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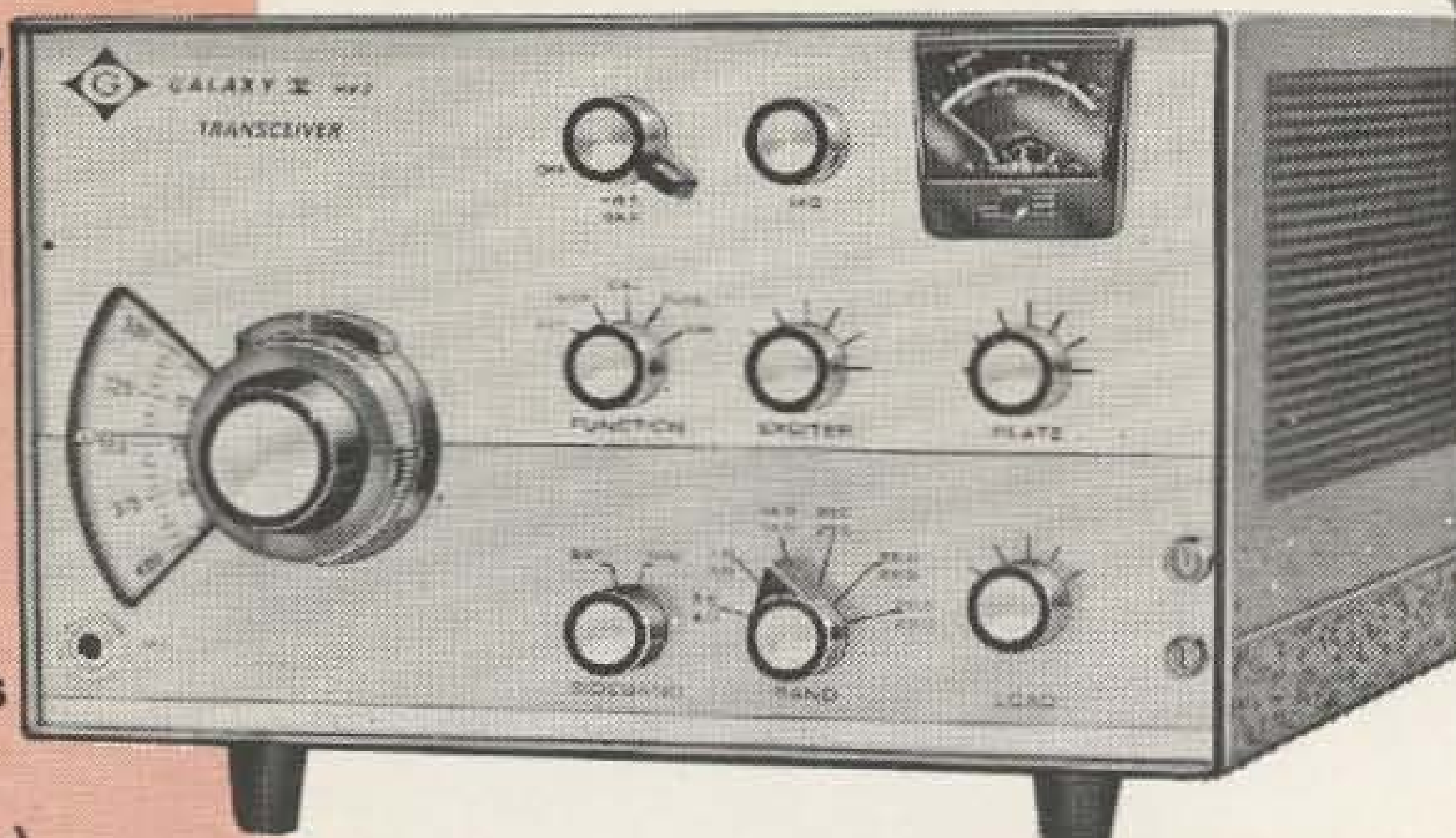

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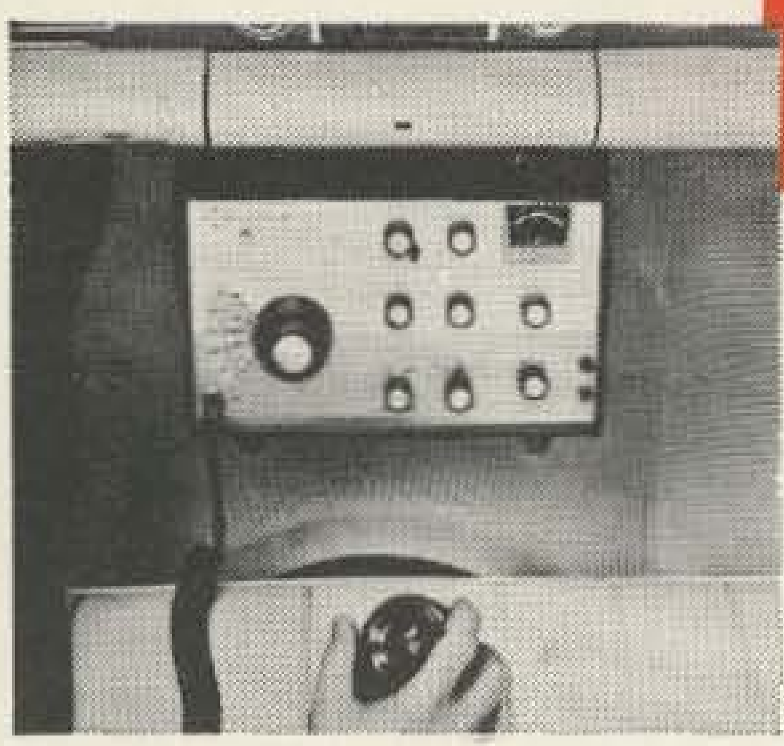

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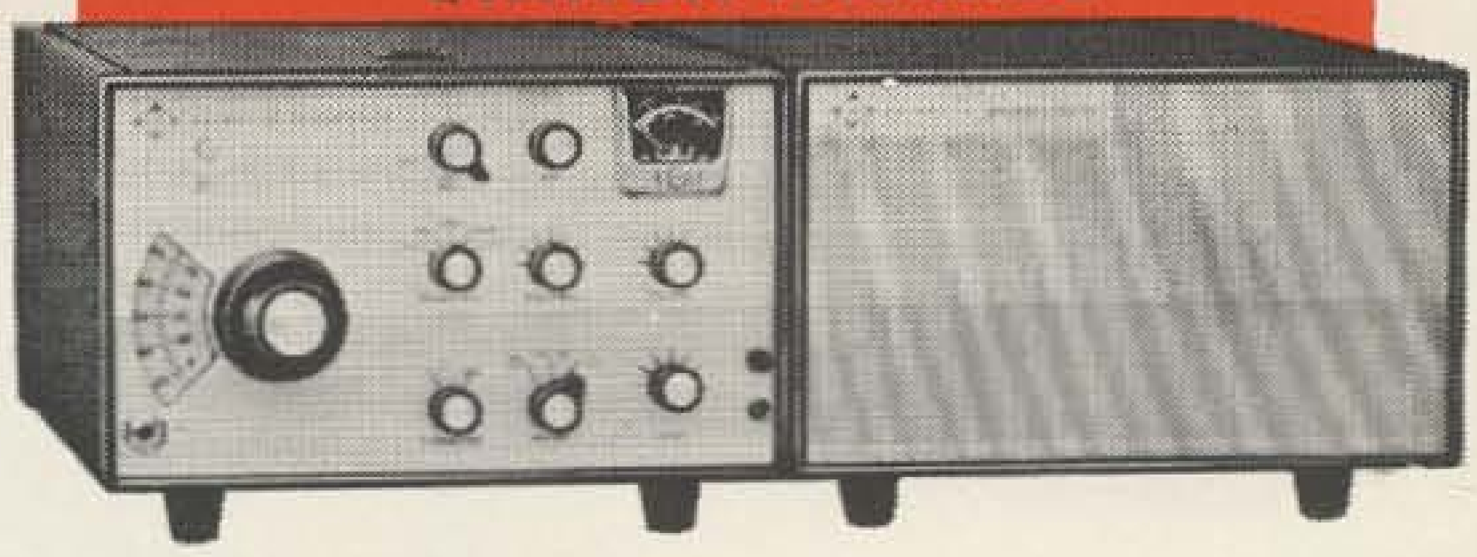

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73 MAGAZINE

December 1968
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Cover Photo: A collection of current Transceivers you might like to have Santa bring this year.

Editorial Statement: Any errors found in this magazine are put there deliberately. We try to publish something for everyone and some people merely read the magazine to find errors.

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Departments

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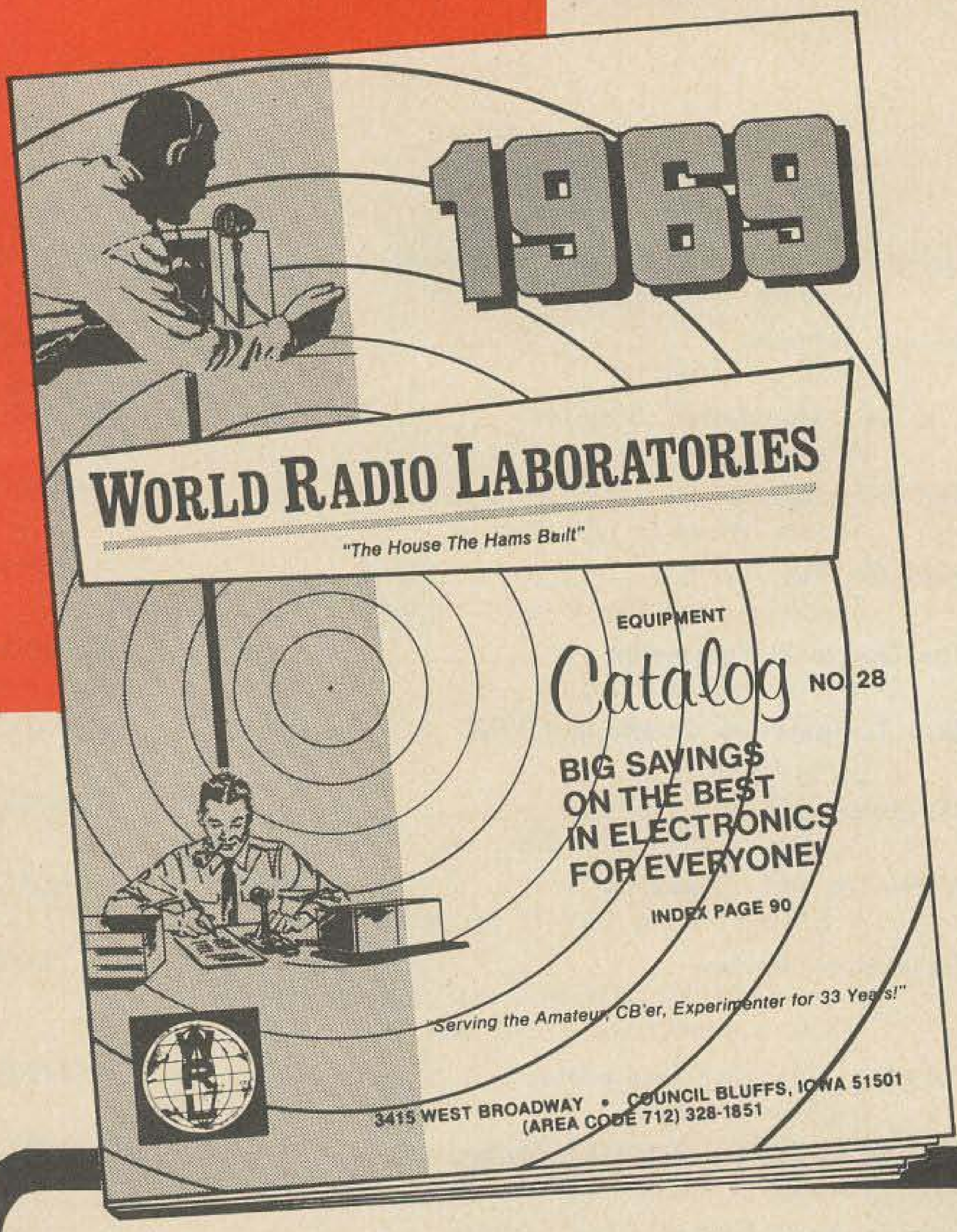

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Editorial Liberties

With this issue, I complete one year as editor of 73. It has been a very full year for me, and therefore has gone quickly.

Having given some serious thought to amateur radio from what might be considered a commercial view, I am becoming more and more impressed with facts. The 'magic' quality of ham radio simply doesn't exist any longer. Our image has changed, and certainly the role of ham radio has changed in the past years.

We (and I'm speaking of amateurs in general) developed the communications industry. "We" created the firsts in radio technology. Gradually, the ones with foresight began manufacturing radio equipment. They developed a better product than most of us could produce in the dim, dark, dank, dismal, buggy basement to which we were confined by the dictates of our spouses. And . . . we bought their products.

We are often confronted by the term "Appliance Operator," used in a derrogatory manner. Do we sneer at the housewife with her push button electric stove, her refrigerator, her modern zig-zag sewing machine. We use these appliances as they were designed to be used. We take advantage of the industry's ability to make a machine which will fill our needs.

Taking a look at other hobby magazines, does a photography magazine tell us how to build a camera? Does the sport car magazine tell us how to build an automobile? Do they tell the flyer how to build an airplane? The answer is, of course, no. They tell us how to *use* the equipment we have bought from a commercially organized company which produces the product we want.

Why is it that amateur radio must take the stand that if you don't build, you aren't really a ham. I firmly believe each ham should understand how his equipment works and be able to do maintenance. But I don't believe many of us could build a modern transceiver which would stack up to any of the commercial equipment available today.

Some hams get their kicks from building. Some read construction articles (even though they don't plan to build) the way others read Playboy. They complain that 73 doesn't have enough construction articles. Believe me, good construction articles are few and far between. With few exceptions, there isn't much new being built. I suspect, and hope, that ICs are going to spark a whole new era in building, but predictions are dangerous. Where does all this leave four magazines, which are, because of public opinion, devoted to construction? QST has no problem. They are blessed? with a large technical staff who can come up with a construction project. The other three have to fight for the good authors and resort to bribery to try to get their articles. Some you win, some you lose. I will continue to work to get the best people in the field to contribute construction articles as often as possible.

However, the appliance operator should not be looked upon with disdain. Having run the gamut of building and refining until our equipment has reached a point of sophistication which we cannot reproduce in the ham shack, isn't it time we learned to use it to its best advantage. Having built equipment which is designed for communication, shouldn't we learn the art of communicating? Listening to some of the idiotic stuff which goes on, I think we have a long way to go.

If what I hear from members of the industry is true, we may well have to begin building again. Going back to *Callbook* figures, they say we have roughly 290,000 hams in the U.S. By the time we eliminate the duplicates (those holding more than one call, or with expired calls remaining in print) and those who are inactive, we can cut that figure in half. When we eliminate the Novice (don't get mad kids) who doesn't spend much money on gear, we wind up with perhaps 100,000 potential buyers of amateur radio equipment. This is a generous estimate.

The manufacturer of a sophisticated transceiver has an initial investment of perhaps a half million dollars in the design of the equipment before it can actually go into production. The average ham buys a new rig about once in 5 years. So the total market, divided between all the manufacturers, is about 20,000 rigs per year. At an average expenditure of $1,000 per happy ham, divided between eight major manufacturers, the whole operation borders on charity. You may think, when you spend $500 on a new piece of equipment, that someone is getting

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de W2NSD/1

This UFO business is beginning to come out in the open a bit more and it is almost respectable to talk about them in many circles. It is interesting that there does not seem to be one single scientist who has carefully investigated the subject without becoming convinced that not only do the UFO's exist, but that they are extraterrestrial. If you have any friends who are still skeptical about UFO's you might suggest that they spend 6¢ and write to their Congressman and ask him to send them a copy of the House of Representatives Symposium on Unidentified Flying Objects, a Hearing before the Committee on Science and Astronautics on July 29, 1968.

The report should leave little room for disbelief in UFOs. Dr. James Harder, Associate Professor at UC Berkeley, says this: "Over the past 20 years a vast amount of evidence has been accumulating that bears on the existence of UFOs. Most of this is little known to the general public or to most scientists. But on the basis of the data and ordinary rules of evidence, as would be applied in the civil or criminal courts, the physical reality of UFOs has been proved beyond a reasonable doubt. With some effort we can accept this on an intellectual level, but find a difficulty in accepting it on an emotional level, in such a way that the facts give a feeling of reality. In this respect we might recall the attitude many of us have toward our own deaths: We accept the facts intellectually, but find it difficult to accept them emotionally." Dr. Harder suggests that the first thing that should be done toward further serious investigations of the UFO's is the establishment of an early-warning network. Since UFOs are frequently seen in the same area on succeeding nights he suggests that research teams set up immediately after a sighting with all of the instruments they can muster. He suggests that the Air Force provide transportation for the teams and their gear.

Dr. Baker of UCLA explained to the Symposium why most tracking radar is adjusted to ignore UFOs and why little is seen of them on our early-warning radars. He suggested changes in the radar systems which would permit them to sense UFO's and not just throw them out because they don't follow the missile trajectory pattern that the radars are set to watch for. It seems that there are hundreds of uncorrelated targets monthly which are not investigated at all because they are obviously not missiles.

It is interesting that UFOs are seen primarily by people who have not hitherto been believers in UFOs . . . though there is no record of anyone remaining a disbeliever after the experience. Of course only a very small percentage of the people who have seen them actually report their sighting. A recent poll indicates that about 5,000,000 people in the U.S. have ssen the UFOs so far, while there have been only about 12,000 filed reports.

Are UFOs spotted on radars? Yes, time after time . . . from land and air radars. Are they ever seen by large groups of people or are they almost always seen by isolated individuals? Frequently by groups and now and then by large groups. Three were seen flying across the airport at Longview, Washington during an Air Show, each from a different direction, about fifteen minutes apart. All three were seen by over 150 gawkers at the show when they were pointed out by the P.A. system announcer. All were seen clearly. Many airline pilots have seen them up fairly close, though few report them any more due to the jibes they get from other pilots and the company.

The hope of the scientists who gathered for the Congressional Symposium was that the "curtain of laughter" could be raised so that serious scientists could study UFOs and observers could more freely report on sightings. They also hope that a world-wide communications network can be established and that automated and instrument teams be set up to provide more information on UFOs.

Stanton Friedman, a physicist with Westinghouse Astronuclear Laboratory takes to task the few remaining critics of UFO reports such as Menzel and Klass saying, "I feel that these gentlemen have made strong attempts to make the data fit their hypotheses rather than trying to do the much

(*Turn to page* 70)

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Using the First Ham Integrated Circuit

Squelch, VOX, Speech Compression, and more, in a new Integrated Circuit designed with the Ham in mind!

For several years, 73 has been a leader in publishing articles on ham applications for currently available digital and analog IC's. Until now, however, no IC's had been produced specifically for two-way-radio use. At least one IC manufacturer, recognizing the need for such circuits, in the potentially large commercial, military, and amateur market, is now aiming a major development effort toward communication "subsystems on a chip", and it is expected that other manufacturers will follow. Besides the direct benefits of improved performance, decreased size, and lower component costs, which will reach amateur radio through commercially-built rigs, the new specialized chips will enable even the casual homebrew artist to construct sophisticated, complex equipment he might previously have considered beyond his reach.

The first Communication IC now available is the National Semiconductor LM270 Audio AGC/Squelch Amplifier. It is basically an operational amplifier, whose gain is controlled by a dc voltage, plus a built-in sensitive squelch threshold detector. The ten pin circuit replaces entire sections of today's transmitters, receivers, or transceivers, and makes speech compression, VOX, receiver squelch, and other functions practical in even the simplest homebrew rigs. While the chip contains 36 junction devices (transistors and diodes), and 20 resistors, it is size, rather than complexity which determines an IC's cost, so that the LM270, which is about the size of a single medium power transistor, is already cost competitive with the less complex discrete-component circuits it replaces. As volume commercial use of the circuit increases, the circuit is likely to be available at even more attractive prices.

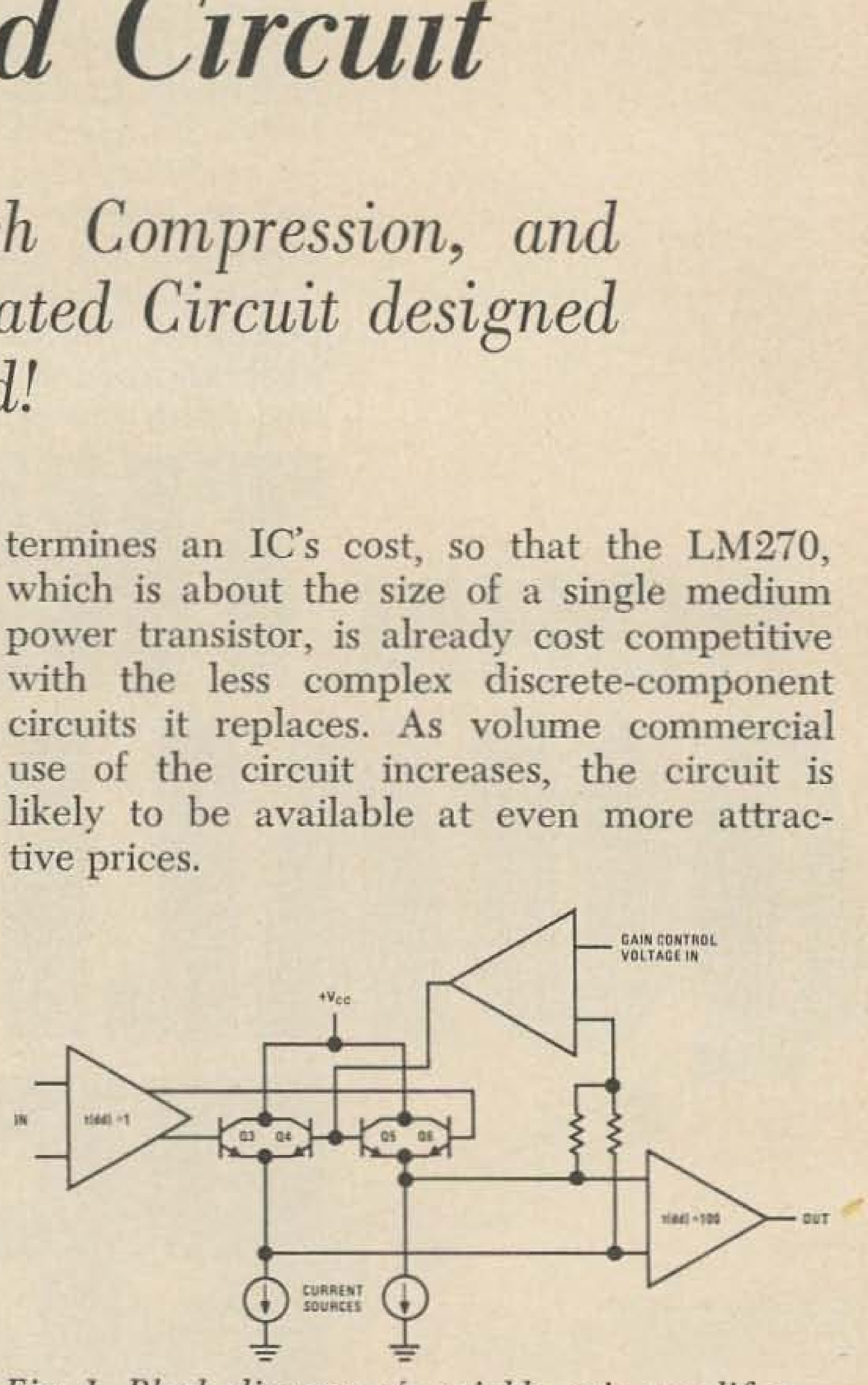

Fig. 1. Block diagram of variable gain amplifier.

Inside the can

The LM270 consists of several separate functions, designed to work together in a self-contained system, to produce control voltages for external use, or to respond to applied control signals. Heart of the circuit is a balanced series-shunt variable attenuator, formed by the four transistors in **Fig. 1**, which allows a large gain control range, with low distortion (for inputs less than 100 mV p-p), and which can be directly coupled to other parts of the system, eliminating the transformer or capacitor

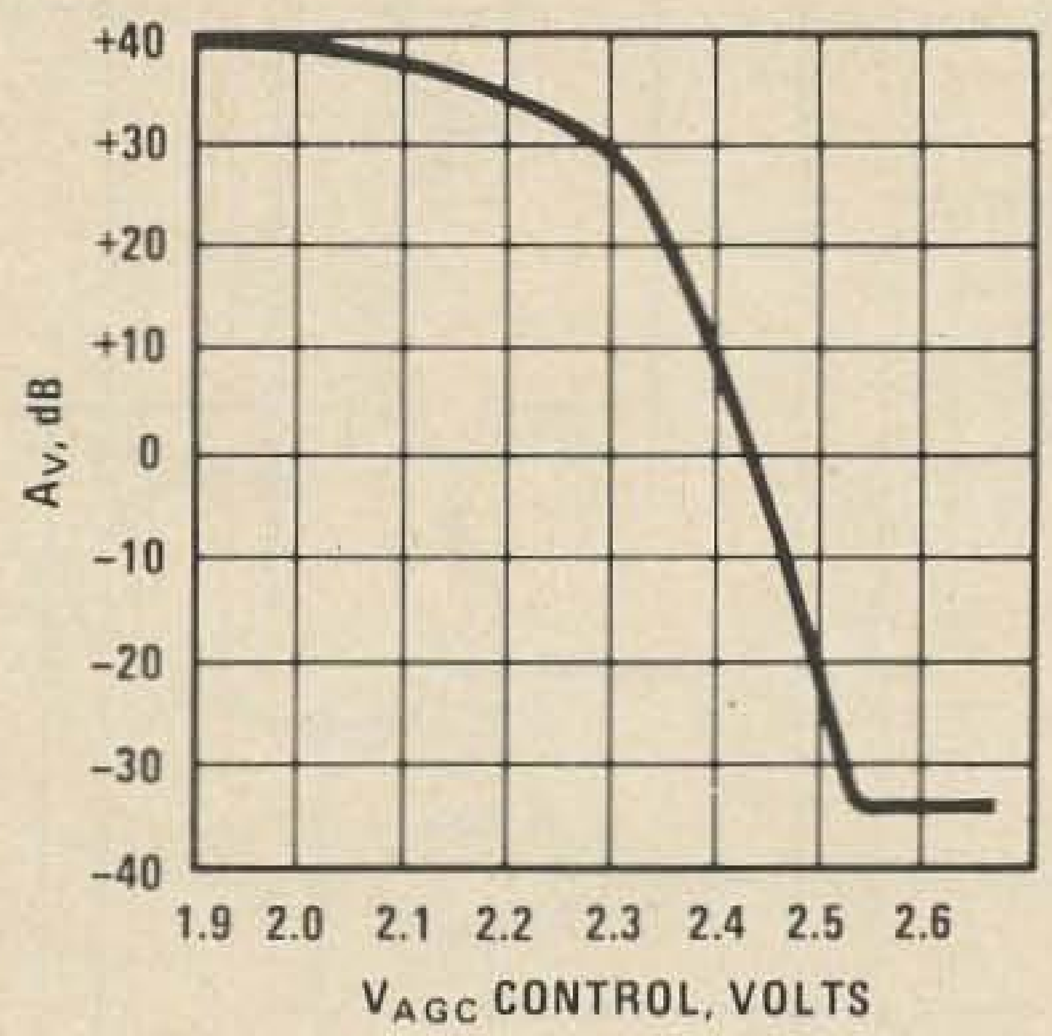

Fig. 2. Typical voltage gain vs. control voltage applied at pin 4.

coupling necessary with all other variable arrangements. From a twelve volt supply, the gain vs. control voltage relationship is a smooth curve, as in **Fig. 2**, which gives a constant gain of +40 db for control voltages between zero and +2 volts, and is effectively "shut off" above +2.6 volts.

A separate subsystem within the LM270 is the squelch detector, **Fig. 3**. Using the same input differential amplifier as the variable gain circuit, the high gain peak detector formed by Q20, Q36 and Q21 responds to very small inputs (as little as a millivolt, depending on setting of the external threshold pot), by rapidly discharging an external capacitor. In the absence of input signal, C(ext) charges above +2.6 V, which, when tied to the gain control input, keeps the output amplifier "off". A momentary input peak above the threshold causes Q21 to rapidly discharge C(ext) below +2 volts, turning the amplifier fully "on". This arrangement gives a fast attack, slow release squelch, which catches first speech syllables, and waits long enough to avoid "cutting out" between words.

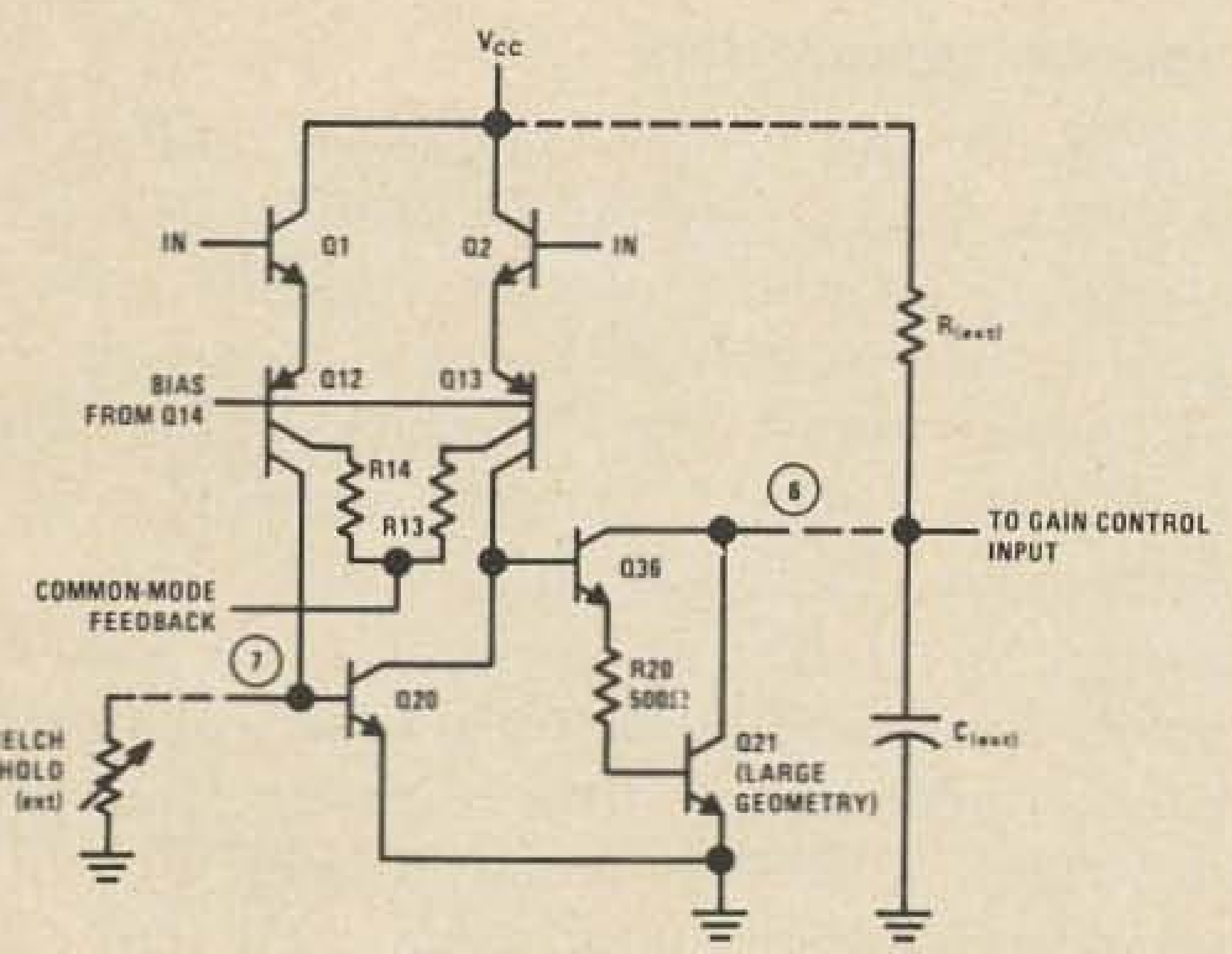

Fig. 3. Differential input circuit and squelch detector.

The complete circuit appears in **Fig. 4.** A detailed explanation of each part, too lengthy for inclusion here, may be found in the references.

Practical ham applications

Before going into specific circuits, a few general remarks are in order. Those familiar with operational amplifiers will easily recognize the LM270 configuration. Differential inputs allow inverting or non-inverting gain, or drive from a "floating" signal source. If single-ended drive is needed, the unused input is simply tied to the same reference voltage as is the actual input. All that is required is that both inputs be at equal dc potential, somewhere between +4.5 volts and the positive supply. Like an "op amp", the LM270's dc output voltage stays at approximately half of the positive supply voltage, for all supplies between +4.5 and +24 volts, so that symmetrical output clipping occurs.

Two identical gain control inputs, pins 3 and 4, are provided, which allows control by two independent sources at the same time, such as simultaneous AGC and squelch. By bypassing pin 2, the gain control inputs become emitter-follower positive peak detectors. The control inputs are protected by 6.5 volt zeners (Q33 and Q34). If the control input is expected to rise above +6.5 volts, a 10K series resistor at that input should be used to prevent excessive dissipation in the zeners.

Remote gain-controlled audio amplifier

A simple application is a preamplifier, **Fig. 5**, whose gain is manually controlled, noiselessly, by a dc voltage from a remote location, rather than running long, capacitive coax signal lines to and from that location. Pin 4 is bypassed by an external capacitor, to eliminate noise pickup. Since the gain-control curve, **Fig. 2**, is approximately logarithmic, a linear pot will give a desirable logarithmic audio attenuation characteristic.

For illustration, the second control input is shown connected to an IC logic gate, of the DTL, RTL or TTL varieties now available at low cost. This gate, operating from a five volt supply, can be part of a logic

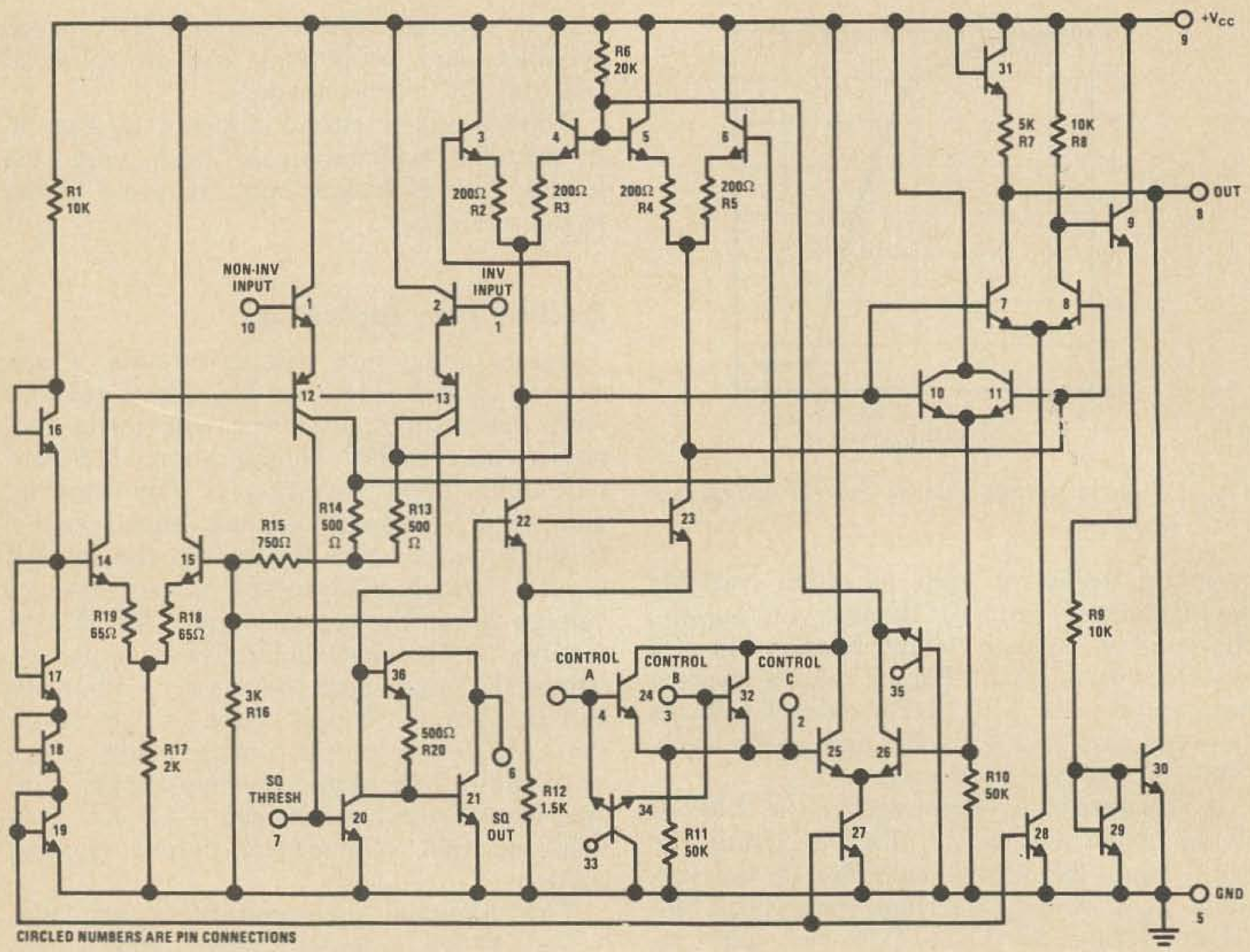

Fig. 4. Complete LM270 Schematic.

arrangement to override the remote control, and shut off the amplifier under present conditions. The resistors and capacitors shown biasing the single-ended input are used to illustrate one way of operating the inputs at a fixed dc voltage; subsequent examples will show simpler schemes.

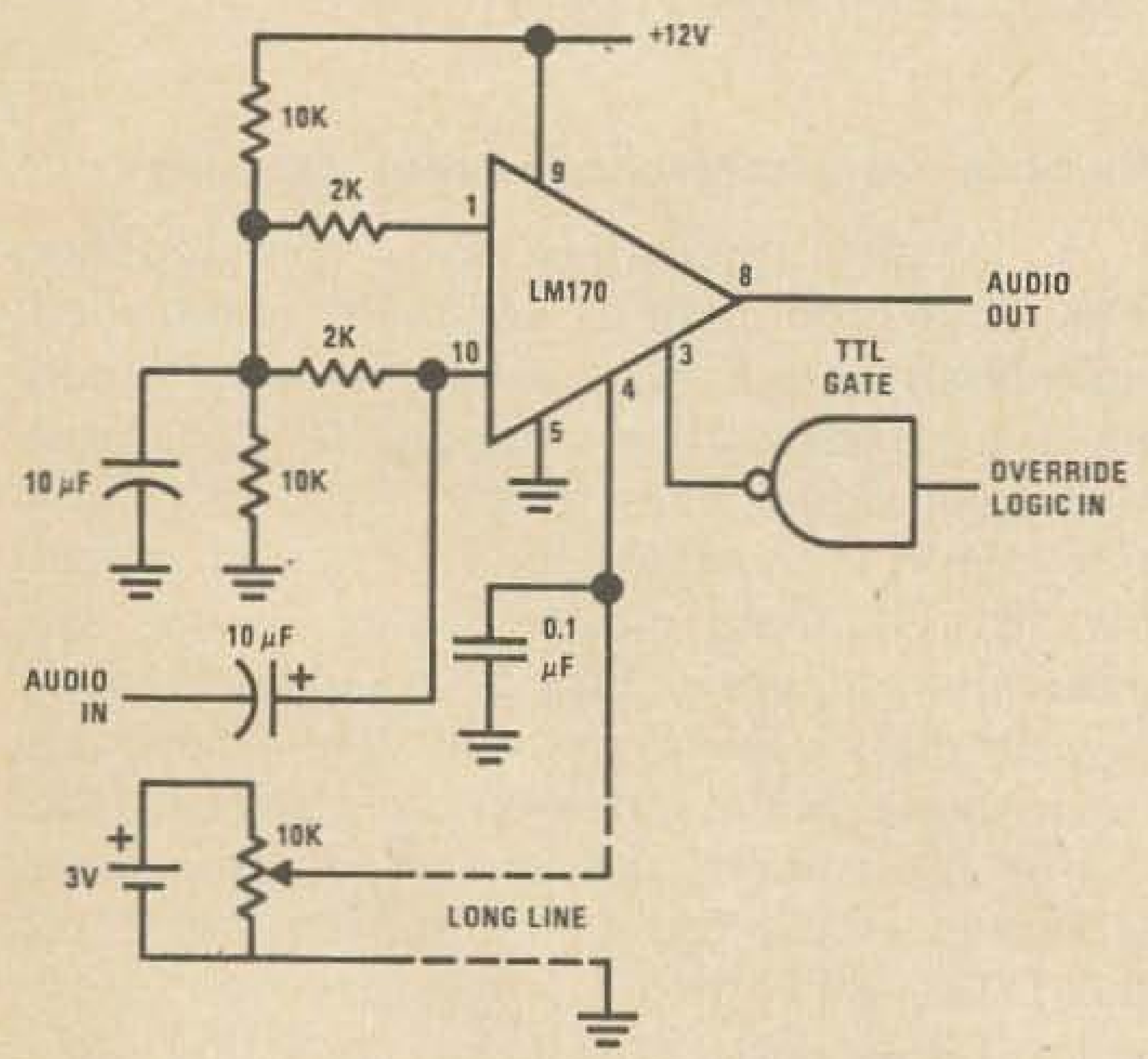

Fig. 5. Remote or digital control amplifier.

Speech compressors

Fig. 6 and **7** are basically audio AGC systems, which respond to peak speech levels above a set threshold by quickly reducing gain to a level which keeps succeeding similar peaks below the threshold. This differs from the usual "speech clipper", as it causes no distortion, but simply keeps the output level at an approximately constant level. In a modulator (any type), such AGC keeps modulation always near, but never in excess of, 100 percent. In **Fig. 6**, a PNP transistor (almost any type will do) adds enough gain to the control loop to operate over a large range of input levels. In **Fig. 7**, the additional gain of the receiver or modulator is used for this purpose. Varying load impedances can cause the gain of these stages to vary; taking the control signal from the system's audio output automatically compensates for load variations, in much the same way as an ALC system operates. The scope photo, **Fig. 8**, shows how the output (vertical axis) remains nearly constant while the input (horizontal axis) varies over a wide range. Note that both AGC circuits use the internal emitter-follower detectors, and that both inputs are biased from the positive supply through equal resistors, although other biasing works equally well.

Squelch preamplifier with hysteresis

Audio squelch is useful in both receiving and transmitting systems, to cut out background noises. The sensitive circuit of **Fig. 9** includes a number of refinements, which make it smooth-acting, and easy on QRM weary ears. The threshold pot at pin 7 can be a front-panel control, to cut in at any desired level. Attack time is on the order of a millisecond for nearly any capacitor value at pin 6, but release time is determined by the external RC time constant. The fixed 100 k resistor may be replaced by a 100 k pot, in series with a 10 k resistor, to give operator-adjusted release time.

Part of the voltage at pin 6 is fed back to the threshold pot; since there is an "on" and an "off" voltage at pin 6, this creates a controlled amount of threshold hysteresis, which greatly enhances the circuit's immunity to rapid fading or erratic speech patterns. A typical threshold control setting

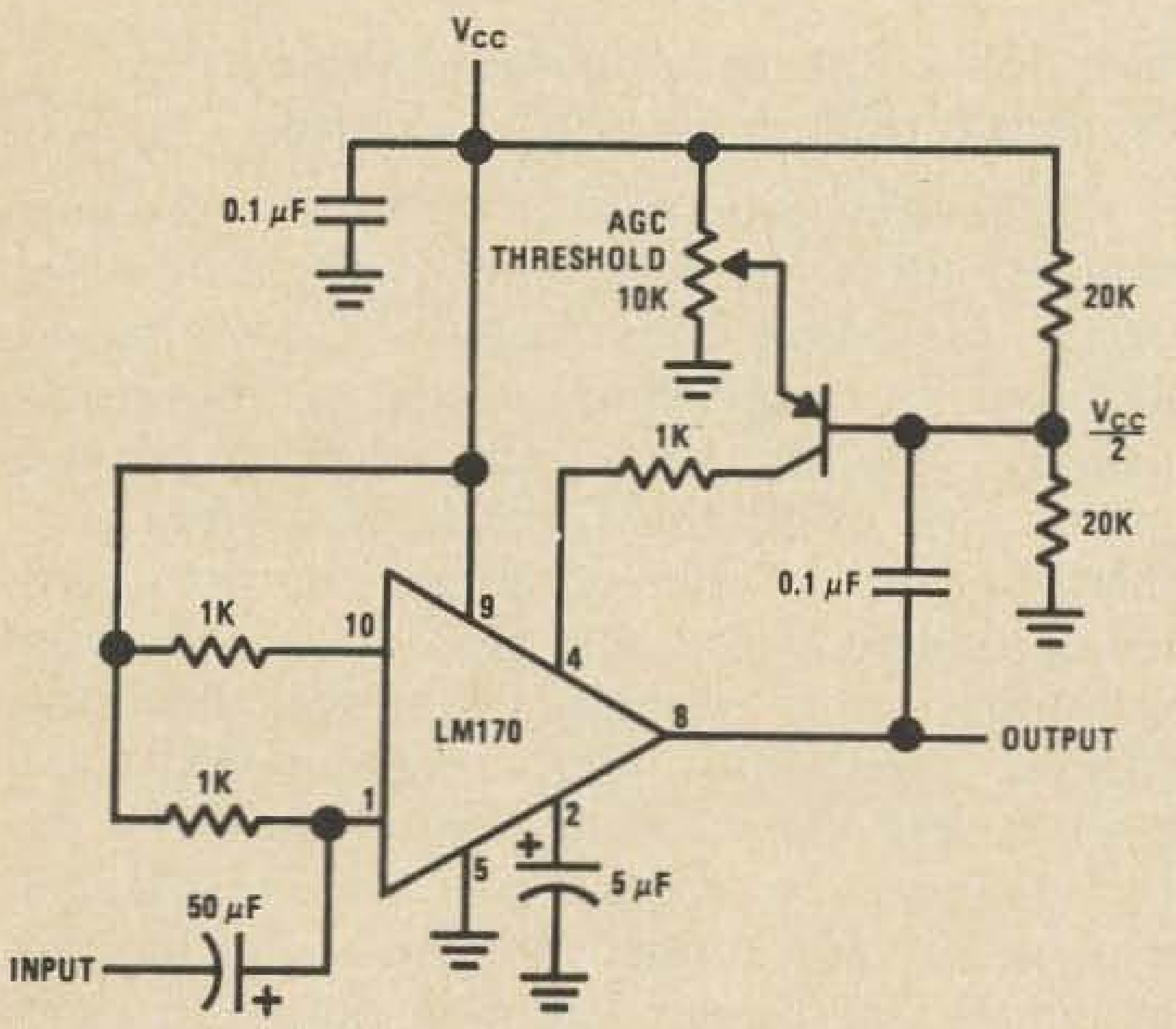

Fig. 6. Speech compressor.

might be one at which amplification cuts in above 20 mV p-p inputs. With the feedback values shown, the input level must drop below 12 mV p-p for a time equal to the RC time constant, before gain is cut off. Shorting across the 200 ohm resistor defeats the hysteresis.

Unlike most squelch systems, which are just switches, the LM270 provides a grad-

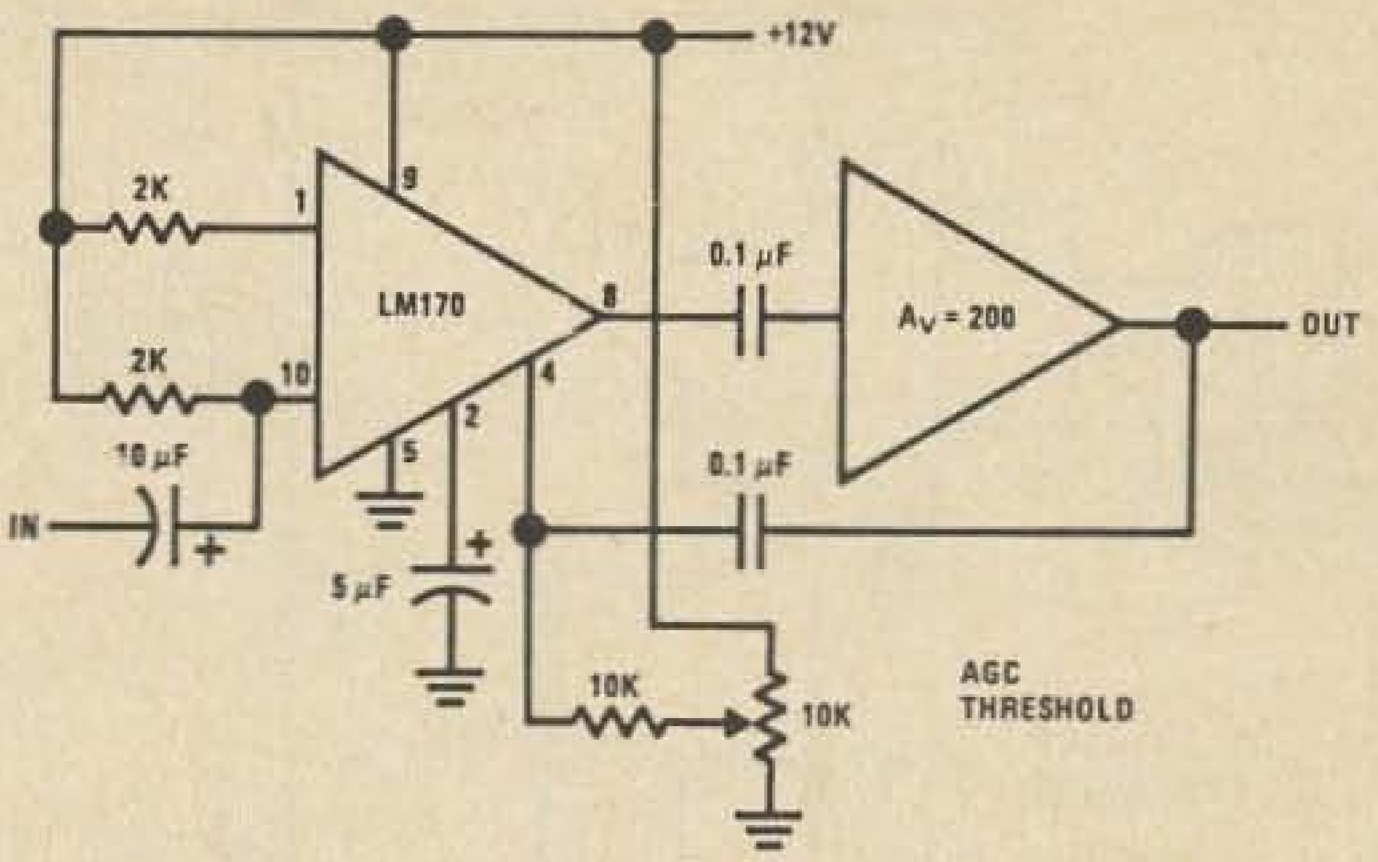

Fig. 7. Speech compressor using subsequent gain for better control.

ual fadeout of background noise, when releasing. This is because the RC combination charges slowly along an exponential curve, and passes through the variable gain region on its way to complete cutoff. **Fig. 10** shows the squelch action with a 25 µF capacitor and 100 k charging resistor. In the upper trace, a constant 1 kHz signal just below the squelch threshold keeps the output, in the lower trace, off. Abruptly increasing the input above the threshold immediately turns the amplifier on. Reducing the input does not turn off the output, but merely reduces it proportionally, during the release period. Finally, after about one second, the output tapers off to zero again.

In this example, another input biasing scheme is illustrated; the LM270 can be driven directly from a high impedance dynamic microphone, such as the Shure 401A, with dc bias for both inputs derived from the positive supply, and no other external components required. In receiver squelch, one of the previously illustrated input arrangements might be used. The high frequency

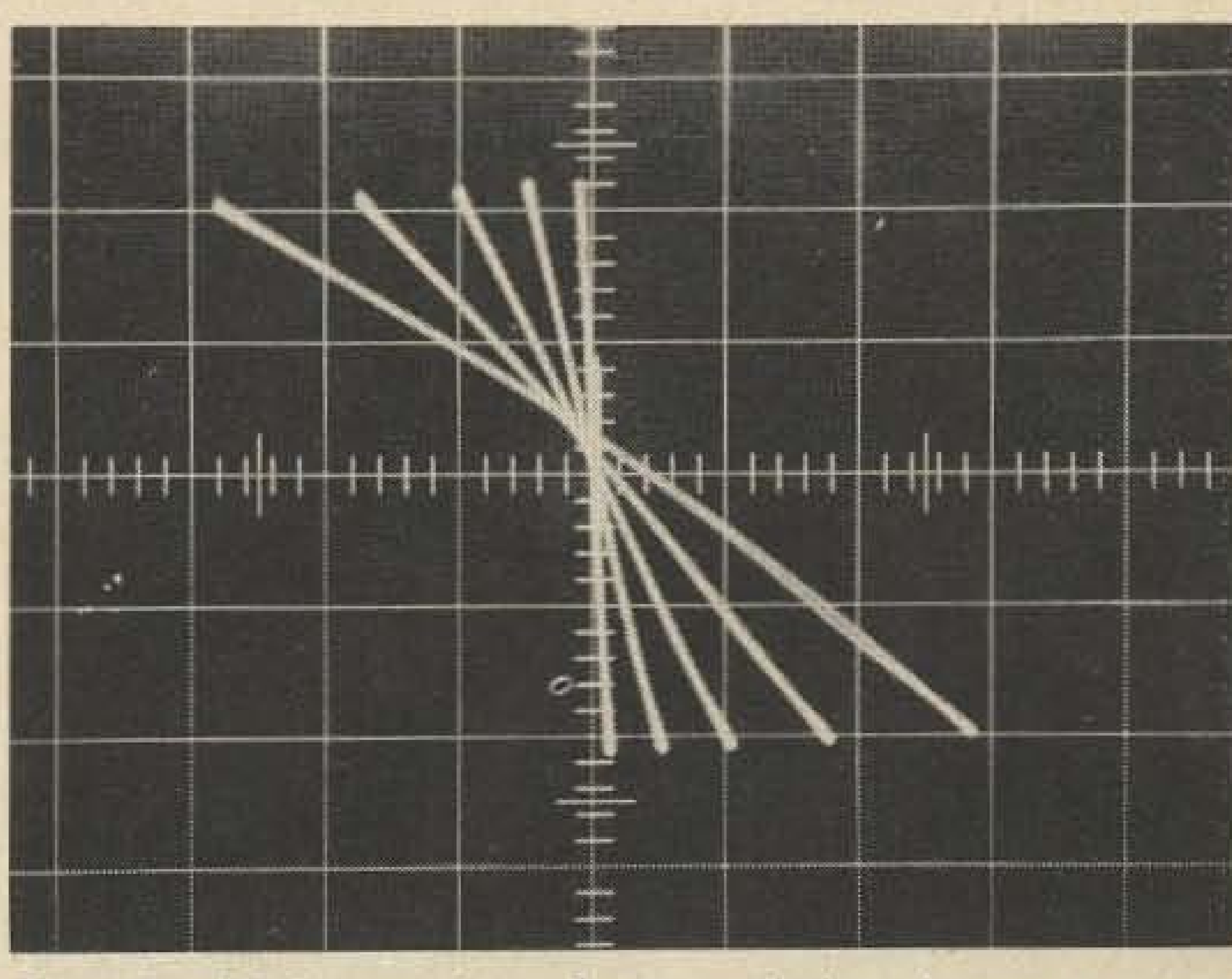

Fig. 8. AGC transfer characteristics, input vs. output, for varying input.

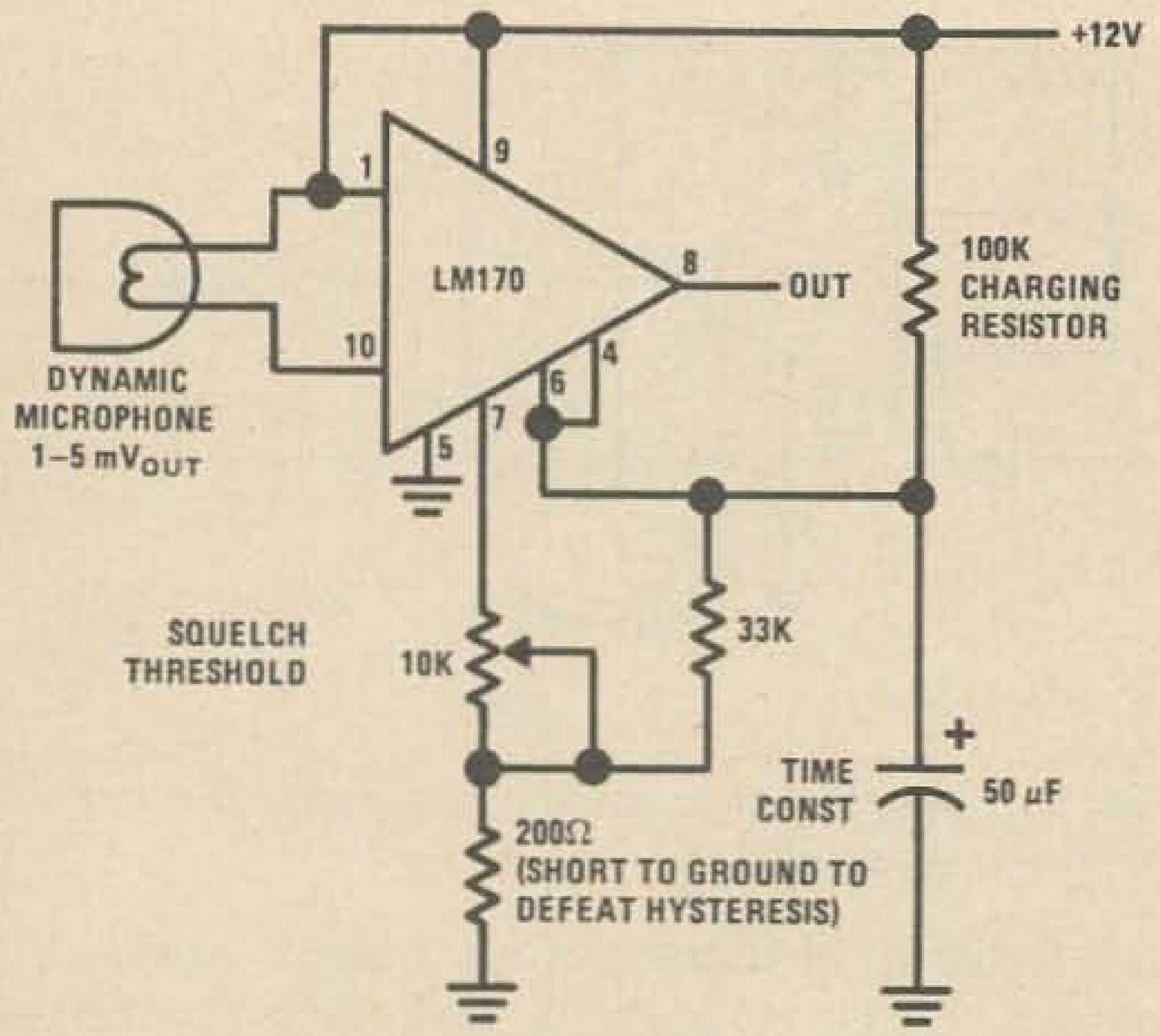

Fig. 9. Squelched preamplifier with hysteresis.

response of the squelch may be rolled off with a .05µF capacitor from pin 7 to ground, to reduce squelch triggering from high frequency noise above the speech spectrum.

A simple VOX mike preamp

Using a small power transistor driving a relay, the LM270 makes a combination VOX and microphone preamp small enough to build into a mobile-type communications mike. With the relay contacts wired across the push-to-talk switch, such a microphone can add VOX to existing transmitters with minimum disturbance of wiring. The basic circuit of **Fig. 11** can be improved, as in **Fig. 12**, by driving one amplifier input from the microphone, and the other from an attenuated part of the receiver's loudspeaker output. (Correct phase must be determined experimentally, by reversing either loudspeaker or microphone leads for best performance.) This takes advantage of the differential inputs provided on the LM270, to cancel ambient speaker signals reaching the mike (anti-trip VOX). A diode shunts the relay coil to protect the PNP power transistor. Any relay drawing less than 100 mA from a +12 volt supply may be used, small model-airplane types being suited for inclusion inside the mike case. In **Figs. 11 and 12,** amplifier gain is not cut off by the squelch detector; however, the VOX circuit may combine with any of the preceding applications to give, for example, a preamp containing both VOX and speech compression.

