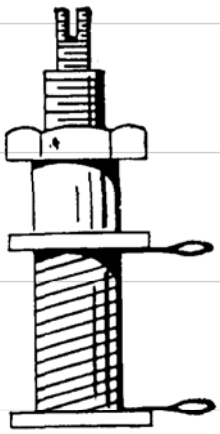


Slug Tuned Coils

Why will one slug-tuned coil work in a circuit and another, apparently similar, not work? The factors that determine the frequency range in which a slug-tuned coil will operate are discussed below and some ready reference data is supplied.

BY R. M. BALDWIN,* K4ZQR

ANYONE who has been exposed to ham radio for any length of time, is familiar with the slug-tuned coil. Familiar, perhaps, in the knowledge of what one looks like; but I'll venture to predict that most average hams have a lot to learn about what makes a slug-tuned coil behave the way it does.

My own search for knowledge began with a deep sense of frustration. I'm an avid reader of practically every ham publication, and my junk box never approaches that "well-stocked" level simply because I'm always building something. Sometimes they work and sometimes they don't, and as often as not the villain is the subject of this little treatise—the slug-tuned coil.

An author will specify a ⅜" slug-tuned form, No. 168B4956, and even though we are blessed here in town with one of the pioneer electronic supply houses in the United States—they never heard of it. So I dig into the trusty junk box and come up with a ⅜" slug-tuned form that looks like the author's illustration. Will it work? You never know until you try, and I'll tell you right now you probably won't be any better off in this same situation after reading the rest of this article—only you might know why it *didn't* work.

Tuning slugs or ferrite cores are made by a number of manufacturers to different specifications. They are blends of various powdered-iron materials with other metallic oxides added, and they are molded and sintered at temperatures up to 1200° centigrade to create desired mechanical and magnetic characteristics.

The unit for measuring magnetic flux density is *Gauss*, and the measure of applied magnetizing force is the *Oersted*. The characteristic of a given core of specific formulation is defined by the relation of flux density to applied force, plus the effects of frequency and temperature upon these properties.

The term permeability (μ_o) is used to indicate the over-all magnetic properties of a given slug (measured in Gauss), and among the magnetic specifications listed for a given grade of core or slug material, you will find such things as initial permeability, maximum permeability, incremental permeability, and a lot of other specifications only a design engineer would need to understand.

What is important to remember at this time is that the iron core in a slug-tuned form is designed for a specific job, and if given a chance to do the job it was designed to do it can:

1. Increase the *Q* of a small coil, or in other words, its selective properties.
2. Increase the inductance, thereby permitting

*409 Kaelin Drive, Louisville 7, Kentucky.

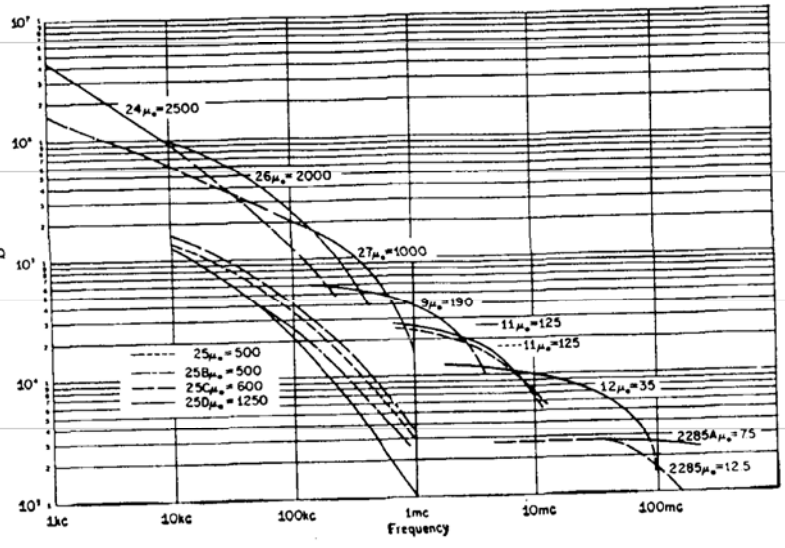


Fig. 1—Plot of MERIT FACTOR *versus* FREQUENCY for Ceramag cores, a product of Stackpole Carbon Company. The data was obtained under toroidal conditions with sinusoidal waveforms and only material losses are shown. The μ_o is constant over the frequency range shown and only the Q changes.

