CQ

W2FX DECEMBER, 1945

The Radio Amateurs' Journal

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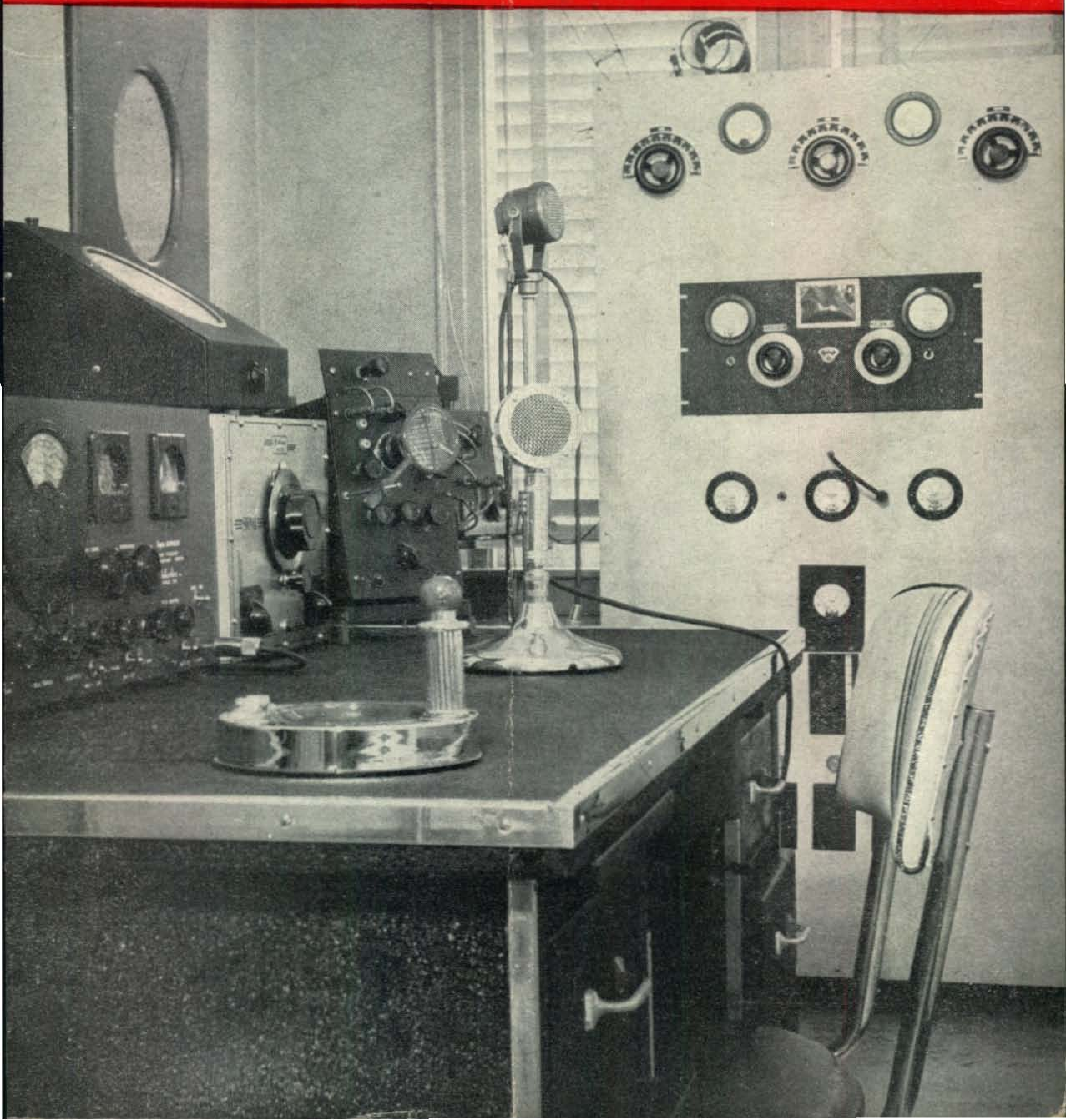
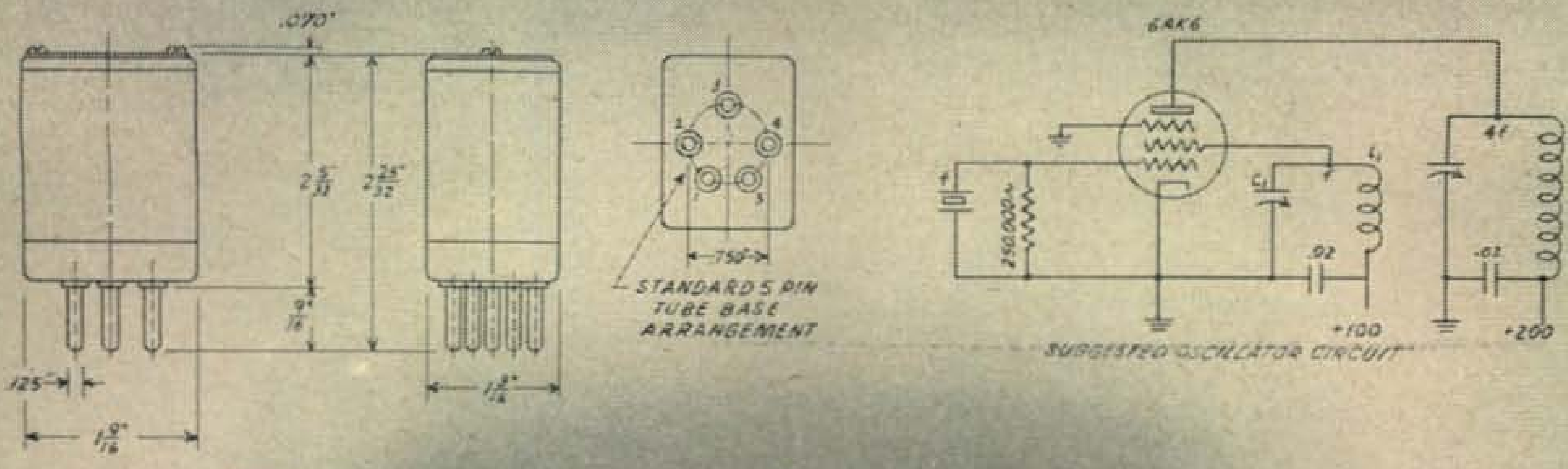
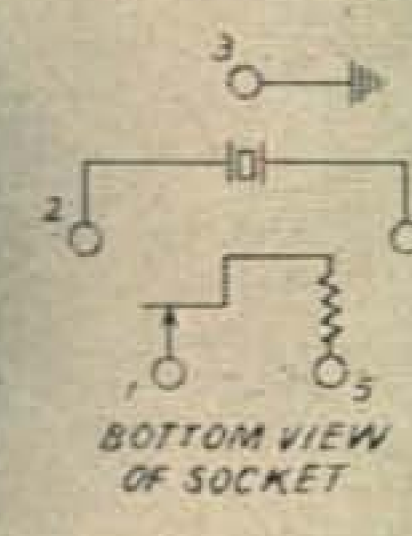
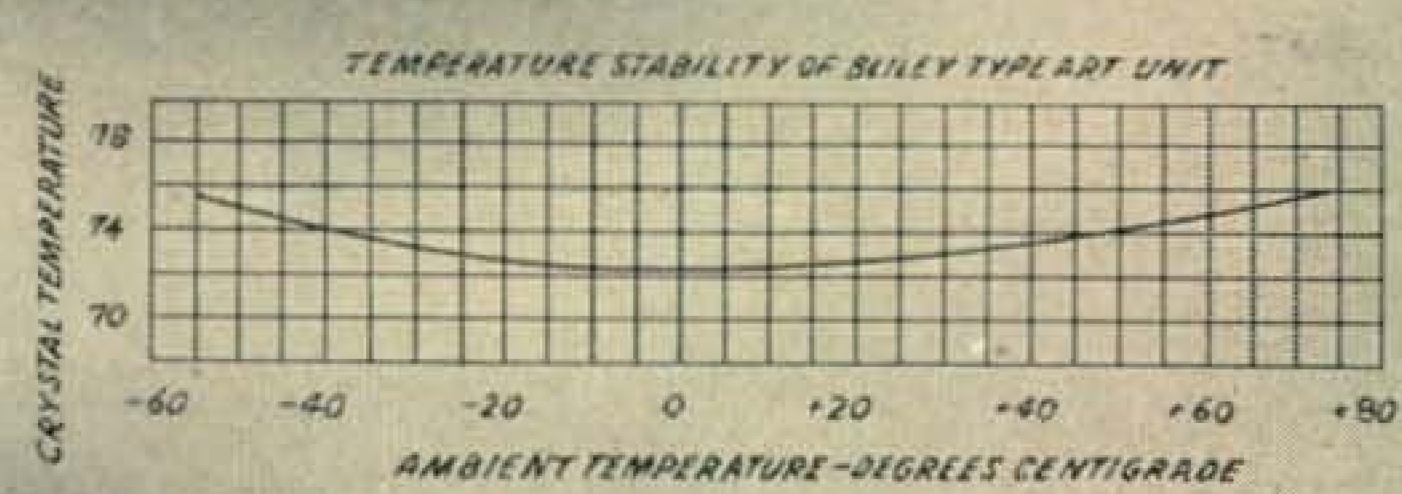


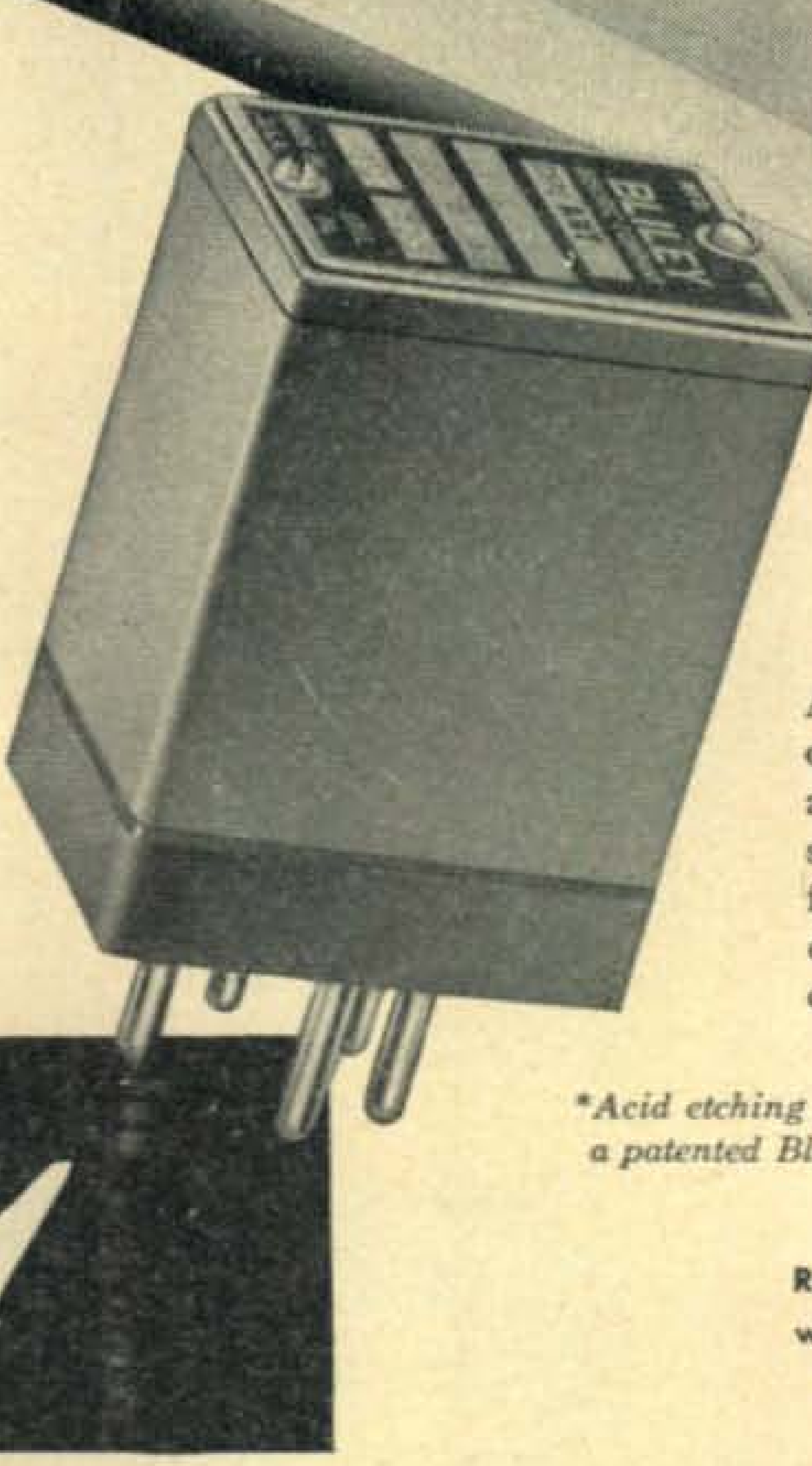


Announcing the BLILEY type ART crystal unit for maximum VHF stability





This new **Type ART** acid-etched*, crystal unit is another Bliley "first", designed for VHF services, such as police and railway communications, where frequency stability must be maintained over temperatures ranging from -55°C. to +75°C. With a built in heater operating on 6.3 V. at 1 amp. crystal temperature is held within ±2°C. The unit will maintain an overall frequency tolerance of ±.005% or better including variations due to the temperature change and tolerances required for crystal production. This rugged, compact crystal assembly is available for any frequency between 3500kc. and 11,000kc.



A schematic diagram of the oscillator circuit and tolerance to be maintained should accompany requests for quotations. See above design for efficient frequency multiplication.

**Acid etching quartz crystals to frequency is a patented Bliley process.*

Bliley CRYSTALS

Radio Engineers — write for temporary Bulletin C-26

BLILEY ELECTRIC COMPANY • UNION STATION BUILDING, ERIE, PENNSYLVANIA

CQ The Radio Amateurs' Journal

JOHN H. POTTS, *Editor* SANFORD R. COWAN, *Publisher*

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VOL. 1, No. 12 DECEMBER, 1945

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One kilowatt all-band station of W2TC—featuring an ECO, rotary beam indicator and an oscilloscope for modulation check

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MISCELLANEOUS

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ZERO BIAS

THE EDITORIAL prediction in the preceding issue of CQ, that bands would be immediately opened to amateur communications above 28 megacycles, has happily come to pass. Amateur stations in Canada, the United States and its possessions may now operate in accordance with the following allocations and restrictions—

28.0 to 29.7 mc—open to c.w. telegraphy
28.1 to 29.5 mc—open to AM phone
28.95 to 29.7 mc—open to FM phone
56.0 to 60.0 mc—open to c.w., i.c.w., AM phone and facsimile
58.5 to 60.0 mc—open to FM phone
144 to 148 mc—open to c.w., i.c.w., facsimile, AM and FM phone, FM telegraphy
220 to 225 mc—not open
420 to 450 mc—not open
1,145 to 1,245 mc—not open
2,300 to 2,450 mc—open to c.w., i.c.w., AM and FM phone, facsimile, television and FM telegraphy
5,250 to 5,650 mc— same
10,000 to 10,500 mc—same
21,000 to 22,000 mc—same

The old familiar WERS 112-mc band can no longer be used—and there is many an amateur who will bid it sad adieu. The 56.0 to 60.0-megacycle allocation is available only until 300a Eastern Standard Time, March 1st 1946. It is expected by then, that television will have cleared the 50 to 54-mc band for amateur occupation. Also, frequencies between 146.5 and 148 megacycles cannot be employed by any amateur operating within fifty miles of Washington, D.C., Seattle, Washington and Honolulu, T.H.

War-time restrictions concerning portable operation and communication with foreign stations have been lifted. All operator and station licenses which were valid between December 7th 1941 and September 15th of the following year, and which have not subsequently been revoked, are automatically validated until 300a Eastern Standard Time, May 15th, 1946. The wording of this last order suggests that applications for new licenses will be considered during this period, which would indicate that the call-letter revision proposed by the FCC will get under way simultaneously.

Canadian licenses which were valid at the time Canada entered the war are similarly extended through March 31st 1946, applications for new amateur experimental station licenses being filed during the interim. However, Canadian amateurs must first secure permission from a government radio inspector before going on the air with his former license.

The Canadian reopening is in the nature of a blanket authorization, and no subdivisions are made concerning the types of emissions permitted in various portions of the bands. Many United States amateurs will undoubtedly "gripe" at the apparently arbitrary method in which the FCC has split up the bands among the various kinds of transmission. There has been a growing feeling for some time that the manner in which the bands should be used—the subdivisions for phone, c.w., etc.—should be left strictly to the amateur himself. That this is a democratic process cannot be denied. However there is nothing in the FCC order that mitigates against such an arrangement in the future. Rather to the contrary, the Federal Communications Commission has set up tentative spectra of intra-band allocations, and it is up to the amateur to see how they work out. Regardless of how we finally decide to slice our bands, such decisions must be incorporated in FCC Rules and Regulations to make them enforceable. Some degree of regulation was essential prior to the war when our main concern was the relatively simple matter of phone (AM) versus c.w. However, with c.w., i.c.w. FM and AM phone, FM telegraphy, facsimile, television and maybe radar all on the agenda, stringent regulations are in order to avoid chaos. As we see it, the FCC has given us a fair and not illogical start.

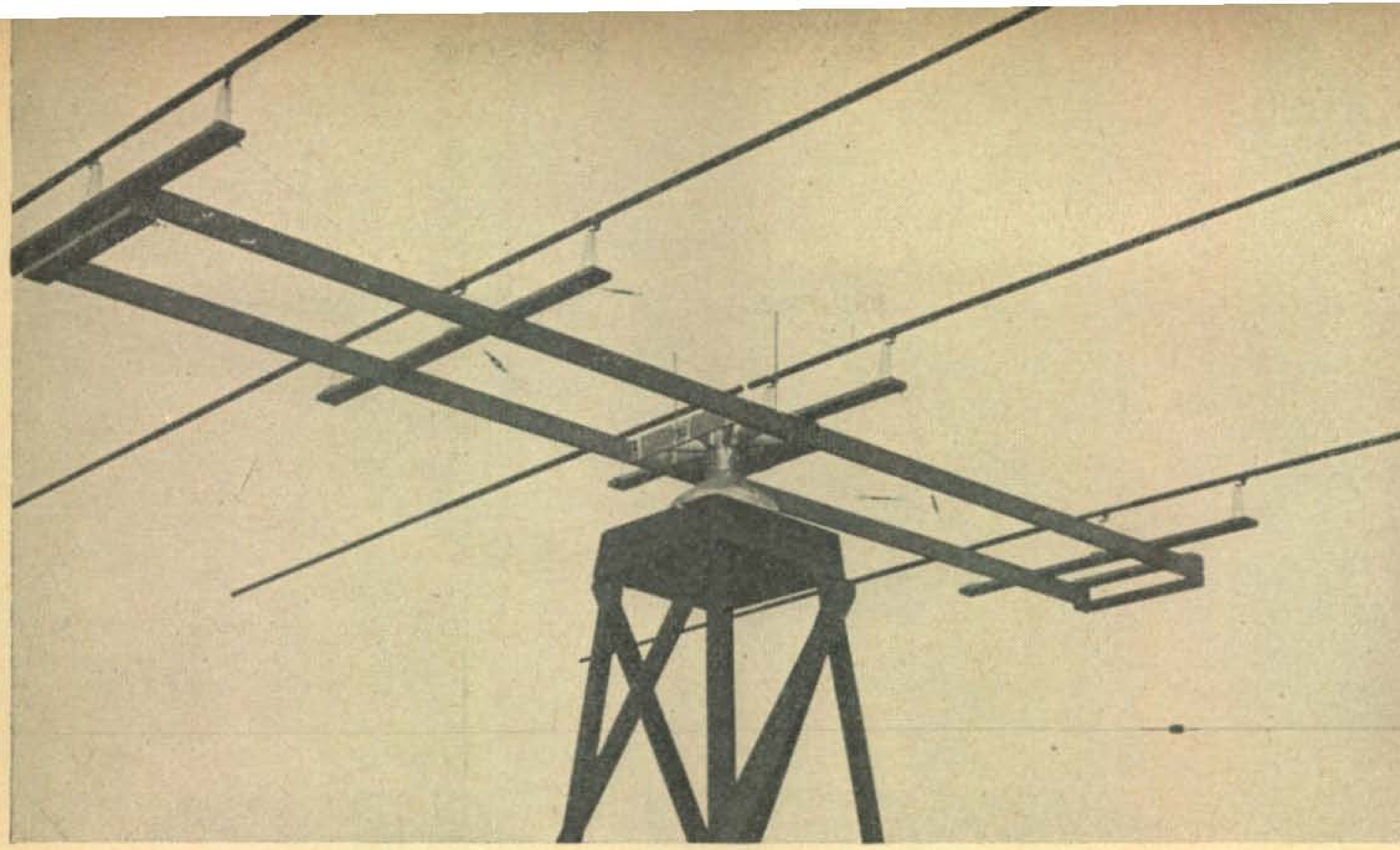


Fig. 1. A four-element rotary beam designed to put the signal where you want it on the newly opened 28-mc band

SIGNAL GAIN With The Rotary Beam

MARK L. POTTER, W9FQU

DB'S AND DOLLARS VS. KILOWATTS . . . BUILDING AND TUNING ARRAYS . . . A NATURAL FOR 28 MC . . . MECHANICAL REQUIREMENTS OF PRACTICAL ARRAYS WITH CONSTRUCTIONAL AND TUNING DATA FOR SIGNAL BOOSTING FROM 14 MEGACYCLES UP

How to squeeze a few extra watts out of the transmitter has always been the general run of amateur thinking—the thought being, of course, that a slight increase of power output would result in a stronger signal at the receiving end. Many amateurs have no doubt even doubled the power output of their transmitters, but were sadly disappointed that their signals were not much better than before—only a minor increase being noticeable.

Everyone will agree that the power radiated by a transmitter must produce power at the receiver in order to operate a pair of head phones or loudspeaker. In dealing with phones or speaker, our thoughts are naturally governed by what we hear, and since the sensitivity of our ears follows a logarithmic curve, we resort to acoustical facts. Engineering data are available, which prove that a gain of 1 db (1 decibel) does not noticeably increase signal intensity from a loudspeaker or head phones. Even a gain of 2 db does not appreciably augment the response. A gain of at least 3 db (representing a power increase of 2) is necessary to indicate appreciably to one's ears, a louder signal. Even a 3-db increase, or doubling power output, doesn't mean a great deal in terms of a signal likely to ride over QRM or QRN.

By way of explanation, the db is most useful

[*Photographs courtesy of Gordon Specialties Co., Chicago*]

because it is logarithmic, and thus corresponds to the response of the ear to sounds of varying loudness. Actually, it is the ratio of power levels and is determined by the formula:

$$\text{db} = 10 \log_{10}\frac{P_1}{P_2}$$

—where P_1 and P_2 are respectively power output and power input. For example, supposing one has a 100-watt transmitter and increases it to 200 watts output. The db gain is—

$$10 \log \frac{200}{100} \text{ or } 10 \log 2$$

Log tables show that the logarithm of 2 is 0.30103, so the db gain is ten times 0.30103, or 3.0103. In many engineering computations, a fraction sometimes doesn't appreciably alter results, which is true in this case, so we drop it and use the figure "3-db gain," which we obtain from doubling the power output. The same 3-db gain applies in all cases where the power is doubled, regardless of whether one raises 100 watts to 200 watts, or 500 watts to 1,000 watts. It's the ratio, only, of what we start out and end up with that determines the result.

Even in view of these figures, which speak for themselves, many amateurs will still eagerly look forward to doubling their power output; but they are going to be keenly disappointed when they find that the fellow at the other end reports only a slight, barely perceptible increase in signal strength. A "California kilowatt" is not dangling at the end of the rainbow when a fellow doubles, or even triples, his power! Before increasing the power of the transmitter, let's look at *Table* 1 which converts power increases into db—remembering, of course, that it takes at least 3-db jumps to make any noticeable difference in signal intensity at the receiving end.

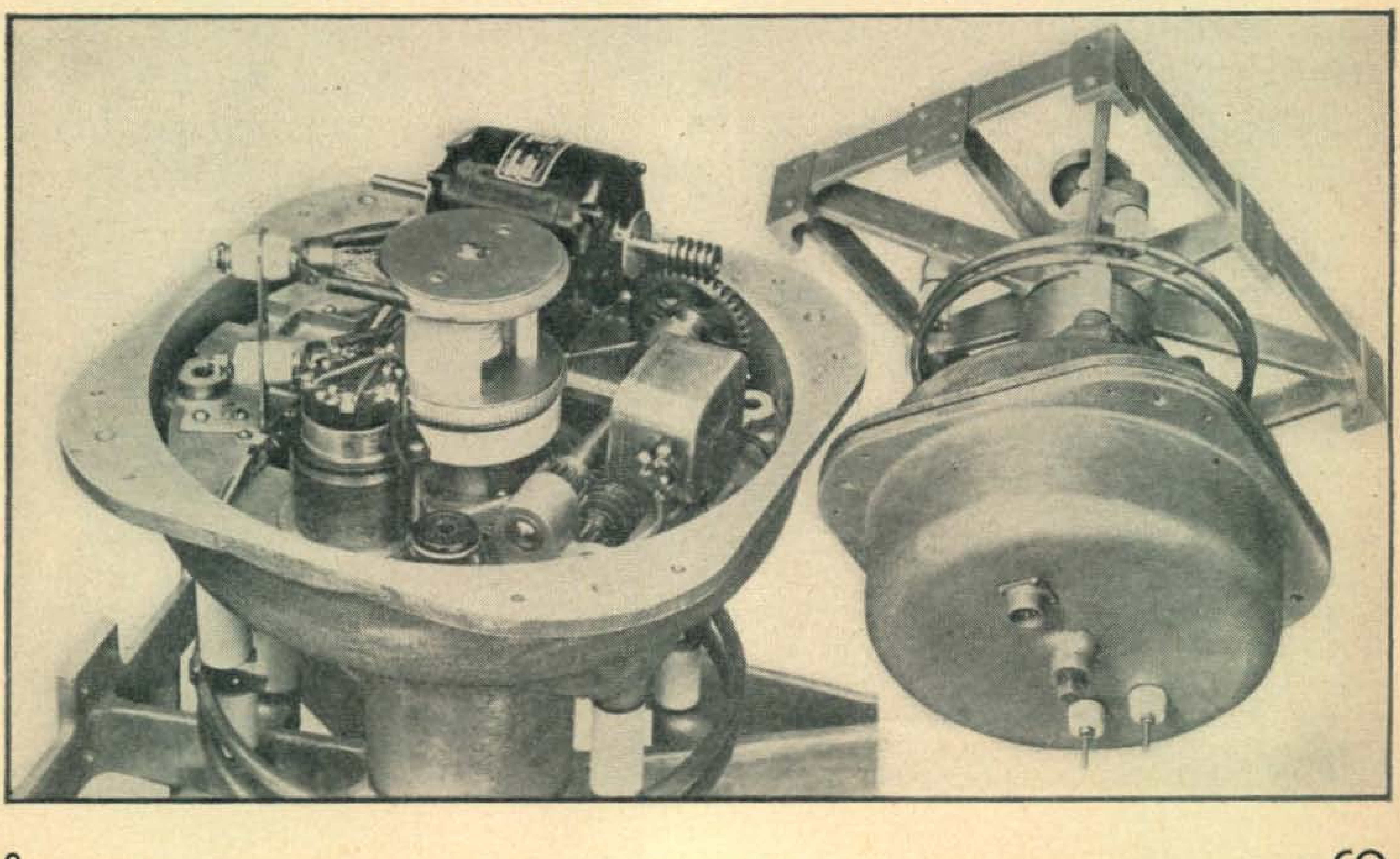
Table 1

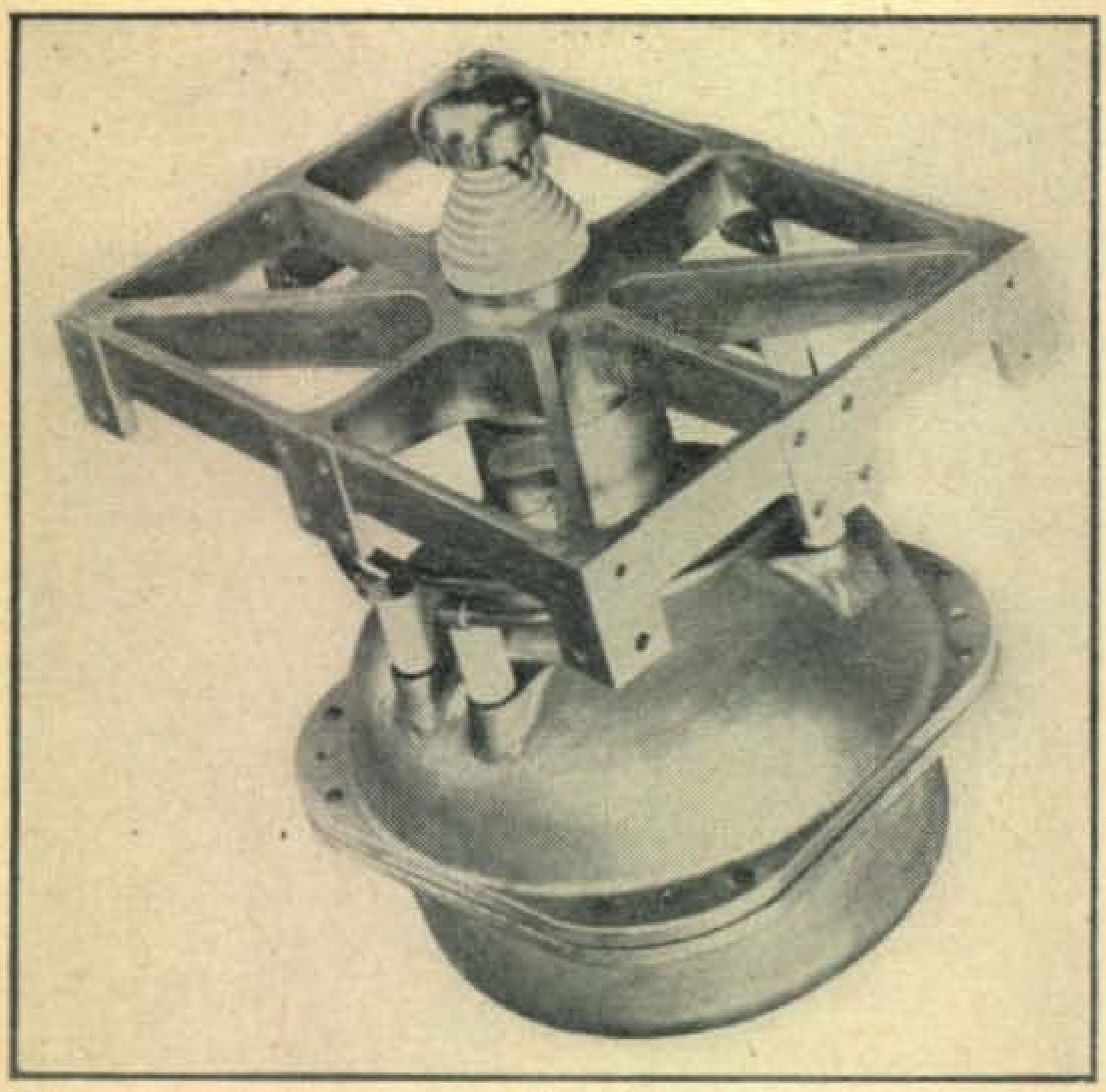
db GAIN	POWER RATIO INCREASE $\frac{(P_1)}{(P_2)}$
1	1.26
2	1.58
3	2.00
4	2.51
5	3.16
6	3.98
7	5.01
8	6.31
9	7.94
10	10.0

A 6-db, or better yet, a 10-db gain would be worth shooting at in terms of signal strength improvement at the receiving point—the only place where it counts. A larger transmitter does not impress a single thing on the receiving operator, unless the power increase is big enough to mean a real, honest-to-goodness signal strength increase to his ear. But the average amateur does not possess sufficient capital to enlarge his transmitter to the extent of a 6 to 10-db gain.