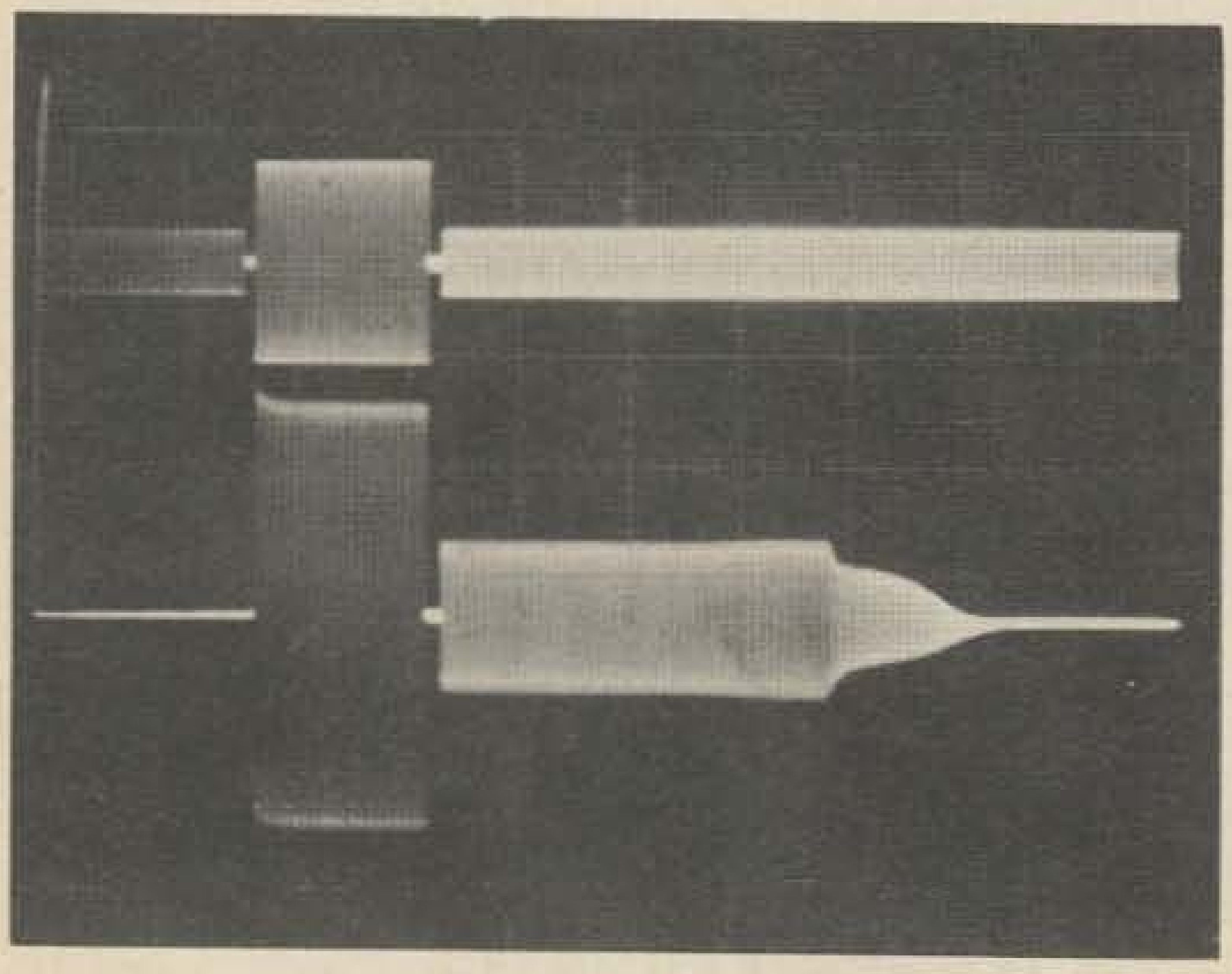

Fig. 10. Fast attack, slow release squelch action.

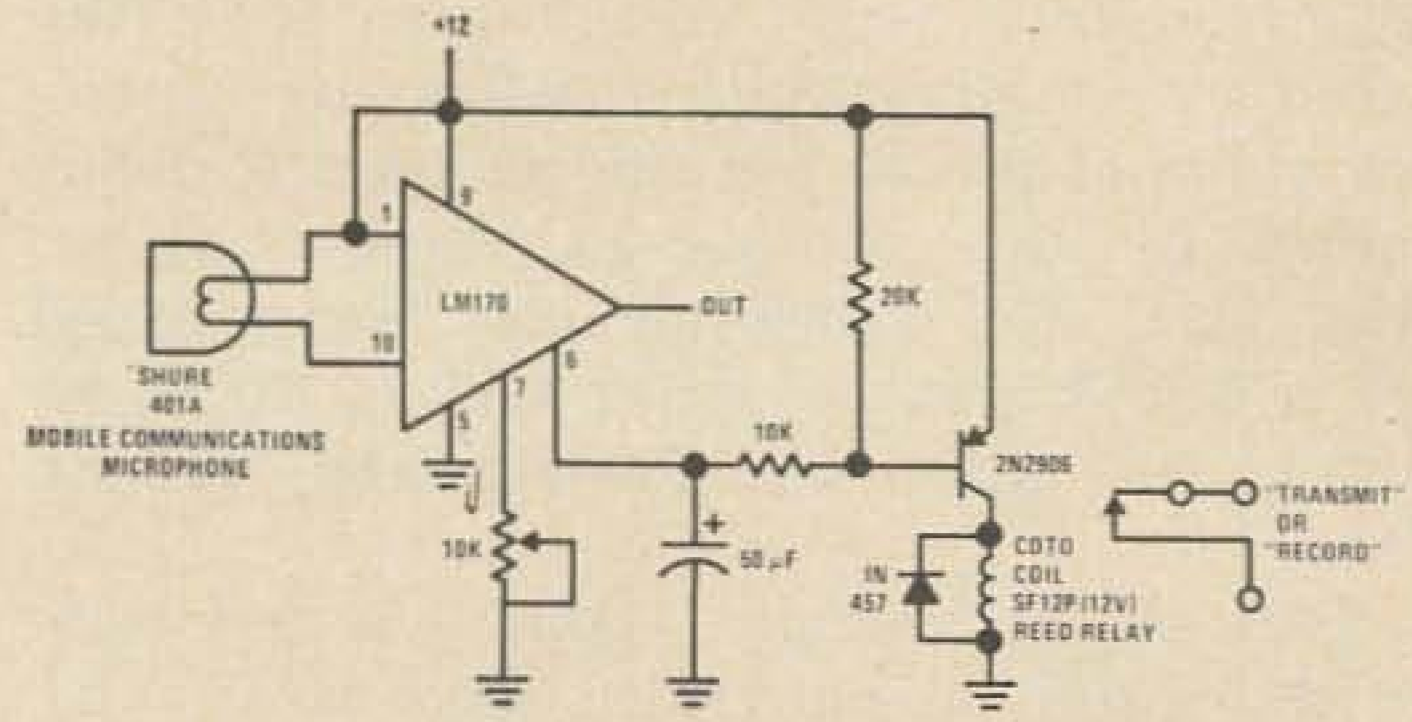

Fig. 11. VOX/mike preamp.

Twin-tee constant amplitude audio oscillator with remote level control

Oscillation occurs in a twin-tee, op-amp type circuit, when total feedback gain equals unity (including filter losses). Conventional methods of regulating oscillator amplitude usually rely on nonlinear loading of the gain stage. With the LM270, however, gain may be set by detecting the output, and using this to force the gain to exactly the minimum value required to sustain low distortion oscillation. The "AGC Oscillator" circuit, **Fig. 13,** automatically compensates for changes in oscillator load impedance. The exact amplitude at which this action occurs is set by an external pot, and may

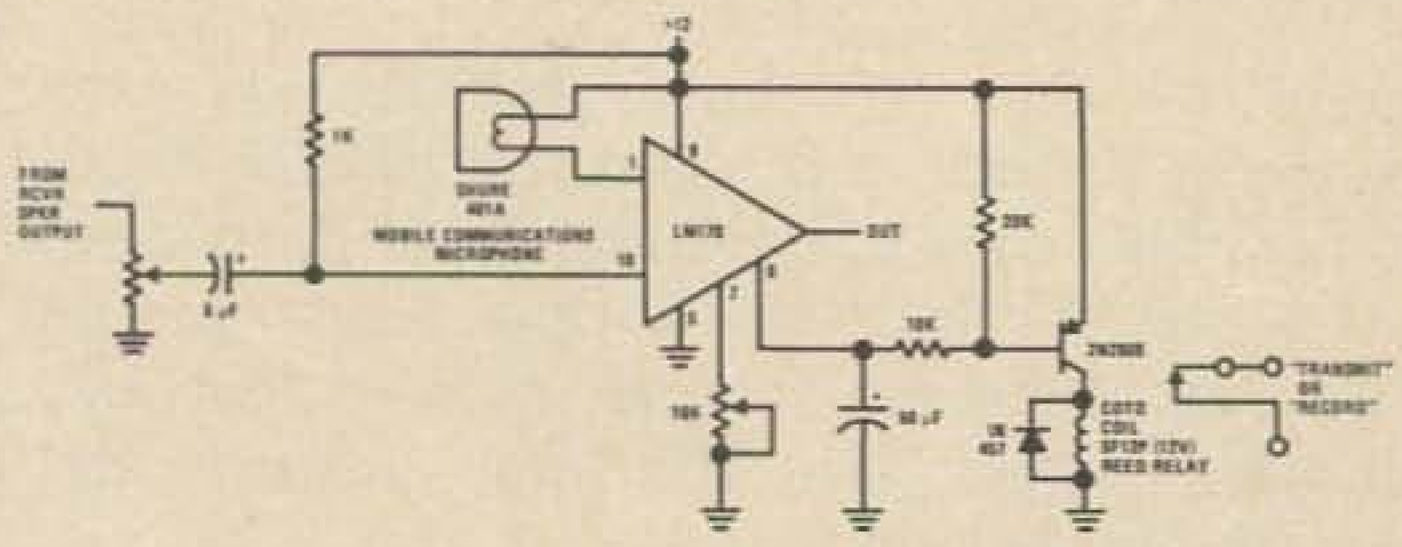

Fig. 12. VOX/mike preamp with anti-trip.

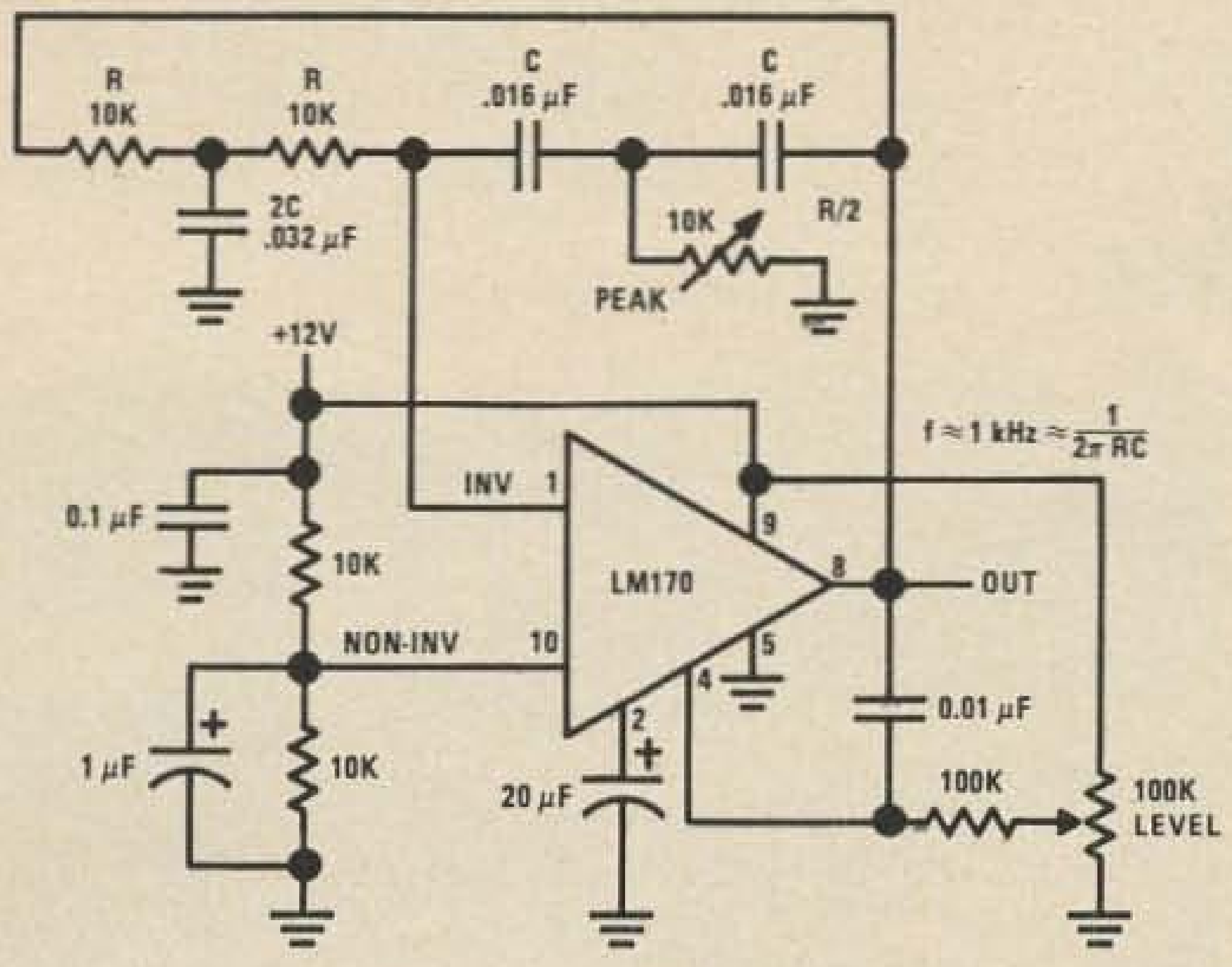

Fig. 13. Twin-Tee constant amplitude audio oscillator.

be set at any value below the maximum undistorted output of the amplifier itself. The "twin-tee" values shown give a 1 kHz output; other frequencies can be calculated from the formula:

$$f = \frac{1}{2\pi RC}$$

A modulated 455 kHz signal generator

An inexpensive, high "Q", 455 kHz ceramic filter can be substituted for the twin-tee feedback network in the preceding example, to make a regulated-output AM *if* alignment generator, **Fig. 14.** If the AGC threshold voltage, which determines the amplitude of stabilized output, is varied at a slow (audio) rate, the output *rf* amplitude will be forced, by the AGC feedback, to track the audio modulation.

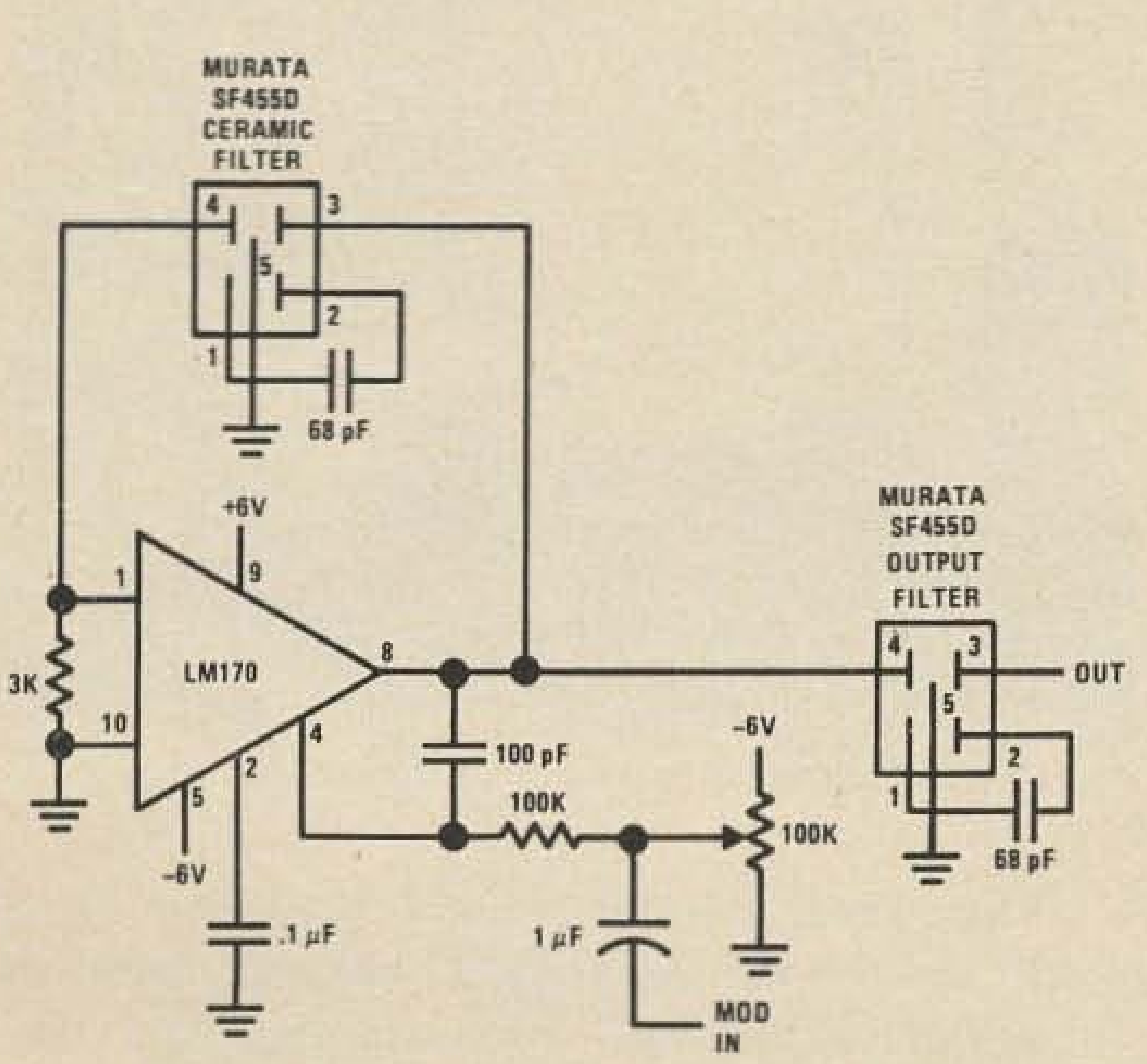

Fig. 14. 455 kHz modulated, regulated output signal generator.

Conclusion

The LM 270 is a very versatile ham IC, which can make your next homebrew rig more advanced than many commercial jobs, with a minimum of the usual headaches. A little thought will reveal many applications, not covered in this article, in speech processing, RTTY, mountaintop repeater control, and others requiring either a variable gain amplifier or a sensitive squelch detector.

Future developments in the communications IC area are going to raise a few more eyebrows; it is expected that nearly all low power level sections of both receivers and transmitters will be built in integrated form in the near future, but these developments must wait for subsequent articles. Meanwhile, whet your appetite with the LM270, the first ham IC. . . . W6DNS

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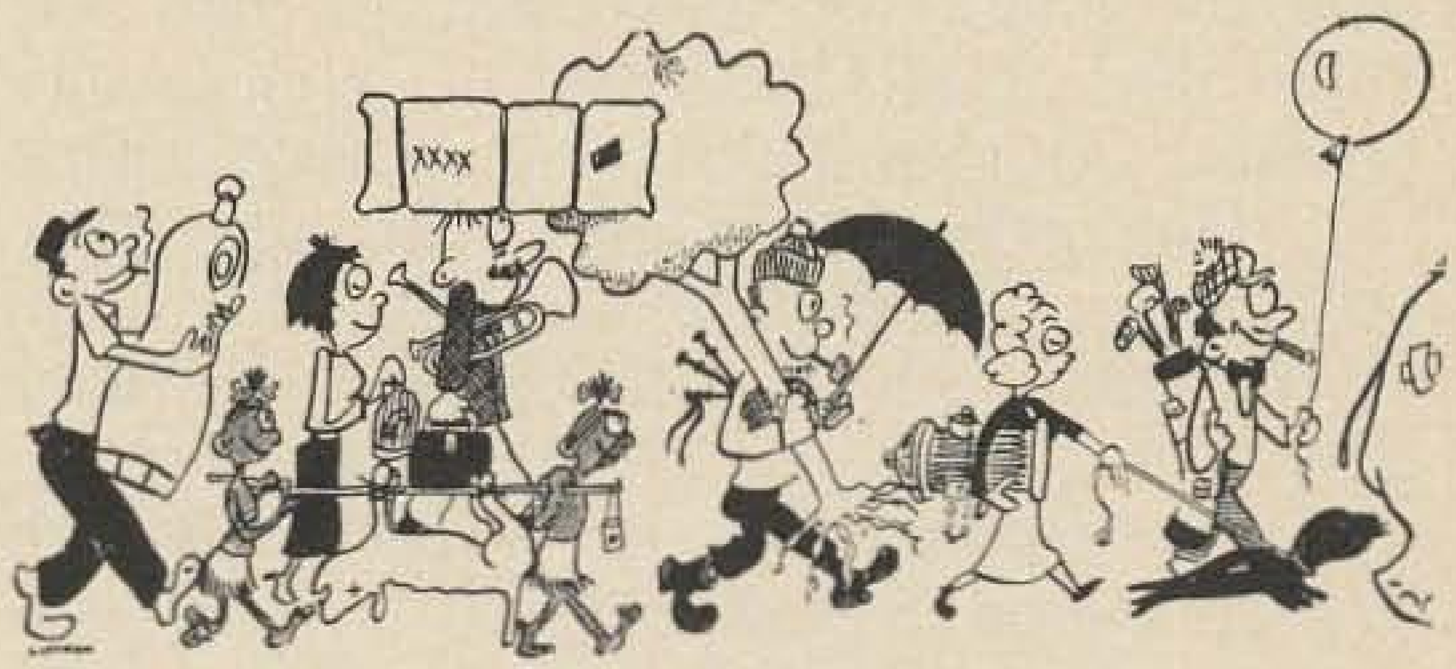
2. *R. Hirschfeld*, "Linear Integrated Circuits in Communication Systems", WESCON 1968 Proceedings, Session 1, Paper 3
3. "Ceramic Filter Data Sheet", Murata Corp. of America, 160 Broadway, N.Y., N.Y. 10038



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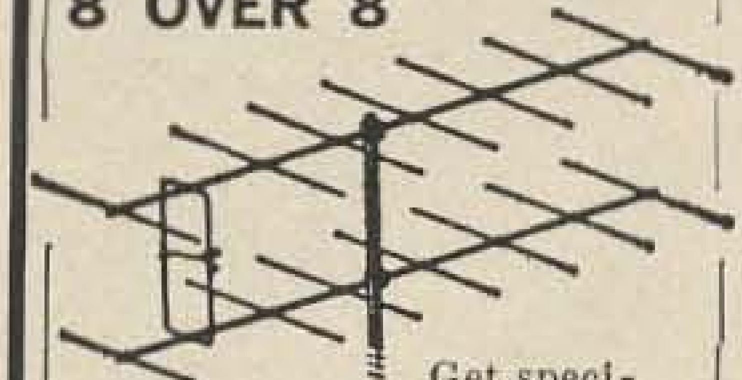

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Mouse Tunnels

An Answer to the Rat's Nest

J. A. Carroll K6HKB/1
CMR 1 Box 1438
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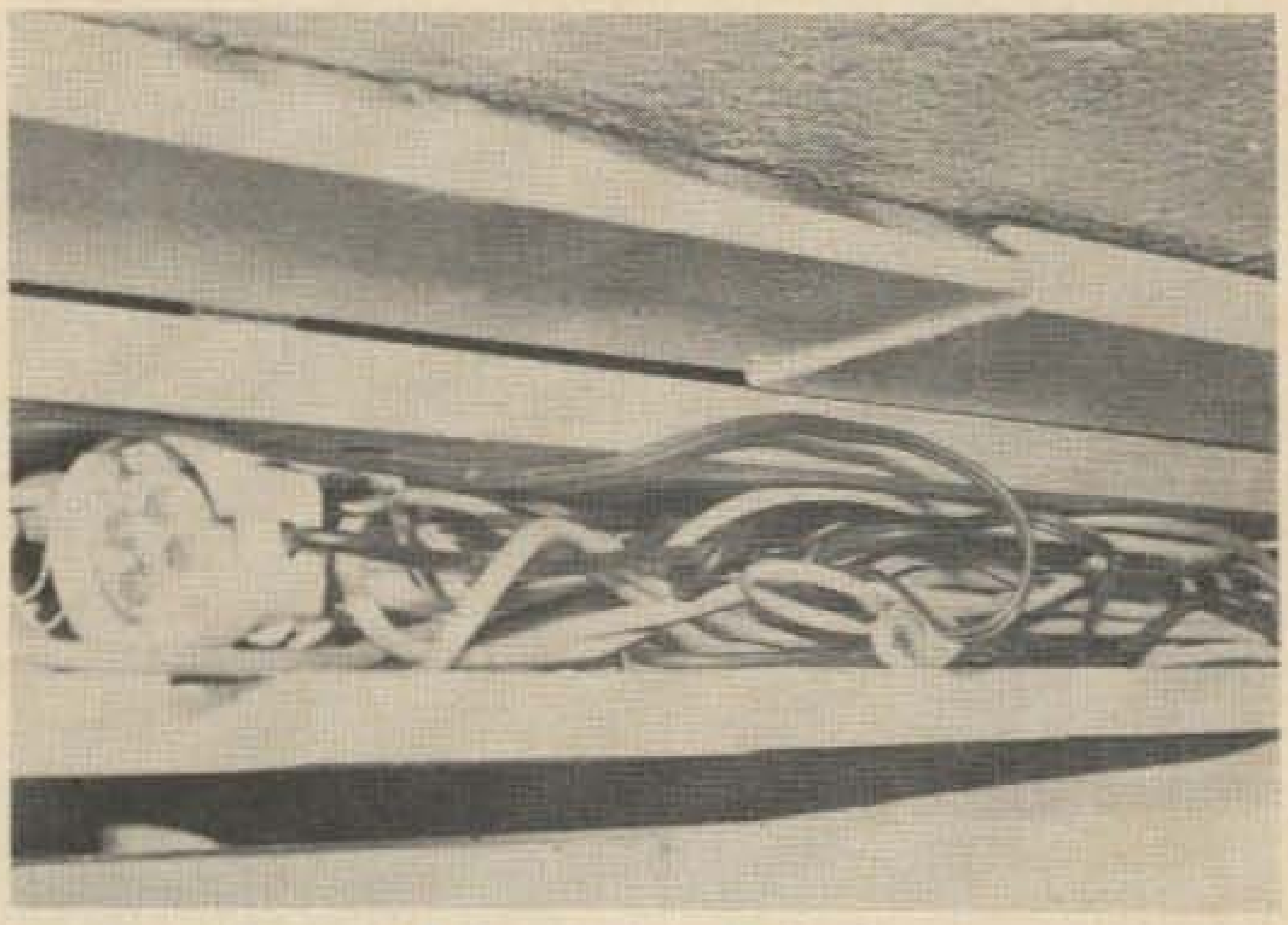
Most of us get a good-sized collection of cable behind the rig, and sooner or later find reason to cuss the tangle it gets into. About the time my roommate (Fred Wirth, WA8DOM) and I couldn't get into certain parts of the room without walking on the wiring, we decided to do something. The objective was to get the wiring out of the way and into a compact form without tying it down permanently and making it hard to rearrange.

Our answer was the "mouse tunnel," a low-cost adaptation of the sheet-metal raceways used in commercial installations. It's a wooden trough with a lid, 2⅞" x 3⅝" inside, with notches in the front every 6 inches to permit cables to exit where desired.

The photos show most of the construction. After the front board gets its notches, nail a few pieces of scrap wood temporarily to the top edges of the front and back boards to hold them the proper distance apart, so that the joints to the bottom board will hold them that way later on. The two side boards are glued to the bottom, with enough finishing nails to hold them until the glue sets. One every 6 inches is enough. They should be driven below the surface with a nail set, so they won't scratch the floor later.

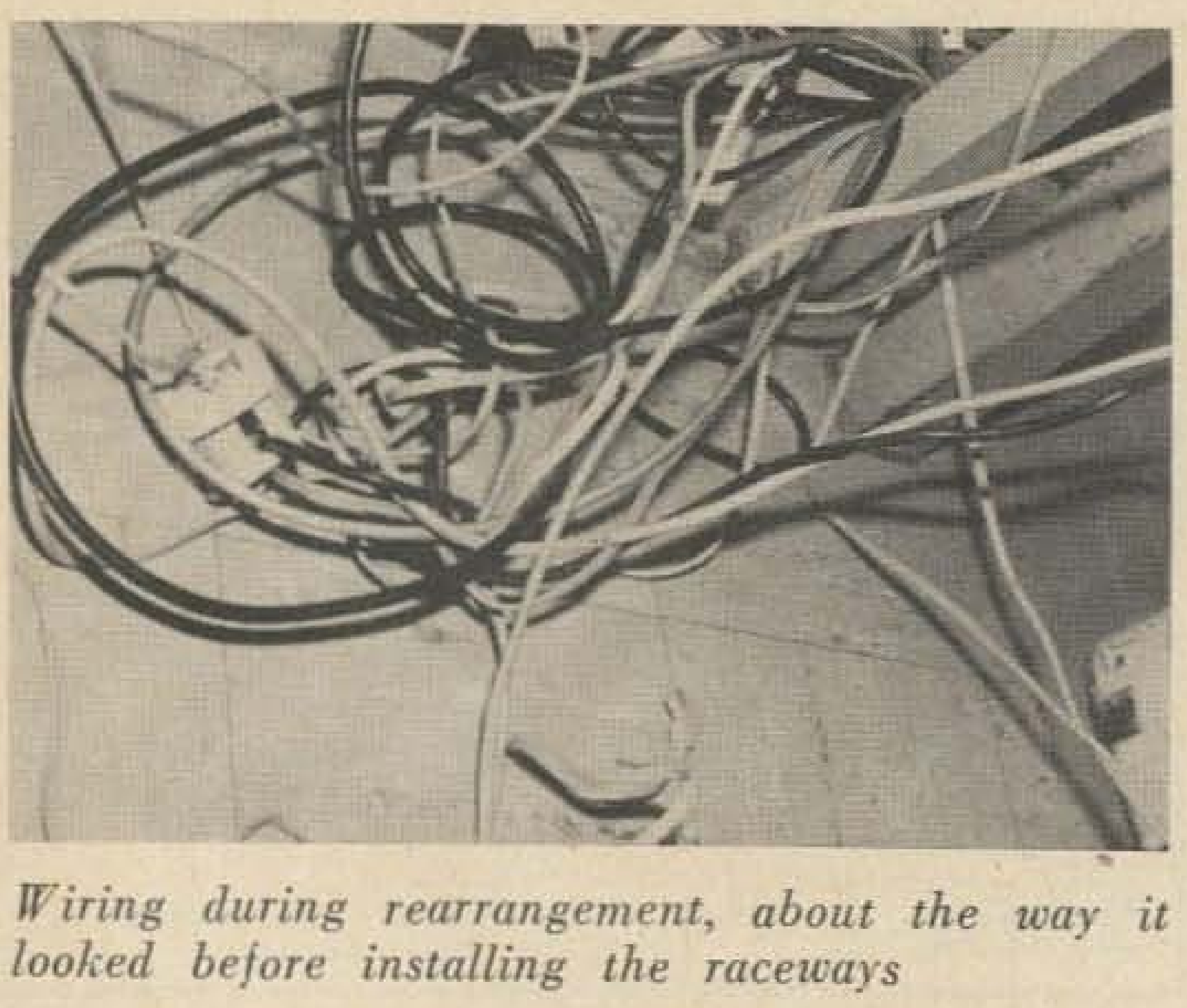
One small hinge every 4 feet is enough to keep the lid from sliding off, but a section of any lengh should have at least two. No other fastenings are needed, because the weight of the lid will hold it closed with the cables inside.



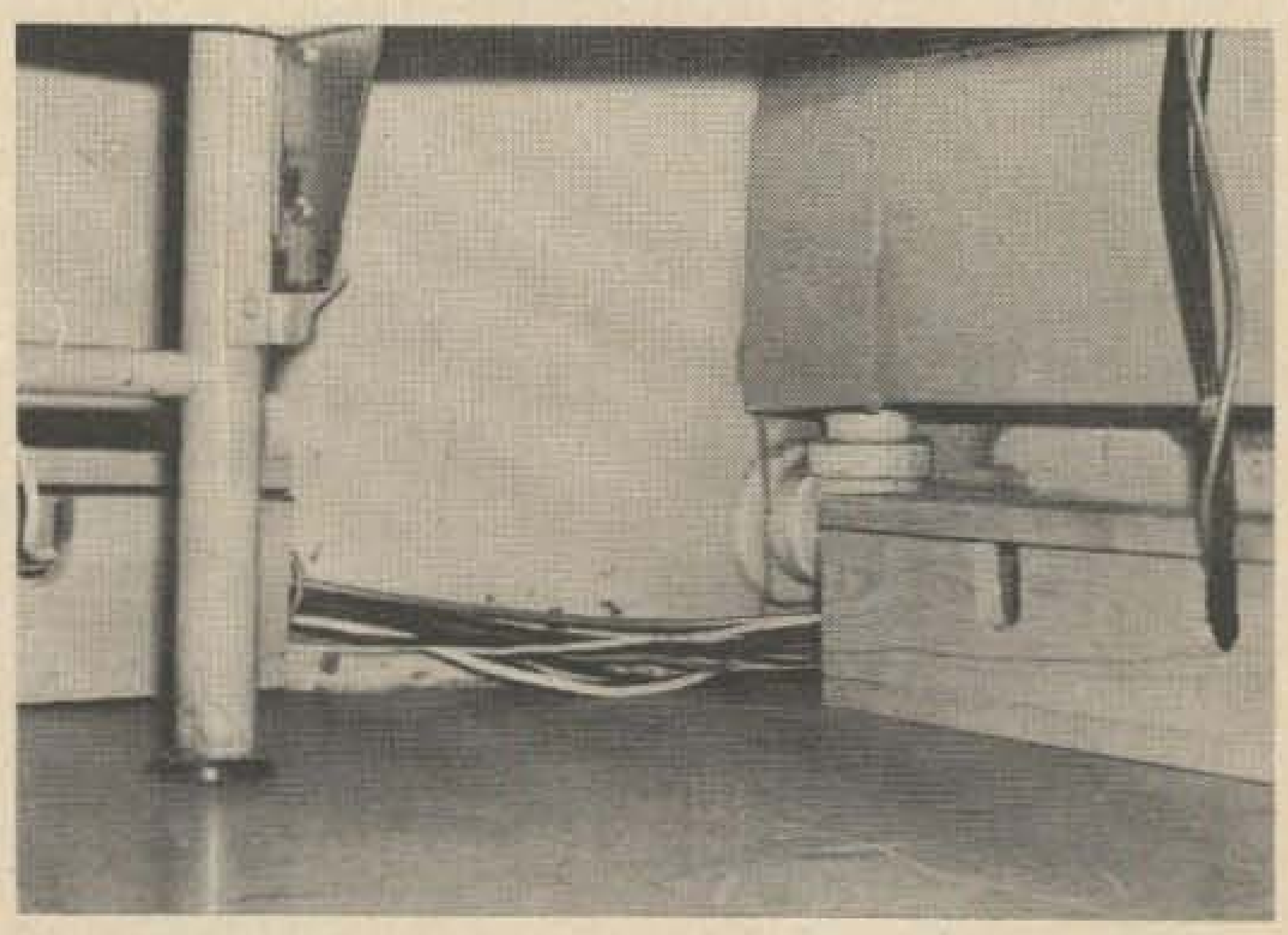
Cables laid in the tunnel

I built four sections totalling about 20 feet in one evening, and using all new material, spent a little less than $8.

Installation consisted of laying the tunnels on the floor along two sides of the room, putting the cables inside, and closing the lids. Cables come out the nearest notch to each piece of equipment, and excess is snaked back and forth inside the raceway, so there's no pile left on the floor. Changes in the cable runs are relatively easy, because the cables run parallel, and they don't get tangled because they can't be disturbed.



Wiring during rearrangement, about the way it looked before installing the raceways



Final appearance—cables in place, lids closed

Wire mesh trough would probably be as good or better, though I haven't tried it. In either case, cost and construction time for a foot-long piece are negligible.

. . . K6HKB/1

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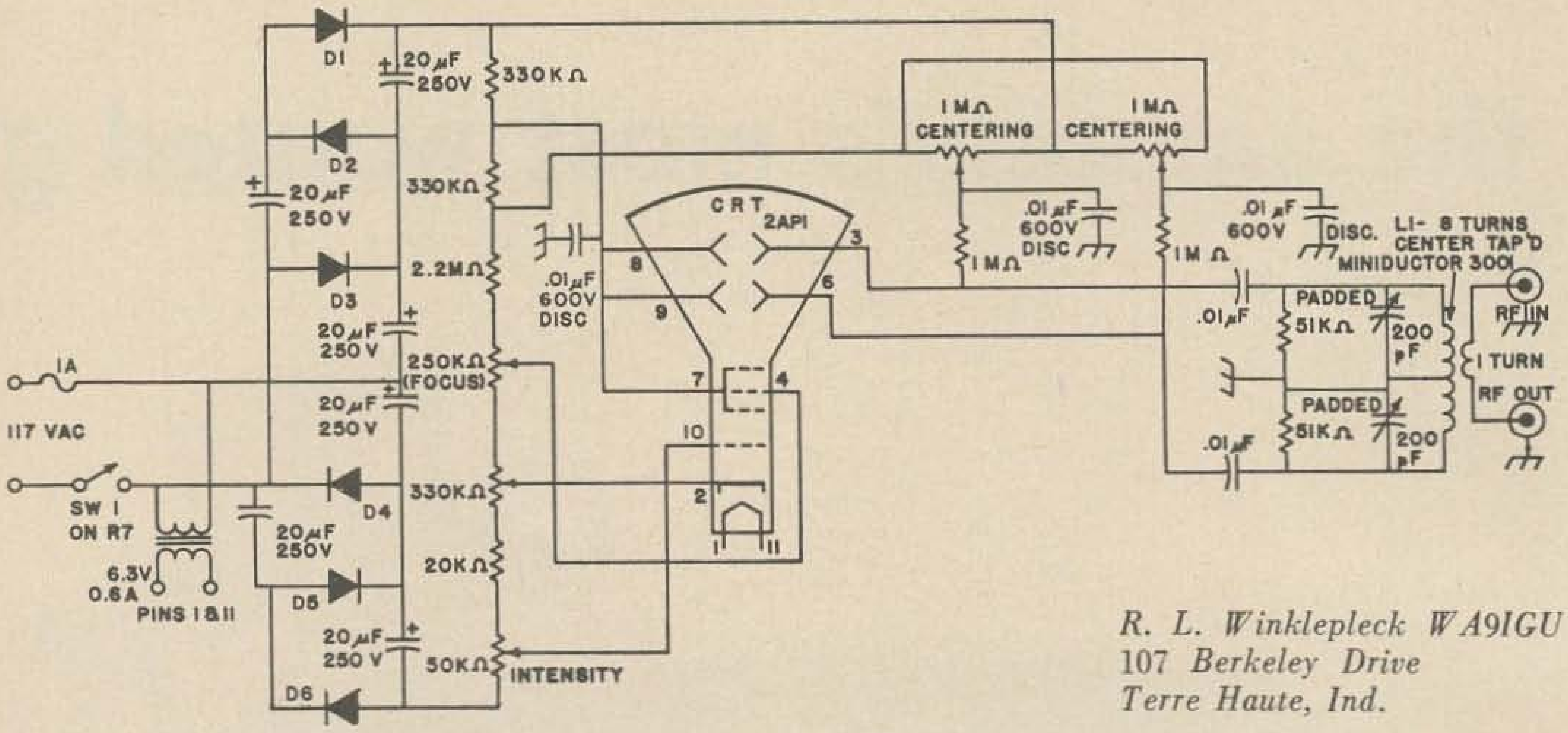


R. L. Winklepleck WA9IGU
107 *Berkeley Drive*
Terre Haute, Ind.

Circular Modulation Monitor

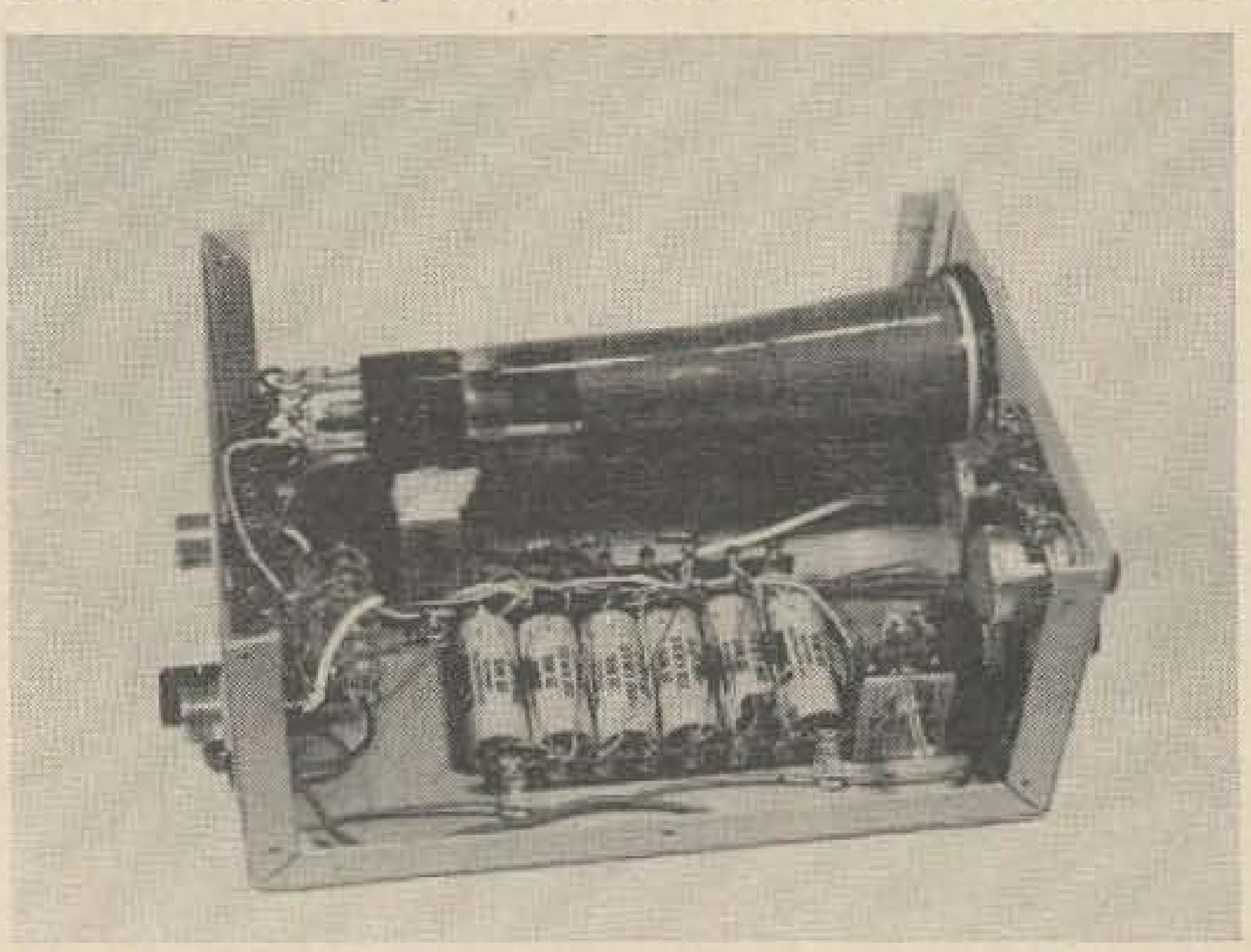
It's as important to keep an eye on your modulation as it is to regularly check your power output. Both characteristics combine to give you a good, intelligible signal.

There are many ways to check your modulation percentage and freedom from distortion. Each method has it's advantages. Nothing, however, is quite as good as CRT observation and here's a unique scope presentation. It'll have you going around in circles.

For a circular modulation indication it's only necessary to shift a sample of your *rf* output 45° each way and feed these two signals, phased 90° apart to the vertical and horizontal plates of a cathode ray tube. This shift is accomplished with a center-tapped inductance with trimmer capacitors across each half. The trimmers tune to the exact phase shift necessary to produce a circle and resistors across the tuned circuits lower the circuit "Q" sufficiently to prevent them from locking in phase. L2, the *rf* pickup link, is adjusted to provide the pattern size desired.

You may use this tuned circuit with any scope you have available or you may build one especially for this purpose. The one illustrated uses a surplus two inch scope tube usually available for a couple of bucks. The circuit is standard except possibly the high voltage supply. High voltage scope transformers are somewhat expensive. The voltage multiplier/rectifier circuit used here is simple and inexpensive. It provides 800-volts and can be duplicated with almost any silicon rectifiers and electrolytic capacitors with a 200-volt or higher rating. Current consumption is only two or three mils so even 5 mfd capacitors will do the job. While it's connected directly across the power line there is no hazard since the chassis is grounded only for *rf*. No horizontal sweep is required.

The chassis is formed from two bent up rectangles of sheet aluminum. Tie strips are used for those components which don't mount directly to the base. The CRT bezel



The row of electrolytics with associated diodes make up the high voltage supply. The mini-ductor on the back panel is L1 and L2 is the single turn of wire with white insulation.

is a plastic wide-mouth bottle cap with the center cut out. It is epoxied in a press-fit hole cut in the front panel. The base of the CRT is supported by the filament transformer. If no socket is available a few pin clips from octal sockets will provide convenient pin connections. Be sure that all 60-cycle and dc voltages are isolated from the chassis. The only chassis grounds, other than in the phase shift circuit, are *rf* bypass capacitors, C7, C8 and C9.

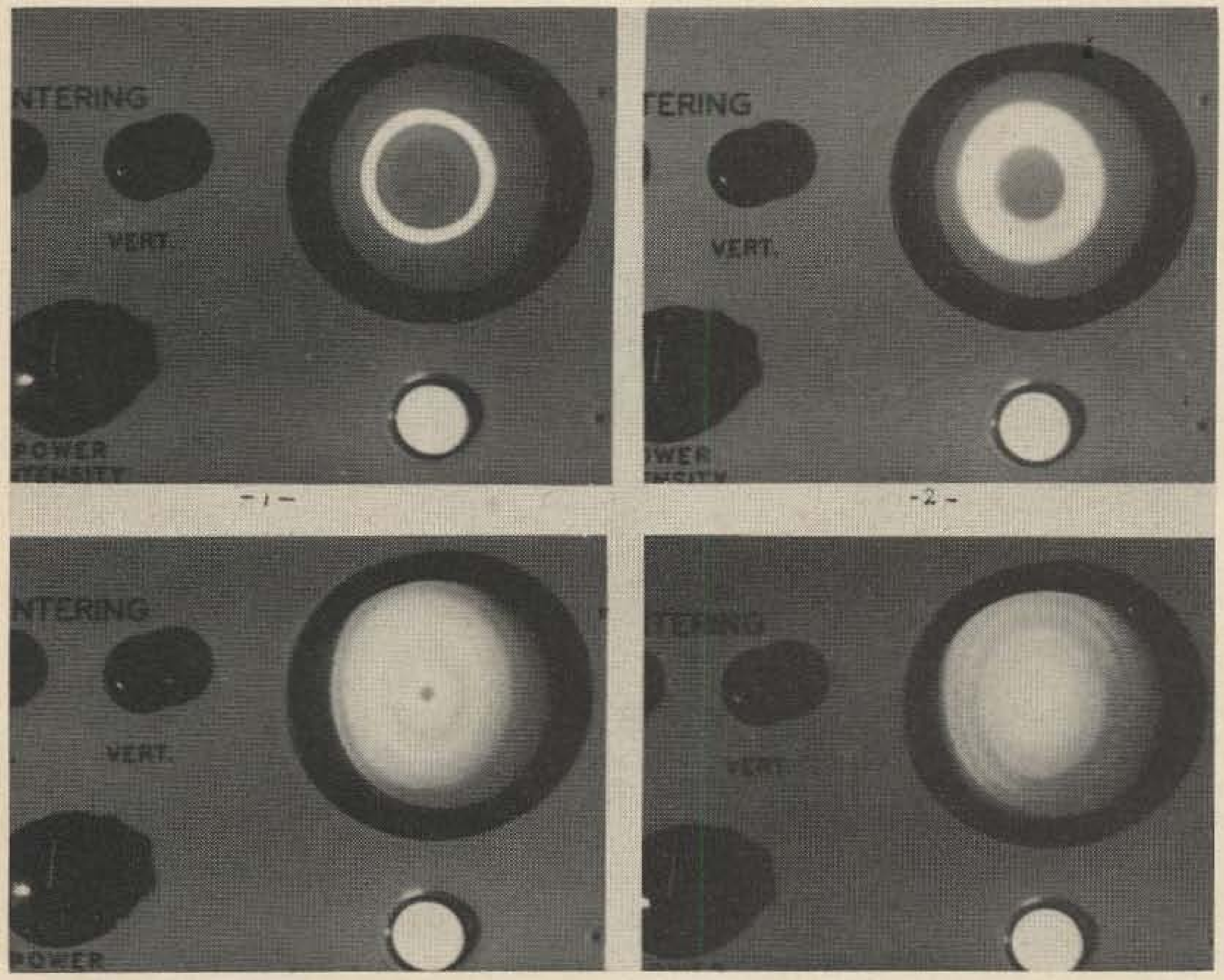
Before *rf* is applied, a single spot will appear on the face of the CRT. This can be centered with R8 and R9 and focused with R4. It's intensity is adjusted with R7. Try one or two turns around L1 for L2, connect the transmitter output to one coax fitting and the antenna or a dummy load to the other. If a diagonal line appears before *rf* is applied, reverse the power line plug. Turn on the transmitter and the CRT pattern will become a circle as C12 and C13 are adjusted to produce the 90° phase shift. This circle should be no more than one-half the diameter of the CRT. If it's too large reduce the turns or the coupling of L2. If too small change L2 to increase power transfer.

Modulate your transmitter and an annulus will result bounded by two circles; one larger and one smaller than the circle produced by the unmodulated carrier. As you talk, this annulus will become thin at low modulation levels and quite thick on modulation peaks. The percentage of modulation is equal to the difference of the two radii divided by their sum multiplied by 100. At 100% modulation a completely shaded circle will be produced with a dark dot in the center. A bright dot in the center warns of over 100% modulation.

The CRT pattern also tells several other things about your signal. If the shading of the annulus is not uniform when a steady tone is transmitted some distortion is present. If you adjust to a perfect circle using a purely resistive dummy load an antenna with capacitance or inductance will produce an oval. The amount of distortion accurately indicates the extent of maladjustment. Since the size of the unmodulated circle is directly related to the amount of *rf* in your feed-line this monitor can serve as a very sensitive tune-up indicator.

The value given for L1 permits use on the six meter band. By using less inductance you can tune up on two, or move down to the dc bands with more inductance. Increasing L1 to ten turns will permit use on the Citizens' Band. The few CB'ers who still are running five watts will need to increase L2 several turns to pick up enough *rf* for a good pattern. The correct inductance for the frequency of interest can be determined from the charts in the Handbook. Possibly a more scientific approach is by cut and try with a grid dip meter.

. . .WA9IGU



Without a carrier a white spot shows in the center of the CRT. An unmodulated carrier produces a circle.

1. *Very low modulation.*
2. *Approximately* 33% *modulation.*
3. *Nearly* 100% *modulation.*
4. *Bright spot in center warns of over* 100%.

The Mini-Square

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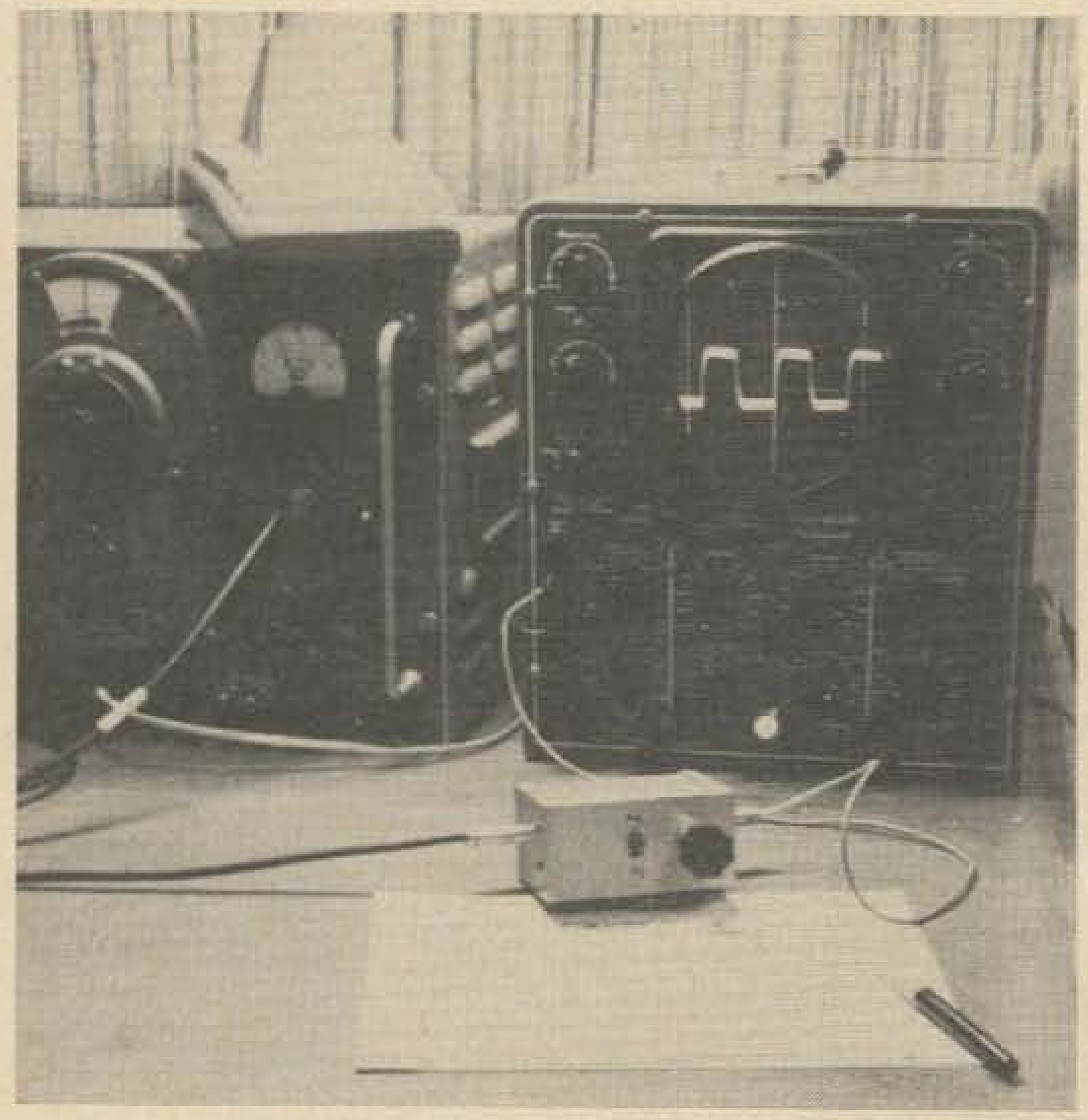


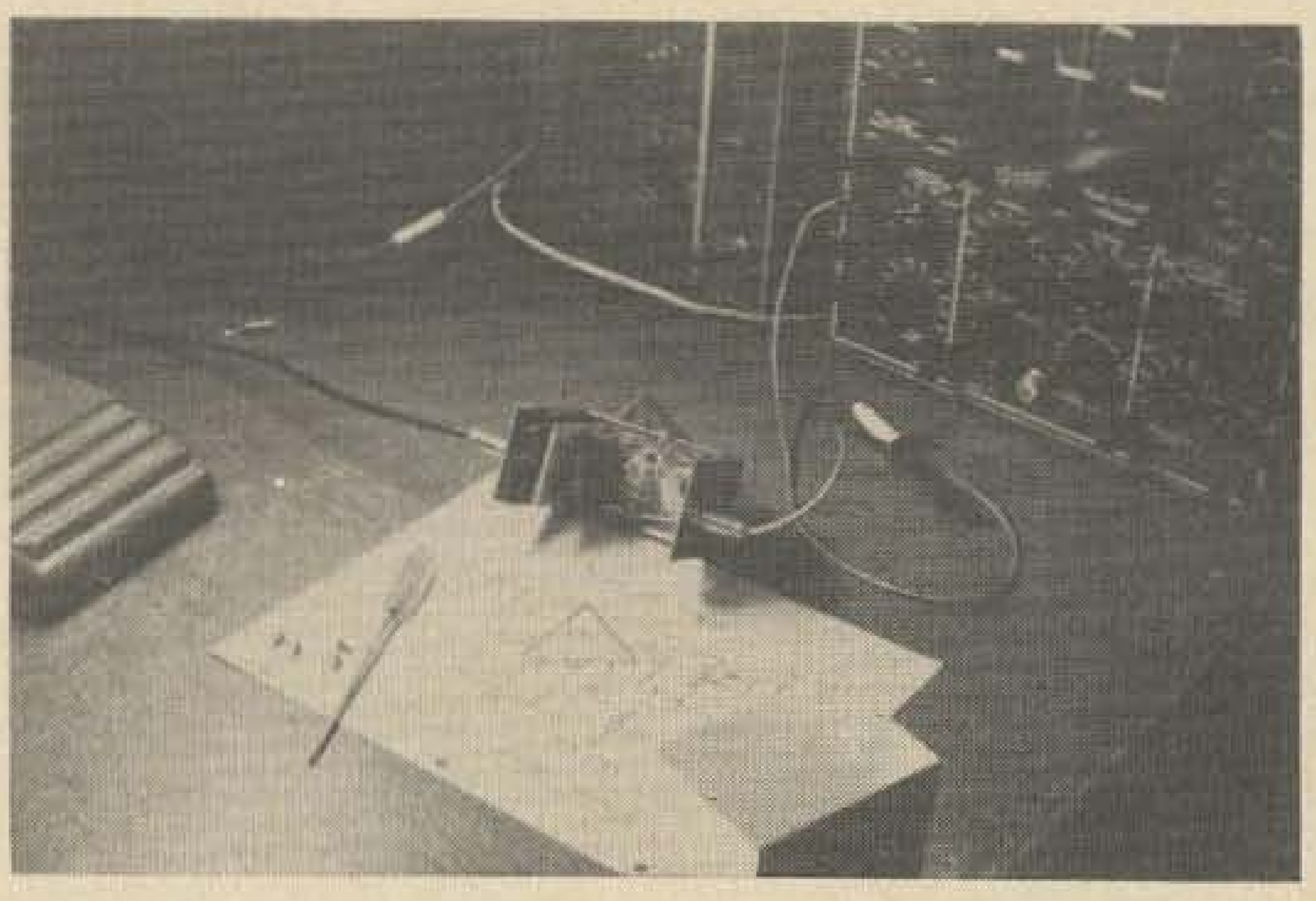
Any technician who has worked with audio equipment knows the value of square waves for checking performance of audio equipment. This article describes a simple and inexpensive integrated circuit amplifier/limiter that can provide a good quality square wave when driven by a sine wave source. The unit should not take more than a weekend to assemble, and will provide the experimenter with an interesting demonstration of the capabilities of this integrated circuit.

The circuit

The CA3011 is a wide band amplifier/limiter that contains ten transistors, seven diodes, and eleven resistors in a TO-5 case. With the connections shown in figure one, taken from RCA, it has a typical voltage gain of 70 db. The input limiting voltage required is about 250 microvolts, but the input voltage for using it as a square wave generator may be as high as several millivolts. It is usable up to 20 MHz, but the gain decreases, and the input voltage required for limiting increases above one MHz. The performance at the lower frequencies may also be reduced. The CA3011 is used typically for FM amplifiers at 10.7 MHz. For information on performance and applications, consult the reference at the end of this article.

Construction

As shown in the photographs, the circuit is assembled on a small piece of perforated board mounted inside a commercially manufactured (LMB) aluminum box. Layout is not at all critical, and almost any method could be used provided that leads are not too long. A small slide switch was used to turn the power off and on from the standard nine volt transistor radio battery. The capacitors can be mylar or ceramic with any voltage rating of ten volts or more. The resistors are half-watt. RCA jacks were used as input and output connectors.



Conclusions

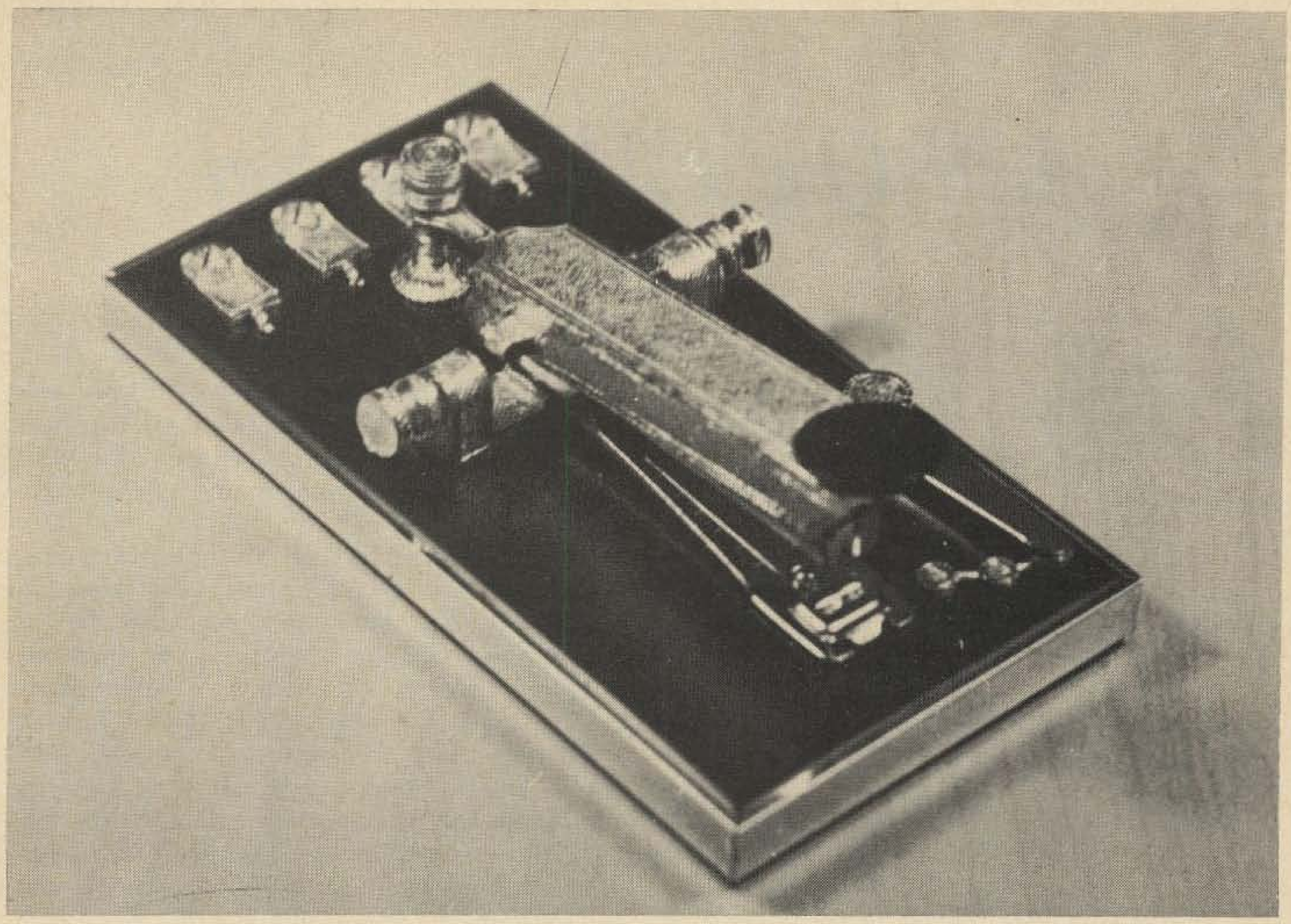
This unit will provide a symmetrical, good quality output wave form, but it must be driven by a good sine wave for best results. Impedance mis-matching can cause distortion in the waveform, and the builder may wish to raise the values of the input and output resistors. For the same reason, varying the output level control may also cause distortion. Increasing the gain control setting on the oscilloscope also affected the shape of the output waveform on the 'scope pattern in the picture.