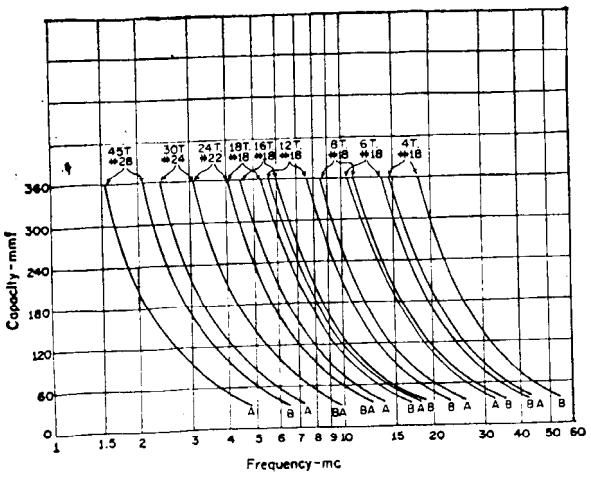


Fig. 2—Frequency—Capacity chart for the National XR-50 form. The A curves are with the cores set for maximum inductance and the B curves are for minimum inductance.

use of smaller coils than would be possible with air-core coils alone.

3. Act as a tuning device. In general, the higher the permeability (μ) the more effect the slug will have upon the inductance and hence the tuning range.

On the other hand, the introduction of a slug into a coil can, if not properly chosen, actually lowers the Q of the system, and the right amount of permeability to do the job is the problem which has to be successfully solved, for best results.

To observe the characteristics of various cores, examine fig. 1. Shown is a graph, supplied by Stackpole Carbon Company, plotting Q *versus* frequency for various Cermag brand ferromagnetic cores.

On this chart, the various grades of Ceramag are graphically illustrated in relation to frequency. The numbers represent initial permeability (μ_o = 1000 Gauss in the case of Ceramag No. 27). You can easily imagine the results you would get if you reached into your well-stocked junk box and pulled out a coil form with the characteristics of their No. 27, and proceeded to wind a 50 mc coil on it. Too much permeability —too many losses—too low a Q; no merit factor, in other words.

Coding

At this point we all should begin to wonder why the manufacturers of slug-tuned coil forms don't package construction data such as optimum frequency range in with their products, instead of simply sealing up one No. 168B4956 form in a poly bag, and letting you guess the rest.

Well, all is not quite lost because there is some help available in a limited way from color codes used by a few manufacturers. If you pick up a form, and it has a dab of one of the following colors on the end of the slug, you can get a fair idea of the frequency range over which it might be effective from this data.

Yellow — Up to 1.5 mc
Red — 1 mc to about 20 mc
Purple — 10 mc to 30 mc
Blue — 10 mc to 40-50 mc
Green — 20 mc to 50 mc
White — 50 mc and up

This isn't an ironclad code, and purple slug from one manufacturer might be good at 40 mc while another make might only go to 20 mc. It is a guide, however, providing you *can* find a color code.

Published Data

Another approach is to use known published data on coil forms. Undoubtedly, one of the reasons for the popularity of the National Radio XR-50 form was the inductance vs. turns chart they supplied with it. We have reproduced this

