W2FX FEBRUARY, 1946

CQ

The Radio Amateurs' Journal

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RME 45

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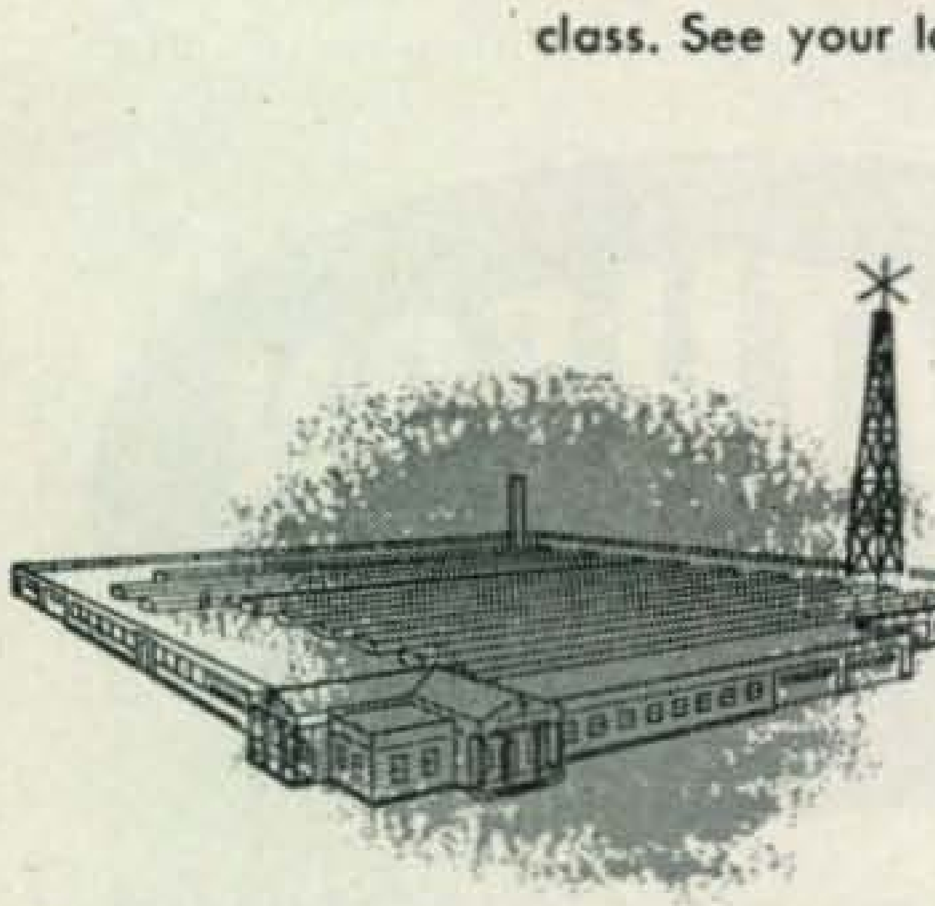

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CQ The Radio Amateurs' Journal

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

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VOL. 2, No. 2 FEBRUARY, 1946

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COVER

W2JIH, Freeport, New York. Jim Hill's 1-kw phone station which has already performed some remarkable DX records since the reopening of 10 meters. An example — January 6, 1946 XU3IK was called on regular schedule. This was followed by a QSO with AC4YN in Tibet. Report received: R5 S8+! **W2JIH is a professional antenna man.**

ARTICLES

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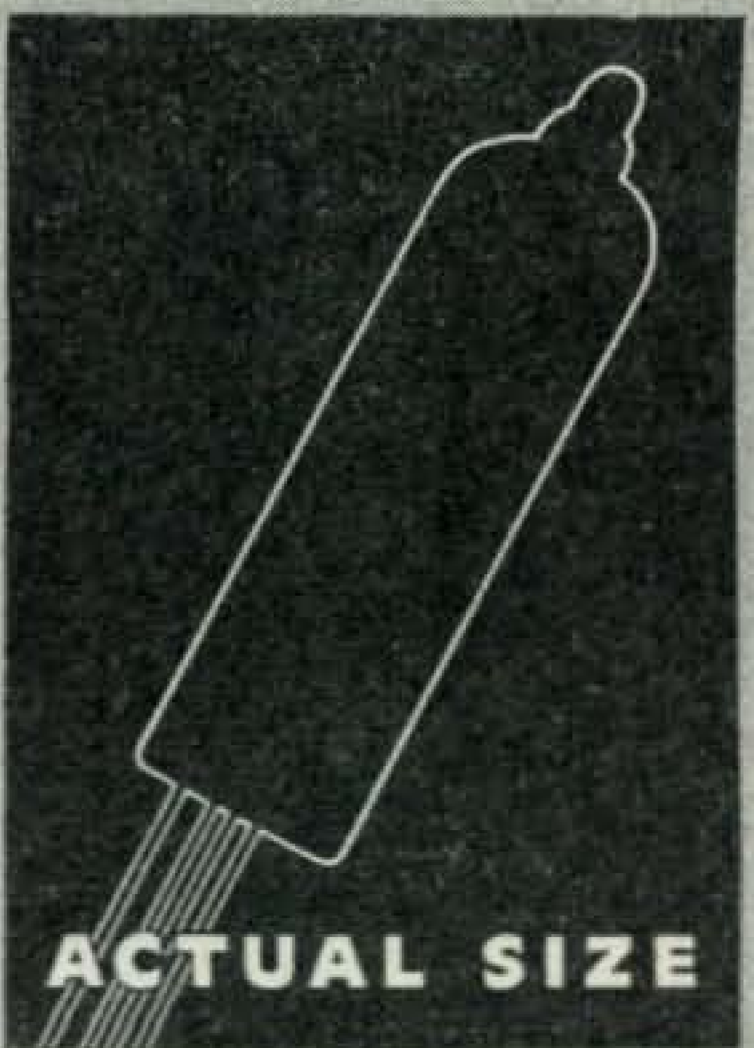

* The size of this tube, designated as T-3, will permit *cigarette-pack* size portable radios.

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AT THE PRESENT WRITING no information is available concerning the opening of the lower-frequency amateur bands. While no impatient amateur, organization or magazine is in position to evaluate all the considerations which delay the return of these frequencies to amateur station operation, it is not illogical to assume that the entire situation is tangled up in an abundance of red tape. That the red tape cannot be cut like the Gordian Knot, and we may have to reconcile ourselves to regaining our bands piece-meal, is not too unreasonable. It is a mathematical improbability that necessary war-time services can be cleared from 20, 40 and 80 meters simultaneously and the frequencies turned over to the amateur on a single platter. But it likewise follows that there exists no sound reason why these allocations should not be released individually, as other traffic is eased, and it is our belief that 20 meters could be returned to amateur purposes immediately.

Monitoring stations of *CQ* magazine have logged the following countries (both allies and former enemies!) operating with apparent legality on 14 megacycles: PY – Brazil, LU – Argentina, TI – Costa Rica, EL – Liberia, I – Italy, PA – Netherlands, SU – Egypt, EP – Iran (Persia), EI – Ireland, CY – the Faeroes, F8 – France, D – Germany, G – England, HB – Switzerland, ZP – Paraguay, ON – Belgium and VS1–Straits Settlements.

These territories cover practically all war-time "theaters of operation." The fact that battered Singapore (the capital of Straits Settlements) is again functioning on "20," presents a commentary that tosses no bouquet toward the bureaucracy responsible for witholding this band from amateur operation in the United States. Fourteen megacycles is, of course, an international frequency throughout the year. Interference caused by seventeen other countries with the services now occupying this band in the U.S. should be sufficient to render this allocation unsatisfactory for other than amateur communications. The entire situation, and this applies as well to 40 and 80 meters, in aggravated by the unimpressive quantity and quality of non-amateur transmissions on what are internationally recognized as amateur bands.

Micro-wave Potentialities

Many amateurs whose log-books are veritable tomes of 40 and 80-meter QSO's are inclined to cast a dubious eye on the micro-wave assignments allocated to the amateur by the FCC. They of course admit the possibilities of 5-meter transmission—which is old stuff—and the WERS effectively demonstrated that much can be accomplished around 112 and 144 megacycles. But this is just about scraping the bottom of the etheric Plate for operators with the kilocycle complex.

One need not exhume the classic experiments of Hertz to argue that there is nothing new in the idea of micro-wave transmission. Amateurs were experimentally active in this "misty mid region of Weir" some time before Pearl Harbor, and distances up to 60 miles (the limit being imposed by line-of-sight plus some minor bending) were spanned between 500 and 1,000 megacycles—all of which presages promise for our 420-450 and the 460-470 citizens' radio bands. As far back as 1931, the International Telephone and Telegraph Laboratories successfully demonstrated a duplex "micro-ray" telephone and telegraph circuit between Dover and Calais. This link operated with a power of one-half watt on approximately 1,500 megacycles. The transmitting and receiving antennae were only two inches long! Radiation, emitted and received, was concentrated by means of 10-foot parabolic reflectors, with a total gain of 56 decibels. This circuit was placed in commercial operation two years later, between the airports at Lympne, England, and St. Inglevert, France, where it functioned satisfactorily until interrupted by war.

All of which would seem to indicate immediate possibilities for the amateur 1,215-1,295-megacycle band, and place the 2,300-2,450-mc allocation within easy reach—even without considering the improved equipment, tubes and techniques developed during World War II.

All things considered, the question may soon be, *quo vadis*?—where do we go from 22,000 megacycles?

Tests Prove Eimac Vacuum Condensers Far Superior in Operating Efficiency

Ability to handle high current at high frequencies is the true measure of the performance of a capacitor. A high peak voltage rating based on low frequency measurements does not tell the whole story.

The chart on this page shows the results of tests at 50 Mc. conducted on a standard Eimac VC50-32 Vacuum Capacitor and three other 50 mmfd. vacuum capacitors, designated on the chart by "A," "B" and "C." At just over 17 amps. (approximately 1525 peak volts across the capacitor) Unit "A" (rated at many times the applied voltage) became sufficiently heated to melt the solder on the end caps. Under this same test, the Eimac VC50-32 operates at less than 70°.

Eimac introduced the vacuum capacitor in 1938. It is interesting to note that the original Eimac capacitor design is still outperforming all comers. Such outstanding performance is typical of all Eimac products, which is one of the reasons why they are first choice of leading electronic engineers throughout the world.

1113

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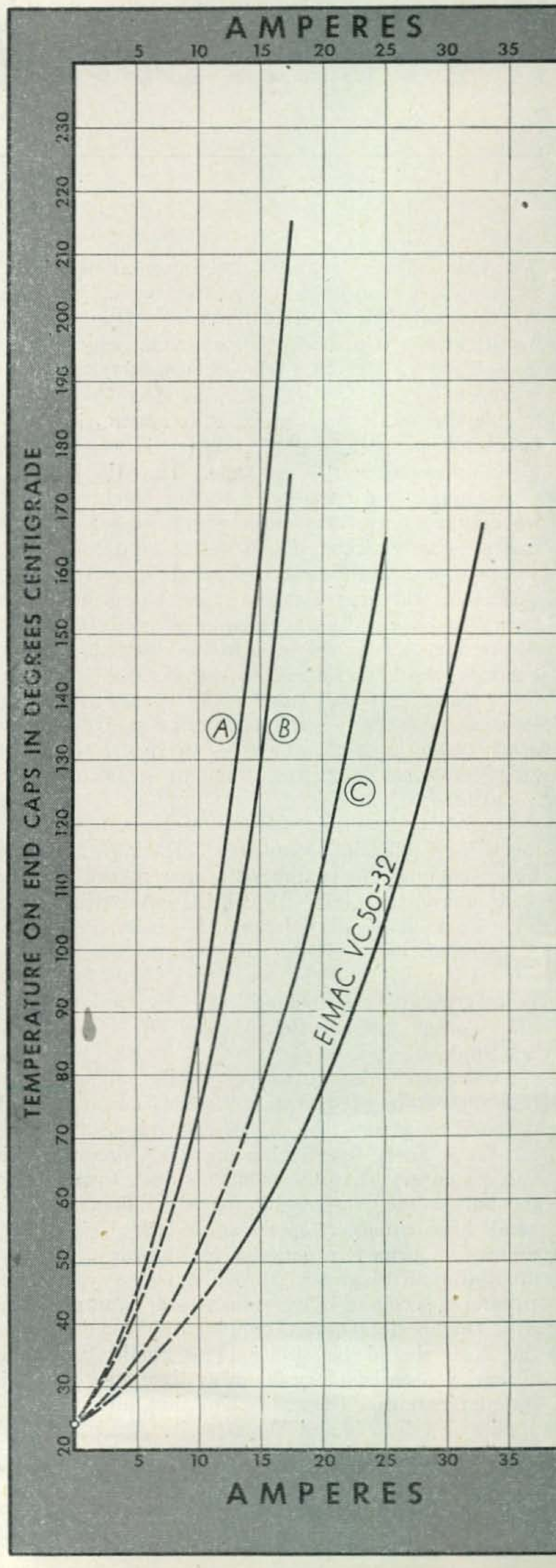
EIMAC VACUUM CAPACITOR TYPE VC50-32
General Characteristics

Mechanical:
Maximum Overall Dimensions

Length	6.531 inches
Diameter	2.281 inches

Electrical:

Maximum Peak Voltage	32,000 volts
Maximum RMS Current	28 amps.



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SUPERHET CONVERTER

For 144 Megacycles

HOWARD A. BOWMAN, W6QIR

For Use with the Basic Unit or a 10-Megacycle Communications Receiver

WITH THE FIXED-TUNED superhet described in *CQ* for December 1945 working satisfactorily and affording broad-band intermediate amplification, the next step was a converter capable of feeding signals into the unit. Since we were operating on 112 mc when the basic unit was designed, the converter first took form as a provision for that band. The speedy shift that carried amateur activity to 144 megacycles didn't exactly catch us unprepared; but with ten meters opened simultaneously we were undecided as to whether to redesign the converter for 144 mc or start on a new job for "ten." To make a long story short, we did both.

The Tube Problem

We had some time ago come to the conclusion that an efficient converter for anything above 60 mc required either acorn or button-base UHF tubes. Possibly the fact that we acquired all three of the tubes used in the converter without any great cash outlay had something to do with our decision to use the latter instead of acorns; but the fact remains that they do function efficiently, even at frequencies much higher than those on which we are now operating.

All things considered, however, we are rather of the opinion that acorns are somewhat easier

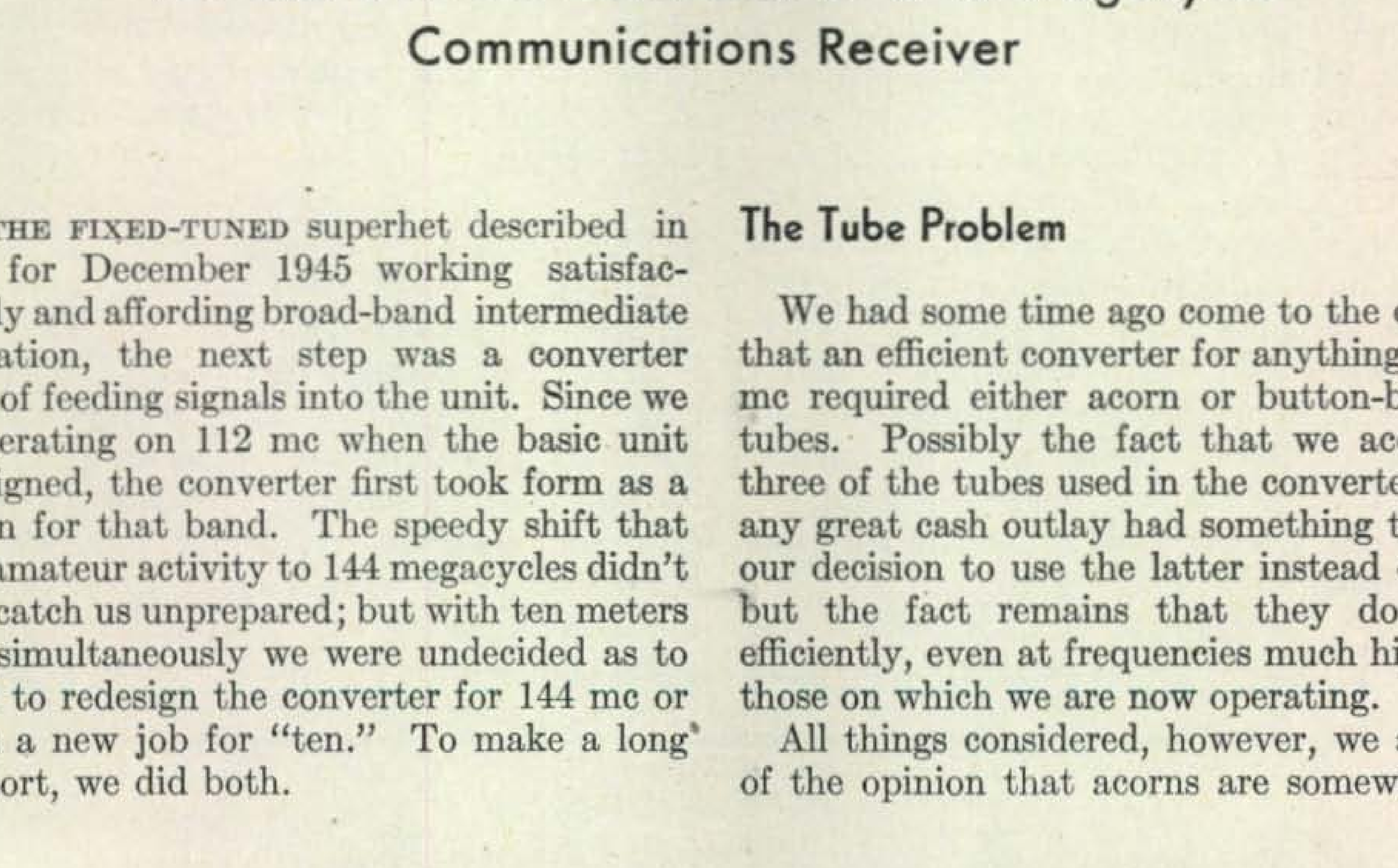


Fig. 2. Panel view of the completed unit. The scale is hand-drawn on stiff white cardboard

to build into a job of this kind. For one thing, the pentodes have a suppressor connection brought out to a base pin. This makes for greater flexibility, particularly in mixer circuits. Also they are double-ended, which facilitates input-output circuit isolation without resort to intricate shielding and the size of the sockets is such that mounting resistors and bypass capacitors is mechanically simple. For these reasons acorn tubes merit serious consideration.

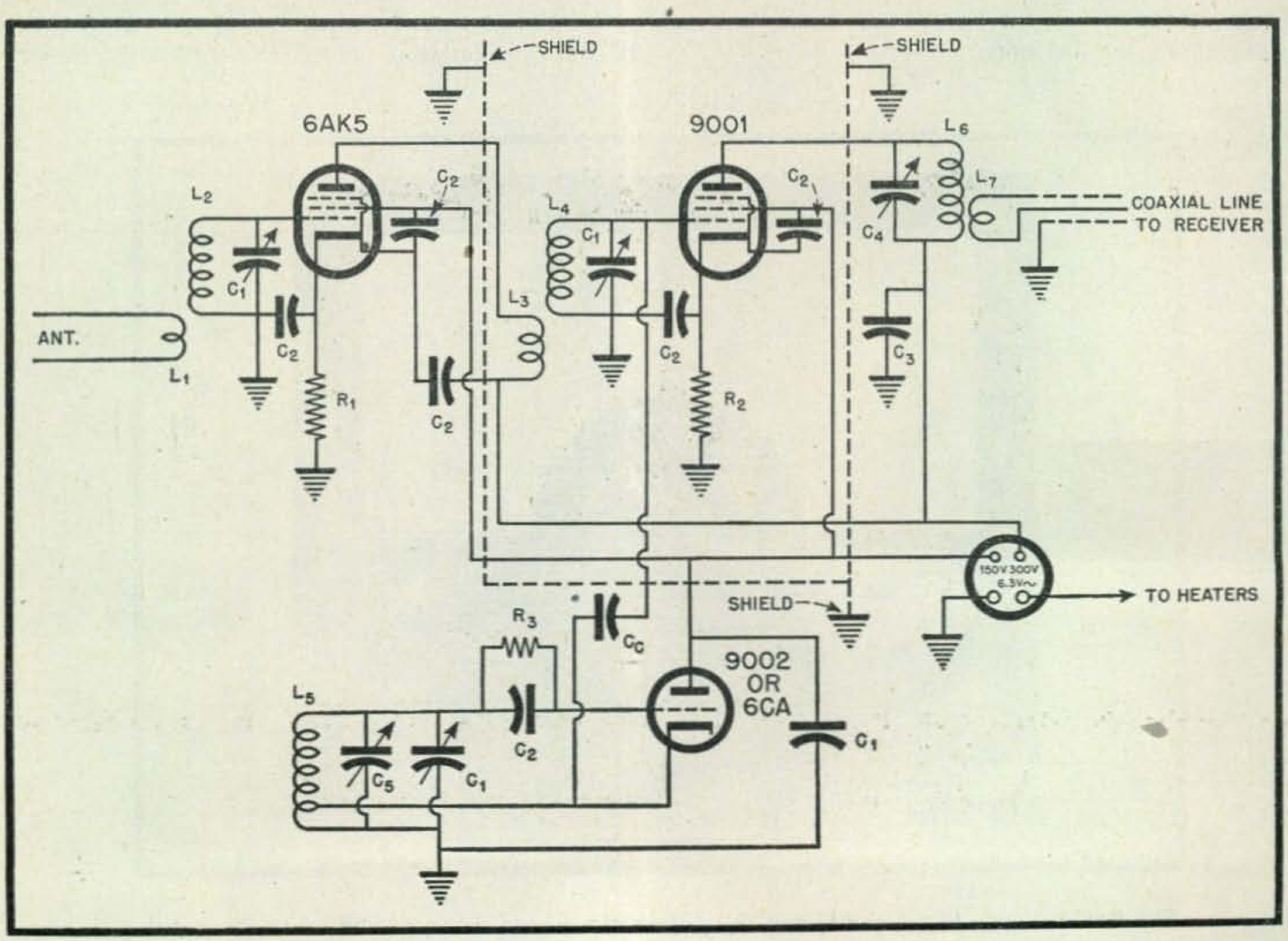
The button-base tubes have the virtue of small physical dimensions, thus affording a compact layout, but, as pointed out in the above paragraph, this is not an unmixed blessing when one tries to place mica bypass between the screen and cathode terminals on the socket. However, once the button-base tubes were elected, we went gunning for a pair of 9001's to be used as r-f amplifier and mixer, and a 9002 or 6C4 as the oscillator. We obtained a 9001 and a 9002, and had a chance to acquire a 6AK5—which is a really hot little bottle. It looks much the same as a 9001, but has considerably more wallop as a radio-frequency amplifier. Since the 9002 triode was on hand for the oscillator, we used it, but would prefer the 6C4 if available. The cost is about half, and the 6C4 is every bit as good, in addition to being considerably more rugged.

We next went shopping for suitable sockets. We didn't want to use the polystyrene type because of the difficulty in soldering to lugs and therefore chose sockets of ceramic construction. The oscillator socket is a plain ceramic job. The other two have mounting ears and a small base shield as an integral part of the socket in addition to a top or bulb shield with an internal spring to grasp the tube.

The three tuning capacitors are of the very small UHF type. They are manufactured by many firms under various trade names such as "Tiny-Mites," and can be bought quite cheaply on the surplus market. We removed all plates except a single stator and rotor, so that the maximum capacity is somewhere in the neighborhood of $8 \mu\mu f$. The tuning capacitors for the output transformer amd oscillator band-set are similar in type, but both are of the screwdriver adjustment design.

Circuit:

The circuit (*Fig. 1*) is perfectly straightforward electrically, with no trick features. The antenna is inductively coupled to the grid coil of the r-f stage, and the plate of the radio-frequency tube is inductively coupled to the mixer grid coil. The oscillator is a grounded-plate Hartley and has given no hum difficulty, even though this trouble sometimes develops in such a circuit because of undesirable heater-cathode coupling. We understand that hum is often traceable to a poor tube.



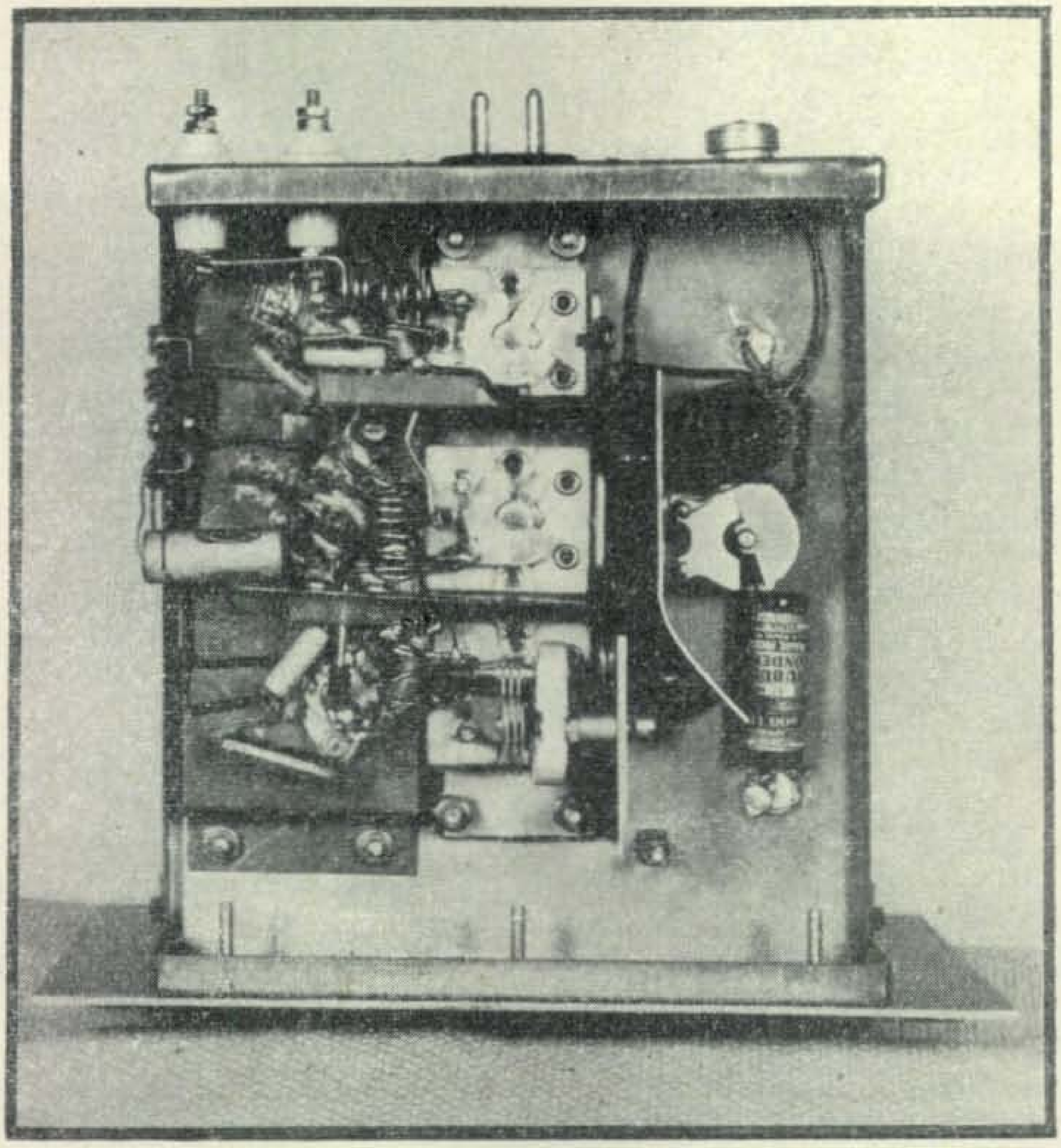


Fig. 3. Under-chassis construction and shielding. The rear connectors are antenna stand-offs, power plug and mike connector for piping the r-f out put to the master unit.

In the process of getting down (or up) to 144 mc, we discarded some 3-30 mica trimmers which we had tried across the mixer and r-f coils. Coils must be tracked by squeezing or spreading turns on the inductors, but this is no onerous job since the tuning of these stages is broad. All coils are wound with # 14 tinned wire, and are soldered directly to the tuning capacitors. The layout employed results in a grid lead about one inch long between the socket grid terminal (except in the oscillator) and the stator terminal of the capacitor. This lead is also of # 14 tinned wire, and may be considered as part of the tuned circuit, padded by the input capacity of the tube. In effect, then, the tuning capacitor is tapped across a portion of the inductance.

Plate and screen bypasses for the pentodes are small ceramic units, returned to the # 7 socket terminal (the cathode-suppressor connection). The # 2 terminal, which is the other cathode connection, is bypassed to the common ground for that stage. The d-c return to ground is through an appropriate resistor. Bypassing capacity does not appear too critical, but we are inclined to think that slightly higher capacity—say about .0005, or even .001, would be preferable if it could be obtained without adding greatly to lead length. We could obtain no physically small bypasses in these values, and settled for the ceramic condensers shown.

Oscillator voltage is picked off the cathode and injected into the grid circuit of the mixer by means of a home-made capacitor consisting of a piece of # 14 wire soldered to the mixer grid terminal and brought horizontally into the oscillator compartment through the interstage shield. A piece of pushback is soldered to the oscillator cathode terminal with the free end coiled about the #14 wire, supplying a capacity which may be varied by adding or removing turns or by sliding

Fig. 1. Wiring diagram for the 144-mc converter. Parts specifications are as follows—

C_1 - 10 $\mu\mu$f Bud "Tiny Mite" (or equivalent) cut to one rotor and one stator plate
C_2 - 100 $\mu\mu$f ceramic
C_3 - .01 μf tubular
C_4 - 35 $\mu\mu$f
C_5 - 25 $\mu\mu$f
Cc - coupling condenser (see text)
L_1, L_3 - 3 turns #14, 3/8" dia. 1/4" long
L_2, L_4, - 3 turns #14, 3/8" dia. 1/2" long
L_5 - 2 turns #14, 3/8" dia. 1/2" long
L_6 - 18 turns #24 enamel 3/4" dia. 3/4" long
L_7 - 10 turns #24 enamel close-wound at B+ end of L_6
R_1 - 1,500 ohms 1/2 watt
R_2 - 10,000 ohms 1/2 watt
R_3 - 50,000 ohms 1/2 watt

the winding along the wire to provide optimum injection voltage to the 9001.

Construction

The converter was built on a 7″ x 6″ x 2″ open-end chassis. A 3/8″ lip bent down around the three sides of each open end contributes strength to the chassis which is of stock size and design. The 7″ x 8″ aluminum panel is slightly more than 1/16″ thick. The dial bezel was homemade of a piece of somewhat thinner aluminum, and both were sprayed with "telephone gray" lacquer with a "Flit gun." The dial movement is the planetary mechanism from an old National type "A" dial, and the entire combination, as finally assembled (*Fig. 2*), resembles the "ACN."

