# Notes on Amateur Radio Transmitter Design

Compiled by

JAMES MILLEN

R Fox

R. Fox

Price 50¢

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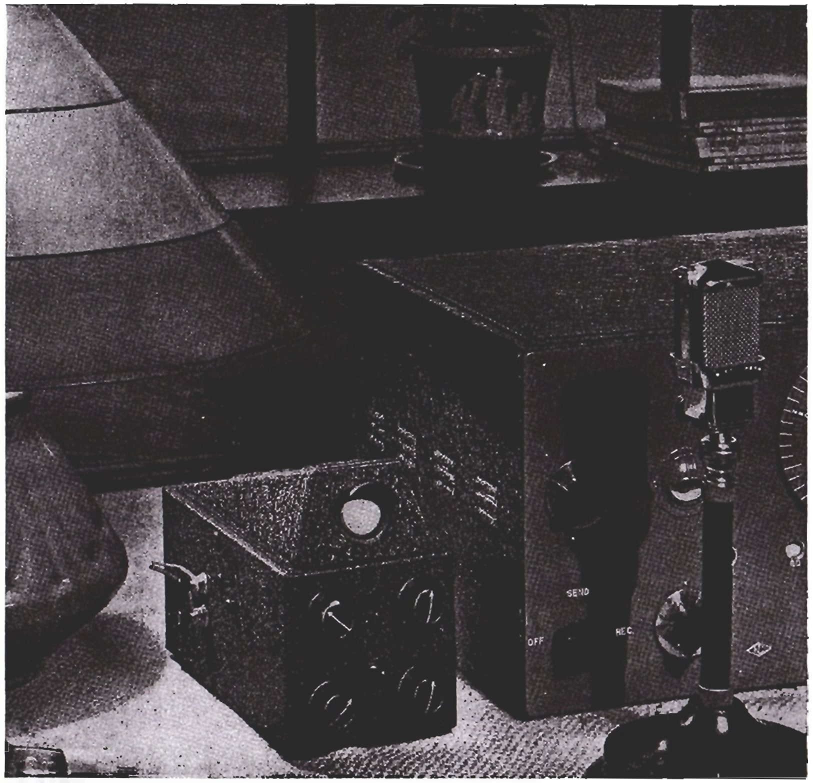
PUBLISHED BY JAMES MILLEN, INC., MALDEN, MASS



*The Oscilloscope is just as an essential part of an amateur 'phone transmitter as the microphone. Shown here is the new, inexpensive, National Type CRM unit, using the midget 913 tube.*

Tr.
Fr. Adrian Stallbaumer, OSB
Oct. 54

# INTRODUCTION

THIS BOOKLET is not offered as a handbook on amateur transmitter design, but as a miscellaneous collection of ideas, suggestions, and handy data that it is hoped will prove helpful to the amateur, whether he is new or old, planning a revision of his station equipment. For a complete and somewhat more academic treatment of the subject, Amateur Transmitter Design, no book is likely to surpass the A.R.R.L. official *Radio Amateur's Handbook.*

Most of the apparatus described and illustrated herein was originally designed for use at W1HRX. In addition, we are indebted to Herb. Becker, W6QD; Martin Brown, W6ABF; George Grammer, W1DF; and Ed. Ruth, W2GYL, and Dana Bacon, W1BZR for the privilege of including illustrations and descriptions of transmitters built by them for use in their own stations.

In order to secure at least some semblance of order in the presentation of the subject, the contents of the booklet have been divided into sections on Exciters, Final Stages, Complete Transmitters, Modulators, Power Supplies, and Antennae. Naturally, some transmitters are so physically designed that it is rather hard to arbitrarily divide them under such headings for editorial presentation; consequently, in the chapter on Complete Transmitters will be found some material pertaining theoretically at least to some of the other divisions.

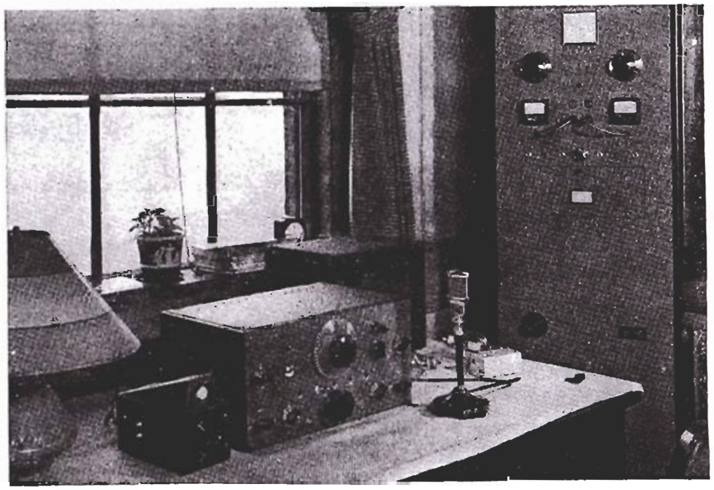
In treating Final Stages, all references to linear amplifiers have been purposely avoided, as their use up to the present in amateur communication work has been quite limited. Primarily, this is because until a little over a year ago, when W. A. Doherty of the Bell Telephone Laboratories presented his paper on High Efficiency Linears, it was generally considered that their efficiency was limited to about 25 per cent. Sufficient time has not yet elapsed for the amateur fraternity to put into extensive application the principles of the Doherty high efficiency linear amplifier. Perhaps another year may see a trend in that direction.

All material on ultra-high frequency equipment has also been purposely avoided, as it is felt that such material is rightfully the subject of another booklet.

In addition to the individuals mentioned above, we are also indebted to the editors of *QST* for permission to re-use many of the illustrations which appeared originally in *QST*. We are also indebted to M. L. Muhleman of *All-Wave Radio* for the illustrations on pages 54 and 56, and to the Radio-Television Supply Co., the Radio Supply Company and the magazine, *Radio*, all of Los Angeles, for the illustrations of the W6QD and W6ABF transmitters.

James Millen

*April 1, 1938*



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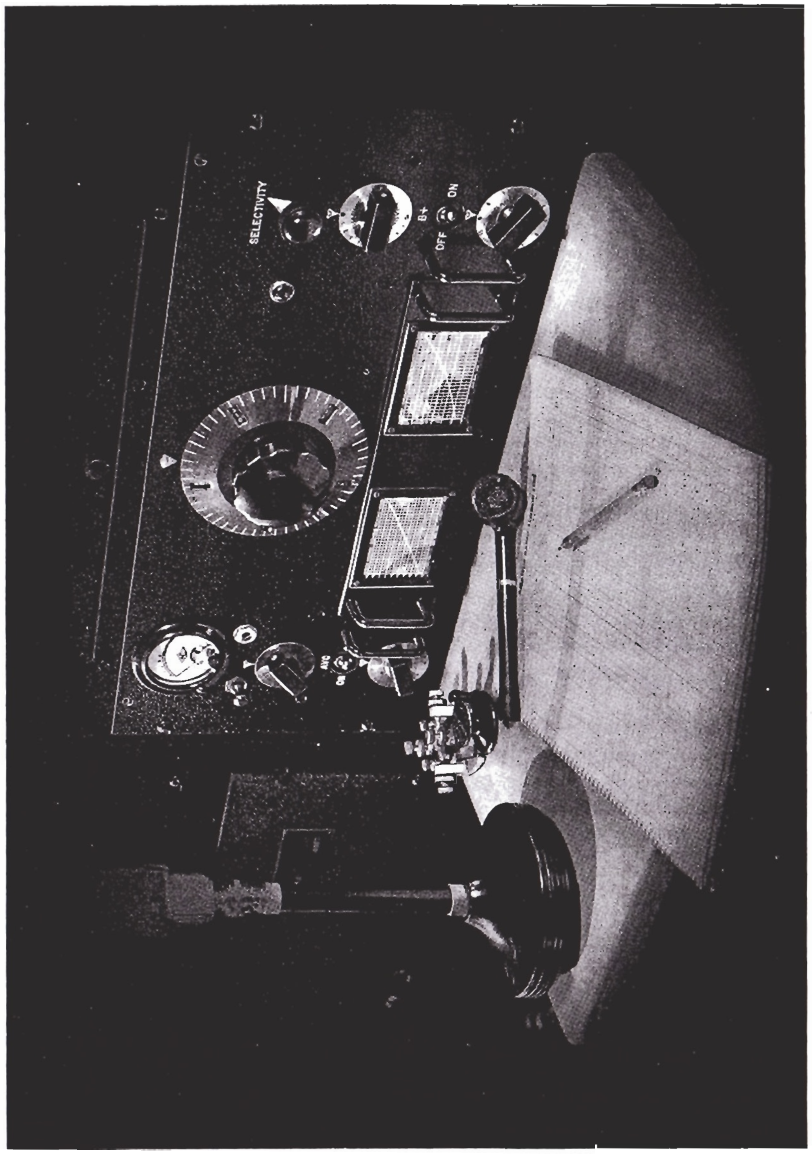


# The EXCITER

In recent years the trend in both amateur and commercial transmitter design practice seems to be toward the treatment of the exciter as a separate unit. During the past year or so, much progress has been made in the design details of exciter units with a view toward increasing their reliability, compactness, universal applicability, ease of band-shift, and vernier control of frequency adjustment.

The advent of the 53 tube, and its counterpart the 6A6, has made possible a very practical and compact circuit which is the basis of most of the exciters described and illustrated herewith. In using the double-triode type of tube, such as the 53-6A6, one of the sections is used as a triode crystal oscillator and the other as a triode doubler. In most of the accompanying layouts, the triode sections are used in normal sequence; in the case of the transmitter shown on page 23, however, very material simplification of the circuit wiring was secured by "crisscrossing." Thus, one triode section of the first tube is used as a crystal oscillator while one triode of the second tube is used as a doubler; then the remaining section of the first tube is used as the second doubler, and, finally, the remaining section of the second tube as the final doubler.

While our preference for exciter circuits leans strongly to the use of the 53 type tubes, nevertheless the Tritet circuit developed by Jim Lamb, Technical Editor of *QST*, has also found considerable favor. In the Tritet exciter illustrated in Figs. 1 and 2, is shown all the details on a compact unit using an 89 tube as the crystal oscillator-frequency-multiplier, and an RK-25 pentode buffer.

According to Lamb, the Tritet circuit has, besides harmonic output, two other advantages over simple triode or pentode oscillators. It is a very persistent oscillator — crystals rarely fail to "start" when plate voltage is applied. "Crankiness" with regard to oscillation is a common failing with the simpler circuits, especially if the crystal is not as active, piezo-electrically, as it might be. The second advantage is the buffering action attributable to electron-coupling between crystal and output circuits. This makes the crystal less susceptible to changes in loading (such as might be caused by tuning a following stage) and hence enhances the frequency stability.

But so much for circuits: we will confine our space to the description of practical compact layouts readily adaptable to either type circuit and permitting flexible operation on any band. The Tritet arrangement just referred to uses conventional plug-in coils and panel-controlled variable tuning condensers. In Fig. 3 is a similar arrangement using the double-53 circuit.

Figs. 6 and 15 are typical of the "53" type of exciter circuits. Additional circuits will be found on pages 23 and 43; the one on page 23 being of the criss-cross variety.

Most of the plug-in type of coils used in the exciters such as the ones in Figs. 1, 3, 4, etc., are wound on forms 1½ inches in diameter, such as were originally designed for receiver use. Of particular interest are the forms of this type which instead of being molded of ordinary bakelite are molded of the low-loss dielectric material known as R-39. R-39 is made of ground mica held together with a minimum of pure bakelite resin. It does not contain wood-flour, clay, or other such fillers generally used with ordinary molded plastics, and which contributes so much to the high

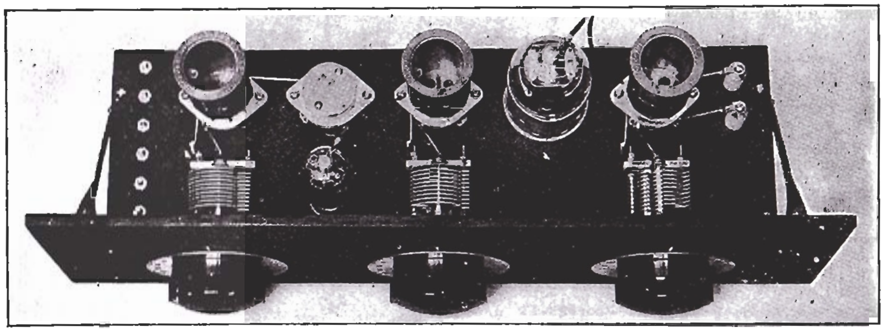


FIG. 1 — A TWO-TUBE FIVE-BAND EXCITER UNIT OR LOW-POWER TRANSMITTER

*Using an 89 and 802 or RK-25, with plug-in coils. In this view the shield about the oscillator plate coil (center) has been removed to show parts and wiring. The shield about the lower part of the amplifier tube is a regular large-size tube shield cut to fit around the shield ring inside the tube.*

R. F. losses of such materials. The table on the lower right-hand corner of page 8 will be found particularly helpful in designing exciter coils on 1½ inch forms. The following is the data for use with these curves:

Curve A — winding length, one inch; Curve B — winding length, 1½ inches; Curve C — winding length, 2 inches. After determining the number of turns for the capacity and frequency band to be used, consult the wire table below to find the wire size which will fit in the space available. No. 18 wire is about the largest size that need be used; larger sizes are difficult to handle on this type of form. Keep in mind that the capacity indicated is the actual shunt capacity. This includes tube and stray circuit capacity; an allowance of at least 15 μμfd. should be made for this stray capacity.

It is handy to remember that when soldering the ends of the coil to the prongs in the coil form base, about the only practical method to use is to dip the prong in a small pool of solder, and withdraw it slowly.

| Gauge No. B. & S. | Turns per Linear Inch | |
|---|---|---|
| | Enamel | D.S.C. or S.C.C. |
| 18 | 23.6 | 22.0 |
| 19 | 26.4 | 24.4 |
| 20 | 29.4 | 27.0 |
| 21 | 33.1 | 29.8 |
| 22 | 37.0 | 34.1 |
| 23 | 41.3 | 37.6 |
| 24 | 46.3 | 41.5 |
| 25 | 51.7 | 45.6 |
| 26 | 58.0 | 50.2 |
| 27 | 64.9 | 55.0 |
| 28 | 72.7 | 60.2 |
| 29 | 81.6 | 65.4 |
| 30 | 90.5 | 71.5 |
| 31 | 101. | 77.5 |
| 32 | 113. | 83.6 |

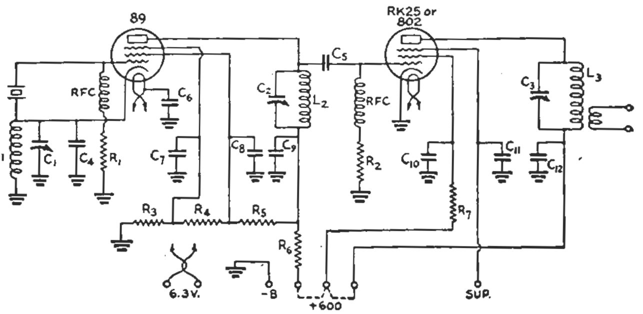
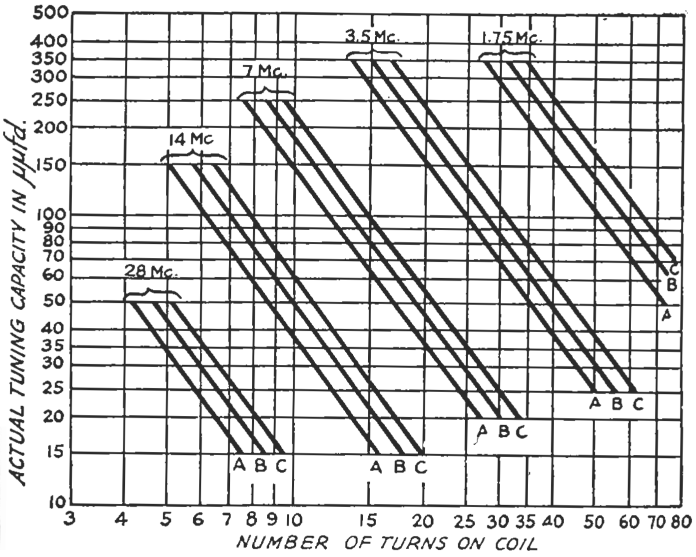


FIG. 2 — CIRCUIT DIAGRAM OF THE TWO-STAGE TRI-TET EXCITER UNIT

*The three connections marked "600 volts" can be tied together. Oscillator plate, buffer plate and screen leads are brought out separately to facilitate metering.*

*C1, C2, C3 — 100-μμfd. (National ST-100).*
*C4 — 100-μμfd. mica.*
*C5 — 50-μμfd. mica.*
*C6 to C9, inc. — 0.01-μfd. paper, non-inductive, 400-volts (Aerovox).*
*C10, C12 — .002-μfd. paper, non-inductive, 1500-volt (Sprague).*
*C11 — .001-μfd. mica.*
*R1 — 50,000 ohms, 1 watt.*
*R2 — 50,000 ohms, 2 watt.*
*R3 — 10,000 ohms, 1 watt.*
*R4, R5 — 10,000 ohms, 1 watt.*
*R6 — 10,000 ohms, 25 watt.*
*R7 — 25,000 ohms, 25 watt.*
*L1 — Oscillator cathode coil:*
  *For 1.75-mc. crystal: 28 turns, No. 20, close-wound.*
  *" 3.5 " " 14 " " 18, winding length 1 inch.*
  *" 7 " " 7 " " 18, " " 1 "*
*L2 — Oscillator plate coil:*
  *1.75 mc.: 65 turns No. 22, close-wound.*
  *3.5 " 32 " " 18, winding length 1½ inches.*
  *7 " 16 " " 18, " " 1 "*
  *14 " 8 " " 18, " " 1 "*
*L3 — Buffer plate coil:*
  *1.75 mc.: 65 turns No. 22, close-wound.*
  *3.5 " 32 " " 18, winding length 1½ inches.*
  *7 " 18 " " 18, " " 1 "*
  *14 " 10 " " 18, " " 1 "*
  *28 " 5 " " 18, " " 1 "*

*All coils wound on 1½-inch diameter forms such as National R39 with enamelled wire. Link coils on L3 consist of one or more turns, closely coupled to L3 at the bottom (cold) end; exact number must be found by experiment to give optimum loading of buffer tube.*



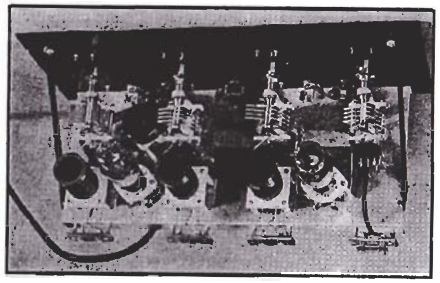


FIG. 3 — PLAN VIEW OF THE EXCITER UNIT SHOWING IN DETAIL THE ARRANGEMENT OF THE COMPONENTS

*Two 53 tubes do the work of four triodes in the crystal oscillator (left) and three doubler stages. The coils in place are for 56-mc. output from a 7-mc. crystal.*

Shortly after this unit was originally built, Herb Hollister, W9DRD, developed the idea of pre-tuned tank circuits, as illustrated in Figs. 4, 5, 6, and 7.

Referring to the rear view of the exciter, shown in Fig. 4, we start at the right with six crystal holders lined up on the edge of the chassis. The mounting was made from a strip of Victron, using wafer socket clips for contacting the holder prongs. Next, along the rear of the chassis we have the 3.5-Mc. oscillator coil, the first 53, the 7-Mc. coil, the 14-Mc. coil, the second 53, and the 28-Mc. coil. The condensers for all four coils are mounted beneath the chassis on the bakelite strip which forms the back edge of the chassis. In the center, directly behind the meter, is the RK23 buffer with its quartette of tank circuits clustered round.

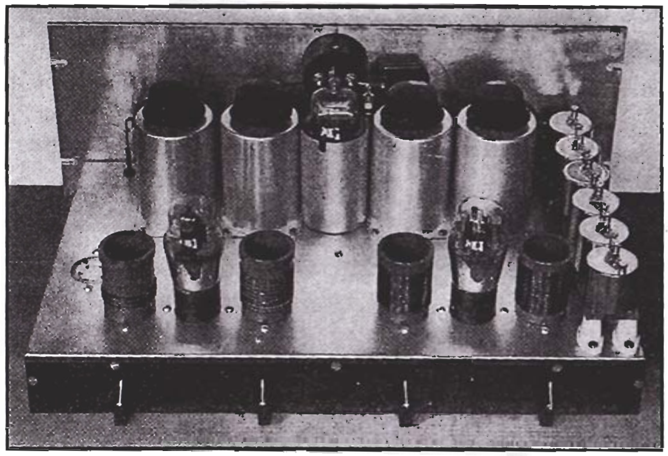


FIG. 4 — SEEN FROM THE REAR, THE EXCITER LOOKS A GOOD DEAL LIKE A NEATLY-BUILT SUPERHET

*But don't be deceived by its appearance; the output on any of the four bands is sufficient for driving a pair of 800's as modulated Class-C amplifiers. Although the oscillator and doubler coils are wound on plug-in receiving coil forms for convenience, actually they are permanent fixtures. The socket which can be glimpsed behind and to the left of the ten-meter doubler coil is for the power-supply plug.*

Now, taking a quick glance at the schematic circuit (Fig. 6), the plot unfolds in all its simplicity. The grid of the first triode section of our first 53 is driven by any of the six crystals which may be selected by the six-point switch. These A-cut crystals are ground to frequencies in 3.5-Mc. band—which will permit the widest possible selection of harmonics for such interference-free spots as may appear in the four bands, 10, 20, 40, and 80 meters. The second triode section of the same 53 is tuned to 7 Mc. The first section of the second 53 is tuned to 14 Mc. and the second section of the same tube to 28 Mc. These four tanks once peaked will require no retuning with crystals whose fundamental frequencies fall between 3500 kc. and 3575 kc. It will, of course, be necessary to retune for a crystal in the 3.9-Mc. 'phone band, but in this case it is only the oscillator tank condenser; and, after all, it should be worth that extra effort to get to work on the 75-meter 'phone band.

The four sections of the two 53's are permitted to run constantly, and therefore we have excitation voltage in each of the four bands on tap at all times with which to drive the grid of the RK-23 buffer. Capacity feed is used, with the tap coming directly off the plates of the 53's, through a four-point switch the arm of which is hooked to the RK-23 grid.

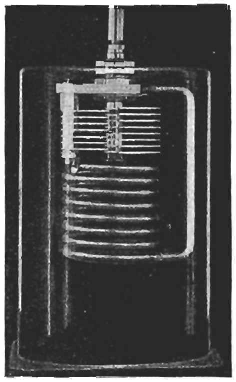


FIG. 5 — AN "X-RAY" VIEW OF ONE OF THE BUFFER TANK CIRCUITS

*The tank coils are mounted below and suspended from the tuning condenser. The individual circuits are peaked at about the center of the band for which they are designed. No fine adjustment has been found necessary in working over the higher-frequency bands with different crystals, as is explained in the text.*

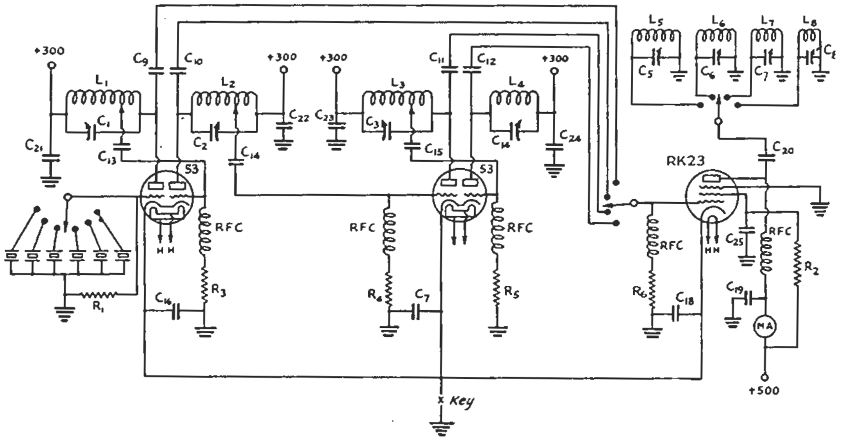


FIG. 6 — CIRCUIT DIAGRAM OF THE BAND-SWITCHING EXCITER

*$C_1$ — 100-μμfd. midget air condenser*
*$C_2$, $C_3$, $C_4$ — 50-μμfd. midget*
*$C_5$ — 100-μμfd. midget*
*$C_6$ — 50-μμfd. midget*
*$C_7$, $C_8$ — 35-μμfd. midget*
*$C_9$ — $C_{20}$, inc. — .001-μμfd. mica condensers*
*$C_{21}$ — $C_{25}$, inc. — .01-μfd. mica condensers*
*$R_1$ — 5000 ohms, 2-watt*
*$R_2$ — 10,000 ohms, 2-watt*
*$R_3$ — 20,000 ohms, 2-watt*
*$R_4$, $R_5$, $R_6$ — 10,000 ohms, 2-watt*
*$L_1$ — 3.5-mc. oscillator coil; 35 turns No. 22, diameter 1½ inches, winding length 1½ inches*
*$L_2$ — 7-mc. doubler coil; 20 turns No. 16, diameter 1½ inches, winding length 1½ inches*
*$L_3$ — 14-mc. doubler coil; 10 turns No. 16, diameter 1½ inches, winding length 1¼ inches*
*$L_4$ — 28 mc. doubler coil; 3½ turns No. 14, diameter 1½ inches, winding length ¾ inch*
*$L_5$ — 3.5-mc. buffer coil; 30 turns No. 16 diameter 1½ inches, winding length 1½ inches*
*$L_6$ — 7-mc. buffer coil; 16 turns No. 14, diameter 1½ inches, winding length 1¼ inches*
*$L_7$ — 14-mc. buffer coil; 9 turns No. 10, diameter 1¼ inches, winding length 1¼ inches*
*$L_8$ — 28-mc. buffer coil; 3¼ turns No. 10, diameter 1¼ inches, winding length ¾ inch*
*RFC — Sectional-wound chokes, high-frequency type*
*The tuning condensers, $C_1$-$C_8$, inclusive, are National Ultra-Midgets*

In order to facilitate construction, several forms of commercially available fixed-tuned tank units have been developed. The first of these, shown at the right in Fig. 12, is for direct mounting to the chassis, in the Hollister manner. An effective application of this unit is shown in Fig. 11.

It is built up in a modified form of the newer Western Electric practice of vertical chassis arrangement for "dish" relay rack mounting. The variations from standard Western Electric practice that have been made can hardly be called an improvement, but are resorted to solely for the sake of adapting this type of construction to the amateur's workshop. The vertical chassis for the exciter (and buffer) offers worth-while advantages. Construction and wiring is simplified, tanks and crystals are readily accessible, and an uncrowded compactness is achieved.

This particular exciter also possesses other unique features. In the first place, it is designed for use in a two-band transmitter and actually comprises two complete separate exciters in one unit. By means of the key switch on the front panel, the B-supply is thrown from one unit to the other, and thus R.F. output made instantly available on either the 20-meter or the 75-meter bands. The 20-meter section uses a single 53 tube with a group of 40-meter crystals, whereas the 75-meter side uses but one-half of a single 53 tube with 75-meter crystals.

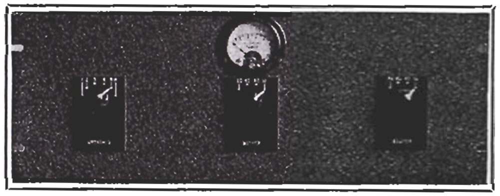
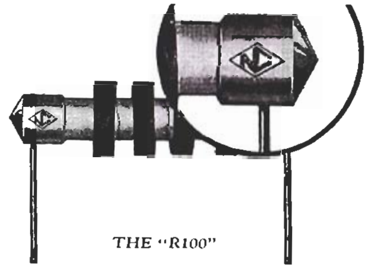


FIG. 7 — BAND-CHANGING BECOMES A PLEASURE WITH AN EXCITER LIKE THIS ONE

*No tuning adjustments to be gone through — simply flip the "buffer" and "exciter" switches to the band desired and select any one of six crystals on the "crystal" switch. The 53's handle the oscillator and doubler functions; the buffer, always used as a straight amplifier, is an RK-23.*



THE "R100"

Experience has shown that a more preferable arrangement would have been to use 160-meter crystals and both sides of the 53 for the final output in the 75-meter 'phone band. Of particular interest in this unit is the switch for selecting various crystals; this switch is illustrated in Fig. 9, and is, in actuality, a combination single-pole multi-point switch and variable trimmer condenser. The condenser is so adjusted as to retune the crystal circuit as crystals of different frequencies within a given band are selected. Its range is readily adjusted by varying the spacing between the rotor and stator plates.