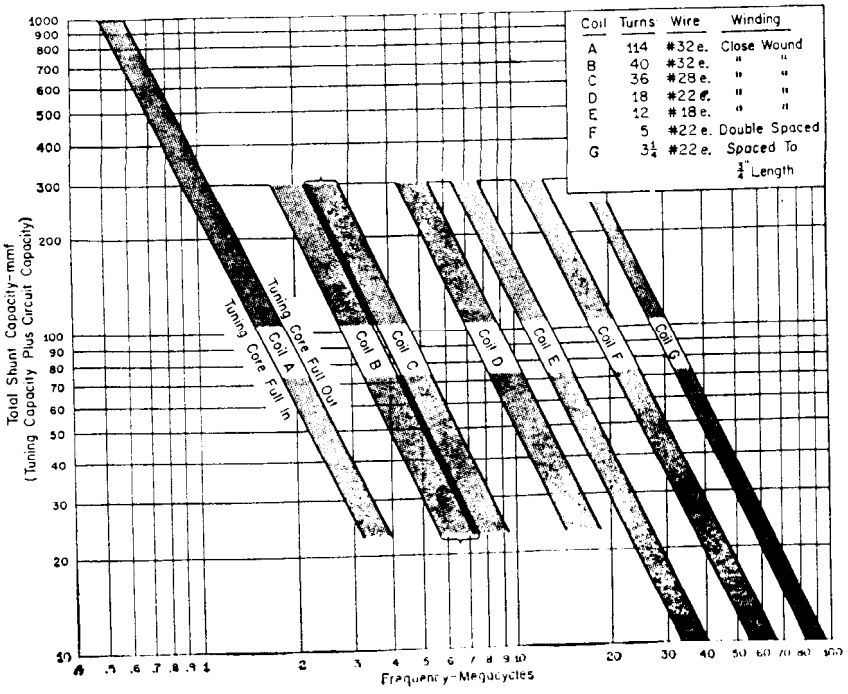


Fig. 3—Chart used to determine windings and parallel capacity value required to tune from 0.5 mc to 95 mc with Millen No. 74001 form.

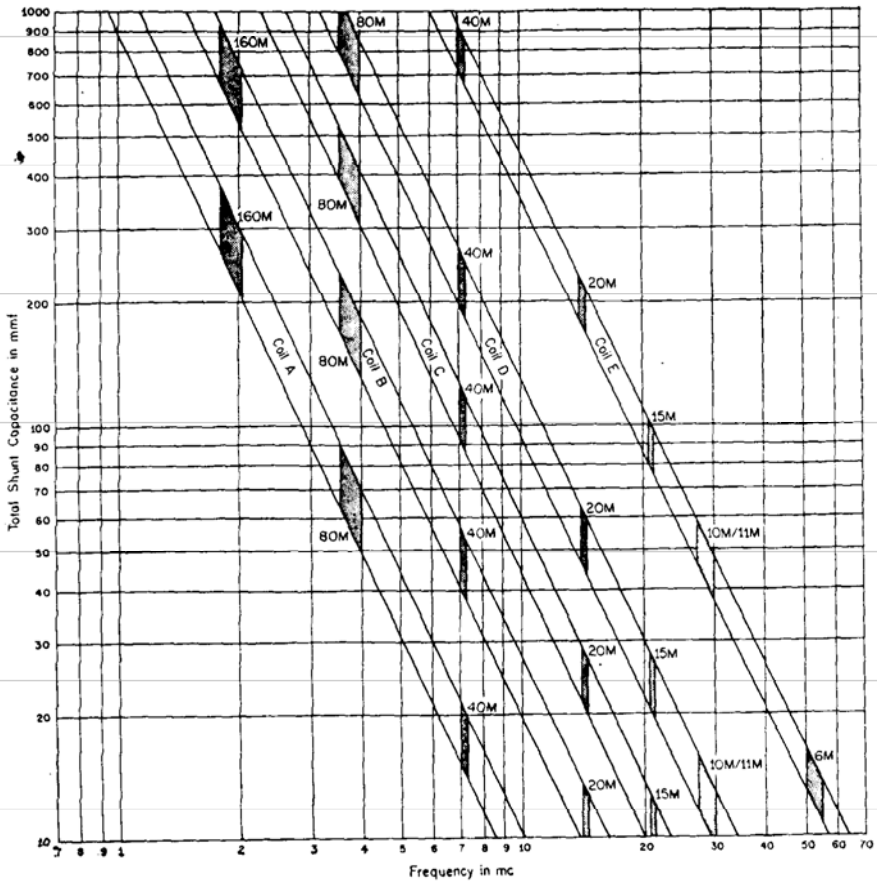


Fig. 4—Data needed for the use of Millen coil form #69046 is given above. The two lines, X and Y, for each coil represents the slug full in (X) and slug full out (Y). The Total Shunt Capacitance represents the tuning capacity plus the circuit capacity.