The capacitors were mounted (credit to W8WLG) on a piece of Lucite about ¼″ thick and 1 3/8″ x 5″. The shafts are spaced 1 5/8″ apart along the center line of the chassis. Holes were drilled in the chassis to clear the shafts and their associated locking nuts, and the Lucite bolted to the chassis. The capacitor shafts are at right angles to the chassis, protruding with their axes ninety degrees from the dial-drive axis. To transmit power around the required ninety-degree bend, we had a friend turn out four identical drive wheels on a lathe. These are made of brass, but could, of course, be of other metal, or even plastic, and must be either a force-fit for a ¼″ shaft or have a set-screw. Many of the plastic materials lack sufficient body to sustain the strain of a set-screw.

The drive wheels are 5/16″ thick and 1 3/8″ in outside diameter. The center is drilled for a ¼″ shaft, and a groove (1/8″ deep x 3/16″ wide) is turned into the circumference. The actual size of the wheels is of little moment—the chief object is to get them all the same size. The wheel for the dial itself is drilled through from the groove to one side to pass the drive cord, so that the cord may be tied to a spring. Diametrically opposite this hole, another hole is drilled and tapped 6-32, and a spade bolt is screwed into this to hold the other end of the spring. To change the vertical motion of the cord, as it leaves the dial, to a horizontal motion capable of driving the capacitor wheels, a pair of small brass idler wheels are mounted on a shaft supported by a pair of tiny brackets (*Fig. 4*).

Drive Cord Technique

The drive cord (a good grade that will not stretch) is tied to the spring, which is left loose from its spade bolt holder. The cord is threaded through the hole in the dial wheel and the spring pulled up tight. The cord now passes over the wheel, coming off toward one of the idlers. It goes under the idler, leading off horizontally to the first capacitor drive. Looped around this wheel, it then proceeds to the second and third in order, looping around each. From the last wheel it runs directly back to and under the other idler, upward to the hole in the drive wheel, through this, and is tied tightly to the spring. The spring is now attached to the spade bolt, providing tension on the system.

It was found advisable to secure the cord to each capacitor drive wheel by drilling a pair of #50 holes through the rims about 1/16″ to each side of the set-screw. As the cord loops around the wheel, it passes from the groove out through one of these holes, then back in the other hole, continuing around the wheel. This makes slippage impossible, and it clears the wheel at the set-screw, enabling adjustment after the cord has been installed.

All of the above may sound complicated, but actually it is very, very much simpler than trying to line up an equivalent number of capacitors so that they may be driven by shaft couplings. The cord takes care of minor misalignments, and the drive is positive.

Since the capacitors are mounted below chassis by space equal to the thickness of the Lucite plus the ceramic capacitor body, it was necessary to locate the tube sockets as close as possible to minimize lead length. This was accomplished with a small sub-chassis of sheet copper 5″ long and 2″ wide, folded so as to form a very shallow "U." It is about 5/8″ deep and has ½″ lips for bolting to the chassis. The tube sockets are bolted to this copper sub-chassis, and a 1 1/8″ hole was punched in the chassis proper above each socket to permit inserting the tube (*Figs. 3* and *4*).

The sockets line up beside the associated capacitors. In each case a piece of # 14 tinned wire is bent so as to join one heater terminal, the central stem shield, and the condenser rotor with a central point on the copper sub-chassis immediately between socket and capacitor. All grounds for each stage return to this one lead. It should be noted, however, that most bypassing in the pentodes returns to the cathodes. Only the cathode is bypassed to ground.

Shielding

Shielding consists mainly of a pair of copper baffles separating the stages, about 1¼″ high with the bottoms cut irregularly to clear the Lucite. Two small tabs are bent at right angles to permit soldering to the copper sub-chassis at one end and to the main chassis at the other. Two additional strips of copper are soldered across each tube socket, shielding the input from the output circuits. A small piece of aluminum mounts the oscillator band-set capacitor, holding it so that its terminals just touch those of the tuning capacitor and boxes in the oscillator sec-

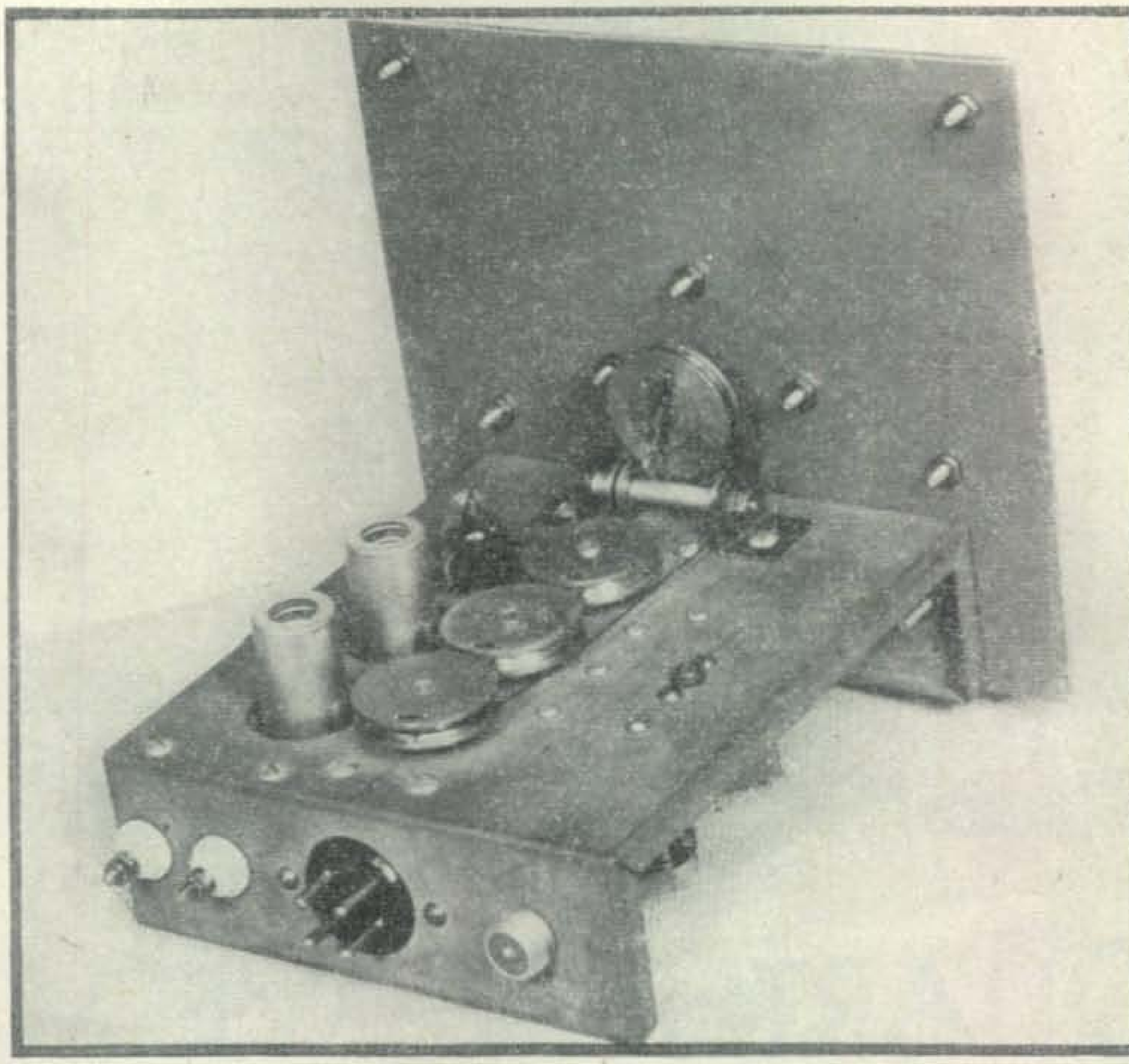


Fig. 4. Above-chassis detail showing the pulleys and drive cord arrangement which gang the tuning capacitors

tion. Another piece of aluminum shields the output transformer and its tuning capacitor from the r-f and mixer stages.

The output transformer is wound on a ¾" polystyrene form, secured to the chassis by means of a 6-32 screw through the closed end of the coil form. The capacitor is mounted beside the coil on the chassis by means of its studs.

Power is brought to the unit by means of a four-prong male chassis connector. The two large terminals carry heater and ground connections, while the two smaller bring in 105 volts from the VR-105 and 300 volts from the power supply, both of which are located on the basic unit (*CQ* December, 1945).

Two small feed-through insulators serve to bring in the antenna connections, and these also hold the antenna coil by means of soldering lugs. The output transformer feeds the signal at 10 megacycles into the master unit by means of a shielded microphone connector and a length of coaxial cable.

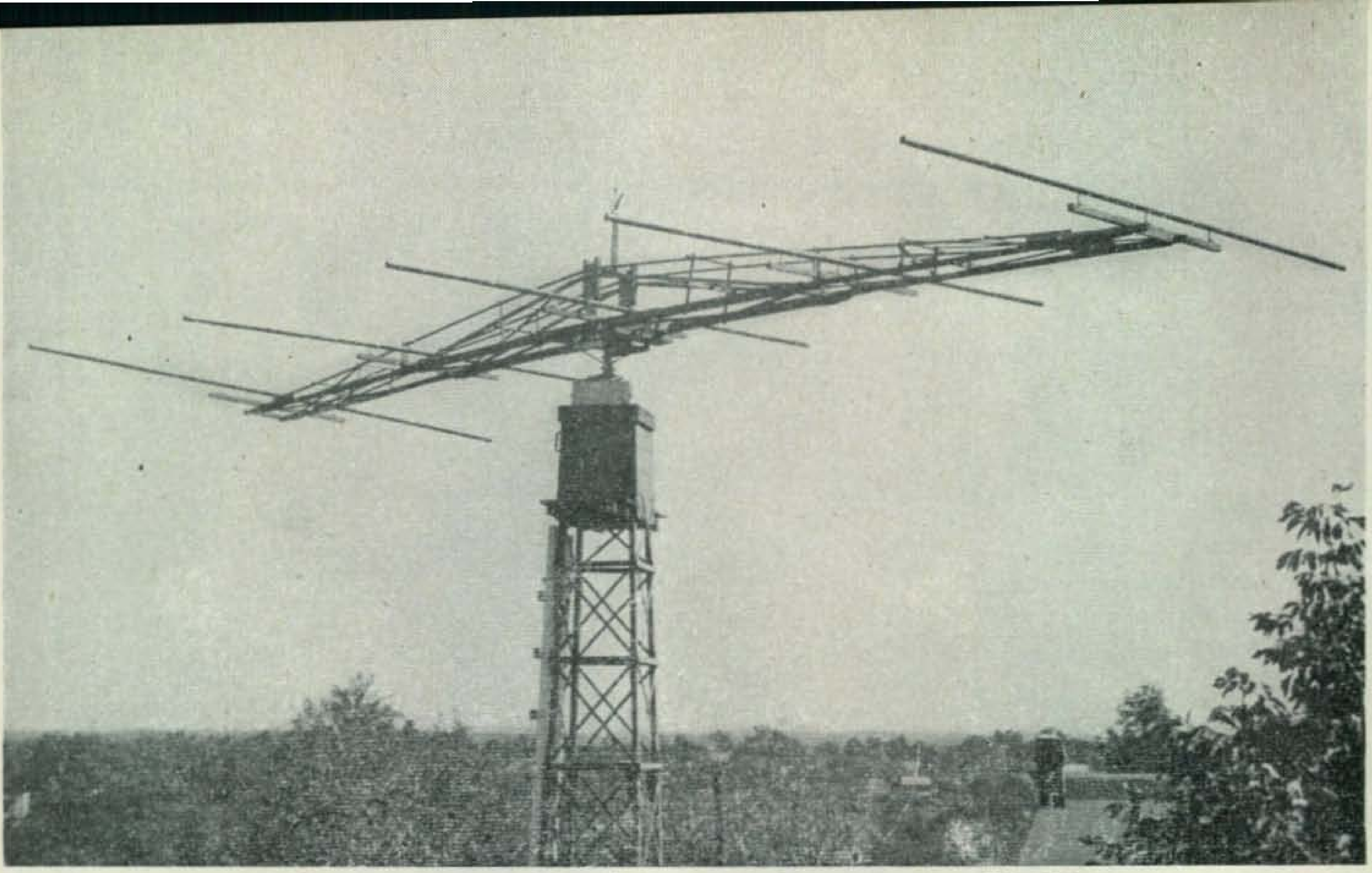
One rather tough problem was how to bring leads through the copper baffle shields. It was necessary to leave the baffles off until nearly all wiring was completed so that we could get a soldering iron into the various compartments. With the shields about to be mounted, we were confronted with the problem of bringing through the excitation lead from the oscillator and the plate winding of the r-f section. Two small pieces of Lucite were cut about 3/8" wide and an inch to an inch and a half long. The points at which we wanted to bring through the leads were located, and the Lucite clamped to the copper. Four # 40 holes were then drilled through both copper and Lucite for the plate winding lead and three for the oscillator excitation. The holes that pass the leads were enlarged in the copper baffle only to ¼". The remaining two holes were used for mounting by means of PK's. The leads pass through the shielding supported by the Lucite, and when cut to length and formed, are soldered in place, and doped with polystyrene cement.

Only two tie-strips are employed. One serves to unify the pentode screen leads and the oscillator plate lead, all of which are fed from the 105 volt regulated source. A second lug on the same strip holds one end of the 6AK5 cathode resistor, and a third lug (grounded and also serving to support the tie strip) holds the other end of the same resistor as well as the cathode resistor of the mixer stage. The other tie point joins and supports the leads running from the high voltage connection to the r-f plate coil as well as to the output transformer.

Lining-up

The first step in lining-up is to determine whether or not the oscillator is operating, and to set its range so that it will cover the desired band. The oscillator operates 10 megacycles lower than the radio-frequency, and mixer stages, hence must cover at least the 134-138 mc range in

[*Continued on page 54*]



Quarter-wave spaced five element rotary beam antenna at W2CUZ

QUARTER-WAVE VS. CLOSE-SPACED BEAMS

DONALD WHITTERMORE, W2CUZ

Quarter-wave spacing as compared with close-spacing for rotary beams is a highly controversial topic. W2CUZ presents some definite opinions favoring quarter-wave spacing. His results are worth considering

THIS IS A REPORT on several ten-meter beam antennae erected before satisfactory results were obtained. A story of high hopes that were quickly squashed when the first antenna did not measure up to claims made in descriptive material and then the final satisfaction when the last design gave the desired results. It took countless hours of constructing and experimenting which started in October 1939 and carried through to this year—much longer than any married ham should take to maintain peace in the family.

After many months of good results from two 8JK antennae (one for east and west, one for north and south directions), I finally yielded to all the high praise I had read and heard about the close-spaced beam and decided to build one. Also, increased activity on the band resulted in fewer number of 100% completed QSO's and had some bearing on my decision to put up a better antenna to compete with the California kilowatts.

A thirty foot wood lattice type mast of conventional design was erected to support a five element close-spaced antenna. It was decided to use two inch copper round gutter pipe for several reasons:—light in weight yet mechanically strong, excellent conducting qualities, reasonably priced and available at large hardware and plumbing supply houses. The reflector was spaced .15 of a wavelength from the antenna and each director was separated by .10 of a wavelength.

When the time came to make the initial tests it was certainly a letdown when the first report made it plain the old 8JK's (theoretical gain of 5-6 db) were still putting out stronger signals than the new array! Fortunately it had been possible to leave them up for use as a basis of comparison.

Sincle close spaced beams were known to be very critical to element length, it looked like our first method did not give a fine enough adjustment. All elements were then cut in half with a smaller diameter mid-section that could be easily telescoped. Every conceivable combination and adjustment of element length was tried but the 8JK was still a better antenna.

It was felt that perhaps the three directors had dropped the radiation resistance so low that it was approaching the loss resistance. Removal of one of the directors and a complete retuning of the system made no difference. The known limitations of close spaced beam feed lines made us reason the 400 ohm spaced line may not be piping *all* the transmitter into the antenna. A coaxial matching transformer was first tried, then a quarter wave "Q" type matching section and finally the simple "y" match. Still, there was no appreciable improvement.

By this time we were in the midst of January's cold weather, the ten meter DX season was at its peak with DX pounding through daily with beautiful signals and still no progress had been made over the old standby 8JK—what would be the next move?

About this time, I happened to hear of the excellent results our old friend Earl Thomas (W2BMK) was having with his quarter wave spaced five element antenna. That meant extending the boom to thirty-five feet but we were willing to try anything in spite of the weather.

Fortunately the rotator mechanism top was designed so that either end of the antenna boom could be tilted down the side of the mast. This feature enabled us to lengthen the boom from 16 to 35 feet to accommodate the five element, quarter-wave spaced (*Fig. 1*). The boom plus elements now weighed 220 pounds.

The elements were adjusted to a length called for in the standard antenna formula:—

Reflector—Theoretical half wave—$\frac{492}{f}$

Radiator—94% of Theoretical half wave

Director—86% of Theoretical half wave

A simple "Y" was employed to match the feed line to the radiator. This was not at all critical. The "Y" connectors could be moved several inches each side of the perfect match connection point before field strength started to drop off.

What a difference! We had only to watch the HRO "S" meter to see that here was an antenna that finally topped the 8JK. Comparative reports on the received signals showed an average of 3 to 6 db higher signals over the 8JK.

It might be well to note that field strength readings were taken during all stages of the various tests on all antennae combinations. Several interesting points were revealed:—

1. Actual forward power gain measured ten times over the radiator alone meaning that our 100 watt output transmitter could now compete with the 1KW boys. Front to back ratio was 100 MA to 5 MA on current squared meter.

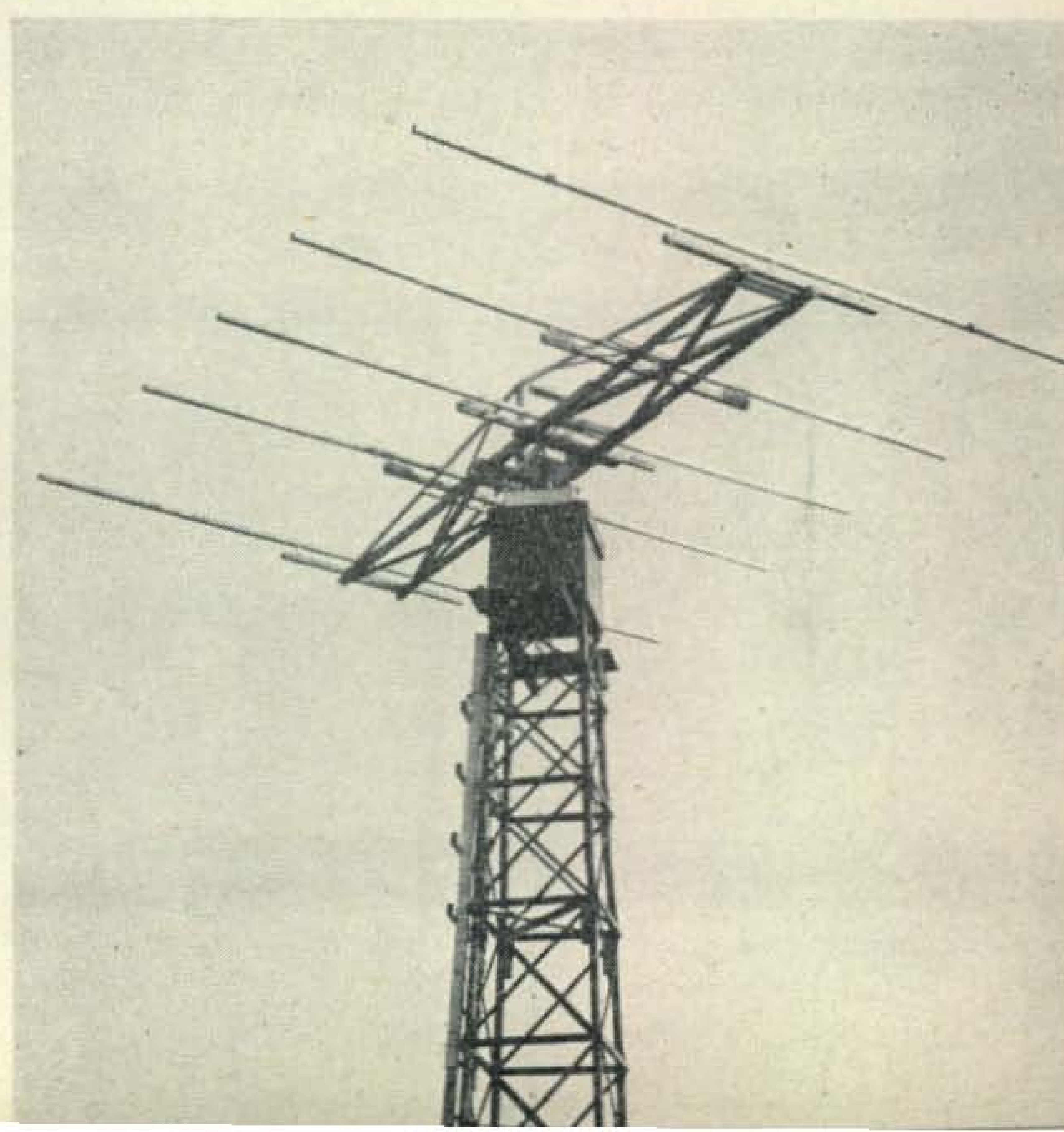
2. Transmitter frequency could be shifted from 28,500 kc to 29,926 kc with negligible change in field strength.

Frequency	Final plate Ma	Field Strength
28564 kc.	100	60
28,712	"	63
28,932	"	60
29,216	"	55
29,920	"	70

As an indication of line balance the same current at any point was obtained by inserting three 0-1 ampere r-f thermo-coupled meters in a section of the transmission line longer than a quarter wavelength. Two were placed in one side of the line and separated about ten feet and one was placed in the other side of the line half way between those in the opposite side.

An appreciable line unbalance was expected when it was decided to insert slip rings at the bottom of the rotator to permit 360 degree rotation. The final plate current increased from 118 ma to 150 ma but was lowered to 135 ma by a slight adjustment of the "Y" antenna matching stub. Field strength did not change.

	#1 meter	#2 meter	#3 meter
Before slip rings were inserted	480ma	400ma	430ma
After slip rings were inserted	400ma	390ma	580ma



Original close spaced five element rotary beam antenna of W2CUZ

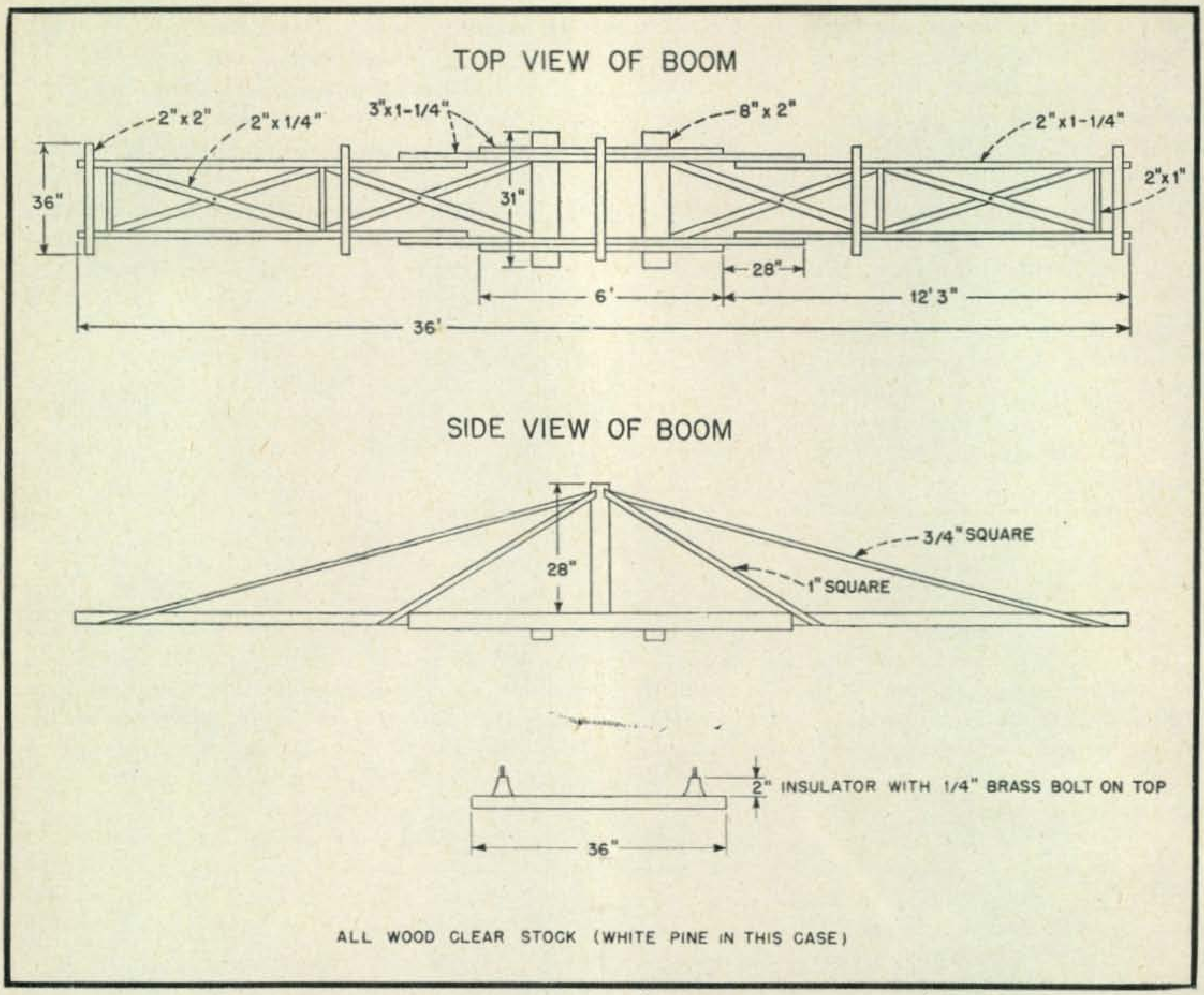


Fig. 1. Antenna boom to support five element quarter-wave spaced array

Beam Protection

Protection against lightning was made by connecting a length of quarter inch copper tubing through the center of all the elements. This has no effect on the operation of the antenna since it is connected to the lowest voltage point (null). Permanent connection to ground was then made by using a quarter wave stub as pictured in *Fig. 2.* Since it is a flat (constant impedance) line, the stub can be inserted at any point of the line where it is most convenient to obtain a direct route to ground.

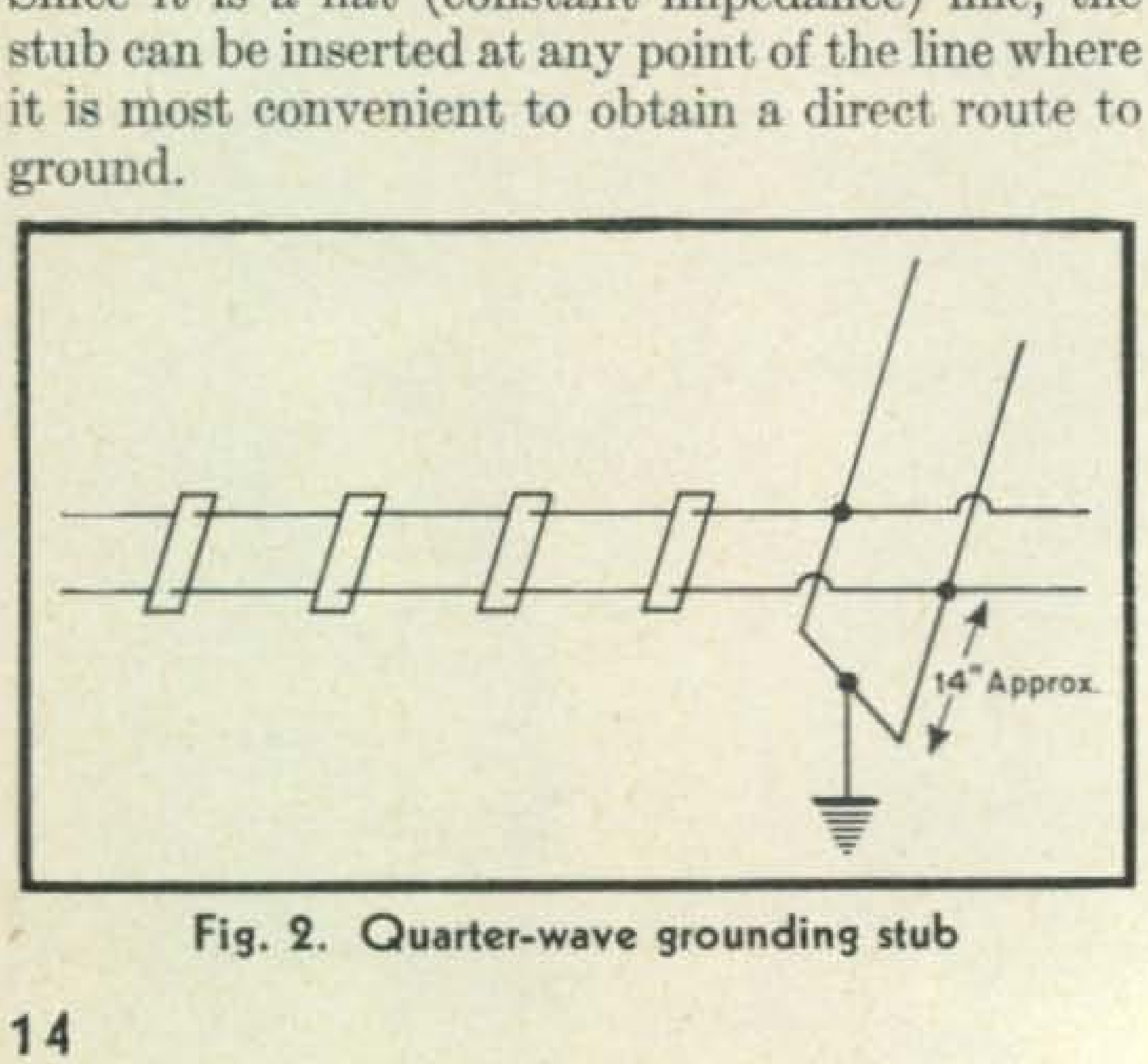


Fig. 2. Quarter-wave grounding stub

The wind direction indicator was placed on top of the boom in order to keep it headed into the wind during heavy storms. A better arrangement would be to devise a method of decoupling the gear drive in the rotator to permit the boom to swing freely into the wind when not in use.

The sale of government surplus stocks has made available selsyn equipment for the finest type of direction indicator at a reasonable cost. Any of these selsyns running from size one to seven can be used with equal results.

Conclusions

1. The theory of close spacing is excellent but putting it in practice is another thing. It is quite possible that the loss resistance of this array was close enough to the radiation resistance (approximately 6 ohms in a five element close spaced antenna) to cause a large part of the transmitter energy to be dissipated before it had a chance to be radiated into free space.

2. It seems that the average article on close spaced arrays calls for tuning the system for the maximum front to back ratio and then it is only effective at the frequency it is tuned to. This can be done after going through an elaborate tuning procedure, but it is forward gain that pumps a stronger signal to the station being worked. The same thing is true in receiving where the writer feels it is more important to receive a stronger signal from the station being worked than to sacrifice gain for a better front-to-back ratio.

Advantages of Quarter Wave Spacing:

1. All elements can be cut on the ground to the length called for in the formulae, mounted on the antenna boom and put into operation without further adjustment.

