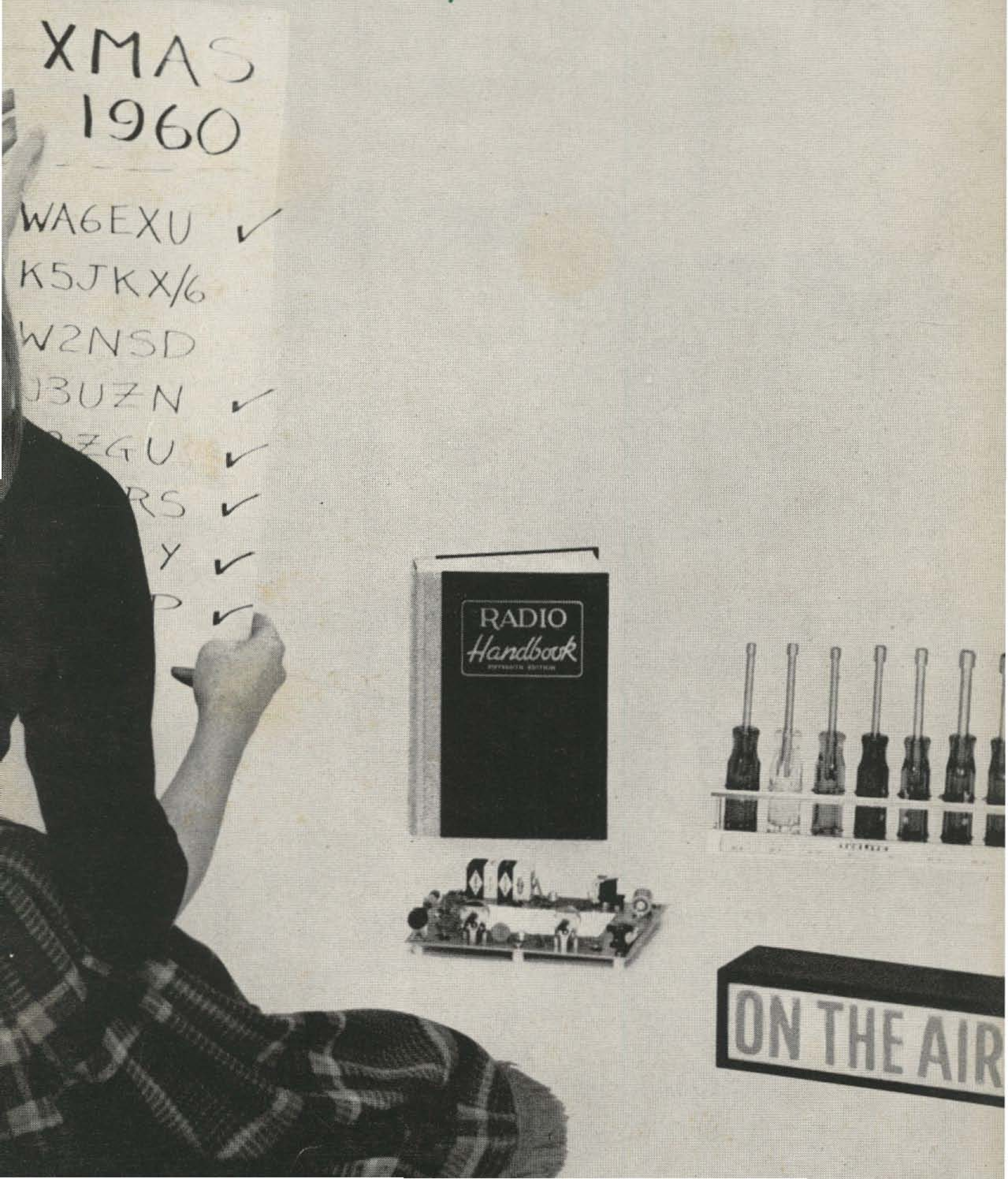
73

December 1960

37¢

Amateur Radio



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publications manager .... David Fish
associate editor .... Jim Kyle K5JKX
associate editor .... Don Smith W3UZN
associate editor .... Jim Morrissett WA6EXU
contributing editor .... John Campbell W2ZGU
subscriptions .... Virginia K2MNW

The Cover: Virginia mulls over the shopping list we've assembled on page 6. All items are under $20 and are needed in every ham shack. Photograph by Mort Weldon.

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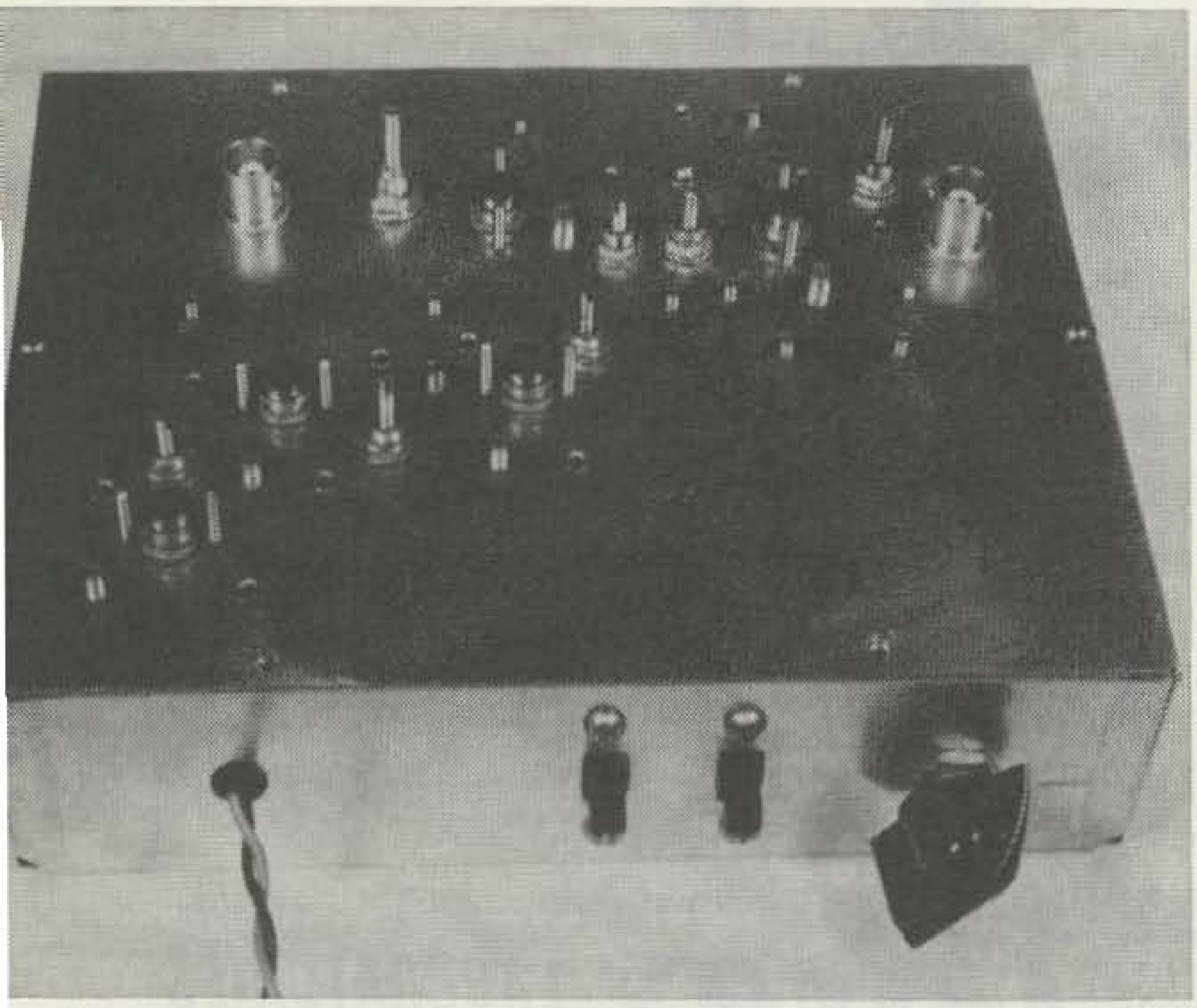


A Transistorized Crystal Controlled Converter

. . . for the 220 mc (1-¼ meter) Amateur Band

J. Specialny W3HIX
Philco Corporation/Lansdale Division

This report describes a 1¼ meter converter for the 220-225 mc amateur band. It employs five Philco MADT VHF transistors and operates at a supply voltage of 12 volts. A communications receiver capable of tuning the 10 to 15 mc frequency range can be used as the *if* system.

THE unit employs five transistors, all operating in common emitter configuration. Transistor TR1, operating as a neutralized rf amplifier, is coupled to the mixer through a double tuned circuit. This method of interstage coupling is preferred because of its ability to reject signals outside the rf bandpass and to minimize feed through at the *if* frequency. The antenna is coupled to the amplifier through a tap on the input coil L1. Shunt capacitor C1 tunes the input circuit to the proper frequency. A series matching capacitor C2 applies the incoming signal to the low impedance base which typically is about 60 ohms. Neutralization is provided for by a capacitor network consisting of C3 and C6. Neutralization provides an increase in rf power gain of approximately 3 db as well as good circuit stability, although the amplifier would be quite stable if neutralization was not used.

The rf amplifier output circuit is tuned by inductor L2 and capacitors C4 and C5. A manual rf gain control is incorporated to reduce the gain on strong signals. The method used here is termed "forward gain control" and is noted for its excellent overload characteristics. The term "forward" is derived from the fact that the collector current is increased to reduce the stage gain rather than decreasing the collector current as is done in the reverse method. A resistor R5 is inserted in series with output circuit and the negative terminal of the power supply. As the current increases by adjustment of gain control potentiometer R3 the voltage available between the collector and emitter of the rf stage decreases causing the gain to drop. This drop in power gain is nearly linear as the collector to emitter voltage is varied from eight volts to one half a volt. The MADT is the only VHF transistor suited for this type of gain control. Resistor R4 provides emitter stabilization and resistors R1, R2 and R3 determine the biasing level. The value of collector current varies from 2.5 to 6 ma depending on the setting of R3. The normal operating value is 2.5 ma for maximum gain. A stand by receiver switch is incorporated in the emitter lead.

Mixer

The output of the rf amp is coupled to the mixer transistor TR2 (Philco T1833) by loosely coupling mixer coil L3 to amplifier coil L2 (see coil data for details). Capacitor C7 tunes coil L3 and the value of capacitor C8 is selected to match the input resistance of the mixer. The local oscillator power is injected into the emitter terminals by returning the bypass capacitor C13 to ground through a tap on coil L8. An *if* frequency of 10-15 mc was selected. Coil L4 and capacitor C9 tune the collector output to this frequency range and the output is coupled to the load through coil L5 which is wound over the cold end of coil L4. The 3 db *if* response of the converter is about 3 mc. Since most of the activity is centered around 221 mc, the *if* response was peaked to 11 mc. The rf response at the mixer base is quite flat from 219.5 to 225.5 mc.

Emitter resistor R8 provides dc stabilization and resistors R6 and R7 determine the operating point.

Harmonic Generator

This section provides at least 180 millivolts rms of injection voltage to the emitter terminal of the mixer TR2 (Philco T1833). The local oscillator frequency is on the low side

PARTS LIST

C1=0.05 to 5.0 mmfd Piston Capacitor
C2=1.5-7.0 mmfd Ceramic Trimmer. (A fixed capacitor of about 2.5 mmfd can be substituted.)
C3=2.2 mmfd Ceramic
C4=4.7 mmfd Ceramic
C5=0.5-8.0 mmfd Piston Capacitor
C6=50 mmfd
C7=0.5-8.0 mmfd Piston Capacitor
C8=100 mmfd
C9=3 mmfd
C=10—1.0-18 mmfd Piston Capacitor
C11=1.0-18 mmfd Piston Capacitor
C12=0.5-5.0 mmfd Piston Capacitor
C13=0.01 mfd Ceramic 75V
C14=0.0015 mfd Ceramic stand off type.
C15=0.01 mfd Ceramic 75V
C16=470 mmfd Ceramic
C17=68 mmfd Ceramic
C18=68 mmfd Ceramic
C19=0.0015 mfd Ceramic stand off type.
C20=2.0 mmfd Mica
C21=5.0 mmfd Ceramic
R1=8200 ohms 1/2w
R2=2700 ohms 1/2w
R3=10,000 ohms Potentiometer
R4=470 ohms 1/2w
R5=820 ohms 1/2w
R6=15 K 1/2w
R7=4.7 K 1/2w
R8=1.5 K 1/2w
R9=8.2 K 1/2w
R10=3.3 K 1/2w
R11=1.5 K 1/2w
R12=39 K 1/2w
R13=4.7 K 1/2w
R14=470 ohms 1/2w
R15=39 K 1/2w
R16=4.7 K 1/2w
R17=470 ohms 1/2w

COIL DATA

L1—6 turns #20 tinned copper wire 3/16" l.d. 1/2" winding antenna tap 1 turn from ground end.

L2—3½ turns #26 tinned copper 5/32" l.d. 1/4" winding length.

L3—4½ turns #24 tinned copper 5/32" l.d. 1/4" winding length.
L2 and L3 form a double tuned circuit. Air wound in the same direction; spacing between coils as noted above.

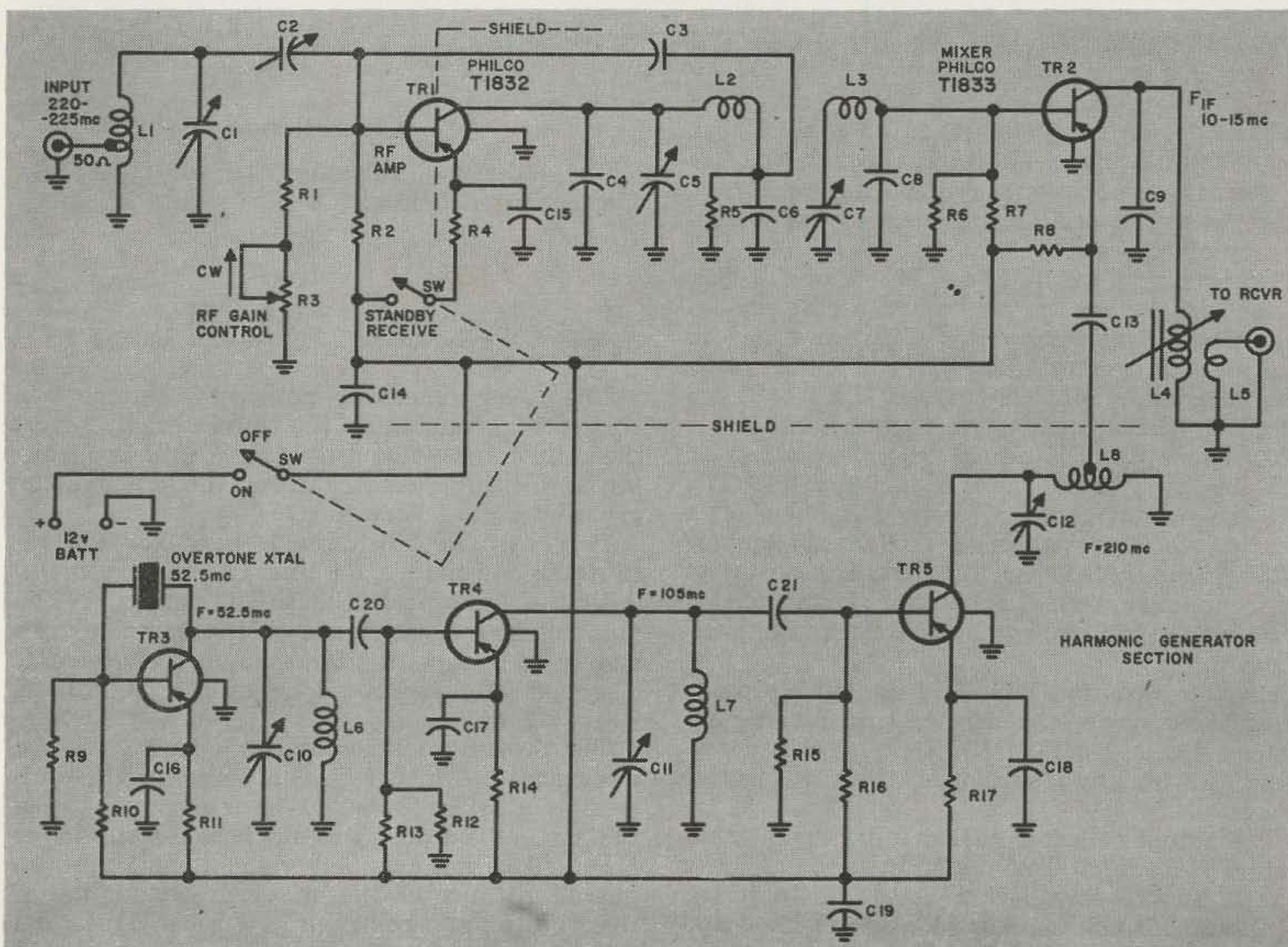
L4—72T #34 Nyclad copper wire close wound. W.L. about 5/8" on 3/8" ceramic form (Cambion type PLS-5 2C4L) powdered iron slug.

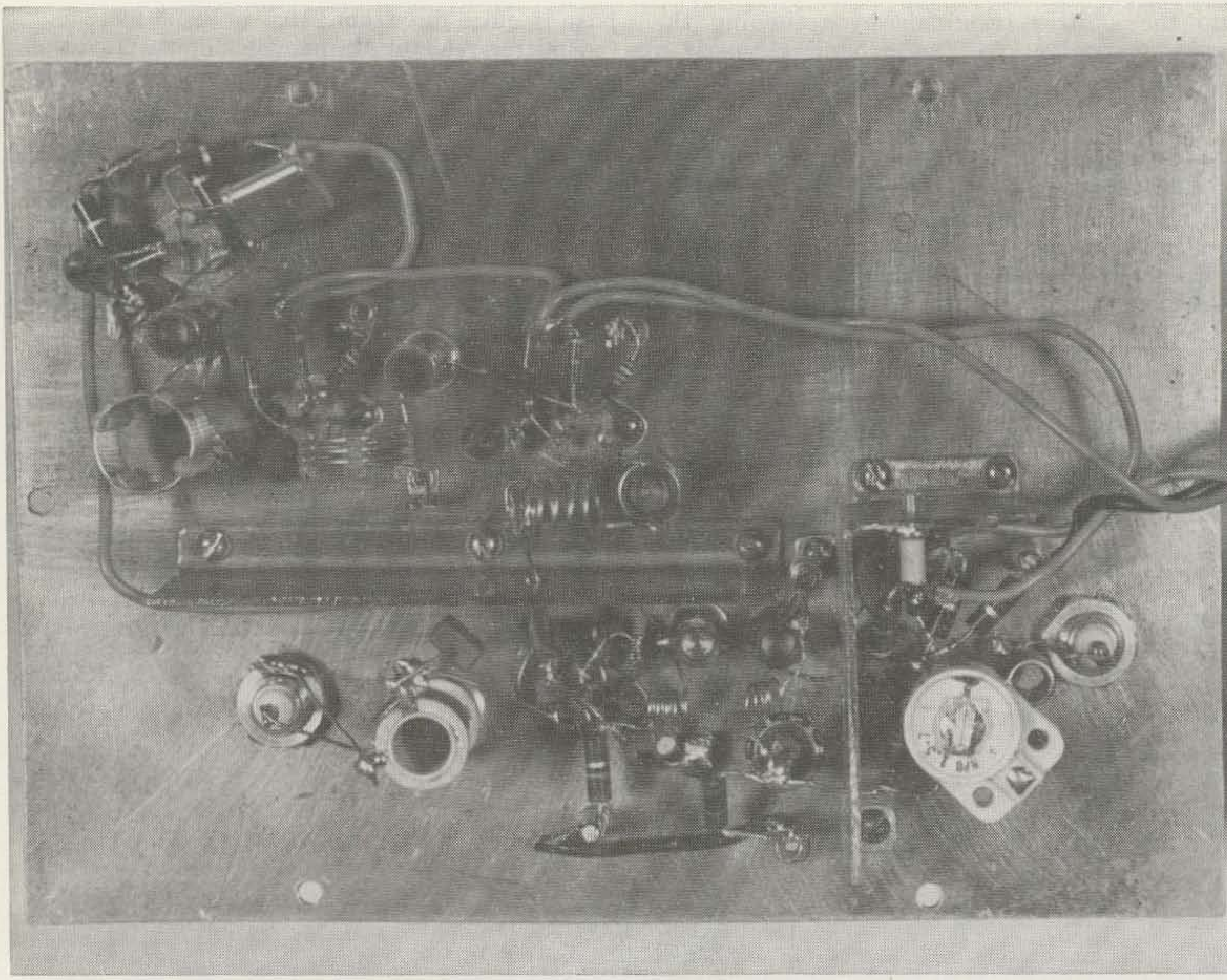
L5—15 turns #34 Nyclad copper wire close wound over ground end of L4.

L6—9 turns of #3003 Minductor (B & W) or air dux #416T.

L7—3 turns of #3003 Miniductor (B & W) or air dux #416T.

L8—5 turns #18 tinned copper wire 1/4" l.d. W.L. = 1/2" tapped about 1/4 turn from end.





and the output frequency is 210 mc. This high frequency output is obtained through the use of two stages of frequency doubling and a one stage overtone oscillator operating on a frequency of 52.5 mc.

Transistor TR3 (Philco T1859 or T1695) is used in the crystal controlled oscillator circuit. Coil L6 and capacitor C10 are tuned to 52.5 mc, the overtone frequency of the crystal. The oscillator output drives TR4 (Philco T1859 or T1695) through coupling capacitor C20. The output is tuned to a frequency of 105 mc by coil L7 and capacitor C11. The 105 mc output from frequency doubler TR4 is used to drive another frequency doubler TR5 (Philco T1859 or T1695) through coupling capacitor C21. The output frequency of TR5 is tuned to 210 mc by coil L8 and capacitor C12.

Emitter resistors R11, R14 and R17 provide the necessary dc stabilization and biasing resistors R9, R10, R12, R13, R15 and R16 determine the biasing current of their respective stages.

The actual collector current flowing in transistors TR4 and TR5 is influenced to some extent by the level of rf exitation from the oscillator TR3 since a combination of fixed and self biasing is employed in these stages.

Operation

The individual collector and total currents are tabulated below:

TR1	TR2	TR3	TR4	TR5	Total IC with divider current
2.5 ma	1.8 ma	2.0 ma	2.0 ma	2.0 ma	14 ma

The sweep generator method of alignment is suggested in tuning up the converter. However, the unit can be tuned up fairly well by peaking it up on a carrier from the transmitter or an rf signal generator.

If a variable capacitor is used for C2, alternately adjusting C1 and C2 for maximum output should peak the input properly. The point of best noise figure should coincide very nearly to the point of maximum power gain. The noise figure should be in the vicinity of 5.5 to 6.5 db.

The overall power gain is about 22.0 db. An additional 1.5 to 2.0 db can be realized by inserting a series tuned 11-12 mc trap between the mixer base and ground because the input circuit does not completely short the 12 mc input admittance of the mixer. It was felt that the additional tuning procedure involved did not warrant the addition of the trap. 73

The RF Sniffer

Jim Kyle, K5JKX/6
1851 Stanford Ave.
Santa Susana, Calif.

EVERY now and then there's a need to know if any rf is present in a circuit. Frequency isn't so important—the question is simply. "Is there rf here?"

Your grid-dipper can frequently answer this, if used in the wavemeter mode, but occasionally it's not sensitive enough—particularly if you're working with a receiver oscillator where power is measured in microwatts.

Here's an rf Sniffer which will indicate the slightest trace of rf in a circuit. In addition to checking receiver oscillators, it's a perfect gadget to ensure perfect neutralization of a transmitter final.

Designed by W5JCB along classic lines, the Sniffer is built around a microammeter. While most 0-50 ma meters still bear price tags in the $15 region, an import stocked by Arrow Sales Inc., North Hollywood, Calif., and listed as their catalog number 606PM1, sells for only $5.95.

Using this meter, the total cost of the Sniffer should be less than $6.75 complete—the only other parts are a 1N34A diode and a .001 mfd capacitor.

Connect the components as shown in the schematic and photograph. Use long-nosed pliers as a heat sink between the diode and the solder joint when wiring, to prevent diode damage. Note that the pickup loop of 14 gauge wire is insulated with a strip of spaghetti.

That's all there is to construction of the Sniffer. Here are some of its uses:

Amplifier Neutralization—Couple the Sniffer to the antenna terminal with a temporary two-turn link around the pickup loop. Remove plate and screen voltage from the final amplifier. Apply drive. Adjust neutralization for minimum indication on the Sniffer—but don't expect to be able to get it down to zero.

Oscillator Checking—Place the pickup loop near the oscillator coil. If the oscillator's working, the Sniffer will indicate rf. Touching either the grid or plate lead (use an *insulated* tool for this test, not your fingers) should reduce the Sniffer's indication.

Receiver Troubleshooting—Check the oscillator as described above. If it's okay, next check the mixer plate coil by placing the Sniffer pickup loop near it. If you get an indication here, move to the first if stage and place the pickup loop near the plate pin of the tube socket. Proceed through the receiver until you lose the indication. The trouble is somewhere between the last indication and the point at which it disappeared.

