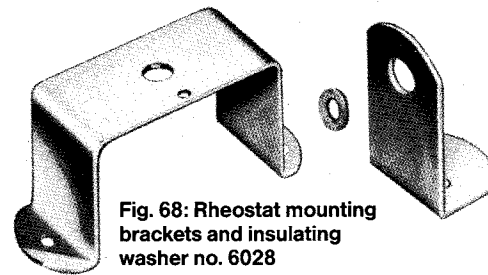


Fig. 68: Rheostat mounting brackets and insulating washer no. 6028

Mounting Brackets are made of zinc-plated steel. They furnish a convenient mounting for units located and controlled on the rear of a panel, in an enclosure or for "breadboard" construction.

HORIZONTAL TYPE

For Models	Mtg. Hole Centers	Mtg. Hole		Width	Height	Cat. No.
		Dia.	For Max. Screw			
H, J	3"	3/16"	No. 8	2 1/16"	1 1/16"	6520
G, K, L	5"	3/16"	No. 8	4 3/16"	2 3/16"	6521

VERTICAL TYPE

For Models	Mtg. Hole Centers	Mtg. Hole		Height to Shaft Center	Hole Size	Cat. No.
		Dia.	For Max. Screw			
H, J, G	1 1/2"	5/16"	No. 6	1 1/8"	1/2"	6522*
H, J, G	1 3/2"	5/16"	No. 6	1 1/8"	3/8"†	6523

*Supplied with insulating fibre bushing, Cat. No. 6028, as illustrated, for 3/8" dia. bushing of rheostats, to provide additional insulation to ground.

†Includes 3/16" dia. hole at 1/2 center for standard non-turn washer.

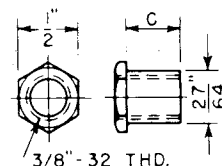


Fig. 69

Shoulder Type Mounting Nuts

Shoulder nuts are used when it is desired to have the end of a screw-driver slotted shaft below the top of the mounting nut. The nuts are tapped 3/8"-32 and require a 7/16" diameter hole in the panel. Refer to page 17 for more information on use.

- Shoulder Nut, "C" = 7/32" Cat. No. 6056
- Shoulder Nut, "C" = 15/32" Cat. No. 6057

Non-Turn Washers

To prevent rheostats which are mounted by a single bushing, such as the Models H, J, G, K, (and sometimes L) from turning on the panel, they are provided with a washer which has a projecting lug to fit into an additional hole in the panel. The lug can be ordered located at any 90° position, and it can be bent down if not wanted. Supplied in "6 o'clock" position unless otherwise specified.

- Standard Non-Turn Washer—"B" = 5/32" Cat. No. 5050
- Long Tip Non-Turn Washer—"B" = 1/4" Cat. No. 5051
- Narrow Tip Non-Turn Washer—"B" = 5/32" x 1/8" Cat. No. 5052

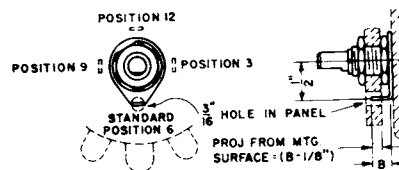


Fig. 70: How non-turn washer is used.

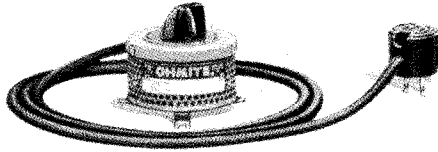


Fig. 71: Table-mounted cage for Model J with Series Plug Terminal No. 607

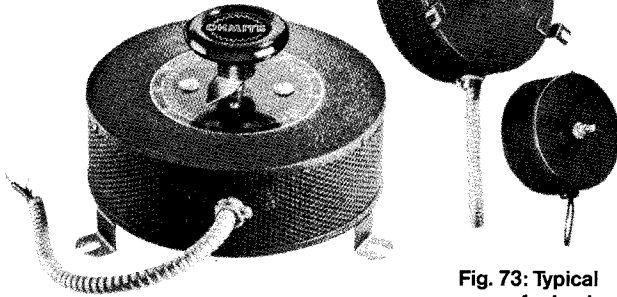


Fig. 72: Table mounted cage for Model R with Terminal No. 604

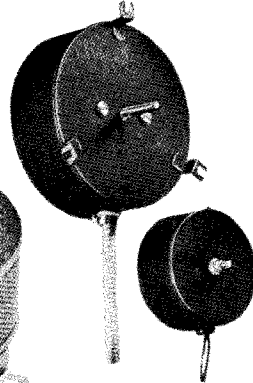


Fig. 73: Typical cages for back-of-panel mounting.

Application: A ventilated enclosure should be used when a rheostat is to be mounted where there is possibility of mechanical injury or likelihood of human contact with electrically "live" parts. Cages also provide a convenient means of table top mounting and are a necessity for portable applications. Classifications of cages per NEMA definitions are given under that heading. Dustproof cages are frequently used where there are unusual amounts of dust or particles in the air.

Cage Wattage Ratings: Rheostats in ventilated enclosures can be used at full wattage, but rheostats in dustproof enclosures must generally be operated at reduced wattage to avoid overheating caused by the absence of ventilation. Rheostats in circuits where the ratio of maximum to minimum current exceeds 2 can be operated at full rating, but rheostats where the current ratio is less, should be operated at not over 50% of the free air wattage.

Cage Types: A variety of cages are available to meet different requirements. Standard cages are the General Purpose Ventilated Type GPV or Dustproof Type GPD. Lightweight Sealed Type LWD, Explosion-proof EXP, Weather-proof or Watertight Type WP, Drip-proof Type DP, Gastight Type GTR, Hermetically Sealed (Gas or Air Filler) Type HSG and Fluid Filled HSF are also available in some sizes.

Standard General Purpose Cages

Description: Ventilated cages have perforated metal sides and are gray wrinkle finished. Dustproof cages are similar but without ventilating holes.

TERMINAL TYPES		
Cages can be supplied with terminals as listed below		
Terminal	Available On	Type No.
Binding Posts—2 Terminals	L,P,N,R,T,U	601
Binding Posts—3 Terminals	L,P,N,R,T,U	602
Wire Leads—2 Asbestos Insulated Wires, 6 inches long	All	603
Wire Leads—3 Asbestos Insulated Wires, 6 inches long	All	622
BX Cable—2 Conductor, 6 inches long	P,N,R,T,U	604
BX Clamp and 6" Wire Leads	P,N,R,T,U	605
Pipe Flange for 1/2" Conduit, with 2 Wire Leads, 6 inches long	L,P,N,R,T,U	606
Line Cord—6 ft., Heater (Type HPD) with Series Plug	All	607*
Line Cord—6 ft., Heater Type with Rubber Covered Cord (Type HSJ and Series Plug)	All	607R*
Line Cord—6 ft., Heavy Duty Rubber Covered with Heavy Duty Plug	All	628
Line Cord—6 ft., Heavy Duty Rubber Covered with Grounding Terminal Plug	All	623
90° Elbow "Condulet" fitting with 3-wire leads	P,N,R,T,U	624
Outlet Box 4" x 4" with 3 Terminal Strip	P,N,R,T,U	625
Outlet Box 4" x 4" with 6 Terminal Strip	P,N,R,T,U	626
Screw and Nut Terminals—3, with Coverplate and 7/8" dia. hole for BX fitting, etc.	P,N,R,T,U	627

*Specify No. 607G or 607GR if grounding plug is required.

STANDARD VENTILATED AND DUSTPROOF RHEOSTAT CAGES

For Rheostat Model†	H	J	G	K	L	P	N	R	T	U
Cage Diameter	2 3/8"	3 1/8"	3 3/8"	3 3/4"	4 1/2"	7 1/2"	7 1/2"	9 1/2"	13 3/8"	13 3/8"
Height or Depth Behind Panel	2"	2"	2 3/8"	2 3/8"	2 3/8"	3 3/4"	3 3/4"	4 1/4"	4 1/8"	4 1/8"
Mounting Bolt Radius	1 9/16"	1 15/16"	2 1/4"	2 1/4"	2 5/8"	4 1/4"	4 1/4"	5 1/32"	7 3/8"	7 3/8"
Mounting Bolt Slots (120° Apart) for Screw Size	No. 10	No. 10	No. 10	No. 10	No. 10	1/4"	1/4"	1/4"	1/4"	1/4"
Approximate Weight, Pounds (without rheostat)	0.18	0.26	0.41	0.41	0.53	1.25	1.25	2.0	6.8	6.8
Table Mounted Ventilated Cage Cat. No.	6550	6551	6552	6553	6554	6555	6556	6557	6558	6559
Table Mounted Dustproof Cage Cat. No.	6570	6571	6572	6573	6574	6575	6576	6577	6578	6579
Equipment	A	A	A	A	A	C	C	C	C	C
*Back-of-Panel Ventilated Cage Cat. No.	6560	6561	6562	6563	6564	6565	6566	6567	6568	6569
*Back-of-Panel Dustproof Cage Cat. No.	6540	6541	6542	6543	6544	6545	6546	6547	6548	6549
Equipment	B	B	B	B	B	C	C	C	C	C

*Models H, J, G, K, L mount by means of rheostat bushing on panels up to 3/16" thick. Models P, N, R, T, U mount by means of 3 screws on panels up to 1/2" thick except 1" on Models P and N.

†For Model E rheostat cages, see pages 9 and 29.

Equipment A: Terminal No. 603, Knob No. 5116, Dial No. 5000.
Equipment B: Terminal No. 603, Knob No. 5150.
Equipment C: Terminal No. 604, Knob No. 5105

NEMA-NEC Enclosure Classifications

The "National Electrical Manufacturers Association" (NEMA) Industrial Standards IC-2-128 provides for a variety of enclosures to meet different ambient conditions.

Listed below are the principal types, the corresponding National Electrical Code designations (from article 500) and the equivalent Ohmite type designations.

NEMA (National Electrical Mfg. Association)		NEC (National Electrical Code)		DESCRIPTION PER STANDARDS	OHMITE TYPE DESIGNATIONS	
TYPE	CLASS	CLASS	GROUP		TYPE	DESCRIPTION
I				General Purpose Ventilated or Closed (Dustproof)	GPV (or GPD)	Sheet Metal Enclosure with Perforated Metal Sides
IA				Semi Dust-Tight	GPD	Sheet Metal Enclosure
V		III & IV		Dust-Tight	EXP	Heavy Walled Cast Enclosure with Threaded Cover Fastening (or Ground Joints) "Explosion-Proof"
VII	I	I	C, D	Hazardous Locations (Gas)		
IX	II, F&G	II	E, F&G	Hazardous Locations (Dust)		
III				Weather-Resistant	WR	Cast Enclosure with Gasketed Cover and Shaft
IV				Watertight		
XII				Industrial Enclosure—Dirt and Oilproof		

Note: As size, weight, delivery time, and cost vary greatly with the type of enclosure, the exact type required should be carefully considered before making a selection.

Series Plug Terminal

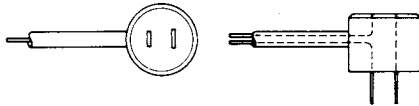


Fig. 74: Series Plug No. 6050 for Terminals No. 607 and No. 607R

Application: For connecting a rheostat (or resistor) in series with a load and the line by simply plugging the load attachment plug into the series plug which itself is plugged into the power receptacle. Also available with grounding terminal.

Description: The series plug consists of a bakelite body

with a receptacle in the top and prongs on the bottom. The series plug is connected to the rheostat by means of a line cord.

Series Plug only Cat.No. 6050
 Series Plug with Grounding Pin Cat. No. 6050G
 Series Plug with 6 ft. Heater Cord Type No. 607*
 Series Plug with 6 ft. Rubber Cord Type No. 607R*

*Specify No. 607G or 607GR if grounding plug is required.

Heat or Other Control Rheostats

Wattage of Device To Be Controlled		Rheostat Control Cat. No.	Cage		Net Weight lbs.
Watts	Volts		Dia.	Height	
40-65	115	SRC65	3 1/8"	2"	.58
85-100	115	SRC100	3 1/8"	2"	.58
120-150	115	SRC150	3 3/4"	2 3/8"	.93
175-220	115	SRC220	3 3/4"	2 3/8"	1.05
300-350	115	SRC350	4 1/2"	2 3/8"	1.63
430-500	115	SRC500	7 1/2"	3 1/4"	2.25

Application: To control the temperature involved in heat-sealing, wax and solder pots, soldering irons, furnaces and for other uses within the specified current range.

Description: The rheostats listed are mounted in perforated, gray wrinkle finished metal cages with knob and dial, Series Plug and six-foot heater type cord as described above. Designed to reduce power in load by approximately 50% maximum, for 115V, use.

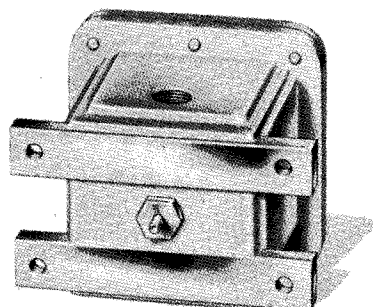


Fig. 76: A special explosion-proof rheostat enclosure

Explosion-Proof Enclosures

Ohmite explosion-proof enclosures are primarily for use in hazardous locations where the atmosphere may carry explosive gases or dust.

These enclosures meet the requirements of NEMA Type VII, Class I, Hazardous Locations (gas), (NEC Class 1, Group C and D); and NEMA Type IX, Class II, Groups F and G, Hazardous Locations (dust), (NEC Class II, Groups E, F and G). They also meet the requirements of NEMA Type V, Dust-tight, (NEC Class III and IV). The enclosures are made of thick-walled castings with accurately machined, tight fitting covers and tight fitting shaft. If explosive mixtures penetrate the enclosure and are ignited by a spark or heat, the flame will be extinguished by cooling as the products of combustion go through the small clearance openings, thus preventing ignition of the explosive mixture on the outside of the enclosure. Enclosures for surface mounting or back of panel, can be supplied for Models H to U single or two in tandem. Further information will be supplied for specific requests.