Any desire to increase transmitter power less than four times at a single jump—about a 6-db gain—seems a waste of money. To go from 100 to 200 watts doesn't accomplish anything really

(Below, left) The "works" of a rotator that will handle anything up to a 14-mc four-element array. The collector rings with 300° contact are noiseless. (Below, right) Roto-Beam rotator with housing—bottom view. Space is provided inside the lower housing bowl for a flexible coaxial ¼-wave matching section





Top side of the rotator. Continuous rotation in either direction is provided by a three-wire, variable speed, high torque motor. Maximum speed is 1½ r.p.m.

worthwhile, but to jump from 100 to 1,000 watts (10-db gain) means a real, very noticeable gain in signal strength at the receiving end. However it would be much better indeed to invest what money one has in improving the antenna, because money spent in the radiating system does the maximum amount of good at the most economical cost.

The Antenna

A wealth of excellent material has been published in the popular amateur magazines from time to time, on the many kinds of radiating systems. Some of these informative articles have "soaked in" to a certain degree, but the average amateur can profit to a very marked extent by making it a point to investigate thoroughly the antenna best suited to his particular needs, and one that will fit into his backyard, or on top of his house. After the type and size (depending on the frequency selected) have been determined, the next step is to make it operate as efficiently as possible. All of the comparisons which follow in this article will be made against a one-half wave antenna, which is generally accepted as a standard in making comparisons.

Types of Antennas

Both the RADIO, ARRL and antenna handbooks contain a wealth of material on the popular types of antennas, as well as directional arrays or beams. For one who has only a limited amount of space and capital, a simple half-wave antenna properly adjusted and fed does a good job. However, a half-wave antenna wastes considerable power, inasmuch as its radiation is spread in practically all directions. In addition, this type of antenna, as well as any other type which radiates in all directions, causes needless QRM.

This is a very important factor, in view of the fact that reliable estimates indicate that there will soon be 250,000 to 300,000 amateurs in the United States, as compared to 50,000 to 60,000 just before Pearl Harbor. One of the answers that will help relieve this problem considerably lies in *point to point communication*. In other words, signals should be directed toward the receiving point only, so that QRM will be reduced to a marked extent in other directions. The rotary beam antenna is an answer to point-to-point communication.

This fact was demonstrated time and time again during the period from 1935 to the end of 1941 when the rotary beam started to come into its own. It wasn't until a year or two just before the war that amateurs the country over really gave serious thought to rotary beam antennas, so only a comparatively few had these radiating systems in operation. Those that did, won practically all of the DX contests; and in addition, those operating with only 100 watts input gave the impression that 600 to 1,000 watts were being used more often than not.

It is the writer's opinion that a three or four-element parasitic array is best suited for amateur requirements, simply because it is easy to construct and adjust, and requires only a minimum amount of space. A three-element beam, consisting of a half-wave antenna, plus one director and one reflector, radiates over an arc of approximately 60°; a four element array—a half-wave antenna, two directors and one reflector—over a narrower arc of approximately 40°. Radiation outside of these arcs is minor and tends to dissipate itself within a relatively short distance. The ratio of maximum radiation (the direction in which the beam is pointed) to the minimum radiation (180° away, or the reverse direction) is called the front-to-back ratio. With a four-element beam, this ratio can be as high as 30 to 1, if the elements are adjusted properly. What a boon to the elimination of QRM!

Of equal importance is the db gain, or increase in signal strength, in the desired direction, resulting from a three or four-element beam—all this, of course, without increasing the power of a transmitter by even a single watt. Before we proceed farther, let's look at *Table* 2 which should convince even the most skeptical.

Table 2

NUMBER OF ELEMENTS	FRONT-TO-BACK RATIO	db GAIN	RELATIVE POWER INCREASE
2-element beam	10-15 db	4-5	2.51-3.16
3-element beam	15-25 db	6-7	3.98-5.01
4-element beam	20-30 db	7-9	5.01-7.94

There is little or no choice in determining whether to increase the power input of one's transmitter, or to install a rotary beam antenna. For the same apparent increase of power, a beam costs less, and eliminates much QRM. What's more, a beam works equally well on reception. In reception it tends to reject all signals, except those coming from the direction in which it is pointed. On these desired signals, the db gains shown in the table apply.

The Beam Rotator

A beam rotator should have excellent mechanical sturdiness to withstand the weight of a rugged wood framework that will rigidly hold the elements, as well as the weight of the elements themselves. The total weight may vary from 50 to 150 lbs. on arrays from 14 mc up. Furthermore, there must be a factor of safety to allow for stresses and strains developed during storms, when wind velocities approach alarming proportions.

The housing, containing the driving motor and other component parts, should be absolutely weather-proof—not just weather-resistant. Only a non-ferrous or rustless material should be used in the housing, so that weather conditions will not affect it. All bearings should preferably be of the oil-less kind. Continuous rotation, either clockwise or counter-clockwise and only a motor having a high-starting torque should be used to drive the mechanism. The speed of the rotator should be in the neighborhood of one to two r.p.m.

For maximum transfer of radio-frequency energy, provision should be made for direct connections to the antenna, and this can be accomplished only through the use of rotating electrical joints, or collector rings. Such sliding contacts should be self-cleaning, absolutely noiseless on reception when the rotator is turning. Moreover, they should be capable of carrying up to 20 r-f amperes. Of course, only high-frequency insulating materials can be tolerated.

A thoroughly proved method which allows continuous rotation, plus direct connections to the antenna, is through the use of a sealed air dielectric coaxial section, preferably having a characteristic impedance of 52 ohms, running through the vertical shaft of the rotator—one end terminating into the two halves of the antenna element and the other end connected into two collector rings, having ample and positive contact area. With such a setup, it is easily possible to match the impedance of a two, three, or four-element beam to a 452-ohm two-wire open transmission line (#12 wire spaced two inches apart). For instance, approximately 4.7 feet of the currently popular RG8U coaxial flexible cable (widely used by both the Army and Navy), plus the short length of air-insulated coax in the rotator, represents a quarter-wave section on 28.3 mc that will accurately match the impedance of a four-element beam, which is approximately 6 ohms, to the 452-ohm open line previously mentioned. On 14.15 mc, approximately 10.4 feet of RG8U is needed to match the 452-ohm transmission line to the 6-ohm antenna of a four-element beam.

Why and How to Match Impedance

It is well to remember that the sole use of a transmission line is to transfer power from a transmitter to the antenna with a minimum of loss. Minimum loss occurs only when a transmission line is terminated into an impedance equal to its own impedance. All well and good; but since it is not practical to build open wire transmission lines (the most efficient kind) with an impedance much below 452 ohms, and since the impedance of a two, three, or four-element beam varies only from 6 to 16 ohms, what can we do about it? There are several ways of matching these impedances. A simple, and yet efficient method, is through the use of a quarter-wave matching section of RG8U coaxial cable. A quarter-wave matching section has an "inverting" property that can be put to practical use where it is necessary to match a transmission line of one impedance to an antenna of a different impedance. To accomplish this, the matching section must have an impedance calculated as follows:

$$Z(\text{matching section}) = \sqrt{Z(\text{transmission line}) \times Z(\text{ant.})}$$

For example, the 452-ohm open-wire transmission line, mentioned previously, can be matched to a 6-ohm four-element beam antenna through a quarter-wave matching section having a characteristic impedance of 52 ohms.

$$Z \text{ matching section} = \sqrt{452 \times 6} = \sqrt{2712} = 52 \text{ohms}$$

The transmission line looks into a load of:

$$\frac{(Z \text{ of matching section})^2}{Z \text{ antenna}} = \frac{52^2}{6} = 452 \text{ ohms}$$

(this is equal to its own impedance)

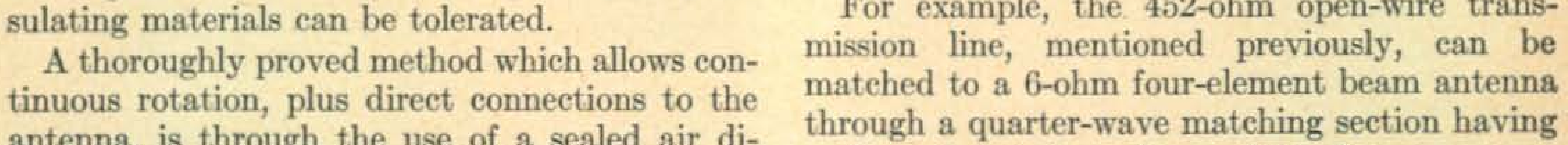


Fig. 2. Telescopic construction. Sections B, C, D and E are all five feet long, with 1", 7/8", 3/4" and 5/8" outside diameter respectively—covering the 14-mc band. For 28 mc, sections D and E are not needed

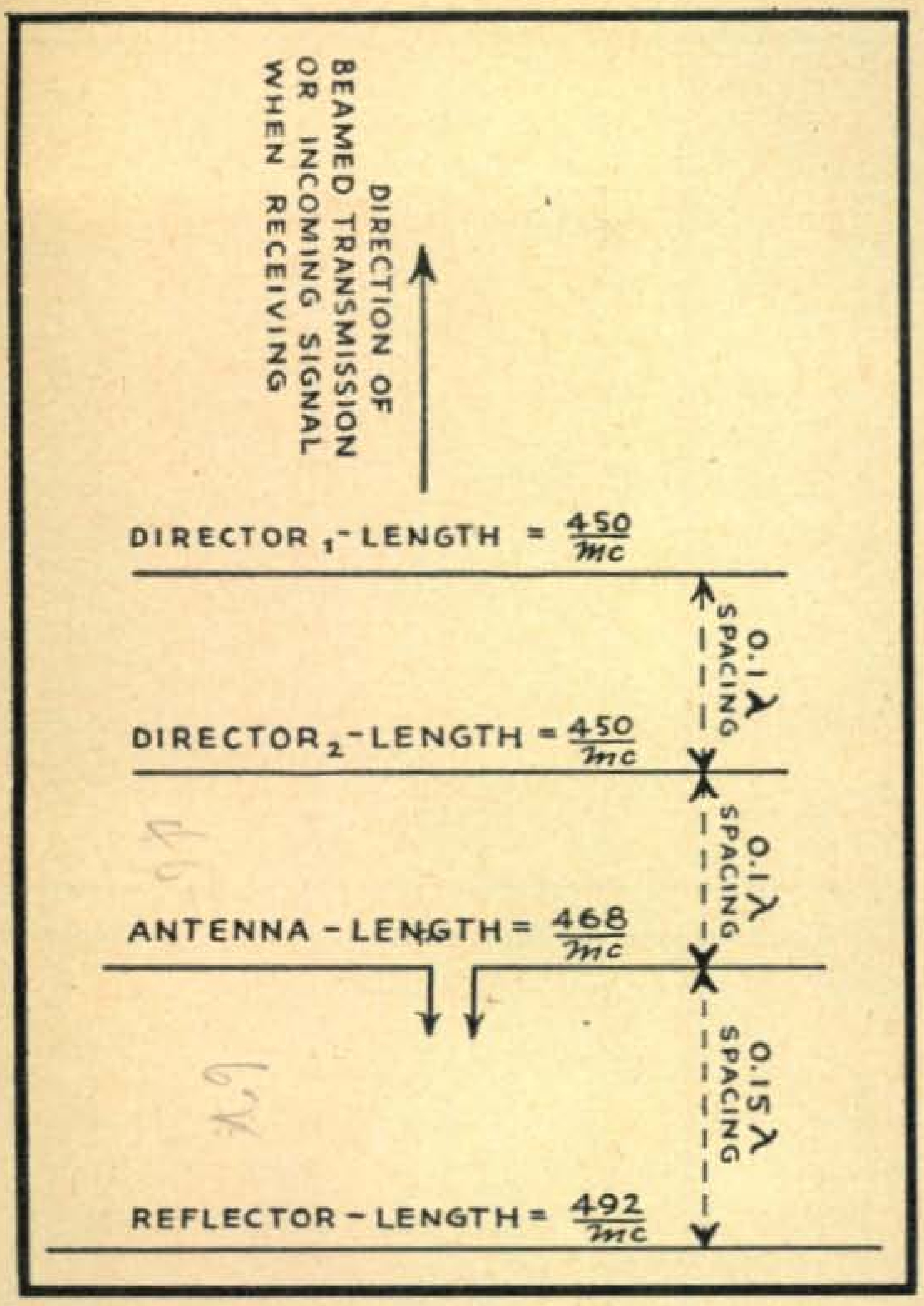


Fig. 3. Top view of a four-element parasitic array. Eliminate $Director_1$ and you have a three-element array. The simple antenna and reflector combination will also boost signals

The antenna looks into a source of:

$$\frac{(\text{Z of matching section})^2}{\text{Z transmission line}} = \frac{52^2}{452} = 6 \text{ ohms}$$

(this is equal to its own impedance)

For those who decide on a two or three element beam, the following figures for antenna impedance, or to be more accurate, the antenna resistance, should be used in the above formulas:

2 element	16 ohms (approx.)
3 element	9 ohms "
4 element	6 ohms "

The Elements

The only requirement for the elements—the radiating part of the array—is that they must be sufficiently rigid to prevent undue sagging near and at the ends. There must be a minimum tendency of whipping during abnormal winds. Actually, prevention of undue whipping is most important, for under such a condition, the spacing between the antenna, directors and reflector would be altered, thus throwing the array out of resonance with the frequency of the transmitter. A satisfactory and weather resistant system can be constructed by making the framework of the array from 1″ x 3″ red cedar, suitably painted. This wood stands the weather well, although cypress can be used with equal success. Only pieces relatively free from knots should be selected. In building the installation shown in illustration *Fig. 1* (28 mc), the longitudinal members bolted to the rotator are 13 feet long; the cross members, 3 feet long. All wood parts of framework are guyed with # 16 galvanized wire pulled taut with small turnbuckles. The standoff insulators are bolted to cross members to support each of the directors and the reflector. As the antenna is open at the center, four insulators are required.

The 28-mc Array

By using three-foot cross members with insulators spaced equally apart, sufficient anchorage is provided to support and hold the elements in their proper relation to each other. To minimize end sagging and whipping, #24ST aluminum tubing (heat treated for rigidity) was found entirely satisfactory. For proper weight distribution (heaviest sections at the center and lightest sections at the end), and for ease in adjusting lengths, five foot telescoping pieces having the dimensions indicated in *Fig. 2* work out very well. With the arrangement suggested, the completed telescoped sections to the right and to the left of the center of each director and reflector can be moved in or out of the two foot center section, which should be held stationery when making these adjustments. During this final tune-up process, the clamps on the standoff insulators, which hold the elements, must be sufficiently loosened to allow variation of lengths, after which they should be securely tightened, thereby completing the job.

As shown in *Fig. 3* there is nothing complicated about the elements. Each of the directors and the reflectors are electrically one section, while the antenna itself is made in two equal half sections which connect to the transmission line through the rotator. Formulas for determining proper lengths are as follows:

Length of antenna (both halves) = 468/mc
Length of director = 450/mc
Length of reflector = 492/mc
—where mc = megacycles.

A four-element array designed to hit approximately the center of the now open 28-megacycle amateur band (and which will cover the entire band with only a minor drop in efficiency at either end) would stack up as follows: Antenna (both halves) 16.14 feet; each director 15.52 feet, and the reflector, 16.97 feet. Dimensions computed from these formulas should be used for approximations only, because trees, buildings and neighboring power and telephone lines will all affect frequency to some extent. Consequently, after a parasitic array for a certain frequency has been computed from the formulas and constructed, the next step is to adjust the lengths of all the elements as follows:

Adjusting the Array

First, disconnect the directors and reflector at their respective centers. As low power is not only needed but desired for making the necessary adjustments, couple the input end of the transmission line to the oscillator or a low-power stage. Connect the other end of the transmission line through the one-quarter-wave matching section to two r-f ammeters, the remaining terminals of which are connected to the two adjacent ends of the antenna element. (Any r-f ammeter, from a galvanometer on up, can be used, provided it is suitably shunted to prevent burning out. The idea is to insert an r-f ammeter that will give a readable indication in each half of the antenna element. The amount of current doesn't matter—all we want are relative and equal, simultaneous readings.)

Adjust the lengths of the two antenna elements (keeping both lengths equal at all times) for maximum current on the ammeters. The ammeters should now be removed from the circuit. Next enlist the services of an amateur one or two miles away (who has a receiver equipped with an S or R meter). Point the array 180° away from his station and adjust the length of the director closest to the antenna until your friend reports minimum signal strength. Then, repeat the operation on the second director and also follow the exact procedure on the reflector. It is important first to adjust the closest director and then the second director, following with the reflector. This will complete the rough adjustments.

The final adjustments are merely a repetition. First, adjust the antenna for maximum current, after which adjust the closest director and then the farthest director, and finally the reflector. (Of course, your amateur friend is still cooperating in making these final adjustments.) After removing the ammeter we are ready to couple the final amplifier of the transmitter to the transmission line. After checking all other adjustments, turn on high power. (For further refinements the transmission line should be examined for standing waves.)

The procedure outlined for adjusting a parasitic beam array makes possible the maximum amount of front-to-back ratio, which is most important. It is not possible to adjust the system so that it has both minimum backward and maximum forward radiation. Either must be sacrificed slightly in favor of the other. However, the fact is well recognized, that minimum backward radiation is more desirable. Even so, the gain in the opposite, or direction in which the beam is pointed, is fairly close to the theoretical

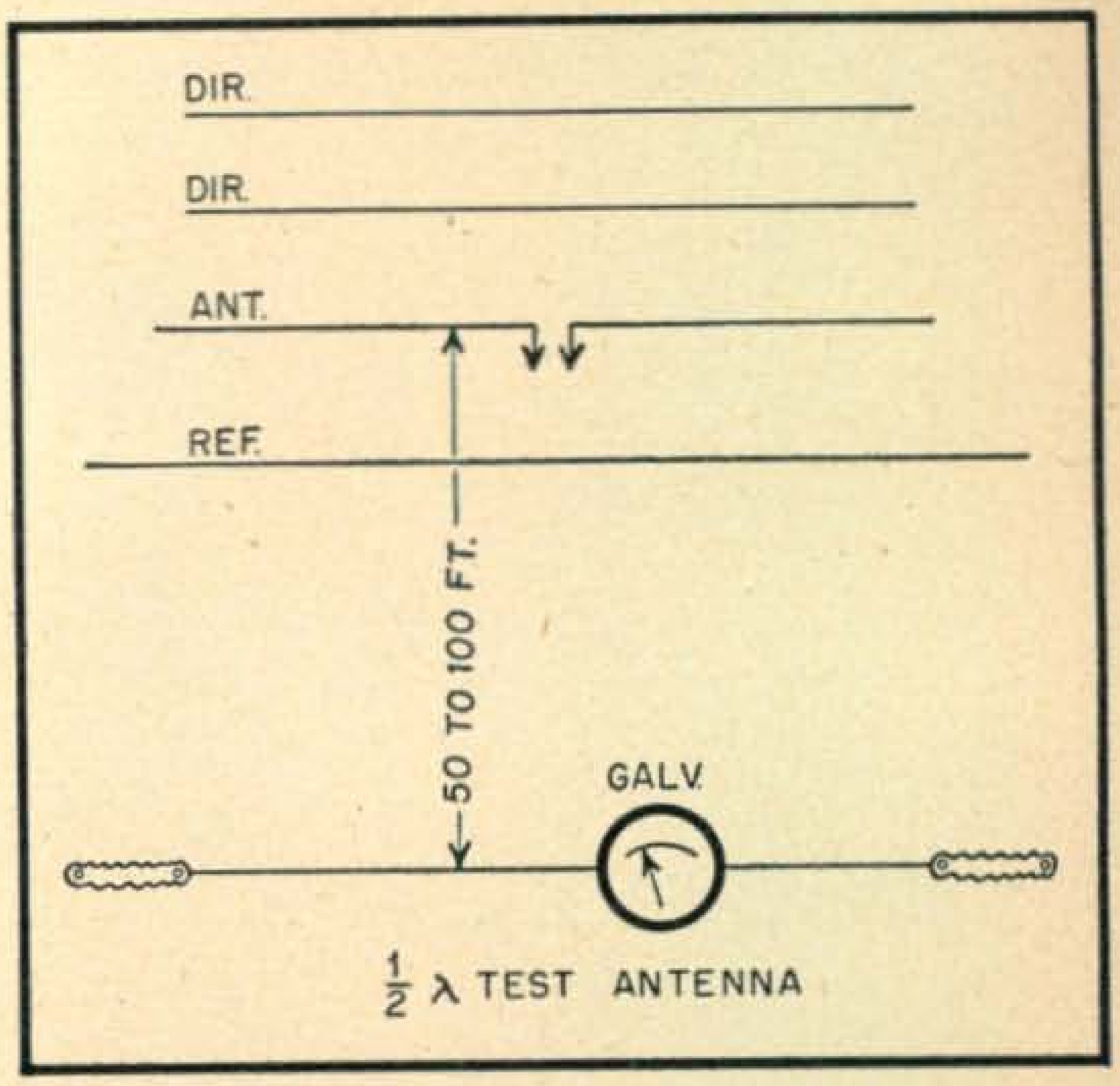


Fig. 4. Alternate method of tuning the four-element array

maximum. It is important to remember that the beam is equally effective in reception as on transmission. Minimum backward radiation results in less QRM from stations, excepting those in the path of the beam.

Alternate Method of Adjusting Array

Another proved method of adjusting the array is quite simple, and can be used very effectively if an amateur having a receiver with an S meter is not located close by. All that is necessary is a thermo-couple galvanometer and a half-wave antenna, made of either #12 or #14 wire, spaced at a distance of 50 to 100 feet away from the parasitic array. The plane of this antenna should be the same as the array—horizontal if the array is of a horizontal type, and, conversely, erected vertically, if the array is a vertical (which generally would be the case on the ultra high frequencies). The thermo-couple galvanometer should be connected exactly in the center of this "test" half-wave antenna as in *Fig. 4*. Here again, low power is desirable in the tuning up.

The process is identical to the method previously outlined, in that the array is pointed 180° away from the "test" antenna. With the reflector and director elements disconnected at their centers, both halves of the antenna element should be adjusted to the point of maximum current reading on the galvanometer. Here is where a friend or a good pair of binoculars comes in handy. After the antenna element has been tuned, the nearest director should be joined at the center and then adjusted for minimum galvanometer current. Next, the farthest director (if the beam is a four-element array) is similarly adjusted for lowest galvanometer reading. Final-

[*Continued on page 46*]

FIVE BAND
Variable Frequency Oscillator

FRANK C. JONES, W6AJF

EXCEPTIONAL STABILITY AND SIMPLIFIED TUNING FROM 3.5 THROUGH 30 MEGACYCLES (INCLUDING 21 MEGACYCLES) WITH EXCELLENT KEYING CHARACTERISTICS

ALTHOUGH THE AMATEURS of the nation still await the green light to resume operation in their major channels, the time is opportune for the construction of new and better equipment in order to have the station in readiness when the bans are removed. The influx of large numbers of new amateurs will result in greater congestion of available channels, and a good variable-frequency oscillator will be essential for those who strive to attain the greatest possible number of contacts available in the 3.5, 7, 14, 21 and 28-megacycle bands.

A variable-frequency oscillator should have almost the same stability as crystal control—a requirement that results in additional cost. However, the advantage of shifting quickly from band to band, and the ease of operation on any desired frequency in any band, more than compensate the added expense. A good VFO is not easy to build and a poorly constructed one is worthless. The constructor should consequently determine to do a first-class job on such an oscillator, regardless of the cost and time required to build the device.

