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THE NEW 970-SERIES POTENTIOMETERS— HIGH-QUALITY PERFORMANCE AT MODERATE PRICES

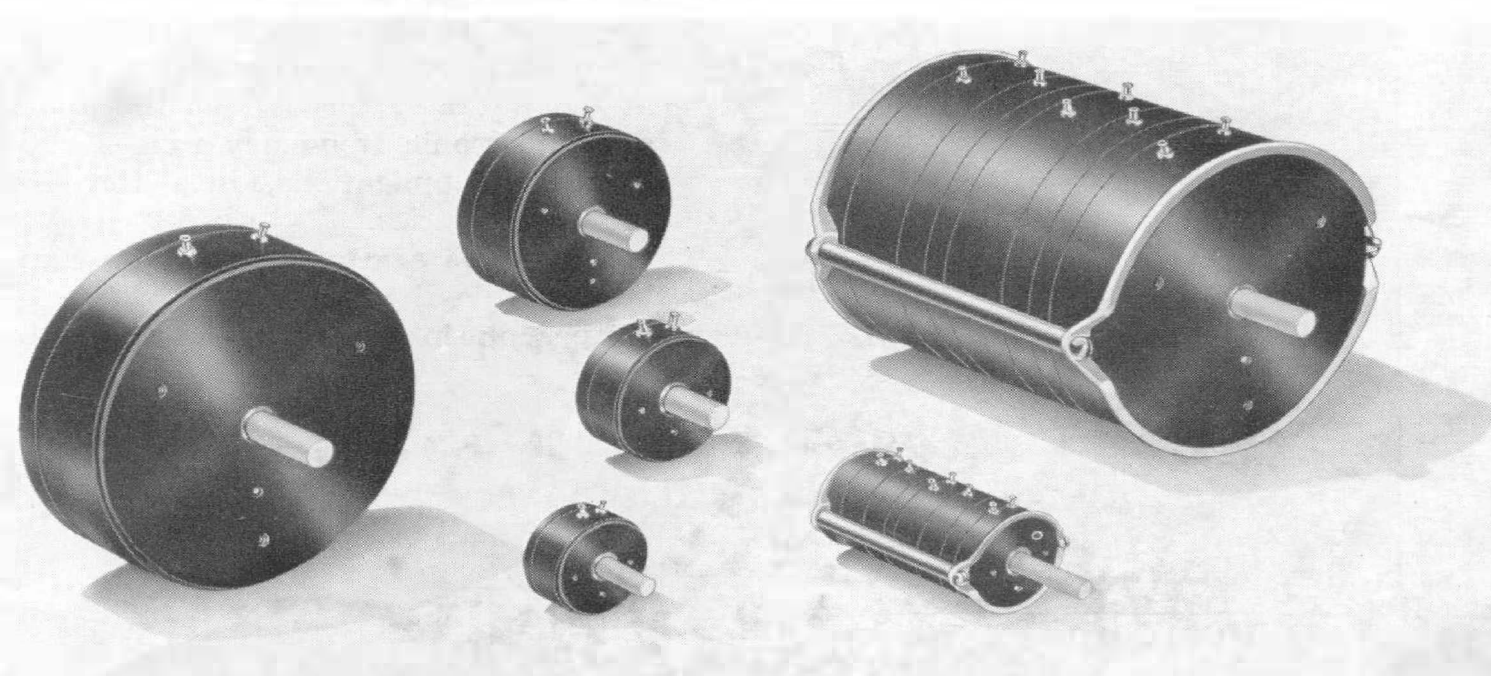
The General Radio Company has been manufacturing wire-wound rheostats and voltage dividers for nearly forty years. These controls are designed for general use in electronic equipment. Their characteristics have not been circumscribed by a need for the lowest possible cost, as in mass-produced radio-receiver volume controls; nor have they been extended to the degree found possible in today's closely machined, but very expensive, ultra-precision potentiometers.

Many years' experience with potentiometers and rheostats have brought out the design features important for applications in General Radio instruments. Concentration on these features has led to designs that satisfy not only our own requirements but those of many customers, who find these medium-priced controls, of good all-round characteristics, to be just right for their applications as well.

It is in this tradition that the new 970 series of variable resistors has been evolved, not to make "just another potentiometer," but to upgrade a distinctive class of controls whose existence has been amply justified.

