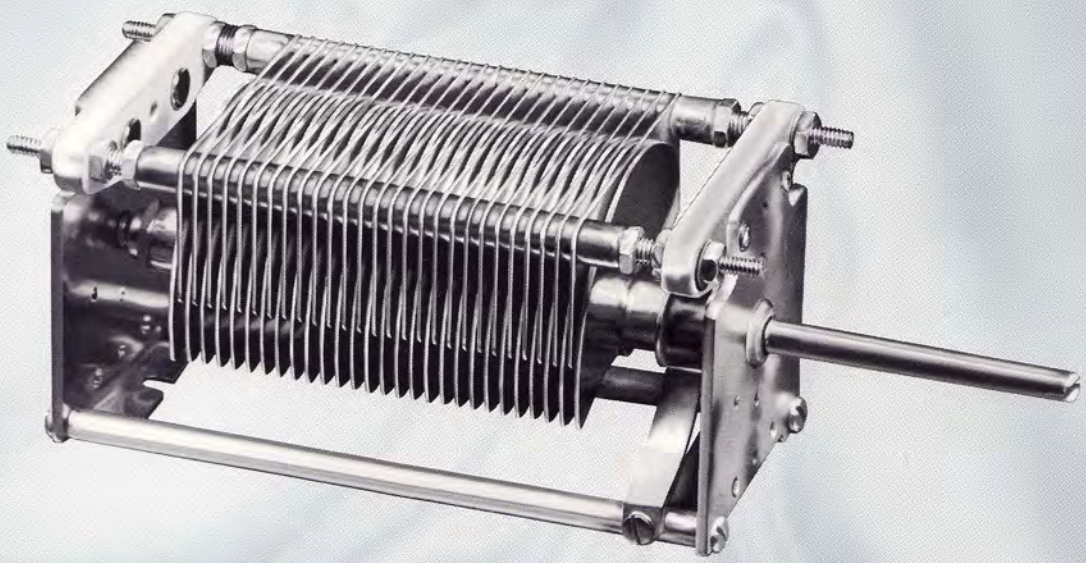
OREN ELLIOTT PRODUCTS, INC.

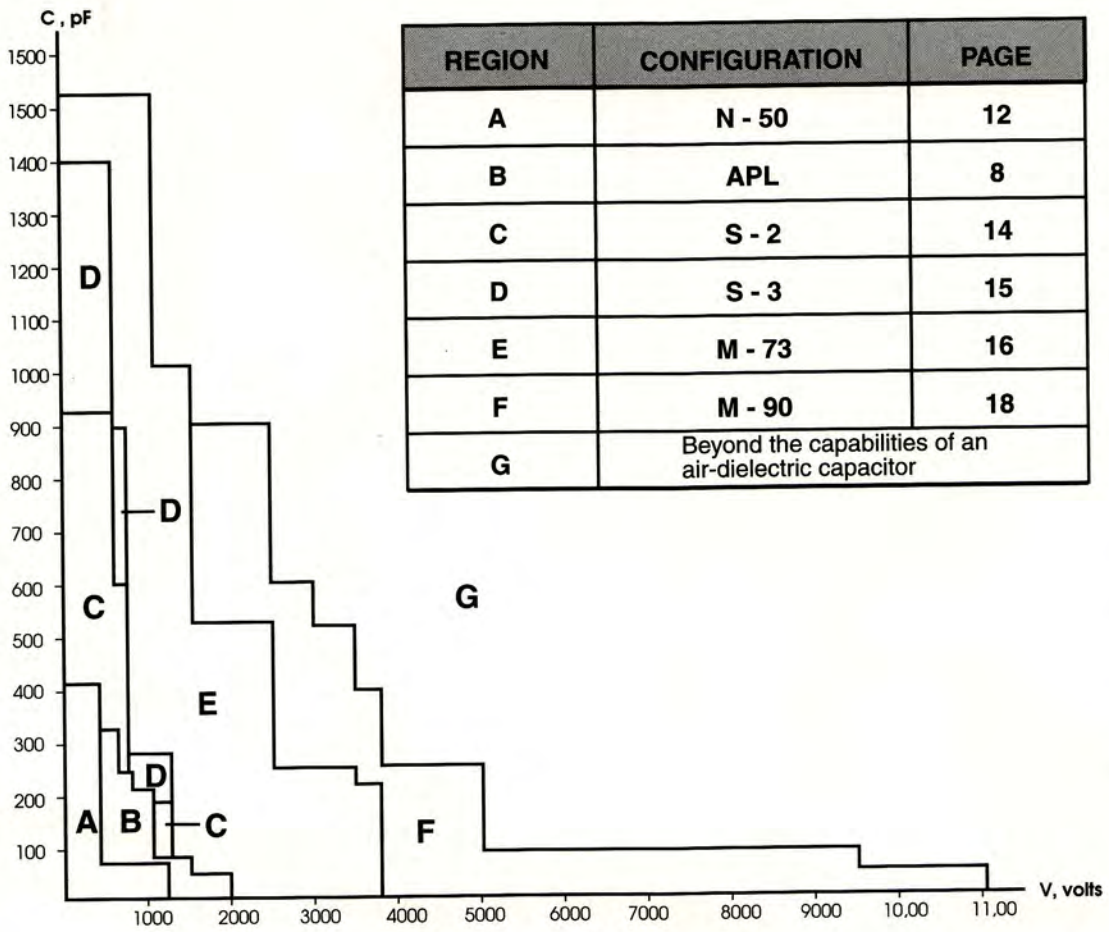


AIR VARIABLE CAPACITORS

PRECISION SCREW MACHINE PRODUCTS

P. O. BOX 638
128 W. VINE
EDGERTON, OH 43517

INDEX



REGION	CONFIGURATION	PAGE
A	N - 50	12
B	APL	8
C	S - 2	14
D	S - 3	15
E	M - 73	16
F	M - 90	18
G	Beyond the capabilities of an air-dielectric capacitor	

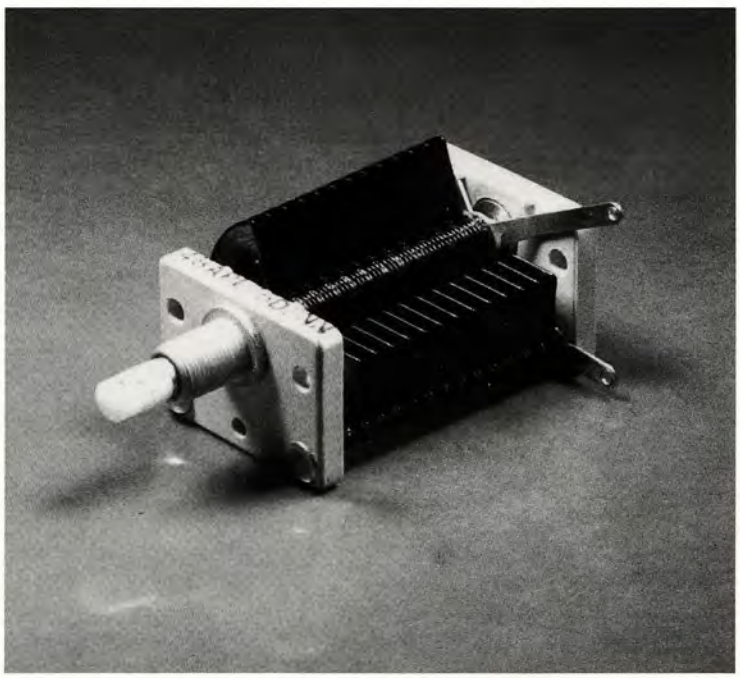
The graph and chart at left can serve as a guide to which type of air variable capacitor can meet your needs. Voltage is graphed along the horizontal axis and capacitance along the vertical. If you need a capacitor with a certain maximum voltage and a certain maximum capacitance, simply plot the point determined by these two coordinates, determine which region in which it lies, and use the chart to find the corresponding configuration. If, for example, you need a capacitor that can withstand 1500 V while delivering 400 pF, plot the point (1500, 400); this lies in zone E, so an M-73 would work.

INTRODUCTION

Oren Elliott Products, Inc. is the largest domestic manufacturer of air-dielectric variable capacitors. We also manufacture precision screw machine products, custom sub-assemblies, variable inductors, and vernier drives.

Our factory has produced capacitors since 1925, first as American Steel Packaging Company and then as All Star Products. In those early years, applications of our major products were almost exclusively limited to short-wave radio. During World War II, we supplied the Allies with 35,000 capacitors per day, and by the end of the war our company was the world's largest producer of air trimmers. Since Oren Elliott Products Inc.'s inception in 1983, our products have been used in such diverse applications as magnetic resonance imagery equipment, antique radios, mass spectroscopy equipment, silicon chip plasma etching and deposition devices, and surface-to-air missile guidance systems.

Our primary product, the air variable capacitor, has been replaced in a large portion of the short-wave radio market by transistor technology. The air-dielectric capacitor will never be completely supplanted by varactor diodes, however, because of its inherent advantages. Diodes' properties change with changes in temperature, leading to thermal drift. An air-variable's dielectric, however, is always (by definition) at the ambient temperature. The capacitance of a diode can be changed only by changing the voltage in that part of the circuit; air-variables require no mechanism for varying the voltage, resulting in a simpler overall circuit. Finally, the most obvious advantage of air-dielectric capacitors over all other capacitors is the self-renewing dielectric material: Arc-over, temperature changes, and time itself cause no deterioration of the dielectric. There are, in fact, quite a few working short-wave sets from the 1930's that contain American Steel Packaging condensers. Perhaps this fact hints at one reason for the decline in popularity of air variable capacitors among designers and manufacturers of ham radio equipment: They didn't fit in with the modern manufacturer's philosophy of built-in obsolescence; fewer sets could be sold if they lasted forever.

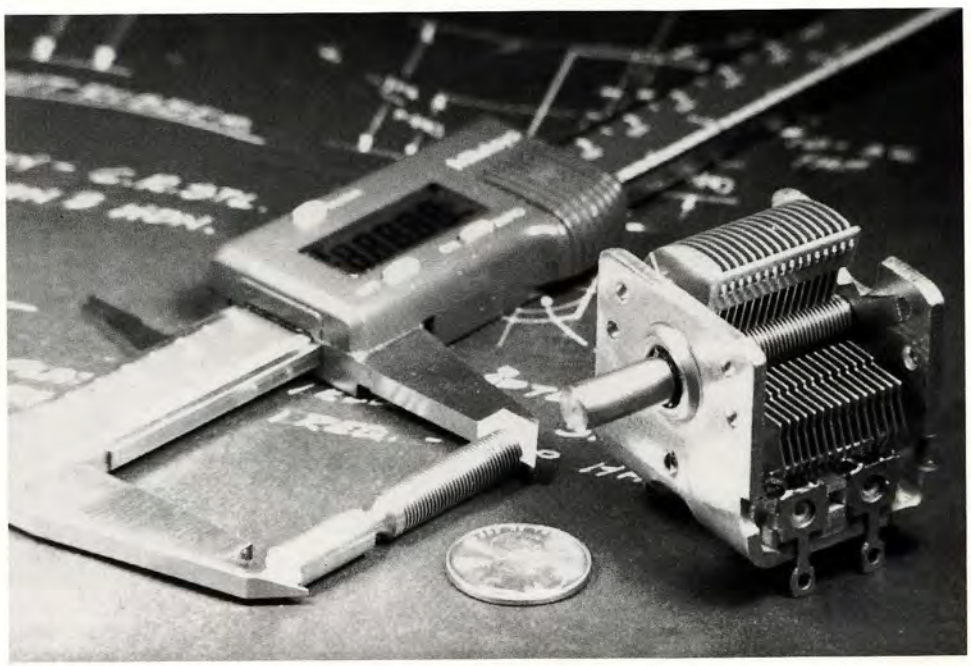


Our facilities consist of complete screw machine, secondary, stamping, tool & die, and assembly departments. Through extensive in-house manufacture of subcomponents and flexible manufacturing techniques, we are able to offer our customers highly specialized, customized products in virtually any quantity with reasonable lead-times and very reasonable prices.

SCREW MACHINE PRODUCTS

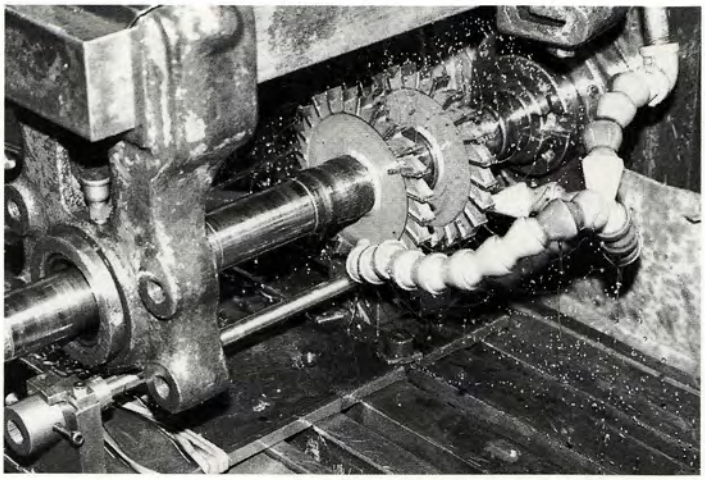
Many of the subcomponents of an air variable capacitor are quite challenging to machine. Because of small air gaps and the tendency for small machining errors to accumulate into critical errors, our screw machine and finishing departments are often required to hold tolerances as small as .0001". This ability for precise work, coupled with the fact that our facilities' capabilities far exceed current demand for air variable capacitors, have naturally led to a thriving and ever-expanding screw machine job-shop business.

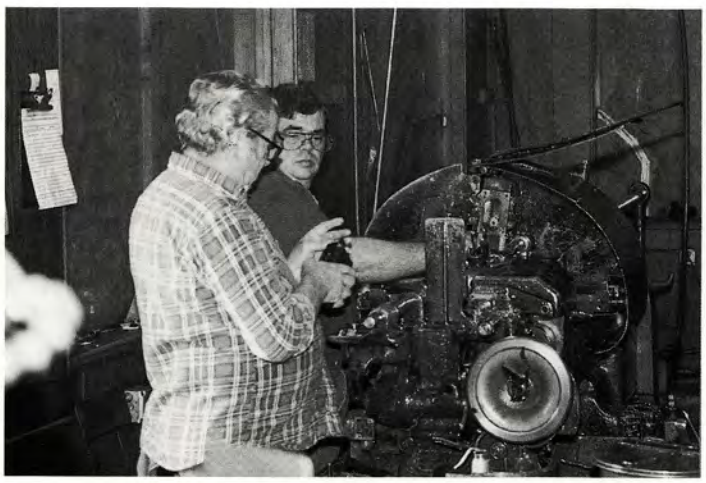
Our screw machine department currently consists of about twenty machines, most of which are single-spindle Swiss-type. Our finishing department includes CNC lathes, turret lathes, mills, drill presses, tappers, brushes, and tumblers. We've had experience with virtually every imaginable secondary operation, including (but not limited to) several varieties of turning and milling, recessing, cross-drilling, acme threading, knurling, burnishing, stamping and forming, and press-fit assembly. Our screw machines' maximum diameters range up to 1½", with no minimum diameter. We have worked in several alloys of steel, brass, copper, aluminum, stainless steel, silver, and phosphor bronze, as well as delrin, nylon, and PVC. We have also worked in several shapes of bar stock, including round, square, hex, rectangular, flat, and pinion. Typically, our customers specify tolerances of ±.005" or ±.001", but we are capable of holding tolerances of ±.0001" on most operations.

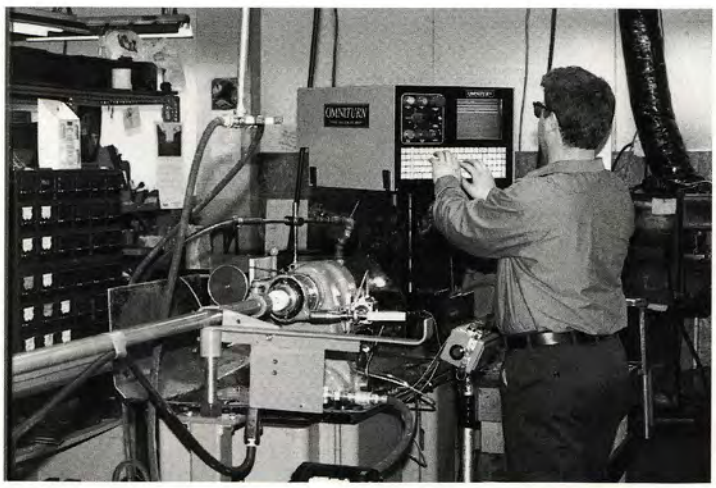


Because our screw machine operation is a business-within-a-business, effective overhead is quite low, enabling us to competitively bid for jobs as small as 100 pieces. At the same time, our physical facilities have enabled us to run jobs as large as 1,000,000 pieces. We offer competent technical support, and are always willing to work with customers during the design and redesign stages. If your company uses screw machine products, please fax us a print for a prompt, competitive quote.