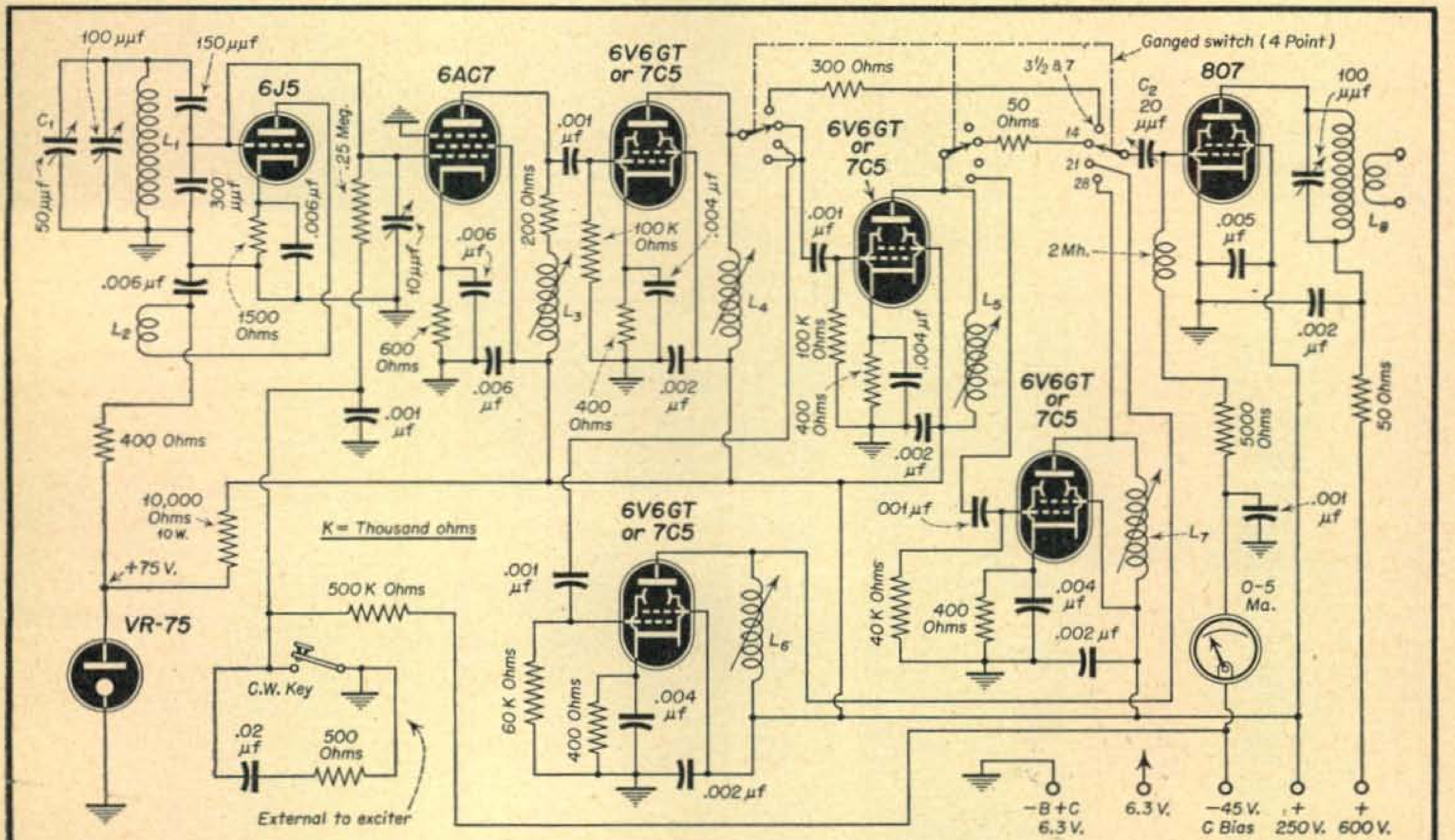


Fig. 1. Variable-frequency oscillator keyed for break-in operation. Output coils (L_8) are standard plug-in or turret type. Other coil data are given in text

Oscillator Tuning Capacitor

The VFO illustrated represents an attempt to approach the operating stability of a crystal oscillator. The only component which may give rise to operational difficulty is the variable tuning capacitor in the oscillator circuit. Several types of midget tuning condensers were given extensive tests. All of these capacitors proved troublesome and the frequency jumps were as great as 50 to 200 cycles at the fundamental, due to poor mechanical design such as end-play in the bearings. Capacitor C_1 in the circuit diagram (*Fig. 1*) should be of the type used in government frequency meters or other precision oscillators. These precision-made capacitors will be on the market soon, and should be the sole choice of the constructor who strives for optimum performance from his equipment. (Illustrations, *Fig. 2*, shows a conventional variable tuning capacitor.)

The oscillator of the 5-band VFO uses a 6J5 triode connected across only a portion of the tuned circuit, together with a class "A" 6AC7 buffer stage. Improved frequency stability resulted from this combination, as compared with a standard VFO employing such tubes as the 6V6GT or 6SK7. The latter use the screen grids as a triode oscillator system with a lower G_m than that of a 6J5 or 7A4 triode. Higher G_m means that oscillation can be maintained with a lower value of coupling to the frequency-determining circuit, so that tube capacity changes (with variations of temperature) and supply voltage will have less effect on the frequency.

Buffer and Doubler

The 6AC7 buffer tube amplifies its 2-volt grid drive to obtain approximately 40 volts in the broadly resonant plate circuit. This, in turn, drives the first 7C5 or 6V6GT doubler tube. Each 7C5 or 6V6GT stage either doubles or triples the frequency over the *entire* width of the associated amateur band. Each plate circuit may be switched either to the 807 buffer stage or to a following doubler or tripler stage. The circuit arrangement is such that the effective tube input capacities are approximately equal. The VFO tuning dial and the 807 plate circuit adjustments are the only operations required throughout any one frequency band.

The 807 plate circuit utilizes standard 50-watt plug-in coil forms of the manufactured type, with sufficient turns of wire removed from an additional 14-megacycle coil to tune the new 21-mc band. Band-switching coils can be used advantageously in the 807 plate circuit if such an assembly is available for 3.5, 7, 14, 21 and 28 mc. The exciter was designed primarily for the four higher frequency bands, but will deliver output at 3.5 to 4 megacycles when the 807 plate is tuned through this band, since ample voltage is present in the 7C5 or 6V6GT plate circuit to drive the grid of the 807.

All of the intermediate plate circuits use inductively tuned systems for broadly resonating them together with the tube input and output capacities. The 3.5-mc 6AC7 plate coil is of the BCL oscillator type, with an iron-core slug for tuning purposes. The remaining plate coils are solenoids, 1 inch in diameter, tuned with copper disks to the approximate center of each frequency band. The 807 grid drive over the whole of each band is nearly constant at the lower frequencies and does not vary more than 30 per cent at the higher frequencies of any band.

Various sizes of 1-watt carbon resistors are series-connected in the circuit in order to broaden the tuning and to equalize the 807 grid-driving current for different bands. Excessive drive on 7 and 14 megacycles was experienced prior to the inclusion of the series resistors, in spite of the fact

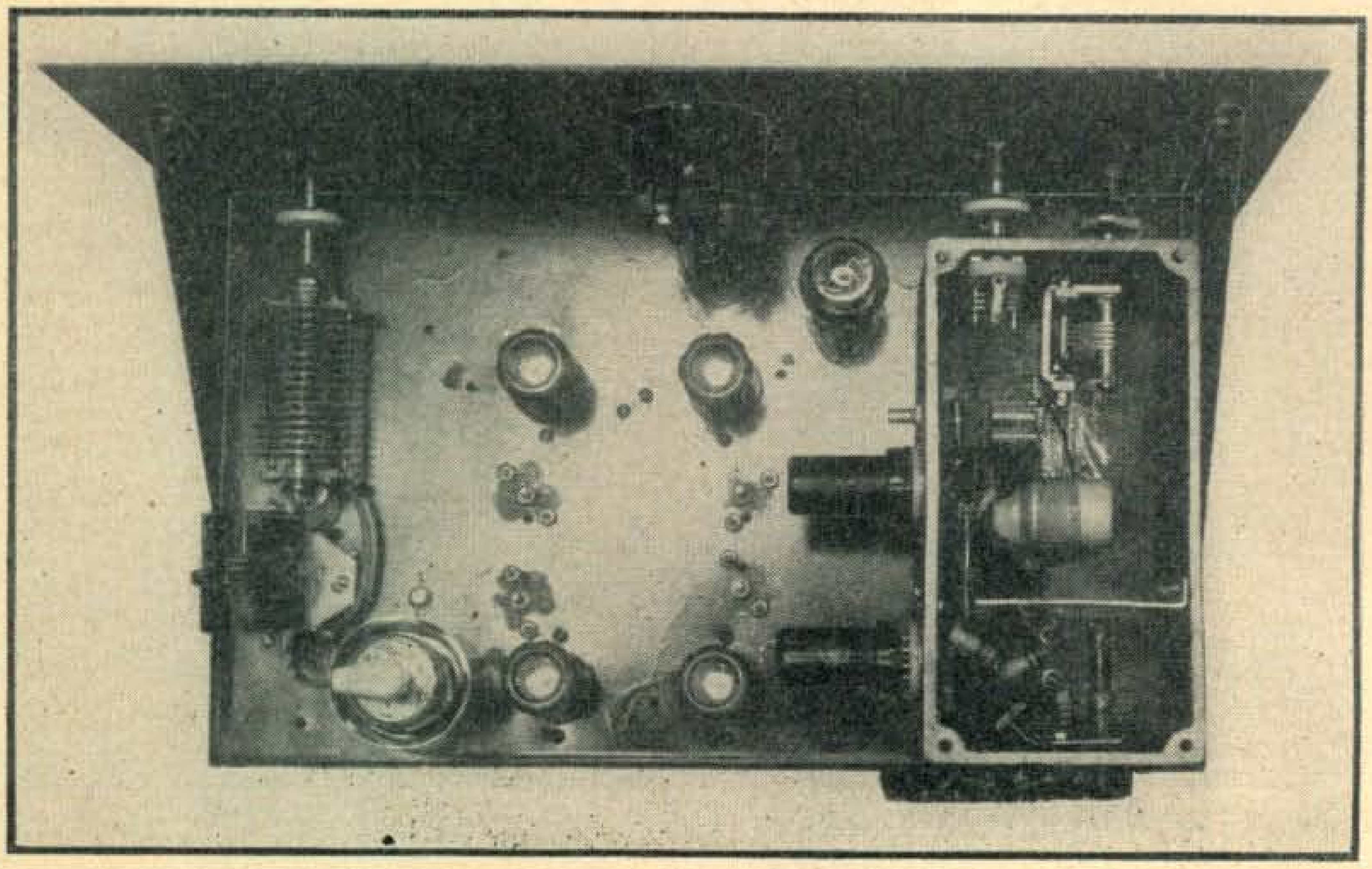


Fig. 2. Top view of the VFO. The oscillator section is separately "boxed"

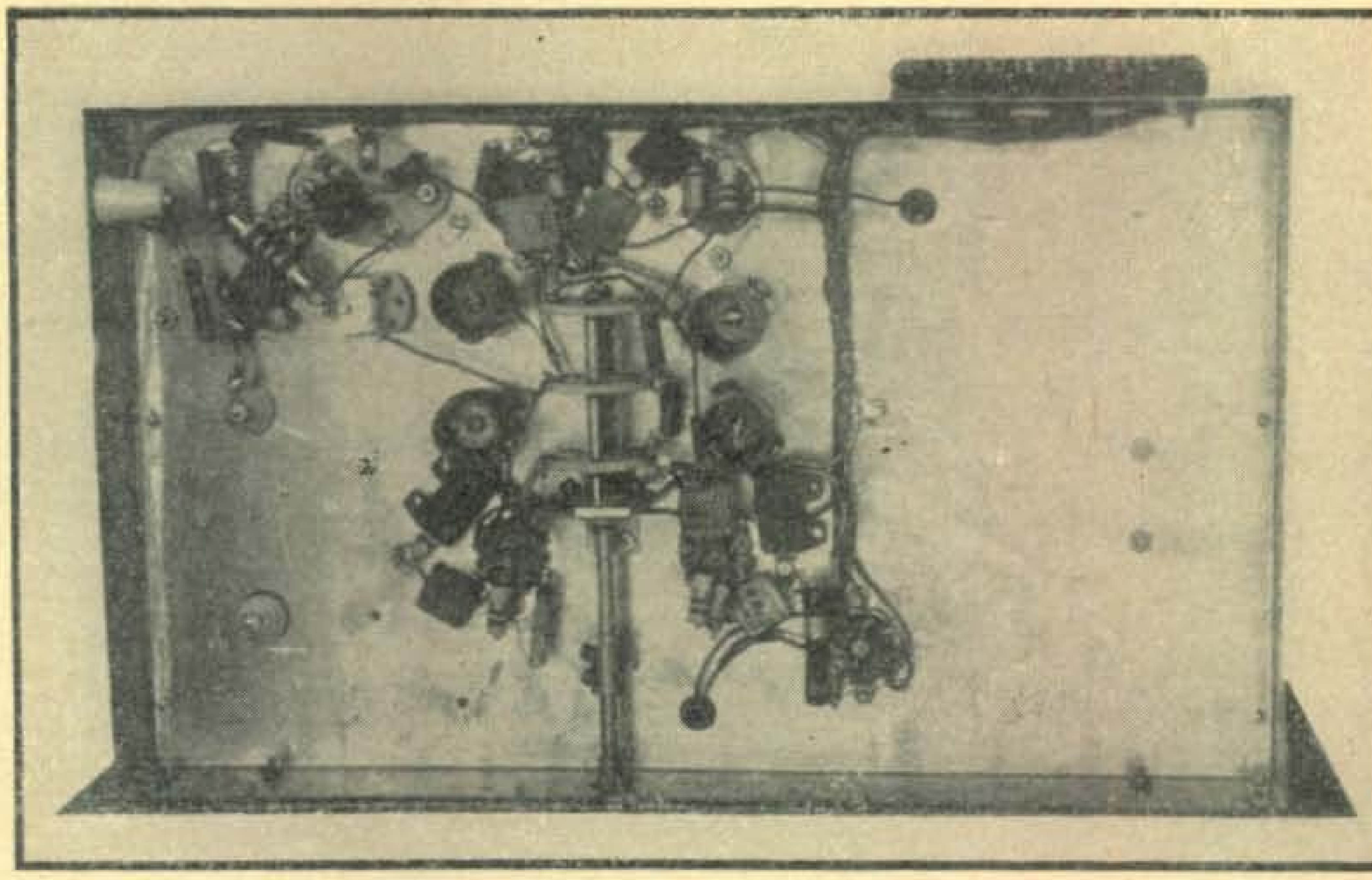


Fig. 3. Under-chassis arrangement showing coil tuning adjusting screws. A versatile exciter or a 50-watt c.w. transmitter — as you like it

that less than 20 $\mu\mu$f coupling capacity was in series with the 807 grid.

A plate supply of 200 to 250 volts at 120 to 150 milliamperes is ample for handling the entire exciter, with the exception of the 807 plate requirement. With 600 volts on the 807, approximately 30 to 40 watts output can be obtained—sufficient to drive almost any push-pull power amplifier with a rating up to ½-kw input. By increasing the plate supply to 275 or 300 volts, the 7C5'S or 6V6GT'S will drive one of the larger screen-grid tubes such as the 4E27 (in place of the 807) for an output of approximately 200 watts. The capacity C_2 in the schematic diagram should be somewhat larger, such as 35 or 50 $\mu\mu$f, and the bias and various plate voltages be increased to normal values for the particular type of tube employed.

Construction of The VFO

The entire exciter was built on a 10″ x 17″ chassis, with the VFO unit in a 4″ x 4″ x 8″ cast bronze metal box atop the chassis (*Fig. 2*). All of the 7C5 circuits and the band-changing switch are located beneath the chassis (*Fig. 3*) in order to provide shielding for the 807 plate circuit. The VFO box is fitted with an interior shield to isolate the 6AC7 plate circuit from the VFO tuned circuit. (In spite of this some frequency change occurs if the first 7C5 grid circuit is touched or disturbed.)

The VFO coil (L_1) consists of 18 turns of #20 silk-covered wire on a 1¼″-diameter *ceramic* coil form. The winding is ¾″ long, and near the grounded end a 6-turn tickler coil is wound of smaller wire (L_2). The 150 and 300 $\mu\mu$f shunt capacitors are zero-temperature coefficient tube "silver micas." A 100 $\mu\mu$f variable shunt permits setting the 50 $\mu\mu$f main tuning capacitor and dial for coverage of the 3.5 to 4-mc range.

The 6J5 and 6AC7 tubes are mounted in ceramic sockets on the side of the VFO compartment box in order to reduce effects of temperature variation. The 6J5 plate voltage is stabilized at 75 volts by means of a VR75 voltage-regulator tube which operates from the main 250-volt power supply.

The 6AC7 plate coil (L_3), in series with a 200-ohm resistor to broaden its tuning adjustment, is an adjustable BCL-type oscillator coil. The iron-dust tuning slug varies the inductance from 30 μh to 130 μh. This circuit requires approximately 75 μh in the 6AC7 plate.

The 7-mc doubler coil (L_4) consists of 30 turns of #26 wire, ¾″ long, on a 1″ diameter bakelite form secured to the chassis with spade bolts. All of the 7C5 or 6V6GT plate coils are wound on 1″ diameter forms, with a copper disk for tuning adjustments. The 14-mc coil (L_5) has 14 turns of #22 wire, ¾″ long; 21 mc (L_6) 9 turns of #18 wire, ½″ long, and the 28-mc coil (L_7) has 7 turns of #18 wire, ½″ long.

The copper tuning disks, the exact size of a penny, are drilled and tapped for an 8-32 machine screw which serves as a plunger inside the coil form. These adjusting screws extend upward through 8-32 machine nuts sweated to the chassis with a heavy iron and solder. Once the inductors are adjusted to the correct values, the screws are locked in position with an additional 8-32 nut.

The cast-metal box for the oscillator compartment requires care in the mounting of the parts, since rigid construction is essential. Ceramic insulation is used for all parts within this box. The proper selection of flexible shaft couplings to the front panel dial and vernier frequency adjusting knob is likewise important, since the coupling must be freely flexible for longitudinal motion, yet with *no backlash whatsoever* in a rotating direction.

[*Continued on page 44*]

CLASS "B"

The Practical Application of Tube Data to Secure Optimum Efficiency With Minimum Distortion

NOTHING IN RADIO looks simpler than a Class B modulator and its driver such as shown in *Figs. 1A* and *1B*. This apparent simplicity is borne out in practice when we can take operating conditions from charts in handbooks, but it is another story when operation under different conditions is contemplated. However, if complete data are available for operation at one plate voltage, the following formulae and Ohm's law will allow calculation for operation under different conditions:

$$i_p = \frac{I_p}{.637} \qquad (1)$$

$$P = \frac{E_{rp} \times i_p}{2} \qquad (2)$$

—where i_p is instantaneous peak current per tube, I_p indicates peak d-c current, P is power output of the modulator, and E_{rp} is the instantaneous peak voltage developed across each half of the output transformer primary.

The procedure will be illustrated for two types of tubes, 807's and 811's. While the 807 is a beam tetrode, it is treated as a triode. A pair of them are rated 120 watts audio output at 750 volts, ICAS, but operating stipulations for this voltage are not listed in most handbooks. Operating conditions for 400 volts are given as follows:

Plate potential, 400 volts
Grid bias voltage, –25 volts
Screen potential, 300 volts maximum
Zero-signal plate current (both tubes), 100 milliamperes
Maximum-signal plate current (both tubes), 240 milliamperes
Peak audio voltage, grid-to-gird, 78 volts
Maximum-signal grid driving power 0.2 watts (approximate)
Load resistance, plate-to-plate, 3,200 ohms
Maximum signal power output 55 watts (approximate)

We know that the maximum plate dissipation for the 807 is 30 watts, ICAS rating; therefore we have all necessary information for calculating conditions for 750-volt operation.

From Paper to Practice

Because of the action of the screen grid (with potential fixed at the maximum of 300 volts), increasing the plate voltage will not increase the plate current appreciably. However, 750 volts at 100 milliamperes is 75 watts, more than the maximum 60 watts for the pair. For best results it is generally wise to run approximately 25% less than the maximum permissible dissipation at no signal, or 45 watts. The new no-signal plate current will be 45/750, or 60 milliamperes. The grid bias must be increased the same percentage that the plate current was decreased: 25 x 100/60 = 42 volts approximately. (After the circuit is set up, the screen voltage should be adjusted as accurately as possible to 300 volts, and the bias then varied so the no-signal plate current is the proper value.)

Next we find the instantaneous peak current per tube, the instantaneous peak voltage drop across half the output transformer primary, and, indirectly, the voltage across the tube on these peaks. Maximum signal current is rated as 240 milliamperes. Thus by (1) the peak current is 240/.637 = 377 milliamperes, which current must not be exceeded if reasonable tube life is to be expected. The peak current flows alternately through each half of the output transformer primary and the voltage developed is found by multiplying the inpedance in ohms by the current. Plate-to-plate impedance is given as 3,200 ohms. Impedance of half the primary is 3,200/4 = 800 ohms. A current of 377 ma through 800 ohms produces a potential drop of approximately 300 volts. The difference between this voltage and the B-supply voltage is the drop across the tube on current peaks. This voltage is fixed by tube characteristics and driving power requirements.

MODULATORS

HERBERT S. BRIER, W9EGQ

The new voltage across half the primary of the output transformer will be 750 − 100 = 650 volts. The impedance necessary to develop this voltage at 377 milliamperes is 650/.377 = 1725 ohms. Plate-to-plate impedance will be 6,900 ohms. Power output by (2) will be, 650 + .377/2 = 122 watts, approximately.

Operation on 400 Volts

Going back to the data for 400-volt operation, we see that a peak audio grid-to-grid potential of 78 volts is required to obtain full output. The voltage from either grid to ground is half this, or 39 volts. Subtracting the fixed bias shows that the grids are driven 14 volts positive on excitation peaks.

Under the new conditions, the instantaneous plate current and voltage are the same as before; therefore the grids must be driven to the same positive values. The new peak grid voltage will be the bias, 42 volts, plus 14 volts, or 56 volts (112 volts grid-to-grid).

The 0.2 watts grid driving power shown is the average value while the peak value is twice this, or 0.4 watts. It is necessary to find the peak current to calculate the new driving power requirements, and it is convenient to know the grid impedance on excitation peaks. Peak current is 0.4/39, or approximately 10 milliamperes. The new driving power will, therefore, be 0.56 watts, peak, or 0.28 watts, average. The old grid impedance was approximately 3,900 ohms, and the new impedance is 5,600 ohms.

Driver Transformer

This completes the calculations for the modulator itself, but the improper driver tube or wrong driver transformer will ruin the performance of the best Class B modulator. Usually the driver transformer is dismissed with, "use as large

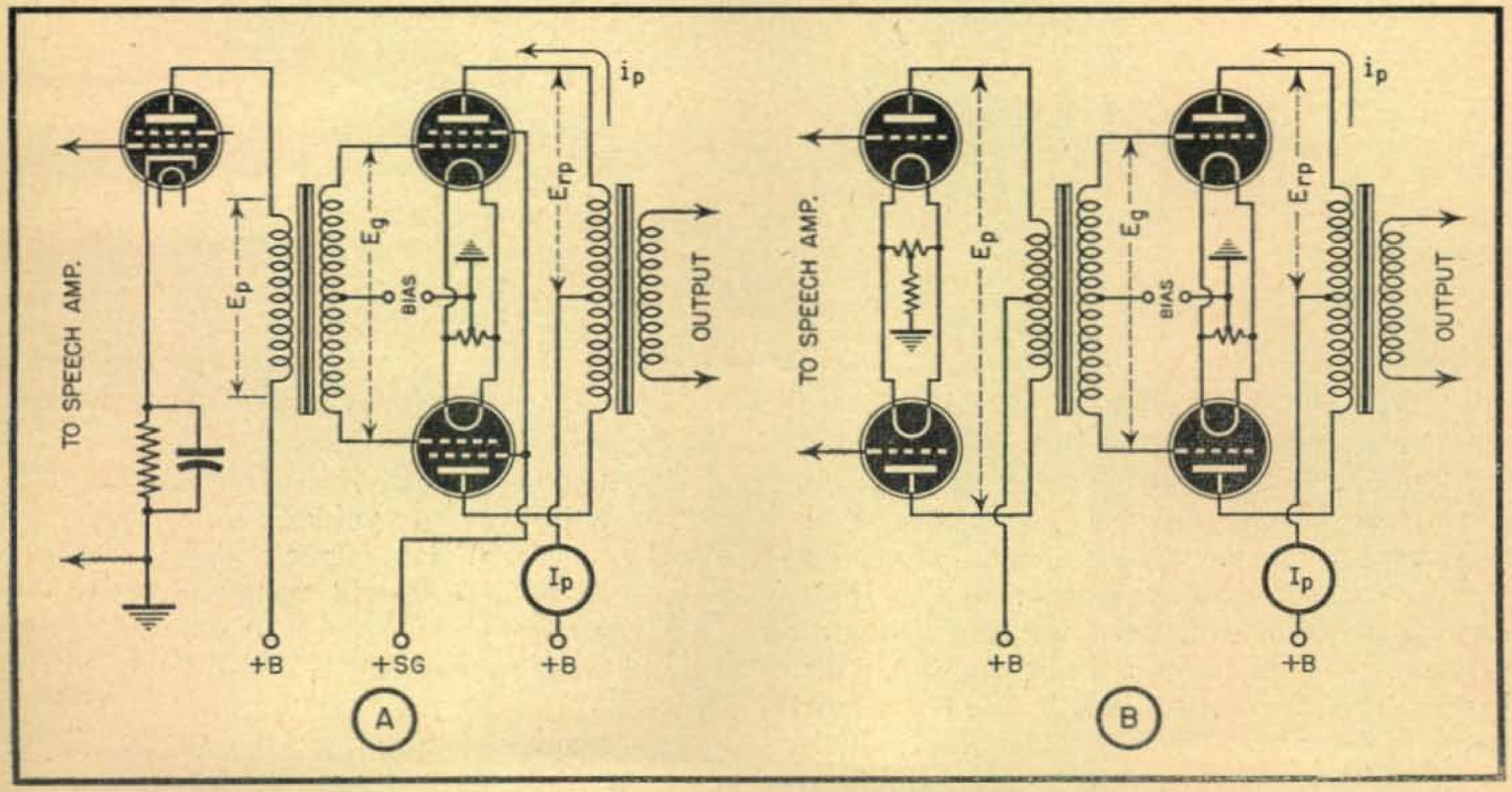


Fig. 1. Typical Class B modulator circuits analyzed in the accompanying article

a step-down ratio as possible in the driver transformer." The question is how much is "as large as possible."

To determine this it is first necessary to choose a driver tube. Triodes are the logical choice because they produce much less distortion than other types. From the tube manual we learn that a 6F6, triode-connected, a 6L6, triode-connected, or a 6A3 is rated at enough power output to drive the 807's. Tabulated, their important characteristics are:

6F6: 0.8 watts output, plate resistance 2,600 ohms, amplification factor 6.8, bias 20 volts.

6L6: 1.3 watts output, plate resistance 1,700 ohms, amplification factor 8, bias 20 volts.

6A3: 3.5 watts output, plate resistance 800 ohms, amplification factor 4.2, bias 45 volts.

Of equal importance with power output is the peak voltage available from the driver tube. This can be learned by laying out load lines equivalent to different values of load resistance on the characteristic charts of the tubes, or a close approximation may be obtained with the following formulae:

$$E_p = 0.8 \times E_g \times \mu \text{ (single-tube Class A)} \quad (3)$$

$$E_p = 1.6 \times E_g \times \mu \text{ (push-pull)} \quad (4)$$

—where E_p is the peak audio voltage developed across the load resistance, E_g represents the d-c grid bias, and μ is the amplification factor of the tube.

Single tube output voltages are:

6F6: 0.8 x 6.8 x 20 = 109 volts
6L6: 0.8 x 8 x 20 = 128 volts
6A3: 0.8 x 4.2 x 45 = 151 volts

Obviously, each tube develops enough audio voltage to allow a degree of step-down in the driver transformer. There will be some voltage loss in the transformer, and to be on the safe side, we will assume this to be 30%. This is excessive, but it allows a reserve of gain to take care of aging tubes and other variables. Thus the 56 volts peak at the 807 grid will look like about 73 volts to the driver tube. Therefore the step-down ratio will be 1.5 to 1 with a 6F6; 1.75 to 1 with a 6L6, and 2 to 1 with a 6A3.

As far as voltage and power output are concerned, any of the three tubes is satisfactory as a driver; but the low plate resistance of the 6A3 makes it superior to the others. On the other hand, it requires over twice the grid voltage to drive it. A good compromise is the 6L6, which has a fairly low plate resistance, and yet is much easier to drive than the 6A3. The 6F6 is inferior to either, not only because of its higher plate resistance, but more of this resistance is reflected into the driver transformer, as a result of the lower transformer step-down ratio.

For reasons beyond the scope of this article, this reflected impedance should not be more than 10% of the minimum grid impedance for highly biased tubes, or 20% for the zero-bias types. It is this impedance that is meant when you see a foot-note under the characteristics of a tube which reads, "effective grid impedance should not exceed — ohms." As impedance varies with the square of the turns ratio, the impedance reflected into the grid circuit will be 1,150 ohms for 6F6; 567 ohms for 6L6; and 200 ohms for 6A3.