Coil A—62t. #28e., close spaced.
Coil B—40t. #24e., close spaced.
Coil C—28t. #20e., close spaced.
Coil D—18t. #18e., close spaced.
Coil E—10t. #18e., spaced to fit between clips.

chart (fig. 2) because it apparently isn't generally available, and any home-brew artist could do a lot worse than use this data if he is working in the ranges of from 3 to 30 mc. As you can see, this one just about does it except for v.h.f., by using a combination of different wire sizes, number of turns, and capacity. Strangely, this is the only data of this sort apparently available on National forms.

J. W. Miller Company manufactures a number of ready-made coils and also offers coil forms. No frequency-capacity charts are available on these forms but from the data sheets packed with them it can be determined that good results up to 8 mc or so can be obtained with their No. 4400 coil form, and from 2.5 mc up to 25 mc with their No. 4500 with red marked core.

James Millen, another major manufacturer of coil forms, has extensive engineering data on most of their forms. Their "Cadillac" coil form is the No. 74001, which is a completely shielded form with an octal base. The slug is tuned from below the octal socket as the shaft extends through the keyway. With various combinations of shunt capacity, and by also varying the wire size and number of turns, this form can be made to tune from 0.5 to 95 mc. This chart is shown in fig. 3.

In addition to the shielded coil form, Millen makes a line of ceramic forms from 3/16" to ½" in diameter and with winding space from 11/32" to 1½". Data on their No. 69046 coil form is shown in fig. 4 with the ham bands blocked in. This form will cover from 160 meters all the way up to 6 meters with, of course, various combinations of capacitance and wire sizes and numbers of turns.

For the v.h.f. crowd, all is not lost either. Notice that we hit 6 meters on that last chart. Take the same coil form and use a copper slug, and it's Millen's form No. 69045, which will reach 2 meters or 6 meters with three turns of No. 14 tinned and spaced to fit between the clips. Of course, to tune 2 meters you only need about 10 mmf of capacity, while it takes around 80 mmf to tune 6 with this combination.

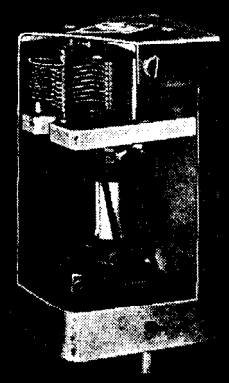
National also makes v.h.f. coil forms, and those with brass slugs, such as their XR-91, will hit 2 meters. Unfortunately, no chart data seems to be available so the capacitance and wire turns data is cut and try. I have substituted this form with good results, however, on 2 meter construction projects when I couldn't buy the one specified.

Cores made of non-ferrous materials affect the inductance of a coil in opposite fashion to those of iron. Insertion of a brass core, for example, tends to decrease the inductance rather than increase it. Such cores, however, result in a better *Q* at v.h.f. frequencies above 50 mc as a general rule.

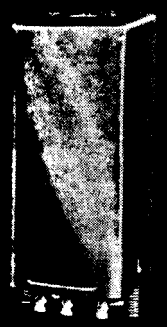
Conclusions

That there is more to this slug-tuned coil form business than meets the eye should now be apparent. This article probably hasn't solved that problem of whether you can substitute that junk box form for the No. 168B4956 your parts distributor never heard of—but you will at least have an idea of why it didn't work after reading this—and then you can go out and buy one that will. ■

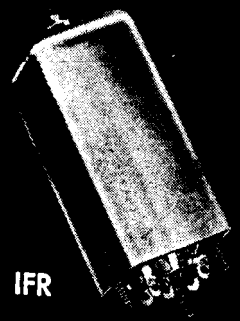
I. F. TRANSFORMERS



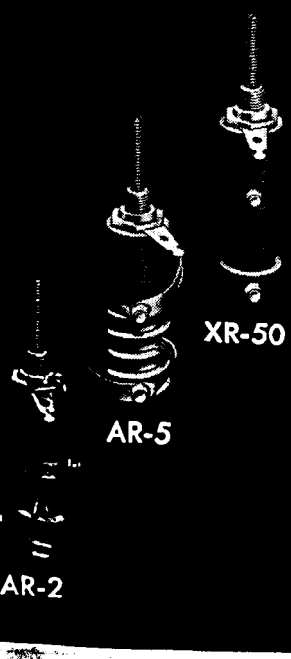
IFC
IFCO



IFL
IFM
IFN
IFO



IFR



XR-50
AR-5
AR-2

IFC, Transformer,

IFCO, Oscillator,

Litz coils wound on a polystyrene form and ceramic insulated air-dielectric trimming condensers make these transformers inherently stable and exceptionally retentive of tuning. The 4½" x 2⅜" x 2" shield can has two 6-32 spade bolts for mounting. Available for either 175 KC or 450-550 KC. Specify frequency.