Contemporary usage demands controls with outstanding mechanical per-

Figure 1. Type 970-Series Potentiometers are available in the four diameters shown here. Ganged units are available on special order.



formance and features that can only be achieved by utilizing to the utmost today's knowledge of materials and manufacturing techniques. To be suitable for general instrument use, however, these devices must also be designed with due consideration for electrical parameters other than resistance, as well as for adaptability and reasonable cost.

The new 970 types meet these objectives. They are quality potentiometers, moderately priced, sturdy and versatile, with resistance-performance specifications approaching the best available, plus a-c performance substantially better than those found in today's high-precision d-c types. This combination of mechanical precision, good electrical characteristics, and general adaptability makes these new components even more useful than earlier models and in a broader field of applications.

The new 970 series of potentiometers progresses through 8 sizes, ranging in diameter from 1¼ inches to 4¼ inches, in power dissipation at 40°C ambient from approximately 2 to 20 watts, and comprises stock resistance values in 1, 2, 5 sequence from 2 ohms to 500,000 ohms. The chart on pages 4 and 5 gives a panoramic view of the series and emphasizes the completeness of the coverage.

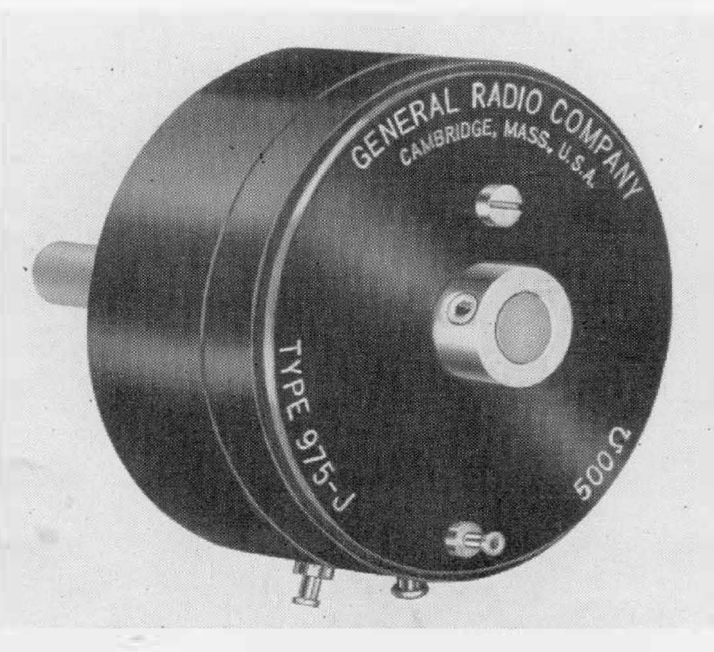


Figure 2. External view of a Type 975 Potentiometer.

Because there is a close family relationship between individual types in the 970 series, a detailed description of any one suffices for all. Figure 2 is an external view of a typical model, illustrating the dust-proof total enclosure and the external hub. When the two setscrews in this exposed hub are loosened, the shaft can be adjusted or removed entirely without opening the enclosure and exposing the interior to dirt or damage. This permits easy phasing and ready substitution of shafts of different lengths or materials.

Removal of a single cover screw makes the interior readily accessible for inspection, even when the control is mounted. Figure 3 is a view of an opened unit arranged so that the salient features can be observed, and shows the simplicity of construction that permits low cost and dependability.

The low capacitance across the winding and between winding and ground is attained by reducing to a minimum the number and size of metal parts. The base and cover cups are phenolic moldings, and the shaft is fabricated from glass-reinforced polyester resin. The thin winding form of phenolic laminate keeps inductance down. Potentiometers of this construction are useful not only at dc, but also throughout the audio and supersonic frequency ranges and, in many applications, into the low radio frequencies.

The brush arm and spring are combined into a single stamping of spring-temper phosphor-bronze, as shown in the photograph. A punched key on this piece engages a milled keyway in the hub, and the two parts are then swaged together. The screw that holds the cover to the base passes through a horseshoe-shaped slot in the brush arm to serve as a rotational stop. Force exerted against the stop is transmitted directly and positively to the hub by the central portion of the arm and does not strain the outer ring, which carries the brush. The entire outer ring serves as an extra-long spring, to make brush pressure uniform, independent of accumulated tolerances.