This has made an interesting project with only a nominal expenditure of time and money, and can introduce the experimenter to other useful and facinating projects in the wonderful world of integrated circuits.

. . . WB6BIH

Reference

Radio Corporation of America. *RCA Linear Integrated Circuits*. Harrison, New Jersey : RCA, 1967.



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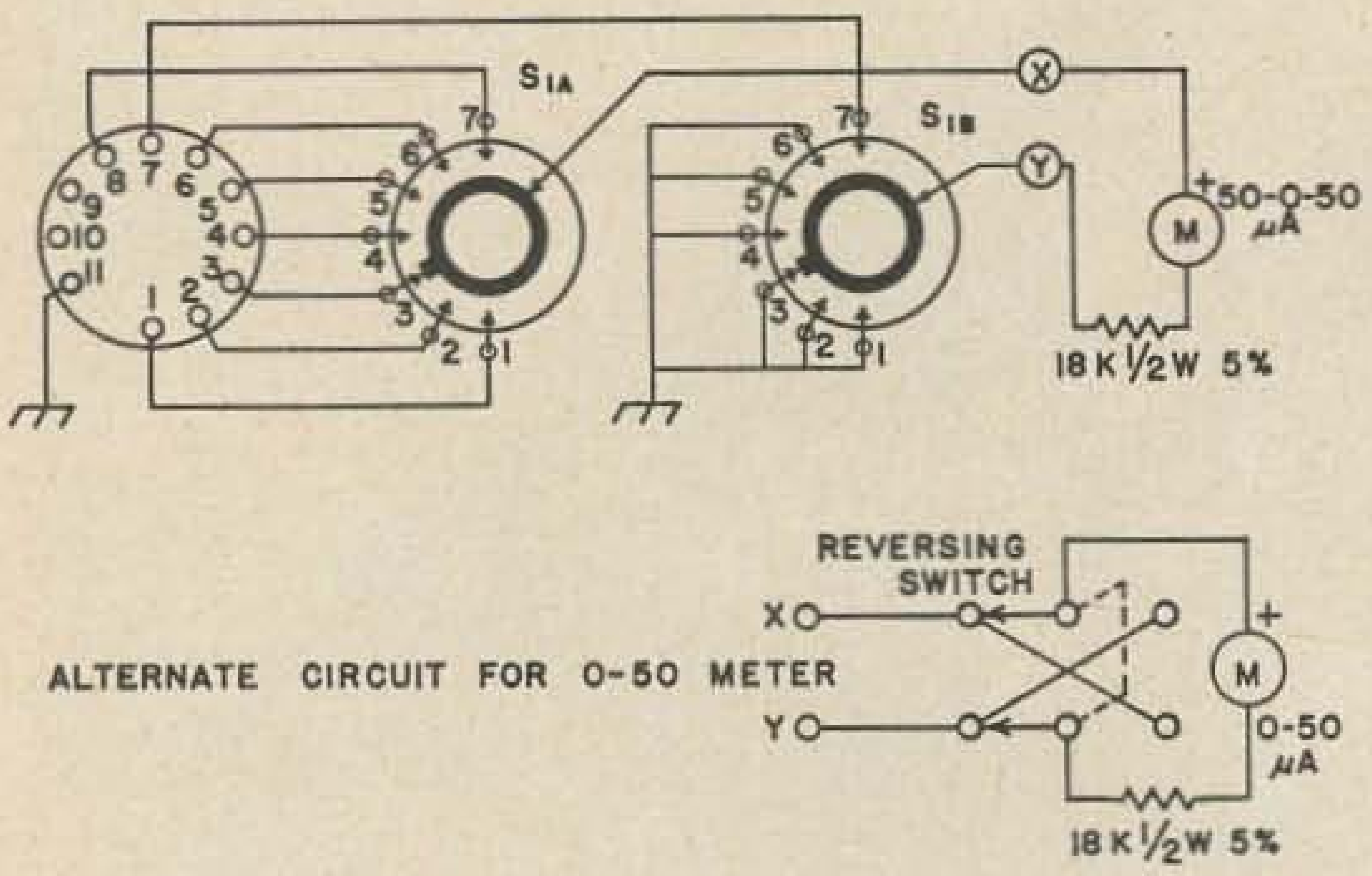

Fig. 1. The basic Schematic for The Casual FM'er.

Most Amateur FM'ers are aware that Motorola base and mobile equipment have central metering jacks for both the transmitter and receiver. These jacks provide a convenient method of measuring each stage during tune-up and alignment procedures. The basic Motorola test set, consisting of the alignment meter, field strength meter, and *if* xtal oscillator, costs approximately $200. The extra deluxe version with the deviation meter and peaking generator costs almost $500. Thus, it is easy to see why most amateurs stick to their VOM's when aligning their Motorola equipment.

The purpose of this article is to outline the construction of a suitable test set for Motorola equipment which can be constructed in varying degrees of sophistication. The basic set consists of a 50 µA meter, and a seven position two pole switch, an 18K 5% ½ Watt resistor, and an 11 pin plug to match the metering socket. This basic unit may be plugged into either the transmitter or receiver to meter the various stages. If a 0-50 µA meter is used a reversing switch will have to be used to allow the discriminator (receiver position 4) to be read in both a positive and negative direction. If a 50-0-50 µA meter is used (as in the K9STH unit) this switch is not needed.

The basic unit may be constructed on a small chassis or mini-box large enough to house the meter and switches. The schematic appears as **Fig. 1.** This unit is quite satisfactory for the casual FM'er who requires limited versatility. In fact, the basic unit is similar to the Motorola P-8449-B metering chassis used in many up-right base stations.

For the more serious FM'er or for clubs which desire a more versatile piece of equipment the basic test set may be expanded in varying degrees. The first expansion consists of adding a microphone and receiver audio output circuits. The microphone circuit allows a conventional Motorola microphone to be used to key and modulate the transmitter without the need for going to the control head. The use of a speaker in the test set will allow incoming signals to be easily heard. The additional circuitry appears as **Fig. 2.**

The third expansion is the addition of field strength meter facilities. The circuit is quite conventional. A short whip may be used for the input circuit. The additional circuitry appears as **Fig. 3.**

The fourth expansion makes the meter movement into a 0-15 VDC voltmeter for measuring automobile battery voltages. This is quite useful for many VOM's do not have a 0-15 volt range. Most meters have a 0-10V and 0-50 V range, which do not allow accurate measurement of 12 volt automobile systems. The calibration of the

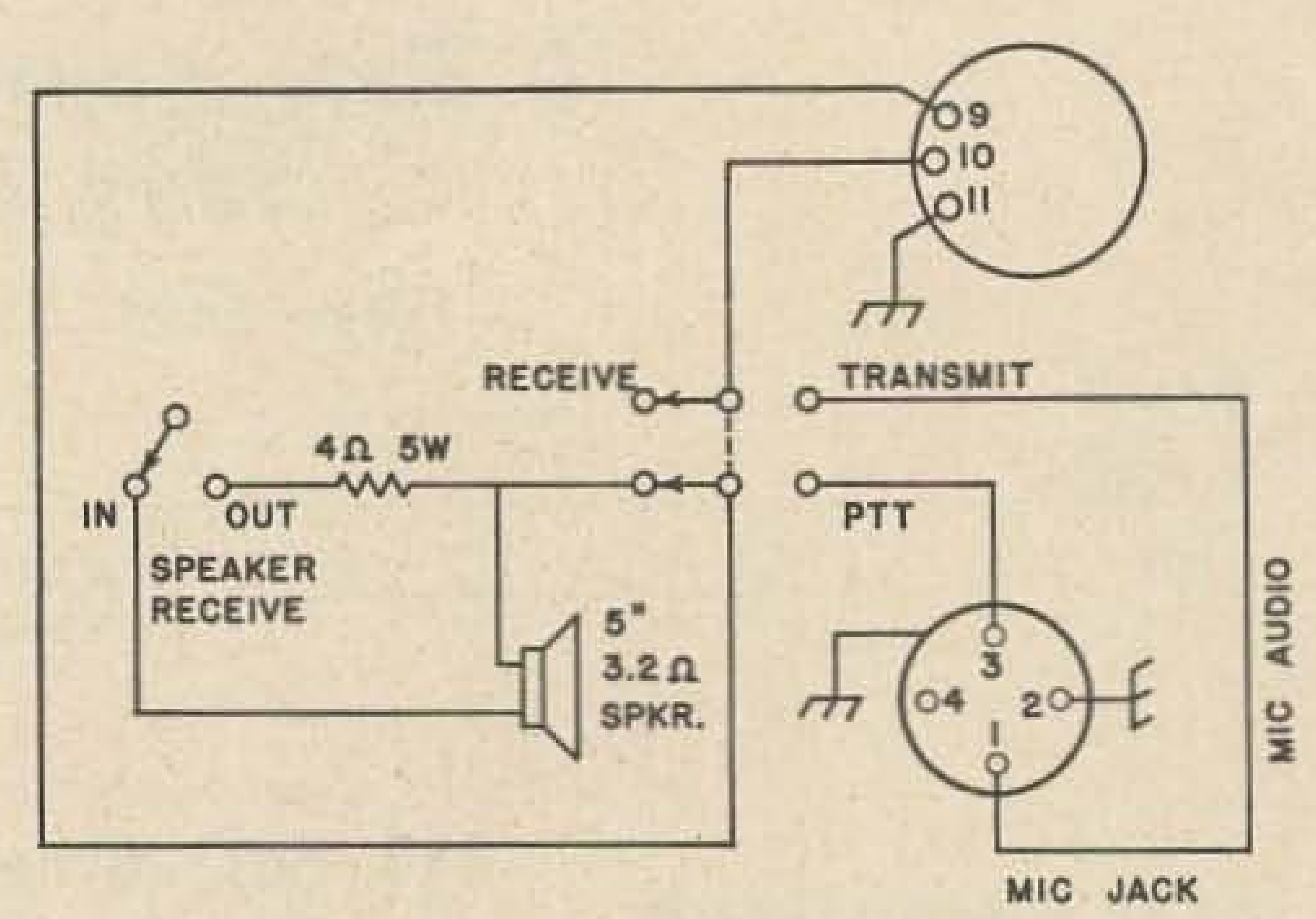

Fig. 2. Addition # 1 Makes Fig. 1 more versatile.

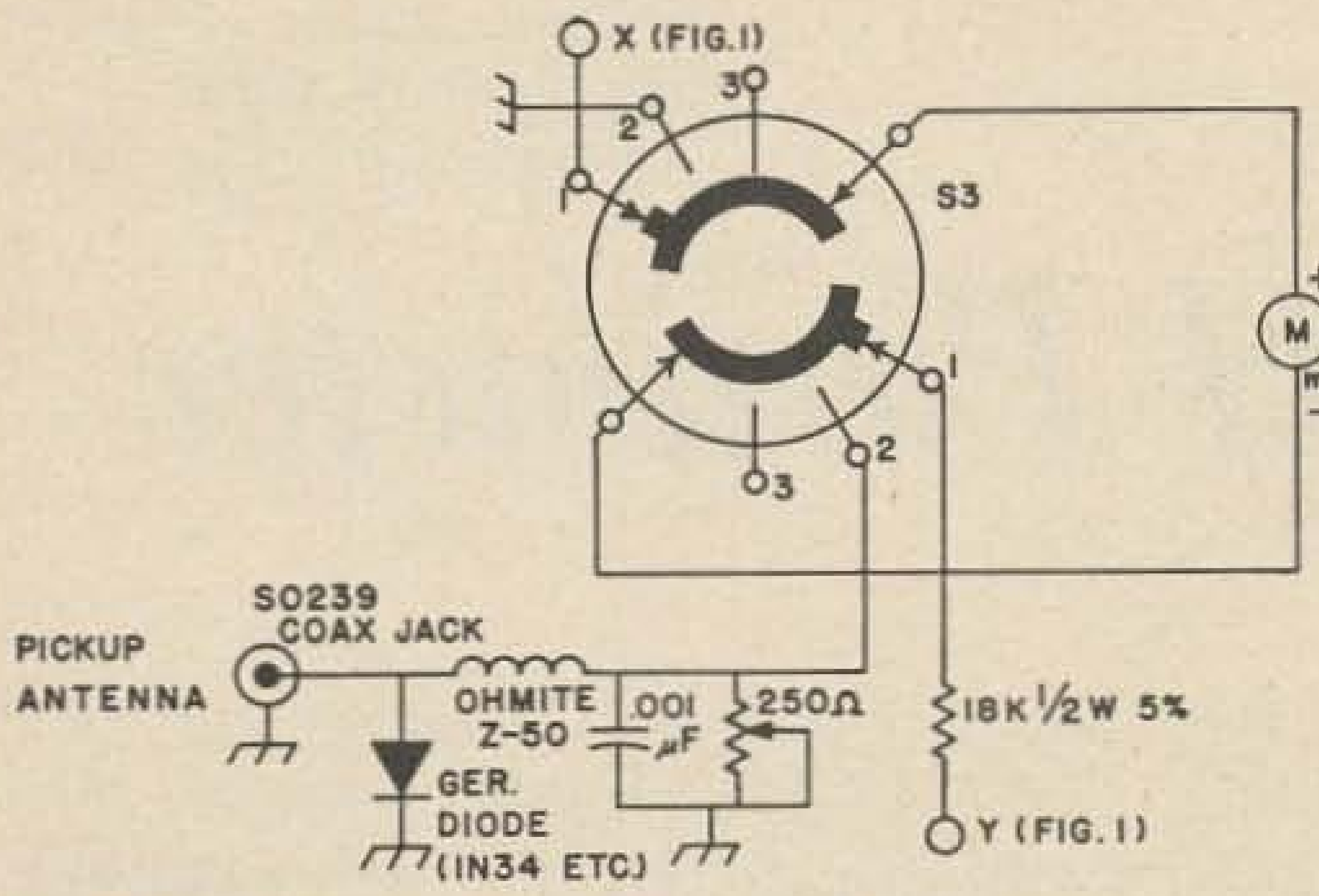

Fig. 3. Adding a Field Strength Meter.

meter can be done either mentally or by the addition of another scale. The easiest method is mental calibration, for each 10 increments on the meter scale represent 3 volts. The additional circuitry appears as **Fig. 4.**

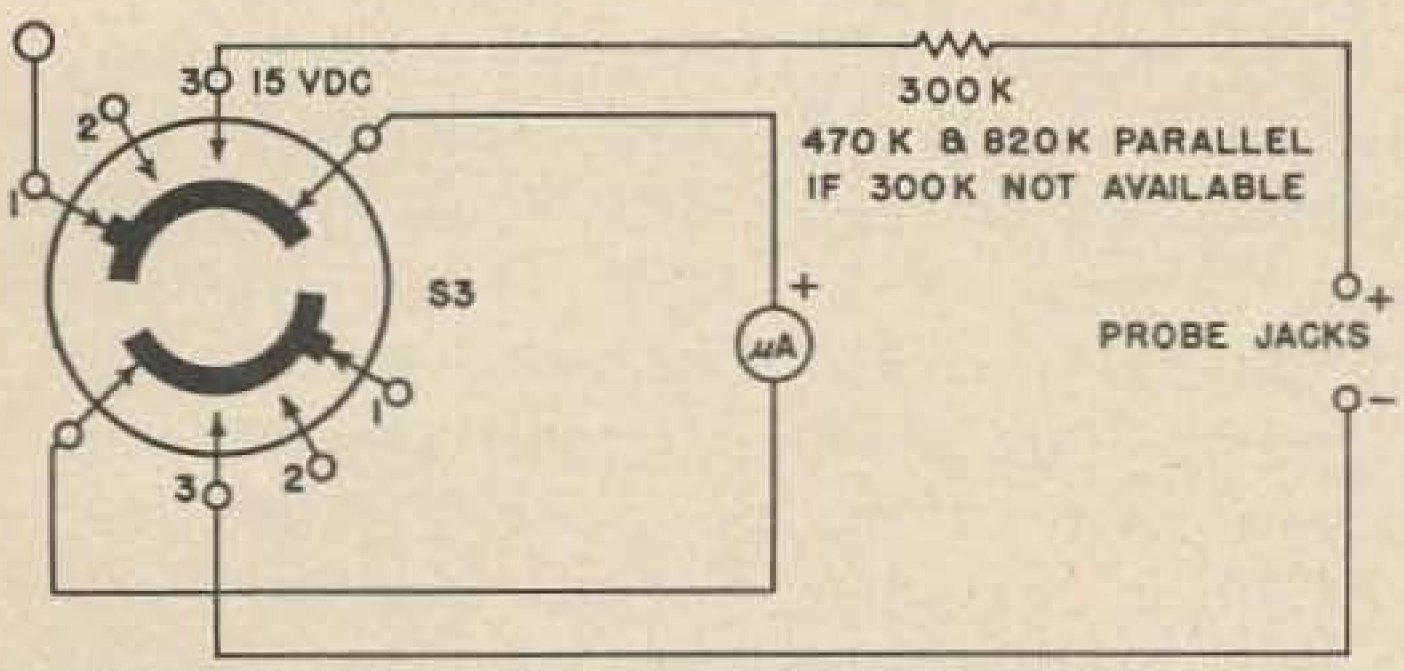

Fig. 4. The Meter becomes a Voltmeter.

The fifth expansion is the addition of a crystal controlled 455 kHz oscillator. This is needed when zeroing the discriminator during receiver alignment procedures. Two other crystal positions may be used for the frequencies of 450 kHz and 460 kHz (for narrow band) or 440 kHz and 470 kHz (for wide band). This allows the low *if* filter to be checked (if the second limiter reading is not almost identical on both crystal positions, the filter is probably defective). Also, the crystal positions may

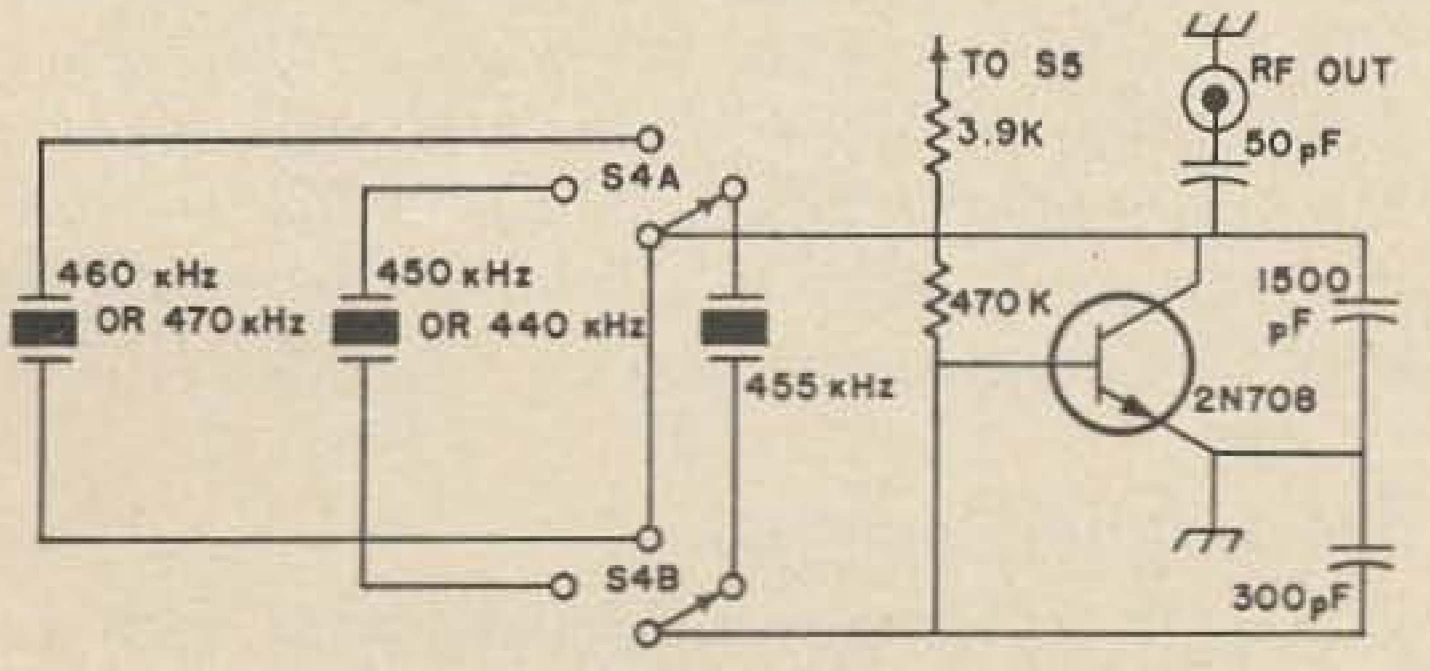

Fig. 5. Adding 455 kHz Oscillator

be used to calibrate an oscilloscope for measuring deviation. Since my semi-conductor supply and knowledge are relatively small, I referred to the March 1967 issue of *73*. This is the issue that contains the article entitled "73 Useful Transistor Circuits". The 100 kHz calibrator circuit, figure 62, will oscillate at 455 kHz. The schematic is reproduced as **Fig. 5.**

The sixth expansion is an audio oscillator. When this oscillator is adjusted for an output of 1 volt RMS the deviation of the transmitter may be easily set. Also, an au-

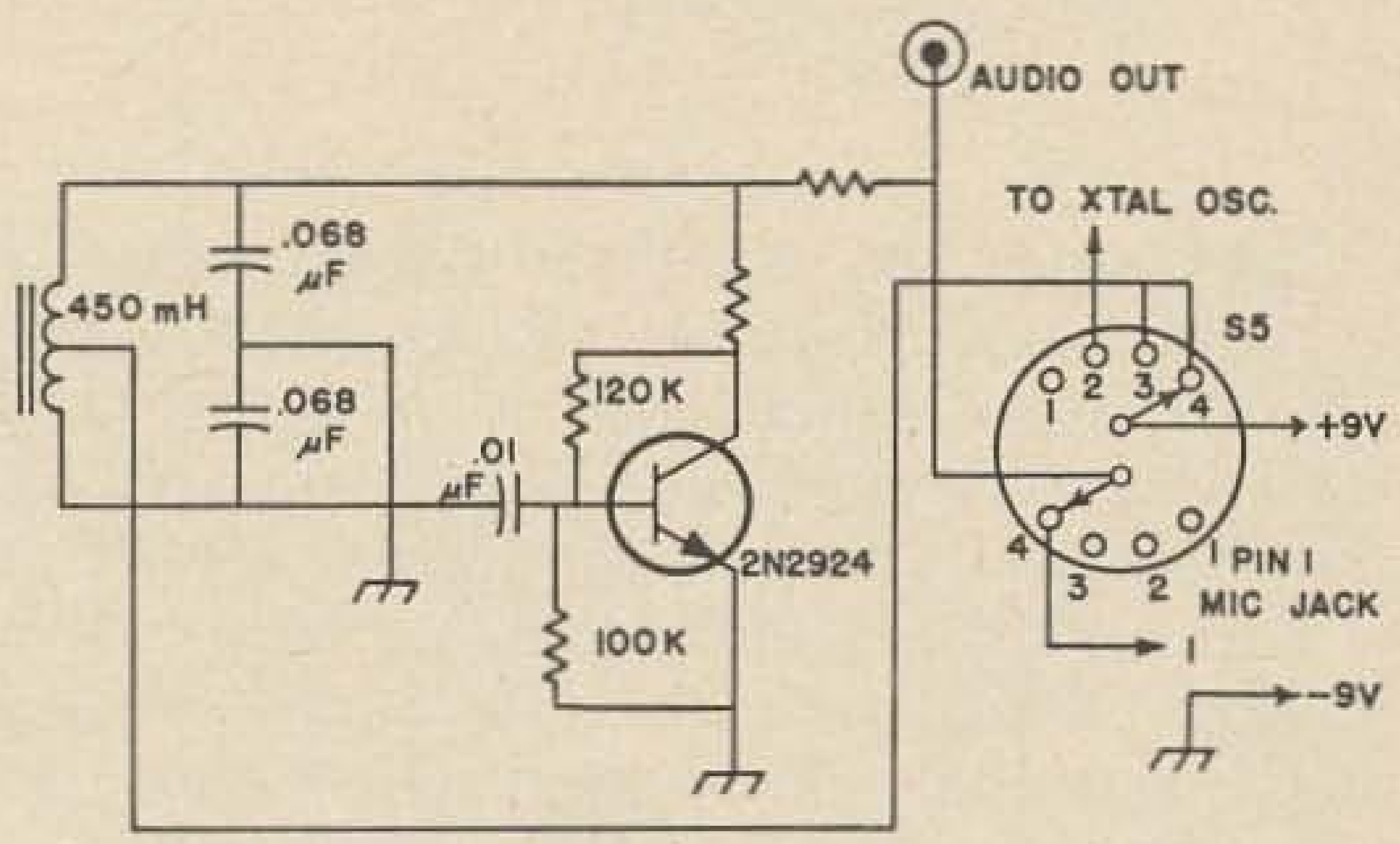

Fig. 6. Audio Oscillator.

dio oscillator is quite useful in trouble shooting both receiver and transmitter circuits. Again reference is made to the article mentioned above. Figure 61, page 26A, is a 1 kHz oscillator. The value of inductor listed may be hard to find, but an audio interstage transformer (1:3 ratio) worked in a bread-board circuit when the primary was used for the inductor. The schematic is reproduced as **Fig. 6.**

The actual constructural details are left to the individual amateur. A medium sized chassis will hold the complete circuit while the smaller versions may be scaled down as needed. The simplest version could be built in a small mini-box with the 50 μA movement of a VOM used as the indicator.

If you are not an active FM'er or have no interest in VHF then this article will have been of no use to you. If you are interested in VHF and/or FM, then I hope that you will find the Add-on Test set a useful addition to your test equipment inventory.

. . .K9STH

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The Elusive H Parameter

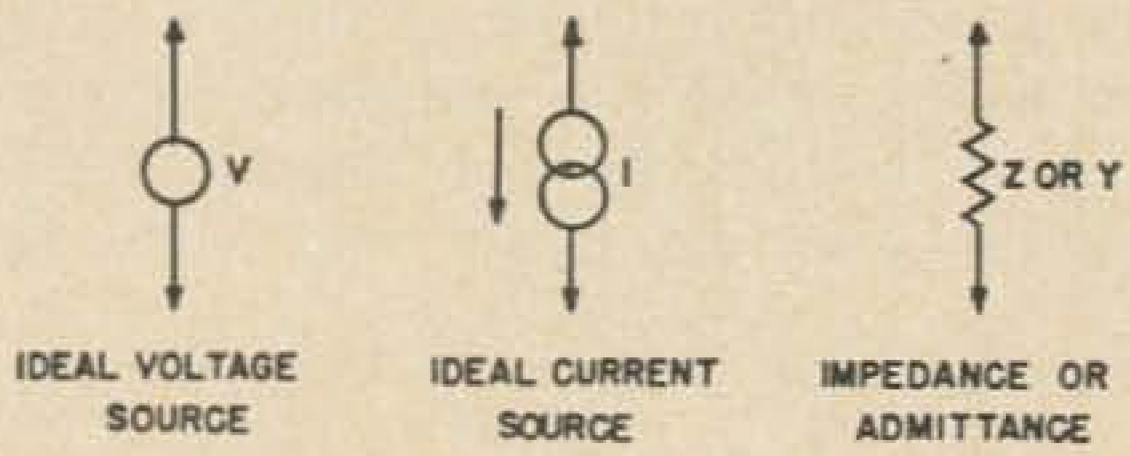

Fig. 1. Basic ideal elements.

Ever since the transistor became readily available at low prices, it has been very popular with experimenters. With a little reading and a good deal of playing around, these people can become quite proficient at this fascinating and relatively inexpensive hobby. Some, however, are quite puzzled at the seemingly nonsensical names given to transistor parameters such as h_{ie} and h_{fe}. A description of the origin and development of the h parameters is not a complicated task, and makes a very interesting story. The first step in this investigation will be to consider a few basic concepts in electronics theory that will be used to introduce the h parameter model and explain its elements.

The model concept

The model is a purely theoretical circuit or element that is used to represent or describe a more complex device. The model is made up of "pure" elements that are interpreted as containing only the properties that they describe. For example, the symbol for an inductor would indicate only inductance, while any real coil would also have a finite resistance associated with it.

Three basic elements that will be dealt with in this discussion are indicated in **Fig. 1.** In part (a), the symbol for a voltage souce is shown. The ideal voltage source is assumed to have zero internal resistance so that no matter what is connected in parallel with it, the voltage will always be the same. The magnitude of the voltage is usually given with the symbol, and is represented by the "V" beside the ideal voltage source. The voltage source also can be a variable source, and the magnitude of the voltage will be given by a mathematical expression, usually the product of two numbers. The ideal current source is shown in part (b) of **Fig. 1.** This element has an infinite internal resistance, and anything that is connected in series with it will have the same current flow, the magnitude of the source. The magnitude of the current is given by "I", and can also be variable or controlled as with the voltage source.

The reader will probably notice a similarity or contrast between the ideal voltage source and current source. The two are precise opposites, or duals. The concept of duality is a useful tool when an individual gets used to working circuit problems in a certain way. If he does not like the way a circuit is arranged, he can change the circuit to its dual, work the problem, and then get the dual of the answer which will then be the desired result in the original circuit. For example, the dual of voltage is current, the dual of capacitance is inductance, and the dual of series is parallel.

The third basic element that will be needed for this discussion is shown in **Fig. 1** part (c). This is the ideal resistance, or its dual the ideal conductance. At this point it will become necessary to make a change in terms. Since the expression "resistance" is valid only for dc, a new term will be needed. The word we are seeking is impedance. Impedance can be used with either dc or ac, and will always mean the voltage in the circuit divided by the current, regardless of whether it is ac or dc. Admittance is the dual of impedance, and will replace the term conductance. The symbol for impedance is Z, and the symbol that will be used for admittance is Y.

The two-port concept

Fig. 2 shows a two port network with an input and output. A signal applied to the

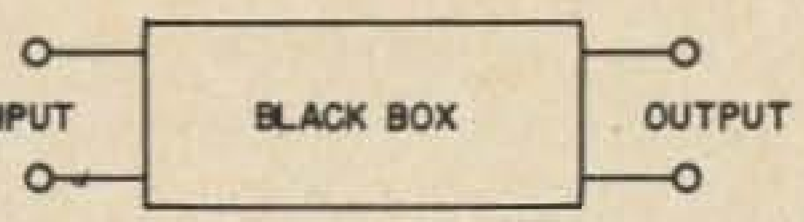

Fig. 2. Two-Port circuit.

left terminals, or port, will appear at the right terminals, modified in some way depending on the contents of the "black box" in the middle. The object in the middle can be any device that is desired, such as an amplifier. It would be handy if we could find a suitable model made up of ideal elements that could be used to represent the behavior of the thing in the black box. One model that could be drawn is shown in Fig. 3. This model can be used to represent a voltage amplifier, and has a characteristically low impedance associated with it. Also, we can take the dual of the circuit as shown in **Fig. 4.** Note that the dual of a voltage in series with an impedance is a current source in parallel with an admittance. It just so happens that this circuit can represent a current amplifier, and has a characteristically high impedance associated with it.

Now all the building blocks are present to enable us to assemble the final model that will represent a bipolar transistor.

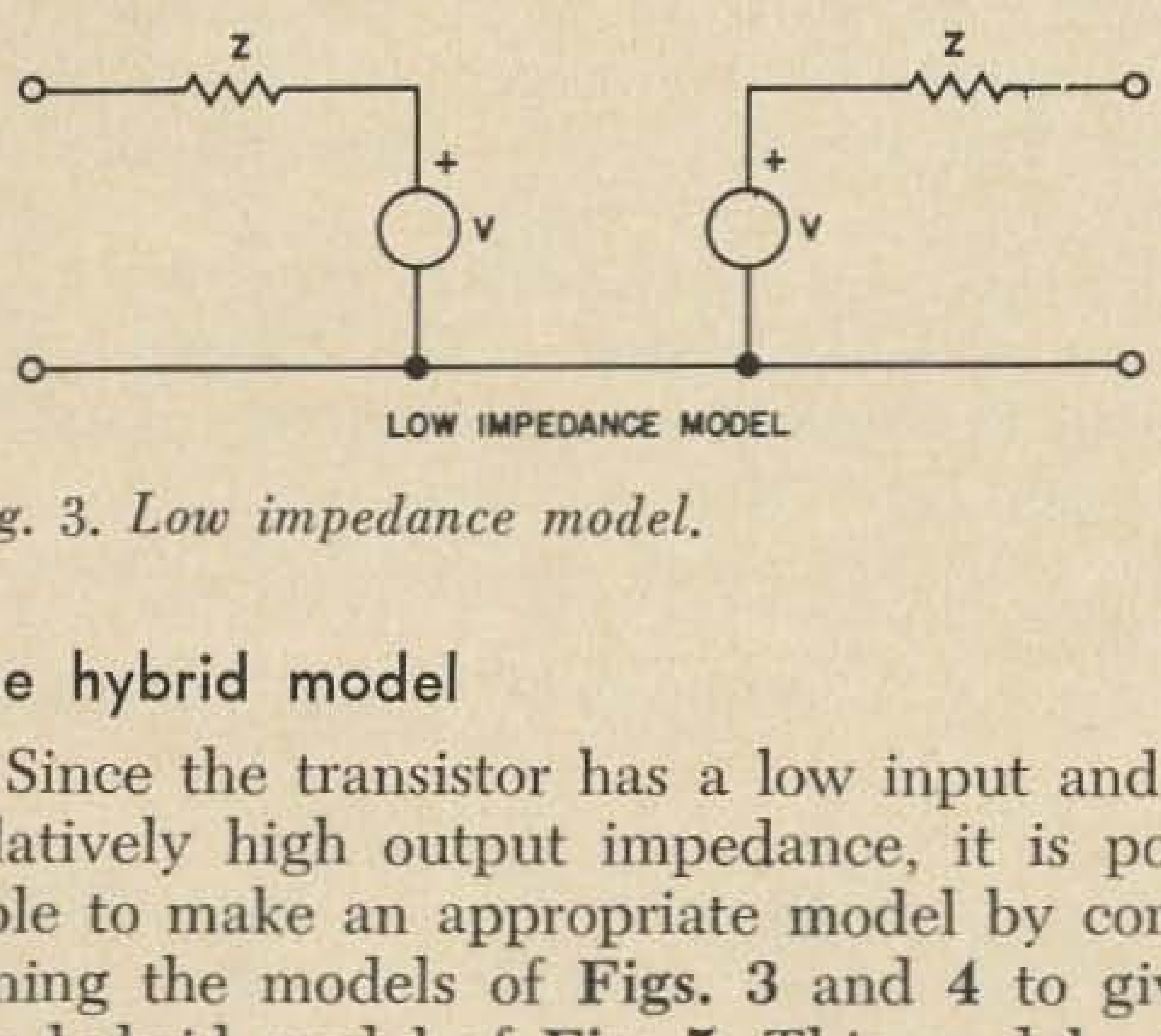

Fig. 3. Low impedance model.

The hybrid model

Since the transistor has a low input and a relatively high output impedance, it is possible to make an appropriate model by combining the models of **Figs. 3** and **4** to give the hybrid model of **Fig. 5.** This model will have a low input impedance and a high output impedance, which is just what we desire. Thus, it is from the word "hybrid" that the h in the h parameters was obtained. The names of the elements in the model represent characteristics of the transistor, and their names were picked completely by convention. The first subscript is used to indicate which particular characteristic in the model is being described, and the second subscript indicates the configuration. The three

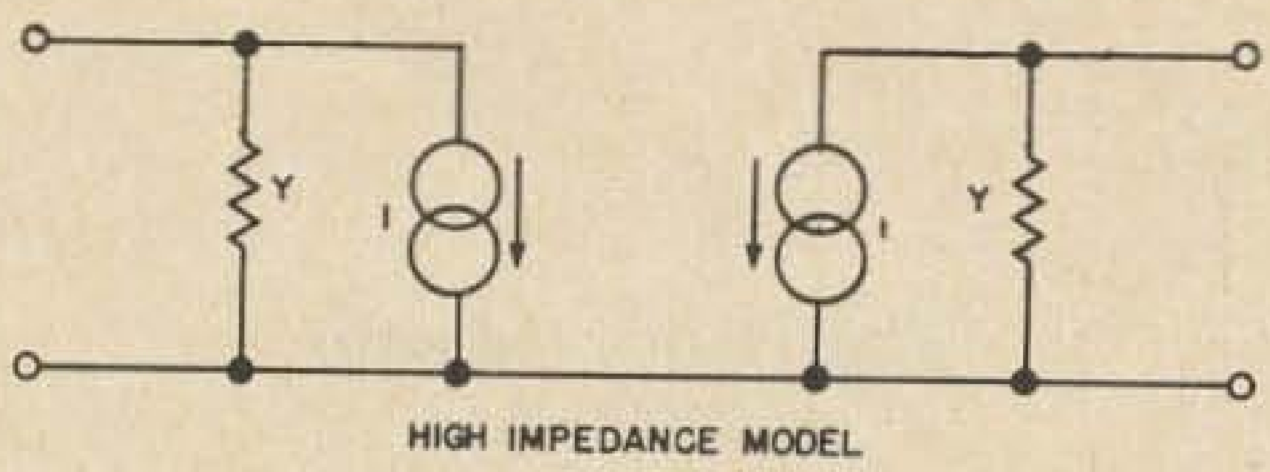

Fig. 4. High impedance model.

Table One
Definition of H Parameters

PARAMETER	COMMON EMITTER	COMMON COLLECTOR	COMMON BASE
INPUT IMPEDANCE	h_{ie}	h_{ic}	h_{ib}
REVERSE VOLTAGE FEEDBACK	h_{re}	h_{rc}	h_{rb}
FORWARD CURRENT GAIN	h_{fe}	h_{fc}	h_{fb}
OUTPUT ADMITTANCE	h_{oe}	h_{oc}	h_{ob}

possible configurations are common base, common emitter, and common collector. These terms are listed in **Table 1** with the underlined word in the left column indicating the word from which the symbol was obtained. Most of the terms are self-explanatory, but the term h_{re} is probably unfamiliar. This refers to the effects of base-width modulation at the emitter junction. This is shown as a voltage source in the input, and tends to oppose the input signal. The voltage source is controlled by the collector-emitter voltage, e_{ce}, and the magnitude of the source is h_{re} multiplied by e_{ce}. The term h_{re} is the one that is often ignored because of its very small magnitude, and is usually insignificant for most applications. The forward current amplification factor, h_{fe}, is the most important parameter, and the value of the current source is h_{fe} multiplied by i_b, the base or input current. This discussion has referred to the common emitter configuration because it is the most popular,

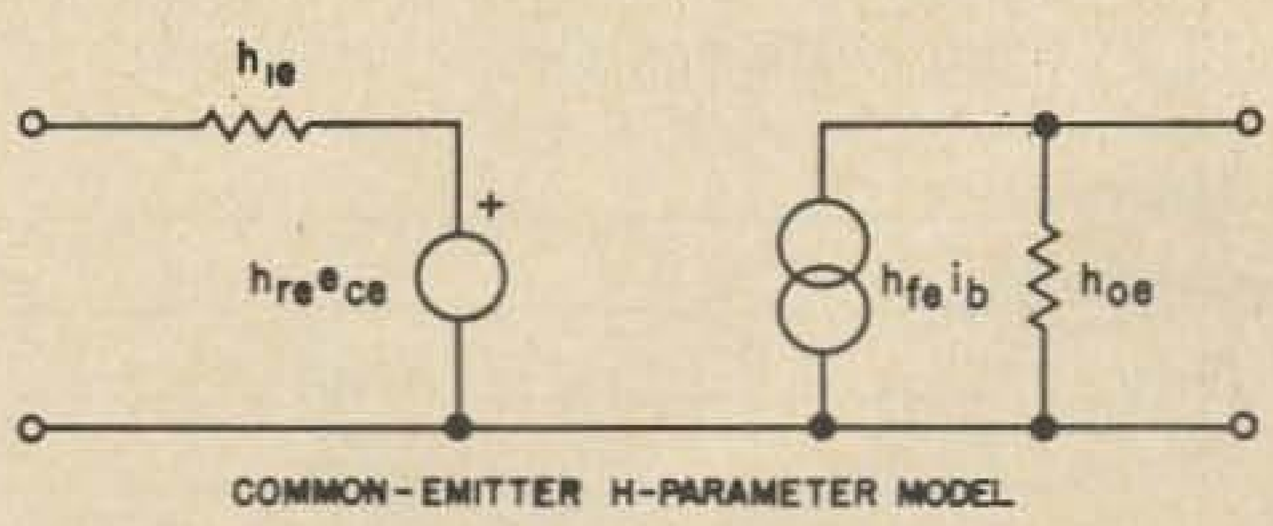

Fig. 5. H parameter model for common emitter.

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but a similar explanation could be constructed for the two other configurations as indicated in table one. The model discussed is applicable only to ac signals and does not give any information about dc or steady state voltages or currents.

Conclusion

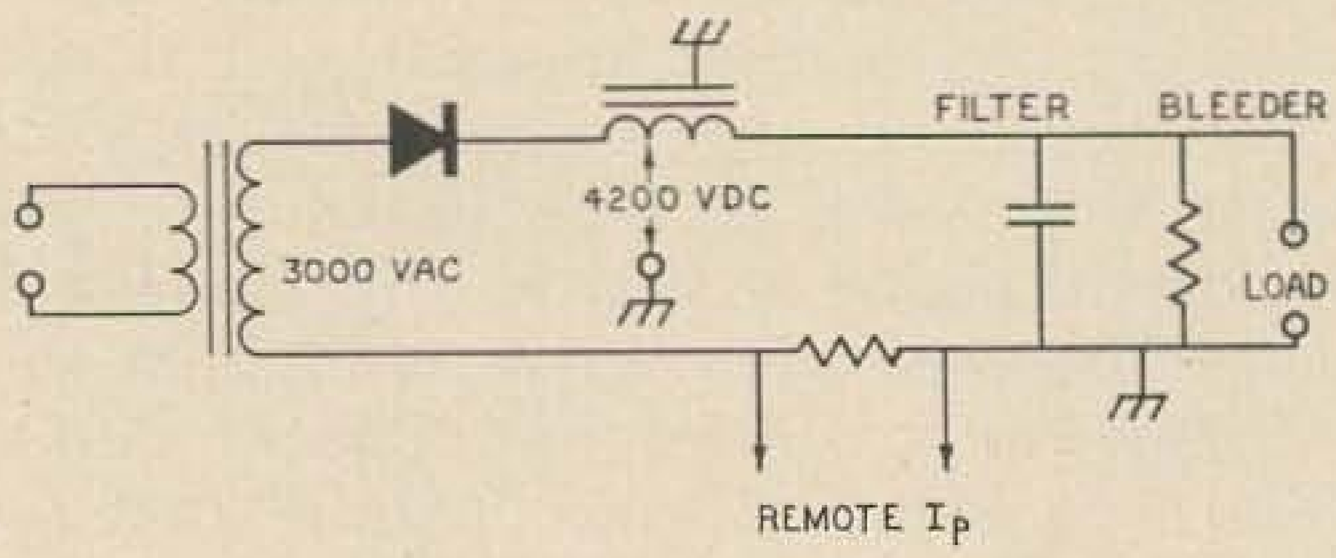
The hybrid model is a very handy tool that was conceived to represent the bipolar transistor and provide a way of naming and describing the characteristics that the designer must know to build any particular piece of electronic hardware where transistors are used. The model is also useful in learning some of the concepts that must be explained in basic transistor theory. Regardless of the way that it may have looked, the h parameters do have a very real meaning, and were not given their names "just for the h of it."

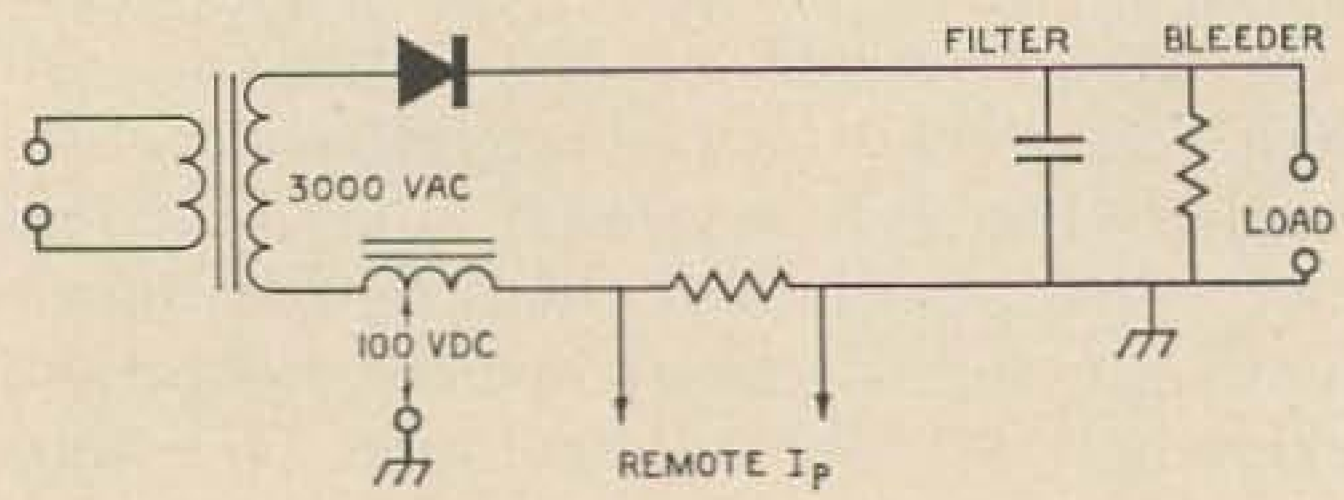
. . . WB6BIH

HV Choke Protection

A common problem with chokes in high voltage supplies is arcing from the winding to the core. This is due to the full supply voltage appearing between these points. A simple remedy is to move the choke from the positive to the negative power supply lead. This reduces the winding to core potential to a small fraction of its original value and for all practical purposes eliminates choke breakdown. The following half wave example demonstrates the required change. Note that nothing about the current metering, load, or protective circuitry is affected.

William P. Turner, WAØABI





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A Zero Temperature Coefficient JFET V.F.O.

The major causes of vfo drift and instability are voltage variations, loading, shock, vibration and temperature. The effects of the first four on oscillator stability can cause chirps, clicks, sudden jumps in frequency and the like. A gradual long or short term oscillator frequency drift on the other hand is primarily a function of temperature.

This article describes a vfo in which the drift due to temperature has been reduced substantially while using inexpensive components and by taking advantage of a peculiar characteristic of the Junction Field Effect Transistor not shared by either tube or transistor: zero dc drift. The FET can be biased to an operating point where its parameters remain constant throughout as large a temperature range as −55° C. to +150° C.

The operating point at which the FET exhibits zero parameter change with temperature is called the zero temperature coefficient operating point and is determined by the FET gate to source bias called V_{gz}. It has been experimentally determined that this required bias is from .6 volt to 1 volt less than FET pinch-off voltage.[1] FET pinch-off voltage Vp is a parameter which appears on FET specification sheets. It is defined in two ways. (1) is is that value of gate to source bias voltage which results in drain current cutoff. (2) it is also that value of dc drain voltage corresponding to a point just to the right of the drain voltage/drain current characteristic curve knee. These two voltages are equal in value. An increase of drain voltage above the V_p value results in a very small increase in drain current.

If the attempt is made to use the published value of V_p in order to determine the zero temperature coefficient operating point V_{gz} we immediately run into a two-fold problem. (1) individual FETs, like transistors, may deviate to a large extent from pub-

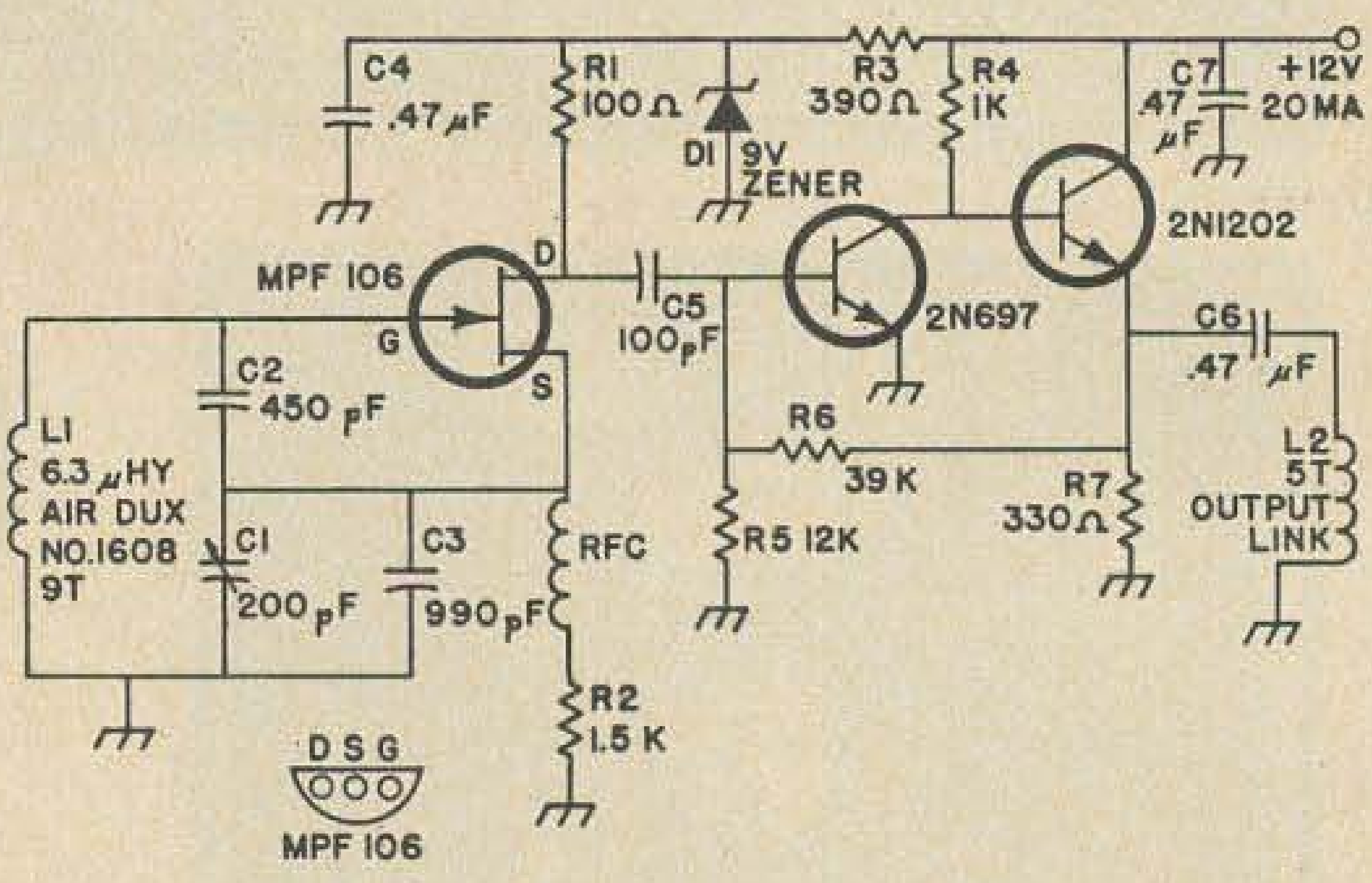

Fig. 1. Schematic diagram.

lished typical specification sheet values. (2) we are faced with the decision to fix a point on a gradually increasing quantity because drain current or gate voltage do not change abruptly in the region of pinch-off. Even manufacturers have difficulty in this regard. A study of several manufacturers specification sheets will reveal drain current cutoff values ranging from 1 milliampere to 1 microampere.

However all is not lost. It simply becomes necessary to measure FET pinch-off. In order to avoid the second difficulty cited above we shall measure pinch-off indirectly. An expression for V_p is:

$$V_p = \frac{2\ Id_{ss}}{G_{max}}$$

$$\text{Where } G_{max} = \frac{E_o}{E_{in}\ R1}$$

I_{dss} is called saturation drain current and is that value of drain current which flows with zero gate to source bias voltage. G_{max} is another FET parameter and is the maximum low frequency FET transconductance. It so happens that this maximum value occurs at zero gate to source bias also. Therefore these two quantities can be measured simultane-

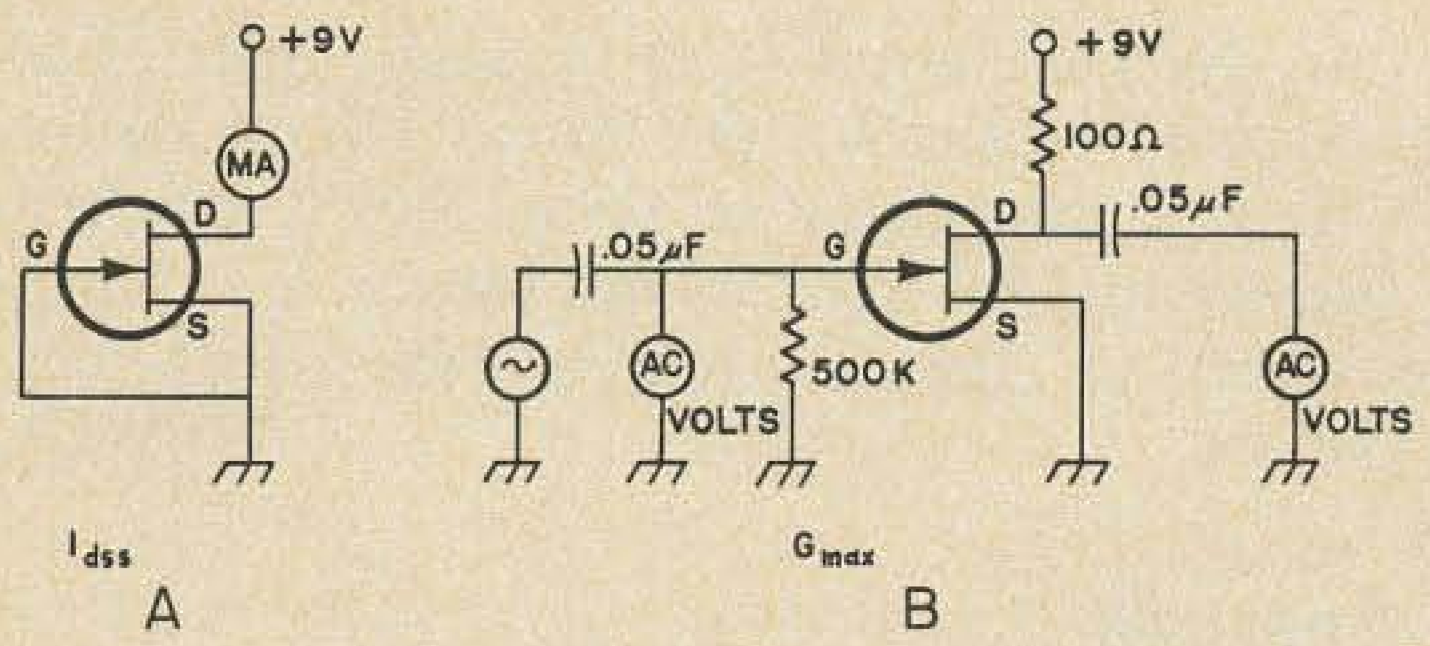

Fig. 2. Simple test set up.

ously. I_{dss} and G_{max} can be measured in the simple test set-up shown in **Fig. 2A** and **2b**. Once I_{dss} and G_{max} have been measured we can calculate V_p by means of the equation for V_p. It then becomes a simple matter to know what the zero temperature coefficient operating point V_{gz} must be. Referring to **Fig. 2B**, E_o is the ac signal output voltage measured across drain load resistor R1 by means of an ac voltmeter. E_{in} is the ac signal voltage input to the FET as measured by the ac voltmeter. E_{in} should be kept in the range of tenths of a volt in order to avoid overdriving the test FET into saturation or cutoff. The signal input voltage should be just sufficient to yield usable readings on the ac voltmeter.

In order to reduce further calculations the graph of **Fig. 3** has been prepared. From this graph the value of drain current can be determined as a percentage of I_{dss} saturation current plotted against pinch-off voltage V_p.[2]

FETs are inherently high impedance devices. In the usual class C oscillator operation the input gate to source junction becomes forward biased during part of the input voltage cycle. The FET input impedance then drops to a very low value and results in heavy damping of the tuned circuit. The presence of the gate leak resistor imposes additional loading of the tuned circuit. In some oscillator designs this has reached a surprisingly low value. The net result is a lowering of tuned circuit Q which in a vfo must be maintained as high as possible. To circumvent this undesirable situation the FET oscillator will be operated class A.

Fig. 1 shows the schematic of a JFET class A oscillator operating at the zero temperature coefficient point in the 3.5 mHz band. The immediate distinguishing features of the oscillator are the absence of the familiar gate resistor/capacitor combination and the presence of the source bias resistor.

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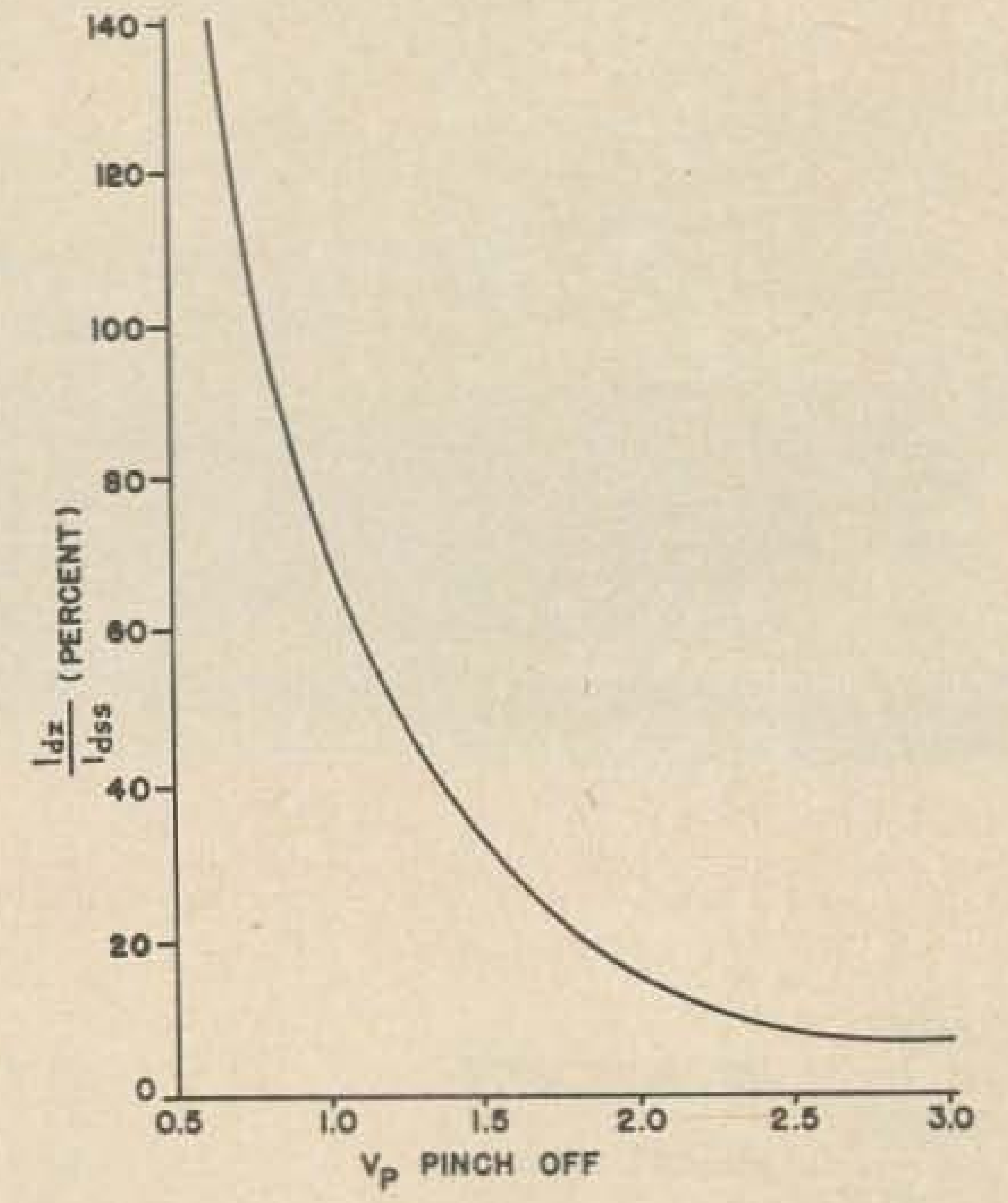


Fig. 3. See Text.

In class A operation the gate-source junction must not be driven into forward bias. Since the gate bias has been fixed due to the considerations described above the only remaining variable is gate signal voltage. Gate signal voltage is determined by the ratio of C2 and C3. The source tapping point is a compromise between sufficient voltage feedback to insure oscillation and a value of voltage which will not overdrive the gate. While the FET is oscillating momentarily ground the gate lead; drain current must not change by more than a barely perceptible amount. As a practical matter, there is nothing particularly critical about the source tapping point and the values of C2 and C3 shown on the schematic are correct for several FET samples.

In this circuit, in which particular attention has been given to achieving maximum drift stability do not expect appreciable power output from the FET. FET power output is in the region of microwatts. A two-transistor buffer amplifier is used following the FET to provide load isolation and yield a usable power output.

No degree of drift stability in the FET can ever compensate for the thermal drift characteristics of the tuned circuit coil/capacitor combination. In ordinary operation a FET is a negative temperature coefficient device. At a gate voltage or bias beyond V_{gz} the FET exhibits positive temperature coefficient characteristics. The intriguing possibility immediately suggests itself that the operating bias can be trimmed to purposely introduce an equal and opposite drift characteristic to that of the tuned circuit. Alternately a thermistor or temperature sensitive resistor can be used in the source lead to introduce a precise temperature drift correction. . . . W6WQC

Appendix

In the vfo constructed by the author a Motorola MPF 106 FET was used. The test results from **Fig. 2A** yielded an I_{dss} of 7 milliamperes. The test result for G_{max} using **Fig. 2B** with .5 vac input yielded .32 vac out across the 100 ohm drain load resistor. G_{max} was therefore 6400 micromhos.

$$G_{max} = \frac{E_o}{E_{in}\ R1} = \frac{.32}{.5\ (100)}$$

$$= 6400 \text{ micromhos.}$$

V_p was then 2.2 volts.

$$V_p = \frac{2\ Id_{ss}}{G_{max}} = \frac{2\ (.007)}{.0064} = 2.2 \text{ v.}$$

From the graph of *Fig.* 3 $\frac{I_{dq}}{I_{dss}} = 15\%$

therefore $I_{dq} = .15\ (I_{dss})$

$I_{dq} = .15\ (.007) = 1.05$ milliamperes.