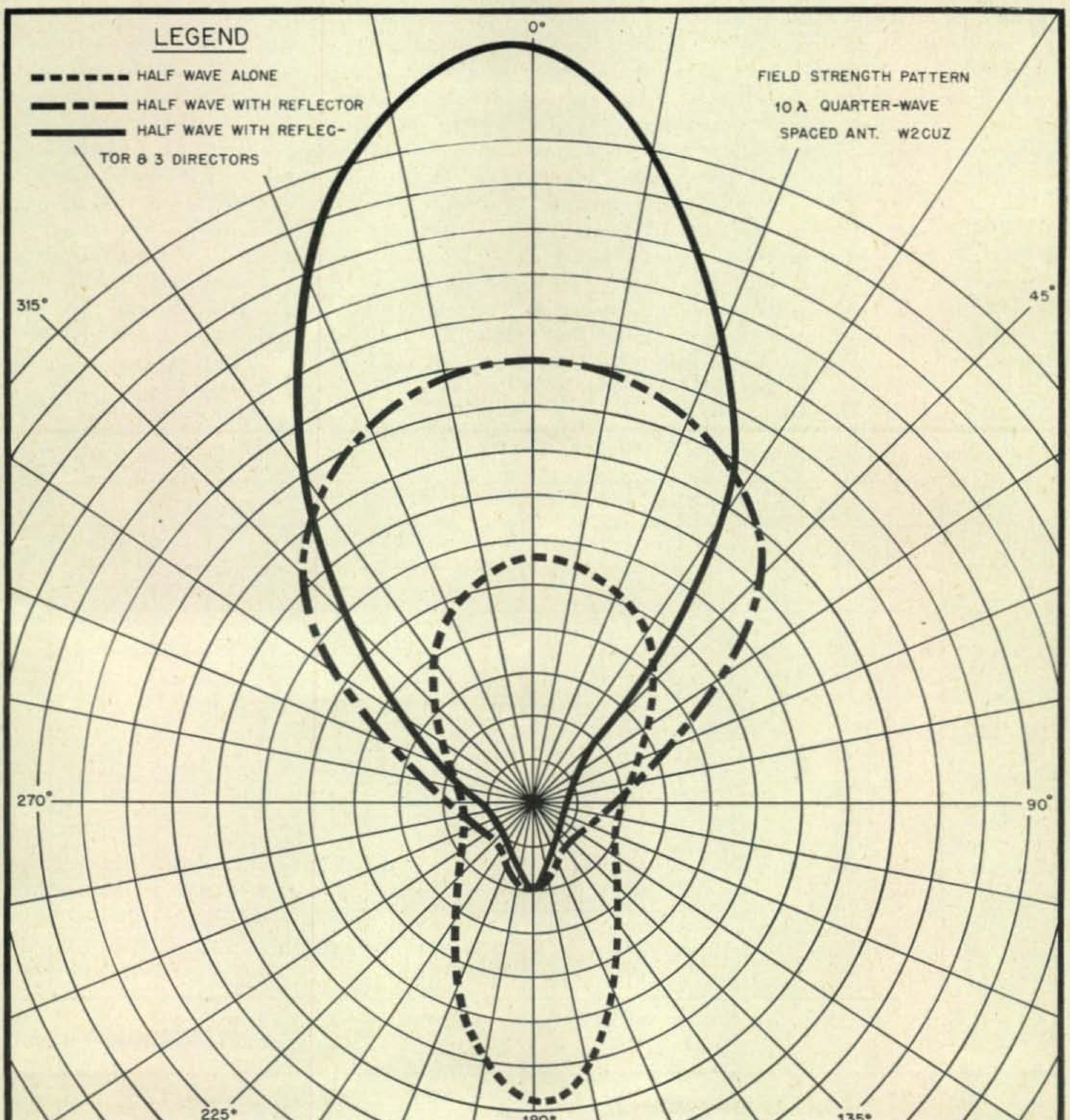
2. Antenna is not critical to rain, icing conditions nor nearby objects in the field.

3. Normal, inexpensive insulators can be employed. This is not true in close spaced arrays where the standing waves on the low radiation resistance antenna reach such a high value that it must be well insulated and kept clear of nearby objects.

4. Practically any type of feeder system can be used with good results.

5. By using large diameter elements, high efficiency can be obtained over the *entire* ten meter band. (A commercial example is the NBC cigar shaped antenna on top of the Empire State Building that is capable of passing a band width of over 10 megacycles for the video channel.)

6. It also has the advantage of lowering the angle of radiation. We found it much easier to get through to the west coast when the skip was first spreading to that part of the country.



SIX METER DX

The New 50-54-Megacycle Band Shows Promise and Possibilities

OLIVER PERRY FERRELL

WHEN THE AMATEUR takes over the 50-54-mc band, the long-sought-after contacts and DX over 2,000 miles by *F-region* reflections appear just around the corner. The possibility of this 2,000-mile DX path and MUF (maximum usable frequencies) in the 5 to 6-meter region has always fascinated a large number of VHF enthusiasts. After trying to stretch the MUF to 56 megacycles for ten years, it seems almost a new start as we move up into the borderline wavelengths.

For a basis of DX possibilities in the *F-region*, the only comparative estimate up to the present time is the pre-war operation of some 50 to 60 broadcast stations in the 40 to 50-mc band. In the heyday of 56-mc DX, seasoned VHF men tuned the 7-meter broadcast band to get an idea of conditions and the possibilities of DX on 5 meters. We here in the States listened for the television stations in London (41.5), Paris (42.0) and Berlin (42.5), while those elsewhere listened for our broadcast stations around 45.0 mc.

From an *F-region* ionospheric viewpoint the 6-meter band has some definitely better characteristics than the old 5-meter band. The chart, *Fig. 1*, gives the weekly MUF starting on November 17, 1937. Here we can see the actual MUF for a distance of 2,200 miles fall inside the low

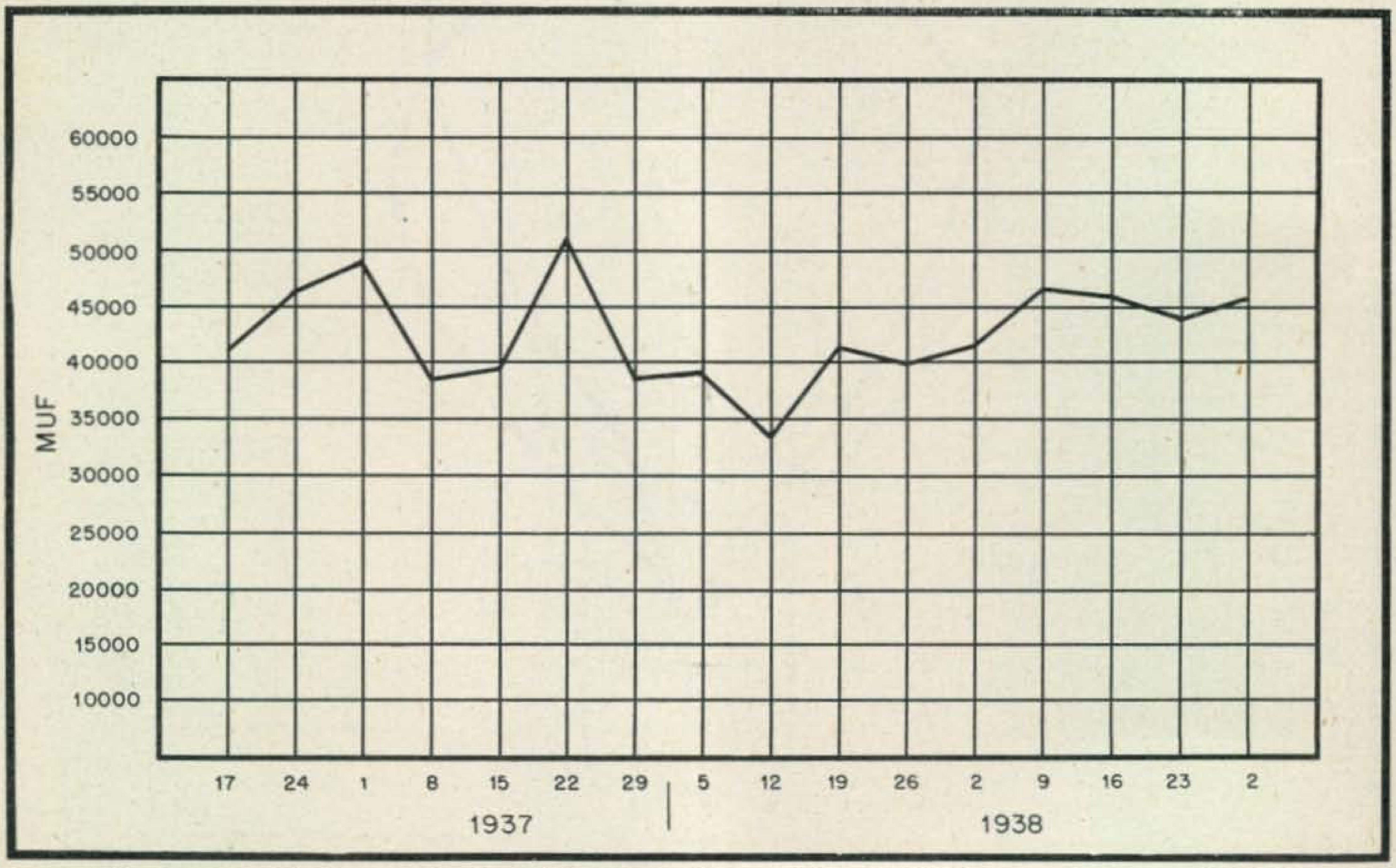


Fig. 1. Maximum usable frequencies from Nov. 17, 1937 to Mar. 2, 1938 for a distance of 2,200 miles. Figures are not adjusted for Lorentz polarization correction of about 5% in some instances

end of the new band. For other F_2 layer heights and path lengths exceeding 2,500 miles, and presuming you are radiating at a really low angle, it might be possible to get the MUF up to 53.0 megacycles. When this happens, the long haul from W6 to VK is a sure thing. But, most important when is this all likely to come about?

DX Peaks

The long range trend of the F_2 layer critical frequencies show—a definite peak in the winter months of 1937-38. This maximum apparently *precedes the sunspot maximum* by about 6 to 9 months. It is agreed internationally that the sunspot maximum did occur in May of 1938. Recently, W. Gleissburg of the Istanbul, Turkey, University Observatory, prepared a detailed calculation of the new sunspot cycle that began in 1943-44. The mathematical probability of Gleissburg's assumptions being correct is astoundingly high. For example, it is 95 per cent probable that the next sunspot maximum will occur in May 1948. If this is true the interval between maxima will be much less than the average of 11.1 years. Likewise it is also 95 per cent probable that the 1948 maximum will exceed the 1938 maximum, which itself was greater than all preceding maxima since 1870.

Of particular interest to the amateur is the rate of increase of the sunspot numbers. Starting in the fall of 1945, the number of sunspots are increasing by about 55 per cent every 10 months. After reaching the maximum in 1948 the rate of decline will, however, be very slow—dropping less than 20 per cent a year. (The probability of this is over 97 per cent.) Therefore, the new sunspot cycle we are now in will be noted for its unusually high maximum and rapid increase in sunspot numbers within the next two years.

Sunspot Numbers

At the time you are reading this the sunspot numbers, as well as the F_2 layer critical frequency, will have attained values corresponding to the winter of 1935-36. This would imply favorably that conditions on the new 50-54-mc band will deserve careful attention next fall. Graph, *Fig. 2*, will explain this further. Based on the rapid increase in sunspot numbers, with corresponding F_2 layer critical frequencies obtained at Washington during the last sunspot cycle, it will be seen that the December quarter, 1946, will have an average peak critical frequency of about 11,500 kc, or a MUF over 38.0 megacycles. This, of course, cannot predict the individual diurnal maximum, which on occasion may exceed 12,500 kilocycles or a MUF of 40.0 mc (F_2 multiplier approximately 3.3 in this quarter) Nor can any estimate be made concerning reflection from the region of the "G layer."

E. H. Conklin repeatedly stressed the importance of the *"G layer"* in out-of-season DX over 2,500 miles above 50 mc. A. Likhachev has

[*Continued on page 52*]

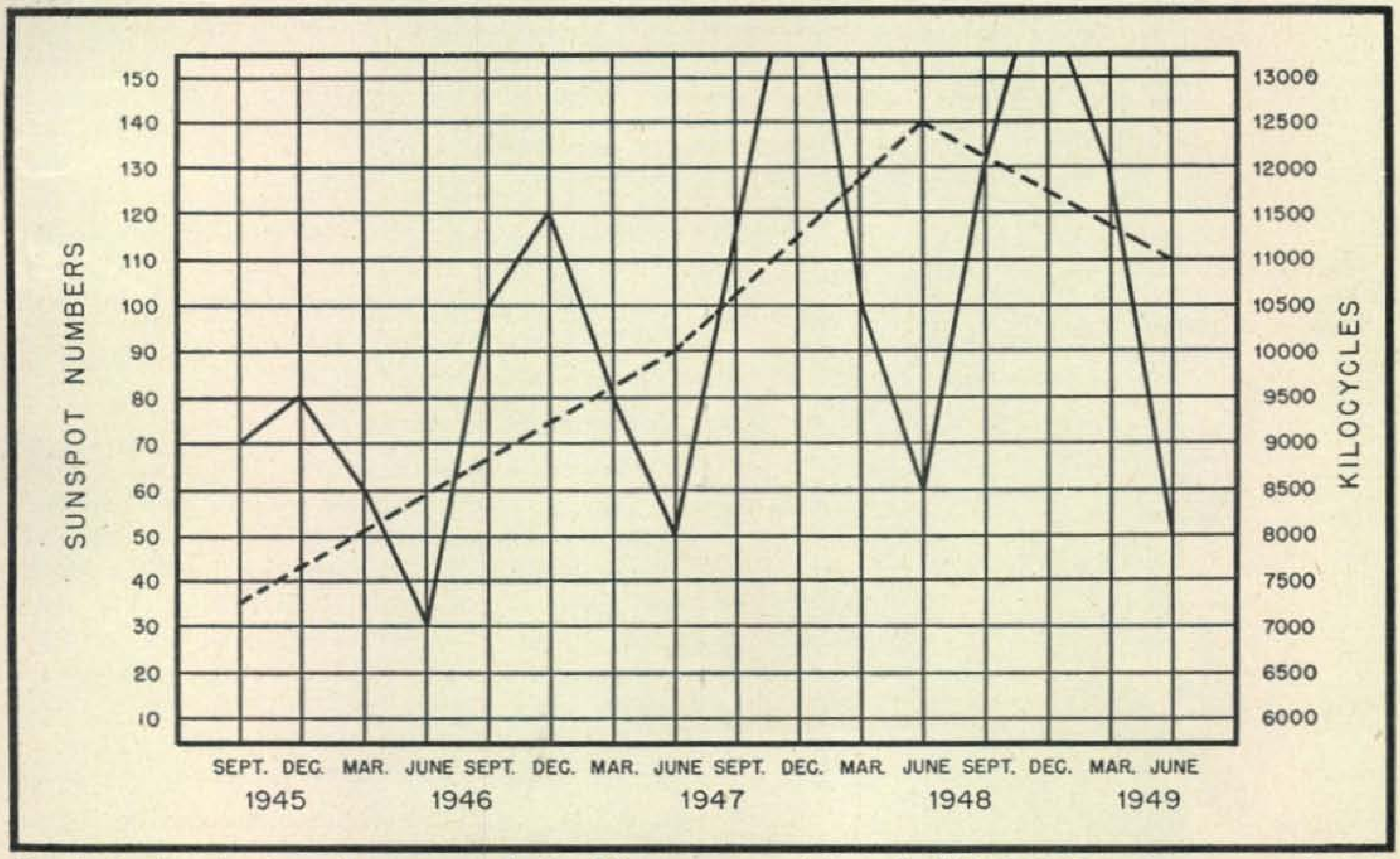
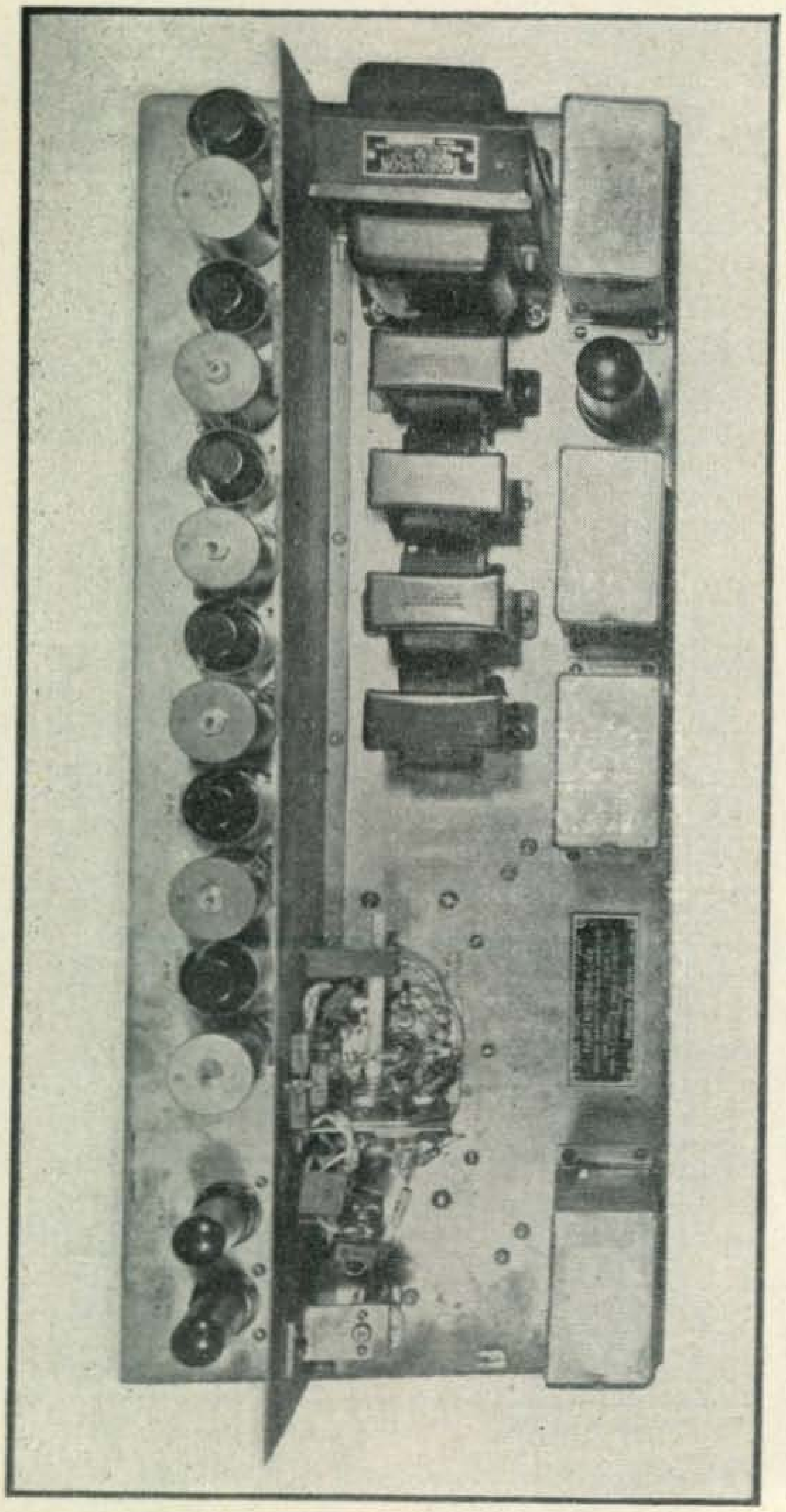


Fig. 2. Predicted estimated sunspot and critical frequency trend from the fall of 1945 to the summer of 1949. The solid line represents the critical frequency and the dashed line the sunspot number trend

Low Cost

HIGH FREQUENCY SUPERHET

HENRY GEIST, W3AOH



The BC 406. A 15 tube, 205 mc superhet; this view is taken *before* conversion to a tunable high-frequency amateur receiver

The reopening of the ten meter amateur band brought forth the fact that a number of amateurs who disposed of their receivers during the war were unable to buy them back and that it would be a long time before substitutes were available. The writer happens to be one of those unfortunates who just couldn't wait to get back on the air.

Fortunately, the Army Signal Corps released as surplus the type BC406 receiver which has unlimited possibilities of filling the present need for a high frequency receiver, that can be converted easily to operate on the ten, five and two meter bands. It is a fifteen tube, 205 megacycle super-heterodyne formerly used in Signal Corps radar equipment consisting of: six acorn tubes in the front end, four i-f stages (type 6SK7) on 19.5 mc, second detector and a video amplifier. There are also two 6SN7 tubes employed as switching oscillator and amplifier, but they are not used in the conversion described.

Construction Features

The high quality of its components, well-designed layout (both electrically and mechanically), and rugged construction makes it particularly desirable for amateur use. All capacitors are mica and silver mica, except for one paper type. Heavy copper shield cans are used for i-f transformer and tube shielding. The power supply unit (110 a.c.) employs four section filter capacitors and chokes instead of the usual one or two section types. The layout on the 2½"x

The answer to a DX man's dream is an acorn tube superhet on 10 meters. This conversion of a Signal Corps unit will give many helpful ideas for home-brew high-frequency superhets that really perform

10½"x26" deep chassis is so arranged that the r-f tuning section with the dial panel can be placed at one end. The receiver occupies only 12" of the operating table top.

The wide i-f bandwidth has the advantage of making intelligible modulated oscillator signals that have become more numerous in the higher frequency band.

The i-f frequency of 19.5 mc has several distinct advantages.

1. It gives an extremely high signal-to-image ratio. Image is the unwanted signal of the two signals to which the i-f system will respond. For example, when a local oscillator is set to a frequency of 28,465 kc to respond to a transmitted frequency of 28,000 kc, it will also respond to a signal on 28,930 kc if the i-f frequency is 465 kc. Either frequency gives the 465 kc beat needed for the second detector. It is not difficult to see that the higher the i-f frequency, the higher the image ratio; for example, in this converted receiver the local oscillator is set to 47,500 kc to respond to a signal of 28,000 kc. It also will respond to a signal on 67,000 kc, which is 19.5 mc removed from the resonance point of the tuned r-f input and will, therefore, never be heard.

2. The pulling effect on the oscillator frequency, which is caused by tuning the mixer grid circuit, is completely eliminated because the incoming signal is 19.5 megacycles lower than the oscillator frequency. Still further isolation is obtained by using a buffer amplifier (954) between the oscillator and mixer tubes.

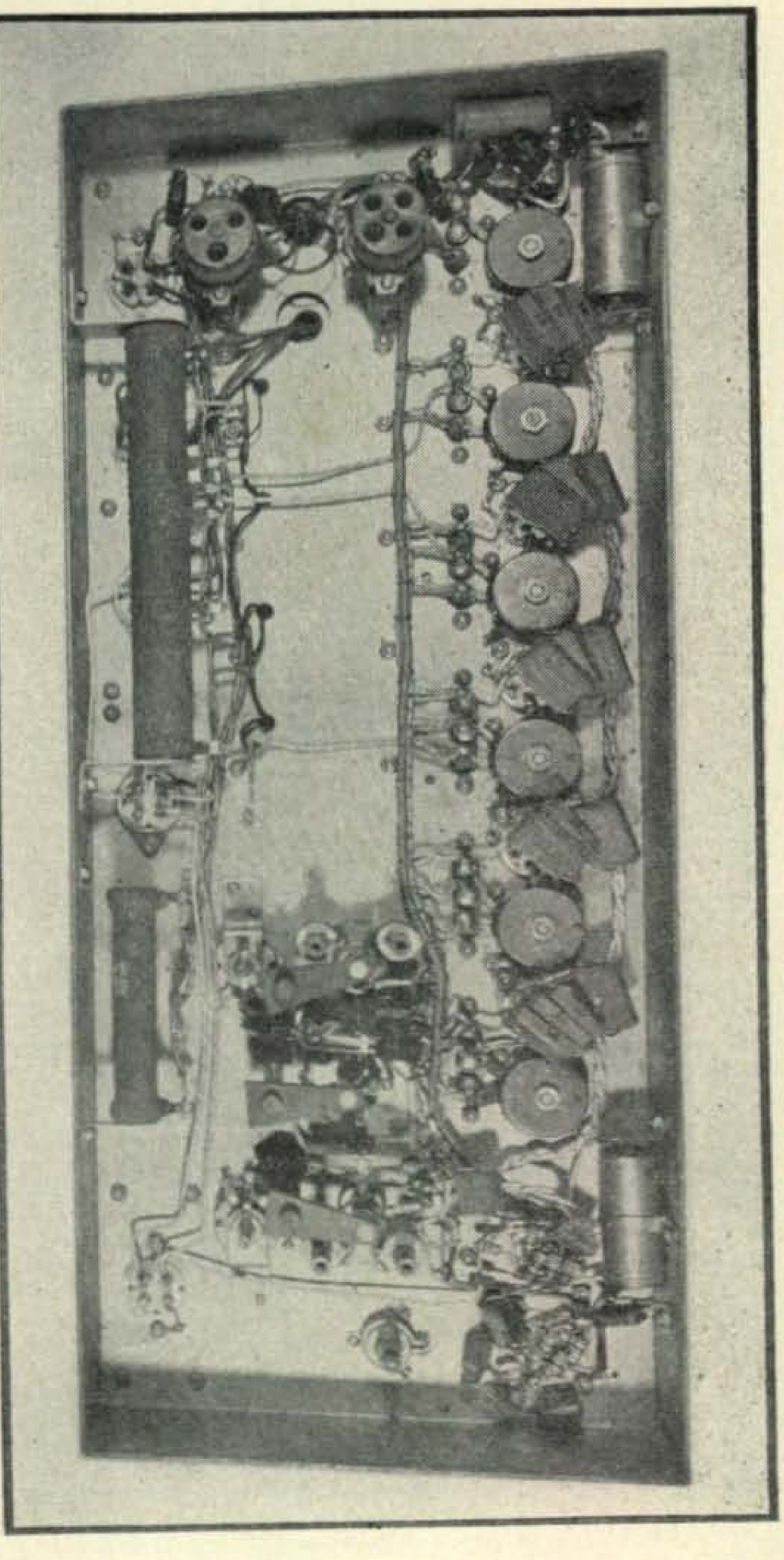
Bottom view of the BC 406. This remains essentially unchanged after conversion. The majority of components are stock items

Original Circuit

Before outlining the conversion details, a brief description of the original, unusual acorn tube section is in order. The input consists of two first r-f acorn stages designed to operate from separate antennae. They couple into the common second 954 r-f stage and from there into a 954 mixer. The local oscillator circuit is a novel arrangement in that a buffer r-f amplifier (954) is employed between the 955 oscillator and the mixer. The oscillator and amplifier output is injected in the mixer through the second r-f plate circuit.

All components are readily accessible for rapid conversion. Before converting, however, the original layout should be carefully studied to determine where filament, plate and screen voltages can be picked up for the new r-f end.

The original receiver should be tested before conversion is started. Remove the ground connector to terminal *G* on female receptacle *B*, in



order to prevent grounding one side of the 110 a-c line. Connect the a-c line to screen terminals #2 and *G* on the female receptacle *B*.

The loudspeaker is placed in the plate circuit of the 6SJ7 in place of the blocking condenser and resistor.

The cathode circuit of the first i-f stage is left open for an external gain control used in the Signal Corps system. Clip all wires going to the cathode socket connection and insert a 300-ohm, ½-watt resistor bypassed to ground with a .1 μf condenser. If all steps have been satisfactorily completed to this point a low-level hum will indicate proper performance.

Conversion Steps

Much time will be saved if the work is done step by step as outlined:

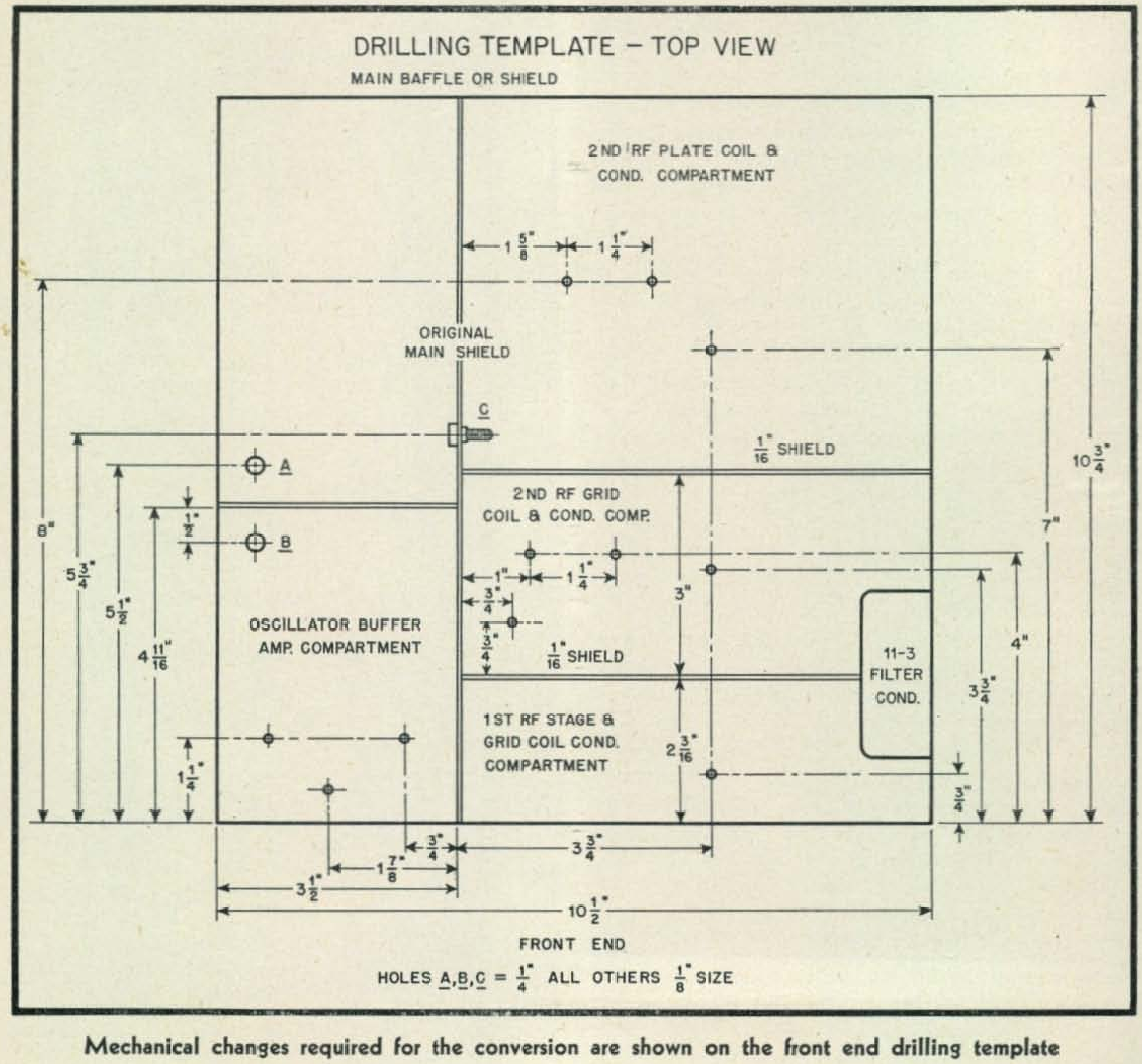
1. From the under side of the chassis remove the *two* first r-f stage assemblies and associated wiring, the S. W. amplifier, oscillator sockets and associated wiring.