Summing Up

Because higher voltage than listed in the charts is applied to the 807's, we should check to be sure that plate dissipation is not exceeded on current peaks. A potential of 750 volts x 240 milliamperes = 180 watts. Subtracting, 180 watts − 122 watts = 58 watts; therefore we are within the ICAS plate dissipation rating for the tubes.

Putting all these data in convenient form, we have:

Plate voltage, 750 volts

Grid bias voltage, − 42 volts

Zero-signal plate current (both tubes), 60 milliamperes

Screen grid voltage, 300 volts (maximum)

Peak audio voltage, grid-to-grid, 112 volts

Maximum-signal grid driving power, 0.28 watts (approximate)

Load resistance plate-to-plate, 6,900 ohms

Maximum-signal plate current (both tubes), 240 milliamperes

Maximum-signal power output, 120 watts (approximate)

Driver tube, 6L6, triode-connected

Driver transformer step-down ratio, primary to half the secondary, 1.75 to 1

When it is necessary to operate at a lower voltage than listed in the charts, the same procedure for finding the instantaneous currents and voltages is used. Then the new plate load impedance and power output are calculated. A pair of 811's will be considered. Operating conditions at 1250 volts are:

Plate potential, 1250 volts

Grid bias, zero volts

No-signal plate current, 48 milliamperes

Audio grid-to-grid voltage (peak), 140 volts

Grid driving power, 3.8 watts (approximate)

Load resistance, plate-to-plate, 15,000 ohms

Power output, 175 watts (approximate)

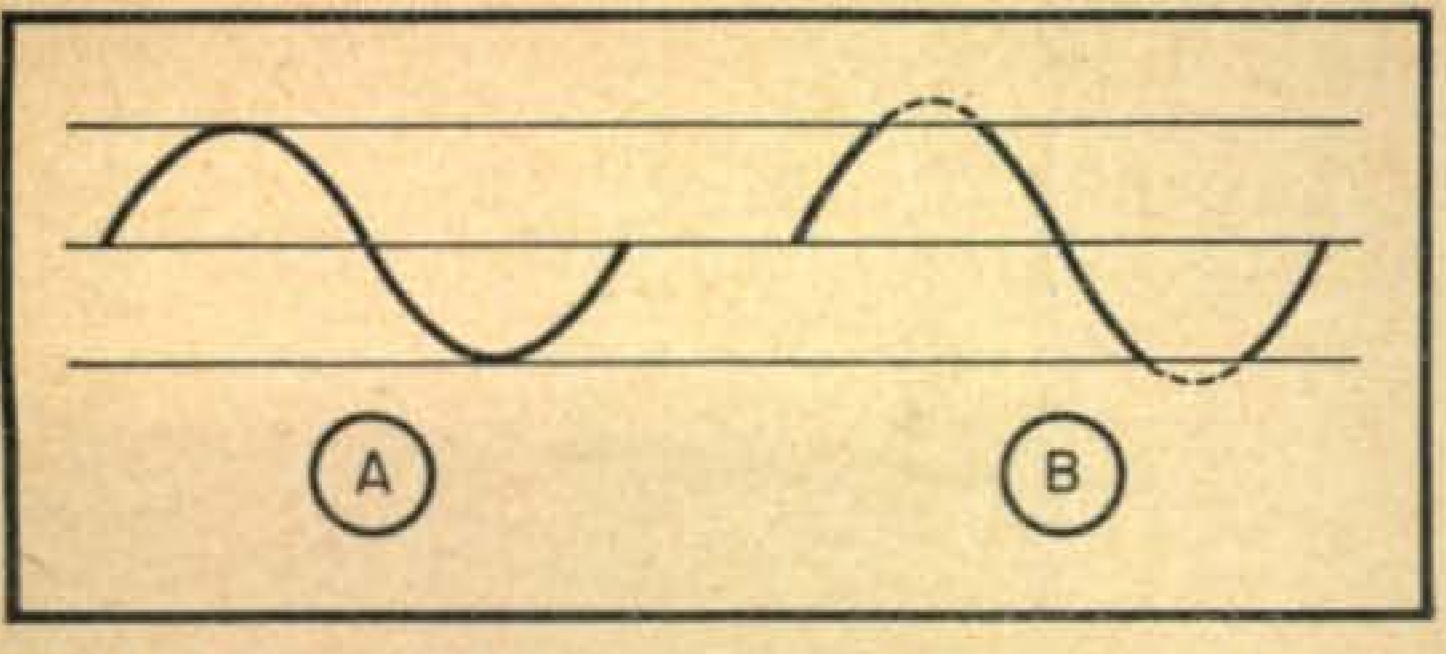


Fig. 2. Action of instantaneous plate current with sine wave input to Class B tubes. Normal operation is shown in A, while curve B indicates too high a plate load impedance. The dotted-line portion of the curve is cut off, resulting in bad distortion

By means of (1) we find the instantaneous peak current to be, 200 / .637 = 310 milliamperes. Drop across the modulation transformer is 15,000 / 4 x .310 = 1160 volts. Drop across the tube is 1250-1160 volts = 90 volts. Suppose we wish to operate the tubes at 1,000 volts, the voltage drop across the transformer will be 1,000 − 90 = 910 volts. The new load impedance, per tube, is 910 / .310 = 2936 ohms, or 11,744 ohms, plate-to-plate. Power output by (2) will be 910 x 0.310 / 2 = 141 watts.

As the tubes are zero-bias type, no adjustment of bias voltage is required (let the no-signal plate current be what it will—about 20 milliamperes). With grid voltage, instantaneous peak plate current and plate voltage being the same, grid driving requirements will also be identical—3.8 watts. A pair of 6A3's or 6B4's are logical choices for the driver. Taking driver transformer losses into account, the 70-volt audio potential at the grid of the 811 will appear as approximately 90 volts to the driver stage.

By (4) we find the peak audio voltage available from the push-pull 6A3's will be approximately 1.6 x 60 x 4.2 = 403 volts. Therefore the driver transformer can have a step-down ratio as high as 4.5 to 1. This ratio will reflect about 40 ohms into the secondary of the transformer from the plate resistance of the drivers. As the minimum impedance of the 811 grids is approximately 700 ohms, this value is almost negligible.

Tabulating these data, we have:

Modulators, push-pull 811's

Plate voltage, 1,000 volts

Grid bias, zero volts

Zero-signal plate current, 20 milliamperes (approximate)

Peak audio voltage, grid-to-grid, 140 volts

Maximum-signal grid driving power, 3.8 watts (approximate)

Load resistance, plate-to-plate, 11,750 ohms

Maximum-signal plate current (both tubes), 200 milliamperes

Maximum-signal power output, 140 watts (approximate)

Driver tubes, push-pull 6A3's

Driver transformer step-down ratio, primary to half the secondary, 4.5 to 1.

Plate Voltage vs. Load

It is interesting to investigate what would happen if an attempt were made to operate the tubes at the lower plate voltage without changing the load impedance. The first thing we observe is that the drop across the load would be more than the d-c plate voltage if the current went to the same peak value—obviously an impossible condition. If the grid excitation is increased until the plate milliameter goes as high as 200 milliamperes, one might think that the stage is operating properly; but actually the plate current peaks would be cut off as shown in *Fig. 2*, and only the average current would increase. The net result would be extremely bad harmonic distortion, increased plate dissipation, and inordinately high grid driving power required.

However, suppose that it is necessary to use the same transformer and load impedance at the lower voltage, is there any hope of obtaining satisfactory results? Yes—if the instantaneous plate current is reduced enough to assure that the minimum drop across the tubes is still approximately 100 volts. A potential of 900 v / 3750 ohms = 240 milliamperes, new instantaneous peak current. Power output, by (2), will be 900 x .240 / 2 = 108 watts output. Multiplying 240 x .637 = 156 milliamperes d.c. indicated on the plate meter. This type of operation is thoroughly practical, except that output is reduced more than necessary.

On the other hand consider what happens with too low a load impedance. Suppose a Class B output transformer designed for 203A's, 9,000 ohms plate-to-plate load resistance, is used with the 811's at 1250 volts. Peak current is once again limited to 310 milliamperes. The potential drop across half the transformer primary will be 2,250 ohms x .310 = 700 volts, appromimately. Output will equal 700 x .310 / 2 = 108 watts. Peak signal input would be 250 watts; therefore plate dissipation will equal 250 − 108 = 142 watts—far above the dissipation rating of the 811's. Just as high output would be obtained from the tubes at 800 volts on the plates with this load impedance with much better efficiency.

This system for determining proper operating conditions for Class B modulators and their drivers is not set forth as one of absolute accuracy, but it does give thoroughly practical results.

RADIO IN THE

AMATEUR EQUIPMENT AIDS CIVIL AIR PATROL WAR AND PEACE ACTIVITIES

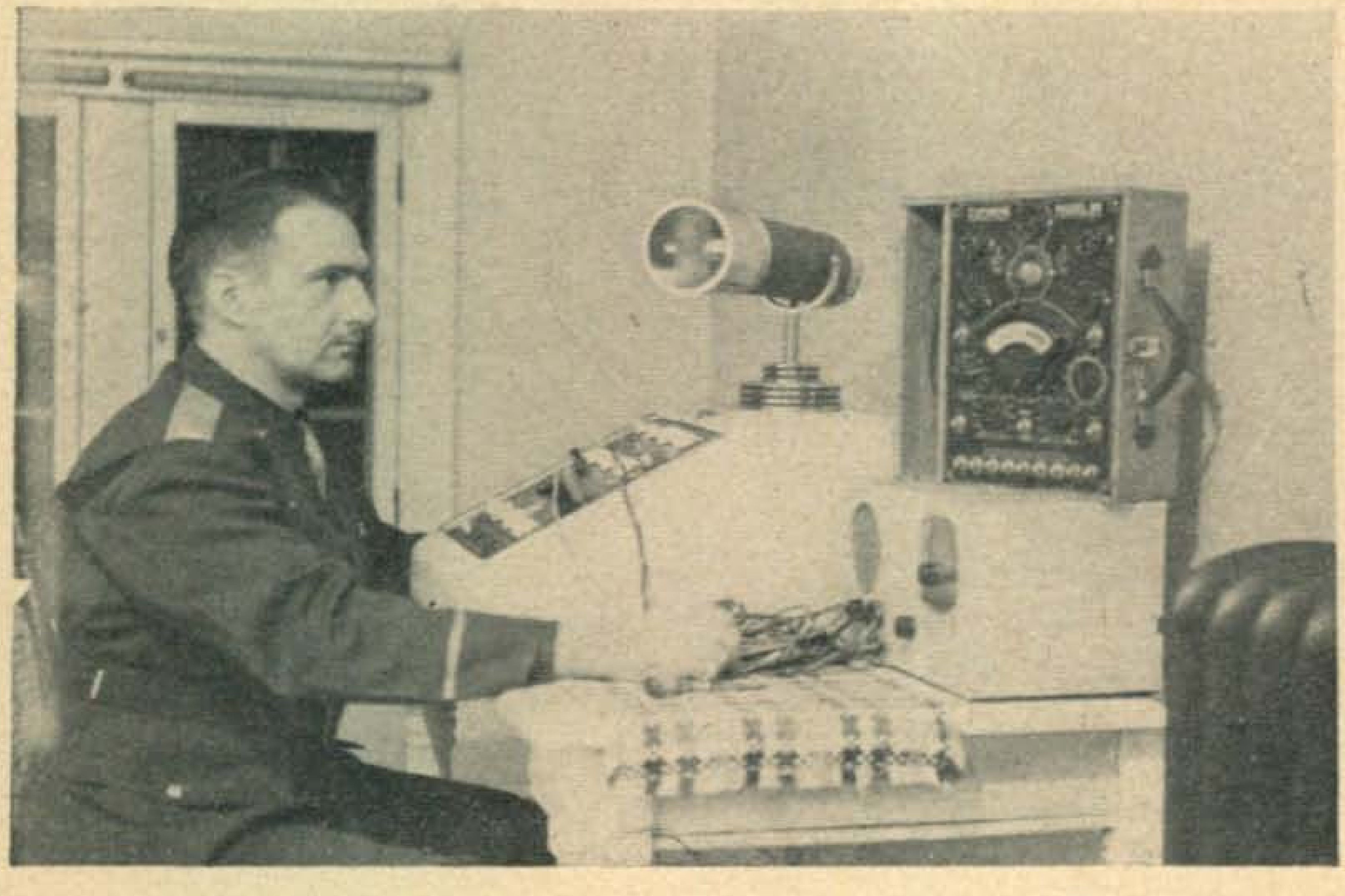
THE CIVIL AIR PATROL needs little introduction. It is an auxiliary of the Army Air Forces and had its beginning shortly before the war. It has an enviable safety record of hours flown in planes that were often inadequate, even dilapidated and overloaded. In many cases radio played a big part in that safety record—especially in the coastal patrol operation which was important in the first year of the war.

Over 24 million miles were flown on coastal patrol duty by the CAP and many bases started out with amateur radio transmitters converted to the low frequency aircraft band between 200 and 400 kc. Radios in planes were generally operated on low frequencies but frequencies around 4 mc were used at some bases and at other points, CAA installations also helped out in general emergencies.

**Instructor, Washington Squadron 334*

CAP Still Active

The CAP still conducts searches for lost army and civilian planes. In flooded areas Civil Air Patrol units have turned out for aerial reconnaissance. Many lives have been saved by flying blood plasma or other medical aid to scenes of disaster. CAP planes have dropped war bond leaflets and flown tracking missions for the army. Members receive only expenses for this work.



Keep 'em flying was often an ex-amateur's job in servicing CAP equipment

CAP

LT. CARL H. STELLO, CAP*

CAP pilot being "briefed" by army operations officer

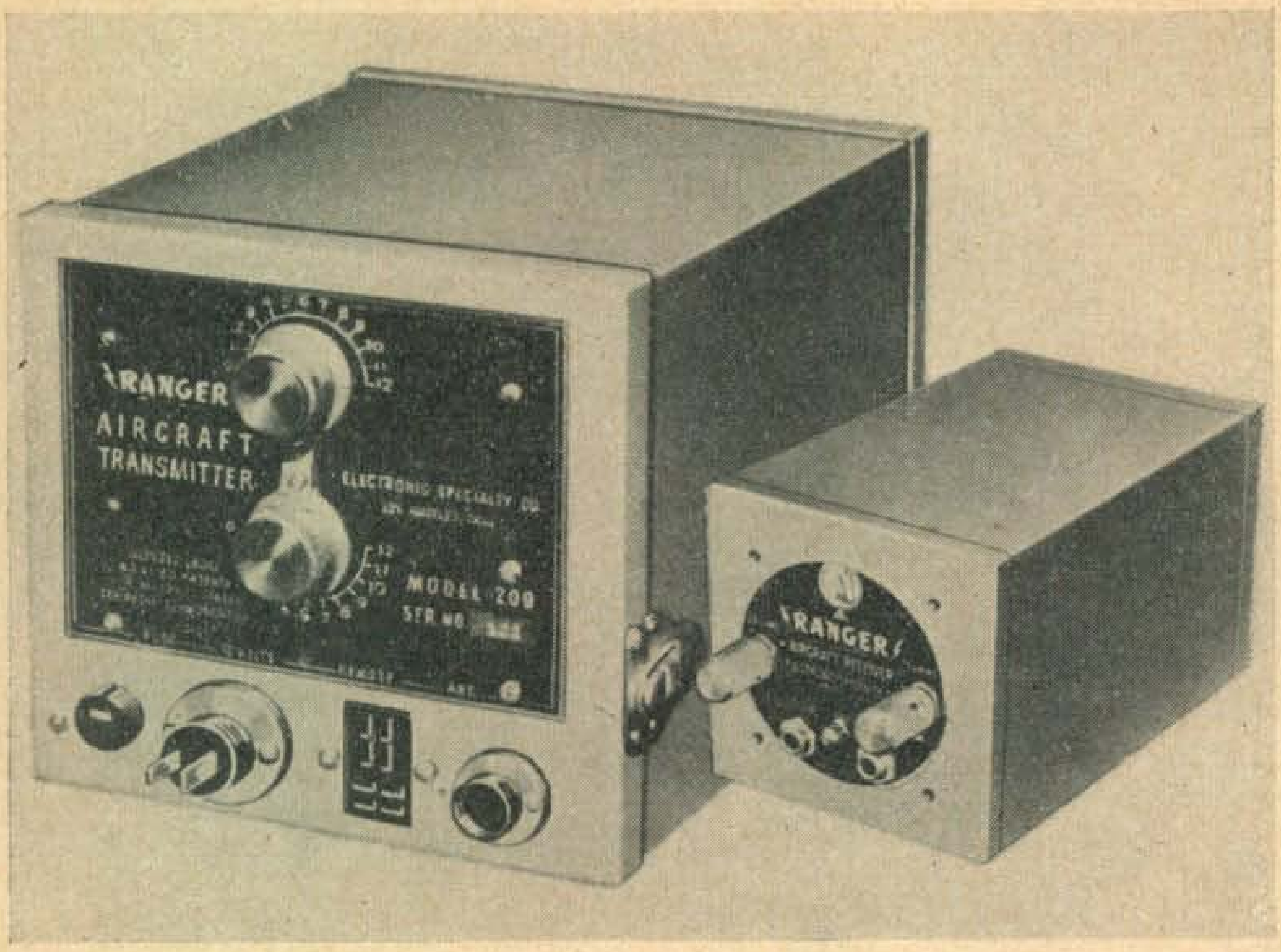
Ranger Model 117 receiver. This entire receiver weighs 1 pound 12 ounces and may be mounted through a standard 3 inch instrument hole. The 5 tube superheterodyne circuit incorporates AVC, coaxial lead-in and built-in antenna matching transformer

The Civil Air Patrol as a wing in each of the 48 states, subdivided into squadrons and flights in more than 1,000 communities with over 100,000 members, who are entitled to wear regular army uniforms with CAP insignia. At present the main job of the CAP is to provide basic training to boys and girls—especially to 17 year old boys, who are interested in enlisting in the Air Corps Cadets. These cadets are taught a number of radio and aircraft subjects such as radio code, communications, navigation, meterology and aircraft engines. They are sometimes given rides in army and CAP planes. The army has allocated a number of small planes to CAP units all over the country for this purpose. (Many squadrons need amateurs to help them build code practice sets and teach radio.)

Radio Apparatus

CAP radio equipment on coastal patrol duty was salvaged largely from out-of-date pre-war stocks, but it worked most of the time. Radio communications were vital to these pilots who flew out over water—as far as 100 miles from land—often under adverse weather conditions in old civilian planes and without parachutes. Army tracking missions were just as hazardous since these involved night flying and there were several fatalities as might be expected in such operations.

Many rebuilt amateur radio transmitters were used in CAP active duty. Much of the equipment was old and in constant need of repair. Sea water and salt air has a corrosive effect on radio equipment, but in general these radios stood up better than might be expected. Repair parts were scarce in the early days of the war, batteries were difficult to obtain and the majority of coastal patrol bases were located at remote points far removed from supply houses and wholesalers, or even retail outlets. The communications officers and radio technicians were mostly former amateurs who were over-age or otherwise not qualified for the regular army. Only a man with



Ranger Model 116 Receiver and Model 209 Transmitter. The receiver is a five tube superhet equipped with AVC and a range filter covering the 195 and 410 KC band. The transmitter is a fixed tuned model, once preset requiring no pilot-tuning. Total weight of both units is 15 lbs. 13 ozs.

long amateur radio training or an experienced radio serviceman could keep the equipment working since much of it was composite—with no circuit diagrams. Even the proper servicing equipment often was not available; and men's lives depended on communications, especially over the water.

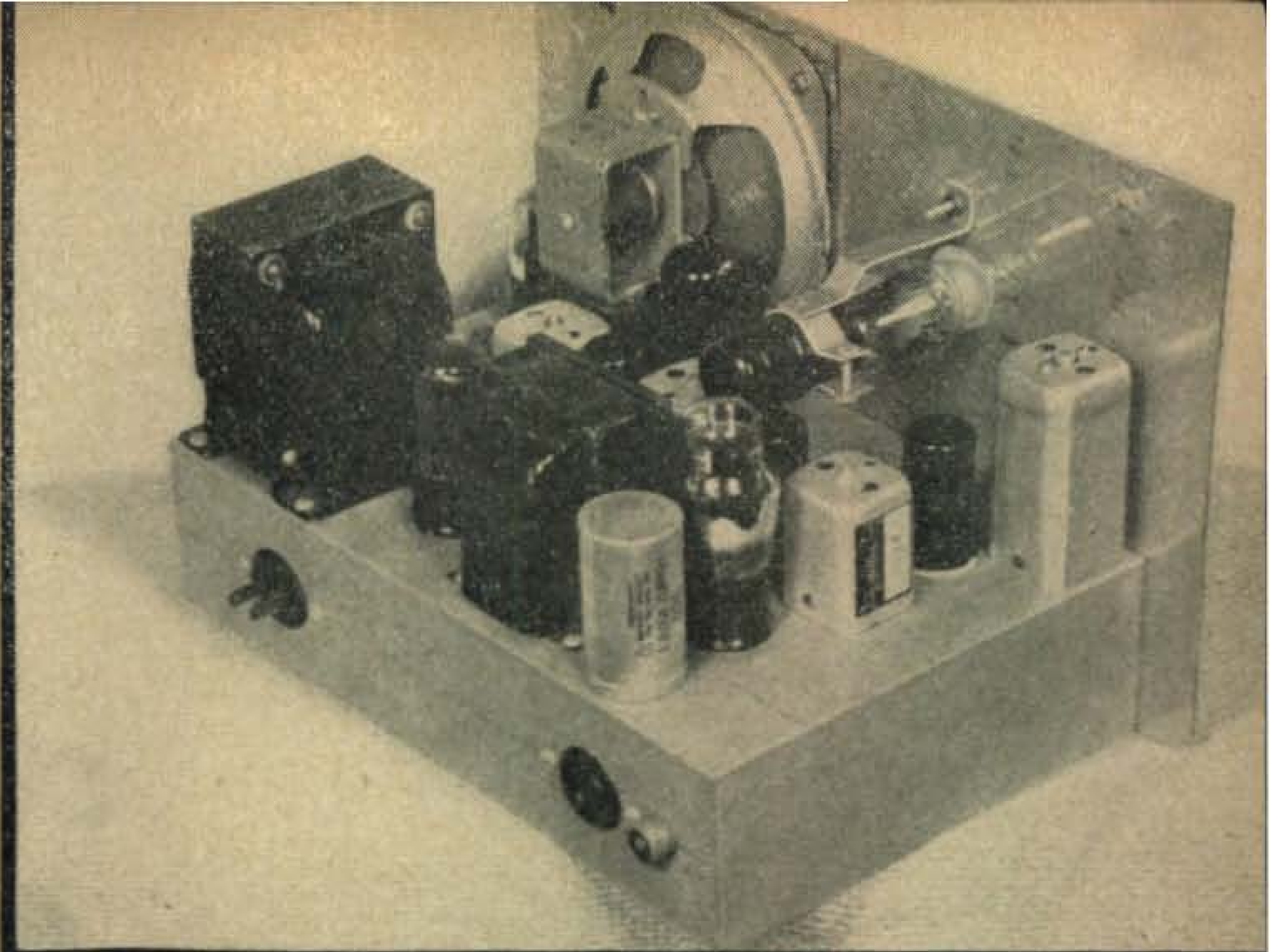
CAP Emergency Service

The CAP lived up to a real emergency. When war was declared, every plane that could fly and every boat that would float was needed because the armed forces then did not have the facilities to patrol the waters along vital shipping routes. One submarine was reported in the Mississippi river stuck in the mud by a CAP plane, which at that time did not carry bombs. After that, CAP craft were allowed to carry bombs and were given special ordnance crews to arm them. Submarines about to attack convoys crash-dived on the approach of CAP planes, which undoubtedly accounted for the loss or damage of several submarines, although figures have not been released. All of these missions were performed by volunteers throughout the nation. On coastal patrol, members from 45 states saw service.

The Civil Air Patrol has created a nationwide demand for flight instruction. This means more pilots. More pilots mean additional planes and they will need more and better radio equipment for the coming flying age. It is expected that CAP will be a permanent part of this air-minded era.

While much of the CAP radio equipment was "composite" and revamped from the ham shack, commercial rigs became available toward the end of the war ▮

Fig. 3. Taking a gander from the rear—clean-cut and compact. Converter power supply is plugged in from this chassis, while the mike jack pipes the r-f input from the converter



An A-M DOUBLE-CONVERSION SUPER

The Basic Unit For Use With a Ten-Megacycle Converter Which Will Be Described in a Following Issue of CQ

HOWARD A. BOWMAN, W6QIR

MUCH WATER HAS passed over the dam since the WERS days—which is merely a metaphor meaning a lot of UHF experimentation at W6QIR aimed toward reducing interference on congested bands. The result, at the present stage of developments, is an amplitude-modulated superhet with transformer-coupled i.f. Future use of FM is by no means ruled out—the i.f. is broad enough and there is room on the chassis for the discriminator circuit—but we were chiefly interested in receiving signals from stations that are not intentionally frequency modulated. While designed primarily for the 144-megacycle band, the converter, with which the basic mixer-amplifier unit is used, is readily adaptable to operation on other bands now open to amateur communication. The basic unit may be described as follows:

1. A 6SA7 mixer, with its input at ten megacycles (to operate from a converter) and its oscillator on fifteen megacycles, providing an output of five mc to work into—

2. Two stages of 6AC7/1852 five-megacycle i-f amplification, suitably broadened with the use of plate and grid circuit loading resistors, feeding into a—

3. Second detector and AVC circuit using a 6H6.

4. Audio circuit, employing a 6J5-6V6GT combination. Included also on the chassis are the—

5. Power supply of 125 ma capacity using a 5Y3GT/G rectifier and a VR105 voltage regulator.

6. 6E5 magic eye indicator tube.

Ten or 12-mc intermediate-frequency transformers would be better than the type used, as they are characterized by an inherently broader resonant curve. However, an extra i-f stage would probably be required, the gain being somewhat lower at higher frequencies. Some such transformers may be on the surplus market in the not distant future.

Construction

The layout is straightforward, as indicated in the wiring diagram, *Fig. 1* and the photographs, *Figs. 2, 3* and *4*. The power supply is to the rear of the 8″ x 12″ x 3″ chassis. The mixer and i-f stages proceed from the left across the chassis, winding up with the audio section at the front center and right, just behind the speaker.

One problem we ran into and solved to our satisfaction was that of making power and grid-return (AVC) connections to the i-f transformers. Like many such transformers, ours came with leads. This meant that the B plus and grid returns had to be brought out to tie points so that the necessary resistors and bypass condensers might be wired into the circuit. Since this procedure is wasteful of space and somewhat difficult in high stages, we did a bit of remodeling.