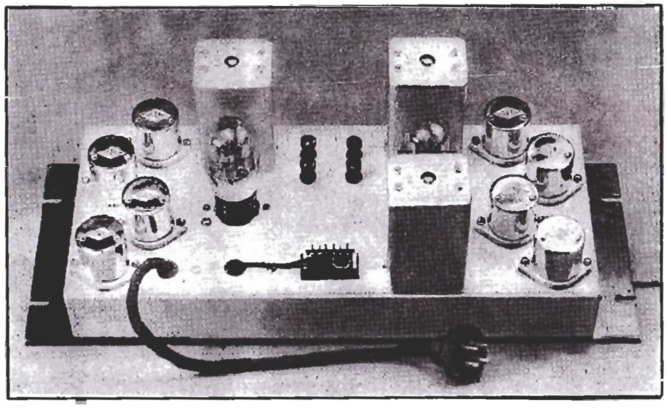


FIG. 8 — THE EXCITER UNIT, FACE DOWN, WITH THE 75-METER SECTION AT THE LEFT AND THE 20-METER SECTION AT THE RIGHT

*The tank circuits are contained in the shield cans, the tuning condensers being adjusted with a socket wrench.*

The actual adjustment is extremely simple. With the crystals plugged in their proper sockets and the switch turned to the highest frequency, the rotor plate should be all the way out. Now tune the tank circuit in the usual way, using the main condenser. Next, turn the switch to the lowest frequency. This puts the lowest-frequency crystal in circuit and turns the rotor all in. Now retune by moving the stator plates of the vernier condenser by means of the nuts on the stator studs. Do not touch the main tank tuning condensers. The adjustment is now complete. For the two intermediate frequencies it is unlikely that the tank will be exactly in tune, but it is even more unlikely that they will be more than a fraction of a per cent out of tune, which is more than good enough.

From the above, it might seem that the range of the condenser must be adjusted for a group of crystals operating in one band only. This objection is easily overcome, however, if the crystals to be used in another band are chosen so that the ratios of the upper and lower frequencies are the same. For instance, 75-meter crystals having frequencies between 3920 and 3980 KC would require exactly the same range of vernier condenser capacity as a group of 160-meter crystals operating at frequencies between 1960 and 1990 KC.

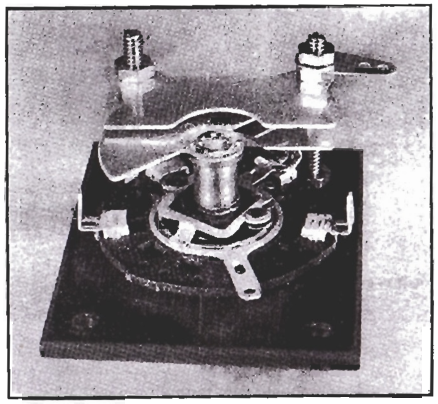


FIG. 9 — CLOSE-UP OF COMBINED CRYSTAL SELECTOR SWITCH AND OSCILLATOR TANK TRIMMER CONDENSER

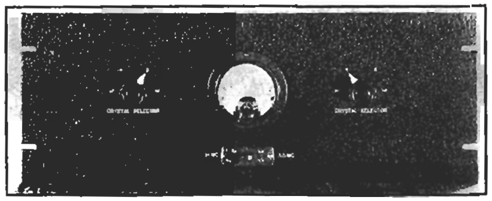


FIG. 10 — PANEL VIEW OF THE EXCITER UNIT, SHOWING THE TWO CRYSTAL SELECTOR CONTROLS (RIGHT AND LEFT), WITH THE BAND-SWITCH BELOW THE PLATE MILLIAMMETER

FOR CIRCUIT DIAGRAM AND PARTS LIST, SEE PAGE 43

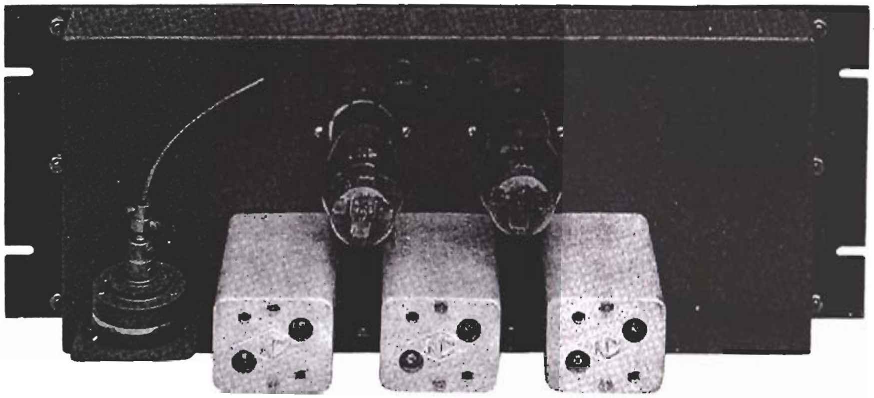


FIG. 11

In Fig. 11 is still another example of the use of fixed-tuned tank units to form an efficient and compact exciter. This particular unit is for operation in the 20-meter 'phone band, using an adjustable air-gap type of variable frequency crystal control, in which the crystal is mounted behind the panel and controlled from the knob on the front by means of a length of flexible shafting, furnished with the crystal holders for just that purpose.

It was designed for driving the pair of RK-20 buffers shown in Fig. 60 on page 40 which were in turn used to drive the twenty meter one kilowatt final amplifier at W1HRX using a pair of W.E.251s. The crystal is an 80 meter Hollister in the National CHV variable holder, giving a 25 KC range in the 20 meter 'phone band. The circuit uses a pair of 53s. Simplicity of construction is secured by using a pair of FXT fixed tank units mounted on a shallow vertical chassis in which is concealed all of the wiring. Control of the crystal frequency is brought out to the front panel by means of the flexible drive shaft furnished as standard equipment with the CHV holder. Where the drive shaft passes through the hole in the chassis, a standard soft rubber grommet, such as used on A.C. cords, is employed to secure smooth turning.

By using 6-prong plug-in bases for the pretuned tank circuits it is possible to have an independent link-coupling winding on each output tank and to connect all of the corresponding socket terminals in parallel across the output terminals. In practice it will be found advisable, for quick band shift, to have additional tank circuits fitted with the output coils for those bands upon which the exciter is to be operated, inasmuch as the loading of the link circuit appreciably changes the tuning of the tank coil being used in the output stage, as against the tuning of the same tank coil when the output winding is open and the stage is being used as a doubler. If, however, the slight additional time required to re-tune the tank is of less importance than economy, then, of course, the one unit can be made to serve double duty by means of a slight retuning operation.

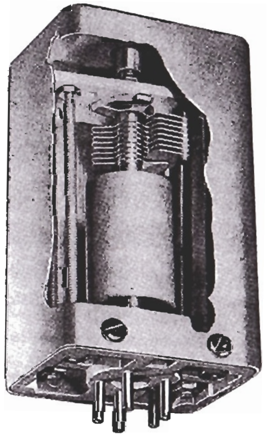
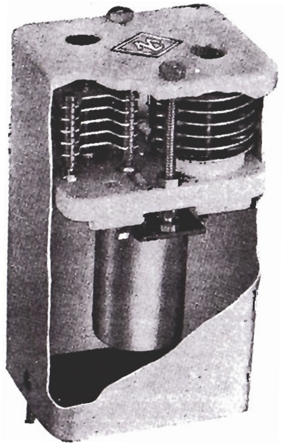


FIG. 12

*In addition to the exciter tank units of the style shown at the right, similar type units can be made up to fit particular requirements by mounting standard National ultra-midget condensers and XR-2 coil forms in the same size shield cans shown at the left. In addition, plug-in style bases are available which may be added to either of these units in order to form a plug-in type of tank circuit, which makes possible the design of an exciter which can be shifted from band to band by changing the removable pretuned tank units. An exciter employing such an arrangement is shown in the illustrations on pages 13 and 14.*



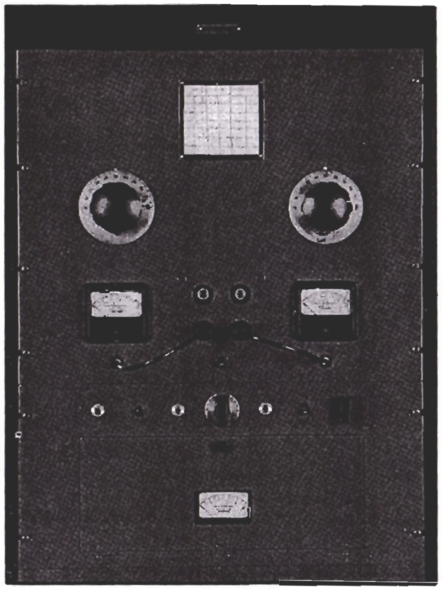


FIG. 13 — MODERNISTIC APPEARANCE CHARACTERIZES THE TRANSMITTER ASSEMBLY IN WHICH THE EXCITER IS MOUNTED BELOW THE BUFFER-FINAL UNIT

*A hinged panel opening gives quick access for changing the shielded plug-in coil units.*

Another circuit detail which, while neither new nor original is yet seldom seen in amateur equipment, is the method of using a dummy plug for switching the d.c. meter from one circuit to another, rather than the more general practice of conventional jacks with a plug-and-cord connected to the meter.

Another commercial trick for securing neat wiring is the use of dummy lugs, such as those between the r.f. chokes and the resistors. These handy little gadgets can be obtained from any radio dealer.

While commenting on wiring, it might be well to suggest that whenever a switch is mounted on the panel of the unit, such as the B-supply switch in this instance, a pair of terminals be located at some handy place in the rear and connected across the switch terminals so that should it be desirable at any time to control the switching by either an extension lead or a relay, it will not be necessary to remove the complete unit from the rack and half-disassemble it in order to delve into the interior to get at the switch contacts. This point is particularly applicable to power supplies, which, sooner or later, you will want to control either directly or by relays from a master switch on the operating table. After all, in our anxiety to get a new transmitter on the air, most of us at first have at least six switches to throw, in various parts of the room, before being able to shift from "send" to "receive." Sooner or later, however, we settle down to at least a brief spell of just plain operating, during which time we all take a little pride in seeing just how quickly we can shift.

In the rear view most of the wiring can be seen. There is a handy trick used by commercial companies for wiring jacks that is not generally understood by the average amateur; it is to prepare the leads and solder them to the jack contacts before mounting the jack in place. By so doing, the necessity for soldering in an awkward position is eliminated. It is also possible to skin and tin the wires so that the insulation comes right up to the contact and does so without being frayed or sloppy looking. The jack is then mounted in place, the leads run through the necessary bushings to their proper terminals and, if necessary, re-cut and skinned for soldering to the other pieces of apparatus which are invariably more conveniently located for neat soldering; as are, in this case, the socket terminals.

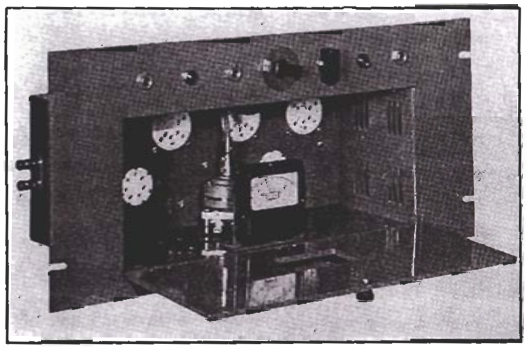


FIG. 14 — FRONT VIEW OF THE EXCITER UNIT WITH THE COILS REMOVED

*The dial in the center is the crystal gap control for varying frequency. A dummy plug is fitted into the four jacks for meter switching. Between the jacks at the left is the pilot light and between those at the right is the on-off toggle switch.*

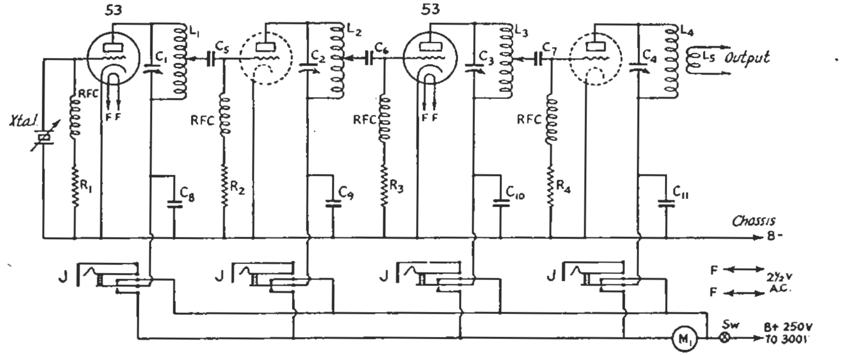


FIG. 15 — FOUR TUNED CIRCUITS WITH TWO DOUBLE-TRIODE TUBES ARE USED IN THE EXCITER CIRCUIT. THE TRIODE ELEMENTS ARE DIAGRAMMED SEPARATELY FOR CLARITY

*$L_1$, $L_2$, $L_3$, $L_4$ — Plate coils in shielded units (see coil table).*
*$L_5$ — Output link coil (see table).*
*$C_1$, $C_2$, $C_3$, $C_4$ — Two 35-µµfd. ultra-midget tuning condensers in parallel except for 28-Mc. (Included in National FXTB coil units — see text).*
*$C_5$, $C_6$, $C_7$ — 100-µµfd. mica condensers.*
*$C_8$, $C_9$, $C_{10}$, $C_{11}$ — p.01-µfd. mica condensers.*
*$R_1$, $R_2$, $R_3$, $R_4$ — 10,000-ohm 2-watt grid-leak resistors.*
*RFC — 2.5-millihenry r.f. chokes (National Type R-100).*
*$M_1$ — 0-50 d.c. milliammeter (Triplett).*

*The crystal is a special Hollister type in a National Type CHV Vari-Gap crystal holder.*

## FEATURES:

An effective, dependable circuit
Variable frequency control
Pre-tuned band shifting
Compactness
Universal application
Ease of construction
Relative low cost of component parts

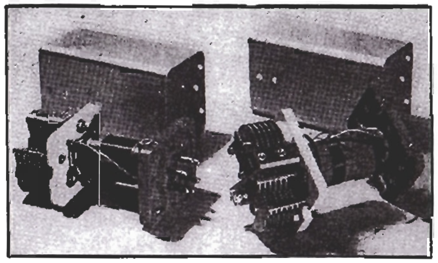


FIG. 16 — TWO OF THE COIL UNITS WITH THEIR SHIELDS REMOVED TO SHOW THE CONSTRUCTION

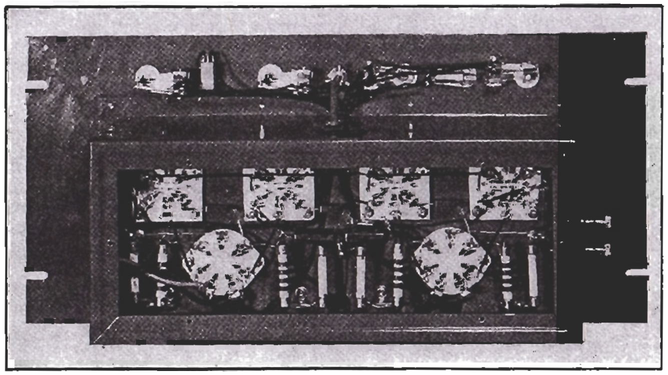


FIG. 17 — REAR VIEW OF THE UNIT WITH THE BACK AND THE DUST COVER OF THE CONTROLS REMOVED TO SHOW THE WIRING

COIL TABLE

| *Coil* | *$L_1$* | *$L_2$* | *$L_3$* | *$L_4$* | *$L_5$* |
|---|---|---|---|---|---|
| Band (Mc.) | 3.5 | 7 | 14 | 28 | |
| Coil form dia. | 1″ | 1″ | 1″ | 1″ | 1″ |
| Wire size | 28 enam. | 24 enam. | 24 enam. | 24 enam. | 20 d.s.c. |
| Turns per inch | 60 | 24 | 24 | 24 | |
| Turns | 35 | 20 | 9 | 5 | 2-turn link |
| Tap (turns from plate) | 13 | 4 | 4 | | |

# CRYSTAL HOLDERS

THERE are many different types and styles of crystal holders. Most used in amateur transmitters in the past has been the flat plate pressure type. The National holder of this style, the CHT, has as one of its unusual features, the arrangement for quick and easy changing of crystals which is quite an advantage to the station operator having a limited number of holders at his disposal. When the number of available crystals and holders are not limited, it is convenient to incorporate several in each exciter unit as already shown in several of the exciter illustrations on the preceding pages.

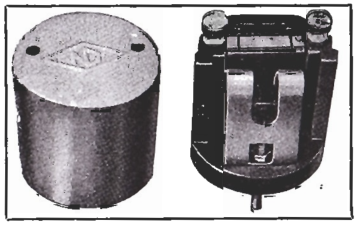


FIG. 18 — THE NATIONAL TYPE CHT CRYSTAL HOLDER MAY ALSO BE USED WITH SPACER BARS AS HERE SHOWN TO PROVIDE AN AIR-GAP TYPE OF MOUNTING

*In this instance, the crystal is one of the thick low-frequency resonator types used in the intermediate frequency amplifier of the single signal type of super-heterodyne. The spacer bars are made of glass ground to size, and provide, in this case, an air gap of .002″.*

A more compact and less expensive arrangement is the new type multiple holder in which four holders with selector switch have been combined into a single unit. While provided with a plug-in base for mounting in a standard five prong tube socket, the unit may also be single hole panel mounted. In many ways this latter is the most preferable arrangement in that the selection switch is easily accessible. When so mounted, connections are made directly to the ends of the plug prongs.

In the photograph below will be discerned the thermal bar against which all four of the crystals are mounted, as well as the low-capacity switch which makes the action of any one crystal completely independent of the others.

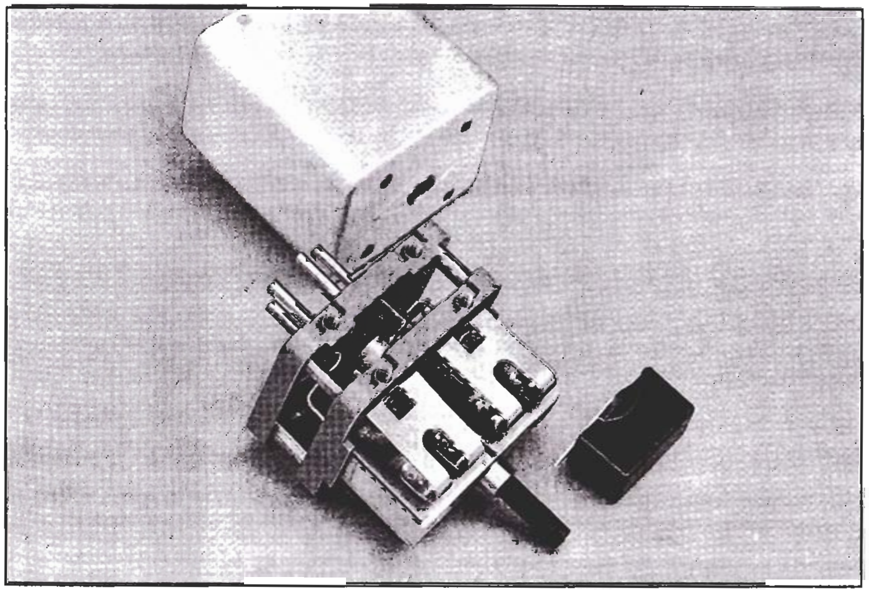


FIG. 19 — THE SAME GENERAL TYPE CONSTRUCTION IS EMPLOYED IN THE NATIONAL FOUR-CRYSTAL MULTIPLE HOLDER AS IN THE TYPE CHT SINGLE UNIT

# *Variable Frequency* CRYSTALS

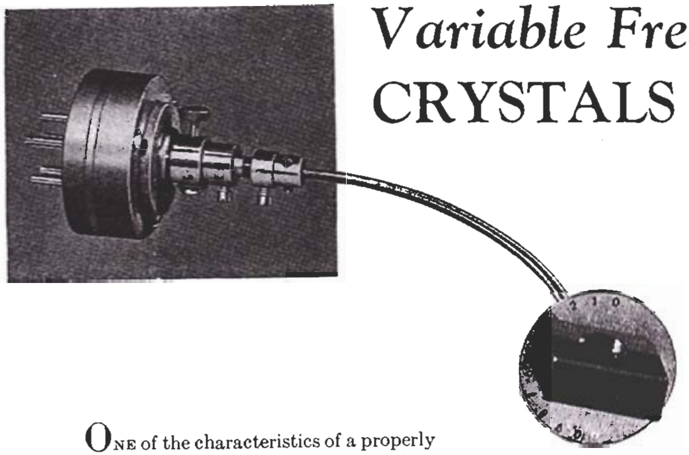


FIG. 20—THE NATIONAL VARI-GAP HOLDER

ONE of the characteristics of a properly finished A-cut crystal is its ability to oscillate with uniform output as the air gap of the holder is varied through a reasonable range. By taking advantage of this principle, it has been possible to develop the type holder illustrated in Fig. 20. Fig. 21 shows an average performance curve. In the commercial model, the air gap is varied by means of a special shaped cam, resulting in practically a straight line frequency tuning curve. The outstanding advantage of a "variable frequency" crystal-control arrangement is, of course, the ease with which minor frequency shifts can be readily made without the danger of going outside of the band limits. Not only is this valuable in avoiding heterodynes, but also in calling a station with which a definite schedule has not been previously made.

The Hollister crystals furnished with the National vari-gap holders are normally ground for a fundamental frequency in the 3900–4000-kc. band. As the frequency range is one part in 600, the range of any one unit at the fundamental frequency is approximately 6 kc. In the 20-meter 'phone band this means a range of 24 kc. and in the 28-Mc. band, a range of approximately 48 kc.!! In actual operation this range is wide enough to permit evasion of heterodyne interference, and still not so wide that out-of-band operation becomes a hazard.

It is important that a carefully ground low-drift type crystal of proper design be used with the mounting described. Many crystals have been found to oscillate smoothly with an air-gap of more than three times the crystal thickness, while some crystals apparently good enough for use in contact-type holders have flatly refused to coöperate in the air-gap mounting.

The standard 5-prong type base is furnished with the vari-gap crystal holder so that it may be readily plugged into any conventional exciter unit in place of a standard crystal holder. When so used, it may frequently be desirable to remove the flexible drift shaft and fasten the dial directly to the control shaft at the top of the holder.

In the transmitter shown in Figure 28 on page 23 will be seen such an application.

A locking screw is also provided so that the frequency adjustment may be locked at any given setting whenever it is desired to use the unit for fixed frequency operation.

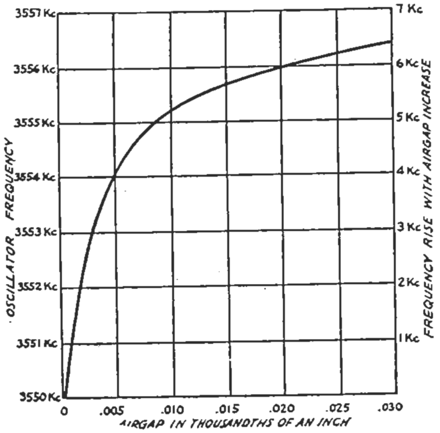


FIG. 21—OSCILLATOR OUTPUT POWER REMAINS PRACTICALLY CONSTANT OVER A FREQUENCY RANGE OF 6 KC. WITH A 3550-KC. CRYSTAL

# FINAL STAGES

UNDER just what classification belong the "buffer" stage or stages is, generally rather a moot point. In some cases the buffer is physically, at least, built right into the exciter, as in the case of the W9DRD unit on page 10. Then again it is built into the final stage assembly as in the transmitter on page 25. Of course, there are many instances also, such as in the transmitter on page 41 when the buffer rates a separate panel of its own.

Having already been partially treated in some of the exciters just described and about to be treated more fully in connection with the complete transmitter descriptions soon to follow we will drop further mention of buffer stages herewith and pass on to a few notes and comments on Final Output Stages.

Aside from symmetry of layout, which is desirable from the standpoint of ease of neutralization, and of proper placing of the grid and plate tank circuits from an interaction angle, the one most generally neglected, and yet most important part of a final power amplifier design is the output tank circuit.

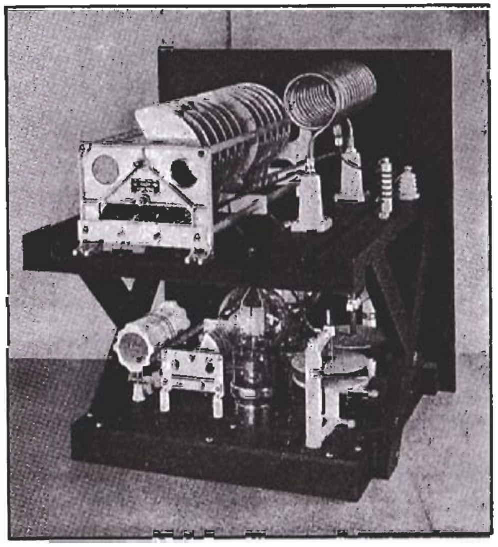


FIG. 22 — A REAR VIEW OF THE HIGH-POWER PUSH-PULL AMPLIFIER

*This view shows the arrangement of the tubes and circuit elements. Filament bypass condensers and power wiring are underneath the base.*

Unfortunately, an oscillatory circuit is quite complicated mathematically. Radio textbooks explain such calculations in detail, but amateurs can hardly be blamed for resorting to "rule-of-thumb." After all, amateur radio is a hobby, not a course of mathematics.

As a matter of fact, "rule-of-thumb" does very well when it is guided by experience and followed by skilful adjustment. Judging from the letters we receive, however, there is no general agreement as to the best type of circuit or the proper $\frac{L}{C}$ ratio. We do not wish to become involved in highly technical discussions or mathematics on this page, but we are going to try to clear up some of the confusion regarding the proper $\frac{L}{C}$ ratio in final amplifier plate tank circuits.

We are on safe ground in saying that the impedance of the plate circuit should be high, since this permits the tube to operate at highest efficiency. This impedance equals $\frac{L}{RC}$ approximately. Therefore, for any given coil efficiency ("Q"), we may conclude that the impedance increases as L increases, and that the tank circuit having the lowest capacity has the highest efficiency.

The above statements apply particularly to unloaded circuits. When the circuit is loaded, another consideration enters, namely storage capacity (or flywheel effect, if you prefer). To make this clear, suppose a single tube, Class C, is driving a loaded parallel resonant circuit. Once each cycle, the tube will supply a short pulse of power to the oscillating circuit. The circuit, however, must supply power steadily to the load, throughout the entire cycle. Obviously then, the storage capacity must be large compared to the peak input per cycle, or poor waveform and unsatisfactory operation will result. As the tube bias is decreased, the driving impulses will become of longer duration and less storage is needed. When grid bias is decreased to Class B conditions, the input power will be supplied over an entire half cycle and the $\frac{L}{C}$ ratio may be safely doubled as compared to Class C. Going one step further, push-pull Class A or B gives power over the entire cycle, and the $\frac{L}{C}$ ratio may be increased to perhaps eight times the Class C value.

Other things being equal, the power output is proportional to the plate current. Therefore if the plate current is doubled, the energy storage should be doubled, which means that the $\frac{L}{C}$ ratio should be ¼ as high. (Double capacity, one half inductance.) Similarly, double plate voltage also requires double the energy storage. But since doubling the plate voltage doubles the oscillatory voltage, the storage capacity is automatically increased four times. Therefore doubling plate voltage permits using an $\frac{L}{C}$ ratio four times as high. (Double inductance, one half capacity.)