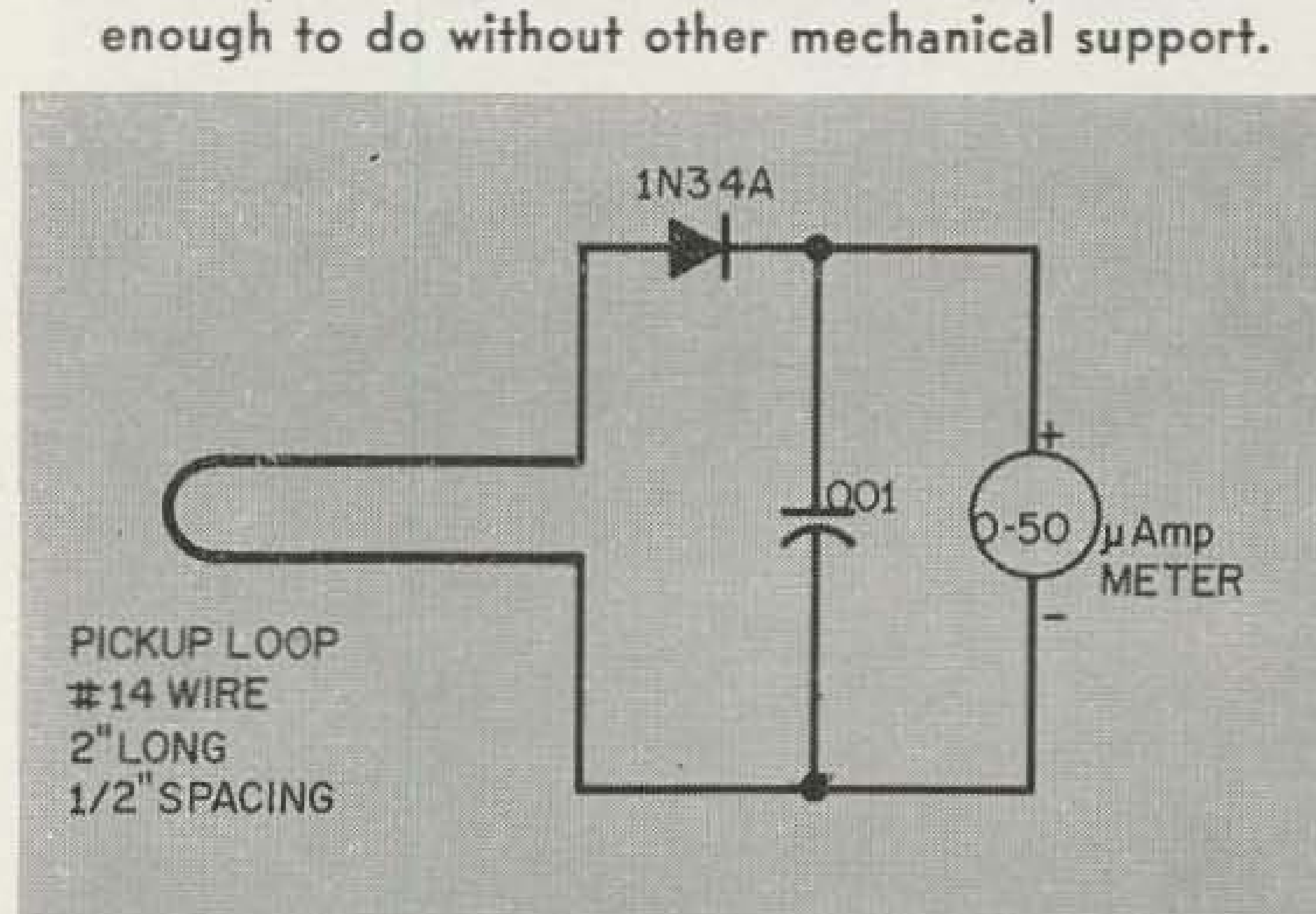
Field Strength Meter—Couple a short antenna to the pickup loop by two turns of wire around the loop. Field strength will be indicated in a comparative manner by the meter. It cannot be calibrated, but proves useful in tuning mobile or beam antennas, etc.

SWR Measurement—(Parallel lines only). Move the Sniffer long the line. Mark maximum reading and minimum reading over a half-wavelength. Divide minimum into maximum. The quotient is, roughly, your VSWR. This method is by no means exact, but will indicate whether the line is under or over a 2:1 SWR.

UHF Frequency Measurement — Set up Lecher wires. Couple the rf Sniffer lightly to the tank circuit instead of using a flashlight bulb. Use Lecher wires in normal fashion, reading Sniffer indications for maximum and minimum. This is much more exact than the normal methods.

Improvised Grid-Dipper—If you have a signal generator available, it can be used with the rf Sniffer to serve as a "grid-dip" meter to locate resonance for any tank circuit. Couple both the generator and the Sniffer lightly to the unknown tank. Vary generator frequency. A sharp rise in Sniffer indication indicates the resonance point.

Mount capacitor and diode on back of meter with shortest possible leads. Attach pickup loop directly to negative meter terminal; it's stiff enough to do without other mechanical support.



Balanced Modulator Dynamic Demonstrator

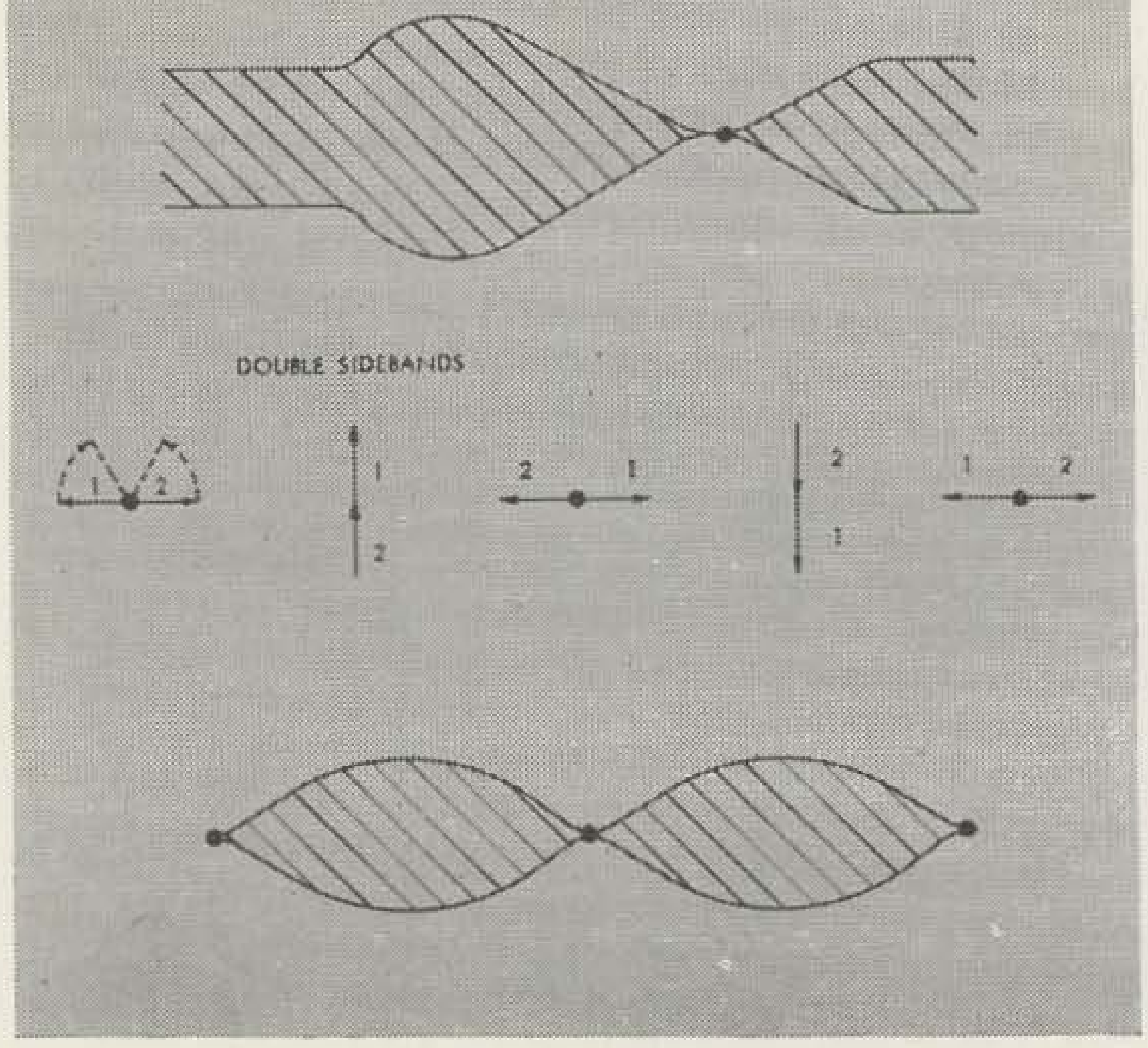
E. H. Sommerfield W2UQB
818 Wallace Street
Endicott, New York

THERE comes a time in every "ham's" life when he is called upon to impart to others his knowledge and experience on a given subject. This occurred to the writer recently when he was approached by "Doc"[1] W2JVZ, of the Greene Amateur Radio Society of Greene, New York, and invited to deliver a lecture on Balanced Modulators. Now one just does not get up before a group and point out a balanced modulator configuration and ask the listeners to accept the facts of carrier cancellation and sideband generation, neither does one go into a long series of vacuum tube equations. Its the correct mathematical procedure, but it's also a great cure for insomnia! No! The sensible approach is to analyze, via vectors, CW, AM, DSB and SSB, in that order, and demonstrate these forms of modulation on a dynamic demonstrator. This is the procedure the writer followed. After the talk the audience was invited to "twiddle knobs." As a result, an enjoyable and enlightening evening ensued.

The state-of-the-art of balanced modulators was examined to determine which circuit configuration would lend itself conveniently to the demonstration of all four of the aforementioned modes of modulation. It might be noted that CW is considered, by definition, a mode of modulation. The W2UNJ exciter was selected as a model for the following reasons:

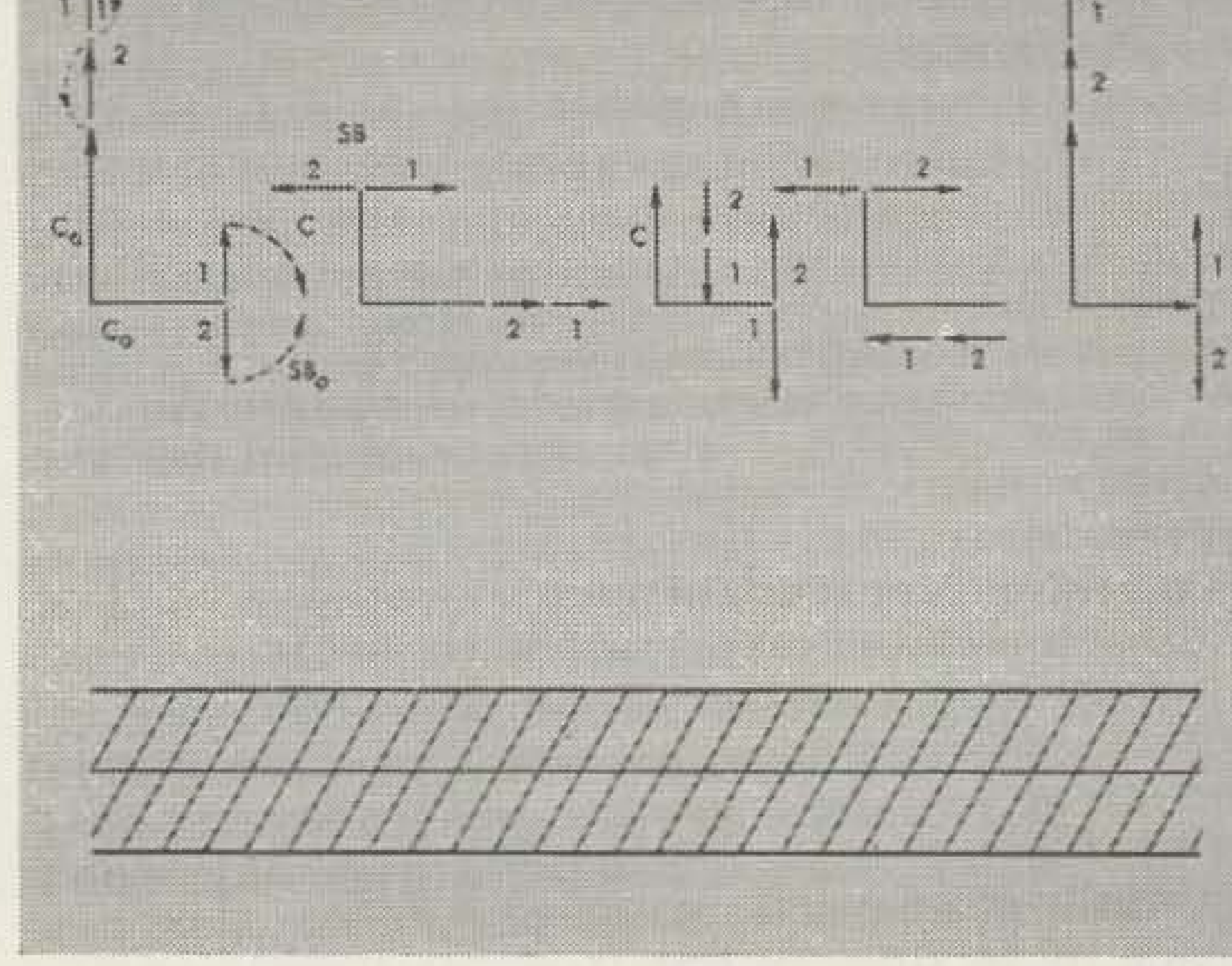
1. Each tube, or generator, could be applied to the tank circuit, or rf summing network, independently, without upsetting the other generators.
2. All terminals, input, output, and modulation were isolated from each other

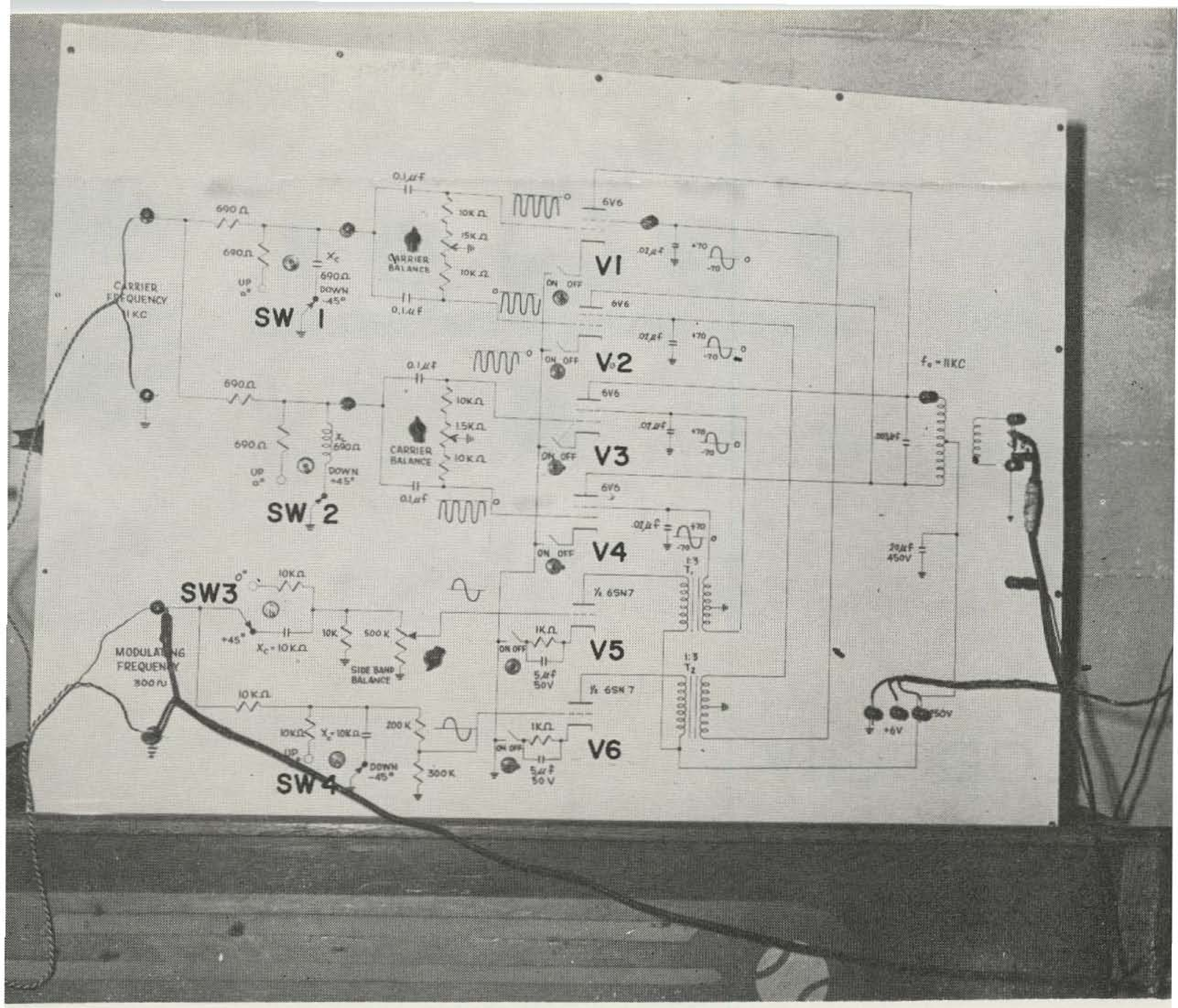
[1]Dr. Centerwall—W2JVZ



(*Note that since the screens of the carrier tubes are operated at ground, very little RF output is obtained; therefore, under AM conditions very low modulation is applied.)

Fig. 1.





preventing interaction between the different frequencies used.

3. Because of 1 & 2, audio frequencies could be used for both carrier and modulating signals. This permitted the use of long lead lengths necessary to physically mount controls and switches where the panel artwork directed.

If rf frequencies were used for the carrier, oscillation would have no doubt resulted. A single frequency was used for modulation with special emphasis being made that a phase shifting network, commercially available, would hold the phase difference, for the standard audio frequency range of 30-3000 cycles.

The circuit is shown in the attached photo. With the exception of the modulating phase shift networks, it is identical to the W2UNJ exciter described in many previous ARRL Handbooks. Although the overall circuit theory has been adequately covered in the previously mentioned handbooks, some circuit information was gained by noting the results obtained when the different generators were connected onto the tank circuit.

Abnormal operation can be displayed in SSB by switching S_1-S_4 (one at a time) to 0° and noting the increase in output ripple that occurs from the appearance of the unwanted sideband.

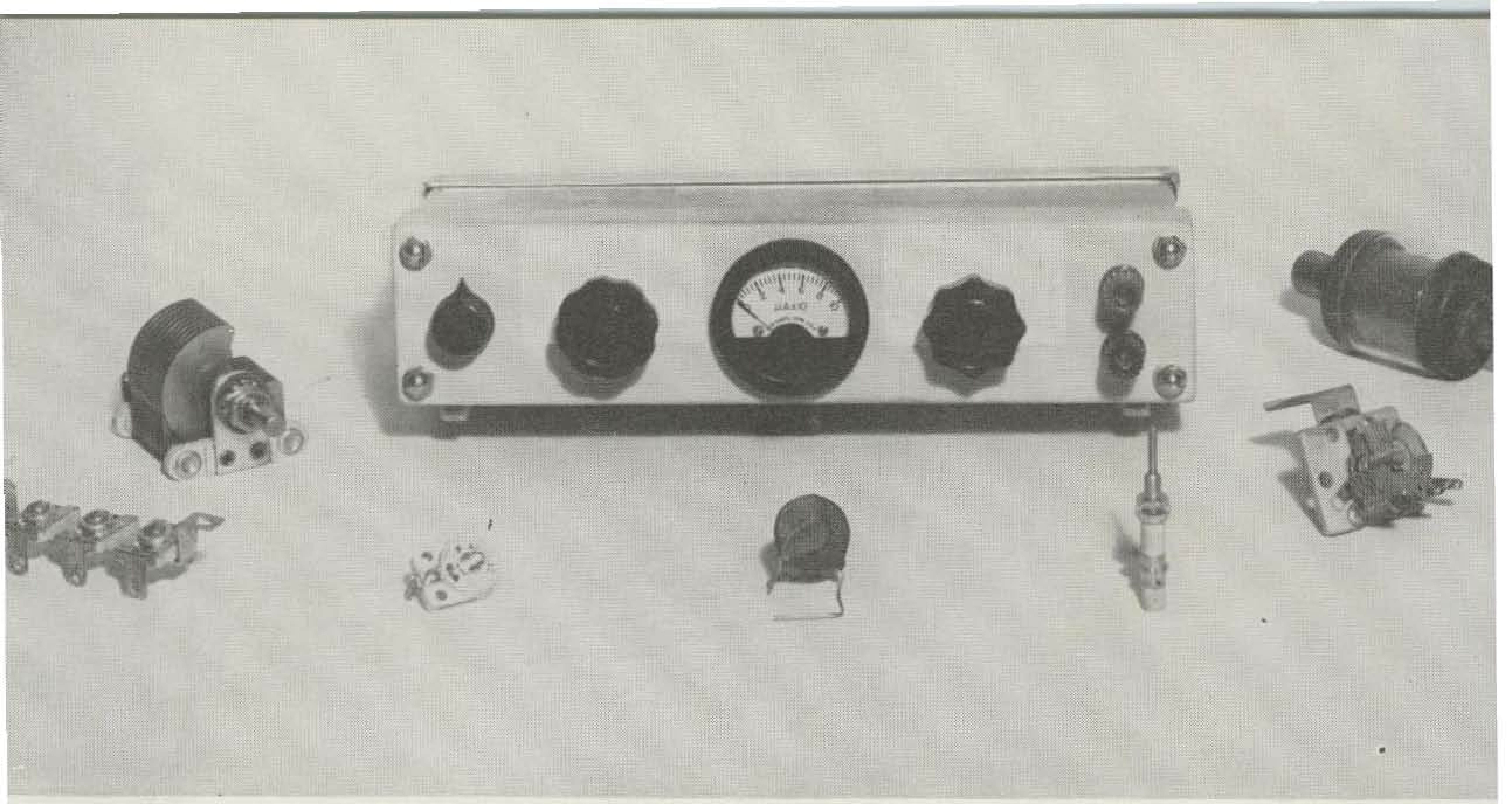
Before each mode was presented, Figure 1 displayed on large charts were referred to. to explain the theory.

An effort was made, at the conclusion, to point out the advantages of both DSB and SSB as a modes of modulation insofar as overall communications efficiency is concerned. Also, mention was made of the newer and more efficient balanced modulator configurations.

Although crude perhaps in its pedagogical approach, the effectiveness of this method of lecturing can be attested to by the number of additional invitations received to repeat it. 73

Table I describes the conditions of the various generators for the different modes of modulation.

Mode	V_1	V_2	V_3	V_4	V_5	V_6	SW_1	SW_2	SW_3	SW_4
CW	—	—	ON	—	—	—	0°	0°	0°	0°
AM	—	—	ON	—	ON*	—	0°	0°	0°	0°
DSB	—	—	ON	ON	ON	—	0°	0°	0°	0°
SSB	ON	ON	ON	ON	ON	ON	—45°	+45°	+45°	—45°

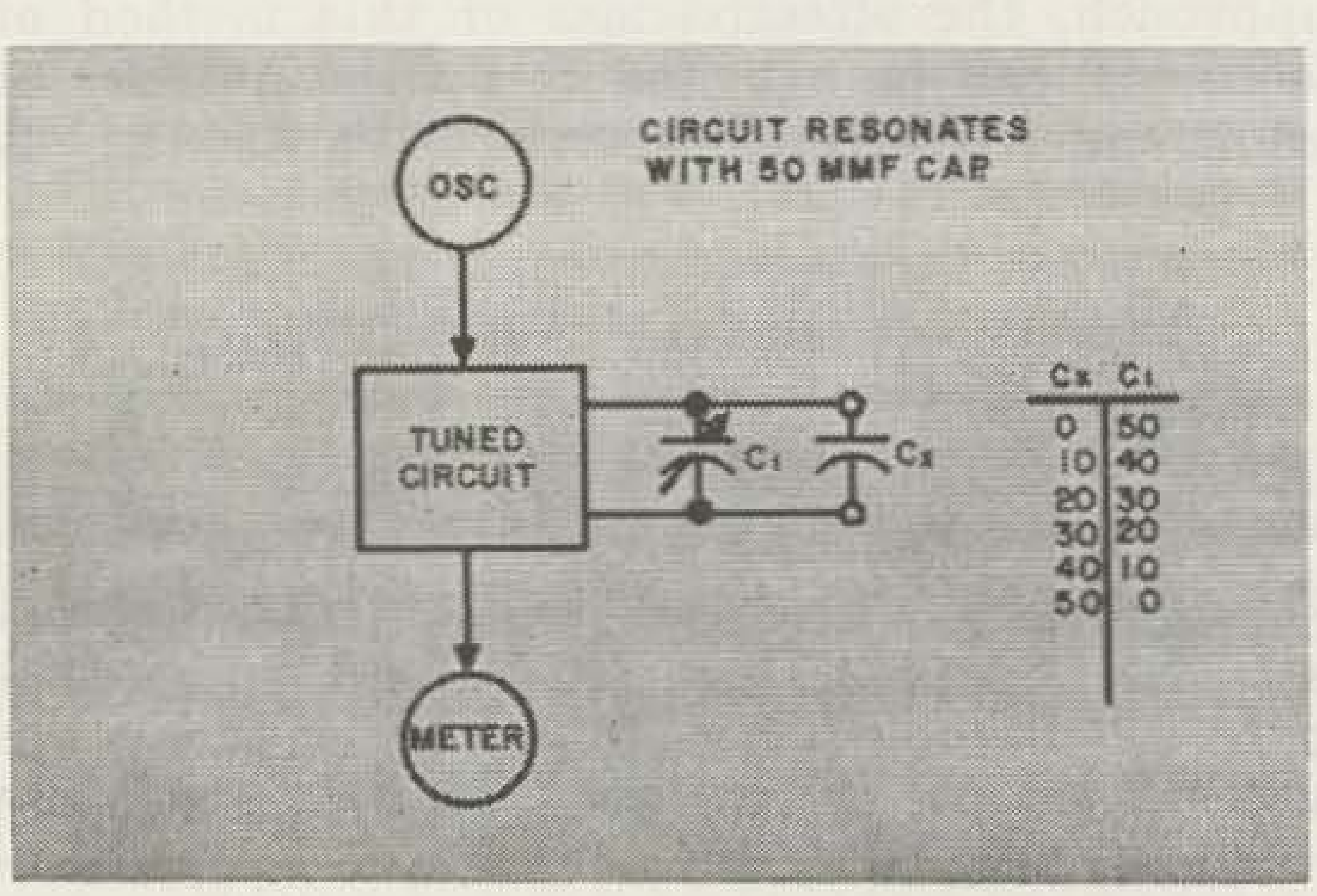


Capacity Meter

Tom Lamb K8ERV
1066 Larchwood Road
Mansfield, Ohio

... Second only in usefulness to the GDO

Fig. 1—Capacity measurement by the substitution method.