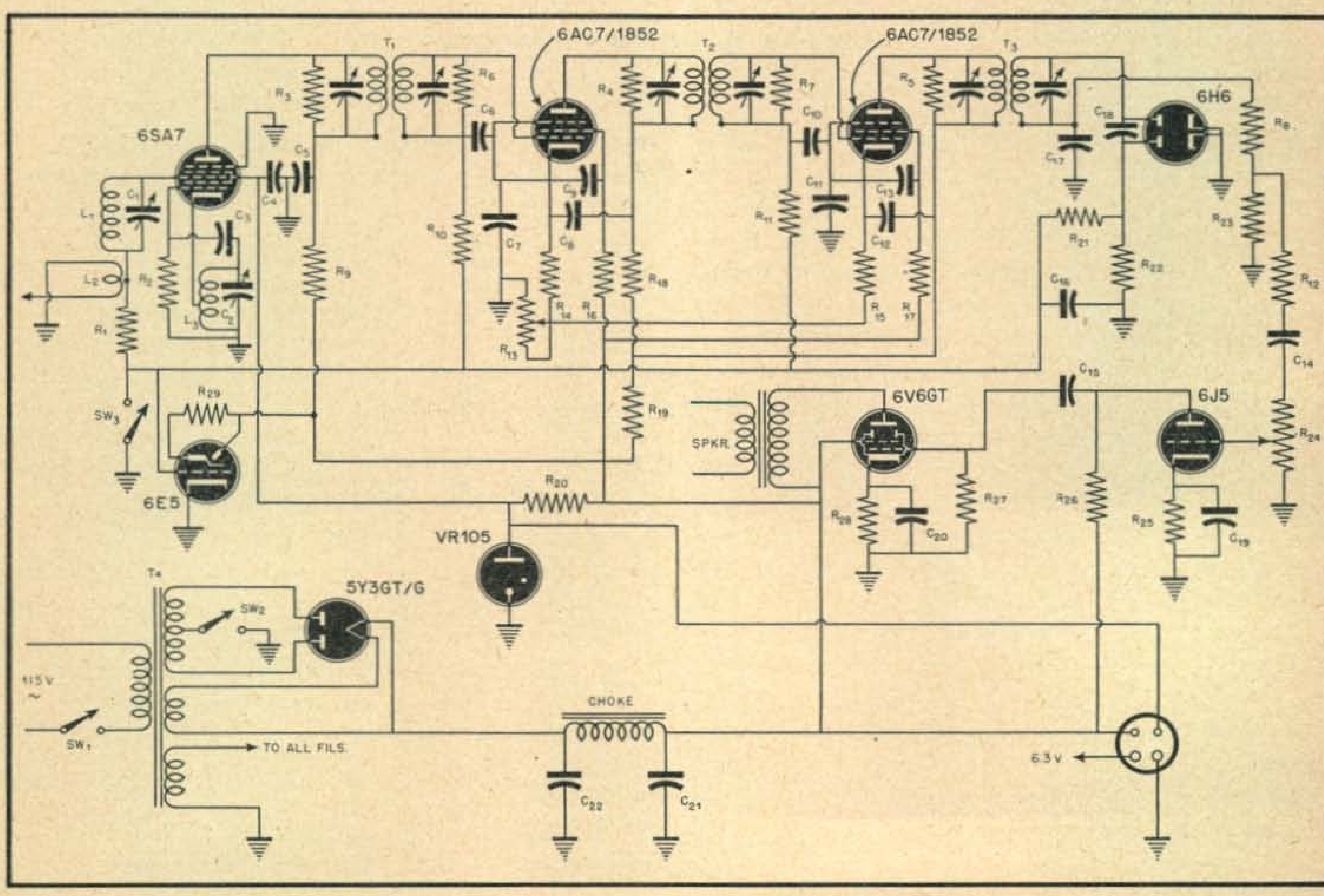
The transformers were removed from their cans and the two offending leads removed. (Since the grid and plate leads run directly to their respective tube socket contacts, these need not be changed.) For each transformer we cut a pair of 4-inch lengths of #14 enameled copper wire—scraped and tinned. One end was formed into a small flattened hook and forced into the rectangular opening in the trimmer lug. The wire was then soldered tight to the lug, so oriented that it passes along the transformer and projects from the bottom of the can when the transformer is reassembled.

The chassis was drilled to mount the transformer by its spade lugs in the usual manner. Lead holes were drilled ¼″ in diameter. A piece of Lucite about 1/8″ thick and large enough to mount just below each transformer under the chassis, is held to the chassis by the transformer's mounting lugs. This piece must be the same width as the transformer but about ½″ longer so that holes may be drilled for the mounting lugs. The Lucite slabs are drilled in the exact center of each hole for leads, using a drill small enough to make a force fit with the leads. The resistors and bypass condensers are soldered as close as possible to the Lucite, and the remainder of the wire clipped off. The entire lead projecting below the chassis approximates ¼ inch—a considerable improvement over the use of tie points. The i-f loading resistors were soldered across the trimmer lugs within each transformer shield can.

In the i-f circuit, the bypasses all return to the suppressor-cathode connection, which is bypassed to ground. The screen bypass is across the socket, affording some measure of shielding between input and output circuits of each stage. We tried a small baffle shield in the original model, but the capacitor seems to work just as well. There is no trace of instability in the i-f amplifier.

Cathode Bias

A little experiment with the value of the cathode resistors on the 1852's and with the cathode gain control will pay dividends in added wallop. Apparently the 1852 gain doesn't increase much until the bias is rather low, then



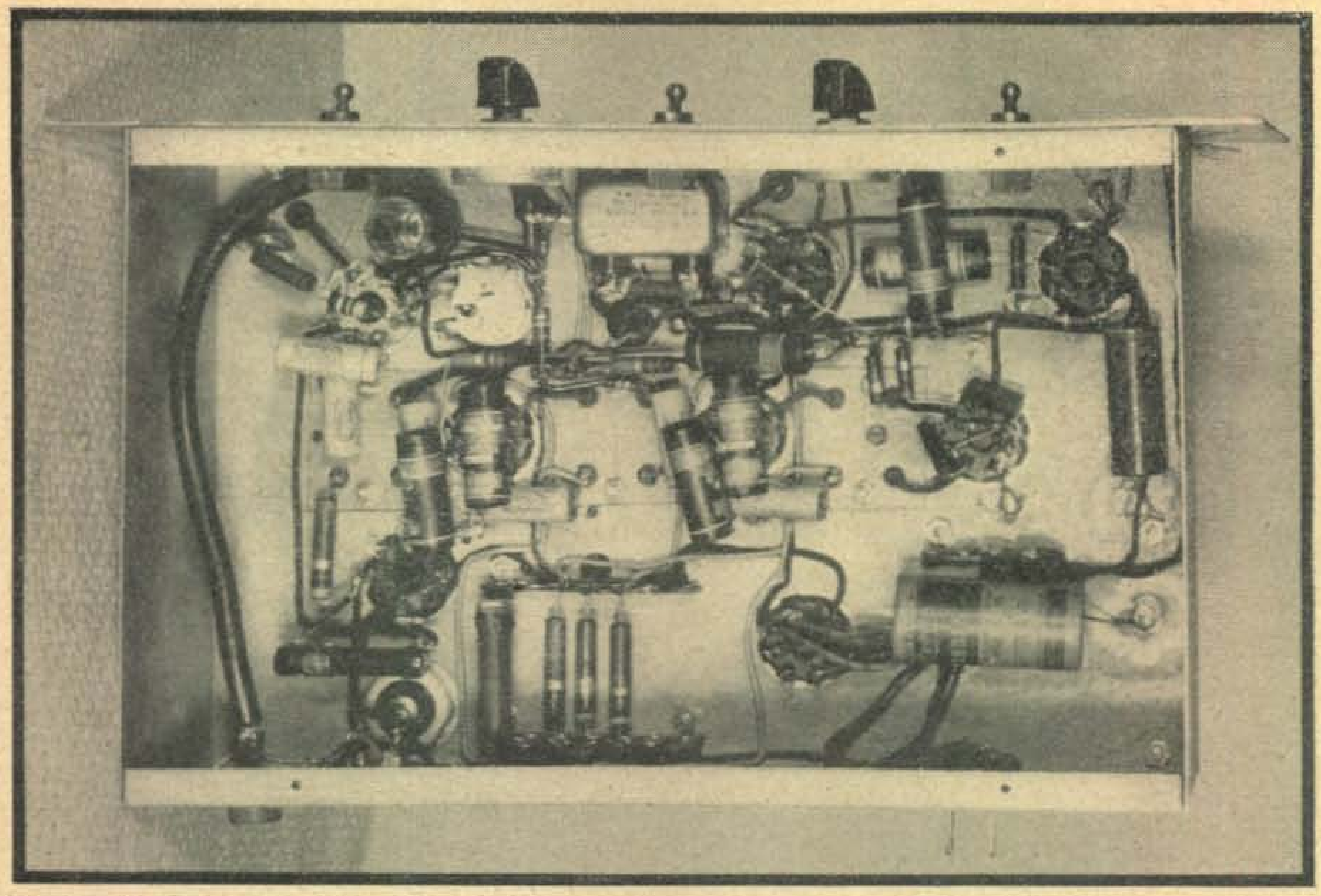


Fig. 2. Under-view of the chassis. Input controls to the left. Note Lucite bottom plates on the i-f cans

tends to rise rapidly for a very slight change in bias. A logical procedure is to set the cathode resistors without the potentiometer (grounding each instead), trying successively smaller values until the stage goes into oscillation. Then back off to a larger value so that the circuit is at the point of maximum gain—on the verge of instability. The potentiometer may now be inserted in the circuit. This should be of such a taper, if obtainable, as to show a relatively large increase over the first half of its rotation, but an extremely small relative increase over the latter half.

Both the second detector-AVC and audio circuits are entirely conventional. We suggest that if a separate speaker is used, a three-contact plug and connector be employed, with a jumper so arranged as to remove plate and screen voltages from the 6V6 when the speaker is disconnected. Such a device prevents the loss of many an output tube. Elimination of the built-in speaker makes the panel and the entire unit somewhat smaller and more compact. The 6E5 tuning eye works off the AVC circuit in the normal manner and a switch is included for turning off the AVC by shorting it to ground if desired.

The Mixer

The 6SA7 input mixer is no novel idea. Actually what we have is a fixed-tuned receiver with its input channel on ten megacycles. That it is designed to be fed by a converter rather than by an antenna is immaterial. As a matter of fact it works rather well with an aerial, and we've pulled

Fig. 1. (left) Diagram of the basic UHF super unit. This is designed for use with a 10-mc converter (watch for it in CQ). The parts list follows—

C_1—25 μμf variable
C_2—100 μμf variable
C_3—50 μμf mica
C_4 through C_{16}—.01 μf 600 volts paper
C_{17}, C_{18}—100 μμf mica
C_{19}, C_{20}—25 μf 50 volts
C_{21}, C_{22}—16 μf 450 volts
CHOKE—10 h 150 ma
L_1—10 turns #24 enameled close-wound 1/8" from grounded end of L_2
L_2—40 turns #24 enameled close-wound 3/4" dia.
L_3—15 turns #24 enameled space-wound to cover 1" on 3/4" form tapped 3 turns from ground end
R_1—300,000 ohms
R_2—200,000 ohms
R_3, R_4, R_5—30,000 ohms
R_6, R_7, R_8—50,000 ohms
R_9—40,000 ohms 1 watt
R_{10}, R_{11}, R_{12}—100,000 ohms
R_{13}—500 ohms wire-wound pot.
R_{14}, R_{15}—100 ohms 1 watt
R_{16}, R_{17}—60,000 ohms 1 watt
R_{18}—2,000 ohms 1 watt
R_{19}—6,000 ohms 10 watts
R_{20}—7,000 ohms 10 watts
R_{21}, R_{22}—500,000 ohms
R_{23}—500,000 ohms
R_{24}—500,000 ohms carbon pot.
R_{25}—2,500 ohms
R_{26}—100,000 ohms
R_{27}—250,000 ohms
R_{28}—300 ohms 1 watt
R_{29}—1 megohm
Sw_1, Sw_2, Sw_3—SPST toggle switches
T_1, T_2, T_3—5-mc i-f transformers
T_4—power transformer. 700 volts CT 125 ma, 6.3 volts 3.5 a., 5 volts 3a.

in a number of signals in the 9 to 10-mc region by clipping on an antenna and tuning the oscillator condenser section.

Building this part of the unit is mainly a matter of mechanics. The L/C ratios must be approximately correct, the coils wound, mounted, wired neatly, and fairly well isolated. The coil-capacitor constants were worked out on the basis of 100 $\mu\mu$f in the oscillator and 25 $\mu\mu$f for the input circuit. The 100 $\mu\mu$f capacitor provides frequency stability in the oscillator, and the smaller input capacity facilitates resonating that circuit.

The oscillator tuning components are enclosed in an old i-f transformer shield can. Holes were drilled and the capacitor mounted so that its slotted adjustment stud protrudes from the top of the can. Before mounting, the rotor connection was grounded to the can and a length of bare tinned wire soldered to a stator connection. This lead is long enough to go through the bottom of the can and the chassis. The coil was wound on a small polystyrene form sawed off so that it fits snugly across the inside of the can where it is held by a 6-32 screw, the nut for which is cemented on the inside of the coil form. We wound the coil as per the dimensions in the schematic, arrived at by means of the ARRL "Lightning Calculator," and hit it on the nose the first time.

The Finer Points

The coil was positioned so that the cathode tap comes off toward the open end (bottom) of the can, making this lead short. The grounded end of the coil fastens to a soldering lug mounted between coil form and can and held in place by the mounting screw. The grid lead is brought off as an open lead, scraped and then soldered to the wire from the capacitor stator. A piece of fine spaghetti is first slipped over this lead as insulation between coil and capacitor while another length insulates it from coil through a grommeted hole in the chassis to a tie point. From here it proceeds to the injection grid through a small mica capacitor. The cathode lead also passes through a grommeted hole, but runs directly to the cathode terminal on the socket.

The input circuit components are near the tube socket, under the chassis. The coil form is the same size as that used for the oscillator and is separated from the chassis by a ½" mounting stud. The grounded side of the primary or antenna coil is wired to a lug under the coil form (just as with the oscillator coil). The grid end of the secondary proceeds directly from coil to tube socket as a spaghetti-insulated continuation of the coil wire itself. The other two leads terminate at a tie-strip. One receives the center conductor of the short coaxial cable which connects the primary to the input terminal on the back drop of the chassis. The grid-return lead on the secondary is connected into the AVC network.

The input terminal mentioned above is a conventional chassis-type male microphone connector mounted on the back of the chassis. No attempt was made to match the primary coil of the input circuit, coaxial cable, and output of the converter with which we shall use this unit. It was a cut-and-try proposition; but it works very satisfactorily.

Wiring

A neat job of wiring contributes to efficiency and makes trouble-shooting that much easier. Plate and screen dropping resistors were wired to a pair of five-lug insulated tie points mounted parallel with each other. Leads of pushback wire run to designated points. Every component is tied down in some manner. Wherever r.f. is involved, leads are cut as short as is consistent with good mechanics. It is our belief, that a slightly

[*Continued on page 51*]

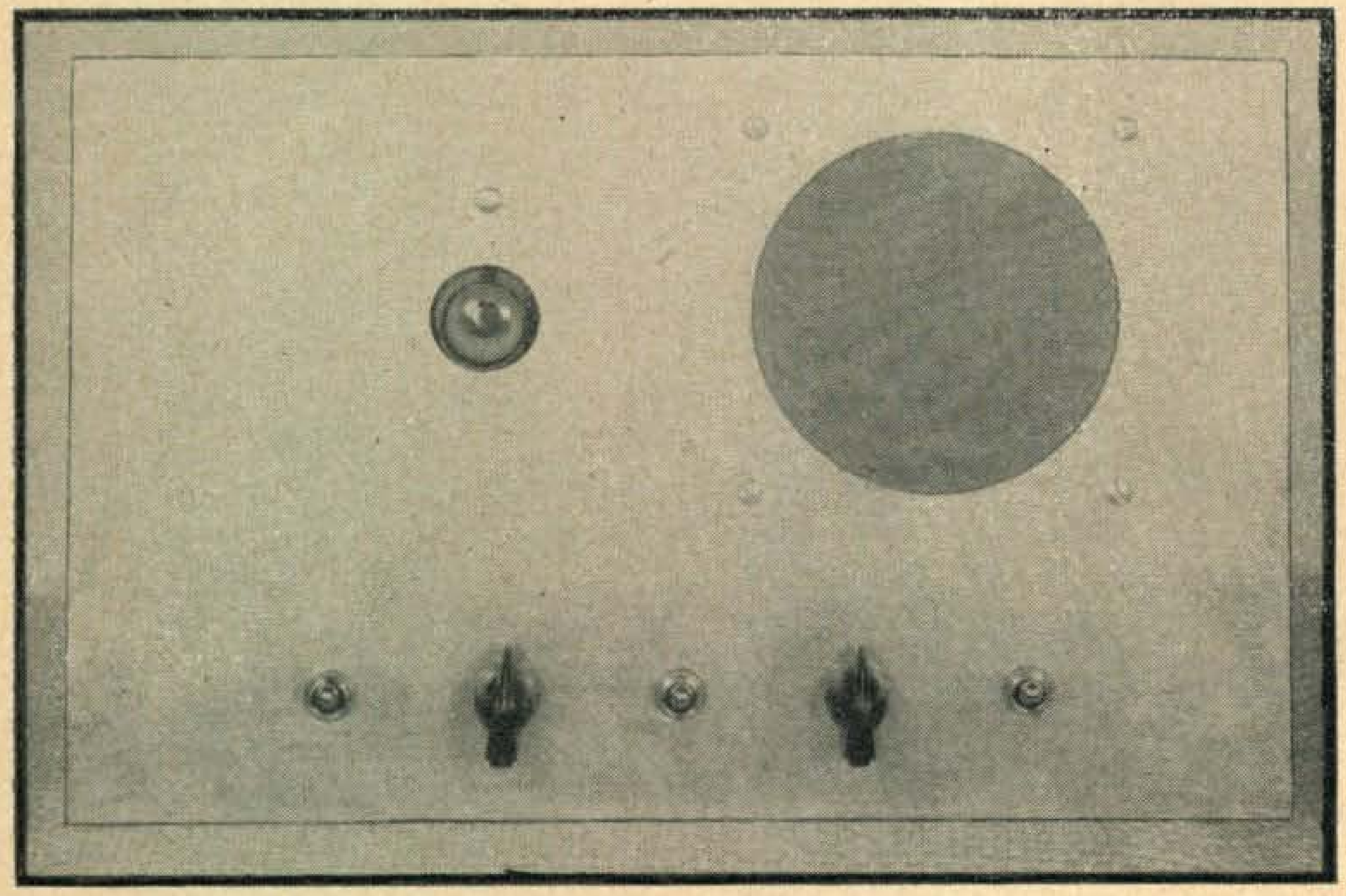


Fig. 4. Front view of the finished unit. The converter, a companion unit, will be described in an early issue of CQ

RADAR AT WORK

LAWRENCE and RAYMOND LeKASHMAN, W2IOP

A "chain home low" radar station on the British coast. These installations detected low-flying planes. The five-bay four-stacked array is power turned atop a 185-foot tower. Should work nicely on the proposed 21-mc band!

The Chronological Story of RADAR Since the Early "Echo" Days to Image RADAR at the End of the War

RADIO AMATEURS HAVE already made considerable and lasting contributions to the science of radar. Thousands are returning from the war with a vast fund of knowledge of new techniques, new theories, and new devices developed in radar research. This new knowledge will be evidenced in the next few years by increased quality of amateur transmission, large scale experimentation in microwaves, and even by some direct radar experimentation by amateur radio operators.

Toward the end of the war, public announcement was made, at least in part, of the role played by radar. Coming as it did from under the wraps of secrecy, it captured the popular imagination, and became the subject of millions of words of publicity. The purpose of this article is to review in condensed form the field of operational radar.

Interest in radio detection as a military device dates from communications experiments carried on by two civilian scientists working for the United States Navy, Dr. A. Hoyt Taylor and Leo C. Young. In the autumn of 1922 they observed a distortion or "phase shift" in received signals due to reflection from a small wooden steamer on the Potomac. The principle of pulse ranging was first used in 1925 by Drs. Gregory Breit and Merle A. Tuve of the Carnegie Institution for measuring the distance to the ionosphere—the radio-reflecting layer near the top of the earth's atmosphere.

In the summer of 1930, Hoyt and Young made the important observation that reflections of radio waves from an airplane could be detected. As a result, the Director of the Naval Research Laboratory submitted to the Navy Department a detailed report on "Radio-Echo Signals from Moving Objects." Subsequently Mr. Young proposed that an attempt be made to get the transmitter and receiver into the same ship. After much experimentation, a radar set, built at the Naval Research Laboratory and operating on a wavelength of a meter and a half, was installed on the U.S.S. *New York* in December 1938.

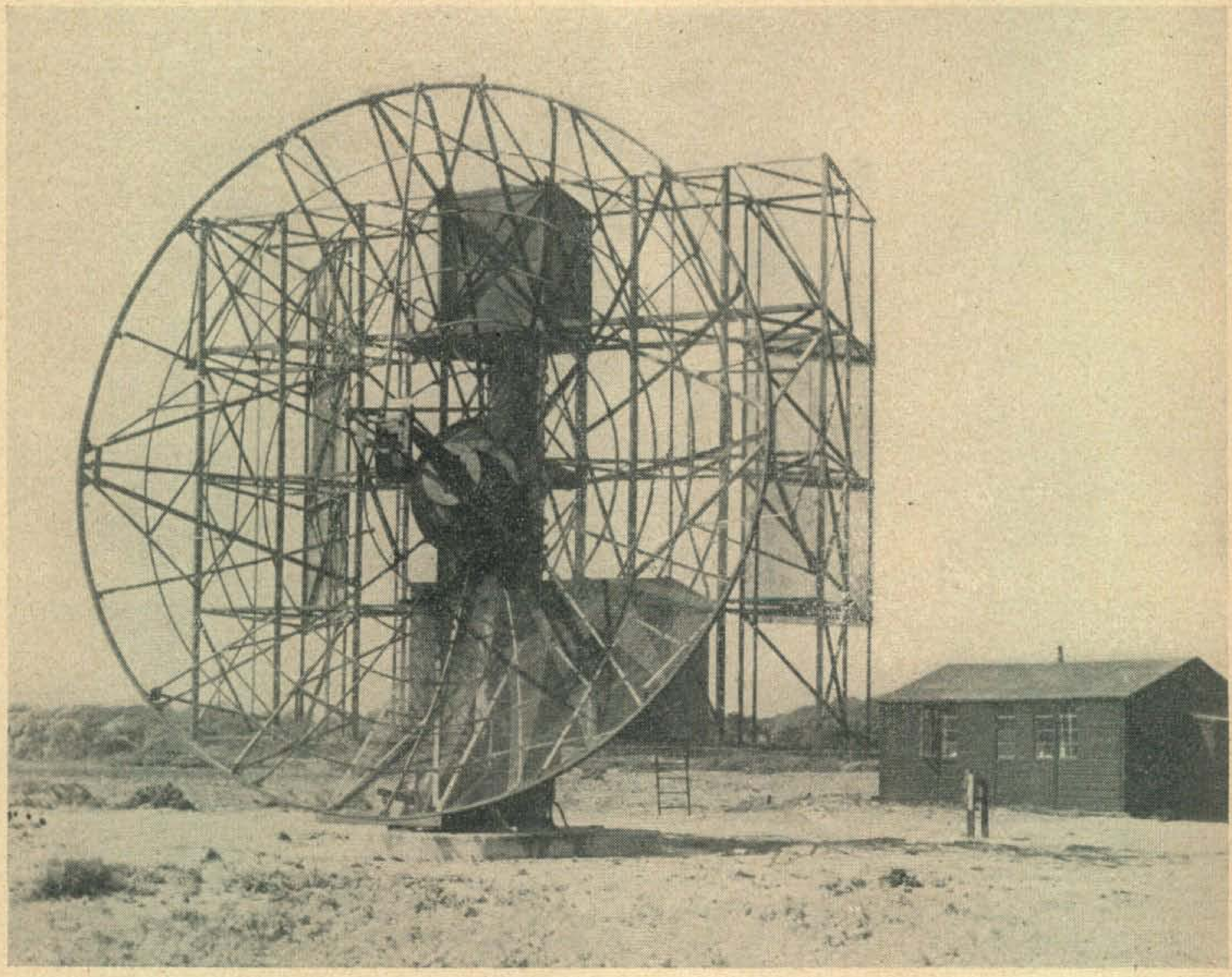
The Army's first pulse radar was designed as a complete anti-aircraft detector system at the Signal Corps Laboratories early in 1936. A radically improved form of transmitter tube was developed later; and a complete set-up demonstrated to the Secretary of War, showed a range of more than 100 miles against bombers.

Working independently, the British had made somewhat parallel investigations. At the end of 1934 the Air Ministry was so impressed with the inadequacy of visual and acoustic means of detecting the approach of hostile aircraft, that they set up committees for the scientific survey of air defense. The radio department of the British National Physical Laboratory conceived the idea that, since airplanes reflected enough energy to disturb radio reception, they might be detected and located by an improved apparatus of the kind built to receive radio echoes from the ionosphere. The demonstrations by the radio research staff held such obvious promise that a decision was made by the Air Ministry to establish a chain of five stations on the east coast of England. This was the first operational radar system installed anywhere in the world.

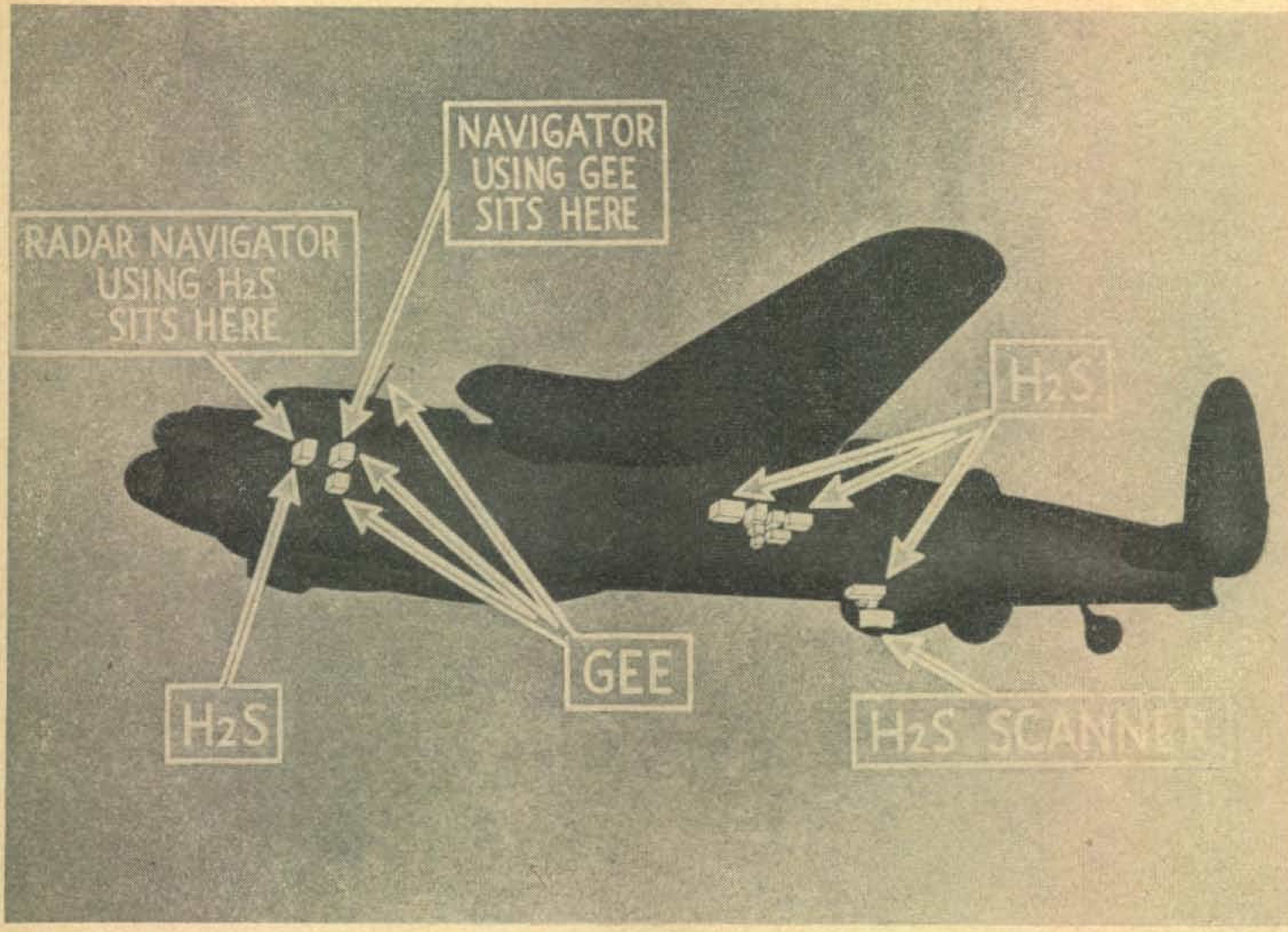
"AWS"—Aircraft Warning Sets

By the outbreak of war all vulnerable areas on the south and east coasts of Britain were covered. For effective defense—as the Battle of Britain proved—it is not enough merely to detect approaching aircraft and know their distances. Efficient fighter interception demands three-dimensional location of the enemy—distance plus direction and altitude—and an estimate of the numbers.

Height-finding was developed about the same time as the bearing determination became possible, through the application of known optical laws. By comparing the strength of the received echo at two sets of aerials at different heights above ground, the altitude of aircraft could be determined to within about 500 feet.