It is a simple matter to summarize the foregoing principles, combining them in a formula which is based upon past experience

$$\frac{I_{\text{ma}}}{E_{\text{volts}} \times \text{Freq.}_{\text{mc}}} \times K = \text{Tank Condenser Capacity (mmf.)}$$

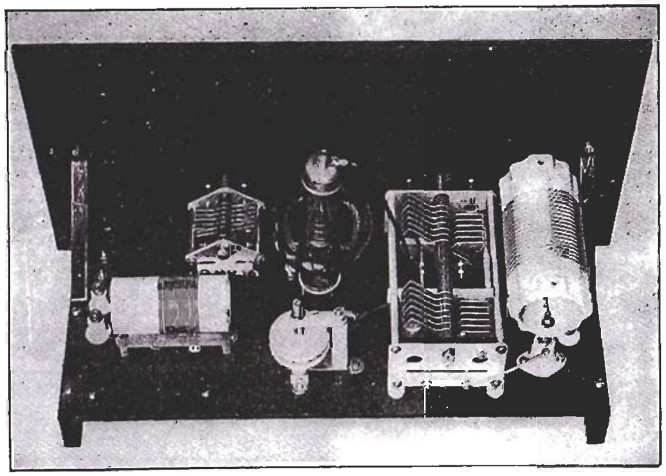


FIG. 23 — A SINGLE-TUBE HIGH-FREQUENCY AMPLIFIER OF MEDIUM POWER

*For use on 7, 14 and 28 mc. This unit can be used with either a 50T or RK36. Plug-in coils, wound on manufactured forms, are used for changing bands. Condensers are mounted to bring the shafts out symmetrically on the front panel.*

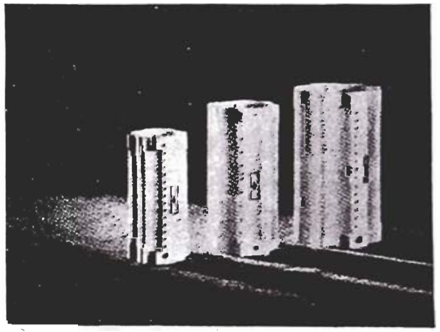
"K" will depend upon the type of transmitter, as follows:

| | |
|---|---|
| Single ended c.w. | K=2600 |
| Single ended Phone | K=5200 |
| Push-Pull c.w. | K=650 |
| Push-Pull Phone | K=1300 |

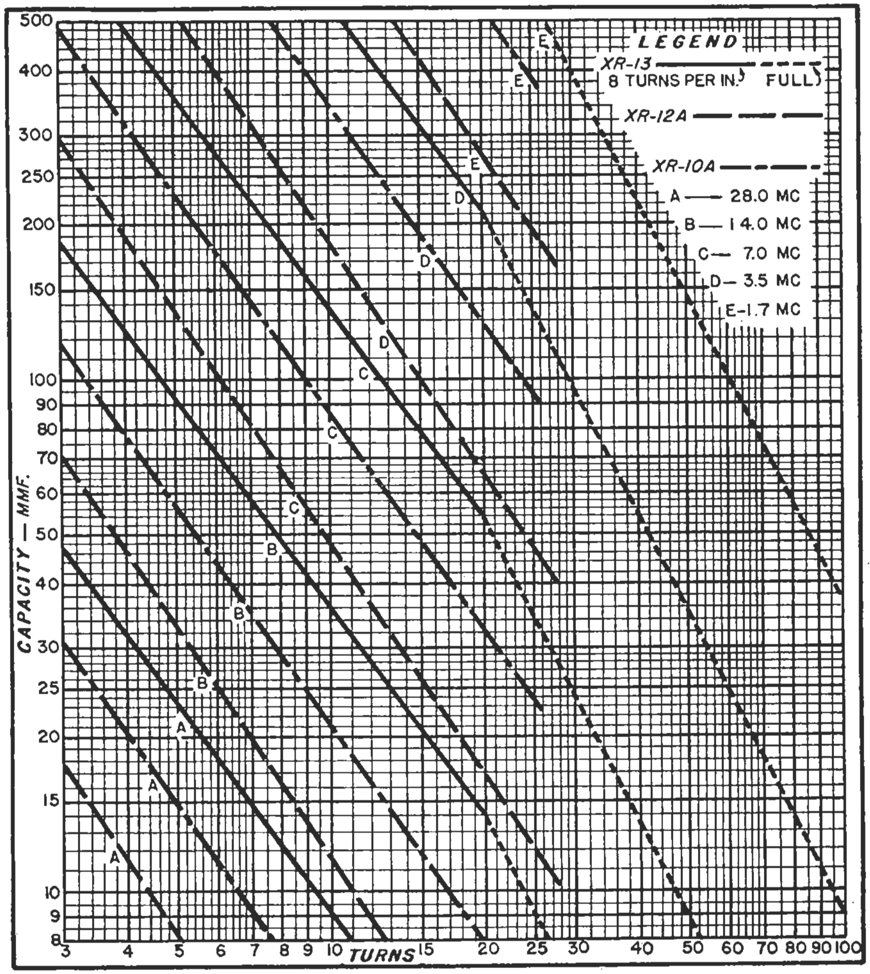
While we do not claim any great accuracy for this formula, we believe the information it gives will help the amateur in building a new transmitter, or in obtaining better performance from his present rig.

Perhaps at this point it might be well to digress for just a moment, and comment on bias supplies. The normal practice in the average low-power amateur transmitter is to use grid-leak bias. It is convenient and inexpensive. In larger transmitters, however, such practice is hazardous. Should, for any reason, the excitation fail, considerable damage to the tubes and associated equipment will undoubtedly result. To use a complete battery bias supply is frequently awkward and expensive. A practical compromise is to use a combination of both, employing just sufficient battery voltage to reduce the plate current to the final stage to a sufficiently low value, should excitation fail, to prevent damage for the few moments that this plate current will be flowing before the operator can cut off the high voltage supply. In the case of the large transmitter at W1HRX, we use the DC exciter voltage to the high voltage generator for this purpose, inasmuch as the output of the exciter generator is approximately 250 volts.

But now let us get back again to this business of L C ratios.



# CAPACITY *versus* TURNS



The chart above will prove a convenient means for determining the correct coil form and number of turns of wire to use with the calculated capacity. There are five groups of curves (one for each ham band) plotted for three of our coil forms. The XR-13 is our 1¾″ dia. Buffer Coil Form, the XR-12A (4″ dia.) and the XR-10A (2½″ dia.) are our Transmitter Coil Forms. As an example of the use of the chart, suppose the calculated capacity is 60 mmf. and the operating frequency of the rig is to be 7 megacycles. Then for this frequency we refer to group "C" of the curves and at this capacity we find that the XR-12A requires 8 turns, the XR-10A requires 13 turns and the XR-13 requires 18 turns (wound 8 turns to the inch). If the transmitter is to be operated only on one band, the type of coil form will be determined by individual requirements. However if plug-in coils are to be used then it will be convenient to use only one type of form throughout. The best type can be determined by calculating the capacity required for each frequency and by referring to the chart to see which coil form can be used in all cases.

There is one thing to remember when selecting the tank condenser; the chart capacities are the sum of the tube, wiring and the tank condenser capacities.

Having arrived at the design of the output tank circuit, the next question is the mounting. Few indeed are the variable condensers designed with a view toward simplifying the work of the transmitter constructor with limited shop facilities. Just recently, however, a complete line of mounting lugs, brackets, and jack strips have been designed by National for use with their line of transmitting inductance forms and transmitting condensers so that these two units which have been designed to work together electrically may also be easily used together mechanically. An ideal application of one of these combination coil-condenser units is shown in the transmitter on page 25. In addition to their use in forming tank circuits, they may also be used in combination, as shown at the centre top of the illustration, to form a compact Everett type of antenna filter network.

In the accompanying illustration, it will be noted that the smaller UR-13 Isolantite coil form is not threaded as are the larger sizes. The surface of this coil form is quite rough, and as normally it is wound with smaller sized wires, it was found generally more convenient to have an unthreaded surface so that coils with different pitch of winding can be readily constructed. Whether the wire be silk-covered or just plain enamel, it can be rigidly held in place if the finished coil is given a good coat of National Coil Dope. ("National liquid Victron" is made by dissolving the scrap Victron accumulated from production of One-Ten receivers, etc., in Victron solvent. As this cement contains no other impurities, it has an extremely low loss factor.)

When mounting any type of ceramics whether they be transmitter coil forms, stand-off insulators, ceramic mounting strips, etc., it is well to use a small cardboard, fiber, or cork washer under the head of each screw. By so doing, it is possible to tighten up on the screw just as if it were being used on metal without danger of damaging the ceramic. The ceramic in itself is generally of ample strength provided the pressure exerted by the screw head is uniformly distributed. The washer serves this purpose and prevents excess pressure on a single point.

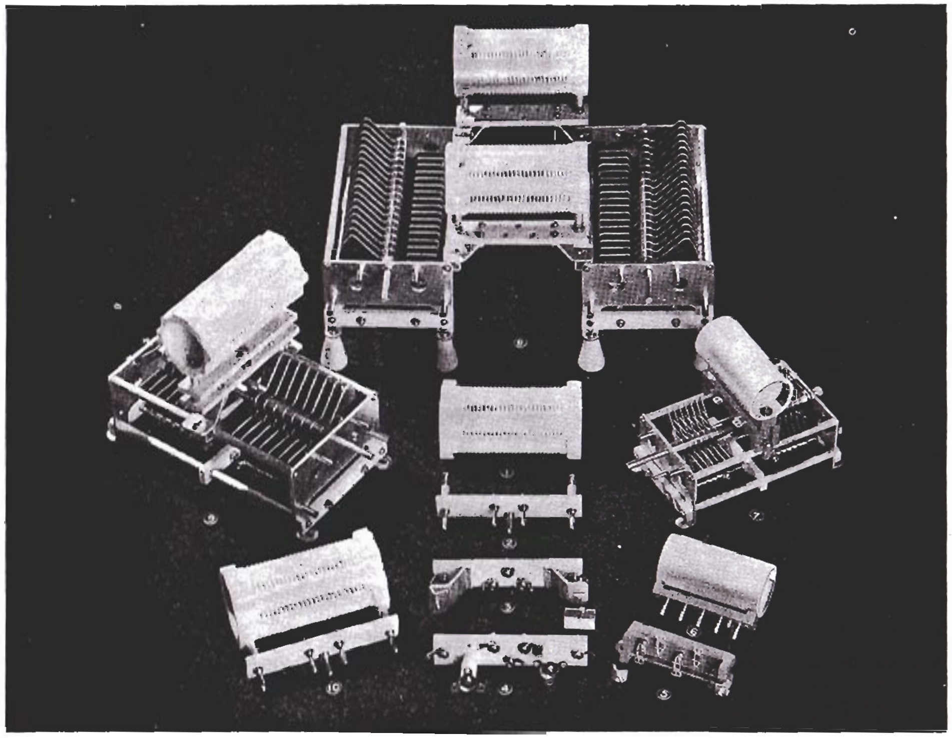


FIG. 24. — AT THE LEFT IS THE XR-10A FORM MOUNTED ON THE FRAME OF A TYPE TMA NATIONAL CONDENSER, WHILE AT THE RIGHT IS THE XR-13 COIL FORM AND TYPE TMC CONDENSER

*Plug-in mounting strips are shown in both of these applications.*

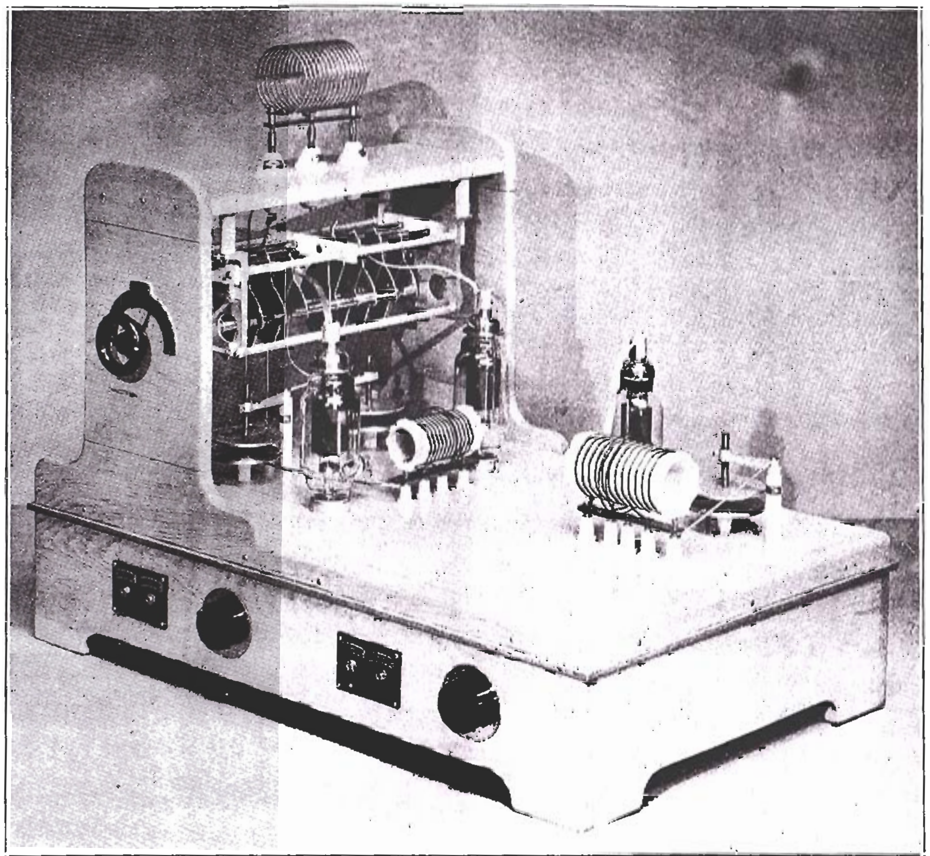


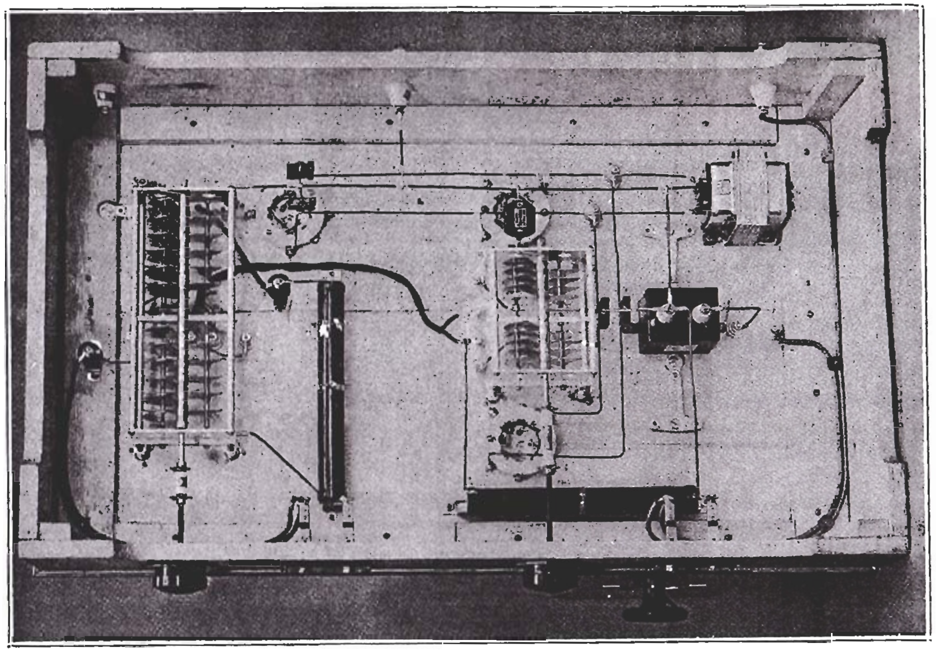
FIG. 25

# Some Complete TRANSMITTERS

Frequently it is desirable to build a complete transmitter as a single unit, rather than as an assembly of such individual units as exciters, buffers, and final amplifiers. An interesting example of such construction is the outfit at W6QD, illustrated herewith. The construction used differs from the conventional breadboard layouts of the past, in that many of the component parts are mounted on different levels so as to shorten the leads and thus provide a more compact, symmetrical, and efficient layout.

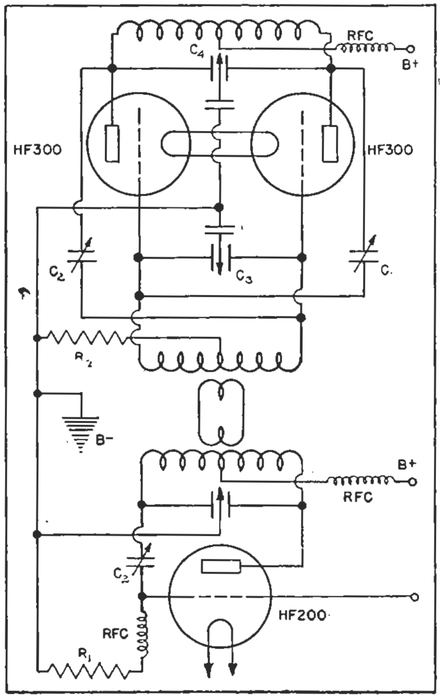
By means of plug-in coils this one kilowatt outfit is easily shifted between the 20- and 40-meter c.w. bands, upon which W6QD confines its operation. The addition of suitable coils and modulation equipment will make the transmitter equally effective upon the 10- and 20-meter 'phone bands.

A pair of Amperex HF-300's are used in push-pull in the final stage and normally operated at a plate voltage of 2800 to secure an input of exactly one kilowatt. The final tank circuit comprises an air-wound inductance, mounted with plugs and jacks supported with National XS-2 high-frequency bushings. The capacitor is the large National type TML-30DE, having a breakdown voltage rating of 20,000 and a capacity of 30 mmf. per section. Type NC-150 neutralizing condensers are used in both the buffer and final stages. Link coupling is used between the buffer and the final stage, and the link-coupling coils are so constructed, as will be seen from the photo, as to



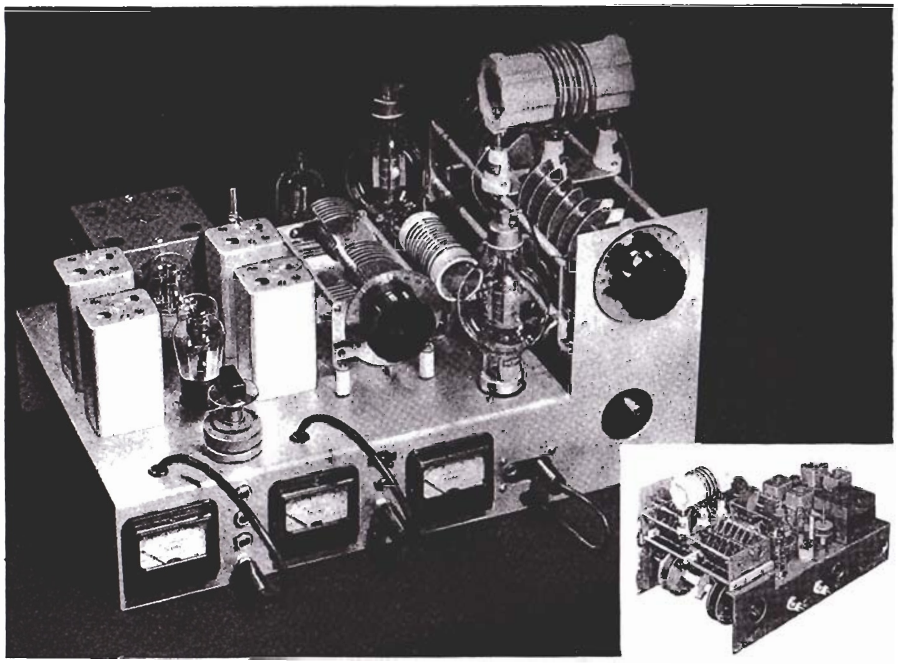
remain in position when the plug-in inductors are changed.

An amplifier in which such care has been used to secure symmetrical mechanical layout in the final stage, even to the smallest details, as in the case of the W6QD transmitter, will be found to work well at the higher frequencies, particularly on the 10-meter band, when others which have been indifferently designed in this connection give trouble. Symmetry of design of the output stage, in particular, has been given extremely careful consideration in all of the transmitters described and illustrated in this booklet.



FIGS. 26 AND 27

*In the under-view of the W6QD transmitter shown above, will be noted how the two type TMA transmitting condensers, which are operated "above ground," are insulated from the base by small GS-1 stand-offs. They are also insulated from the dial drives by means of the National TX-1 and TX-2 Isolantite insulated couplings. By being so insulated, as well as so located beneath the sub-base, there is little danger of anyone coming into contact with them.*

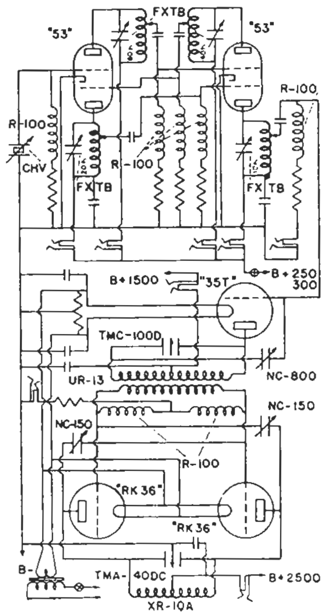


*FIGS. 28, 29, 30*

Following the thought originated in connection with the W6QD transmitter of the preceding pages, we have, in designing the one shown herewith, gone a step further and incorporated not only the entire exciter, including the variable frequency crystal holder, but also the filament feeding transformer in a single compact one-half kilowatt outfit. Meter economy is secured by providing jacks and plugs for switching the meters between different plate and grid circuits. The exciter uses two 53 tubes in the "crisscross" circuit arrangement, to which we have previously referred. Using a 75-meter crystal, the output from the last section of the second 53 is ample to drive the 35T Eimac high-mu triode used as a buffer. This tube, in turn, can fully drive a pair of RK-36's, even with 600-watt input.

This particular transmitter has been operated a great deal on the 10-meter 'phone band and found to be particularly well adapted to such high-frequency operation. In this design, as in the case of the previous one, great care has been exercised to secure symmetry of mechanical arrangement in the final stage.

The scheme of mounting the filament transformer directly on the chassis of a transmitter of this type has been found to be extremely worth while in eliminating long leads carrying heavy



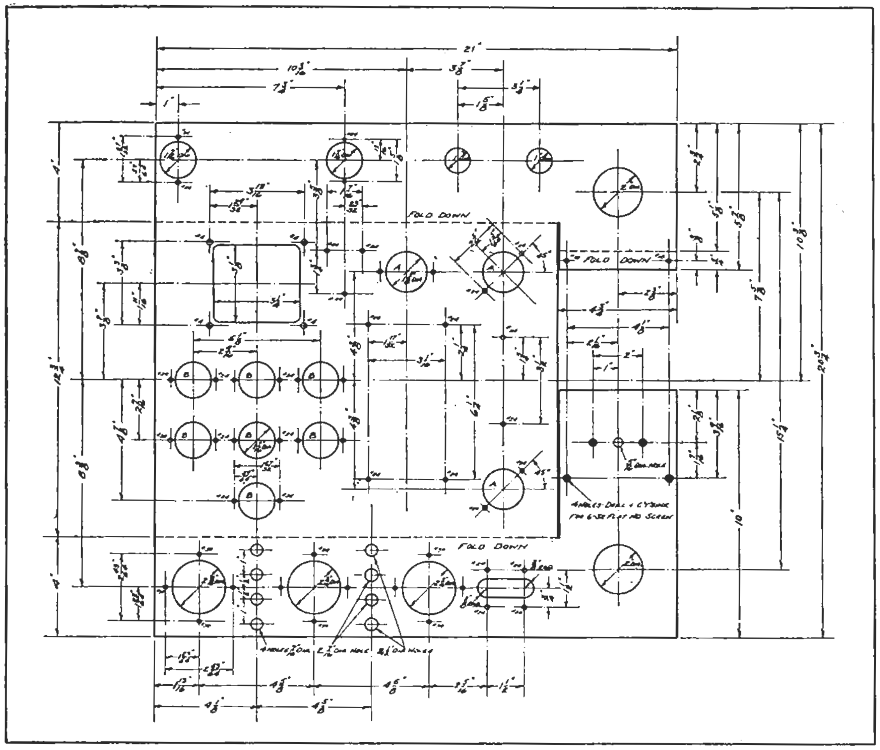


FIG. 31

currents. The chassis itself is cut and formed from a single sheet of one-sixteenth inch half-hard aluminum. Fig. 31 gives the essential construction details. By forming the chassis in the manner indicated, mounting brackets for the final stage tank condenser are eliminated. A bracket made from sheet aluminum is, however, required for suspending the NC-150 neutralizing condensers of the final stage.

### Parts List

| | |
|---|---|
| 4 | National Isolantite 5-prong sockets |
| 2 | " Isolantite 7-prong (large) sockets |
| 1 | " Isolantite 4-prong socket |
| 3 | " Isolantite XM-10 sockets |
| 2 | " NC-150 neutralizing condensers |
| 1 | " NC-800 neutralizing condenser |
| 1 | " TMA-40DC condenser |
| 1 | " TMC-100D condenser |
| 2 | " Type 0 No. 2 dials |
| 1 | " UR-10A coil form assembly |
| 1 | " UR-13 coil form assembly |
| 1 | " CH-V Vari-gap crystal holder — with Hollister crystal |
| 4 | National FXTB 5-prong fixed tuned exciter tanks |
| 7 | " R-100 chokes |
| 4 | " GS-1 Stand-off insulators |
| 4 | " No. 12 Grid-grip clips |
| 1 | " Type 38 filament transformer |
| 8 | Three-way 'phone jacks |
| 2 | S.P.S.T. Toggle switches |
| 2 | triplett meters — Type No. 326 — 0–50 mils. |
| 1 | " " — Type No. 326 — 0–300 mils. |
| 1 | Aerovox Type 1883 condenser — .001 mfd. — 7000 volts |
| 1 | " " 1882 condenser — .001 mfd. — 3500 volts |
| 2 | " " 1450 condenser — .01 mfd. |
| 4 | " " 1465 " — .0001 mfd. |
| 1 | 60-ohm center-tapped resistor |
| 5 | 20,000-ohm resistors — 2-watt |
| 2 | Tubular condensers — .1 mfd. — 400 volts |

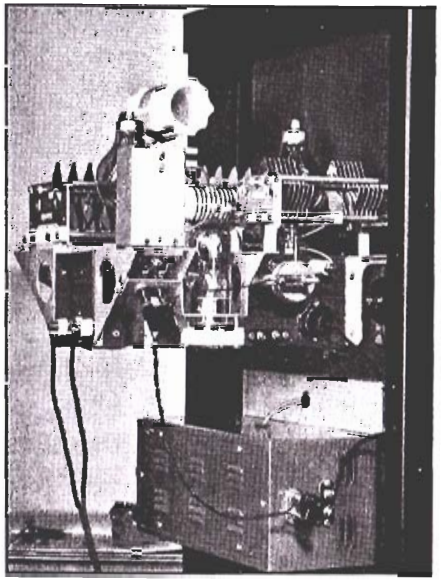
Feeling that it really takes no more time to do a good mechanical job in the first place than the more usual rag-time one, it is the particular intent herewith to illustrate and comment upon the mechanical rather than the electrical design features of a moderate-power r.f. final amplifier recently designed for use with a companion exciter unit (see pages 13 and 14) to form a complete one-half kilowatt 'phone transmitter. Consequently, we will use more than the customary number of photographic illustrations and devote less space to circuit comments and description. Particularly interesting should be the views taken prior to wiring and panel mounting.

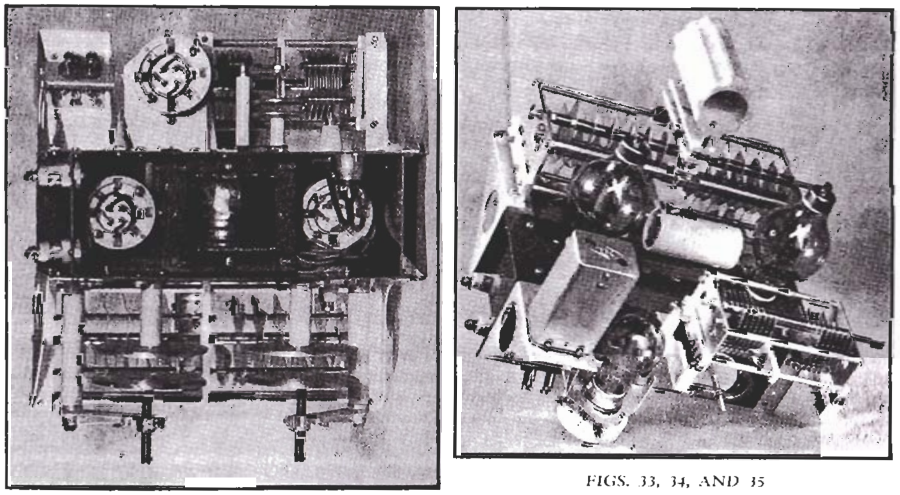
Structurally, the transmitter is built around the central steel chassis of U-frame, under which is mounted the filament transformer and the RK-38 sockets, and to the sides of which are attached the aluminum brackets carrying the relatively lightweight r.f. components, such as the two variable condensers, the neutralizing condensers, input tank circuit, and the buffer tube socket. This chassis unit is illustrated in Figs. 33, 35 and 38, without wiring and without mounting of the front panel, in order to illustrate the simplicity and neatness of this type of construction.

Perhaps at this time it may be well to point out some of the constructional details that contribute much to the neat final appearance of the complete unit. Most prominent in this connection are, of course, the aluminum brackets carrying the variable condensers; actually, it takes very little, if any, more labor on the part of the constructor to form-up the type of brackets shown from sheet aluminum in an ordinary vise, than it does to bend up strip stock in the more normal manner. The round holes cut in the two rear brackets add much to the appearance and little to the labor, as holes of this size are very easily cut in aluminum with an ordinary trepanning tool or fly-cutter.

By mounting the filament transformer in the manner shown, not only is its relatively heavy weight supported by the strongest part of the chassis, but extremely short leads also result.

Coupling between the exciter and this amplifier is by means of a low-impedance link with a pre-tuned plug-in tank, mounted adjacent to the buffer tube on the amplifier chassis.