'Hermetically' Sealed Rheostats

To completely isolate rheostats from the ambient atmosphere, rheostats can be supplied in 'hermetically' sealed enclosures. Terminals are brought out through glass seals. The shaft is sealed by a special O-ring. The enclosures may be filled with dry gases or various liquids. Recommendations will be made for specific cases.

Sealed
Lightweight
Enclosures For
Rheostat
*Models
E, H, J, G, or K

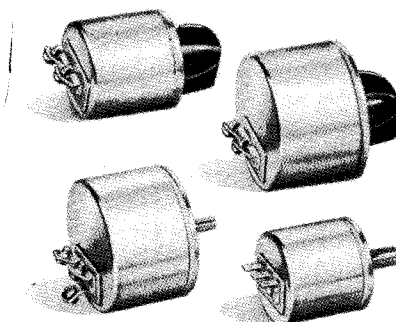


Fig. 77

Compact enclosures, made from lightweight drawn cups, and equipped with two or three screw terminals (or 3 solder lugs), as required, are available for the Model E, H, J, G, and K rheostats. They are dust-tight, but not hermetically sealed. The enclosures are permanently closed by a rolled double seam. The Model E, H and J enclosures correspond to the sizes called for in Military Specifications MIL-R-22 and Models H and J as included in MIL-R-6749. When units are desired to meet the MIL specifications, they should be ordered by the code designation of the pertinent specification. Commercial types are listed in the table. Unless otherwise specified, rheostats ordered with off-position will have three terminals.

*Model C normally enclosed; Model E stocked enclosed and unenclosed—see page 9.

Model	Description			Avg. Wt. With Rheo. Pounds	Cat. No.
	Terminals	Dia.	Length		
E	2	1 ³ / ₄ "	1 ⁷ / ₃₂ "	.06	6584A
E	3	1 ³ / ₄ "	1 ⁷ / ₃₂ "	.06	6584B
H	2	1 ³ / ₄ "	1 ³ / ₄ "	.30	6580A
H	3	1 ³ / ₄ "	1 ³ / ₄ "	.30	6580B
J	2	2 ¹ / ₂ "	1 ³ / ₄ "	.45	6581A
J	3	2 ¹ / ₂ "	1 ³ / ₄ "	.45	6581B
G	2	3 ¹ / ₁₆ "	2 ¹ / ₄ "	.75	6582A
G	3	3 ¹ / ₁₆ "	2 ¹ / ₄ "	.75	6582B
K	2	3 ¹ / ₁₆ "	2 ¹ / ₄ "	.90	6583A
K	3	3 ¹ / ₁₆ "	2 ¹ / ₄ "	.90	6583B

Note: Bushings for 1/4" thick panel, max., (1/8" for Model E) supplied as standard. Two terminals will be connected for counter-clockwise increase of resistance, as viewed from knob, unless otherwise ordered. When soldering lugs are wanted, they must be specified; add suffix L to Cat. No. Rheostat ohms, current, etc., must be specified.

Application: Rheostat control of the speed of fractional and integral horsepower motors is the most widely applicable method, is generally the simplest and is easily added to existing installations. Ohmite rheostats provide close, smooth, compact, convenient motor-speed control in countless industrial and appliance uses, such as:

Arc Lamps	Respirators
Blue-Printers	Dental and Medical Equipment
Film Printers	Flame Cutters
Motion Picture Projectors	Machine Tools
Fans	Portable Tools
Blowers	Laboratory Mixers
Pumps	Model Trains
Unit Heaters	

Advantages of Ohmite Rheostats: Smooth, close, continuously variable control, permanently good performance, freedom from deterioration, and compactness make Ohmite rheostats ideal for this services.

All Motors Not Speed Controllable: While all types of direct current motors can be speed-controlled, only a few kinds of alternating current motors are controllable, hence it is essential to obtain the correct type of A.C. motor when speed control is required. Speed controllable motors are listed in the table on page 31.

The following alternating current motors are not speed controllable: Split Phase, Repulsion Start-Induction Run, Repulsion-Induction, Capacitor Start and Run (except for special fan duty motors), Capacitor Start-Induction Run, Synchronous, and Squirrel Cage. No type of speed control is generally available for standard models of these motors because of the use of centrifugal starting switches, inherent constant speed or other design details.

Choice of Motor Depends on the Load: Only the universal motor (a form of series-wound motor) is available for service on both alternating and direct current. It is a high-speed type of motor (3000 to 15,000 R.P.M.) with strong starting torque. The speed varies widely with changes in the load. Generally, the rheostat setting for a given speed will be slightly different on A.C. than D.C. because the characteristics of a series motor change with the type of current. Resistors are often connected in the circuit on D.C. to make the characteristics more nearly identical with the A.C. characteristics. The shunt wound direct current motor has a very slight change of speed with loads.

Motor manufacturers find it necessary to change the inherent characteristics such as starting torque, running torque, etc., to suit different applications of the same motor and therefore rheostats, too, must be designed to

suit each particular application. In general, motors of similar rating made by different manufacturers require somewhat different rheostats for best control.

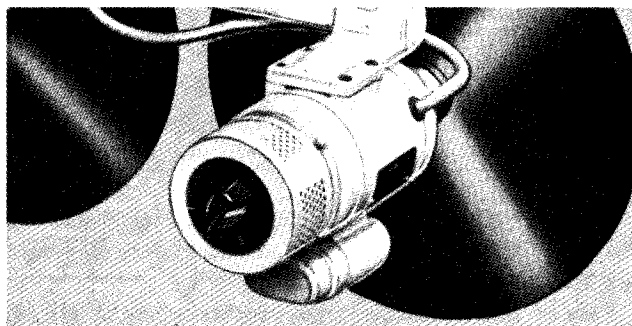


Fig. 79: An application of a rheostat in a special cage for motor speed control

Speed Control Laws for D.C. Motors: Speed is proportional to the voltage across the armature and inversely proportional to the field flux.

Torque (turning moment expressed in pound-feet or ounce-inches) is proportional to the product of the armature current and the field strength.

These laws apply to all forms of direct current motor speed control and help explain the principles underlying the different control circuits.

Different Types of Control: Several different types of control are shown in the table on page 31. A study of this table will help to show that the choice of control depends on:

1. Whether A.C. or D.C. or universal operation is required.
2. The type of motor.
3. The type and amount of load.
4. The exactness of speed control desired.
5. The speed range to be covered.

Another circuit, not shown, uses two rheostats connected in tandem, one in series with the armature and one in parallel with it. This circuit is used to produce very slow speed control of shunt wound motors.

In addition to the circuits shown, Ohmite rheostats are utilized on the motor-generator systems of speed control which are used on A.C. motors of integral horsepower sizes. There are also multi-speed variations of the circuits shown which utilize Ohmite Power Tap switches and Ohmite Fixed Resistors; also governor-controlled motors which utilize Ohmite Fixed Resistors. Ohmite VT Variable Transformers can also be used on AC; applications, or on DC in conjunction with a rectifier.

Rheostats with Reversing Switch: Rheostats with two separate windings and a toggle switch can be supplied for single knob speed control and reversing of D.C. motors. One winding controls forward speed, the other reverse.

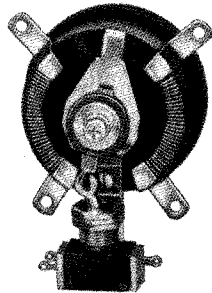


Fig. 80: A reversing-type, speed control rheostat

Rheostats Individually Designed: Loads have been classified for general calculation as (a) Machine Duty, where the current is assumed 80% at 50% speed, and (b) Fan Duty, where the load current is assumed as reduced to 40% of maximum at 50% of full load speed.

While loads have been grouped arbitrarily in the above two classifications, each application varies from these theoretical values to such an extent that for the best control, the rheostats must be designed for the particular application. This means that the actual currents and resistances under load must be obtained to permit proper design; the nameplate data from the motor is generally insufficient.

Type of Control	Type of Motor	General Characteristics of Control	Circuit Diagram
I. SERIES RHEOSTAT	D.C. Series or Shunt D.C. Permanent Magnet Universal A.C. Series A.C. Repulsion A.C. Shaded Pole	Most used for fractional H.P. appliances, A.C. or Universal, where the load is constant or variations in speed with load are unimportant. Speed will vary widely with the load. 50% reduction of full load speed is maximum used on larger motors—more on smaller motors—depends on type of load.	
II. ARMATURE SHUNT RHEOSTAT	D.C. Series A.C. Series Universal	Reduces speed but maintains torque. Speed will vary less widely with the load than with Series Control. 50% reduction of full load speed is maximum used on larger motors—more on smaller motors—depends on type of load.	
III. COMBINED ARMATURE SHUNT AND SERIES RHEOSTATS	D.C. Series A.C. Series Universal	Widest speed range—maintains torque—useful where load varies. Speed will remain fairly constant regardless of load. Range of 5 to 1 or more is possible depending on type of load.	
IV. ROTOR SERIES RHEOSTATS	A.C. Polyphase Wound Rotor	Standard method for wound rotor motors—also used on single-phase type. Speed will vary with the load. 50% reduction in speed is the maximum generally used. Greater reduction is possible.	
V. FIELD RHEOSTAT	D.C. Shunt	Most used type for integral H.P. industrial applications. Speed remains fairly constant at any load. Speed increases with added resistance. Range depends on motor design. Field must never be opened.	
VI. ARMATURE SERIES RHEOSTAT	D.C. Shunt	Used to lower speed. Speed will vary with load. Speed decreases as resistance is added. 50% maximum on larger motors.	
VII. COMBINED FIELD AND ARMATURE SERIES RHEOSTATS	D.C. Shunt	Used for widest speed range. Speed variation with load depending on position of control. Speed range depends on motor design.	
VIII. AUTO-TRANSFORMER WITH TAP SWITCH	Special A.C. Capacitor Motor	Used for fan type duty or other low starting torque, constant type of loads. will vary with load. Speed range depends on motor design.	

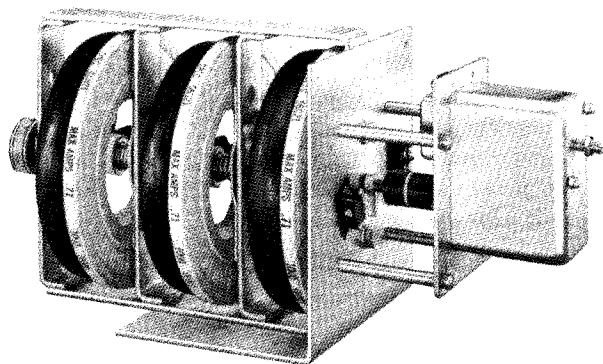


Fig. 81: Typical Ohmite motor-driven rheostat assembly

Ohmite rheostats, either single or in tandem, can be motor operated under remote control. While customers can adapt drives of their own to the rheostats, Ohmite offers standard reversible motor drives assembled to the rheostat of your choice. These standard drives encompass a selection of traverse speeds designed to meet the most frequent requirements and faster delivery can be provided on these. The standard drives are available with 115-volt DC or AC motors in traverse speeds as follows:

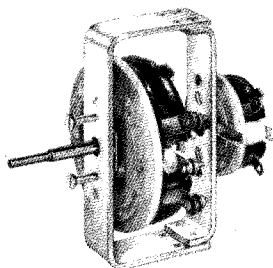
TRAVERSE SPEED	
DC Motor (Seconds)	AC Motor (Seconds)
3-4	4
10-12	8
40-50	16
100-120	30
	45

The standard arrangement includes the necessary limit switches and cams to stop traverse at the end of the rotational arc. Reversal is accomplished by moving a 3-position control switch to the "reverse" position. Users may also specify additional switches for programming associated equipment during the traverse of the rheostat.

Non-Standard Drives: Ohmite can adapt motor drives to meet applications where the requirements are so special that the standard motor driven assemblies are not suitable. Such requirements could include special speeds, 360 degree rotation using "bridged-gap" rheostats (page 24), self-reversing rotation, special auxiliary programming switches, slip clutches, combinations of rheostats and other controls such as transformers or composition potentiometers and other variations. Complete specifications in such cases must be submitted to Ohmite for engineering evaluation and quote.

Concentric Control Rheostat Assemblies

Fig. 82: Tandem assembly with rheostats independently controlled



Two rheostats can be separately controlled by means of concentrically located knobs. This may be done for convenience in operation, to conserve panel space, or where it may be desired to use one rheostat as a vernier for another.

The two rheostats are mounted on a tandem assembly frame with the shaft of the rear unit extending through the hollow shaft of the first. A hand-wheel, or knob, controls the rheostat closest to the mounting panel and a smaller knob controls the other rheostat.

Any combination of models of rheostats can be mounted for concentric control, with the larger rheostat preferably next to the panel. When the largest rheostat is no larger than a Model L, the hollow shaft is 1/4" diameter and the through-shaft is 3/16" diameter. When the larger rheostat is a Model P, N, R, T, or U, the standard hollow shaft is 3/8" diameter and the through shaft is 1/4" diameter. A hollow shaft of 1/2" diameter and through-shaft of 3/8" diameter can be supplied also. The tandem assembly can consist of more than two rheostats with the additional rheostats turning with either shafts. Mounting dimensions are similar to an equivalent standard tandem assembly. Write for further information for specific applications. Panel thickness must be given.

Combinations with Other Controls: Tap switches, low power wafer-type switches, composition potentiometers or variable transformers can be combined with rheostats in concentric control assemblies, with the auxiliary device operated by the through-shaft.

Concentric Control Tandem Mfg Code Word: CONCO

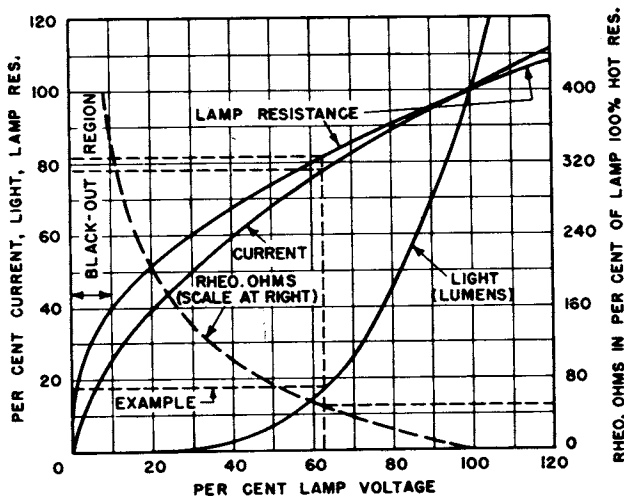


Fig. 83: Average curves for tungsten filament lamps

An Ohmite Rheostat, when connected in series with an incandescent lamp, provides ideally smooth, gradual control of light output from full intensity to any desired degree of dimming. Such control is utilized in photography (lighting of subjects, projection and contact printers, and safe lights); in medicine and dentistry (examination lights); in aviation (instrument lights); in advertising displays, theater stage lighting, and in other applications.