MEASURING variable or small unmarked capacitors is often a major problem. The Grid Dip Oscillator method is inconvenient and often more work than it is worth. The meter described will measure 0-40 mmfd and 0-900 mmfd in two ranges, and will resolve one mmfd on the low range.

The operation is shown in Fig. 1. A coil is tuned to resonate at one mc by two capacities, C1 and CX. An oscillator excites the circuit at one mc. and an rf voltmeter indicates resonance. Assume the circuit resonates with a total capacity of 50 mmfd. If there is no CX connected, then C1 must be 50 mmfd. to resonate. If an unknown capacity is now connected, C1 must be reduced exactly the amount of CX to bring the circuit back to resonance. If C1 is calibrated, the value of the unknown is indicated directly on the C1 dial.

This process is called capacity measurement by substitution. The unknown substitutes for an equal amount of capacity in the calibrated variable. This method has several important features. First, and most important, the accuracy and long time stability depend only on the calibrated variable condenser. Drifts in the battery, oscillator, and inductances will not affect the instrument. Second, the meter is unaffected by the hum pickup that often plagues homemade bridges. Third, condensers that are lossy at radio frequencies can be detected. Fourth, it is easy to measure capacities at the end of a long, high-capacity cable.

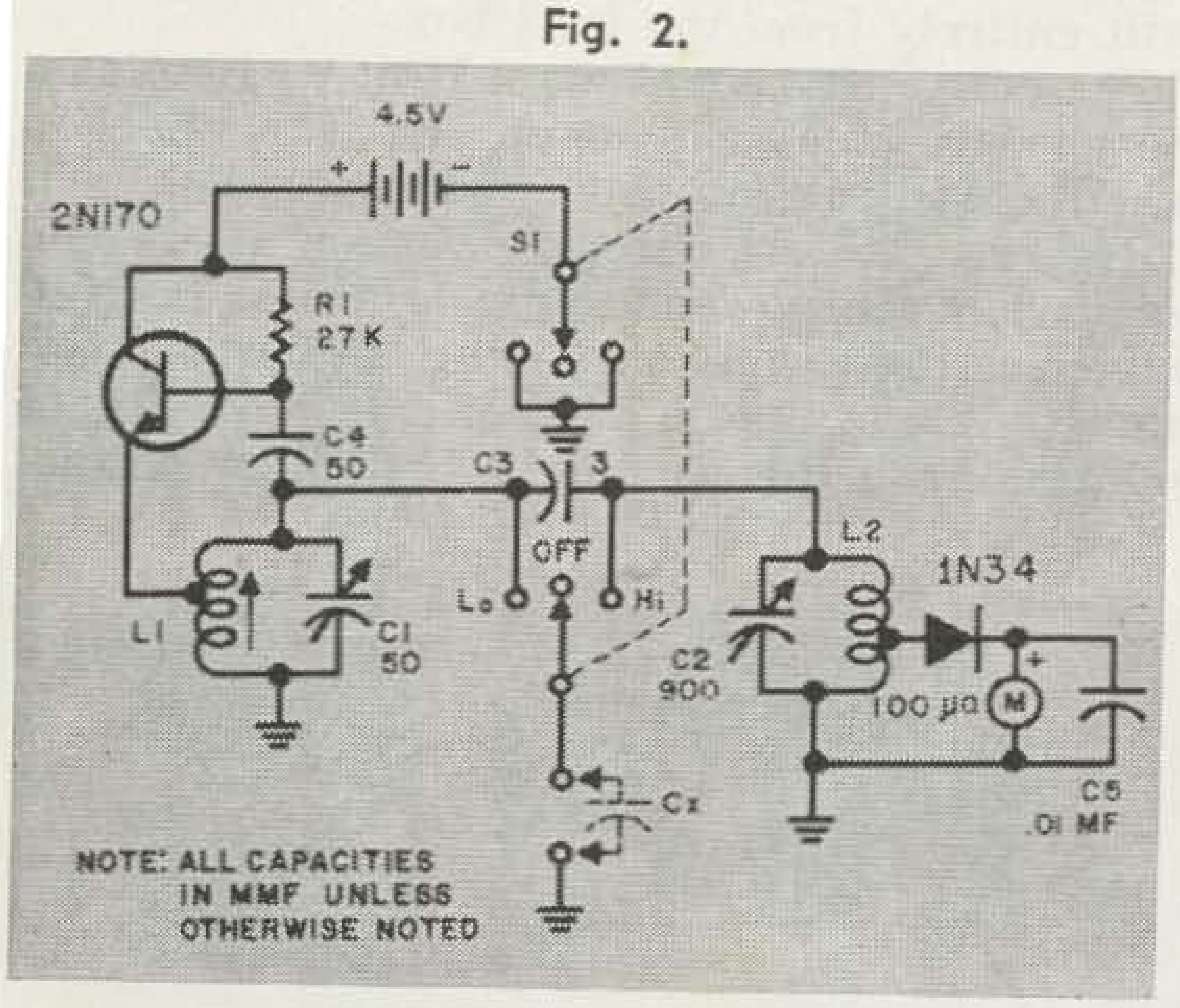
Fig. 2 shows the complete circuit. A simple transistor oscillator drives the tuned circuit

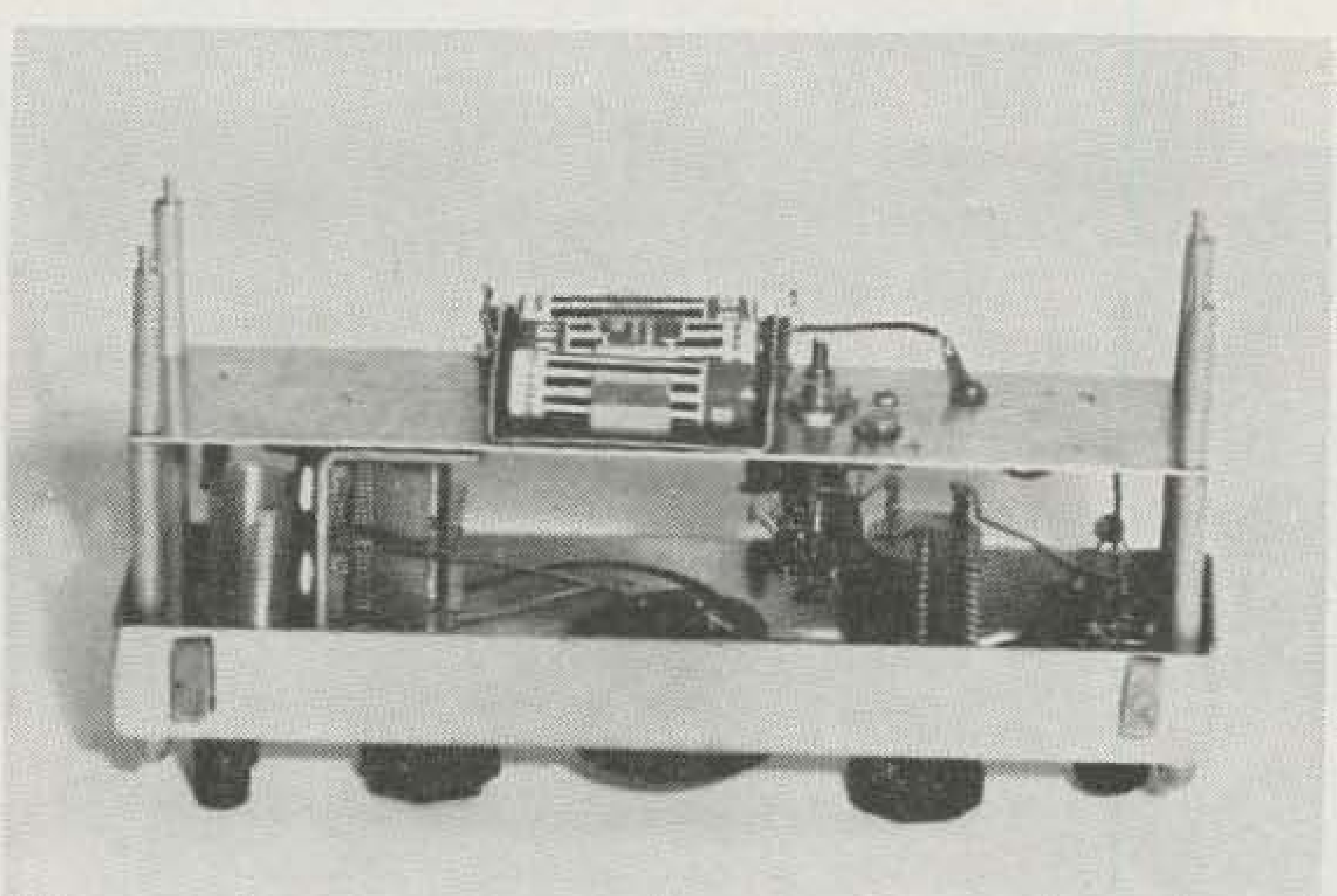
L2C2 through a small coupling condenser. A diode voltmeter indicates circuit resonance by a maximum reading. The operating frequency in my case was 1450 kc, but is not critical so long as the L1C1 and L2C2 circuits resonate at the same frequencies with C1 and C2 at maximum capacity. I suggest that L2 be duplicated and L1 be adjusted as described later. The leads to C3, S1, and the CX terminal should be short and spaced away from ground to reduce stray capacity in this part of the circuit.

Adjustment

Turn S1 to the "Hi-C" position and set C1 and C2 to maximum. Adjust the slug in L1 for a maximum meter reading. (If no reading is obtained, either the oscillator is not operating or it is not tuning to the frequency of L2C2.) The meter reading should be sharp but smooth as L1 is tuned. If C3 is too large, the meter will umjp, due to the two tuned circuits interacting. If C3 is too small, the meter indication will be low. In my case the maximum reading was 20 μa.

Fig. 2.





Now switch S1 to "Lo-C" and reduce C1 to again peak the meter. The difference in the two C1 settings is due to stray capacity in the instrument. The meter is now ready for calibration.

Calibration

Turn S1 to "Hi-C" and set C2 to very near its maximum capacity. Mark the C2 dial "O." Peak the meter with C1., which becomes the calibration or zero adjustment for the C2 dial. Now place known capacities across the CX terminals, and peak the meter with the C2 dial. Mark the known values on the C2 dial. The maximum capacity that can be measured is the value of the maximum capacity of C2.

Small capacities are substituted in the oscillator circuit which, because of its lower operating capacity, gives a more spread out scale. Set C2 at its zero mark and switch S1 to "Lo-C". Peak the meter with C1 and mark the C1 dial "O". Place small known capacities on the CX terminals and calibrate the C1 dial. The C2 dial now becomes the zero adjustment for the low capacity scale. The maximum capacity readable on the C1 dial will be less than 50 mmfd because of stray capacities.

Operation

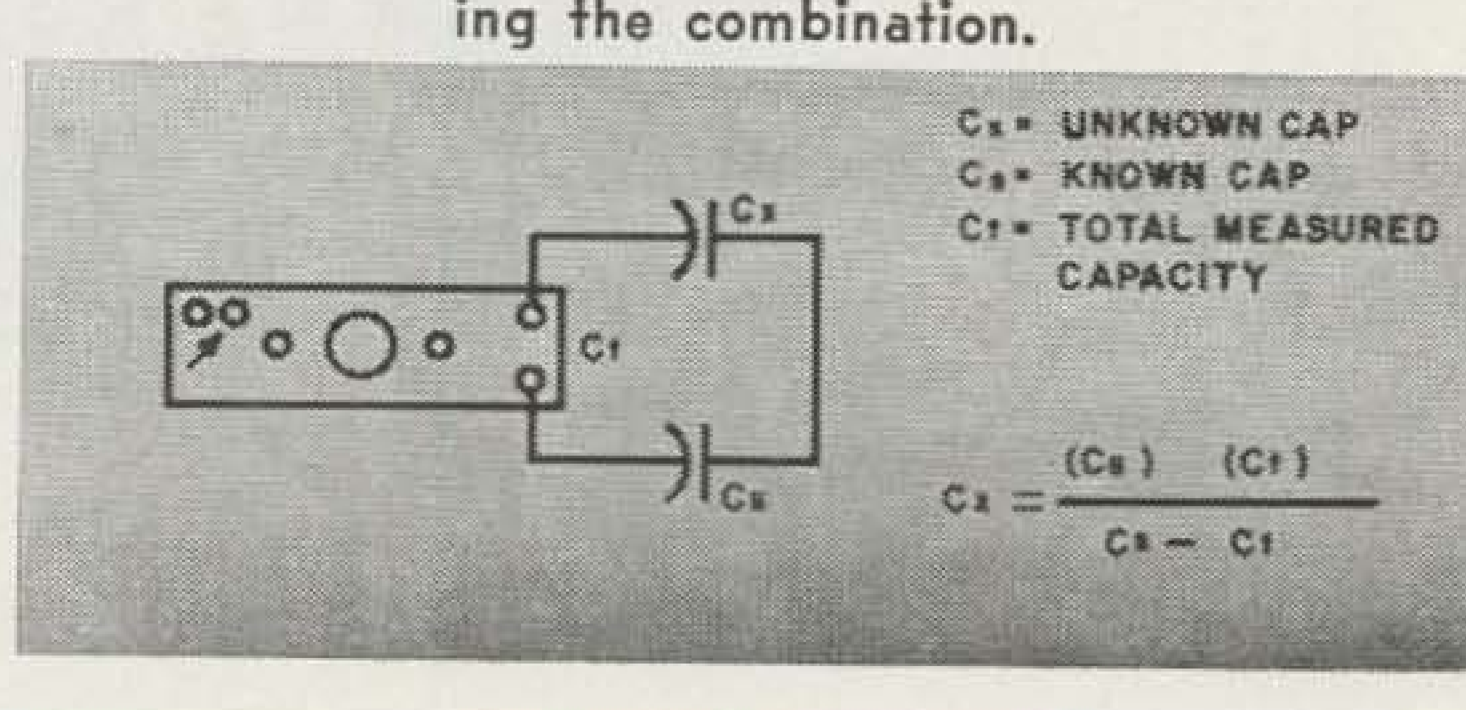
To operate the capacity meter, simply set the scale in use on zero and peak the meter with the other dial. Add the unknown capacity and re-peak the dial in use and read the unknown capacity.

Capacities above the range of C2 may be measured by placing them in series with a known capacity of about 1000 mmfd and reading this combination. The unknown may then be calculated as shown in Fig. 3. If desired, a second scale could be calibrated on C2 for use with a particular series condenser.

At resonance the total capacity tuning L1 and L2 do not change between the zero and measure adjustments. Therefore the meter readings should be exactly the same. A high Q (low loss) condenser will not affect the meter reading, but a low Q unit will decrease the reading. Generally, any condenser that affects the meter reading should not be used in a high Q or tuned cricuit.

This meter has been in use for two years and is second only to the GDO in usefulness around the shack. 73

Fig. 3—A large capacity can be measured by placing a known capacity in series and measuring the combination.



The Multivibrator in Amateur Vox Circuitry

Roy E. Pafenberg
P. O. Box 844
Fort Clayton, Canal Zone

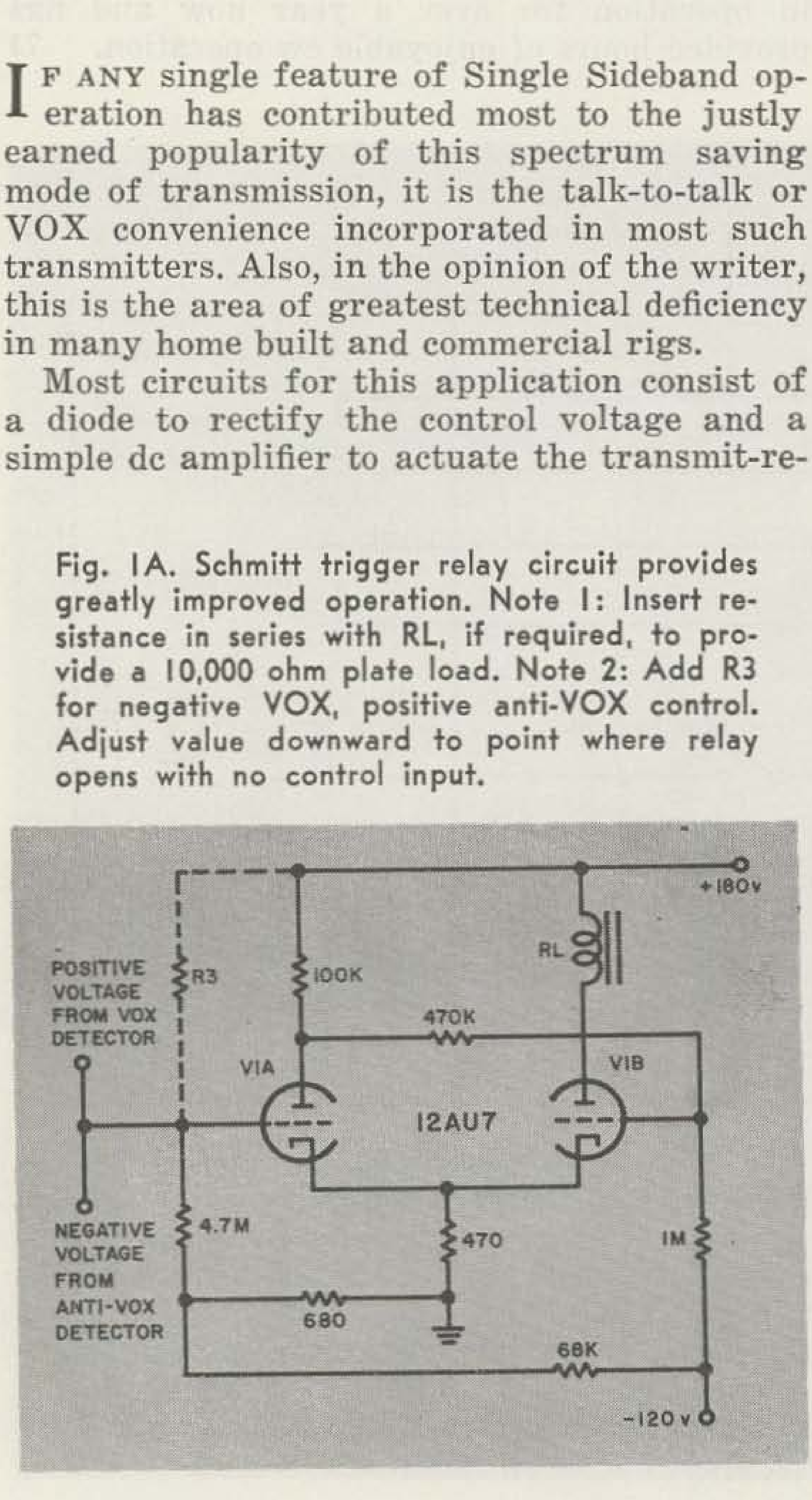
Pulse Circuits are Adapted to Provide Superior Performance in this Critical SSB Application.

If any single feature of Single Sideband operation has contributed most to the justly earned popularity of this spectrum saving mode of transmission, it is the talk-to-talk or VOX convenience incorporated in most such transmitters. Also, in the opinion of the writer, this is the area of greatest technical deficiency in many home built and commercial rigs.

Most circuits for this application consist of a diode to rectify the control voltage and a simple dc amplifier to actuate the transmit-receive relay. An RC network is inserted between the detector and the amplifier to hold the relay closed between normal pauses in speech. Anti-VOX may be added by rectifying the audio output of the station receiver and applying an equal and opposite voltage to the input of the dc amplifier, thus preventing actuation of the VOX by the receiver speaker. Although the dc amplifier is usually driven into saturation by the control signal, circuit performance is strictly at the mercy of the relay until the output stage current exceeds the normal operating current rating of the relay winding. Most relays, in the range of current between the release and operate points, are more or less erratic and unpredictable in operation. It is extremely difficult to manufacture a relay that will meet specifications as to shock, vibration and orientation, in both operated and nonoperated conditions, and at the same time exhibit completely reliable and predictable performance from zero to rated maximum winding current. Further, the rise time of an integrated dc voltage, derived from random speech, may be relatively slow. This results in considerable dwell time in this unreliable area of operation.

One apparent solution to this problem is to drive the relay with a fast acting electronic switch. This switch must have smoothly and precisely adjustable sensitivity, long term stability, and the output must be an unequivocal on or off. Fortunately, just such a device is available and, while not widely used in this application, is admirably suited to the task. The case in point is the monostable multivibrator.

Fig. 1A. Schmitt trigger relay circuit provides greatly improved operation. Note 1: Insert resistance in series with RL, if required, to provide a 10,000 ohm plate load. Note 2: Add R3 for negative VOX, positive anti-VOX control. Adjust value downward to point where relay opens with no control input.



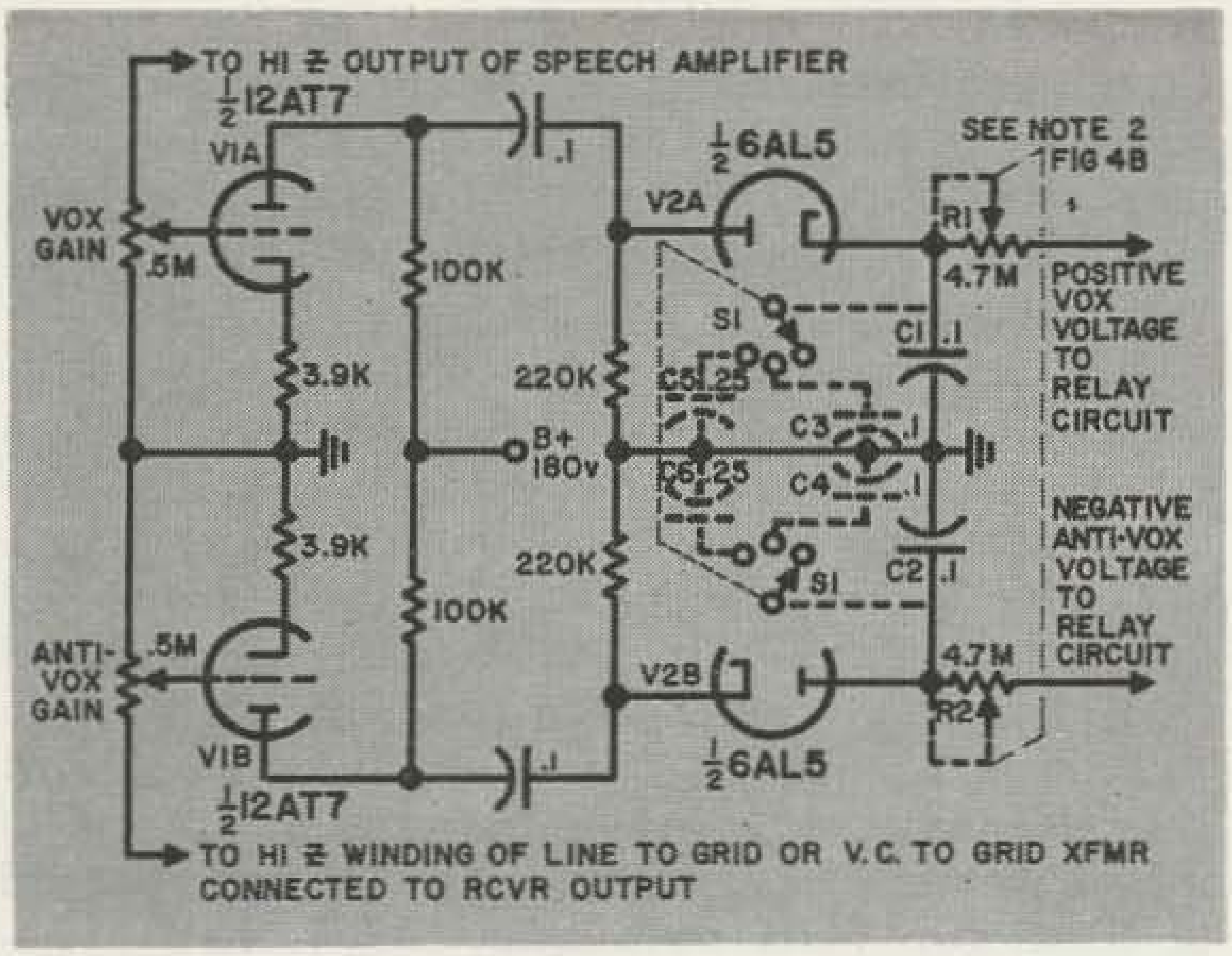


Fig. 1B. Suggested audio and detector circuit for the Schmitt trigger shown in Fig. 1A. Note 1: If variable C adjustable delay is desired, change C1 and C2 to .05 mfd and add C3, C4, C5, C6 and S1. Note 2: If variable R ad justable delay is desired, change R1 and R2 to 10 megohm dual potentiometer. The fixed values shown for C1, C2, R1, E2 provide optimum recovery delay.