Fighter Direction aerial system for "GCI" (Ground Controlled Interception). The paraboloid is 35 feet in diameter, and the cabin, mounted on the aerial structure, houses both transmitter and receiver



Cutaway of an RAF Lancaster heavy bomber showing location of radar equipment described in this article. A thousand such "heavies" could be concentrated over a German target by British radar ground stations hundreds of miles away. Some installations called for as many as 30 "boxes" using hundreds of tubes

Identification

The first necessity after determining the position of an aircraft was to ascertain if it was hostile or friendly. It may be thought that all airplanes would give the same kind of electrical response whatever their "flag." Indeed, this was the problem—how to make friendly aircraft continuously exhibit a difference from others in their responses. A remarkable series of British devices culminated in one giving coded alterations of the returned echoes. These devices are known under the generic term "IFF" (Identification, Friend or Foe.)

Development of Microwaves

The large aerial system used for the British coastal chain could not be adapted for naval or aviation purposes. As early as 1935 it was clear that a device for fighter interception would have to be evolved, with aerials small enough to be housed in the thickness of the wing. Also, it was apparent that for most naval purposes small aerial systems, capable of producing narrow beams, would be essential.

Much intensive research was made into the use of shorter wavelengths. At 1.5 meters, conventional radio transmitting tubes were adequate to give the required pulse power, but no generator of waves much shorter was known with an output of more than about one one-hundredth the power required. The problem of developing a generator of microwaves was turned over to a research group at the University of Birmingham, sponsored by the Admiralty. With the cooperation of British industry, this group developed a practical form of cavity magnetron. Electromagnetic waves, no more than several centimeters in length, have been successfully generated, carrying the power of many kilowatts.

Micro-Early-Warning—"MEW"

During early 1943, the bulk of the German bombers came in very low, attempting to get under the long-wave radar upon which the Allies were relying. Five new American-built microwave sets proved valuable in supplying coverage against such low planes. This was the first proof that microwave equipment had a place in air warning, supplementing the original British and Signal Corps long-wave radar, improved versions of which, however, later played a part in safeguarding Okinawa.

A set called "ASV" (Air to Surface Vessel), which showed the presence of shipping, was installed in RAF coastal command aircraft in 1939. This was actually the first instance of airborne radar being used in the war.

Airborne Interception

By early 1941, the first microwave radar sets for interception were installed in night fighters. In the whole of January only four enemy bombers fell to the British. The figure went up to 24 in March, 52 in April, increasing to 102 in May. Losses became so great that the Luftwaffe could no longer afford them and the night blitz was conquered. This was brought about in the main by combined methods of radar ground control and "AI" (Air Interception radar) in night fighters.

A whole new technique of aircraft control was rapidly built up, called "GCI"—Ground Controlled Interception. A controller on the ground, watching the air situation on a special radar set, chose a specific Nazi airplane as a target, gave detailed course instructions ("vectors") to the fighter under his control, and skillfully maneuvered the fighter to a position one to three miles behind the target. The fighter was then instructed to "flash his weapon," and the AI radar in the plane took over.

"SLC"—Searchlight Control Radar

Searchlights were no longer essential for discovering the enemy, but in the Battle of Britain, and especially in the clear skies of the Middle East, they proved very helpful to the pursuing night-fighters. Radar Searchlight Control (SLC or "Elsie") put an end to inefficient searching of the skies. When the order "expose" was given and a great beam penciled through the night, *it was on the target!*

One of radar's most uncanny developments—a gun which aims itself and follows a moving target automatically and unerringly—was the climax of the British Army's research into radar applications. It was known as "GL" or Gun Laying Radar.

In the U. S., by mid-1943, a radar was developed in conjunction with the Bell Telephone electronic anti-aircraft fire computer. These two devices, with the new power-driven and automatically controlled guns of the Anti-Aircraft Artillery, gave the United States the most accurate and powerful local area defense against air attack that the world has ever seen. Artillery radar is now so accurate that its error is less than the ballistic error of the guns. This means that if the target is not hit "blind" with the first shot, it is the gun itself, or its charge, which is not quite accurate—not the aim.

Combat Information Center

The Navy was simultaneously integrating these various types of radar for the defense of their task forces at sea. The result of their work was the creation of "CIC"—Combat Information Center. The purpose of CIC is to coordinate information—predominately from radar, but also from lookouts and technical devices other than radar—evaluate this information and determine what the enemy is doing. CIC has grown and developed hand-in-hand with shipboard radar. In fact, it was originally called Radar Plot, its function being just that—to plot the movement of planes and ships tracked by radar, and to direct friendly fighter planes to an interception where enemy raids developed.

Giving a clear picture of a whole convoy and its outlying escorts, radar was a tremendous help in station-keeping at night or in bad weather. As operating skill grew, and the sets were improved, not only could a clear picture of a convoy be obtained, but conning-towers and periscopes could be "picked up" at great distances. Indeed, anything was likely to "get in the way"—a big piece of wreckage, a rock, another ship all showed up in good time.

"H2S" (BTO) Bombing Through Overcast

In 1943, several bombing aids were developed by the British from their ASV equipment to meet the need for accurate bombing through clouds. The "H2S" set is a startling device which enables a navigator to see, on a cathode-ray tube screen, a picture in glowing green spots and shadows comparable to a map of the area over which he is flying. The signals on all other radar sets at that time were just a distortion of a quivering line. Now H2S showed at last a direct image on the "PPI," or "Plan Positive Indicator."

At the same time in the U. S., the first production of the Army "LAB" (Low Altitude Bombsight) was coming off the line. LAB was designed as an attachment to radar on the one hand and to the Norden sight on the other. When used at low altitude against ship targets, it scored one direct hit in three tries even during the training of the first crews who had a chance to use it.

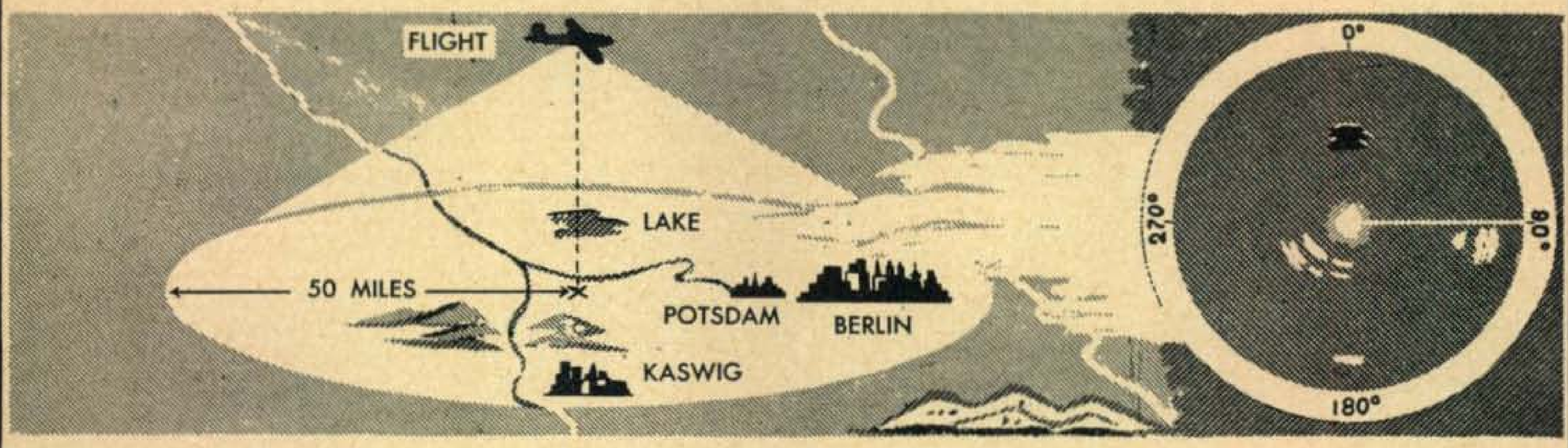
High altitude bombing was something else again. The availability of the microwave frequencies suggested that a set like the British BTO, but with greater accuracy, could be built. The U. S. Radiation Laboratory in co-operation with the Army and Navy turned out "Mickey," as the Eighth Air Force called BTO. A technique for coordinating the work of the BTO operator and bombardier was worked out. The radar op-

HOW THE TARGET IS LOCATED

MICROWAVE ASV AND HIGH ALTITUDE BOMBING SET

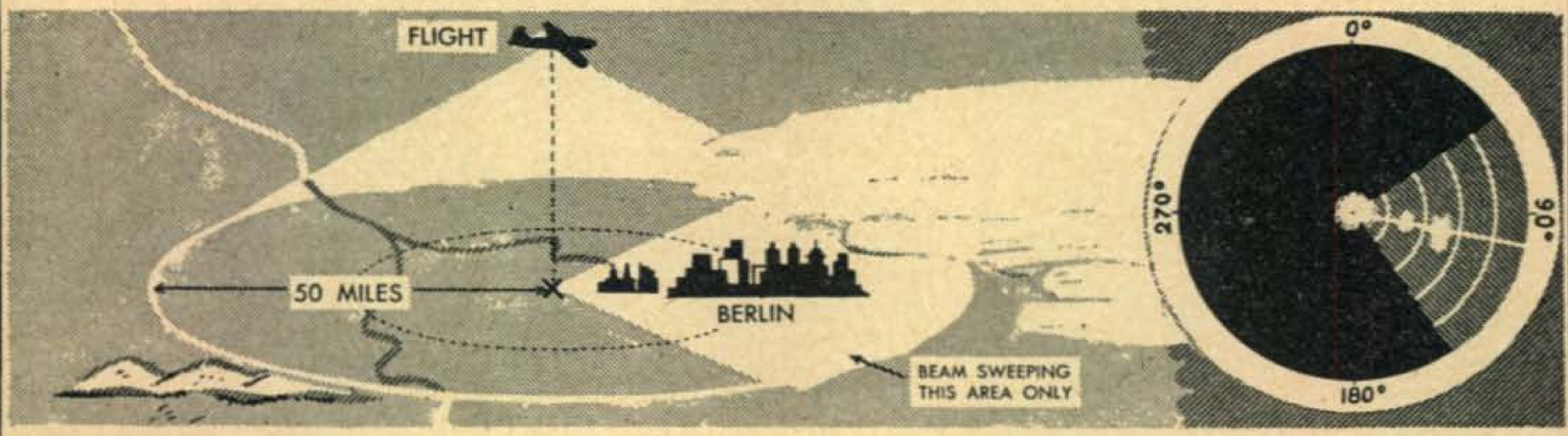
FLIGHT SHOWN STARTING FROM ENGLAND TOWARD TARGET (BERLIN). X SHOWS LOCATION OF FLIGHT OVER CHANNEL.

APPEARANCE OF PPI ON 50 MILE RANGE. BRIGHT LINE SHOWS HEADING OF 90°



40 MILES FROM TARGET (BERLIN). NAVIGATOR MUST STUDY MAP TO LOCATE AREA BY TOPOGRAPHIC FEATURES.

PPI WITH 50 MILE RADIUS. BERLIN IS BRIGHT SPOT AT 40 MILES AND 100°. POTSDAM IS SMALL SPOT AT 30 MILES AND 100°. LAKE AT 25 MILES AND 0° SHOWS AS DARK SPOT.



25 MILES FROM TARGET. SECTOR SCAN IN OPERATION, AIRCRAFT HEADING IS NOW 100°

10 MILE RANGE CIRCLES ON 50 MILE PPI SCALE SHOW BERLIN AT 25 MILES.

erator goes on as if he were going to do the whole job, and the optical bombardier keeps his sight lined up according to the radar sighting. This means that, if the radar is right, the telescope of the Norden is always pointed at the aiming point down below the clouds. The slightest break in the undercast which permits the bombardier to see, enables him to take over the run and complete it optically. This system combines the best features of radar and visual bombing, and makes the bombardier and radar operator a team instead of competitors.

Gee-Radio and Loran

Early in the war the British developed a new type of navigation system which employs radar pulses, but does not use the pulse echoes. Each airplane is equipped with a special receiver that enables the navigator to interpret signals sent out by a ground station. This was Gee-Radio, one of the most important of the new electronic devices. It made possible extremely accurate position fixes at ranges over 350 miles. Later in the war, a system developed by the Americans called LORAN, was put into use, with a vastly extended range.

A number of systems were devised to make possible bombing through clouds by using pulse navigation. "OBOE," developed in March 1943, required ground operators to guide the aircraft and signal bombing. It was replaced by "Gee-H," in which the navigator on board the airplane controls the equipment and works out the moment for bomb release. This in turn was supplanted by an American system called SHORAN, which featured greater accuracy and easier operation.

Absolute Altimeter

Radar altimeters existed before the war but reached their present high degree of performance in military service. Present radar altimeters indicate automatically the height above ground within 50 feet at altitudes as great as six miles.

One major tale remains. It is the story of "Rebecca Eureka," the radar device used by the airborne forces. Eureka was the name given to small radar beacons or "racons" dropped by parachute with the first wave. "Rebecca" was a radar receiving set installed in gliders and troop carriers which made it possible for subsequent waves to home directly to the drop zone.

A U.S. Martin Mariner patrol bomber radar equipped. The "ops" on these jobs may turn out a new and interesting breed of radio amateur

WAR SURPLUS

[*From page 34*]

for 24-volt aircraft use, as are small motor-driven switching devices. The same situation applies to dynamoters which supplied the plate and bias voltage for aircraft electronic equipment. Frequently equipment arrives at the disposal point without adequate technical specifications or diagrams, and unless the purchaser happens to be familiar with the apparatus, he may purchase something of little use to him and with no resale value.

Xmitters and Receivers

In the matter of receivers and transmitters used by the armed forces, it is well to bear in mind that much of this material has undergone extremely rough usage and may be a source of dissatisfaction to the purchaser. However, the prospective buyer need not feel discouraged by the above comments, since there is some new equipment, accompanied with adequate instructions, available, and many standard items well-known to the radio man can be purchased without misgivings. The accompanying photograph displays samples of radio apparatus purchased by the writer from agencies of the RFC or radio dealers.

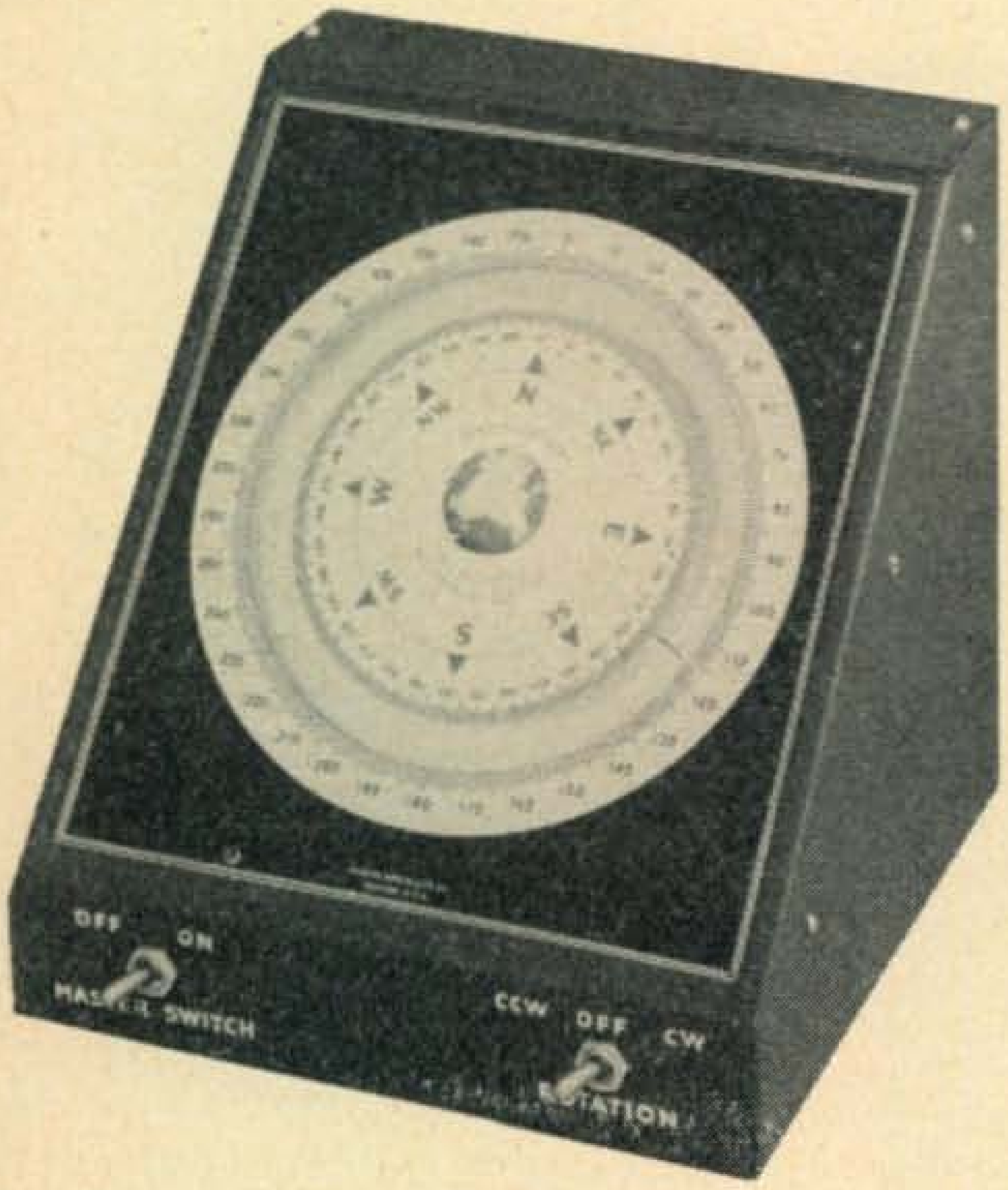
The ECO illustrated sold for under $10 and is complete and ready to operate. It contains a stabilized power supply, and an audio keying monitor. The output is 10 watts with a high order of stability. (Certainly a very fine bargain.) The high-voltage tuning capacitor shown sold for less than $2.00 and the various pieces of VHF gear were picked up for a few cents each. The author also purchased aluminum antenna masts in five-foot sections, equipped with interlocking joints, at a cost of less than five cents per foot. Four-inch plywood antenna mast material has been available as well as high grade co-ax feed line.

Test Equipment Coming

Up to the present time the writer has seen little test equipment on the shelves. Very few receivers and FM units have been offered; but it is the writer's opinion that this is only the beginning of a vast flow of usable radio equipment, and that much is yet to come. For example, nearly every signal section of the armed forces used one or more IE56 tube tester-analyzer combinations. While there should be large quantities of these units declared surplus in time, as yet not a single one has appeared.

Veteran Privileges

A veteran of this war may make use of the services of the Small War Plants Corp. which will accept his application for items other than array either above or below its normal horizontal position with respect to the surface of the earth. Tilting does, however, tend to *raise* the angle of radiation. This has the apparent effect of making short distance work possible, but at the same time lowers, and sometimes eliminates, the signal response at a distant receiving point. It has been found possible, with a four element array, to work from 108 to 125 miles on 2½ meters by tilting it upward 30° to 40° in the direction of the



Selsyn control indicator for the rotary beam shows the direction in which your signals are going—checks within five degrees of the array position

receiving point. The only feasible method at the present time of lowering the angle of radiation is to place the array between ½ and 1½ full wavelengths above ground—the exact height depending on the angle of radiation desired.

Height

It is not considered within the scope of this article to cover thoroughly the matter of how high to erect the antenna above the ground. Briefly, however, one should come as close as possible to 0.75 wave length on the 20 meter band and 1.5 wave lengths on the 10 meter band. These figures are not critical, but if conditions permit, they are well worth following. An optimum height would be approximately 53 feet, which represents 0.75 wave length on the 20 meter band and 1.5 wave lengths on the 10 meter band. Assuming a perfectly conducting ground and not many nearby trees and buildings, this height would produce a 20° angle of radiation on the 20 meter band and a 10° angle on the 10 meter band—both theoretically ideal conditions.

was used. A small key thump was minimized by connecting an .02 μf capacitor and a 500-ohm resistor across the key contacts. Complete elimination of all keying clicks can be obtained by connecting a larger condenser, such as .1 μf in place of the .001-μf condenser at the lower end of the oscillator gridleak to ground, and then connecting a 10,000 to 20,000 ohm-resistor in series from this junction point to the key. Unfortunately, there will then be an increase in keying chirps or warble, and thus a compromise must be made to satisfy individual requirements. The R/C constants in the keying circuit may be changed easily for this purpose.

The VFO frequency for any setting gave a change of approximately 200 cycles in an hour's warm-up. A few volts variation in the 115 a-c line potential resulted in a change of approximately 50 cycles in the 3.5-mc band. Sudden changes of $\pm$50 to 100 cycles were sometimes noted, due to the mechanically poor construction of the VFO variable condenser C_1. Some poorer types of condensers resulted in shifts as great as 600 cycles.

SIGNAL BEAM

[From page 12]

ly, the reflector should be connected at the center and adjusted for minimum galvanometer current.

Best practice dictates making all adjustments after the array has been installed at its permanent operating height above the earth's surface. If this is not possible, the array should be set up on a temporary mounting 5 or 6 feet above the earth, then raised to its permanent location after all the necessary tuning—that is, length adjustments on the elements—has been made. This method, while not quite as accurate, is entirely satisfactory for an average installation.

Tilting the Array

It is not possible to lower the angle of radiation (desirable for long distance work) by tilting the

technical and non-technical functions of the club will be elaborated and diversified in a manner acceptable to the entire membership. Program committees will be responsible for arranging lectures, tests, demonstrations, competitions and open-forum discussions of a varied nature so that all who attend the meetings will derive the greatest possible benefit from club activities.

Former members will be retained on the roster and new members will be admitted by invitation. The club is one of the oldest on record, having been founded several years prior to the first World War. Its membership includes many of the original "two-letter calls," and its technical staff has long been considered an authority in the amateur field.

Prospective members are invited to communicate with Wm. Ladley, W6RBQ, 200 Naylor St., San Francisco, 12, California.

CRYSTAL CHIRPS

In our October issue New Products section we referred to an Eimac type 4-250A power triode. This should have been tetrode.

V-F-O

[From page 15]

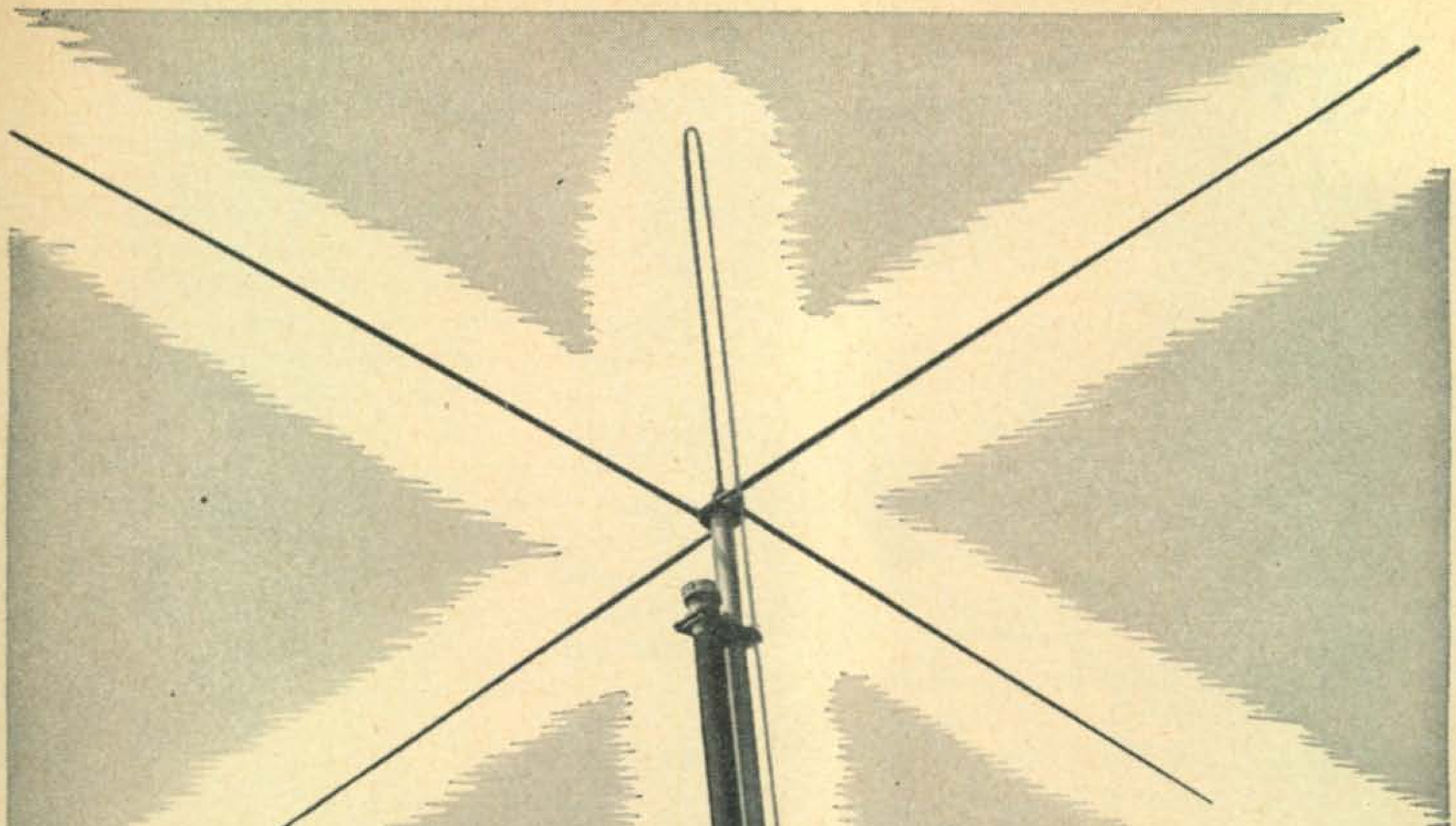
Resistors are unnecessary in any of the screen circuits since the bias resistors were chosen to assure operation at reasonably high G_m and moderate plate and screen currents.

Operation of The VFO

A frequency meter should be available for setting the VFO to any frequency in the 3500 to 4000-kc range. The VFO should cover from 3500 to 3750 kc for the 7.0 to 7.3-mc band; 3500 to 3600 kc for the 14.0 to 14.4-mc band; 3500 to 3583.33 kc for the 21.0 to 21.5-mc band, and from 3500 to 3712.5 kc for the 28.0 to 29.7-mc range.

The d-c milliammeter in the 807 grid circuit may be used in the preliminary line-up of all stages. Adjustment of the coil inductances by means of the iron or copper tuning slugs may be made for each band by noting the readings of the grid meter. It is good practice to disconnect the 807 screen-grid lead when making these tests, unless the 807 plate voltage is reduced. Otherwise the 807 screen current will be excessive when there is no voltage on the plate.