The hub rotates in a reamed brass insert molded into the cover to form one bearing. The shaft is rigidly held by this hub and a second bearing is provided by a stainless-steel insert in the base. The hub is closely fitted to its bearing, which is approximately in the plane of the brush and therefore contributes to linearity and stability of setting. The shaft bearing, in consequence, can have a slight allowance to accomodate thermal expansion of plastic shafting. Reasonable play in this latter bearing has a negligible effect on the brush position. Stainless steel is used because it wears well with all shaft materials, including such abrasive ones as ceramics and glass fibers. The location of the two bearings, at the extreme ends of the enclosure, provides maximum stability.

The moving contact, which is spot-welded to the spring arm, is a wire whose diameter is chosen to yield fine resolution, small transition from winding to end terminal, and precise angle of electrical rotation. It is made of a heat-hardened precious-metal alloy, selected to be compatible with the resistance alloy used. The non-corrosive and wear-resistant qualities of this alloy contribute to reliability and long life.

The turret terminals are both riveted and soldered to the ends of the winding and to the spring-bronze contact take-off in the cover, so that none of the fixed internal connections depend on pressure alone. The terminals are made of brass, plated with tin alloy for easy soldering, and are hollow to minimize thermal capacity and conductivity. They will, therefore, not loosen in the phenolic when properly soldered.

The resistance cards are accurately wound by skilled workmen, on specially designed winding machines using the best wire alloys available. The standard tolerances for total resistance listed on the chart were chosen because they can

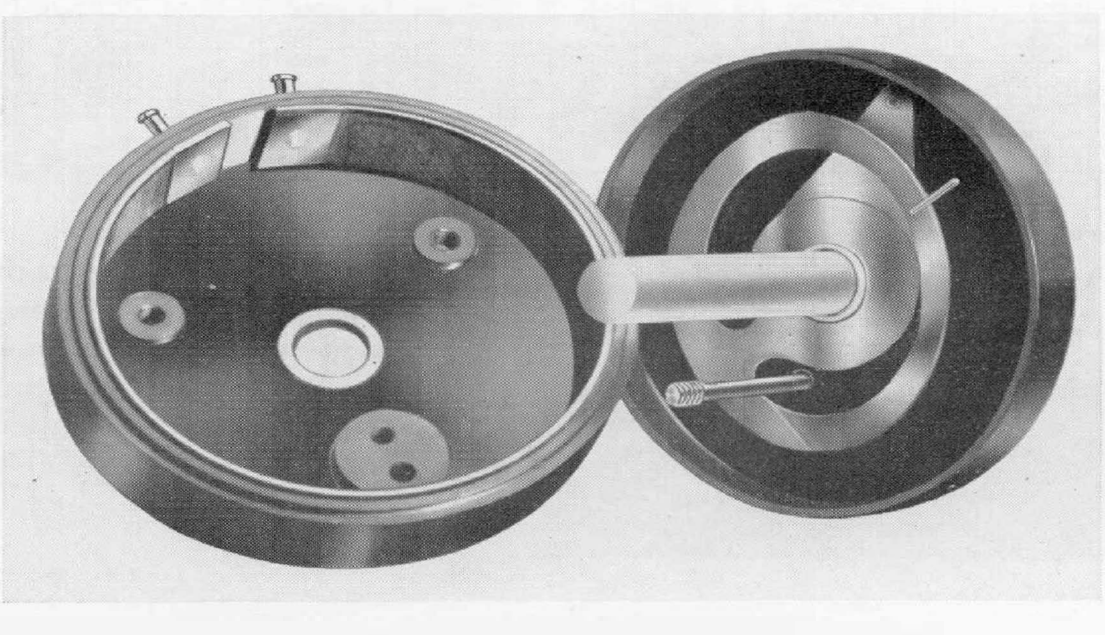
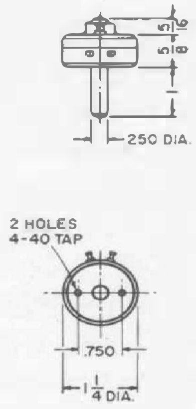
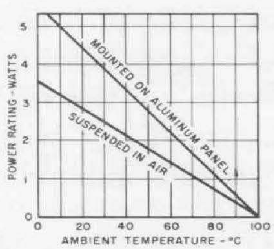


Figure 3. View of an opened unit showing features of design and construction.