IFL FM Discriminator

IFM IF Transformer

IFN IF Transformer

IFO FM Ratio Discriminator

IFL, IFM, IFN and IFO transformers operate at 10.7 Mc. and are designed for use in FM Superheterodyne receivers. Coils are precision wound on grooved polystyrene forms and tuning is accomplished by movable iron cores. Bandwidth is not affected by tuning slug position. The transformer cans are 1⅜" square and stand 3⅛" above the chassis. Two 6-32 spade bolts are provided for mounting.
The IFL transformer is a 10.7 Mc. FM discriminator transformer suitable for use in conventional FM receiver discriminator circuit and is linear over a band of ±100 Kc.
The IFM transformer is a 10.7 Mc. IF transformer with a 150 Kc. bandwidth at 1.5 db attenuation. Approximate stage gain of 30 is obtained with IFM Transformer and 6SG7 tube.
The IFN transformer is a 10.7 Mc. IF transformer with a 100 Kc. pass band at 1.5 db attenuation. Approximate stage gain of 30 is obtained with IFN transformer and 6SG7 tube.
The IFO transformer is a 10.7 Mc. FM discriminator transformer of the ratio type and is linear over a band of ± 100 Kc.

IFR. Low-priced quality IF transformer. 455 kc. 2⅜" high x 1⅛" square.

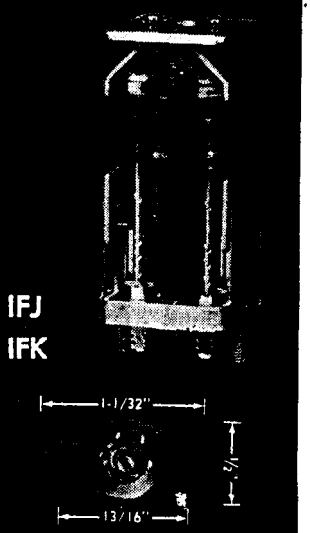
IFS. Same as IFR but 1720 kc.

IFJ, with variable coupling

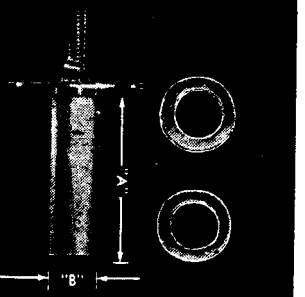
IFK, with fixed coupling

15 Mc. IF transformers suitable for ultra high frequency superheterodynes. They are made in two models with and without variable coupling. Approximate stage gain of 10 is obtained with IFJ or IFK Transformer and 6AB7 tube.

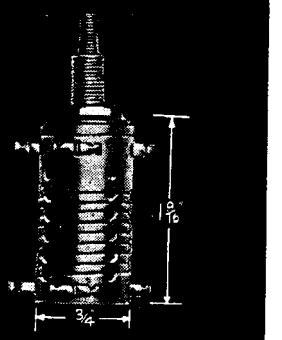
SA:4842
A 456 kc. discriminator transformer for narrow band frequency modulation. Two slug-tuned secondaries are employed and discrimination is accomplished by resonating one at approximately 10 kc. above, the other at approximately 10 kc. below the center frequency of the i.f. channel.



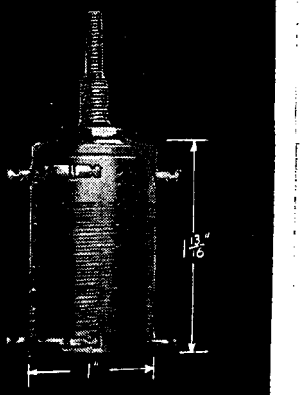
IFJ
IFK



XR-80—XR-90 Series



XR-70 XR-71
XR-72 XR-73



XR-60 XR-61
XR-62 XR-63

COILS AND COIL FORMS

AR-2 H.F. Coil

AR-5 H.F. Coil

The AR-2 and AR-5 coils are high Q permeability tuned RF coils on low loss mica-filled bakelite forms. The AR-2 coil tunes from 75 Mc. to 220 Mc. with capacities from 100 to 10 mmfd. The AR-5 coil tunes from 37 Mc. to 110 Mc. with capacities from 100 to 10 mmfd. The inductive windings supplied may be replaced by other windings as desired to modify the tuning range.