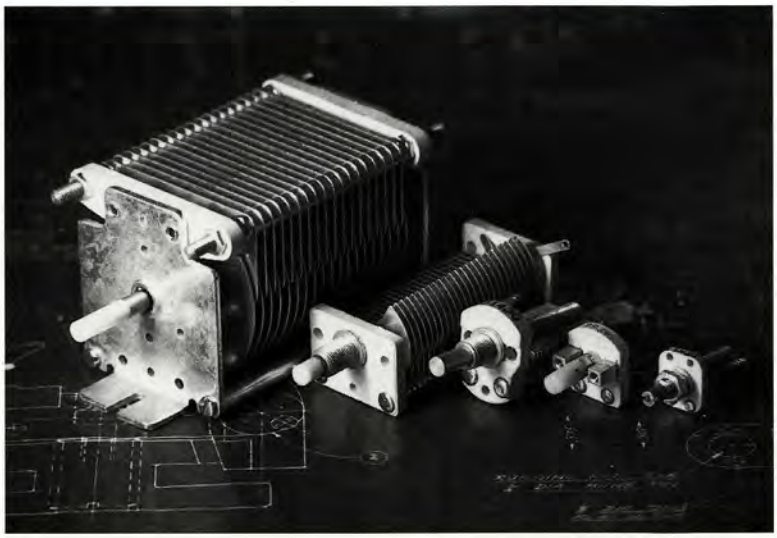
SCREW MACHINE PRODUCTS







ASSEMBLY PRODUCTS



Our assembly products can be divided into three major categories: Air variable capacitors, variable inductors, and vernier reduction drives. Most of our capacitors can be put into one of three general types: Air trimmers, condensers, and M-73's.

The distinguishing feature of an air trimmer is its ceramic frame, which holds the stationary bank of blades (or stator), as well as the bearing in which the rotating bank of blades (or rotor) rides. This bearing is usually threaded, and the capacitor is usually mounted by inserting this bearing through a hole in a panel. Air trimmers are used in applications that require an economical price, high voltage breakdown, and small physical size.

Condensers are built into a U-shaped wraparound plated steel frame; insulation between oppositely charged banks of blades is accomplished through phenolic stator supports. A trait unique to condensers is a 180° limit on the rotation of the rotor. Condensers are used in applications that require an economical price, high capacitance in confined spaces, rugged durability under inertial shock and vibration, and special mounting requirements.

M-73's are large units with a plated steel frame at each end; insulation between rotor and stator is achieved with heavy ceramics riveted onto the frames. They are overbuilt in terms of physical and electrical durability, and are used in applications that require high voltage breakdown, large capacitance, and durability.

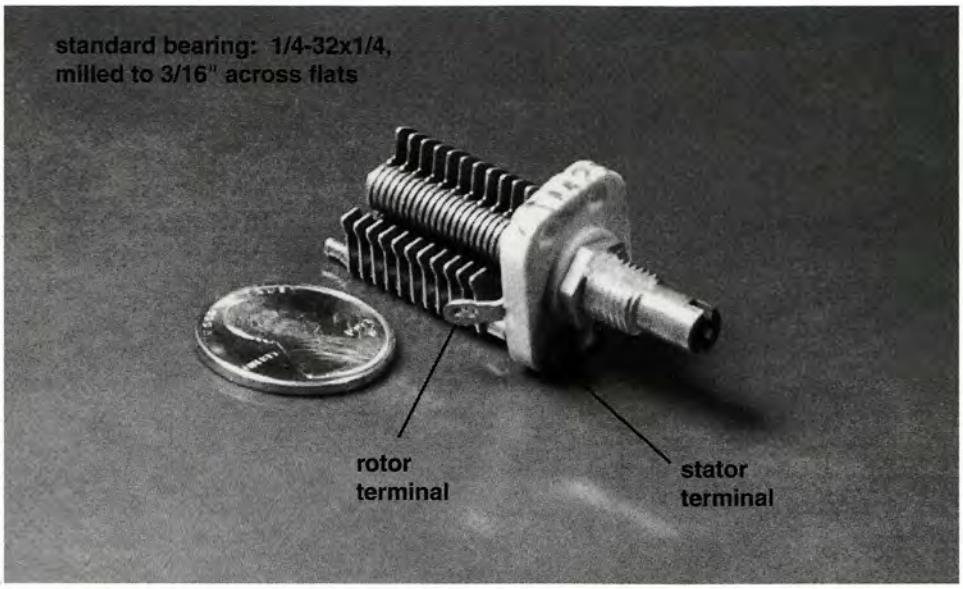
CALLING FOR A QUOTE OR PLACING AN ORDER

Typically, when a customer needs an air variable capacitor, he has specific requirements in terms of maximum and minimum capacitance, maximum voltage, physical dimensions, special mounting requirements, and cost. These factors determine which general configuration (ATM, APC, APL, NS-51, N-50, S-2, S-3, or M-73) would best meet his needs. Once the general type has been determined, the customer has several options available; these options will be explained in greater detail in the following pages.

When ordering an air trimmer (ATM, APC, or APL), the customer must decide on one of three spider (rotor contact) positions, the shaft length, the position of any solder lugs, and the bearing type. Two other options on the APC and APL are an insulated (delrin) shaft extension and the addition of tapped mounting posts to the ceramic. When ordering a condenser (NS-51, N-50, S-2, or S-3), the customer must decide on shaft length, and whether he needs trimmers, solder lugs welded to the frame, a vernier reduction drive, and tapped mounting holes. Options with the M-73 include shaft length, an insulated shaft extension, solder lugs on the frame or the stator, and tapped mounting holes.

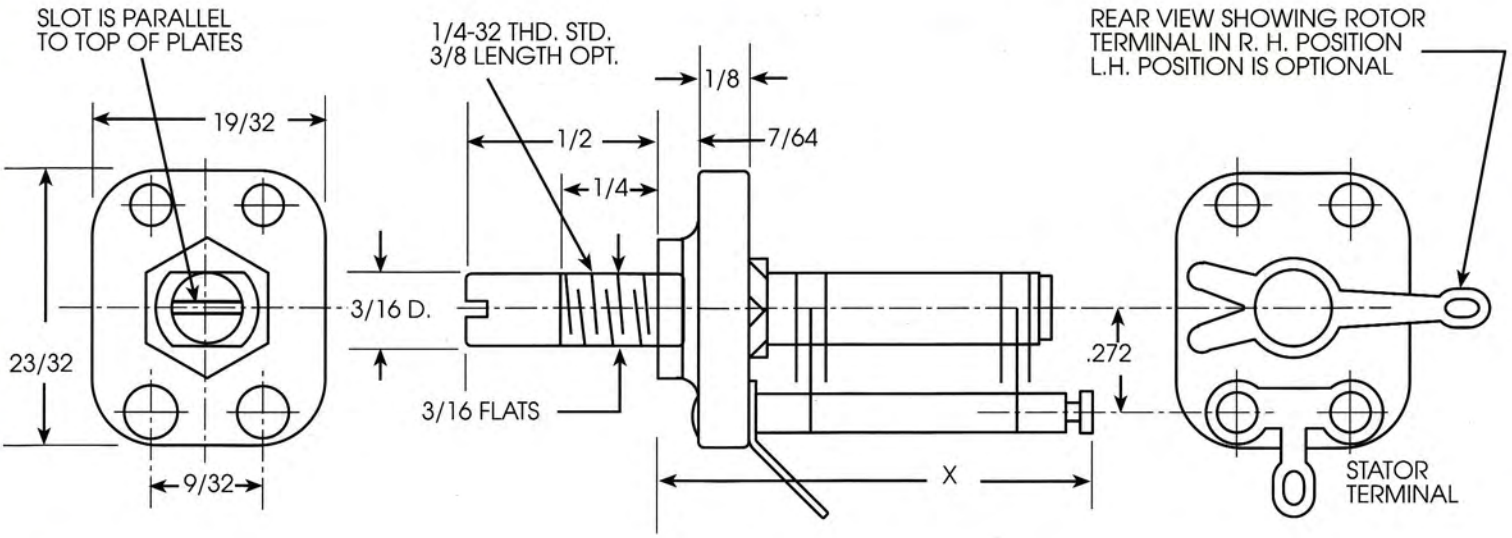
When calling for a quote, the customer should bear in mind that the price is a function of the configuration, the number and spacing of blades, options chosen, and quantity. The price will include a small setup charge for orders of less than 250 air trimmers or condensers, or less than 100 M-73's. Methods of payment include prepayment, COD, and net 30; a net 30 account can be established with 3 trade references and 2 bank references. Lead-times can vary from one to six weeks, but typically we can produce parts within four weeks of the placement of an order.

ATM

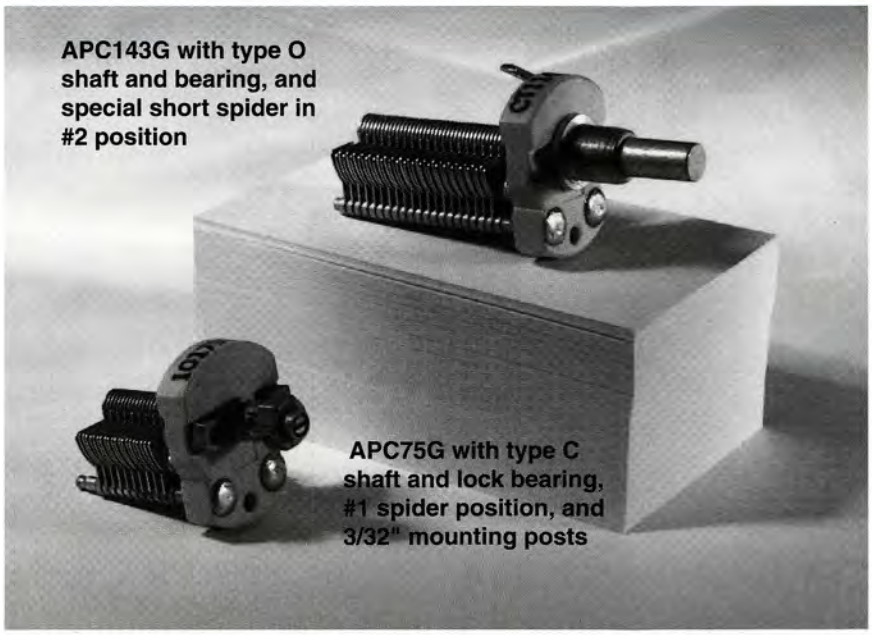


The ATM is our smallest, least expensive variable capacitor. It can be used to replace screw-type air dielectric and mica dielectric capacitors.

The ATM's air gap is .016", and it can withstand a maximum voltage of 500 VAC. A lock-bearing is available, with which an ATM can be used as a factory-tuned fixed capacitor.



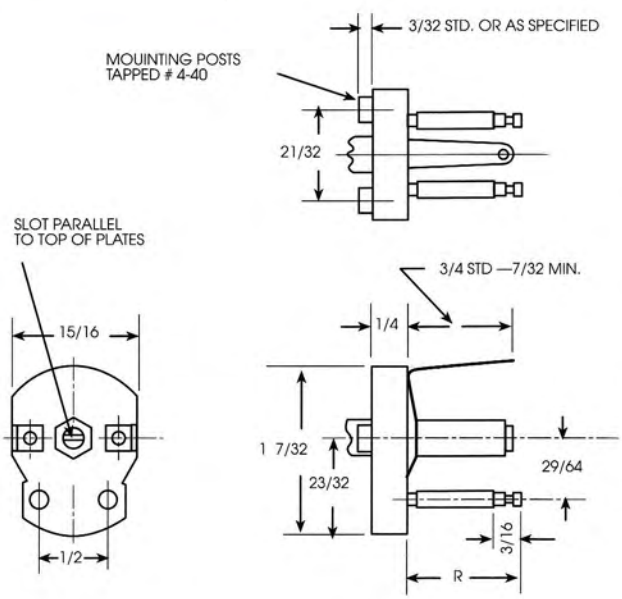
PART NUMBER	# of BLADES	MIN. CAP (pF)	MAX. CAP (pF)	X DIM.
ATM3	3	1.2	3.0	37/64
ATM4	4	1.3	4.0	39/64
ATM5	5	1.4	5.0	41/64
ATM6	6	1.5	6.0	43/64
ATM7	7	1.5	6.9	45/64
ATM8	8	1.6	7.9	47/64
ATM9	9	1.7	8.9	25/32
ATM10	10	1.8	9.9	13/16
ATM11	11	1.9	10.9	27/32
ATM12	12	2.0	11.9	7/8
ATM13	13	2.1	12.9	29/32
ATM14	14	2.1	13.8	15/16
ATM15	15	2.2	14.8	31/32
ATM16	16	2.3	15.8	1
ATM17	17	2.4	16.8	1- 1/32
ATM18	18	2.5	17.8	1- 1/16
ATM19	19	2.6	18.8	1- 3/32
ATM20	20	2.7	19.8	1- 1/8
ATM21	21	2.8	20.8	1- 5/32
ATM22	22	2.9	21.8	1- 3/16

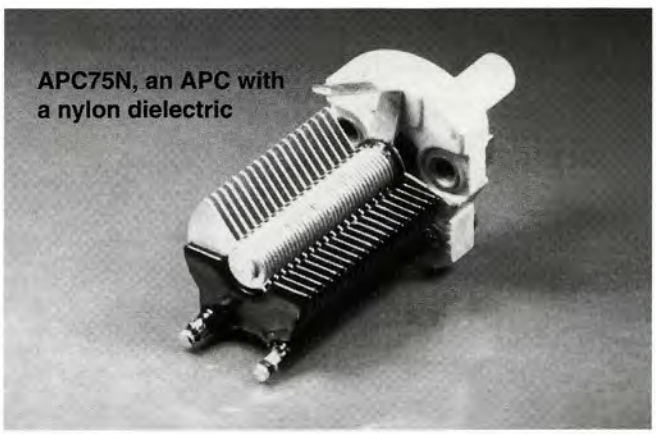


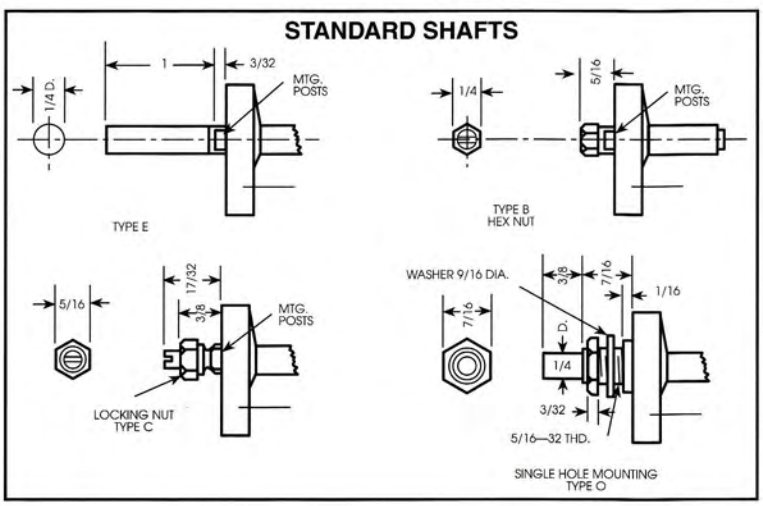
The APC is the most durable air trimmer, and has been used in several very demanding military applications. It is frequently equipped with a lock-bearing and is used as a factory-adjustable trimmer capacitor, but it can also be used as an operator-controlled tuning capacitor.

The APC is quite versatile, and several variations on the main theme are available. The shaft can be slotted, insulated, or both. The APC can be installed by single hole mounting (in which the threaded bearing is held in place on the panel by one or two nuts), or with mounting posts, which provide electrical insulation between the energized blades of the capacitor and the panel to which it is mounted.