TYPE 971

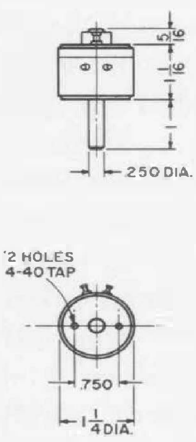


APPROXIMATE WEIGHT 1/2 OZ.
EFFECTIVE ELECTRICAL ROTATION 320°±5°
TOTAL MECHANICAL ROTATION 330°±5°
STANDARD RESISTANCE TOLERANCE ±5%
AVERAGE TORQUE 1 OZ. IN.

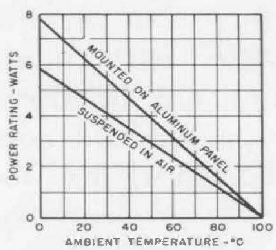


TYPE LETTER	NOMINAL RESISTANCE OHMS	TEMPERATURE COEFFICIENT OF RESISTIVITY	RESOLUTION	STANDARD INDEPENDENT LINEARITY
B	2	+.07 %	<1%	±2%
C	5			
D	10	±.002%		
E	20			
F	50		<.5%	
G	100			
H	200			
J	500			
K	1000	+.002%		
L	2000			
M	5000		<.2%	
N	10,000			
P	20,000			

TYPE 972

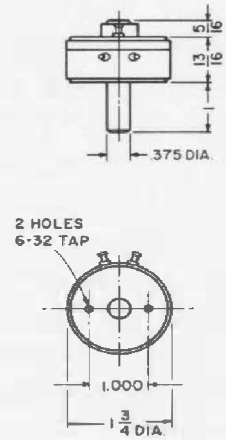


APPROXIMATE WEIGHT 3/4 OZ.
EFFECTIVE ELECTRICAL ROTATION 320°±5°
TOTAL MECHANICAL ROTATION 330°±5°
STANDARD RESISTANCE TOLERANCE ±5%
AVERAGE TORQUE 1 OZ. IN.

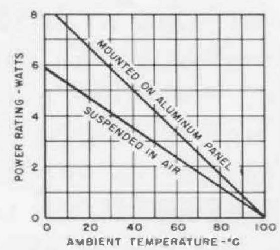


TYPE LETTER	NOMINAL RESISTANCE OHMS	TEMPERATURE COEFFICIENT OF RESISTIVITY	RESOLUTION	STANDARD INDEPENDENT LINEARITY
C	5	+.07 %	<1%	±2%
D	10			
E	20	±.002%		
F	50			
G	100		<.5%	
H	200			
J	500			
K	1000			
L	2000	+.002%		
M	5000			
N	10,000		<.2%	
P	20,000			
Q	50,000			

TYPE 973

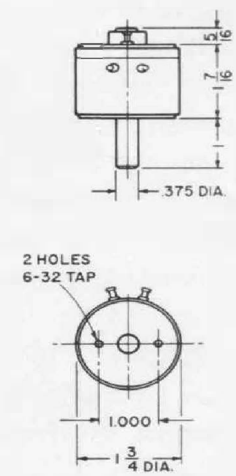


APPROXIMATE WEIGHT 1 OZ.
EFFECTIVE ELECTRICAL ROTATION 320°±5°
TOTAL MECHANICAL ROTATION 330°±5°
STANDARD RESISTANCE TOLERANCE ±5%
AVERAGE TORQUE 1 1/4 OZ. IN.

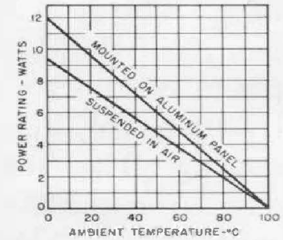


TYPE LETTER	NOMINAL RESISTANCE OHMS	TEMPERATURE COEFFICIENT OF RESISTIVITY	RESOLUTION	STANDARD INDEPENDENT LINEARITY
C	5	+.07 %	<.5%	±1%
D	10			
E	20	±.002%		
F	50			
G	100			
H	200			
J	500		< 2%	
K	1000			
L	2000	+.002%		
M	5000			
N	10,000		<.1%	
P	20,000			
Q	50,000			

TYPE 974



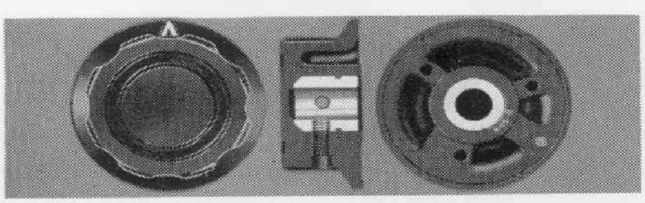
APPROXIMATE WEIGHT 1 3/4 OZ.
EFFECTIVE ELECTRICAL ROTATION 320°±5°
TOTAL MECHANICAL ROTATION 330°±5°
STANDARD RESISTANCE TOLERANCE ±5%
AVERAGE TORQUE 1 1/4 OZ. IN.