XR-50
These mica-filled bakelite coil forms may be wound as desired to provide a permeability tuned coil. The form winding length is 11/16" and the form winding diameter is ½ inch. The iron slug is ⅜" dia. by ½" long.

XR-51 same but with brass slug

CERAMIC SLUG-TUNED COIL FORMS

XR-70 (grooved for #19 wire, with iron slug)
XR-71 (same, brass slug)
XR-72 (not grooved, winding length 1", with iron slug)
XR-73 (same, brass slug)
XR-60 (grooved for #26 wire, with iron slug)
XR-61 (same, brass slug)
XR-62 (not grooved, winding length 1¼" with iron slug)
XR-63 (same, brass slug)
High-grade ceramic coil forms conforming to JAN specifications. May be wound as desired to provide a permeability-tuned coil. Extra lugs provided.

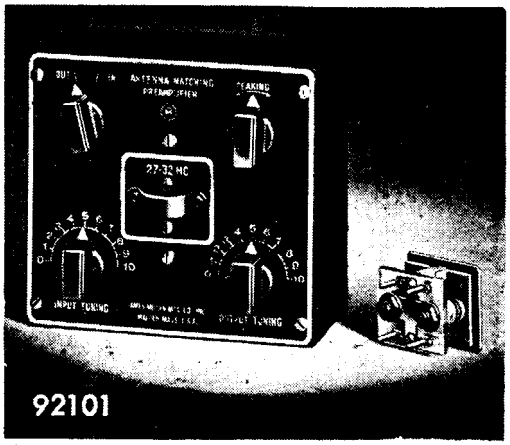
NEW PERMEABILITY TUNED CERAMIC COIL FORMS

Small ceramic coil forms designed primarily for high frequency applications and conforming to government specifications. Coil form is Grade L4 ceramic (JAN 1-10); base is silver-plated brass; core is brass or iron. Supplied with two nylon rings to separate coils if more than one is wound on same form. Small holes in rings can be used to secure leads.

TYPE	CORE	"A" DIM.	"B" DIM.
XR 80	BRASS	1¼"	17/64"
XR 81	IRON	1¼"	17/64"
XR 82	BRASS	1¾"	17/64"
XR 83	IRON	1¾"	17/64"
XR 90	BRASS	1¼"	⅜"
XR 91	IRON	1¼"	⅜"
XR 92	BRASS	1¾"	⅜"
XR 93	IRON	1¾"	⅜"

JAMES MILLEN

MALDEN · MASSACHUSETTS



R9'er MATCHING PREAMPLIFIER

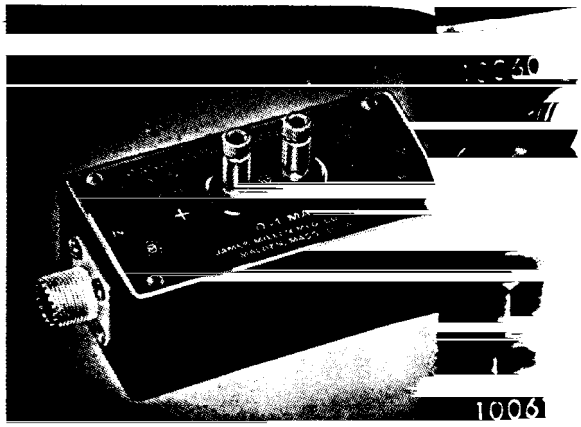
The Millen 92101 is an electronic impedance matching device and a broad-band preamplifier combined into a single unit, designed primarily for operation on 6 and 10 meters. Coils for 20 meter band also available.