The size and resistance of the rheostat is determined by the lamp to be controlled and the amount of dimming desired. Because a larger rheostat or a tapered winding of more sections is needed for blackout than for 1% light, important economies can often be made if it is permissible to open the circuit before blackout. It is strongly recommended that the minimum amount of light desired be determined by a substitution trial or by measurement with a photo-electric light meter, as visual estimates generally are not sufficiently accurate.

The curves in Fig. 83 show the per cent lamp current, voltage, and resistance, and the per cent required rheostat ohms for any percentage of dimming. The curves apply to 115 volt standard tungsten filament lamps and, in general, to any other lower voltage tungsten filament lamp. Rheostats listed in the table cover the most common applications. They are unmounted units, taper wound as required. The second letter of the Catalog Number corresponds to the model, details of which will be found on pages 9 to 13. A knob, as listed on page 26, should be

ordered if one is desired. Our Engineering Department will be glad to recommend the proper rheostat for any special application on receipt of the following information:

Lamp type, volts and rated current, minimum light (in per cent of maximum), and off-position if wanted. For uncommon types of lamps, supply a sample for test or a curve of light and current versus volts.

LAMP DIMMING RHEOSTATS

Lamp Watts	Minimum Brilliance of Light as Percentage of Full Intensity			
	10%	1%	½% & Off	Blackout
25	LHA25	LJB25	LJC25	LJD25
40	LHA40	LJB40	LGC20	LKD40
50	LJA50	LGB50	LKC50	LKD50
60	LJA60	LKB60	LKC60	LKD60
75	LJA75	LKB75	LKC75	LLD75
100	LKA100	LKB100	LKC100	LPD100
120	LKA120	LLB120	LPC120	LND120
150	LKA150	LLB150	LNC150	LND150
180	LKA180	LNB180	LNC180	LND180
200	LLA200	LNB200	LNC200	LND200
§No. 1	*LGA1	LNB1	LRC1	LRD1
§No. 2	*LLA2	LRB2	LTC2	LUD2
§No. 4	*LNA4	LUB4	†LTTC4	†LUUD4

*50% light instead of 10%. †Two rheostats in tandem.
 ‡Light is reduced to ½% and then the circuit is opened by a No. 352 Off-Position.
 §Numbers 1, 2 and 4 are photoflood lamps which operate at 250, 500 and 1000 watts respectively.

Motor Driven Lamp Dimmers

Ohmite rheostats arranged for motor drive are often used as faders in advertising displays. Such rheostats are of the bridged gap type (page 24) for continuous rotation. Fig. 84 (A) shows a method of using one rheostat to fade between two lamp banks (both going out as the arm passes the center lead). Figure 84 (B) shows a method for gradually bringing a lamp from out to full on and back to out once every revolution.

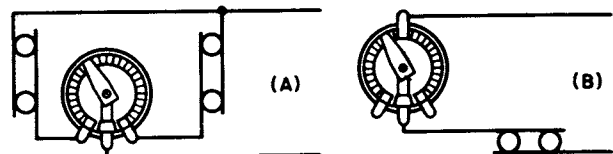


Fig. 84: Fader circuits arranged for continuous rotation

Rheostats for Military Specifications

OHMITE[®]
Manufacturing Company

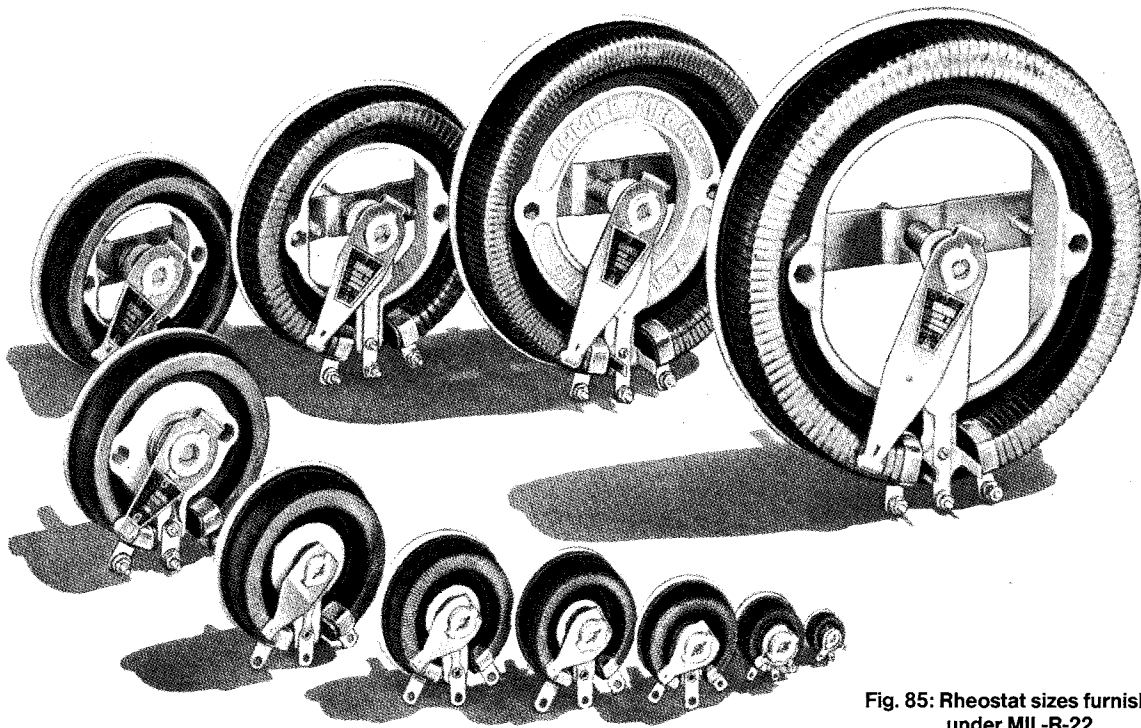


Fig. 85: Rheostat sizes furnished under MIL-R-22

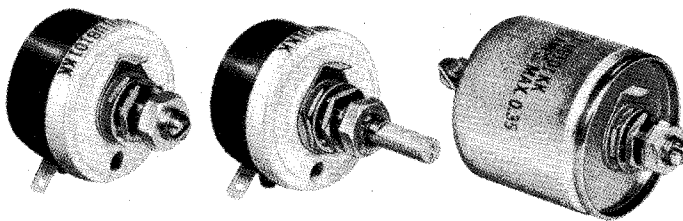
Ohmite power rheostats have seen service in military applications for many years. They have established their noted dependability in widely dispersed areas subject to the extremes of environment from the tropics to the arctic. Ohmite's inert, all ceramic and metal construction is the reason for the durability and ruggedness required to meet the exhaustive tests of the military specifications.

All of the styles (sizes) required by the fundamental rheostat specification, MIL-R-22 (Resistors, Variable, Wirewound, Power Type) from the tiny 5 watt Style RP05

(Model C) to the 1000-watt RP55 (Model U) are supplied by Ohmite with the various options required by the military options such as enclosures, locking shafts with slots or flats, off-positions, etc.

Ohmite also supplies rheostats to meet military specification MIL-R-6749 for Aircraft Rheostats. This specification covers 25 and 50-watt enclosed rheostats used in aircraft, primarily for light dimming purposes. The physical sizes correspond to Styles RP11 and RP16 of MIL-R-22 with a few differences. The entire specified range of winding tapers is provided under this specification.

To Order: When a QPL item is required always order by Military Designation, not by Ohmite Type number.



Slotted with locking bushing

Flatted with locking bushing

Enclosed with locking bushing

Fig. 86: Typical locking-type rheostats supplied under MIL-R-22.

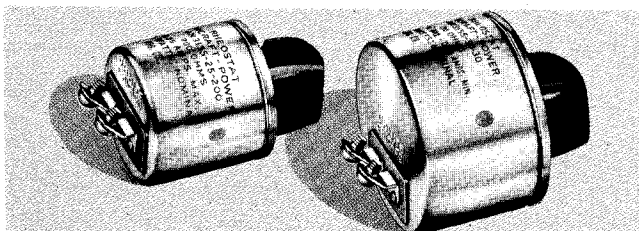


Fig. 87: Aircraft Power Rheostats for MIL-R-6749

MIL-R-22 RHEOSTATS, WIREWOUND

Military Designation	Watt Size	Ohmite Type	Military Designation	Watt Size	Ohmite Type
RP05⊙	5	Model C, enclosed	RP16	25	Model J, enclosed
RP06	12.5	Model E	RP20	75	Model G
RP07	6.25	Model E, enclosed	RP25	100	Model K
RP10	25.0	Model H	RP30	150	Model L
RP11	12.5	Model H, enclosed	RP351⊙	225	Model P
RP15	50	Model J	RP401⊙	300	Model N
			RP451⊙	500	Model R
			RP501⊙	750	Model T
			RP551⊙	1000	Model U

MIL-R-6749 RHEOSTATS⊙: AN (Enclosed)
AN3155 25 and 50 Watt

MIL-R-15109 RHEOSTATS: HI-SHOCK
Models E⊙, H⊙, J, G, K

Notes: ⊙ 1,000 ohms, max.

⊙ Not applicable to CAMESA (Canadian equiv. to DESC-E)

⊙ Also enclosed

Application: Ohmite Vitreous Enamelled Rheostats provide smooth, close, gradual control of generator voltage. The permanence of their characteristics, smoothness of operation, exactness of control, and compactness have made them first choice among generator and switchboard designers. By providing practically continuous variation of resistance in even the smallest sizes, they have made possible great savings in control-panel space. This makes them particularly useful on portable equipment, such as welding generators and power supplies.

Range of Sizes: With a series of ten wattage sizes, there is an Ohmite rheostat, or tandem rheostat assembly, suitable for every size generator in the range from the smallest to units of several hundred kilowatts.

Individually Designed: Ohmite field rheostats will be individually designed by our Engineering Department to fit each generator field condition upon receipt of the following information: State whether self or separately excited, give field resistance (hot), maximum field current (state at what volts for self-excited machines), minimum field current, rheostat resistance (if known). For self-excited machines it is desirable to supply a field magnetization curve.

Standard Designs: The rheostats listed on the following pages are tapered or uniformly wound, as required, designed to provide control for separately or self-excited generators. A number of models with differently tapered windings are listed for each resistance value. Current values depend on both the maximum voltage and the field resistance. Maximum design volts used were 32, 40, 64, 80, 100, 125, 160, 200, 250, 320 and 400. Ratios of rheostat resistance to field resistance were set at equal, 1.6 times, 2.5 times or 4 times.

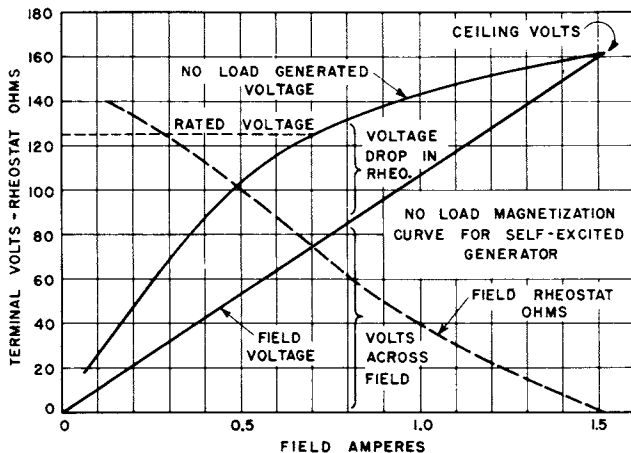


Fig. 88: Design curve for field rheostat

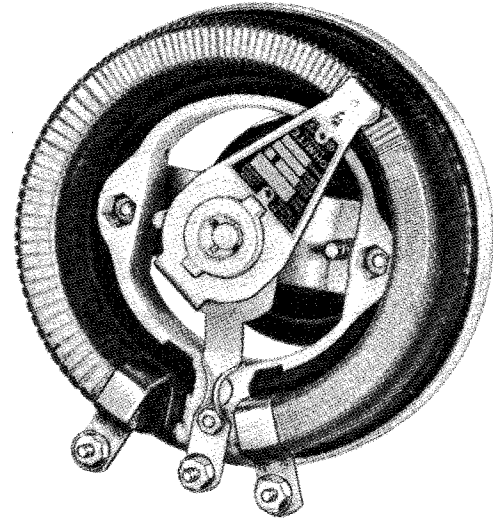


Fig. 89: Typical field control rheostat, wire side view.

Design of Field Rheostat For Self-Excited Generator

A magnetization curve (such as Fig. 88) for the particular machine should be obtained from the generator manufacturer. The no load curve is used for machines which may be operated without load or with a light load; a full load curve may be used for a generator which is permanently connected to a load.

The first step is to locate the "ceiling volts"—the highest voltage up to which the generated voltage will build when there is no resistance in series with the field. At this point $E_G = R_{field} \times I_{field}$. A straight line drawn through zero and "ceiling volts" represents the voltage necessary to produce the field current at any intervening point. The vertical distance between this line and the curve of generated voltage represents the voltage drop which must be taken up by the field rheostat.

The second step is to draw the curve of field rheostat ohms versus field current. This is obtained by Ohms' Law: $Rheostat\ Ohms = Volts\ Drop\ in\ Rheostat \div Field\ Amps$. The total resistance required will depend upon how low it is desired to bring the terminal voltage.

Knowing the maximum voltage, the resistance and maximum and minimum currents, a rheostat may be selected from the tables or Ohmite engineers will design a special unit for the job.