FIGS. 33, 34, AND 35

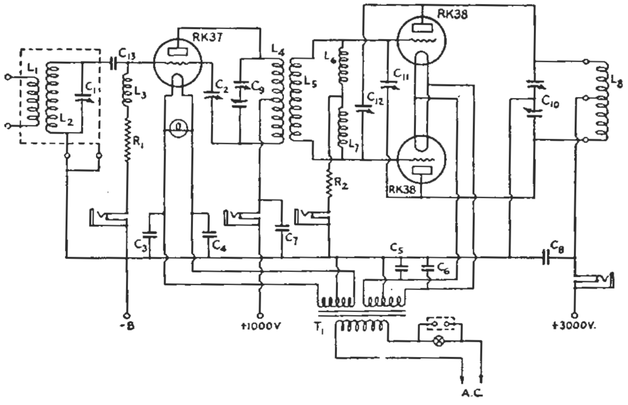
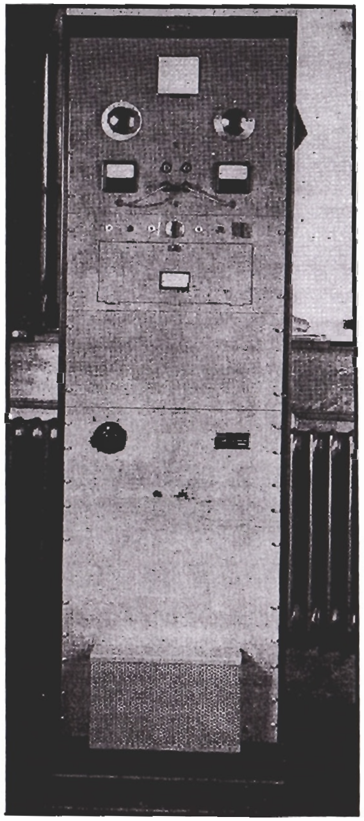
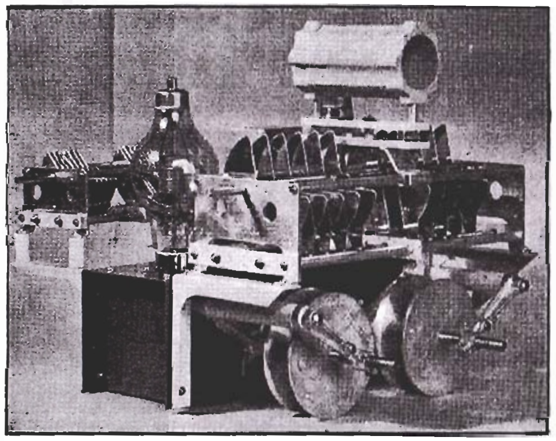


FIG. 36—CIRCUIT DIAGRAM OF THE 20-10-METER DRIVER-AMPLIFIER

*$C_1$ — 50-μμfd. variable (National FXTB, units connected in parallel).*
*$C_2$ — Neutralizing condenser (National NC-800).*
*$C_3$, $C_4$, $C_5$, $C_6$, $C_7$, $C_8$ — 0.01-μfd. mica (Aerovox).*
*$C_9$ — Split-stator, 100 μμfd. per sction, 0.077-inch airgap (National TMC-100D).*
*$C_{10}$ — Split-stator, 40 μμfd. per section, 0.359-inch airgap (National TMA-40DC).*
*$C_{11}$, $C_{12}$ — Neutralizing condensers (National NC-150*
*$R_1$ — 20,000 ohms, 2 watts.*
*$R_2$ — 12,000 ohms, 10 watts.*
*$T_1$ — Filament transformer, 5 volts, 16 amps., and 7.5 volts, 3.25 amps.*
*$L_3$, $L_6$, $L_7$ — Short-wave chokes (National R-100).*





FIGS. 37 AND 38

COIL DATA

*$L_1$ — 28 Mc., 2 turns; 14 Mc., 3 turns; both No. 24 d.s.c. wire.*
*$L_2$ — 28 Mc., 5 turns; 14 Mc., 10 turns; No. 20 enameled, spaced 20 turns per inch.*
*$L_4$ — 28 Mc., 6 turns No. 16, 2 turns per inch, c.t.*
*14 Mc., 16 turns No. 14 enameled, 6 turns per inch, c.t.*
*$L_5$ — 28 Mc., 5 turns No. 16, interwound with $L_4$.*
*14 Mc., 13 turns No. 14, 5 turns per inch.*
*$L_8$ — 28 Mc., 4 turns No. 10 enameled, 4 turns per inch.*
*14 Mc., 12 turns No. 10 enameled, 7 turns per inch.*
*Note: $L_1$ and $L_2$ wound on 1-inch diameter forms (in FXTB unit).*
*$L_4$ and $L_5$ — wound on 1¾-inch diameter Isolantite forms (National UR-13 unit).*
*$L_8$ wound on ceramic form 2½ inches in diameter (National UR-10A unit).*

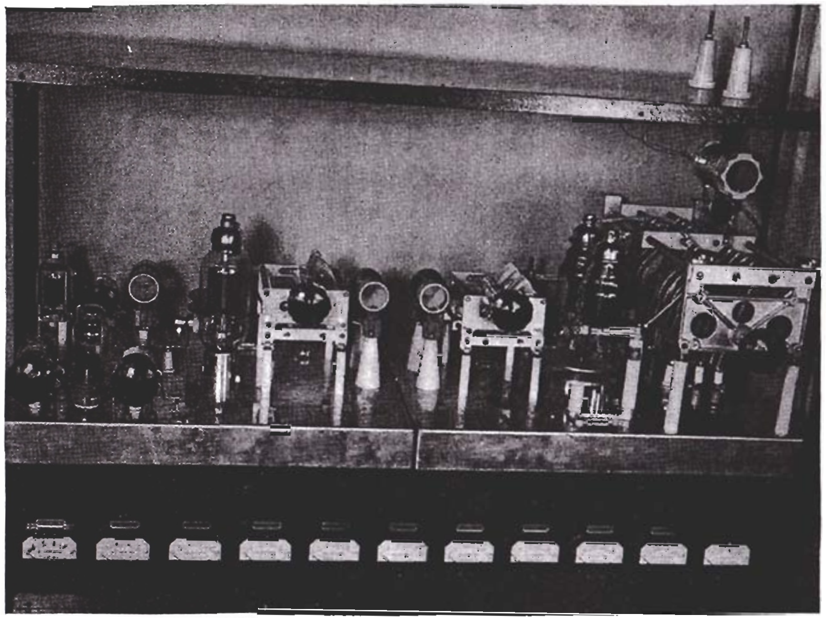


FIG. 39—THE COMPLETE R.F. SECTION OF THE ONE-KILOWATT TRANSMITTER AT W6ABF

The illustrations on this page show the semi-breadboard style of construction used by W6ABF in a newly completed one-kilowatt 20-meter 'phone transmitter. The layout is quite straightforward. The exciter-buffer unit at the left is link-coupled to the final amplifier at the right. A National vari-gap crystal holder can be seen in the left-hand front corner. All of the meters for the transmitter are located on the panel, directly below the shelf containing the R.F. section. Modulator and power supply are below the meters. The diagram below shows the tube line-up.

**Principal Parts**

| | | |
|---|---|---|
| 1 | National | TML-50DB+ condenser |
| 2 | " | TMA-50DA condensers |
| 2 | " | TMS condensers |
| 1 | " | NC-800 neutralizing condensers |
| 3 | " | NC-150 neutralizing condensers |
| 1 | " | Vari-gap crystal holder with Hollister crystal |
| 3 | " | UR-13 coil form assemblies |
| 1 | " | XR-10A coil form assembly |
| 4 | " | R-100 chokes |
| 1 | " | R-154 choke |

Miscellaneous national isolantite sockets, stand-off insulators, etc., etc.

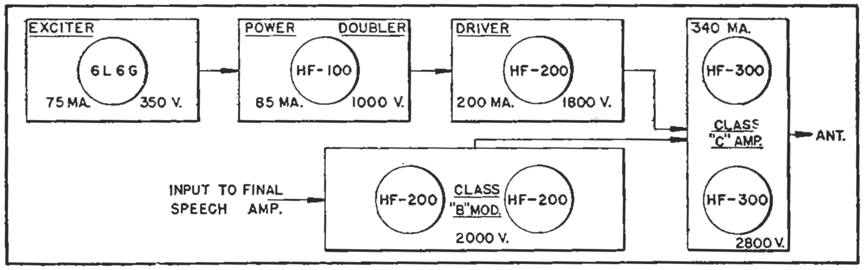


FIG. 40

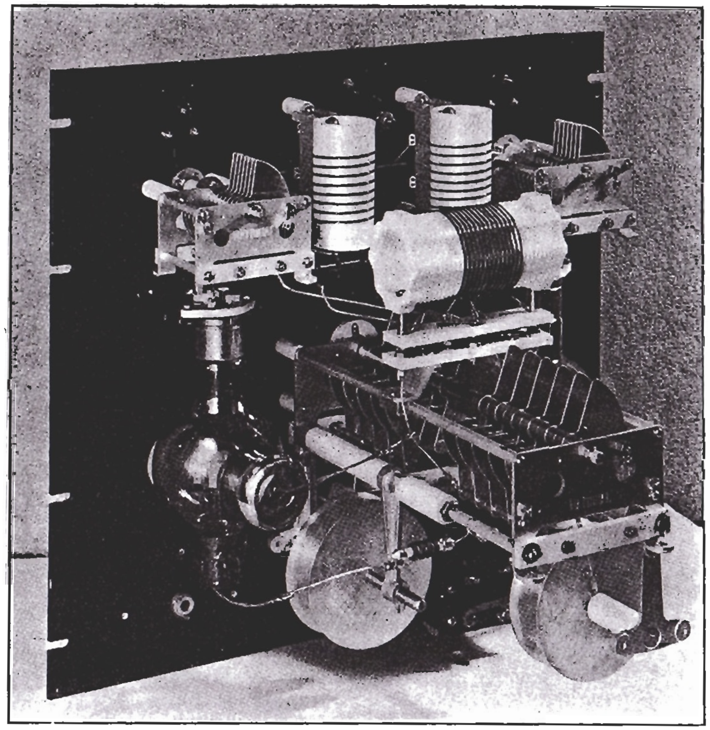


FIG. 42 — A VERY UNUSUAL LAYOUT FOR AN 852 POWER AMPLIFIER

*Note the symmetrical parts arrangement, compactness, and short leads.*

One of the most generally used tubes in medium-powered amateur phone transmitters is the 852. Here is shown a rather unusual, but most effective layout for a 600-watt Class C amplifier and antenna tuning network designed to use a pair of 852s. A careful study of the illustration will show how two standard National NC-150 Neutralizing Condensers have been combined with a National Type TMA-40DC split stator transmitting condenser and an UR-10A tank form into a single unit. By mounting a tube upside down at each side of this single RF unit, the entire amplifier practically completes itself. The filament transformer is mounted on the back of the front panel, just below the plate tuning condenser. In the illustration it can be seen between the two neutralizing condensers.

The antenna tuning network comprises a pair of TMC-100 Condensers and a pair of UR-13 Inductance forms. RF Chokes (R-100s) are used in the grid circuit as this amplifier was designed for capacity coupling of the grids directly to the output circuit of an RK-28 buffer, mounted on the "panel below" in the relay rack. An RK-28 was selected for this purpose rather than an RK-20 (which would have furnished sufficient driving power) as it may be operated directly from the same high-voltage power supply (3000 V) as the 852s without power loss in dropping resistors. The suppressor of the RK-28 is then operated slightly negative rather than heavily positive, so as to reduce the output to the required level and thus reduce the plate current and consequently the load on the power supply unit.

Also note how all of the variable condensers are insulated from the front panel with National GS-1 stand-off insulators. In using the GS-1 stand-offs in this manner it is more convenient to remove the standard hardware and just employ the Isolantite pieces. TX-1 Isolantite Insulated Couplings are used on the drive shafts.

The panel is a standard 19" x 3/16" x 17¼" aluminum relay rack style. On the front, in addition to the three type O dials, for the three variable condensers, are three meters for indicating plate, grid, and antenna currents.

In the illustration, it is rather difficult to see what holds the sockets in place. Actually they are suspended from small brackets mounted directly on the back of the front panel. They are painted black, however, and consequently are not readily discernible in the illustration.

The main transmitter in use at W1HRX at present is a 1-KW. 20-meter 'phone unit with a pair of W.E. 251As in the final, modulated with a pair of RCA 851s in Class A-B. This final amplifier, illustrated herewith, is driven by the lower-power RK-20 transmitter, described on page 40. When so used, the suppressor bias of this smaller transmitter is changed, of course, from negative to positive and the suppressor-modulating amplifier shifted to the input of the 851 Class AB audio stage. Link-coupling is used between the plate coil of the RK-20 push-pull stage and the grid coil of the 251A push-pull final stage. The RK-20s supply ample RF power to properly drive the 251As in this type of application.

As the mechanical construction features are a little unusual, we are showing several views.

The relay rack front panels carry all of the "behind the panel" structures. The RF and the modulator panels are separate units. The supporting framework of the RF section is made of ¾" duralium angle. The "sockets" for the 251As are homemade from standard fuse clips, National Grid Grips and some of the Isolantite insulating bars made for the Type TML condensers, but also sold separately. The filament transformers are located close to the filament contacts of the tubes to provide leads as short as possible for the heavy AC filament heating current. Quarter-inch copper tubing is used for filament leads and the volt meters are connected directly to the socket terminals. Both the plate and grid coils are "plug-in," as this same amplifier is used at times on the 10- and 75-meter 'phone bands in addition to 20.

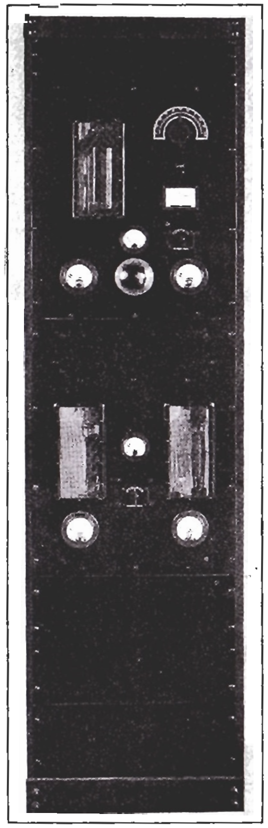


FIG. 43 — FRONT VIEW OF THE 1-KW. AMPLIFIER-MODULATOR

*The two small indicators are the controls for the filament transformer primary tap switches.*

The two NC-500 neutralizing condensers are suspended on a strip of aluminum formed in channel fashion for rigidity and suspended on brackets directly beneath the TML-40DC final tank condenser. The final tank coil is self-supporting, and constructed from ¼" copper tubing. It is fitted with the large size General Radio banana plugs for plugging directly into jacks on a strip of Micalex mounted on top of the condenser. This location of the final tank coil, in addition to being close to its associated condenser, also places it free and clear of any surrounding objects that might introduce dielectric losses. It is also out in the open where it may quickly and easily be changed in band shifting.

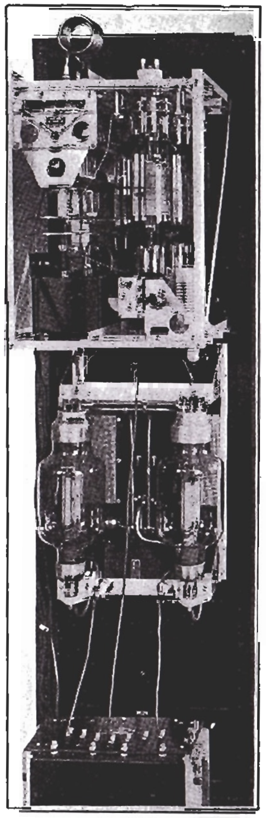


FIG. 44 — A REAR VIEW OF THE KW. AMPLIFIER-MODULATOR

*The transformer at the bottom is not a pole pig but the audio coupling transformer!*

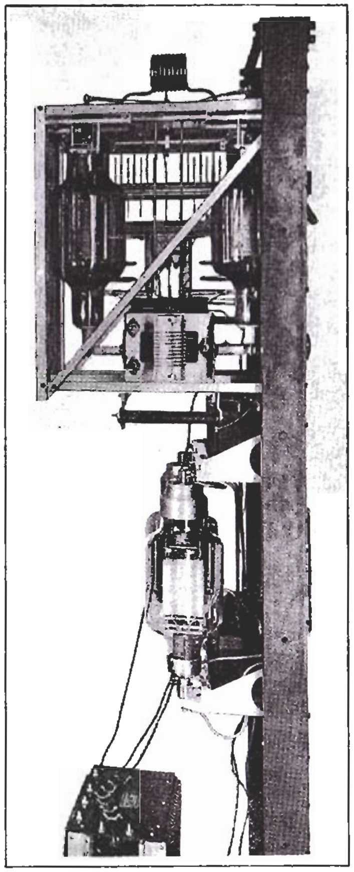


FIG. 45

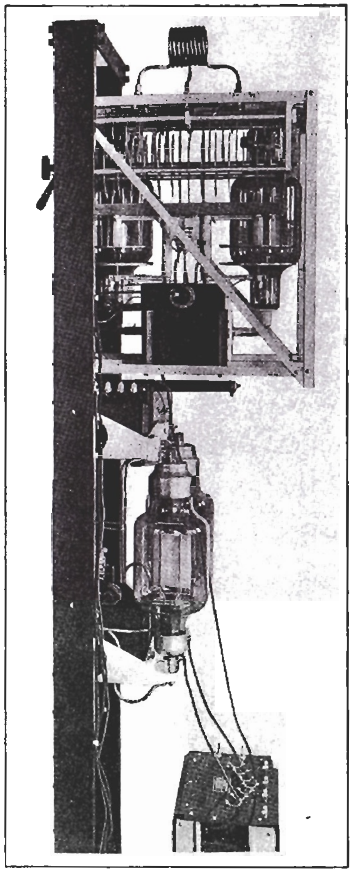


FIG. 46

FIG. 47, at the left, shows the 1-KW. Amplifier and also the operating position with HRO Receiver, speech amplifier, exciter, and RK-20 buffer amplifier.

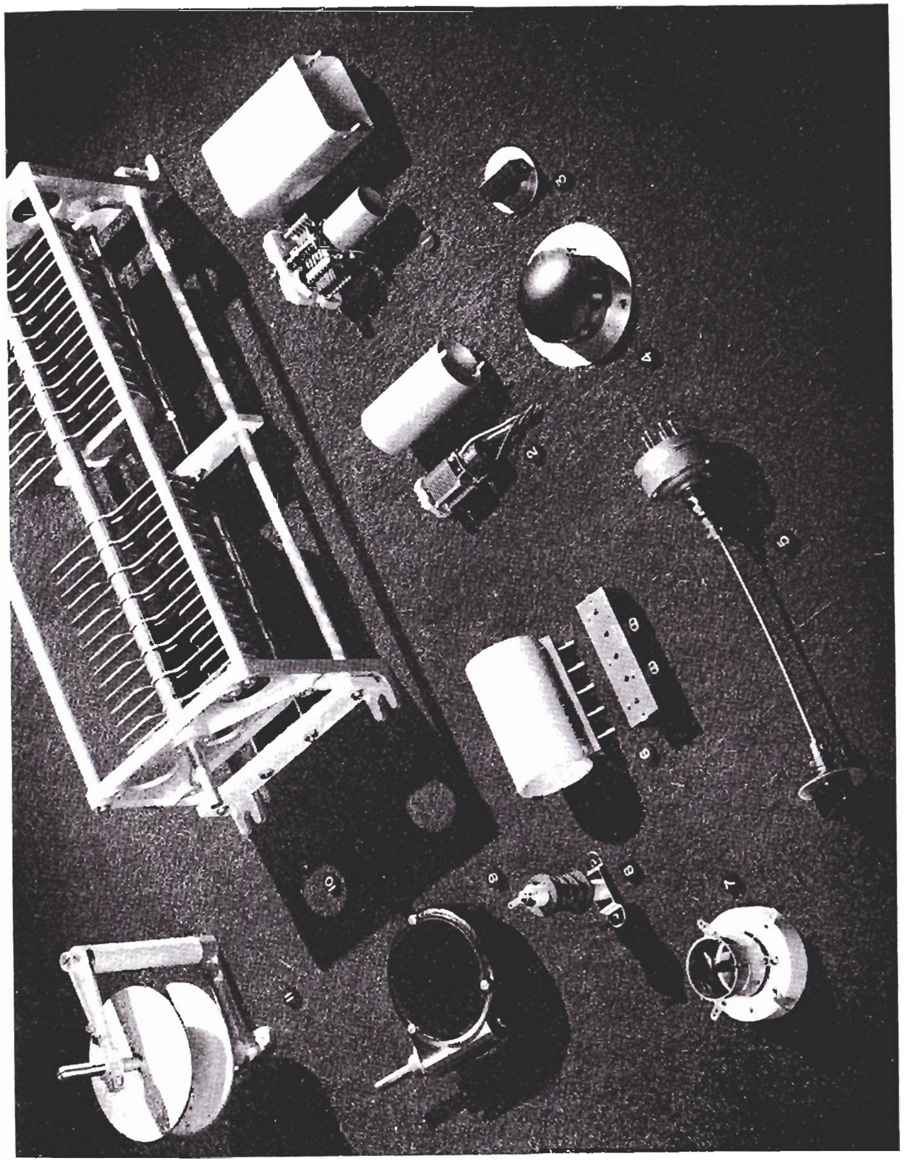


FIG. 48 — A GROUP OF SOME OF THE NEWER NATIONAL COMPONENT PARTS

A slightly different style of construction than that used in any of the other transmitters shown in this booklet, is that of Figs. 49 and 50, designed and built by W2GYL. All of the units are constructed on standard relay rack panels in the more conventional manner, but, instead of being mounted on a standard rack, are mounted in a light gauge steel cabinet with hinged rear door. Such cabinets are now being stocked by many of the larger parts dealers and are finding considerable favor among those amateurs especially, who have small children in their family from whose wanderings the wiring of any transmitter must be protected.

The complete transmitter, including exciter, buffer, final stage, modulator, and power supplies, is housed in the one rack-cabinet. The top panel carries the antenna tuning system comprising an inductance link coupled to the final plate tank coil, the tuning condenser, and the thermal-couple ammeter.

Reference to the rear view shows that the usual stepladder construction has been avoided. There are two important reasons for this change. One is that the assembly results in the elimination of long filament leads. No filament lead in this transmitter is longer than three inches. The filaments for the RK-30's are supplied by two individual filament transformers located directly above their sockets. The second important result of avoiding stepladder construction is to provide a "chimney effect" for the whole transmitter so that the heat generated by the tubes rises toward the top of the case and draws in cool air through the louvres down near the floor. A distinct departure from usual construction is the inversion of the modulator tubes, which has the effect of putting the tubes themselves in plenty of free space along with a material shortening of the leads.

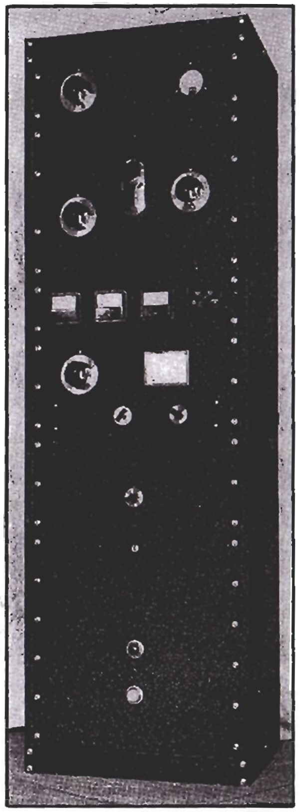


FIG. 49 — FRONT VIEW OF THE TRANSMITTER

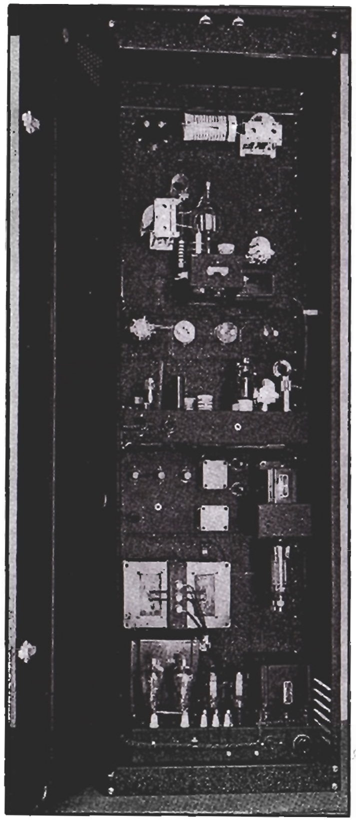


FIG. 50 — REAR VIEW OF THE TRANSMITTER

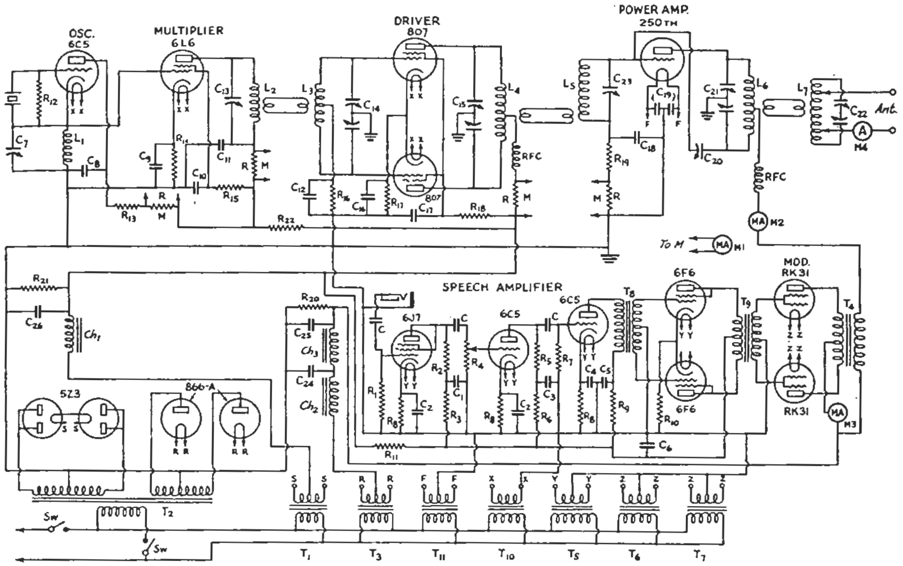


FIG. 51 — THE COMPLETE TRANSMITTER CIRCUIT

*$L_1$ to $L_7$ — See coil table*
*C — 0.1-μfd. 400-volt tubular*
*$C_1$, $C_3$ — 0.1-μfd. 400-volt tubular*
*$C_2$, $C_4$ — 5-μfd; 25-volt electrolytic*
*$C_5$ — 0.25-μfd. 400-volt tubular*
*$C_6$ — 8-μfd. 400-volt electrolytic*
*$C_7$, $C_{13}$ — 100-μμfd. midget variable (National UM-100)*
*$C_8$ — 0.004-μfd. mica*
*$C_9$, $C_{10}$, $C_{11}$, $C_{12}$, $C_{16}$ — 0.01-μfd. 500-volt tubular*
*$C_{14}$ — Double-section variable, 0.018-inch air gap, 100-μμfd. per section (National STHD-100)*
*$C_{15}$ — Double-section variable, 0.026-inch air gap, 100-μμfd. per section (National TMS-100D)*
*$C_{17}$, $C_{19}$ — 0.004-μfd. 1000-volt mica*
*$C_{18}$ — 0.002-μfd. 1000-volt mica*
*$C_{20}$ — 10-μμfd. neutralizing condenser (National NC 800)*
*$C_{21}$, $C_{22}$ — Double-section variable, 0.077-inch air gap, 100 μμfd. per section (National TMC-100D)*
*$C_{23}$ — 50 μμfd. variable, 0.065-inch air gap (National TMSA-50)*
*$C_{24}$ — 2-μfd. 1500-volt filter condenser*
*$C_{25}$ — 4-μfd. 1500-volt filter condenser*
*$C_{26}$ — 8-μfd. 600-volt filter condenser*
*RFC — 1-mh. 600-ma. r.f. choke (National R-154U)*
*$M_1$ — 0-200 d.c. milliammeter*
*$M_2$ — 0-500 d.c. milliammeter*
*$M_3$ — 0-250 d.c. milliammeter*
*$M_4$ — 0-2 ampere r.f. meter*
*$R_1$ — 5-meg. ½-watt resistor*
*$R_2$ — 0.25-meg. ½-watt*
*$R_3$, $R_6$ — 25,000-ohm ½-watt*
*$R_4$ — 250,000-ohm volume control*
*$R_5$ — 50,000-ohm ½-watt*
*$R_7$ — 100,000-ohm ½-watt*
*$R_8$ — 2500-ohm ½-watt*
*$R_9$ — 10,000-ohm 1-watt*
*$R_{10}$ — 750-ohm 10-watt*
*$R_{11}$ — 5000-ohm 50-watt*
*$R_{12}$ — 75,000-ohm 1-watt*
*$R_{13}$ — 20,000-ohm 1-watt*
*$R_{14}$ — 5000-ohm 10-watt*
*$R_{15}$, $R_{16}$ — 20,000-ohm 10-watt*
*$R_{17}$ — 200-ohm 10-watt*
*$R_{18}$ — 10,000-ohm 10-watt*
*$R_{19}$ — 5000-ohm 25-watt*
*$R_{20}$, $R_{21}$ — 50,000-ohm 100-watt*
*$R_{22}$ — 2500-ohm 10-watt*
*R — 20-ohm 10-watt (milliammeter shunts)*
*$T_1$ — 10-volt 4-amp. filament transformer (Kenyon T-365)*
*$T_2$ — Double secondary plate transformer, 1450-volt 500-ma. and 630-volt 200-ma. (Kenyon T-660)*
*$T_3$ — 2.5-volt 10-amp. filament transformer (Kenyon T-360)*
*$T_4$ — Class-B output transformer (Kenyon T-460)*
*$T_5$, $T_{10}$ — 6.3-volt 3-amp. filament transformer (Kenyon T-351)*
*$T_6$, $T_7$ — 7.5-volt 4-amp. filament transformers (Kenyon T-353)*
*$T_8$ — Push-pull input transformer, ratio 1:2 (Kenyon T-58)*
*$T_9$ — Class-B input transformer (Kenyon T-258)*
*$T_{11}$ — 5.25-volt 12-amp. filament transformer (Kenyon T-357)*
*$Ch_1$ — 14-henry 250-ma filter choke (Kenyon T-164)*
*$Ch_2$ — 6–21-henry 500-60-ma. swinging choke (Kenyon T-521)*
*$Ch_3$ — 12-henry 500-ma. filter choke (Kenyon T-177)*

COIL DATA

| | $L_1$ | $L_2$ | $L_3$ | $L_4$ | $L_5$ | $L_6$ | $L_7$ |
|---|---|---|---|---|---|---|---|
| 28 Mc. | 10 t. No. 18 close wound | 4 t. No. 18 Length ½″. Link 1 turn at cold end | Split winding 2 t. ea. side c.t. 2 t. link wound in center. Total length winding and link 1″ | 8 t. No. 14 1¼″ dia. link 2 t. in center. Winding length 2″ | 4 t. No. 18 Link 2 t. at cold end winding length ½″ | 8 t. No. 12 1½″ dia., length 2½″ | 11 t. No. 12 on National XR10A form, full length of form |
| 14 Mc. | Same as above | 7 t. No. 18 length ½″. Link 1 t., cold end | Same as above except 4 t. each side center tap | 10 t. No. 18 on National XR13 form. Length 2½″. Link 2 t. inside center coil form | 7 t. No. 18 length ½″ link 2 t., cold end | 10 t. No. 12 on National XR10A form, full length of form | Same as above |

All wire used is enamel covered

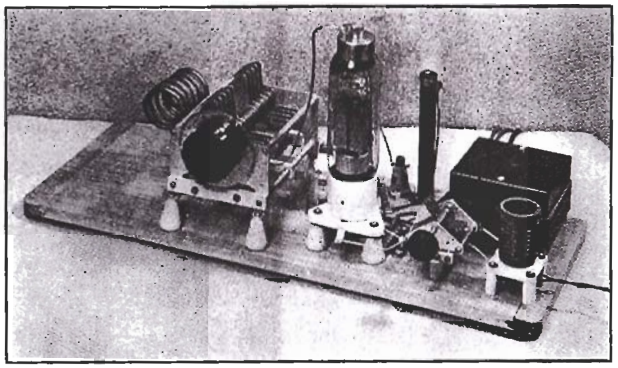


FIG. 53—THE 803 IN AN EXPERIMENTAL SET UP

The extremely low R.F. driving power, the small amount of audio-modulating power, and the freedom from neutralization difficulties, has made the R.F. pentode a much used final stage tube in moderate-power 'phone transmitters. While the initial cost of the tube itself is slightly higher than that of a triode of equivalent rating, the saving in associated equipment generally considerably more than offsets this difference.