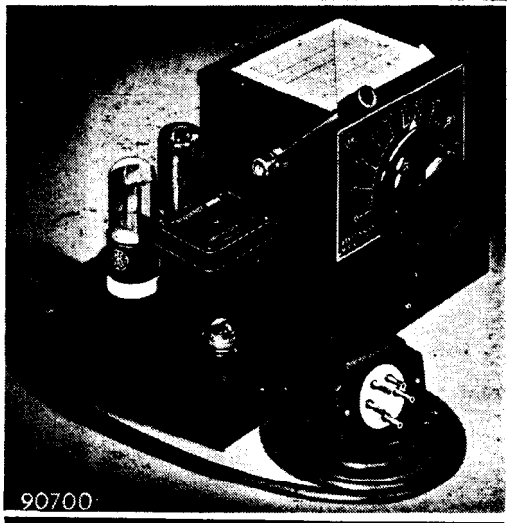
No. 92101, less tubes..... $

STANDING WAVE RATIO BRIDGE

The Millen S.W.R. bridge provides easy and inexpensive measurement of standing wave ratio on antennas using co-ax cable. As assembled the bridge is set up for 52 ohm line. A calibrated 75 ohm resistor is mounted inside the case for substitution in the circuit when 75 ohm line is used.

No. 90671..... $

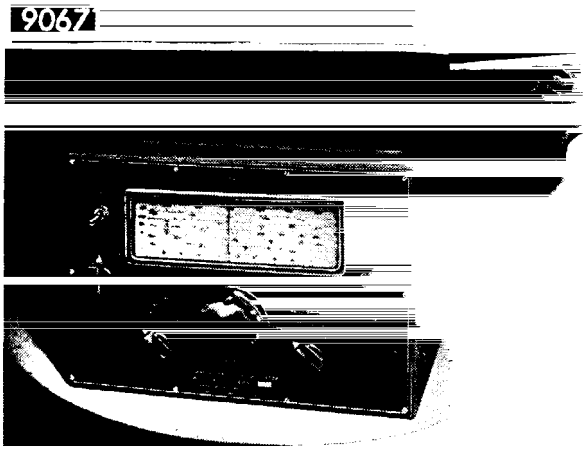




FREQUENCY SHIFTER

A favorite frequency shifter, plugs in, in place of crystal, for instant finger-tip control of carrier frequency. Low drift, chirpless keying, vibration immune, big band spread, accurate calibration.