There are four air gaps available, ranging in maximum voltage from 500 V to 1000 V; their corresponding capacitances and dimensions are given as a function of the number of blades in the table below. This same data is given explicitly in the charts on the next page. We also offer the option of a nylon film dielectric on the APC, which increases the maximum voltage of the .016" air gap to 1100 V.







air gap	n (total # of blades)	R (length)	min. cap. (pF)	max. cap. (pF)	max. volt (V)
.016	$2 \le n \le 40$	.03n + .377	.124n + 2.25	3.5n - 3.5	500
.020	$2 \le n \le 38$	.034n + .386	.15n + 2.2	2.73n - .16	600
.032	$2 \le n \le 26$	.046n + .362	.2n + 2.1	1.95n + .29	700
.048	$2 \le n \le 20$	.064n + .278	.25n + 2.0	1.42n + .87	1000

APC ELECTRICAL DATA

.016" AIR GAP: 500 V max.

PART NUMBER	# of BLADES	- R - DIMENSION	MIN. CAP.	MAX. CAP.
APC 6-G	2	7/16	2.5	6.0
APC 10-G	3	7/16	2.7	9.7
APC 13-G	4	7/16	2.8	13.3
APC 17-G	5	7/16	3.0	17.0
APC 20-G	6	1/2	3.1	20.6
APC 24-G	7	1/2	3.3	24.3
APC 28-G	8	9/16	3.4	27.9
APC 31-G	9	9/16	3.6	31.6
APC 35-G	10	41/64	3.7	35.2
APC 39-G	11	41/64	3.9	38.9
APC 42-G	12	45/64	4.0	42.5
APC 46-G	13	45/64	4.2	46.2
APC 50-G	14	49/64	4.3	49.8
APC 53-G	15	49/64	4.5	53.5
APC 57-G	16	53/64	4.6	57.1
APC 61-G	17	53/64	4.8	60.8
APC 64-G	18	57/64	4.9	64.4
APC 68-G	19	57/64	5.1	68.1
APC 72-G	20	61/64	5.2	71.7
APC 75-G	21	61/64	5.3	75.3
APC 79-G	22	1- 1/64	5.4	78.9
APC 82-G	23	1- 1/64	5.5	82.5
APC 86-G	24	1- 5/64	5.6	86.1
APC 90-G	25	1- 5/64	5.7	89.7
APC 93-G	26	1- 9/64	5.8	93.3
APC 97-G	27	1- 9/64	5.9	96.9
APC 100-G	28	1-13/64	6.0	100.5
APC 104-G	29	1-13/64	6.1	104.1
APC 108-G	30	1- 9/32	6.2	107.7
APC 111-G	31	1- 9/32	6.3	111.3
APC 115-G	32	1- 11/32	6.4	114.9
APC 118-G	33	1- 11/32	6.5	118.5
APC 122-G	34	1- 13/32	6.6	122.1
APC 126-G	35	1- 13/32	6.7	125.7
APC 129-G	36	1- 15/32	6.8	129.3
APC 133-G	37	1- 15/32	6.9	132.9
APC 136-G	38	1- 17/32	7.0	136.5
APC 140-G	39	1- 17/32	7.1	140.1
APC 143-G	40	1- 19/32	7.2	143.7

.048" AIR GAP: 1000 V max.

PART NUMBER	# of BLADES	- R - DIMENSION	MIN. CAP.	MAX. CAP.
APC 4-V	2	13/32	2.5	3.7
APC 5-V	3	13/32	2.8	5.1
APC 6-V	4	17/32	3.0	6.5
APC 8-V	5	17/32	3.3	7.9
APC 9-V	6	43/64	3.5	9.3
APC 11-V	7	43/64	3.8	10.8
APC 12-V	8	51/64	4.0	12.2
APC 14-V	9	51/64	4.3	13.6
APC 15-V	10	59/64	4.5	15.0
APC 16-V	11	59/64	4.8	16.4
APC 18-V	12	1- 3/64	5.0	17.8
APC 19-V	13	1- 3/64	5.3	19.3
APC 21-V	14	1- 3/16	5.5	20.7
APC 22-V	15	1- 3/16	5.8	22.1
APC 24-V	16	1- 5/16	6.0	23.5
APC 25-V	17	1- 5/16	6.3	24.9
APC 26-V	18	1- 7/16	6.5	26.3
APC 27-V	19	1- 7/16	6.8	27.8
APC 29-V	20	1- 9/16	7.0	29.2

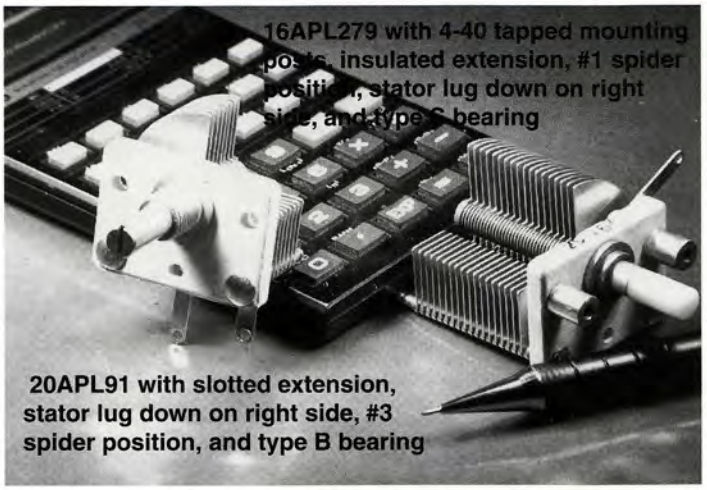
.020" AIR GAP: 600 V max.

PART NUMBER	# of BLADES	- R - DIMENSION	MIN. CAP.	MAX. CAP.
APC 5-L	2	29/64	2.5	5.3
APC 8-L	3	29/64	2.7	8.3
APC 11-L	4	29/64	2.8	11.2
APC 14-L	5	29/64	3.0	14.2
APC 17-L	6	17/32	3.1	17.1
APC 20-L	7	17/32	3.3	20.1
APC 23-L	8	39/64	3.4	23.0
APC 25-L	9	39/64	3.6	26.0
APC 29-L	10	43/64	3.7	28.9
APC 32-L	11	43/64	3.9	31.9
APC 35-L	12	3/4	4.0	34.8
APC 38-L	13	3/4	4.2	37.8
APC 41-L	14	13/16	4.3	40.7
APC 44-L	15	13/16	4.5	32.7
APC 47-L	16	57/64	4.6	46.6
APC 50-L	17	57/64	4.8	49.6
APC 52-L	18	31/32	4.9	52.6
APC 55-L	19	31/32	5.1	55.5
APC 58-L	20	1- 1/32	5.2	58.4
APC 61-L	21	1- 1/32	5.4	61.4
APC 64-L	22	1- 7/64	5.5	64.3
APC 67-L	23	1- 7/64	5.7	67.3
APC 70-L	24	1- 11/64	5.8	70.2
APC 73-L	25	1- 11/64	6.0	73.2
APC 76-L	26	1- 1/4	6.1	76.1
APC 79-L	27	1- 1/4	6.3	79.1
APC 82-L	28	1- 21/64	6.4	82.0
APC 85-L	29	1- 21/64	6.6	85.0
APC 88-L	30	1- 25/64	6.7	87.9
APC 91-L	31	1- 25/64	6.9	90.9
APC 94-L	32	1- 15/32	7.0	93.8
APC 97-L	33	1- 15/32	7.2	96.8
APC 100-L	34	1- 17/32	7.3	99.7
APC 111-L	38	1- 11/16	7.9	111.5

.032" AIR GAP: 700 V max.

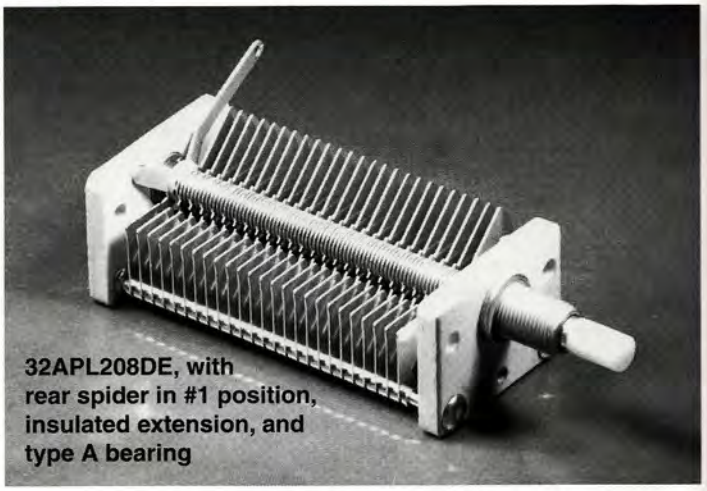
PART NUMBER	# of BLADES	- R - DIMENSION	MIN. CAP.	MAX. CAP.
APC 4-P	2	29/64	2.5	4.2
APC 6-P	3	29/64	2.7	6.2
APC 8-P	4	31/64	2.9	8.1
APC 10-P	5	31/64	3.1	10.1
APC 12-P	6	19/32	3.3	12.0
APC 14-P	7	19/32	3.5	14.0
APC 16-P	8	11/16	3.7	15.9
APC 18-P	9	11/16	3.9	17.9
APC 21-P	10	25/32	4.1	19.8
APC 23-P	11	25/32	4.3	21.8
APC 24-P	12	7/8	4.5	23.7
APC 26-P	13	7/8	4.7	25.7
APC 28-P	14	31/32	4.9	27.6
APC 30-P	15	31/32	5.1	29.6
APC 32-P	16	1- 1/16	5.3	31.5
APC 34-P	17	1- 1/16	5.5	33.5
APC 35-P	18	1- 5/32	5.7	35.4
APC 37-P	19	1- 5/32	5.9	37.4
APC 39-P	20	1- 1/4	6.1	39.3
APC 41-P	21	1- 1/4	6.3	41.3
APC 43-P	22	1- 23/64	6.5	43.2
APC 45-P	23	1- 23/64	6.7	45.2
APC 47-P	24	1- 29/64	6.9	47.1
APC 49-P	25	1- 29/64	7.1	49.1
APC 51-P	26	1- 35/64	7.3	51.1

APL



16APL279 with 4-40 tapped mounting posts, insulated extension, #1 spider position, stator lug down on right side, and type C bearing

20APL91 with slotted extension, stator lug down on right side, #3 spider position, and type B bearing

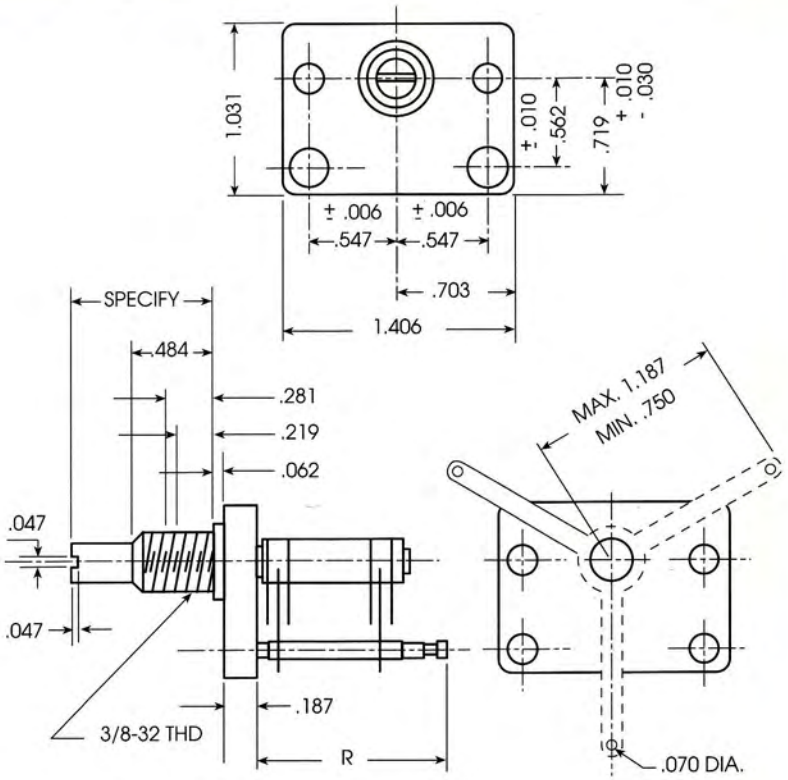


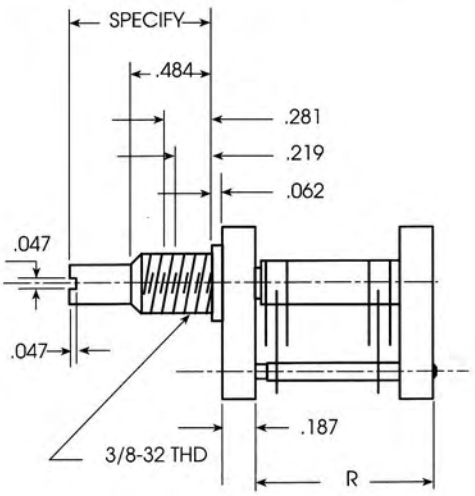
32APL208DE, with rear spider in #1 position, insulated extension, and type A bearing

The APL is used as a tuning capacitor in a variety of RF test equipment and ham radio gear. The APL's combination of low price, high maximum voltages, fairly large capacitances, and low-leakage L-4 grade ceramic have made it a popular configuration: Currently (1995) we produce approximately 50,000 APL's each year.

The APL is usually installed by single-hole mounting, but mounting posts are available, as are lock-bearings and 180° rotor-stop bearings. Most APL's have solder lugs for electrical connection to the stator, and most of the APL's that we currently sell have an insulated shaft.

A variation on the standard APL configuration is the APL-DE, a "double-ended" APL. The rear ceramic adds strength and rigidity, and is necessary on extremely long APL's with close spacing, like the popular 32APL208DE (.032" air gap, 208 pF maximum capacitance). We currently offer five standard air gaps, whose corresponding maximum voltages range from 600 V to 1500 V.





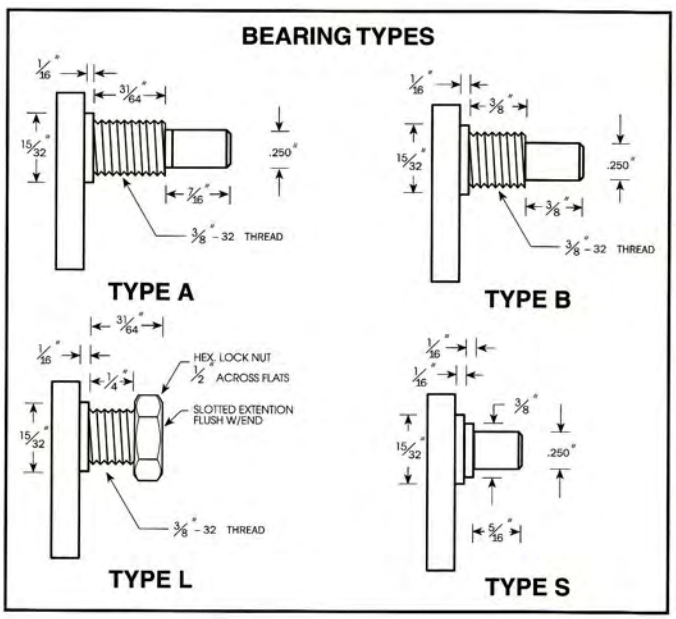
APL ELECTRICAL DATA

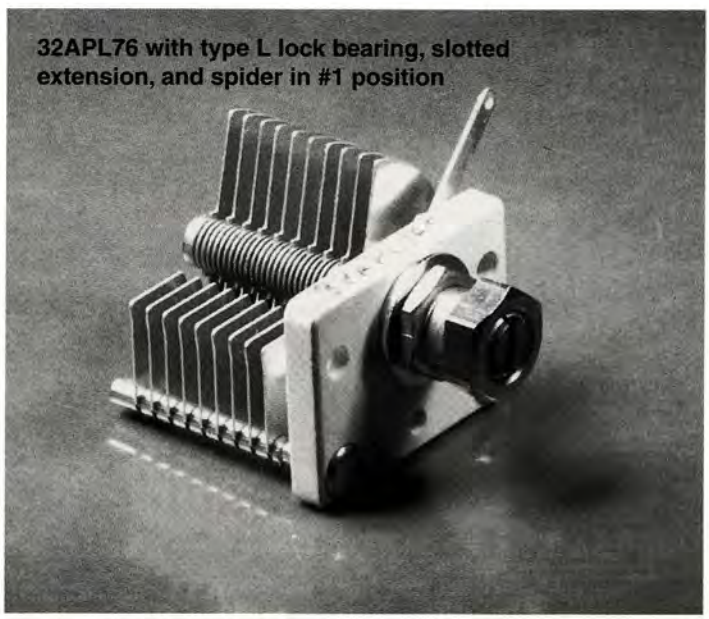
.016" AIR GAP: 640 V max.