TYPE LETTER	NOMINAL RESISTANCE OHMS	TEMPERATURE COEFFICIENT OF RESISTIVITY	RESOLUTION	STANDARD INDEPENDENT LINEARITY
D	10	+.07 %	<.5%	±1%
E	20			
F	50	±.002%		
G	100			
H	200			
J	500			
K	1000		<.2%	
L	2000			
M	5000	+.002%		
N	10,000			
P	20,000		<.1%	
Q	50,000			
R	100,000			

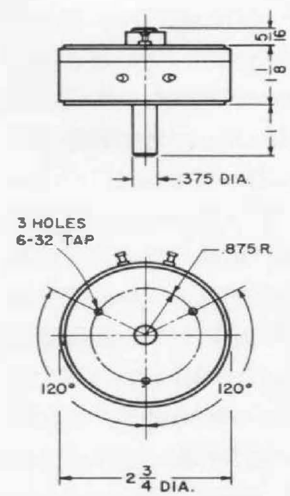
For Prices See Pages 7 and 8.

Knobs Suitable for Use with 970-Series Potentiometers

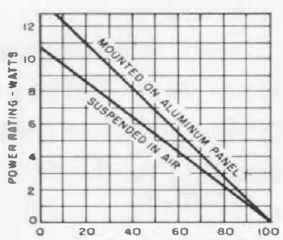


These phenolic knobs are molded in one piece with a brass insert bored for a 3/8-inch shaft. A bushing is furnished with each knob to adapt it to a 1/4-inch shaft. Knob is clamped to shaft by two set-screws spaced 90° apart, except in TYPE KNSP-6, which has 135° spacing.

TYPE 975

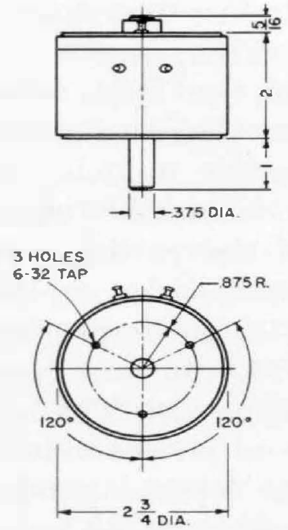


APPROXIMATE WEIGHT	3 OZ.
EFFECTIVE ELECTRICAL ROTATION	320°±2°
TOTAL MECHANICAL ROTATION	330°±5°
STANDARD RESISTANCE TOLERANCE	±2%
AVERAGE TORQUE	3 1/2 OZ. IN.

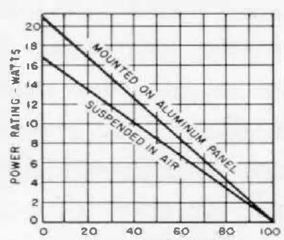


TYPE LETTER	NOMINAL RESISTANCE OHMS	TEMPERATURE COEFFICIENT OF RESISTIVITY	RESOLUTION	STANDARD INDEPENDENT LINEARITY
*D	10	+.07 %	<.5%	±1%
*E	20			
*F	50	±.002%		
*G	100			
*H	200			
J	500		<.2%	±.5%
K	1000			
L	2000			
M	5000	+.002%		
N	10,000		<.1%	
P	20,000			
Q	50,000		<.05%	
R	100,000			

TYPE 976

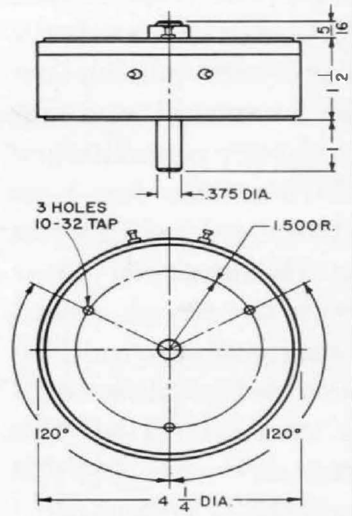


APPROXIMATE WEIGHT	4 OZ.
EFFECTIVE ELECTRICAL ROTATION	320°±2°
TOTAL MECHANICAL ROTATION	330°±5°
STANDARD RESISTANCE TOLERANCE	±2%
AVERAGE TORQUE	3 1/2 OZ IN.