2. From the top side of the chassis, clip all the wiring going to the local oscillator, buffer amplifier, second r-f and mixer tube sockets.

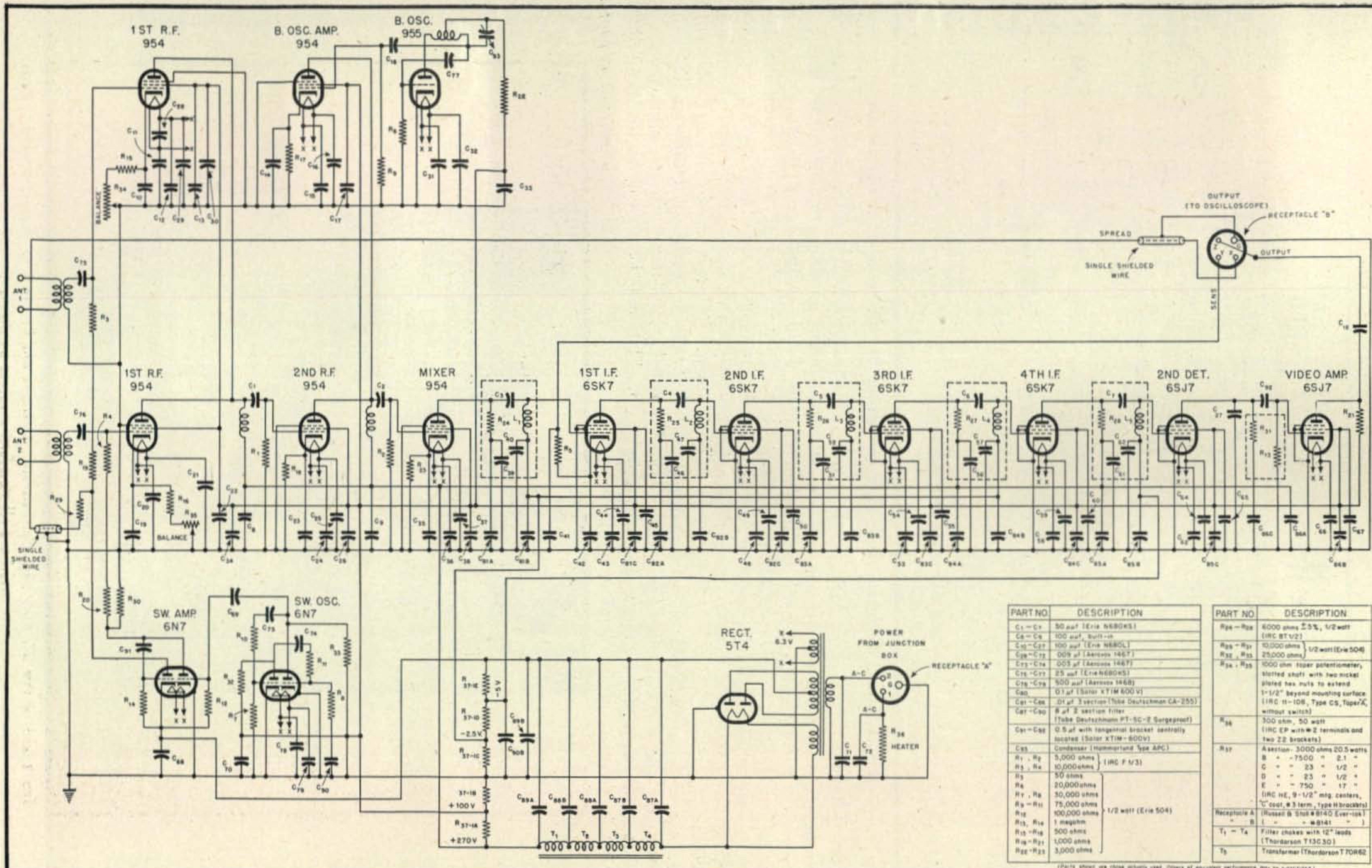
3. The second r-f tube socket and shield is separated from the oscillator assembly by cutting with a hacksaw, but at least one-half inch of the shield should be left at the corner for the remounting of the oscillator assembly.

4. The local oscillator and associated buffer amplifier, bypass condensers and resistors mounted on the tube sockets are left as originally mounted but the oscillator coil is removed.

This completes the tearing down of the original layout and we are now ready to proceed with the steps involving conversion. It is important to be sure that the ground returns go to a common point for each socket and that they be kept as short as possible in order to guarantee proper stability.



Mechanical changes required for the conversion are shown on the front end drilling template



PART NO.	DESCRIPTION
$C_1 - C_7$	50 μμf (Erie N680K5)
$C_8 - C_9$	100 μμf, built-in
$C_{10} - C_{27}$	100 μμf (Erie N680L)
$C_{28} - C_{72}$	.005 μf (Aerovox 1467)
$C_{73} - C_{74}$	.005 μf (Aerovox 1467)
$C_{75} - C_{77}$	25 μμf (Erie N680K5)
$C_{78} - C_{79}$	500 μμf (Aerovox 1468)
C_{80}	0.1 μf (Solar XTIM 600 V)
$C_{81} - C_{86}$	.01 μf 3 section (Tobe Deutschmann CA-255)
$C_{87} - C_{90}$	8 μf 2 section filter (Tobe Deutschmann PT-SC-2 Surgeproof)
$C_{91} - C_{92}$	0.5 μf with tangential bracket centrally located (Solar XTIM-600V)
C_{93}	Condenser (Hammarlund Type APC)
R_1, R_2 / R_3, R_4	5,000 ohms / 10,000 ohms } (IRC F 1/3)
R_5 / R_6 / R_7, R_8 / $R_9 - R_{11}$ / R_{12} / R_{13}, R_{14} / $R_{15} - R_{18}$ / $R_{19} - R_{21}$ / $R_{22} - R_{23}$	50 ohms / 20,000 ohms / 30,000 ohms / 75,000 ohms / 100,000 ohms / 1 megohm / 500 ohms / 1,000 ohms / 3,000 ohms } 1/2 watt (Erie 504)

PART NO.	DESCRIPTION
$R_{24} - R_{28}$	6000 ohms ±5%, 1/2 watt (IRC BT 1/2)
$R_{29} - R_{31}$ / R_{32}, R_{33}	10,000 ohms / 25,000 ohms } 1/2 watt (Erie 504)
R_{34}, R_{35}	1000 ohm taper potentiometer, slotted shaft with two nickel plated hex nuts to extend 1-1/2" beyond mounting surface (IRC 11-106, Type CS, Taper A, without switch)
R_{36}	300 ohm, 50 watt (IRC EP with #2 terminals and two 22 brackets)
R_{37}	A section- 3000 ohms 20.5 watts B " -7500 " 2.1 " C " " 23 " 1/2 " D " " 23 " 1/2 " E " " 750 " 17 " (IRC HE, 9-1/2" mtg. centers, "C" coat, # 3 term., type H brackets)
Receptacle A " B	(Russell & Stoll # 8140 Ever-lok) (" " # 8141 ")
$T_1 - T_4$	Filter chokes with 12" leads (Thordarson T13C30)
T_5	Transformer (Thordarson T70R62

(Parts shown are those actually used. Others of equivalent performance may be substituted.)

Original circuit schematic requires few changes. Circuit alterations are shown in Figure 1.

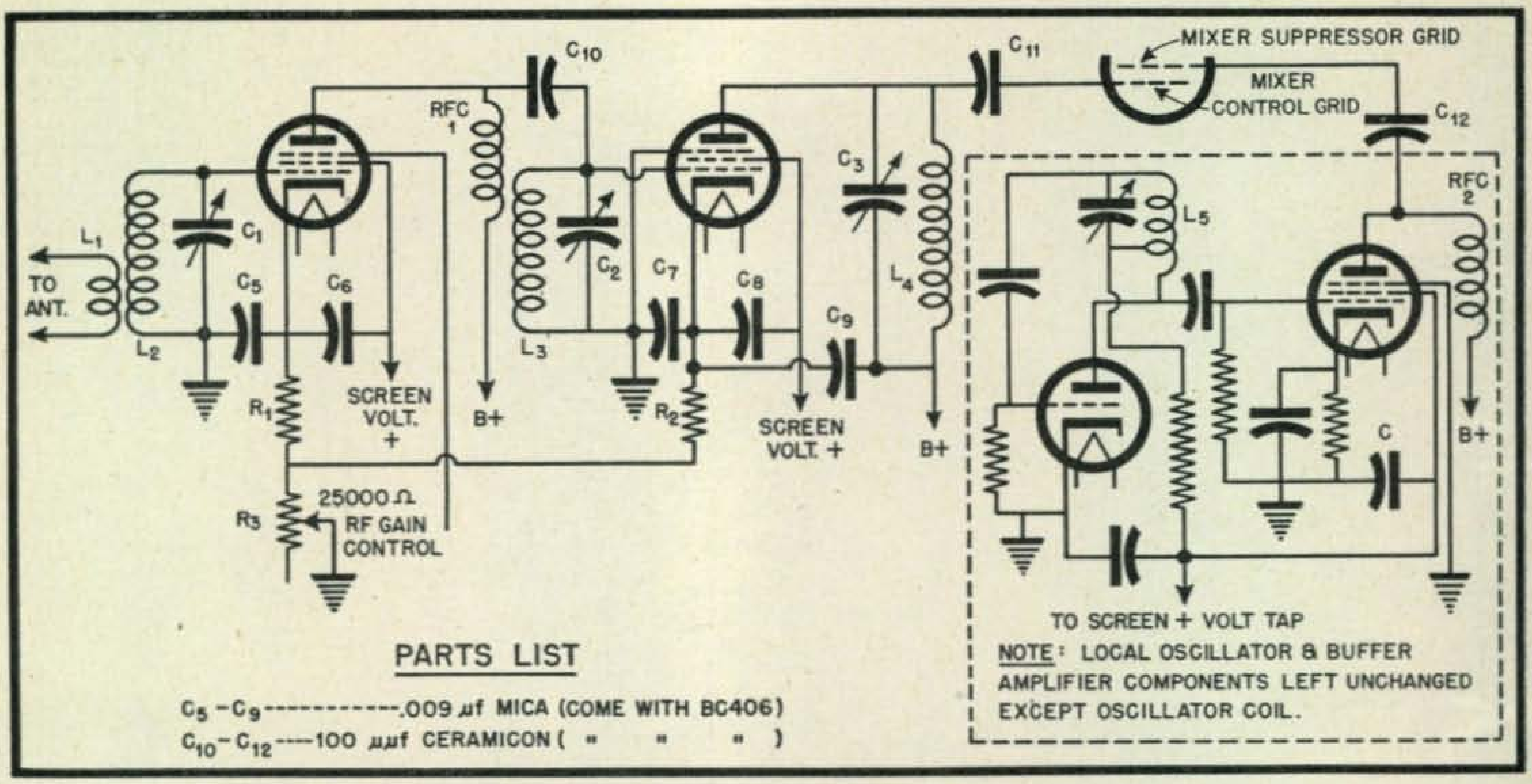


Fig. 1. Circuit alterations required to convert the BC 406 receiver for amateur use

Circuit Changes

Since the original set operated on a fixed frequency of 205 mc and tuning was accomplished over a very limited range with adjustable iron core inserts through the coils, four 15 $\mu\mu$f variable condensers are used to give band coverage.

1. Place the oscillator-amplifier assembly directly over the S. W. oscillator-amplifier tube-socket holes with the center of the oscillator socket 2 inches from the end of the chassis. This makes possible the mounting of the oscillator-buffer amplifier bracket angle against the main shield running the full length of the chassis.

2. Drill a ¼″ hole in the main shield one-half inch from the mixer socket suppressor connecter and insert a National feed-through bushing. This is used to carry the output voltage of the oscillator buffer amplifier to be injected in the mixer via the suppressor.

3. Plate and screen voltage for the oscillator-

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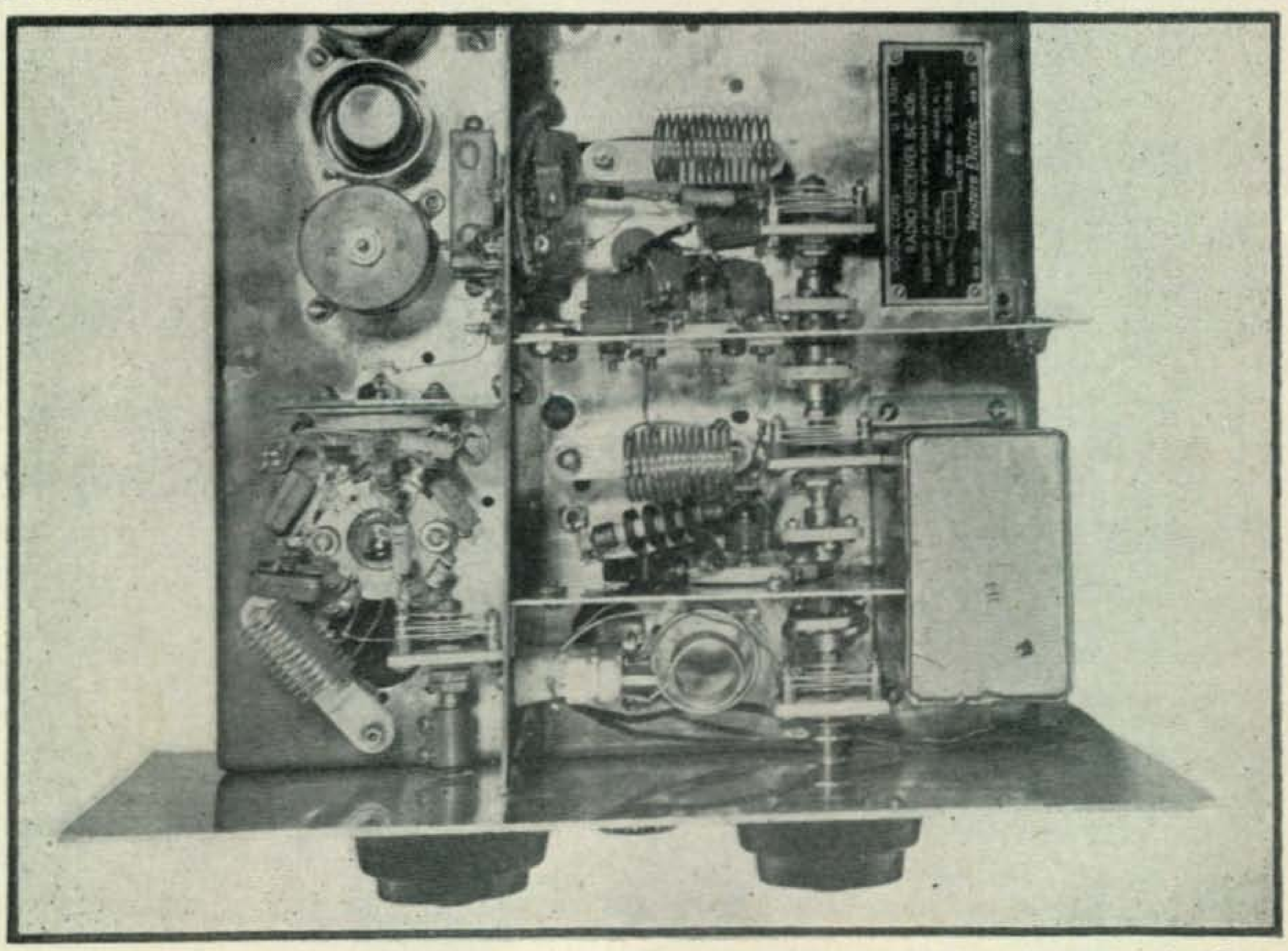

Front end of the BC 406 after conversion. Changes are simple and straightforward. Parts used are all standard amateur equipment

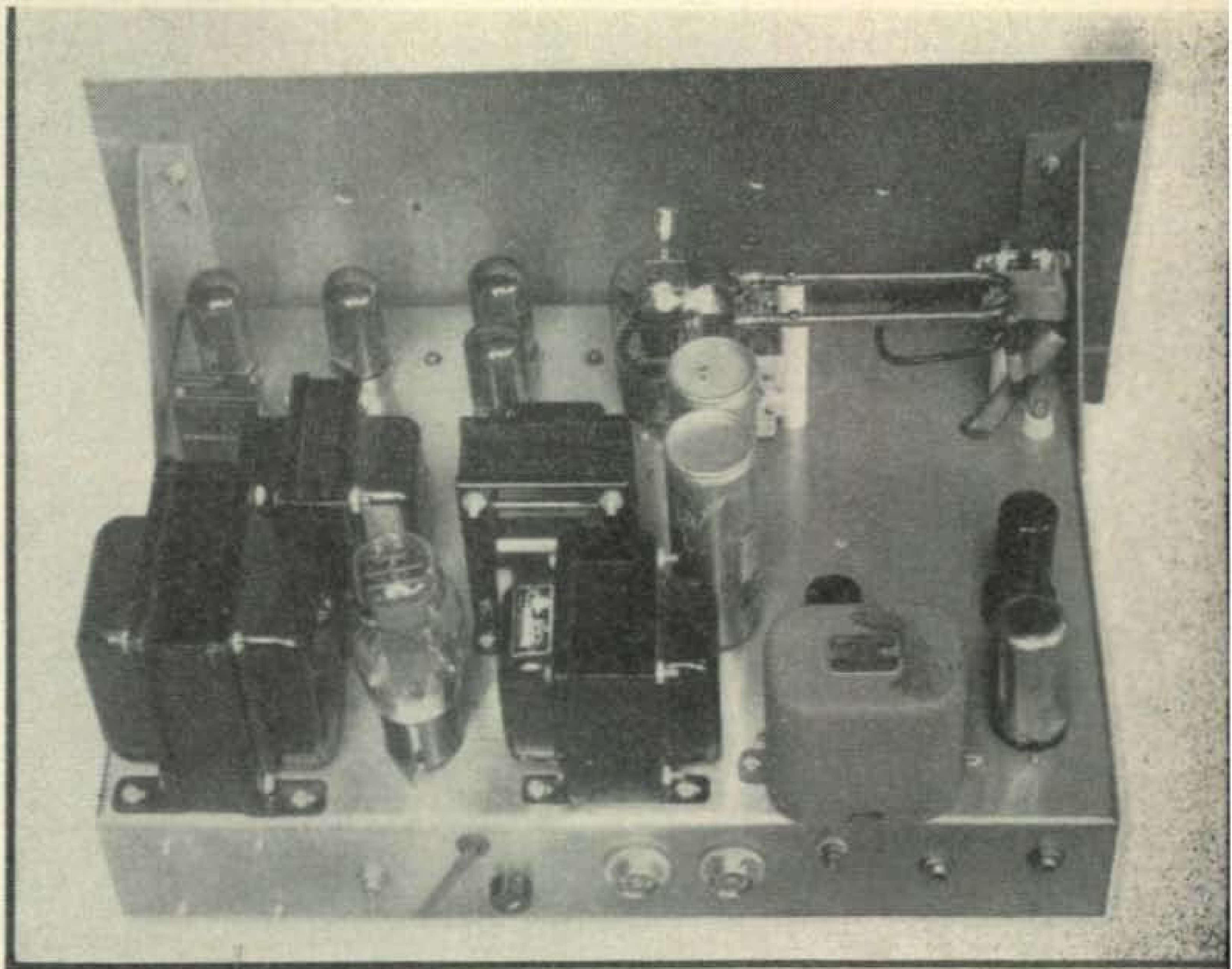

Fig. 2. Rear view of the rack-and-panel 146-megacycle transmitter. Antenna coupling at the upper right

RACK-AND-PANEL TRANSMITTER

For 144 Megacycles

FRANK C. JONES, W6AJF

Crystal Control Cathode-Modulated 815 Delivering 15 Watts into the Antenna

THE CATHODE-MODULATED VHF transmitter described in this text is designed for the amateur who desires to construct a compact single-unit transmitter for relay-rack mounting. The entire set is mounted on a 12" x 17" x 3" chassis with an 8¾" x 19" relay-rack panel. Provisions are made for a common concentric-fed antenna, for both transmitting and receiving, by means of an antenna switching relay, concentric line plugs and jacks.

Circuit Arrangement

The circuit (*Fig. 1*) includes a 7C5 or 6V6GT oscillator-doubler, two triplers and a single 815 output amplifier. The carrier output with cathode modulation ranges from 10 to 15 watts. The output with plate modulation could be raised to 40 watts, but only at the expense of an additional power supply and modulator. Cathode modulation was chosen because of its simplicity and low power-supply requirements.

The 7C5 oscillator is of the type developed by the writer and others in the pre-war era and subsequently in wide use by the armed forces during the war. The crystal current is extremely low and the tube will supply approximately 100 volts r-f drive on the second harmonic of the crystal.

The first tripler stage has a split-plate circuit tuned to three times the grid-circuit frequency in order to drive a push-pull tripler stage. With this combination of doubling and tripling *twice*, an 8.1-mc crystal is required for 146-megacycle operation. Fair results are obtainable by quadrupling in the second 7C5 instead of tripling, in which case the crystal frequency is a shade higher than 6 mc. Tripling or quadrupling in the crystal stage is possible by careful adjustment of screen voltage, but at considerable loss in grid

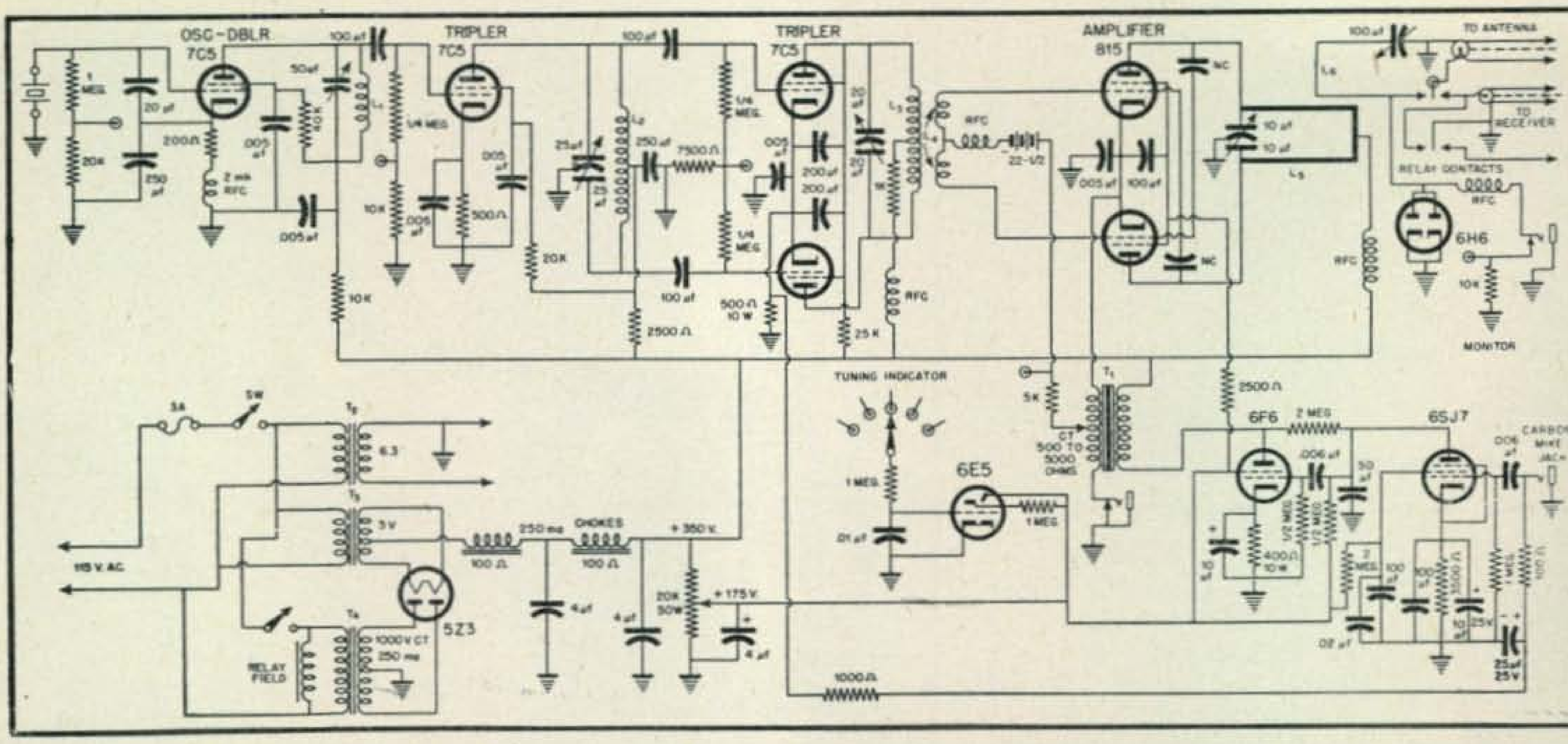

Fig. 1. Circuit diagram of the VHF transmitter with cathode modulation. Output can be stepped up to 40 watts with plate modulation with an additional plate supply and modulator. L_1 is wound 17 turns 1 inch long with a 1" dia. L_2, 9 turns, 1 inch long 5/8" dia. L_3, 3 turns ½" dia. L_4, 2 turns each side of center, ½" dia.

drive to the succeeding stage. The 815 should always be driven by a tripler stage in order to utilize the push-pull connection with a consequent reduction of tube capacities. A push-pull arrangement cannot be used in a doubler or quadrupler stage.

Output Circuit

The 815 is cross-neutralized by running a pair of 2-inch 10-32 machine screws up through the polystyrene chassis insulators in such a manner that these bolts extend upward alongside the glass envelope of the 815 tube, directly by its two plates. Cross-connection of the machine-screw heads to the grids of the tube will provide neutralization of the usual form. The 815 tube is not thoroughly screened and a very small neutralizing capacity is therefore desirable to prevent plate-circuit tuning from affecting the grid-circuit current and drive.

The grid drive to each stage, and the approximate r-f output, are measured by means of a 6E5 tuning indicator tube with rotary switch for selecting a portion of the d-c grid voltage developed in each grid circuit. A 6H6 rectifier,

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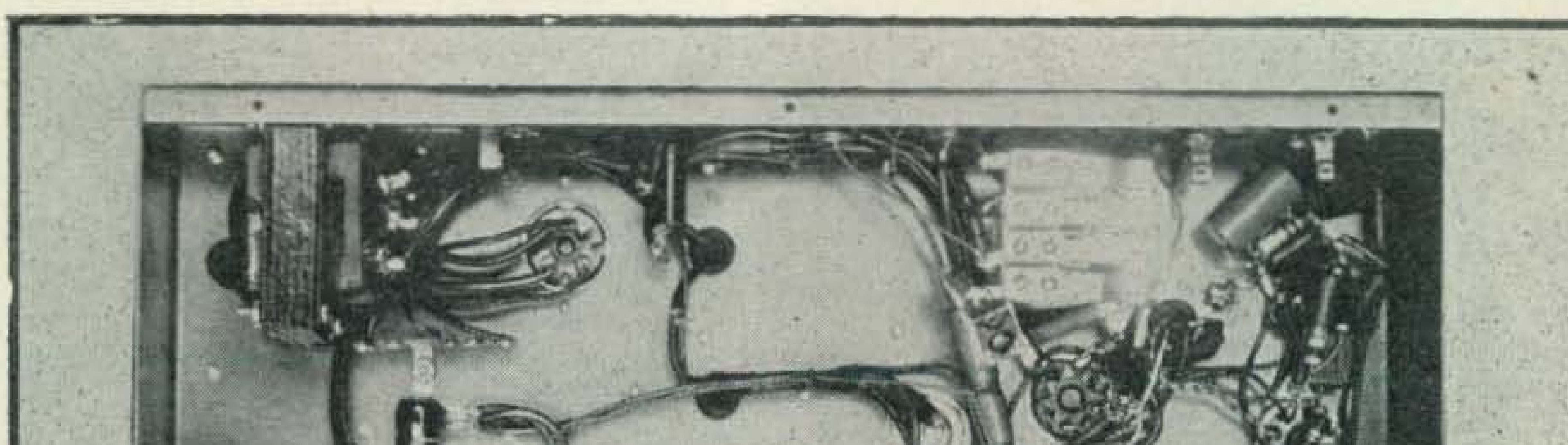

Fig. 3. Under-chassis view of the VHF rig shows constructional and wiring detail

ANTENNAS

For the VHF Bands

LOYAL STEPHEN FOX, EX-W2AHB

Simple Tubular Designs for 50, 144 and 220-Megacycle Allocations These Basic Antennas are of Particular Interest to the New Ham

THE NEW VHF bands of 50-54 mc, 144-148 mc, and 220-225 mc do not necessarily require any radical departure in antenna design from that which has been previously used for VHF frequencies. The antennas to be described are the simpler, non-directional arrangements which are not difficult to construct, and are time-tested and proved. Open-wire feed and *Q*-section matching are employed. Arrays, matching stubs, and concentric cable feed are subjects worthy of separate and individual consideration and therefore are not included here.