PART NUMBER	# of BLADES	- R - DIMENSION	MIN. CAP.	MAX. CAP.
16APL-10	2	1/2	2.6	10.5
16APL-18	3	1/2	2.8	18.6
16APL-26	4	1/2	3.0	26.4
16APL-34	5	1/2	3.2	34.0
16APL-41	6	9/16	3.4	41.6
16APL-49	7	9/16	3.6	49.4
16APL-57	8	5/8	3.8	57.3
16APL-65	9	5/8	4.0	65.2
16APL-73	10	11/16	4.2	73.1
16APL-80	11	11/16	4.3	80.9
16APL-88	12	3/4	4.5	88.8
16APL-96	13	3/4	4.6	96.7
16APL-104	14	13/16	4.9	104.8
16APL-112	15	13/16	5.2	113.0
16APL-120	16	7/8	5.5	121.3
16APL-128	17	7/8	5.8	129.6
16APL-137	18	15/16	5.9	137.7
16APL-145	19	15/16	6.1	145.9
16APL-153	20	1	6.4	154.2
16APL-161	21	1	6.7	162.5
16APL-169	22	1- 1/16	7.0	170.8
16APL-178	23	1- 1/16	7.2	179.0
16APL-186	24	1- 1/8	7.5	187.3
16APL-194	25	1- 1/8	7.7	195.5
16APL-202	26	1- 3/16	8.0	203.8
16APL-211	27	1- 3/16	8.2	212.0
16APL-219	28	1- 1/4	8.4	220.5
16APL-228	29	1- 1/4	8.5	228.9
16APL-236	30	1- 5/16	8.8	237.5
16APL-244	31	1- 5/16	8.9	245.9
16APL-253	32	1- 3/8	9.1	254.4
16APL-261	33	1- 3/8	9.3	262.9
16APL-270	34	1- 7/16	9.5	271.4
16APL-279	35	1- 7/16	9.6	280.0
16APL-287	36	1- 1/2	9.8	288.7
16APL-296	37	1- 1/2	9.9	297.3
16APL-305	38	1- 9/16	10.2	306.1
16APL-313	39	1- 9/16	10.5	313.9
16APL-321	40	1- 5/8	10.8	322.7

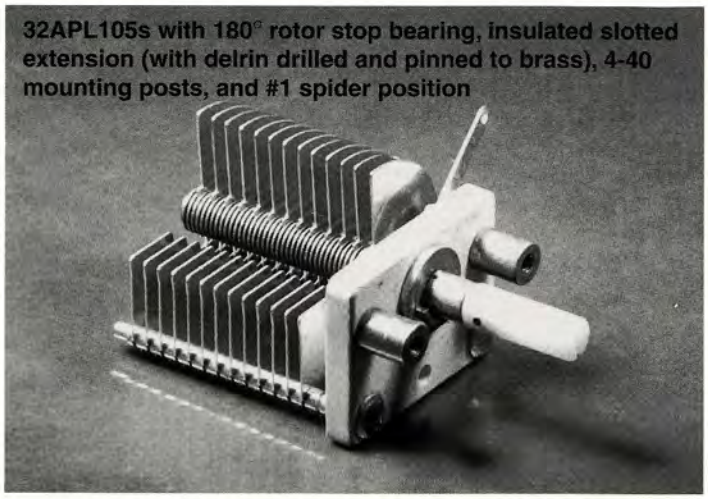
.020" AIR GAP: 800 V max.

PART NUMBER	# of BLADES	- R - DIMENSION	MIN. CAP.	MAX. CAP.
20APL-8	2	1/2	2.4	8.2
20APL-14	3	1/2	2.4	14.0
20APL-20	4	1/2	2.6	20.4
20APL-26	5	1/2	2.8	26.8
20APL-33	6	37/64	3.0	33.2
20APL-39	7	37/64	3.2	39.6
20APL-46	8	21/32	3.5	46.1
20APL-52	9	21/32	3.7	52.5
20APL-58	10	23/32	4.0	59.0
20APL-65	11	23/32	4.2	65.4
20APL-71	12	51/64	4.4	71.8
20APL-77	13	51/64	4.7	78.3
20APL-84	14	55/64	4.9	84.8
20APL-91	15	55/64	5.2	91.5
20APL-98	16	15/16	5.5	98.1
20APL-104	17	15/16	5.7	104.6
20APL-110	18	1	5.9	111.1
20APL-117	19	1	6.1	117.6
20APL-123	20	1- 5/64	6.3	124.1
20APL-130	21	1- 5/64	6.5	130.6
20APL-136	22	1- 5/32	6.8	137.2
20APL-143	23	1- 5/32	7.0	143.7
20APL-149	24	1- 7/32	7.3	150.3
20APL-156	25	1- 7/32	7.6	156.9
20APL-163	26	1- 19/64	7.9	163.5
20APL-169	27	1- 19/64	8.2	170.1
20APL-176	28	1- 3/8	8.4	176.6
20APL-183	29	1- 3/8	8.6	183.2
20APL-189	30	1- 7/16	8.8	189.8
20APL-195	31	1- 7/16	9.0	196.4
20APL-202	32	1- 33/64	9.2	203.0
20APL-209	33	1- 33/64	9.4	209.6
20APL-215	34	1-37/64	9.6	216.2
20APL-222	35	1- 37/64	9.8	222.8
20APL-229	36	1- 21/32	10.2	229.6
20APL-235	37	1- 21/32	10.5	236.3
20APL-242	38	1- 47/64	10.8	243.2





APL ELECTRICAL DATA



32APL105s with 180° rotor stop bearing, insulated slotted extension (with delrin drilled and pinned to brass), 4-40 mounting posts, and #1 spider position

.032" AIR GAP: 1070 V max.

PART NUMBER	# of BLADES	- R - DIMENSION	MIN. CAP.	MAX. CAP.
32APL-6	2	7/16	2.5	6.4
32APL-10	3	7/16	2.5	10.3
32APL-14	4	7/16	2.7	14.5
32APL-18	5	7/16	2.9	18.6
32APL-22	6	5/8	3.1	22.7
32APL-26	7	5/8	3.3	26.8
32APL-30	8	23/32	3.5	30.9
32APL-34	9	23/32	3.8	35.1
32APL-39	10	13/16	4.1	39.3
32APL-43	11	13/16	4.4	43.5
32APL-47	12	29/32	4.7	47.7
32APL-51	13	29/32	5.0	51.8
32APL-55	14	1	5.3	56.0
32APL-60	15	1	5.6	60.2
32APL-64	16	1- 3/32	5.9	64.4
32APL-68	17	1- 3/32	6.2	68.6
32APL-72	18	1- 5/32	6.5	72.8
32APL-76	19	1- 5/32	6.6	76.8
32APL-80	20	1- 1/4	6.9	81.0
32APL-85	21	1- 1/4	7.2	85.2
32APL-89	22	1- 11/32	7.5	89.4
32APL-93	23	1- 11/32	7.8	93.6
32APL-97	24	1- 7/16	8.1	97.8
32APL-101	25	1- 7/16	8.4	102.0
32APL-105	26	1- 9/16	8.7	106.2
32APL-110	27	1- 21/32	9.0	110.7
32APL-115	28	1- 3/4	9.3	114.9
32APL-119	29	1- 3/4	9.6	119.1
32APL-123	30	1- 27/32	9.9	123.3
32APL-128	31	1- 27/32	10.2	127.5
32APL-132	32	1- 15/16	10.5	131.7
32APL-136	33	1- 15/16	10.8	135.9
32APL-140	34	2- 1/32	11.1	140.1
32APL-144	35	2- 1/32	11.4	144.3
32APL-149	36	2- 1/8	11.7	148.6
32APL-153	37	2- 1/8	12.0	152.8
32APL-157	38	2- 7/32	12.3	157.0
32APL-161	39	2- 7/32	12.6	161.2
32APL-165	40	2- 5/16	12.9	165.4
32APL-170	41	2- 5/16	13.2	169.6
32APL-174	42	2- 13/32	13.5	173.8
32APL-178	43	2- 13/32	13.8	178.0
32APL-182	44	2- 1/2	14.1	182.2
32APL-186	45	2- 1/2	14.4	186.4
32APL-191	46	2- 19/32	14.7	190.7
32APL-195	47	2- 19/32	15.0	194.9
32APL-199	48	2- 11/16	15.3	199.1
32APL-203	49	2- 11/16	15.6	203.4
32APL-208	50	2- 25/32	15.9	207.5

.048" AIR GAP: 1500 V max.

PART NUMBER	# of BLADES	- R - DIMENSION	MIN. CAP.	MAX. CAP.
48APL-4	2	9/16	2.3	4.8
48APL-7	3	9/16	2.3	7.4
48APL-10	4	5/8	2.6	10.3
48APL-12	5	5/8	2.9	13.0
48APL-15	6	11/16	3.2	15.9
48APL-18	7	11/16	3.5	18.7
48APL-21	8	13/16	3.8	21.6
48APL-24	9	13/16	4.1	24.4
48APL-27	10	15/16	4.4	27.3
48APL-29	11	15/16	4.7	30.1
48APL-32	12	1- 1/16	4.9	32.9
48APL-35	13	1- 1/16	5.1	35.6
48APL-38	14	1- 3/16	5.4	38.5
48APL-41	15	1- 3/16	5.7	41.3
48APL-44	16	1- 5/16	6.0	44.2
48APL-46	17	1- 5/16	6.3	47.0
48APL-49	18	1- 7/16	6.6	49.9
48APL-52	19	1- 7/16	6.9	52.7
48APL-56	20	1- 9/16	7.1	56.5

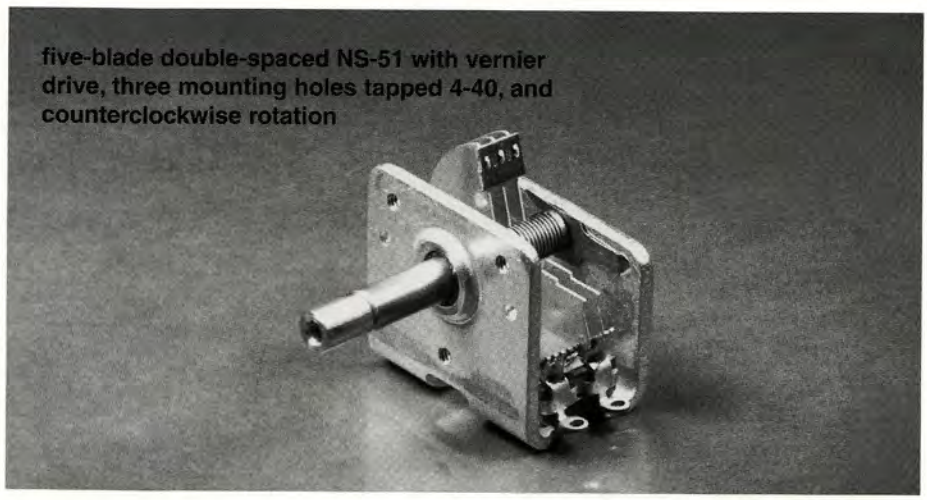
.080" AIR GAP: 2000 V max.

PART NUMBER	# of BLADES	- R - DIMENSION	MIN. CAP.	MAX. CAP.
80APL-4 DE	2	19/32	2.5	4.1
80APL-6 DE	3	19/32	2.5	5.6
80APL-8 DE	4	15/16	3.0	7.7
80APL-10 DE	5	7/8	3.5	9.7
80APL-12 DE	6	31/32	4.0	11.8
80APL-14 DE	7	1- 1/16	4.5	13.8
80APL-16 DE	8	1- 15/32	5.0	15.9
80APL-18 DE	9	1- 1/4	5.5	17.9
80APL-20 DE	10	1- 5/16	6.0	20.0
80APL-22 DE	11	1- 13/32	6.5	22.0
80APL-24 DE	12	1- 1/2	7.0	24.0

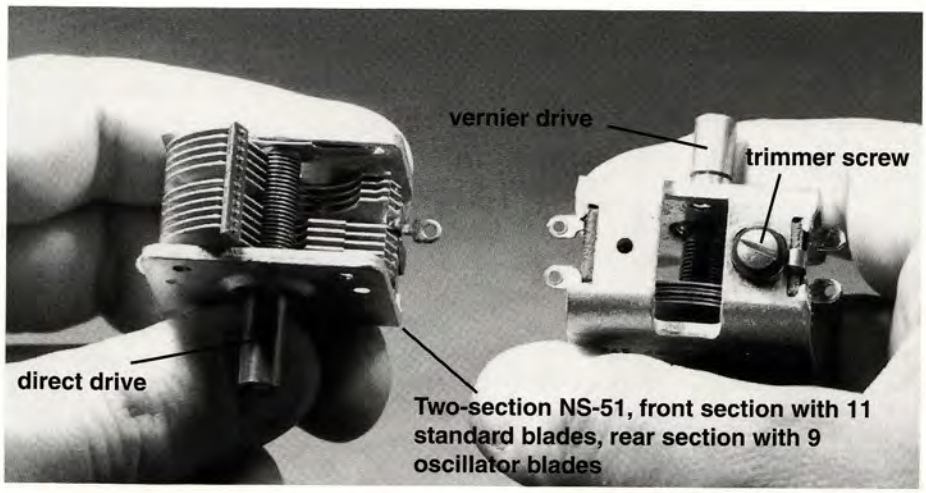
NS-51

The smallest condenser currently in production, the NS-51 is used in low-voltage confined-space applications. The NS-51 uses the same blades as the N-50, and the electrical data on the NS-51 can be found on pages 12 and 13. Mounting can be achieved through tapped holes in the bottom, front, or rear of the frame, or through the use of mounting studs.