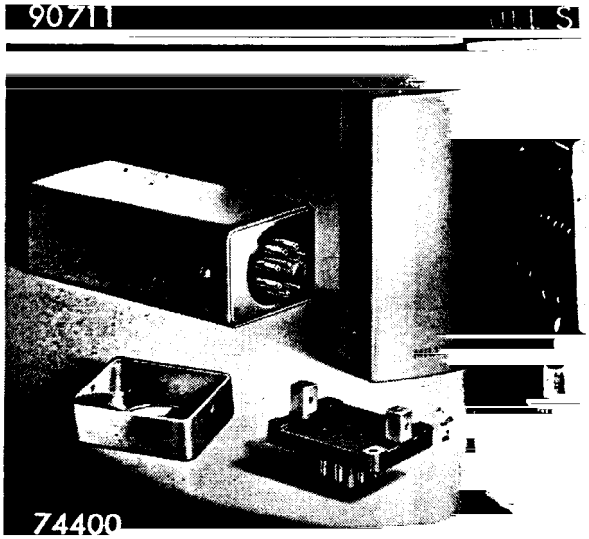
Model 90700, with tubes..... $

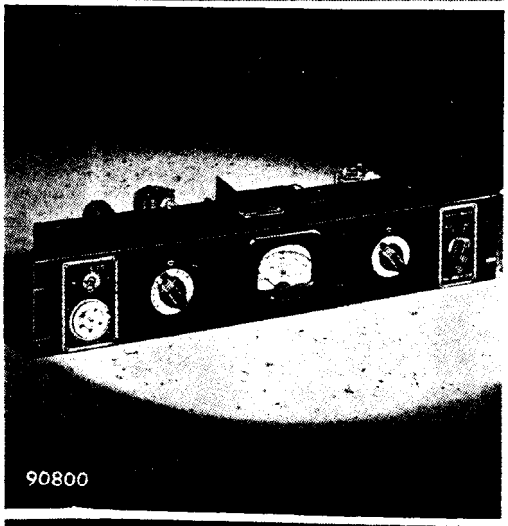


VARIABLE FREQUENCY OSCILLATOR

The No. 90711 is a complete transmitter control unit with 6SK7 temperature-compensated, electron coupled oscillator of exceptional stability and low drift, a 6SK7 broad-band buffer or frequency doubler, a 6A67 tuned amplifier which tracks with the oscillator tuning, and a regulated power supply. Output sufficient to drive an 807 is available on 160, 80 and 40 meters and reduced output is available on 20 meters. Close frequency setting is obtained by means of the vernier control arm at the right of the dial. Since the output is isolated from the oscillator by two stages, zero frequency shift occurs when the output load is varied from open circuit to short circuit. The entire unit is unusually solidly built so that no frequency shift occurs due to vibration. The keying is clean and free from all annoying chirp, quick drift, jump, and similar difficulties often encountered in keying variable frequency oscillators.

No. 90711, with tubes..... $





50 WATT TRANSMITTER

Based on an original Handbook design, this flexible unit is ideal for either low power amateur band transmitter use or as an exciter for high power PA stages.

Model 90800, less tubes..... $

OCTAL BASE AND SHIELD

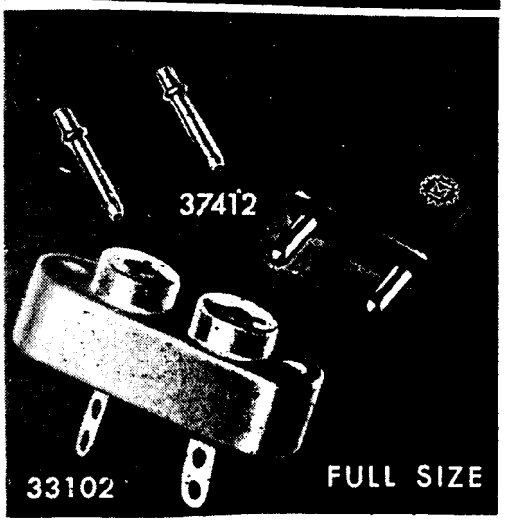
Low loss phenolic base with octal socket plug and aluminum shield can 1 7/16 x 1 7/8 x 3 15/16.

No. 74400..... $

TRANSMISSION LINE PLUG

An inexpensive, compact, and efficient polyethylene unit for use with the 300 ohm ribbon type polyethylene transmission lines. Fits into standard Millen No. 33102 (crystal) socket. Pin spacing ½", diameter .095".

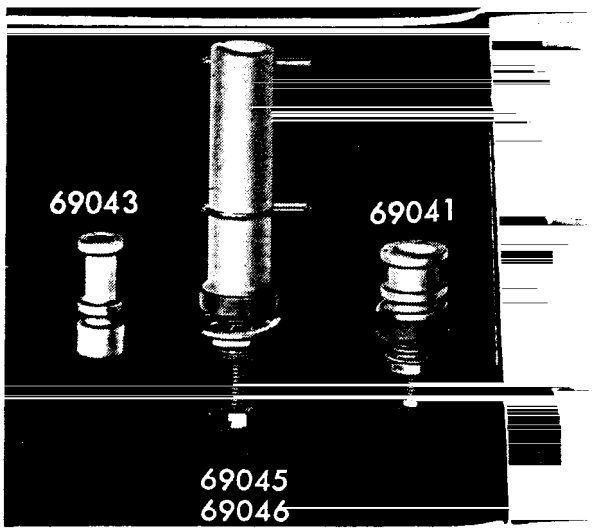
No. 37412..... $



PERMEABILITY TUNED CERAMIC FORMS

In addition to the popular shielded plug-in permeability tuned forms, 74000 series, the 69040 series of ceramic permeability tuned unshielded forms are available as standard stock items. Winding diameters and lengths of winding space are 13/32 x 7/32 for 69041–2; 1/4 x 3/8 for 69043–7–8; 1/2 x 1 1/16 for 69045–6; 3/16 x 3/16 for 69044.

No. 69041—(Copper Slug)..... $
No. 69042—(Iron Core).....
No. 69043—(Iron Core).....
No. 69044—(Copper Slug).....
No. 69045—(Copper Slug).....
No. 69046—(Iron Core).....
No. 69047—(Copper Slug).....
No. 69048—(Iron Core).....



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