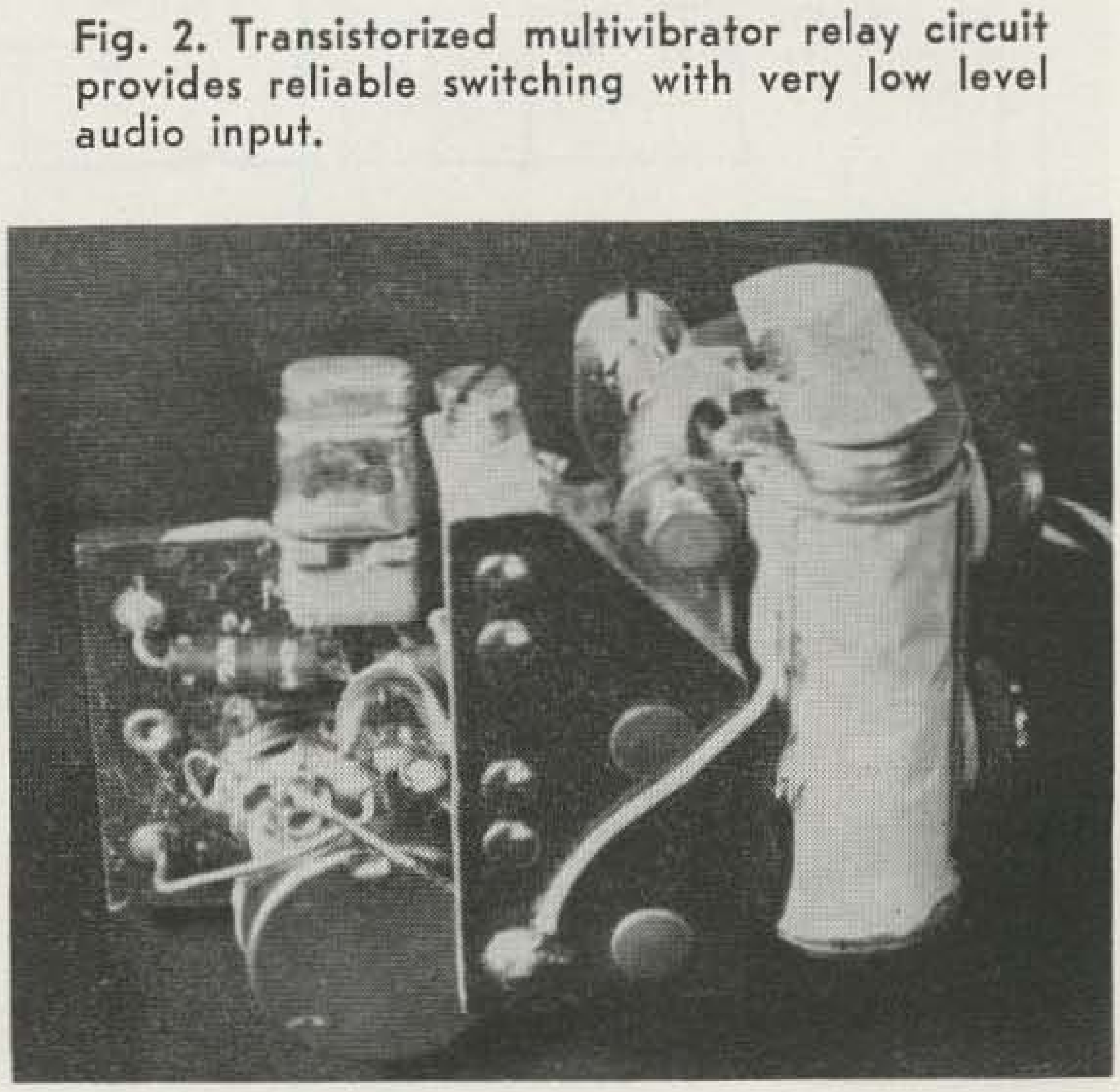
While the basic circuit has many variations, the most suitable of these is the Schmitt trigger. The output of this circuit has two states, either cutoff or saturation, while the input possesses a selective or slicing characteristic. That is, when a signal or control voltage below a precisely determined trigger point is applied, there is no change in output. When the control voltage exceeds this point, the output stage triggers from cutoff to saturation. The circuit switches back to its quiescent condition when the control voltage falls slightly below the operate point. There is no appreciable in-between condition as the switching time is measured in microseconds. All of this is obtainable at no additional cost, since the component requirements of the Schmitt trigger are less than those of many dc amplifier circuits. Further, a very sensitive or high quality relay is not necessary. Almost any relay will do, so long as it has the required number of contacts and its operating current approximates the saturation current of the output stage.

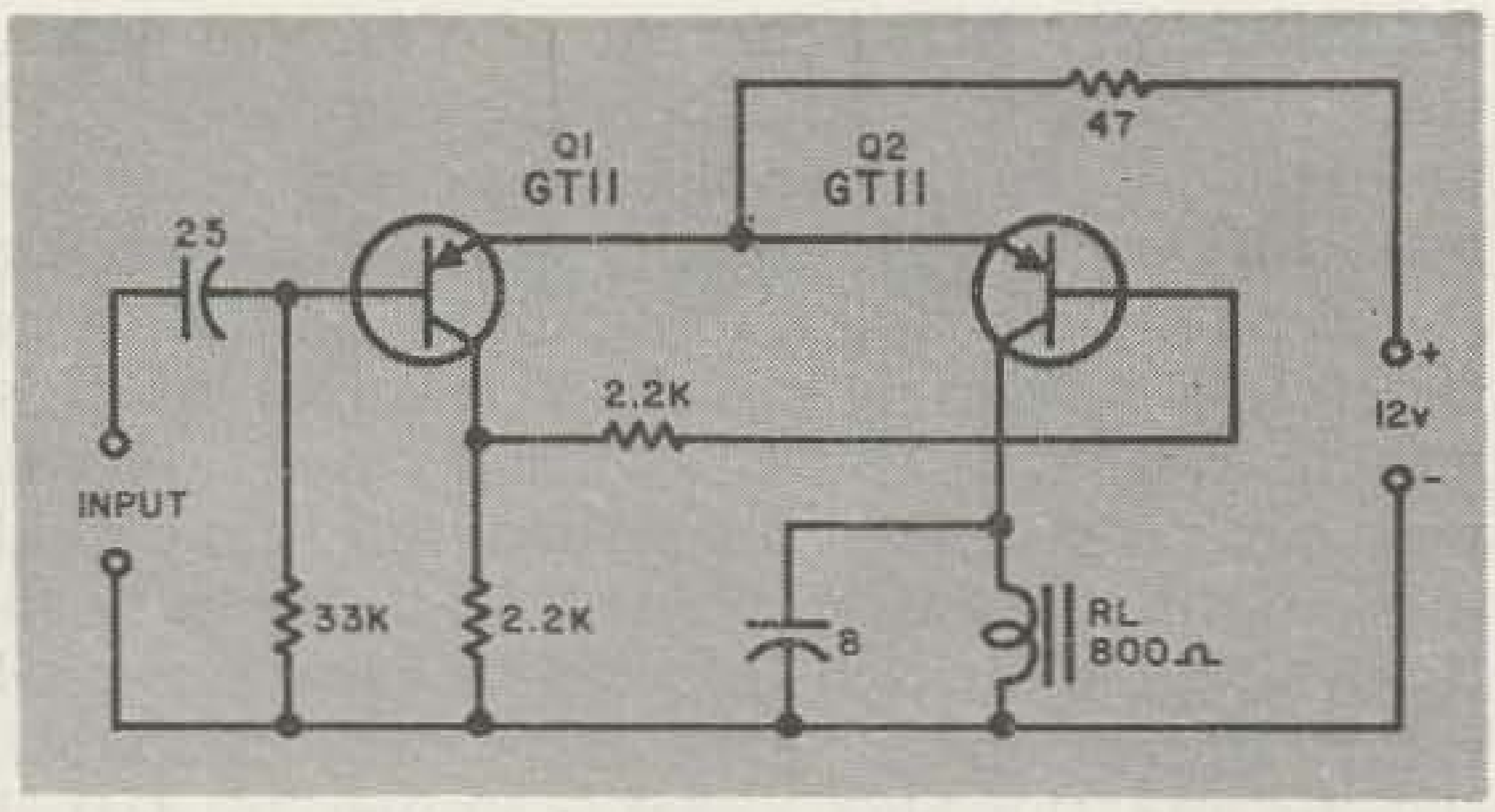
Practical testing now appeared in order, so a speech amplifier and VOX assembly, using the circuit shown in Fig. 1A, was constructed for use in a surplus conversion project. With the configuration selected, the output stage is normally saturated and a positive control voltage is required to switch the Schmitt trigger circuit. The device functioned perfectly, switching reliably on 3 volts dc and switching back when the VOX voltage fell slightly below that point. A positive voltage applied to the grid of V1A causes a drop in the plate potential of that stage. This plate is coupled to the grid of V1B, which is normally clamped at cathode potential. The plate current of V1B decreases, thus the cathode potential drops and the grid potential of V1A increases. The action is regenerative and V1B rapidly cuts off. Lowering the applied bias signal to a point slightly below the trigger voltage causes a reversal of this action. With the control voltages available, it was more convenient to return the input grid to a slightly negative point and to use a positive voltage to switch the stage. If the reversed relay operation is considered objectionable, simply add the bias resistor shown in dotted lines and a negative signal will saturate the output section of V1, although a slightly greater control voltage will be required. The improvement of this circuit over the conventional dc amplifier type of voice control is remarkable. No attempt was made to further optimize the circuit since operation, with values shown, was satisfactory in every respect.

Input and detector circuits suitable for use with this Schmitt trigger relay are shown in Fig. 1B and are typical of those normally used in this application. The VOX gain control is advanced until the unit is tripped by normal speech. Since the relay circuit operates on a "slicing" principle, considerable delay or recovery time adjustment may be obtained by varying the VOX gain between the points where normal speech trips the relay and ambient room noise causes operation. The theory of this is simply that the more the rectified control voltage exceeds that required to operate the relay, the longer it takes that voltage to decay to the point where the reverse operation occurs. After adjustment of the VOX gain, the Anti-VOX gain should be advanced to the point where normal speaker level will not trip the relay.

If the range of delay adjustment is not considered adequate, the values of R1 and R2 *or* C1 and C2 may be simultaneously changed to

Fig. 2. Transistorized multivibrator relay circuit provides reliable switching with very low level audio input.





Compact, transistorized multivibrator controlled relay assembly. The complete switching circuit is shown here.

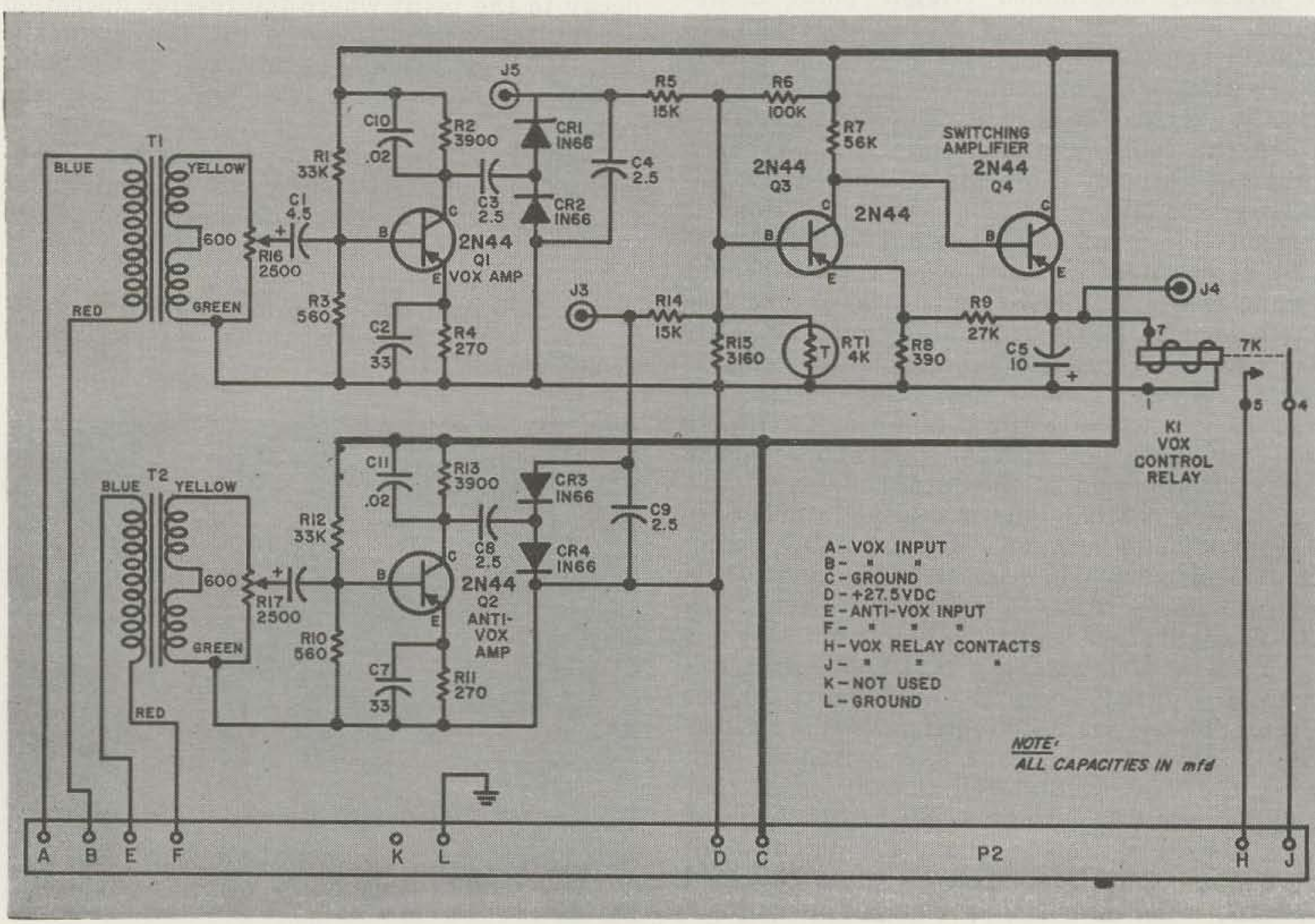
covery time is required, either the R or C option of Fig. 1B may be installed. Replace R1 and R2 with a 10 megohm dual potentiometer or install the capacitor switching network shown.

Transistorization

Having confirmed that use of the multivibrator in vacuum tube VOX circuits offered the apparent advantages, attention was turned to the use of transistors in this application. The writer desires to construct a fully transistorized SSB exciter with all of the operational features and performance characteristics of the better available commercial equipment. The following material was gathered for the preliminary design of the VOX circuit of this future project.

The use of a transistorized monostable multivibrator for relay control is not new. Such a circuit was featured in an article, "Multivibrator Operates Relay", by G. B. Miller, and published in the December 5, 1958 issue of "Electronics". While the circuit, reproduced in Fig. 2, was designed to function with an ac switching signal, the basic slicing action with the attendant advantages is present. While it might appear that an ac operated relay would be ideal for VOX switching, this is not necessarily true. While it functions perfectly in the VOX action, the integrating characteristic of the circuit makes the application of the Anti-VOX signal a difficult task. This emitter-coupled circuit is of interest in such applications and its performance is remarkable. If the Anti-VOX feature is not required, this circuit is a good, clean solution to the problem. Switching is obtained with an input signal of about 10 millivolts from a 10 ohm source and the circuit switches back when the signal drops slightly below this level. One additional advantage accrues in the use of multivibrators in

Fig. 3. Vox Anti-Vox module of the Collins Radio 786F-1 Sideband Generator. This portion of the 310F-6E Exciter illustrates a commercial application of transistorized voice control switching circuitry.



transistorized switching circuits. A transistor is capable of switching power far in excess of its Class A amplifier rating if the transition time between cutoff and saturation is very short. Therefore, any circuit that would permit the output stage current to dwell at some point between cutoff and saturation would greatly increase the output stage power handling requirement. If the relay recovery time is too short, the value of the capacitor shunting the relay may be increased in value up to several hundred percent without adverse effects.

Collins Radio in one of their "firsts" has used transistorized switching amplifiers in their military/commercial 310F-6E High Frequency Communications Exciter. The circuit, courtesy of Collins Radio Company, is shown in Fig. 3. Another feature contributing to the performance of his unit is the use of a voltage doubler configuration in the VOX and ANTI-VOX rectifier circuits. This technique is particularly valuable when using transistors, since the required voltage swing may be difficult to obtain without using special transformers. In any event, this circuit is seeing increasing use in receiver AGC and transmitter ALC applications.

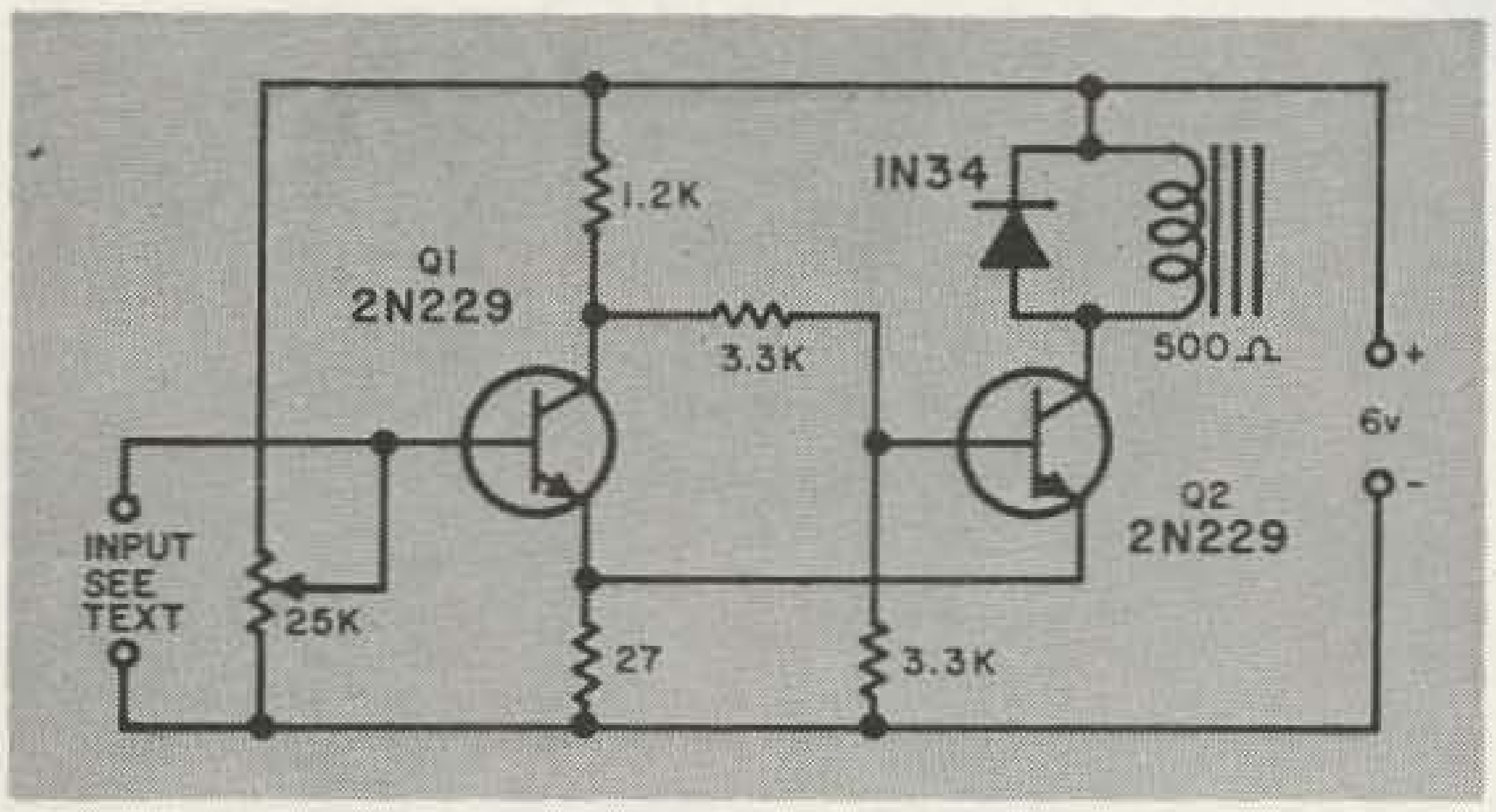


Fig. 4A. DC version of the transistorized multivibrator relay switching circuit.

The device shown in the photograph was constructed to test the ideas generated by this approach. The circuit, shown in Fig. 4A, was adapted from a circuit described in the Sylvania manual, "Performance Tested Transistor Circuits". The potentiometer in the input circuit is a change from the original bias network and permits setting the input stage bias for best operation. No real attempt was made to miniaturize the circuit, since the relay, the only one immediately available, was the limiting factor. Actually, the circuit is very noncritical and almost any general purpose NPN transistor may be used. If the battery and diode polarities are reversed, PNP transistors will serve equally well.

Base bias of the input transistor is initially set slightly below the point where the relay operates. In this condition, Q1 conducts and Q2 is cutoff. As the base bias of Q1 is reduced by the rectified control signal, the collector current is reduced and the collector voltage rises. This rise appears at the base of Q2 and when it reaches a critical value, Q2 conducts, switching the multivibrator. Relay current under these conditions is either negligibly small or, for all practical purposes, infinitely large. Therefore, positive, fast relay action is obtained with only a few millivolts variation in input signal. Desired operating delays in relay action may be achieved by altering the time constant of the RC network in the VOX and ANTI-VOX control signal rectifier circuits. Starting point values for this application may be found in Fig. 3. Since the detector circuits of Fig. 3 are designed for use with PNP switching transistors, the VOX and ANTI-VOX inputs of Fig. 3 must be reversed to permit use with the NPN switching circuit of Fig. 4A.

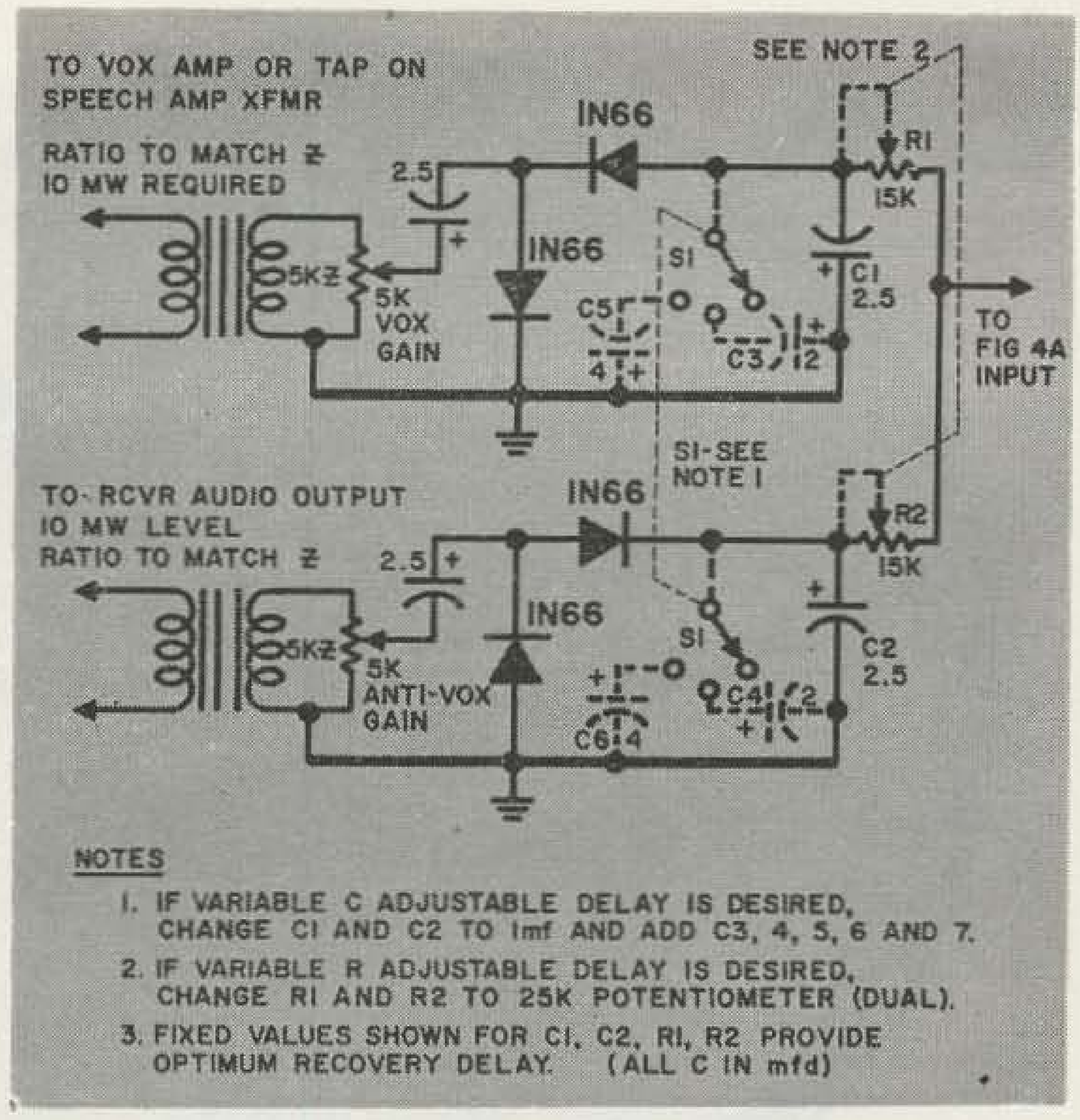


Fig. 4B. Suggested input and detector circuit for the transistorized relay shown in Fig. 4A.

The information presented herein was developed to meet the previously described specific requirements and it is believed that the objectives have been realized. The results warrant more general application of this type control circuitry and, while certainly not in finished construction project form, this data should be of considerable value to anyone embarking on a similar project.

The same considerations, with respect to recovery time delay, that were described with reference to Fig. 1A and 1B apply to the transistorized version. Fig. 4B shows suitable input and detector circuits for use with the relay unit shown in Fig. 4A. If the recovery time delay of the circuit, using values specified, is not acceptable, alter R1 and R2 *or* C1 and C2 for the desired time constant. If adjustable recovery time is desired, replace R1 and R2 with a dual 25,000 ohm potentiometer or install the capacitor switching network shown.

The Perfect Squelch

Staff

ESPECIALLY in mobile or VHF operation, the background noise emitted by a receiver when no signal is coming in can become tiring in a hurry. Fortunately, it's not difficult to squelch out this noise with a muting circuit.

Such circuits are popular. This popularity is attested to by the number of different articles published on them in the last five years. The only trouble is this: with so many different circuits in print, how are you going to choose the one which best suits your needs . . . the perfect squelch?

To help you make this decision, we've gathered these circuits all in one place. Advantages and disadvantages of each are listed to help you choose which one will work best for your own installation.

Before going into details of the various squelch circuits, let's take a look at the basic purpose of such a system and the various ways in which this purpose may be accomplished.