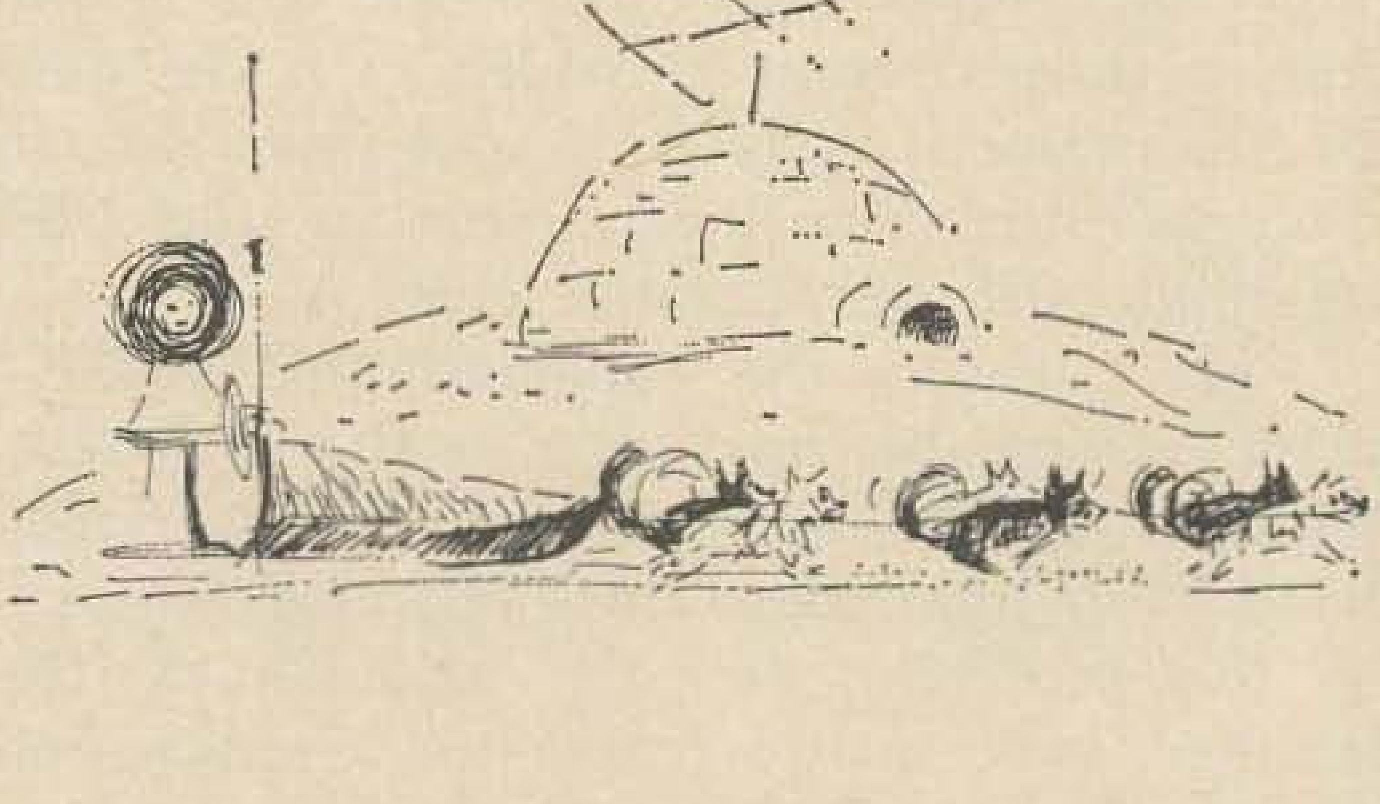
The value of the FET source resistor was chosen to result in a drain current of 1 milliampere. The resistor value was 1.5 k.

References

References

(1) *Specifying FET's*—J. S. Sherwin, Electronics Products, August 1966.

(2) *Behavior of Field-Effect Transistor Characteristics With Temperature*—L. J. Sevin, Texas Instruments Application Note, July 1, 1963.



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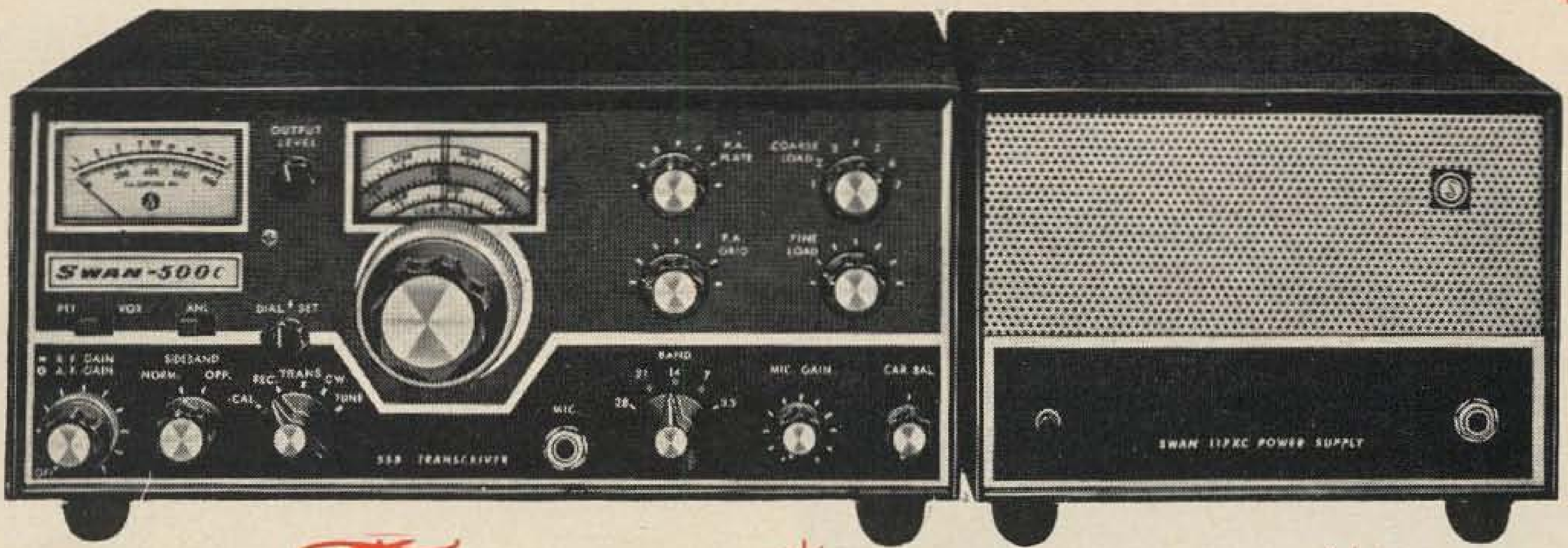

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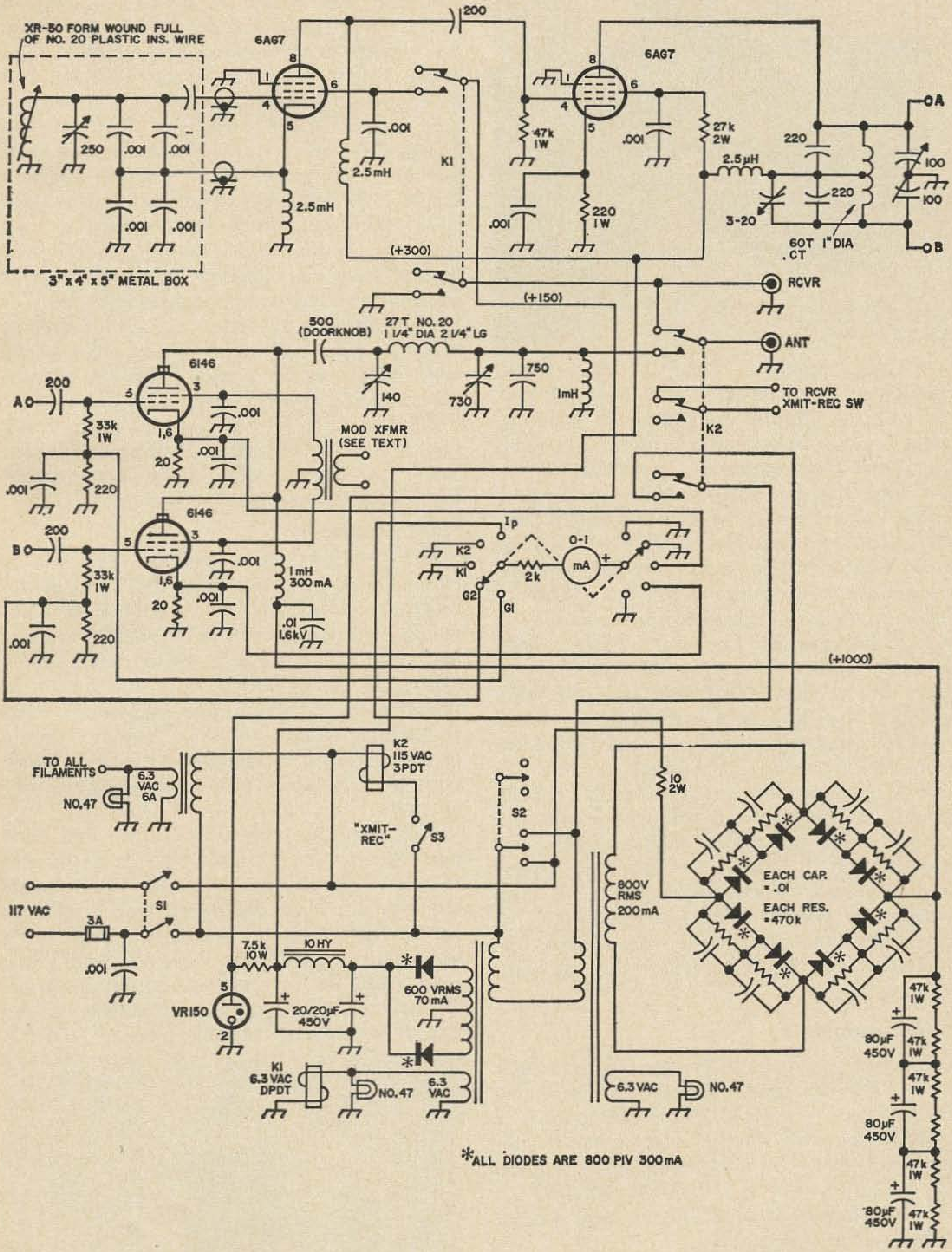
After some ten years of absence from the low frequency ham bands in deference to the sun spot cycle and the lack of space for an antenna for other than six and two meters I heard rumors that ten meters was once more opening up. In a fit of wild spending I purchased a Lafayette HA-350 and started listening in on the low bands. Everybody seemed to be running gallons, half gallons and some poor slobs were only using quarter gallons. To me this was very surprising and just a bit painful to contemplate, as in the old days 100 watts was a thing to reckon with. Everybody seemed to be SSB and anyone who was running an "old fashioned" AM rig always seemed to be somewhat apologetic about his behaviour. To be very honest I don't know a thing about the highly refined theory of how the modern SSB rigs work so I promptly subscribed to "73 Magazine" to get a good ham periodical coming once more into the shack. I cracked the *Radio Handbook* and started to read the ads for commercial rigs. The price structure of an outfit I would like to own caused me to review the finances and after rejecting a new mortgage on the family shack I felt that there had to be a home brew means of getting back on the low ham bands without having the SSB boys become unhappy with "another old fashioned ham" on the band.

The answer I turned to was DSB. Sure I would radiate two sidebands, but that telltale carrier would be so weak that I would maintain my respectability.

A search of the junk box turned up a couple of 6146 tubes from my old modulator and a husky power transformer from an old TV set. With an assortment of old chassis at my disposal I started to work. The original design called for crystal control but when I went to my friendly ham store and asked for 80 meter phone crystals he looked at me like I was from Mars. He patiently explained that he hadn't had a call for 80 meter phone crystals in seven years. Back to the drawing board. I had heard about the Clapp circuit and all its variations but the good old High C circuit with a 6AG7 was as up to date as I was prepared to be. The VFO was built in a separate 3 by 4 by 5 inch box with heavy components rigidly braced. The main fault of the old High C circuit seemed to be capacitor heating due to the somewhat high circulating tank current. I attempted to avoid this by using four good quality mica's in series parallel in the feedback divider of the oscillator. This plus the lack of heat due to the VFO being in its own box away from all tube heat turned out a VFO that just sits where you set it from a cold start. With a stable VFO under my belt I next turned to an isolating stage between the VFO and the high level balanced modulator. This used another 6AG7 with an untuned or aperiodic grid circuit and a tuned plate circuit. This tuned circuit is a center tapped coil wound on a five inch piece of old broom handle. The coil is shunted by two 220 pF silver micas in series. The variable element is a split stator capacitor (donated by a fellow ham) of 100 pF in each section. The tuning range covers the entire 80 meter band with 10 kHz to spare on each end so there is no chance of accidentally doubling in this stage.

The balanced modulator which feeds the antenna was next. Since the 6146 grids are being fed in push pull the plates have to be tied together to get the carrier eliminated.



This makes the use of a Pi output tank very handy. The audio is fed to the final screens in pushpull. Note that there is no B plus applied to the screens.

Either I didn't have the right books available or everybody but me knows all about feeding audio to DSB screens, but I personally went through a small crisis getting the modulation to perk. Here is what I found out as regards this particular rig. I found that about 130 volts RMS was needed from each screen to ground for full peak modula-

tion. The modulator I used was a junk box three watt amplifier with a 6V6 in the output and an output impedance of 8 ohms. After much trial and error I found that feeding the 8 ohm output of this audio amplifier into the six volt winding of a small power transformer whose secondary was 250-0-250 was just the thing to do. Under modulating conditions the amplifier and the transformers are running pretty much unloaded and this can lead to transient difficulties on peaks which earned me a few reports of lousy audio before I found out how to solve the problem. One side of the 8 ohm primary was grounded and about six dB of feedback was introduced into the modulator from the hot side. This feedback from an essentially unloaded winding acts like a peak limiter, in effect up to a point the quality improves with increased output. With this modification to the modulator the "poor audio" reports vanished. A feedback loop within the amplifier did not do the job, it was only when the output transformer was included in the loop that the problem vanished.

Power supplies

The VFO and the buffer are fed from their own 300 volt supply. The particular transformer used measured 300-0-300 and is a conventional full wave condenser input supply using 800 V PIV rectifiers of the bargain type. Notice that the filament winding on this transformer is used only to light a pilot lamp and to operate K-1.

The High Voltage supply for the 6146 high level balanaced modulator consists of an old TV transformer which gives 800 volts across the secondary. This feeds a full wave semiconductor bridge and is filtered by three 80 mfd 450 volt electrolytics in series. Each diode in the bridge is parallelled with a 470 k 1 watt resistor and a 0.01 disc ceramic for voltage division and spike protection. The entire bridge assembly is mounted on a 4 by 4 by ¼ inch plexiglas sheet. Each electrolytic is parallelled with two 47 K 1 watt resistors in series for voltage division and bleeding purposes. This supply delivers about 1100 volts unloaded and about 1000 volts full load. Respect its ability to put you out of this world if you get careless. Notice that the filament winding of this transformer does nothing but light a pilot lamp indicating that the transformer is hot.

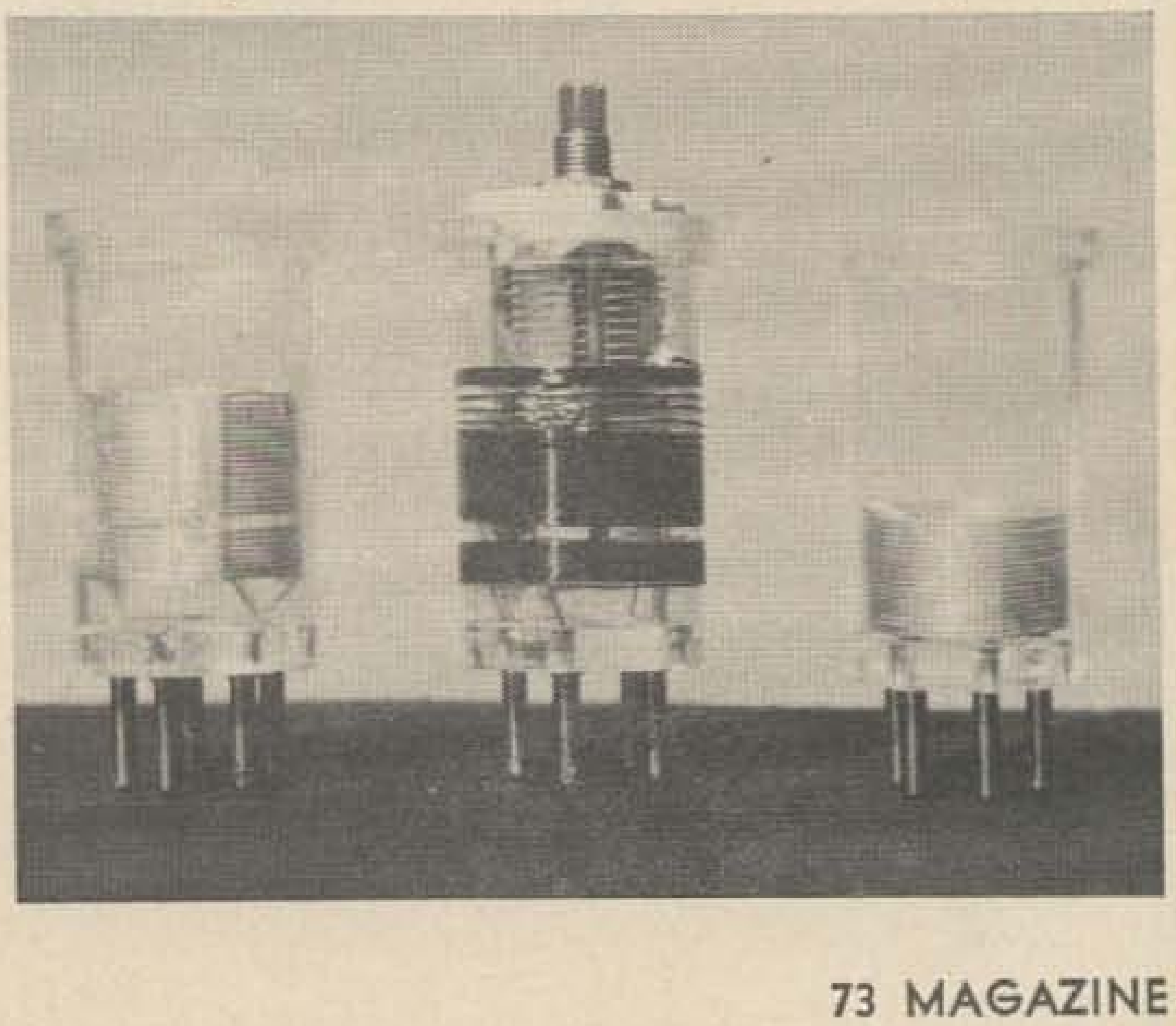
As a tribute to modern technology, the low voltage supply boasts a VR-150 to supply regulated voltage to the VFO screen.

All filaments are lit from a separate six volt six amp filament transformer, which same also sports a pilot light showing that the filaments have been energized.

Relay operation

K-1 performs two functions. The first is to cut off screen voltage to the VFO in the receive mode. If this were not done the VFO would continue to operate until the low voltage supply filters had drained down below about 15 volts. The second function is to throw a shunt across the receiver antenna so that on either the "spot" function mode or transmit the receiver is not overpowered with rf. This Relay is a small DPDT 6 volt ac unit.

K-2 Performs three functions. Frst, one pair of contacts shunts the send/receive switch of the receiver. Secondly, it transfers the antenna from the transmitter to the receiver. The third function is to complete the ac circuit to the high voltage supply primary, and the low voltage supply primary. The switch that operates this relay is the one designated as transmit/receive. (SW-3).



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Spot function

In the spot position of Sw-2 K-2 is bypassed and the low voltage primary is energized. K-1 closes, turning on the VFO and shunting the receiver antenna input. When spotting has been accomplished Sw-2 is returned to the normal position and the low voltage supply is once more under control of the K-2 contacts.

Metering

The final stage is the only stage metered. A nine position two pole rotary switch is used with every other position being blank. This is to get enough physical separation between positions for easy marking of the functions. Each grid current and each cathode current is metered for the final tubes accounting for the first four positions of the switch. The fifth position is used to measure total plate and cathode currents along with the small current through the light bleeder on the HV supply.

Electrically the meter is a 0-1 mil movement with enough series resistance to make it a two volt meter full scale.

The grid currents are read across 200 ohm resistors making the meter appproximately 0-10 mA. Each cathode current is read across a 20 ohm resistor making the scale approximately 0-100 mA and the total current is read across a 10 ohm resistor connected between the negative terminal of the bridge and ground. This scale is roughly 0-200 mA. Normal grid current is between three and four mA, normal cathode currents is 12-15 mA with no modulation. Total plate current on voice peaks will hit 60-80 mA on the meter. With steady sine wave input the meter will hit 90-100 plate mils. With this much input the transmitter will fully light a 75 watt lamp used as a dummy load. Actually it's a pretty bright 75 watts but this is subjective and not very scientific so use your imagination.

The only mildly critical thing about the metering set-up is to try to get the two grid current metering resistors as close as possible in value. This will help in balancing the modulator as we shall see later on.

Tune Up from a cold cold start

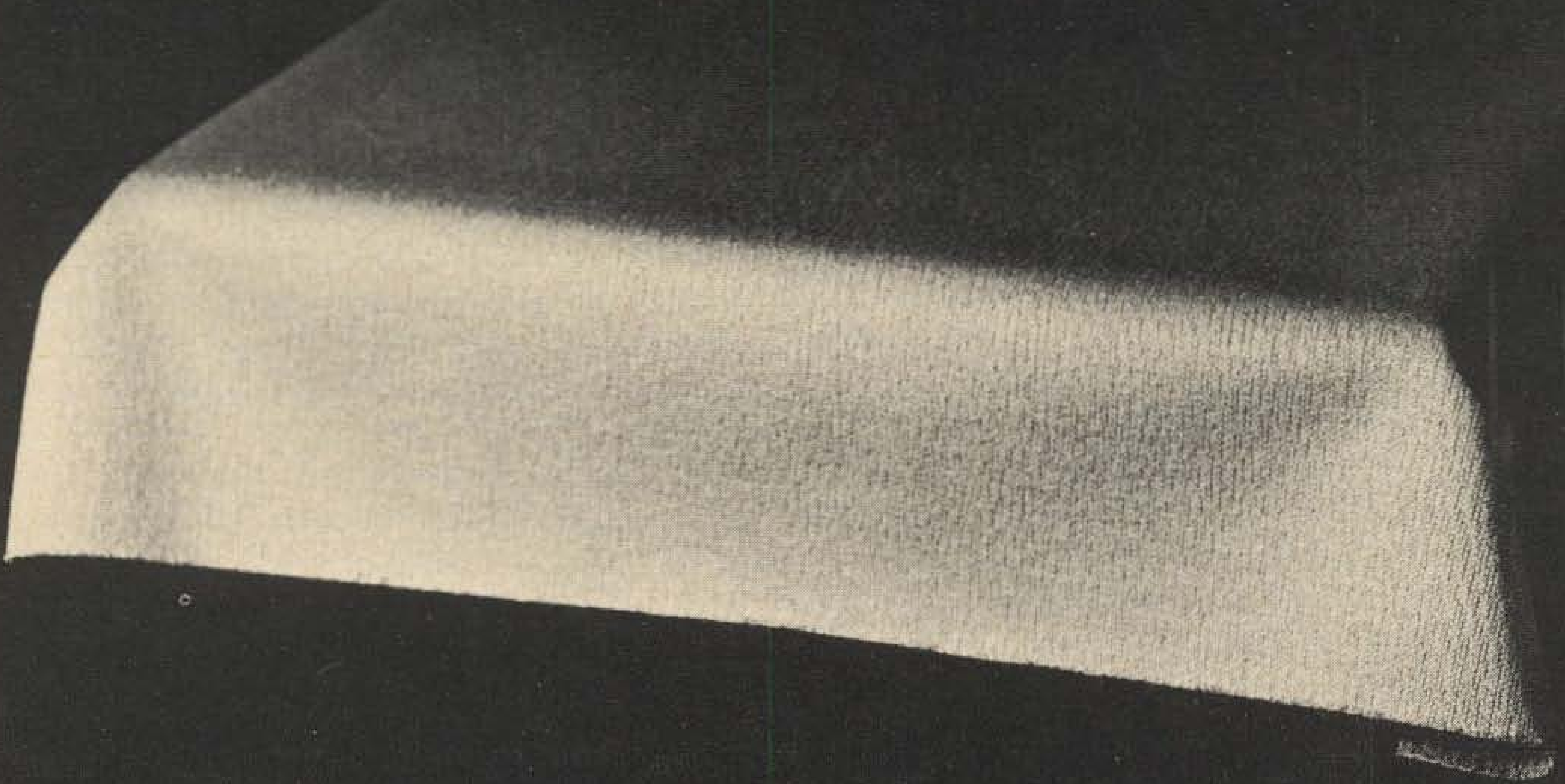
Plug in the ac cord, cross your fingers and turn on the filament switch (Sw-1) Throw Sw-2 to spot which will turn on both the VFO and the buffer. Tune in the VFO signal on the receiver and set the slug in the coil so that the upper and lower limits of frequency are those that you desire. The prototype hit the upper band limit with the slug almost all the way out of the coil. The phone band covered 80 divisions of the 100 division dial.

Turn the meter to check for final grid current. If you are unusually lucky the currents will be equal but the odds are quite against it. The small 3-20 pF trimmer across the grid tank should be adjusted to make the grid currents equal. Depending on your own physical layout as it affects the capacity balance of the grid tank you have to experiment with which side of the coil the trimmer has to go to be most effective. You only have two choices so it's no big deal to get the right position. Once you have the grid currents balanced the cathode currents may be checked for curiosity but their balance is generally more indicative of the shape the tubes are in than anything else and the readings are not critical as long as they are within 10-20% of each other. Restore Sw-2 to its "normal" position which is opposite to the "spot" position. Connect a 75 watt lamp as a dummy load and plug the modulator into the rig.

Throw Sw-3 to Xmit and recheck the grid current. Using the grid tuning as an excitation control set the grid currents for about 4 mA.

Put some sort of a sine wave signal into the modulator (steal some filament ac thru a resistor if you don't possess an audio generator) and crank up the gain a bit. Put the meter on the plate current position and goose up the audio until it shows about 30 mA. Tune the Pi input condenser for plate dip and the output condenser for maximum output as shown by the bulb load. Then crank up the modulator until the plate current rises to about 80-100 mils. Retune the final tank condensers and if all is well your 75 watt bulb should be glowing with a nearly blinding irridescence. Disconnect the rig and install the mike into the modulator. Talk into the mike and observe the action of the plate meter. A full whistle will make the meter and the bulb agree that power is being produced. It wil also show you that only a professional liar could look at the plate meter under modulation and guess what the input power is. On a rough basis the peak plate current is about 60% over what the meter

Patience.



Just because it's Christmas, don't make a hasty move. Like spending $650 on a receiver that will be obsolete in January.

And the receiver you buy today will be obsolete in thirty days. Because that's when Davco Electronics will again revolutionize the amateur radio industry with the unveiling of the DR-50 solid state receiver.

The DR-50 has an integrated circuit IF strip which includes two mechanical filters. It features a built-in AC or DC power supply, a built-in speaker, a linear slide rule dial, a positive acting noise blanker, and weighs in at only nine pounds.

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sluggishly shows. With a convenient 1000 volts on the plate which makes each input mil an input watt (isn't that convenient) you can questimate to your hearts content what your power input is. What really counts is the other guys receiver combined with your consumate operating skill to make a successful contact.

Making a bulb light up is one thing but getting the soup into the antenna is something else. My own personal antenna for 80 meters is 180 feet of wire that goes from the cellar back to the garage, over the garage roof and back to the old apple tree. Since the Pi net won't match the wild blue yonder impedances of this lash-up (apple trees have very high impedance when used as antenna terminations) I feed the Pi output into an L section, which consists of about thirty turns of #18 wire close wound on a scott towel core followed by a shunt variable of about 200 pF. This lets me feed my long wire in good style. A true space age rf tuning and modulated rf output indicator consists of an NE-2 with a 47 K series resistor shunted across the L section condenser to ground. This little blinking light never fails to impress visitors to the shack much more than the miracle of ham radio communication, the unanimous never varying comment being "ooooh look, that little light blinks when you talk.

Most articles end just about here because the writer has just torn up the tenth rewrite and snarled at his wife and kids for some peace and quiet. The end result is that some things meant for inclusion never get included much to the discomforture of the innocent reader who promptly damns the publisher. Take heart and read on.

Little things that count

If the plate meter is watched carefully as you switch from receive to transmit you will see it bounce to full scale before it settles down to normal readings. This is normal as it is the result of filter charging current.

If you hear a sort of gargling sound in your receiver as you switch from transmit to receive your own particular VR tube may be at odds with the world. Don't throw it out. Just ground the unused contact on K-1 that is on the B plus switching side. This will cure the problem. Personally I like the sound so I took the ground off after I learned it would cure the trouble.

During the spot function you may notice some modulation on your signal if someone happens to talk in the shack and the mike gain is up. This is normal. The rf to the grids of the final *is* being modulated by the audio getting to the screens.

Also regarding the spot function. You may find that having the oscillator and the buffer on during "spot" is just too much rf floating around for your particular receiver. Notice that Sw-2 calls for a DPDT switch but the schematic shows only one set of contacts being used, namely those associated with the low voltage xfmr primary. If you are troubled by excess spot rf simply wire the unused contacts of this switch so that the buffer plate and screen gets no B plus in the spot function mode. If you wire the rig in this manner don't forget to short out the switch connections during the initial first tune up or you will not be able to check the grid drive and set the grid balance as described earlier. After this balance is set remove the shunt from the switch and you are in business.

Make sure that the modulator you use will give a good three watts of clean audio measured into a resistive load. If you do this and troubles arise you can be sure that it is not "Modulator power." It helps greatly to tailor the audio response of the modulator. Ideally it should be well down by 250 cycles and roll off pretty well by 4500-5000 cycles. If somebody says you sound mushy it means you forgot something. What you forgot is that the screen bypasses in the final are across the high impedance winding of the modulator secondary. Do your high frequency roll off correcting with these shunt condensers in mind and you won't get a "mushy" report.

The VFO inductor utilized a national XR-50 slug tuned coil form wound full of #20 plastic insulated hook up wire. This may cause some consternation from the purist to use such wire for a VFO inductor, all I can say is it works just fine.

The Final tank inductor is in reality a part from an ARC-5. It is a winding as described, wound on a beautiful ribbed ceramic form. It cost all of forty cents at Fertik Electronics, 9th & Tioga streets here in Philadelphia.

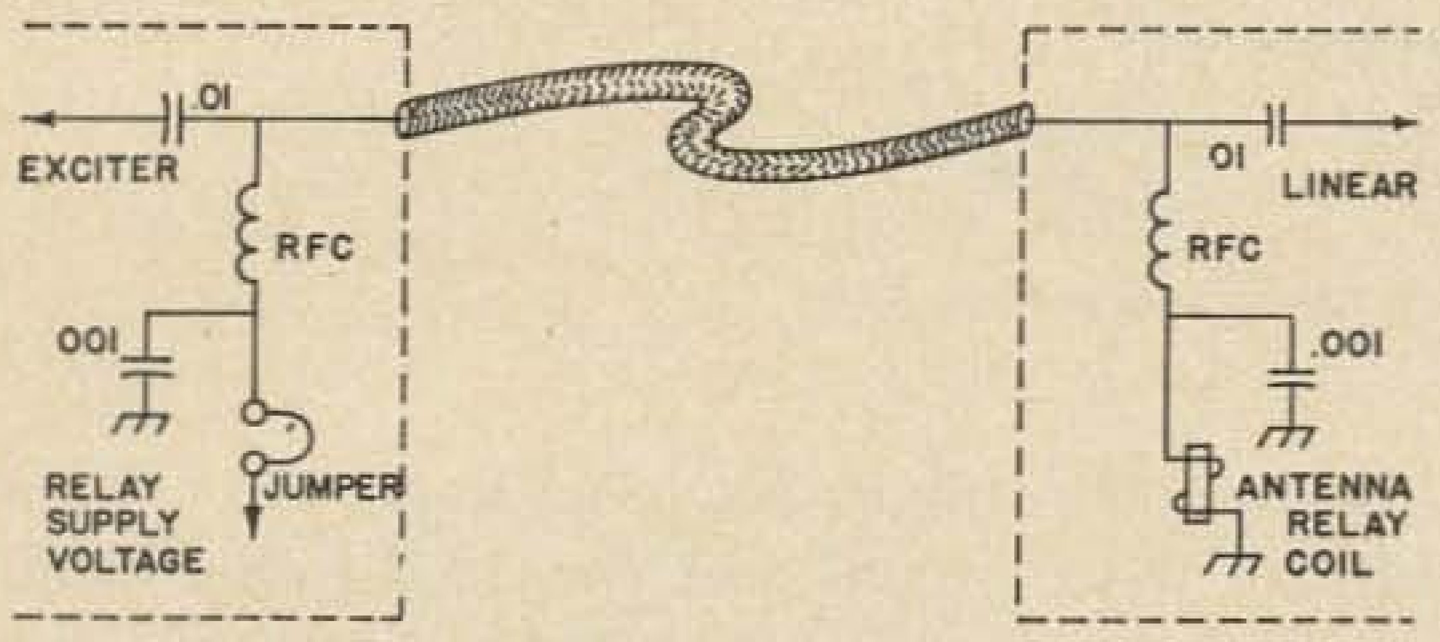
The three pole double throw 115 volt ac relay came from the same place with a $1.50 price tag. Naturally you can substitute other coil voltages depending on your junk box.

The virtue of the control set-up as described is that there is but one switch to throw in going from transmit to receive.

This little rig puts out a clean DSB signal. It has given no TVI trouble although I do make it through the little 5 tube acdc cracker box in the kitchen, a la donald duck. The low frequency bands have changed greatly in the last ten years but some things never change. If you have some guy running a gallon on your frequency, you lose. Howsomever, intelligent listening, picking your spot, plus a good receiver and a fair amount of good old fashioned ham courtesy will let you make many enjoyable contacts with this rig. Happy DSB.

. . . W3KBM

Controlling the Linear Changeover Relay



One of the design considerations faced by the builder of a linear amplifier is how to activate the antenna changeover relay within the linear.

It can be done directly with a switch or in a more elaborate manner with an *rf*-biased tube with a control relay in the plate circuit.

The system shown here, particularly useful in connection with a mobile truck-mounted linear amplifier, impresses the relay control current onto the coax link between the exciter and the final right along with the *rf*.

.01 dc isolating capacitors must be used at either end of the line as shown, if not already present. The *rf* chokes can be almost any variety that will safely handle the relay current, since the *rf* voltage is low on a low impedance line and hence not very demanding on the characteristics of the chokes used.

A removable jumper or a switch must be used at the exicter end to disconnect the relay supply voltage when the exciter is used to drive an antenna directly.

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A Novice FET Converter

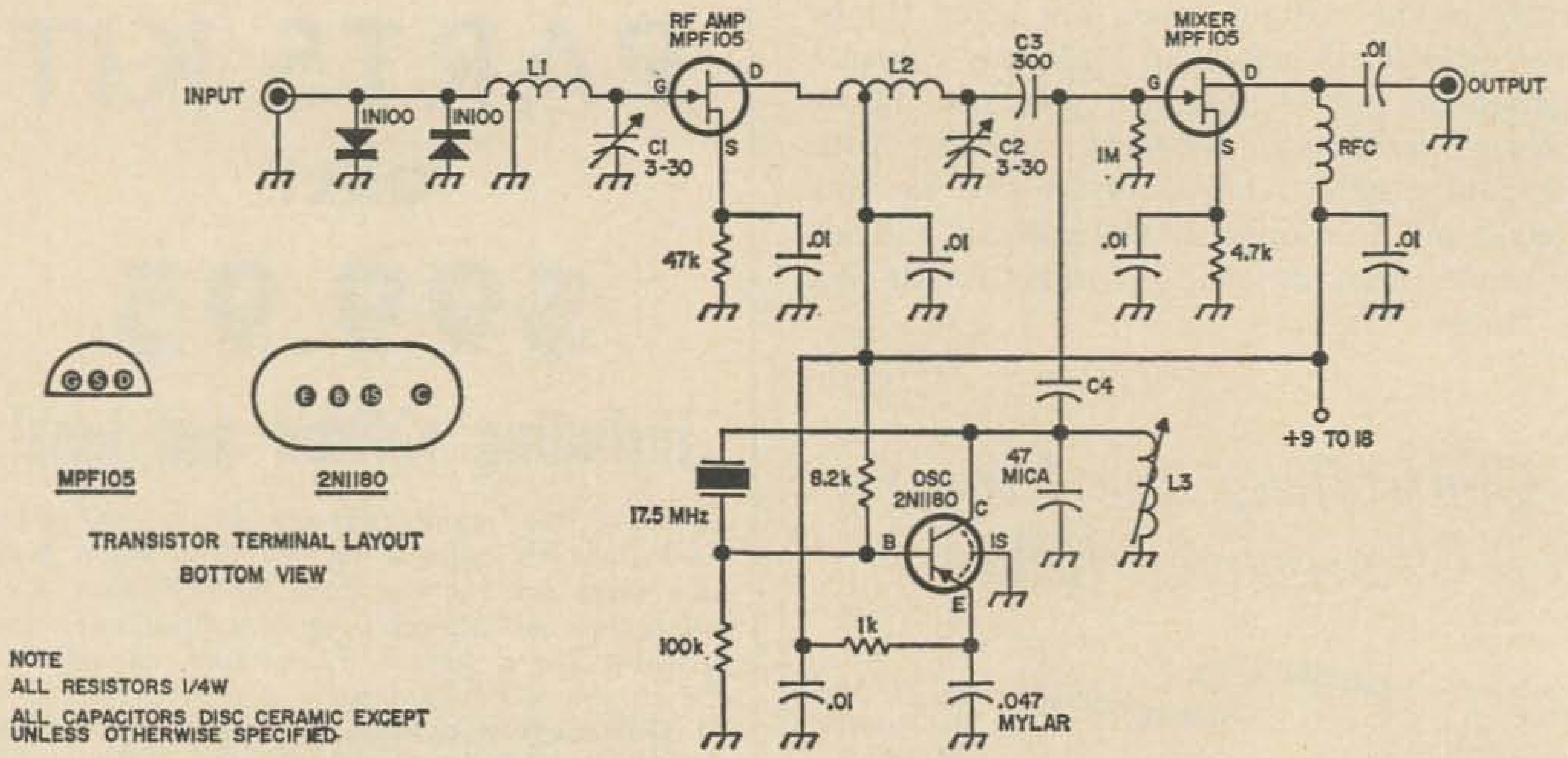

Fig. 1. Schematic diagram of the Novice Converter.

Because the author has obtained good results from home-brew multi-band FET converters[1,2], an effort was made to design a 15 Meter converter suitable for construction and use by the novice. The resultant converter is stable and performs well when used with a reasonably good 80 Meter receiver.

The converter schematic is shown in **Fig. 1.** Motorola MPF105 FET's are used for the rf amplifier and mixer, while a 2N1180 is used as the local oscillator. For the Novice who is l o o k i n g at his first converter schematic, the following paragraph may be helpful:

The heart of a converter is the mixer stage, which, in the Novice FET converter, consists of those components to the right of C_3 and above C_4 in the schematic. After passing through the *rf* amplifier, a signal from a distant Novice's transmitter, between 21.10 and 21.25 MHz, is applied to the mixer through C_3, while a 17.5 MHz signal, generated in the local oscillator, is applied through C_4. If the Novice signal is at, say, 21.15 MHz, then an inspection of the mixer output will reveal (among others) a signal at 3.65 MHz, which is "identical" to the Novice signal, except for frequency. The mixer has combined the 21.15 MHz Novice signal and the 17.5 MHz local oscillator output to produce a signal corresponding to their difference frequency, 3.65 MHz, which can be received on an 80 Meter receiver. A little arithmetic will show that the entire 15 Meter Novice band can be tuned by tuning the 80 Meter receiver between 3.60 and 3.75 MHz.

The *rf* amplifier is designed to provide only enough gain to override the noise generated in the converter, thereby minimizing susceptibility to cross-modulation. However, the use of stagger tuned input and output circuits to broaden the bandpass of the *rf* amplifier may degrade the converter performance somewhat in this respect. Inductors for the tuned circuits are wound on toroid cores for the sake of compactness and to minimize coupling between coils. Since the magnetic flux of a toroidal coil is almost completely contained within the coil, magnetic coupling between the input and output of the *rf* amplifier is minimized and no shielding is required. As it stands, the *rf* amplifier (and the entire converter) is stable either with or without an antenna connected.

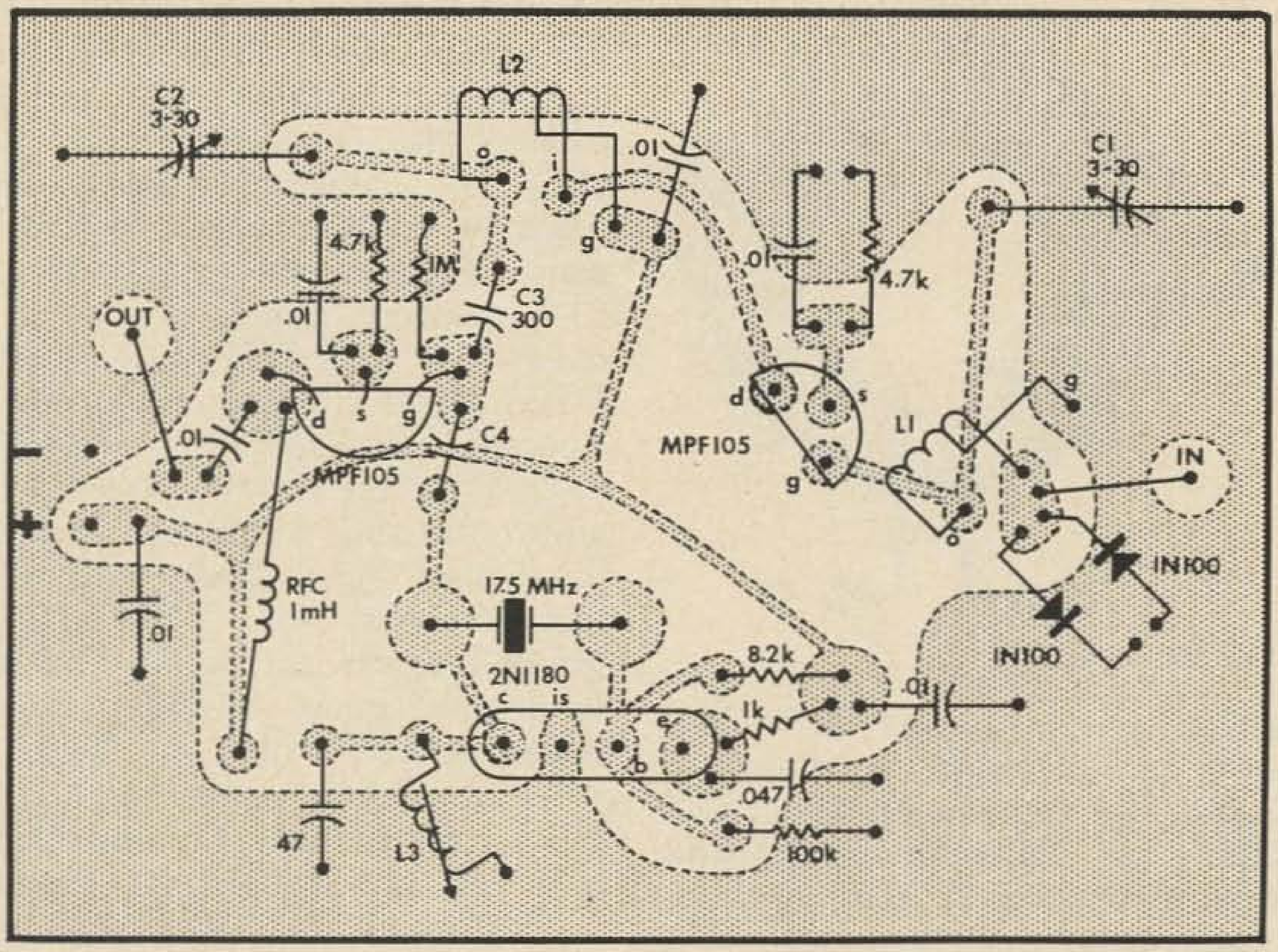

Fig. 2. Component side of the printed circuit board for the Novice converter.

Three models of the converter were made using conventional air-core coils and all were unstable to a degree, even with shielding.

A pair of 1N100 diodes is connected across the converter input to prevent excessive voltages from being applied to the first FET when the station transmitter is on the air.[3] A socket is provided for this FET to facilitate replacement, if necessary.

Coil data

C_4—two 2-inch lengths of insulated hookup wire twisted together.

L_1—23 turns no. 24 enamel wire, tapped at 4 turns, on 1/2-inch O.D., 5/16-inch I.D., 3/16-inch long powdered-iron toroid core. (Ami-Tron Associates T-50-2 Red).

L_2—21 turns no. 24 enamel wire, tapped at 4 turns, on same type form as L_1

L_3—25 turns no. 30 enamel wire, close-wound on 1/4-inch diam. iron slug tuned form (Miller 20A000RBI usable).

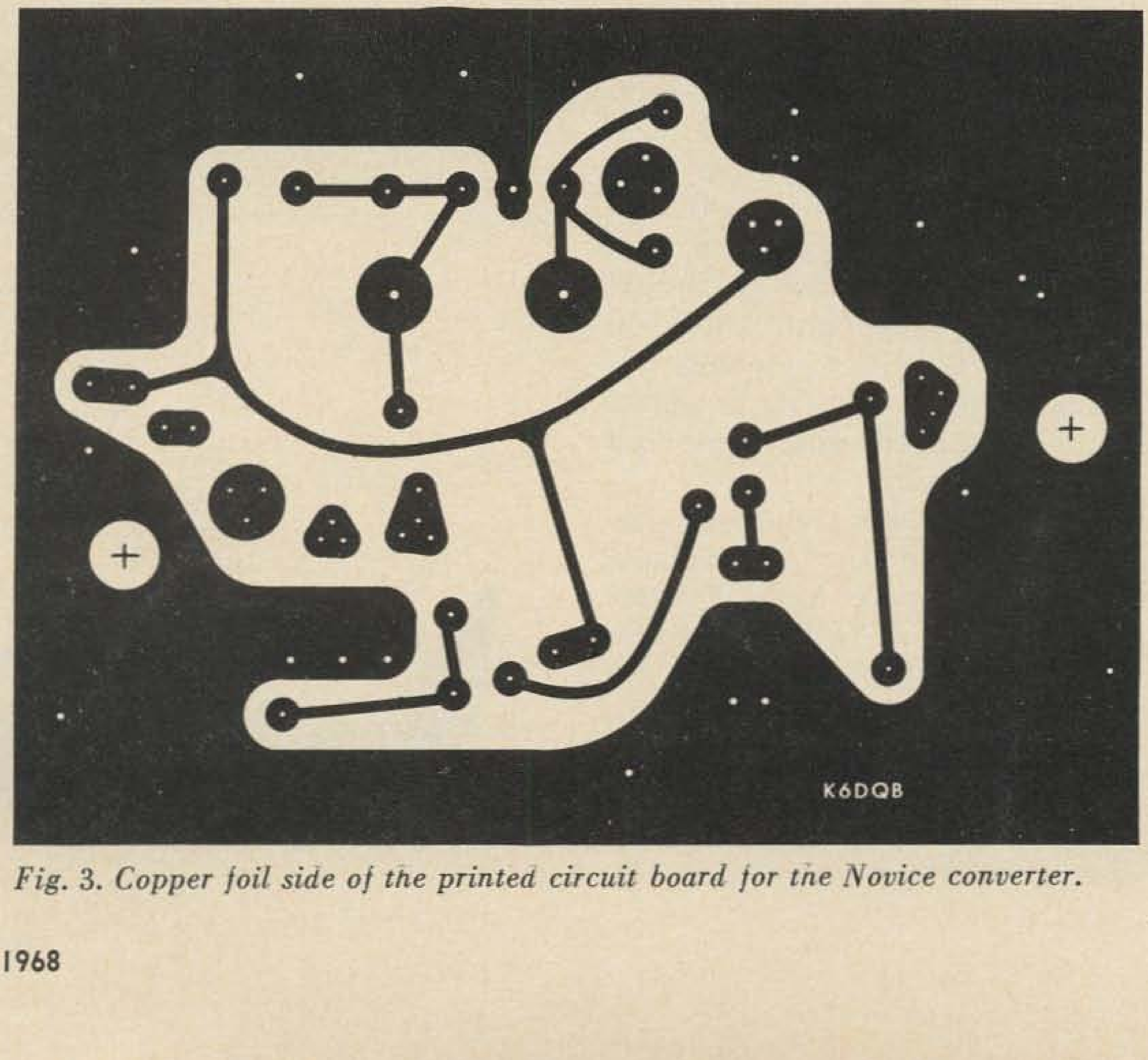

Fig. 3. Copper foil side of the printed circuit board for the Novice converter.

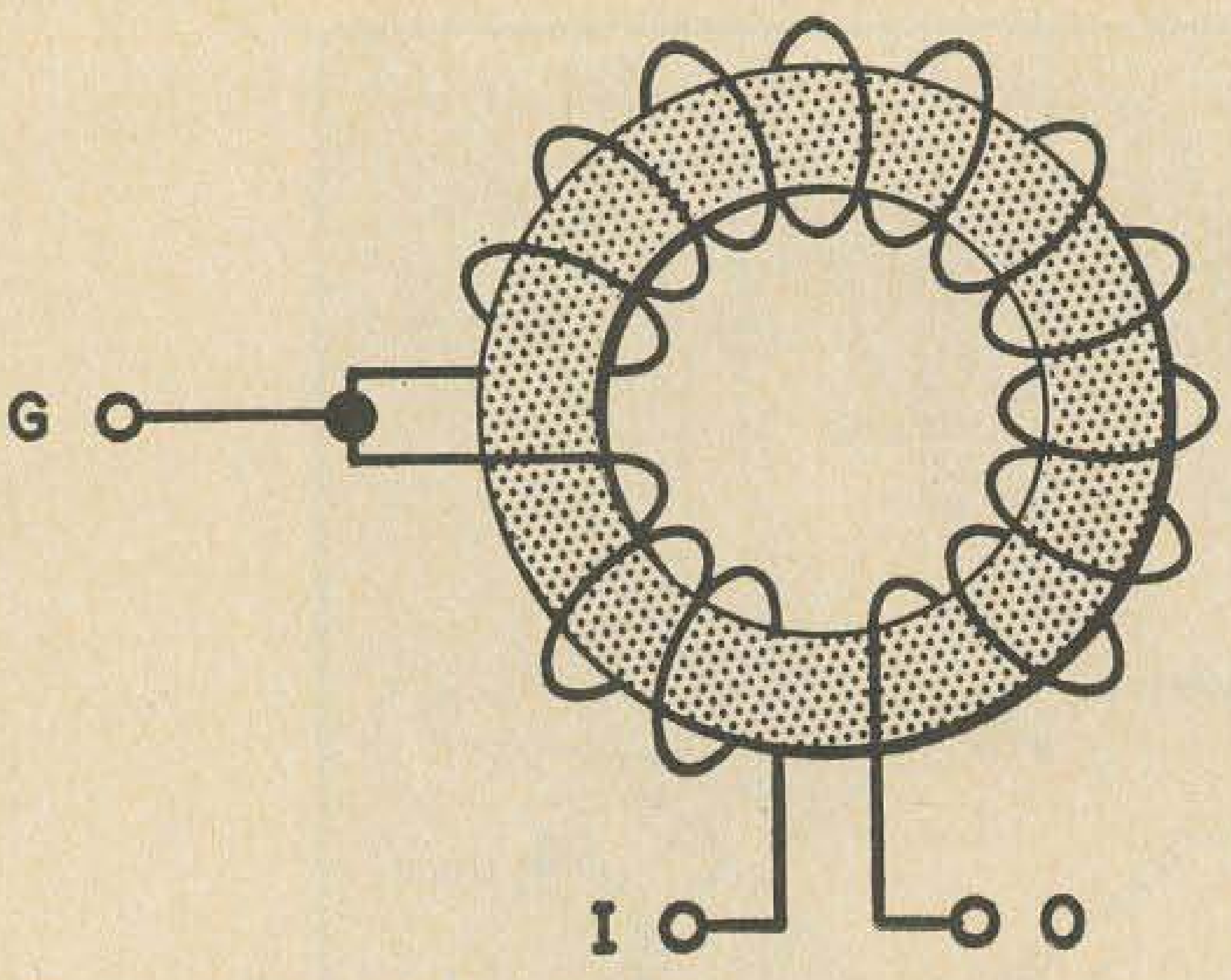

Fig. 4. Detail of the toroid.

The converter is constructed on a 3 x 4 inch printed circuit board as shown in the photograph. The component layout and masking pattern are shown in **Figs. 2 and 3.** The author used an E-Z Etch kit from Ami-Tron Associates[4] which contained a 4 x 6 inch board, etchant powder, and masking material. The board was cut in half and etched with half the etchant supplied. Although the kit provides ample masking material for making narrow lines and small circles, there is no provision for masking the large solid areas at the edges of the board. A heavy coat of fingernail polish makes an acceptable mask for this purpose and can be removed with polish remover or steel wool after etching is complete.

The tuned circuit inductors are wound on toroid cores which were also obtained from Ami-Tron. A convenient method for tapping the coils is shown in **Fig. 4.** Starting with the input (I) lead, add turns until the tapped turn is reached. Form the wire into a U on the outside of the toroid and twist the sides of the U together. Scrape away the enamel at the bottom of the U (but do not break the wire) and solder on the ground (G) lead. Continue winding until the required number of turns is in place. The turns should be spaced around the full circumference of the toroid.

The transistors and diodes should be the last components to be soldered to the board as they are quite susceptible to heat damage. As a transistor or diode lead is soldered to the board, it should be held firmly by a pair of long nose pliers on the component side of the board. The pliers will act as a heat sink and protect the device.

After the converter is completed, check the foil side of the board for accidental shorts, poor connections, and the like. When all is in order, insert the 17.5 MHz crystal and the *rf* amplifier FET in their sockets, connect the converter to an antenna and 80 Meter receiver, and apply power. *Never insert or remove transistors with power applied.* Tighten the screws in C_1 and C_2. If no Novice signals are heard when the receiver is tuned between 3.60 and 3.75 MHz, adjust the slug in L_3 until they are. Tune in a weak 15 Meter Novice signal near 3.65 MHz on the 80 Meter receiver and adjust the slug in L_3 and the screw in C_1 for loudest signal. Then tune in a 15 Meter Novice signal near 3.70 MHz on the 80 Meter receiver and adjust the screw in C_2 for loudest signal. If either signal is loudest when the screw of C_1 or C_2 is fully clockwise (maximum capacity), add a turn or two to the output (O) end of the appropriate coil and readjust the capacitor.

The author has no means by which to quantitatively evaluate cross-modulation susceptibility, but the converter seems to perform well in that respect. It's sensitivity is about the same as that of the 'authors' 10-20 Meter FET converter of similar design. For a $15 investment (if all parts are purchased new), it gives a good account of itself. . . . K6DQB

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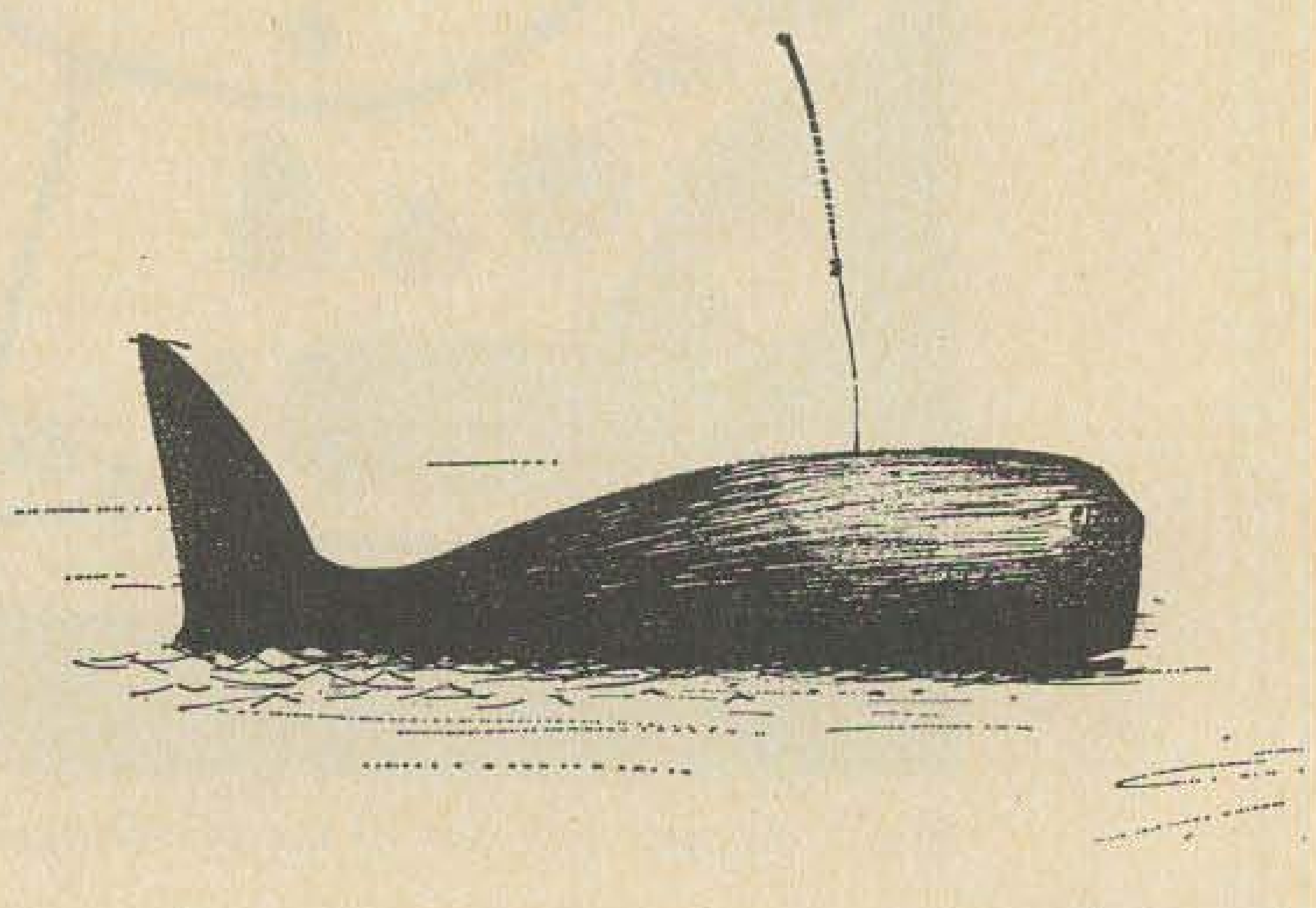
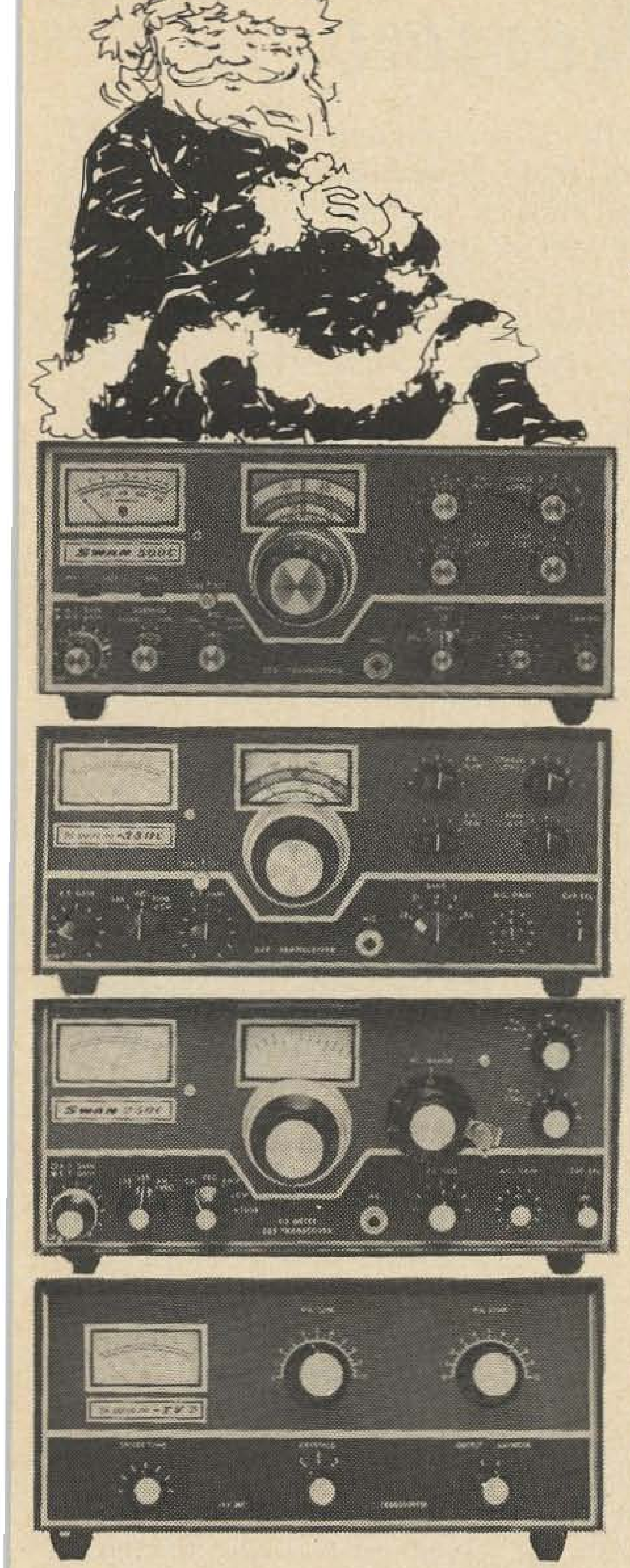
1. Creason, *A Field Effect Transistor Converter For 10, 15 and 20 Meters*, 73, May, 1967.
2. Creason, *A Field Effect Transistor Converter For 40 and 160 Meters*, 73.
3. Jones, *Using Low Cost FET's on Six*, 73, February, 1967.
4. Ami-Tron Associates, 12033 Otsego St., North Hollywood, Calif., 91607. The 1-board E-Z Etch kit sells for $3.49, the T-50-2 Red toroid core for $0.45.