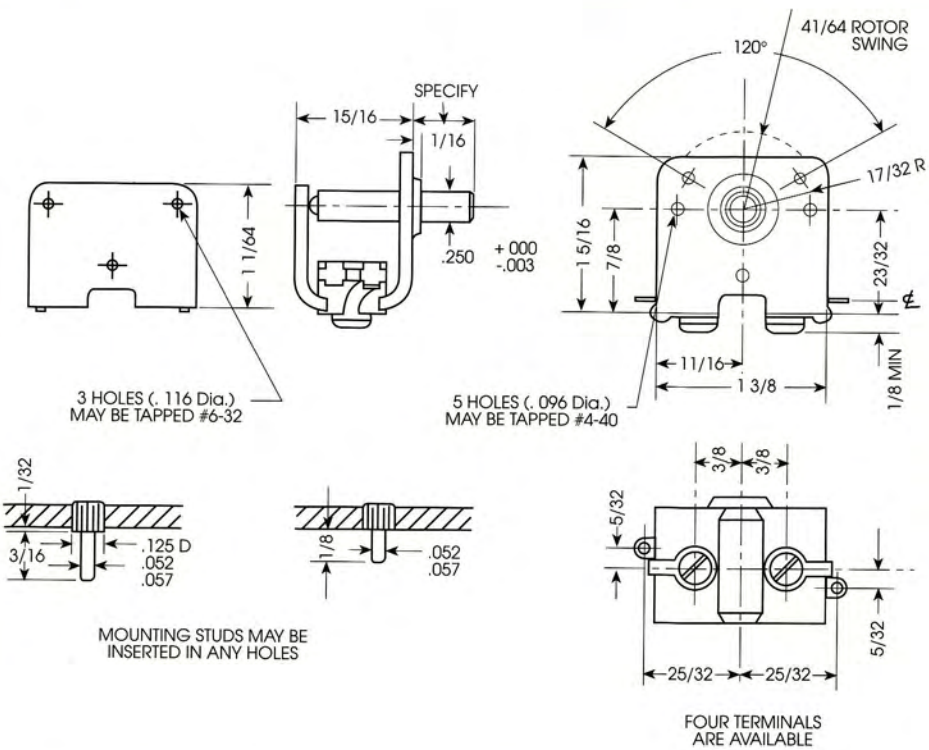
Another option available on condensers is the trimmer. A trimmer is a tiny mica-dielectric compression capacitor built into the air-variable and connected in parallel with it. It can be adjusted with a screw, and can be used to fine-tune the condenser. For example, if your application calls for a tuning capacitor with a maximum capacitance of exactly 109.5 pF, you could use a 9-blade NS-51 with a trimmer. Each 9-blade NS-51 has a minimum capacitance of 6.0 pF and a maximum capacitance of approximately 104.5 pF, but each capacitor will vary by a couple of pF. With a trimmer, the maximum capacitance can be increased by as little as 2 pF or as much as 15 pF, depending upon your adjustment of the trimmer screw.



five-blade double-spaced NS-51 with vernier drive, three mounting holes tapped 4-40, and counterclockwise rotation

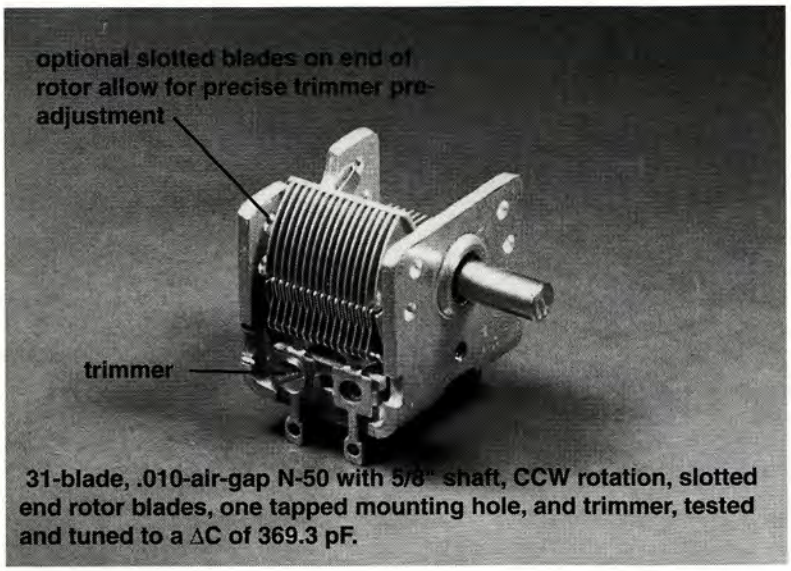


Two-section NS-51, front section with 11 standard blades, rear section with 9 oscillator blades



Another option is the vernier reduction drive. Available in all condensers, the vernier drive is a remarkably well designed mechanism that allows for more precise, controlled rotation of the rotor. The NS-51 and the N-50 vernier drive provides a rotation ratio of approximately 8:1; that is, a 360° rotation of the shaft extension results in only 45° of movement in the rotor. Using a system of rolling balls rather than gears, the vernier (a.k.a. planetary) drive creates little friction, suffers almost no wear or slippage, and takes up no more space than a conventional direct drive.

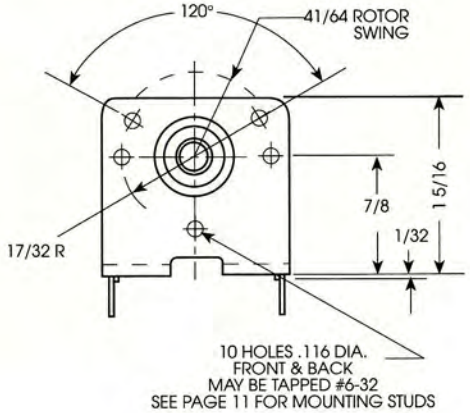
N-50

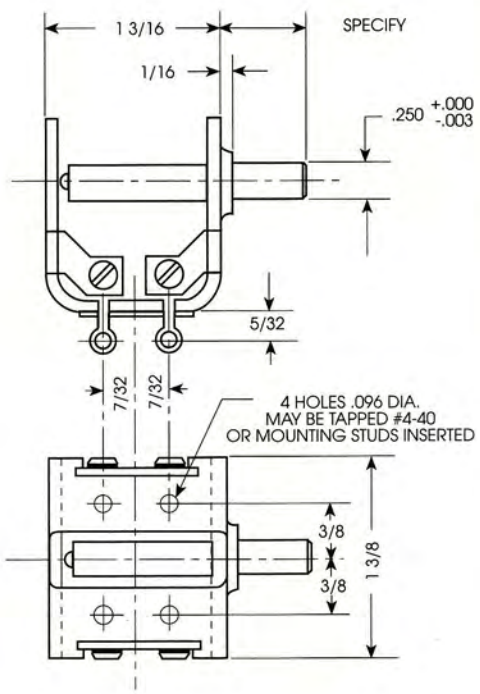


31-blade, .010-air-gap N-50 with 5/8" shaft, CCW rotation, slotted end rotor blades, one tapped mounting hole, and trimmer, tested and tuned to a ΔC of 369.3 pF.

The N-50 is a compact, rugged, economical unit used in a myriad of low-voltage applications, and is our most popular condenser configuration. Although it is slightly larger than the NS-51, the N-50's almost cubical shape makes more efficient use of the space that it occupies, and it delivers a remarkable amount of capacitance for its volume.

Like the NS-51, options on the N-50 include shaft length, mounting studs, tapped mounting holes, an 8:1 vernier reduction drive, and trimmers. On the N-50, however, the trimmer screw is located on the side rather than the bottom.





Max. and min. capacitances, NS-51 and N-50, standard blades, .010" air gap (350 V max.)

NUMBER OF BLADES	MIN. CAP.	MAX. CAP.
5	5.0	54.2
7	5.5	79.4
9	6.0	104.5
11	6.8	129.9
13	7.5	155.2
15	7.9	180.3
17	8.2	205.2
29	8.8	230.4
21	9.5	255.7
23*	10.3	281.1
25	11.1	306.5
27	12.0	332.0
29	13.9	358.6
31	14.9	384.2
33	15.9	409.9

Max. and min. capacitances, NS-51 and N-50, oscillator blades, .010" air gap (500 V max.)

NUMBER OF BLADES	MIN. CAP.	MAX. CAP.
5	4.7	43.5
7	5.2	63.9
9	5.7	83.9
11	6.5	104.3
13	7.2	124.6
15	7.6	144.5
17	7.9	164.7
19	8.5	185.0
21	9.2	205.3
23*	10.0	225.7
25	10.8	246.1
27	11.7	266.5
29	13.6	287.9
31	14.6	308.4
33	15.6	329.1

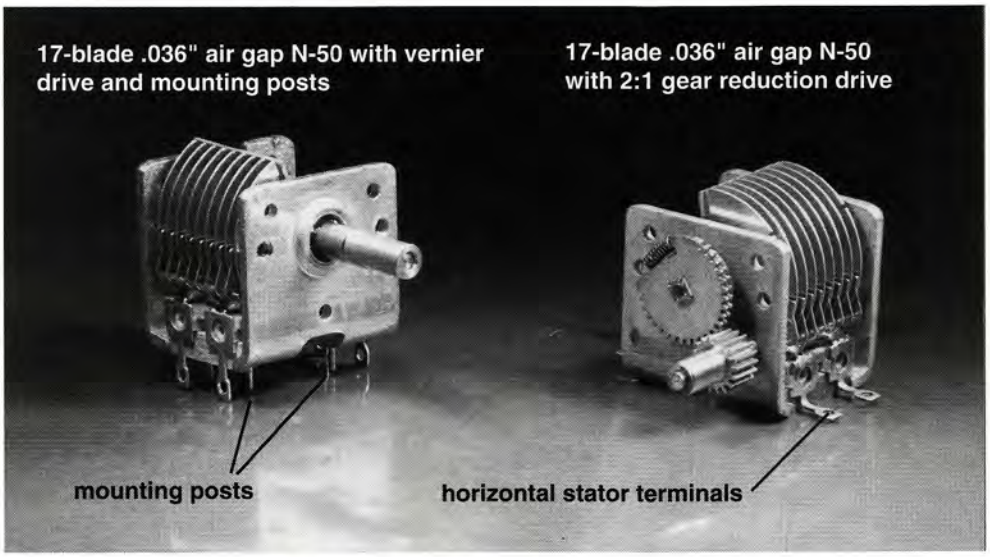
Max. and min. capacitances, NS-51 and N-50, standard blades, .036" air gap (1200 V max.)

NUMBER OF BLADES	MIN. CAP.	MAX. CAP.
3	4.9	11.2
5	5.4	19.1
7	6.2	27.0
9	7.1	35.0
11*	7.9	42.9
13	9.0	50.8
15	10.1	58.8
17	11.5	66.8

Max. and min. capacitances, NS-51 and N-50, oscillator blades, .036" air gap (1200 V max.)

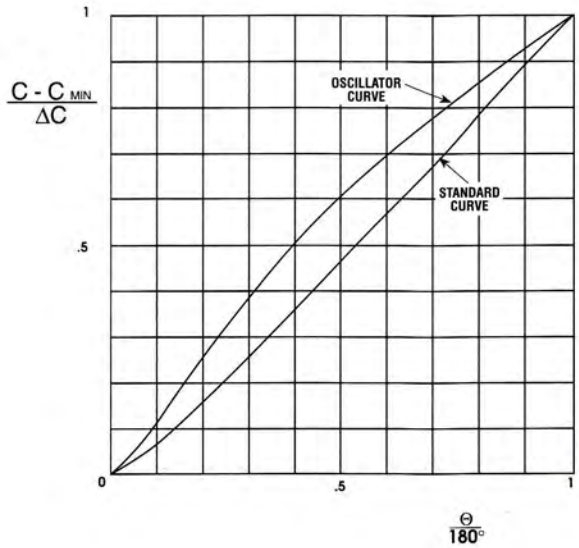
NUMBER OF BLADES	MIN. CAP.	MAX. CAP.
3	4.6	9.0
5	5.1	15.3
7	5.9	21.7
9	6.8	28.1
11*	7.6	34.4
13	8.7	40.8
15	9.8	47.2
17	11.2	53.6

* Maximum possible on NS-51



Unlike air trimmers, the relationship between the capacitance of a condenser and the angular position of its rotor is not simply a linear function. The nature of this function is determined by the shape of the stator blade, and there are two types available: Standard and oscillator. In general, oscillator sections will produce an approximately straight line on a graph of frequency as a function of rotation, while standard blades approximate a straight line on the graph of capacitance as a function of rotation. Oscillator blades have slightly less overall surface area than standard blades, and cannot achieve as much capacitance; respective minimum and maximum capacitances for the two available air gaps are given on the preceding page.

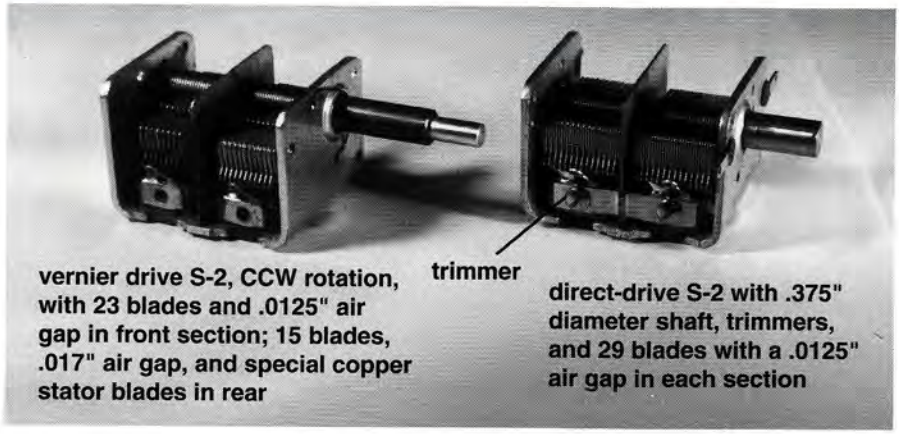
At right, the relationships between rotation and capacitance are given explicitly. Below, these relationships are depicted graphically: Along the horizontal axis is graphed the ratio of the angle Θ of the rotor to 180° (maximum rotation); along the vertical axis is graphed the quantity $\frac{C - C_{min}}{\Delta C}$, where C is the capacitance at angle Θ, C_{min} the minimum capacitance, and $\Delta C = C_{max} - C_{min}$ (and so C_{min} and ΔC are constants for any given capacitor).



Capacitances as a function of rotation: N-50 and NS-51, standard blades	
Cmin = min cap Cmax = max cap ΔC = Cmax - Cmin	
% ROTATION	CAPACITANCE
0	Cmin
10	(.0586) ΔC + Cmin
20	(.1520) ΔC + Cmin
25	(.2035) ΔC + Cmin
30	(.2559) ΔC + Cmin
40	(.3632) ΔC + Cmin
50	(.4699) ΔC + Cmin
60	(.5767) ΔC + Cmin
70	(.6840) ΔC + Cmin
75	(.7392) ΔC + Cmin
80	(.7956) ΔC + Cmin
90	(.9049) ΔC + Cmin
100	Cmax

Capacitances as a function of rotation: N-50 and NS-51, oscillator blades	
Cmin = min cap Cmax = max cap ΔC = Cmax - Cmin	
% ROTATION	CAPACITANCE
0	Cmin
10	(.1047) ΔC + Cmin
20	(.2454) ΔC + Cmin
25	(.3148) ΔC + Cmin
30	(.3770) ΔC + Cmin
40	(.4985) ΔC + Cmin
50	(.6011) ΔC + Cmin
60	(.6965) ΔC + Cmin
70	(.7825) ΔC + Cmin
75	(.8244) ΔC + Cmin
80	(.8653) ΔC + Cmin
90	(.9400) ΔC + Cmin
100	Cmax

S-2



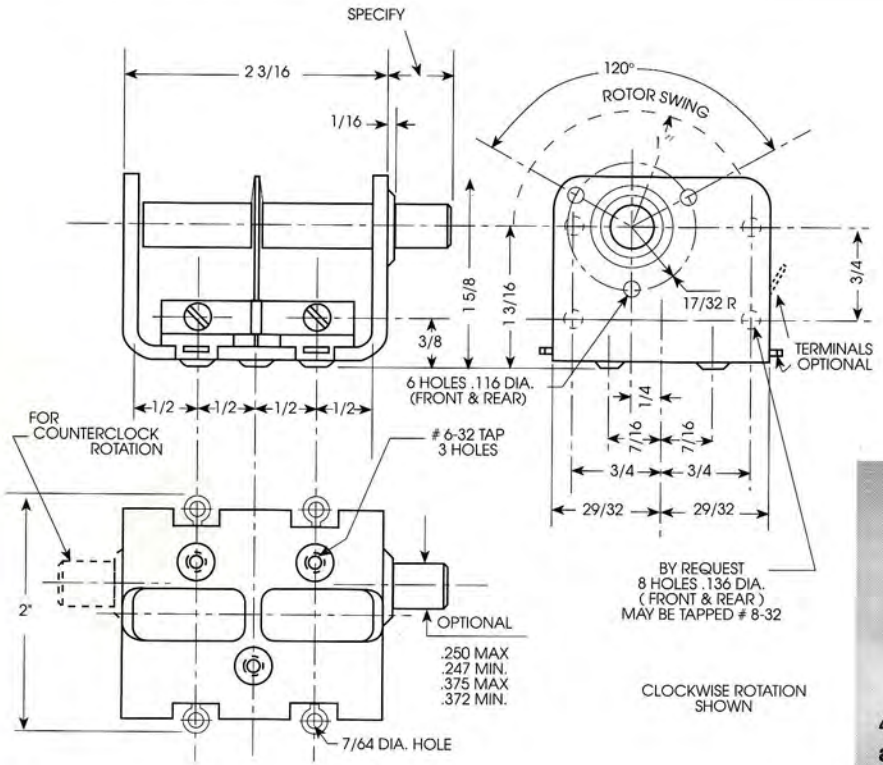
vernier drive S-2, CCW rotation, with 23 blades and .0125" air gap in front section; 15 blades, .017" air gap, and special copper stator blades in rear

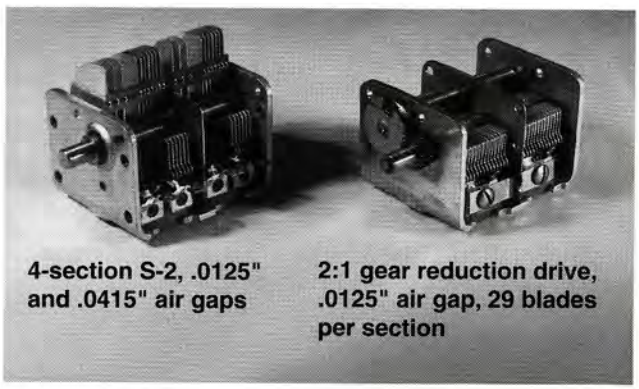
direct-drive S-2 with .375" diameter shaft, trimmers, and 29 blades with a .0125" air gap in each section

The S-2 and S-3 were once produced in large numbers for early AM/FM radios. It was this application that the S series curve (see graph, next page) was designed toward; however, the S-series is currently used in a variety of other applications, most of them involved in ham radio gear and test equipment.