The purpose is simple—to quiet audio output from a receiver when no signal is coming in. The ways of doing this, however, are legion . . . and each has its own set of pros and cons.

You can open the audio path with a carrier-controlled switch (the basic operation of most squelch circuits) or you can short-circuit this same audio path with a similar switch acting in reverse. You can use another carrier-operated switch to turn the whole receiver on or off—but this requires, in essence, two receivers, and so is not very practical in use.

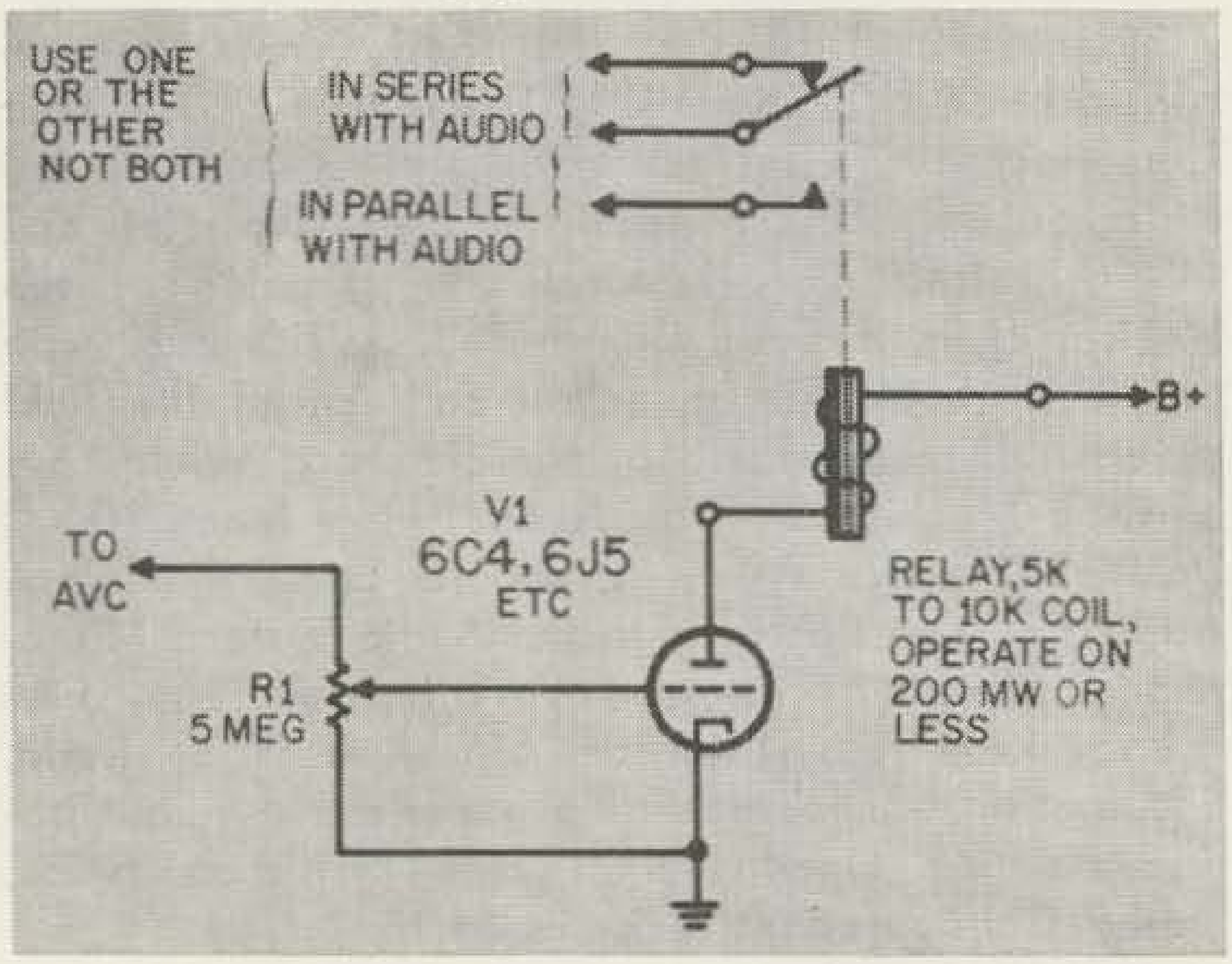


Fig. 1—Schematic Diagram of Relay-Squelch Circuit.

Another approach is to use part of the audio signal itself to control a switching circuit. Squelches based on this principle are usable for sideband or CW as well as AM and FM. Any muting device which depends on the carrier for operation won't work so well with carrierless sideband.

You can see that all these techniques require some sort of switching circuit. However, this switch may be either a relay, a biased diode, a multi-grid vacuum tube, a combination of triodes, a transistor, or any other electronic device which allows one signal to control passage of another.

By the mathematical laws of permutation and combination, and considering only the items specifically listed above, this works out to a total of 20 possible different circuits. When you take into account differences in equipment, the number of possible practical circuits runs rapidly into the thousands.

We aren't going to talk about any thousand circuits here. We aren't even going to talk about 20 of them, since some of the possible combinations don't work out in practice. We *are* going to talk about all the practical squelch circuits which have appeared in the literature since 1945.

These circuits fall into six broad categories. The best-known of these is possibly the relay-squelch circuit, made famous by the SCR-522 and since adapted to many other receivers.

Other categories include shunt-tube squelch,

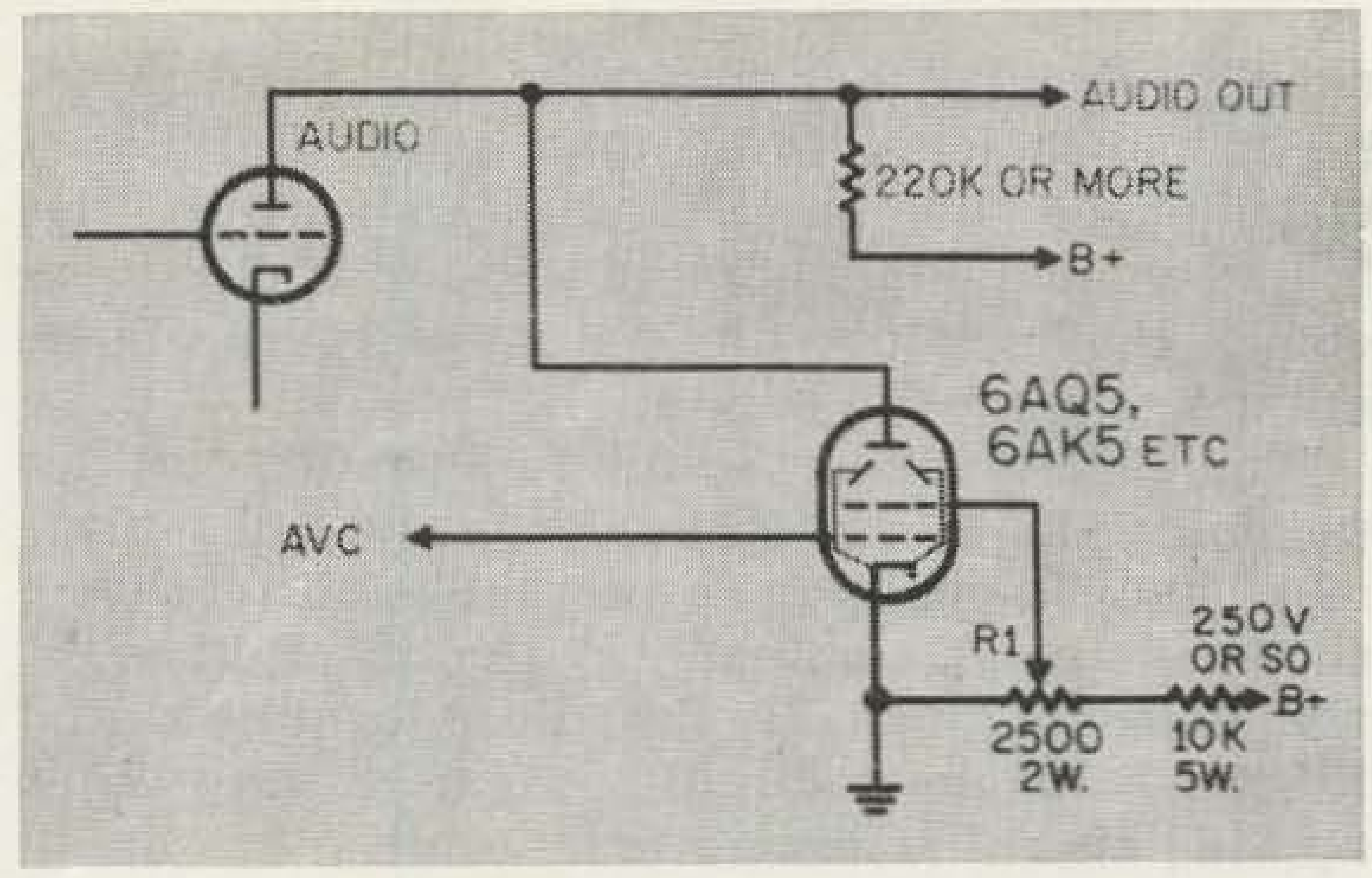


Fig. 2—Schematic Diagram of Shunt-Tube Squelch.

biased-detector muting, balanced-modulator quieting (the best example of which is the famed TNS), noise-operated circuits, and audio-cutoff (the basis of Western Electric's family of CODANs).

Since the relay-operated circuit is one of the best known, let's look at it first (Fig. 1). Component values shown on the schematic are all non-critical; almost any combination of junk-box parts should work well. The only requirement is that the relay operate when AVC voltage increases.

In operation, when no signal is tuned in the AVC level is at a minimum. The squelch tube (V1) draws plate current, holding the relay actuated. With arrival of a signal, AVC voltage rises. This voltage cuts V1 off, allowing the relay to drop out. The portion of AVC applied to the grid of V1 is selected by R1, the squelch-level control, allowing the operator to select the operating point of muting.

Contacts of the squelch relay can be connected to short an audio tube's grid to ground, or to open the speaker leads, as desired. Shorting the grid to ground usually results in quieter operation, but care must be taken to be sure you don't remove the tube's protective bias when you short it out.

Advantages of the relay squelch include ease of construction, inexpensiveness (when you have a well-stocked junkbox), and sureness of operation.

Disadvantages include the mechanical "plop" of the relay every time it operates, and the loading of the AVC line by R1. R1 will reduce the AVC time constant enough to prevent use of "hanging" AVC action on sideband signals. In addition, if you must purchase the relay and can't find a suitable surplus unit, it will probably cost close to $10 to build.

One of the least-known squelch circuits is the shunt-tube arrangement shown in Fig. 2. Like most other muting devices, it depends on AVC voltage for control—but unlike most other circuits, it requires almost no alteration of the receiver's existing circuitry. The only change necessary is substitution of a 220K ohm resistor in the first audio plate circuit if the existing resistor has a lesser value.

In operation, the squelch tube draws plate current if AVC is not present. By proper choice of tube—a 6AK5 or 6AQ5 is ideal—this drain may be made so heavy that voltage at the first-audio-tube plate drops nearly to zero. With almost no plate voltage, gain of the audio tube drops to nothing and the receiver is quiet.

When AVC arrives at the grid of the control tube, its plate current is reduced and voltage at the audio-tube plate rises because of less drop through the 220K resistor. When AVC is high enough—the amount of AVC necessary is determined by the control-tube screen voltage, set by R1—the control tube is cut off and the audio tube receives full plate voltage. Signals then pass through the audio stage.

Advantages of this circuit include the limited amount of receiver rework necessary and the low cost of parts.

Disadvantages include the necessity of providing filament power for another tube, and limited control of the squelching point (with a sharp-cutoff control tube, any AVC greater than about 5 volts will open the squelch regardless of control setting).

Biased-detector muting, one of the simpler

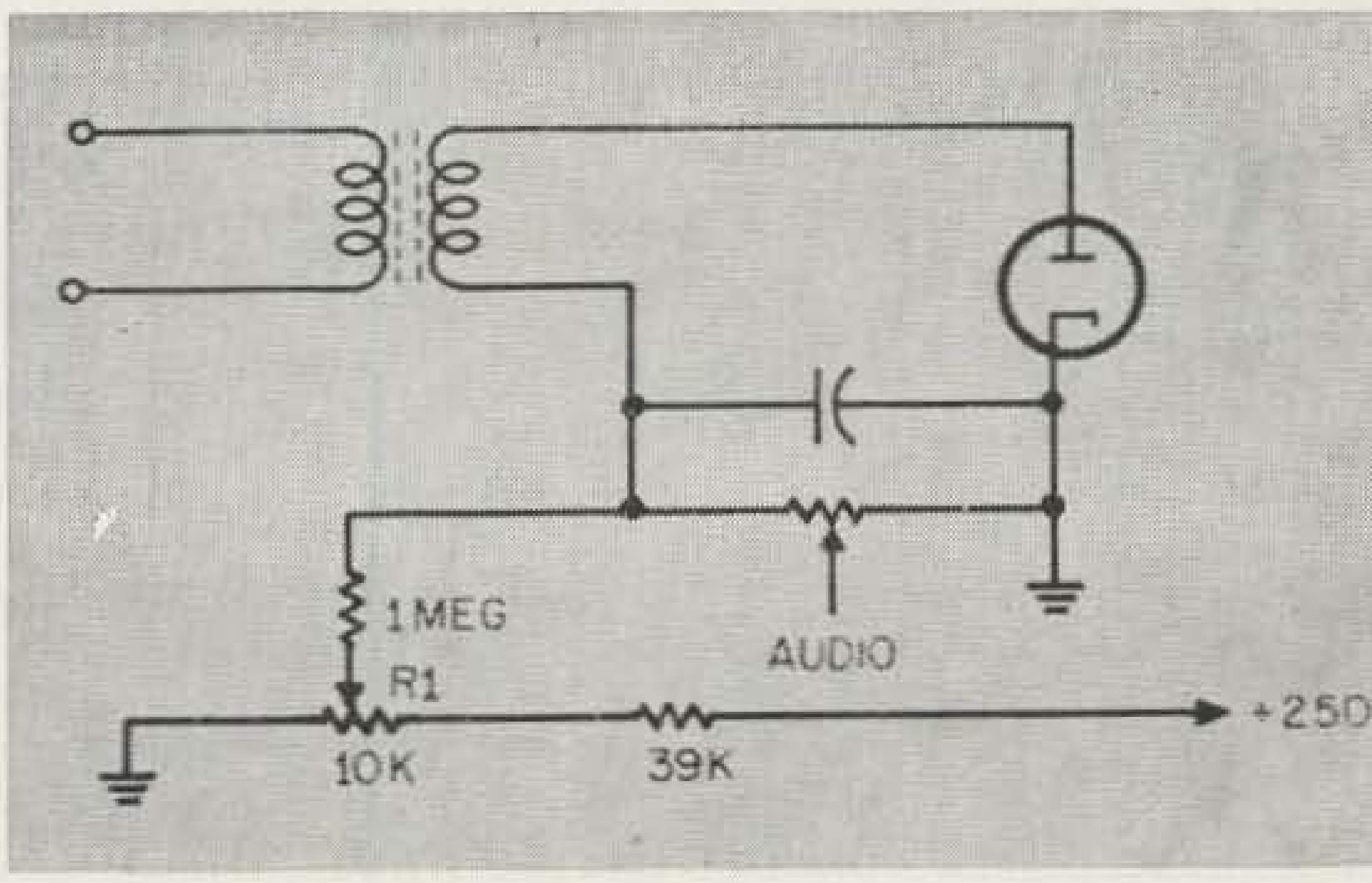


Fig. 3—Basic Biased-Diode Muting Circuit, Schematic Diagram.

squelch circuits, has probably been the subject of more articles than any other individual circuit type. The basic circuit is shown in Fig. 3, and a more-sophisticated version which overcomes the greatest disadvantage of the basic circuit appears in Fig. 4.

The principle of operation of this circuit depends on diode switching. Whenever the plate of a diode is negative in respect to the cathode, the diode can't conduct. On the other hand, if the plate is positive the diode conducts and looks like a short circuit so far as any other applied signal is concerned.

By applying a positive voltage to the detector plate, the detector is effectively shorted and no audio (noise) can be fed to the receiver output. An incoming signal will also be shorted, until its amplitude is great enough to overcome the detector bias and drive the plate negative on peaks.

At that point, normal detector action resumes and the signal is heard. Adjustment of this critical bias point is made simply by varying the voltage applied to the detector plate with R1.

The basic circuit has only three added parts and requires only two connections to the receiver (aside from a grounding point). Cost is less than a dollar. Other advantages include an automatic delayed-AVC result (since the detector must overcome the squelch bias to develop AVC as well as audio) and a total lack of complicated adjustments.

However, the biased-diode basic circuit has a major disadvantage — distortion. Signals which are extremely strong compared to the noise will be relatively unaffected, but consider the case of a signal barely above the noise threshold. Only the peaks of the signal will open the squelch, and the resulting output signal will bear little resemblance to the original. In fact, it will be unreadable.

To overcome this disadvantage, the more-sophisticated biased-diode detector shown in Figure 4 was developed. It is adapted from a circuit described in 1943 by K. R. Sturley.

In operation, with no input signal, tubes V2 and V4 are conducting. The cathodes of V3, V4, and V5 are all positive, and since V2's plate is positive and it is conducting, its cathode will also be positive to ground.

With V2's cathode positive, the cathode of V1 will be positive also, and the detector will be unable to operate for exactly the same reason as in the basic circuit. AVC voltage will be zero, as will audio output.

When a signal comes in, it is coupled through the capacitors to the plate of V3. V3, acting as a shunt detector rather than the conventional series type, rectifies the signal to produce a negative voltage at the top of the 25K load resistor. This voltage goes through the 470K isolation resistor to the grid of V4, increasing the tube's resistance and lowering the positive voltage on the cathode bus.

At a level determined by the setting of level control R1, the positive voltage on the cathode bus is cancelled by the fixed negative bias voltage. At any signal level greater than this, the negative bias overrides and changes the polarity of the cathode bus. At this time, V5 conducts and allows AVC voltage to pass. At the same time, V2 is cut off. With V2 cut off, the positive voltage is removed from the cathode of V1 and the detector resumes normal operation.

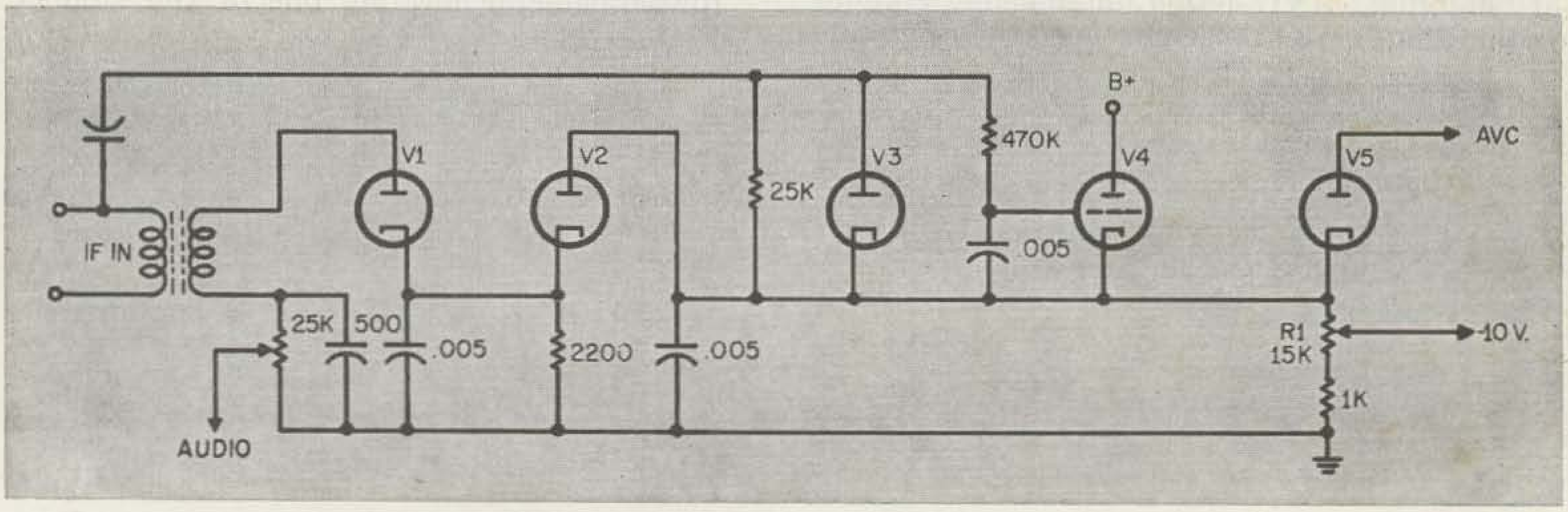
The distortion inherent in the basic circuit is overcome in this circuit by proper choice of RC time constants. Before all switching elements operate and allow the signal to pass, the signal must be far enough above the squelch level to be out of the distortion zone.

The relative freedom from distortion is the only advantage the circuit of Fig. 4 has over other squelches. Obvious disadvantages are the circuit complexity and the necessity for complete rebuilding of the audio detector-AVC portion of the receiver.

The balanced-modulator squelch used in the TNS circuit is shown in Fig. 5 in simplified form. For a detailed construction-type schematic of the TNS, see the references.

In operation, with no incoming signal, neither V1 nor V2 has any grid bias. Cathode bias provided by identical resistors keeps plate current within safe limits. Squelch control R1

Fig. 4—Advanced Biased-Diode Muting Circuit, Schematic Diagram.



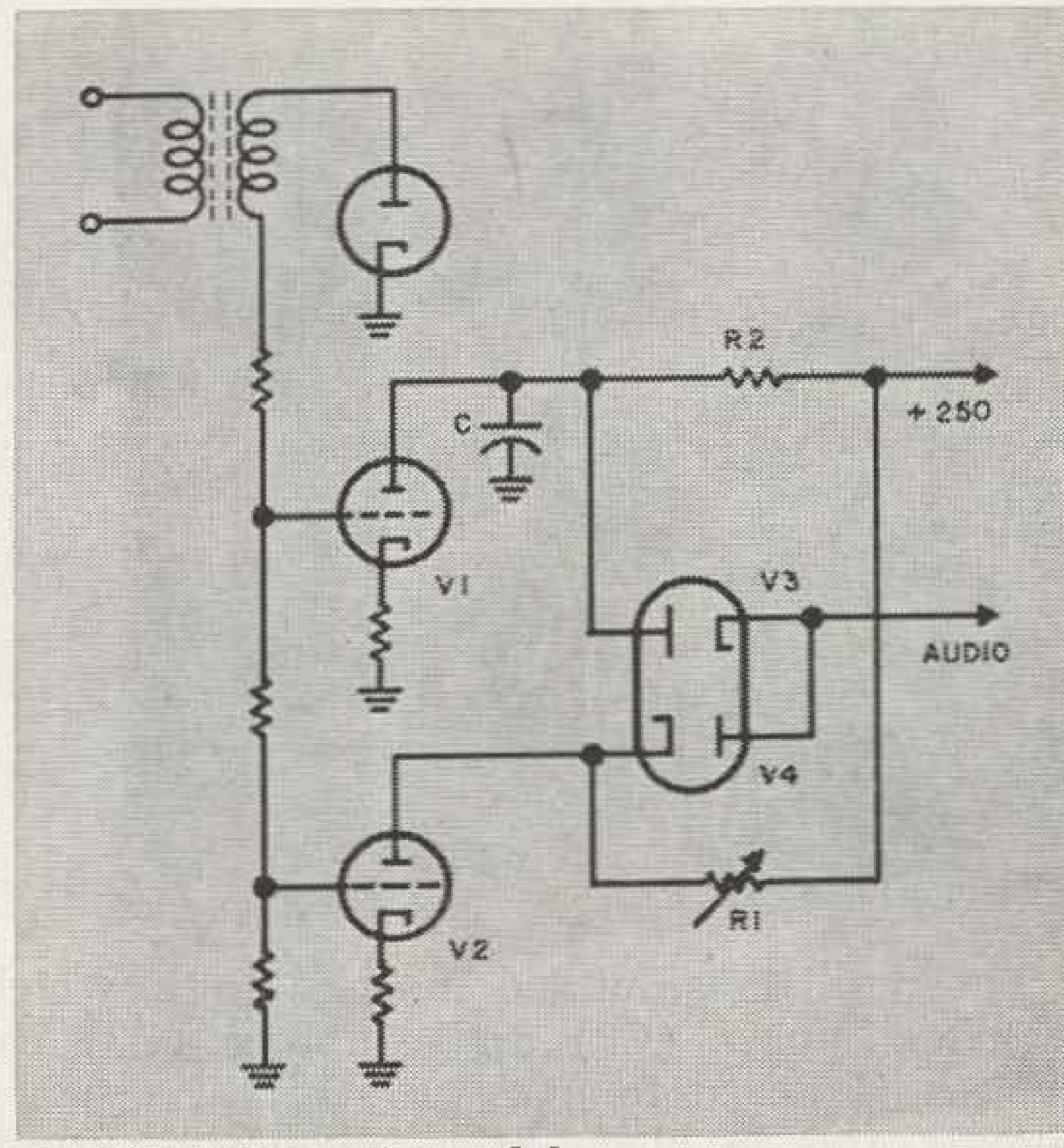


Fig. 5—Balanced-Modulator (TNS) Squelch, Simplified Schematic Diagram.

is set so that the voltage at the plate of V2 is slightly more than the voltage at the plate of V1.

Since the plates of both V1 and V2 are direct-coupled to diodes V3 and V4, this setting of the squelch control makes the cathodes of both diodes positive with respect to their plates. With the diodes not in conduction, no audio signal passes through.

With a signal coming in, the picture changes. The input voltage divider (which replaces the normal detector load resistor) is designed so that V1 receives half the AVC voltage as grid bias, while V2 gets only one-tenth.

This drives the plate of V1 positive as compared to the plate of V2, and biases V3 and V4 into conduction. Audio goes through.

Capacitor C, in conjunction with R2, perform the noise clipping. See Bill Orr's "Mobile Handbook" for a complete explanation of the TNS circuit—we're only concerned with its squelching action here.