The 807 grid-bias supply of negative 45 volts furnishes a keying voltage for the oscillator and buffer blocked-grid keying method. The VFO has ample stability to permit keying either in the +B or grid-bias leads. However, there was less key thump and chirp when blocked-grid keying



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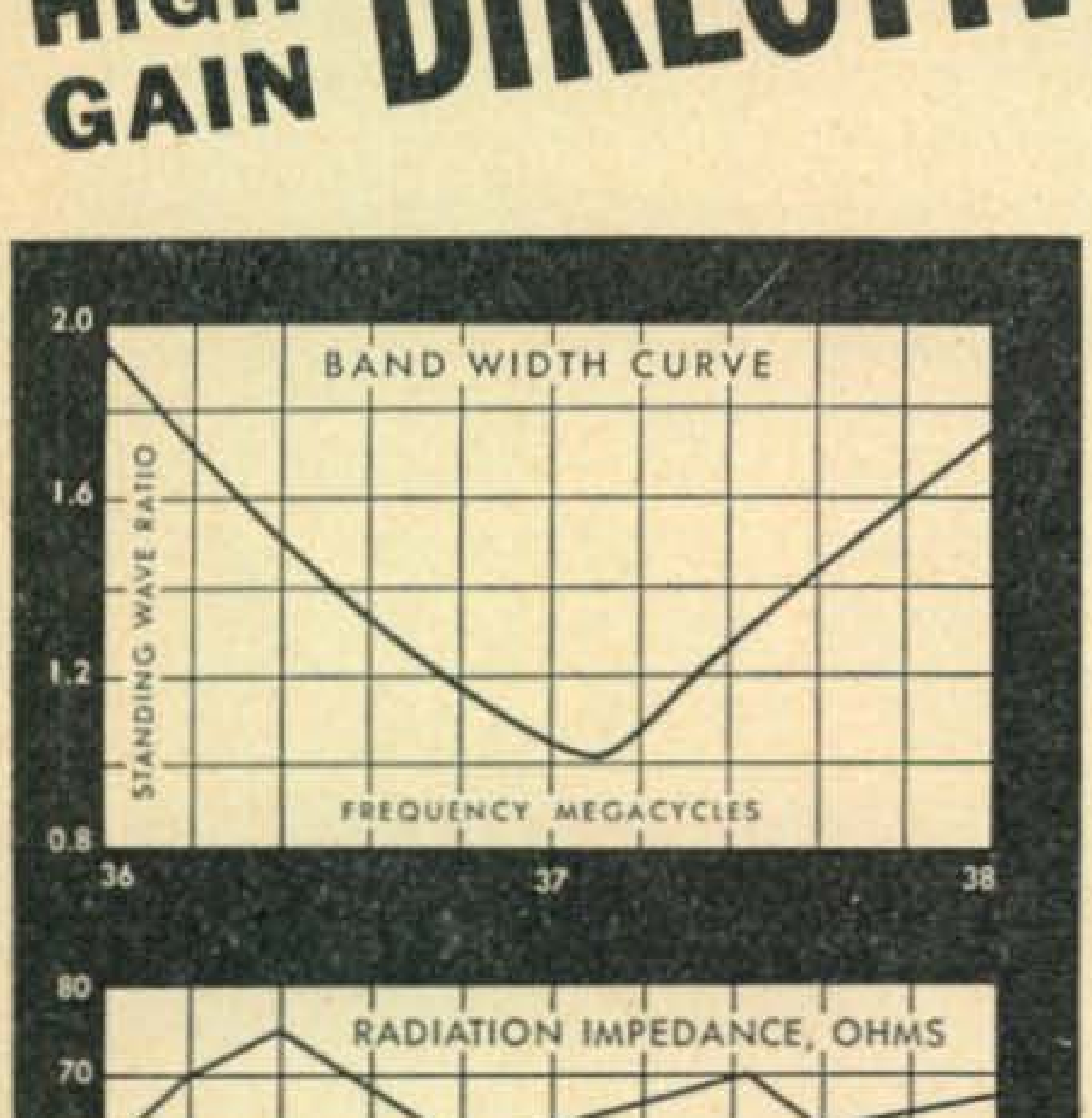

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HAM NEWS

CRYSTAL RESEARCH LAB ISSUES NEW CATALOGUE

Of interest to amateur radio engineers and to "hams" is the new catalogue just released by Crystal Research Laboratories of Hartford, Conn.

This catalogue shows interesting views of plant personnel at work in crystal production. One entire page is devoted to the facsimile of a movie film depicting the consecutive production steps from the raw quartz to the finished crystal. The entire catalogue is clear and concise and various types of crystals are fully illustrated and described both as to operation and use.

Crystalab points out, however, that many other types and varieties of crystals can be produced by them in addition to those described herein. They specialize in making close tolerance crystals to order in any quantity. Those interested in securing a free copy are asked to write Crystal Research Laboratories, Inc., 29 Allyn Street, Hartford 3, Connecticut.

SAN FRANCISCO RADIO CLUB, INC., MEETS AGAIN

After a prolonged period of wartime inactivity the pioneer San Francisco Radio Club, Inc., will again hold meetings regularly on alternate Fridays in a centrally located meeting hall, the address of which will be announced over the air and on notices posted in various radio stores. Committees have been appointed to survey the city for suitable meeting quarters of ample size to accommodate the anticipated increase in membership which will result from the homecoming of many radio amateurs from the armed forces. Wm. Ladley, W6RBQ, one of the city's most active amateurs, and Clayton F. Bane, W6WB, President of Technical Radio, Inc., invited a small group of local amateurs to a round-table discussion at the State Armory Building on September 20th for the purpose of discussing the methods whereby the club would once again be enabled to function in an effective manner during the post-war period. The meeting was attended by the following: W6CVP, W6WB, W6QUC, W6NGV, W6MXV, W6WN, W6DOT, W6MZ, W6RBQ, W6JYN, W6UQ, W6LV, W6BUJ and W6AHH.

It was proposed that in future years there be but a single, powerful radio club in the city of San Francisco, with a single aim and purpose, and that the greatest possible service be rendered to old-timers and newcomers alike. The scope of

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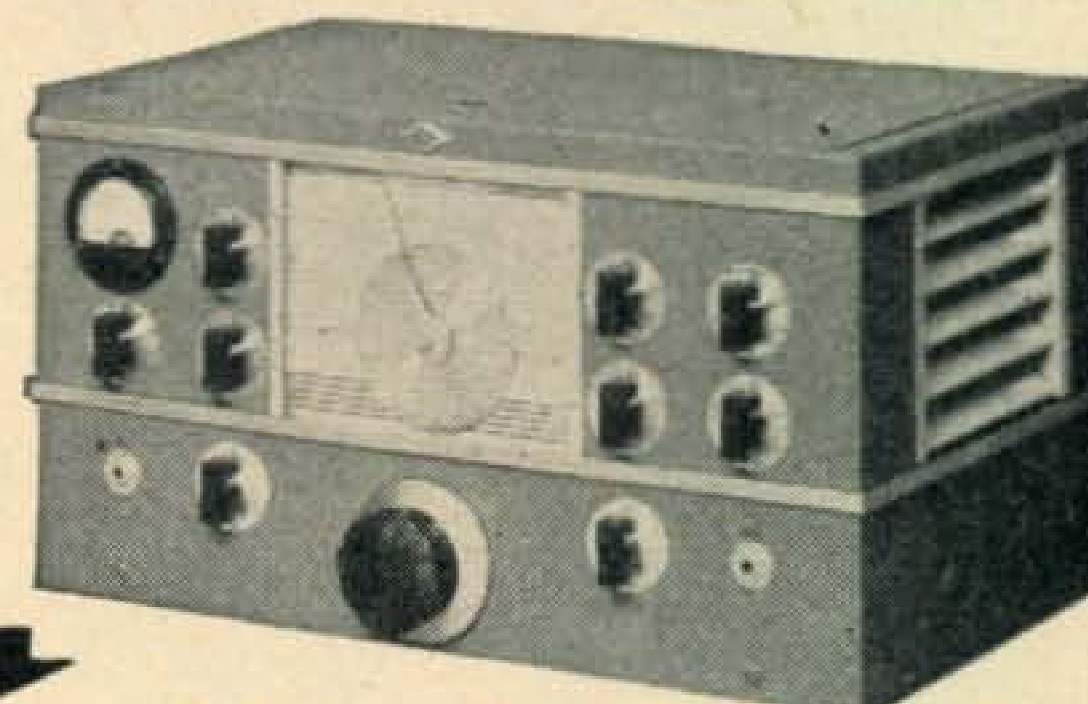

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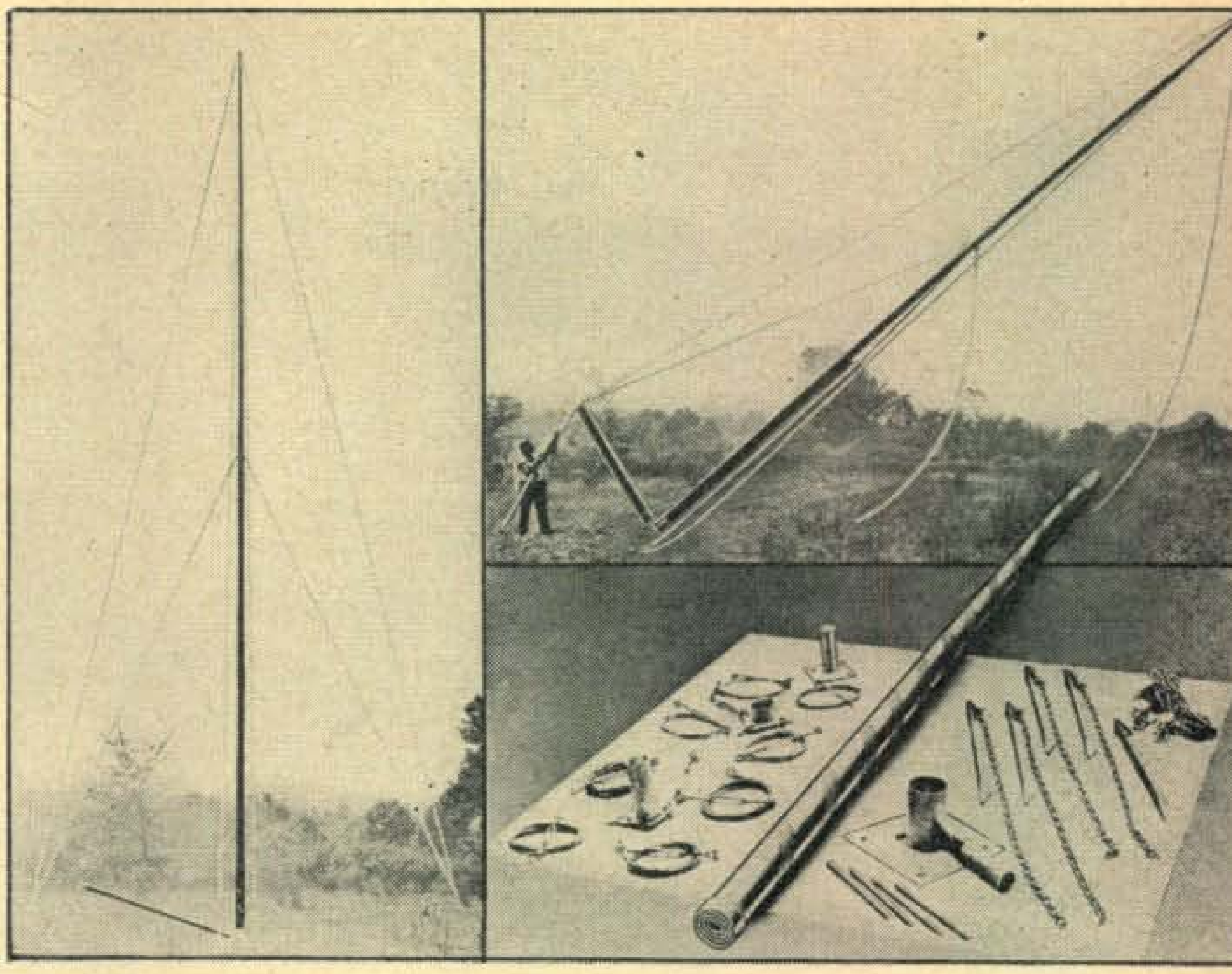

Fifty feet of antenna pole which telescopes into kit proportions complete with base plate, guy wires, spikes and anchors

The Plymold Corporation of Lawrence, Mass., manufacturers of "Plytube" antenna masts, announces a newly designed and tested 50-foot "Ham-Mast" built and attractively priced for the amateur trade. According to the manufacturer, erection hazards have been completely eliminated, and two men can hoist the Ham-Mast into place in fifteen minutes flat. The mast is non-metallic, compact, light and will withstand wind velocities of 100 miles an hour.

The mast is made of four sections which telescope into a bundle 14 feet 3 inches long. All accessories are supplied, and the erection kit, which accompanies the mast, includes boom, boom cylinder, boom top collars and rope vangs, block-and-tackle and boom anchor. The mast is now in production and reasonably quick delivery is promised by the manufacturer.—*CQ, Dec. 1945.*

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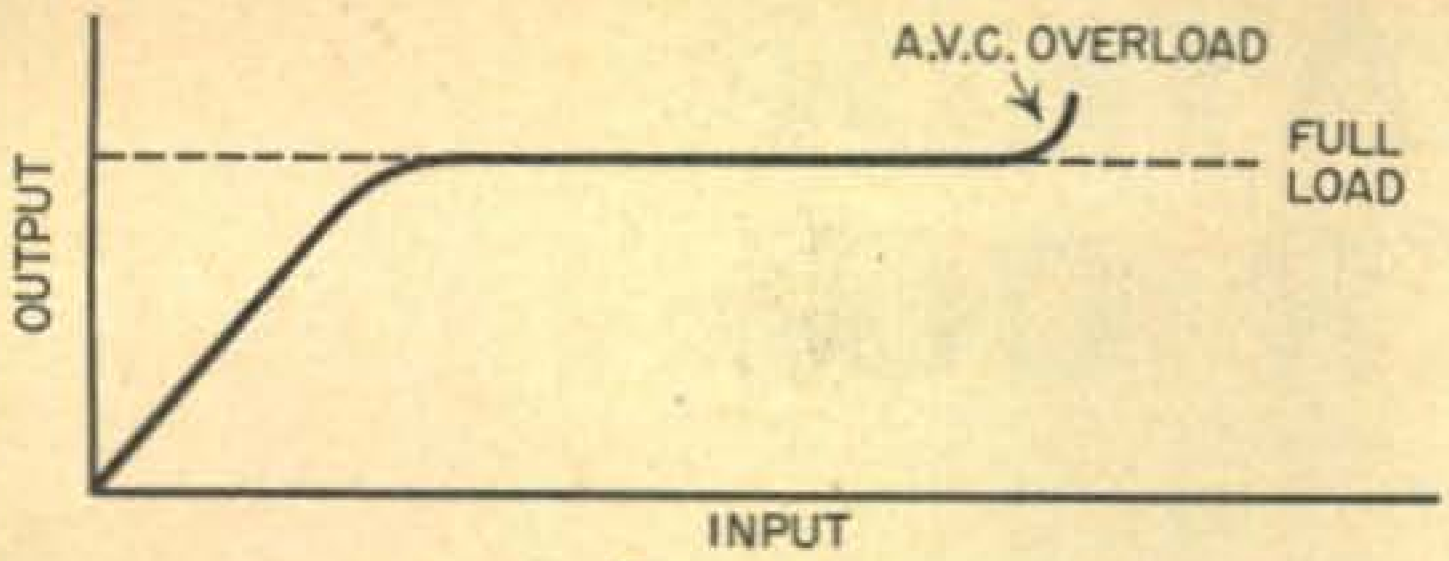

Figure 4

dium of delaying a-v-c bias until full load is reached, after which it functions normally. This may be accomplished, as shown in *Fig. 5*, by biasing the a-v-c source beyond cutoff by an amount sufficient to prevent any rectifying action until approximately full load is attained. For all higher inputs, the automatic volume control functions normally. The uniformity of the flat portion of the input-output characteristic of a radio receiver employing a.v.c. is attained by controlling several tubes. In general the more tubes controlled the flatter the characteristic. In the circuit of *Fig. 5*, the grid cathode circuit functions

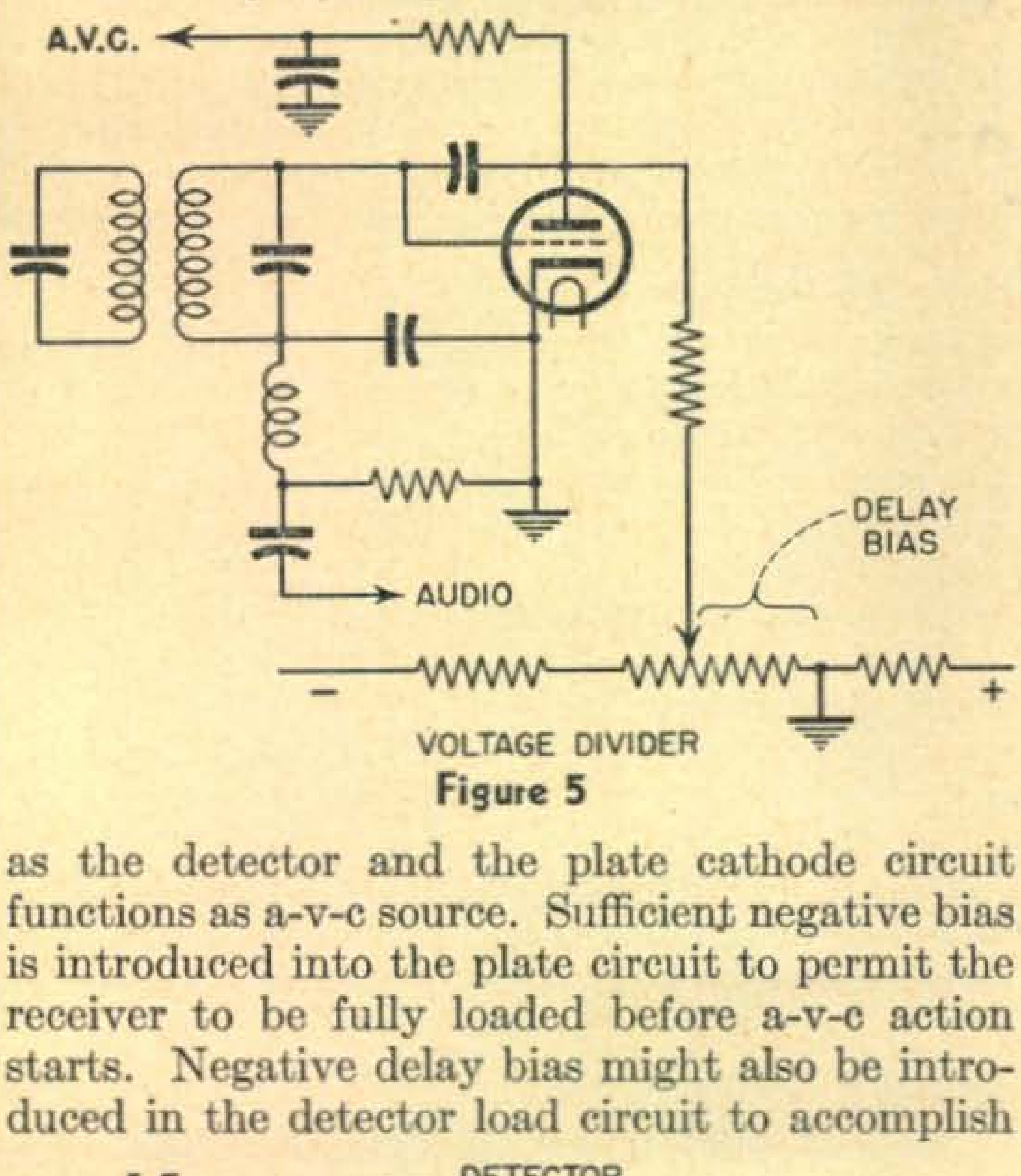

Figure 5

as the detector and the plate cathode circuit functions as a-v-c source. Sufficient negative bias is introduced into the plate circuit to permit the receiver to be fully loaded before a-v-c action starts. Negative delay bias might also be introduced in the detector load circuit to accomplish the same purpose if only one diode were used both for detection and a.v.c. This is not as desirable, however, as the circuit shown in *Fig. 5* since signals too small to load fully the receiver cannot be heard.

To overcome the a-v-c overload condition shown in *Fig. 3* and *Fig. 4*, amplified a.v.c. is

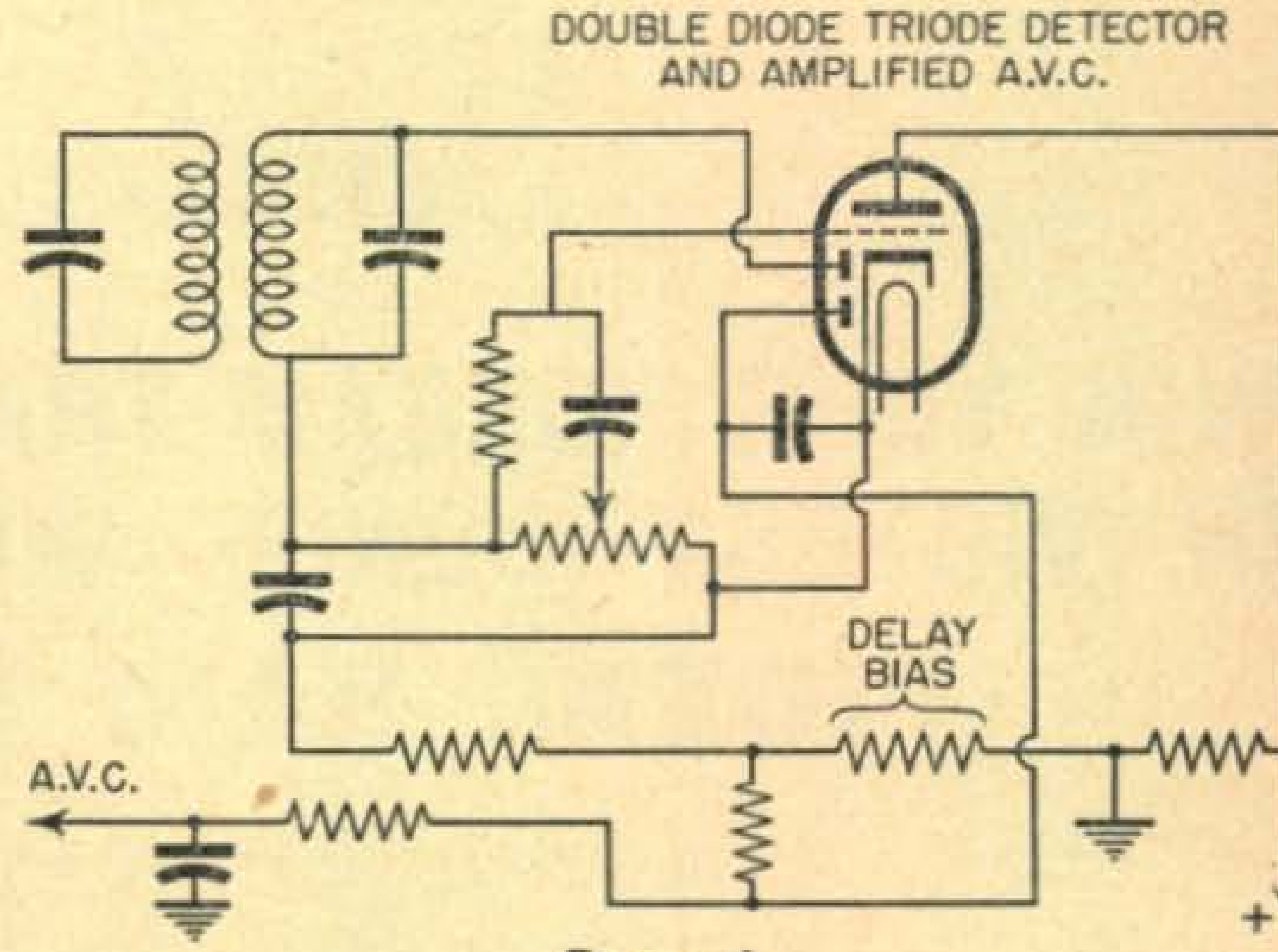

Figure 6

sometimes used. An amplified a-v-c circuit is shown in *Fig. 6*. The input required to overload this a-v-c circuit is increased by a value equal to the amplification constant of the triode portion of the double-diode triode tube used. In *Fig. 6* the intermediate-frequency input is fed to one of the diodes, which acts as a normal linear detector. A resistor is used to feed the triode grid from the detector load circuit, to permit amplifying the direct-current bias in the load circuit. The amplified direct current is then applied to the second diode which functions as a normal a-v-c source.

Still another type of a-v-c circuit is the quiet automatic volume control, or "q.a.v.c." as it is sometimes called. Such a circuit is shown schematically in *Fig. 7*. These circuits operate on the principle of releasing a large negative bias normally imposed on the grid of the first audio tube. Under conditions of no signal, the audio tube is biased well beyond cutoff, so that no audio output from noise or static will result.

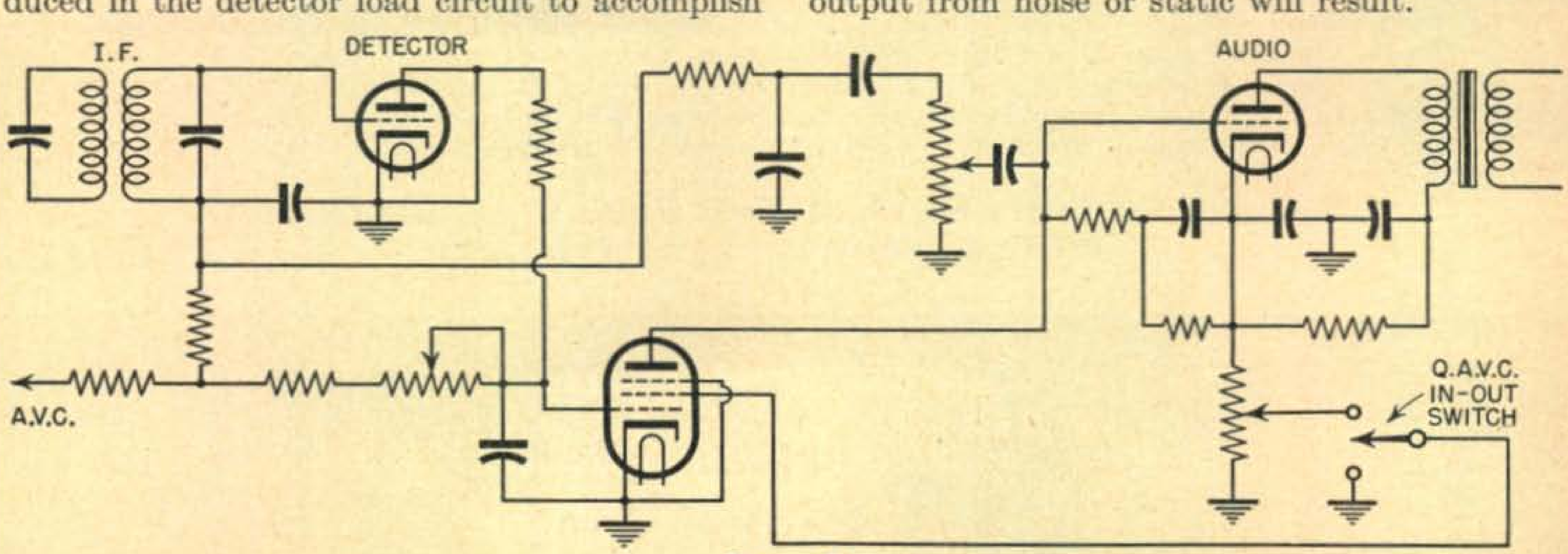

Figure 7

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In addition to receiving completely built transmitters of their own design, the winners in each power class division will divide the total of $2250 in Victory Bonds volunteered by the participant manufacturers sponsoring the contest.

Here Are the Highlights of the Contest

Entries must be postmarked on or before February 15, 1946—the official contest closing date. Transmitter designs in either of two power classes may be entered. Class 1—input power to the final transmitter stage up to 250 watts. Class 2—input power to the final transmitter stage of from 251 to 1000 watts. Contestant must submit entry blank, full schematic diagram and front panel drawing, with sufficient data necessary to build his "Dream Transmitter." Each entry must be accompanied with a 150-250 word statement by the contestant as to why he believes his transmitter design is outstanding and should win. The prize winning transmitters in each power class will be built by the engineering department of Taylor Tubes, Inc. and presented to the winning contestants as soon as practicable after all entries have been judged and the winning designs selected. The $1125 Victory Bond prize in each power class will be presented to the winners immediately after the winning designs have been announced. See the official entry blank for complete particulars.

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Aerovox Corporation, New Bedford, Mass.; American Phenolic Corporation, Chicago, Ill.; Barker & Williamson, Upper Darby, Pa.; Bliley Electric Co., Erie, Pa.; Gothard Mfg. Co., Springfield, Ill.; International Resistance Co., Philadelphia, Pa.; E. F. Johnson Co., Waseka, Minn.; Solar Mfg. Corporation, New York, N. Y.; United Transformer Corporation, New York, N. Y.

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RADIO AMATEUR'S WORKSHEET

No. 7. AUTOMATIC VOLUME CONTROL

The first automatic volume control circuits used separate tubes for detection and automatic volume control. The tubes were biased to approximately cutoff and since the applied radio frequency voltages were small, the tubes operated over the parabolic portions of their dynamic characteristic. The direct current in the load circuits were proportional to the square of the applied input voltage. As a result, if one signal was twice as large as another, the bias fed back to the grids of the controlled tubes was four times as large in the second case as in the first. A circuit using a separate a-v-c tube is illustrated in *Fig. 1*.

The speed with which a-v-c action takes place is determined by the time constant of the circuit through which the bias is applied. The time constant of the supply circuit of *Fig. 1* is $R_2C_2 + R_1C_1$ and is the time required for the a-v-c voltage to build up to 63% of maximum, or to decay from maximum bias to 63% of maximum bias.