OHMITE



MANUAL OF ENGINEERING INFORMATION

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GEORG SIMON OHM
1787-1854

In 1827, Dr. Georg Simon Ohm mathematically demonstrated the relation between resistance, voltage and current in electrical circuits. Ohm's Law is fundamental in all resistance calculations.

BULLETIN 1100



HOW TO MAKE RESISTANCE CALCULATIONS

OHM'S LAW

The fundamental law of the electric circuit is Ohm's Law which has been stated as follows: *The current in a circuit is directly proportional to the E.M.F. (Electromotive Force) in the circuit and inversely proportional to the resistance.* In formula form it is:

$$I = \frac{E}{R} \text{ or } R = \frac{E}{I} \text{ or } E = IR$$

The following formula, also used in connection with resistor calculations, expresses the basic fact that the power in watts is equal to the product of the volts and amperes:

$$W = IE$$

Because $E = IR$ this can be written:

$$W = I \times IR \text{ or } W = I^2R \text{ or } W = \frac{E^2}{R}$$

The power formula is known as Joule's Law.

Ohm's Law can be expressed in several different forms, all of which are conveniently tabulated below. Note that in working out any problem, all terms must be reduced to volts, amperes and watts when used in any of the formulas. For example, 30 milliamperes must be written as 0.030 amperes, 2.5 K.W. must be written as 2500 watts, 1 megohm as 1,000,000 ohms, and so forth.

$W = \text{Watts}$	EI	I^2R	$\frac{E^2}{R}$			
$E = \text{Volts}$		IR		\sqrt{WR}		$\frac{W}{I}$
$I = \text{Amperes}$			$\frac{E}{R}$	$\sqrt{\frac{W}{R}}$	$\frac{W}{E}$	
$R = \text{Ohms}$	$\frac{E}{I}$				$\frac{E^2}{W}$	$\frac{W}{I^2}$

Fig. 1: Table of Ohm's Law Formulas for Direct Current Circuits.

OHM'S LAW FOR ALTERNATING CURRENT

Ohm's Law in the forms given in Fig. 1 applies to direct current circuits. However, the same formulas can be used for alternating current circuits, provided the amount of inductance (because of coils) or capacitance (because of capacitors or distributed capacitance)

in the circuit is negligible. Thus, for commercial frequencies (25 or 60 cycles) Ohm's Law can be used for the calculation of circuits involving heaters, lamps, vacuum tube filaments, etc., which for all practical purposes may be considered as pure resistance.

Even in circuits which have reactance, the direct current form of Ohm's Law still applies so far as the resistor itself is concerned (even at frequencies at the high end of the audio frequency range), because the reactance of the resistor, in that frequency range, is generally negligible when compared to the resistance. This is not true, however, at radio frequencies. Non-inductive type resistors are used at the radio-frequencies in order to minimize the changes due to frequency (see "Non-Inductive Resistors" in "Resistor" catalog).

The formulas given in Fig. 2 apply to single-phase alternating current circuits containing reactance, such as circuits involving relays, magnets, solenoids, motors, chokes and filter circuits. It can be noted that these formulas reduce to the same form as the direct current formulas when the reactance is zero and cosine θ thereupon becomes equal to 1.

$E = \text{Volts}$		$\frac{W}{I \cos \theta}$	IZ	$\frac{\sqrt{WR}}{\cos \theta}$	$\sqrt{\frac{WZ}{\cos \theta}}$	
$I = \text{Amperes}$	$\frac{W}{E \cos \theta}$		$\frac{E}{Z}$	$\sqrt{\frac{W}{R}}$	$\sqrt{\frac{W}{Z \cos \theta}}$	
$Z = \text{Ohms}$	$\frac{E}{I}$	$\frac{W}{I^2 \cos \theta}$		$\frac{R}{\cos \theta}$	$\frac{E^2 \cos \theta}{W}$	$\sqrt{R^2 + X^2}$
$R = \text{Ohms}$	$\frac{E^2 \cos^2 \theta}{W}$	$\frac{E}{I \cos \theta}$	$Z \cos \theta$		$\frac{W}{I^2}$	$\sqrt{Z^2 - X^2}$
$W = \text{Watts}$	$\frac{E^2 \cos \theta}{Z}$	$EI \cos \theta$	$I^2 Z \cos \theta$	$I^2 R$		
$\cos \theta = \text{(Power Factor)}$	$\frac{IR}{E}$	$\frac{W}{I^2 Z}$	$\frac{WZ}{E^2}$	$\frac{R}{Z}$	$\frac{W}{EI}$	$\frac{R}{\sqrt{R^2 + X^2}}$
$X = \text{Ohms}$	$(X_L - X_C)$		$\left(2\pi fL - \frac{1}{2\pi fC}\right)$			$\sqrt{Z^2 - R^2}$

$Z = \text{Impedance}$
 $X_L = \text{Inductive Reactance}$
 $X_C = \text{Capacitive Reactance}$
 $f = \text{Frequency in cycles per second}$
 $L = \text{Inductance in henries}$
 $C = \text{Capacitance in farads}$
 $\theta = \text{Angle of lead or lag}$
 $\omega = \text{Angular velocity} = 2\pi f$

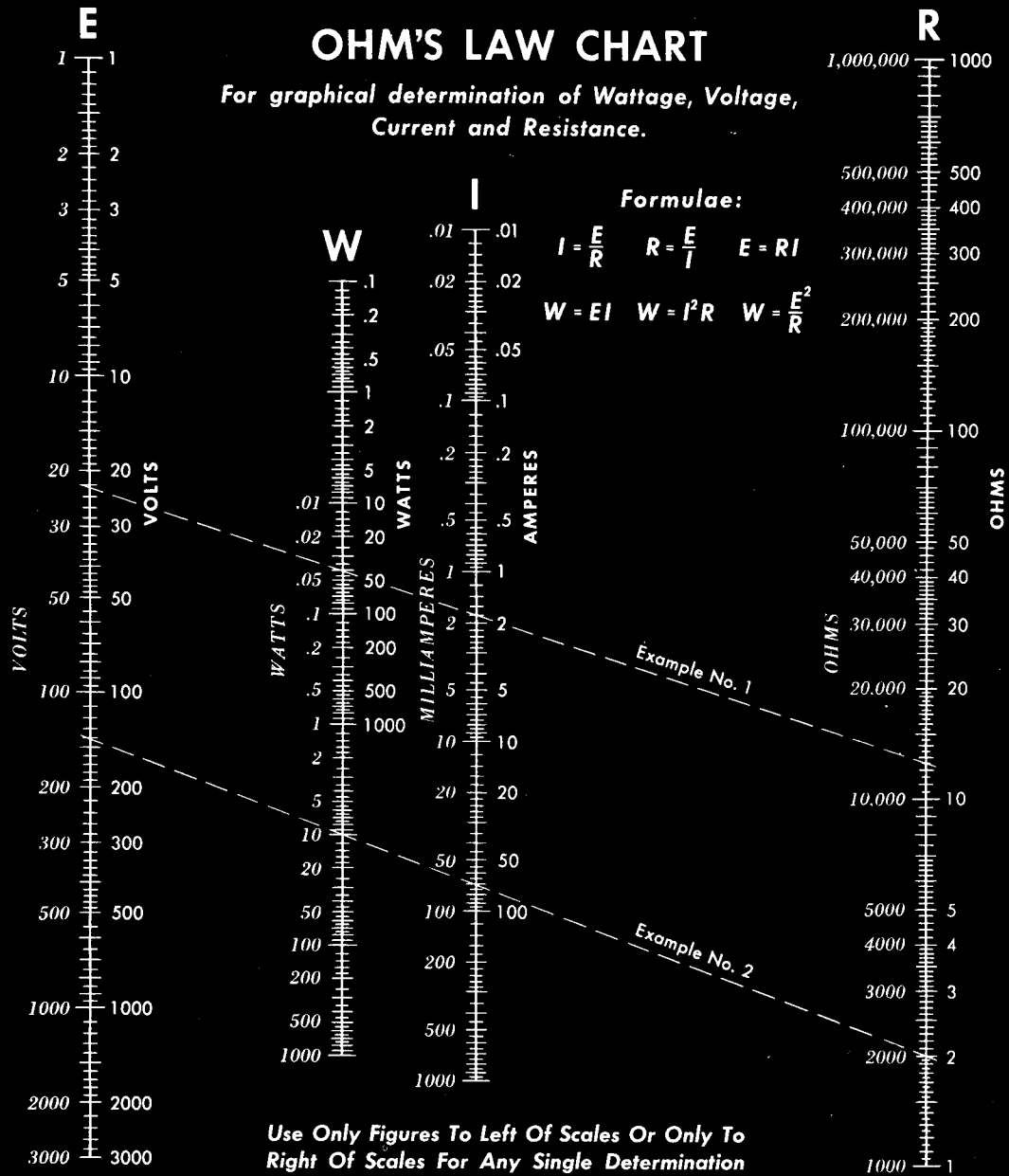
Note: Power Factor is often expressed as a percentage.

Fig. 2: Table of Ohm's Law Formulas Modified for Alternating Current, Single Phase Circuits.

OHMITE

OHM'S LAW CHART

For graphical determination of Wattage, Voltage, Current and Resistance.



HOW TO USE THIS OHM'S LAW CHART

This alignment chart enables graphical solution of Ohm's Law problems. To use, place a ruler across any two known values on the chart; the points at which the ruler crosses the other scales will show the unknown values. The *italic* figures on the left of the scales cover one range of values and the figures on the right of the scales cover another range. For a given problem, all values must be read on the left set or right set of numbers only, as required.

Example No. 1: The current through a 12.5 ohm resistor is 1.8 amperes. What is the voltage across it? The wattage? Answer: Dotted line No. 1 through $R = 12.5$ and $I = 1.8$ shows E to be 22.5 volts and W to be 40.5 watts.

Example No. 2: What is the maximum permissible current through a 10 watt resistor of 2000 ohms? Answer: Dotted line No. 2 through $W = 10$ and $R = 2000$ shows I to be 70 milliamperes.

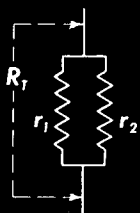
OHMITE PARALLEL RESISTOR CHART

For graphical determination of the resistance of resistors in parallel.

Formulae:

$$R_T = \frac{r_1 \times r_2}{r_1 + r_2}$$

$$r_2 = \frac{R_T \times r_1}{r_1 - R_T}$$



r₁
BRANCH

R_T
TOTAL

r₂
BRANCH

r_{2A}
BRANCH

R_{TA}
TOTAL

Example No. 3

Example No. 1
and No. 2

HOW TO USE THIS PARALLEL RESISTOR CHART

This alignment chart enables graphical solution of problems involving resistances connected in parallel. The values of the parallel resistors r_1 and r_2 and of the total effective resistance R_T must be read on the scales marked with the corresponding letters. To use, place a ruler across the two known values; the point at which the ruler crosses the third scale will show the unknown value. Pairs of resistances which will produce a given parallel resistance can be obtained by rotating a ruler around the desired value on scale R_T . The range of the chart can be increased by multiplying the values on all the scales by 10, 100, 1000, etc., as required. Scales r_{2A} and R_{TA} are used with scale r_1 when the values of r_1 and r_2 differ greatly.

Example No. 1: What is the total resistance of a 75 ohm resistor and a 150 ohm resistor connected in parallel? Answer: From dotted line No. 1, R_T is 50 ohms.

Example No. 2: What resistance in parallel with 750 ohms will give a combined value of 500 ohms? Answer: From dotted line No. 1, r_2 is 1500 ohms.

Example No. 3: What is the combined resistance of 1750 ohms and 12,500 ohms? Answer: Scales r_1 and r_{2A} are used and from dotted line No. 3, R_{TA} is 1535 ohms.

Example No. 4: What is the combined resistance of 400, 600 and 800 ohm resistors in parallel? Answer: First find R_T for 400 ohms and 600 ohms. Then set the 240 ohms thus found as a new r_1 and 800 ohms as r_2 and the final answer is found to be 185 ohms.



CURRENT, VOLTAGE AND POWER IN THREE-PHASE CIRCUITS

3 PHASE CONNECTIONS (BALANCED LOAD)		
	DELTA	STAR-(Y)
$E_L =$	E_{Ph}	$\sqrt{3} E_{Ph} = 1.73 E_{Ph}$
$E_{Ph} =$	E_L	$E_L/\sqrt{3} = E_L/1.73 = 0.577 E_L$
$I_L =$	$\sqrt{3} I_{Ph} = 1.73 I_{Ph}$	I_{Ph}
$I_{Ph} =$	$I_L/\sqrt{3} = I_L/1.73 = 0.577 I_L$	I_L
Total Volt-Amperes =	$3 \times E_{Ph} \times I_{Ph}$ $= \sqrt{3} E_L \times I_L$ $= 1.73 E_L I_L$	$3 \times E_{Ph} \times I_{Ph}$ $= \sqrt{3} E_L \times I_L$ $= 1.73 E_L I_L$
Total Watts =	$PF \times \text{Total Volt-Amperes}$ or $PF \times 1.73 E_L I_L$	
Power Factor (PF) =	Cosine of angle by which E_L leads or lags I_{Ph}	Cosine of angle by which E_{Ph} leads or lags I_L
	$\frac{\text{Total Watts}}{\text{Total Volt-Amps.}} = \frac{\text{Total Watts}}{\sqrt{3} E_L I_L}$	

Fig. 3: Table of Three Phase Relationships.

RESISTANCES IN SERIES

Total Resistance $R_T = R_1 + R_2 + R_3 \dots + R_N$ Ohms

RESISTANCE OF PARALLEL CONNECTIONS

For resistances in parallel:

$$\text{Total Resistance } R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_n}} \text{ Ohms}$$

For two resistances in parallel:

$$\text{Total resistance } R_T = \frac{R_1 \times R_2}{R_1 + R_2}$$

When one of the resistances and the total are known the formula is conveniently written:

$$R_2 = \frac{R_T \times R_1}{R_1 - R_T}$$

When the resistances are all equal, the total parallel resistance is equal to the value of one resistance divided by the number of units. For example, the total resistance of two equal resistances in parallel is one-half that

of one, the parallel resistance of three equal resistances is one-third that of one.

The handy chart on page 4 can be used for quickly determining the approximate resistance of two resistors in parallel.