Least-publicized of all squelch circuits, in ham literature at least, are those operated by noise. Most commercial two-way mobile gear uses this type of squelch.

The distinguishing feature about the noise-operated squelch is the origin of its control signal. While other muting circuits depend primarily on AVC developed by an incoming carrier, the noise-operated version picks up AF noise from the detector, amplifies it, rectifies it ,and uses the resulting DC as a control signal.

This works because most receivers exhibit a degree of "quieting" of background hiss with an incoming signal. With some high-quality VHF receivers, incoming signals produce an increase in background noise—and with these sets, a noise-operated squelch won't work.

Workings of the noise-operated muting circuits are explained in block-diagram form in Figure 6. A practical schematic, derived from the RCA Carfone series of commercial two-way sets, is shown in Fig. 7.

Looking at the two illustrations together, C1 and the 10-mh rf choke together comprise a 10-kc resonant circuit. This resonant circuit is the "high-pass filter" of the block diagram, picking off noise components of the detector output and feeding them to the triode section

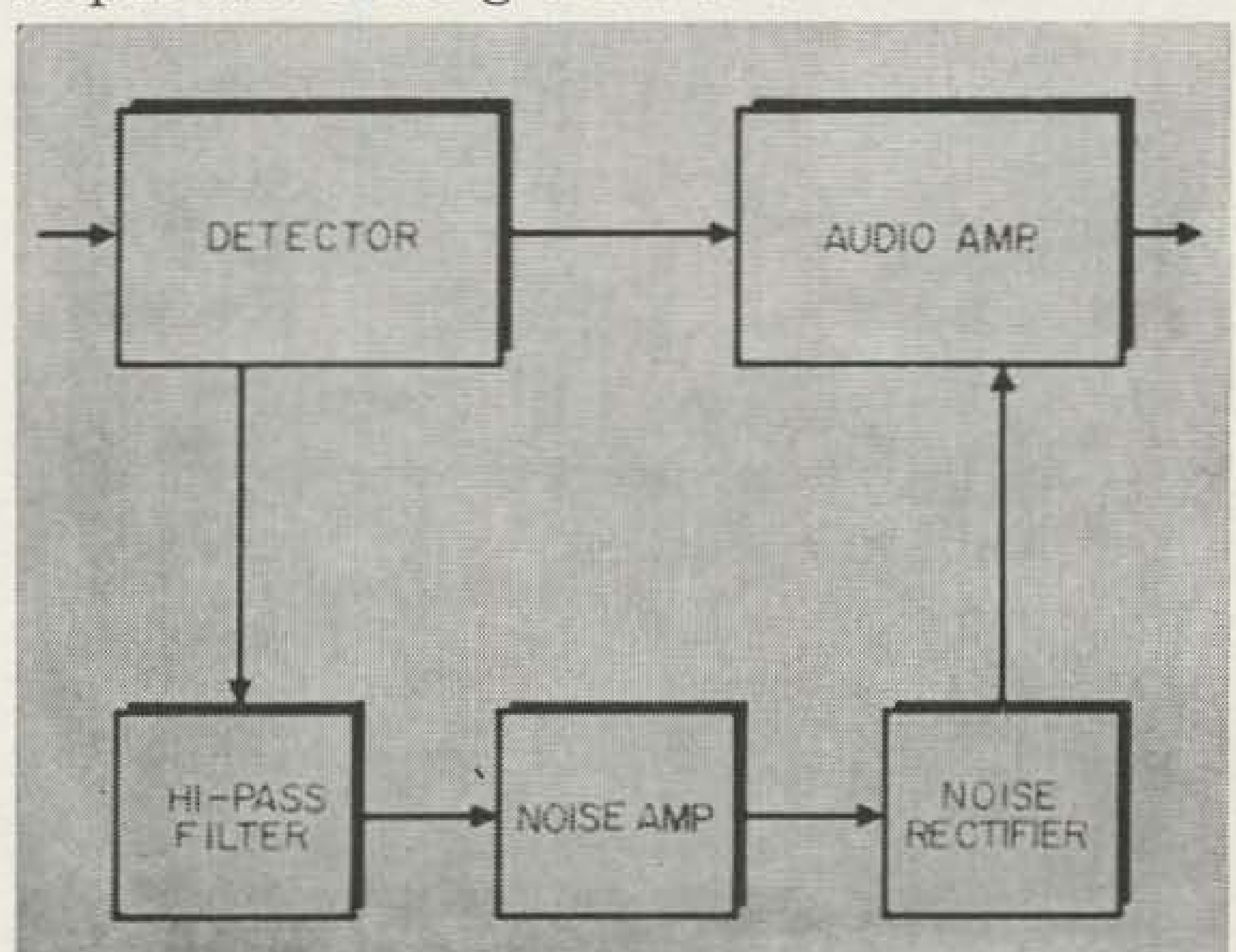


Fig. 6—Noise-Operated Squelch, Block Diagram.

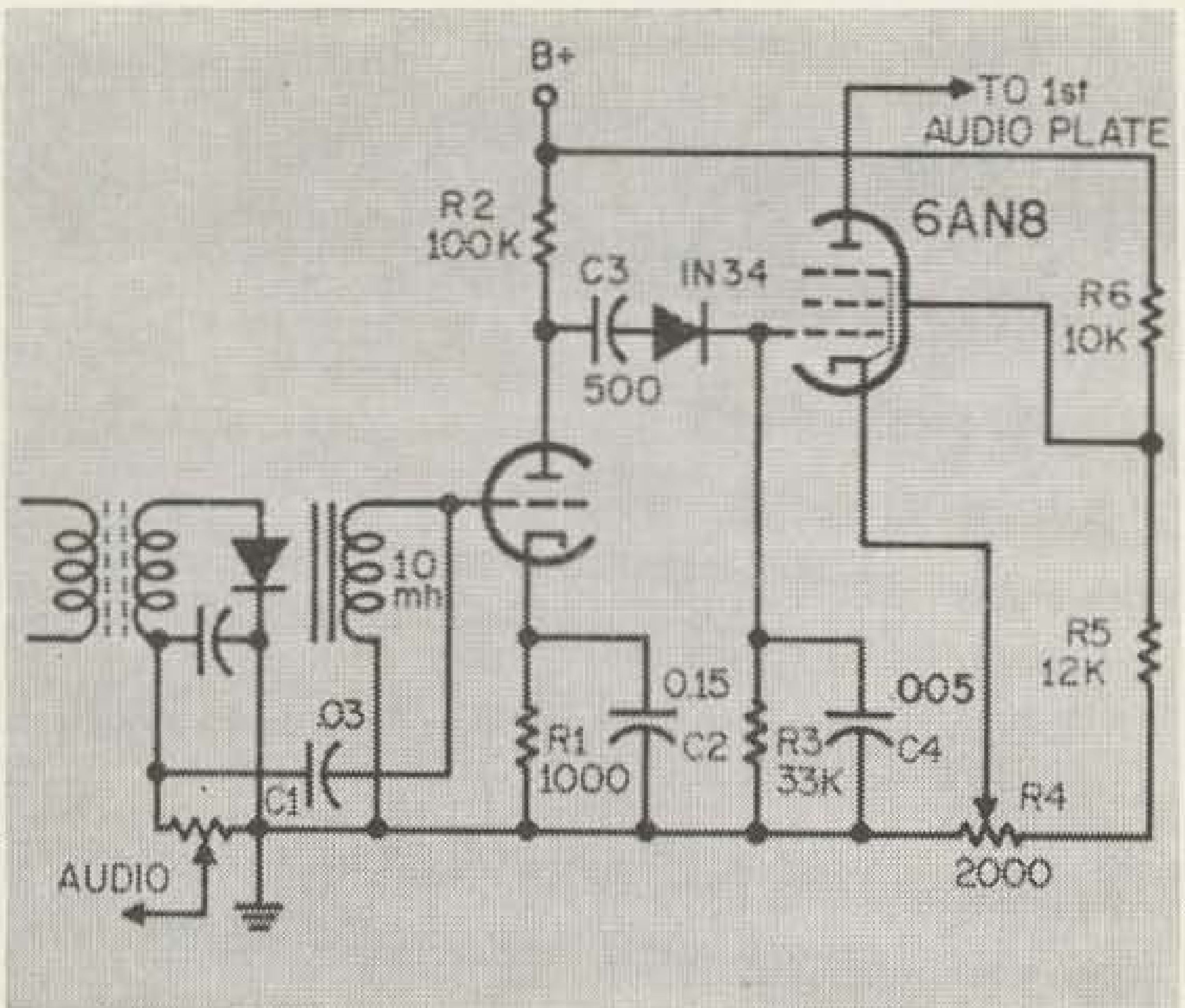


Fig. 7—Noise-Operated Squelch, Schematic Diagram.

of the 6AN8.

The noise is amplified in this stage, which includes bypass (C2) and coupling (C3) capacitors tailored to pass only high-frequency signals and to block voice-frequency output. The 1N34 rectifies this amplified noise voltage to produce a positive voltage at the top of R3, which is coupled directly to the 6AN8 pentode control grid.

This positive voltage on the grid doesn't hurt the tube, since a similar positive voltage is also applied to the cathode through R4, the squelch control (which may be remotely mounted since it carries only dc), and the voltage divider, R5 and R6.

The pentode half of the 6AN8 is the audio-control tube, operating in the same fashion as the shunt-tube squelch discussed earlier in this article.

In the absence of signal, noise is picked off and amplified. It reaches the grid of the 6AN8 pentode as previously explained. Cathode voltage on the 6AN8 will have been adjusted, via the control, to be slightly less than that on the grid. As a result, the tube conducts heavily, dropping plate voltage of the audio tube to less than a volt and cutting off all sound from the set.

When a signal appears, the noise level diminishes. This causes the voltage at the output of the noise rectifier to decrease, leaving the 6AN8 pentode's control grid less positive than its cathode. The tube is cut off, plate voltage to the audio stage rises to the design value, and the set functions normally.

Advantages of this circuit which make it particularly attractive to the commercial manufacturers include its relative indifference to incoming signal strength. So long as the signal is above the noise level, it will operate the squelch—something not possible with any AVC-operated squelch. It also removes the squelch control from both high-voltage and signal-carrying circuits, allowing remote placement with no difficulty.

Disadvantages, naturally, include complexity and expense. While the entire circuit can be put together on a Vector turret socket and mounted in a small Minibox, it's still one of the most complicated of the six basic squelch circuits. With so many parts, it's more liable to failure due to the inherent perversity of inanimate objects. And troubleshooting this squelch circuit can drive the most patient technician mad, since any symptom can be caused by any component.

This brings us, naturally, to the audio-cutoff muting circuit. Developed for transoceanic telephone circuits by the Western Electric Company, it falls between the shunt-tube cir-

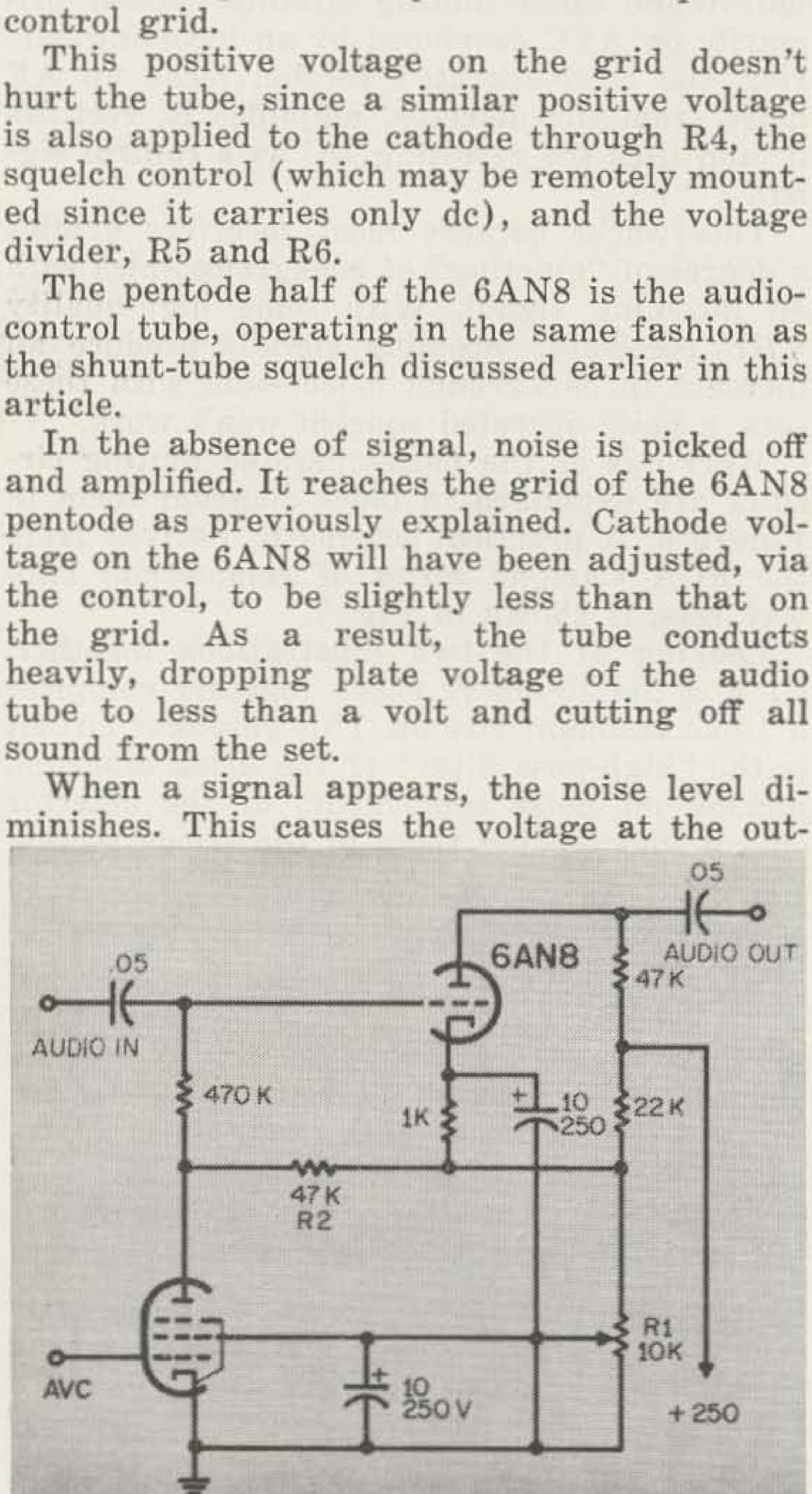


Fig. 8—Audio-Cutoff Squelch (CODAN), Schematic Diagram.

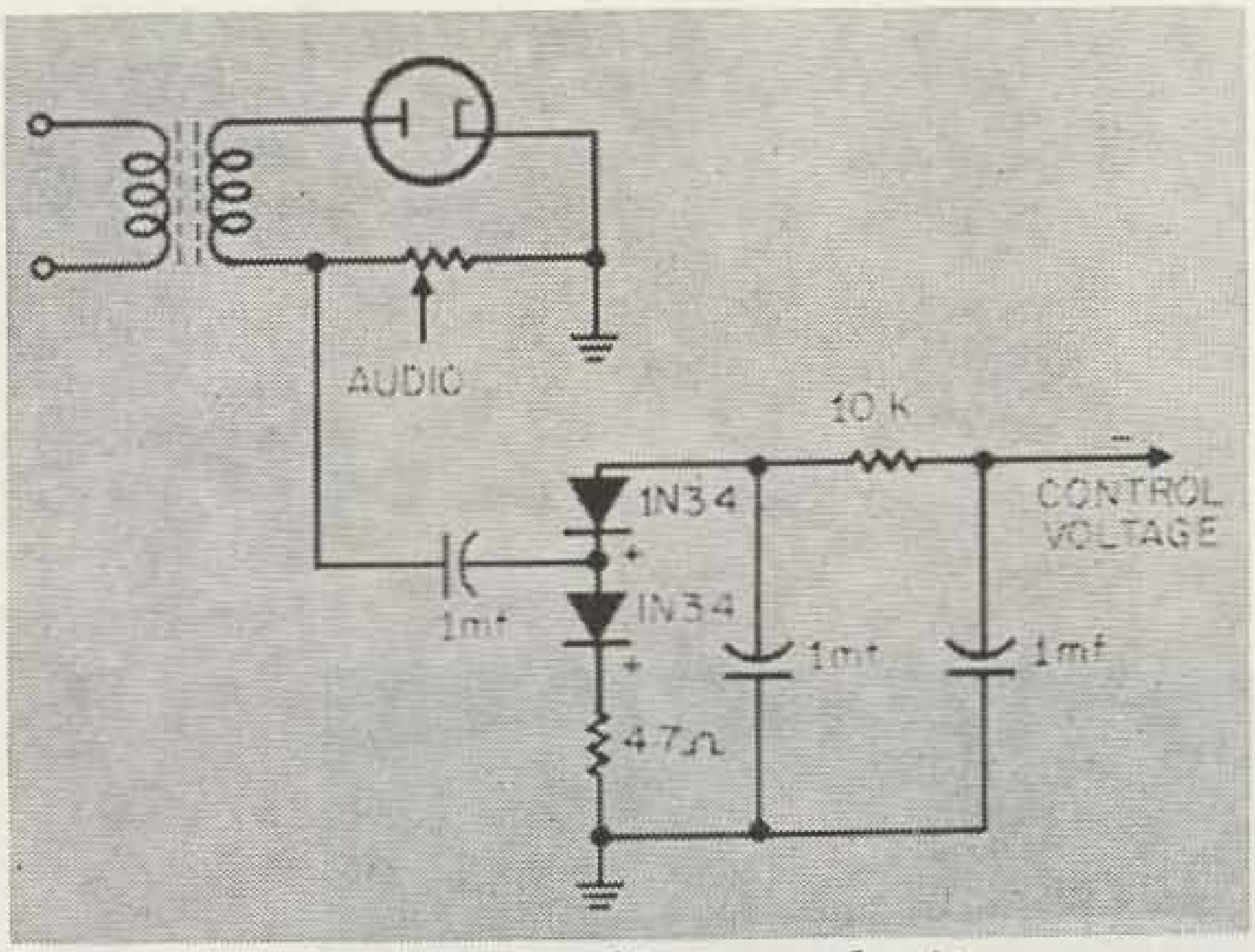


Fig. 9—Audio-Derived Control Voltage Adapter for Any Squelch Circuit, Schematic Diagram.

cuit and the noise-operated genre in complexity. A diagram appears in Fig. 8.

This circuit, like most others, is operated by AVC voltage. However, unlike some others it does not offer any load to the AVC bus.

In the absence of AVC, the pentode section of the 6AN8 conducts heavily. Just how heavily is determined by the setting of squelch control R1, which adjusts screen voltage and also determines the amount of negative voltage required to cut the tube off.

Plate current of the pentode section must pass through R2, which is also in the grid-cathode circuit of the triode section. The resulting voltage drop across this resistor is applied to the triode as negative grid bias, cutting the tube off and killing audio output.

When AVC is applied to the pentode, it is cut off and no plate current flows through R2. With no voltage drop, the audio tube functions normally.

Advantages of this circuit include a wider range of control in the squelching level (the CODAN can be set to operate for S7 signals but to reject those which are S6 or below) and additional audio gain, compared to other squelch circuits.

Disadvantages are its complexity as compared to shunt-tube, relay, or biased-diode muting circuits; the relatively high voltage applied to the squelch control; and the sensitivity to hum directly due to added audio gain. All parts of this circuit must be shielded, and especial care must be taken to keep the heater leads away from the audio signal path.

That completes the six basic squelch circuits —but there's still one more thing worth mentioning.

In all except the noise-operated circuit, the AVC line furnished the control signal which triggered the squelching switch. This works fine on AM or FM, but if your receiver is not equipped to use AVC on CW and sideband you won't be able to enjoy the advantages of squelch with these modes of communication.

A simple way to lick this difficulty is shown in Fig. 9. By picking audio voltage off the detector output at the top of the volume control, rectifying it in a voltage doubler, and using the negative output as control for the squelch, dependence on the AVC line is eliminated. Any audio developed at the detector will actuate the squelch, allowing it to be used with all communication modes. 73

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Langford-Smith, *op cit,* page 1127.

F. E. Terman, *Electronic and Radio Engineering,* fourth edition.

IN 1957 two radio amateurs, John Chambers (W6NLZ) and Ralph Thomas (KH6UK), astounded the scientific world by doing the impossible. They communicated with each other over the 2500 mile path between Southern California and Hawaii on 144 mc, a line-of-sight band! Only a short decade ago, radio textbooks described this frequency as having very limited range, and actually gave a formula for computing distance. The answer was usually 25 miles, or so!

A Low Noise

You can be assured John and Ralph did not accomplish this tremendous feat using super-regen receiver or even superhets with a simple 6BQ7 cascode rf amplifier. The received signals were a small fraction of a millionth-volt (microvolt). At this level the rf amplifier stage, the antenna, and even the cosmos, gang up on the signal and try to push its head under a sea of noise. This noise is the hiss you hear on a television receiver between channels, and is the mating call of electrons in motion.

You can't do much about cosmic noise, or the antenna for that matter, but you can construct an rf amplifier which will contribute as little noise to the signal as possible. This converter incorporates such an rf amplifier. Its impressive performance is indicated by the signals received when it was tuned to the satellite frequency of 108 mc. Excellent recordings were made of the 10 milliwatt "Vanguard" transmissions when it was at the zenith of its orbit, some 23,000 miles away! Although no spectacular dx has been received on two meters, due to a poor location, the receiver noise increases considerably when the 10 element beam is turned toward the sun[1, 2].

Theory of Operation

The purpose of this type of converter is to *translate* signals from the transmitted frequency down to a more convenient range. Most amateurs possess a communications receiver covering 1.5 to 30.0 mc, but few have the time or inclination to construct a receiver for 2 meters. By building this low-noise converter, they can have a first class receiver with only a few hours work.

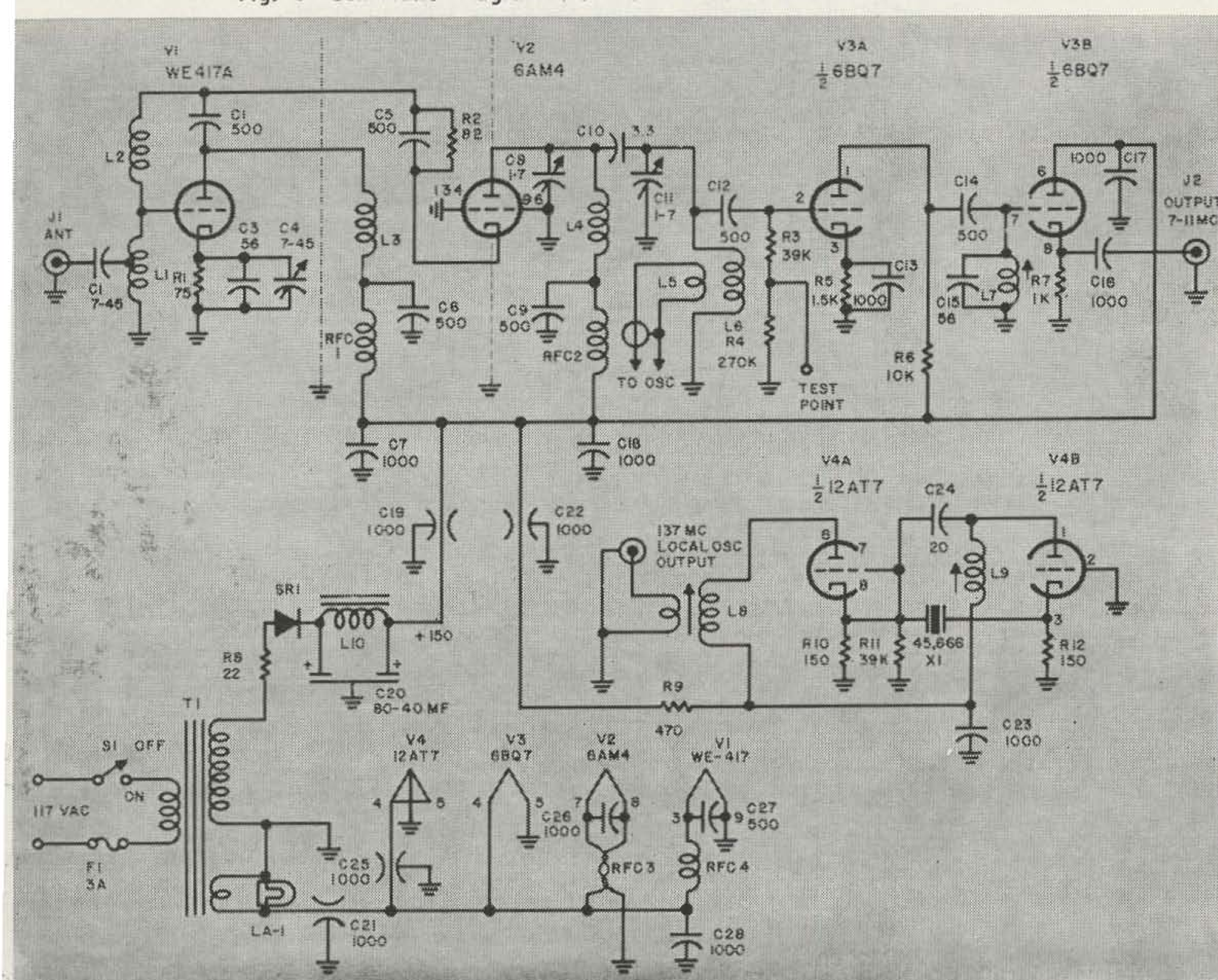
Fig. 1 is the schematic diagram of the low-noise converter. The antenna, connected to J1, is coupled to the rf amplifier grid coil (L1) through a 7-45 mmfd trimmer. This capacitor brings about an impedance match between the transmission line and tuned circuit and avoids experimenting with various tap points on L1.