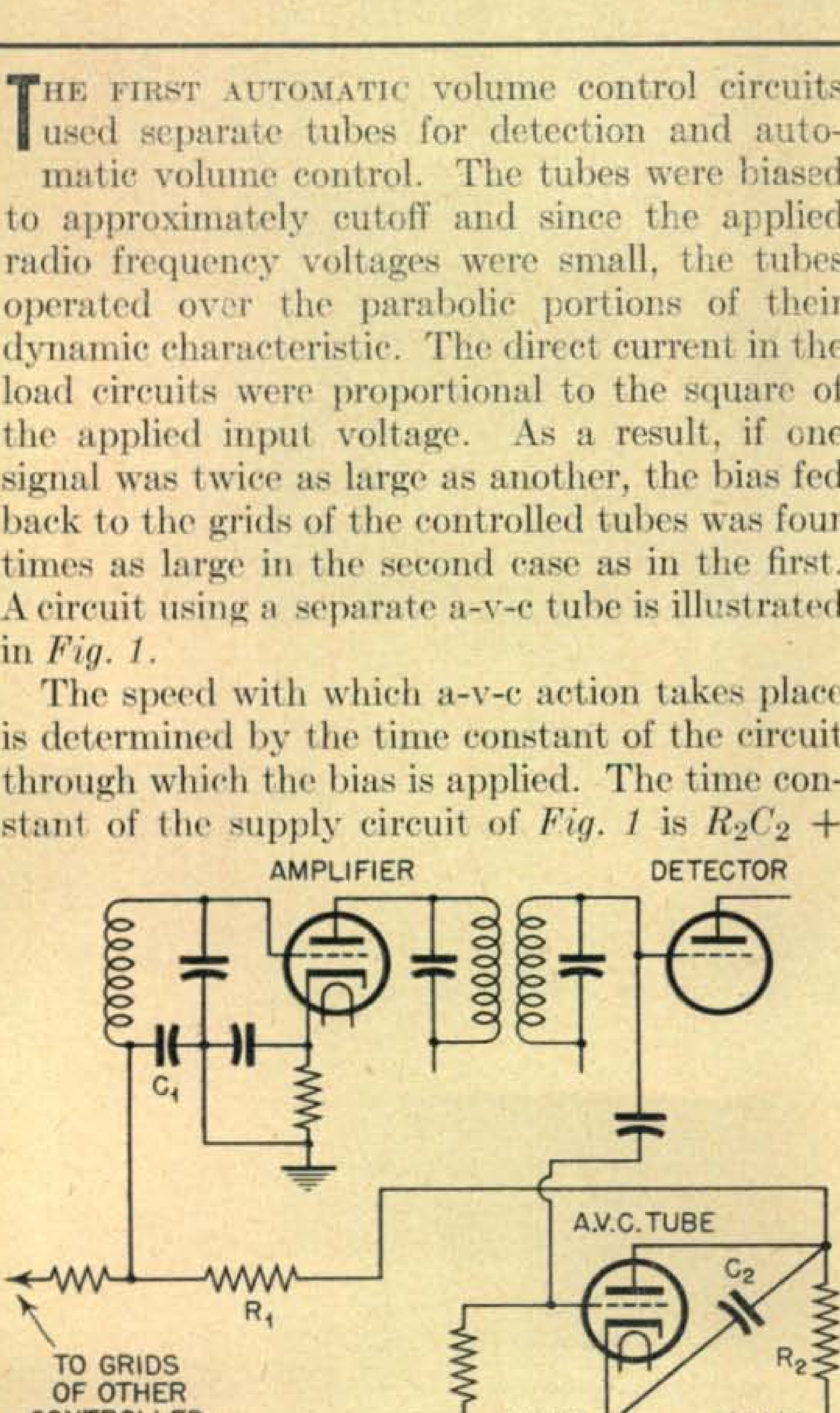


Figure 1

It is desirable that the a-v-c voltage bias be exactly proportional to the incident carrier voltage and independent of the percentage modulation of the carrier. If a linear detector such as the diode is employed, the rectified d.c. is proportional to the incident carrier voltage and independent of the percentage modulation. The conventional circuit arrangement of the diode used as a combined detector and a-v-c source is shown schematically in *Fig. 2*.

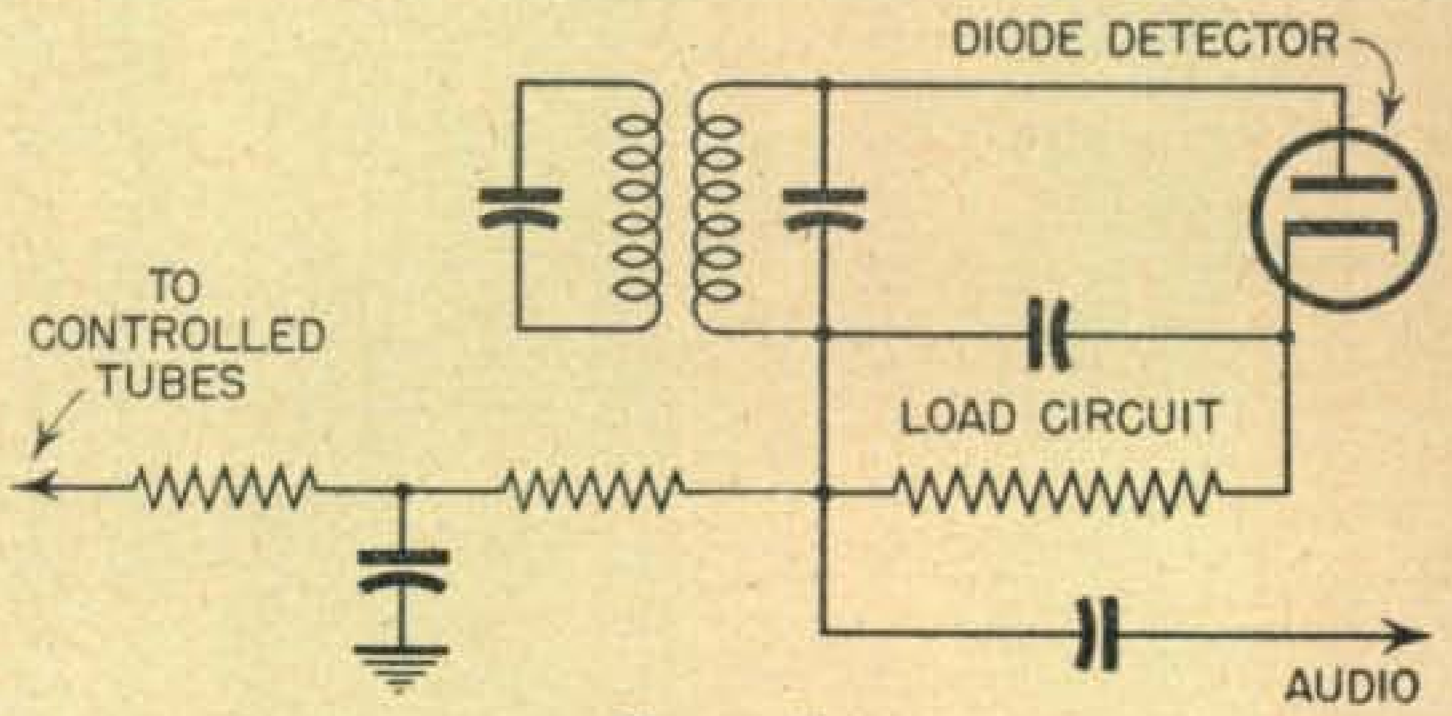


Figure 2

Curve A of *Fig. 3* illustrates the input-output characteristic of a radio receiver employing manual volume control but no a.v.c. If a.v.c. is used, increasing signal strength will tend to reduce the receiver gain proportionately. As a result the use in output with increasing input is reduced. The input-output characteristic of a radio receiver employing a.v.c. is illustrated by *Curve B* of *Fig. 3*. In this case the output rises slowly to full load, where it remains essentially constant until the a-v-c system overloads after which the output may again rise.

A more desirable input-output characteristic is illustrated in *Fig. 4*. Here the same desirable flat characteristic is achieved but the rise in output for small inputs is more rapid, in fact almost as rapid as though the receiver had no a-v-c action at all. This curve may be attained through the use of delayed automatic volume control. Delayed a-v-c action is attained through the me-

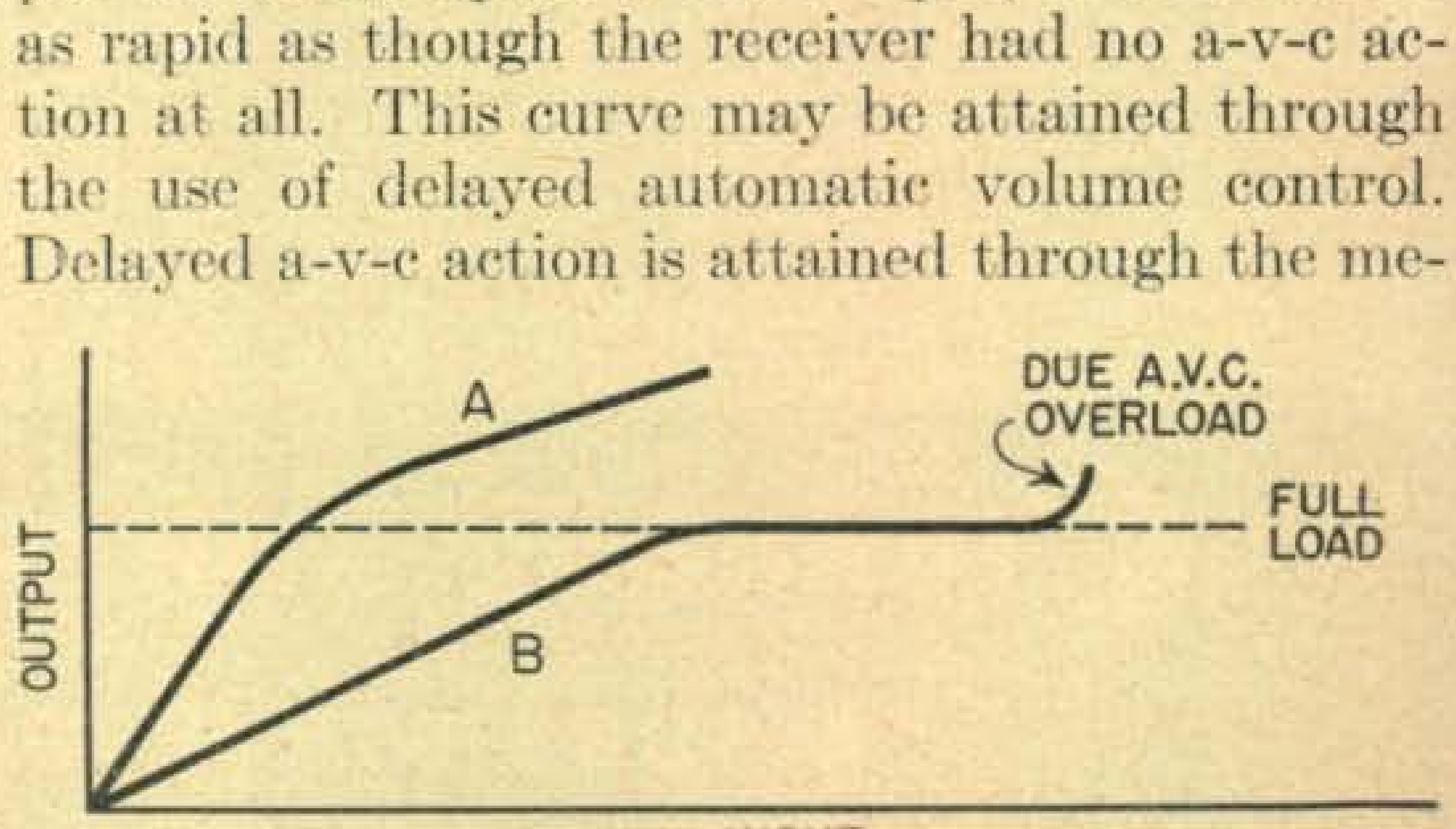
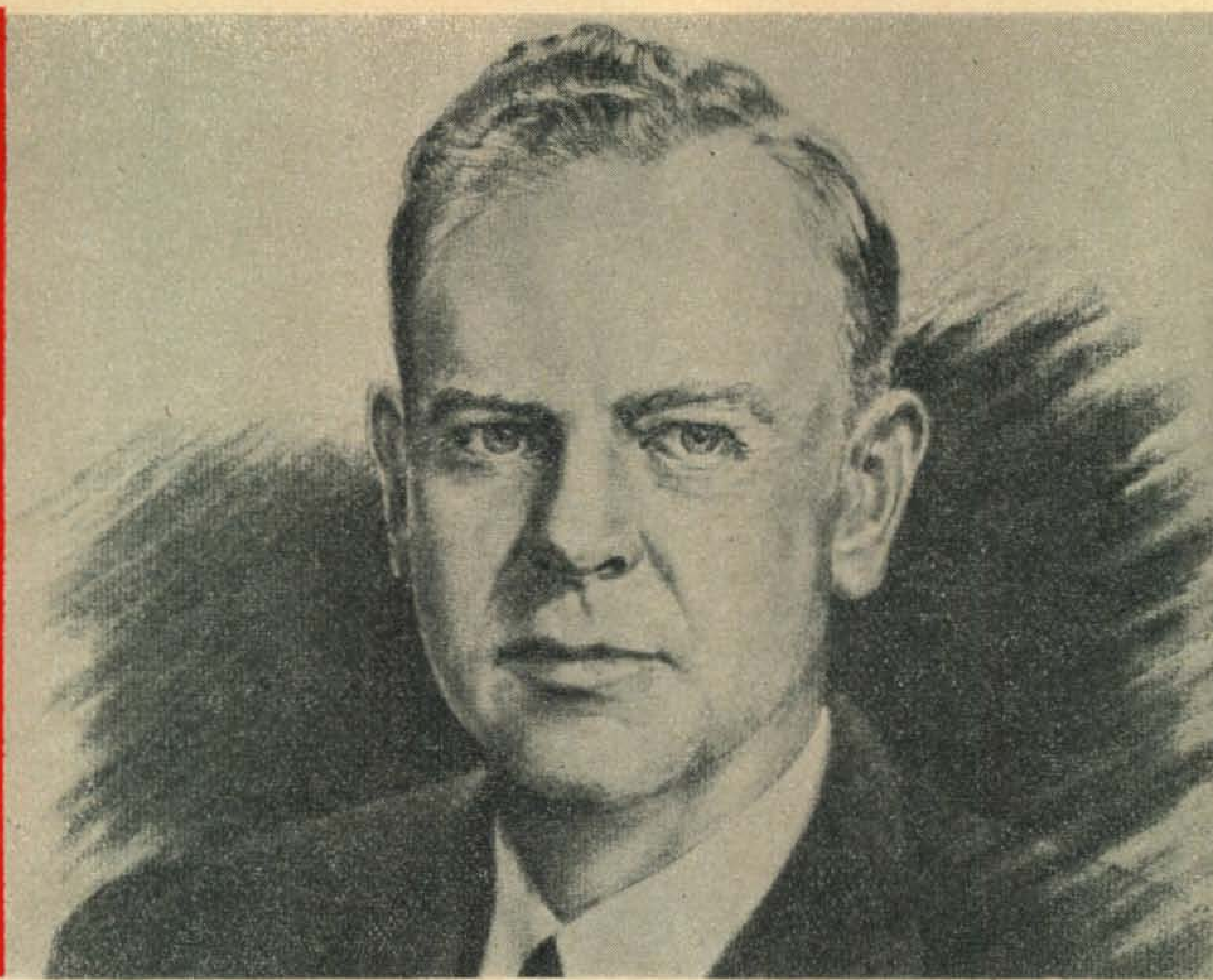


Figure 3



Portrait of Randolph C. Walker by John Carlton

War Surplus Equipment For The Ham

MAJOR M. R. GUTMAN, USAAF (Inactive), W2VL

The amount of war surplus radio apparatus (particularly transmitters, receivers and test equipment) which will be made available to the amateur, is unfortunately a debatable question. According to reliable information, much of this material is being "cannibalized"—an army expression meaning deliberately to render unfit for service. CQ is investigating further into the whys and wherefores of this possible situation

During the past month considerable surplus government radio equipment has been placed on the market by the Reconstruction Finance Corp. Several organizations in New York City have been designated as RFC agents and are disposing of surplus radio and electronic equipment. The present policy is to sell to manufacturing firms or radio jobbers. However, returning veterans have been classed as jobbers and may purchase apparatus. Some of this equipment is for sale by radio parts jobbers at very attractive prices. For example, new 829B UHF tubes have been offered for under $5.00 while they last.

Parts Available

The various agencies of the RFC have many fine parts available to eligible purchasers. Power transformers, audio transformers, variable tuning capacitors, relays, resistors, filter capacitors, G.I. earphones, etc., are available at a fraction of the original cost to the government. However a word of caution is in order. Much of the equipment has been designed for special services, especially apparatus engineered for AAF use. Transformers designed for an input of from 400-2700 cycles instead of 110 volts 60 cycles a.c. can be had in large quantity. Relays are usually wound

[*Continued on page 48*]

War surplus equipment purchased by the author at less than cost to the government. The ECO sold for under $10.00

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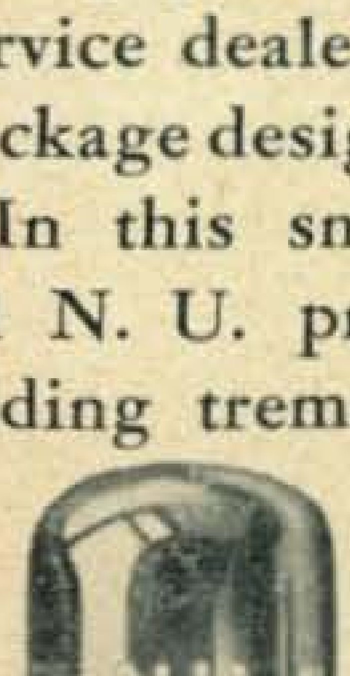

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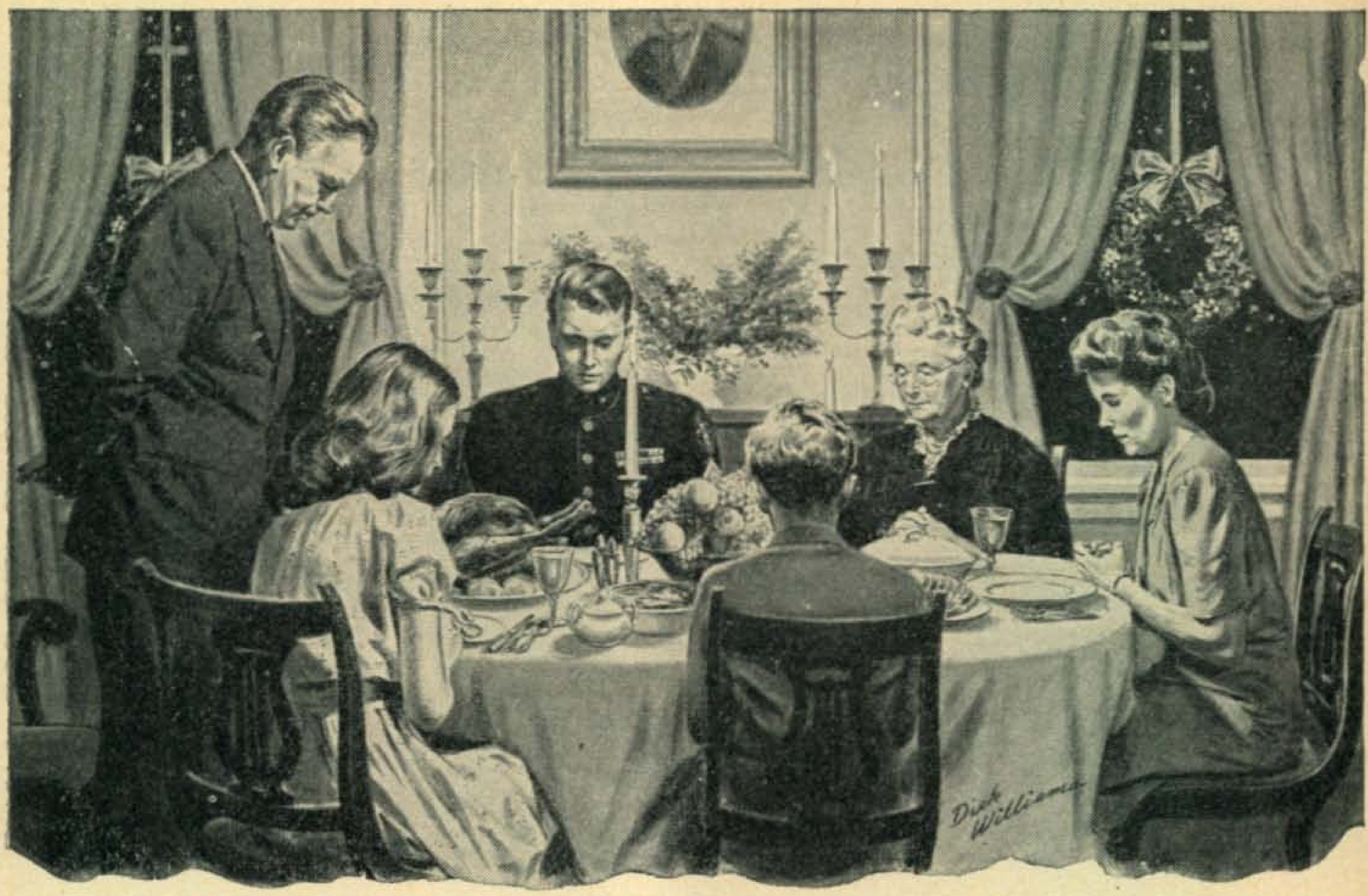

What's the other thing we ought to do this Christmas?

FOR the last four years, the Christmas phrase "Peace on earth, good will to man" has had a pretty hollow, bitter ring.

This year, it won't.

And surely, one thing each of us will want to do this Christmas is to give thanks that peace has finally come to us—both peace—and victory.

One other thing we ought to do:

In our giving, this year, let's choose—first—the kind of gift that helped to bring us peace and victory and will now help us to enjoy them.

★

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CQ MAGAZINE

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CLASSIFIED ADS

electronic equipment, such as power tools or even army vehicles. However it is necessary that this material be required for his own business needs and not for pleasure purposes. Equipment may be purchased on credit after proper references have been obtained. The veteran radio man may place his application for equipment as original inventory in his business.

As the various rules and regulations of the different government agencies are frequently changed, it is wise to call or write the agency concerned and inquire concerning any new regulations. Questions from readers of this article will be answered if stamped envelope accompanies the request, and the writer will be glad to help any member of the radio fraternity benefit by the surplus radio parts market. Letters may be addressed care of CQ.

A-M SUPER

[From page 26]

longer lead may be justified in terms of the mechanics involved, even if it is less desirable electrically. We are particularly averse to starting a lead and then breaking it midway to insert a resistor or capacitor.

The voltage regulator tube is used only in the oscillator section of the 6SA7. The stabilized 105-volt output is wired along with 300 volts from the main supply, 6.3 from the heaters and a ground connection, to the female four-prong chassis connector on the back of the chassis from which power can be fed to the converter. Throughout the unit, one side of each heater connection is grounded—which simplifies wiring considerably. The 6E5 leads extend through a grommeted hole in the chassis to the tube socket.

Lining-up

Lining-up the unit ordinarily calls for a signal generator tuning from 5 to 10 megacycles, but can be accomplished without this instrument if care is exercised. Without the signal generator, hunt around with the primary trimmer of the first i-f transformer until "set noise" is heard. The other trimmers are then lined up for greatest noise. Next tune the oscillator condenser.

Twenty feet of wire clipped to the primary of the input stage made a satisfactory antenna, and the first station heard was one several hundred miles away operating on 9.57 megacycles, which proved that our coil calculations hadn't been so far amiss. Actually there is little point in worrying about getting coil and condenser constants "right on the nose." The main thing is to locate the mixer input somewhere in the ten megacycle region, and the oscillator five megacycles away from it. The tuning range of the i-f transformers is rather limited and one can't go far wrong.

Advertising Index

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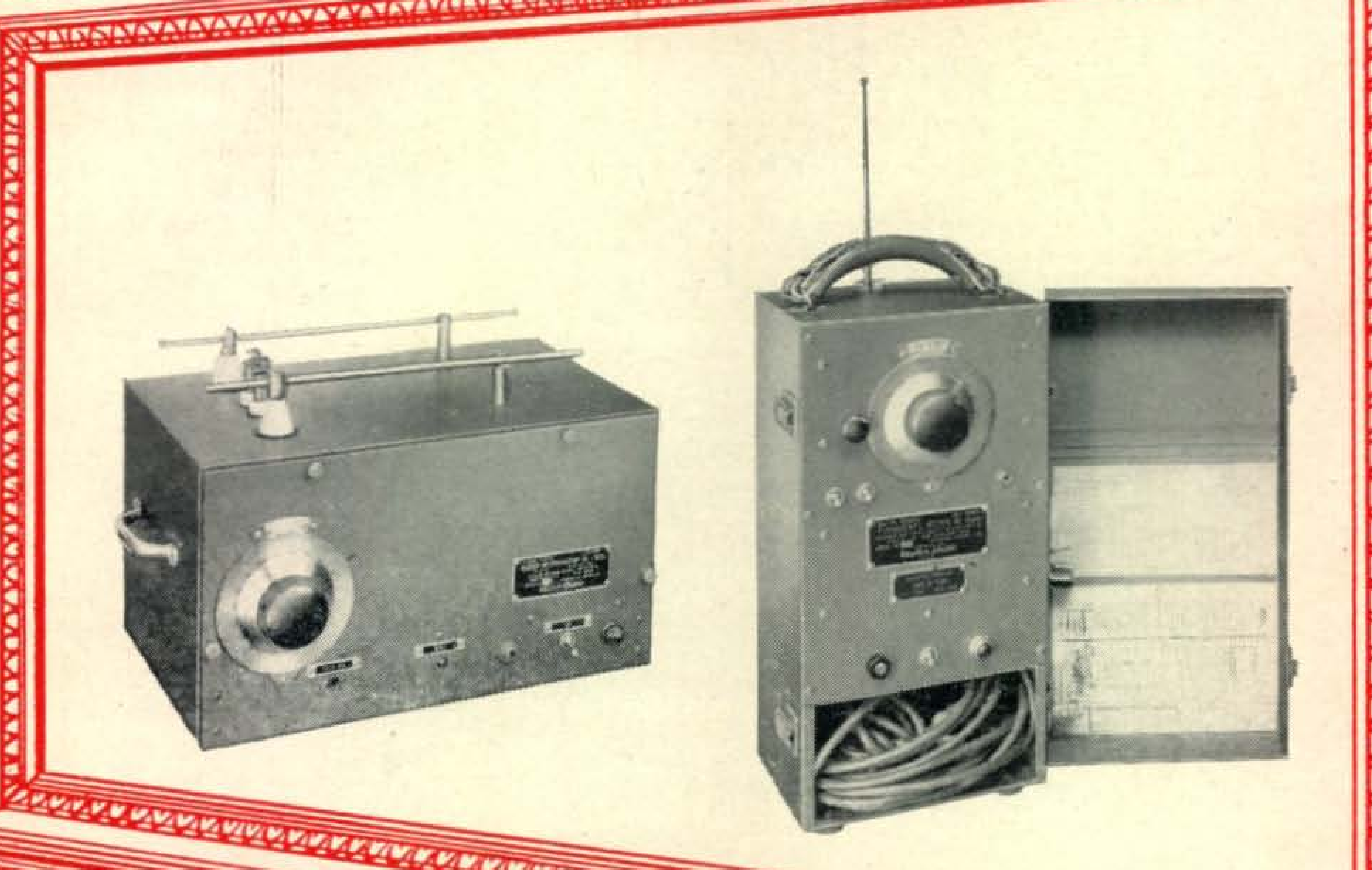

Scoop!

Left: Radio Modulator BC-423. High frequency signal generator operating from 195 to 205 mc., modulated at approximately 5000 cycles. Ruggedly built in steel case. Designed so that it can be re-adapted to many applications. Can be used as high frequency receiver, transceiver or frequency meter. Good for lab demonstrations requiring low power, ultra high frequency generator. Can be converted to 2½ or 1¼ meter receiver.

Right: Frequency Meter BC-438. Ultra-high frequency signal generator operating from 195 to 205 mc. with crystal calibration. Aluminum chassis in steel case. Removable nickel plated 19" telescopic antenna. Use as high frequency receiver or transmitter. Can be converted to cover any frequency range. Takes dry batteries for portable use. Precision tuning control make it ideal for "on the nose" ECO transmitter control unit.

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