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Transceiver Review

Heathkit SB-101

Heath is producing a sizable line of transceivers, and at the top of the pile we find their SB-101 transceiver tuning all ham bands over 80 thru 10 meters. It goes in a case 14⅞" x 6⅝" by 13⅜" deep, and weighs 17½ pounds. The kit comes for $340, or you can purchase it assembled for $540. An external power supply is required priced at $64.95 for the mobile 12-volt supply or $49.95 for the ac supply.

Tuning ranges and stability are guaranteed by Heath's preassembled Linear Master Oscillator. Receiver sensitivity is better than 0.5 microvolt for 10 db. signal-plus-noise to noise ratio in sideband operation. Sideband selectivity is 2.1 kHz at minus 6 db., 5 kHz at minus 60 db. for a 2:1 shape factor. An optional filter is available for CW work offering 400 Hz bandwidth at minus 6 db. and 2.0 KHz at minus 60 db. When this filter is installed a choice of filters is available from the front panel.

Transmitter final power input is 180 watts PEP continuous voice, or 170 watts CW at a 50% duty cycle. RF power output is 100 watts to a 50 ohm nonreactive load on 80 thru 15 meters, down to 80 watts on 10 meters.

Transmit-receive control is PTT or VOX on sideband, keyed-tone VOX on CW. A CW sidetone is available to speaker or phones when operating CW.

Heathkit HW-100

Heath's Single-Banders have been extremely popular and several conversion articles have appeared describing modifications for greater utility. Seeing the writing on the wall, Heath has recently introduced a 5-band version of their Monobanders, with a few trimmings thrown in from their more expensive SB-101A rig. The economical design methods and use of already-available engineering components have held the price down to $240 for a really versatile piece of gear.

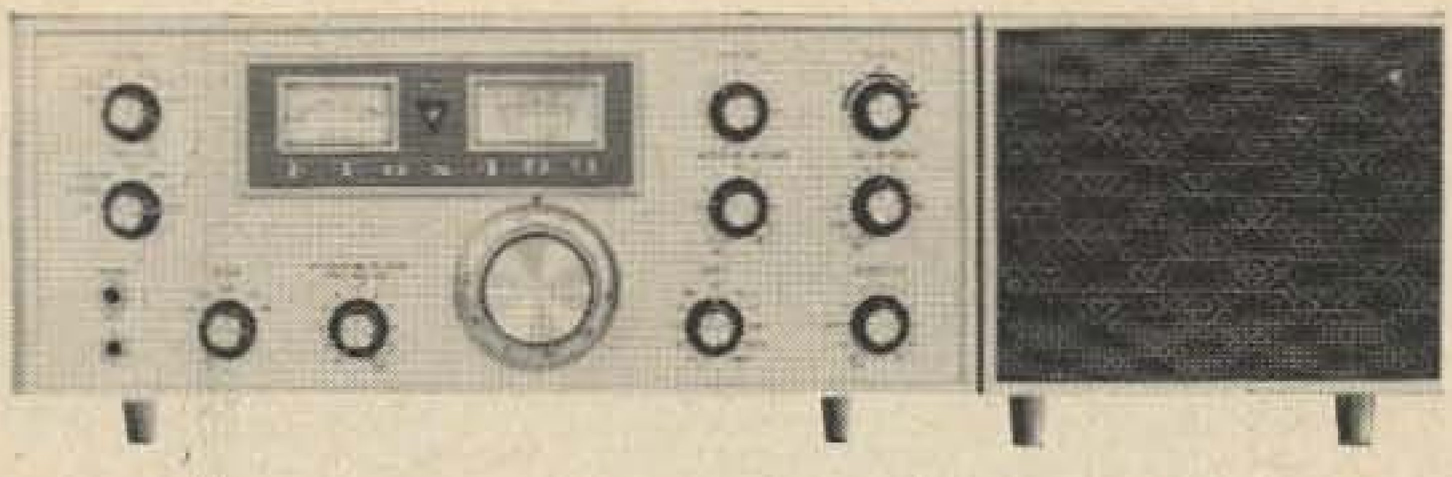
The HW-100 weighs under 18 pounds, uses a Monobander power supply to run 180 watts PEP sideband or 170 watts CW. Operating range is 80 thru 10 meters in five bands, and frequency stability is less than 100 Hz per drift after warmup or for plus/minus 10% line voltage drift. Sensitivity is better than 0.5 microvolts for 10 db signal to noise ratio, and filter bandwidth is 2.1 kHz at minus 6 db, 7 kHz at minus 60 db.

Heathkit HW-12A, HW-22A, HW-32A.

Shown above is Heath's HW-12A, one of three 200 watt PEP single-band transceivers that have been very popular over several years. All are designed to use the same stable low-frequency VFO, tuning from 1.5 to 1.8 MHz, and in their latest form all offer a choice of upper or lower sideband. Size is 6¼" x 12¼" by 10" deep, weight 15 pounds for all models.

Separate power supplies are required, and these are available for ac operation, or for dc mobile application.

Receiver sensitivity is 1 microvolt for 15 db signal to noise ratio, audio output 1 watt into 8 ohms. Drift is 200 Hz per hour after warmup, selectivity fixed by a crystal lattice bandpass filter. Carrier and unwanted sideband suppression is 45 db. HW-12A, $99.95; HW-22A, $104.95; HW-32A, $104.95.



YAESU FTdx 400

A recent arrival from Japan, the FTdx 400 transceiver was planned and designed for the American amateur utilizing standard locally-available parts. It covers the bands 80 thru 10 meters, with provision for three additional 500 KHz receiver bands. Frequency stability is better than 100 Hz drift per 30 minutes after warmup.

The transmitter is rated at 500 watts PEP sideband, 440 watts CW or 125 watts AM. This transceiver has a built-in power supply, which must be a pretty good one because although the transceiver is not notably larger than others it is considerably heavier: it weighs 50 pounds. Its cabinet size is 15¾" x 6¾" by 13¾" deep.

Receiver sensitivity is 0.5 microvolt for 20 db. signal to noise ratio on 14 MHz sideband. Bandwidth is 2.3 KHz at minus 6 db. and 3.7 KHz at minus 55 db. with IF and RF images better than 50 db. down. Audio output is 1 watt at 5% distortion, and frequency stability is less than 100 Hz drift per 30 minutes after warmup.

Active elements are present in unusual profusion. The Yaesu transceiver uses 18 tubes, which is about average, but it also has 42 additional semiconductors in a hybrid circuit, designed to make the most effective use of both tubes and semiconductors. One unusual feature is calibration points at 25 KHz intervals as well as 100 KHz points, with vernier dial accuracy specified as better than 500 Hz when calibrated at the nearest 25 KHz point.

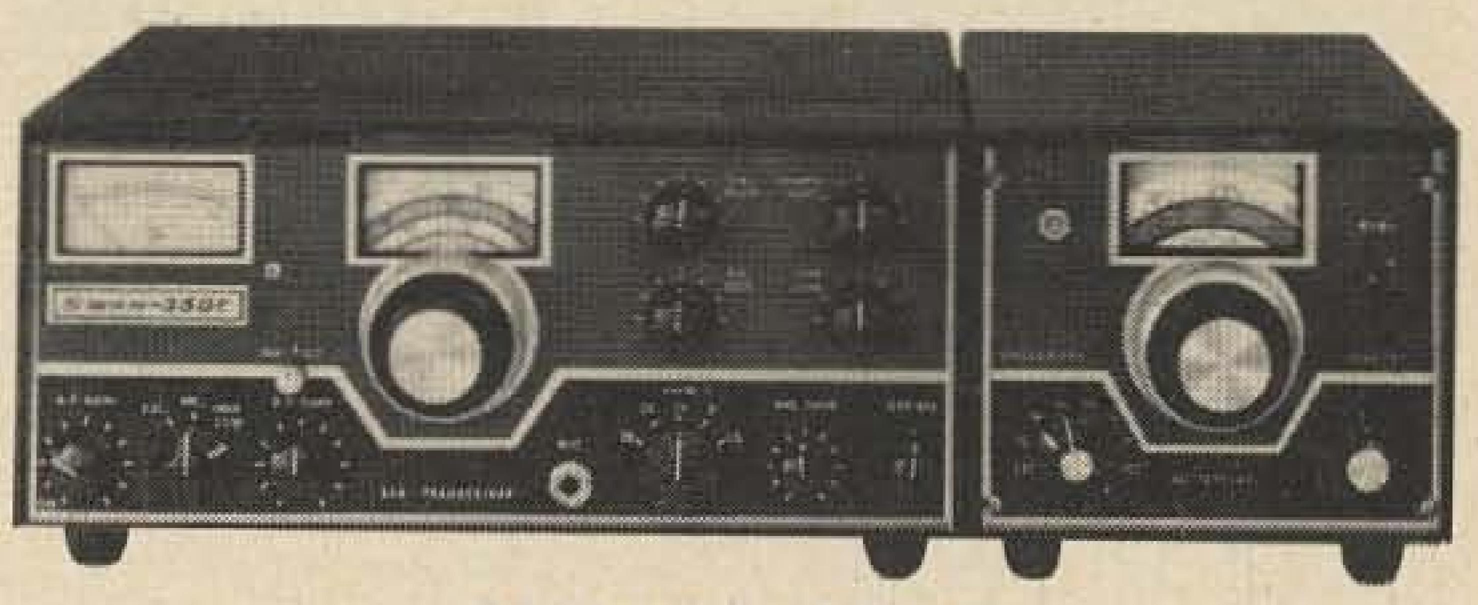
Any units not shown in this review are not due to lack of editorial interest, but because the manufacturer did not send us information.

SB-34

The SB-34 is unlike most transceivers in having a built-in power supply. And the supply is a universal type, which will operate from either a 12 volt battery or from 117 VAC. The only revision required is a change of leads. And for mobile operation the SB-34 has a low-drain standby setting which turns off the transmitter tube filaments and some other circuitry to reduce car battery drain to ½ ampere.

Frequency coverage is 3.775 to 4.025, 7.050 to 7.300, 14.100 to 14.350 and 21.200 to 21.450 kHz, with 1 KHz divisions on all bands. Selectable upper or lower sidebands, three IF's with a collins Mechanical Filter on 455KHz.

Case size is 5" x 11¼" by 10" deep, weight 19 pounds. The transmitter PEP input is 135 watts to two 6GB5's, and drift is under 100 Hz per 30 minutes under normal ambient conditions.



SWAN 350C

Looking at the model designation you might believe the Swan 350C is rated at 350 watts somehow. Actual ratings are 520 watts PEP sideband input on all bands, 360 watts CW and 125 Watts AM SSB plus carrier.)

Receiver sensitivity is better than 0.5 microvolt for 10 db signal-plus-noise to noise, with audio output rated at up to 4 watts into a 3.2 ohm load. Filter specs are 2.7 kHz at minus 6 db, 4.6 kHz at minus 60 db, and ultimate rejection better than 100 db.

The tuning range is 80 thru 10 meters in five bands. Metering checks PA cathode current to 800 mA on transmit, with the same meter indicating up to 70 db over S9 on receive.

Swan's Operation & Maintenance manual contains some very nice material about sideband theory and operation, and includes some useful information. For instance, if a sideband signal is transreceived at 20 db over S9 and the unwanted sideband is suppressed 50 db (Swan's spec for their 350C) the unwanted sideband will be audible at about S5. The manual is a strong sales point for the transceiver. Price: $420.00.

A power supply with speaker is available for 117 vac operation, at $105, or for 230 volt operation at $115. Another supply without speaker is available for $65. For dc mobile operation an ac supply can be used with Swan's Converter Module, at $65, or the ac supply can be left in the house and the Swan operated from a complete 12 vdc supply costing $130. The new 500-C Swan described below uses the same power supplies as the 350C.

SWAN 500C

The new Swan 500C is similar to the 350C, but has been refined by the introduction of a pair of RCA's 6LQ6's, development of the drive mechanism, a new *if* frequency of 5.5 MHz, and an increased number of tuned circuits in the receiver. All this has upped the price from the 350C's $420 (the 350C is still in production) to $520 for the improved model.

General technical specifications remain about the same, but Swan mentions the new 6LQ6 final can usually get up to 570 watts before flat-topping. Also, the new Swan has acquired a number of additional diodes and two new tubes. One of these is a 100 kHz crystal calibrator, optional in the 350C. The new panel suggests other changes not mentioned in the manufacturer's literature.

Hallicrafters SR-400

Hallicrafters' SR-400 contains some interesting ideas in transceiver design. For instance, it has a noise blanker circuit that turns off the receiver *if* when noise pulses exceed a given level. This prevents overloading and blocking, allowing the *if* to return to operational condition in far less time than would be required for an overloaded circuit to recover.

The SR-400 comes in a 16½" x 7¾" x 15" deep case. Power supply is external, and may be Hallicrafters' PS-500 supply containing a loudspeaker. or a dc supply operating off 11 to 16 volts for mobile operation.

Transmitter linear power input is 400 watts PEP on sideband, or 360 watts maximum for CW. Distortion products are down 30 db minimum, carrier and spurious emissions 50 db below rated PEP output. An 800 Hz sidetone oscillator is provided for CW monitoring.

Tuning ranges cover 80 thru 10 meters in eight 500 kHz bands, with the variable-tuning portion of the circuitry always operating in the range of 6.0 to 6.5 MHz. The six-pole crystal lattice filter is 2.1 kHz wide at minus 6 db, and 4.2 kHz wide at minus 50 db. Frequency stability is better than 250 Hz drift in the first hour and under 100 Hz drift per hour after warmup.

Receiver sensitivity is better than 0.3 microvolts for 10 db signal to noise ratio. Audio output is one watt maximum, and the AVC control is at least 60 db input change for 10 db change of output level. Price: $799.95 less Power Supply.

Hallicrafters SR-2000

Squeezed into a cabinet the same size as Hallicrafters' SR-400 we find a complete kilowatt-type transceiver. It tunes all the amateur bands, and runs up to 2000 watts PEP sideband or 900 watts CW.

Shown next to the transceiver is the special power supply required. This supply is probably about 50 pounds weight, and contains metering as well as a loudspeaker for the transceiver. The metering is designed for safety.

Tuning ranges and general performance are very similar to the SR-400, evidently the SR-2000's junior brother. Cost is higher, though, at $1095 for the transceiver power supply.

Drake TR-4B

Trying to get a TR-4B photo we wound up with a TR-4 instead. However, the B version is not very different. Fitted into a case 10¾" x 5½" x 14⅜" deep, this transceiver uses 20 tubes, two transistors and eight diodes. Weight is 16 pounds, external power supply required.

Transmitting specs are 300 watts PEP input to the PA in sideband operation, 260 watts CW. This transceiver can run AM, using screen modulation, with 260 watts PEP input. VOX and PTT functions are provided, and a transmitter alc circuit prevents driving the output stage into nonlinearity. For CW, there is a sidetone oscillator.

The filter shape factor is extremely good. Minus 6 db bandwidth is 2.1 kHz, and at minus 60 db the bandwidth is broadened out (if you can call it that) to 3.6 kHz, for a shape factor of 1.7:1.

Receiver sensitivity is less than 0.5 microvolt for 10 db signal to noise, and audio output is 2 watts maximum. An rf gain control also adjusts the effectiveness of the agc system, which at maximum setting can maintain the output within 3 db for a 60 db change in input signal. That is, if the input increases from 1 microvolt to one millivolt, you will just about hear the difference.

Tuning ranges cover the amateur bands 80 thru 10 meters in seven 600 kHz ranges. The solid state VFO is a linear permeability tuning design, fixed at a coverage of 4.9 to 5.5 MHz for all input frequency ranges.

An ac power supply is available at $99.95, or a 12-volt dc supply for $125. A new 24-volt dc supply has just been introduced at $210, and this one carries a 110 VAC outlet for operating accessory gear. A remote VFO and additional accessories for mobile operation are also available. Price: $599.95.

Galaxy V

That frequency scale way off to the left side of the panel looks as though it is about ready to jump off. But by all reports the users like it, and it seems to be a good arrangement for mobile work.

The Galaxy transceiver is rated at 300 watts PEP sideband or 300 watts CW. Upper or lower sideband outputs are available, with VOX operation with an accessory unit. Sideband suppression is better than 55 db, with the carrier 45 db down. Overall audio response in transmitting is down 6 db at 300 and 2400 Hz.

Receiver sensitivity is better than 0.5 microvolt for 10 db signal to noise ratio. The agc system will maintain the audio output within 6 db for a 60 db change in signal strength. Over a 40 db range, the output is essentially free from pops and pumping, and these nuisances can be avoided over any range with the help of the rf gain control.

The receiver audio output is 3 watts at low distortion into a speaker impedance of 4 to 8 ohms nominal impedance. Price is $420.00.

NCX-500

National's new NCX-500 is a surprisingly light (15 lb.) transceiver, rated at 500 watts PEP sideband, 360 watts CW or 125 watts AM. An external power supply provides for fixed or mobile operation.

Carrier suppression in the transmitter is minus 50 db, and the unwanted sideband is at least 40 db down. The transmitter is designed to work into an impedance of 40 to 60 ohms. An ALC system prevents flat-topping from noises or too-loud speech. Sideband output is Lower on 80 and 40, Upper on 20, 15 and 10 meters.

Receiver sensitivity is nominally 0.5 microvolts for a 10 db signal/noise ratio. Full AGC on receive, and audio output is 2 watts into 3.2 ohms. 5 kHz dial calibration is the same on all bands. The crystal lattice filter operates at 5.202 MHz with a 2.8 kHz bandwidth at minus 6 db, and a 2.2:1 shape factor.

The transceiver is $6\frac{3}{16}$" high, 13⅜" wide and 11" deep. It front panel is ⅛" extruded aluminum. The AC-500 power supply is the only one listed in National's literature but since the rig comes with a mobile mounting bracket a dc supply should be along very shortly. An accessory 100 kHz crystal calibrator is available.

Priced at $399.95, the NCX-500 is available from National Radio Co., 37 Washington St., Melrose, Mass. 02176. The AC-500 power supply, which operates from ac only, is priced at $95.00.

Collins KWM-2

The KWM-2 comes in a 14¾" wide, 7¾" high, 14" deep case, light gray with a simulated leather front panel. Weight is 18 pounds three ounces. External power supply is required.

Frequency coverage is in 200 KHz wide tuning ranges fixed by a set of 14 crystals. As provided, the KWM-2 covers the amateur bands from 80 thru 10 meters. For commercial or MARS operations the KWM-2A carries an extra crystal board for an additional 14 ranges. Except for this modification the KWM-2A is the same as the KWM-2.

Power input to the final is 175 watts PEP sideband, 160 watts CW. There is no AM capability. Carrier and unwanted sideband are minus 50 db. Other engineering specs are equally impressive, with the help of special negative feedback design of the final amplifier.

The receiver sensitivity is 0.5 microvolt for 10 db signal to noise. Selectivity is 2.1 kHz at 6 db, 4.2 kHz at 60 db down. Image rejection is better than 50 db, receiver output 1 watt max. AGC holds audio within 20 db for a 100 db input signal change from 10 microvolts to 1 volt.

Related gear is ac external power supply, $168; dc external power supply, $235; 30L-1 linear power amplifier for 1000W PEP, $520. Price: $1150.

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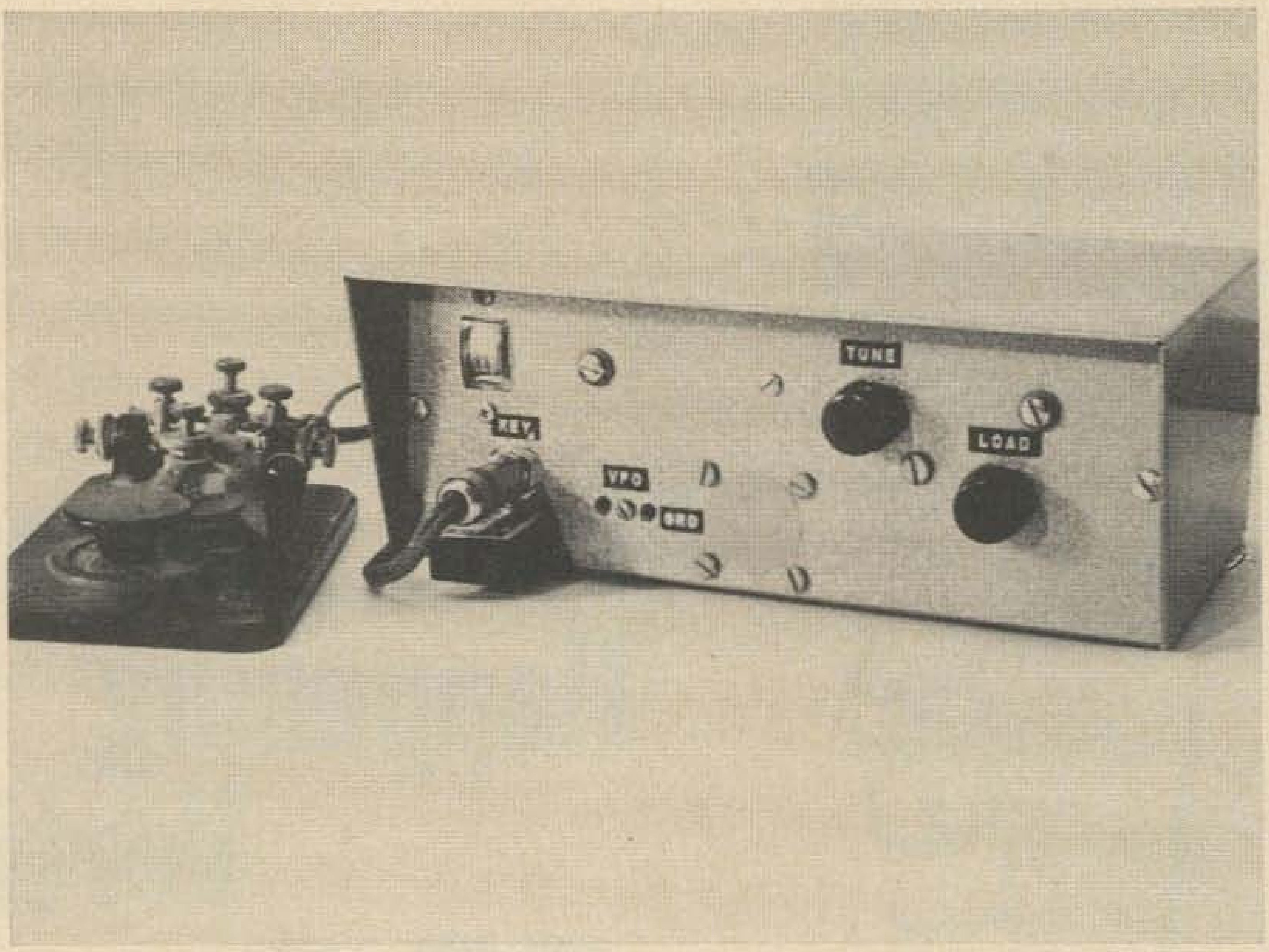


30 Watt Transistorized Transmitter

Roy E. Gould W5PAG
4748 DeBeers Drive
El Paso, Texas 79924

For several years I have been interested in transistorized transmitters and have read all the magazine articles I could find on the subject with interest. The first transmitters I read about were very low power, but the power has slowly been rising. The biggest problem in building a transmitter that puts out very much power has been in locating a suitable transistor for the final.

I have been disappointed until recently in finding an inexpensive transistor that can handle much power at amateur frequencies. Several months ago I learned about the Texas Instruments TIP 14, which has a 10 watt power rating and sufficient frequency response to be a good 80 meter amplifier. It doesn't cost a fortune, only $1.50. After learning of the existence of this transistor, I couldn't resist building a transmitter with a pair of them in the final.

This article describes that transmitter, a 30 watt, 80 meter CW rig. While 30 watts is not high power it is sufficient to do a good job when conditions are favorable and is relative high power for amateur band transistorized rigs. The final uses a form of π-net coupling, an unusual circuit in amateur transistorized rigs.

The circuitry

The oscillator is crystal controlled and is otherwise untuned. The circuit is simple and a major component in the circuit is the transformer. This transformer is wound on a toroid core. The primary is connected to the collector of the oscillator transistor. A feedback winding excites the crystal and the remaining secondary drives the next stage. The 47 ohm emitter resistor raises the input impedance of the stage to a level the crystal can work into easily.

The use of the toroid allows the building of a small circuit, makes tuning the stage unnecessary, and greatly reduces feedback from the final tank coil. These are important considerations when building the transmitter into a small cabinet. The cost of the toroid core is about the same as that of a tuning capacitor.

The oscillator stage can also be used as an amplifier and can be driven by a vfo. I used a Knight tube type vfo that has a no-load

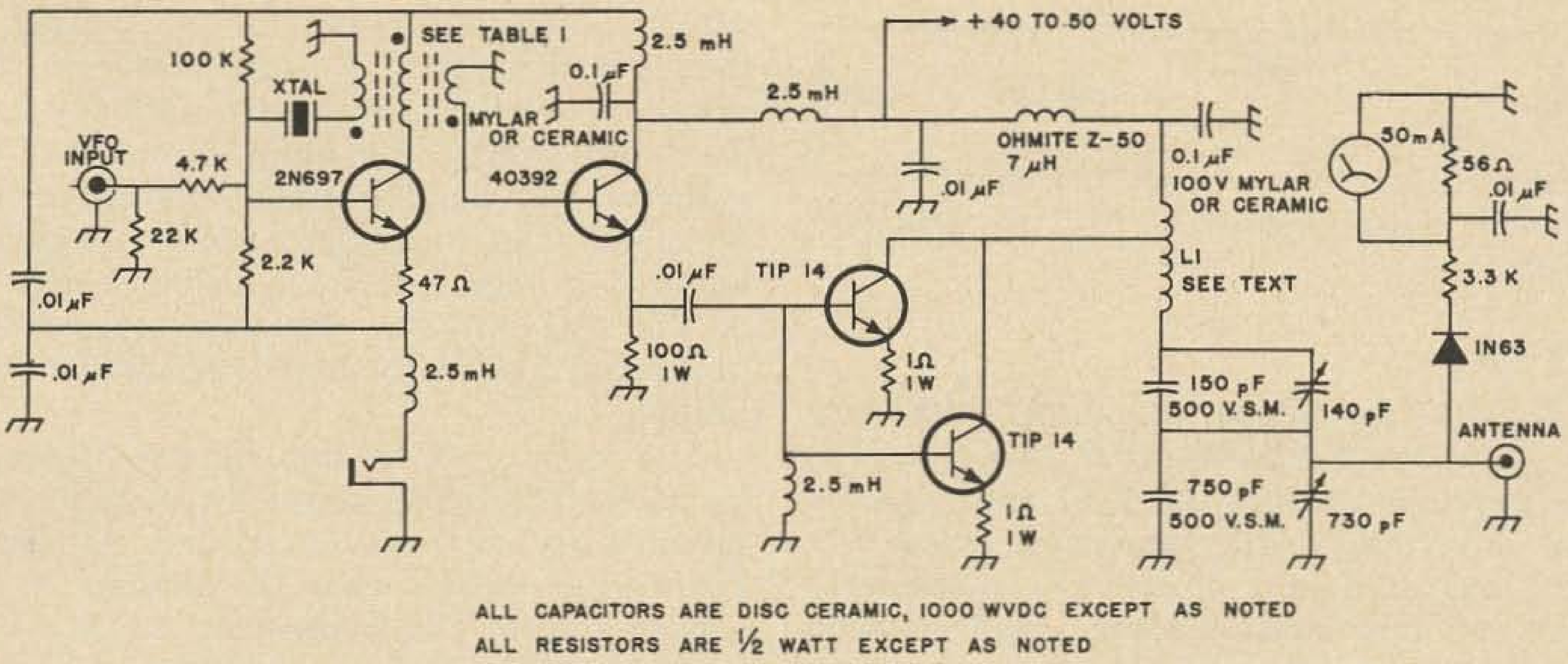


Fig. 4. Circuit diagram of the transistorized transmitter.

output voltage of 110 volts rms. The vfo voltage is fed to the base of the oscillator transistor through an attenuator network to obtain a drive voltage the stage can safely work with. The circuit works well and greatly increases the flexbility of the transmitter.

The driver stage is basically an emitter follower and isolates the oscillator from the final and drives the final from a low impedance source. The driver transistor is operated with no bias and amplifies only the positive portion of the input voltage. When there is no drive, the transistor draws no current. The stage provides no voltage gain, but does give current gain.

The final amplifier is a parallel class-C amplifier. The collectors and bases of the two TIP 14's are connected together but the emitters go to ground through 1 ohm resistors. The main purpose of these resistors is to divide the collector currents evenly between the two transistors. This helps to minimize the effect of using two transistors whose gains are far from equal.

The rfc provides a dc connection to ground for the base circuit of the final transistors, placing a small reverse bias on the final transistors. Since transistors don't conduct unless base current flows, no collector current will flow unless drive is applied

Proper tuning is indicated by an rf voltmeter. The rf voltage is rectified and the pulsating dc is applied to the tuning meter through a resistive voltage divider. Proper tuning is indicated by maximum indication on the meter.

The Texas Instruments TIP 14 transistor is ideal for use in an 80 meter power amplifier because it has a minimum f_t of 40 MHz and has a power rating of 10 watts up to a temperature of 75°C. It is further attractive because it costs only $1.50.

Since the TIP 14 is rated at 10 watts up to a temperature of 75°C, it can handle more power than most transistors with a 10 watt rating. This is because most transistors are rated at their maximum power level at 25°C (room temperature). Above this temperature, the power rating of the transistor decreases. Because the transistor ordinarily has to be above room temperature to get rid of the power it is dissipating, its power rating is reduced. The TIP 14 need not suffer any decrease in power rating because with a good heat sink, its temperature can be kept below 75°C.

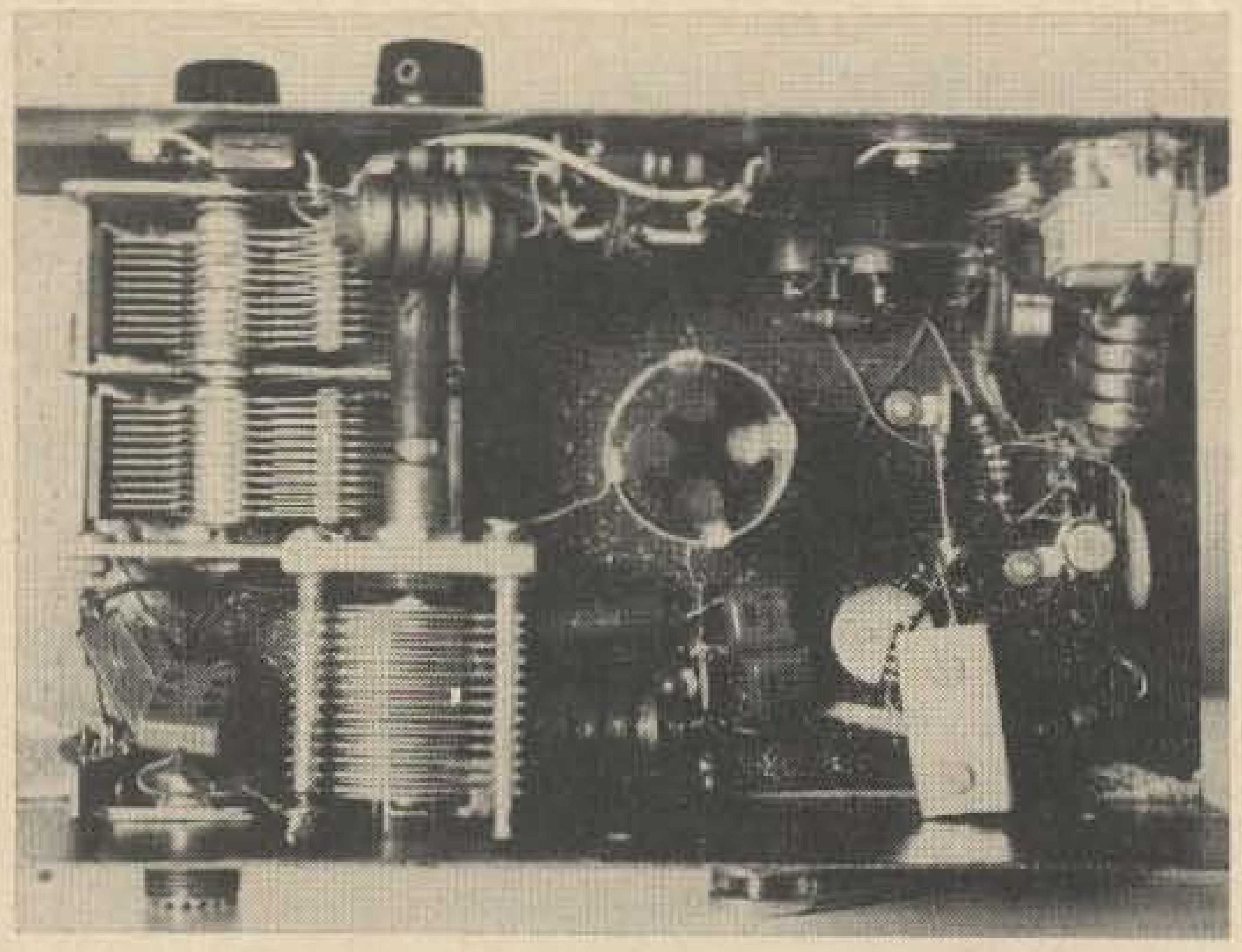
The combined power dissipation rating of the two TIP 14's used in the final is 20 watts, and if the efficiency of the final were 50 percent, the power input to the final could be 40 watts without exceeding the power rating of the transistors. In a breadboard circuit, the power output from the final was measured to be slightly over 19 watts and the power input was nearly 40 watts. The transmitter described in this article cannot deliver that much power because there is not enough drive for the final. The breadboarded driver circuit would not work in the small cabinet used because the transmitter oscillated severely in the close quarters. A different driver circuit was devised and it cannot drive the final to full output.

Figure 2. Basic π-network used as the final tank circuit.

The tank

Perhaps the largest stumbling block for the designer of transistorized transmitters is the requirement that the final must operate into a relatively low impedance load if a very large amount of power is to be obtained. Tank circuits conventionally used in tube circuits are not practical because very large values of capacitance and low values of inductance are required if a tank with a low input impedance is to be obtained. The often used π-net in its common form could provide the required impedance transformation but is not very practical because very large tuning capacitors in the 0.01 μF range are required. Two π-nets could be used back to back but this is not very handy because three controls would be required. The usual tank used by amateurs is a simple L-C circuit with two taps on the coil; one for the final and one for the antenna. This works but has the disadvantage of requiring an antenna tuner or of finding the proper tap points by trial and error for the antenna to provide a proper load.

I have always liked the π-net as the tank and coupling circuit for final amplifiers because of its flexibility and ability to adjust to changing loads. Therefore, I tried to design a π-network that would work with transistors. The basic π-net circuit I used is shown in **Fig. 2.** The basic difference between this circuit and the one normally used for tubes is that the input element is the inductor and the horizontal element is the capacitor. The input impedance across the inductor is high but a tap near the bottom of the coil provides the impedance transformation needed to match the load to the transistor.


Top view of the inside of the transmitter. The tuning capacitor is mounted on the top and back of the loading capacitor and the tank coil is glued to four plastic mounting rods.

The π-net used in this rig was designed to match 5000 ohms across the inductor to a resistive load of between 25 and 100 ohms. The coil is tapped near the bottom of the coil at a point which presents a load of 30 to 40 ohms to the final transistors. The tank is designed to have a Q of 15.

A tank using the same circuit could be used with tubes but ordinarily wouldn't be because there is no advantage over the conventional circuit, and the tuning capacitor has to be isolated from ground. Isolating the tuning capacitor from ground is not really a serious disadvantage however, and creates a problem mainly in mounting the capacitor.

Construction

Good high frequency construction techniques should be used. The oscillator circuitry should be separated from the final tank coil as far as possible to avoid unwanted oscillations. A wire connection should be used between ground points rather than relying upon the chassis connection. All bypass capacitors are disc ceramics except the 0.1 μF capacitors which are made with Mylar.

The tuning capacitor must be electrically insulated from ground. The section of this capacitor that is connected to the shaft should be connected to the high side of the loading capacitor because the voltage at this point is not high. Preferably, the shaft should be insulated from the knob.

The oscillator transistor does not require a heat sink, but the driver and final transistors do. The driver transistor is easy to heat sink because its case has a mounting flange. I bolted a piece of aluminum to the top of this transistor using silicone grease to increase heat transfer. The TIP 14 transistors are easy to mount with one screw. They are encased in plastic and are mounted with a mounting tab which also provides the connection to the heat sink. This tab is in electrical contact with the collector and must be insulated from the cabinet on which it is mounted. I mounted the two final transistors on the inside of the front panel using mica and silicon grease. One reason I mounted them on the front panel was to make it easy to test their temperature with a finger. With the low voltages used there is no shock hazard, but slight rf burns can occur. (Don't touch the mounting screws when the key is down.

The transformer used in the oscillator is wound on ⅜ inch diameter toroid core. Winding data for this transformer is given in Table 1. The transformer must be connected with the polarity indicated in **Fig. 1** if the oscillator is to operate properly.

The final tank coil, L_1, was made from a one inch diameter Miniductor with 16 turns per inch. The coil has 29 turns and the final transistors connect to a tap 3½ turns from the bottom of the coil.

Table 1
Toroid Transformer Data

Winding	No. of Turn	Wire Size
Primary	16	26
Output	9	32
Feedback	14	32

Most of the parts used should be easy to obtain, however, the RCA 40392 transistor, the toroid core and the TIP 14 transistors may be difficult to obtain locally. All are listed in the *Newark Electronics Corporation Catalog No. 68*. The 40392 costs 91 cents, the TIP 14 costs $1.50 and the toroid core costs $1.20. The ⅜ inch diameter toroid core is manufactured by the Indiana General Corporation and is made of Q-1 material.

I built the transmitter except for the power supply in a 3 x 4 x 8 inch Bud Mini-Cowl cabinet. There is plenty of room in this

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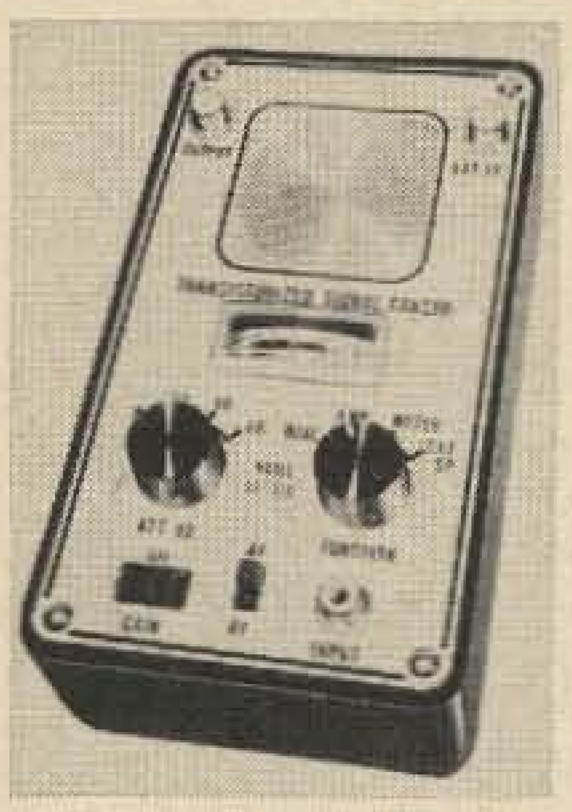

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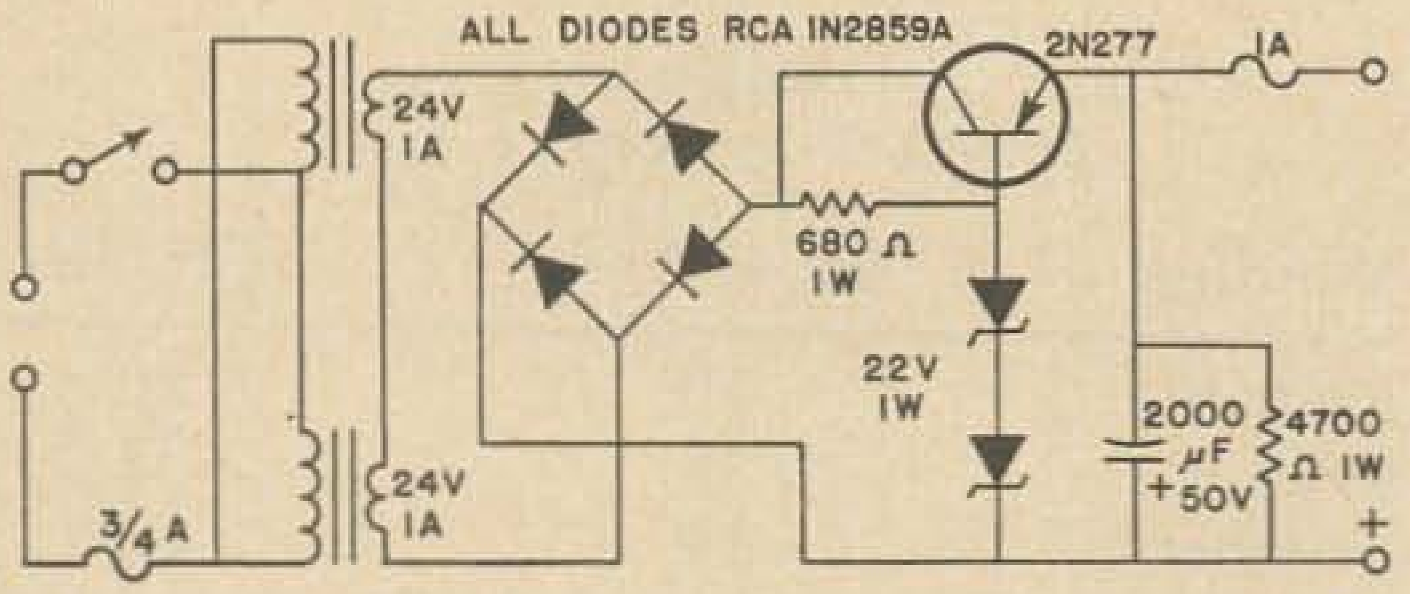

Figure 3. Schematic diagram of the power supply.

cabinet although the construction is fairly compact. The final tuning capacitor is mounted on the back of the loading capacitor. Since a shaft extension was needed, I used a piece of polystyrene rod for the extension, which insulated the knob from the *rf*.

The oscillator and driver stage could be built on a printed circuit board or on a vector board, but I used two, five terminal strips to build these sections. There are not many connections and this is an easy way to build the circuits. Most of the components in the final are mounted to the cabinet and a two terminal strip was required to wire this section.

The power supply

The power supply uses two 24 volt filament transformers with the secondaries connected in series. The secondary voltage is rectified by four diodes in a bridge. The voltage is then regulated by the transistor, whose reference voltage is fixed by the Zener diodes. The voltage is then filtered by the 2000 μF capacitor.

The power supply works well and the regulation is good. The Zener diodes I used are actually a litter higher in breakdown voltage than their rating indicate, and the no-load output voltage is 47 volts. The output voltage with a 1 ampere load current is 43.5 volts and the percent ripple at this current is 1.4 percent.

The construction of the power supply is not critical. The main problem is getting the secondaries in series so that their voltages add. If the voltage from the two secondaries in series is nearly zero, reverse the connection to one winding.

Operation

The transmitter should be connected to a fairly well regulated power supply capable of delivering 40 to 50 volts at 1 ampere. The transistors have 60 volt ratings so don't apply over 60 volts under any circumstances. The dc from the power supply should be fused with a 1 ampere fast blow fuse to protect the final.

A ground and a good antenna, preferably a half-wave dipole, should be connected to the transmitter. Even though the final uses π-net coupling, it cannot match badly mismatched loads. If a badly mismatched load is to be matched, an external antenna tuner can be used or the tap on the final tank coil could be changed.

An active 80 meter crystal should be plugged into the crystal socket or a vfo into the vfo socket. Most crystals should operate satisfactorily in the circuit. If a vfo is to be used, its no-load output voltage should be near 110 volts rms. If it is much diffierent than 110 volts, the value of the series resistor in the attenuator network (4.7 KΩ on the circuit diagram) may need to be changed. If there is too much drive, increase its value; if there is not enough, decrease it.

The only controls on the transmitter are the final tuning control and the loading control. The final should be loaded by first completely closing the loading capacitor. Then tap the key and turn the tuning knob until maximum voltage is indicated on the tuning meter. Then turn the loading control until maximum voltage is indicated, followed by again peaking the voltage with the tuning control. After the maximum voltage indication has been obtained by alternately adjusting the tuning and loading knobs, the rig should be ready to operate.

The power input to the final can be determined by measuring the input power to the entire transmitter and subtracting 4 watts, the approximate amount of power consumed by the oscillator and the driver. The efficiency of the final is about 50 percent, so the output is about one-half the input power.

Final comments

This is not a high powered rig, but it has been a good performer for me. I used it with a quarter-wave antenna about 20 feet high. My best DX was with a station in Washington state, an airline distance of about 1500 miles. It should do as well for you.

. . . W5PAG

Acknowledgement

The author is indebted to Mr. Brice for taking the photographs.

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Carole Allen W5NQQ
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Do Something Different!

Variety is the spice of radio club life, and some of the country's most active groups credit their successes to their special projects. The Stuyvesant High School Radio Club, for instance, distributes "The Groundwave," a publication acquainting over 1000 area residents with accomplishments in the electronics field.

The RAMS of California decided to equip its members with as many hand-held transceiver type emergency units as possible. They also assisted an invalid boy in getting his novice license and setting up a station. Since there are countless hams around the country who cannot see or move about to erect antennas, construct equipment, or maintain it, one of the most worth-while projects a club can choose is to aid a handicapped ham in keeping his station in running order.

Volumes could and should be written about groups such as the San Gabriel Valley California club who developed a satellite tracking receiver in 1957 which was nationally recognized. The receiver design incorporated a principle which was soon being used by U.S. tracking stations.

Along this same line, club participation in satellite tracking and high frequency communication offers the ultimate in electronic adventure. Information on transmitters, receivers, antennas, frequencies, and all the necessary scoop is available from the American Radio Relay League, Newington, Connecticut. Project Oscar (Orbiting Satellite Carrying Amateur Radio) launched December 12, 1961, was a grand chance for a club to listen with collective ears for the fading HI it sent on its orbits.

Back to earth, there are smaller projects to be undertaken that are just as rewarding. Club stations can be constructed, permanent antenna installations completed, emergency power plants set up, trouble-shooting gear bought, and other jobs that are too big for one but just perfect for many.

And as a strictly-for-fun project, the Possum-Trotters, a club with headquarters at Paris, Illinois, bought matching hamfest shirts in bright yellow for every ham and family member from baby to grandpa. Every summer, they pack picnics and "caravan" together to hamfests.

Whether it's big or small, pick a project and see the club light up!

Double "Trouble"

If your club has a high percentage of "live wires" and an extra portion of pep, why not sponsor a hamfest or a convention some time? Sure, either one takes a lot of work, but it can also be fun. And just in case you're thinking you need a hundred members to try something big, take a look at the Starved Rock Radio Club of Ottawa, Illinois. Here in the Midwest scarcely more than a dozen hams put on a hamfest every June for over 5000 persons. Admittedly, the more workers the easier the job, but the point is that a tiny club can sponsor either a hamfest or a convention if they put their minds and shoulders to it.

A convention can be called more of a white shirt and tie affair while a hamfest is a shirt sleeve gathering with families and picnic baskets in the great out-of-doors. Weather, of course, is a very vital factor at a hamfest while a convention is usually held in a hotel and lasts two or three days requiring an hour by hour schedule of forums, lectures, exhibits, luncheons, banquets, and speakers.

Aside from these basic differences, much of the same planning goes into both events. For instance, most of the committee chairmen, listed below, would also be needed to promote a hamfest:

General Chairman
Vice-Chairman
Publicity
AREC and RACES
ARRL Booth
Exhibit Manager
Finance
Ladies Program
Awards Booth
Registrations
Mobile Judging
Hidden Transmitter Hunt
Hospitality
Programming
Parking

If you and your club are "newcomers" in the sponsoring "game," it's good to take a look at other clubs. Hit the road for every hamfest and convention you can find. Take a notebook along and jot down ideas you like and those you don't. Whoever said to profit by other's mistakes must have planned a hamfest.

The Dayton Hamvention and many other large gatherings are held year after year resulting in committees of cool-headed veterans who can meet any emergency. But, for the most part, conventions are sponsored once-in-a-blue-moon by a group or council of clubs. Enlisting the help of ten or twenty clubs and coordinating all the volunteers is a challenge; in fact, the General Chairman has to be a "miracle worker" to organize all the groups and come up with cooperation.

A small club actually has the advantage here because all the members know each other. Around a metropolitan area, there are so many hams that few are well-acquainted, and the General Chairman has to introduce his helpers right off the bat.

The first big machine to roll is pushed by the publicity people since hams have to know before they go. Individual mailings may be expensive but they're vital in order to get dates and rates around. Notices in magazines and signs erected at events earlier in the year are effective with last minute mailings to jog an absent minded ham's mind.

George Griffis, K7EIS, was Promotion Chairman of the ARRL's 25th Annual Convention September 1, 2, and 3, 1962 at Portland, Oregon. Knee-deep in planning, he reports that a skeleton group of eight men

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15. 18" Hammond lighted globe ($25)	12.00
16. Polaroid Big Swinger camera ($25)	17.90
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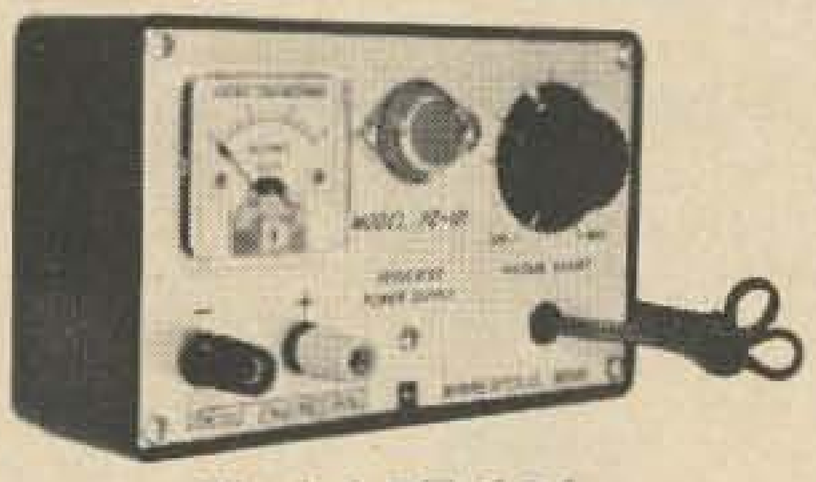

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were carrying the ball there. Starting at the top is an Executive Chairman, then the Council Chairman of radio clubs in the Portland area, with Chairmen of Registration, Promotion, Program, Finance, and Entertainment and a Convention Manager, too. Behind the scenes are dozens of assistants and just as many patient XYL' who spent many a lonesome evening and probably wound up at the registration desk or working on the women's program.

Decisions by the hundreds face the folks who organize hamfests and conventions, and since at least 75 per cent of them involve money, the first thing to do is get financial feet on the floor. Ideally, the committee should strive to keep prices as low as possible—not only for registrants but for manufacturers who sign up for booths and exhibits. Money doesn't grow on anybody's tree not even the fellow who represents the hottest selling rig in the country. Sure, manufacturers make hay among crowds of prospective check-writers, but let's face it, they have a load of expenses for transportation, meals, tips, rooms, and you-name-it. Since no big affair is complete without exhibits of new and surplus equipment, it seems only fair that factory reps and their budgets should be handled with kid gloves.

Along this same dollar-sign line is the price of registration. "The lower the better," most hams agree, but obviously a convention held at a hotel where minimum payments must be made, come rain or shine, will cost more than a hamfest held in an open pasture. Those who like conventions and can attend them regularly expect to pay, but if entrance fees can be kept down, a greater number of hams will probably flock in to enjoy the exhibits and forums. The treasurer may get nervous about the lower charges, but not when he finds himself opening the cash drawer twice as often to take in registrations.

Prizes, of course, are a "must" and two important points to ponder are (1) how to get 'em and (2) how to get rid of 'em. Practically every manufacturer or businessman in the electronics game is prepared to donate a raft of prizes every year or offer some kind of "mark-down" on new equipment. It's up to the committee to decide whether to put all the eggs in one basket and give a complete station as first prize or to buy lots of small prizes to accompany the donations. Unless you have personally waltzed out of a convention or hamfest with a $1000 prize, you'll probably agree that the more prizes awarded, the happier the hams involved.

It's going to take time to award a lot of loot, and many prize chairmen advocate hourly drawings to get rid of small prizes, saving the big stuff until last. This eliminates a three hour drawing of log books, single tubes, and screw drivers while an antsy audience boils in the sunshine or fidgets about getting the suitcases out of the hotel room before check-out time.

Anyone who's been through the mill will tell you that it would take at least ten volumes to describe every phase of planning for a hamfest or convention. And, beside that, the best way to learn is to get into the swim of things. In short, if you and your club aren't afraid of hard work, late hours, and last minute jitters followed by feelings of real accomplishment and wonderful memories, take some advice from our astronauts, and GO! . . . W5NQQ

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Getting Your Higher Class License

Part IX—More on Transmitters

Much of the technical content of all our license exams deals with the proper adjustment and operation of transmitters. This month, we'll wrap up the last of three installments covering the Advanced Class transmitter-oriented questions.

The specific questions we're covering this time are as follows (numbers, as always, are those from the FCC study list):

28. How does a full-wave bridge rectifier operate? What is the schematic diagram of this rectifier circuit?

43. Define frequency deviation in FM transmission.

49. How should a linear amplifier be adjusted for linear operation?

50. How is the power output of a 100-percent modulated AM signal related to the carrier power?

51. Why does a type 6146 tube have three prongs connected to the cathode?

As you can see, this is somewhat of a Mulligan stew of subject matter; the power-supply question could just as easily have been discussed under the heading of "receivers" and the remaining ones include design, adjustment, and operating techniques. However, we'll try to follow our usual practice and rephrase the questions into broader ones covering not only the specific details asked in the study list but as many related points as possible.

In order to define "frequency deviation" a knowledge of all the special terms used to describe FM is necessary. Our first question thus becomes "What Terms Are Used To Describe FM and What Do They Mean?"

Adjustment of linear amplifiers is included in the answer if we ask "How Are *RF* Amplifiers Adjusted For Proper Operation?", so that becomes question number two for us.

The full-wave bridge is only one of the popular power-supply circuits. Question number three therefore is "What Are The Popular Power Supply Circuits and How Do They Work?"

Multiple cathode convertions on the 6146, again, are only one example of some of the practical problems of tube design. All can be answered if we find out "Why Are Tube Pins Connected As They Are?".

And finally, power output of an AM signal when modulated is just one of the factors involved in determining the power output of any rig. "What Is Output Power, Anyway?" wraps them all up.

Ready for our modified question list? Let's go!

What terms are used to describe FM? What do they mean? While the theoreticians insist that only two kinds of modulation are possible—amplitude and angle—those of us who must deal with the real (that is, non-mathematical) world have quite a few more kinds to keep in mind. To name only those more commonly used in hamdom, there are CW, AM, SSB, DSB, and FM.

Each of these has its own particular set of words to describe the essential characteristics of the modulation; in CW keying may be "hard" or "soft", AM may overmodulate, either type of sideband may generate "buckshot"—and FM may do almost anything.

Most of us have already learned the essential words to talk about AM, CW, and sideband just in the course of everyday operation. Unless you're an FM buff, though, the chances are good that you aren't as familiar with the FM jargon—and that's what this question is all about.

While it doesn't *really* work like this, most of us find it easiest to think about FM by visualizing a carrier of steady power being moved about in frequency by the audio which is modulating it. The *rate* at which the carrier frequency swings is determined by the *frequency* of the audio, and the *distance* from the center frequency that it swings is determined by the *loudness*.

In this oversimplified picture, a low-frequency signal and a high-frequency signal (both audio, that is) will swing away from center equally if both are equally loud. The bass tone, though, will swing more slowly than the treble.

While an AM signal can overmodulate and cause objectionable splattering across the bands, an FM signal cannot be overmodulated at the transmitter. "Overmodulation" in FM is determined at the receiver; any time the signal swings across a wider range than the receiver can handle, it is overmodulated. For legal purposes, the equivalent of AM's overmodulation is "excessive frequency deviation"—or too wide a swing. In the bands below 52.5 MHz, maximum swing permitted is 3 kHz.

Now about those words. We've been using some of them so far. "Frequency swing" is the number of Hertz, kilohertz, or megahertz that the signal moves from one side to another. The bandwidth occupied by the signal is equal to two times its maximum frequency swing. "Frequency deviation" is the same as "frequency swing".

"Modulation index" is another term employed frequently in FM. The modulation index of an FM signal is equal to the frequency deviation divided by the modulating frequency. That is, if your audio is a 3-kHz tone and your deviation is also 3 kHz, the modulation index is 1.0. With the same deviation but a modulating frequency of 300 Hz, the modulation index is 3000/300 or 10.0.

"Modulation index" also applies to AM but is determined differently there—"modulation percentage" is simply 100 times the "modulation index" in an AM transmitter, so that the maximum modulation index permissible in AM is 1.0 and the average is more like 0.3 to 0.5. The higher modulation index attainable in FM is one of the advantages of this type of modulation.

FM is frequently divided into two classes for discussion—"wide band" and "narrow band". "Narrow band" always has a smaller modulation index (less frequency swing) than does "wide band", but beyond that the terms "wide" and "narrow" are strictly relative.

For instance, when hams talk of narrow-band FM (NBFM) they mean FM with less than 3 kHz frequency deviation or swing, as prescribed by FCC rules for operation below 52.5 MHz. In this kind of conversation, "wide band" means anything with wider deviation than 3 kHz.

But in the two-way communications industry, "wide band" means anything greater than 15 kHz or so swing, and "narrow band" is anything less. Thus a signal with 5 kHz swing would be "wide band" to a ham and yet "narrow band" to a two-way man.

It gets worse. FM broadcasting has a maximum frequency deviation of 75 kHz while TV's deviation (on the FM audio part of the TV signal is 25 kHz. The TV audio signal is sometimes called narrow-band since it is not as wide as FM broadcast. So it all depends to whom you're talking.

We've used another FM term, "center frequency", quite a bit already without defining it. That's the frequency of the carrier when no modulation is present. It gets its name because it's at the "center" of the channel. Frequency deviation is to both sides of the center frequency. If your center frequency is 50.055 MHz, for instance, and you are using 3 kHz deviation, your signal may swing from a low of 50.052 to a high of 50.058 MHz as it is modulated.

The final important term in FM is "threshold"; FM signals have a special characteristic not found with any other type of modulation. When they're strong enough, they actually take over and suppress background noise. They even suppress any interfering signals on the same channel. Up until the FM signal is strong enough to exercise this "capture effect", though, you can't even find it.

The signal strength at which the signal is "strong enough" is known as the "threshold" of the signal. It is determined almost exclusively by the modulation index of the signal. The greater the modulation index, the greater the signal you must have to reach the threshold—but the greater will be the noise suppression, once the threshold is reached.

For illustration, if an FM signal has a

modulation index of 1 (such as a ham NBFM signal), the signal must be about 3 db above the background noise for the threshold to be reached. By the time the signal is 4 db above noise, capture effect has cut in and the noise is reduced another 4 db. This gives an 8 db signal-to-noise ratio, twice as good as that provided by the signal alone.

If, however, that same signal had been a ham WBFM signal with modulation index of 4, it would have had to be at least 10 db above the noise level to reach the threshold. The improvement, however, would have been almost 15 db instead of just 4—so that the received signal would be 25 db above received noise instead of merely 10 db. The total signal-noise ratio, in this case, is 3 times better than that for the NBFM signal.

How are rf amplifiers adjusted for proper operation? Like any other amplifier, an *rf* amplifier consists of three major portions—the input circuit, the amplifier itself, and the output circuit. To operate properly, all three of these portions must be functioning as the designer intended.

The adjustments available to us as operators, though, normally affect only two of the three portions. The amplifier itself usually has no adjustments which we can readily reach (although in some cases, bias on the amplifier tube is adjustable). Operating adjustments—for any *rf* amplifier, linear or not—are usually limited to those for drive, tuning, and loading. The drive adjustment is a part of the input circuit, while tuning and loading are in the output circuit.

All *rf* amplifiers must be properly tuned in order to operate. This is accomplished, as you probably are aware, by applying a steady input signal and tuning for a pronounced "dip" in final plate current. The only critical point here is to be certain that the amplifier is tuned to the desired frequency rather than to some unwanted harmonic of the input signal—and that's a relatively easy check to make.

The differences in adjustments for the different kinds of amplifiers (CW, modulated AM, linear AM, or sideband linear) show up most prominently in the drive and loading controls, although loading and tuning adjustment do interact with each other. Before we look at the details of these adjustments, let's examine again how any such amplifier works.

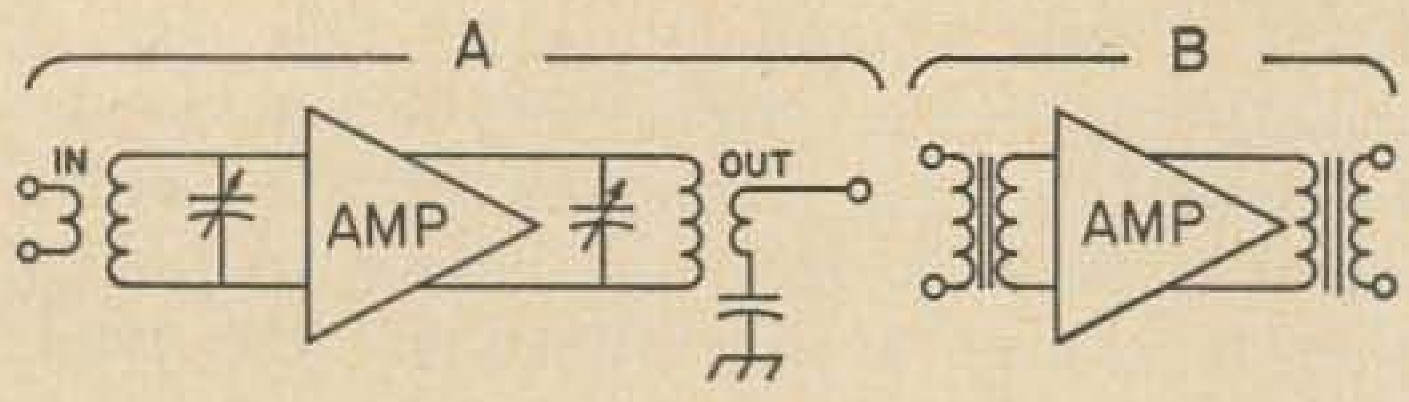

Fig. 1. A typical rf amplifier circuit is shown at left; Audio equivalent at right. Adjustments are drive (input circuit), tuning (output circuit), and loading (indicated).