Options for the S-series include a 6:1 vernier reduction drive, a 2:1 gear reduction drive, threaded mounting posts, and a double-ended configuration (see bottom photo). Trimmers are also available, which add up to 18 pF per section.

The maximum and minimum capacitances given in the table below are for just one section; thus, if the two sections are tied together, an S-2 can function as a large (up to 930 pF) single-section condenser. Each section can also be divided into two insulated sections, creating a 4-section capacitor. There are two curves available (standard and oscillator), and three standard air gaps: .0125" (600 V maximum), .017" (800 V maximum), and .0415" (1300 V maximum).



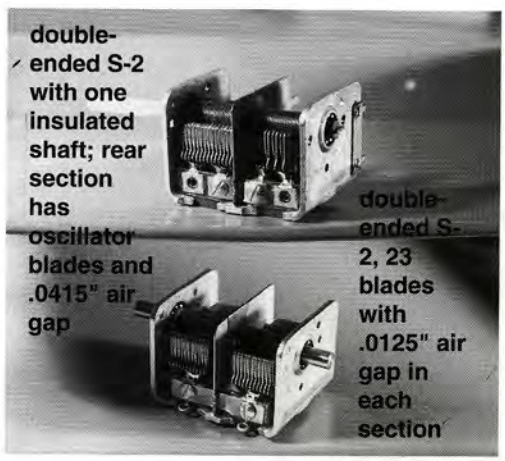


4-section S-2, .0125" and .0415" air gaps

2:1 gear reduction drive, .0125" air gap, 29 blades per section

MAXIMUM AND MINIMUM CAPACITANCES, S-2 & S-3 (in pF)

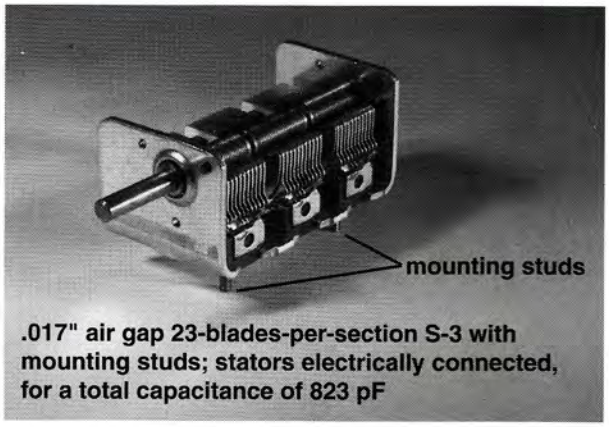
Number of blades	STANDARD BLADES						OSCILLATOR BLADES					
	.0125 air gap		.017 air gap		.0415 air gap		.0125 air gap		.017 air gap		.0415 air gap	
	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.
3	4.9	38.2	4.9	30.3	4.6	14.2	5.5	22.7	6.3	18.0	5.4	11.0
5	6.1	70.7	5.0	54.6	4.8	24.0	6.0	42.0	6.5	32.1	5.6	16.4
7	6.6	103.5	5.2	79.2	5.0	33.8	6.5	60.5	7.0	46.3	5.8	21.9
9	7.1	136.3	5.3	103.4	5.6	46.1	7.0	79.0	7.7	60.1	6.0	27.6
11	7.3	168.8	5.5	126.8	6.6	58.5	7.2	97.2	8.0	73.5	7.0	33.9
13	7.5	201.3	5.7	150.9	7.9	69.7	7.4	115.4	8.7	87.2	8.4	40.0
15	7.8	234.0	6.1	174.5	9.4	80.9	7.7	133.7	9.0	100.6	10.2	46.5
17	8.2	266.7	6.2	199.2	10.4	92.6	8.1	152.1	9.8	114.5	11.4	52.9
19	8.7	299.5	6.7	223.0	—	—	8.6	170.6	10.0	127.8	—	—
21	9.3	332.4	7.5	248.0	—	—	9.2	189.2	10.8	141.7	—	—
23	10.3	365.7	8.4	274.3	—	—	10.2	208.2	11.6	155.6	—	—
25	11.5	399.2	9.5	297.5	—	—	11.4	227.4	12.4	169.4	—	—
27	12.5	432.5	—	—	—	—	12.4	246.4	—	—	—	—
29	13.5	465.8	—	—	—	—	13.4	265.4	—	—	—	—



double-ended S-2 with one insulated shaft; rear section has oscillator blades and .0415" air gap

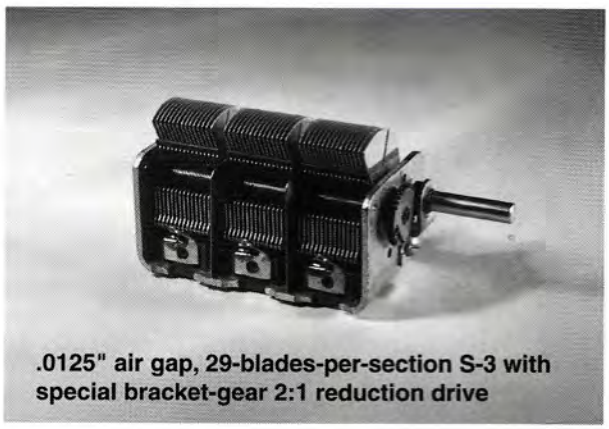
double-ended S-2, 23 blades with .0125" air gap in each section

S-3

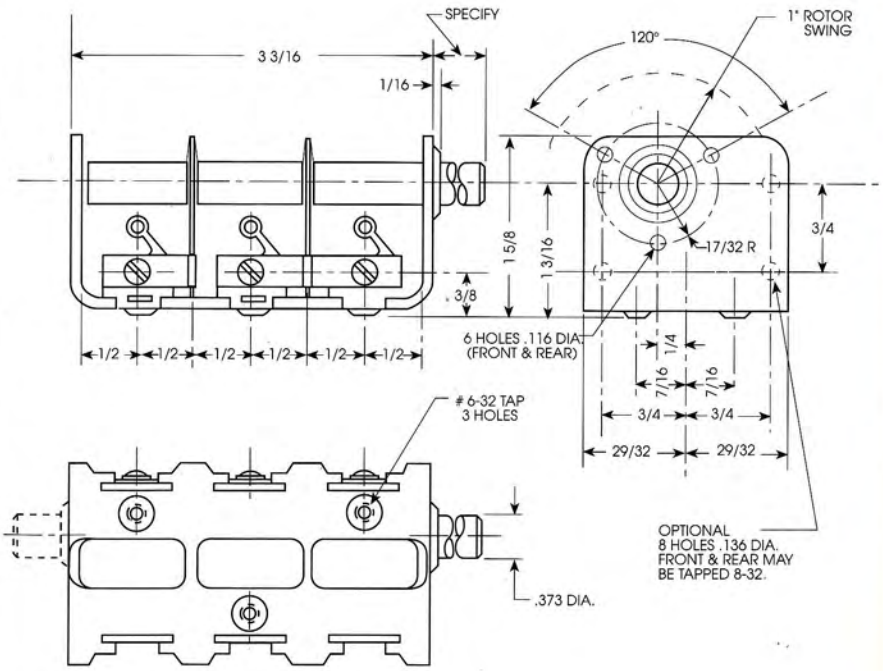


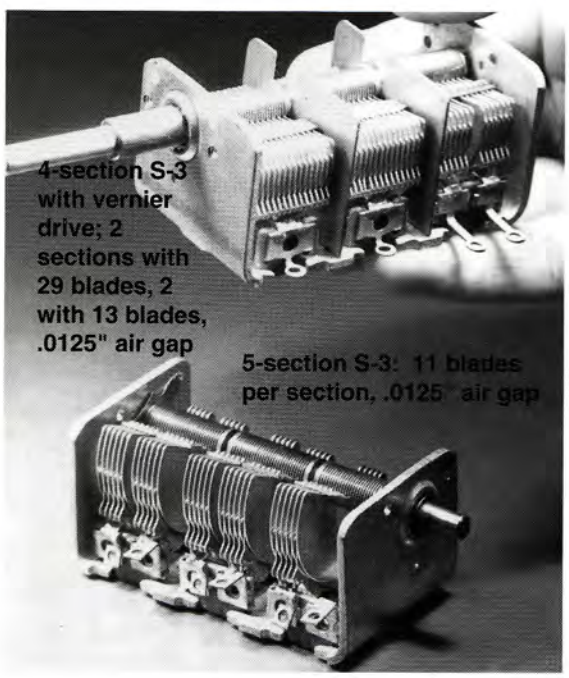
.017" air gap 23-blades-per-section S-3 with mounting studs; stators electrically connected, for a total capacitance of 823 pF

The S-3 is the largest condenser currently in production, and can deliver a total capacitance of almost 1400 pF, comparable to the much larger M-73 (pages 16 & 17). As in the S-2, each section can be divided, creating a 6-section capacitor.

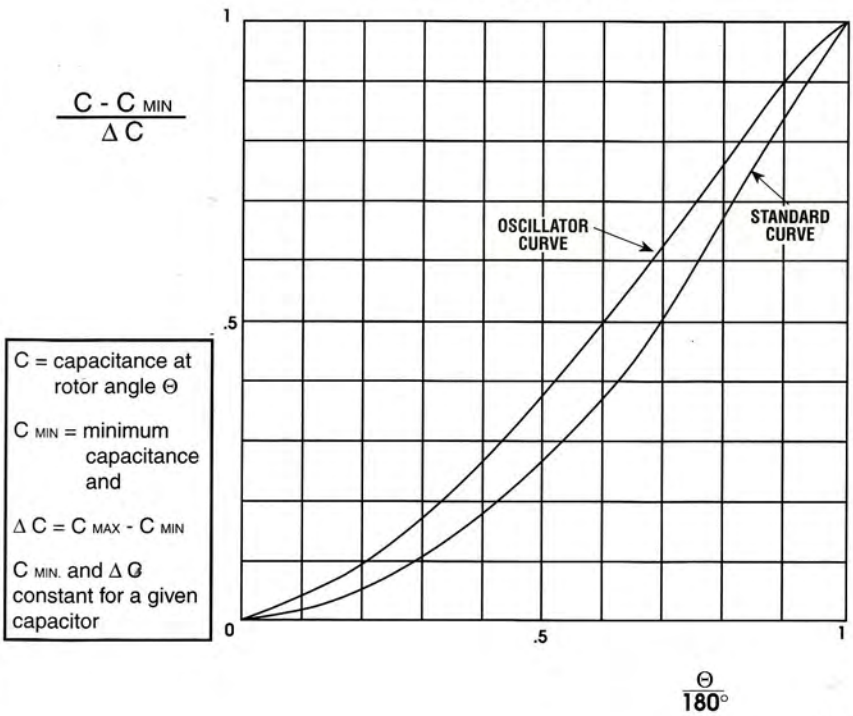


.0125" air gap, 29-blades-per-section S-3 with special bracket-gear 2:1 reduction drive





Capacitance as a function of rotation, S-2 and S-3



C = capacitance at rotor angle Θ

C_{MIN} = minimum capacitance and

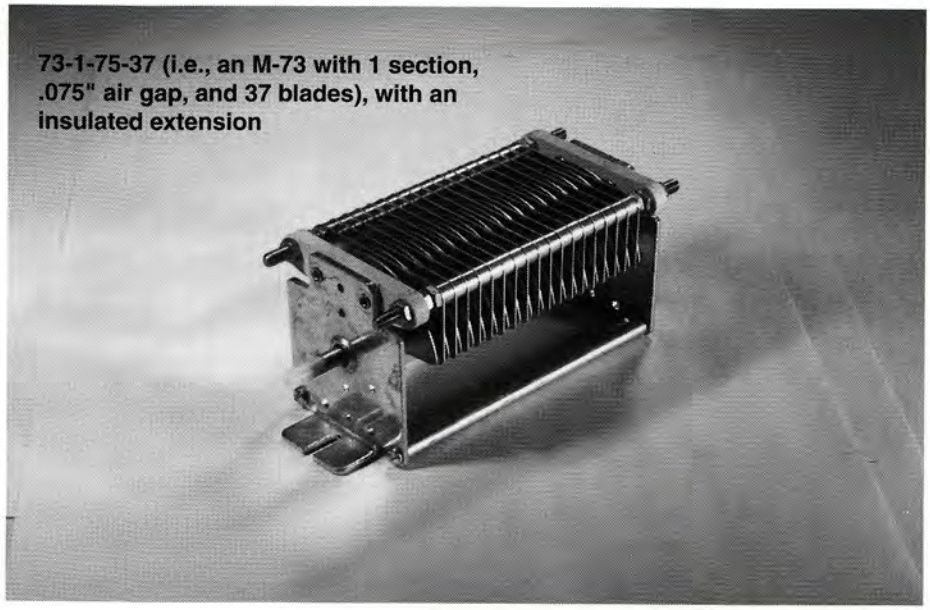
$\Delta C = C_{MAX} - C_{MIN}$

$C_{MIN.}$ and ΔC constant for a given capacitor

M-73

The M-73 is a high-voltage, heavy-wattage, continuous duty capacitor. Insulation between the rotor and stator is achieved through 1/4" thick, high quality, military spec ceramics riveted to the plated steel end plates. These end plates are tied together by solid aluminum and brass bars, forming a rigid structure. The rotor rides on ball bearings housed between the front end plate and the stainless steel shaft, and the blades are heavy .032" thick aluminum.

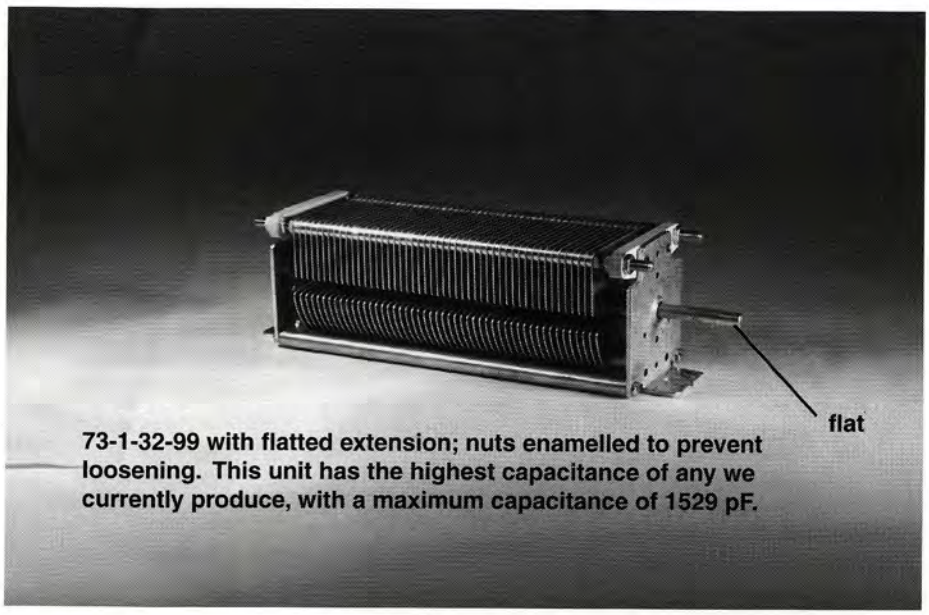
In the M-73, the relationship between rotation and capacitance is almost perfectly linear. M-73's have performed well in several challenging applications, including short wave radio, controlled-plasma manufacturing, and magnetic resonance imagery.



73-1-75-37 (i.e., an M-73 with 1 section, .075" air gap, and 37 blades), with an insulated extension

Several options are available, including nine standard air gaps (see chart below). The shaft extension's length can vary, and it can be insulated, slotted, or flatted; also, mounting holes on the frame can be tapped 6-32. There are two types of high-amperage rotor contacts available, which are often required in M-73's used in controlled-plasma etching and deposition devices used in silicon chip manufacturing.

There are several different double-stator configurations available. In some, the two sections are adjacent to one another, and their capacitances increase together. In others, the two banks of stator blades lie opposite each other, and capacitance in one section increases as capacitance in the other decreases.