Tube Construction

These antennas are to be built from tubing

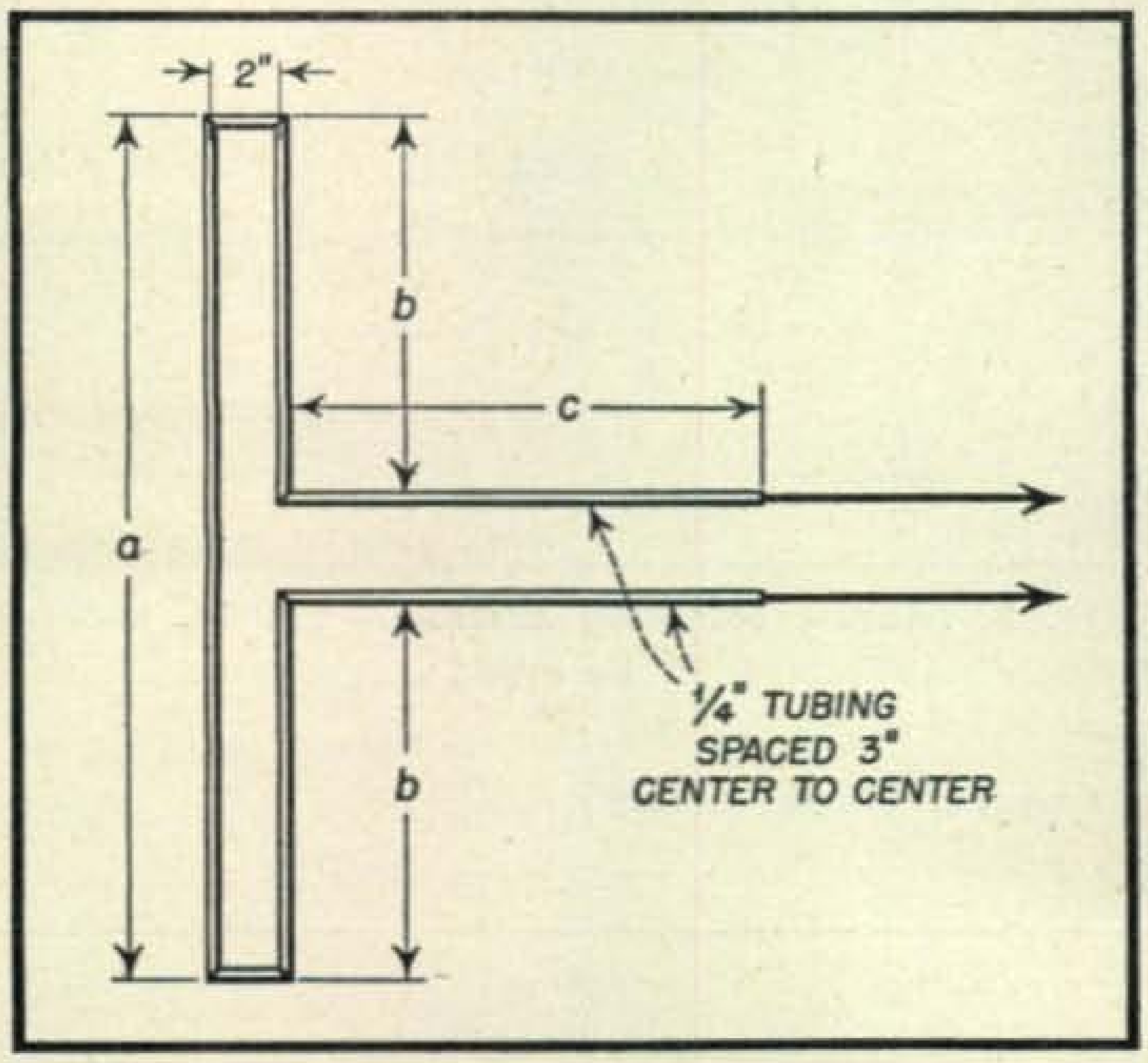

Fig. 1. The folded doublet. All elements are of tubing

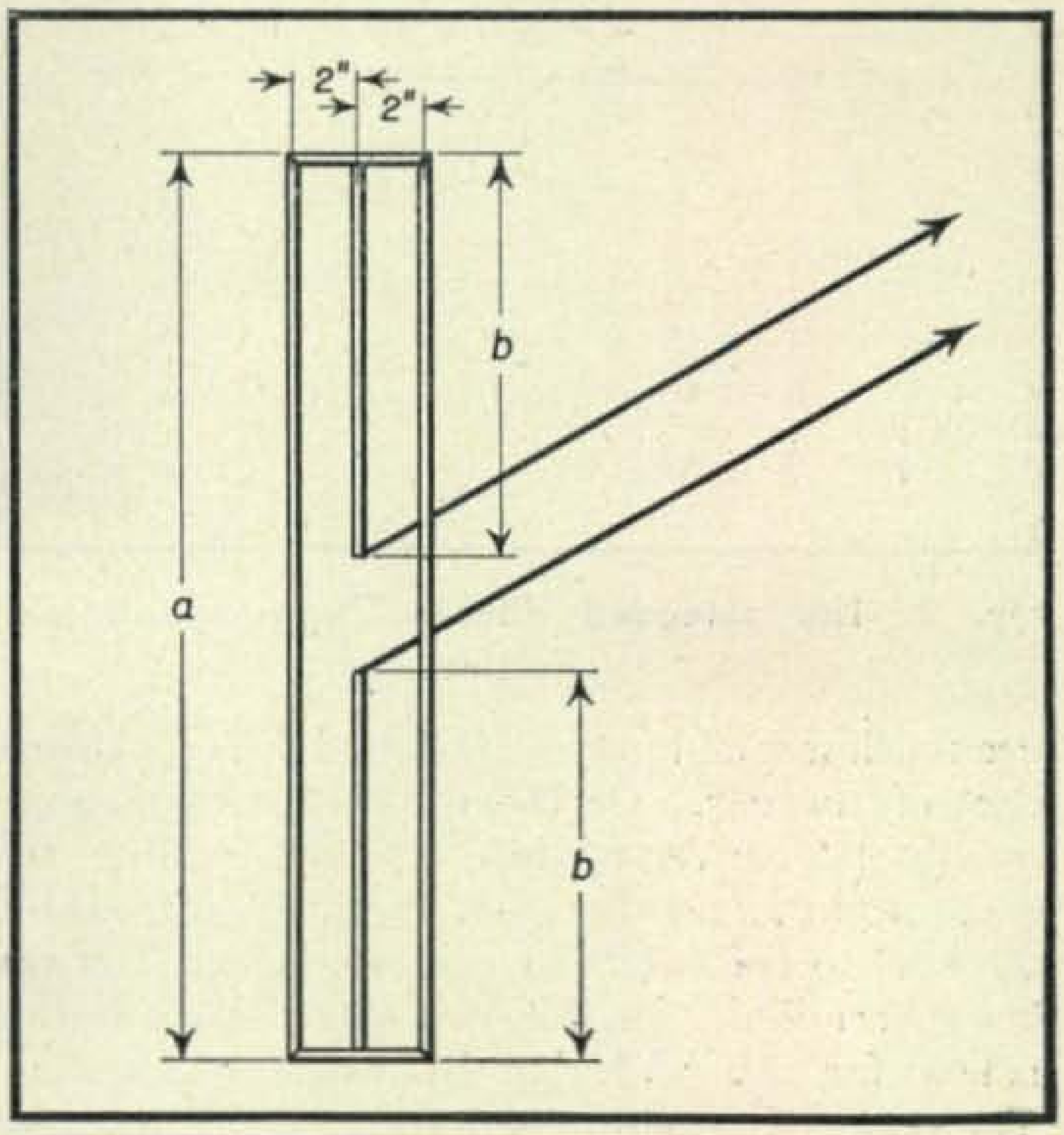

Fig. 2. Another section added to Fig. 1. raises the impedance to approximately 500 ohms

(copper, brass or aluminum)—not wire. Wire antennas have a high Q, therefore peak sharply at the resonant frequency. For efficiency over the 4 to 5-mc width of the VHF bands, tubing of ½ to 1-inch diameter should be used. Connections should preferably be soldered. As a second choice the ends of the tubes may be flattened, drilled, and bolted together. Support the tubes with suitable stand-off insulators, and run the feeders at a right angle to the antenna for as great a distance as possible.

In *Fig. 1* we have the folded doublet. As the impedance at the center is about 300 ohms, this antenna may be fed directly with a pair of #8 wires spaced ¾ inch; but for a feeder of smaller wire size the Q—section should be used. Add another section as shown in *Fig. 2* and the antenna impedance will then be a very close match for a 500 ohm line, so that no Q-section is required.

The extended double Zepp, *Fig. 3*, is always an excellent performer and very easy to build. Next, in *Fig. 4*, is the familiar J—a half-wave vertical with a quarter-wave matching stub on the bottom end. The e and one of the c portions are, of course, a single piece of tubing. As the bottom of the J is at ground potential, in mobile use this lower end may be fastened directly to any part of the car. Or the car BC antenna may readily be converted into a J by adding the bottom piece and the short vertical, and leaving the lead to the car BC receiver connected at the lower terminal. In this way the same antenna is used for either VHF or BC without switching. The point of attachment for the feeder must be determined experimentally for the best results.

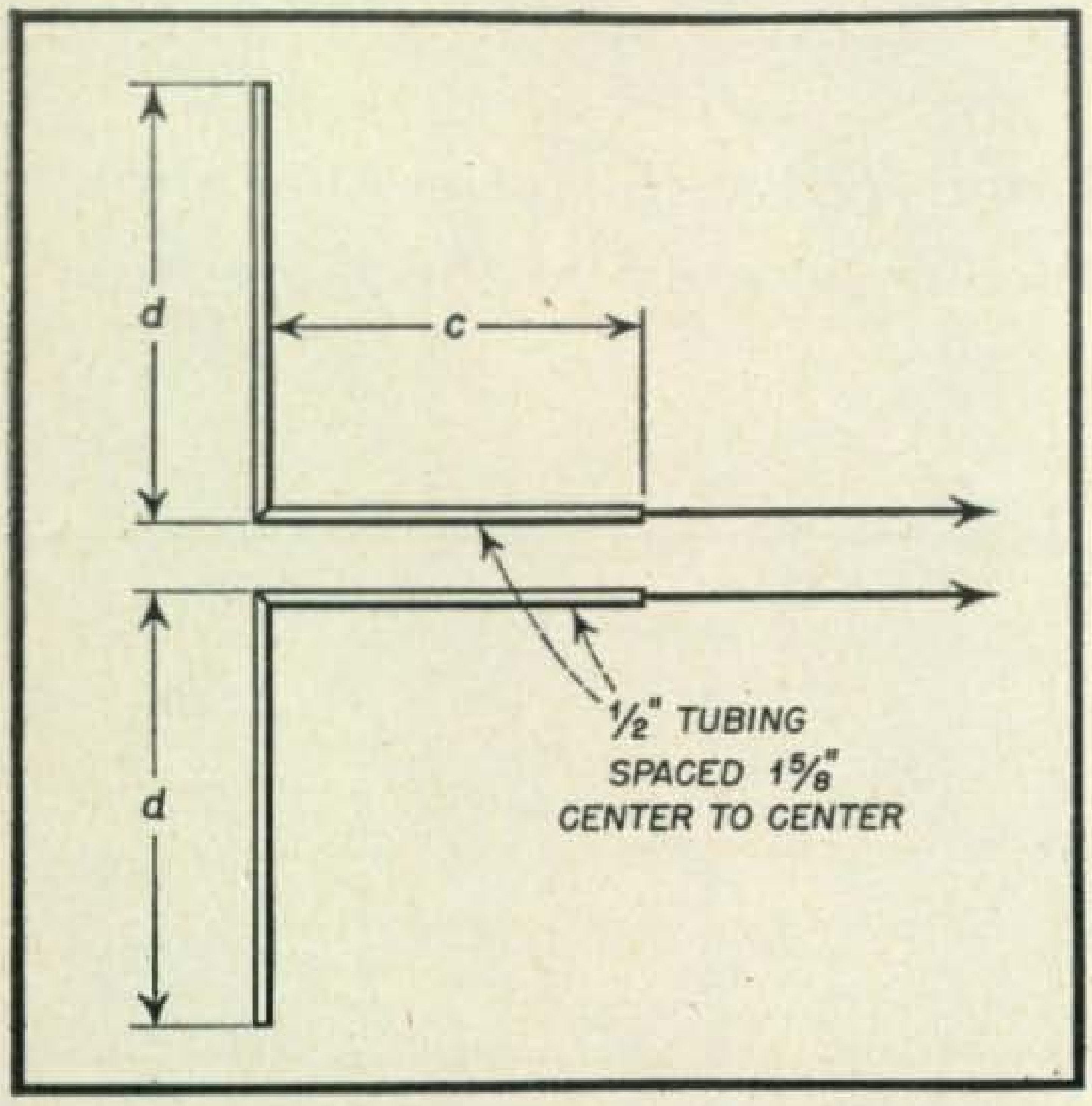

Fig. 3. The extended double Zepp—simple and effective

Mobile Antenna

The half-wave antenna of *Fig. 5* is especially designed for mobile operation. The capacitor setting should be that which least detunes the transmitter when the line is connected at the transmitter end. This capacitor is not used to adjust transmitter loading, as this adjustment should be made only by varying the position of the coupling coil.

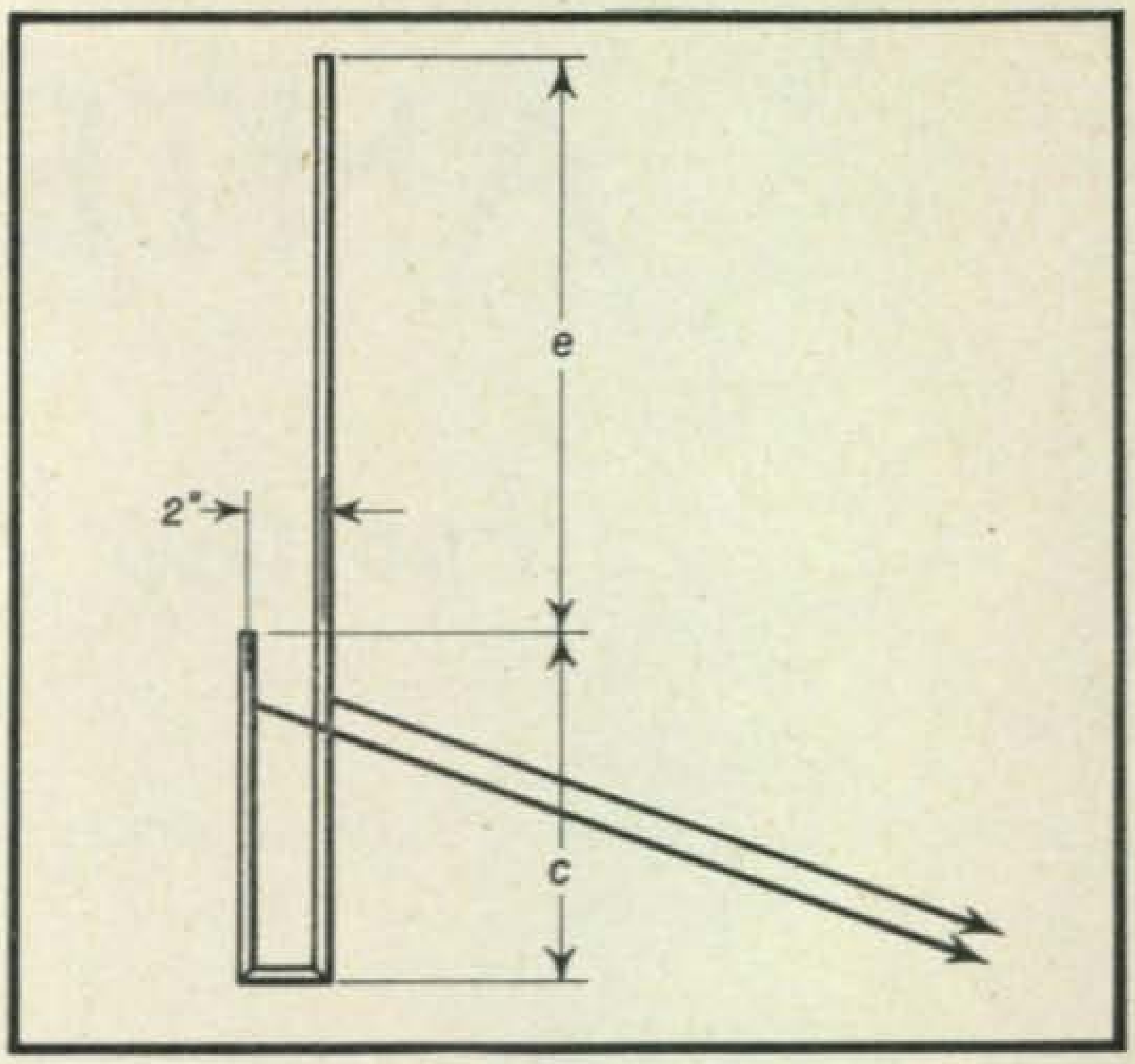

Fig. 4. The "J"—a half-wave vertical with a quarter-wave matching stub

Feeders are #14 bare copper wire, spaced 2 inches. All other dimensions shown in the diagrams are given in the table below.

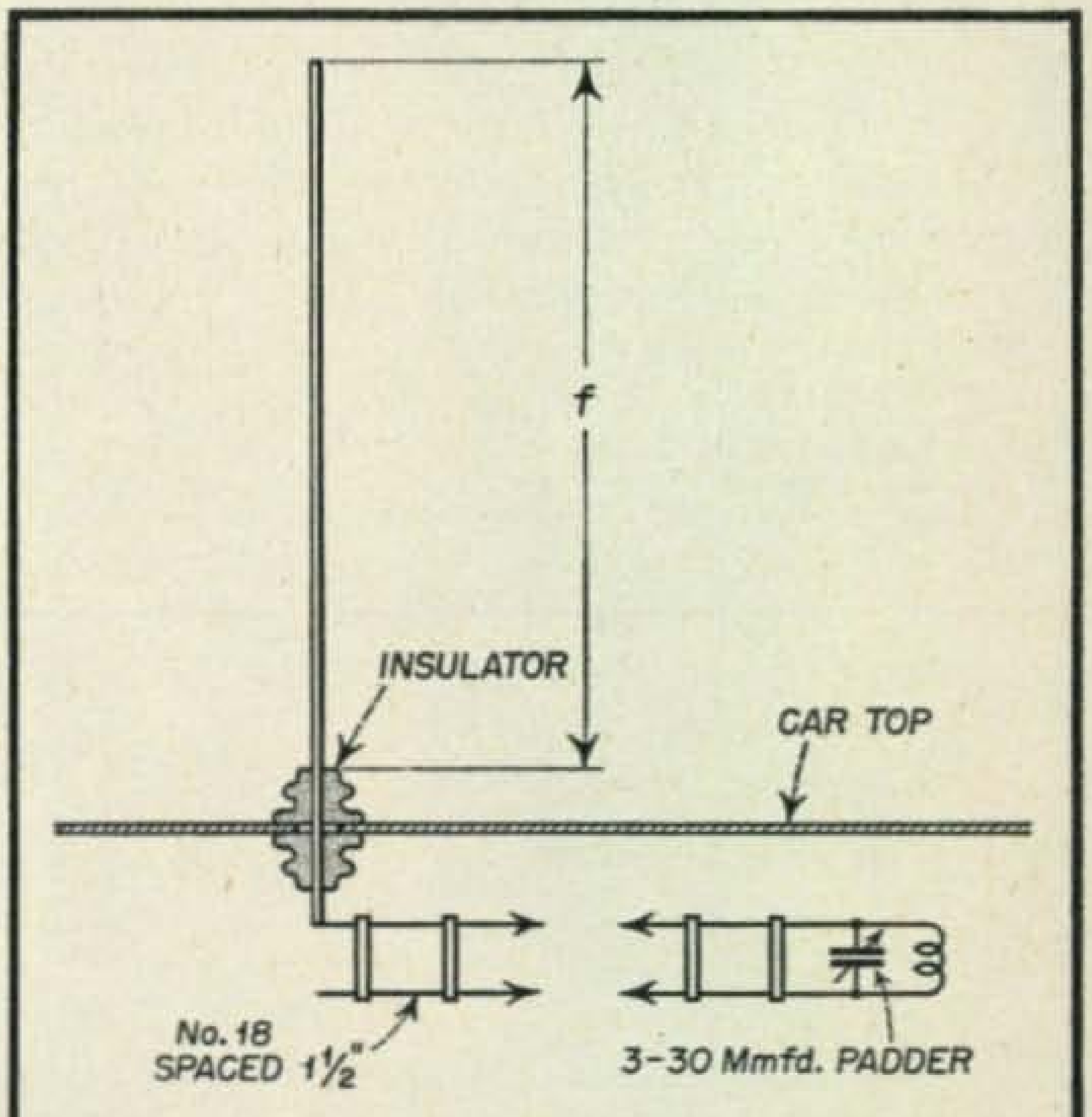

Fig. 5. Mobile half-wave antenna. The BC rod can be used

TABLE OF ANTENNA ELEMENT DIMENSIONS

mc	*a*	*b*	*c*	*d*	*e*	*f*
52	110½"	54¼"	55½"	136¼"	106¼"	——
146	39¼"	18 5/8"	19¾"	48½"	38"	35"
222½	25 7/8"	11 15/16"	12 31/32"	31 29/32"	24 29/32"	23½"

Fundamental

ELECTRICAL MEASUREMENTS

A. K. McLAREN

Theory and Practice of a Simple Impedance Bridge that Will Check Resistance, Capacity, Inductance and Impedance

All electrical measurements are based on the fundamental properties of the elements involved. These properties cannot always be resolved in pure form in the construction of elements commonly used in electrical circuits, but usually the inherent property for which the element was constructed is predominating enough that the other incidental properties may be neglected for practical purposes. The fundamental properties of electrical elements are capacity, inductance and resistance. Impedance is also an important characteristic of elements, and is used in making all measurements described in this article.

Usually an instrument designed for measuring a certain property is employed in each case and an instrument of each type is necessary to make all needed tests. Also these instruments must be calibrated and are subject to variations in calibration. The instrument to be described makes measurements in terms of impedance; and an accurate ohmmeter, together with a variable audio-frequency oscillator and a vacuum-tube voltmeter, complete the equipment needed to make all measurements.

Calibration and Range

The audio-frequency oscillator can be calibrated from standard 440 and 4.000-cycle frequencies broadcast from WWV, the U.S. Bureau of Standards. Measurements can be made of capacitors or inductor, at these frequencies and then they can be used as standards for calibrating the rest of the oscillator range. The range of measurements with the instrument to be described will depend on the frequencies covered by the oscillator and the sensitivity of the V.T.V.M. The impedance measuring device itself is essentially a vacuum-tube voltmeter (in fact a double V.T.V.M.).

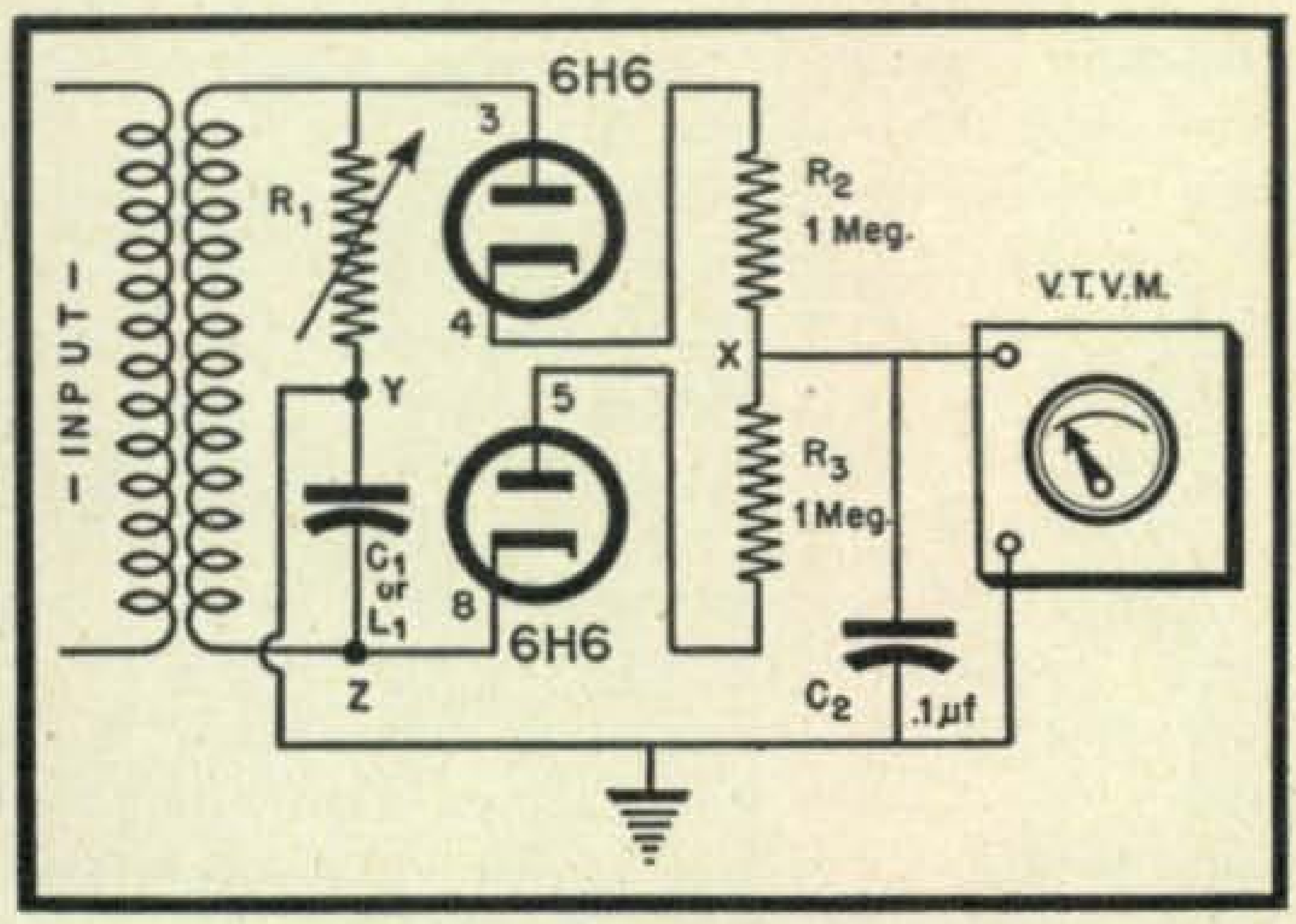

Fig. 1. Diagram of a simple impedance bridge that can be adapted to a multitude of uses. Elements to be measured are connected between X and Z

As will be seen from the circuit of *Fig. 1,* when the impedance of R_1 is adjusted to equal the impedance of C_1 or L_1 then the voltage at the point connecting the two will be 90 degrees out of phase with either side of the transformer. In effect point X will also be 90 degrees out of phase due to the fact that the transformer voltage is rectified by the 6 H 6 twin diode, and a d-c voltage drop is produced across R_2 and R_3 which is practically equal to the transformer voltage.

Theoretical Points

The top diode will be positive and the lower diode will be negative. This voltage is center-tapped and since point Y is 90 degrees out of phase, or zero, then there will be zero voltage between the two points. If the transformer center tap is varied either side of center by adjustment of R_1, then the voltage on that side is higher and will be rectified by one of the diodes and appear at point X as a d-c voltage. This voltage 's filtered by C_1 to eliminate the a-c voltage variations.

The V.T.V.M. thus swings from positive to negative or from above zero to below zero as the 90 degree point is passed in adjusting resistor R_1. At the 90-degree point no voltage appears at point X. If a zero-center V.T.V.M. is used it will show either a positive or negative voltage. If a left-hand zero meter is employed an arbitrary reading above zero may be chosen as the zero point.

If R_1 is not equal in impedance to C_1 or L_1, then a direct-current voltage will appear at point X, either positive or negative depending on whether the voltage is leading or lagging one side of the transformer or the other.

The action is rather involved, but simply by adjusting R_1 to equal the impedance of the element being measured results in no d-c voltage at point X and the resistance of R_1 is measured on an ohmmeter. The value of R_1 is then equal to the impedance of the element being measured and may be compared on a reactance slide rule to compute the value in terms of impedance at frequency. Frequency measurement is accomplished in the same way by using known values of capacity or inductance and then finding the frequency with which the measured impedance of the element coincides.

At first glance it seems that the center-tapped resistor could be connected across the transformer and an alternating-current voltmeter used as an indicator. This cannot be done because an a-c voltmeter will not indicate voltages below zero. Also, the voltage drop at X or Y will not be the same, so no zero point would be found. The triangle of forces shows the relation of two voltages 90 degrees out of phase (*Fig. 2*). The sine curves of the two voltages are shown at A, and B the triangle of forces.

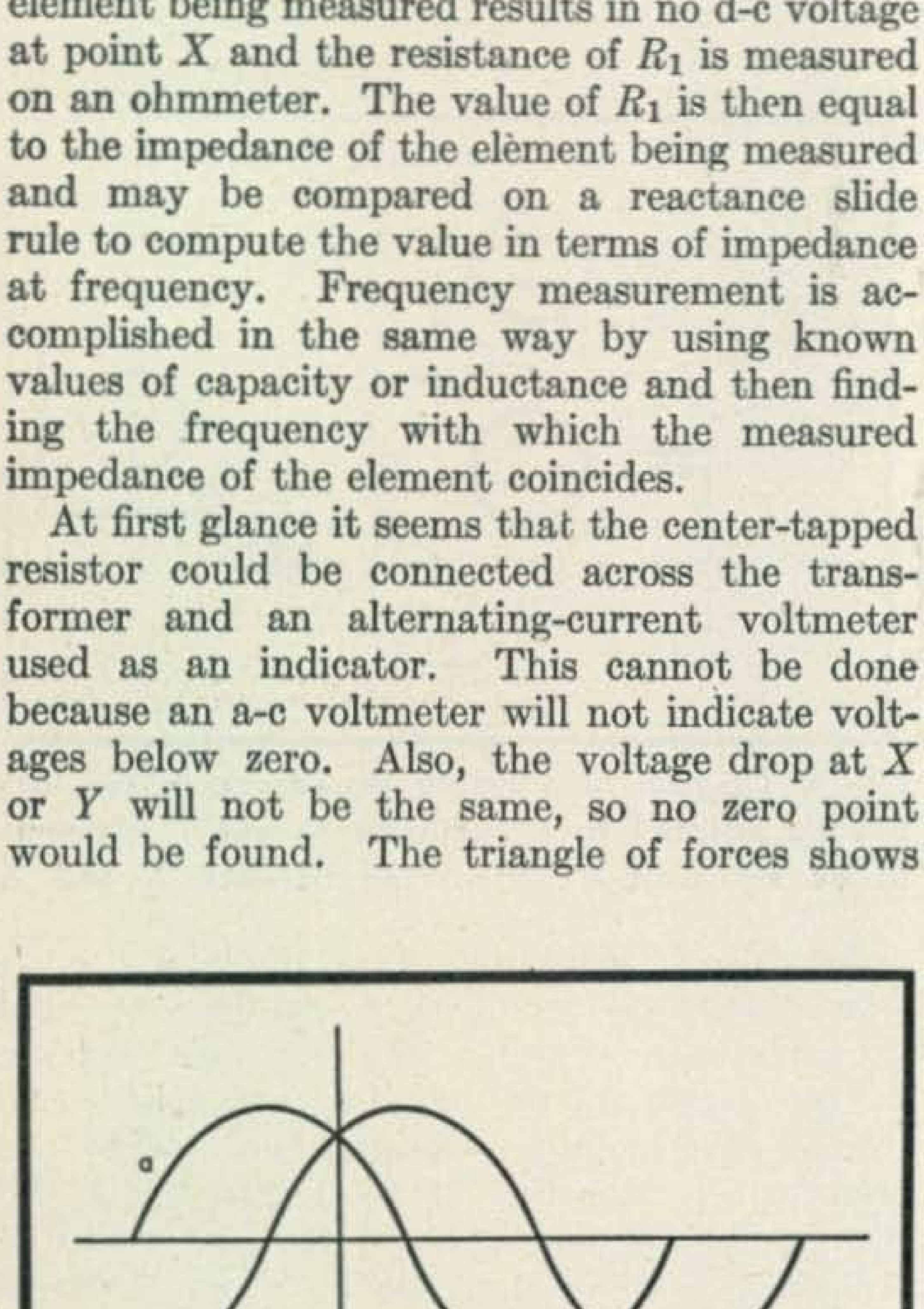

Fig. 2. Phase relationship in the bridge circuit as indicated by sine waves and vectorially

At the point where the vertical line crosses the two curves the two voltages will be equal and the resultant voltage will be the length D as shown by the triangle *Fig. 2B*. Current through C_1 and R_1 is in phase with the voltage across the transformer, and since the voltage appearing across a capacitor lags the current through it by 90 degrees, then the voltage across the condenser is lagging the transformer voltage by the same amount.

The current through R_2-R_3 is in phase with the voltage, with the result that the voltage between points X and Y are 90 degrees out of phase (without C_2 connected). The resultant voltage will therefore appear between points X and Y and no zero point will be found with an a-c voltmeter.

The resultant voltage is "grounded" by C_2 *Fig. 1*, and since voltages across equal impedances will be equal, it follows that the potentials at the center taps of R_2-R_3 and R_1-C_1 will be zero and no voltage will be indicated by a d-c meter.