When suppressor modulated, the maximum carrier power is approximately 25 per cent of the DC power input to the plate circuit. Inasmuch as the legal limitations on power used by amateur transmitters is determined by the DC input to the plate circuit, rather than the actual carrier magnitude, the pentode would have no field of application in the final stages of transmitters designed for maximum legal output. In the case of 100 per cent modulated carriers of the order of 100 watts, or less, they are, however, quite ideal. Of course, for use for c.w. purposes, in which case the efficiency approaches that of the triode, there is no legal handicap and they have the definite advantage over triodes of low R.F. driving power and the elimination of neutralizing condensers and associated circuits.

R.F. pentodes may be divided into three general groups: Those of the 802-RK-25 size, principally used in very low-power transmitters or in buffer stages; in the second group would be classed the RK-20 and the RCA 804, which are ideal for use in moderate power transmitters, both 'phone and c.w., and as buffers for driving one-kilowatt transmitters using triodes, such as 852's, 251A's, etc., in the final stage. In the third group would fall the RK-28 and the RCA 803, a pair of which, when suppressor modulated, will furnish a carrier of 60 watts or more, and when used with positive suppressor bias for c.w. purposes, a carrier of approximately one-quarter kilowatt. The table on page 35 tabulates all of the essential characteristics of these three groups of tubes for ready comparison.

Fig. 52 on this page illustrates an experimental transmitter made up with a single RK-28 in the final stage and a single 802 (removed from the socket in the illustration) as the Tritet crystal oscillator-exciter. While the complete internal shielding of the tube itself makes possible the elimination of neutralization, this condition is only arrived at when the input and output circuits are sufficiently isolated. An excellent example as to just how this can be efficiently done is shown in this particular transmitter, where the output tank circuit is located at the very top of the transmitter and the grid input circuit at the very bottom, as far removed as possible from each other and yet so located as to provide short leads between the two tanks and their associated tube elements.

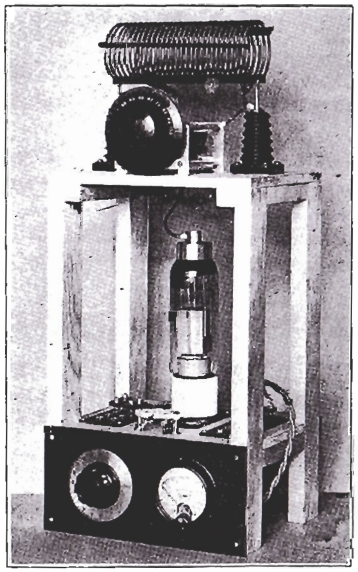
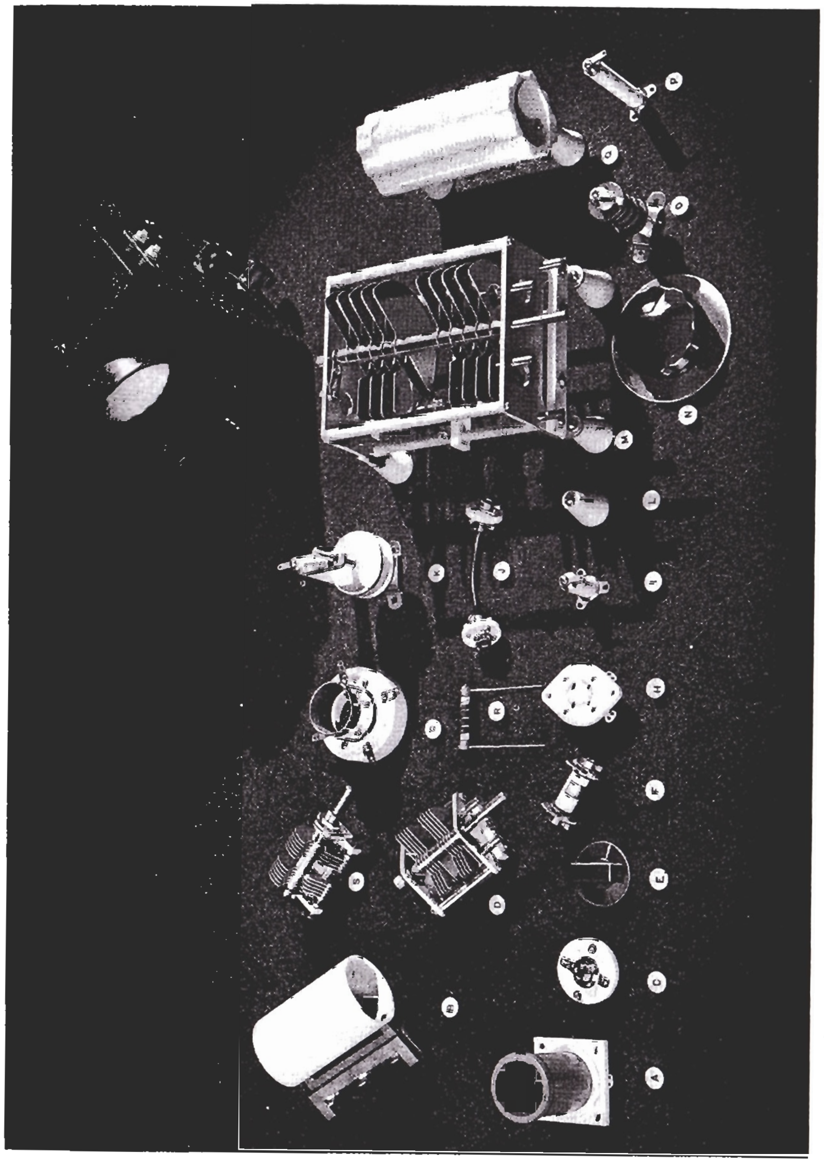


FIG. 52—THE NEW RK-28 PENTODE IN AN EXPERIMENTAL TEST SET-UP

*A quarter kilowatt output with only a few watts driving power is only one of the things we like about this tube. With suppressor modulation a carrier output of 65 watts or more is readily obtainable, the audio power required being less than one-half watt.*

Fig. 53 shows another experimental breadboard layout of the more conventional style, in which a single 803 is experimentally tried out. This transmitter is essentially the same as that in Fig. 52.

Excitation is secured from a separate exciter link-coupled to the tuned grid circuit of the 803 by means of plug-in grid coils.



A GROUP OF PARTS THAT SHOULD SUGGEST MANY INTERESTING TRANSMITTER DESIGN POSSIBILITIES

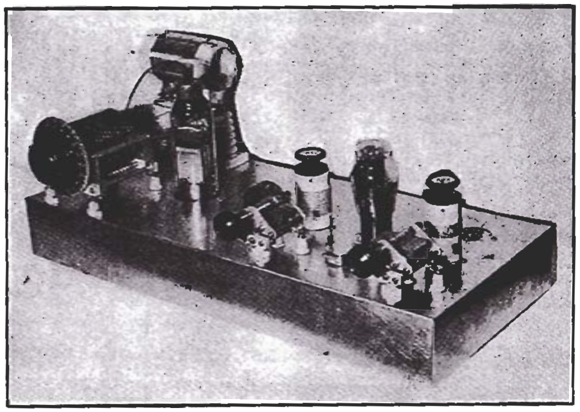


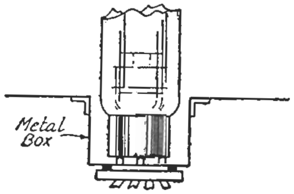
FIG. 54 — SIMPLE — BUT IT'S THE COMPLETE R.F. END OF A THREE-BAND TRANSMITTER RATED AT 100 WATTS C.W. AND 20 WATTS ON 'PHONE

*A 59, pentode or Tri-tet, drives an RK-20 amplifier, using 3.5- and 7-mc. crystals. No buffer stages are needed.*

In addition to the many other advantages of the R.F. pentode when used in a low-power transmitter, is the convenience with which band-shifting can be accomplished. W1AF designed and built the transmitter illustrated in Figures 54 and 55, which is practical proof of this feature. This transmitter also serves to emphasize the low cost of the associated equipment required in pentode transmitters. The aluminum chassis measures 17" x 10" x 3" and is thus short enough to be mounted on a relay rack panel, as was subsequently done at W1AF, so that the complete transmitter, including speech equipment, modulator, and power supply, could be carried in a single relay rack. Note in particular the way in which the grid and plate circuits of the RK-20 have been carefully isolated. By mounting the socket of the RK-20 under the aluminum sub-base, the grid-circuit leads are shielded from the plate-circuit leads.

It will be noted from the circuit diagram that provision for using the oscillator for electron-coupled output on 7.0 and 14 Mc. has also been built into this compact transmitter, so that frequency changes within a band can be made quickly and easily. Inasmuch as none of the variable condensers in this transmitter are operating at ground potential, they must be carefully insulated on stand-offs from the aluminum base and the leads to them carried through suitable insulating bushings, such as the National XS-6. The cathode coil is shorted when operating on the 3.5- and 7.0-Mc. bands, in which case the oscillator is operated as a straight pentode. This is done automatically by bending over a corner of one rotor plate of $C_1$ so that it will touch the stator when set at full capacity.

Crystals in the 3.5- and 7.0-Mc. bands are needed for operation on the 3.5-, 7.0- and 14-Mc. bands. When operating on 14 Mc., the oscillator is operated in tritet fashion, doubling in the plate circuit of the 59. Only two coils are needed for the amplifier plate circuit; one for use on 14 Mc. and the other for use on both 3.5 and 7.0 Mc. Four turns of the 3.5-Mc. tank coil are shorted in order to secure low C operation on the 7.0-Mc. band.



THE SHIELD-BOX MOUNTING FOR THE RK-20

*This is a cross-section; the box actually has four sides and a bottom, with the tube socket mounted on the latter.*

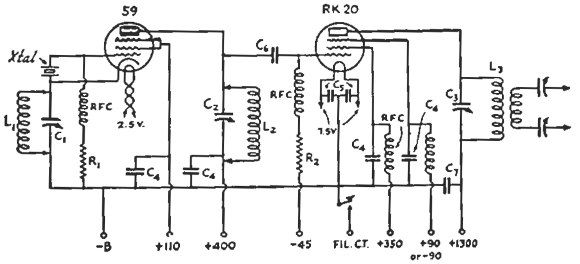


FIG. 55 — CIRCUIT DIAGRAM OF THE TWO-STAGE PENTODE TRANSMITTER

$C_1$ — *250-μμfd. cathode tuning condenser (National TMS-250)*
$C_2$ — *100-μμfd. oscillator plate condenser (National TMS-100)*
$C_3$ — *150-μμfd. amplifier plate condenser (National TMC-150)*
$C_4$ — *.002-μfd. mica condenser, receiving type (Sangamo)*
$C_5$ — *.004-μfd. mica condenser, receiving type (Sangamo)*
$C_6$ — *100-μμfd. mica condenser, receiving type (Sangamo)*
$C_7$ — *.002-μfd. mica condenser, 5000-volt (Sangamo)*
$R_1$ — *50,000 ohms, 2-watt rating (I. R. C.)*
$R_2$ — *15,000 ohms, 2-watt rating (I. R. C.)*
RFC — *S.w. chokes (National Type 100)*

*See separate table for coil data.*

*Antenna tuning equipment will depend upon the type of antenna system used. With series tuning of Zepp feeders, tuning condensers of 250-μμfd. each will be satisfactory.*

Another application of the RK-20's to a compact transmitter is shown herewith. Two of the RK-20's are used in push-pull in the output stage and the entire transmitter, built of units on standard relay rack panels, is mounted in one of the standard National table-type racks.

This particular transmitter was originally built for semi-portable use, inasmuch as it could be quickly disassembled and each unit dropped into a special carrying case for shipment as regular baggage. The RK-20's in the final stage are mounted horizontally, with a baffle arranged to electrostatically shield the input and output circuits. The antenna tuning network is also combined into the same unit as the final amplifier. Three separate power supplies are used: one for the exciter; one for the audio system, and one is the high-voltage unit for the plate and screen circuits of the RK-20's.

The exciter unit has already been described on page 9. Originally it was intended to use this transmitter on all bands, including 56 megacycles, but it was later found impractical to secure satisfactory performance on this latter band. The transmitter was, however, operated for many months on all of the other bands, including 28 megacycles. The coils for these bands, namely, 28, 14, 7 and 3.5 Mc., are shown in Fig. 57. On page 39 is given complete data on the construction of these coils, as well as a close-up view of the final stage with the 3.5-Mc. coils in place. Band-changing is quickly accomplished by shifting the link-coupling circuit to the proper output terminal block on the exciter unit and changing the coils in the final stage and antenna-tuning filter network.

In mounting RK-28's horizontally, it is important to so arrange each socket that the plane of the filament is always vertical. Thus if the filament should sag slightly, as is quite possible under normal operating temperature, a material change in tube characteristics will not take place. Fuse clips mounted on National type GS-1 standoffs make ideal plate terminals for tubes so mounted.

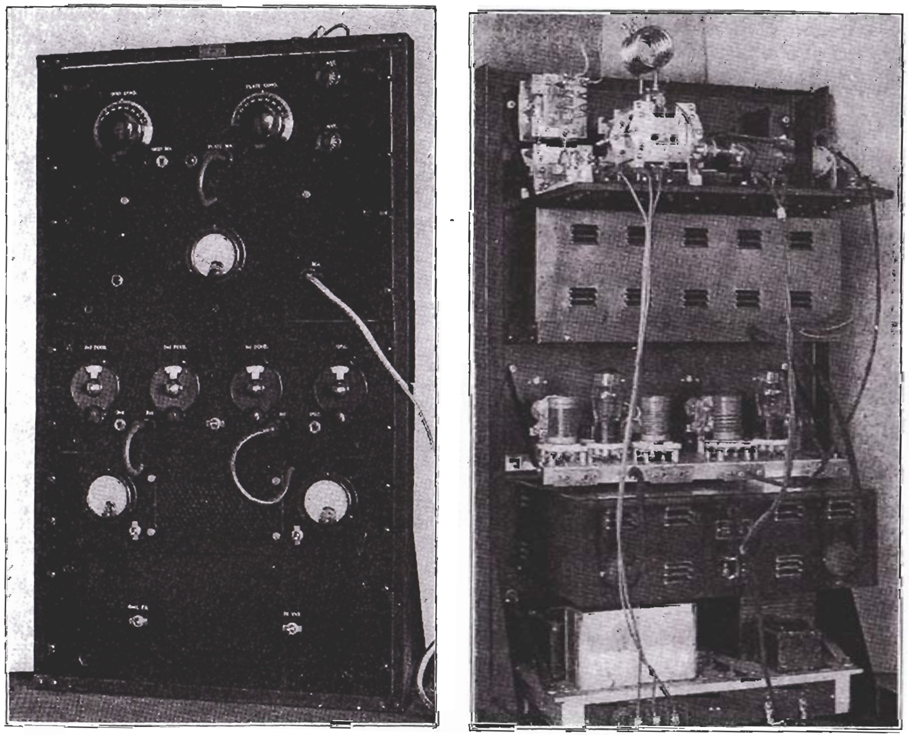


FIG. 56 — FRONT AND REAR VIEWS OF THE COMPLETE TRANSMITTER IN ITS RACK MOUNTING

*From top to bottom the panel units are: final pentode amplifier and antenna coupling filter, speech amplifier and modulator, crystal-controlled exciter, modulator and exciter power supply, and 1000-volt power supply for the final stage. Note the individual jack strips (rear) for each stage of the exciter from which r.f. output of the desired frequency is tapped by the plug-and-cord link to the final stage.*

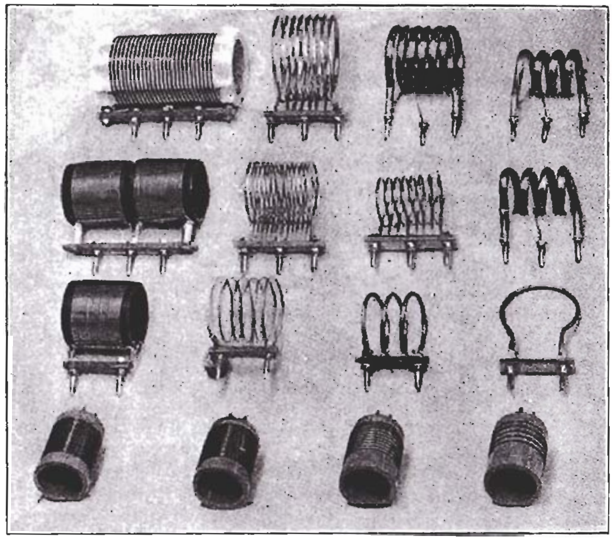


FIG. 57 — ILLUSTRATING THE FIVE TYPES OF COIL CONSTRUCTION USED

*Winding data are given in the tables.*

To most amateurs, electric meters or instruments present only one problem, that of balancing the budget. Toward the solution of this problem we can offer little help, unfortunately, but we do think some of the suggestions below may be helpful in making the most of available meters.

We shall start with two warnings. The first is this: beware of steel meter panels. Iron, being magnetic, will shunt the permanent magnet in D.C., Thermo, and Rectifier A.C. instruments, causing the meter to read low. This error is larger than one might imagine. Before writing this page, we tested a number of instruments of different makes in a standard steel relay rack panel. With the meter in the worst position, the error was from 10 per cent to 20 per cent, depending upon make. In the position where they are normally used, the error is, fortunately, about one-half as much.

Sometimes it is expedient to remove a meter from its case, to repair resistors, change scales, and so forth. This is not an operation that we recommend, as the meter is very apt to be "sticky" afterward. Apparently, the principal reason for this "stickiness" is almost invisible dust which drags against the moving system. It is very difficult to guard against this as magnetic particles are attracted to the air gap and non-magnetic dust is attracted to the scale and coil by the electro-static charge which is often present. If you must take your meters apart, do it only in a place where the air is clean, and lay a clean sheet of paper over the table surface that you are working on.

Many transmitters are designed to use a single meter for all measurements, by the use of jacks with a plug on the meter leads. This single instrument is usually a milliammeter of high enough range to carry the maximum current anywhere in the transmitter, probably 200 MA or more. However, this range is much too high for many purposes. For instance, a low range of perhaps 20 MA is highly desirable as an indicator of grid current when neutralizing or checking excitation. A multi-range instrument could be used, but

(*Cont. 2nd col., p. 39.*)

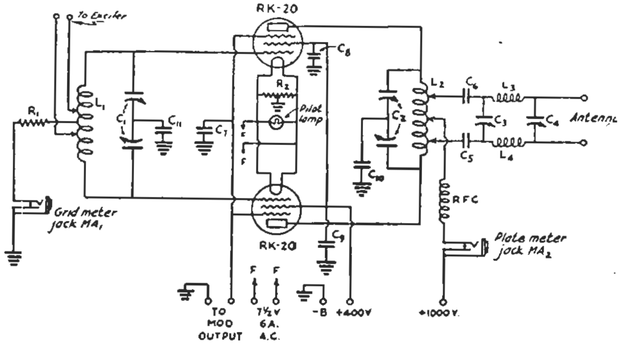


FIG. 58 — THE RK-20 FINAL AMPLIFIER CIRCUIT

*$L_1$ and $L_2$ — Grid and plate coils. See coil table.*
*$L_3$ and $L_4$ — Antenna coupler coils. See coil table.*
*$C_1$ — Split-stator midget variable, 50-μμfd. per section (National Type STD 50 or equivalent).*
*$C_2$ — Split-stator transmitting condenser 100-μμfd. per section, 3000-volt (National TMP-100 or equivalent).*
*$C_3$ and $C_4$ — Receiving type variable condenser, 150-μμfd. (National EMA-150 or equivalent).*
*$C_5$, $C_6$ and $C_7$ — 0.001-μfd. mica bypass condensers.*
*$C_8$, $C_9$, $C_{10}$ and $C_{11}$ — 0.01-μfd. mica bypass condensers.*
*$R_1$ — 12,000-ohm 25-watt grid leak.*
*$R_2$ — 50-ohm filament center-tap resistor.*
*RFC — Receiver-type r.f. choke (National Type 100 or equivalent).*
*MA1, MA2 — Single-circuit closing jacks for 0-200 milliammeters.*

POWER AMPLIFIER COIL DATA

| *Frequency Mc.* | *$L_1$ (Grid)* | *$L_2$ (Plate)* | *$L_3$ and $L_4$ (Awt.)* |
|---|---|---|---|
| 1.75<br>(160-meter band) | 81 T.<br>3″ D.<br>5″ L.<br>No. 18 | 51 T.<br>4″ D.<br>6″ L.<br>No. 14 | 34 T.<br>3½″ D.<br>1½″ L.<br>No. 16 |
| 3.5<br>(80-meter band) | 54 T.<br>2″ D.<br>3¾″ L.<br>No. 16 | 34 T.<br>3″ D.<br>4½″ L.<br>No. 14 | 34 T.<br>1¾″ D.<br>1½″ L.<br>No. 16 |
| 7.0<br>(40-meter band) | 28 T.<br>2″ D.<br>1⅞″ L.<br>No. 16 | 22 T.<br>2½″ D.<br>3″ L.<br>No. 14 | 12 T.<br>2″ D.<br>1½″ L.<br>No. 16 |
| 14.0<br>(20-meter band) | 14 T.<br>2″ D.<br>2½″ L.<br>No. 14 | 8 T.<br>3″ D.<br>2¼″ L.<br>No. 10 | 6 T.<br>2″ D.<br>1½″ L.<br>No. 14 |
| 28.0<br>(10-meter band) | 8 T.<br>1½″ D.<br>2″ L.<br>No. 14 | 6 T.<br>2″ D.<br>2″ L.<br>¼″ tub. | 3 T.<br>1¾″ D.<br>1½″ L.<br>No. 10 |

T. = No. of turns. D. = diameter of coil. L. = Length of coil. No. = Wire gage (B & S). Tub. = Copper tubing of specified diameter. Total turns are given for push-pull plate and grid coils; put tap at center.

Plate coils for 1.75, 3.5 and 7 mc. are wound on standard National Steatite transmitting coil forms. Plate coils for 14, 28 and 56 mc. are self-supporting. (See coil photo.)

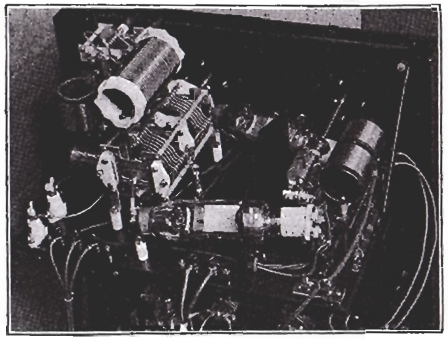
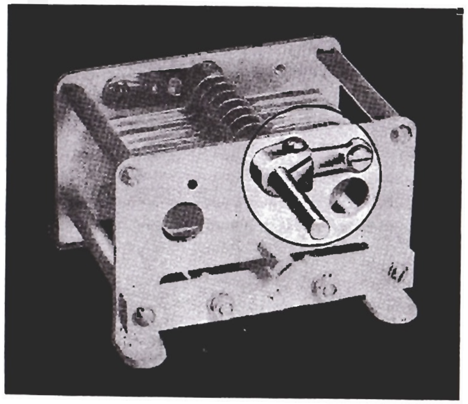


FIG. 59 — LOOKING DOWN ON THE PUSH-PULL FINAL STAGE

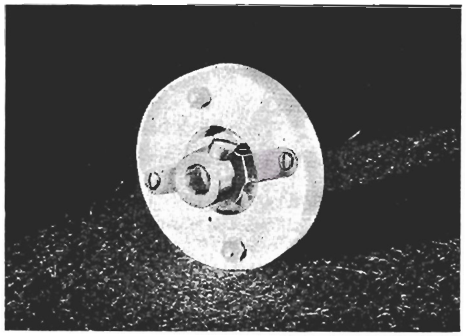
*Link-coupled grid input circuit at the right, plate tank and antenna coupler at the left.*

(*Continued from page 38*)

it is expensive and can easily be damaged if the wrong range is inadvertently used. We have a suggestion. For the meter, use a 50-millivolt one-mil instrument. In each circuit where it is desired to measure current, wire in a shunt of the proper range connected to an open circuit jack suitably marked to show instrument range and circuit position. These shunts are quite inexpensive and are easily obtainable. In use, it is thus merely necessary to plug in the meter and the proper range is automatically cut in. Best of all, the meter is also available for voltage measurements, in which case multiplier resistors are used instead of shunts, of course. If a "universal" rectifier instrument is used, even A.C. filament voltages can be measured. It is obvious that the system is flexible, but it also happens to be quite inexpensive. One precaution should be observed when using shunts in this way. The leads and contacts between the meter and its shunt must be of low resistance, as this affects the accuracy of the meter. One-fourth of an ohm, or less, is satisfactory and not difficult to obtain.



Above is illustrated a handy gadget for locking the rotor shaft of a variable transmitting condenser. This simple device clamps the rotor sufficiently rigid to make adjustments proof to vibration and unauthorized tampering. Thus, once a transmitter is properly tuned, the settings for the condenser equipped with such a locking device can be definitely secured. The rotor lock is designed primarily to fit National condensers having ¼″ shafts, but may, of course, be fitted to many condensers of other manufacture.



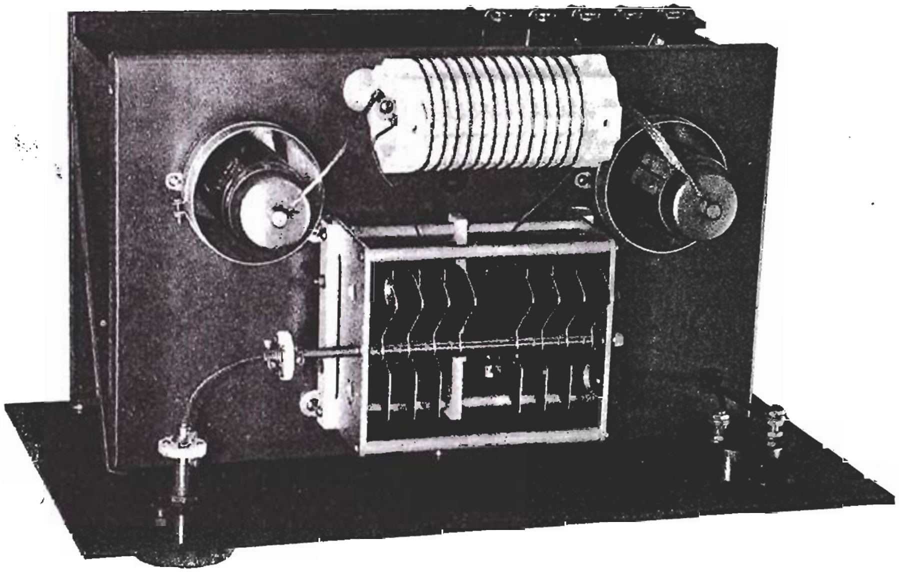


FIG. 60

The two views of the RK-20 amplifier shown on this page clearly illustrate its unusual layout and construction features. While originally designed as the final stage of a suppressor modulated 'phone transmitter, the unit is now being used to drive the Class C one-kilowatt amplifier shown on pages 29 and 30. In both services it has proven most satisfactory, the unusual layout not only providing short leads and symmetry of the push-pull circuit, but also extremely effective shielding between the input and output circuits. The shield cans around the tubes are held in place by means of the clamps normally furnished as standard equipment with the large electrolytic receiving condensers. They are quite ideal for this use as they permit ready adjustment of the shield height.