73-1-32-99 with flatted extension; nuts enamelled to prevent loosening. This unit has the highest capacitance of any we currently produce, with a maximum capacitance of 1529 pF.

air gap	max. voltage	min. capacitance	max. capacitance	mounting distance, L
.030	950	.537z + 5.0	37.36z - 8.1	.113z + 1.5
.032	1100	.616z + 5.4	30.735z - 7.8	.125z + 1.5
.037*	1325	.564z + 5.8	25.88z - 5.4	.112z + 1.5
.045	1550	.637z + 7.3	22.015z - 1.7	.152z + 1.4
.075	2500	.854z + 6.2	13.80z - 1.6	.211z + 1.3
.080	2700	.888z + 6.0	12.92z - 2.2	.222z + 1.3
.100	3100	.977z + 5.7	10.77z - 6.3	.264z + 1.2
.120	3500	1.096z + 4.5	9.455z - 6.8	.302z + 1.1
.140	3700	1.262z + 3.7	8.41z - 7.1	.342z + 1.1

* .037 spacing uses thin blades

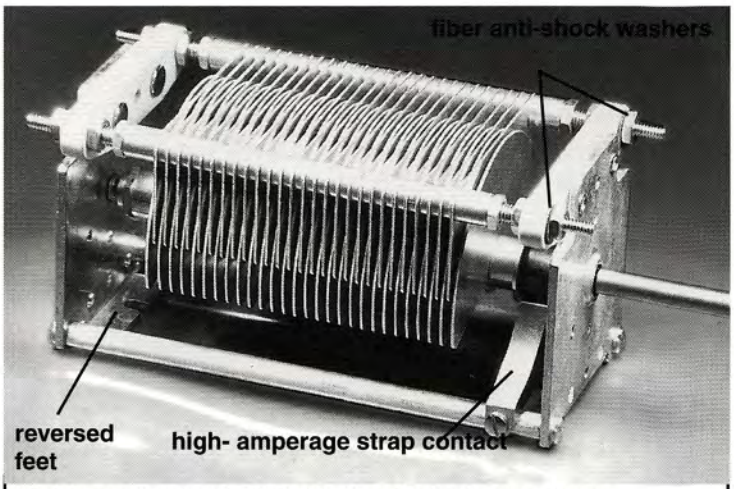
In the chart at left, minimum and maximum capacitances and mounting distance are given as a function of z, the number of rotor blades, where there are (z - 1) stator blades and thus (2z - 1) blades total.

Suppose, for example, that you need a ΔC of approximately 200 pF and your maximum voltage is 2000 V. Set 200 pF equal to ΔC for a .075" air-gap M-73:

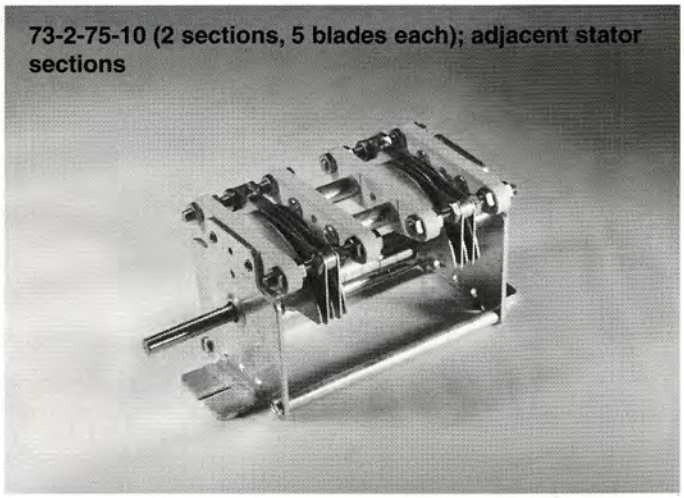
$$200 = \Delta C = C_{max} - C_{min} = (13.80z - 1.6) - (.854z + 6.2)$$
$$200 = 12.946z - 7.8$$
$$z = 16.05$$

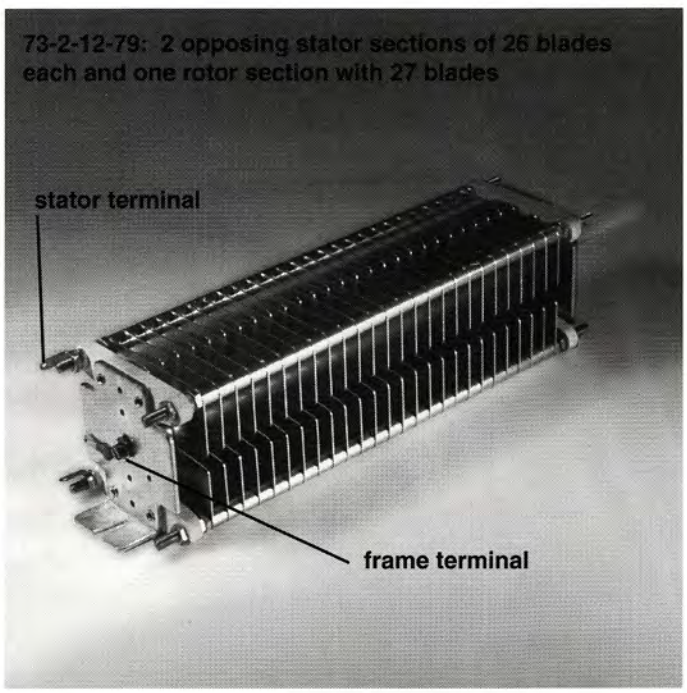
Let z = 16; so L = 4.68. Thus, if you have enough room, a single-section, .075"-air-gap, 31-blade M-73 (i.e., part # 73-1-75-31) should suffice.

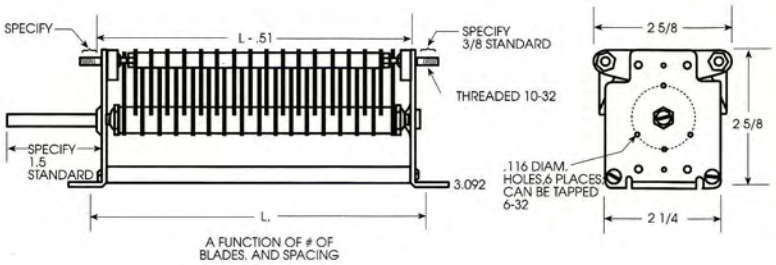
M-73

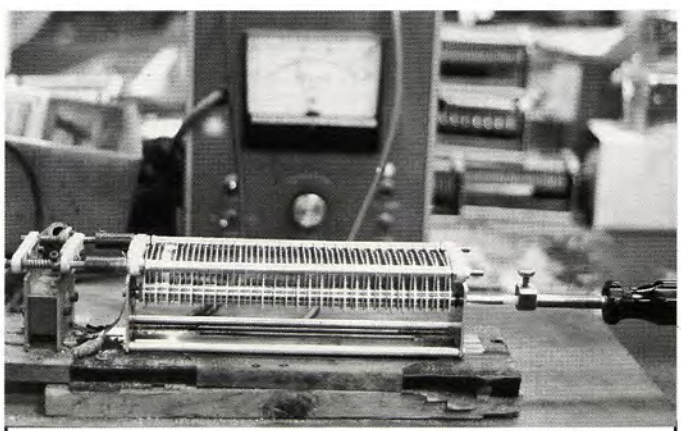


Highly customized 73-1-30-55 with high-amperage contact, slotted extension, stator bar ends turned down to 6-32, anti-shock washers,and reversed mounting feet









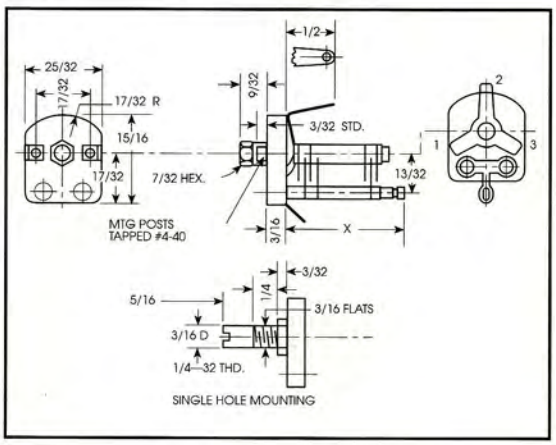
Before shipment, every M-73 undergoes maximum voltage testing.

OBSOLETE/EXOTIC CAPACITORS

Considering the fact that dozens of configurations of air variables have been manufactured here since World War II, it is not surprising that a few of those configurations have lost their popularity. Some configurations have been replaced by others: For example, customers who once purchased MAPC's now use APC's and APL's.

In other cases, the application for which a given configuration was designed has become obsolete. For example, the "miniature" AM-FM radio designs of the 1950's and 1960's are no longer in demand, and so the M-60 is no longer currently needed. We still have the tooling required to manufacture these capacitors, however, should a new application come along.

Unlike the other configurations shown on these two pages, the M-90 has not been rendered obsolete. It is a relatively new configuration which has not yet been run in large production quantities. With its standard .420" air gap, the M-90 can withstand 9500 V. It is designed for very specialized high-voltage applications in radio transmission and plasma control. It can also be used as an economical (albeit bulky) alternative to the shockingly expensive vacuum variable.



MAPC

Air gap: .013

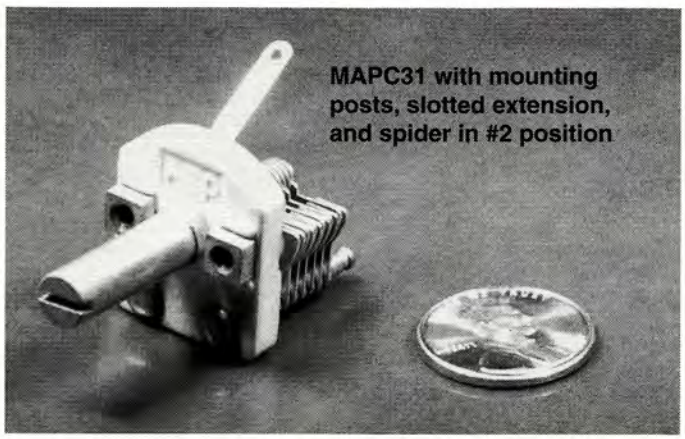
Max. voltage: 500

pF/air gap: 2.73 (approx.)

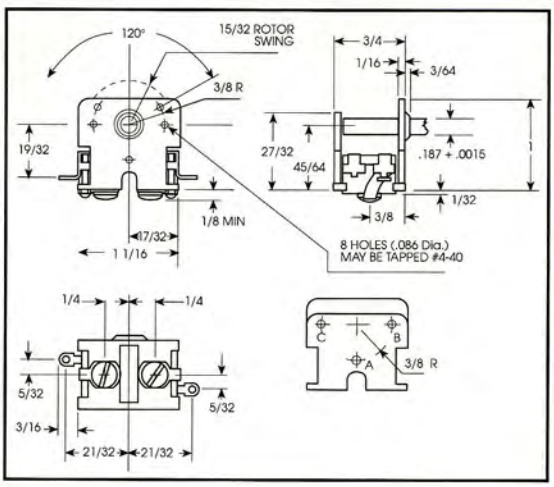
Max. # of blades: 38

Curve: linear

Options: similar to APC



MAPC31 with mounting posts, slotted extension, and spider in #2 position



M-60

Air gap: .0067

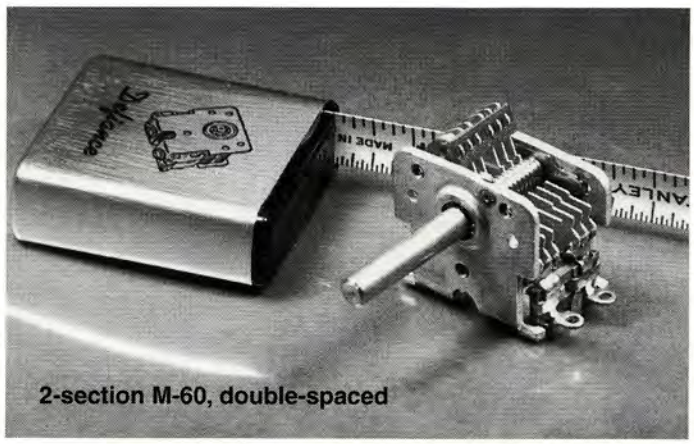
Max. voltage: 250

pF/air gap: 10.7

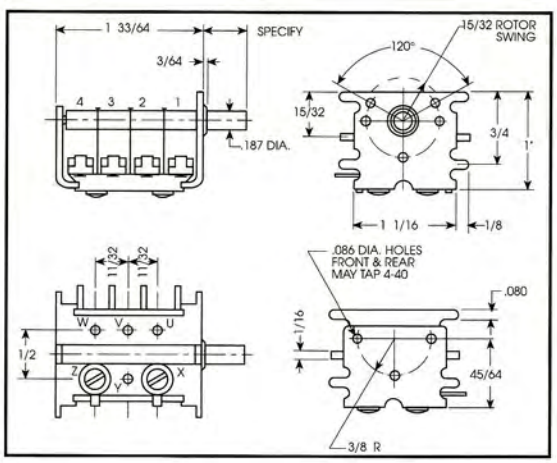
Max. # of blades: 13

Curve: non-linear, similar to N-50

Options: similar to N-50



2-section M-60, double-spaced



M-603

Air gap: .026

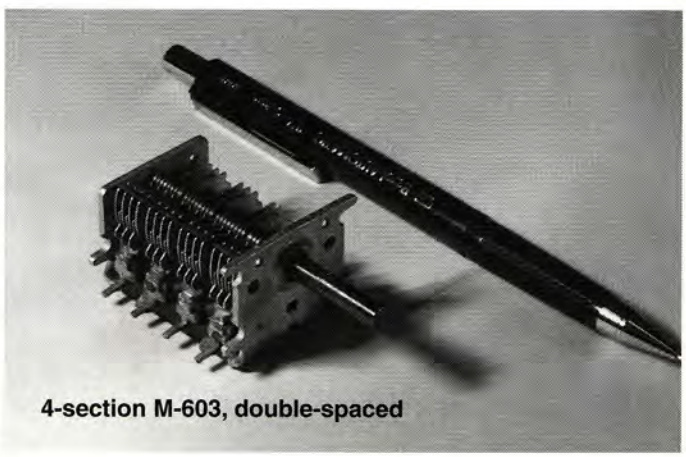
Max. voltage: 750

pF/air gap: 3.4

Max. # of blades: 7/sect; 4 sect.