If R_1 is not equal in impedance to C_1, a higher or a lower voltage will be impressed on one or the other of the diodes and, rectified, will appear as a positive or a negative potential across C_2. If C_1 is replaced by an inductance the same conditions will still prevail but the phase will simply be reversed.

Sine Wave Current

Since all a-c electrical measurements are based on sine wave current, a sine wave generator must be used for these measurements. The 60-cycle line current may be employed to measure capacity values from .05 μf to 8 μf or more, and from .2 henry to 100 henrys by using a 50,000-ohm rheostat. This is permissible at this low frequency. At higher frequencies a 10,000-ohm resistor is desirable.

The range of the instrument is limited only by the frequencies available and the sensitivity of the voltmeter. Values from one millihenry to several hundred henrys and from .001 to 15 μf may be measured within reasonable frequency limits.

The signal source must be free from harmonics or spurious frequencies. The input transformer may be reversed and if there are spurious frequencies or harmonics present the reading will not be the same. A push-pull amplifier can be used which will cancel the second harmonic and if a high fidelity amplifier is employed the other harmonics will not be troublesome.

[*Continued on page 51*]

THE ELECTRON GUN

B. W. SOUTHWELL, W6OJW

The pre-war amateur was familiar with the cathode-ray tube largely as a device indicating percentage and quality of modulation. Future use of the CR tube in television, radar, experimental and service work is a foregone conclusion. It may well become the radio amateur's most versatile tool, and he should understand cathode-ray theory and practice as well as he does a simple diode.

THE HEART of the cathode-ray tube is the electron gun—an axially symmetrical structure of electron lenses contained within the neck, where the electron beam is generated and aimed with high velocity at the fluorescent screen on the face of the tube. The heater element is located inside the cathode cylinder and is a .010″ diameter tungsten wire several inches long. In order to neutralize its magnetic field, it is wound in the form of a non-inductive helix or double spiral. The winding is then cleaned and coated to approximately 3 or 4 times its original diameter by dipping into pure aluminum oxide in amyl acetate with a small amount of nitrocellulose as a binder. After drying in air, the coated heater element is then baked in hydrogen at 1600° centigrade for several minutes. The coated heater is inserted inside the cathode cylinder and it normally operates at about 500 degrees C. above the cathode temperature.

The Cathode

The indirectly heated oxide-coated cathode is the source of the electron beam and the most vital part of the gun. It consists of a cylinder, closed at one end, and composed of the purest nickel obtainable. The cathode is about .12″ in diameter and one-half inch long. The cylinder is electrolytically cleaned, fired in hydrogen at 700 degrees C. and is then sprayed on the top of the closed end with a mixture of pure barium and strontium carbonates. Again a small quantity of nitrocellulose is used as a binder.

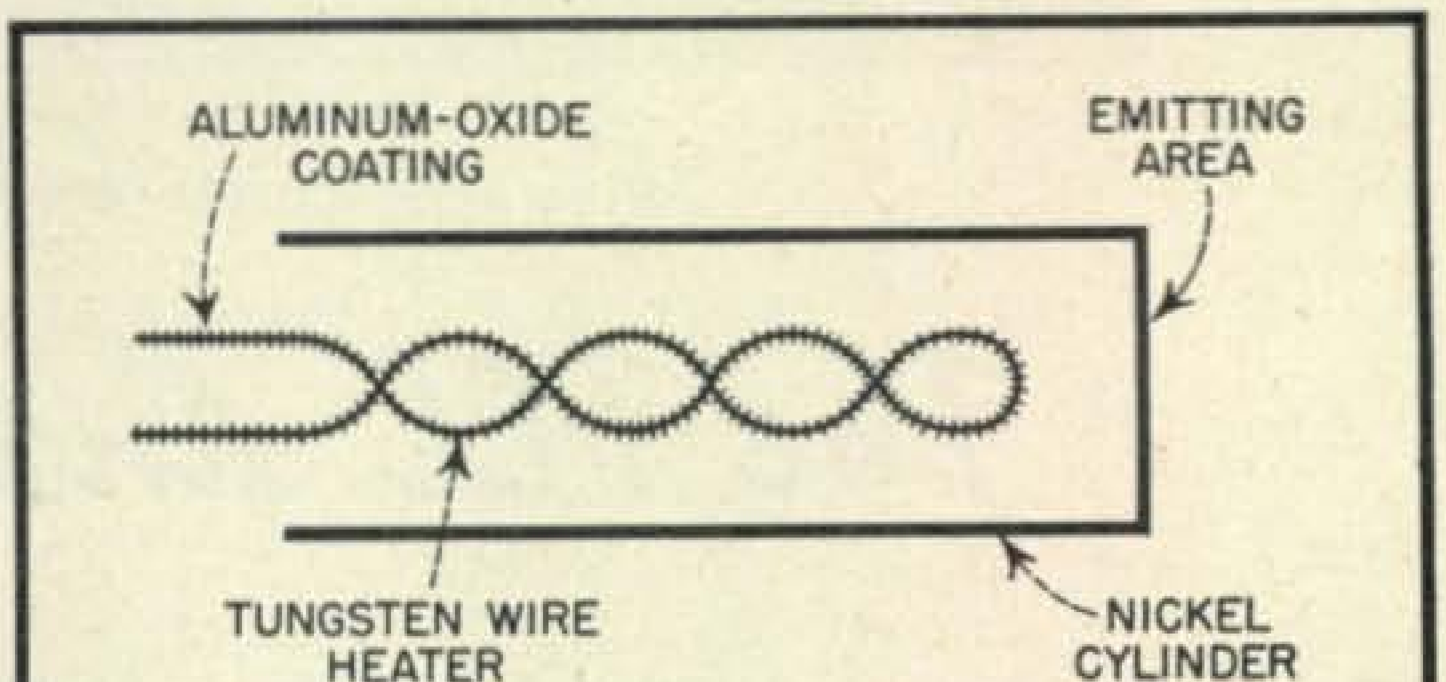

Fig. 2. Cathode and heater detail in the cathode ray "gun"

Next in order from the base of the tube is the control grid. This is formed generally of copper-nickel alloy or stainless steel in the shape of a metal cylinder closed at one end with a disk in the center of which is an aperture to control the electron beam. The control grid varies the current in the beam. It is on this grid that the video signal from a television receiver is impressed. Blanking is obtained by taking an amplified sawtooth signal from the plate of the horizontal-sweep amplifier which is then capacity-coupled to the control grid of the cathode-ray tube. When the horizontal sawtooth signal is amplified it is

[Continued on page 40]

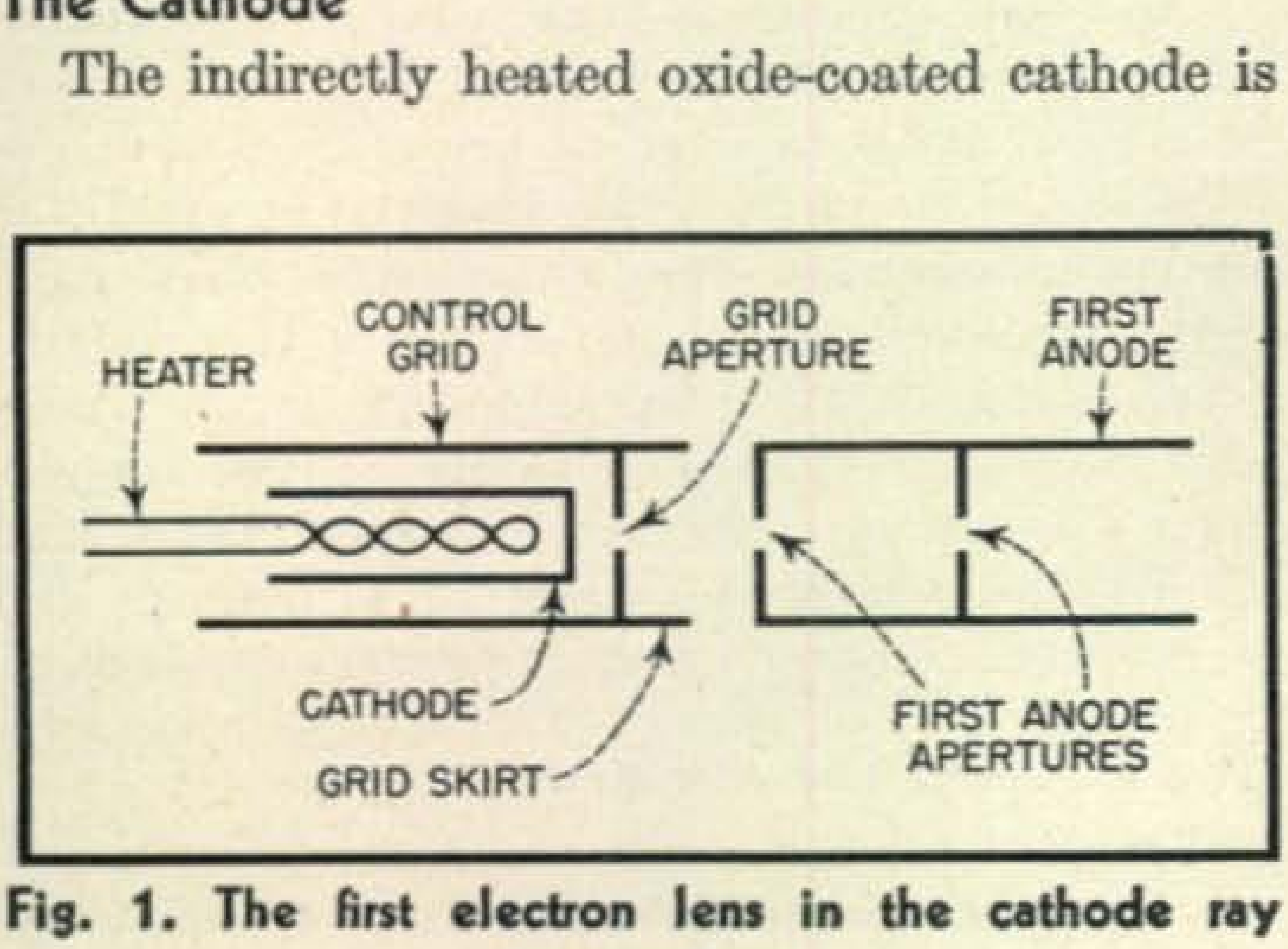

Fig. 1. The first electron lens in the cathode ray gun structure

Left to right W8AU, W2JOT at FCC Monitoring Position

The FCC And The Amateur

Co-Operation Curtails Illegal Operation and Promotes Amateur Prestige

LOUIS DeLaFLEUR, W8AU

After the outbreak of the European war in September, 1939, it became more and more important that the United States Government have available an adequate network of direction finder and other monitoring stations to guard its internal security against espionage and to keep its various agencies in touch with radio traffic between various potential enemy points throughout the world.

The Federal Communications Commission was the logical government agency to handle this work since it had been engaged in monitoring and direction-finding for many years while enforcing radio laws. The FCC uncovered illegal radio stations assisting rum-runners during the prohibition era, who used this means of communication between boats and shore to arrange rendezvous for the disposal of their cargoes. It had located radio transmitters, some fixed and some carried on the operator's person, which were employed to provide a means of rapid communication between a race track tout and a confederate in a position to place a bet with an unsuspecting bookmaker. There were also illegal broadcast stations, which popped up from time to time, some of them broadcasting commercials.

And then, there was that familiar type known among licensed amateurs as the "bootlegger" who usurped a call (or made up one) and operated as a rule within the amateur bands to the detriment of all law-abiding licencees. Such situations are filled with heartbreak for the violator and his family, and, depending on the situations surrounding the illegal operation, may result in a felony conviction (Alcatraz is a lovely island) to haunt the violator throughout life, perhaps preventing his employment in some chosen endeavor.

The FCC and The Amateur

The Federal Communications Commission has the responsibility of locating and preparing the

[Continued on page 48]

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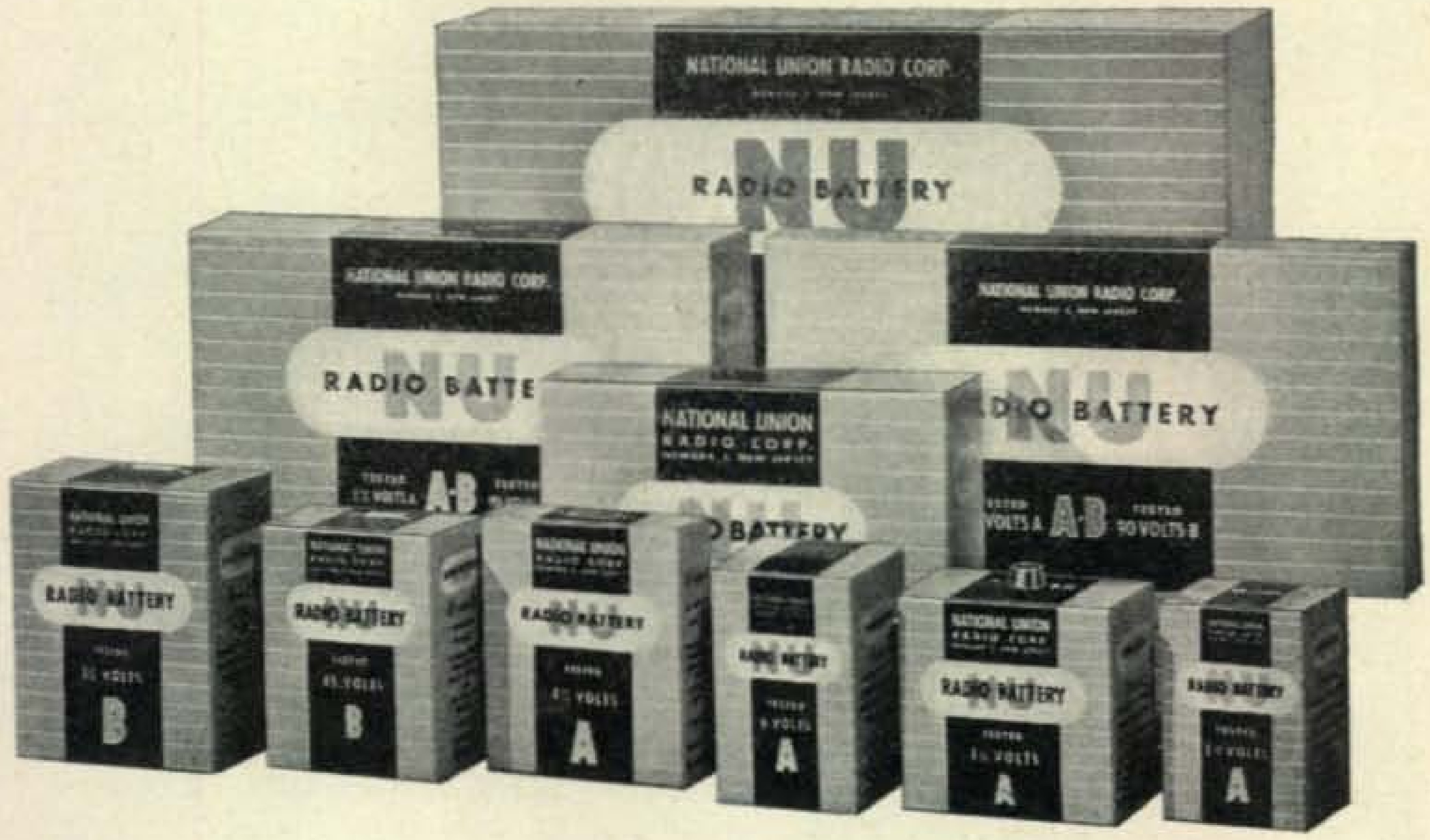

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RADIO AMATEUR'S WORKSHEET

No. 9 THERMAL AGITATION; PUSH-PULL OSCILLATION

THERMAL AGITATION

THERMAL AGITATION or thermal noise is due to the random movement of electrons in electrical conductors. Since any disturbance originating in the antenna tuned circuits of a sensitive radio will be amplified by the entire receiver, it is evident that such disturbances must establish a very definite usable limit on the amplification of any receiver or amplifier. The equivalent voltage set up in an electrical conductor by thermal agitation is proportional to the square root of the acceptance transmission band of the receiver or amplifier; to the square root of the resonance impedance of the first tuned circuit if one is used, and to the square root of the absolute temperature. The resonance impedance of a tuned circuit (see *Fig. 1*) is:

$$Z=\frac{L}{CR}$$

Absolute temperature is based on the centigrade scale and is zero at minus 273 degrees centigrade. Under normal conditions, the thermal agitation voltage in a broadcast receiver is about 2 microvolts.

Thermal agitation actually consists of a series of pulses and the noise energy is about evenly distributed from the lowest audio frequencies to the highest radio frequencies. Therefore a 10-kc band will admit about the same amount of thermal noise *regardless of frequency*—temperature and impedance being the same.

Since a good signal-to-noise ratio is a prime requisite in the design of radio receivers, every

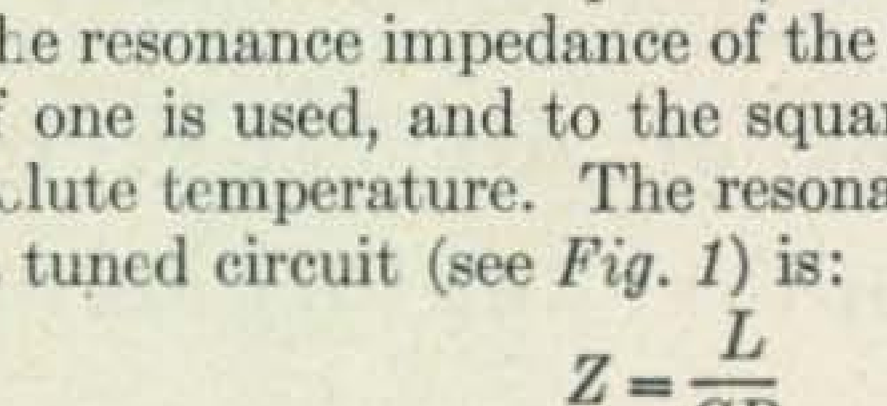

Fig. 1

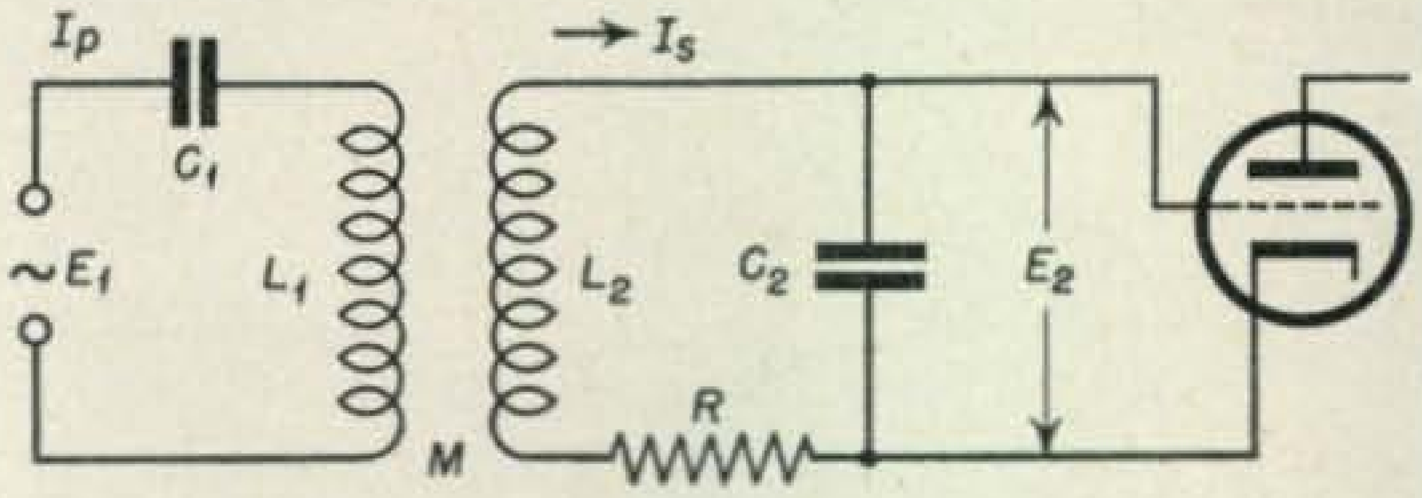

Fig. 2

effort is usually made to absorb as much of the antenna signal voltage as possible, consistent with practical considerations. Consequently the voltage step-up, from antenna to the grid of the first tube should be as high as possible. Best results would of course be obtained if the antenna were tuned and efficiently coupled to the grid of the first tube. Antenna voltage step-up is directly proportional to resonance impedance—but the higher the resonance impedance, the sharper the selectivity.

In this connection it is interesting to determine the expression for antenna voltage step-up in the first tuned circuit of a radio receiver. Diagram *Fig. 2* shows a conventional antenna stage schematically. In this case we have:

$$I_P=\frac{E_1}{\omega L_1-\frac{1}{\omega C_1}}$$

$$I_s=\frac{\omega M I_P}{R}$$

$$E_2=\frac{I_s}{\omega C_2}=\frac{\omega M I_s}{R\omega C_2}=\frac{\omega^2 M E_1 C_1}{R\omega C_2(\omega^2 L_1 C_1-1)}$$

But— $$Q=\frac{R}{\omega L_2}=R\omega C_2$$

Thus— $$E_2=\frac{\omega^2 M C_1 E_1 Q}{\omega^2 L_1 C_1-1}$$

$$\frac{E_2}{E_1}=\frac{MQ\omega^2 C_1}{\omega^2 L_1 C_1-1}$$

This is the usual equation for antenna voltage

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Amplification Factor	65
Mutual Conductance	2750
Grid to Plate Capacity	.2 MMF
Input Capacity	6.5 MMF
Output Capacity	1.8 MMF

4 Prong UX Base—Plate Lead at Top
Size: 4-7/8" by 1-5/8" Maximum

TYPICAL OPERATION

D.C. Plate Volts	1500
D.C. Plate Current	110 MA
D.C. Control Grid Volts	— 300
D.C. Control Grid Current	15 MA
D.C. Screen Grid Volts	375
D.C. Screen Grid Current	22 MA
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step-up. For low impedance primaries $\omega^2 L_1 C_1$ is usually so small that it may be neglected. The voltage step-up varies as the square of the frequency. This is one of the defects of low impedance primaries.

PUSH-PULL OSCILLATION

It sometimes happens that push-pull audio amplifiers will oscillate at frequencies near the upper edge of the band they are designed to amplify or at some still higher frequency. Thus an amplifier designed with a flat response characteristic from 30 to 10,000 cycles per second may oscillate near 10,000 or 12,000 cycles, due to resonance between the leakage reactance of the input transformer and the input capacitances of the tubes. In order for the amplifier to oscillate

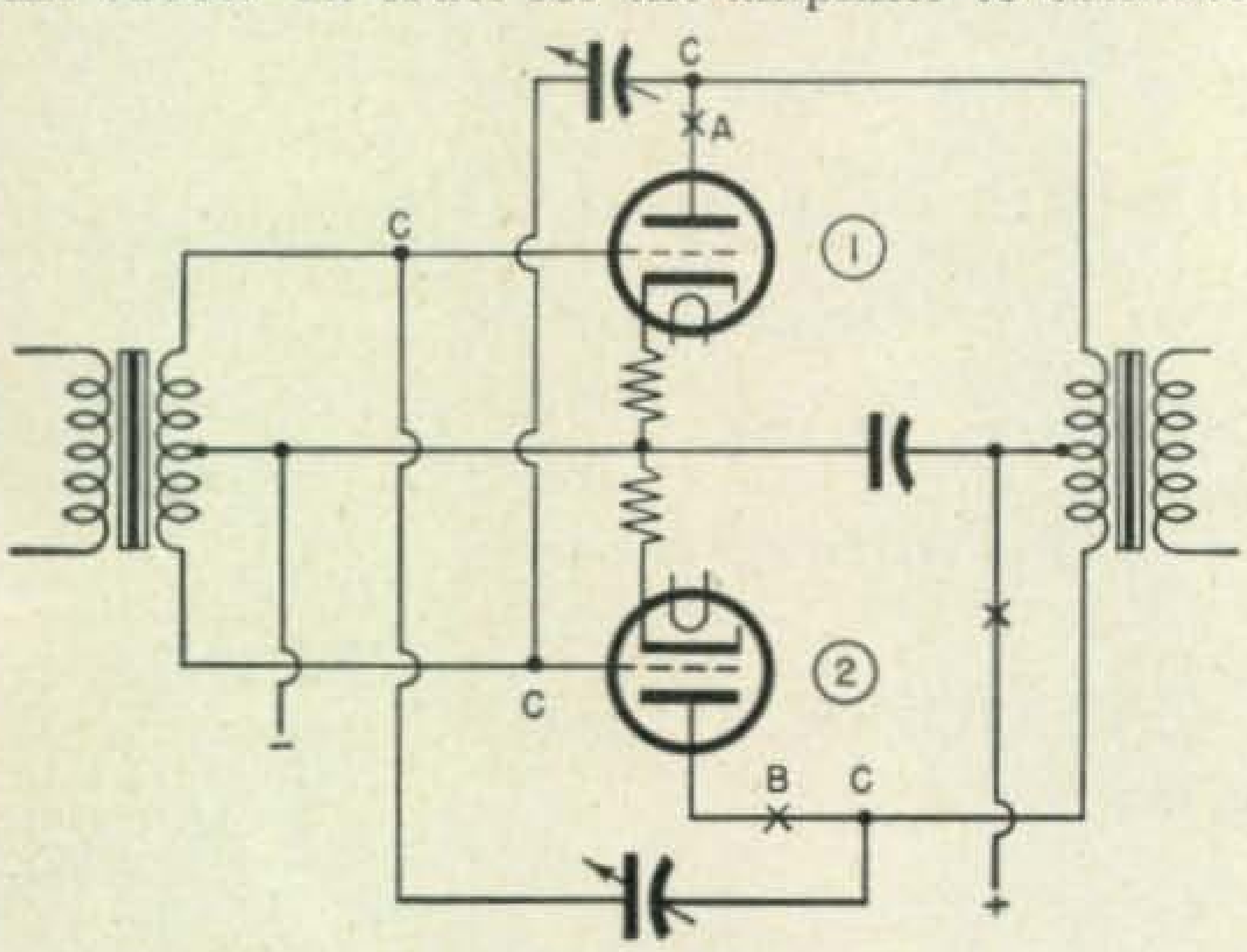

Figure 3

the output transformer must also have appreciable leakage reactance. The coupling between plate and grid circuits is normally through the capacitance between plate and grid of each tube.

This type of oscillation can be eliminated in exactly the same manner that similar oscillations are controlled in the power stages of radio transmitters—that is by neutralization. Diagram *Fig. 3* shows in schematic form a neutralized push-pull amplifier. Neutralization is accomplished by small cross-connected variable capacitors. The neutralization procedure is as follows:

1. Temporarily disconnect the plate voltage supply and open the plate circuit of tube *1* at *A*.
2. Connect a small variable capacitor having a maximum capacitance slightly larger than the grid-to-plate capacitance of the tube between point *C* and the grid of tube *2* as shown in *Fig. 3*.
3. Connect a pair of high-impedance headphones across the output transformer and adjust the variable capacitor until no signal is heard. It is necessary during this procedure to supply a signal of normal level to the amplifier—a tone being preferable.
4. If a sharp minimum cannot be found, adjust

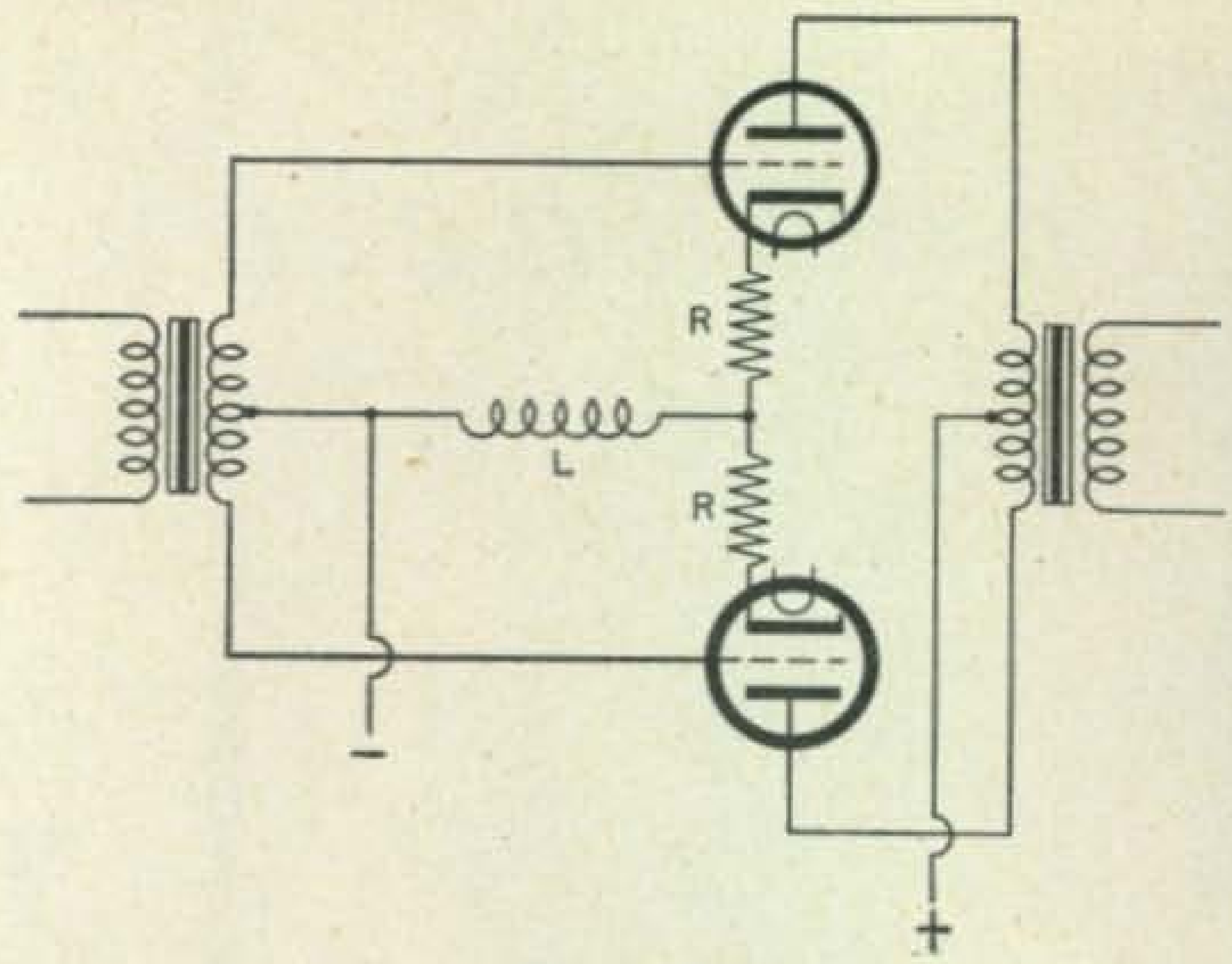

Figure 4

the capacitor midway between the two points at which the signal is barely audible.
5. Close the plate circuit of tube *1* at *A* and repeat the procedure for tube *2*, disconnecting the plate circuit of tube *2* at point *B* and connecting another variable capacitor as shown.