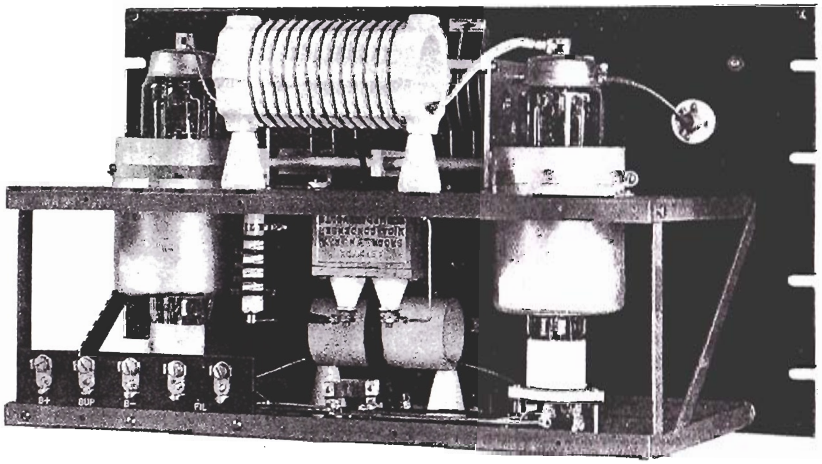


FIG. 61

There are obvious advantages in having a choice of transmitting frequencies quickly available in each amateur band. Many times one would like to use a transmitter on another band if the labor of band-switching was not too great. Then again, a slight change in frequency during a QSO will often take care of immediate interference difficulties.

Such universal transmitters have been built, of course, but the natural complexity of such gear puts it beyond the facilities of most amateurs. In an attempt to make a successful compromise between convenience and necessity, the transmitter described here was recently built.

The most important compromise in simplifying the band switching was to limit operation to two bands. This step was taken with misgivings, but it has not been regretted. Two bands, quickly available, are in practice much more useful than four bands in a transmitter which requires laborious handling of plug-in coils and retuning to make frequency changes. For example, a 'phone man does quite nicely with just the 20- and 75-meter bands, which between them will take care of varying conditions of skip, etc. Similarly, c.w. fellows will in most instances want either the 20- and 40-, or the 40- and 80-meter bands.

With this concession made, the transmitter design took shape rapidly. The system used calls for the switching of complete pre-tuned tank circuits right down from the final stage to the crystal oscillator. Such a method of band switching minimizes troubles due to variation on contact resistance in the switches, eliminates breaking high R.F. currents, and makes unnecessary any retuning whatsoever when shifting bands. Due to the

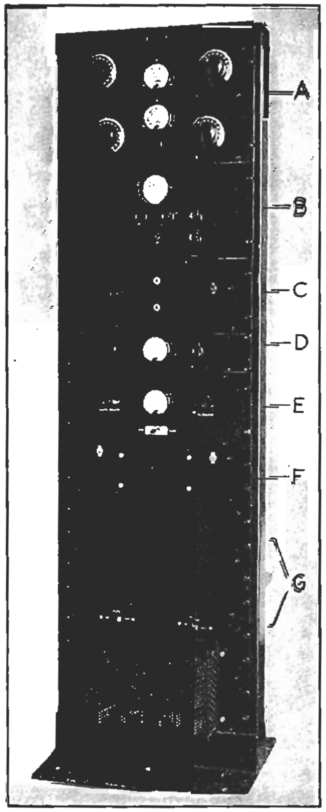


FIG. 62 — THE COMPLETE TRANSMITTER IS MOUNTED IN ONE RACK WITH INDIVIDUAL PANELS FOR THE COMPONENT UNITS

*The letter designations for the panels are identified with the rear view.*

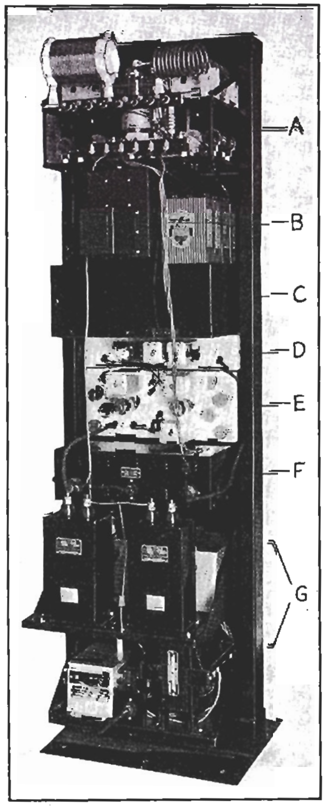


FIG. 63 — REAR VIEW OF THE TRANSMITTER ASSEMBLY

*The panels are identified as follows: A, final power amplifier; B, oscilloscope with p.a. bias batteries; C, speech input and modulator; D, buffer; E, exciter; F, dual low-voltage power supply; and G, high-voltage power supply.*

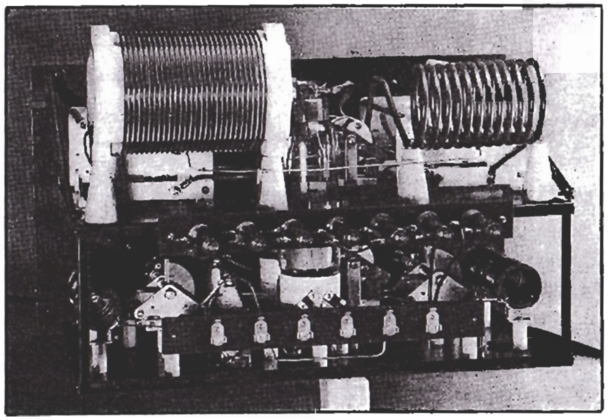


FIG. 64 — SHOWING THE DETAILS OF THE FINAL POWER-AMPLIFIER UNIT AS VIEWED FROM THE REAR

characteristics of medium-power pentodes, such as the 803 and the RK-28, no difficulty with neutralization is encountered in a quick change transmitter of this type.

The exciter unit has already been described in detail on page 11. The buffer, employing a single RK-23, uses pre-tuned series tanks which eliminate any necessity for switching. The final stage uses a pair of separate tanks for each band, switched by a single knob.

The exciter was originally intended to drive a pair of RK-20's in the final stage. For this purpose its output is entirely adequate. When it was decided to use the larger 803 or RK-28 pentodes, however, it was found that the R.F. output was not sufficient except when running with relatively low plate voltage on the final, and consequently the RK-23 buffer was added. The output of this buffer is more than ample, even when using 803's with slightly over 3000 volts on the plate.

The buffer is visible in the rear view, just above the exciter unit. It is built up on the same kind of depressed panel unit that was used for the exciter. The gear on this chassis is quite simple, and the illustration shows the layout of the RK-23, the two tanks, and the plate milliammeter.

The series plate tank circuit will probably be new to some amateurs. The two tanks for 20 meters and 75 meters are of themselves quite conventional, but it will be noted that they are connected in series and are always in the circuit. This is possible because the impedance of a parallel-resonant circuit drops rapidly as it is detuned from the driver. Consequently the unused tank causes only a negligible loss by being left in circuit, and virtually the entire output voltage is built up across the used tank. This scheme also eliminates switching in the output circuit of the buffer, and permits the buffer tanks to be permanently coupled to the grid tanks of the final.

There is a further refinement in the buffer circuit which we believe is quite unique. This is the excitation control $R_8$, which varies the suppressor voltage from zero to about −90 volts. At zero voltage the RK-23 is doing its best, while at the other extreme the full negative bias is sufficient to cause almost complete cut-off. The control is exceptionally smooth at all positions, and is very satisfactory in every way. The negative voltage is obtained from the voltage drop across the bias resistor $R_7$. These resistors are connected in parallel, and could be a single resistor. The reason for the arrangement shown is that it puts the burden of the load on the fixed resistor $R_7$, and makes it possible to use a receiver-type potentiometer for the control $R_8$.

A double-deck type of construction is used in the final stage in order to shield the input and output circuits of the pentodes when mounted vertically, as recommended by the tube manufacturers. This shielding also provides a very handy shelf on which to mount the plate tank-tuning condensers, coils and band-shifting switch. Similar equipment for the grid circuit is mounted on the lower shelf. The grid coils are standard National R-39 receiving coil forms with the pins knocked out of the base and then mounted back to back. The grid and plate switches are ganged together with ordinary link-and-lever construction. These switches may be purchased complete or, as in the case of this transmitter, made from odds and ends to be found in most every amateur workshop. The Steatite discs are from National flexible couplings and the Isolantite strips are from midget receiving condensers. The switch jaws are taken from an old double-pole double-throw knife switch. The shaft is a piece of ¼-inch rod, and the frame and bearings are bent up from a piece of brass strip.

The circuit in general is exactly that recommended by the tube manufacturers. Care should be used, however, in running the high-voltage plate supply lead to see that it is so placed and by-passed that R.F. is prevented from getting into the power supply. The condenser and R.F. choke shown in the illustration and diagram were found essential for this purpose, even though the circuit is of the push-pull variety. Likewise, an R.F. by-pass condenser should be connected across the plate-circuit milliammeter. The screen voltage is obtained from the dropping resistors mounted on the back edge of the upper deck. The suppressor-grid and control-grid biasing voltages are obtained from B-batteries.

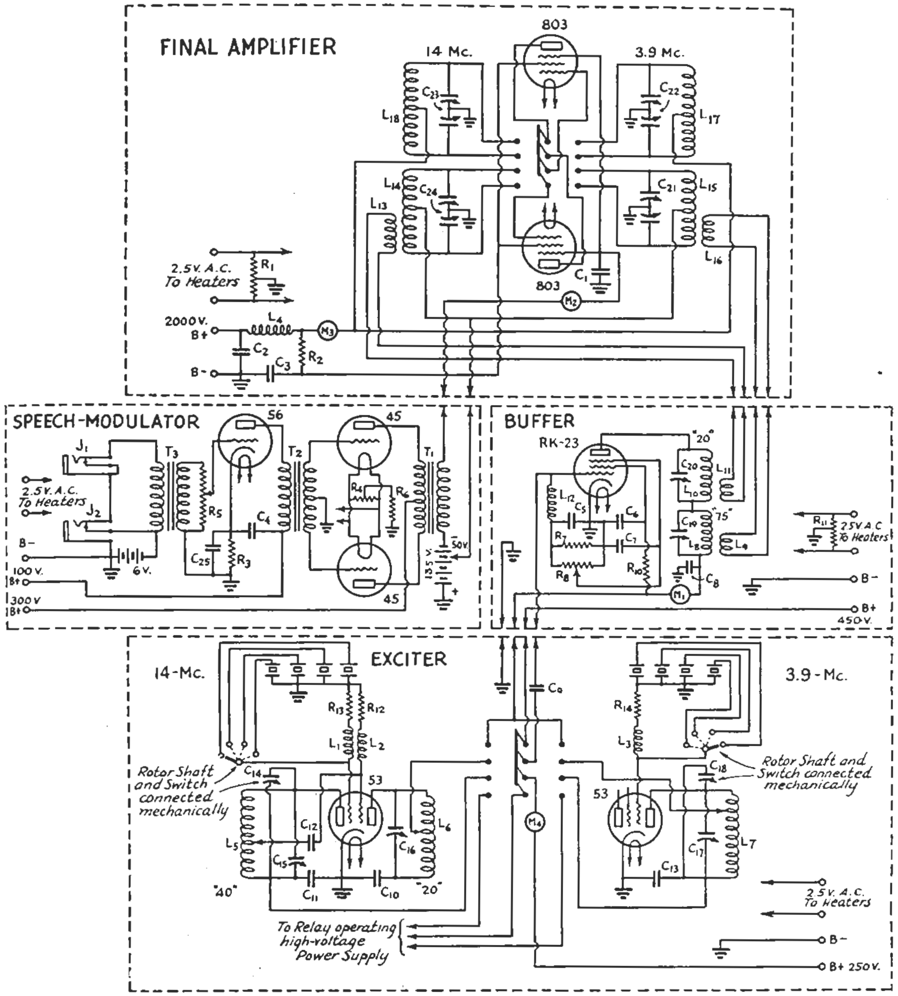
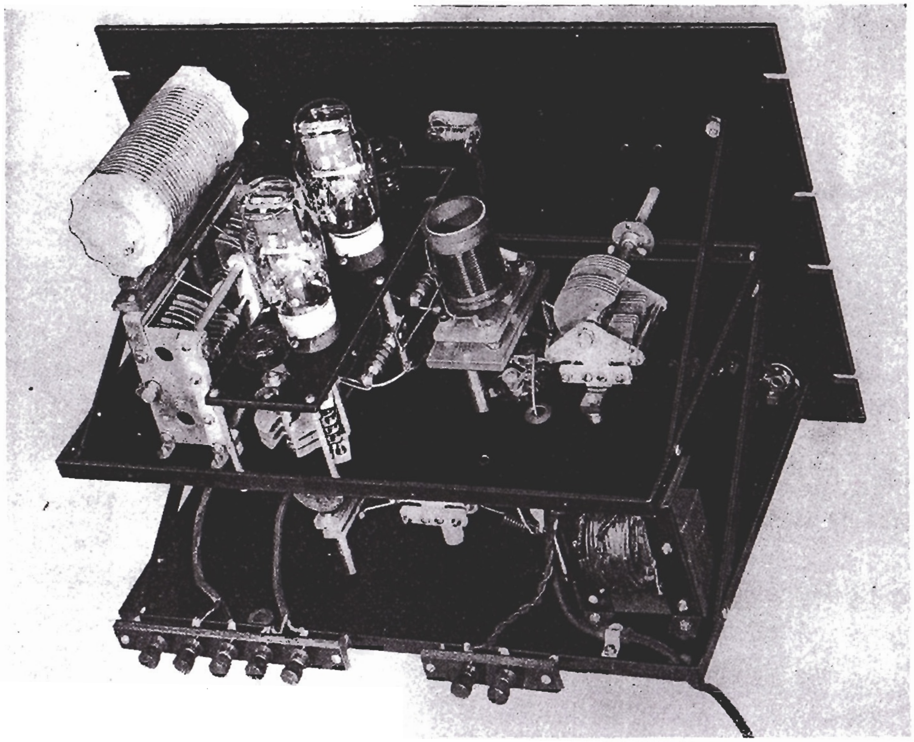
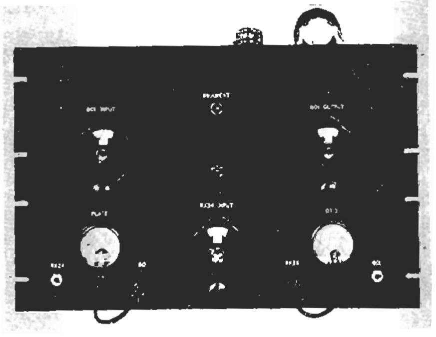


FIG. 65 — CIRCUIT OF THE TWO-BAND TRANSMITTER

$L_1$, $L_2$, $L_3$, $L_{12}$ — 2.5-mh. r.f. chokes (National R-100).
$L_4$ — 4-mh. transmitting r.f. choke (National R-154).
$L_5$ — 22 turns, center tapped, No. 24 enameled wire on 1″ dia.
$L_6$ — 11 turns, center tapped, No. 24 enameled wire on 1″ dia.
$L_7$ — 40 turns, center tapped, No. 28 enameled wire on 1″ dia.
$L_8$ — 48 turns, No. 28 enameled wire on 1″ dia.
$L_9$, $L_{11}$ — 3 coupling turns on 1″ dia.
$L_{10}$ — 13 turns No. 24 enameled wire on 1″ dia.
$L_{13}$, $L_{16}$ — 3 coupling turns on 1½″ dia.
$L_{14}$ — 16 turns No. 12 wire, 8 turns per inch on 1½″ dia. Center tapped.
$L_{15}$ — 60 turns No. 22 wire, 30 turns per inch on 1½″ dia. Center tapped.
$L_{17}$ — 27 turns No. 10 wire center tapped wound on 4″ dia., 6 turns per inch (National XR-12A coil form).
$L_{18}$ — 10 turns ¼″ copper tubing self-supporting on 3″ dia., 2 turns per inch.
$C_1$, $C_2$, $C_3$ — 0.001-μfd. fixed.
$C_4$, $C_5$, $C_6$, $C_7$, $C_8$, $C_{10}$, $C_{11}$, $C_{13}$ — 0.01-μfd. fixed.
$C_9$, $C_{12}$ — 100-μμfd. fixed.
$C_{25}$ — 0.01 μfd. fixed.
$C_{14}$, $C_{18}$ — Vernier condenser on crystal switch. (See text.)
$C_{15}$, $C_{16}$, $C_{17}$, $C_{19}$, $C_{20}$ — 25-μμfd. receiving type variable condensers (National UMA-25).
$C_{21}$, $C_{24}$ — Split stator transmitting condenser, 70 μμfd. per section, 1000-volt (National TMS-70D).
$C_{22}$, $C_{23}$ — Split stator transmitting condenser, 50 μμfd. per section, 6000-volt (National TMA-50DA).
$R_1$ — 120-ohm fil. c.t.
$R_2$ — 10,000-ohm 200-watt.
$R_3$ — 3000-ohm 1-watt
$R_4$, $R_{11}$ — 20-ohm fil. c.t.
$R_5$, $R_8$ — 50,000-ohm potentiometer (vol. control type).
$R_6$ — 750-ohm 1-watt.
$R_7$, $R_9$ — 10,000-ohm 1-watt.
$R_{10}$ — 12,000-ohm 10-watt.
$R_{12}$ — 20,000-ohm 1-watt.
$R_{13}$, $R_{14}$ — 5000-ohm 1-watt.
$M_1$, $M_4$ — 0–50 d.c. milliammeter.
$M_2$ — 0–30 d.c. milliammeter.
$M_3$ — 0–300 d.c. milliammeter.
$T_1$ — Audio output transformer (National S11).
$T_2$ — Audio input transformer (National S51).
$T_3$ — Microphone transformer, 200-ohm input.
$J_1$ — 200-ohm input or microphone current jack. (See text.)
$J_2$ — Single button carbon microphone jack. (See text.)





**THE BUFFER AND DRIVER AT W1BZR.**

Designed to operate as the connecting link between a low-power universal exciter and the final amplifier shown on page 28, the assembly shown above has several features of interest. The buffer tube, an RK-34, may be seen near the center of the upper view, where a section of the top shelf has been cut out, allowing the tube itself to make connection between the two chassis levels. The input circuit, link-coupled from the exciter, is connected to the grids of the RK-34 through two small chokes which effectively prevent high-frequency parasitic oscillations. One of these chokes is shown clearly, just at the left of the tube socket.

The input circuit of the driver (push-pull 801's) can, by means of the 5-prong plug-in arrangement, be tapped off the RK-34 plate coil at any desired points. This plug-in system, and that of the 801 tank, are the forerunners of the UR-13 and UR-10A, illustrated in the catalog section of the booklet.

In common with other such equipment, the driver will give excellent performance when used as a final amplifier, with inputs up to 80 watts. Good efficiency is maintained at frequencies as high as 60 Mc., and due to the symmetry of the circuit, the settings of the neutralizing condensers, when once determined, never need be changed.

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# MODULATORS

There are a number of possible ways to modulate a transmitter, and occasionally some very curious circuits are developed. The prize for work along this line probably goes to a system we saw a few years ago, in which the usual arrangement was reversed and the final RF amplifier modulated the audio. Very curious effects were obtained in this manner, none of them desirable.

Among the more orthodox modulation systems are grid bias modulation, suppressor modulation, and plate modulation. Grid bias modulation has the virtue of requiring relatively little audio power, but it has definite disadvantages. The carrier plate efficiency of the modulated stage is low, being of the order of 30 per cent or somewhat less in usual practice. At 100 per cent modulation it rises to 60 per cent efficiency. Furthermore, adjustment for proper operation is a little troublesome, for both excitation and modulation are introduced into the same control grid circuit, and adjustments are not independent. This latter objection is avoided in suppressor grid modulation, where excitation and modulation are not combined in one circuit. In other respects, the two systems are very similar, and plate efficiencies are about the same.

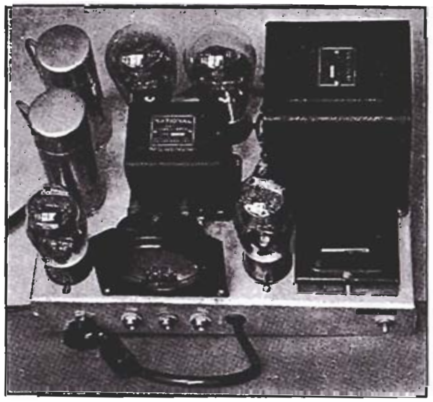


FIG. 66 — THE UNIT CONTAINS A CRYSTAL-MICROPHONE SPEECH AMPLIFIER, DRIVER AND CLASS-B MODULATOR, AS WELL AS A POWER SUPPLY FOR THE LOW-POWER STAGES

*While the 46's in the Class-B stage normally would be considered to have an audio output in the vicinity of 20 watts, for speech work they can readily be made to modulate a Class-C input of 80 watts, as explained in the text.*

Plate modulation is the most widely used arrangement. It permits the highest plate efficiency of any modulation system (about 65 per cent) and will readily modulate up to 100 per cent and with negligible distortion. Unfortunately it requires quite large amounts of power. For 100 per cent modulation, the modulator must supply an audio signal whose peak voltage is equal to the plate supply voltage. This peak voltage determines the maximum peak instantaneous power required from the modulator, and is the deciding factor when a Class A modulator is used, since the average plate dissipation of a given Class A amplifier remains constant for any waveform or output up to its peak capacity. This is not true of Class B amplifiers, for in Class B the average plate current and plate dissipation vary with the average power output. Thus, although the Class B stage must be able to handle the peak power without distortion, its capacity is more likely to be determined by the average power required in actual practice. If the signal is a sine wave, calculations show that the average audio power required for 100 per cent modulation is equal to 50 per cent of the carrier power. However, George Grammer has pointed out that the wave form of speech bears little resemblance to the sine form, and that in general the average audio power required with speech is only about 25 per cent of the carrier. An economical modulator designed by George Grammer to take advantage of this fact is shown in Figure 66, Figure 67, and Figure 68. This unit is sufficiently noteworthy to warrant a rather complete description. It was intended for a transmitter using a pair of 801 tubes at their normal input of 84 watts. It employs a pair of 46's in Class B and has an output of about 20 watts. On normal speech this has proved to be sufficient to modulate the Class C input of 84 watts quite satisfactorily. However, in order to supply the required peak power, it was found necessary to increase the plate voltage from the rated maximum of 400 v. to 500 v. This voltage overload is not a serious one, as the ratings are quite conservative. The rated peak plate current of 200 ma. is not exceeded.

The constructional details of the unit are rather obvious from the illustrations, circuit diagram, and list of parts. A few notes are in order, however. The speech amplifier in the unit uses a 57 pentode first stage having a rated gain of 100, and a 57 triode-connected second stage having a gain of about 14, giving a total gain of approximately 1400. The driver stage requires a peak grid swing of 50 volts. An input of about .03 volts peak is therefore necessary for full output, and this can be supplied quite nicely by a crystal microphone when it is held near the lips.

The chassis is a stock item available in most radio stores, and measures 7 by 11 by 2 inches. The arrangement of the parts was the result of experiment to find the positions for minimum

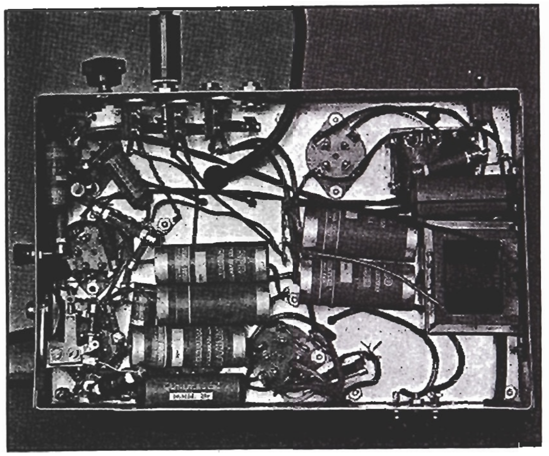


FIG. 67 — UNDER THE MODULATOR UNIT CHASSIS

*The binding post on the left wall of the chassis is the ground post; below it is the microphone jack. The binding posts at the bottom right are the output terminals from the secondary of the modulation transformer. The filter choke is on the right wall. The top (front) wall contains the gain control, jacks for reading driver plate current, Class-B amplifier grid and plate currents, and the on-off switch for the power supply.*

hum pickup, and the positions shown were found to be very satisfactory in this respect. Due to the small size of the chassis, care will have to be taken if this arrangement is changed.

While on the subject of speech amplifiers, one further point should be mentioned. When handling speech, a limited frequency range is not only permissible but in most cases desirable. It has been found that a frequency range of 250 to 2500 cycles transmits speech almost as intelligibly as an unlimited range. Some of the naturalness is lost, but it can be understood just as accurately. Approximately this frequency range is used by the telephone companies, and experience has shown it to be quite adequate.

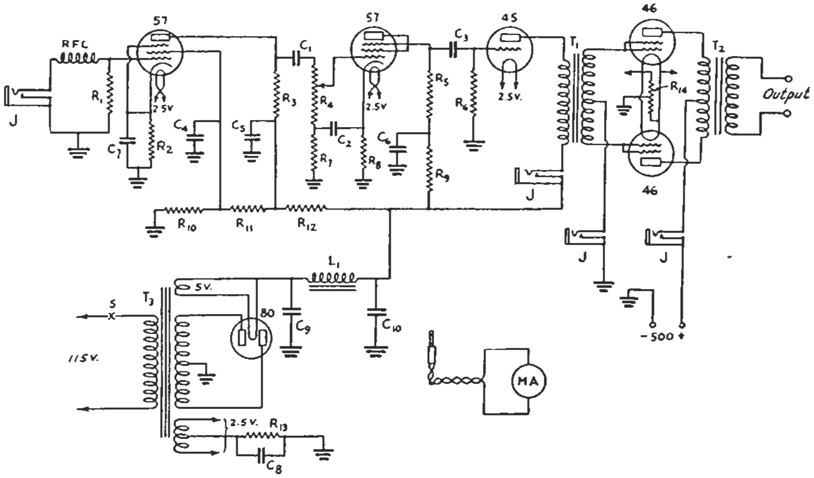


FIG. 68 — CIRCUIT DIAGRAM OF THE SPEECH AMPLIFIER AND ECONOMY CLASS-B MODULATOR

*The power supply furnishes plate and filament power for the first three tubes only; the Class-B stage must be supplied from a separate source. If a power transformer having an additional 2.5-volt winding is used, filaments of the 46's may be heated from the second winding.*

*$R_1$ — 5 megohms, ½ watt.*
*$R_2$ — 3500 ohms, ½ watt.*
*$R_3$ — 250,000 ohms, ½ watt.*
*$R_4$ — 500,000-ohm volume control.*
*$R_5$ — 50,000 ohms, 1 watt.*
*$R_6$ — 0.5 megohm, ½ watt*
*$R_7$ — 0.1 megohm, ½ watt.*
*$R_8$ — 2250 ohms, 1 watt.*
*$R_9$ — 10,000 ohms, 1 watt.*
*$R_{10}$ — 50,000 ohms, ½ watt.*
*$R_{11}$ — 250,000 ohms, ½ watt.*
*$R_{12}$ — 50,000 ohms, ½ watt.*
*$R_{13}$ — 1500 ohms, 2 watt.*
*$R_{14}$ — 20-ohm center-tap resistor.*
*$C_1$ — 0.1μfd., 400-volt.*
*$C_2$ — 0.1 μfd.*
*$C_3$ — 0.1 μfd., 400-volt.*
*$C_4$, $C_5$, $C_6$ — 2-μfd. electrolytic, 400-volt.*
*$C_7$, $C_8$ — 10-μfd. electrolytic, 25-volt.*
*$C_9$, $C_{10}$ — 8-μfd., electrolytic, 400-volt.*
*$T_1$, $T_2$ — Class-B input and output transformers; (National Type BI and BO respectively). The input transformer should have a turns ratio, total primary to one-half secondary, of 2:1. Output transformer turns ratio should be between 1.05:1 and 1.3:1, total primary to total secondary.*
*$T_3$ — Midget power transformer, 275 volts each side center-tap with 5-volt and 2.5-volt windings. (Thordarson type T-5002.)*
*L — 22-henry, 35-ma. filter choke (Thordarson type T-1892).*
*J — Single closed-circuit jacks.*
*MA — 0.200 d.c. milliammeter.*
*RFC — Short-wave choke (National type 100).*

Such a range permits economies in the design of the amplifier for many reasons. Speech microphones have higher output than high-fidelity ones, and usually are less expensive also. The same is true of audio transformers, in general. Also, the lower limit of 250 cycles is enough higher than the hum frequencies to practically eliminate all difficulties from this source in the input stages. Furthermore, the distribution of energy in speech is such that rejection of the frequencies below 250 will usually cause a marked reduction in the average power required for modulation, while the elimination of frequencies above 2500 will reduce interference by narrowing sidebands.