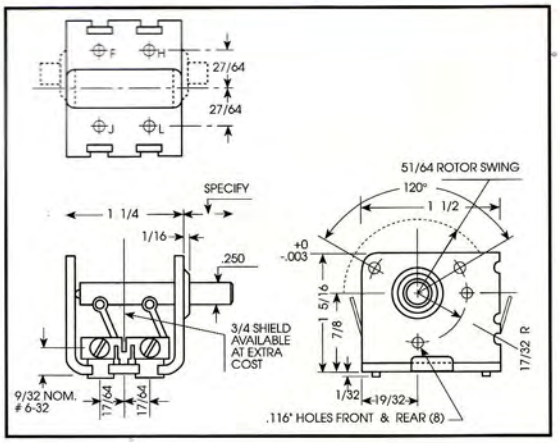
Curve: same as M-60

Options: same as M-60



4-section M-603, double-spaced

OBSOLETE/EXOTIC CAPACITORS



M-642

Air gaps: .010, .014

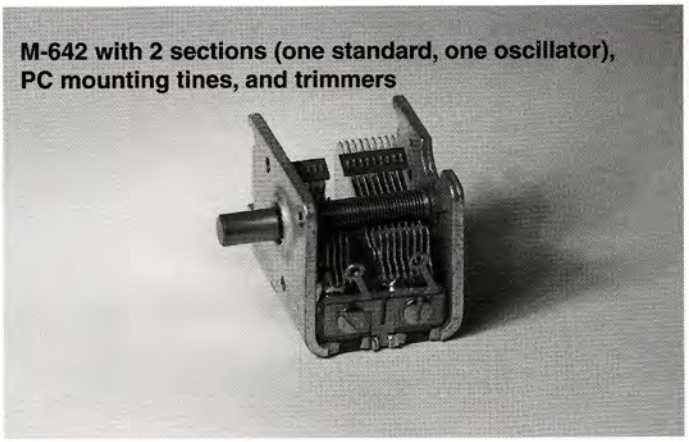
Max. voltage: 350, 500

pF/air gap: 12.9, 6.0

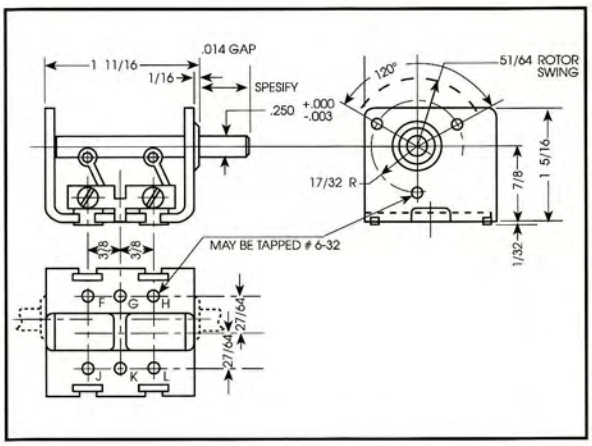
Max. # of blades: 21, 17

Curve: similar to S-curve

Options: PC - mounting tines



M-642 with 2 sections (one standard, one oscillator), PC mounting tines, and trimmers



R-42

Air gaps: .010, .014

Max. voltage: 350, 500

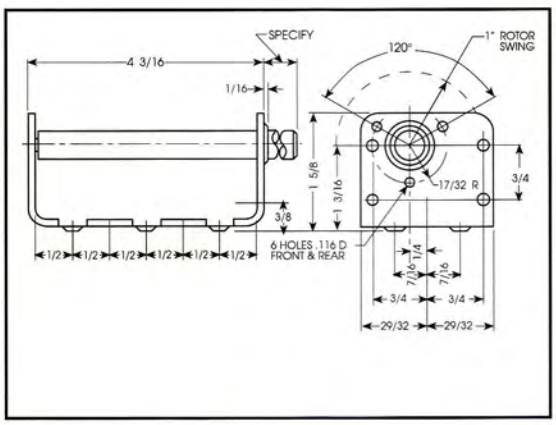
pF/air gap: 13.6, 6.4

Max. # of blades: 29/ sect., 21/sect.

Curve: similar to S

Options: length and # of sections

3-section R-42 with special stator terminals and 2" shaft



S-4

Air gaps: same as S-2, S-3

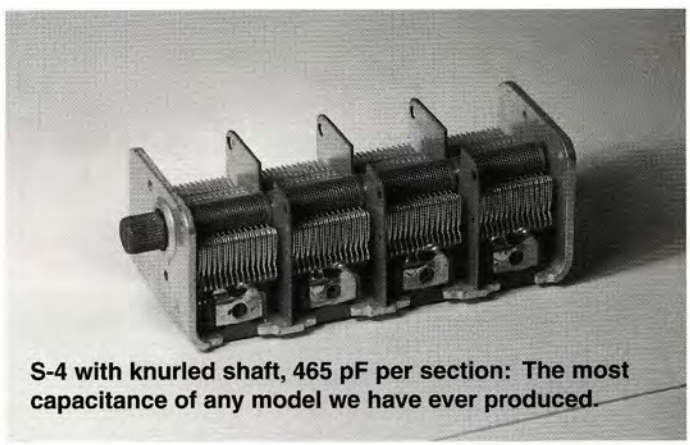
Max. voltage: same as S-2, S-3

pF/air gap: same as S-2, S-3

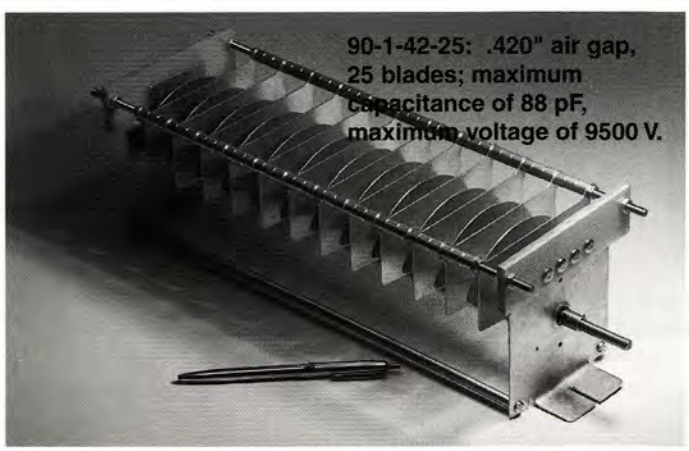
Max. # of blades: same as S-2, S-3

Curve: same as S-2, S-3

Options: same as S-2, S-3



S-4 with knurled shaft, 465 pF per section: The most capacitance of any model we have ever produced.



90-1-42-25: .420" air gap, 25 blades; maximum capacitance of 88 pF, maximum voltage of 9500 V.

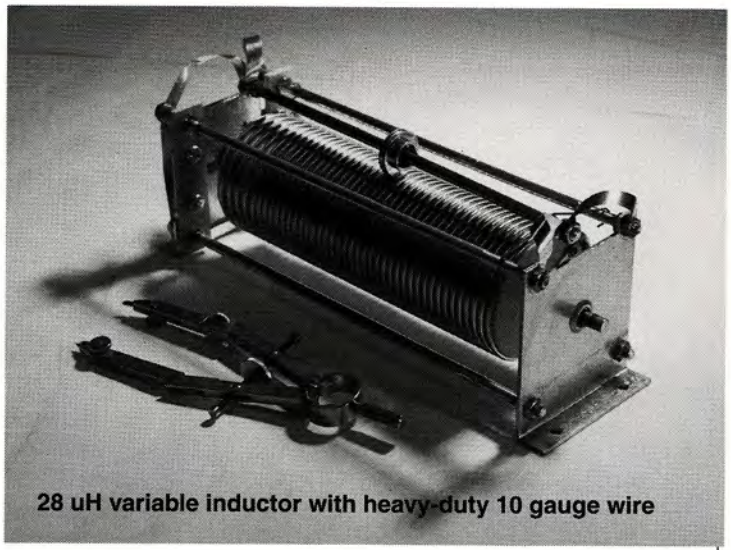
Standing 4¼" high by 4¼" wide, and with typical lengths of over one foot, the M-90 is, by far, our largest assembly product.

With the standard .420" air gap, the M-90 is guaranteed at 9500 V. Other air gaps can be achieved, ranging from .075" to .625", with maximum capacitances from 2500 V to 11,000 V.

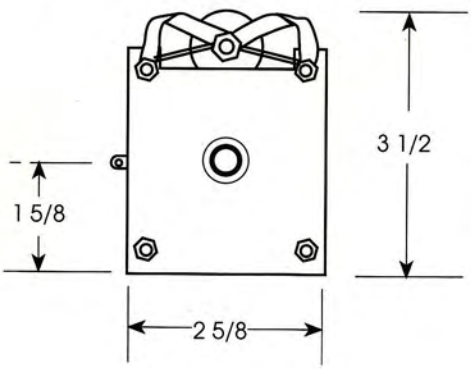
VARIABLE INDUCTORS

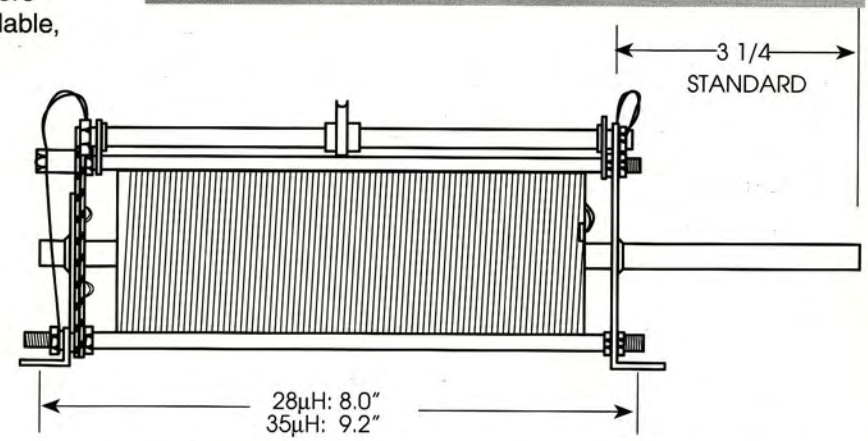
The OEP roller inductor offers truly continuous variation in inductance throughout its range: Literally any inductance between 0 and 35 µH can be achieved, with a practical working resolution of .01 µH. This is much finer control than any slug coil, and is infinitely finer than a toroidal coil with a finite number of leads.

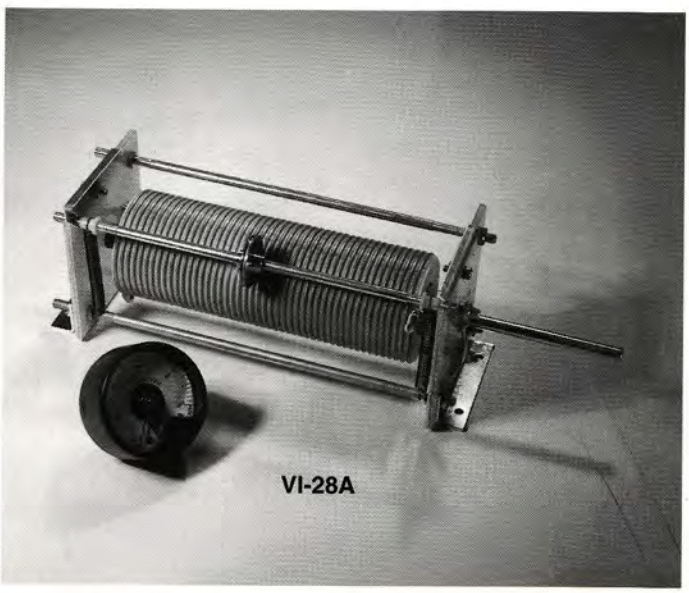
Used for decades in the best high-power short wave antenna tuners, the OEP roller inductor has undergone several modifications over the years. The plated copper busbar wire (10 or 12 gauge) rests in a precision-machined helical groove cut into a solid cylinder of teflon-delrin polymer. This core rides on 12 carbon steel balls nested in plated steel frames; the insulators on the rear frame are composed of virtually indestructible glass-based phenolic. There are two standard sizes of variable inductors available, with ranges of O - 28 µH and O - 35 µH.



28 uH variable inductor with heavy-duty 10 gauge wire





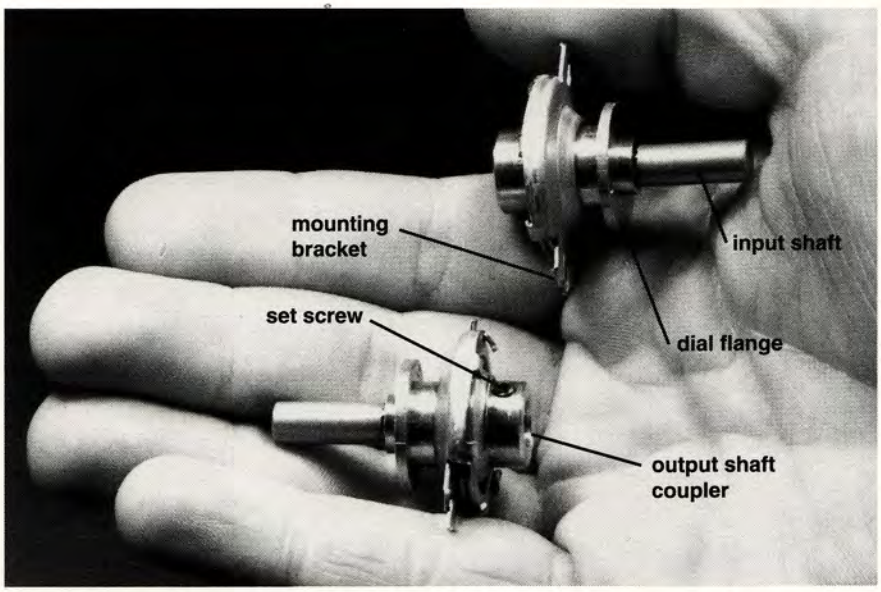


VI-28A

35 uH variable inductor

The latest version of the variable inductor, part # VI-28A, features a corner-mounted wheel, coiled extension springs, and a positive wheel stop, preventing the wheel from ever leaving the coil. At the time of this writing, this model has not yet reached full production.

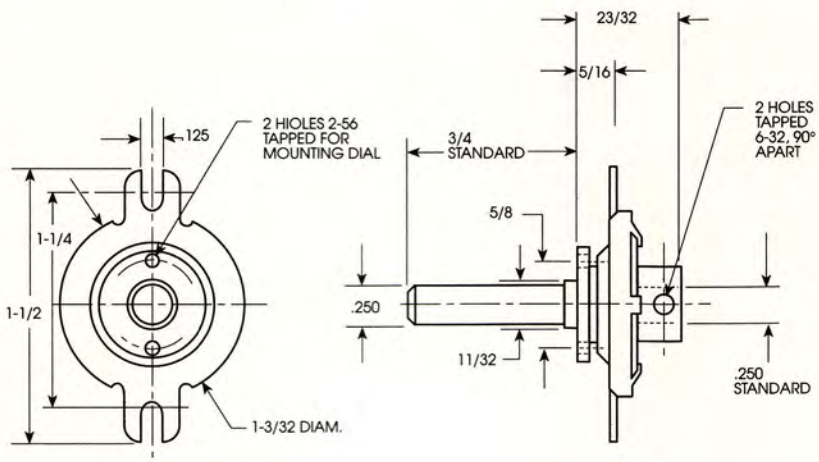
VERNIER REDUCTION DRIVES

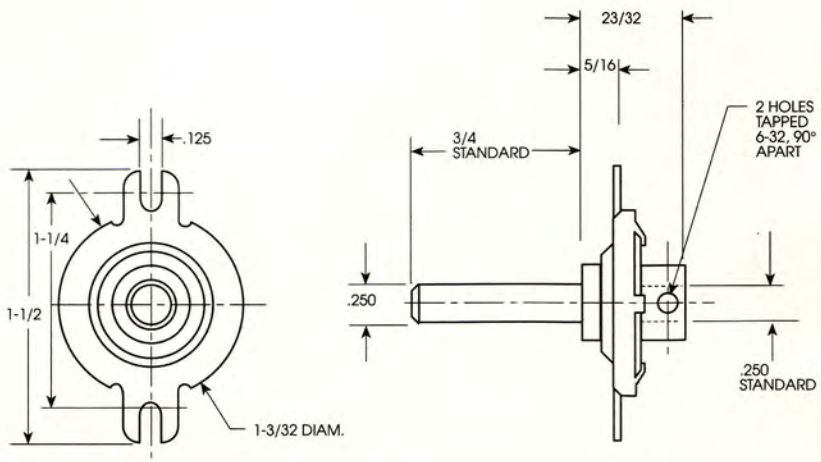


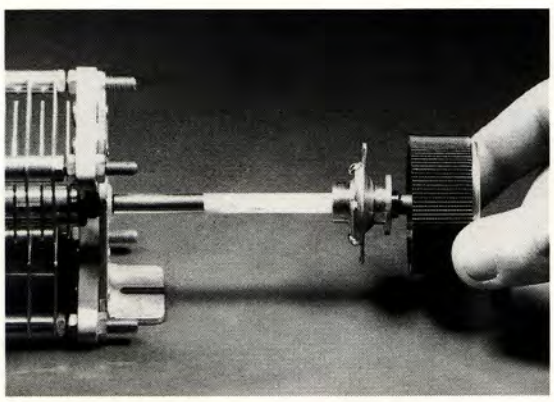
The vernier reduction drive, also known as the ball drive or planetary drive, is a remarkable unit. Based on an ingenious system of ball bearings rolling between two surfaces while housed within a rotating bushing, the vernier reduction drive is often used to enhance the fine-tuning control of an air-variable capacitor.

In most applications, a knob is attached to the vernier drive's input shaft, a variable capacitor's shaft is fastened into the vernier drive's output shaft coupler, a vernier dial is attached to the unit's dial flange, and the unit's mounting bracket is attached to a stationary housing or cabinet. When the knob is turned through one complete rotation, the vernier dial and the capacitor's shaft rotate one-sixth of a rotation.

Thus, a very small change in capacitance does not require extremely fine motor skills on the part of the operator. Most remarkable is the fact that this "gearing down" is achieved without gears. The ball drive is compact,reliable, durable, and economical. There are two models available: The BD-601, for use with a vernier dial, and the BD-602, without the dial flange.







OREN ELLIOTT PRODUCTS, INC.

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