After the amplifier is neutralized and plate voltage again applied at point *X*, it may be necessary to readjust both neutralizing capacitors slightly if oscillation still persists.

Another method of preventing high frequency oscillation in push-pull amplifiers, is the use of a low resistance choke-coil (50 to 100 millihenrys inductance) as a common circuit element in the grid return. This is illustrated schematically in *Fig. 4*.

The resistance of the choke must be taken into consideration since it carries the combined plate current of both tubes and thus adds to grid bias. If the d-c resistance of the choke-coil is small compared to bias resistors *R* it will have a negligible effect on bias. If a choke of the proper resistance is available it may be used as the grid bias member, or if incorrect, in combination with a single resistor of the proper size as shown in *Fig. 5*. Such a choke-coil, while effectively preventing high-frequency oscillation, will not alter the high-frequency characteristics of the amplifier.

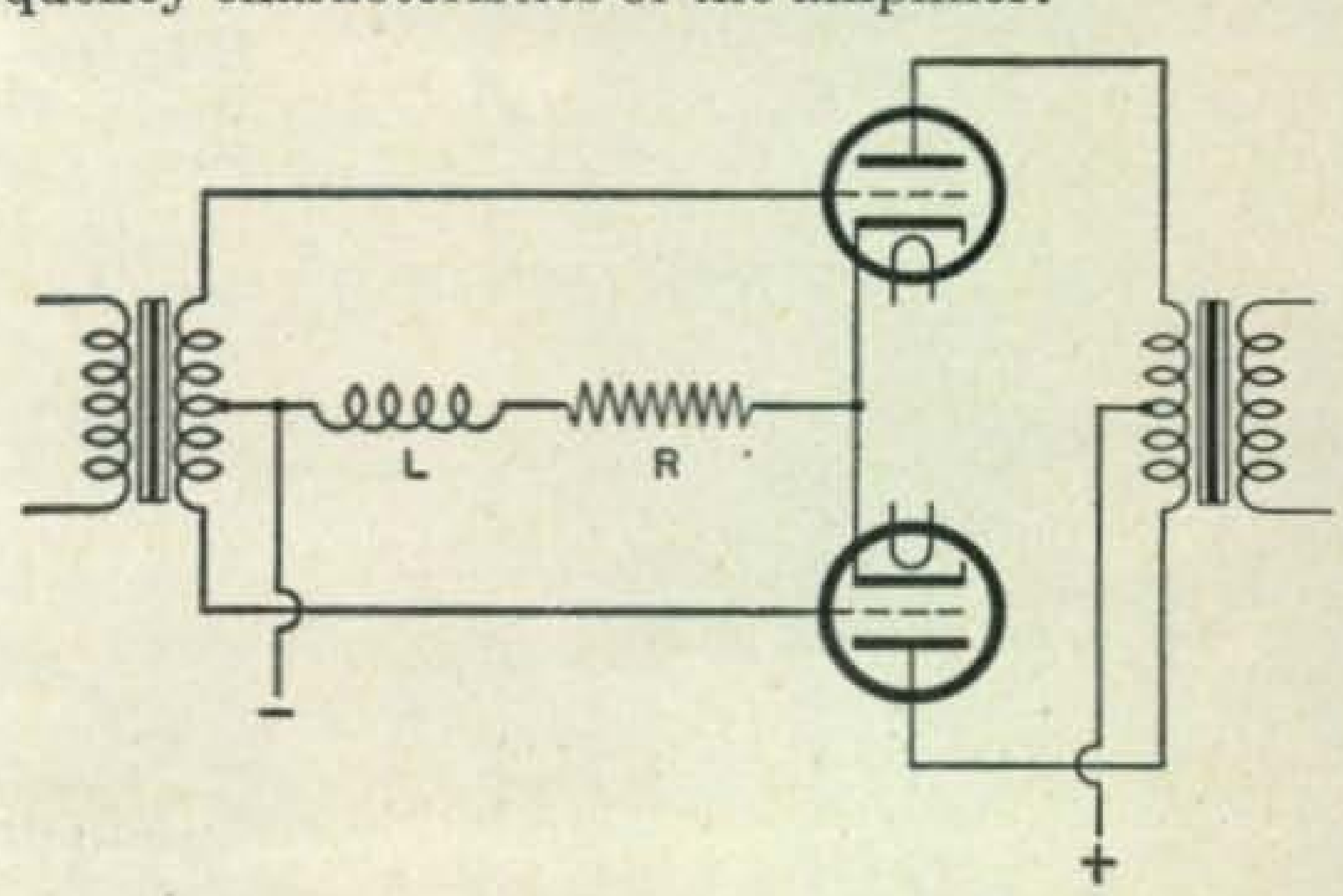

Figure 5

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INSIDE THE VACUUM TUBE, BY JOHN F. RIDER. PUBLISHED BY JOHN F. RIDER, PUBLISHER, INC., 404 FOURTH AVE., NEW YORK 16, N. Y. 424 PAGES, 8 5/8 x 5 3/8 INCHES. PRICE $4.50.

This text on vacuum tubes represents a new and interesting departure from the conventional treatment of the subject. It has been written to provide a firm foundation of elementary vacuum tube operation so that students may proceed to more advanced texts with a clear conception of what goes on in tubes. The author has presented the theory through a discussion of electrostatic fields, and this difficult approach is made interesting and understandable to the student by means of unusual drawings and captions, and simply written text. Thus the usual dry and unpalatable physical discussions have been avoided, yet an accurate presentation of electron physics pertaining to vacuum tube operation is adduced. After these fundamentals have been firmly established, the characteristics and functions of tubes are discussed along more conventional lines.

The book consists of 15 chapters and an appendix giving general plate voltage-plate current characteristic curves, with a typical load line for triodes, tetrodes, and pentodes, as well as a complete list of letter symbols used in vacuum-tube circuit analysis. The first four chapters deal with electrons, electron emission, movement of charges, space charge and plate current. A discussion of the fundamentals of tube characteristics follows, then diode and triode structures and operation are covered and dynamic characteristics analyzed. Voltage and power amplifiers, cathode circuits and miscellaneous vacuum tubes are treated in other chapters.

Three anaglyphs, which show in three-dimensional form-pictures that convey more clearly ideas otherwise difficult to understand, are another feature of this book.

Mathematical formulae are given, and where their comprehension requires a knowledge of advanced math, simple numerical examples are presented and explained in a way which makes the presentation clear to those who possess only an elementary knowledge of the subject. Even algebraic equations are interpreted in terms of simple arithmetic. Illustrations of vacuum tube applications in amplifier circuits are based on practical examples encountered in radio design.

The author has done a characteristically thorough job on this book and *CQ* has no hesitancy in recommending it as an excellent elementary text on the subject.

ELECTRONIC DICTIONARY, BY NELSON M. COOKE AND JOHN MARCUS, PUBLISHED BY MCGRAW-HILL BOOK CO., NEW YORK, 433 PAGES, LEATHERETTE BINDING, $5.00.

The field of electronics embraces that branch of science which concerns itself with the conduction of electricity through gases or vacuum. Practical applications include radio communications, wire line telephones and telegraph facilities, television, facsimile, radio navigation, radar, industrial control, etc. The majority of these are highly technical in nature and the field is rapidly expanding. As a result, the radio engineer's vocabulary contains hundreds of terms, many of which are not included even in the latest unabridged dictionaries. Rapid growth of electronics during the war has resulted in groups of engineers employing different colloquialisms for the same or similar terms. It is therefore timely that a dictionary of technical terms is published.

This book defines some 6,000 electronic terms in simple style. No mathematics is used although it is this reviewer's impression that a few simple equations would have served a useful purpose in clarifying and adequately defining some of the definitions. The book is well illustrated averaging several figures per page. Many terms, although originally company trade-marks, have been popularized to the extent that they are now considered general usage and these are likewise defined.

A.S.A. standards of abbreviaton and hyphenating are used throughout the text. This book appears to cover its field fully and to contain at least most of the generally useful electronic terms. It is highly recommended for the book-shelf of every communications engineer.

ELEMENTARY ENGINEERING ELECTRONICS, BY ANDREW W. KRAMER, PUBLISHED BY THE INSTRUMENTS PUBLISHING CO., INC., PITTSBURG, PA., 340 PAGES, CLOTH BINDING.

The material in this book originally appeared as a series of articles published in *Power Plant Engineering*. The author explains in simple language and with the use of elementary mathematics, fundamental principles of electron tubes and their applications in industry. The text is particularly directed toward instrumentation.

[*Continued on page 47*]

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Parts and Products . . .

IMPROVED 833A HIGH-POWER TRIODE

An improved 833A transmitting triode in the high-power classification is announced by Taylor Tubes. Similar in almost every respect to the conventional 833, the 833A contains a zirconium-coated anode with the coating sprayed only on that part of the plate which is most subject to heat during operation.

Maximum signal outputs are: as Class B modulators (pair)—2,700 watts; as r-f Class B amplifier, telephony—250 watts; radio-frequency Class C amplifier, plate-modulated—1500 watts; and as r-f Class C amplifier, telegraphy—1600 watts.

Physical dimensions: Diameter—4-19/32" max.; Height—8-5/8". Grid and plate caps at top: 5/8" long by .567" diameter. Two filament caps at bottom: each 1-3/32" long by 3/8" diameter.

Electrical characteristics: Filament (thoriated tungsten) 10 v. (a.c. or d.c.) at 10 amperes. Amplification factor: 10. Interelectrode capacitances: G-F 12.3 $\mu\mu$f; G-P 6.3 $\mu\mu$f; P-F 8.5 $\mu\mu$f.

Typical key-down conditions per tube, Class C, r-f amplifier and oscillator: (ICAS ratings with forced air cooling) d-c plate volts—4,000 v.; d-c volts—minus 225 v.; peak radio-frequency grid voltage—415 v.; direct plate current—0.5 amps; d-c grid current—95 ma (approx.); driving power—35 watts; power output—1600 watts; highest frequency for maximum ratings—20 magacycles.—*CQ, February, 1946.*

Improved 833A High-Power Triode

NEW NATIONAL RECEIVER

W. A. Ready, president of the National Company of Malden, Mass., announces a new receiver, the NC-46. The NC-46, a 10 tube superheterodyne combining capable performance with low price, is described as a marked improvement over the NC-45 models which National built before the war.

Special features include a series valve noise limiter with automatic threshold control, c.w. oscillator, separate r-f and a-f gain controls, and amplified and delayed a.v.c. Power supplies are self-contained and operate on 105 to 130

[*Continued on page 45*]

National NC-46 Receiver

ELECTRON GUN

[*from page 29*]

also reversed in polarity and thus its function is to blank out (cancel) the retrace beam on the fluorescent screen. In an oscilloscope this signal is known as the Z axis. The horizontal and vertical plates are called the X and Y F.C. axes, respectively. By operating the grid at a variable voltage with respect to the cathode, it controls the intensity of the electron beam striking the fluorescent screen. It is sometimes referred to as the intensity grid.

Screen Grid

The cathode cylinder is mounted inside the grid collar with the emitting surface facing the aperture in the grid. The spacing of the cathode surface from the grid is very critical and should be maintained within +.001″. Some cathode ray tubes have an additional electrode called the screen grid consisting of an aperture disk placed between the control grid and the first anode. Its potential is lower than that of the first anode—generally in the order of 100 volts, which makes the total current drawn from the cathode almost independent of the first anode potential. Tubes containing this grid are known as screen-grid cathode-ray tubes.

The first or focusing anode, placed next to the grid, is a metal cylinder closed with a disk at the bottom end facing the grid. An aperture at the center allows the electron stream to pass through on its way to the screen. The cylinder and aperture are concentric and coaxial with the control grid within a tolerance of .002″. The planes of the grid, first and second anodes must be as closely parallel with each other and as near an angle of 90 degrees to the axis of the tube as is possible. The cathode, control grid and first anode comprise what is known as the first electron lens of the gun structure (*Fig. 1*). The cathode and heater are detailed in *Fig. 2*. The portion of the control grid extending beyond the edge of the disk is important from the control characteristic considerations.

Electron Acceleration

The first anode imparts the initial acceleration to the electron beam, and generally contains several aperture disks spaced at intervals along the length of the cylinder. These apertures confine the beam to a comparatively narrow angle. The first anode is operated at a positive potential with respect to the cathode and therefore attracts electrons from the cathode through these apertures. The voltage on the first anode for the best focus is usually about ¼ or 1/5 of that of the second anode. The focusing anode tends to concentrate the electron stream into a narrow beam

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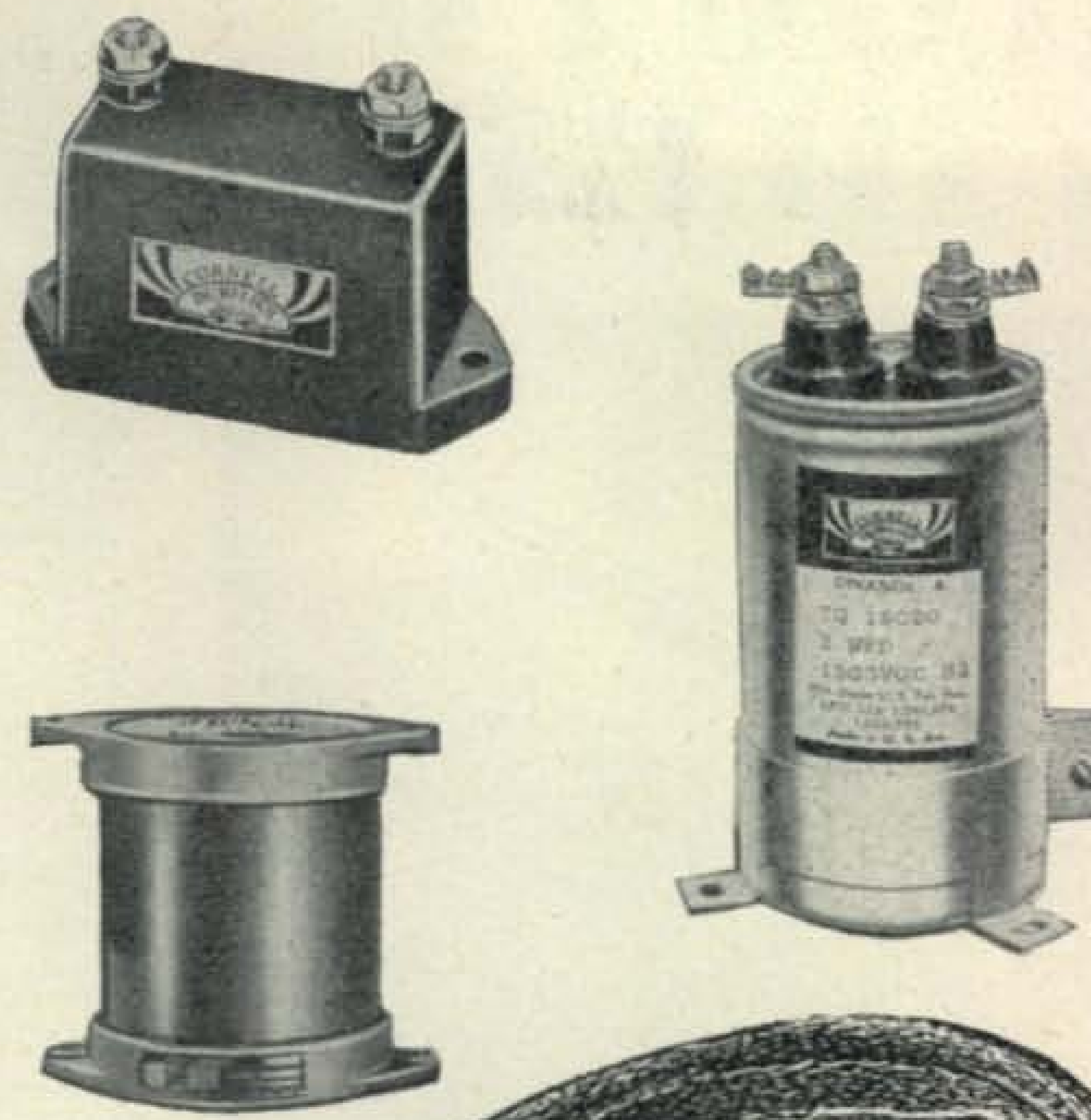

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similar to the manner in which an optical lens system focuses a beam of light.

The second anode is a slightly larger cylinder closed at the farther end from the focusing anode with an aperture disk, and is placed between the first anode and the deflection plates, coaxial with the first anode, and just overlapping the edge of the first anode. This larger anode is also connected to a metallized and conductive colloidal graphite coating applied to the inner walls of the

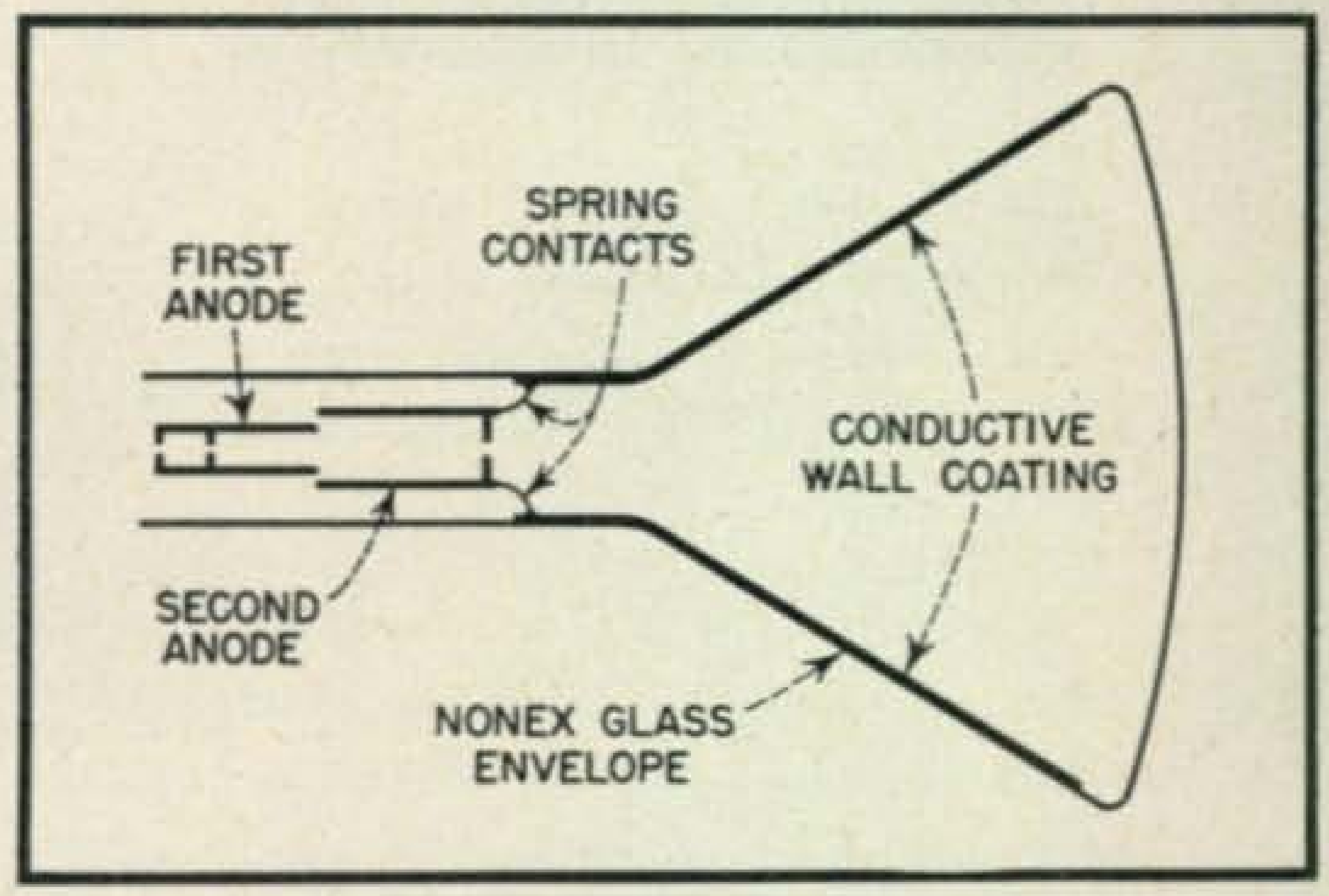


Fig. 3. Spring contacts connect the second anode to the colloidal graphite coating on the inner wall of the tube

nonex glass envelope (*Fig. 3*). Spring contacts connect the second anode cylinder with the wall coating. This anode is maintained at a high positive potential (several thousand volts) and is sometimes called the accelerating grid as it gives the electrons their final spurt on their way to the fluorescent screen. The second anode is the second electron lens within the tube.

All the components thus far described are insulated from each other by means of glass support collars and rigidly mounted to keep their planes near 90 degrees to the tube axis.

Deflection Plates

After leaving the second anode the electron beam passes through two pairs of deflection plates as shown in *Fig. 4*. The first pair are the vertical plates and have the greatest deflection sensitivity. The next pair, closer to the screen, with slightly less deflection sensitivity, are the horizontal plates. Deflection sensitivity can be

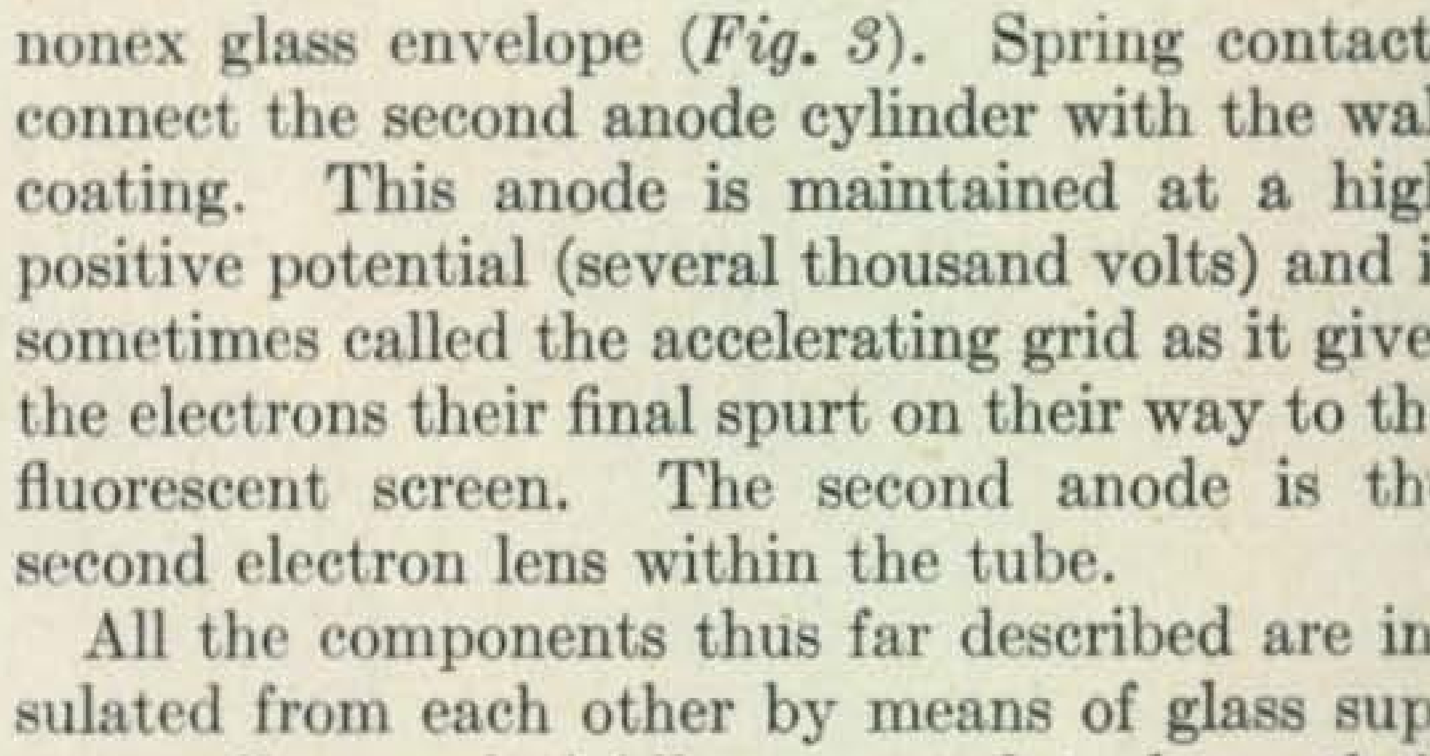
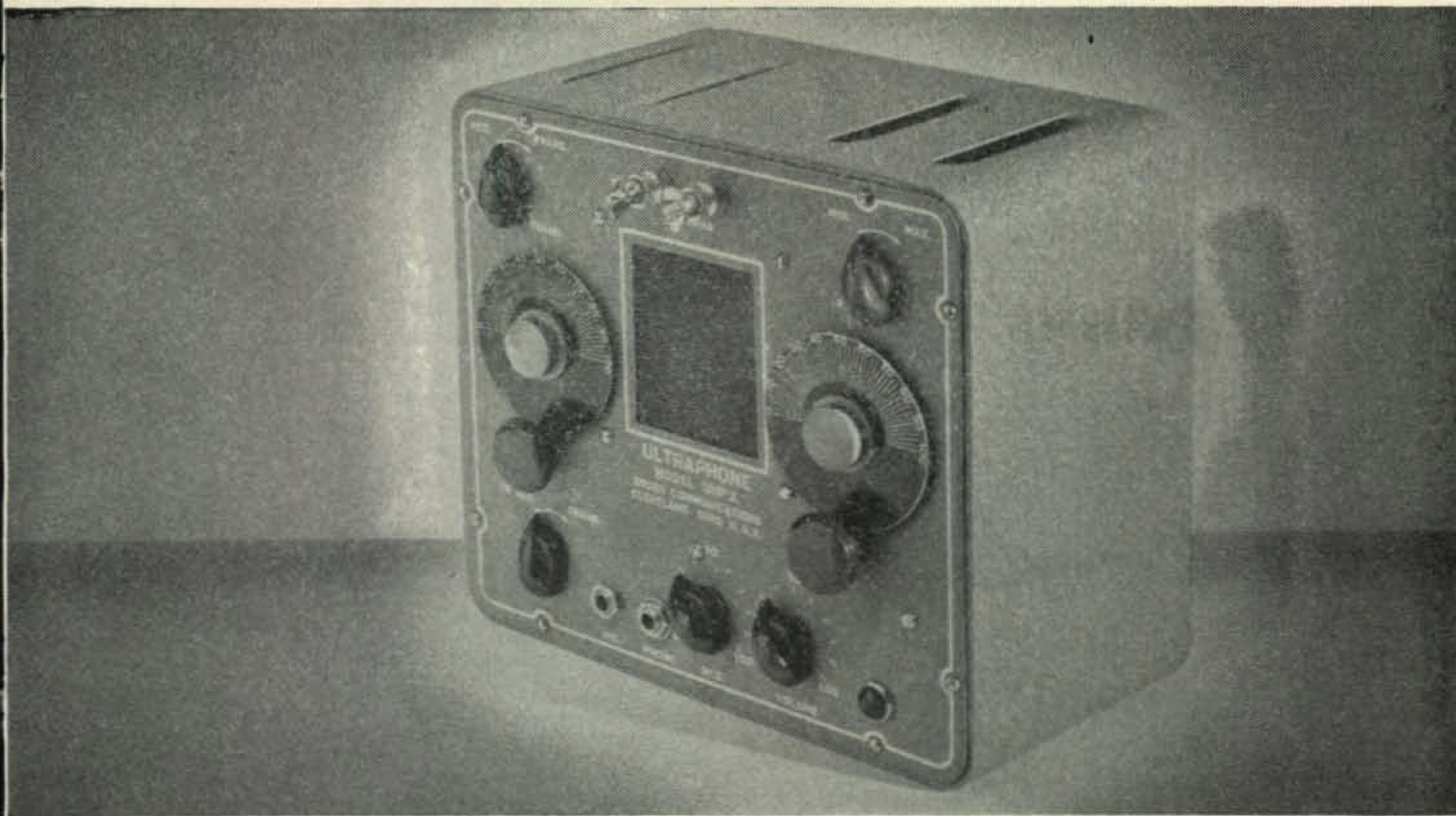


Fig. 4. Showing horizontal and vertical deflection plates which control the electron beam



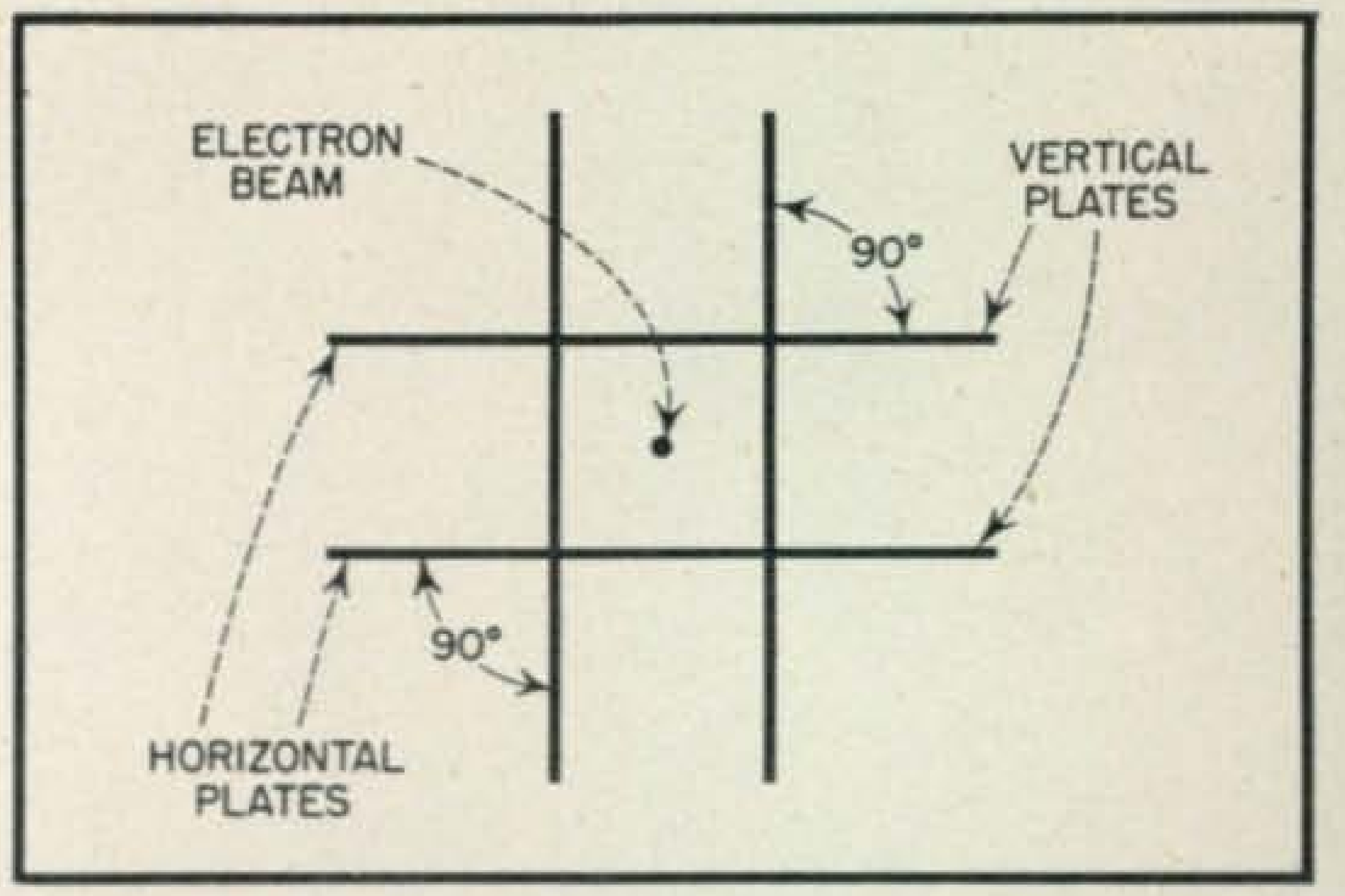


Fig. 5. Deflection plate angles as viewed from the screen end of the CR tube

increased by making the plates parallel for part of their length, and divergent for the remainder.