The rf amplifier circuit is an offshoot of the common 6BQ7 cascode circuit found in most television tuners. However, this circuit, which was designed by W2AZL[3], has many innovations which combine to provide an extremely low noise figure (a figure of merit which determines how weak a signal can be detected). A 6BQ7 in a television tuner might have a noise figure of 7 or 8 db, when set to channel 13, since the response must be at least 6 mc wide. If the same tube and circuit was peaked on a small portion of the 2 meter band, the noise figure might drop to 5.5 db. Replacing the 6BQ7 with a lower noise tube (such as the 6AJ4 or 6AM4) would knock off another

Two Meter Converter

Lester Earnshaw ZL1AAX
Box 51
Warkworth, New Zealand

Fig. 1—Schematic diagram for the low noise two-meter converter.



db. This circuit, incorporating a Western Electric WE417A, is capable of a noise figure which is less than 3 db! The value of reducing the noise figure below this point (with parametric amplifiers, masers, etc.) is subject to considerable debate since cosmic noise usually masks weak signals anyway.

The rf amplifier, V1, varies from the usual cascode configuration in that the anode circuit is resonated (L3) and capacitively coupled to the 2nd rf amplifier. This also permits a lower power supply voltage to be used. Ordinarily this circuit would oscillate due to the grid-plate capacity in V1. However, the addition of a neutralizing coil (L2) feeds back a small amount of out-of-phase energy to cancel the effects of tube capacity. Another "trick" which really soups up the rf amplifier is in the cathode circuit of V1, the use of a resonating capacitor (C4). Tilton has shown[4] that series resonating the cathode inductance truly "grounds" the cathode and minimizes if degeneration. Resistor R1 biases the tube and prevents excessive plate current.

A second rf amplifier, which completes the cascode pair, is a 6AM4. Earlier it was pointed out that this tube is somewhat "noisier" than the WE417A. However, this stage has very little effect on the noise figure and there is no advantage in using another WE417 for V2. Self bias is provided by R2 and the plate is resonant at 2 meters (L4 and C8).

The highly amplified signal is coupled to the mixer (V3a, a 6BQ7) where it combines with the oscillator energy that is link coupled to L6. A beat difference between the signals (the intermediate frequency) appears across R2 and is coupled to the cathode follower V3b. This stage has no amplification but simply provides an impedance match between the if coil (L7) and the receiver.

The Oscillator

The oscillator is a modified Butler circuit with feedback between the two low impedance cathodes. The crystal is a third overtone type and oscillates at 45.666 mc. Coil L9 is also resonant at this frequency and the energy is coupled to V4a, which triples to 137 mc. A small amount of 45 mc energy appears at the cathode of V4a (pin 8) and this rf is coupled back to the oscillator through the crystal to sustain oscillations. The local oscillator signal

Underside view of the converter showing the location of the compartments and shields. The layout in the rf amplifier section should be followed closely.

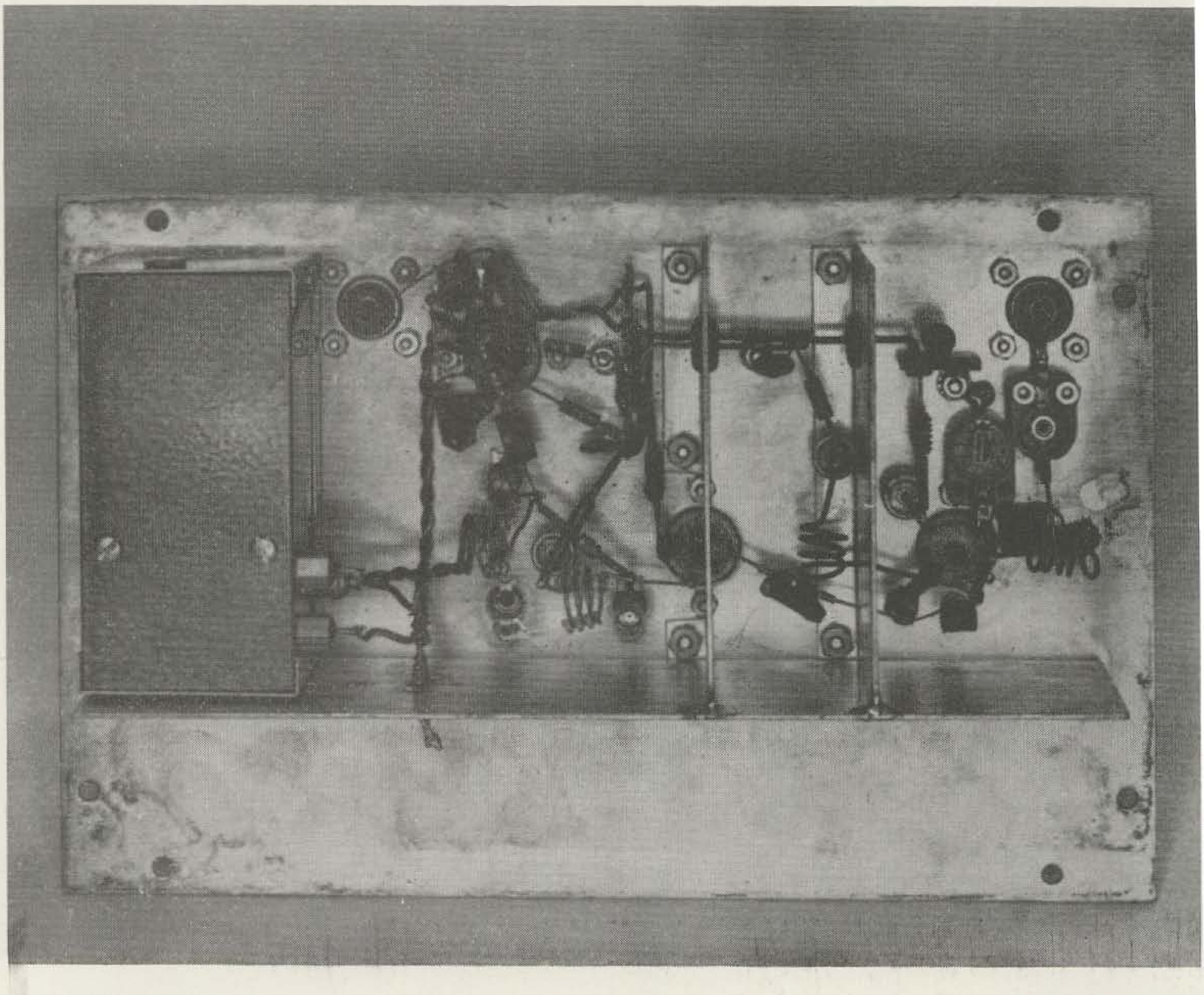


Fig. 2—Crystal and intermediate frequency chart. Note that the local oscillator injection frequency is always three times the crystal frequency and is below the signal frequency by the if.

CRYSTAL FREQUENCY	X3	PLUS IF = 144-148 mc
45.667 mc	137.0 mc	7-11 mc
43.333 mc	130.0 mc	14-18 mc
39.333 mc	118.0 mc	26-30 mc
39.000 mc	117.0 mc	27-31 mc
38.833 mc	113.5 mc	30.5-34.5 mc

(137 mc) is coupled to the mixer from L8 to L6 through a short length of twisted hookup wire. The oscillator circuit is characterized by extremely stable operation. It either oscillates or it doesn't! There are no "half-way" oscillations where the crystal jumps frequency or pops from one mode to another. The frequency drift is also truly remarkable for such high frequency operation. The drift from a "cold start" is only a few hundred cycles. This is quite important when signals arrive intermittently due to temperature inversions. It is nice to know exactly where a station will appear when the band opens up.

The power supply is the most conventional part of the converter. It consists of a simple half-wave rectifier-filter system. An 80-40 mfd electrolytic and 5 hy filter choke provide near pure dc to the plates. An rf filter is included in the filament circuit of the WE417 to prevent undesired regeneration. A bifilar wound choke is used in the filament circuit of V2 since its cathode is at rf potential. Feedthrough capacitors (1000 mmfd) are used to feed filament voltage and B+ into the rf section and oscillator compartment. This complete shielding prevents reception of any spurious signals such as might occur if the 45.666 mc energy leaked out of the oscillator compartment. No if signals can force their way through the power supply either.

Choosing an IF

The choice of an if is not a haphazard thing. If the if is too low, images will become a problem. On the other hand, if it is too high, receiver stability may be the problem. In general, 7 to 11 mc, and 14 to 18 mc, are favored. The 14 to 18 mc range may be preferred for simply by inserting a "4" between the numbers, you can read the signal frequency (144- 148 mc) directly from the receiver dial.

Fig. 2 shows some of the common if's and how they are figured. Note that the local oscillator is always lower than the signal frequency by the amount of the if and the crystal is always one-third of the oscillator output. From this information you can easily determine a crystal frequency for any desired if. The 26- 30 mc range would be used by owners of Collins receivers which cover one and two mc bands. The 27- 31 and 30.5 - 34.5 range is useful for communications receivers which have a special calibrated scale for the two meter band.

If the 14- 18 mc range is selected, rather than 7- 11 mc, capacitor C15 should be removed. If any of the other ranges are used, delete C15 and use only 20 turns on coil L7. The only other coils affected, in the oscillator compartment, will cover the full range and need not be modified.

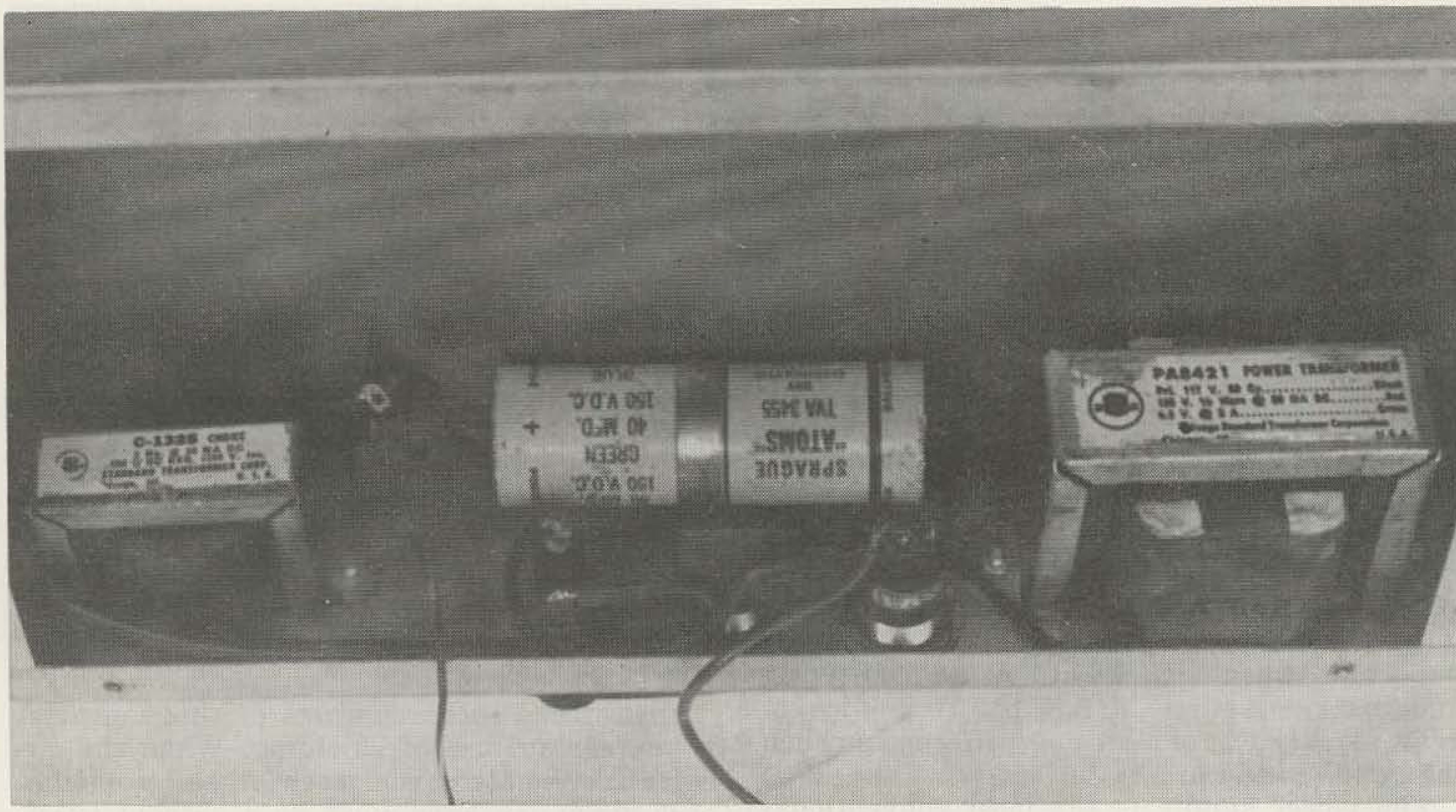
Shielding

One of the success secrets of this converter is the careful use of shielding. When the circuits are isolated from each other by shields, each stage can have more gain without excessive regeneration.

A long shield bracket runs the length of the chassis to prevent stray signals in the power supply from coupling over to the rf circuits. Another shield is placed between V1 and V2. This shield also prevents coil L3 from "seeing" the input coil L1. The hot lead of L3 and the wire from C5 and R2 passes through holes in the shield. At the opposite end, the filament wire passes through a grommet in the shield. No feedthrough capacitor is required since this wire, and the B+ lead, is "stone cold".

Another shield passes through the center of the 6AM4 socket. The center post of this socket, along with pins 1, 3, 4, 6, and 9 are bent over and soldered to the shield. The remainder of the signal circuits are relatively uncritical and no shields are required. Note that all tubes are shielded except V4.

By way of contrast, the oscillator is really "buttoned up". Originally the oscillator was mounted on the chassis and capacitively coupled to the mixer. When the converter was tested, a 60 cycle buzz was heard near each end of the range (7- 11 mc). After many late hours watching the "modulated milk bottle", it was determined that these spurious signals were the picture carriers of channel 2 and 5. A little exploration with a high frequency receiver showed that the extremely strong television signals were bullying their way through the tuned circuits. In the mixer, the spurious signals were able to combine with a small amount of 45 mc (and 90 mc second harmonic) energy to produce a beat in the if range. Rewiring the oscillator and bottling it up in a box turned the trick. Even though the television signal may still force its way to the mixer, all it runs into is 137 mc. Thus any beats created are well outside the if.



The converter power supply is built into the chassis base.

Layout

Other than the details just given, there are no particular precautions regarding layout. You may want to incorporate some ideas of your own and therefore no detailed layout drawing is included. However, a few basic facts are in order.

The converter is built on a 7" X 11" plate which is mounted on the 7" X 11" X 2" aluminum chassis. The chassis serves to enclose the rf circuits in addition to providing a foundation for the power supply. Although it may be "guilding the lily", the chassis and all shield plates were silver plated.

Some constructors may wish to include the power supply on the plate rather than the chassis. This would make the construction somewhat easier and should not create any particular problems other than layout of components.

In the 1st rf compartment (V1) you will find C1, C2, C3, C4, C27, and C28, coils L1, L2, and RFC 4, along with resistor R1. In between shield plates the following components are located: L3, RFC 1, C5, C6, C7, and R1. Note that C6, C9, and C27 are button standoff capacitors and serve as tie points for the associated components. Coil L4 is supported by its leads between C8 and C9. One end of L6 is soldered to the chassis and the other end is supported by the terminal on C11. The test point jack serves as a tie point for R3 and R4. Resistors R6, R7, and capacitor C17 are located between the tube socket and the adjacent terminal strip.

The oscillator circuitry is contained in a 2¼" X 2¼" X 4" chassis box and includes the following components; C22, C23, C24, L8, L9, R9, R10, R11, R12, crystal X1 and socket, and the tube. No terminal strips are required.

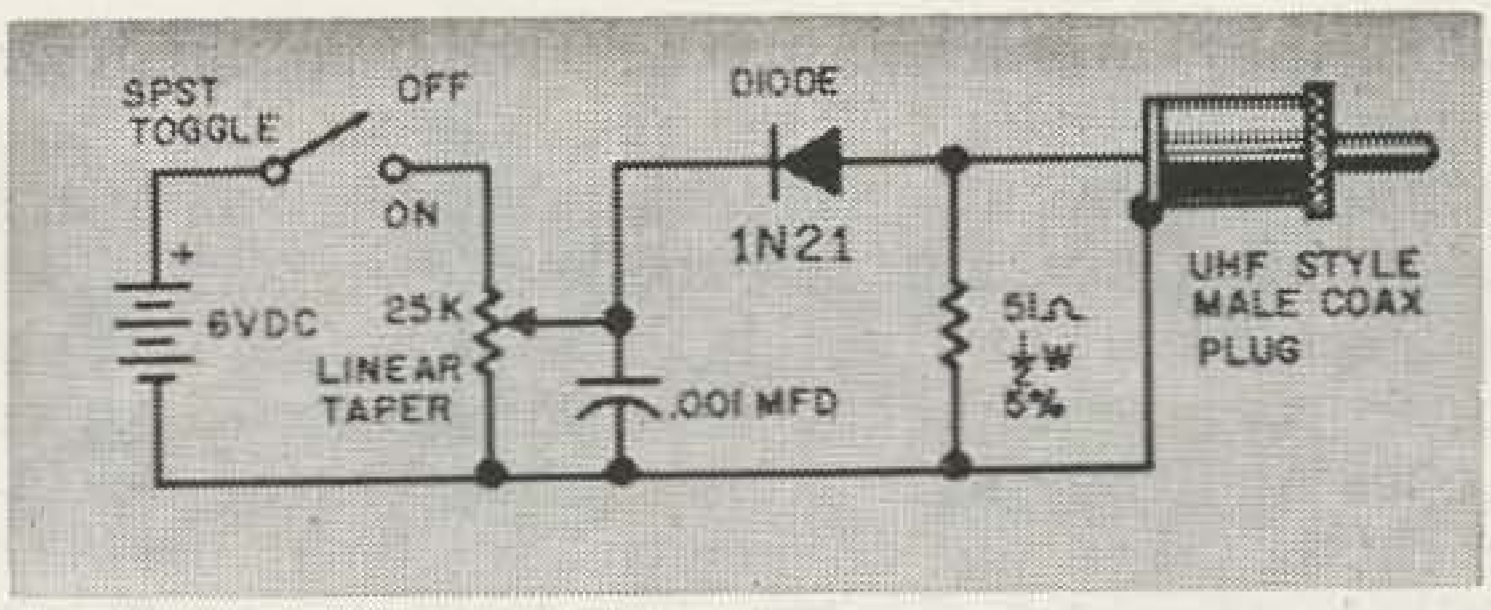
When wiring the converter be sure to keep the leads as short as possible, particularly around the rf amplifier. The same is true for the coils. Other than the slug-adjusted coils, they should be self-supporting with short leads. Two lug terminal strips are used in the rf compartments, and a five lug strip between the 2nd rf and mixer stages provides a tie point for the filament and B+ circuits in that area.

Alignment

If you do a good job of wiring the converter, and are lucky with the setting of the local oscillator coils, the converter will probably work without any tuning whatsoever. However, don't expect to obtain a noise figure less than 3 db without a certain amount of "fiddling". You should be able to obtain a noise figure around 5 db with an "ear alignment". To tune the converter for minimum noise you will need a noise generator to adjust the rf amplifier[5].

Start the alignment by setting the oscillator coils to approximately 45 mc (L9) and 137 mc (L8). Have all circuits energized to load the power supply. The oscillator compartment should hang by its leads and be grounded to the chassis with a short wire. With a grid dip meter, preset the coils to their correct resonant frequency. Then turn the dip meter plate switch off (making an absorption wavemeter out of it) and adjust L9 for an indication of rf. Turn the power supply on and off a few

Fig. 3—Schematic diagram for a simple noise generator, useful in adjusting the low noise converter. The potentiometer is set so the noise approximately doubles when the switch is turned on. Then simply turn the generator on and off and adjust the converter turned circuits for the greatest increase in noise when the generator is switched on.



times to make sure the oscillator starts easily. Next move the dipper to the link (external to the box) and adjust both coils (L8 and L9) for maximum rf consistent with stable operation.

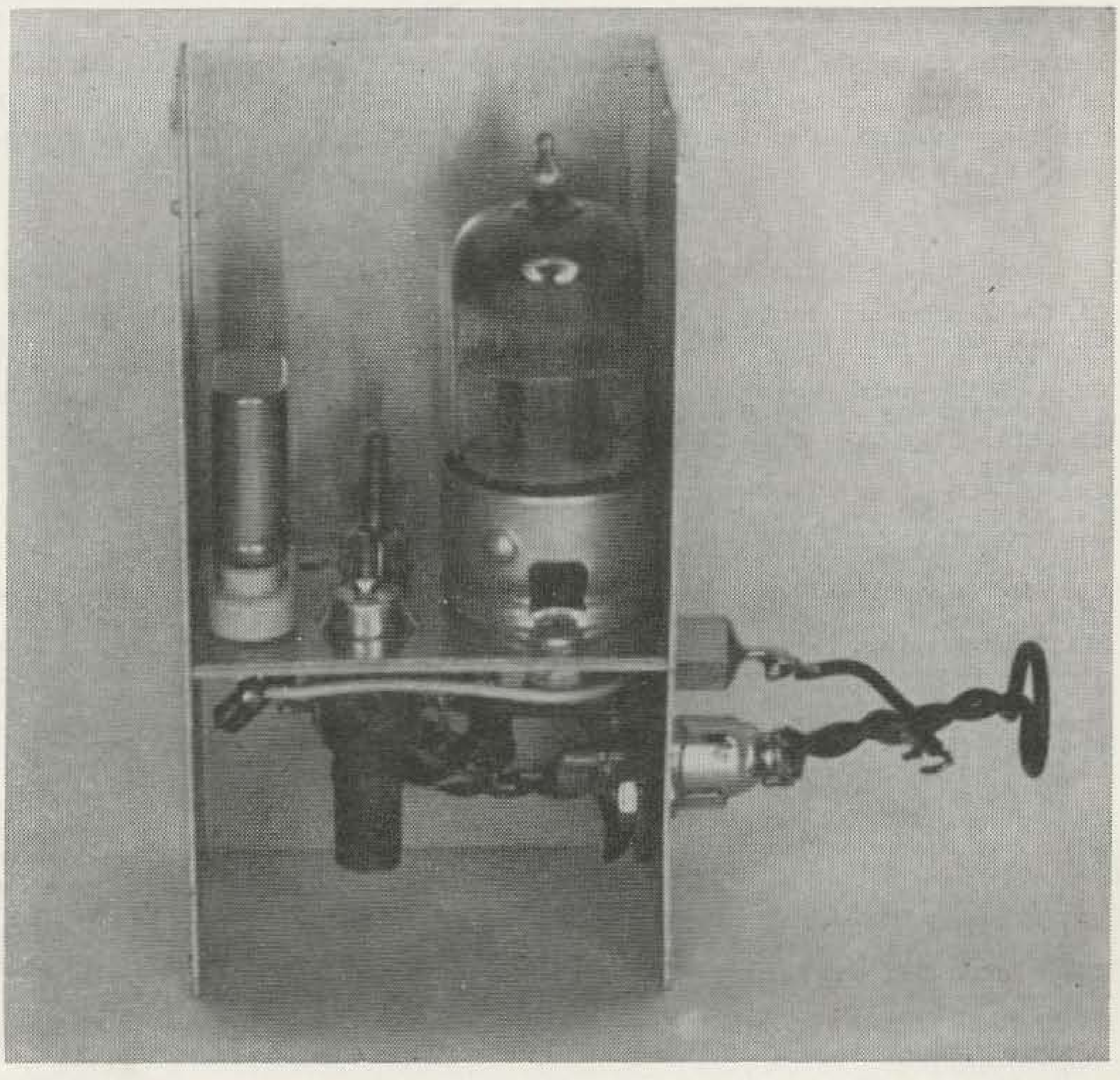
Now, install the oscillator box on the chassis plate and tightly couple the link to L6. If you like, you can again set the oscillator coils by adjusting them for maximum voltage at the test point jack. It is likely that enclosing the coils (by covering the box) may detune them slightly. Connect the converter to a receiver and 2 meter antenna. Peak coil L7 for maximum "hiss" at the center of the band. Then adjust C8 for maximum at the low end and the same for C11 at the high end.

The setting of C1, C4, and the inductance of L1, L2, and L3 will affect the noise figure and are given in the order of importance. Tune in a very weak unmodulated signal and adjust the above five components for the best signal, *consistent* with *minimum* noise. It should be stressed that the point of maximum signal strength *will not* be the proper setting for the best signal-to-noise ratio, or produce the lowest noise figure. By using a "tuning wand" (brass core at one end, powdered iron at the other) check the inductance of each coil. If the brass core improves the noise figure, spread the turns. If the iron core brings about an improvement, compress the turns. The tap point on L1 probably will not require adjustment. However, if the noise figure seems to be best with maximum C1 capacity, move the tap one-half turn toward the "hot" end. Of course the opposite is true for minimum capacity.

To obtain a noise figure which is less than 3 db, you will require a noise generator such as the one shown in Fig. 3. Although this device cannot measure the noise figure, it will tell you when you have arrived at minimum. Its operation is just as simple as the circuit. Connect a dc voltmeter across the diode load in the receiver. Then adjust the noise figure determining components in the rf amplifier for a maximum increase in noise each time the generator is switched on. You will find that each adjustment goes through a minimum and this, of course, is the correct setting.

Obtaining the WE417A

The rf amplifier tube, a WE417A, is made by Western Electric and is not available through regular distribution channels. If you know someone who works at a television sta-



Location of the components inside the oscillator compartment.

tion, they are used in the studio-transmitter microwave links. As a precaution they are usually retired after a certain number of hours of service, but are in excellent condition. The same is true for the telephone company. Their microwave equipment uses hundreds of these tubes and they are often "pulled" if the equipment is taken out of service for short periods. Wholesale tube suppliers, such as Barry, TAB, and JSH Sales, have the WE417A at very reasonable prices. If you prefer to purchase one directly from Western Electric they are available at Graybar Distributors (listed in the phone book) for approximately $15.00. Don't shudder, fellows, this jug makes the difference between the men converters and the boy converters, so to speak.