All of these advantages are so definite that it seems well worth while to give the frequency range careful consideration. It is a point that should be definitely decided before the design is begun, for if advantage is to be taken of the restricted range it is necessary to reject the undesired frequencies. Some sort of filter must be used, and this filter should preferably be placed as near the output stage as possible because only the hum and background noise originating in stages ahead of the filter will be eliminated. If the filter is actually placed in the output, it must be able to handle power, and the same is true of the driver stage. However, there is little voltage amplification and no high impedance circuits in these stages, so that little would be gained by filtering them. Probably the most practical place is in the input to the driver stage.

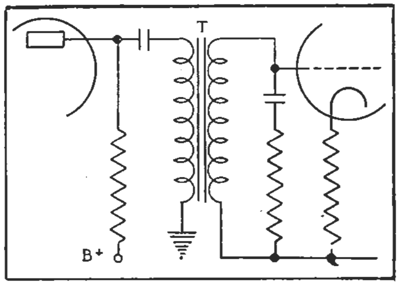


FIG. 69 — THE SPEECH-TRANSFORMER CIRCUIT

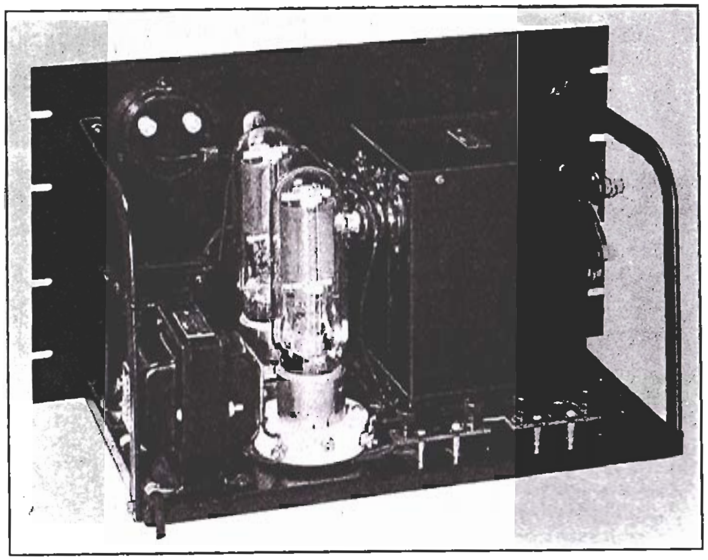
The filter does not have to be a complicated affair, for a sharp cut-off is not at all necessary. The circuit shown in Figure 69 is suggested. In this, T is an audio transformer from which some of the laminations have been removed. $C_1$ is a condenser of the proper value to be in series resonance with the primary of the transformer at about 250 cycles, while $C_2$ is in parallel resonance with the secondary at 2500 cycles. To avoid a sharp resonance peak at the latter frequency it may be necessary to add the damping resistance $R_2$. Resistance may possibly be required in the series resonant (primary) circuit also, but if the proper number of laminations are removed the resonance peak should be just about compensated. The exact circuit constants cannot be given here, for they will depend entirely on the transformer.

There is no question, however, that an audio system of greater range is more fun, and many amateurs prefer to have the frequency range as wide as feasible. We confess that most of our own speech equipment does not take advantage of the economies described in preceding paragraphs.

As these pages have doubtless made evident, we have always preferred to build as much equipment as possible in the form of separate units. This seems to work out particularly well in the case of audio equipment. The basic unit is the speech amplifier. This should have an output of five or ten watts class A, and enough gain to deliver full output with not more than .05 volts input. Such a unit is extremely useful, because it has ample power to serve either as a modulator when suppressor grid modulation is used, or as the driver when large amounts of Class B power are required for plate modulation. The use of the unit as a driver for Class B will be described in following paragraphs.

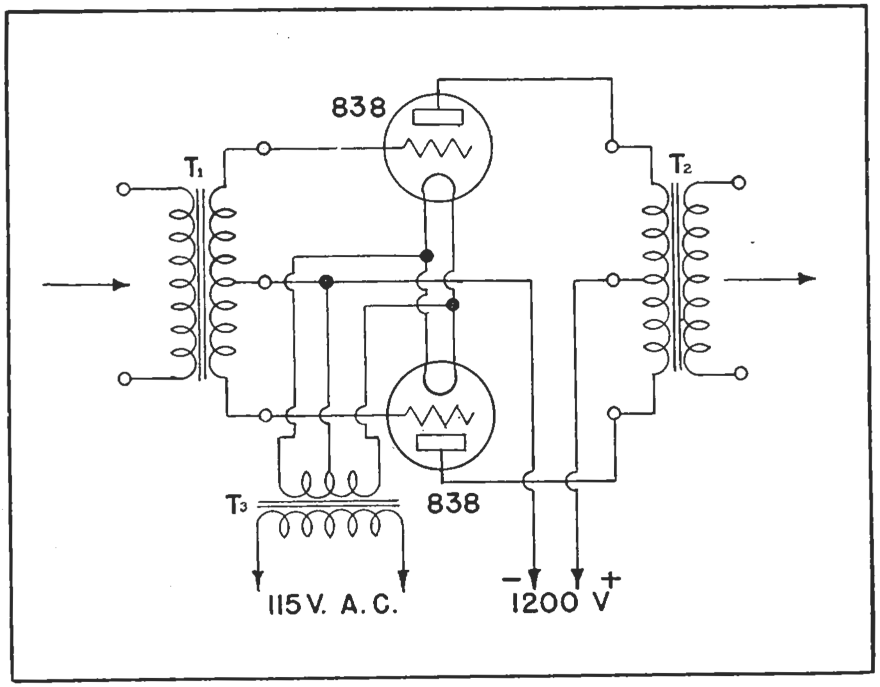
This primary unit can often consist of the amplifier from a broadcast set with one stage of extra amplification. For several years we used such a unit with a pair of 45's in the output, and except for the fact that it did not have quite enough power, it proved to be very satisfactory. Unfortunately, nearly all of the larger and more modern broadcast sets have either Class B or pentode output, neither of which are desirable in a driver stage. As it happens, it is usually quite easy to revamp the older broadcast amplifiers of the variety that used PP 45's and 80 rectifier. These can very easily be changed to use PP 2A3's, which are practically interchangeable with the 45's except for plate current and load resistance, and yet have more than twice the output. These old amplifiers were usually designed to supply plate current for the tuner, and when relieved of this load they are quite able to supply the extra plate current required to make the 2A3's deliver their maximum rated output of 7 watts. The heater winding intended for the tuner can usually be drafted to supply the heavier filament current of the 2A3's. A new output transformer will be required, and this should match the tubes to a 500-ohm line. The use of a low impedance line permits the amplifier to be located remotely if desired, and, being a standard impedance value, it makes the unit more universal.

Another very good way to solve the speech amplifier problem is to go out and buy one. At present we use a Collins 7C amplifier, mounted on a relay rack panel.



FIGS. 70 AND 71

*A ¼-k.w. Class B Modulator using the 838 zero bias tubes.*

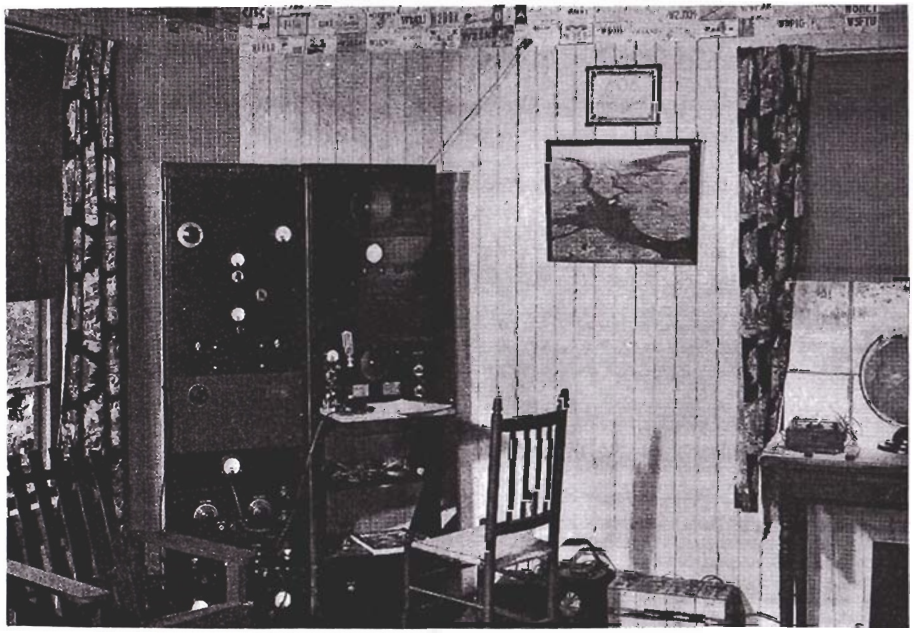


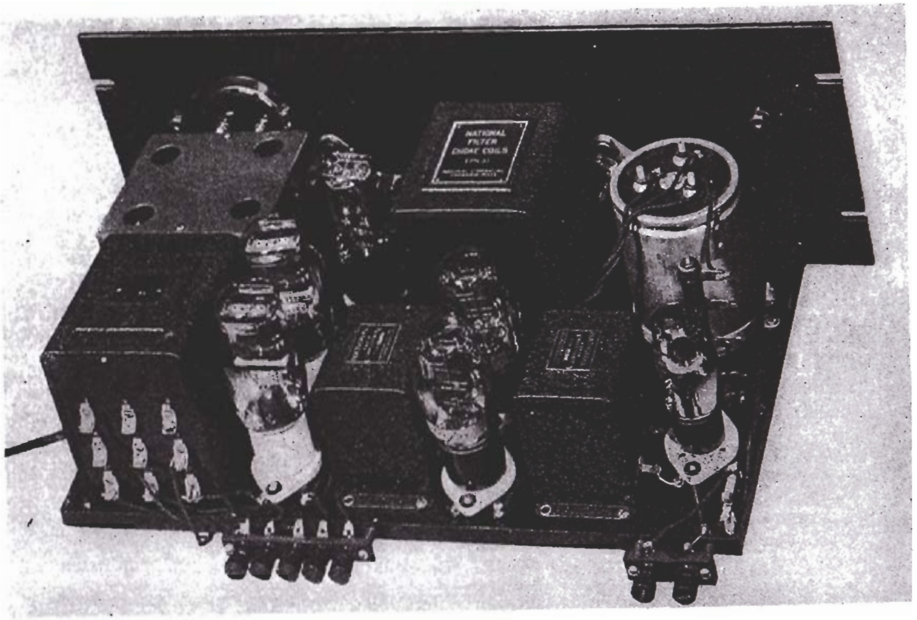
THE CIRCUIT DIAGRAM OF THE CLASS B MODULATOR
*$T_1$ — Input Transformer (500-ohm line to 838 grids).*
*$T_2$ — Output Transformer (838 plates to R.F. load).*
*$T_3$ — Filament Transformer (6.5 amps. at 10 volts).*

As we have remarked, a ten-watt amplifier does very nicely for grid or suppressor modulation, but it does not go very far with plate modulation. Where larger amounts of power are required we use the rig illustrated in Figure 70 and shown in diagram in Figure 71. This unit employs a pair of 838's in Class B and has a rated output of approximately 260 watts. These tubes were picked in preference to the many others of the same approximate output because they operate with zero grid bias. Quite aside from convenience and simplicity, low levels of distortion in Class B operation require that the grid voltage remain constant, and this is easy only when this voltage is zero. The input transformer is designed to match the grids to a 500-ohm line, so that this unit operates very nicely using the speech amplifier described above as driver. It requires a little more power than 2A3's are rated to produce in straight Class A (half a watt more), but this slight additional power is easily obtained either by exceeding the ratings by a small amount, or by inclining toward AB operation.

The output circuit employs a matching transformer of the universal type, taps being provided so that any output impedance likely to be needed can be readily obtained. The proper tap is very easy to determine. When modulating a Class C amplifier, the plate circuit input resistance of the latter, as viewed from the modulator output, will be equal to the plate voltage divided by the plate current. The correct load resistance for the modulator is obtained by looking it up in a table of tube characteristics. The ratio of these two resistances is equal to the square of the turns ratio of the transformer when the match is correct. To determine whether it is step-up or step-down, the simplest rule is that the winding having the highest voltage also has the highest impedance.

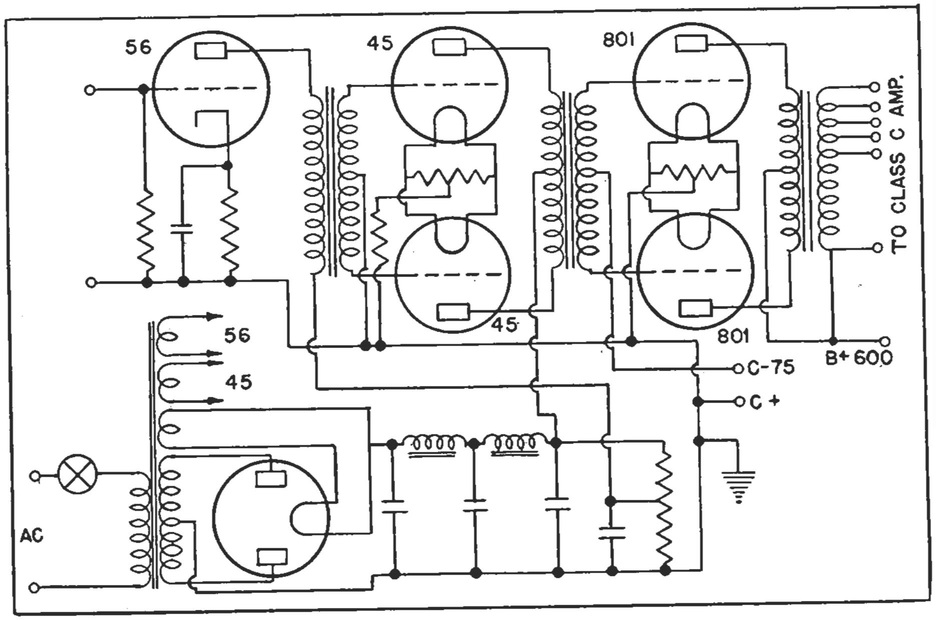
There is one still larger modulator at W1HRX that is quite interesting, though it is doubtful whether any amateur would choose to copy it. It employs a pair of 851 tubes, which are capable of developing about 2.4 KW Class B. Though we never operate them Class B, it is interesting to note that only 6 watts of signal driving power are required, which is well within the capabilities of our speech amplifier. In actual practice they are never called on to deliver more than 500 watts, and as they are rated at 320 watts Class A, it is evident that the most conservative of AB operation gives ample output. The reason for choosing such excessively large tubes requires some explanation. One reason is that W1HRX is located in the country, and power is supplied by a gas engine generator. Although the voltage regulation of our present generating system is much better than that of our earlier attempts, our experience has made us disinclined to run a high-powered Class B stage with home-made power. Another reason (and a good one) is that we had the 851's already. They are a legacy from the pre-Class-B days of W1HRX, when if you wanted power you had to use big bottles to get it.





A combination unit, developed for use in conjunction with the buffer-driver assembly shown on page 44. The power supply for the 45 and 56 tubes is built along the back of the panel and will furnish well-filtered voltage for an external pre-amplifier. Two 801's in push-pull may be operated either in Class B, or in Class A when it is desired to drive a pair of 838's.

The schematic diagram, below, shows the circuit to be entirely conventional. The input leads to the 56 must be shielded and may, in some cases, require filtering to overcome R.F. pick-up.



# POWER SUPPLIES

Because all power supplies tend to be pretty much standardized, without allowing much play for new and novel ideas, they are apt to be treated as a necessary chore. They deserve more attention than they usually get, for they are inherently one of the most expensive items in the transmitter as well as one of the most important.

There is a lot to be said in favor of condenser-input filters. To be sure, it is a characteristic of such filters that high peak currents flow through the rectifier tube. This certainly is not very good for the tube, but judging from experience it is not very bad for it either. The load regulation of condenser-input filters is also poor, so that on fluctuating loads their output voltage varies considerably, making them unsuitable for such uses as serving Class B stages. However, they will give more watts of filtered DC per dollar of cost than a choke-input filter and for such purposes as C biasing voltages and Class A amplifier plate current, the condenser-input filter is just as satisfactory and more economical. The first condenser in a condenser-input filter provides a very convenient means of adjusting the output voltage without power loss. Even a small condenser at this point will increase the output voltage as compared to choke-input by 35 to 50 per cent, depending on the load.

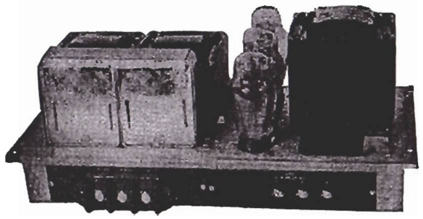


FIG. 72

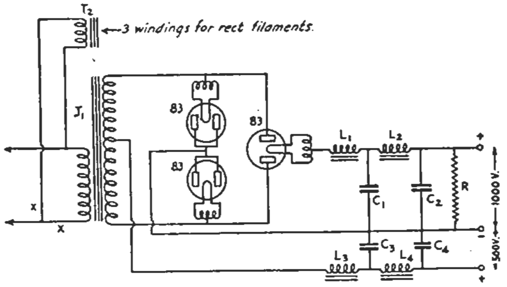


FIG. 73 — A DUPLEX PLATE SUPPLY CIRCUIT

*This plate supply will deliver 500 and 1000 volts at a total of 250 milliamperes (sum of currents from both taps).*
$T_1$ — *Power transformer, 600 volts each side center tap; 350 VA.*
$T_2$ — *Rectifier filament transformer, three 5-volt 3-amp. windings.*
$C_1$ — *2μfd., 1250-volt rating.*
$C_2$ — *4 μfd., 1250-volt rating.*
$C_3$, $C_4$ — *2 μfd., 800-volt rating.*
$L_1$ — *Swinging choke, 8/40 henrys, 275 ma.*
$L_2$ — *Smoothing choke, 12 henrys, 275 ma.*
$L_3$, $L_4$ — *10 henrys, 200 ma.*
R — *40,000 ohms, 25-watt rating.*

Very often resistors can be used instead of chokes for filtering out hum. Chokes are normally used in power supply filters because they present a high impedance to the unwanted ripple and a low impedance to the desired DC. If a resistor, having an impedance similar to that of a choke on AC, is used, it will have essentially the same filtering action as the choke. It will also have a large DC voltage drop. In some cases such a drop is quite permissible. For instance, in early audio amplifier stages only about 200 volts is required although the power supply necessarily supplies 300 to 400 volts in order to take care of the output tubes. Resistors are very often used in this way for RF filtering, particularly in receivers.

Condensers for transmitter power supplies are preferably either of the oil-impregnated-paper type or the electrolytic type. For voltages of about 450 or higher, it has been our experience that oil-impregnated units are by far the most satisfactory. It is possible to operate electrolytic condensers in series for use on high voltages, and our original 2000-volt power supply at W1HRX used a large bank of electrolytics in this way. They gave quite a bit of trouble. Every now and then one condenser in a group would blow, probably because of the difference in leakage resistances of the different units, which caused the voltage to divide unevenly. As soon as one unit blew, the others would go also, of course. It is characteristic of electrolytic condensers for the insulating film to deteriorate when lying idle, so that when a power supply employing them is unused for a time it is necessary to run it at reduced voltage for a short period to reform the film. This precaution was not always taken at W1HRX, and possibly the condenser troubles can be attributed to this in part. On the other hand, we have never had any trouble at all with the oil-impregnated-paper condensers we have used, and are inclined to think that over a period of years they have been less expensive than cheaper units. They certainly can take it.

Properly placed, fuses are a good idea in the power supply. Even small rectifier tubes will handle enough power for short periods to blow a fuse in the

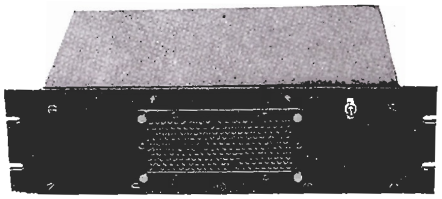


FIG. 74 — A COMPACT RELAY RACK TYPE OF POWER SUPPLY FOR EXCITERS, SPEECH AMPLIFIERS, ETC., IS THE NATIONAL TYPES LRDPU (DUPLEX) AND GRSPU (SYMPLEX) FURNISHING 250 VOLTS DC AND EITHER 6.3 OR 2.5 VOLTS AC

primary of the transformer in case of a short circuit in the load circuit. If there is no fuse to blow, the damage is sometimes appalling. Fuses must be used with care, however, because in certain cases shutting off the power may do more damage than a short circuit. For example, excitation must not fail when final amplifiers with grid-leak bias have power on. As far as fuses go, the answer lies in proper grouping. Circuits which are mutually dependent should have a common fuse, so both will go dead together if the fuse goes.

Of course, the nicest solution to this problem is to use a system of interlocking relays such as have been described from time to time in *QST* and elsewhere. Such arrangements not only protect the equipment from overloads or failures, but also energize circuits in the proper sequence when power is turned on.

With mercury-vapor rectifiers such as the 866, filaments should be allowed to come up to operating temperature before the plate voltage is applied. This usually takes about 30 seconds. There are various time-delay relays on the market designed to provide this interval automatically, but there are several simple and satisfactory "homemade" arrangements. One of the best employs a slow-heating tube such as the 27 with a voltage-dropping resistor in the heater circuit to still further increase the warming-up period. By choosing a suitable value for the resistor, it is quite easy to cause a delay of 30 seconds or more before the 27 draws plate current. A relay is used in the plate circuit to turn on the plate voltage of the high-voltage rectifiers. One virtue of this device is that it compensates for line voltage, etc. If for any reason the rectifiers heat unusually slowly, the 27 will probably do likewise. Another point worth mentioning is that the grid of the 27 may be used also as a safety device. For example, in line with the case already cited, it might be tied in to the exciter circuit so that the 27 would be biased beyond cut-off unless the exciter was working. Thus plate voltage would not be applied to the final amplifier unless there was proper excitation.

Once the component parts that are to be used have been collected, the actual assembly and wiring presents little difficulty. It is hard to go wrong, provided condensers are not placed where they will get too hot, and chokes are not placed where they will have too much coupling with the transformer. The practice of using bus wire and spaghetti for wiring high-voltage power supplies is greatly to be condemned, if for no other reason than danger to the operator. Rubber covered wire of the kind used for house wiring is cheap and much better. The common variety is rated at 600 volts working, but it is also made with insulation for higher voltages. Where a very flexible conductor is required spark-plug cable is satisfactory, though somewhat expensive.

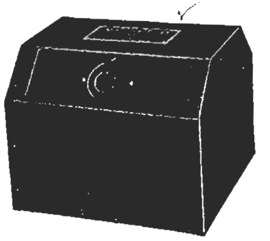


FIG. 75 — THE NATIONAL 5897 PACK IS THE SAME AS THE GRDPU UNIT OF FIG. 74 ABOVE, EXCEPT IN MORE COMPACT AND INEXPENSIVE FORM

The unit shown in Figure 72 is representative of what a well-planned power supply should look like. It is a commercially manufactured unit (made by Acme Delta) and was not intended for relay-rack mounting. The circuit is given in Figure 73, and it will be seen that a straight bridge rectifier circuit is used. In this particular unit, three type 83 full-wave rectifiers were used instead of four half-wave rectifiers. As only four plates are required for the bridge circuit, there are two plates left over. By bringing out a lead from the center-tap of the transformer it is possible to utilize these two plates in a conventional full-wave rectifier circuit giving half the output voltage of the bridge. Thus two separate outputs are available.

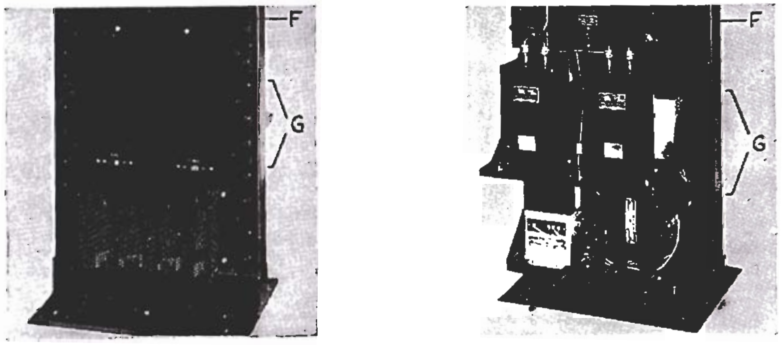


FIG. 76 — TWO VIEWS OF A BRIDGE TYPE 866 RECTIFIER POWER UNIT FURNISHING 2200 VOLTS FOR THE 1-KW FINAL AMPLIFIERS

For supplying the 851's mentioned in the preceding chapter, we originally designed the high-voltage unit shown in Figure 76, using four 866 rectifiers. It is built relay-rack style and in two units, the filament and plate transformers being located in the lower unit and the filter in the upper unit. All of the high-voltage wiring was done with H.T. spark plug cable, supported on GS-1 standoffs. This supply provided 2200 volts at one ampere, and served both the 851 Class A modulators and the Class C modulated amplifier. Later on this equipment was moved to a farm in Middleton where power had to be obtained from a small engine-driven AC generator. This generating plant was rated at 3 KW, which was thought to be ample. However, it was very quickly discovered that the regulation was not very good, and that it was not suitable for operating large Class B modulators. Even a Class B stage of a hundred watts was enough to blink the lights when talking into the microphone. This generating plant was, therefore, demoted to such duties as running receivers, lighting filaments and providing illumination, for which service it has proven quite ideal.

One of the Boston broadcasting stations was being revamped at about this time, and from them we obtained a large motor-generator set. The AC motor on this unit was removed, and in its place an old automobile engine was mounted. This plant, which easily supplies 1 ampere at 2000 volts, has effectively disposed of the problem of where high-voltage power is coming from at the farm. The complete unit is shown in Figure 77. It is mounted close to the radio shack to avoid long and dangerous high-voltage leads. However, it is somewhat noisy, and being close by the operating desk it has been found necessary to shut it off when receiving. This is somewhat of a nuisance, but otherwise the unit has proved very satisfactory.

At the time this booklet is being written, we are in the midst of a slight change in the engine generator set-up. Instead of directly coupling the engine to the generator, as at present, we are adding a jack-shaft and Vee belts so as to provide a three-to-one speed reduction. After all, it is rather ridiculous to have a 40 or 50 horsepower engine turning over at 1800 r.p.m. to drive a 2 or 3 horsepower load.

For small transmitters with Class A modulation such as the one on Page 37, we have had extremely satisfactory results with the standard Kato 1KW gas engine driven 110 V. AC unit.