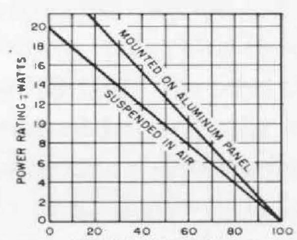


TYPE LETTER	NOMINAL RESISTANCE OHMS	TEMPERATURE COEFFICIENT OF RESISTIVITY	RESOLUTION	STANDARD INDEPENDENT LINEARITY
*E	20	+.07 %	<.5%	±1%
*F	50			
*G	100	±.002%		
*H	200			
*J	500			
K	1000		<.2%	±.5%
L	2000			
M	5000			
N	10,000	+.002%		
P	20,000		<.1%	
Q	50,000			
R	100,000		<.05%	
T	200,000			

TYPE 977

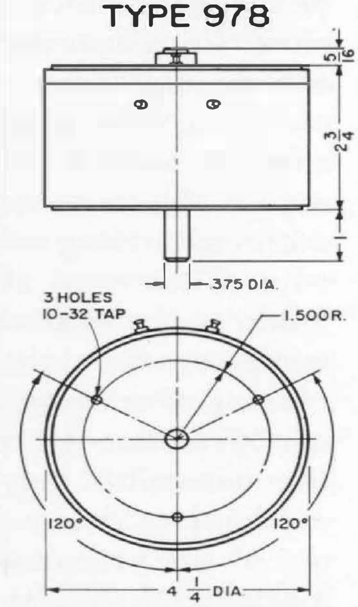


APPROXIMATE WEIGHT	9 OZ.
EFFECTIVE ELECTRICAL ROTATION	320°±2°
TOTAL MECHANICAL ROTATION	330°±5°
STANDARD RESISTANCE TOLERANCE	±2%
AVERAGE TORQUE	10 OZ IN.

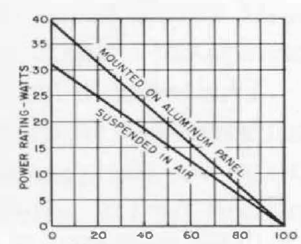


TYPE LETTER	NOMINAL RESISTANCE OHMS	TEMPERATURE COEFFICIENT OF RESISTIVITY	RESOLUTION	STANDARD INDEPENDENT LINEARITY
*E	20	+.07 %	<.2%	±.5%
*F	50			
*G	100	±.002%		
*H	200			
*J	500			
K	1000		<.1%	±.2%
L	2000			
M	5000			
N	10,000	+.002%		
P	20,000			
Q	50,000		<.05%	
R	100,000			
T	200,000			

TYPE 978



APPROXIMATE WEIGHT	12 OZ.
EFFECTIVE ELECTRICAL ROTATION	320°±2°
TOTAL MECHANICAL ROTATION	330°±5°
STANDARD RESISTANCE TOLERANCE	±2%
AVERAGE TORQUE	10 OZ IN.



TYPE LETTER	NOMINAL RESISTANCE OHMS	TEMPERATURE COEFFICIENT OF RESISTIVITY	RESOLUTION	STANDARD INDEPENDENT LINEARITY
*F	50	+.07 %	<.2%	±5%
*G	100			
*H	200	±.002%		
*J	500			
*K	1000			
L	2000		<.1%	±2%
M	5000			
N	10,000			
P	20,000	+.002%		
Q	50,000			
R	100,000		<.05%	
T	200,000			
U	500,000			

* NOT USUALLY MANUFACTURED OR STOCKED. INQUIRIES ARE INVITED.

Type*	Recommended for Type	Skirt Diameter inches	Unit Prices ‡ 5† to 19	20 to 199	200 to 399	400 to 1999
KNS-6 or KNSP-6	971, 972, 973, 974	1 5/16	$0.60	$0.50	$0.47	$0.44
KNS-8 or KNSP-8	975, 976	1 15/16	.75	.65	.61	.58
KNS-10 or KNSP-10	977, 978	2 3/8	1.05	.95	.90	.85

*KNSP-types have pointer; KNS-types do not. † Minimum quantity sold. ‡ Net; no additional quantity discounts be met economically, yet are sufficiently close for most uses. Closer tolerances can be met when required. The brush track on the wound card is carefully cleaned with a special buff which removes the varnish and enamel coating without cutting into the fine resistance wire. To assure stability, the track is made at the edge of the card, where the wires remain tight and maintain their spacing. Furthermore, a thorough cleaning operation can be easily performed on this accessible portion of the element.