Fig 1 shows a block diagram of a typical *rf* amplifier. This may be a linear, a CW final, or a high-level modulated unit; it makes no difference. In fact, you could even replace the input and output tank circuits with transformers as shown in **Fig. 1B** and it would be a good audio amplifier (if the tube voltages were properly chosen).

The tube amplifies the signal, by using the grid *voltage* to control plate *current*. The particular class of amplification (A, B, or C) and a major portion of the amplifier's linearity as well will be determined by the voltages applied to the tube.

The input circuit's main job is to provide the desired amount of voltage swing to the grid of the tube. Depending upon the amplifier design, this circuit may have to transform "power" input into voltage for the grid, or it may merely have to transform the voltage to a higher or a lower level than that swing provided by the preceding stage.

The output circuit has many jobs, but we'll concentrate on only one: it provides the "transformer" action necessary to convert the plate current swing into *rf* power at the right impedance level to feed our antenna line. This normally involves an impedance step-down, just as an audio amplifier ends up at a transformer which steps the output tube's impedance down to match a speaker's voice coil.

When this step-down is correct, the output circuit provides a "load" for the tube—and the choice of voltages for the tube depends in part upon the load seen by the tube. Thus all three major parts of this circuit interact with each other, and no one can operate properly unless both the others are also in the right ball park at least.

An audio amplifier is a broad-band device; the average stereo console amplifier handles a frequency range from below 50

Hz up to at least 15 kHz, which is a 300-to-1 ratio. *rf* power amplifiers, on the other hand, are all relatively narrow-band. Even a "broad-band" final which would cover 80 through 10 meters without retuning would be covering only a 10-to-1 frequency ratio. And the average final tuned to, say, 3900 kHz is covering only about a 3 kHz bandwidth, for a 1-in-1300 ratio of bandwidth to frequency.

The broad-banded audio amplifier requires a specially designed transformer to provide its output circuit. Handling *rf* as we do, we get out more easily. A simple tuned circuit, if properly adjusted, does the impedance transformation for us. One of the "proper" adjustments, though, is the tuning. The other one is the "loading" adjustment, which actually adjusts the coupling between the amplifier and the antenna. The effect is to change the transformation ratio of the output circuit.

The tube's load, provided by the output circuit, is electrically the same as a large resistor. Adjustment of the "loading" controls varies the effective resistance. The lighter the loading, the higher the effective resistance. With higher resistance, less plate current flows and the "dip" when tuning is extremely deep.

The higher resistance also, though, means less power can be transferred through the circuit—or even produced by the tube in the first place. With light loading, the tube is virtually loafing along and little power is delivered to the antenna. This is bad for any *rf* amplifier because all that *potential* power's energy is still wandering around the rig in the form of excessively high voltage swings, and sparks may be expected at the very least.

As loading is made heavier by increasing the adjustment of the loading control, the effective resistance of the output circuit goes down. As the resistance drops, more plate current flows. The additional plate current is able to produce more power by using that high-voltage energy, and the increased coupling which increased the loading in the first place permits more of that extra power to flow out to the antenna.

With a normal class C amplifier (non-linear), standard practice is to crank up grid drive until rated grid current flows, tune the final for the dip which indicates that it is tuned to proper frequency, and increase loading until the desired amount of plate current is indicated on the meter (taking care that the tuning remains correct, since a change of loading will affect the tuning adjustment also).

If you're going all out for maximum power, you may keep on cranking up the loading until the "dip" is virtually undetectable in the belief that this is producing maximum output.

Unfortunately, when you get the effective resistance of the output circuit down to a much lower value than the designer intended in the first place, the amplifier actually puts out *less* power—although it continues to draw more and more current, as you would expect with less resistance. This too is a condition to avoid; the extra current isn't going to the antenna, but is merely trying to melt out your rig!

If maximum power output is your goal, you must have some type of relative power indicator to tell how much is actually getting out. This can be anything from a SWR bridge in the feedline to a field-strength meter—or even a pilot bulb coupled to the feedline, not to the final tank where it won't tell you nearly as much. Then increase loading so long as the power output keeps climbing—and stop!

Drive, the third adjustment, is relatively uncritical in a class C rig. The only requirement is that there be enough of it. Good operating practice indicates that there should *not* be an excess of drive, which will increase the chances of harmonic problems. The grid-current ratings, though, are not Gospels. Once the rig is tuned and loaded properly, drive can be reduced until a reduction in power output is just detectable, and then increased about 20% above this point. For CW use, no increase is necessary. If the rig is modulated, though, additional drive is advisable in order to have a reserve on hand for peaks of modulation.

So far we've looked at the three adjustments for non-linear amplifiers. What happens to them if we are trying to be linear instead?

Tuning remains pretty much the same, if we keep in mind that the permissible operating range of the tube is much more critical for linear than for non-linear use. If the amplifier is properly designed, though, this factor will already be taken care of.

Loading is much more critical. Either under-loading or over-loading in the output circuit of a linear leads directly to distortion.

Drive adjustment also is much more critical. Under-drive is no problem, but excessive drive will lead directly to severe distortion and splattering. Let's look at these two adjustments more closely.

When a linear amplifier is not loaded heavily enough, the effective resistance of the output circuit is too high. At very low levels of input signal this has no harmful effect—but as the input signal increases during transmission of even a single syllable of speech, the too-high resistance sets a limit beyond which output signal cannot climb.

The result is peak clipping, which generates splatter all over the bands and can even put the suppressed sideband back onto the signal.

As the load increases, by adjusting for tighter coupling to the antenna, the effective resistance of the output circuit decreases. When it gets to the point at which the amplifier circuit was designed to operate as a linear, the maximum output power is developed and distortion is minimum.

Increasing loading still more reduces output but does not add significant distortion until the over-loading is severe. Usually the tube is damaged by excessive power dissipation by the time this point is reached.

Distortion is still present in an amplifier which is too heavily loaded, although it is not so severe as in one which is underloaded. The distortion created by too-heavy loading is more usually in the form of intermodulation or "third-order" distortion, which is not so obvious when listening to the desired output signal but which does put back in parts of the sideband you went to such trouble to get rid of in the first place.

While the loading of a non-linear amplifier can be checked quite easily by means of an output-power indicator, that of a linear amplifier virtually requires oscilloscope measurements of the signal. We'll go into this a little later, since most improper operation of linears is due to maladjustment of the drive rather than of loading.

The drive adjustments are probably the most critical ones in adjustment of a linear amplifier. Excessive drive in a linear is a sure way to generate a lousy and illegal signal.

The idea, in adjusting drive to a linear, is to provide *enough* drive for the amplifier to operate properly yet not provide *too much*. Since a linear's input signal may be anything from no signal at all up to the maximum permitted by the drive adjustments, the condition of "too little" drive simply cannot exist. All the adjustments have to do with setting an upper limit beyond which drive cannot go.

In the initial adjustment of a linear rig, each stage from the exciter on out to the final must be adjusted individually. Only after the lowest-power stage in the rig is operating properly can you move on to the next stage toward the antenna. Of course, if you're adjusting a factory designed and built unit, most of this will have already been done for you.

In each stage, the drive must be adjusted so that enough is available to drive that stage to the full rated undistorted output, without driving it over the limit into distortion. Once distortion is put into the signal, at any stage, getting it back out is like trying to remove one piece of solder from the middle of a molten blob on the bench!

In many rigs, the output circuit for one stage is a part of the input circuit of the next. In these cases, the loading control for the first stage is the drive control for the second, and so forth.

With such rigs, the "drive" control employed for final operator adjustment is usually the audio gain control on the exciter. To tune such a unit up—and the same practice can be employed for any linear amplifier—first apply an audio signal a little stronger than your mike can ever develop to the mike jack and ascertain that the audio amplifiers in the exciter can handle this signal without distortion.

When the exciter is adjusted to produce undistorted output from such an input signal, connect the exciter to the linear amplifier and adjust the linear one stage at a time until each, in turn, is producing its rated output—still without distortion.

Should any stage prove incapable of producing its expected output, check that stage carefully. Try adjusting the loading for that stage, as well as rechecking all previous stages.

When the entire amplifier is tuned up in this manner, it will be able to handle any signal delivered by the mike in a linear fash-

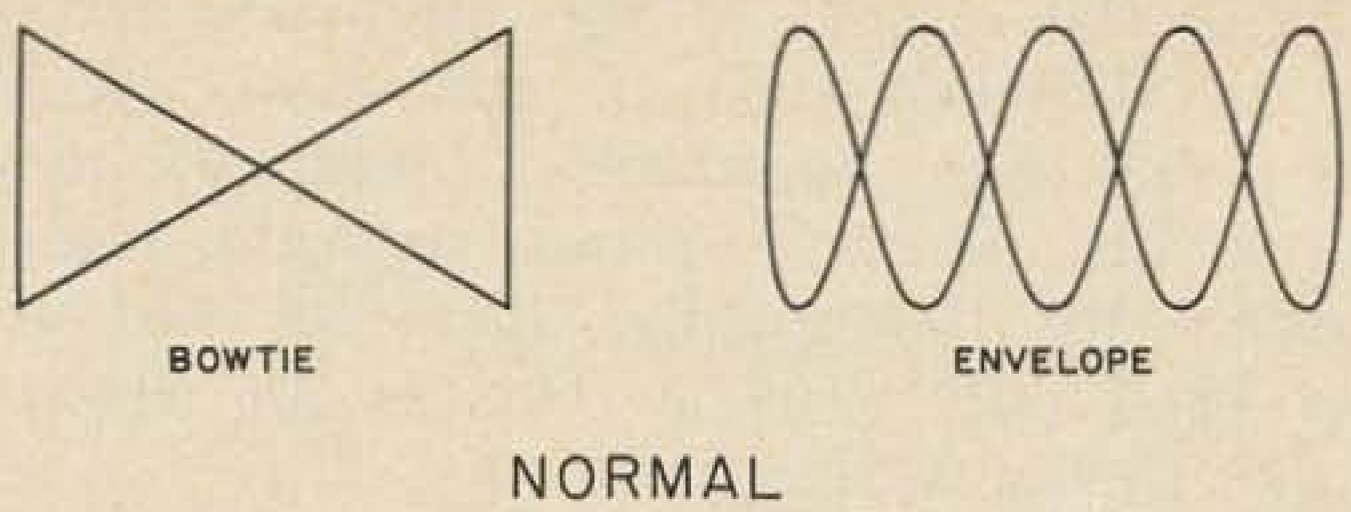

Fig. 2. Oscilloscope displays above are normal indications of linear-amplifier operating properly.

ion. Lock all the adjustments except final tuning and drive.

It should go without saying all these adjustments should be made using a dummy load, rather than with the rig actually on the air. If a legal-limit amplifier is being tuned in this fashion, it will be operating at several times the legal limit during the final stages of adjustment.

All that is now necessary to complete adjustment on the air is to retune the final and readjust final loading after connecting the antenna, to the same operating conditions. This is easiest to do if, after the initial tune-up, you reduce the audio gain until the rig is operating at about half its rated power. Note the audio gain setting and final plate current. With steady-tone audio, plate current will also be steady.

Then after connecting the antenna just apply the same input signal with the same audio gain setting, and load for the same value of plate current. The same loading conditions will automatically be established.

From this point on, the only operating adjustment is the audio gain control—which determines the drive applied to the entire rig.

To determine the proper settings, though, requires (as we mentioned earlier) a scope hooked up to view the output signal. Either an "envelope display" or "bow-tie" pattern can be used. **Fig. 2** shows the output patterns to expect from either when everything

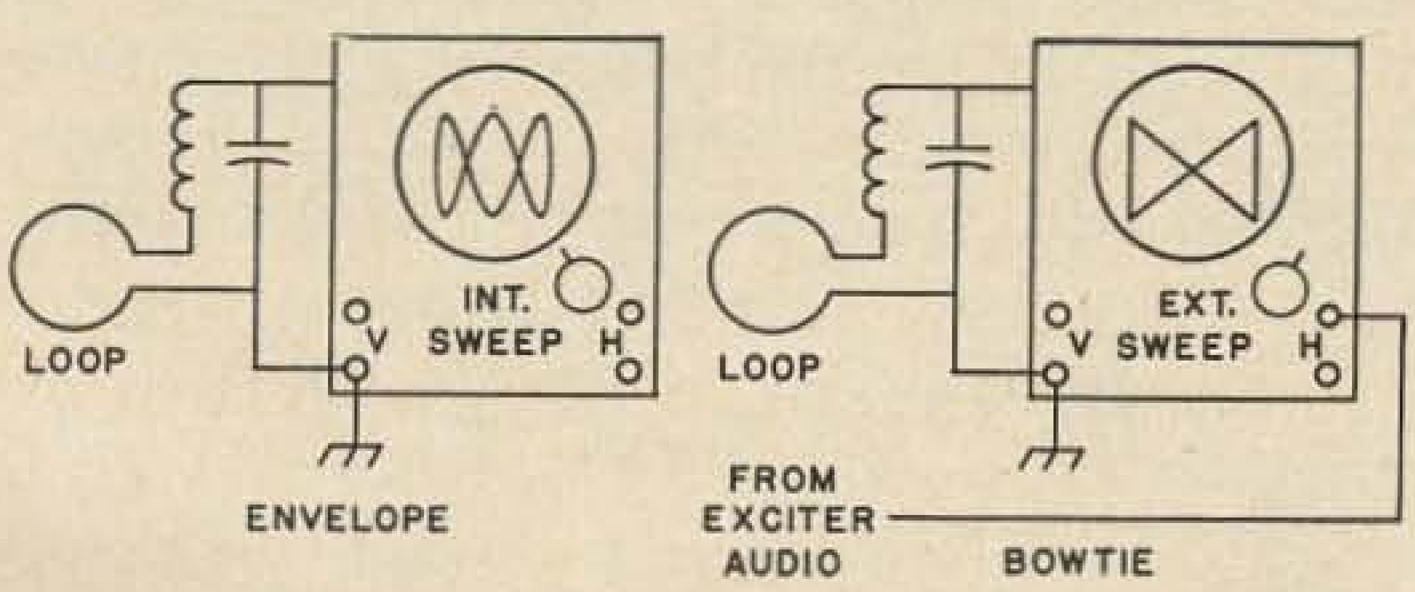

Fig. 3. Test set-ups for both types of displays. In either case, tank circuit is tuned to operating frequency and connected through a capacitor directly to vertical deflection plate of CRT.

is correct. **Fig. 3** shows the hookups for generating both types of displays. **Fig. 4** shows some of the abnormal patterns you may get with excessive drive, under-loading, or over-loading.

What are the popular power supply circuits and how do they work? Power supplies show up in many places. In this question, we aren't even considering the transistorized power supplies used for mobile work, either. But receivers, transmitters, and test equipment alike share the requirement for dc to operate—and the wall plugs provide us with ac. The power supply does the job

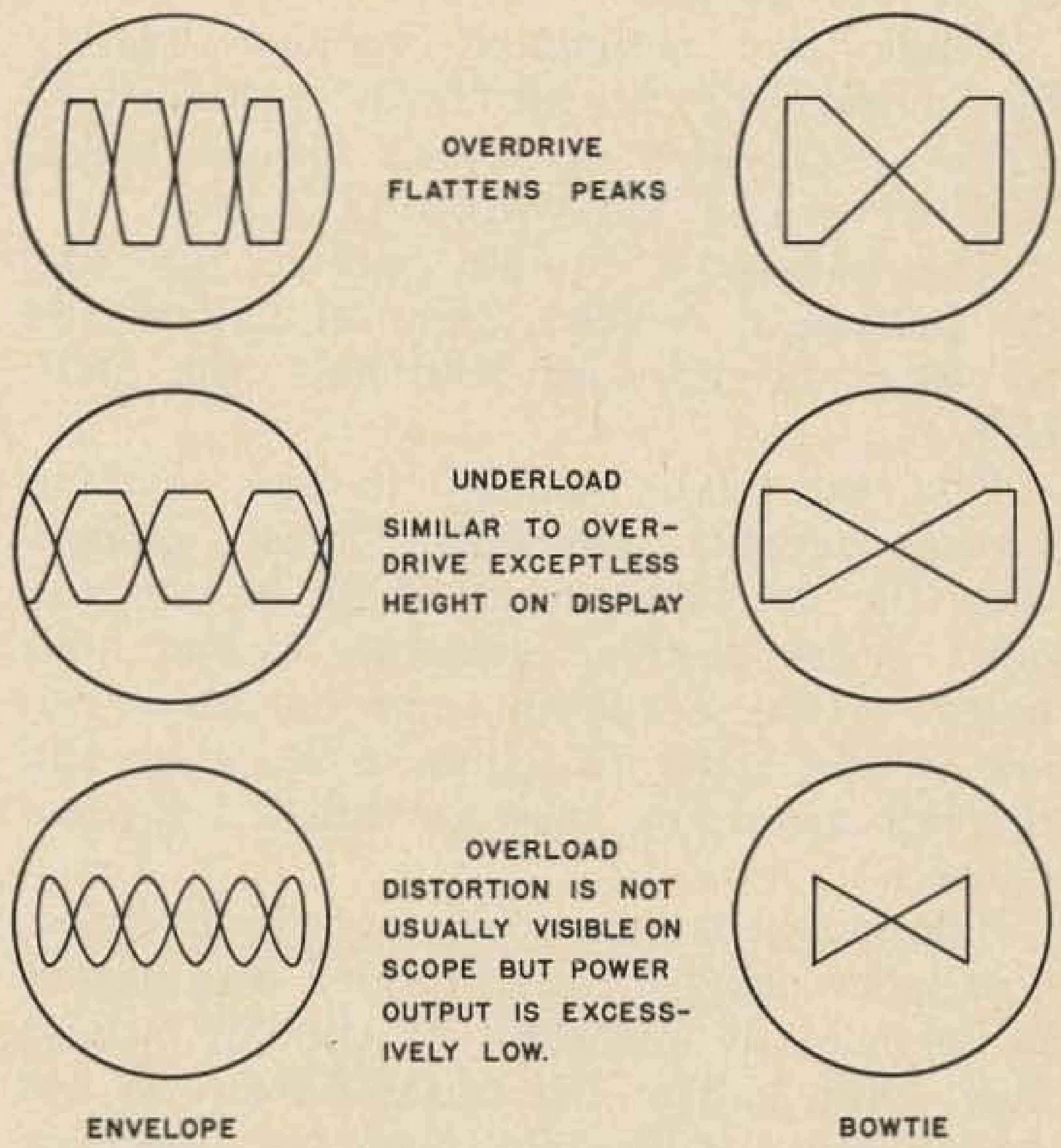

Fig. 4. Typical patterns exhibited by linear amplifier with operation not normal. Refer to SSB handbooks for more detailed views; these are to illustrate the theory involved rather than to provide an operating guide.

of changing the 115-volt 60-Hz ac from the wall plug into dc of the proper voltage and current characteristics to power our equipment.

All power supplies for this purpose employ rectifiers, either solid state (silicon diodes or selenium stacks) or tube type (vacuum tubes or mercury-vapor tubes). Most also employ transformers to adjust the voltage level although some operate directly from the power lines.

The job of the rectifier is to change ac into dc. Any individual rectifier element operates by simply blocking half of the ac waveform so that what gets through is all

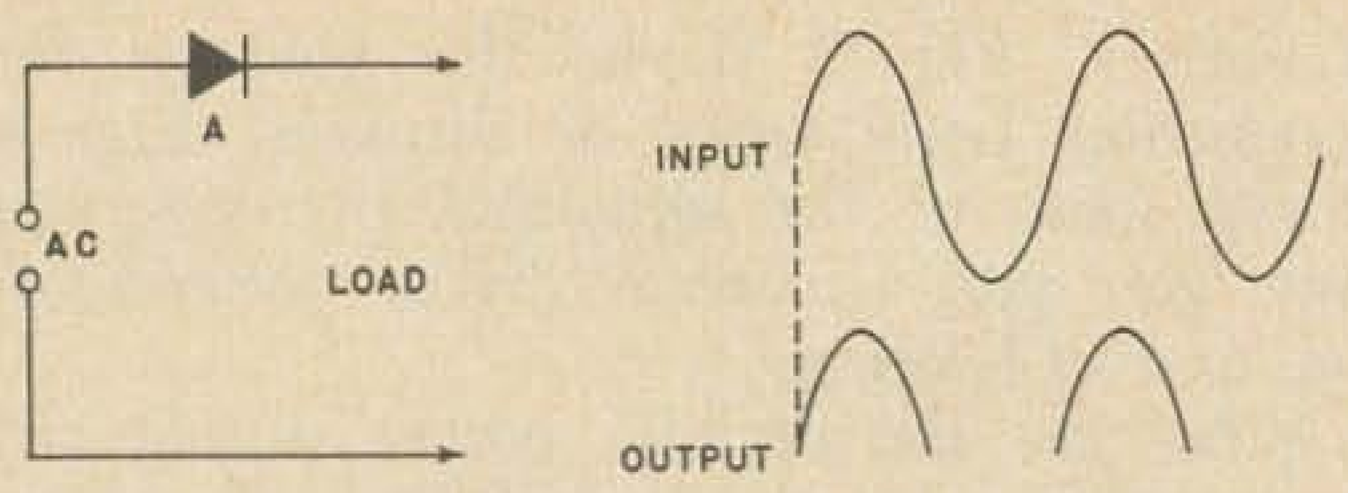

Fig. 5. Half-wave rectifier circuit and waveforms.

going the same direction—and this accomplishes the change. The resulting dc, although still pulsating at a rate related to the frequency of the original ac, is all going the same way. The filter circuit then smooths out the pulsations to provide "pure" dc for our devices.

While any individual rectifier merely blocks half the ac waveform, rectifier *circuits* are divided into two classes called "half-wave" and "full-wave" respectively.

The half-wave circuits operate just like the individual rectifier; they let half of the ac wave through and hold back the other half.

The full-wave circuits, though, contain several rectifier elements. These circuits *steer* the ac waveform through one or the other of the rectifier elements, so that both halves of the waveform come out as dc going in the same direction. Since they use the full waveform, they are called full-wave circuits.

The most common full-wave circuit cheats a little by using a center-tapped transformer to reverse the direction of the ac current flow. Only half of the transformer is in use during any half-cycle, and the rectifiers determine which half this is.

Fig. 5 shows the operation of this circuit, in comparison to the half-wave circuit in **Fig. 6.** You can see that the circuits are most similar. In both, rectifier A begins to conduct at the point marked "1" in the waveforms and conducts until the point marked "2". When time "2" is reached, rectifier A begins blocking current flow. In the half-wave circuit, no current flows again until time "3". In the full-wave circuit, rectifier B begins to conduct at time "2" and conducts until time "3". However, rectifier B is connected to the other side of the transformer center-tap, and the circuit's electrical return path is through the center tap. Thus the transformer is effectively turned end-for-end at time 2, and back to its original position at time 3. Both halves of the input ac are used—but only half the transformer is in use at any given instant.

With the advent of the solid-state rectifier, a different type of full-wave circuit has come into popularity. (With vacuum tubes, the circuit requires separate transformers for the rectifier filaments and so was used only rarely.) This is the bridge circuit shown in **Fig. 7.**

The major advantage of the bridge circuit as compared to the older full-wave circuit of **Fig. 5** is that the full, transformer secondary is used at all times. It also permits full-wave rectification without requiring a transformer. The bridge circuit operates entirely by "steering" current flow.

For instance, at the point marked "1" in the waveforms both rectifiers A and C can conduct while rectifiers B and D are blocked. This condition continues until time "2", and so current flows out of the bridge as indicated by the arrow.

At time 2, the polarity of the ac input reverses. This blocks rectifiers A and C, but permits rectifiers B and D to conduct. Current out of the bridge still flows in the same direction.

At time 3, the ac polarity reverses again and returns to the same condition that existed at time 1. You can see that the full ac cycle is steered through to the load, but is always flowing in the same direction when it reaches the load circuit. For half a cycle it flows through rectifiers A and C, and for the other half through rectifiers B and D.

Most tube-type receivers use either the full-wave circuit of **Fig. 5** or the half-wave circuit of **Fig. 6** (if they are inexpensive receivers without a power transformer). Solid-state equipment, on the other hand, employs the bridge almost exclusively. Transmitter power supplies almost invariable use full-wave rectification because it is more efficient and is also easier to filter into "pure" dc required by law. The choice between bridge and center-tap circuits is about even, though, with medium-power rigs more likely to use the bridge and high-power equipment usually using center-tap circuits together with mercury-vapor rectifier tubes.

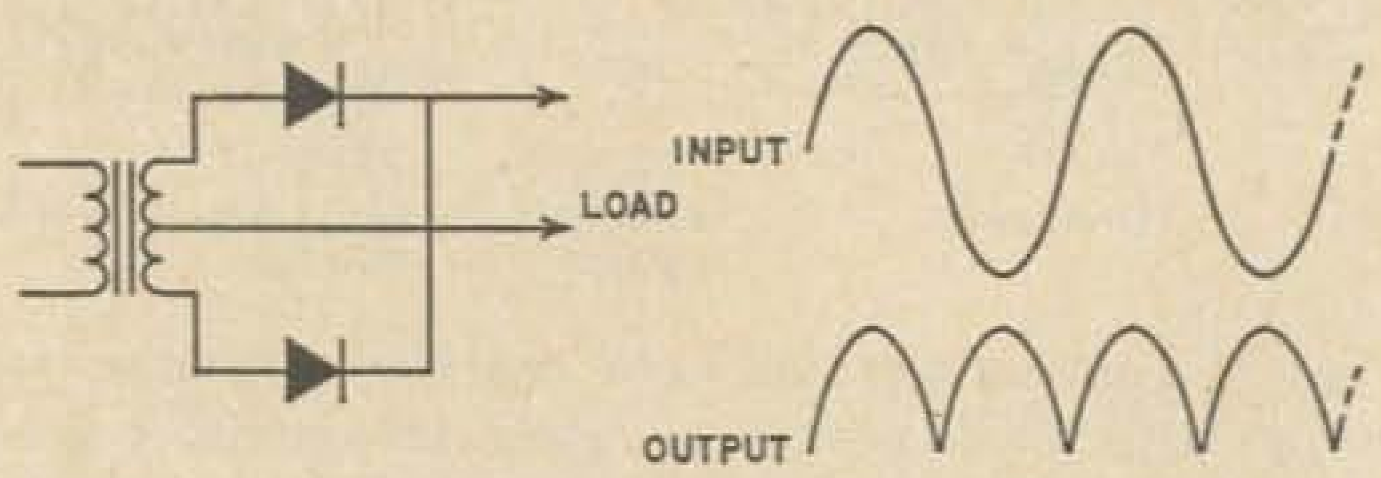

Fig. 6. Full-wave circuit and waveforms.

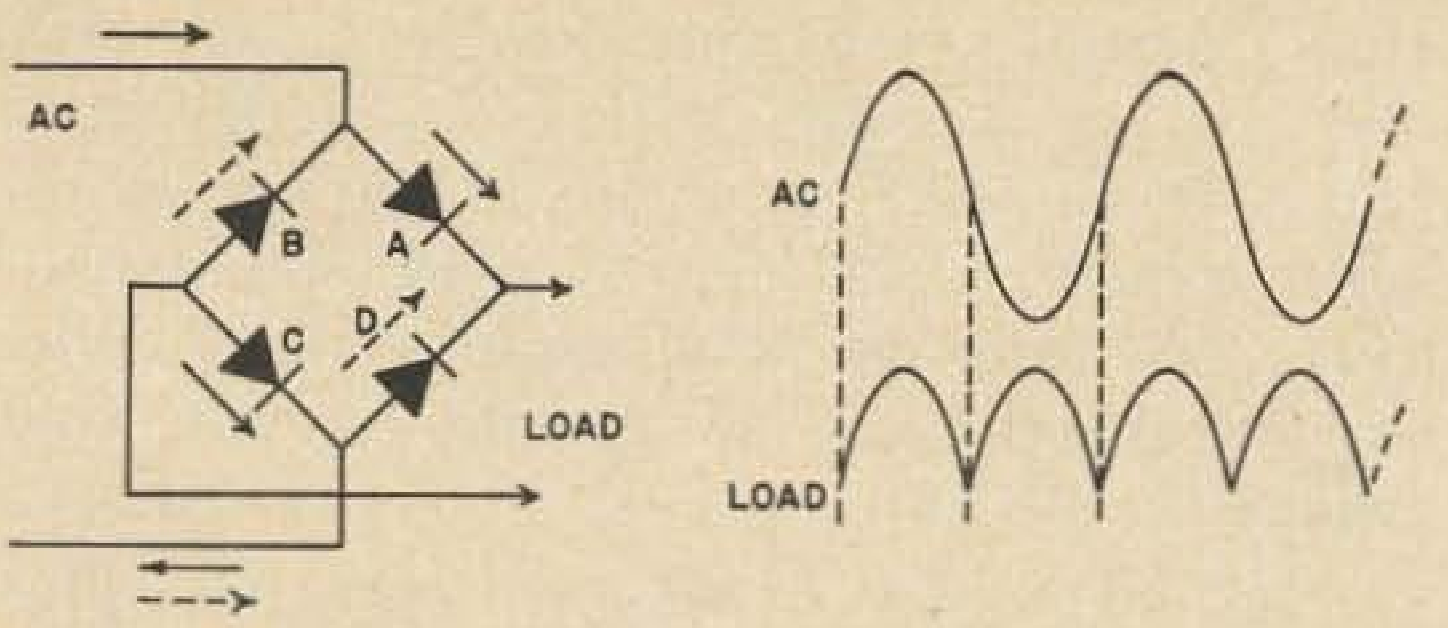

Fig. 7. Full-wave bridge circuit and waveforms.

Why are tube pins connected as they are? The earliest vacuum tubes had only four pins—two for the filament, and one each for the grid and the plate. Many modern tubes have many more pins, but no more elements—and yet every pin is connected to an element. A 9-pin miniature receiving triode for VHF amplifier use, for instance, may have two of its nine pins connected to the filament, one to the plate, three to the grid, and the remaining three to the cathode.

A single wire suffices to make electrical contact between two points. Why, then are tubes built with two, three, or even four pins connected to the same internal elements?

Manufacturers design tubes this way for two major reasons. Both reasons have to do with high-frequency performance.

Multiple grid pins are most frequently found in tubes intended to be used as grounded-grid amplifiers at VHF. In such an application, it's important that the grid actually be at ground for the *rf* as well as for dc. In fact, there's really no need for a dc ground so long as the grid is completely grounded for the *rf*—and some circuits are so designed.

And while a single wire suffices to make electrical contact between two points so far as dc is concerned, it may *not* do so for *rf*.

Any wire has a certain amount of inductance, even if it's not bent into a coil. To high-frequency *rf*, this inductance acts about the same way a resistor does to dc. A single wire, if it has great enough inductance, *doesn't* make proper electrical contact.

The inductance can be reduced by shortening the wire's length, or by using larger wire. In a tube, though, both the length of the wire and its maximum diameter are fixed by mechanical considerations. A limit is soon reached, for any particular tube design, beyond which the inductance of each lead cannot be reduced.

Three resistors connected in parallel will have only one-third the resistance of each one individually (if all are of the same value). Similarly, three separate leads connected in parallel will have one-third the effective inductance of one.

Thus by using more than one lead, with a separate pin for each, the tube designer can reduce the inductance between the actual tube element and the point outside the tube to which it is connected.

That's one of the reasons. Associated with this reason is a sub-reason: In any circuit using a vacuum tube, the reference "ground" point for the circuit's current flow is *not* the equipment chassis. Instead, it is the tube's cathode. All plate and/or grid current must flow through the cathode surface.

Since the cathode must be in vacuum inside the tube, though, you can't get to it directly to make any connections. All your connections have to be made to the tube's pins.

The inductance of the leads from the pin to the cathode itself, as we said, acts about like a resistor. When current flows through a resistor, it produces a voltage across that resistor. Similarly, when *rf* flows through an inductor it produces a voltage across that inductor—even if the inductor is a length of wire inside the tube.

Modern amplifier tubes have extremely high gain. A very small signal in the grid circuit is amplified into a rather large signal in the plate circuit.

The cathode's surface is in both the grid and the plate circuits. This cannot be avoided. If both the grid and the plate external circuits return to the cathode by way of the same tube pin, then the inductance of the lead from cathode surface to pin is also in both the grid and the plate circuits.

And when the amplified signal in the plate circuit flows through this inductance, the resulting voltage is automatically in the grid circuit as well. The result—feedback and possible oscillation (see Part III of this series for more on this).

By using two or more separate pins, each with its own leads, from the cathode to the rest of the circuit, the lead inductance can be kept effectively out of the picture. With the grid circuit returning to one pin

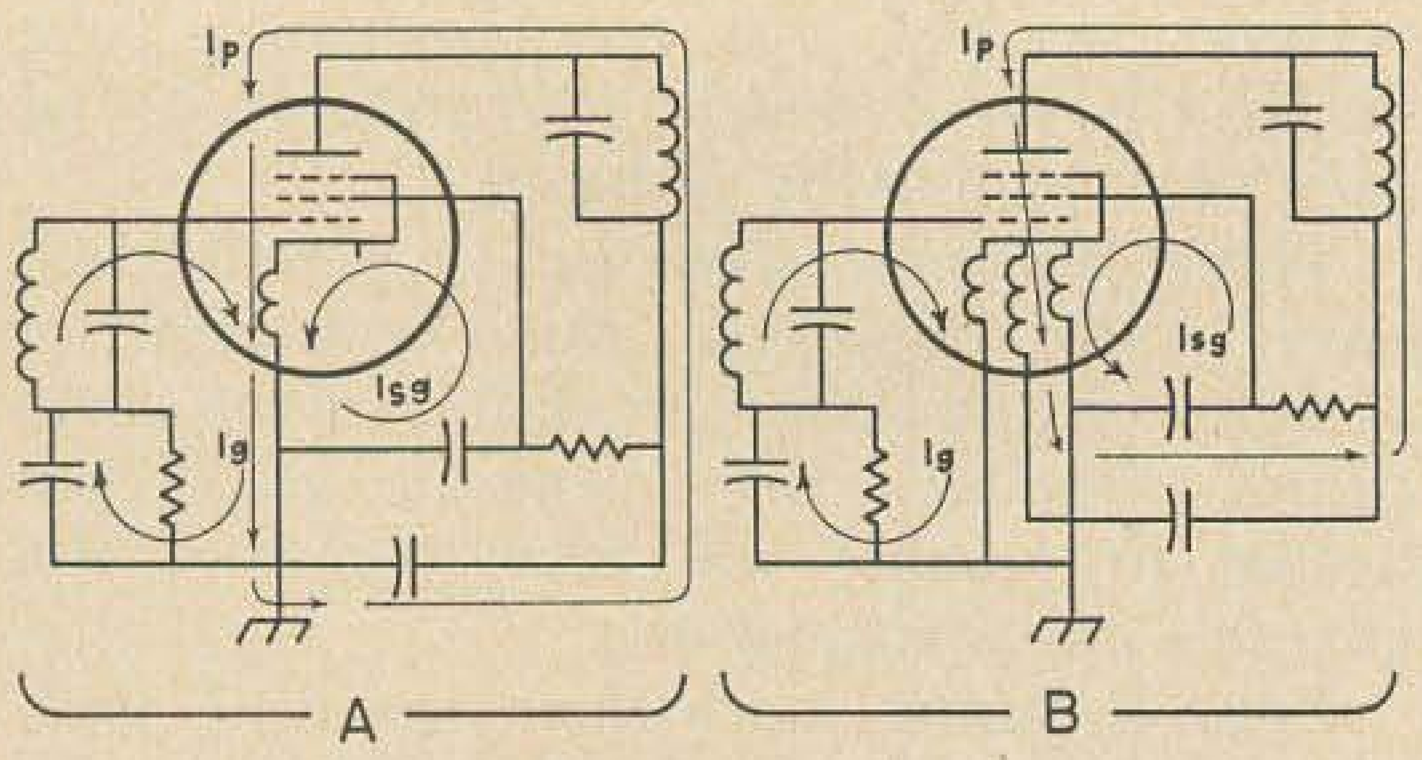

Fig. 8. Multiple pins are used in modern tubes to provide separate paths for input and output circuits involving same element. A shows only one cathode pin is available, so grid, plate, and screen current all circulate through inductance of single cathode lead and may interact. Three separate pins in B permit the three circuits to be kept completely separate. Effect is of importance only at high frequencies.

and the plate circuit to the other, any voltage developed across the plate circuit's lead inductance cannot get into the grid region —and one built-in source of feedback is eliminated. This is the reason that most modern high-gain transmitting tubes provide multiple cathode connections, as in the 6146.

Fig. 8 shows this effect pictorially. The lead inductance is shown as an *rf* choke —because, as the frequency gets high enough, that's how it acts. And we learned back in Part III of the series that feedback can be effective at *any* frequency, not just at the frequency you're tuned to. The type of feedback the multiple pins are intended to eliminate is one of the primary causes of parasitic oscillation.

The other major reason for use of multiple pins also has to do with feedback, but does not involve lead inductance at all and is usually applicable to VHF receiving tubes *not* intended for grounded-grid amplifiers.

Many of these tubes have multiple cathode pins, all of which are intended to be strapped directly to ground. These pins are located on the base in positions which separate the grid, plate, and other-active-element pins. When all these pins are grounded, they form effective shields to reduce feedback between input and output circuits of the tube.

The pin arrangement on multi-section-receiving tubes is also chosen with a sharp eye toward the intended uses of the tube. Pins are usually located in such a manner that external connections can be made with the shortest possible wires. This is the reason why several types of tubes are available having identical electrical characteristics, but different pin arrangements—some are arranged for one specific circuit, and others for others.

Not all tubes, of course, even use pins for the external connections. The popular 4x150/4CX250 series of power tubes, for instance, has no plate pin; the outer shell of the tube *is* the plate and any connection is made directly to it. The older "lighthouse" tubes featured similar construction, as does the 416B UHF tube. Planar tubes carry this idea into today's designs. Again, elimination of lead inductance and shielding between input and output circuits are the primary reasons for such arrangements.

What is output power, anyway? One of the least understood quantities we'll ever deal with in radio is that known as "transmitter output power".

For instance, most of us are aware that the maximum legal *input* power to a transmitter, as indicated on the meters, is 1000 watts. It's also no secret that most transmitters are at best no more than 75% efficient at turning this input power into output power, so it would be logical to expect that the maximum legal output power would be somewhere fairly close to 750 watts.

However, it's possible to run a rig *legally* on the HF bands with as much as 4000 watts input power and corresponding 3000 watts output power with one type of modulation while another type of modulation is restricted to only 1000 watts in and 750 watts out. When you get into the VHF and UHF regions where pulse modulation is permissible, input powers on the order of 100,000 watts can be had legally. At these frequencies efficiency drops so your output probably won't exceed 50 kilowatts or so —but still!

The trick in all this lies in that innocent phase "as indicated on the meters". Even when running 100-kw peak input during pulse modulation, the meters must not exceed a 1-kw input reading. Since meters are relatively slow to react—a dc meter cannot, for instance, react rapidly enough to indicate 60-cycle ac—the meter cannot tell whether you are applying 100 kilowatts for 10 microseconds and then no power at all for the next 990 microseconds, or are putting in a steady 1000 watts all the time.

This is not the magic trick it might appear to be; the receiver at the other end of the line is hard-pressed to tell the difference either. A 100-kw pulse signal which is present only 1 percent of the time is no more effective than a 1-kw steady signal which is always there. The advantages, if any, of pulse modulation do not lie in the field of getting extra power for nothing.

The 4-kw figure mentioned for HF bands is more of a play on words. Power, either input or output, comes in several different flavors. There is "peak" power—which may mean any of three distinctly different conditions–, "average" power, and "RMS" power.

To get an idea of the different possible meanings of the term "peak power", let's look at an ordinary 60-watt light bulb operating from normal 117-volt ac wall power.

During each cycle of the ac power, the voltage on the line rises from some negative value through zero to a positive peak, then falls back smoothly through zero to a negative peak which is a mirror image of the positive peak, and returns to its original value.

This complete cycle is repeated 60 times every second. And while we call this power "117-volt" or maybe "110 volts", its voltage is actually always changing. It is exactly 117 at only four instants during each cycle—once on the way up between zero and positive peak, once again on the way down, a third time between zero and negative peak, and the final time as it climbs from the negative peak toward zero.

The reason we call it "117-volt" power is that it will produce the same amount of heat in a resistor as would 117 volts of dc applied to the same resistor. This is the "RMS" value, and is a convenient label.

But the peak voltage of this 117-volt power line is actually about 165 volts; it reaches this voltage only twice during each cycle, and doesn't stay there any appreciable length of time either time.

Our light bulb is a resistor. The more voltage we apply to it, the more current will flow. The RMS current in a 60-watt 117-volt bulb would be 60/117 amp, or about 0.513 amps. The resistance, by Ohm's law, equals the voltage divided by the current or 117/0.513, which comes out to be about 230 ohms.

Now when we apply that "peak" voltage of 165 volts to the 230-ohm resistor which is our light bulb, we will get a "peak" current of about 1.38 amps—and when we multiply voltage by current to find out the "peak" power we discover that our "60-watt" bulb uses a peak power of 230 watts!

This is an impressive figure, sure. But the bulb doesn't give us a bit more light at peak power of 230 watts than it does at "60" watts. This is *one* meaning of "peak power", and you can see that it's not very meaningful. By this viewpoint, *any* full gallon is running 4000 watts peak input power.

This kind of peak power is sometimes called "instantaneous peak power", because it is present only for an instant at the peak of each cycle of the ac.

A more meaningful way of talking about "peak" power is to discuss "peak envelope power". This refers to the *RMS* power (or dc power, if input power is under discussion) present when the *audio* modulating signal is at its peak. Most sideband rigs are rated on PEP power.

This kind of peak power is what actually gets the signal through. The figures are much less than those for the same transmitter for "instantaneous peak power", but are higher than for "meter peak power" which we'll discuss next, or "average power". In sideband operation, PEP power is the power you get when the rig is adjusted for maximum linear output as discussed earlier in this installment.

In a FM rig, the output power does not change appreciably with modulation. In a CW rig, the power is either there or it is not. PEP power of a CW rig is the same as the key-down power; the term is almost meaningless for FM.

An AM transmitter, with carrier, is much like an FM or a key-down CW rig when nobody is talking. The carrier is still present. When you modulate, however, the audio power from the modulator is either added to, or subtracted from, the carrier power. The result is that peak envelope power is greater than the average carrier level.

Virtually all of the theory about AM modulation and its effects on power assumes modulation with a steady audio tone rather than voice, because the steady tone is a known signal and voices differ in their characteristics.

With a steady tone, and modulating the carrier to the 100-percent level, the resulting modulated signal's power will drop exactly to zero at the negative peak of the tone's cycle. In order for this to happen, the modulator's average power must be exactly half that of the carrier. On the positive peak of the tone's cycle, then, the envelope will have all the power of the carrier *plus* all the power from the modulator, and so will be half again greater than that of the carrier alone.

The peak envelope power of a 100-percent modulated AM signal—when the modulation is a steady tone—is always half again greater than the PEP of the same carrier unmodulated.

When voice is applied rather than the steady tone, the picture changes. Voices are not symmetrical; their positive peaks may be higher than their negative peaks or vice versa. The "100-percent" modulation point is defined as that amount of modulation which permits carrier power to be reduced to zero at any point in the modulating cycle. If the voice's highest peak comes out as a negative peak from the modulator, this will cause 100-percent modulation to occur with less voice loudness than if it comes out positive. In any case, the average level of the voice is far lower than those peaks—and so the 50-percent increase of power with modulation never occurs.

Now let's look at the "meter peak" power. This is simply the *highest* power indicated by the rig's meters while you're talking. Its chief importance is that *it* is the power which is regulated by the FCC, and must never exceed 1000 watts.

A properly operating AM rig will show no fluctuation at all in the meters when audio is applied, unless it's using "controlled carrier" modulation. Any flickering indicates improper modulation. The theoretical 50-percent increase in PEP is never visible on the meters, because the meters indicate only dc and the power from the modulator is ac in the audio range.

A sideband rig, on the other hand, will flicker widely with speech. So will a CW rig being keyed, or an AM rig using controlled carrier. Regulations specify that power of a CW rig be measured with key down; for the others, the requirement is simply that the meters never indicate power above the legal limit.

Next Month. We've come all this way and managed to bypass those little problems which require arithmetic, such as the calculation of series impedances or determinations of transformer turns ratios. Next month we'll explore those. Don't let the prospect scare you—nothing more complex than arithmetic is involved. Until then, happy hunting. ■

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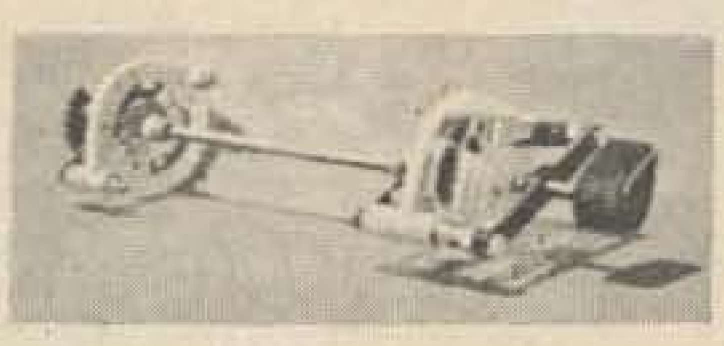
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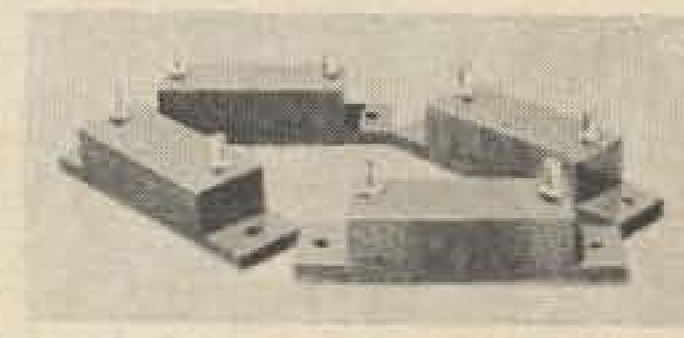
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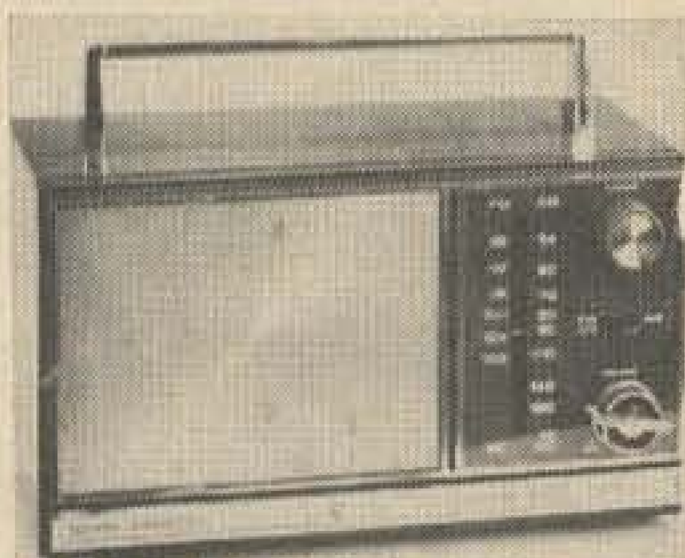

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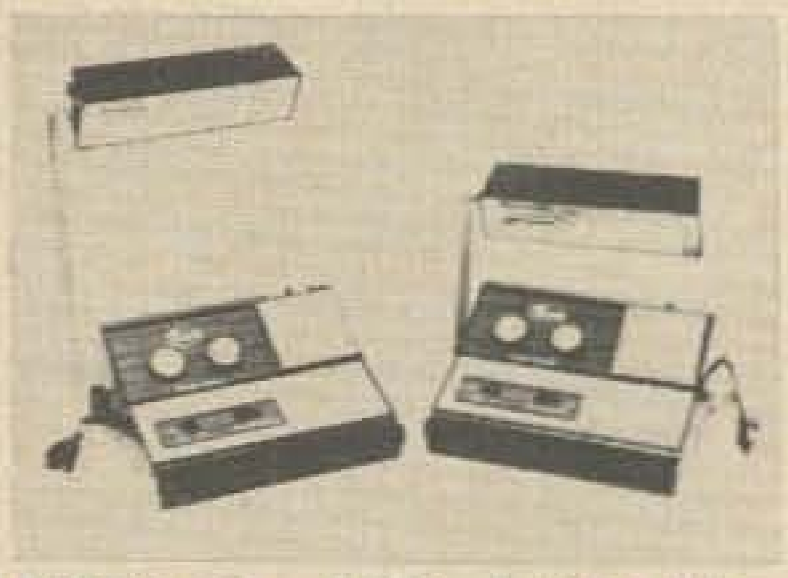

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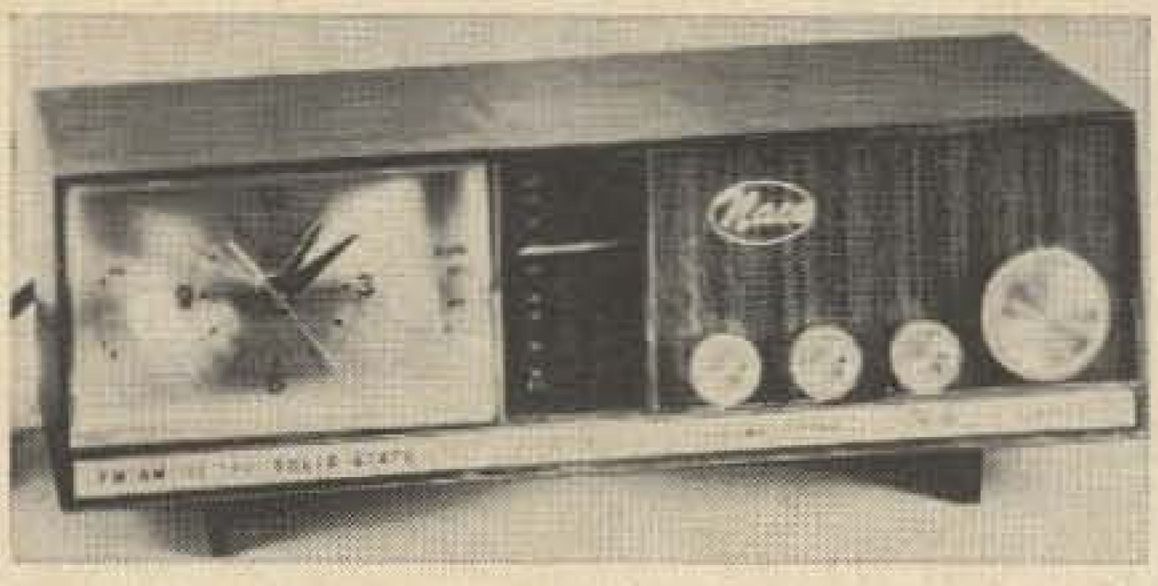

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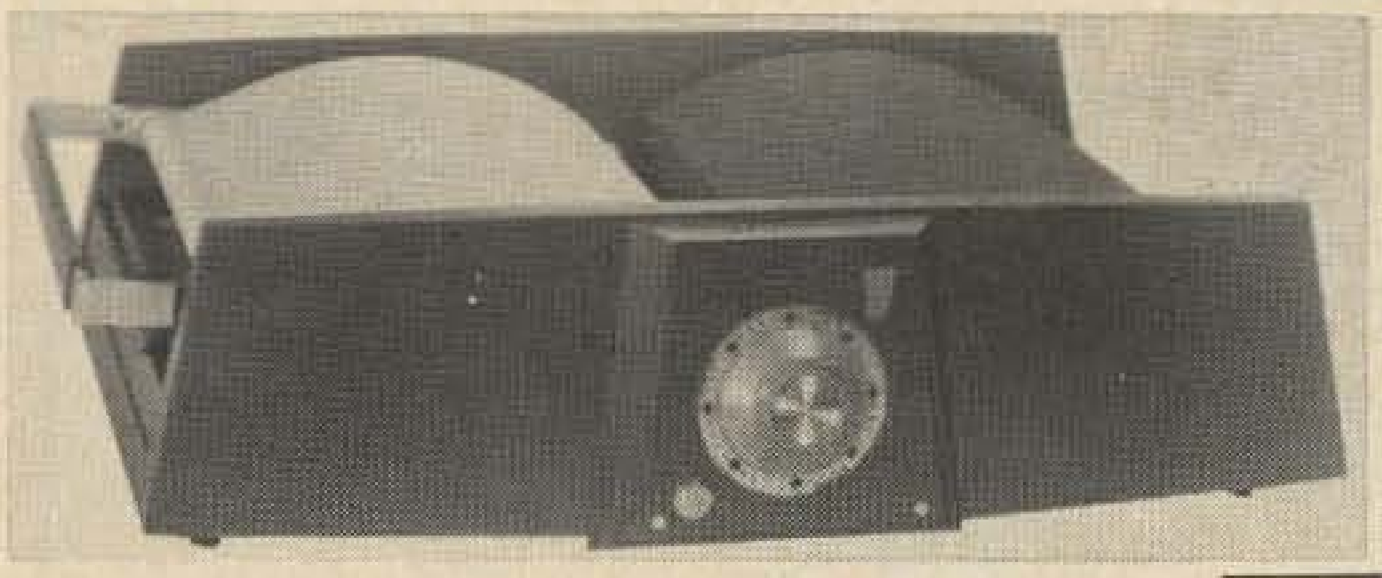

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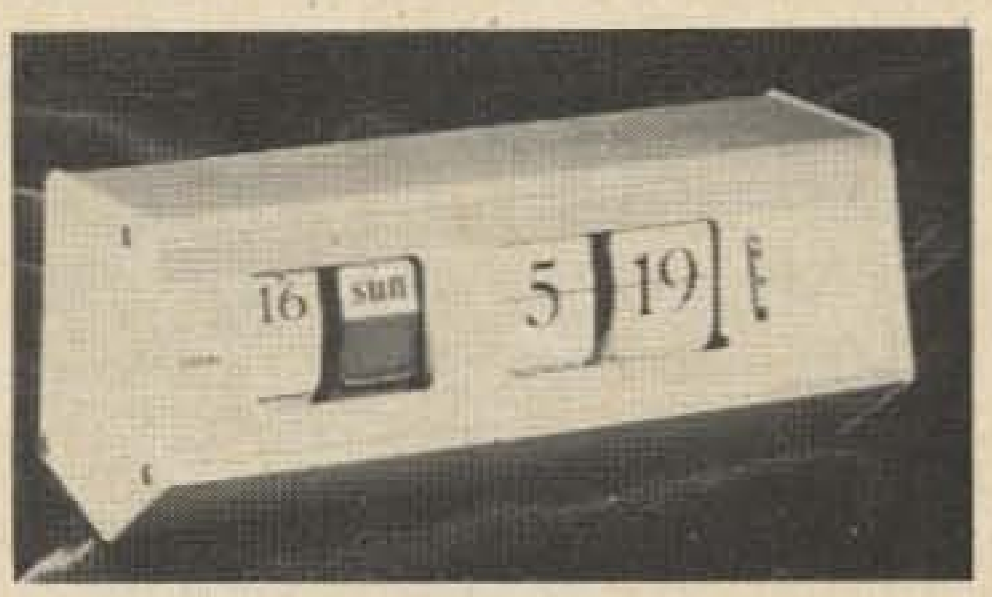

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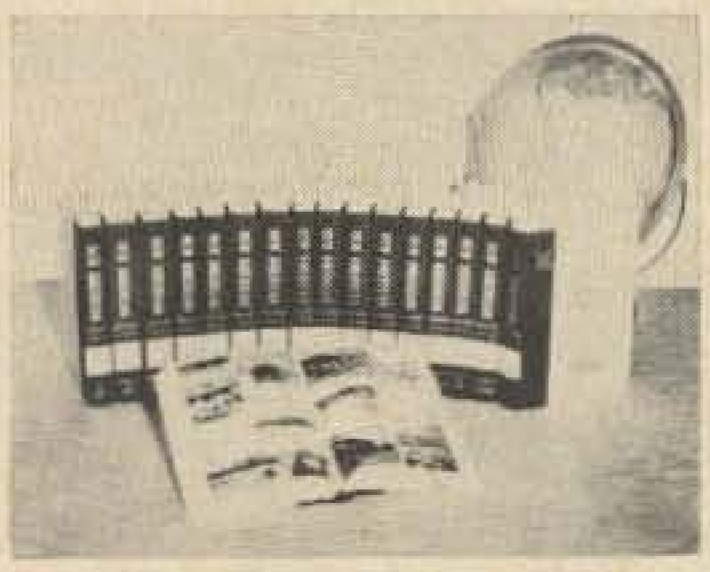

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W2NSD/1 from pg 4

more difficult job of creating hypotheses which fit the data." He goes on further to say, "I have concluded that the earth is being visited by intelligently controlled vehicles whose origin is extraterrestrial."

Dr. McDonald of the University of Arizona has been studying UFO reports on an intensive basis for over two years and has interviewed several hundred witnesses. He has reluctantly come to the conclusion "that the UFOs are entirely real and we do not know what they are, because we have laughed them out of court. The possibility that these are extraterrestrial devices, that we are dealing with surveillance from some advanced technology, is a possibility I take very seriously." Dr. McDonald goes on further to say, "For the record, I should have to state that my interviewing results dispose me toward acceptance of the existance of humanoid occupants in some UFO's. I would not argue with those who say this might be the single most important element of the entire UFO puzzle."

Friends, something very definitely is up here and it looks as if a large responsibility for the expansion of investigation of the UFOs rests on the shoulders of amateur radio. With only a small amount of organizing we can be set up to provide nationwide alerting when UFOs are spotted.

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Next comes the need for your own personal decision that you are going to try to help those interested in doing something to bring this problem out into the open. Your interest and a little time are needed to get the amateur radio UFO network built up into a 24-hour a day alerting amateur net. Amateurs who have substantial signals and will be available on the same evening week after week for about an hour of net operation should drop a card to Jim Sipprell K2HYQ, the overall net coordinator, at Box 209, Kenmore, New York. The frequency is 14.3 and the time is 0200 GMT, which is 9 PM EST.

By next spring I hope we will be ready to get everyone interested in the net set up with an alerting system. I believe that we will use a 60-cycle calling arrangement. This will be easy to standardize. Graybar has some 60-cycle tuned relays available inexpensively which can be hooked up to the receiver and left tuned to the Net channel. They are sensative to within a half cycle so other frequencies won't bother them. When any station comes on the net channel and sends a tone which is modulated with a 60-cycle note the relay will pick up and let you know. This means that both AM and SSB stations can work together in the net.

If you feel that you are ready to become involved in something really important then join the UFO net merely by checking in on any Wednesday night. In your own area you should contact your newspaper, radio and television stations, and police and let them know that you are a member of a national communications effort towards investigating UFO's. Ask that any reports be given immediately to you and offer to let them know, if they are interested, if something should appear to be headed your way from some other area.

. . . Wayne

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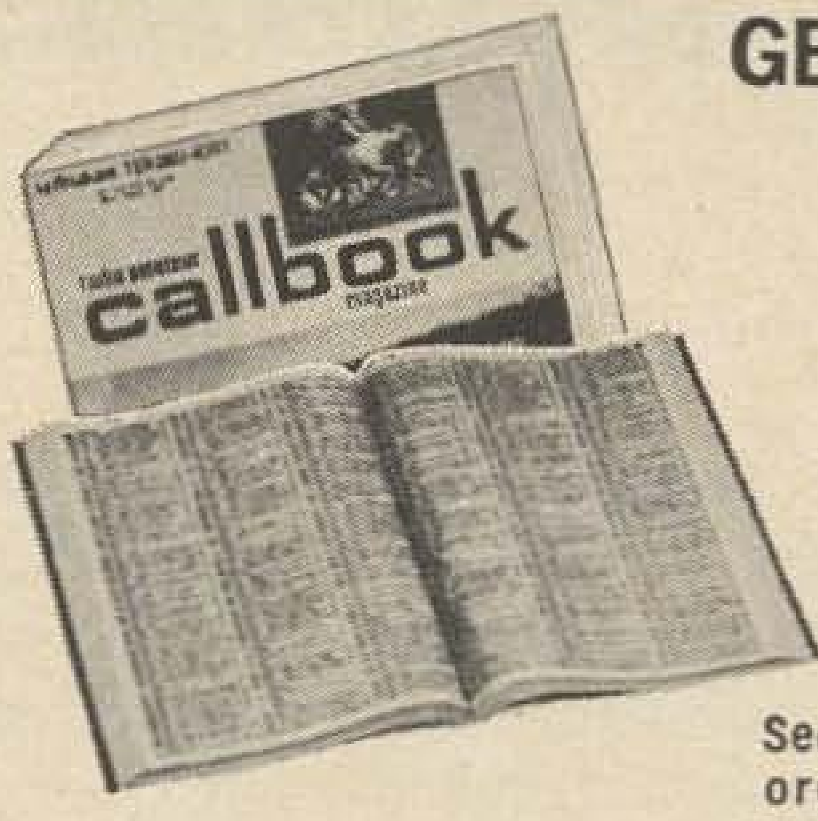

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Christmas Gift Ideas

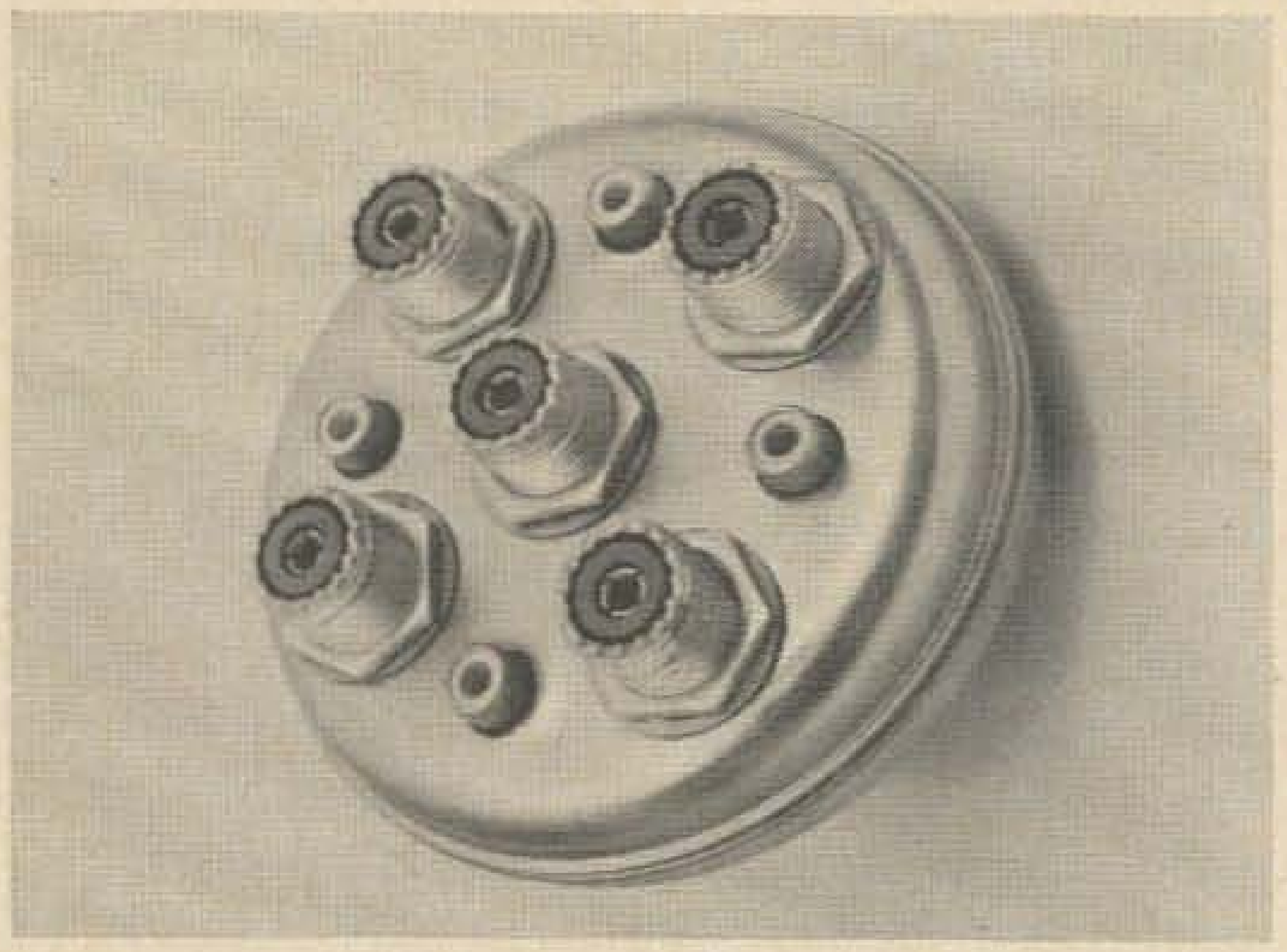
Are you trying to choose a gift for somebody with technical or amateur radio interests? That can be a very hard problem, if you do not understand what it is all about. Where can you turn for advice?