The resistance of any number of resistors in parallel can be determined readily by calculating the current in each resistor, adding the currents and dividing the voltage across the resistors by the total current.

KIRCHHOFF'S LAWS

Kirchhoff's laws are extremely useful for the calculation of circuits containing more than one source of voltage or containing parallel paths.

First Law: "The algebraic sum of the potential drops around every closed circuit is always equal to zero."

Note that one direction is assumed positive for voltages and currents, and that opposing voltages, or circuits which are traversed in the opposite direction, take negative signs. A resistance drop is always negative with respect to the direction of the impressed voltage.

$$E_1 \pm E_2 \dots \pm E_n - IR_1 - IR_2 \dots - IR_n = 0$$

or $E = \Sigma IR$

Second Law: "The algebraic sum of the currents at any junction of the conductors is always zero."

That is, the total current flowing towards a junction point of several conductors must be equal to the sum of the currents flowing away from the point.

DISSIPATION AND STORAGE FACTORS—ADMITTANCE PARAMETERS

*D = Dissipation Factor	$\frac{R}{X}$	$\cot \theta$	$\frac{1}{Q}$	$\frac{G}{B}$
*Q = Storage Factor	$\frac{X}{R}$	$\tan \theta$	$\frac{1}{D}$	$\frac{B}{G}$
Y = Mhos Admittance	$\frac{1}{Z}$			
G = Mhos Conductance	$\frac{1}{R}$ (For $X=0$)	$\frac{R}{Z^2}$		
B = Mhos Susceptance	$\frac{1}{X}$ (For $R=0$)	$\frac{X}{Z^2}$		*D and Q are numbers

Fig. 4: Table of Terms Used for Capacitors, Coils and Circuits.



HOW TO DETERMINE THE RESISTANCE REQUIRED FOR YOUR APPLICATION

SECTION I. BY CALCULATION

When the current through, and the voltage across a resistor are known from the given conditions of a circuit, the resistance can be readily calculated by Ohm's Law. Cases which are calculable, rather than determinable only by test, are most often those in which the resistance is used as a voltage dropper to operate a low voltage device from a higher voltage source, or to limit the amount of current passing. Typical cases are: operation of low-voltage lamps or devices from 110 or 220 volt lines; dropping or bias resistors in radio circuits; current limiting heater control.

Example 1: It is desired to operate a 6 volt, 15 C.P. lamp drawing 2.02 amperes from the 115 volt power line. What resistance is required?

Method: Volts across resistor = (115-6) = 109

$$\text{By Ohm's Law: } R = \frac{E}{I} = \frac{109}{2.02} = 54 \text{ ohms}$$

$$\text{Also Watts} = EI = 109 \times 2.02 = 220 \text{ watts}$$

Note: If the lamp were to be operated at less than 6 volts, the fact that the lamp resistance is not a constant would have to be taken into account.

The lamp resistance can be calculated by reference to the graph, "Average Curves for Tungsten Filament Lamps" in the "Lamp Dimming" portion of the "Rheostat" catalog.

Selecting a Resistor: (a) Using Stock Units. A total resistance of 54 ohms can be made up of two Catalog No. 0701 fixed resistors of 25 ohms each, connected in series with a Catalog No. 0362 Dividohm Adjustable Resistor of 5 ohms, which is to have the adjustable lug set at 4 ohms.

(b) *Using Made-to-Order Units.* A single unit $1\frac{1}{8}'' \times 11\frac{1}{4}''$, Code: 11 $\frac{1}{4}$ P46 F-54, of 54 ohms and operating at 94% load could be used; or two units $1\frac{1}{8}'' \times 8\frac{1}{2}''$, Code: 8 $\frac{1}{2}$ P46F-27, each of 27 ohms and connected in series to operate at 63% of rated watts, might be chosen.

Example 2: It is desired to control a 500 watt, 115 volt heater by means of a rheostat so that the amount of heat (number of B.T.U. per hour) may be reduced 50%. What rheostat resistance is required?

Calculation:

$$\text{Maximum current } I = \frac{W}{E} = \frac{500}{115} = 4.35 \text{ amperes}$$

$$\text{Heater resistance is } \frac{E}{I} = \frac{115}{4.35} = 26.4 \text{ ohms}$$

Because the amount of heat produced is directly proportional to the watts, the heater watts must be reduced to 250. The current is then:

$$I = \sqrt{\frac{W}{R}} = \sqrt{\frac{250}{26.4}} = \sqrt{9.47} = 3.08 \text{ amps.}$$

$$R_{Total} = \frac{115}{3.08} = 37.4 \text{ ohms.}$$

$$R_{Rheostat} = R_{Total} - R_{Heater} = 37.4 - 26.4 = 11.0 \text{ ohms.}$$

Selecting a Rheostat: (a) *From Stock.*

The smallest rheostat available from stock for this particular case (see "Rheostats"), is a Model N, 300 watt unit of 15 ohms, Catalog No. 0657. This rheostat is selected because it is the nearest stock unit that has a current rating (4.47 amps.) greater than the 4.35 amperes maximum required for this application.

(b) *Made-to-Order.*

A Model P with uniform winding can be used for this application.

TAPPED RESISTORS—VOLTAGE DIVIDERS—POTENTIOMETERS

The procedure for calculating a typical voltage divider is given in Example 3. The same method can be extended to cover a voltage divider of any number of sections. When a rheostat or "Dividohm" adjustable resistor is used as a potentiometer, it is in effect a voltage divider with variable sections and can be calculated in the same way.

Example 3: To find the resistance and wattage of each section of a voltage divider for a radio transmitter. *Conditions:* Rectifier voltage (maximum across bleeder) = 1000 volts. To be provided with taps at 750 volts, 40 milliamperes, and 500 volts, 20 milliamperes. Bleeder current to be 40 milliamperes.

Method: The first step is to make a sketch similar to Fig. 5 showing the voltages and currents. Commence with Section A, which carries only the bleeder current I_A . By Ohm's Law:

$$R_A = \frac{500}{.040} = 12,500 \text{ ohms}$$

$$W_A = 500 \times .040 = 20 \text{ watts}$$

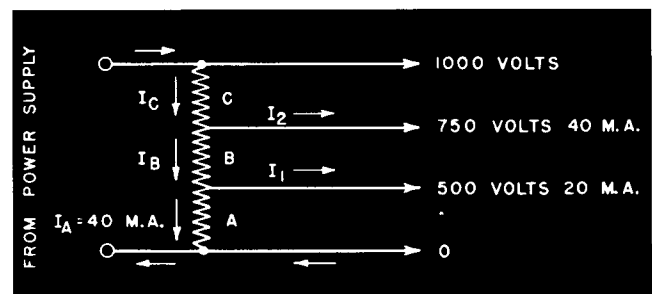


Fig. 5: Voltage Divider Diagram for Example 3.

HOW TO DETERMINE THE RESISTANCE REQUIRED FOR YOUR APPLICATION



Section B carries the bleeder current I_A plus the current I_1 , drawn at the 500 volt tap or

$$I_B = 40 + 20 = 60 \text{ milliamperes}$$

$$R_B = \frac{250}{.060} = 4,166 \text{ ohms}$$

$$W_B = 250 \times .060 = 15 \text{ watts}$$

Section C carries the current in Section B plus the current drawn at the 750 volt tap.

$$I_C = I_B + I_2, \text{ or } I_C = 60 + 40 = 100 \text{ milliamps. or } 0.1 \text{ amp.}$$

$$R_C = \frac{250}{.1} = 2500 \text{ ohms}$$

$$W_C = 250 \times .1 = 25 \text{ watts}$$

$$R_{Total} = 12500 + 4166 + 2500 = 19,166 \text{ ohms}$$

$$W_{Total} = 20 + 15 + 25 = 60 \text{ watts.}$$

Note that the voltage between the taps of a voltage divider will change if the currents drawn from the various taps change, and that the bleeder current (section A) is increased under no-load conditions and is then equal to supply voltage divided by total bleeder resistance. All sections should be designed to carry the maximum current which would occur under the different conditions of use.

Selecting the Resistor (a) from Stock.

The total resistance required is 19,166 ohms; hence a Dividohm adjustable resistor of 20,000 ohms can be used. Three adjustable lugs will be needed to form the divider. The current rating of the Dividohm must not be exceeded in any section regardless of the watts to be dissipated in that section. Hence, a Dividohm with a rating equal to, or larger than, the maximum current (0.1 amp.) must be selected. This is Stock No. 1367, equipped with two lugs No. 2158 in addition to the one regularly supplied with the resistor.

The divider could be assembled also by using one of No. 0208, No. 0382 and No. 0583 resistors in series.

(b) *From Made-to-Order Sizes.* A tapped resistor on a $\frac{3}{4}$ " x $6\frac{1}{2}$ " core would be suitable. The winding space allowed for each section and the wire size would be determined by us according to the wattage and resistance.

SECTION 2. BY TRIAL OR SUBSTITUTION

When the amount of control or change to be produced by a resistance unit is not or cannot be known without trial, a temporary or substitute resistance and suitable meters must be connected in the actual circuit; then the resistance is varied until the desired results are secured and the amount of resistance and current noted.

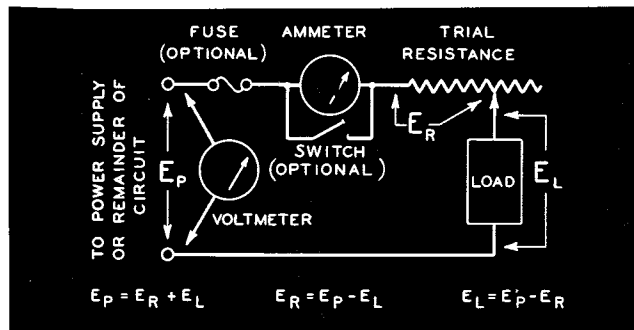


Fig. 6: Typical Test Circuit for Use in Determining Resistance and Current.

Circuit: Fig. 6 illustrates a typical test circuit (which may be only part of a larger circuit). The power supply may be the commercial 115 V. or 230 V. outlet, batteries or a generator. The load may be any device such as a motor, generator field, lamp, or heater. The adjustable trial resistance may be an Ohmite rheostat, or it may consist of a number of Ohmite fixed resistors, or one or more Ohmite adjustable Dividohm resistors. Fig. 7 illustrates a convenient way of inserting the trial resistance and ammeter by means of a series plug (such as Hubbell No. 7772).

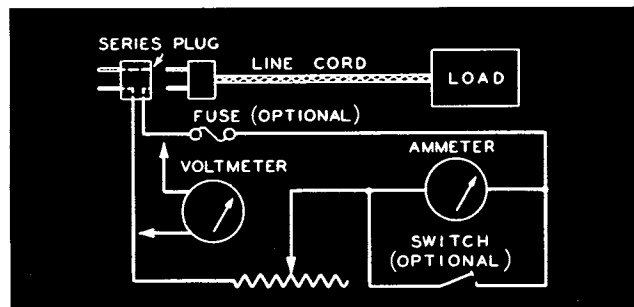


Fig. 7: Typical Test Circuit Using a Series Plug for Connection.

PRACTICAL POINTS ON SELECTING METERS AND WIRING

Before connecting any meter to a circuit, the meter range should be compared with the maximum current or voltage expected, to make sure that the meter range exceeds the values which are to be measured. The expected values can be obtained from the name plate data of the apparatus under test or by calculation from the wattage and voltage. It is well to include a fuse in the circuit to protect the meters and apparatus against accidental overload.

When possible, select meters on which the indications will occur in the upper half of the scale in order to obtain the most accurate reading. When the range between maximum and minimum current is very great, it may be necessary to substitute a lower range ammeter for the minimum values.



HOW TO DETERMINE THE RESISTANCE REQUIRED FOR YOUR APPLICATION

Because of the non-uniform calibration of the scale, alternating current instruments generally cannot be used below approximately 20% of full scale value (except for rectifier type instruments). Small direct current meters commonly have an accuracy of 2% of full scale readings. Alternating current meter accuracy varies (in descending order) according to the type as follows: electro-dynamometer, iron vane and rectifier (5%).

When the load current amounts to several amperes, as in most power applications, the effect of the current drawn by the voltmeter (when connected across the resistance or the load) generally can be ignored. But as alternating current voltmeters are quite generally of low resistance, the amount of current drawn by the meter should be considered whenever the load currents are small. In the case of high resistance, low current circuits (as in radio apparatus), high resistance rectifier type voltmeters or vacuum tube voltmeters must be used to avoid upsetting circuit conditions.

Pulsating Direct Current: Conventional permanent magnet (D'Arsonval) direct current meters read average values. When used on pulsating D.C., the average value indicated is not the true measure of the heating effect or power. For battery charging circuits, the average values are used, but for lighting or heating circuits, the R.M.S. (root-mean-square) value must be used. For unfiltered half-wave rectification, this is 1.57 times the average value; for unfiltered full-wave rectification, it is 1.11 times the average. For filtered circuits where the amount of ripple is less than one-third of the maximum, the difference between the average and R.M.S. is less than 1%.

Wiring: Copper wire of large enough gauge to carry the current without appreciable heating should be used so that the resistance of the connecting wires can be neglected.

MEASUREMENTS REQUIRED

The number of measurements necessary to determine the required resistor depends upon whether the control resistance is to be fixed or adjustable and upon the nature of the load (i.e., of constant or varying resistance). Fig. 8 shows the measurements to be taken for each of the different possibilities. The intermediate tests for Type 3 Control are taken to obtain a curve showing how the current varies between the maximum and minimum.

Over-Voltage: If there is any possibility of operating voltages exceeding the test voltages, it is well to consider the effect on the current rating and resistance required to be certain of obtaining the desired amount of control under the most adverse operating conditions.

TYPE 1. FIXED RESISTOR CONTROL

Example 4: An A.C. relay intended for operation on 110 volts is to be operated from a 220 volt line. The operating current is unknown. What resistance is required?