Electrical noise is minimized by the use of the precious-metal brush, by the mechanical stability of the winding, and by the maintenance of cleanliness in the dust-proof enclosure. A thorough final cleaning is the last assembly operation before the cover is closed, and every unit must pass an oscilloscope test for traces of noise.

The excellent linearity of the 970-series potentiometers is attributable not only to the good workmanship exemplified by the quality of the winding and the closely fitted primary bearing, but also to the basic design. It will be noted in the illustrations, for instance, that the peripheral walls of all these controls are smooth cylinders, inside and out, without bosses or change in section thickness. A molding with this uniform geometry has no unequal curing or aging stresses and will therefore remain round and concentric. The resistance element is cemented directly to the true interior surface, and the assembly is baked to cure the cement and to stress-relieve the card. With this construction, the linearity limits on the specification sheet are readily met by all the units without a need for expensive machining operations. The resulting simplicity of manufacture leads to exceptionally low prices for this degree of precision. Every control is tested and graded for linearity, and closer tolerances than those listed are available by selection at slightly increased prices.

The locations of the mounting holes for the Type 970-series potentiometers are the same as those for the equivalent earlier models, and the maximum dimensions are chosen to be within those of the earlier models. The older Type 301 can be replaced by the new Type 973, the Types 214 and 314 by the Type 975, and the Types 371 and 471 by the Type 976. The holes in the bases of the new potentiometers are tapped, while the earlier models required nuts for mounting. The small models mount with two screws, and the large with three screws, as shown in the chart on pages 4 and 5. This installation method offers several distinct advantages. Any panel thickness can be accomodated by simply selecting screw lengths; screws are easier to install than large nuts; countersunk screws may be used when flush panel surface is desired; and multiple screws lock against rotation without keys or pins which require fussy tolerances.

Ganged assemblies are made with nesting phenolic spacer rings and skeleton-proportioned aluminum clamps as shown in Figure 1. The external hubs on each unit are progressively attached to a common shaft in approximate angular location. Accurate tracking is then obtained by rotating the individual potentiometer bodies prior to final tightening of the clamps. The rabbets on each end of the unit casings register with the cylindrical spacers and with the clamps to keep the assembly concentric during this phasing operation. The small amount of metal in the clamps keeps capacitance between units at a minimum. So many combinations of numbers, values and characteristics can be specified for a ganged control that it is not feasible to list stock models, but inquiries will be welcomed on an individual quotation basis. Since best results are obtained when a ganged assembly is adjusted at the factory, ganging hardware will not, at present, be sold separately.

Variations from the standard models can be easily produced. For example, 360° rotation is achieved (at the factory) by removing the cover screw, cementing a bridge between the ends of the windings and then fastening the cover to the base with the same clamp rings that are used on the ends of a ganged assembly.

Intermediate taps can be provided anywhere around the periphery and are brought out to hollow turret terminals installed in the base cup prior to inserting the resistance element. The winding form is provided with a clearance hole in the general area of each tap and, a loop of wire is left in the winding at the measured resistance point. After assembly an enameled conductor is passed through the terminal, through the winding adjacent the loop and is soldered at each end. The only limitation on the number of taps that can be provided in this compact manner is the external spacing of the terminals.

Any reasonable characteristic of resistance change with rotation can be accomplished by tapering and/or stepping the unused edge of the winding form. A variety of shapes have already been cut for use in General Radio instruments as well as for customers, and inquiries for special functions are invited.[1]

For any potentiometer application, whether it be a special model, utilizing the extreme versatility, or a standard model taking advantage of the outstanding catalog specifications, a 970-type potentiometer is offered as the most practical solution evaluated in quality and performance per dollar.

— H. M. Wilson

[1] P. K. McElroy, "The Versatile Voltage Divider".