After reading through this list maybe you will feel a little more confident, and would like to try a catalog. Why not try our advertisers first? If you have a rather general kind of idea coming up maybe it's right in here on another page. Still another good approach is to talk with somebody having interests similar to the set you're trying to match. Finally, it helps to do some outside reading. Maybe you'll catch the bug and become a radio amateur too!

The items listed here are not specialized. Test instruments are good reliable gifts, since some overlapping of their functions is good practice and the fellow with an expensive piece of gear usually likes to have a simpler, cheaper one. And since the fellow who is just starting generally wants the less expensive variety, too, a purchase in this department is almost sure-fire. Some caution, and good advice in choosing your purchase is indicated, though.

73 Magazine

At a risk of sounding slightly prejudiced we have to admit 73 *Magazine* is an excellent publication for anybody seriously interested in modern ham radio and technology. This year's issues have carried a wide variety of material ranging from simple construction articles to news about recent events in technology, from using old transistor radios to the latest on those remarkable radio signals from space. No other ham magazine offers this wide range of material, interesting to the career oriented man as well as to the hobbyist. A subscription will set you back \$6.00 per year or \$12.00 per three years, and might be supplemented with a book or two from 73 Press. Try our "73 Useful Transistor Circuits" or "Diode Circuits Handbook," two of the best idea books on the market and available at a dollar each.



New Coax Switch

You can disconnect your antenna and still use it, with this new 4-position tapped coaxial switch. In addition to the usual UHF fittings it has four RCA jacks permanently connected to the output lines. Circuits or antennas may be monitored even when they are not connected into the operating system.

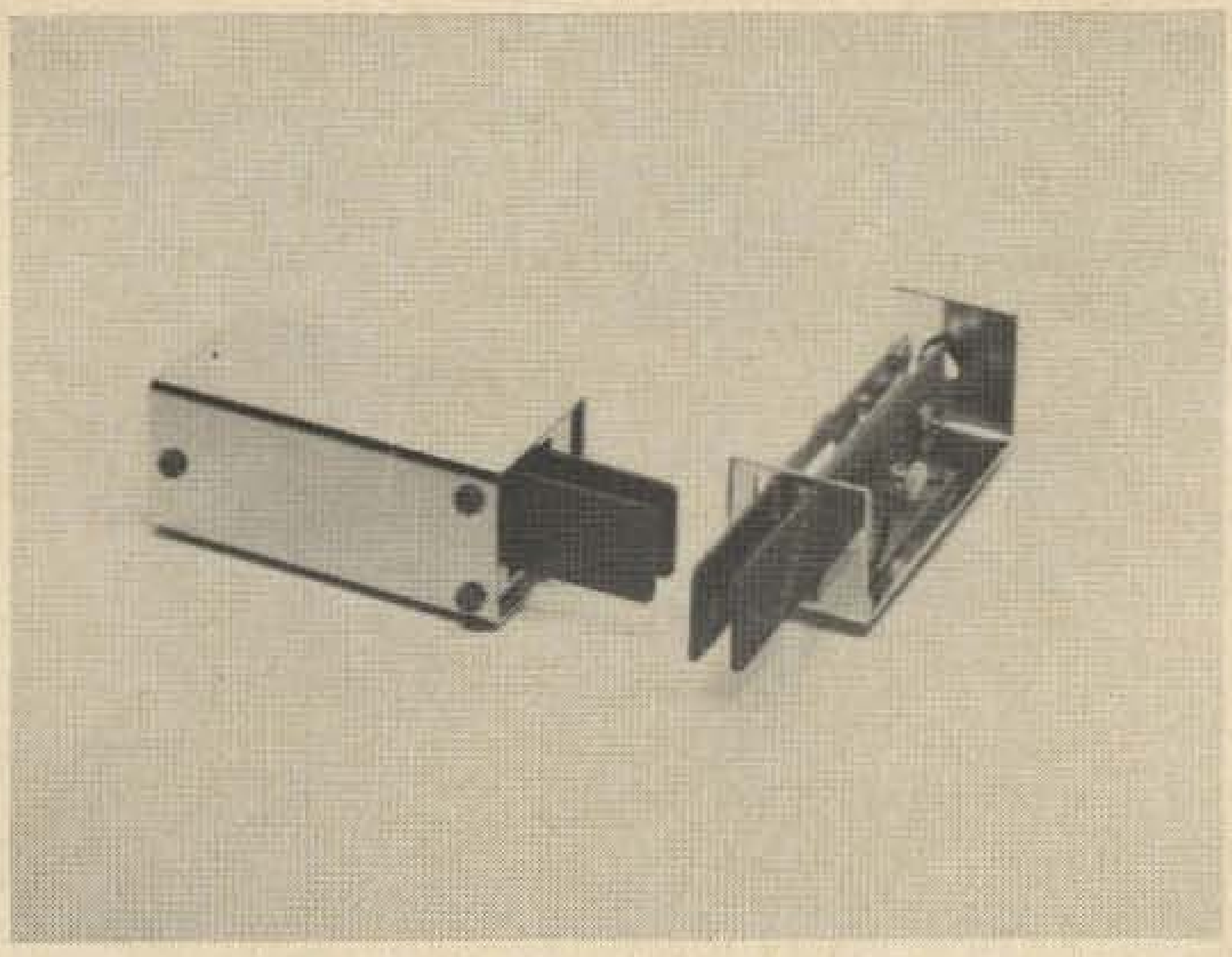
Some suggested applications are the connection of a general coverage of WWV receiver to the antenna system, installation of measuring devices or fix-tuned monitor receivers, or operation of a low-power rig through one of the disconnected antennas while the high-power rig is feeding another antenna.

Priced at about \$12. For further information contact John W. Richardt, Jr., Electronic Applications Co., Route 46, Pine Brook, N.J. 07058.

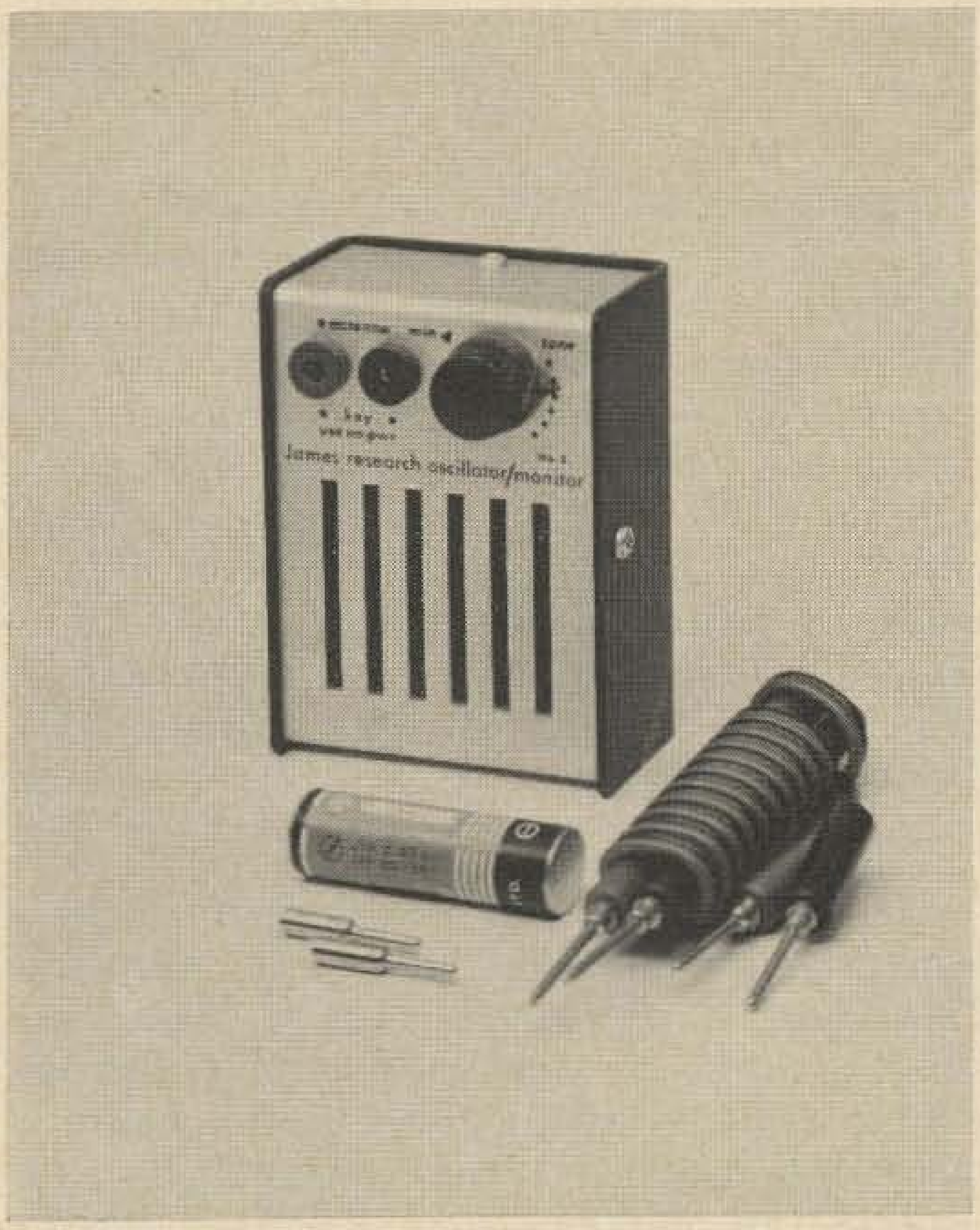
James Research Presents

Permaflex Key — \$19.95
Oscillator/Monitor — \$14.95

Many of the items offered in the Chrismas Present line tend to be quite gadgety. Here are a couple of items that could be confused with members of this class, if you have to go by eye alone, but which really belong in the active & useful category. Both appear simple, yet both are unusual in some way, and will do effective jobs around the ham shack.



First, there is the Permaflex Key. It looks simple, and it is, in a way which hides the ingenuity and careful thinking that has gone into making this a really versatile and reliable key. We can expect imitations to appear in a few months; get the original.



The other item is a simple monitoring device, offering remarkable sensitivity. It serves to tell the operator when his CW transmitter is radiating *rf*, rather than when the transmitter is expected to be working. There is a large difference, sometimes. It requires no connection to the transmitter, a point with appreciable safety factor. It can also be used for workbench applications in new gear construction, and finally it will serve as a code practice oscillator.

The Mark 2 Oscillator/monitor incorporates all of the features of the original unit which has gained acceptance by amateurs as a sensitive *rf* type of CW monitor and a code practice oscillator.

Extended amateur as well as professional use of the unit as a Test Instrument has prompted improvement in its performance and utility.

The Mark 2 features:

Increased *rf* sensitivity by the use of cryogenic production control techniques. The Mark 2 will trigger on less than 10 Milliwatts without direct connection.

Greater audio volume and wider tone control range through the use of improved components.

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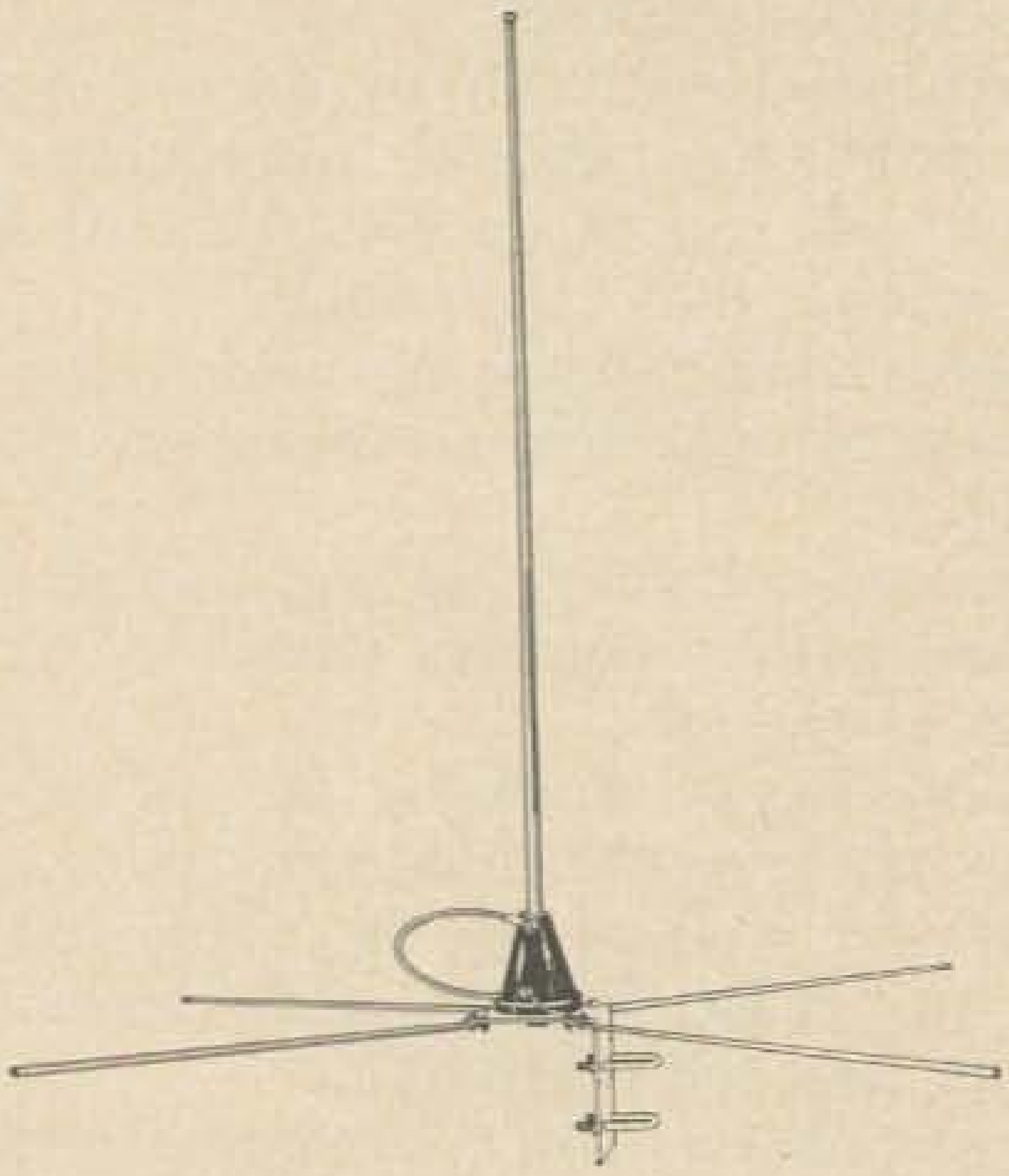
Price $14.95.

Address all correspondence to: THE JAMES RESEARCH COMPANY, DEP'T AR–M 11 Schermenhorn Street, Brooklyn, New York 11201.

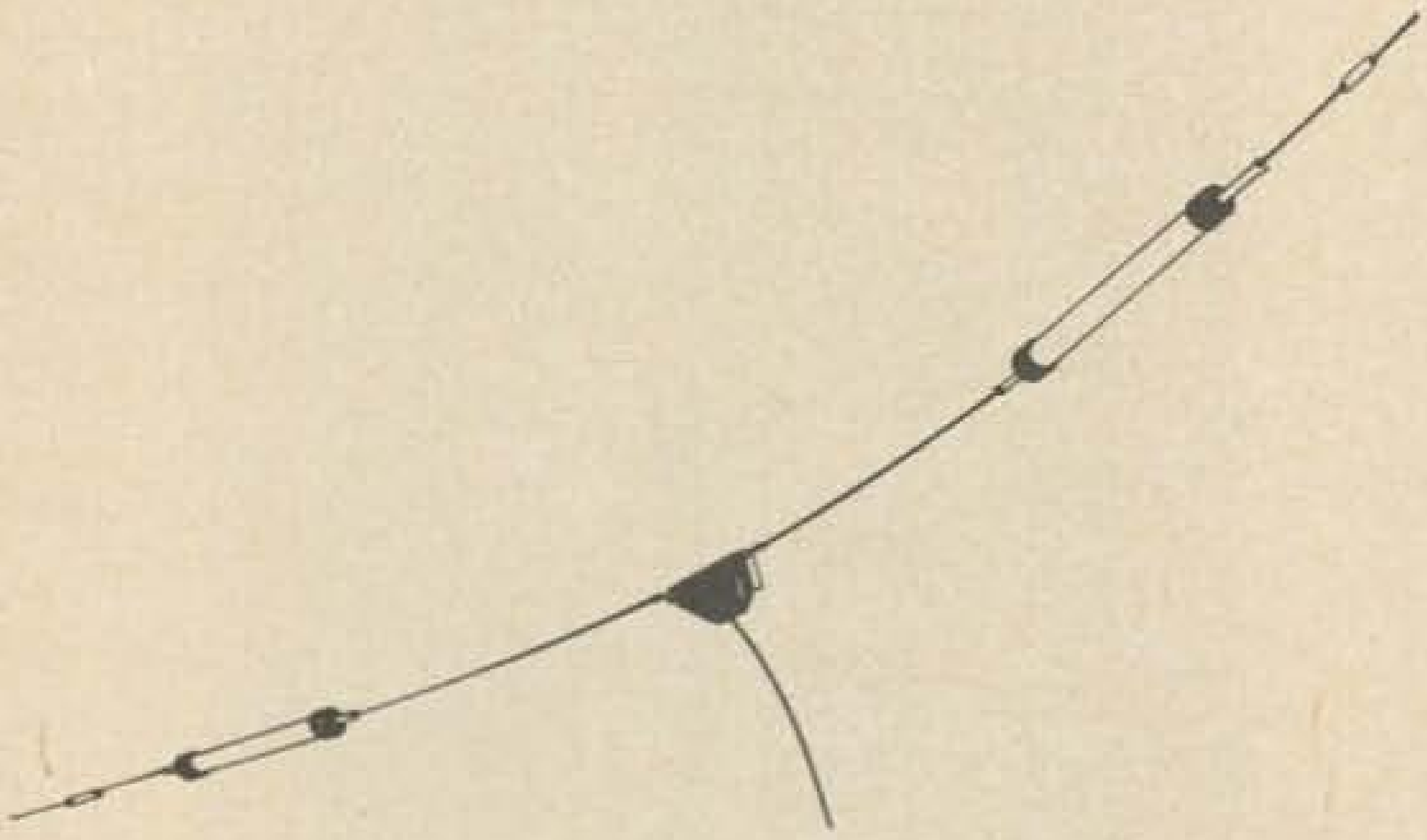
Printed Circuit Kit

Injectorall Electronics Corp. has just released a much-needed printed circuit circuit kit. It contains etchant, resist ink, resist solvent, and other material required to make up two small printed circuit boards. And then the pen and ink will do for very many additional boards, using surplus or other available board materials. Retails at $5.95, from local distributors. For further information write to Injectorall Electronics Corp., Great Neck, N.Y. 11024.

New Mosley Antennas



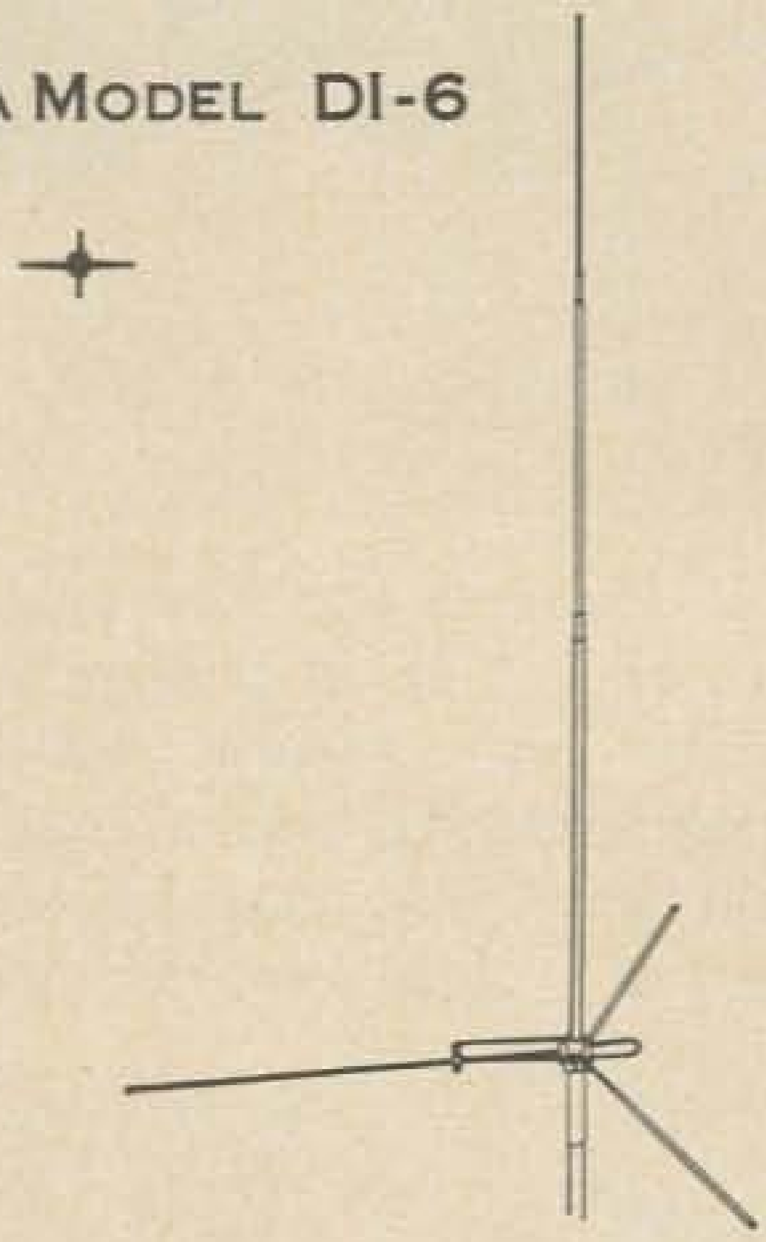
Here is a simple 2-meter antenna, engineering and construction all done, which comes at a very competitive price. The price is even competitive with building your own, if you consider the time that takes and the cost of materials. VSWR better than 1.5:1 over the range of 144 to 148 MHz. $10.58, ask for the Model D1-2 manufactured by Mosley Electronics, Inc., 4610 N. Lindberg Blvd., Bridgeton, Missouri.



Which are the three best ham bands? If you'd like to try for 10, 15 and 20 meters, or for 10, 15 and 40 meters, here is a trap antenna that will operate as a half-wave on three bands without any switching operations. A strain-relief connector takes 52 or 72 ohm coax cable, and end insulators are provided with the antenna. Rated at 1000 watts PEP for sideband communications. Priced at $17.59 from Mosley Electronics, Inc., 4610 N. Lindbergh Blvd., Bridgeton, Mo. 63042.

MOSLEY DIPLOMAT 6

ANTENNA MODEL DI-6



Rated at 2000 watts PEP or 1000 watts CW, the Mosley D1-6 six-meter antenna offers an omnidirectional pattern for general communications use. It is vertically polarized. A special adjustable coupling arrangement provides for optimizing operation at either end of the six-meter band, and swaged aluminum rods serve to reduce wind loading and metal fatigue. The antenna mounts on 1" to 1¼" pipe. Priced at $19.76. Write to Mosley Electronics, Inc., 4610 N. Lindbergh Blvd., Bridgeton, Mo., or ask your local ham or electronics dealer.

Here is a complete dipole antenna system priced well under our rather stretchy $25 limit. A dipole antenna is about the simplest kind of antenna that is really effective without getting into special circuits. Very appropriate for the young short-wave listener, the antenna can also be used for transmitting up to maximum legal power on all amateur bands through 10 meters.

The set comes with detailed assembly instructions for installing the antenna as a horizontal dipole or inverted V configuration. A center connector provides for connection to a coax cable, and end insulators are included. The DIV-80 kit is available from Mosley Electronics, Inc., 4610 N. Lindbergh Blvd., Bridgeton, Mo. 63042. Shipping weight 3 pounds, and it is indeed under $25—it's priced at $7.42. A Best Buy.

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- AC Power $79.95 extra

$420.00
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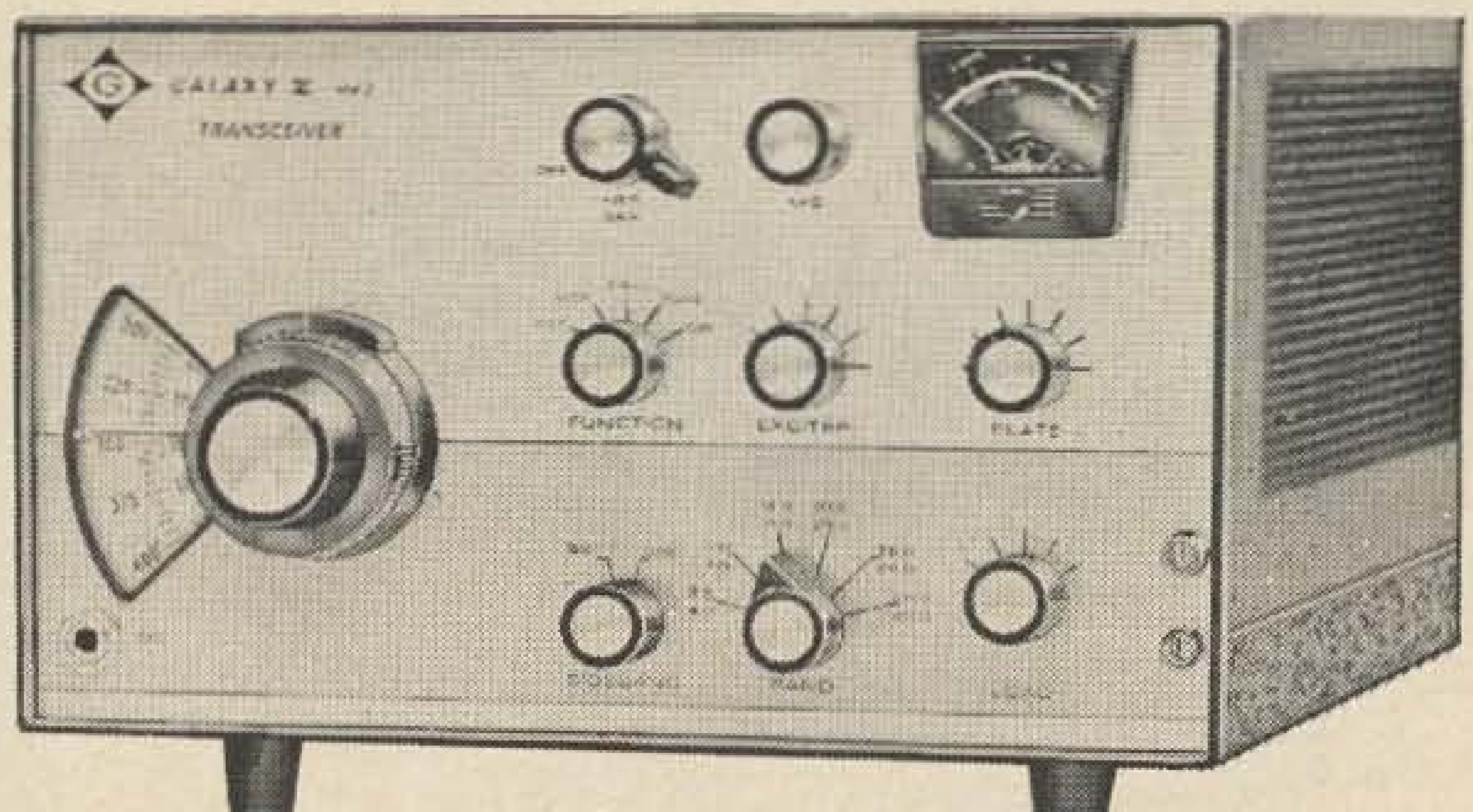

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Antenna Switch

Not all ham radio work goes on indoors, as you probably know already. Maybe there are several outside antennas, fed by one transmission line (which may be a powerful economy arrangement) or perhaps there are adjustments that must be made at the base or the center of the antenna. The least expensive approach involves many trips out to the antenna, or up the mast, but here is a remote-control switch arrangement that may do the same job. It will work with balanced or unbalanced lines (and that's all there are!) for switching or tuning applications. Ask for their Tenna Switch from the Cubex Co., PO Box 732, Altadena, Calif. 91001, at $17.95 postpaid. Also available from some dealers.

IC Projects Handbook

If you'd like to pick up two or three IC's and try getting your feet wet in the field, a copy of Brown & Kneitel's book may be just the thing for you. There isn't much chance of going in over your head, and some of the projects are unbelievably simple. To an eye accustomed to the complex schematics of discrete-components circuits IC circuits just don t look real. Yet the trend in electronics is to these tiny functional packages, and they do deserve a lot of attention. With this handy collection, you can get in some good bench work without spending days catching up on the literature.

The fifty circuits include power supplies (which I'd have placed to the front of the book), a variety of preamps, amplifiers to 50 watts, three code keyers, some signal boosters and other circuits. There are several lab circuits, and I specially noticed a TV color-bar generator that is about as complex as a basic AM receiver—because it uses's IC's.

I thought the book seemed a little odd, without any schematics of the circuits inside the IC's. But then I came to page 127 and found Brown provided a complete set of IC schematics in a separate section. Sometimes these are needed to answer hard questions about circuit behavior. It would have been nicer if parts values could have been included since manufacturers do supply this information. And a couple pages of acknowledgements and a bibliography of other places to look for more details would have been nice, too.

This looks like a nice book to have around, if you're interested in modern electronics. *Electronic Hobbyist's IC Project Handbook* TAB book # 464 by Bob Brown and Tom Kneitel $6.95 hardbound, $3.95 Paperback

Second Op.

Recently revised and brought up to date, the Second Op operating aid quickly provides DX data on stations all over the world. Which zone is he in? Which continent? Country? How about postage, IRC data, QSL bureas? It is all there and the complete collection, ready to use, sets you back a buck and a half postpaid. Current fifth edition, from Publications in Electronics, Inc., 610 Tower Bldg., 216 West Washington Ave., South Bend, Indiana 46601.

Page 1

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RCA Hobby Circuits Manual

This new 224 page manual contains detailed instructions on the construction of 35 practical solid-state circuits for use in the home, automobile, photo lab, and ham shack. It also contains easy to read sections on the theory and practical application of solid-state devices, including ICs and MOS FETs. It should be a useful and interesting book to anyone interested in the dynamic field of semiconductor circuits.

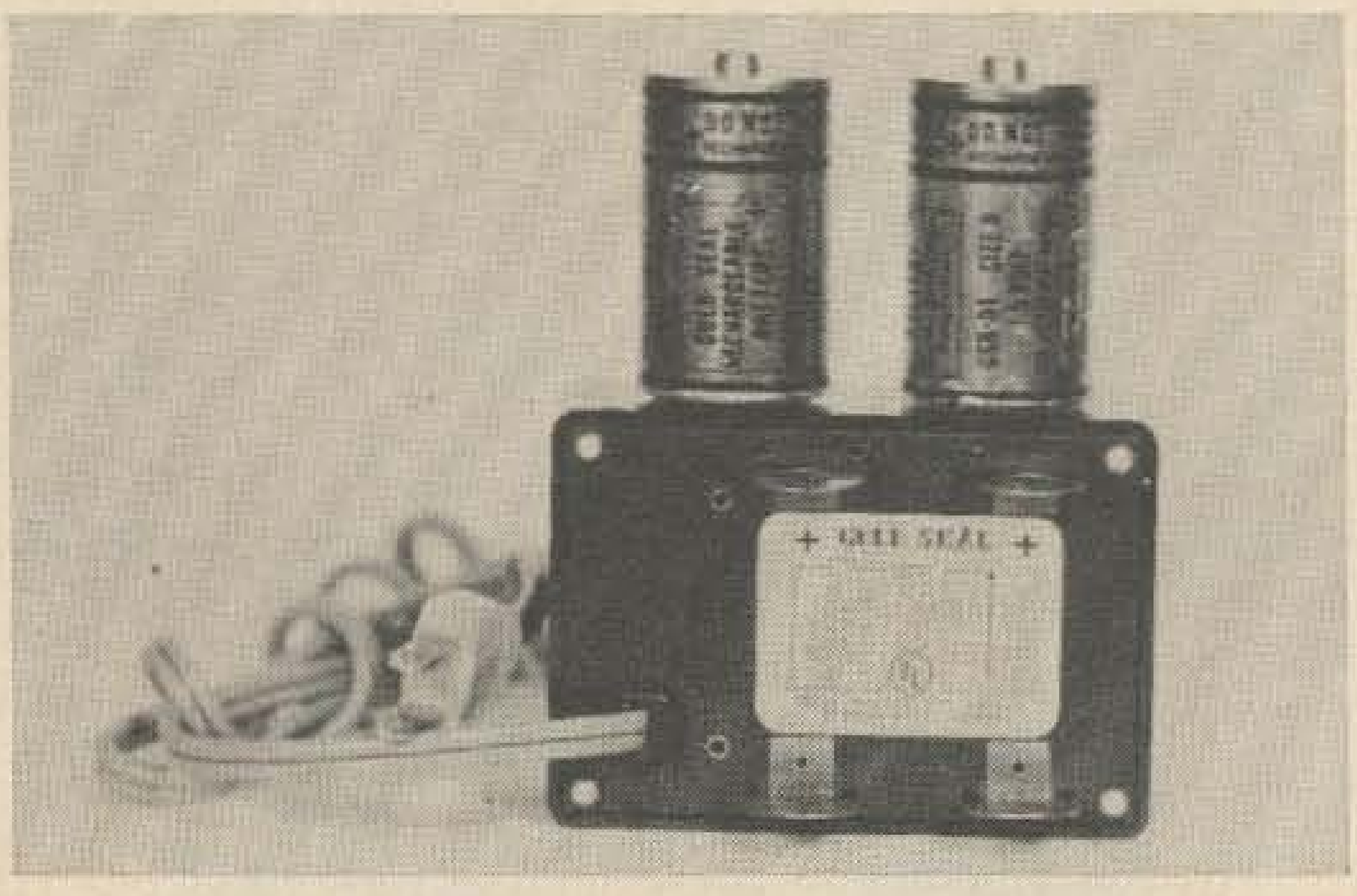
The dip-wave meter being examined by Jack Sterner W2GQK is only one of a dozen solid state circuits of interest to the amateur, covered in the Solid State Hobby Circuits Manual (HM-90) which is available from RCA for $1.75. Additional information is available from your RCA Distributor or from Commercial Engineering, RCA/Electronic Components, Harrison, N.J. 07029.

Radio Shack

A very important part of learning electronics is the discovery of the basic relation between real physical circuits and the schematic diagrams that represent the circuits to the engineer and the designer. This relation is clearest to the beginner who uses it most, and Radio Shack's 10-8 in-one Electronic Project Kit is a good beginner oriented instruction device.

Without soldering or exposure to high voltages, the beginner can quickly wire up several assorted, quite different circuits. They can be torn down and reassembled again, in the manner of a Tinkertoy set. Are those still on the market? If you're old enough to be raising a family you may remember those. Well, this is a sort of an electronic Tinkertoy set, and has excellent educational and practical value.

Ask for Radio Shack's #28-202 Electronic Project Kit, at $7.95.



Battery Recharger

If you have an application that uses lots of batteries, why not think about a rechargeable cell installation? For instance, Gold Seal Battery Co. announces one of their new low cost rechargeable cells will replace a series of 100-zinc-carbon cells, at a cost of $1.10. The rechargeable cells are sealed. A charger drawing 3.3 watts is also available, with a capacity of one or two cells for recharging.

Rechargeable batteries are available from stock at $.10 per D cell, and the Model 201 charger is priced at $4.75. Mail orders add 50¢ please, or you can try a local dealer. From Gold Seal Battery Co., 7350 Reseda Boulevard, PO Box 927, Reseda, Calif. 91335.

From Spark To Space

The story of ham radio in Canada is presented in a very interesting and readable booklet put out by the Saskatoon Amateur Radio Club. I very much enjoyed reading it. The editors (I think it was written by a group) used a historical approach, covering their subject from the beginning right

NOT FOR THE NOVICE

THE FT DX 400 "FULL HOUSE"

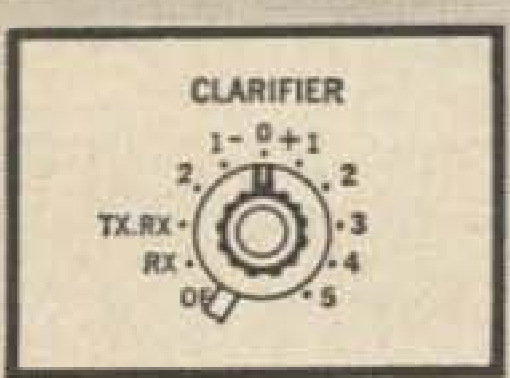
Conservatively rated at 500 watts PEP on all bands 80 through 10 the FT dx 400 combines high power with the hottest receiving section of any transceiver available today. In a few short months the Yaesu FT dx 400 has become the pace setter in the amateur field.

FEATURES: Built-in power supply • Built-in VOX • Built-in dual calibrators (25 and 100 KHz) • Built-in Clarifier (off-set tuning) • All crystals furnished 80 through the complete 10 meter band • Provision for 4 crystal-controlled channels within the amateur bands • Provision for 3 additional receive bands • Break-in CW with sidetone • Automatic dual acting noise limited • and a sharp 2.3 KHz Crystal lattice filter with an optimum SSB shape factor of 1.66 to 1.

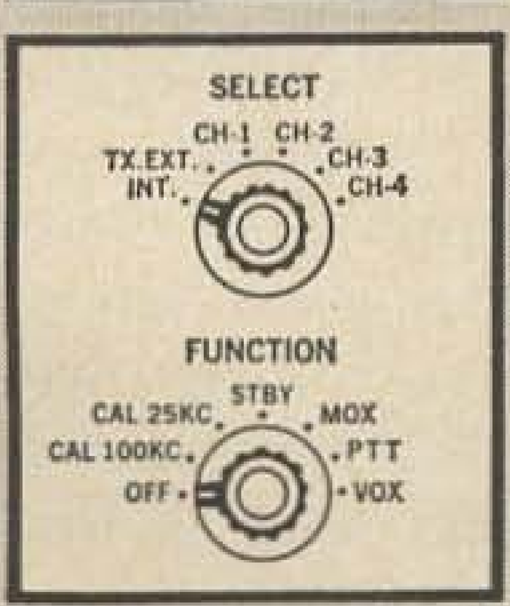
Design features include double conversion system for both transmit and receive functions resulting in, drift free operation, high sensitivity and image rejection • Switch selected metering • The FT dx 400 utilizes 18 tubes and 42 silicon semi-conductors in hybrid circuits designed to optimize the natural advantages of both tubes and transistors • Planetary gear tuning dial cover 500 KHz in 1 KHz increments • Glass-epoxy circuit boards • Final amplifier uses the popular 6KD6 tubes.

This imported desk top transceiver is beautifully styled with non-specular chrome front panel, back lighted dials, and heavy steel cabinet finished in functional blue-gray. The low cost, matching SP-400 Speaker is all that is needed to complete that professional station look.

SPECIFICATIONS: **Maximum input:** 500 W PEP SSB, 440 W CW, 125 W AM. **Sensitivity:** 0.5 uv, S/N 20 db. **Selectivity:** 2.3 KHz (6 db down), 3.7 KHz (55 db down). **Carrier suppression:** more than 40 db down. **Sideband suppression:** more than 50 db down at 1 KHz. **Frequency range:** 3.5 to 4, 7 to 7.5, 14 to 14.5, 21 to 21.5, 28 to 30 (megahertz). **Frequency stability:** Less than 100 Hz drift in any 30 minute period after warm up.

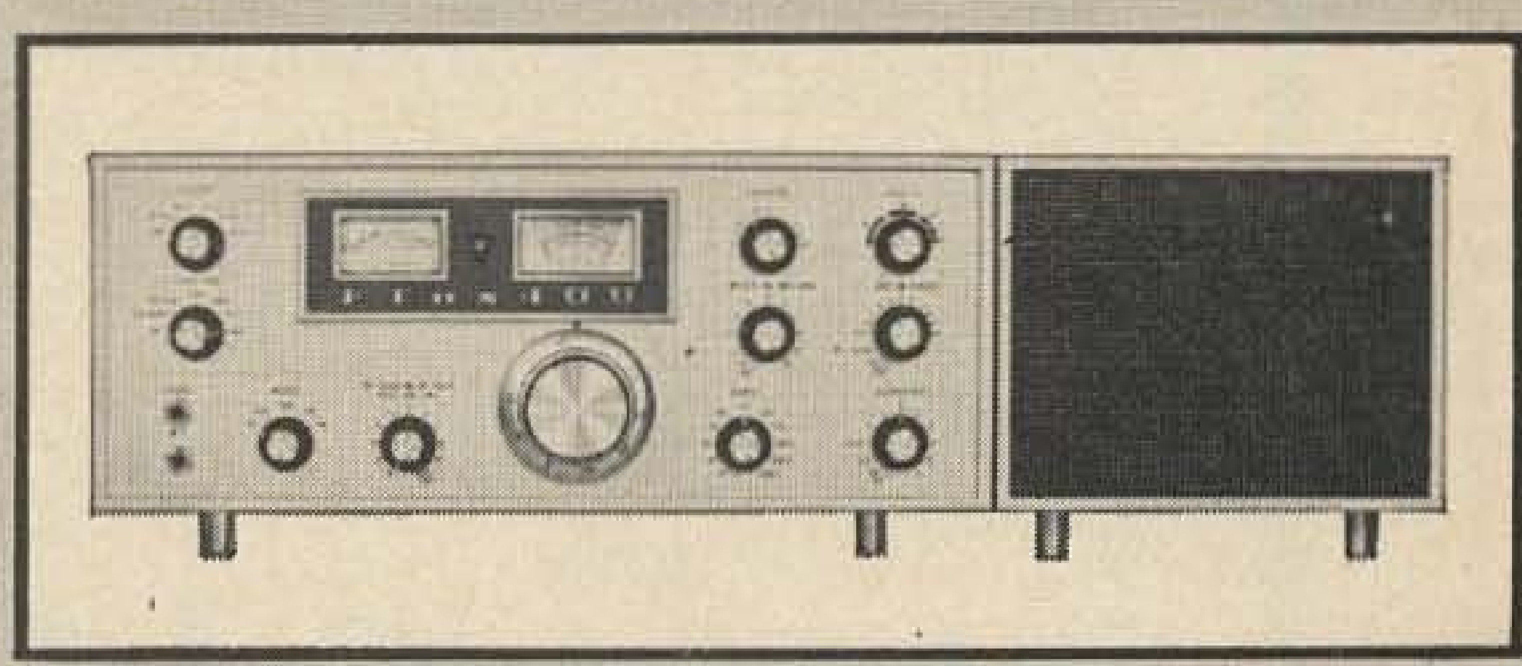


CLARIFIER CONTROL — Does the work of an external VFO — allows operator to vary receive frequency 10KHZ from transmit frequency, or may be used as an extra VFO combining transmit and receive functions.



SELECT CONTROL — Offers option of internal or outboard VFO and crystal positions for convenient preset channel operation.

FUNCTION CONTROL—Selects crystal calibration marker frequency and desired transmit mode of operation.



FT DX 400 $599.95 — SP-400 $14.95

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up to some space communications work hams are doing now. I especially liked the many excellent photos of old radio gear and workers, and on page 87 I noticed the Lakeshore Darts, Draughts, Chowder and Marching Society.

Seems some Canadian hams had a problem of commuting to Montreal to make regular meetings. After discussions on 75 Meters they tried a meeting at a local tavern. About 50 hams attented the meeting and shortly decided on a highly informal approach. Wonderful idea, isn't it? Somehow they ended up with a club title that is often abbreviated to "The Darts & Draughts Club."

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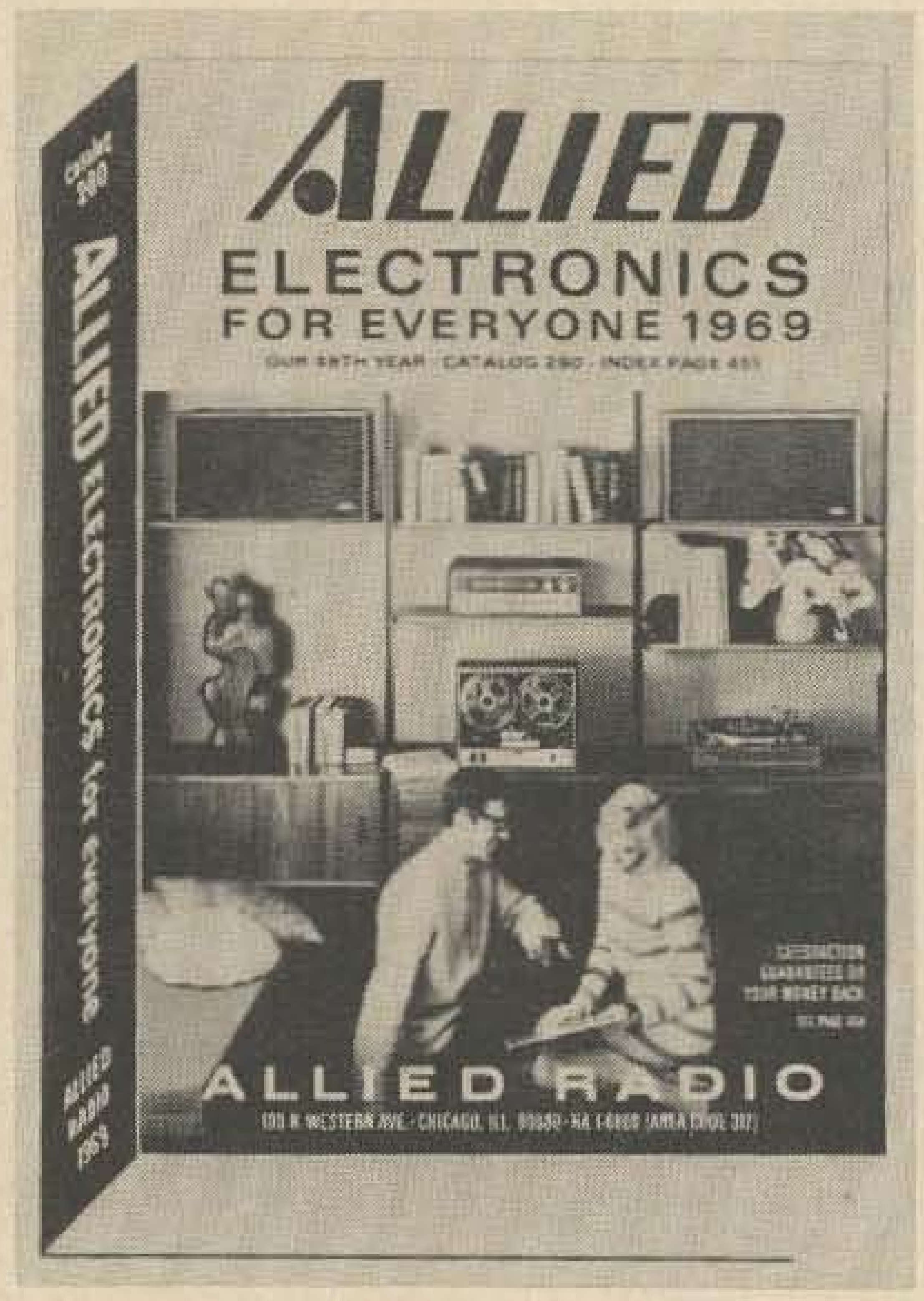

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Lafayette Radio Co.

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Or if you want to achieve the same effect on a smaller scale you could try a pair of Lafayette's F-767 hi-fi stereo headphones. Consumer Reports gave these an excellent rating a few years back and they have been selling like mad ever since. Two significant advantages are, they will do a fine job on a couple of milliwatts of power, and they are not audible all over the house. Tone quality is excellent. Lafayette #99H0035, (2½ pounds) a Best Buy at $11.88.

ARRL Books

The ARRL sells a large variety of simplified technical literature. Some people think this material does not reflect the progress of modern communications and electronics, but there is a gradual year-to-year improvement. And the publications are found everywhere.

At $3.00, the Radio Amateur's Handbook is one of the most generally used construction and shop practices handbooks available, and you can probably find it locally at a radio store. Try your library if you want to see a copy, and almost anybody who is an amateur operator will have one.

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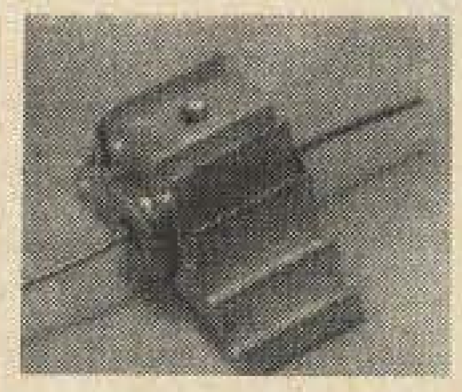

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Three Black Boxes

Fig. 1. Three black boxes which make up a station.

The basic concept of a radio transmitting station often gets overlooked in concern with details. It is good to back off and take a look at just what makes up a radio transmitting station. With this thoroughly understood, we can make a more fruitful approach to the design and application of those components that make up a station.

If we erase the black and look into the left-most box, we could see any one of an almost infinite variety of radio-frequency generators plus its primary power supply. Stripped down to basic symbolic representation, it looks like what's shown in **Fig. 2.** This is true regardless of whether the transmitter uses vacuum tubes, transistors, *rf* alternator, or any other simple or exotic device for generating *rf* energy. It's also true whether the device is for radiotelegraphy or for radiotelephony; whether it is amplitude modulated, frequency modulated, pulse modulated, or any other variant you can dream up.

For the next step, let's skip the middle box and consider the right-hand one. It denotes the radiating device, normally an antenna. An antenna, like a generator, can have an infinite variety of forms: Capacitor, loop, ferrite, magnetic, electrostatic, vertical polarization, horizontal polarization, a c t i v e, passive, frequency-discriminating, broad-band, etc., etc.

To this, add another infinite series of possible feed systems and you'll see why it's wise to show just a black box! Regardless of its physical nature or its electrical configuration, the antenna (and its feedline, if one's involved) has but one function: To couple the *rf* power output of the transmitter to the 377-ohm intrinsic impedance of space in such a manner as to obtain the required radiation pattern (directional, non-directional, vertically-polarized, etc.) At the space-antenna interface, the impedance is 377 ohms. What that impedance is at the spot where the antenna-feeder system inter-connects with the middle black box is a matter that varies greatly, both in the magnitude of impedance and in the nature of impedance (resistive, capacitive plus resistive, inductive plus resistive). This is why the middle box is so important to the functioning of the total radio transmitting station.

Two basic functions are performed by the middle black box. One is frequency discrimination (or selection). The other is impedance matching. Very few generators of radio-frequency alternating current produce pure sinusoidal waveforms. Almost always there is an appreciable harmonic content which must be rejected. In certain types of transmitters, there are undesired by-products of frequency conversions that must not be allowed to radiate. Therefore the middle box has a "tuning" function.

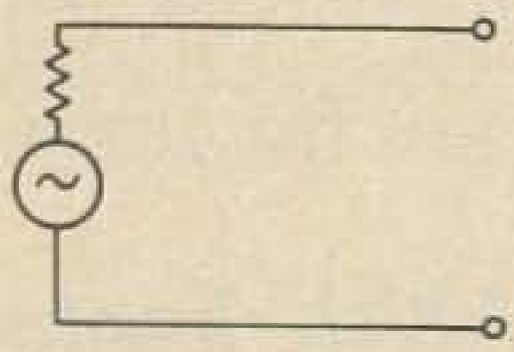

Fig. 2. Basic symbolic representation of any rf generator.

The second function, impedance matching, is more complex. Because of this complexity, it is more difficult to achieve during design and construction. By the same token, it's less well understood. Too many publications gloss over the subject with a few time-worn platitudes that serve only to entrench midunderstanding. The discussions you hear over the air and at amateur radio gatherings reveal the lack of understanding. Yet the basic subject, like most basic subjects, is quite simple and should not be difficult to understand thoroughly. This, of course, holds true only if you don't confuse the situation by making it unnecessarily complex.

Go back to **Fig. 2** and take another look at it. You'll see a generator with its internal resistance. To take maximum power out of this generator, you need to have a load equal to that internal resistance. (Sometimes, for reasons we'll not treat here, we want to mismatch the load. This will decrease the transfer of power but may achieve another, and desired, purpose.) Note that I wrote "resistance", not "impedance". In almost all instances, we'll need a pure resistance to load the generator. Supplying this pure resistance, in the desired magnitude, is the second job we ask the middle black box to do.

You'll recall that the right-hand black box, the antenna plus its feed system, had a very wide range of possible impedances. The middle black box must process these impedances and convert them to a stipulated value of pure resistance. Note that I used the plural form, not singular. Very seldom will this impedance remain constant in an amateur radio station, with its ability to cover many frequencies within a band and many bands within the Amateur Service allocations.

Let's say we have a transmitter with a vacuum tube requiring a load (resistive of 4000 ohms. Also, that we have a doublet antenna center-fed with 52-ohm coaxial cable. There is a small probability that at one frequency (hopefully within an amateur band) this will present an impedance of $52 + j\emptyset$ to the middle black box. Transforming this to $4000 + j\emptyset$ with a pi-network presents no real problem to either a designer or a constructor. Even $25 + j\emptyset$ or $100 + j\emptyset$ can be copied readily. These idyllic situations seldom are found in amateur radio stations other than those using rhombic, disc-cone, or log-periodic antennas! So let's go back to that doublet. As soon as you depart from the one frequency where you found the "ideal" impedance, you'll notice $j\ \emptyset$ vanishing. In its place will be a finite value of either plus or minus j (depending upon the direction of frequency departure) which will increase in magnitude quite rapidly as you swing away from the "ideal" frequency. These values of reactance ("j") are not so simply dealt with by the usual pi-network. They can be coped with, within reason, but to do so requires the design (and construction) of a very flexible impedance-matching circuit. If the middle black box is to perform its full function, this flexibility must be present. Because this device helps to achieve an impedance match, it should be thought of as an integral part of the middle black box.

So you see, a radio transmitting station may be shown as three black boxes. One holds the generator, one holds the impedance-matching portion, one holds the radiating section. One generates the rf power, one matches the generator to the radiator, one matches the radiator to space. Quite simple!

. . . W5EHC

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Facsimile and the Radio Amateur

It's fun and exciting to experiment with facsimile. This mode of communication is gradually becoming as popular as slow-scan television and teletype. There are many potentials for which facsimile can be used in amateur radio. Before we discuss these potentials there are some facts and experiences your author had with facsimile which may be interesting.

From April to the middle of September, Propect Facsimile Antarctic logged more than 300 hours transmitting pictures to KC4USV at McMurdo Station. Although the distance was 8000 miles from the transmitting station to the receiving station, eighty-five percent of the pictures received were of good quality and contrast on their initial transmissions. The small percentage which were of poor or fair quality were retransmitted and received in normal quality. Successful transmissions were made with signal reports of S3 although for the majority, reports were S7 to S9. Some evenings only one picture got through to McMurdo Station before the band "folded", while on other evenings as many as two to ten pictures were transmitted with very good copy. Very little interference was noticed during the six months period of facsimile operations and this may have been due to the selection of frequencies (14.100 to 14.200 MHz) authorized by the Federal Communications Commission. The biggest problem of the facsimile operations were the magnetic storms in the Antarctic which delayed transmitting schedules from one day to a week at a time.

For those not acquainted with facsimile equipment or the operations, this introduction may be of interest and possibly the beginning of another mode of communications for experimentation.

Facsimile Photo of Miss California as received at McMurdo.

Introduction

Facsimile transmission consists of sending pictures or other printed material by radio or land line. It makes use of the process known as scanning. The scanning like the human eye follows each horizontal line from left to right and returns to a starting point at the left hand side of the page or picture and repeats the process many times to reach the bottom. This produces a permanent copy of any material whether type, script, photographs or schematics. Facsimile equipment as used today requires a slow speed (usually 60 rpm for amateur radio) which produces a copy of the record in a matter of minutes.

In the transmitting of facsimile a picture is scanned about 100 lines per inch. As the light beam passes over each portion of the picture it is reflected into a photoelectric cell and the variation in the intensity of the reflected light, due to the character of the picture, creates voltage variations in the output circuit of the photo-cell. These variations make up the picture signal and are a source of modulation for the radio frequency carrier of a transmitter. At the receiving station, the signal is demodulated and the voltage variations created at the transmitter are used to operate a recorder.

The potentials of facsimile communications in amateur radio are unlimited. It needs only imagination to find ways to use facsimile for many purposes. Some common applications in amateur radio are sending and receiving pictures, schematics, bulletins or QSL cards plus anything that calls for a permanent record. There are radio amateurs who have facsimile equipment and use it for copying weather maps from Canada and the satellites high above the earth. In tornado and hurricane areas, these weather maps would help the NCS of the warning networks. The NCS with facsimile equipment would have advanced information on the weather and a permanent record of the weather map.

Equipment

The equipment used by Project Facsimile Antarctic during the facsimile operations to the Antarctic was the TXC-1B Times Corporation Transceiver, MD 168 Modulator, RD 92A/UX Receiving Recorder and CV 1066A Receiving Converter. This was all compatible with the fascsimile equipment at McMurdo Station in the Antarctic. Although the TXC-1B Transceiver can be used for transmitting and receiving, the RD 92A/UX was used as a monitor for all transmissions and occasionally for receiving.

The TXC-1B Transceiver is an electromechanical-optical facsimile set of the revolving drum type for the transmission and receiving of pictures, printed matter, maps or sketches. Received copy is recorded on chemically treated paper. The equipment will transmit or receive a page of copy 12 x 18 inches in 20 minutes. The MD 168 Modulator is used to convert amplitude modulated facsimile signals from the TXC-1B Transceiver to audio frequency shift facsimile signals of 1500 to 2300 cycles. The input signal to the modulator has a frequency of 1800 cycles and an amplitude that varies with the light and the dark parts of the picture being scanned at the facsimile transmitted. The output signal from the modulator is an audio signal with 1500 cycles the maximum signal input and 2300 cycles the minimum signal input to the modulator from the facsimile transmitter. As the audio frequency-shift signal from the modulator is of constant amplitude the transmitted radio frequency from the radio transmitter is modulated at a constant percentage of modulation and is known as subcarrier - frequency modulation.

To receive the audio frequency-shifted signal, the RD 92A/UX Recorder was connected with a CV 1066A/UX Converter. This converted the audio frequency-shifted signal output of the radio receiver into an amplitude modulated signal suitable for the facsimile recorder.

Although Times Corporation Facsimile equipment was used for the operations of Project Fecsimile Antarctic, there are other manufacturers of this equipment such as J. P. Seeburg Corp. who build their machines for Western Union Telegraph Company and the Alden Electronic & Impulse Recording Equipment Company for the U.S. Weather Bureau Stations. Both companies have adjustable speeds on their recorders and can be made compatible between receiving and transmitting stations.

Radio amateurs interested in experimenting with facsimile equipment can secure it through the MARS program, when available. Recently Western Union Telegraph Company donated some of their older model "Interfax" equipment to the radio amateurs in some of the larger cities. If you live in or near one of the larger cities of the United States, contact the technical service manager of the telegraph company. Mention you are a radio amateur and that you wish to experiment with facsimile and would appreciate one of their discontinued models of facsimile equipment, *interfax*. You might be lucky. On the Alden Facsimile equipment, this company sells their discontinued models and inquiries should be addressed to their main office in Westboro, Mass.

Facsimile operations at present are assigned to the frequencies from 50 MHz to 40,000 MHz, however special permission must be authorized by the Federal Communications Commission to use it on the low bands. With slow-scan television just recently becoming legal on the low bands, it is hoped that facsimile operations will also be legally allowed on these bands.