Using the Converter

For best performance the converter should be used in conjunction with a very stable receiver. The sensitivity is not particularly important for the converter has a considerable amount of gain even without an if amplifier. On voice, a bandwidth of 2.5 kilocycles is optimum, while something less than 500 cycles is preferred on CW. An additional consideration is the tuning ratio. A station 3.5 kc wide does not take much room on a dial which covers 10 or more megacycles.

The WE417 is allergic to strong rf fields. The rf energy which leaks through an open antenna relay *could* wipe out the delicate grid in the twinkling of an eye, if the transmitter power is high enough. Some form of protection must be included in the converter connections. The most satisfactory system is to incorporate a second antenna relay in series with the converter input. When the main relay switches the antenna from the converter to the transmitter, a second relay disconnects the converter input from the antenna relay and grounds it.

Earlier it was stated the converter was used on the 108 mc satellite frequency. An extra set of coils were wound up which can be interchanged with the two meter coils in about 5 minutes. Although bandchange switches are impractical at this frequency the conversion from one band to the other is quite simple. Builders who would like to use the converter on 108 mc, in addition to two meters, should make the following changes:

L1—4 turns, #16, ⅜" diameter, centertapped
L2—20 turns, #24 enam., closewound, ¼" diameter
L3—6 turns, #16, ⅜" diameter
L4—same as L3, but 5 turns
L5—same as for 144 mc
L6—same as L3, but 4 turns
L7—same as for 144 mc, but remove C15
L8, L9—same as for 144 mc
X1—45.667 mc, *if* 29.0 mc

For simplicity, and ease of changing from 144 to 108 mc, the same 45.667 mc crystal is used on both bands. On two meters the local oscillator is 7 mc below the low end of the band. When the 108 mc coils are substituted, the oscillator is then 29 mc above the satellite frequency.

References

1. **Cottony and Johler**, "Cosmic Radio Noise Intensities in the VHF Band," Proc. IRE, Sept., 1952, p. 1053.
2. **Bray and Kirchner**, "Antenna Patterns from the Sun," QST, July, 1960, p. 11.
3. **Southworth**, "A Low-Noise 108/144 mc Converter," QST, Nov., 1956, p. 11.
4. **Tilton**, "Hints on Lowering Noise Figures," QST, Nov., 1953, p. 65.

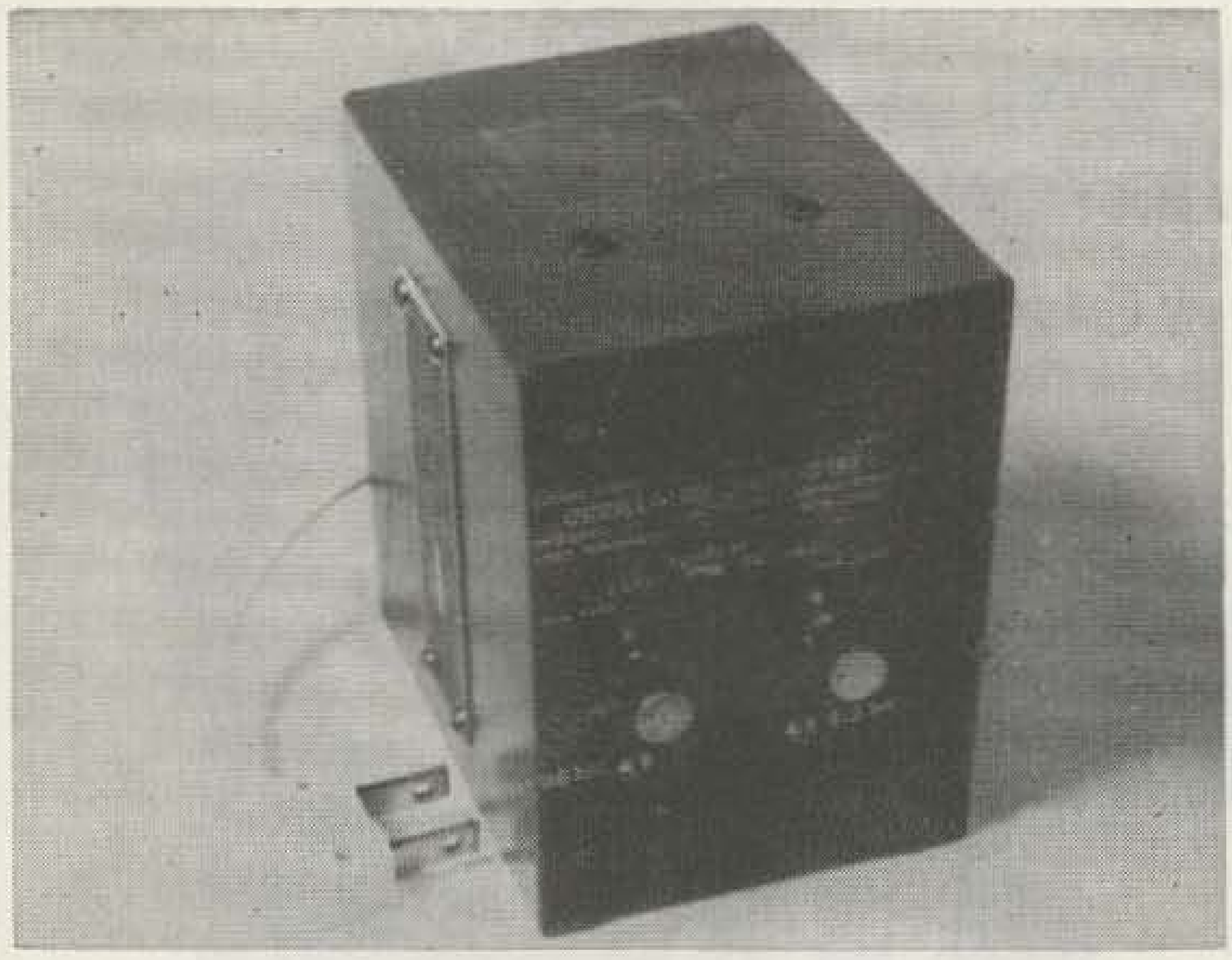
Reference 3 lists additional reading for those interested in noise with respect to high frequency equipment.

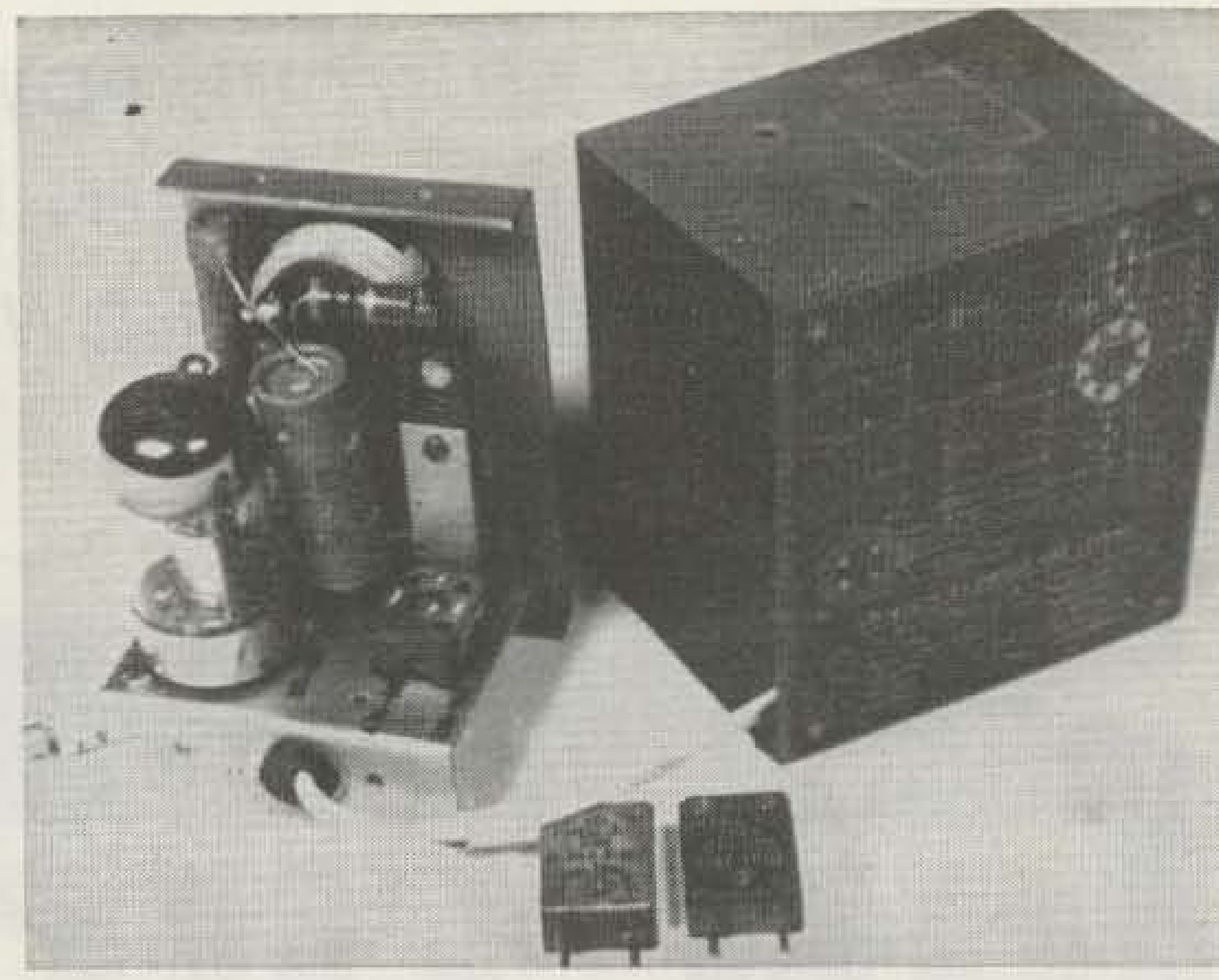
PARTS LIST

C1, C4- 7- 45 mmfd. rotary trimmer (Centralab type 822)
C2, C5, C12, C14- 500 mmfd tubular ceramic (Centralab D6-501)
C3, C15- 56 mmfd tubular ceramic (Centralab D6-560)
C6, C9, C27- 500 mmfd button standoff (Centralab type ZA)
C7 C13, C16, C17, C18, C23, C26, C28- .001 mfd disc ceramic
C8, C11- 1- 7 mmfd piston trimmer (Centralab 829-7)
C10- 3.3 mmfd disc ceramic
C19, C21, C22, C25- .001 mfd feedthrough capacitor (Centralab type FT)
C20- 80- 40 mfd, 150 volt electrolytic (Sprague TVA 3455)
C24- 20 mmfd disc ceramic
F1- 3 ampere fuse (Littlefuse 3AG)
J1, J2- UHF style antenna connector (amphenol SO-239)
L1- 5 turns, #16, ¼" diameter, spaced two-times wire size, centertapped.
L2- 15 turns, #24 enam., ¼" diameter, closewound
L3- 3½ turns, #16 enam., ⅜" diameter, spaced two-times wire size
L4- 4 turns #18, ½" diameter, spaced two-times wire size
L5- 1 turn hookup wire line, at cold end of L6 (see photo)
L6- 2½ turns, #18, ½" diameter, spaced two times wire size
L7- 35 turns, #38 enam., scramble wound on ¼" diameter slug tuned form (see text)
L8- 4 turns, #28 enam., spaced two-times wire size on ¼" slug tuned form. One turn link of #28 wire
L9- 7 turns, #28 enam., closewound on ¼" diameter slug tuned form
L10- Choke, 5 hy., 50 ma (Stancor C1325)
LA1- #47 pilot lamp and holder
R1- 75 ohms, 5%
R2- 82 ohms, 5%
R3, R11- 39K
R4- 270K
R5- 1.5K
R6- 10K

All resistors ½ watt, unless noted otherwise

R7- 1K
R8- 22 ohms, 2 watts
R9- 470 ohms
R10, R12- 150 ohms
RFC1, 2- 30 turns, #30 enam. closewound on 1 meg., ½ watt resistor
RFC3- 15 bifilar turns wound on two 1 meg., ½ watt resistors
RFC4- 7 turns, #16 wound on 1 meg., ½ watt resistor, spaced diameter of wire
S1- SPST toggle switch
SRI- 50 ma. selenium rectifier
T1- power transformer, 125 volts, 50 ma., and 6.3 volts at 2 amperes (Stancor PA8421)
V1- WE417 (Western Electric)
V2- 6AM4 (General Electric)
V3- 6BQ7
V4- 12AT7
X1- Third overtone crystal (International FA-5, see text)





Surplus Frequency Standard

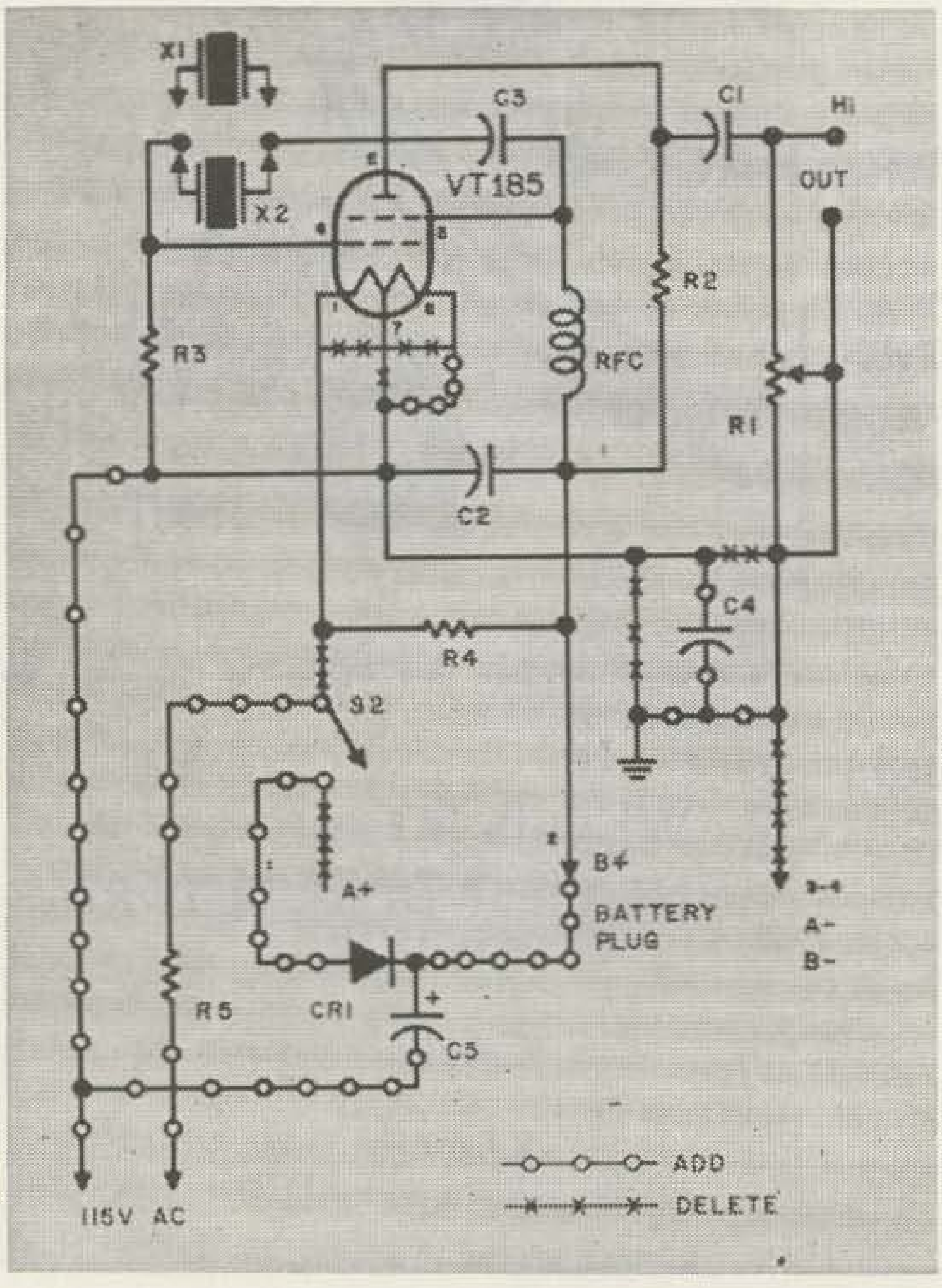
Roy E. Pafenberg
P.O. Box 844
Fort Clayton, Canal Zone

EXISTING PARTS

R1—150 Ω Variable Resistor
R2—1000 Ω ½ Watt
R3—5000 Ω ½ Watt
C1—.0025 mfd. Mica
C2—.001 mfd. Mica
C3—.001 mfd. Mica
S1—D.P.D.T. Slide Switch
S2—S.P.S.T. Switch, ganged to R1
X1—4.3 mc. Crystal
X2—2.88 mc. Crystal
AFC—1.2 MH
VT-185—3R6/1299

NEW PARTS

C4—.01 mfd. Mica
C5—20 mfd. 150V
CR1—Sarkes-Tarzian M-150 Silicon Rectifier
R4—10 Ω ½ Watt
R5—1100 Ω 20 Watt. See text.



AN APPEALING little item of surplus, still in fairly common supply, is the VO-4 Oscillator. The unit is a compact, battery operated, dual frequency, crystal controlled signal generator. The original application of the instrument was as a signal source for use in the alignment of the 2880 and 4300 kc if circuits of the SCR-510 and SCR-610 series of field radio sets.

While crystals for the above frequencies are supplied, the circuit works nicely with crystals from 1 to 12 mc. The simplicity and utility of the unit as a 1 mc standard or as a band edge marker, makes conversion to ac worthwhile.

Fig. 1 shows the schematic of the unit as supplied, with the necessary changes and ac power supply. The slightly unorthodox wiring of the power supply permits best utilization of component terminals as tie points. The other changes lift the circuit from chassis ground and series the filament sections of the 3D6/1299 tube.

The photographs show the mechanical details of the conversion. The crystals and the silicon rectifier were removed for clarity in the photograph. The battery cable is removed and the ac cord secured with a Heyco strain relief bushing. The bracket for the crystal retaining spring is drilled to mount the Sarkes-Tarzian M-500 or M-150 silicon rectifier. The required filament dropping resistor, in the authors version, consisted of a 1000 ohm, 10 watt adjustable resistor, mounted in an existing hole, in series with a 750 ohm, 10 watt, fixed resistor. Any combination that results in approximately 1100 ohms at between 15 and 20 watts will be satisfactory.

All in all, the compact construction and versatility of this crystal controlled signal source make it a desirable project for any ham shack.

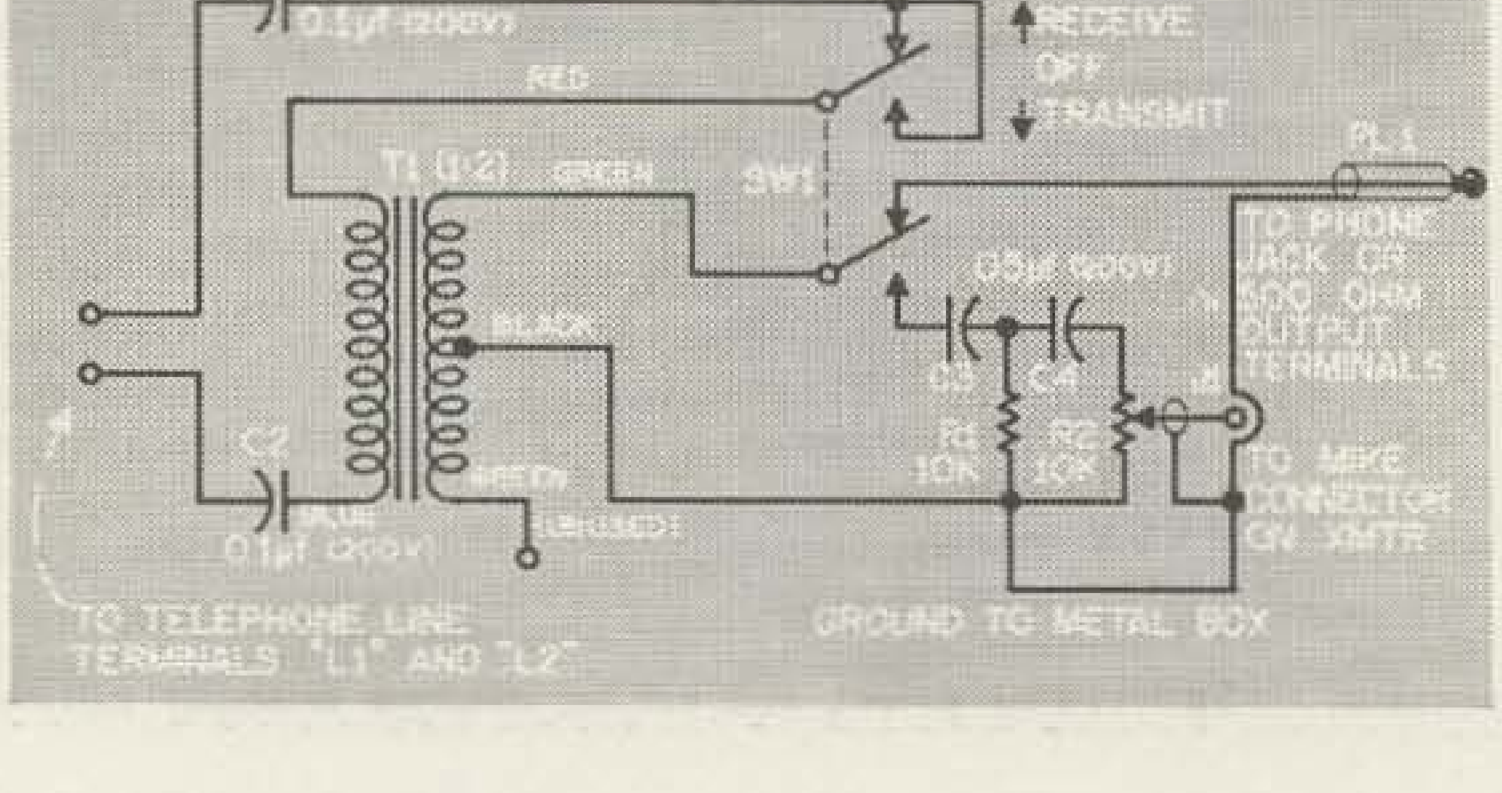
73

A Simple And Efficient Phone Patch

Herbert S. Brier, W9EGQ
385 Johnson Street
Gary 3, Indiana

SIMPLICITY, economy and efficiency are the features of the phone patch described here. T1, a single plate to push pull grid audio transformer with a 1:2 turns ratio (Stancor A-520) is used as a 1:1 coupling transformer between the telephone line and the receiver and transmitter by using only half of its secondary winding. Capacitors C1 and C2 isolate the dc in the telephone line from T1. Capacitors C3 and C4 and resistors R1 and R2 act as a filter to keep the hum and other low frequency noises frequently heard on phone patches from modulating your transmitter.

When SW1, a dpdt neutral-center (switchcraft 30374) lever switch, is in the center position, the patch is completely disabled. When it is in the "Receive" position, the signal from the receiver is piped into the telephone line via PL1, which is plugged into the receiver phone jack. Alternatively, it may be connected to the 500-ohm output terminals of the receiver. Signal level is controlled by the radio receiver volume control and should be no louder than your own voice in the telephone receiver. When SW1 is in the "Transmit" position, the signal from the telephone line is fed into the microphone input jack of the transmitter. Its level is controlled with R2.



The patch is built in a 4" X 4" X 2" metal box (Bud CU-883). Parts arrangement is not critical. My microphone is the type with a connector right on it; therefore, to use the patch, I unscrew the transmitter microphone input cable from the microphone and screw it on PL1. Use shielded microphone cable between the patch and the receiver and the transmitter.

As there are miles of unshielded telephone line connected to the patch when it is in operation, it is not necessary to use shielded wire between it and the telephone line.

Results

While I take a dim view of the practice of running phone patches just to be running phone patches, this patch has been used to keep a regular phone-patch schedule with Antarctica on sideband for a year. Also, it has been used to run phone patches with many of the other foreign countries with which such traffic is permissible both on AM and SB. It works as well as any other patch I have heard or used and better than many of them.

Although it does not permit "voice break-in" on sideband, this is usually an advantage, because it prevents both parties from talking at the same time, as often happens when inexperienced people are patched into each other via hybrid patches. 73

(. . . de W2NSD continued from page 7)
nonth period so we could find out specs and prices without having to send for that "further information" which takes from days to weeks to arrive? Even a brief listing would be helpful.

This could get to be pretty prohibitive if it weren't for the low advertising rates of 73. A quarter page ad is still only $40.

Audio Booster Note

Jim Kyle points out that the value of R13 in the circuit may have to be changed to balance things if your rig has an input impedance which is different than his. If you've had any trouble in getting a balance this should help. For instance with a 1 megohm mike and a 1 megohm input R13 would have to be 2.2 megohms.

Chortle

Propagation forecasting, like weather forecasting, is divided into several schools of thought.

In comparing the Propagation Charts in the November 73 with those in other ham magazines I was surprised to notice that Dave Brown had forecast the period of November 12-15 as one of very bad conditions, while the other forecaster had promised that these dates would produce the best conditions of the month.

While visiting the Voice of America studios on November 16th to record a program for the VOA Ham show, Bill Leonard W2SKE and Gene Kern W2BAK discussed at length the worst radio blackout in recent years which struck from November 12-15.

Congratulations K2IGY and keep up the good work. I'll bet you were really worried when the National Bureau of Standards issued their November 9th advanced forecast for November 10-16th and predicted normal conditions.

News Clippings

Marvin Lipton VE3DQX, in addition to sending out a monthly bulletin to all editors of club bulletins to help them get news for their publications, will be exerpting news items which have made the newspapers for us to print in 73. Please scan your local paper carefully and send Marvin anything hammy that creeps in. Or send it to 73 and we'll forward it up to Marvin for condensing. Send it in, good or bad, to Marvin Lipton VE3DQX, 311 Rosemary Road, Toronto 10, Ontario, Canada.

Shorts

I hate to embroil you in editorial problems, somewhat. Bluntly put: we need more short items, stuff that obviously doesn't require full

(Continued on page 57)