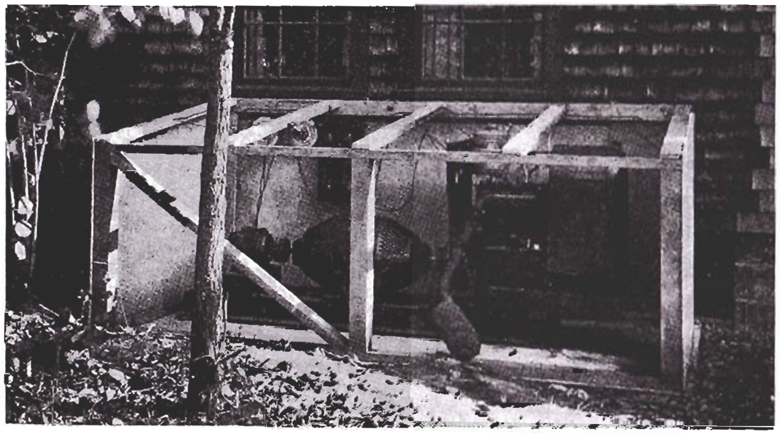


FIG. 77 — THE HIGH-VOLTAGE GAS-ENGINE-DRIVEN GENERATOR WITH COVER REMOVED FROM THE HOUSING

*This machine is started and stopped from inside the station, going "on" only during transmission.*

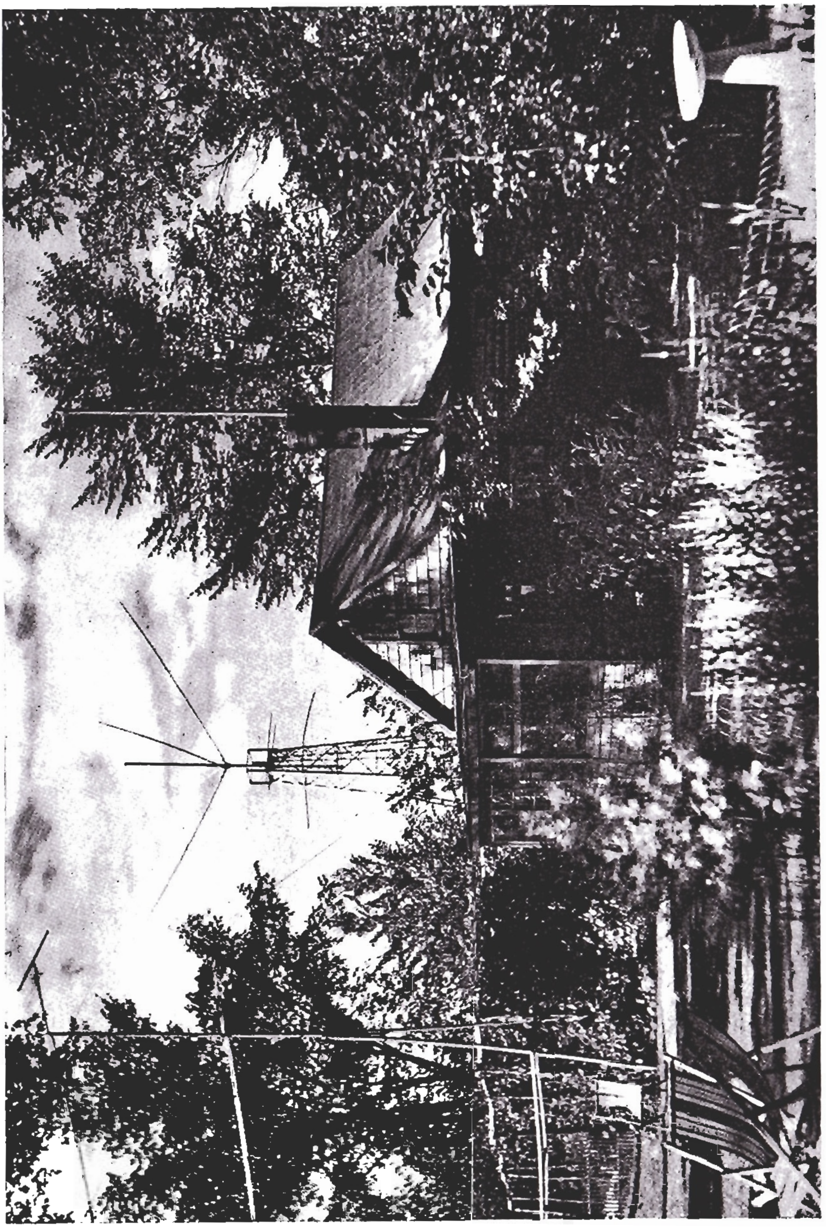


FIG. 78 — THE "SHACK" AT W1HRX

# ANTENNAE

THIS CHAPTER will be well started if we admit right at the beginning that it is not intended to be a treatise on the subject. Such treatment will be found in any one of a number of excellent books, — such as the A.R.R.L. Handbook. This chapter is merely a collection of random notes on our experiences.

For general purpose work on 20 and 10 meters we have had very good luck with the vertical doublet with Q-bar center feed. This system has a lot to recommend it, at the higher frequencies at least. It is easy to adjust, and (unlike twisted pair) is easy to insulate well. Radiation is at a favorably low angle. The system works out particularly well for the fellow who lives in the city where space is at a premium, for room can always be found for a vertical wire and it can usually be placed so that the Q-bar feeders come directly in the second story window.

We favor "homemade" Q-bars, on the ground that they can then be designed throughout to fit the particular job. This, of course, is not true of universal kits. It is possible to buy seamless duralumin tubing in a variety of diameters and in 14-foot lengths which are straight to one part in 1200. As a matter of fact, straight lengths up to 52 feet long are obtainable from the mill, but 14 feet is the usual length stocked. Because of the extra expense and long delay in getting long pieces, it is better to buy in whatever length is most available, and then splice as necessary. It is not difficult to make a good splice, and a suggested method is shown in Figure 81. The plug should be a light drive fit into the open ends of the tubing. The knurl is to insure cutting through the oxide film to get good contact. The plug should preferably be made of the same material as the tubing to avoid corrosion.

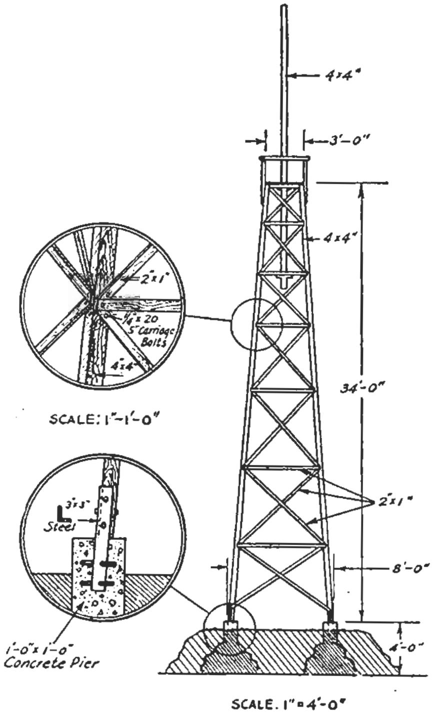


FIG. 79 — DETAILS OF THE SELF-SUPPORTING WOODEN TOWER

*A tapering tower of square cross-section, made with 4 by 4 corner posts and 1 by 2 cross pieces.*

The insulators were specially made to the dimensions shown in Figure 82. As is evident from the drawing, they are not intended to be adjustable, thus eliminating troubles from oval slots, clamps, lead washers, etc. They are simply slipped over the duralumin rod to the position desired and held in place with a wrap of tape. The insulators and tubing shown are designed to match 72 ohms to 600 ohms, or in other words they will match a center-fed half-wave antenna to a feeder using No. 12 B&S wire and 6-inch spreaders (such as National AA-3 spreaders). The convenience and rigidity of the non-adjustable assembly have proved so marked that an extra quantity of the insulators have been made. These are obtainable from National Company for the time being, but are not a regularly listed item with them.

The vertical doublet described was quite effective, but the next step was obvious, — adding a half-wave reflector to get directional effect. One of our more pretentious developments along this line is shown in Figure 78 and Figure 80. Two reflectors and two radiators are used in this array, all suspended from four bamboo poles which fan out like the ribs of an umbrella. The whole is mounted on the top of the mast shown in Figure 79, and is capable of being rotated at will. This array worked very well indeed — while it lasted. Unfortunately, such an array not only looks like an umbrella frame, but in a strong wind it acts like one also. However, Mims of 5BDB has been using a somewhat similar arrangement for some time, and apparently it is immune to any ordinary wind. It employs a single horizontal half-wave reflector and a single radiator, which is structurally much better than the four dangling conductors at W1HRX. Fellows who

FIG. 80 — THE ISOLANTITE BLOCKS SHOWN IN FIG. 82 CAN BE SEEN PLAINLY IN THIS VIEW OF THE COMPLETED FOUR-ELEMENT ARRAY

have heard Mims demonstrate the directional qualities of his array know how very effective it is.

We should perhaps point out that the failure of the antenna lay in the mechanical weakness of the array, and not in the tower which supports it. This tower was put up by local carpenters to our design, and is very much of an asset. This business of being a human fly is all right the first dozen times or so, but after a while the virtues of having a solid railed platform 34 feet up begin to grow on you. Also the ladder bolted rigidly to the side of the tower is a big help when going up with one end of the sky-wire spliced to your belt, your hands full of tools and your pockets full of insulators. This particular tower is, in short, fine from a convenience point of view. However, it is stronger than necessary for most purposes, and its expense is usually not justified.

At the present time a large V antenna is being constructed at W1HRX. The tower described, being already available, is doing service at the apex of the V, but at the farther ends lighter and cheaper towers are planned. These are built of ladders bolted together in the manner shown in Figure 84, and although they are comparatively cheap, they are self-supporting and easy to climb. The ladders used for this purpose should be sound and very strong. A preferred type is shown in the drawing. This sells for about twenty-five cents a foot "over-the-counter," but when six ladders or so are bought at a time the price is somewhat less. The actual construction of the tower requires very little comment. The three ladders are bolted together, using stove bolts and steel angles. These are available at any hardware store. The splices where the ladders are joined end to end are bolted in similar fashion, using fish plates. The first tier of ladders should be of different lengths (such as 8, 12, and 14 feet). This will not only stagger the joints, but will also make the tower much easier to erect. The top tier will also have the ladders of different lengths, of course, to make it come out even. Intermediate tiers will have ladders of the same length. If the tower so constructed is bolted down to a concrete foundation, no guy wires will be required for heights up to about 35 feet, for the structure is quite rigid.

Incidentally, if four ladders are used to make a square tower, it will be about 41 per cent stronger in its weakest direction than the triangular tower. In its strongest direction (parallel to the faces of the square) it is twice as strong, so that the tension of the antenna, etc., should be in this direction. The square tower will require some diagonal bracing.

As has been mentioned above, we are in process of constructing a large V (four wavelengths long) at W1HRX. There seems to be a definite trend in the direction of V's and Diamonds for high-frequency work. They were in disfavor at first because they radiate horizontally polarized signals which was thought to make them unsuitable for use at the high frequencies. Apparently this is true only because most high-frequency receiving antennae have been vertical and therefore unsuitable for the reception of such signals. When proper receiving antennae are used the results have been excellent because of the large power gains obtainable, and interest in these types has been growing.

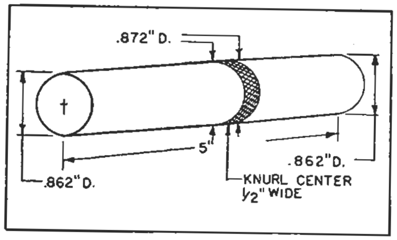
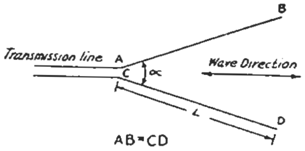


FIG. 81 — THE DETAILS OF THE TAPERED PLUGS, USED FOR JOINING THE DURAL TUBES OF THE Q-BAR TRANSFORMER

As between the V and the Diamond, the former seems to be the more popular. Both take up a lot of room, and usually there are not enough acres of cleared and level land available. As a result, the antenna usually has to be strung up hill and down, through trees and between obstacles. Under such unfavorable circumstances the V seems to work out better, as it seems to be less affected by departures from the theoretically correct layout. Also, it usually is easier to build. The principal advantage of the Diamond, or rhombic, antenna is that it can be made unidirectional by closing the far end with a resistor. We personally have found that matching this resistance to the antenna is a nuisance, and we usually leave it out in practice, in which case the system radiates in two directions like a V. The choice between the two types must depend, of course, on individual circumstances.

With either type it is necessary to use some sort of horizontal antenna for reception. As has been pointed out many times, a directional antenna offers advantages in reception that are at least equal to the benefits in transmission, for it not only increases the strength of the signal but also reduces background noise. As the design of the antenna is the same for both transmission and reception, the same array can be, and usually is, used for both purposes. A changeover switch of some sort is necessary of course. It is a good idea to have this switch interlocked with the power supplies of the transmitter and receiver, so that plate voltages are shut off automatically when the switch is thrown.



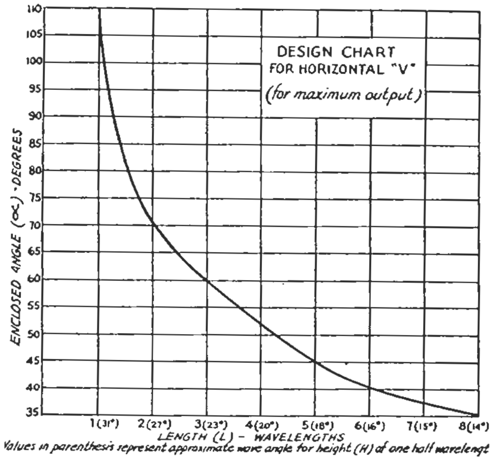


FIG. 83 — DESIGN CHART FOR HORIZONTAL "V" ANTENNAS

Enclosed angle between wires versus length of sides.

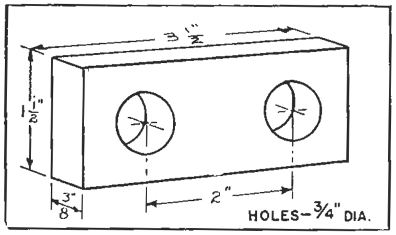


FIG. 82 — THE DETAILS OF THE SPECIAL NATIONAL ISOLANTITE Q-BAR SPACERS

The accompanying illustrations rather succinctly tell the story of our ladder mast, originally designed and erected to support one end of a "V" antenna. The tower shown on the preceding pages served as the support for the apex of the "V" and a convenient tree supported the remaining end.

FIGS. 84, 85, & 86

TOP—THE FIRST REQUISITE IS A HOLE ABOUT THE SIZE OF THE ONE SHOWN IN THIS PHOTOGRAPH

*The ladders will later be spliced together to make the mast.*

CENTER—THE FOUNDATION, READY TO BE FILLED WITH CEMENT

*The anchor strips are spiked to a triangular frame to keep them in position during pouring.*

BOTTOM—READY TO TAKE THE MAST

*The bottoms of the ladders later will be bolted to the anchoring strips.*

### SOME USEFUL POINTERS

The first step in the erection of the mast is the construction of a suitable base. The hole for the base should be at least three feet deep and three feet square, preferably larger at the bottom than at the top.

Cement economy can be achieved by using quite a few rocks in with the cement. Before pouring the cement and placing the rocks, the steel inserts for attaching the ladder to the base should be put in place. A triangular frame of 2 X 4's was found quite practical for this use. The steel inserts were attached to the ends of each of the 2 X 4's with a spike. The entire assembly was then placed in the hole and carefully leveled. Care must be used in shoveling the concrete into the hole and in throwing in rocks to see that the alignment of the inserts is not disturbed.

For inserts we used standard building irons as stocked by most building supply companies for tying masonry walls to timber frames. They are iron straps approximately ¼ inch thick, 1½ inches wide and 2 feet long, with a crow-foot end for anchoring in the concrete. While these supports were quite ample for our particular mast, we feel that on a higher mast it would be well to use much wider strips for this purpose and to have them extend quite a distance farther up each ladder leg than in our case. In an unguyed mast of any appreciable height, there is considerable strain on the corner posts at the position of attachment to the base, and a large overlap between the corner posts and the steel inserts is very advisable.

The cement base should be given ample time to harden before starting the erection of the tower; three or four days is not at all too much. If any old iron wire, steel re-enforcing rods or other such material is handy, it is wise to throw a few pieces into the hole while pouring the concrete.

In some sections of the country it is difficult to obtain the shorter length ladder with parallel sides; that is, one in which the top rung is not shorter than the bottom rung. Also, it is sometimes hard, we find upon inquiring at different Boston hardware stores to get 10- or 15-foot ladders that are exactly the same width as the 20-foot ones. We solved the problem by buying only 20-foot lengths and cutting them into the required sections for staggering the joints. If the mast is to stay in service a long time, it is strongly recommended that heavy plates and bolts be used in the assembly, so that if neglected and allowed to rust, it will be many years in reaching a dangerously weak state.

The tower is first completely assembled on the ground, painted, and all parts carefully numbered; then all but the bottom section disassembled. (A convenient time for painting is when the tower has been pre-assembled; then, before dismantling it for erection, the different sections can be numbered on top of the paint. We made the mistake of numbering first, disassembling, painting, and then trying to fit the pieces together when the tower was half in the air!) The bottom section is easily up-ended by two people and bolted in place to the base inserts. If necessary, thin shims can be driven under some of the corner posts to bring the entire unit truly vertical. A plumb bob dropped through the center is the most practical way to determine when the mast is properly lined up. When the lower part is properly lined up and rigidly fastened, then proceed to add one ladder at a time, as you climb spirally up the assembly. Always advance the suspension point of the plumb bob as you add another unit, and carefully adjust its alignment. Incidentally, be sure to use a belt, rope with the right kind of knot, or other means of securing yourself to the tower during this process, so that both hands are free for fastening bolts and hauling up additional ladder sections. Don't, however, indulge in the trick attributed to W6ZH. As his friends know only too well, Herb is a most meticulous sort of fellow, and when, not so long ago, he wanted to try out some large vertical V's for 60-megacycle work, he found he needed another 8-foot or so extension on one of his California telegraph poles (California used in the same sense as in "California kilowatt"). Not having a lineman's belt, he took some sash cord and carefully fastened himself at the top of his pole, then proceeded to spike in place an overlapping piece of 2 by 4 to give the required additional extension. Just about that time, he was suddenly faced with the problem of how to get the several turns of sash cord out from under the 2 by 4. We have heard that someone finally came to his rescue with a knife!

Just how high a ladder mast can safely be carried without guys is a matter on which we hesitate to express a definite opinion. Maximum local wind velocity will, of course, have much to do with the matter. In our case, the original unguyed mast was limited to thirty feet, plus a three-foot extension to make it suitable for use also as the support for a half-wave vertical radiator at twenty. By the addition of three guys, however, the height may safely be extended a great deal further. Of course if we want to work on the same narrow factor of safety by which some of our friends seem to have been getting by for quite a few years now, we might suggest much greater heights.

SPLICING AND PAINTING

*Twenty- and ten-foot ladder sections are bolted together with angle-iron strips (the bend in the strips is 120 degrees).*

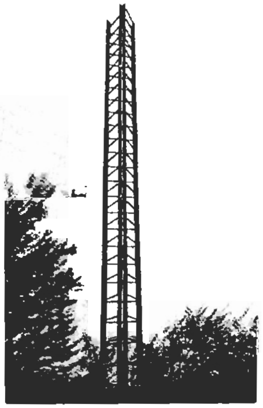
★

THE BOTTOM SECTION IN PLACE ON THE FOUNDATION

*The plumb bob is an essential to keep the mast exactly vertical as its construction goes up.*

UP WITH ANOTHER SECTION!

*The author recommends a linesman's belt for this job, although he doesn't seem to be wearing one.*



READY FOR THE ANTENNA

*With reasonable loads, this type of mast does not require guying until heights of forty or fifty feet are reached. It's a snap to climb it.*

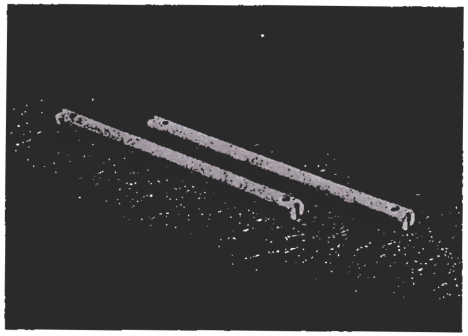


FIG. 90.—THE THIN STRONG LIGHTWEIGHT NATIONAL STEATITE-ISOLANTITE TRANSMISSION LINE SPREADERS PROVIDE FOR A 6-INCH SPACED LINE

*As will be seen from Fig. 92, these spreaders when used with No. 12 wire form a line having a surge impedance of 600 ohms.*

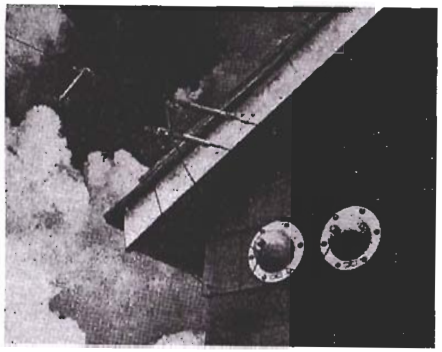


FIG. 91.—GOOD CONSTRUCTION FOR A LONG TRANSMISSION LINE IS TO USE ANTENNA INSULATORS NEAR EACH END, AS SHOWN HERE, TO TAKE THE STRAIN

The illustrations on this page may prove helpful in connection with the construction of open-type transmission lines. In addition to the general high efficiency of such lines they have also the advantages of low cost and easy construction to recommend them. Where multiple Vs, diamonds or other types of directional antennae are employed either some means of remote switching or else several sets of transmission lines must be used.

As previously mentioned, a directive antenna system is just as advantageous for reception as for transmission and, consequently, some means should be employed in the shack for quickly, or better yet automatically, shifting the feeders from the transmitter to the receiver and vice versa at the proper time. A double pole-double throw switch with good insulation and reasonable low intercontact capacity may be used. A more handy arrangement, however, consists in the employment of a relay for this purpose. At W1HRX we have made the functioning of this relay entirely automatic by having it derive its operating voltage from the 6-volt battery charging generator on the gas engine that drives the high-voltage plate supply generator. Thus, as soon as the engine is started up for a period of transmission the relay is energized automatically and shifts the antenna feeders from the receiver input to the transmitter output. For this purpose we use one of the 6-volt Ward Leonard double pole-double throw Nos. 507–523.

The ends of our feeders are attached to the shack just under the eaves with two antenna insulators as shown in Fig. 91. This construction takes away any strain from the lead-in bowls and thus prevents possibility of rain leaks due to the opening of the joint between the bowl and the building wall. Incidentally, before fastening lead-in bowls in place, gaskets should be made of builder's felt well saturated with roofing cement. Also, at this point, it might be well to comment that the difference in price between some of the cheaper lead-in bowls on the market and those offered by the more reputable manufacturers is represented not only in a difference in grade of the ceramic material from which the bowls themselves are fabricated, but also in the hardware. It is rather disheartening to look over a lead-in some weeks after an installation to discover that the supposedly brass hardware is, after all, only nickel-plated steel!

A V, or other such antenna system can accumulate quite an appreciable static charge during a local thunderstorm and should be grounded when not in use.

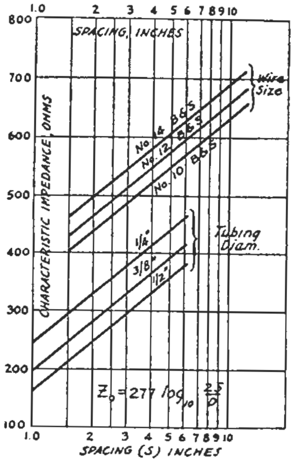
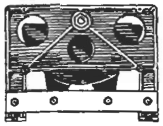
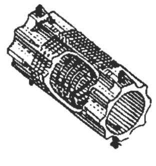


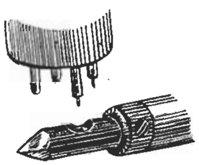
FIG. 92.—GRAPHICAL TABLE OF CHARACTERISTIC IMPEDANCES OF TYPICAL SPACED-CONDUCTOR TRANSMISSION LINES

## Miscellany:



ABOUT CONDENSER INSULATION: High grade ceramic insulators (such as the best quality of Isolantite) are properly regarded as second only to fused quartz for high frequency insulation. Quartz is so very expensive that it is out of the question for most uses. Fortunately it makes but little difference, because the best ceramics give results almost equally good, when properly used. "When properly used" is a big phrase however, and covers a multitude of things. As far as the user is concerned, the main thing is to keep the insulator clean. Dust (and particularly the sooty dust of industrial districts) causes a marked reduction in the breakdown voltage as well as an increase in losses. The best cure is to inclose the rig in a dust cover, but where this is not practical all insulators should be cleaned periodically. Carbon tetrachloride is usually used for this purpose, but it leads to unfortunate results unless proper precautions are taken. Unglazed ceramic insulating materials of the highest grade are quite porous and consequently absorb moisture readily. To prevent this absorption it is usual to impregnate the material with a low-loss wax. As carbon tetrachloride dissolves the wax, cleaning by this method leaves the insulator at the mercy of atmospheric conditions unless reimpregnated or otherwise protected. Probably the best treatment that the amateur can use is simply to paint the surface, after cleaning, with National Victron Coil Dope. This gives excellent results in every way.

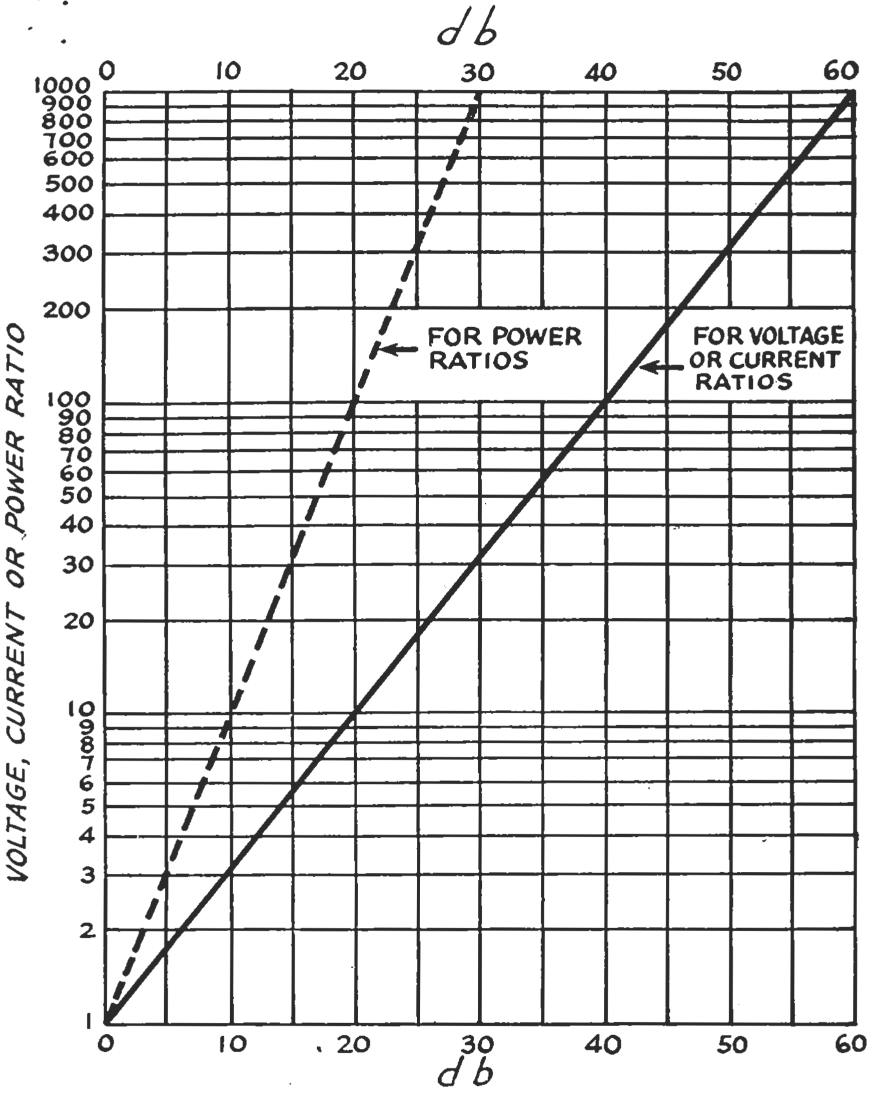




ABOUT PICK-UP COILS: Pick-up coils for antenna or link coupling are often constructed by winding ordinary rubber covered wire around the outside of the coil. Although convenient, this method has serious objections. It is definitely not safe, since the low breakdown strength of the rubber often allows lethal voltages to appear in unexpected places. Further, losses at high frequencies are unreasonably great. A better scheme is to wind the pick-up coil of heavy bus wire, and mount it *inside* the coil form. To do this, wind the pick-up coil with a diameter slightly greater than the inside of the form. Then, holding one end of the coil in each hand, twist it as if you were winding up a spring. As you twist the turns of wire will grow smaller in diameter. When small enough, insert the pick-up coil in place, and release the ends. As it unwinds it will expand again until it fits snugly in the form. The ends of the coil are brought out to terminals on the coil form. The result is a neat, efficient, and well-insulated job.

ON SOLDERING COIL PRONGS: Many plug-in coil forms have hollow terminals similar to tube prongs. We are sometimes asked how to solder wires in these terminals without leaving lumps on the side of the prong. Answer: Dip the prong in a small pool of solder, and withdraw it slowly. This is the only practical method. It is handy to have a small cup drilled in the tip of your soldering iron for this purpose. It should be about ¼" diameter and ¼" deep. Though less convenient, the same results can be secured by melting a lump of solder in an iron spoon.

ON LEAD-THROUGH BUSHINGS: Occasionally also we are asked why we do not make a small lead-through bushing. We do. A GS-8 Stand-off, mounted through the panel, leaves nothing to be desired either for efficiency or neatness.



DECIBEL CHART FOR POWER, VOLTAGE OR CURRENT CALCULATIONS

*To find db gain, divide output power, voltage or current by corresponding input value and read db value for this ratio. To find db loss, as where output is less than input, divide input value by output value. Power, voltage or current values must be in same units (watts, millivolts, microamperes, etc.). The chart also can be used for ratios greater than 1000. For power ratios between 1000 and 10,000, divide given ratio by 10 and add 10 db to value read from the chart For voltage and current ratios between 1000 and 10,000, divide given ratio by 10 and add 20 db to value read from the chart. For example, to find db gain for a power ratio of 8000, read db value for power ratio of 800 (29 db) and add 10 db, the answer being 39 db; or to find db gain for a voltage ratio of 8000, read db value for voltage ratio of 800 (58 db) and add 20 db, the answer being 78 db.*

This chart is reprinted herewith for your convenience through the kindness of the publishers of the A.R.R.L. Handbook.

In the section to follow will be found several National Company Engineering Bulletins describing in detail such essentials of the amateur station as receivers and oscilloscopes. Also for the convenience of the transmitter constructor, is included a copy of the latest National Company catalog of component parts.