PRICE LIST FOR 970-SERIES POTENTIOMETERS

Type	Code Word	Unit Price	Type	Code Word	Unit Price
971-B	ANTRIMBITE	$3.15	973-C	CANDIDCREW	$4.00
971-C	ANTRIMCREW	3.15	973-D	CANDIDDULL	4.00
971-D	ANTRIMDULL	3.15	973-E	CANDIDEARL	4.00
971-E	ANTRIMEARL	3.15	973-F	CANDIDFALL	4.00
971-F	ANTRIMFALL	3.15	973-G	CANDIDGERM	4.00
971-G	ANTRIMGERM	3.15	973-H	CANDIDHUNT	4.00
971-H	ANTRIMHUNT	3.15	973-J	CANDIDJUMP	4.00
971-J	ANTRIMJUMP	3.15	973-K	CANDIDKISS	4.00
971-K	ANTRIMKISS	3.15	973-L	CANDIDLEAP	4.25
971-L	ANTRIMLEAP	3.15	973-M	CANDIDMILK	4.25
971-M	ANTRIMMILK	3.15	973-N	CANDIDNULL	4.25
971-N	ANTRIMNULL	3.15	973-P	CANDIDPARK	4.25
971-P	ANTRIMPARK	3.15	973-Q	CANDIDQUAD	4.25
972-C	BANTERCREW	3.75	974-D	DANCERDULL	4.50
972-D	BANTERDULL	3.75	974-E	DANCEREARL	4.50
972-E	BANTEREARL	3.75	974-F	DANCERFALL	4.50
972-F	BANTERFALL	3.75	974-G	DANCERGERM	4.50
972-G	BANTERGERM	3.75	974-H	DANCERHUNT	4.50
972-H	BANTERHUNT	3.75	974-J	DANCERJUMP	4.50
972-J	BANTERJUMP	3.75	974-K	DANCERKISS	4.50
972-K	BANTERKISS	3.75	974-L	DANCERLEAP	5.00
972-L	BANTERLEAP	3.75	974-M	DANCERMILK	5.00
972-M	BANTERMILK	3.75	974-N	DANCERNULL	5.00
972-N	BANTERNULL	3.75	974-P	DANCERPARK	5.00
972-P	BANTERPARK	3.75	974-Q	DANCERQUAD	5.00
972-Q	BANTERQUAD	3.75	974-R	DANCERRISK	5.00

Price List For 970-Series Potentiometers *(continued)*

Type	Code Word	Unit Price	Type	Code Word	Unit Price
975-J	EAGLETJUMP	$4.75	977-K	GANDERKISS	$6.00
975-K	EAGLETKISS	4.75	977-L	GANDERLEAP	6.00
975-L	EAGLETLEAP	4.75	977-M	GANDERMILK	6.00
975-M	EAGLETMILK	4.75	977-N	GANDERNULL	6.75
975-N	EAGLETNULL	5.25	977-P	GANDERPARK	6.75
975-P	EAGLETPARK	5.25	977-Q	GANDERQUAD	6.75
975-Q	EAGLETQUAD	5.25	977-R	GANDERRISK	6.75
975-R	EAGLETRISK	5.25	977-T	GANDERTICK	7.50
976-K	FANGELKISS	5.50	978-L	HAMPERLEAP	7.00
976-L	FANGELLEAP	5.50	978-M	HAMPERMILK	7.00
976-M	FANGELMILK	5.50	978-N	HAMPERNULL	7.75
976-N	FANGELNULL	6.00	978-P	HAMPERPARK	7.75
976-P	FANGELPARK	6.00	978-Q	HAMPERQUAD	7.75
976-Q	FANGELQUAD	6.00	978-R	HAMPERRISK	7.75
976-R	FANGELRISK	6.00	978-T	HAMPERTICK	8.50
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CORRECTION

(November, 1954, Issue)

Current Rating for TYPE M-10 Variac® Autotransformer

The output current for the TYPE M-10 Variac is incorrectly stated on page 7 of the November *Experimenter*. Correct current ratings for this transformer are as follows:

Rated Output Current: 10 amperes
Maximum Output Current (for line-voltage connection only): 13 amperes

Code Words for TYPE M-10 Gangs

The code word listed for TYPE M-10G2 2-Gang TYPE M-10 Variac Assembly should be corrected to read CABINGANDU.

Code Words for TYPE V-2 Gangs

Code words as listed are transposed, correct as follows:

TYPE V-2G2 2-Gang TYPE V-2 Variac Assembly—BEADYGANDU.
TYPE V-2G3 3-Gang TYPE V-2 Variac Assembly—BEADYGANTY.

The R-C Oscillator

The patent number listed on page 4, should read 2,173,427.

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