Method: The relay, a trial resistance (Ohmite "Dividohm" or rheostat) and a meter are connected in series as in Fig. 6. The resistance is then varied until the relay operates satisfactorily, with the voltage measured across the relay checking at 110V. Typical measured data might be as follows:

Measured Data for Example 4			
I	E _p	E _R	R _{Res.}
.105 Amp.	220 V.	110 V.	$\frac{110}{.105} = 1045 \text{ ohms}$

$$\text{Wattage in Resistor} = EI = 110 \times .105 = 11.55 \text{ watts.}$$

Selection of Resistor: A Stock No. 0375B, 1250 ohm "Dividohm" or 1000 ohm 20 watt Brown Devil.

Type of Control and Load			Conditions for Each Test	Measure Any Two (or Three to Provide a Check)			Measure in Each Case	Measure or Calculate	
Type 1	*Type 2	*Type 3		E _p	E _R	E _L	I	R	
Fixed Resistance Control—Any Load	Rheostat Control—Constant Resistance Load	Rheostat Control—Varying Resistance Load	For Type 3 Loads, More Than 5 Tests Are Often Taken to Obtain More Detailed Information.	Line Volts	Volts Across Resistance	Volts Across Load	Amps. Current	Ohms Control Resistance	
Minimum Tests Required									
	✓	✓		1					
✓	✓	✓		2					
		✓	3		Your test data may be arranged in tabular form similar to this.				

*Measurements for Type 2 Loads are sufficient for Type 3 Loads if a uniformly wound rheostat is to be used.

Fig. 8: Table of Tests and Data Required for Different Types of Controls and Loads.

HOW TO DETERMINE THE RESISTANCE REQUIRED FOR YOUR APPLICATION



TYPE 2: RHEOSTAT CONTROL OF A CONSTANT RESISTANCE LOAD

Typical Applications: The temperature control of heaters, such as drying ovens, solder pots, glue pots, electric furnaces, machine spot-heaters, soldering irons, etc.; field control of generators, balancing of control circuits; etc.

Example 5: A drying oven of 500 watts, 115 volt rating, is to be controlled between its maximum temperature and some lower value (to be determined during the test).

Method: From $I = \frac{W}{E} = \frac{500}{115} = 4.35$ amperes, it can be

seen that a 5 ampere meter will handle the maximum current. The trial rheostat, of course, should be rated to carry this current or more.

Assuming that the temperature will fall at a somewhat lesser rate than the wattage, and that the desired minimum temperature is approximately 75% of the maximum, select a trial rheostat which will reduce the wattage by about one half.

Calculations similar to those given in Example 2, show that approximately 10 ohms will be needed. The circuit in Fig. 6 or Fig. 7 can be used. The trial resistance is increased step by step and time allowed for the oven temperature to stabilize itself until the desired operating temperature is reached.

Data as called for in Fig. 8, Conditions 1 and 2, are taken.

Conditions	I Amps.	E _p Volts	E _r Volts	R Ohms
Maximum	4.35	115	0	0
At Desired Temperature	3.5	115	22.4	$\frac{22.4}{3.5} = 6.4$ ohms

Selecting a Rheostat: Proceed as given under Example 2. Stock Rheostat: Model L, Cat. No. 0529, 7.5 ohms, 150 watts, 4.47 amps. maximum current.

TYPE 3. RHEOSTAT CONTROL FOR A VARYING RESISTANCE LOAD

Typical Applications: Lamp dimming, motor speed control, etc.

Example 6: A ventilating fan is directly driven by a 1/6 H.P., 115 Volt D.C. series motor. It is desired to control the speed of the fan from the maximum down to a value determined by trial. From the chapter, "Rheostat Control of Motor Speed" in the "Rheostat" catalog, it is ascertained that a series rheostat will provide satisfactory control.

Test Must Be Made With Motor Loaded: All tests on motors must be run while they are connected to their normal loads.

Circuit: Fig. 6 or 7. *Meters:* From the name plate data on the motor, it is found that the full load current is 1.5 amperes.

The ammeter should be shorted while the motor is being started so as to protect the meter against the starting surge.

Procedure: From Fig. 8 it can be seen that for complete data, measurements must be taken under at least five different conditions. The first condition is that of full speed, when the load current is at maximum and the control resistance is at zero.

The temporary resistances for the test should be selected so that their maximum current ratings are equal to, or greater than the load current when they are in the circuit. Therefore, the first adjustable resistance to be inserted in the circuit should have a current rating of more than 1.5 amps.

Measured Data for Example 6

Condition	Speed R.P.M.	E _p Line Volts	E _r Volts Across Rheostat	I Amps.	R (Calculated) Ohms
1	1725	115	0	1.50	0
2	1500	115	22.0	1.29	17.1
3	1300	115	39.0	1.11	35.1
4	1100	115	51.8	0.96	54.0
5	900	115	66.7	0.82	81.2

Your test data, including complete name plate description of the motor should be sent to us to permit calculation of the taper-wound rheostat best suited for the application.

Selecting a Rheostat: Proceed as given under Example 2. Stock Rheostat: Model N, Stock No. 0661, 100 ohms, 1.73 amps. maximum current. Tapered Rheostat: A Model L of 82 ohms can be used.



ENVIRONMENTAL FACTORS— EFFECT ON THE POWER RATING OF COMPONENTS

All the components of an electrical apparatus—resistors, rheostats, capacitors, transformers, chokes, wiring, terminal boards, rectifiers, transistors, electronic tubes, etc.—have their own limitations as to the maximum temperature at which they can reliably operate. The attained temperature in service is the sum of the ambient temperature plus the temperature rise due to the heat dissipated in the apparatus. The temperature rise of a component is affected by a number of factors as explained in some detail in Resistor Catalog 100 and Rheostat Catalog 200. Maximum operating temperatures are given also in all of the other catalogs.

The graphs and discussions which follow, amplify and supplement the data previously referred to.

Note that the Multiplying Factors given on the Short Cut Chart, in the "Resistor" catalog, are the reciprocals of the "Percent Load Ratings" shown on the graphs in this section. The percent figures are, of course, expressed as decimals before finding the reciprocals.

AMBIENT TEMPERATURE DERATING

Fig. 9 shows the percent of full load which power resistors can dissipate for various high ambient temperatures. Curves for Rheostats, Riteohm Precision Resistors, and VT Variable Transformers are given in their respective catalogs.

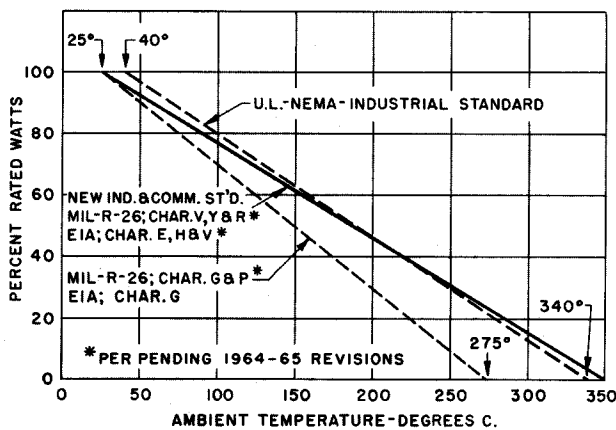


Fig. 9: Derating of Resistors for High Ambient Temperatures.

DERATING DUE TO ENCLOSURE

The amount of derating required, if any, because of enclosure is affected by a number of factors, most of which are hard to determine accurately. The watts per square inch of surface, size, shape, orientation, wall

thickness, material, finish and amount and location of ventilating openings all play a part. Fig. 10 serves to indicate for a particular set of conditions how the temperatures varied with the size of enclosure for a moderate size power resistor.

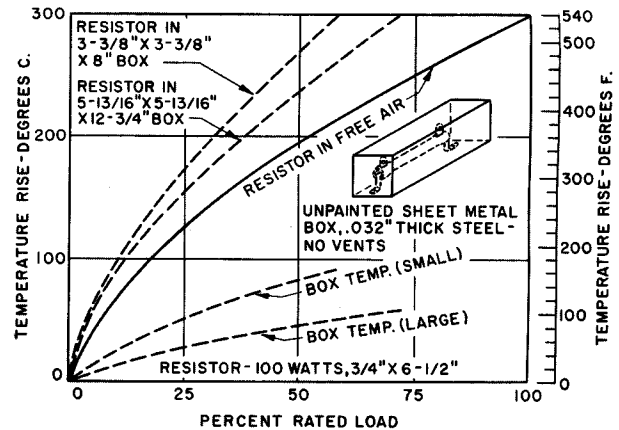


Fig. 10: Example of Effect of Size of Enclosure on Temperature Rise of An Enclosed Resistor.

DERATING DUE TO GROUPING

The temperature rise of a component is affected by the nearby presence of other heat-producing units, such as resistors, electronic tubes, etc. The curves in Fig. 11 show the power rating for groups of resistors with various spacings between the closest points of the resistors, assuming operation at maximum permissible hot spot temperature. If resistors are to be operated at lower hot spot temperatures, the amount of derating for grouping can be reduced.

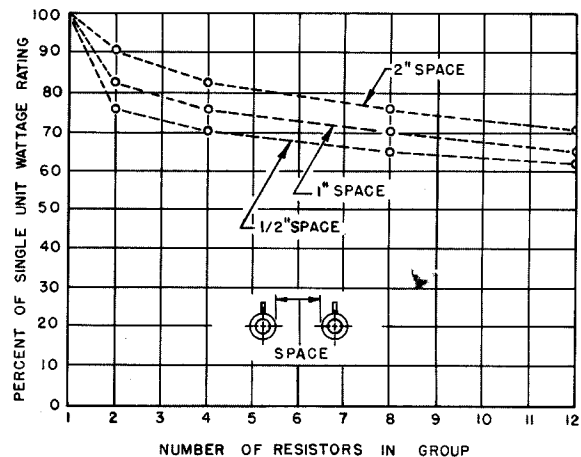
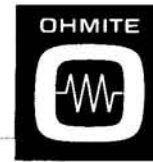


Fig. 11: Derating of Resistors to Allow for Grouping.

ENVIRONMENTAL FACTORS— EFFECT ON THE POWER RATING OF COMPONENTS



DERATING FOR ALTITUDE

The curve in Fig. 12 shows the proportional watts for various altitudes, assuming standard atmospheric conditions.

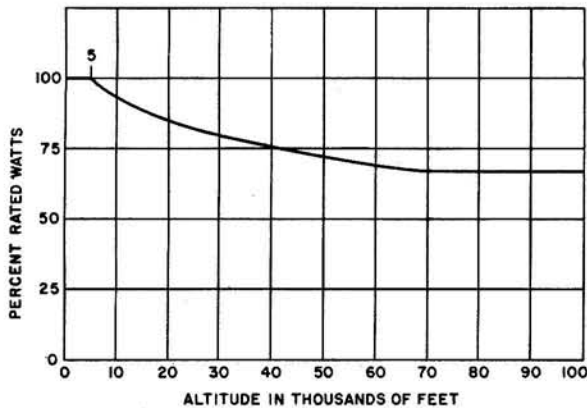


Fig. 12: Derating for Altitude.

PULSE OPERATION

Unlike the environmental factors, which result in reduction of the watt rating, pulse operation may permit higher power in the pulses than the continuous duty rating.

The NEMA has set up certain standard duty cycles for motor control resistors and the resistor ratings for some of these conditions are shown in Fig. 13.

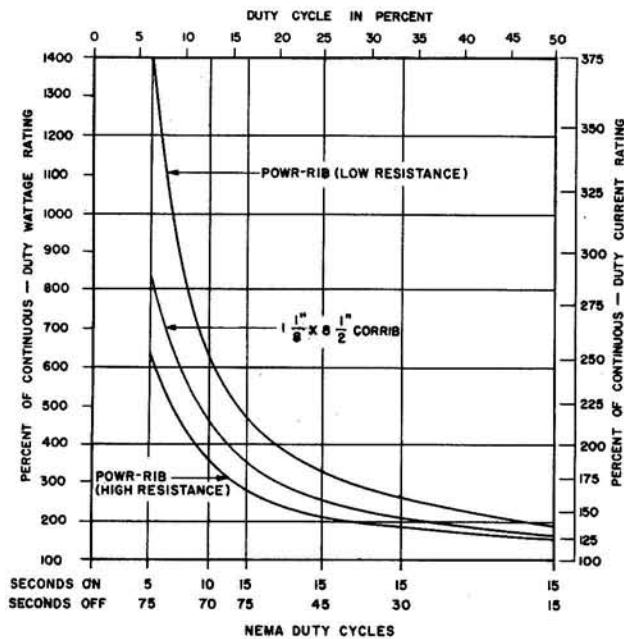


Fig. 13: Percent of Continuous Duty Rating for Resistors for Typical NEMA Duty Cycles.

The curves in Figures 15, 16, 17 and 18 illustrate the more general case of various combinations of on and off time for specified loads up to 1000% for a continuous series of pulses. Intermediate loads can be approximated by interpolation. The "on-time" at which each curve flattens out also indicates the maximum on-time for single pulses (with enough off-time for cooling to ambient). Additional data on single pulses is given by Fig. 14. Resistors will reach about 75% of the rated maximum temperature rise in approximately 5 to 8 pulses and level off at maximum rise in another 10 to 20 cycles, depending on percent load, size, type, etc. Any curve passing above the intersection of the designated on and off-times indicates a percent load which can be used. A resistor operated at the rating of an interpolated curve through the point of intersection would operate at maximum rated temperature rise.

The exact temperature rise, of course, varies with each resistor, depending on size, ohms winding, etc. The curves shown indicate the approximate rise for typical

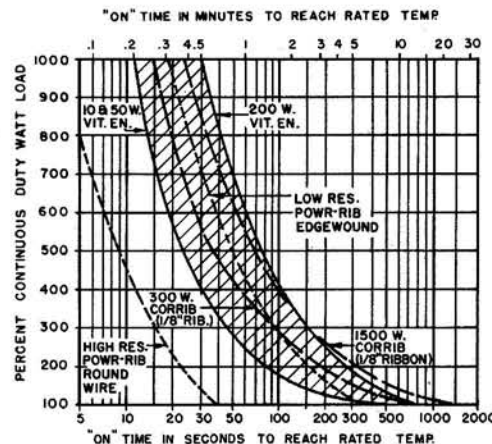


Fig. 14: Time Required for Typical Resistors to Reach Rated Operating Temperature at Various Watt Loads.

units only, as a band or range of values actually exists for each percent load.