The deflection plates must be solidly and accurately mounted and placed at a 90 degree angle (±2 degrees) with respect to each other. The center of the square (or rectangle) bounded by the inner surface of both pairs of plates are coaxial with anode and grid structure in order to prevent beam cut-off (*Fig. 5*). The cathode-ray tube with the complete gun assembly is shown in *Fig. 6*. This design is known as the electrostatic deflection type. When deflection plates are

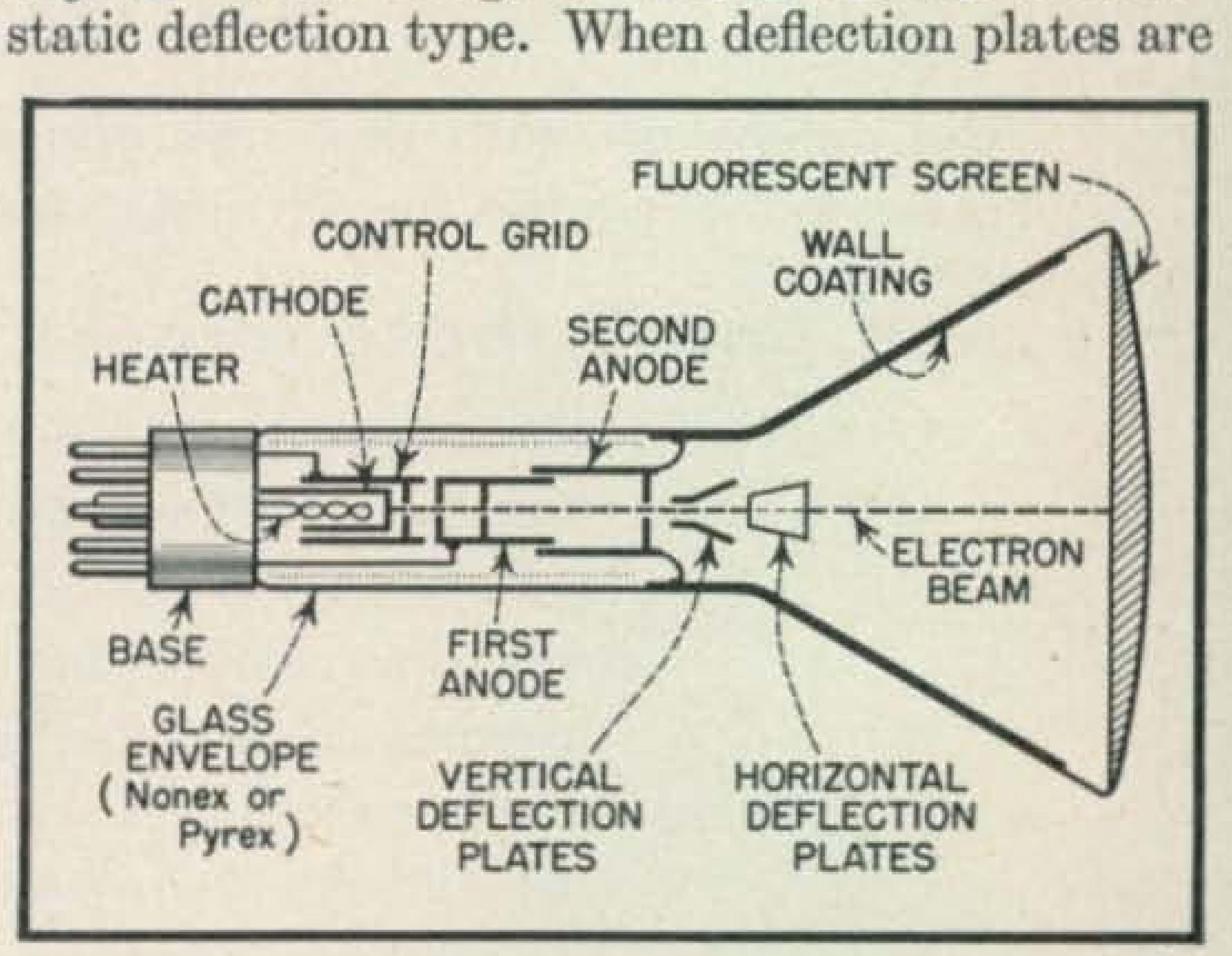


Fig. 6. Complete diagrammatic sketch of the cathode-ray tube

omitted, coils are placed around the neck of the tube just beyond the end of the electron gun and the tube is described as having magnetic deflection. Electrostatic deflection employs voltage for deflection while the magnetic type requires current to accomplish the same effect.

Magnetic Focusing

Electromagnetic focusing substitutes a coil around the neck (*Fig. 7*) of the tube in place of the usual first and second anode cylinders. A field produced by direct current flowing through the coil concentrates the electron stream. The point of convergence can be varied by adjusting either the current in the coil or its position along the neck of the tube. Excellent focusing is ob-

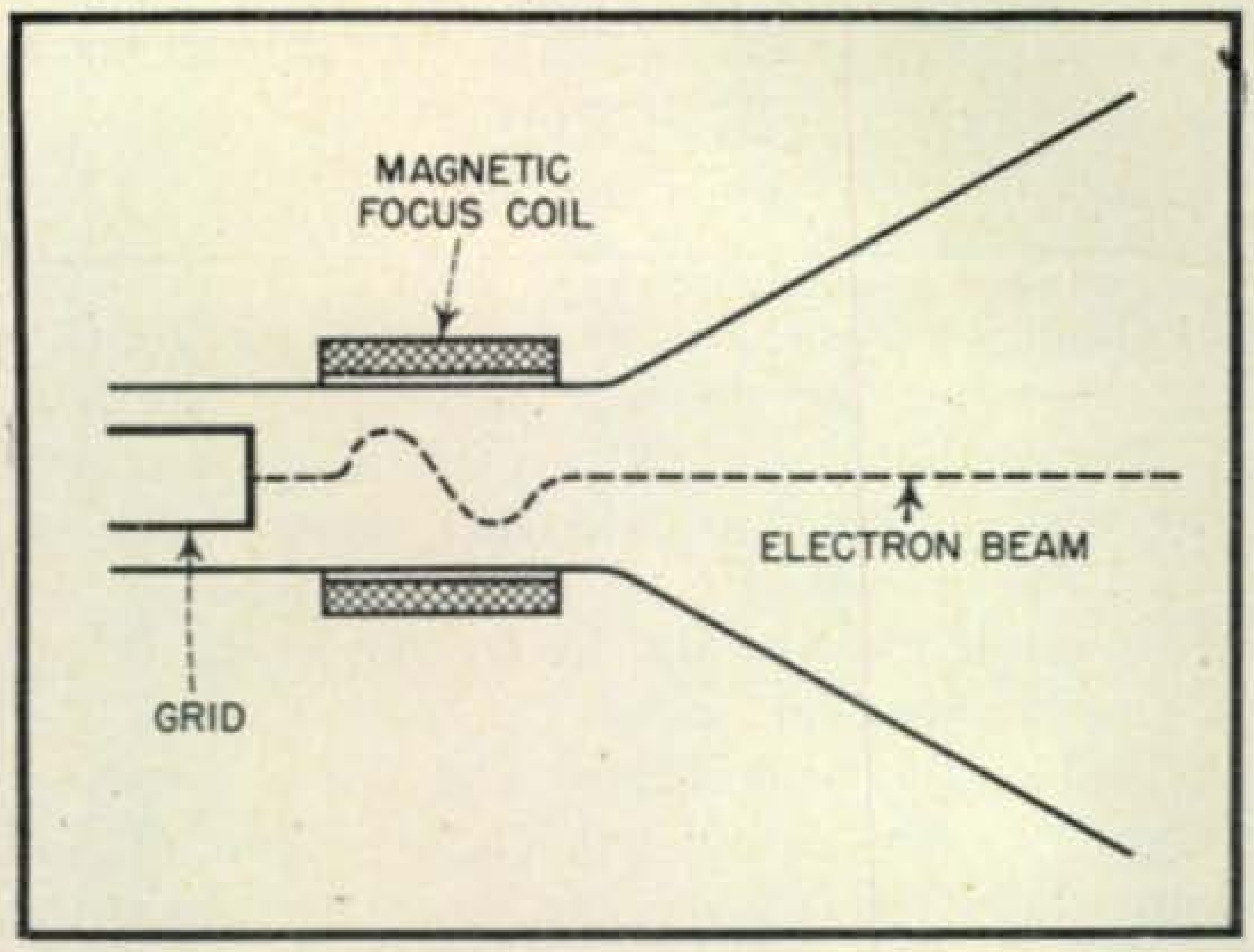


Fig. 7. Magnetic focusing can be employed instead of electrostatic plates

tainable but inconvenience occurs in the mounting and supplying the coil with a steady direct current. All internal focusing electrodes are eliminated. The axis of the focusing coil corresponds with the axis of the focusing system, and the lines of magnetic force produced by it are uniformly distributed.

A small disk or cup is located near the control grid inside the tube in which the getter is placed. The getter is pure barium and is used to reduce pressure in the tube and to eliminate carbon dioxide which is added when the tube is tipped off. Spring leaves which grip the glass neck of the tube to support the electron gun mount are placed along the edge of the second anode cylinder.

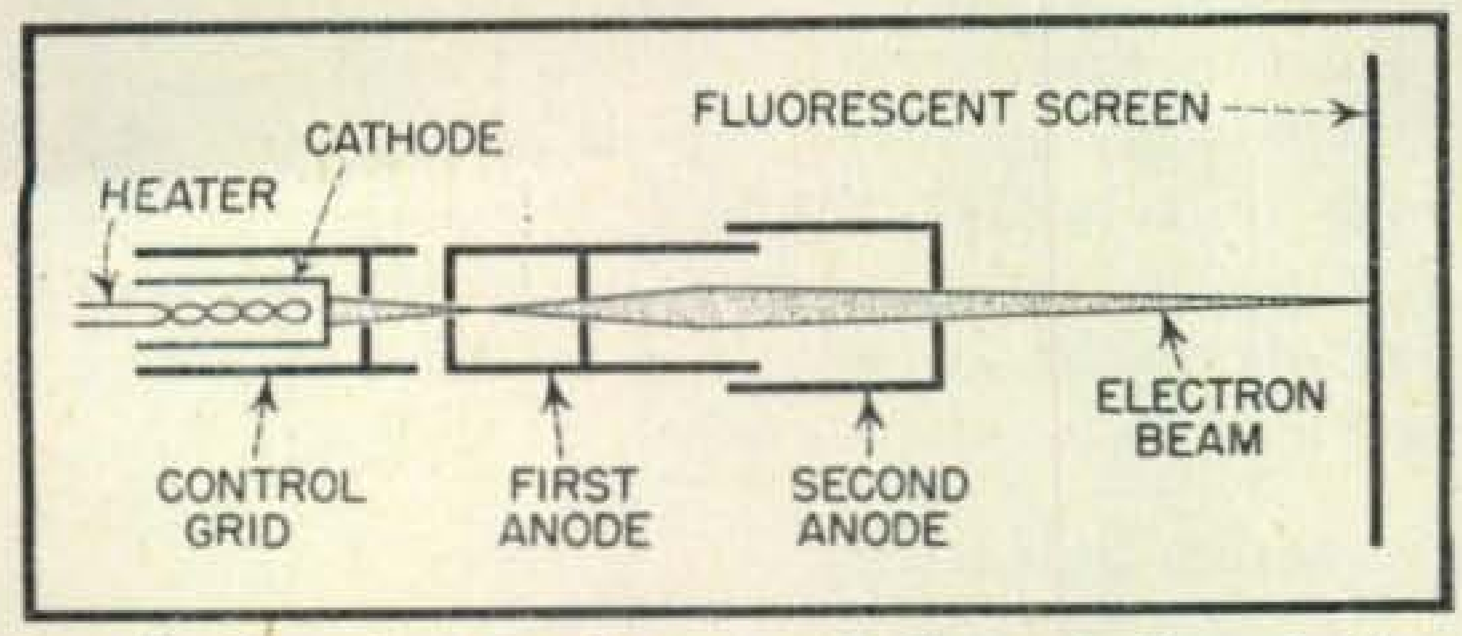


Fig. 8. Showing the beam path through the electron gun

PARTS AND PRODUCTS

[from page 38]

volts, a.c. or d.c. An increased audio output of 4 watts is provided by push-pull 25L6s.

A straight-line-frequency capacitor is used in conjunction with a separate spread condenser. This combination plus the full vision dial calibrated in frequency for each range covered and a separate linear scale for the band-spread capacitor, makes accurate tuning easy. Both capacitors have inertia-type drive. A coil switch, with silver-plated contacts, selects the four ranges from 550 kc to 30 mc. Provision is made for either headphones or speaker. The gray, metal cabinet is styled along modernistic lines with matching speaker available.—*CQ, February, 1946.*

SUPERHET

[*from page 22*]

amplifier tubes is obtained by drilling another $\frac{1}{4}''$ hole through the top of the sub-base, next to the oscillator socket filament connecter and inserting another National feed through bushing.

4. The variable condenser, coil and socket are mounted as shown in the template (Code A and B) drawing.

With the local oscillator and buffer amplifier assembly now completed on one side of the main buffer shield, we are ready to place the tuned r-f stages on the other side of the main shield. By tuning both the grid and plate circuits of the second stage, maximum efficiency and selectivity is obtained. Remember too much emphasis cannot be placed on the fact that all ground returns must go to a common chassis point as near as possible to the tube socket which in this case is one inch from the cathode prong of the second r-f socket. A single #6-32 screw is carried through the shield separating grid from plate circuits in order to return the grid circuit to the same common ground point. When the hole is drilled through shield No. 2 for the acorn tube control grid prong to pass through, it must be kept as small as possible for proper isolation between the tuned grid and plate circuits.

Details of the r-f and mixer circuits are shown in *Fig. 1*.

It was found necessary to incorporate an r-f gain control (25,000 ohm) in the cathode circuits of the two r-f stages because the additional gain increased the tendency of the first detector to block on strong signals.

Increased Selectivity

For ten meter operation selectivity of the first r-f stage is greatly improved by replacing the mixer plate circuit resistor with a tuned circuit. Wind sixteen turns of No. 30 enameled or DCC covered wire $\frac{1}{2}''$ up on the insulated rod from the first i-f grid coil already wound on it. Tuning is done with a 30 $\mu\mu f$ adjustable mica padding condenser.

Still further i-f selectivity can be obtained by increasing the first, second, third, and fourth i-f tube plate circuit resistors to 15,000 ohm (1 watt) and putting cathode bias (300 ohm bypassed with .1 μf) in each i-f stage. Tuning the plate of the first i-f transformer will usually give sufficient selectivity except in extreme interference areas.

While it is not essential, the addition of a Faraday shield removes all traces of capacitive coupling between the antenna input and grid coils and helps to reduce extraneous noises on a balanced line. The usual difficult construction of the Faraday shield if completely eliminated by using one of the midget 40 meter tank circuit such as the type 40 JEL made by Barker-Williamson. It is easily adapted to this use by cutting it through from one end to the other, flattening it out and connecting all the wires in one end to a heavy No. 12 ground wire. Make sure all the wires in the other end are free and not shorting.

Since the circuit employed is conventional and almost all of the components come with the BC406 receiver, additional expenditures are kept to a minimum. Results are gratifying and it is well worth the effort involved.

ADDITIONAL PARTS FOR CONVERSION

- C_1,C_2,C_3—15 μf, 3 plate condensers (Cardwell 2-15-AS).
- C_4—30 μμf padding condenser (National M30).
- L_1—2 turns #14 tinned copper wire 1¼" dia. over ground end of coil.
- L_2,L_3—RF coils, 13 turns. #16 wire ¾" dia. spaced with #28 drill.
- L_4—Antenna coil, 2 turns #16 wire, 1¾" dia. at ground end.
- L_5—Oscillator coil, 12 turns #16 wire 5/8" dia. spaced with #32 drill.
- R_1,R_2—2000 ohm, ½ watt.
- R_3—25,000 ohm volume control.
- RFC_1, RFC_2—(National R 100).
- 1—300 ohm, ½ watt resistor.
- 1—1 megohm, 1 watt resistor.
- 2—Feed-through bushings.
- 3—Insulated flexible couplings.
- 4—Straight line sockets (National XB16).
- 4—Socket plug bases (National PB16).
- Six inches of bakelite rod.

(Parts shown are those actually used. Others of equivalent performance may be substituted.)

BOOK MARKS

[*from page 47*]

Although the author states in his preface, that the book is directed to electrical and mechanical engineers and operators in industrial establishments, the text can be readily understood by anyone with a working knowledge of practical electricity.

The text explains in simple terms how electron tubes function and how their characteristics may be adapted to industrial use. It begins with a simple explanation of the nature of electricity and proceeds to explain the action of the common types of tubes in commercial use. The liberal use of mechanical and hydraulic analogies is employed to explain tube characteristics.

There are 24 chapters with 259 illustrations and a 6 page index. Some of the material covered includes: The Two-element Tube, Triode Amplifiers, Ionization, Thyratrons, Oscillators, Neutralization, Tetrodes, Pentodes, Phototubes, Electromagnetic Radiation, Photovoltaic Cell, Dynatrons, Mercury Arc Rectifiers, Cold Cathode Tubes, and Cathode Ray Tubes.

The concluding chapter, which deals with feedback, is particularly well done although somewhat brief. There are several references and citations but it is this reviewer's opinion that a more elaborate bibliography would have been appreciated by many readers. It is seldom indeed that the reader of elementary texts is not interested in some particular aspect of a book which he might wish to pursue farther. Here, a comprehensive bibliogrpahy can be most helpful.

This book is written in an interesting and easily readable style. It is practical and up to date and appears to be free of errors. The material is presented in logical sequence, and in each case the principle of action is clearly explained before a discussion of application is attempted. It is highly recommended to any reader interested in the particular field it covers.

FCC

[*from page 30*]

evidence for prosecuting violators of the 1934 Communications Act. The machinery to perform this function is manned by radio engineers and operators, about seventy percent of whom were or are licensed amateurs themselves. They understand the amateur's problems thoroughly and personally resent illegal operators availing themselves of the privileges earned by the amateur when he receives his license. With the increased congestion expected in all the amateur bands as a result of the tremendous impetus provided by World War II, there will be little enough room for the legitimate operator without the interference caused by bootleggers.

To locate stations engaged in the transmission of espionage traffic before and during the war, the Commission operated a group of long-range direction-finder stations equipped with Adcock antennas. Beam antennas were employed in the reception of weak signals from all parts of the world. Accurate frequency measurement equipment, as well as other specialized apparatus developed by the FCC, completed the set-up. Monitoring stations were located throughout the country, its territories and possessions, manned by trained personnel, who were able to trace the source of radio emissions to the exact point of origination—even a room in an apartment house. This network has now been reconverted to peace and the illegal operator in the amateur bands is one of those problems which may demand a great deal of attention. Many illegal operators have been spotted since the opening of various amateur bands, and approximately four hundred were located during World War II.

Radio Sleuthing

When an illegal operator transmits on any frequency, he may be heard at any one or several of the Commission's monitoring stations. The interception is flashed by teletype or radio to other monitors which immediately take bearings on the suspected signal and transmit their readings to Washington where they are plotted. The Commission's Washington office then notifies the monitoring station nearest to the fix, which sends out one or more mobile units to make an exact determination of the station's location. Freguently, the interception is made first by the nearest monitoring station, and in that case the mobile units are dispatched immediately without disturbing the long-range stations, and the entire matter is handled on the spot.

During the war, an operator was arrested in New York City for operating illegally on frequencies between 112 and 116 mc and interfering with WERS communications. The signals were first intercepted by the FCC monitoring station in New Jersey, and bearings indicated that the station was in Brooklyn. The New York City monitor was alerted and joined the hunt. Bearings and other methods of determination located the station in a first-floor apartment in Brooklyn, N. Y. A warrant was obtained and the operator arrested while operating his equipment in violation of the Communications Act. During the trial, the judge remarked that the amazing thing (to him) was that the Federal Communications Commission could first hear the signals in New Jersey and then trace them to the exact apartment in Brooklyn. That is the job of the FCC sleuths.

Range No Factor

Illegal operators sometimes claim that, operating with very low power on ultra-high frequencies, their transmissions are limited in range —i.e., they are not of inter-state character and therefor not subject to FCC regulation. A careful interpretation of the Communications Act of 1934 shows that signals do not actually have to be heard in another state to establish interstate evidence. The courts have held that radio is, by its very nature, interstate in character.

Recently the operator of an illegal station was arrested in Malden, Massachusetts, transmitting in the amateur band. He had been arrested in 1941 for the same offense and was therefore a second offender. Licensed operators, who knew of his activities, reported him to the Federal Communications Commission, and appropriate action was taken. Just because a person may live in a community where no FCC monitoring station is located does not insure that he will escape detection. The Federal Communications Commission mobile units are continually patrolling the country, stopping in cities to observe local activities, and listening from vantage points for unlicensed stations. They don't telegraph an advance warning. When the operator throws the switch, he never knows who may be listening to his station and a proper license certainly makes it much more pleasant all around.

Pink and Green

Licensed amateurs frequently receive the familiar pink or green tickets in the mail, calling attention to some violation observed by an FCC monitoring station. A common source for this action currently is the operator who transmits in the 28-29.7 mc band by doubling in the final without first ascertaining that radiation between 14-14.85 mc is non-existent. Since, at this writing, only amateur frequencies above 28 mc are open, signals in the frequency range between 14-14.85 mc stand out like a sore thumb and are easily detected. A familiar green ticket is then mailed to the offending operator calling his attention to the violation and requesting an explanation. It is essential that signals of this sort on frequencies not yet re-opened to the amateurs be kept to a minimum because other agencies are still using those frequencies and the interference produced may have serious consequences. The Commission is doing everything in its power to make these bands again available to the amateur, but until that happy day, it must protect the services on such frequencies against QRM.

Amateur Co-operation

A station operating in the two-meter band was recently intercepted by Federal Communications Commission monitors and identified to be a bootlegger. While monitoring the station's transmissions on separate occasions, three different licensed amateurs were operating the bootleg station. Consequently, when the FCC closed in, these amateurs became involved in the case. Although all the operators said they thought the station was legitimate, none of them had taken the trouble to ask the bootlegger to show his license, in spite of the fact that he had been accused of bootlegging by licensed amateurs over the air. When the log of the bootleg station was examined, it did not reveal the signatures of the licensed operators in charge (as it should if they had operated the equipment in good faith and in compliance with Rule 12.136). As one of the licensed amateurs remarked, after being questioned by Federal Communications Commission representatives about the case, "You never know what trouble your friends can get you into."

MEASUREMENTS

[*from page 28*]

Impedance is more important in most measurements, but if actual values in henrys or microfarads are desired, these may be calculated from the formula $X = \sqrt{Z_2 - R_2}$ in which X = reactance, Z = impedance and R = resistance. This indicates reactance from which inductance or capacity may be found on the reactance slide rule or by calculation.

The values of R_2 and R_3 must be as nearly equal as possible. Resistor R_1 should not be over 10,000 ohms as higher values will broaden the response and accurate readings are difficult to obtain. The setting of R_1 may be calibrated in terms of resistance or impedance for faster operation.

The input transformer should be matched to the load, but this is not critical and, in general, a higher-impedance transformer for a high-impedance and a low-impedance transformer for a low-impedance measurement are all that is necessary. An output transformer with 10 to 50-ohm output impedance is satisfactory for most applications.

Other Uses

Another application of this device is as a frequency control, since it is very sensitive to frequency changes and the output can be amplified to provide still further sensitivity. It can also be used to detect distortion, harmonic percentage or other defects in amplifiers. As a power factor meter it could be calibrated in phase-angle shift at any frequency. This circuit should operate very well as a discriminator in frequency-modulation work, if suitable components for V-F tests are substituted for the values shown. Limiter action as well as the function of discriminator could be confined in this one unit. In fact the applications are almost endless and it is merely a matter of discovering additional utility for the device.

TRANSMITTER

[*from page 24*]

loosely coupled to the antenna feeder, produces d.c. for the same purpose. This tube also serves as a monitor-rectifier for plugging-in a headset in the monitor jack in order to check the speech quality during modulation.

Some loss is introduced by the antenna switching relay, and likewise a degree of impedance irregularity; but the convenience derived from using the same antenna for receiving tends to offset these disadvanatages.

[*Continued on following page*]

CLASSIFIED ADS

Advertising in this section must pertain to amateur or experimentation radio activities. Rate—20c. per word per insertion. Remittance in full must accompany copy. No agency or term or cash discounts allowed. No display or special typographical ad setups allowed. "CQ" does not guarantee any product or service advertised in the Classified Section.

A-F System

The audio-frequency system employs a 6SJ7 voltage amplifier for connection to an ordinary carbon hand mike. A small portion of the cathode current of the second tripler is passed through the microphone by an R-C filter in order to eliminate a battery for mike operation. A 6F6 or 6V6 may be used for the power audio stage which modulates the cathode circuit of the 815 class-C r-f amplifier.

A small amount of inverse feedback provided by a 2-megohm resistor from the 6F6 plate to the 6SJ7 plate improves the modulator characteristics. Grid and cathode modulation present a more variable impedance load to the audio-frequency tube than in the case of a plate-modulated circuit. Both of the former require a greater degree of coupling to the antenna, and a lower value of grid drive for good quality modulation.

Mechanical Details

The photographs (*Figs. 2* and *3*) show the general layout of the components with the exception of the final grid circuit which was later modified to conform with the arrangement shown in the circuit diagram. A small 22.5-volt C battery was used in addition to the gridleak bias to safeguard the 815 tube (especially during tune-up periods). It is possible to eliminate this battery and substitute a 5,000-ohm resistor in place of the battery and radio-frequency choke in the 815 grid circuit. In this case, a 200- or 300-ohm resistor should be plugged into the jack which measures the cathode current of the 815 tube when tuning. The latter was included in order to plug an external milliammeter into the 815 circuit for occasional tests.

This transmitter is not intended as a perfect example to be followed precisely by the constructor, but rather as an accumulation of practical ideas which may prove useful to the builder of amateur radio rigs.

SIX-METER DX

[*from page 17*]

described in *Comptes Rendus* observations of a layer with a virtual height between 400 and 600 kilometers lasting ½ to 4 hours. The critical frequency of this layer has varied from 500 kc to 2500 kilocycles greater than the F_2 observed at the same time. Some formations of a *G layer* are known to occur 5 to 6 hours before a great ionosphere storm, while Kirby and Judson believe it also occurs in the ionization pattern at sunset.

Past Observations

These erratic *G layer* observations would ap-

pear to agree favorably with log reports where F8PA on 56 mc reported hearing W3SI on May 6, 1936 with a QSA5-R5 signal. Later the same year, W3AIR worked W6DOB cross band, with W3AIR on 5 meters. Then on December 27, at 1010 EST, W2HXD copied a test transmission of G5BY on 56,208 kc. It was also in 1936 that Cecil Mellanby, North Wales, British Isles, heard a fading signal signing VK2N—, which was later chalked up to VK2NO.

To summarize we find: *1.* Although the measured critical frequency of the F_2 ionosphere layer never permitted direct contacts on the 56-mc band, it has on several occasions provided a MUF exceeding 50 megacycles, the new band. *2.* The F_2 maximum generally precedes the sunspot cycles by at least 6 months. It is expected that the sunspot cycle maximum will occur in May 1948 and will be recognized by the rapid upward swing in sunspot numbers within the next 2 years. *3.* The fall of 1946 will definitely improve 10-meter contacts and may on one or two days have an MUF above 50.0 mc. *4.* *G layer* reflections which have accounted for much of the trans-Atlantic work on 56.0 megacycles are known through past experience to exist at this particular portion of the sunspot cycle.

SUPERHET CONVERTER

[*from page 11*]

order to tune over the 144-mc amateur band. A receiver covering this region is of great service in checking the oscillator spread. A low powered transmitter may be used as a signal source, and the oscillator band-set capacitor varied until this signal produces a deflection on the 6E5 used on the main unit. Once the band has been located, r-f and mixer stages can be aligned. Probably the best bet is to omit the B plus wire to the 6AK5 plate coil, and to remove this tube from its socket—connecting the antenna temporarily to the plate coil of this stage. Once the mixer is aligned with the oscillator, little difficulty should be experienced in lining-up the radio-frequency stage.

For alignment purposes we employed a frequency meter previously used in WERS work. The parallel rods were equipped with a shorting bar to raise their resonant frequency, and the curve exterpolated from available signals of known frequency. It is also necessary to tune the output transformer for maximum input to the 10-megacycle mixer in the master unit (or communications receiver). This tuning is reasonably broad, and the capacitor may be peaked for maximum indication on the 6E5, for optimum signal, or even for maximum background noise.

Let your HEAD take you

(The average American today has a choice of just going where "his feet take him", or choosing wisely the course to follow. Let's skip ahead 10 years, and take a look at John Jones—and listen to him . . .)

"SOMETIMES I feel so good it almost scares me.

"This house—I wouldn't swap a shingle off its roof for any other house on earth. This little valley, with the pond down in the hollow at the back, is the spot I like best in all the world.

"And they're mine. I own 'em. Nobody can take 'em away from me.

"I've got a little money coming in, regularly. Not much—but enough. And I tell you, when you can go to bed every night with nothing on your mind except the fun you're going to have tomorrow—that's as near Heaven as man gets on this earth!

"It wasn't always so.

"Back in '46—that was right after the war and sometimes the going wasn't too easy—I needed cash. Taxes were tough, and then Ellen got sick. Like almost everybody else, I was buying Bonds through the Payroll Plan—and I figured on cashing some of them in. But sick as she was, it was Ellen who talked me out of it.

"'Don't do it, John!' she said. '*Please* don't! For the first time in our lives, we're really saving money. It's *wonderful* to know that every single payday we have *more* money put aside! John, if we can only keep up this saving, think what it can mean! Maybe someday you won't have to work. Maybe we can own a home. And oh, how good it would feel to know that we need never worry about money when we're old!'

"Well, even after she got better, I stayed away from the weekly poker game—quit dropping a little cash at the hot spots now and then—gave up some of the things a man feels he has a right to. We didn't have as much fun for a while but we paid our taxes and the doctor and—we didn't touch the Bonds.

"What's more, we kept right on putting our extra cash into U. S. Savings Bonds. And the pay-off is making the world a pretty swell place today!"

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