Ratings at over 1000% are not recommended except for POWR-RIB resistors. Curves for intermediate size resistors can be roughly estimated by comparison with the sizes given.

Ratings for single pulses in the milli-second range (and up to 1 to 2 seconds) require individual calculation. This is because the ratings vary greatly with the resistance, or more specifically with the actual weight and specific heat of the resistance alloy used. Calculation is based on the assumption that all of the heat generated in the pulse goes to raise the temperature of the resistance wire.



PULSE OPERATION—COOLING— LIMITED TEMPERATURES

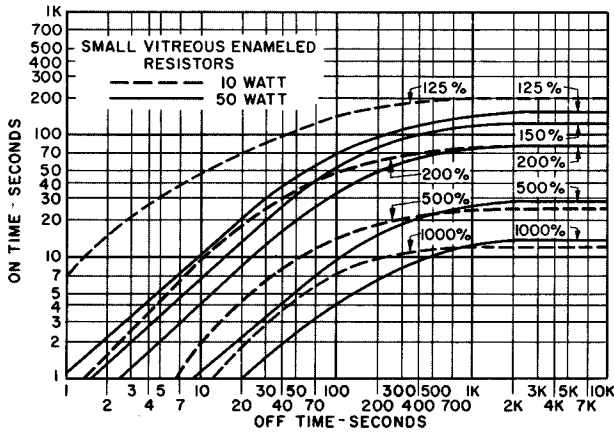


Fig. 15: Percent of Continuous Duty Rating for Pulse Operation of Small to Medium Size Vitreous Enameled Resistors.

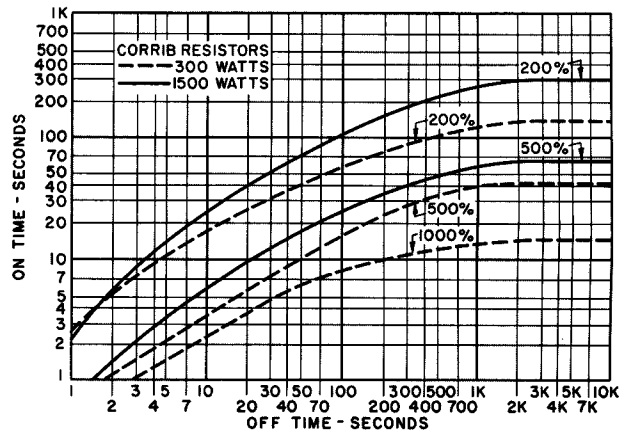


Fig. 17: Percent of Continuous Duty Rating for Pulse Operation of CORRIB, Corrugated Ribbon Resistors.

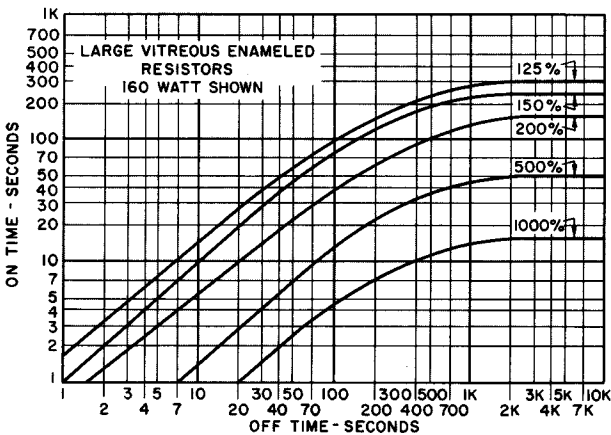


Fig. 16: Percent of Continuous Duty Rating for Pulse Operation of Large Vitreous Enameled Resistors.

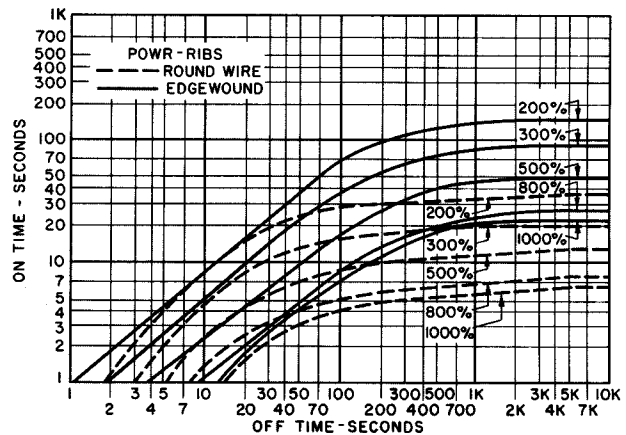


Fig. 18: Percent of Continuous Duty Rating for Pulse Operation of POWR-RIB, Bare Resistors.

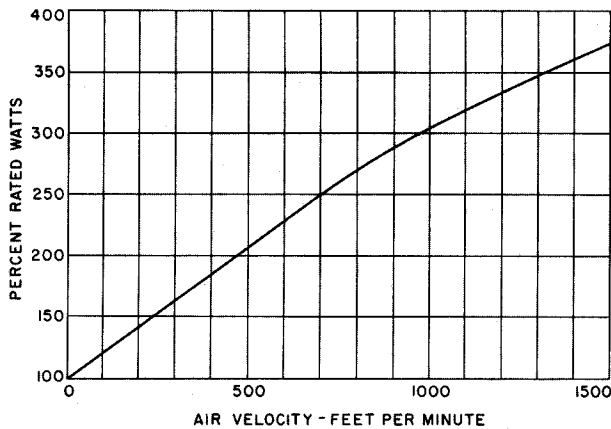


Fig. 19: Percent of Free Air Rating for Typical Resistor or Rheostat Cooled by Forced Air Circulation.

COOLING AIR

Resistors, rheostats and other components can be operated at higher than rated wattage when cooled by forced circulation of air. A typical curve is illustrated in Fig. 19. The curve tends to level off at higher velocities, as excessive hot spots develop where the air flow does not reach all parts uniformly.

LIMITED TEMPERATURE RISE

When it is desired to operate a resistor or rheostat at less than maximum temperature rise, the percent watts for a given rise can be read from "Temperature Rise vs. Load" graphs in each catalog.

RESISTOR DESIGN

Resistance Alloys and Uses



A number of different resistance alloys are used in winding resistors and rheostats as shown in Fig. 20. The general use for each alloy is indicated by the column headed, "Resistance Range for Which Used." Whether a particular alloy can be used on a specific resistor can be estimated by dividing the given resistance by the area of the given winding space and determining whether the quotient falls within the limits given hereafter. The "high resistance" alloys cover the range from approximately 10 to 25,000 ohms per square inch of winding area, the "low to medium" type from 5 to 400 ohms and the "very low resistance" alloys from less than an ohm to 250 ohms. It should be noted that the "Ohms per Square Inch" ranges overlap considerably, indicating that in many instances a given resistor could use any of several alloys. Both the upper and lower limits of the ranges are only approximate and in general can be extended somewhat when necessary.

The actual temperature coefficient of a complete resistor is generally greater than the nominal for the

wire alone. The approximate change in overall resistance at full load is shown in the table.

Other Alloys: In addition to the alloys tabulated which show small changes in resistance with temperature, there are others which sometimes have to be used for very low resistance units. These alloys have higher temperature coefficients, which limit their use to applications where the change in resistance with load is not important. An example is No. 60 alloy, which has a resistance of 60 ohms per circular-mil-foot and a temperature coefficient of +700ppm/°C.

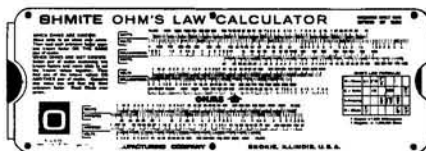
Ballast Wire: There are other alloys which are selected especially for their high temperature coefficient of resistance. These are used for so-called "ballast" resistors where a large change in resistance is desired with a change in load. A typical ballast wire is Nickel, which has 58 ohms/cm² and a temperature coefficient of +4800ppm/°C. Others are "Hytemco" and "Balco" at 120 ohms/cm² and a TC of +4500ppm/°C.

ASTM Alloy Class*	Alloy Composition (Approximate)	Ohms per CMF	Trade Names	Mean Temperature Coeff. of Res. ppm/°C	Temperature Range for TC °C	Resistance Range for Which Used	†Average Resistance Change at Full Load
1a	Nickel base, non-magnetic Ni 75%, Cr 20% plus Al, Cu, Fe, etc.	800	Evanohm Karma Moleculoy Nikrothal L	0 ± 20	-65 to +250	Very high, medium and up, for low temp. coeff.	Under ±1% to ±2%
1b		800		0 ± 10	-65 to +150		
2a	Iron base, magnetic Fe 73%, Cr 22.5%, Al 4.5% (plus Co in one alloy)	800	Alloy 81.5-R Kanthal DR Mesaloy	0 ± 20	-65 to +200	Alternate sometimes for Class 1	Under ±1% to ±2%
2b		800		0 ± 10	0 to +150		
3a	Nickel-Chromium 80%—20%	650	Chromel A Nichrome V Nikrothal B Protoloy A Tophet A	+80 ± 20	-65 to +250	High and medium	+4 to +6%
3b		675		+60 ± 20			
4	Nickel—Chromium—Iron 60%—16%—24%	675	Chromel C Electroloy Nichrome Nikrothal 6 Tophet C	+140 ± 30	-65 to +200	High and medium	+5 to +8%
5a	Copper-Nickel 55%—45%	300	Advance Copel Cupron Cuprothal 294 Neutroloy	0 ± 20	-65 to +150	Low and low to medium for low temp. coeff.	Under ±1% to ±2%
5b				0 ± 40			
6	Manganin 13% Mn, 87% Cu	290	Manganin	0 ± 15	+15 to +35	Low and low to medium for low TC near 25°C	Under ±1% to ±2% †
7	Copper-Nickel 77%—23%	180	180 Alloy Cuprothal 180 Midohm	+180 ± 30	-65 to +150	Very low	+5% to +8%
9	Copper-Nickel 90%—10%	90	90 Alloy 95 Alloy Cuprothal 90	+450 ± 50	-65 to +150	Very low	+5% to +10%

*American Society for Testing Materials, Tentative Specification B267-60T. †—For resistor with 300°C hot spot rise from 25°C ambient except 54°C rise for Manganin.

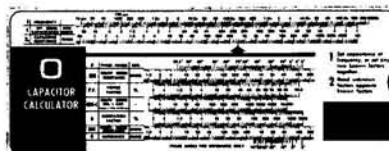
Fig. 20: Table of Resistance Alloys Generally Used for Resistors and Rheostats.

ENGINEERING AND EDUCATIONAL AIDS



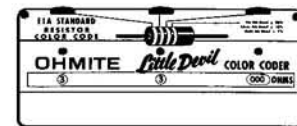
9" x 3" Calculator Solves Ohm's Law Problems with one setting of slide. Two types (1) heavy varnished cardboard and (2) deluxe Vinylite. Has parallel resistance computing scales. Ohm's Law resistance scale ranges from 0.01 ohms to 100 megohms. Current scales provided both in amperes and milliamperes. Also includes A, B, C and D slide rule scales.

Cardboard.....Stock No. 5180—Net \$0.25
Plastic.....Stock No. 5182—Net \$1.50



7" x 2 1/2" Calculator Solves Capacitance Problems involving frequency, reactance, power factor, dissipation factor, equivalent series resistance, impedance and phase angle with one setting of slide. Includes A, B, C, D slide rule scales. Lists capacitance formulae and a comparison chart of different types of capacitors. In heavy, varnished cardboard.

Stock No. 5184.....Net \$0.25



4 3/4" x 2" "Color Coder" decodes the resistance and tolerance of EIA (RETMA) color coded composition resistors. Just turn the color wheels until the colors correspond to the color bands on the resistor and read resistance value directly in ohms in the windows.

Stock No. 5190.....Net \$0.10



COMPONENT APPLICATION PROBLEMS

TAP SWITCH CONSIDERATIONS

Few problems arise in the choice of a tap switch to be used within its normal, published rating. Questions are frequently asked, however, about applications in which one of the normal factors has been altered. Typical variations involve standstill currents higher than rated load-break values, high current surges, operation on 400 cycles, higher voltages, operation of switches in parallel, operation in instrument type applications involving very low currents and voltages, DC ratings and operation at high altitude or high ambient temperature.

Other variations involve mechanical problems such as rotation at many RPM or life when subjected to an abnormally high number of operations.

Only a few of these questions have general answers, such as that switches can be operated on 400 cycles. Practical answers to the other questions depend on the circumstances. Ohmite engineers will be glad to answer specific requests as completely as possible. In many cases an actual trial is necessary to evaluate the suitability of a particular switch.

RELAY APPLICATIONS

Relays are used as basic parts of such a limitless variety of control circuits that many relay types have evolved to handle the different needs. In many cases several different types of relays can be used and the designer's task is to select the one which provides the best balance of performance, mechanical convenience and cost.

Coil operating characteristics constitute one set of conditions, contact load another and mechanical or environmental conditions yet another. AC or DC operation and the amount of power required are the essentials to be considered for the coil. In pulse circuits the operate and release times may be important.

Contact loads and "dry circuit" operation set the requirements on the contacts although expected life (number of operations) is also a factor.

Mechanical considerations include method of mounting, desirability of plug-in connection, dust proof enclosures, hermetic sealing, and special requirements (generally according to military specifications) as to ability to withstand vibration, acceleration and shock, etc. Humidity and ambient temperatures are still other factors.

Ohmite engineers will make recommendations of relays for specific applications upon receipt of full information.

TANTALUM CAPACITOR CONSIDERATIONS

All tantalum capacitors are "electrolytic capacitors" and therefore differ in some characteristics from the "classical" capacitor consisting of two plates (or sets of plates) separated by air or a solid dielectric. In a tantalum capacitor (regardless of type—wire, slug or foil) the dielectric is the thin oxide-layer formed on the tantalum. This layer acts as a dielectric or insulator only as long as the surface it is formed on is electrically positive (the anode).

The following basic formulas apply:

$$\text{Capacitance } C = 0.224 \frac{KA}{d \times 10^6} \text{ microfarads}$$

K = Dielectric constant A = Area of one plate
 d = thickness in inches in inches

$$\text{Charge } Q = CE \times 10^{-6}$$

Q = Coulombs C = Capacitance in microfarads
 E = Volts Coulombs = Amperes \times seconds

$$\text{Stored Energy} = \frac{CE^2}{2} \times 10^{-6} \text{ joules}$$

$$\text{Joules} = \text{Watts} \times \text{seconds}$$

In the application of tantalum capacitors to circuits, the differences between electrolytic and other capacitors must be taken into consideration. Basically, tantalum capacitors are used in typical electrolytic capacitor applications in filter and by-pass circuits where the capacitors are subjected to a constant DC bias and a small AC ripple voltage. This comes about because electrolytic capacitors are generally polar, i.e., act as capacitors only when the voltage does not reverse across them. However, foil type tantalum capacitors (Ohmite Tan-O-Mite Type TF) are also available as non-polar types and can be used on AC within their rating.

All types of capacitors show some changes in capacitance and power-factor or leakage current with temperature, frequency, voltage and time. All of these factors should be considered in the application of tantalum capacitors. Tantalum capacitors which are to be connected in series, require special consideration. On DC, the voltage will divide according to the ratio of leakage currents rather than the capacitances. Also, a series combination of polar and non-polar types on AC shows differences on each half-cycle. Instruments particularly suited for the purpose must be used for measuring tantalum capacitors as the relative amount of AC compared to the DC bias may affect the observed measurement results.

COMPONENT APPLICATION PROBLEMS - REFERENCE DATA



VARIABLE AUTOTRANSFORMER USES

Variable autotransformers provide a convenient means of voltage control of AC operated devices. As applied in Ohmite "v.t." Transformers, they enable control of voltage from zero to 110% or 117% of line voltage (depending on the model). Apparatus requiring 240 volts can also be operated from a 120 volt source, by use of the transformers.

Where no step-up of voltage is required, a rheostat or potentiometer can generally be used, rather than a variable transformer, to do the same control job and the question therefore arises as to what determines the choice between them. A survey of each type of control discloses that transformers and rheostats each have their own advantages such that the details of the application determine the choice.

Variable autotransformers are of course limited to alternating current use, have excellent regulation under changing load, have high efficiency, produce little heat, and are fairly universal in application within their current rating. Current ratings (in general) go hand in hand with physical size, so that large currents require large transformers.

Rheostats can be connected as potentiometers or voltage dividers so as to be able to control the load from zero to line voltage, like the transformer. They are more generally used as series resistances however.

Unlike the transformers, rheostats work on DC as well as AC and can be provided to handle large currents on any size rheostat. They can also operate at higher ambient temperatures than the transformers. In a large percentage of applications, especially where the current or voltage does not have to be reduced to less than 25 to 50%, the rheostat provides the desired amount of control and is smaller, lighter and cheaper.

Tapered windings can also be provided on the rheostats so as to obtain special relationships between the angle of rotation and the controlled effect.

Special circuit arrangements with the load permit variable transformers to be used also for such purposes as providing a variable load of constant power factor, or to provide controlled phase shift.

RADIO FREQUENCY CHOKE PROBLEMS

Problems involving the application of radio-frequency chokes become too involved in radio theory to permit adequate treatment in this manual. Suffice it to say, that while the standard series of Ohmite R.F. "plate" chokes covers a wide range of frequencies, it is of course possible to design chokes to fit other requirements. Recommendations for special chokes will be made by Ohmite engineers upon receipt of full information as to circuit and other considerations.

REFERENCE DATA

PROPERTIES OF VARIOUS METALS AND ALLOYS

MATERIAL	Ohms Per Circular-Mil-Foot At 20° C. (68° F.)	Relative Resistance With Copper = 1	Approximate Temperature Coefficient 20° C.	Approximate Melting Point Degrees Centigrade	Maximum Working Temperature Degrees Centigrade	Specific Heat	Specific Gravity	Weight in Pounds Per Cubic Inch
Silver.....	9.796	0.95	.0038	960		.057	10.5	.379
Copper.....	10.37	1.00	.00393	1085		.10	8.89	.321
Aluminum.....	17.0	1.64	.00446	660		.23	2.70	.096
No. 30 Alloy.....	30.00	2.89	.00118	1100	350	.092	8.92	.322
Brass (Spring).....	36.30	3.50	.0020	965		.10	8.55	.309
Beryllium Copper (Heat Treated).....	41.5 to 57.6	4.0 to 5.55		955		.10	8.21	.297
Phosphor Bronze—5% (Grade A).....	56.5	5.45	.0018	1050		.09	8.88	.320
Nickel.....	58.0	5.60	.0048	1445	500	.11	8.90	.321
Iron.....	61.1	5.90	.0062	1575		.11	7.7	.278
Lohm Alloy.....	60.0	5.78	.0008	1100	350	.092	8.9	.321
Platinum.....	63.8	6.15	.0030	1755		.032	21.45	.775
No. 90 Alloy.....	90.0	8.68	.00045	1100	400	.092	8.96	.324
Lead.....	132.0	12.7	.0039	327		.031	11.4	.412
Everdur No. 1010.....	155.0	15.0	.00034	1019		.09	8.52	.308
No. 180 Alloy.....	180.0	17.3	.00018	1130	400	.092	8.95	.323
18% Nickel Silver.....	190.0	18.3	.00019	1110	260	.09	8.50	.307
Monel.....	256.0	24.7	.00145	1360	500	.127	8.9	.321
Manganin.....	290.0	28.0	±.00002	1020	100	.09	8.39	.303
Copper-Nickel (55%-45%).....	294.0	28.4	±.00002 or 1/4	1290	500	.094	8.9	.321
Stainless Steel—Type 416.....	343	33.1	.0014	1500	677	.11	7.75	.280
Stainless Steel—Type 302 or 303.....	433	41.8	.0011	1410	760	.12	8.03	.290
Nickel-Chromium (80%-20%).....	650	62.7	.00008	1400	1150	.104	8.412	.304
Nickel-Chromium-Iron (60%-16%-24%).....	675	65.0	.00014	1350	1000	.107	8.247	.298
Stainless Steel—Type 1-JR.....	720	69.4	.00015	1400	870	.11	7.34	.265
Nickel-Chromium-Al-Cu (74.5-20-2.75-2.75).....	800	74.5	±.00002 or 1/1		300	.104	8.10	.293



REFERENCE DATA

TABLE OF WIRE SIZES
American Wire Gauge (B&S)

Gauge A. W. G. (B&S)	Diameter Inches	Area Circular Mils	Gauge A. W. G. (B&S)	Diameter Inches	Area Circular Mils
1	.28930	83,700.0	21	.02846	810.0
2	.25763	66,400.0	22	.02535	642.0
3	.22942	52,600.0	23	.02257	510.0
4	.20431	41,700.0	24	.02010	404.0
5	.18194	33,100.0	25	.01790	320.0
6	.16202	26,300.0	26	.01594	254.0
7	.14428	20,800.0	27	.01420	202.0
8	.12849	16,500.0	28	.01264	160.0
9	.11443	13,100.0	29	.01126	127.0
10	.10189	10,400.0	30	.01003	101.0
11	.09074	8,230.0	31	.00893	79.7
12	.08081	6,530.0	32	.00795	63.2
13	.07196	5,180.0	33	.00708	50.1
14	.06408	4,110.0	34	.00630	39.8
15	.05707	3,260.0	35	.00561	31.5
16	.05082	2,580.0	36	.00500	25.0
17	.04526	2,050.0	37	.00445	19.8
18	.04030	1,620.0	38	.00397	15.7
19	.03589	1,290.0	39	.00353	12.5
20	.03196	1,020.0	40	.00315	9.9

Wire Table Relations

The following approximate relations are convenient for rapid mental computations:

Increase in AWG No. By	Multiplies Resistance By
1	1.25
2	1.6
3	2.0
10	10.

To find the resistance per foot of any size wire of any alloy: $OHMS/FOOT = OHMS_{per\ CMF}/CM$

To find the weight per 1000 feet of any bare wire of any alloy:

$$POUNDS/1000\ FEET = .003 \times CM \times SP.\ GR./\ .321$$

$$= .000342 \times CM \times SP.\ GR.$$

ALLOWABLE CURRENT† FOR COPPER WIRE
From National Electric Code 1962

AWG or B&S	Rubber or Plastic		Asbestos	
	1 Cond.* Amps	To 3 Cond.† Amps	1 Cond.* Amps	To 3 Cond.† Amps
18	—	7	—	10
16	—	10	—	15
14	20	15	30	25
12	25	20	40	30
10	40	30	55	40
8	55	40	70	50
6	80	55	100	70
4	105	70	135	90
3	120	80	155	105
2	140	95	180	120
1	165	110	210	140
0	195	125	245	155

*—In free air. †—In raceway or cable.
†—Ratings apply only to certain wire insulation systems.
Consult N.E. code for details.

TEMPERATURE CONVERSION

To convert degrees Fahrenheit (F°) into degrees Centigrade (C°):

$$C^{\circ} = \frac{5}{9} (F^{\circ} - 32) \text{ or } C^{\circ} = .555 (F^{\circ} - 32)$$

To convert degrees Centigrade into degrees Fahrenheit:

$$F^{\circ} = \frac{9}{5} C^{\circ} + 32 \text{ or } F^{\circ} = 1.8 C^{\circ} + 32$$

When a temperature rise (not the temperature attained) is to be converted from one system to the other, the 32° terms in the above formulae are omitted.

OTHER USEFUL DATA

Inches to Centimeters and Millimeters

$$1 \text{ inch} = 2.54 \text{ cm.} = 25.4 \text{ millimeters}$$

Pounds and Ounces to Grams

$$1 \text{ pound} = 454 \text{ grams} \quad 1 \text{ ounce} = 28 \text{ grams}$$

SCREW SIZES

No.	Dia.	No.	Dia.	No.	Dia.
0	.060	4	.112	10	.190
1	.073	5	.125	12	.216
2	.086	6	.138		
3	.099	8	.164		

DECIMAL EQUIVALENTS

1/16	1/64	.015625	3/8	17/32	.515625
	3/64	.046875		35/64	.546875
1/8	5/64	.078125	7/16	37/64	.578125
	7/64	.109375		19/32	.59375
3/16	9/64	.140625	9/16	39/64	.609375
	11/64	.171875		41/64	.625
1/4	13/64	.203125	5/8	43/64	.640625
	15/64	.234375		21/32	.65625
5/16	17/64	.265625	11/16	45/64	.671875
	19/64	.296875		47/64	.6875
3/8	21/64	.328125	3/4	49/64	.703125
	23/64	.359375		23/32	.71875
7/16	25/64	.390625	7/8	51/64	.734375
	27/64	.421875		47/64	.75
1/2	29/64	.453125	15/16	49/64	.765625
	31/64	.484375		25/32	.78125
5/8	33/64	.515625	1	51/64	.796875
	35/64	.546875		53/64	.8125
3/4	37/64	.578125	1	55/64	.828125
	39/64	.609375		27/32	.84375
7/8	41/64	.640625	1	57/64	.859375
	43/64	.65625		59/64	.875
15/16	45/64	.671875	1	57/64	.890625
	47/64	.6875		29/32	.90625
1	49/64	.703125	1	59/64	.921875
	51/64	.71875		61/64	.9375
1	53/64	.734375	1	61/64	.953125
	55/64	.75		63/64	.96875
1	57/64	.765625	1	63/64	.984375
	59/64	.78125		1	1.
1	61/64	.796875	1	1	1.
	63/64	.8125		1	1.
1	65/64	.828125	1	1	1.
	67/64	.84375		1	1.
1	69/64	.859375	1	1	1.
	71/64	.875		1	1.
1	73/64	.890625	1	1	1.
	75/64	.90625		1	1.
1	77/64	.921875	1	1	1.
	79/64	.9375		1	1.
1	81/64	.953125	1	1	1.
	83/64	.96875		1	1.
1	85/64	.984375	1	1	1.
	87/64	1.		1	1.

Motor Speed Control

Rheostat wiring examples

Type of Control	Type of Motor	General Characteristics of Control	Circuit Diagram
I. Series Rheostat	D.C. Series or Shunt D.C. Permanent Magnet Universal A.C. Series A.C. Repulsion A.C. Shaded Pole	<ul style="list-style-type: none"> Most used for fractional H.P. appliances, A.C. or Universal, where the load is constant or variations in speed with load are unimportant. Speed will vary widely with the load. 50% reduction of full load speed is maximum used on larger motors—more on smaller motors—depends on type of load. 	
II. Armature Shunt Rheostat	D.C. Series A.C. Series Universal	<ul style="list-style-type: none"> Reduces speed but maintains torque. Speed will vary less widely with the load than with Series Control. 50% reduction of full load speed is maximum used on larger motors—more on smaller motors—depends on type of load. 	
III. Combined Armature Shunt and Series Rheostats	D.C. Series A.C. Series Universal	<ul style="list-style-type: none"> Widest speed range—maintains torque—useful where load varies. Speed will remain fairly constant regardless of load. Range of five to one or more is possible depending on type of load. 	
IV. Rotor Series Rheostats	A.C. Polyphase Wound Rotor	<ul style="list-style-type: none"> Standard method for wound rotor motors—also used on single-phase type. Speed will vary with the load. 50% reduction in speed is the maximum generally used. Greater reduction is possible. 	
V. Field Rheostat	D.C. Shunt	<ul style="list-style-type: none"> Most used type for integral H.P. industrial applications. Speed remains fairly constant at any load. Speed <i>increases</i> with added resistance. Range depends on motor design. Field must <i>never</i> be opened. 	
VI. Armature Series Rheostat	D.C. Shunt	<ul style="list-style-type: none"> Used to lower speed. Speed will vary with load. Speed decreases as resistance is added. 50% maximum on larger motors. 	
VII. Combined Field and Armature Series Rheostats	D.C. Shunt	<ul style="list-style-type: none"> Used for widest speed range. Speed variation with load depending on position of control. Speed range depends on motor design. 	
VIII. Auto-transformer with Tap Switch	Special A.C. Capacitor Motor	<ul style="list-style-type: none"> Used for fan type duty or other low starting torque, constant type of loads. Speed will vary with load. Speed range depends on motor design. 	