There was lots of work attached to Project Facsimile Antarctic, but Earl, WA6URW, Ellis, WB6EGH and I enjoyed every minute of it. Try experimenting with facsimile and you will feel the same way. . . . K6GKK

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Required Reading for the Die-Hard AM Operator

Would you believe that, in this electronic age, there are still amateur radio stations without the capability of SSB operation? If you find this fact plausible, it should not be difficult to convince you that there are also many hams who don't really know what single sideband is all about (and some of these hams are operating SSB exclusively). We are all familiar with the clichés of the SSB versus AM controversy: "Twice the output of AM with the same power"; "I would need a special receiver"; I don't want anything to do with that quack sounding stuff"; "It only uses half the spectrum space of AM". But how many of us have actually taken the time and trouble to do a little reading to see just what the advantages are to utilizing single sideband as a mode of transmission, and what we must obtain in the way of basic equipment, or put out in cash, to either change to or add SSB to the present station?

Fig. 1 is provided as an overall comparison of AM, double sideband, and single sideband in easy-to-read table format with the hope that it will create enough interest among the non-believers to convince them to read the article. The gain figures are computed with a reference of 1 and are given only as average power values which do not show actual gain advantage. If you have already designed and constructed a single sideband transmitter, this article probably won't tell you anything new. If you have just added a product detector to that old station receiver to make it easier to receive SSB signals, but haven't gotten around to obtaining a transmitter, this article should convince you to take the final step. In the event any of the die-hard AM operators have been stimulated to read this far, be advised that this article is mainly meant for you. Even if you don't believe everything you read it might give you some extra ammunition for your altercations with the "Quackers". In the following paragraphs I have tried to state the differences (not necessary advantages) between AM and SSB in easy to understand terms and give examples which should emphasize the points in various ways. Although double sideband is not a common mode of transmission for hams, its characteristics are included for comparison purposes.

Power

Unfortunately, the most important consideration of the present-day ham appears to be the amount of power the transmitter can provide. With a well matched antenna system we expect all the power in the transmitter final to be transferred to the antenna and into the ether. This case naturally considers the transmission line to be lossless and the antenna to be a perfect radiater. This generalized impression is misleading. First, considering AM transmitters, we must remember that the power is usually given by the manufacturer as so many watts input. This value is dc watts input to the final and, since we cannot expect the final tube to be much over 75% efficient, the unmodulated output will be much less than the rated input. When the transmitter is modulated 100% with a pure sine wave the dc power is varied at the frequency of the sine wave and increased 50% in amplitude. That sounds fine, you say, because allowing for some peak power loss we still have as much average output when modulating with voice as the stated dc power input. However, the power leaving the final of the AM transmitter, and thus that power being sent along the airwaves toward that rare DX station, is not all contributing to the best possible reception on the other end. The transmitter had a carrier frequency which was modulated in order to transmit some intelligence, in this case your voice. Therefore, a band of frequencies

1000 W Av. Output Eff. = 100%	Power Distribution Carrier	USB	LSB	System Gain	Power Gain	Spectrum Space	S/N Advan.
AM	666.6 W	166.7 W	166.7 W	25 db	22 db	6 kHz	None
DSB	Insig.	500 W	500 W	27 db	27 db	6 kHz	None
SSB	Insig.	1000 W in either sideband		30 db	30 db	3 kHz	None

Fig. 1. *Overall comparison of the three modes.*

determined by your voice and the circuit elements of the modulator was mixed with the carrier frequency, producing the carrier, upper sideband, and lower sideband, both of which contain the same information. However, as you remember, we said above that the power could be increased a maximum of 50% by 100% modulation. This increase in power is equally divided between the two sidebands while the major part of the transmitted power is taken by the carrier. Since the carrier contains no intelligence, and only one sideband is necessary at the receiving site for demodulation, our effective power is only one sixth of that being transmitted. In other words, the transmitted AM signal has two thirds of its power in the carrier and only one third in the sidebands.

If we were to suppress the carrier and feed only the two sidebands to the final stage all power would be transmitted in the sidebands, thus doubling our effective power.

Progressing further along this line of thought, if we suppress the carrier and feed the final stage with only one sideband, it should be possible to use the available power to transmit the single sideband, thus utlizing all the power for the transmission of intelligence. This is indeed the case and we have again doubled our effective power.

Example 1: For a transmitter rated at 5KW output and modulated 100%, the power will be divided:

	LSB	Carrier	USB
AM	833.3W	3333.2W	833.3W
DSB	2.5 KW	Insig.	2.5 KW
SSB	5 KW in either sideband		

Example 2: Looking at it another way, the AM transmitter in the above example must have a total output of 30KW to equal the power of the 5 KW SSB transmitter. Therefore, the system gain of the SSB transmitter is six times that of the AM transmitter and the gain in db is:

$$10 \log 6 = 7.78 \text{ db}$$

The above examples were made on the basis of equal signal-to-noise ratios at the receiver, which as explained later is valid, and no limitation to the peak power of the AM final amplifier. However, since the amateur service is allowed to feed the final transmitter stage with only 1000 W, this value obviously becomes the limiting factor.

In an AM transmission the peak amplitude (at maximum voltage swing) for a 100% modulated wave is twice the amplitude of the carrier wave alone. Therefore, the peak power of the modulated wave is four times the normal carrier power. This is caused by the doubling of the plate voltage of the amplifier at the peaks of the modulating wave. When the voltage (E) is doubled, the power will increase four times according to the formula:

$$P = \frac{E^2}{R}$$

Where P = Power out
E = B+ Voltage
R = B+ Resistor

In other words, the power in a 100% modulated wave is 50% greater than the carrier wave alone. Then, if we have a 1 KW carrier signal and a 100% modulated feeding the final stage, our modulated output would be 1.5 KW, disregarding tube efficiency. The peak power output would be four times the normal carrier power or 4 KW.

Example 3: Using the limiting factor of 1000 W unmodulated input to the final we can see that only 500 W can be provided for both sidebands or 250 W in each. This means the AM system can provide an average power (both sidebands) of 500 W to 1000 W for the SSB system, or a 2:1 advantage for the SSB system.

Example 4: Utilizing peak power as a reference, the AM system must peak at 4 KW to equal the SSB peak power of 1 KW. However, the AM system can produce only 500 W in both sidebands while the SSB system can put the whole gallon in one sideband. This ratio of 4 KW:0.5 KW or 8:1 gives the SSB system a signal power advantage of:

$$10 \log 8 = 9 \text{ db}$$

This is just about the difference between a dipole and a junior sized 3 element beam!

Spectrum Requirements

A well designed communications system is not intended to efficiently transmit high fidelity music. If we desired to transmit such material with a frequency range of 20 Hz to 20 kHz using normal amplitude modulation, 40 kHz of spectrum space would be necessary. Some time ago telephone company engineers found that satisfactory voice communications could be transmitted using only the 300 Hz to 3 kHz portion of the audio range. Therefore, audio amplifiers, modulators, and filters are designed to pass only this range of frequencies. Although seemingly narrow when compared to the high fidelity limits, this band of audio frequencies provides intelligible communications. If you have ever noticed the problem of tuning in a YL operator on SSB, you will realize that the higher range of voice frequencies appears to make the bandwidth narrower than it really is.

Example 5: Utilizing only these audio frequencies, the normal AM transmitter will produce sidebands a minimum of 3 kHz above and below the carrier frequency, thus using a total spectrum space of 6 kHz.

Example 6: A single sideband transmitter using the same audio frequencies will produce only one sideband either 3 kHz above or below the carrier frequency, depending on which sideband is being transmitted. As shown, a single sideband transmitter requires only one half the spectrum space necessary for AM transmission.

In addition to the above saving in spectrum space, there is another benefit of SSB which is often forgotten. By greatly suppressing the carrier, we have removed a major source of interference from the bands. When two AM stations are utilizing frequencies less than 6 kHz from each other, interference is caused by heterodyning of the carriers. Two SSB stations, both operating on the same sideband, can easily transmit within 3 kHz of each other without causing interference. It is also possible to operate SSB at even narrower intervals due to the missing carrier, the only interference being in the form of "monkey chatter" caused by the audio of the nearby station.

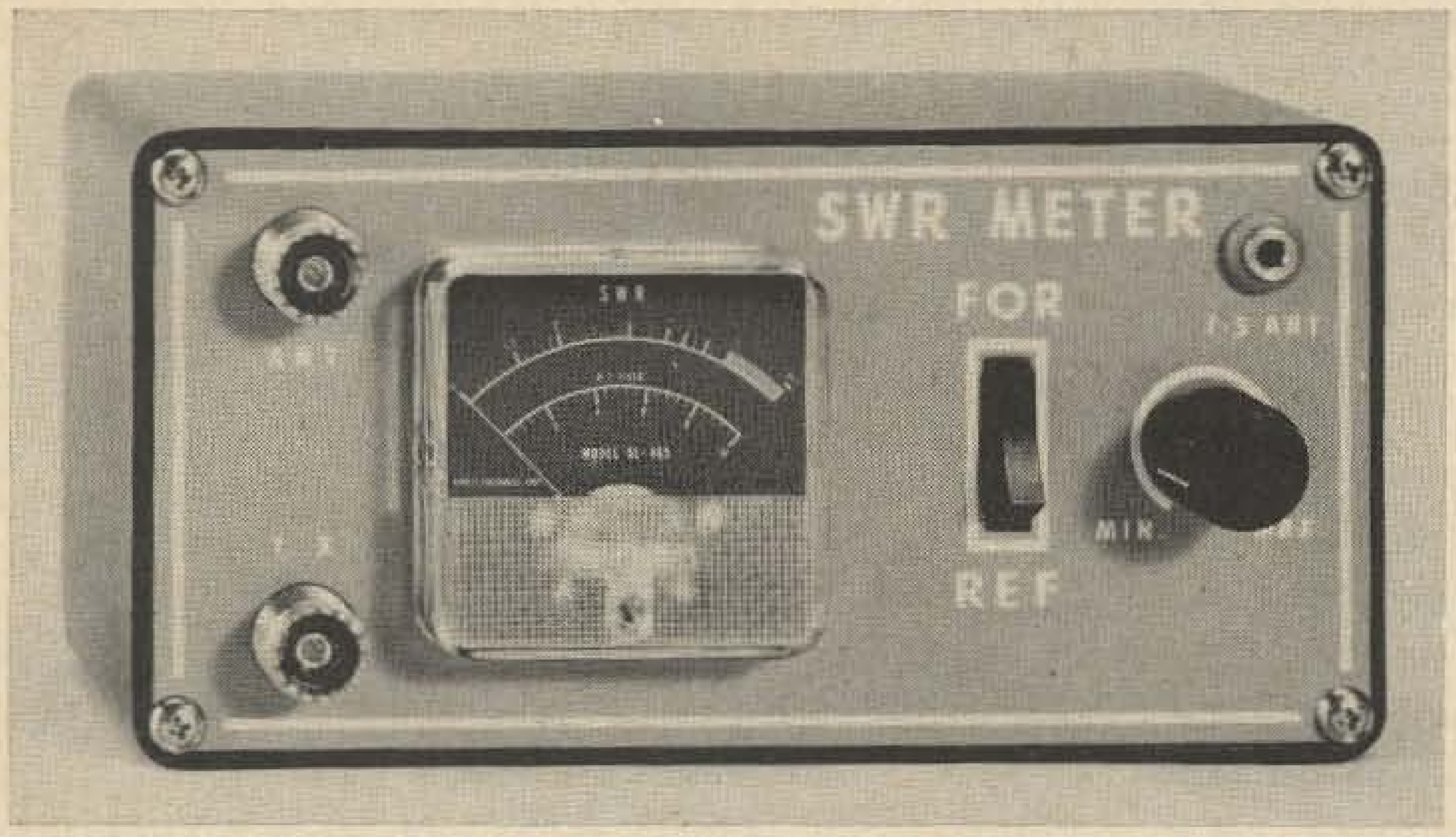
Example 7: Considering the above facts, a 96 kHz portion of the frequency spectrum could be effectively utilized by 16 AM stations or 32 SSB stations. Intelligible communications could also be obtained if an additional 16 SSB stations were evenly spaced among the already present 32. This would give every one of the 48 SSB channels a bandwidth of 2 kHz. Thus an average ratio number of possible transmitters per mode to required spectrum space would show a 48:16 or 3:1 advantage for the SSB mode.

Noise and Propagation

In examples 1 and 2, we noted that the calculations were made on the basis of equal signal-to-noise ratios in the receiver for both AM and SSB signals. The AM receiver detector usually has a 6 kHz bandwidth signal to work with so that both sidebands are demodulated producing equal audio outputs. The SSB system has only one sideband to be demodulated, thus produces only one detector output at one half the amplitude of the AM radio.

Example 8: Although the AM receiver detector produces twice as much audio from an AM signal, the noise on both AM sidebands is twice that on the one SSB sideband, thus there is no signal-to-noise advantage for either system.

At first glance it would appear that we should see some improvement in AM long distance communication over SSB, as far as the signal-to-noise ratio is concerned, due to the wider bandwidth. The Hartley-Shannon law tells us that the total information in a signal is directly proportional to the bandwidth, time taken to send the information, and the signal-to-noise ratio. Therefore, a certain amount of noise interference on a long transmission path can be overcome by increasing the bandwidth of the signal. However, although the AM sidebands cooperate to raise the power output in an AM system, they tend to work against each other over the long distance path when fading occurs. This is due to the fact that the sidebands in an AM system are being "transmitted" by the carrier. When the carrier is received by two different ionospheric signal paths, the different lengths of the paths cause the received signals to be out of phase with each other. The amount of phase difference is dependent on the signal paths and can be 180°, in which case complete cancellation occurs. Any phase difference of the carrier other than 180° will cause some de-



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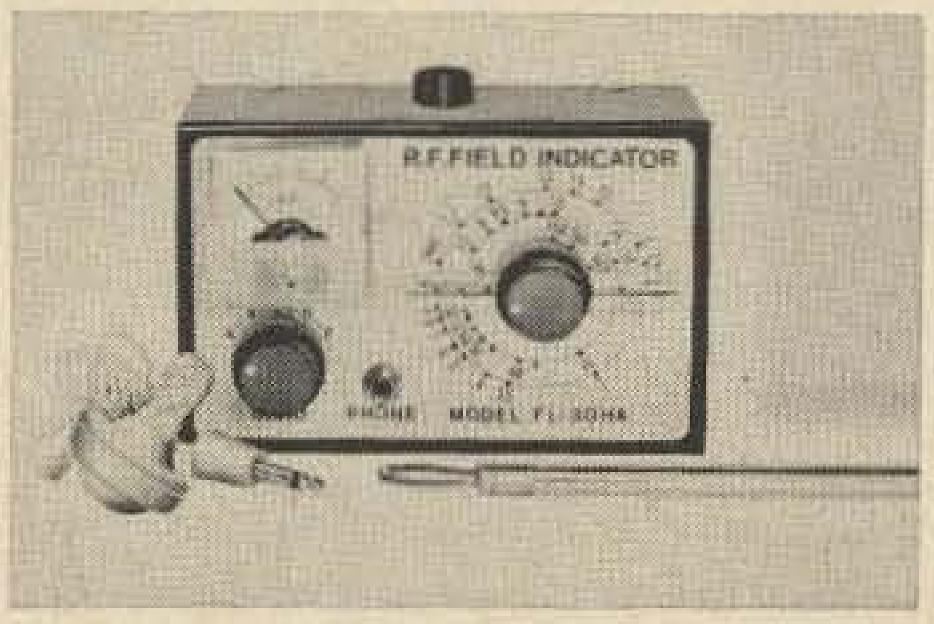

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gree of fading but, more important, it will cause the sidebands to interfere with each other producing distorted audio. Such fading can be avoided by diversity reception (two receivers and two separate antennas) or refined receiver design with special phasing circuitry.

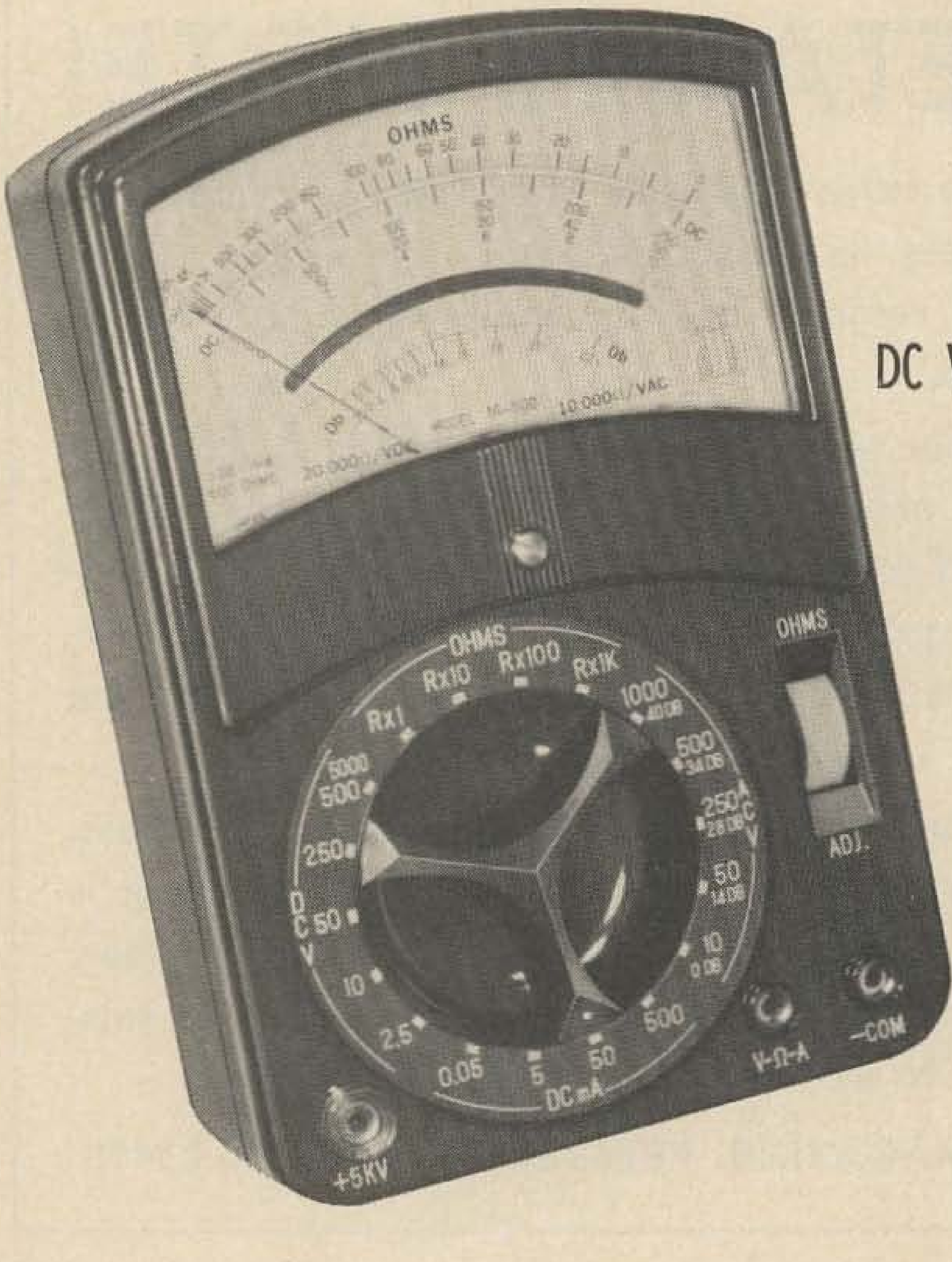
Example 9: Since the transmitted SSB signal contains no carrier, selective fading is not a problem and, under the same conditions, a 12 to 16 db improvement over AM can be realized.

It is possible to use the scatter phenomenon for medium distance (1000-2000 miles) communications. This effect is more prevalent on the high bands and is utilized by the military and government for reliable "back-up" systems. The transmission path is scattered and therefore is dependent on transmitter power rather than propagation conditions.

Example 10: Since communications using the scatter phenomenon is dependent on transmitter power and more power is available in the SSB system as compared to an AM system, it is possible to make contacts with SSB when the bands are "dead" for AM.

Reception

Because an AM signal is transmitted with a carrier it is a simple matter for the operator to find the signal and for the receiver detector to demodulate it producing an audio output. However, in SSB, where no significant carrier is transmitted, there will be no indication at the receiver of any signal being transmitted except when the operator at the other end speaks into the mike. Without a carrier to beat with the receiver heterodyning oscillators the AM detector has no reference and produces only unintelligible distortion. In order to receive SSB the carrier must be reinserted at the receiver. The point of insertion may be almost anywhere before the detector but must be the frequency of the transmitted signal. The best way to convert an AM receiver for SSB reception is to add a product detector. Since this article is not meant to get into the necessary circuitry for single sideband, suffice it to say that the product detector is essentially a mixer/demodulator which is fed with the incoming SSB signal at the *if* frequency. Because there is only one sideband, the driving oscillator output must be quite a bit higher than the signal amplitude to provide a useful audio



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output. The biggest problem in this system, which may be considered a disadvantage by homebreders, is the necessary stability required for the BFO, or oscillator feeding the product detector.

Example 11: If the reinserted oscillator frequency is different from the transmitter suppressed carrier frequency, the output from the synchronous detector (product detector) will show an equal difference in the audio from the original modulating frequency. The injection oscillator frequency may differ from the carrier frequency by ±20 Hz without affecting intelligibility. However, frequency deviations greater than 50 Hz will produce only distortion from the product detector.

Reception of SSB on a receiver with a bfo is possible by setting the bfo at the center of its range and adjusting the *rf* gain control for best reception. Since only one sideband is being received, the audio gain will have to be increased. Although changing the *rf* gain will affect the S meter reading, such adjustment is necessary so that the bfo signal amplitude will be as high as possible above the signal level.

Transmission and Basic Costs

There are a number of companies which manufacture SSB adapters which can be used with most AM transmitters. The best route to go, however, is to purchase a new transmitter or transceiver. If you are still using an old AM/CW rig remember the trade-in value is getting lower every day. The cost of a 500 W (1000 WPEP) single sideband transmitter, which can be used on AM and CW by inserting the carrier, is no more expensive than an AM rig of the same power. Although the transmitter front end components, such as filters, audio networks, and balanced modulators are more expensive to design, there is a savings in the final amplifier where dissapation ratings can be lower than those required for AM. If you don't want to lay out any more cash than necessary (who does?) you can use the old transmitter and receiver as trade-ins on a new transceiver.

Example 12: *Old*

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If you have a linear amplfier, it can be used on SSB as well as AM. If you have been using a Class B amplifier for AM, there are plenty of articles in the "Radio Amateur's Handbook" and past issues of "QST" and "73" which provide information on construction of a linear and which could be used to modify the Class B amplifier to Class AB.

Now that you have read about the differences and possible advantages of SSB, how about dropping a line to one of the equipment dealers advertising in "73" and asking for a trade in quote on your old rig toward a more efficient SSB system. They will even pay the shipping costs!

. . . K3PUR

References:

Stoner, "New Sideband Handbook"
Capitol Radio Engineering Institute, "Communications Engineering Technology"
ARRL, "The Radio Amateur's Handbook"
Goodman, "What is Single Sideband Telephony?", QST, January 1948
Norgaard, "What About Single Sideband?", QST, May 1948

W1EMV continued from pg. 3

rich. Don't you believe it. Ham radio is merely a sideline with most of our manufacturers, or they couldn't afford to stay in business. The best you can say is that they get a tax break on their *losses* from ham radio. Just hope they stay with it, or you may have to drag out the soldering iron and go back to to the easy building of AM equipment.

. . . Kayla W1EMV

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Limitations on Antenna Reciprocity

W. B. Cameron WA4UZM
324 South Riverhills Drive
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This is an attempt to answer the question "How come?" in the February, 1968 issue of 73. Most amateurs are acquainted with the theory (variously called the Rayleigh-Helmholtz theory or the Carson theory of reciprocity) that a good transmitting antenna is reciprocally a good receiving antenna. This works well enough for us to tune an antenna in the one mode with reasonable confidence that it will then perform adequately in the other. However, as with most scientific theories, there are a number of underlying assumptions about other conditions being limited, uniform, and unvarying, and if one or more of these assumptions is not met, performance will be different from what is theoretically predicted. As anyone who has studied antennas carefully will attest, the complications in this field are indeed wonderful, but let us briefly examine a few which are quite likely to affect the amateur's attempt to estimate antenna performance.

In the first place, arguing that an antenna will perform reciprocally in the receiving and transmitting modes assumes that the medium in which wave propagation takes place is homogeneous. This is pretty nearly true for antennas which are mounted high above the earth and operating at line of sight distances with their major axes properly oriented, such as with VHF antennas situated on high towers operating over flat terrain. This assumption is almost never met on the lower bands or under skip conditions. Most amateurs are acquainted with what is called "one-way skip". Conditions can exist whereby the medium in which the wave is propagated is much more favorable for transmission from point A to point B than it is from point B to point A. One of the situations in which this is most readily apparent is on the VHF bands when there is a discontinuity in the temperature of the air masses overhead, producing what is frequently called tropospheric bending. The lens or prism effect in the air masses does not always work precisely the same going both ways. However, the lens is merely a crude analogy when applied to a discontinuity of the air, as is the analogy of a mirror to describe the higher ionized strata which turn a radio wave back toward earth.

Another complication of reflected propagation is that radio waves which go into the ionosphere may become turned around or twisted before being sent back. The result is that a wave which is vertically polarized upon leaving the transmitter may return to some far distant receiving station in a horizontally polarized condition. This means, of course, that an antenna which favors horizontal polarization usually works much better in receiving such a DX signal, although it may not make much difference in transmitting. This may be one of the reasons why people complain about the ineffectiveness of vertical antennas for receiving, although they consistently perform well for low-angle radiation in transmitting. It is not merely that the antenna may not work exactly the same both ways, but the same antenna used for receiving may not face the same conditions that it itself produces in transmitting.

On 144 MHz in the early 1950's, some of us in Cincinnati established to our own satisfaction that, for receiving, capture area was almost as important as gain itself. One of my friends found that transmitting with a large collinear ("bedspring") instead of a Yagi did not produce an appreciably greater signal in the other man's receiver but its use would greatly enhance the signal received at his own end. The explanation seems to lie in the greater capture area of the large "flat" antenna compared to the small "pointed" one. Unfortunately, to simulate this on low frequencies would require an installation comparable to some of the big transmitting antennas at the Voice of America, consequently few hams ever get a chance to investigate the effect of capture area on the low frequency bands.

Related to this problem of capture area is what we might term the angle of acceptance of an antenna. This becomes a factor in multiple element arrays which are not flat with respect to the incoming wave front, whether of the Yagi or Quad or other type. We said that the reciprocity theory could be expected to work only if the antennas were properly oriented. Very few amateurs, even on the VHF or UHF bands, have facilities for controlling the orientation of the antenna except in rotating it horizontally (northeast, southwest, etc.) We know that the signal is not coming in parallel to the earth, but we usually do not do anything about it. Now if we were able to tilt the antenna boom and also rotate the boom axially we could begin to adjust the antenna to the proper attitude with respect to the wave fronts coming in. Some very surprising things would result if we could do so, and anyone who has tried it will bear this out.

I suspect that it is this factor of vertical orientation which may go far to explain the question asked by W4YM, with reference to comparing his two-element and four-element Quads. Much of the signal coming into either antenna is not coming straight on into the cone which we imagine in front of the leading element. Much of the signal is coming in from various angles above this.

Now if the vertical pattern of the antenna were smooth and regular, the angle at which the signal came into it would of course affect the "S" meter reading to some extent, but would not be very critical. Certainly it should not be any more critical than the horizontal angle, which is what we usually consider in the case of a beam. However, the fact is that on many antennas the vertical pattern exhibits several lobes and partial nulls. These are not planned and they are not particularly useful, and for the most part they are completely ignored. However, if the antenna happens to have a null in the forward direction at say, thirty degrees from the vertical, then with signals coming in at this angle, rotating the antenna horizontally will have very slight or erratic effects as compared to the antenna's performance on low-angle DX signals. Anyone who has played around with rotary beams during times of extreme short

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skip can verify these facts and can probably appreciate this explanation. This does not in any way mean that under conditions of high-angle radiation and reception a beam antenna is worthless, but it does mean that we just can't point the receiving antenna at the transmitting station in *one axis alone* and expect optimum results.

By the way, one of the major advantages I see in the Quad over the Yagi is that it compresses the signal vertically as well as horizontally and for a given horizontal angle of radiation or acceptance compresses more energy, and with a smooth pattern, since it is compressing at about the same angle vertically. With many Yagis things are very much different. Some Yagis which show a fine smooth pattern horizontally have a miserable and erratic pattern vertically. The easiest way to test this is to build small tabletop antennas, using as a signal source something like an *rf* interferometer. You can learn a great many instructive things about antenna patterns in this way without a great deal of expense. A satisfactory setup is a pingpong table sitting in your carport or out in the back yard, assuming that the antenna half-wave is only about four or five inches. A severe limitation on this method, however, is that it is exceedingly difficult to learn anything about antenna feed line impedences on these small antennas. As with all other branches of antenna experimenting, you give up something for everything you get.

Further complications in trying to compare a given antenna for transmission and reception lie in matching the feed line to the load. We all know that, in transmitting, antennas should be matched, to reduce the SWR. Moreover, we have reasonably good methods of measuring this in most modern amateur shacks. Note that I only say reasonably good, because our methods are far from any laboratory standard, but they are about as close as any practical need requires. However, I have never been in a ham shack which could do an equally good job of determining the match to the receiver. If the line is behaving differently in the receiving mode from its performance in transmission, we should not expect closely reciprocal results.

When it comes to signal level measurement, most amateurs are unable to compare from one station to another with even a usable degree of accuracy. About all an

"S" meter is good for is a tuning indicator and a take-off point for limited conversation with the man at the other end. I have tried calibrating "S" meters carefully on some of the receivers that I have built, but in recent years have given up and left the things off the receiver entirely. It was simply too much trouble to try to get a scale honest and linear across a usable range and when I did, an accurate report merely insulted the guy at the other end, who had been used to inflated reports from other people using some of the commercial receivers. Let me just state briefly and succinctly that any definitive work testing the reciprocity of a receiving-transmitting antenna would require signal measurement capabilities which were both appropriate and comparable at both ends of the circuit. This is almost never approximated. The best I could ever do was to calibrate my own receiver accurately for one band, using as a reference a transmitter across town where we had a pretty good measurement of the input power, and then testing the antennas we wished to compare between these same two stations, holding other variables constant. This, bear in mind, was for one path only. I could not say anything definitive about these same antennas operating across the reverse path.

Even working between stations in close proximity you may have to select sites carefully to get a clear path. Reflections from objects near the earth do some mighty funny things to a signal and severely distort the "free space" antenna patterns. Reflections from objects far from the earth can also do funny things. I'm told that signals coming back from the moon have a reverse spin, which means that the best antenna for transmitting is precisely the opposite in this aspect from the best one for receiving. The well known spiral ray used on VHF bands attempts to accommodate waves which may be arriving horizontally, or vertically, or somewhat in between. However, it does not take into account the variability in the direction of spin. Even imagining an antenna patterned after the spiral ray but equipped with enough rotation to adjust the elements for spin, and the tilt, axial rotation, and azimuthal rotation of the boom makes one shudder. By this time, we would have so many control wires going up to the antenna that the signal would have a hard time deciding what was the feedline.

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In short, reciprocity theory is a great thing if you respect it for what it is. It does not readily permit an amateur to compare two different kinds of antennas with respect to different modes of use without controlling any of the other variables, which include all of the ones we have listed and a few more. In the words of one of my engineer friends, "What you have here is a complex system, and complex systems are always worse than simple systems, and simple systems are bad enough!"

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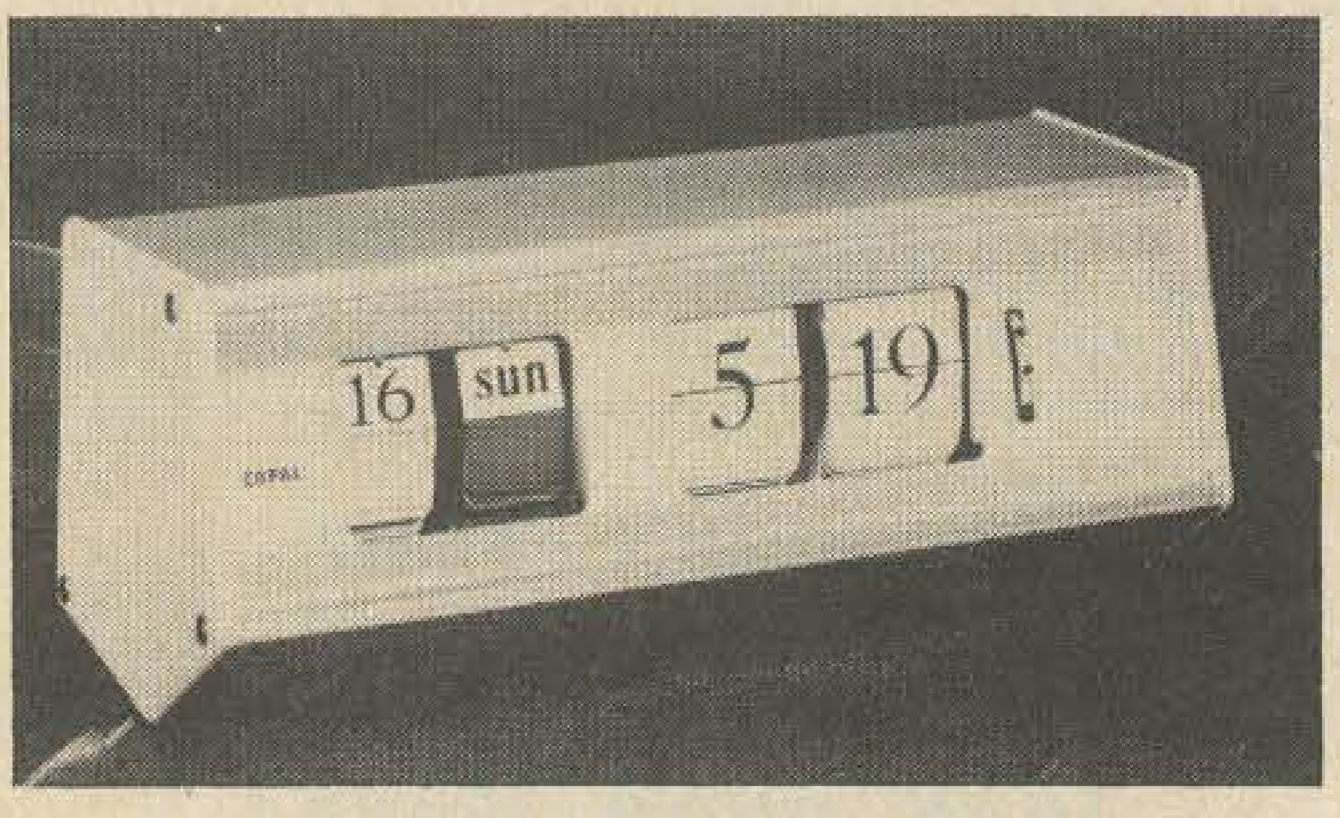

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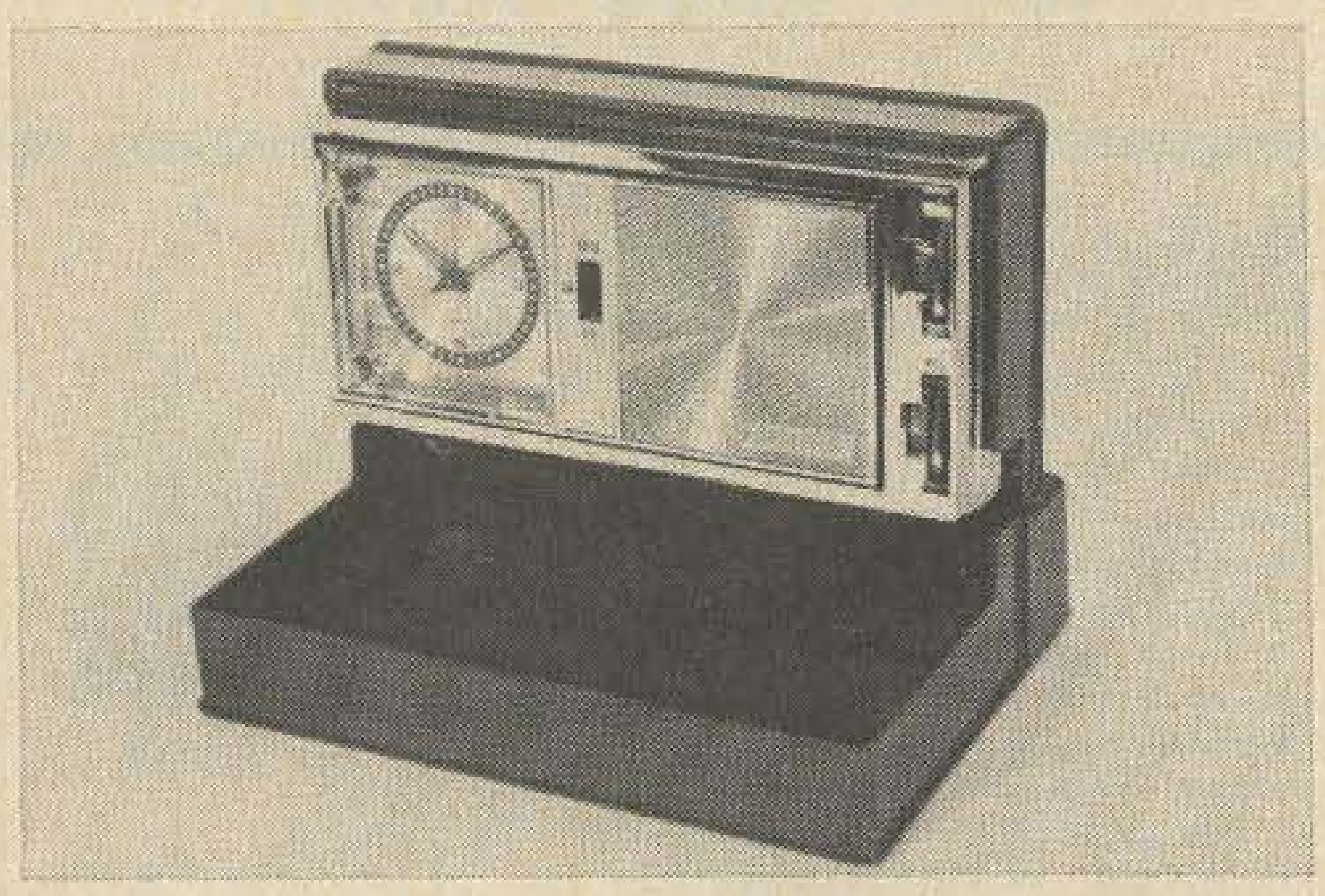

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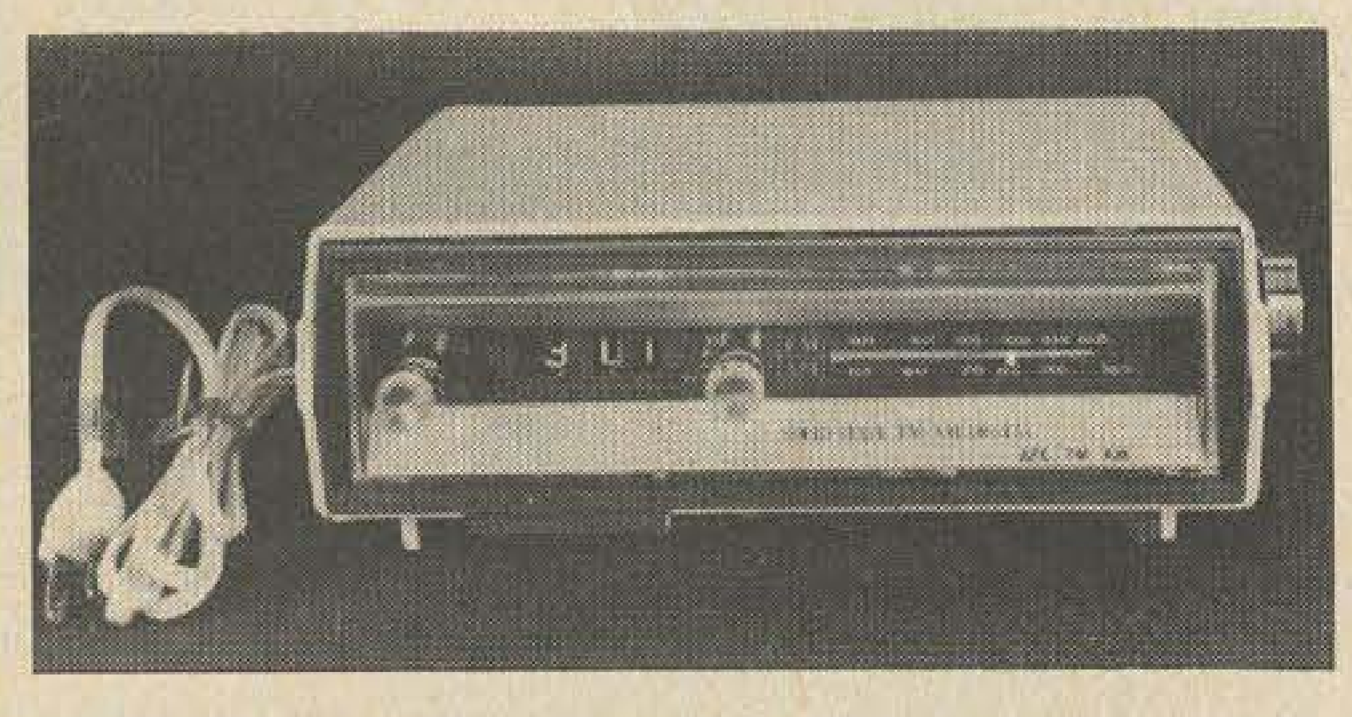

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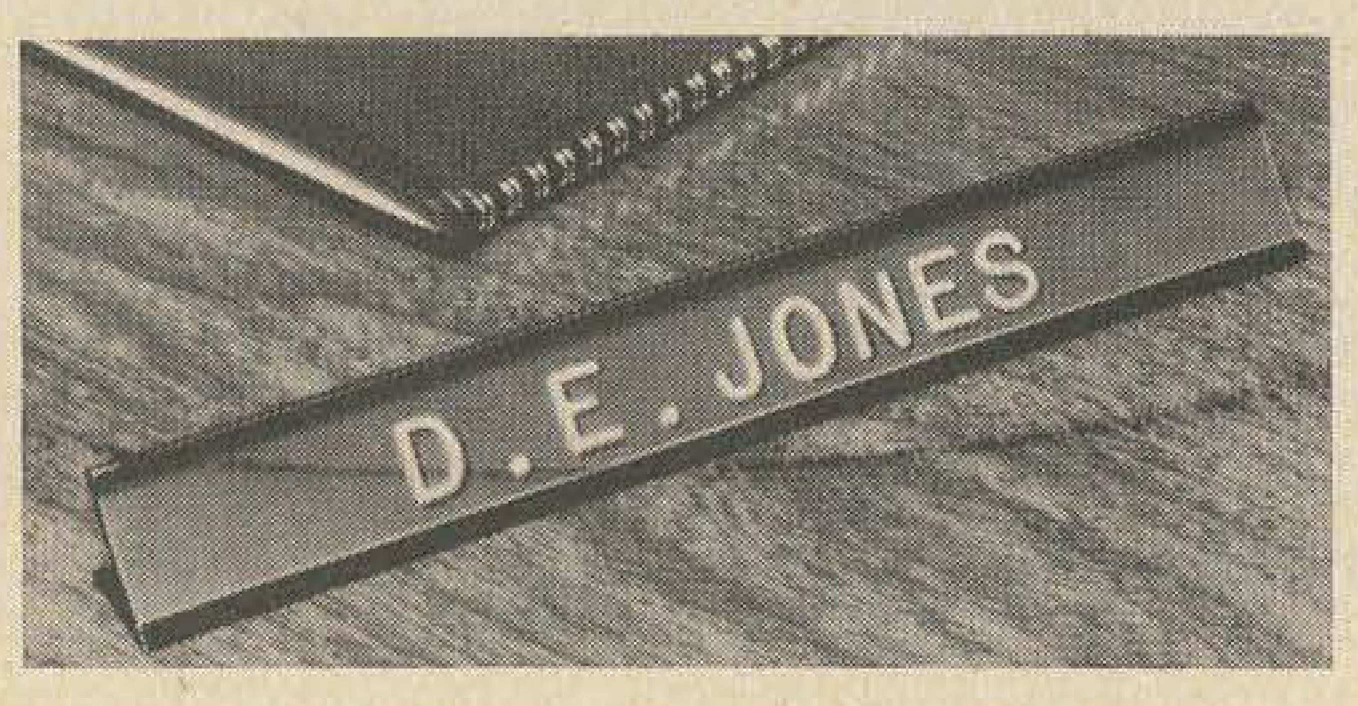

DESK NAME PLATE

Your name and call on a beautiful desk plate might normally cost you around $10. These plates are walnut grained and are available with up to 20 letters and spaces. You can have your full name or your first name and call. Immediate delivery on all orders. 10" long by about 1" high. Identify your station with one of these plates.

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☐ travel clock radio
☐ clock am/fm ☐ name plate

Name & call ....

Address ....

City & State .... Zip ....

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- makes an audible tone to monitor the RF of any CW transmitter from 10Mw to 1 Kw & 100Kc to 1000Mc, using only an 8" pickup antenna.
- can be self-triggered for code practice or the testing of solid state components and circuits.
- aids in tuning up & testing RF oscillator and power circuits.
- 4 transistor, 2 diode circuit, speaker, tone adjust, AA pencell, test leads, 8" ant., & magnetic base.
- cabinet is 16 gauge black & clear anodised aluminum, 3.4 x 2.3 x 1.2"
US made & guaranteed for 1 year.

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Index To Articles Appearing in 73 Magazine in 1968

Antennas and Transmission Lines

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uhf (300 MHz up)

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CW and Keying

DX

Fiction and Humor

FM

Hints and Kinks

Instruction, general

Instruction, Special

Lab and Workshop Notes

Miscellaneous

SUPER SALE! HAMS, SCHOOLS, INDUSTRY! ONCE IN A LIFE TIME PRICES!

Order NOW from this ad. Wholesale prices.

VHF RECVR, Collins or Wilcox, 118-136 mHz, AM, 110 vac, makes first class net or monitor recvr, ex-FAA, was $125.....$60.

DIGITAL COUNTER, 4 row, good condition ....$90.

SIGNAL GEN., Phillips PHP22, German copy of GR equipment, 10 KHz-50MHz $50.

RECVR, RDE, fixed frequency, ac ....$20.

DUAL TAPE RECORDER, 4 channel, remote control, with floor rack, excellent for station logging or background music, was $495 ....$240.

NEW, SONEY TAPE DECK, stereo, was $45 ....$25.

TRANSCEIVER, Lear LVTR-36, 118-136 mHz, 42 crystals, 12 volts, AM, 2E26 final, was $99 ....$50.

SIGNAL GEN., 8-330 mHz, modulation, 115 v., General Radio type 804-C or Federal, was $124 ....$85.

FREQ. METER, 100-500 mHz, .001% accuracy, excellent performer, excellent condition, heterodyne operation,, 25 tubes plus crystal and original calibration book, 115/230 volts, civilian type LA-6 or military FR-6, was $495 ....$350.

FREQ. METER, 10-100 mHz, similar to above instrument, rack mount, 115/230 volts with original calibration book and schematic, best quality made, was $495 ....$250.

PULSE GENERATOR, Measurements Corp type 79A, required for all digital circuit work, 115 vac, was $88 ....$49.

RECVR, ARR-15, 1.5-18.5 mHz, designed by Collins, frequencies to 1 kHz, converted, was $65 ....$40.

FIELD STRENGTH RECVR, 15-150 mHz, ac or dc operation, high quality unit for FM or TV use, Measurements type 59, was $299 ....$180.

TRANSCEIVER, APN-1, 420-260 mHz, dopplar radar, renew, was $9 ....$3.50

TUNER, 300-1000 mHz, TN-18/APR-4, was $39 ....$18.

RECVR, ham band only, 160-10 meters, RME 4350, was $99 ....$70.

SCOPE, Dumont 340, dc to 3 msec. rise time, was $84 ....$55.

MEMO SCOPE, Hughes type 104, with WB/4 plug-in preamplifier, high quality scope, workable, good condition except scope tube, was $325 ....$150.

SPECTRUM ANALYZER, TS-148/UP, 8.4-9.97 gHz, compact, good shop instrument, good condition, was $99 ....$45.

HUNTER 330S, light operated device, commercial quality, for counters, door alarms, or station antenna lights, was $10 ....$5.

VERY LOW FREQUENCY RECVR, audio distortion analyzer, covers 30-16,000 Hz, may be shifted some to receive low freq. stations, General Radio type 736A, was $269....................$99., or HP type 300A, was $175 ....$68.

VTVM Multimeter, Hewlett-Packard type 410A, 1-300 vac, 6 ranges, 1-1000 vdc, 7 ranges, 0.2 ohms to 500 meg, 7 ranges, read to 700 mHz, still an industry standard instrument, requires ac probe tip, was $89 ....$45.

SIGNAL GEN., HP 608B, 10-410 mHz, calibrated output in db, internal modulation, may be pulsed, 115-230 volts, industry standard, was $449 ....$300.

FREQ. METER, GR 720A, 100-3,000 mHz, heterodyne type, accuracy 0.1%, portable, good condition, was $75 ....$65.

SIGNAL GEN., sweeper, X band, made by Kay, has freq. meter, attenuation, other controls, 110 vac, was $59 ....$45.

SURVIVAL TRANSCEIVER, 121.5 & 243 mHz, waterproof, hand-held, VHF-UHF transmitter-recvr, RT159B/URC-4, was $49 ....$20.

TRANSPONDER, radar, X band, RT-93A/APN-11, picture on p. 766 vol 7 MIT Rad. Lab gook, was $25 ....$10.

TRANSMITTER AND POWER SUPPLY, 2-18 mHz, good condition, ART-13 (AM-CW), calibration book, commercial 115 volt power supply, was $95 ....$50.

TRANSCEIVER, FM, Motorola FHTRU-1DL Handie-talkies, plug-in modules, can be modified and repaired, now on business band, working condition, schematic, was $50 ....$20.

TRANSCEIVER, LF recvr, VHF transmitter, Bendix PATR-10A, 12 volts power, was $25 ....$10.

THEODOLITE, Perkin-Elmer, azimuth alignment, electro type, topped by K&E transit, in original steel, shock mounted shipping case, good condition, 200 lbs., was $495 ....$150.

RADAR CONSOLE, FAA type FA-52108, 22 inch PPI display, vertical roll around cabinet, requires only video and sync, inputs plus antenna position data, all standard, with very complete manual, truck only, was $299 ....$75.

DUMMY LOAD, high quality, oil filled with sample diode, Bird type 81, 51 ohms, 50 watts, was $24 .... SOLD OUT

GEIGER COUNTER, continuous duty monitor, Baird-Atomic model 410, was $98 ....$30.

DIGITAL PRINTER, Colored TV Inc. type 103 A, desk sized, was $45 ....$25.

FREQUENCY METER, 500-1000 mHz, built-in meter, made in England, excellent condition ....$25.

ATTENUATOR, UHF type, 1-10 db ....$7.

DECIMAL COUNTER UNIT, Model 705A, Berkeley, counts pulses to 10, has neon lighted numerals, zero to nine $12.75

TELETYPE, Model 26, ($10. crating chg.), was $99 ....$75.

PLUG IN 250 CPS FILTER, 455 kc., Electronics Inc., EIC-7, complete unit, good $3.50

This is the same equipment we have been selling regularly but due to a redirection of company policy, we are closing out many surplus items. Sorry but at these low prices our usual guarantee does not apply. Actual equipment photos available at 50 cents each. Sale ends Feb. 28, 1969.

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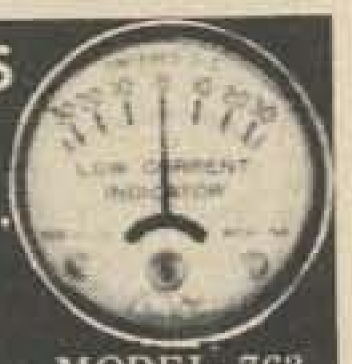
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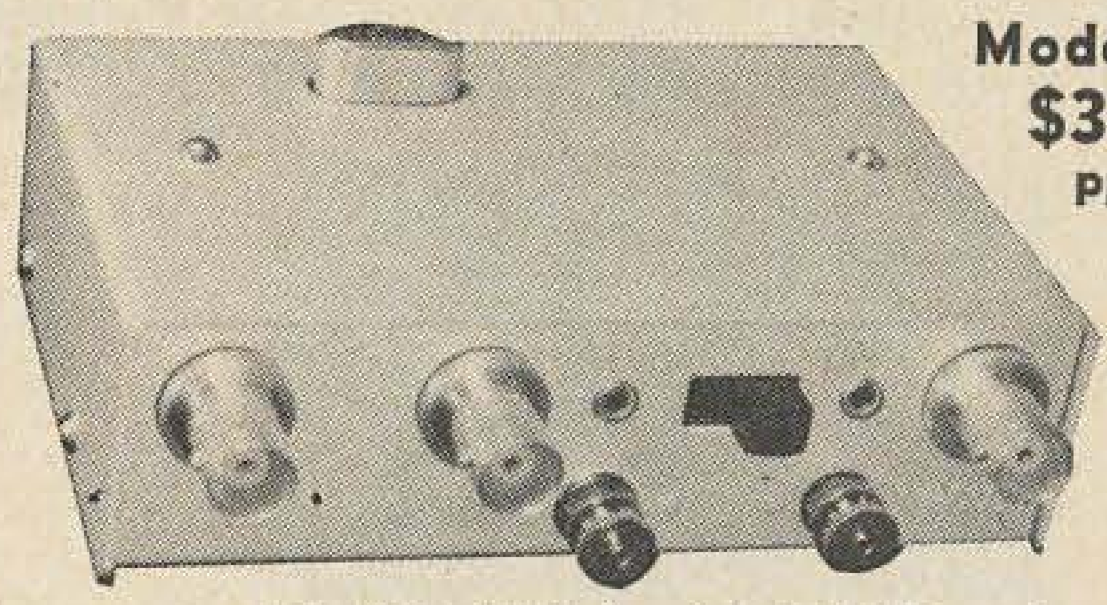
THE BEST
2 METER
CONVERTER



Model 407
$34.95
ppd.

144-146 MHz in. 28-30 MHz out
or 146-148 MHz with a second crystal

A full description of this fantastic converter would fill this page, but you can take our word for it (or those of hundreds of satisfied users) that it's the best. The reason is simple—we use three RCA dual gate MOSFETs, one bipolar, and 3 diodes in the best circuit ever. Still not convinced? Then send for our free catalog and get the full description, plus photos and even the schematic.
Can't wait? Then send us a postal money order for $34.95 and we'll rush the 407 out to you. NOTE: The Model 407 is also available in any frequency combination up to 450 MHz (some at higher prices) as listed in our catalog. New York City and State residents add local sales tax.

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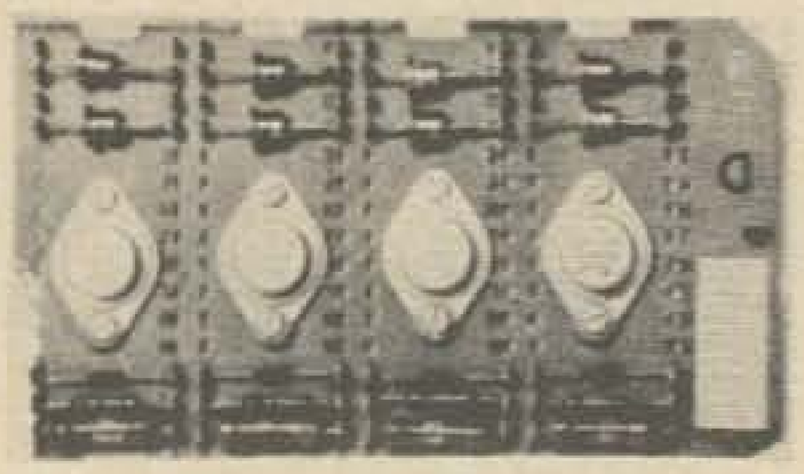
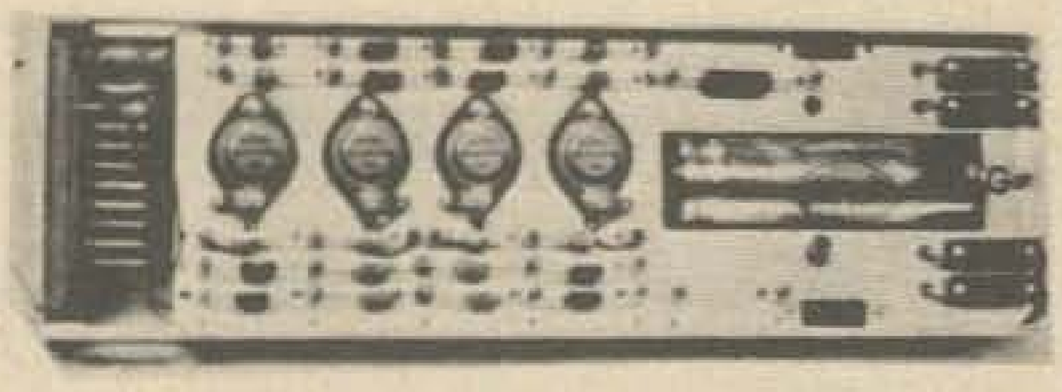
4,000 mfd at 50 volt ... **$1.00 ea., 12 for $10.00**
6,500 mfd at 18 volt ... **$1.00 ea., 12 for $10.00**



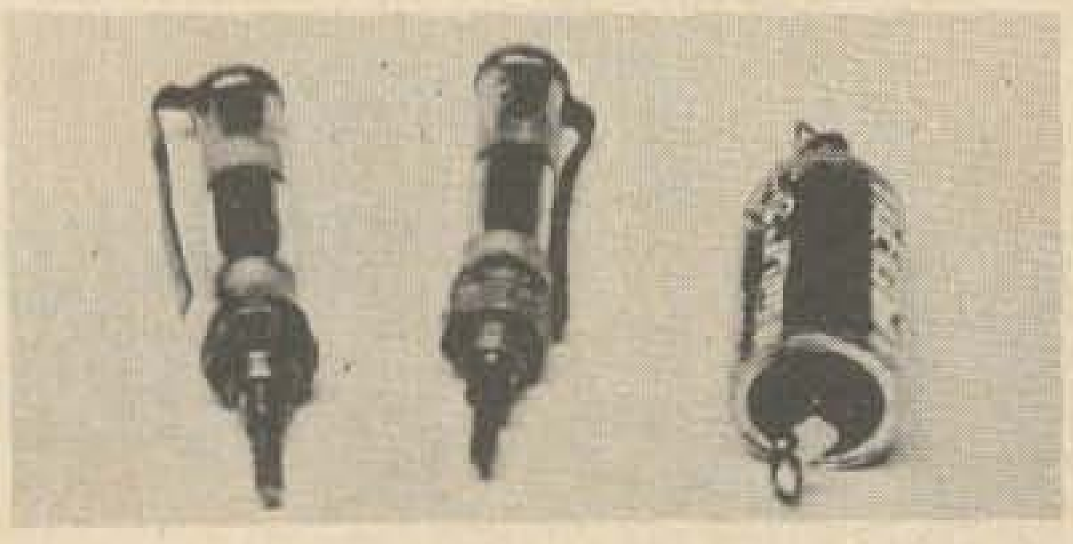
60 WATT TRANSISTORS 80 VOLTS

From computer assemblies, board with 4 each power transistors 2N1137B, 60 watt, 80 volt PNP power .... **$1.25 per board**



SUPER VALUE $2.50

Computer boards with 8 each 2N1137B power transistors and mounting hardware, also include on the board, 4 each 10 volt zeners, 4 silicon diodes 1 amp 800 volt PIV, computer grade cap 2000 mfd 65 volt Bourns trimpots, precision resistors, etc. Complete assembly like new .... Ship wgt. 3 lb. **$2.50**



RF FILTER

From HAWK MISSILE termination contract. Good for 5 amps, 600 volt, 10 cycles to 500 mc, insertion loss 60 DB-plus, low pass pi-network type, excellent as feed-thru filter in converters, transmitters. Hermetically sealed inside are 2 toroidal chokes and 4 low induct. caps. #41102 .... **$1.00 each, 6 for $5.00**

PISTON CAPS

Corning glass, direct traverse type, min. Q at max. C—500 at 50MC. 500 volt breakdown. Capacitance range 1-8 uufd. Brand new military surplus ..... **3 for $1.00 or $3.00 per doz.**

10 amp TRIACS

SALE

PRV	100	200	300	400
Sale	1.40	1.75	2.25	2.60

VARACTOR SIMILAR TO MA4060A

Good for 40 watts at 432 MC, ea. tested in circuit, w/diagram for 432 MC tripler. **$5.00 ea.**

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Radio Amateur Emblems engraved with your call letters.

Charm

☐ Gold
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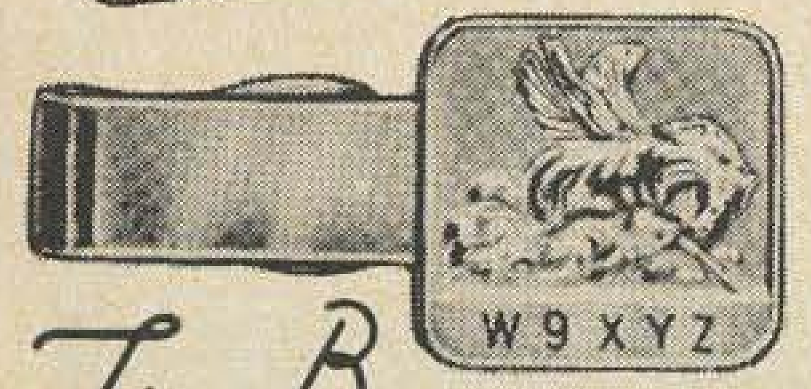
call letters **$5.00 Ea.**



Tie Bar

☐ Gold
☐ Rhodium

call letters **$5.00 Ea.**

All illustrations are actual size.

Lapel Pin

☐ Gold
☐ Rhodium

call letters **$5.00 Ea.**

Two or more emblems at the same time $4.00 each.

Illinois residents add 5% tax.

Amt. enclosed $________

Name________

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City & State________ Zip________

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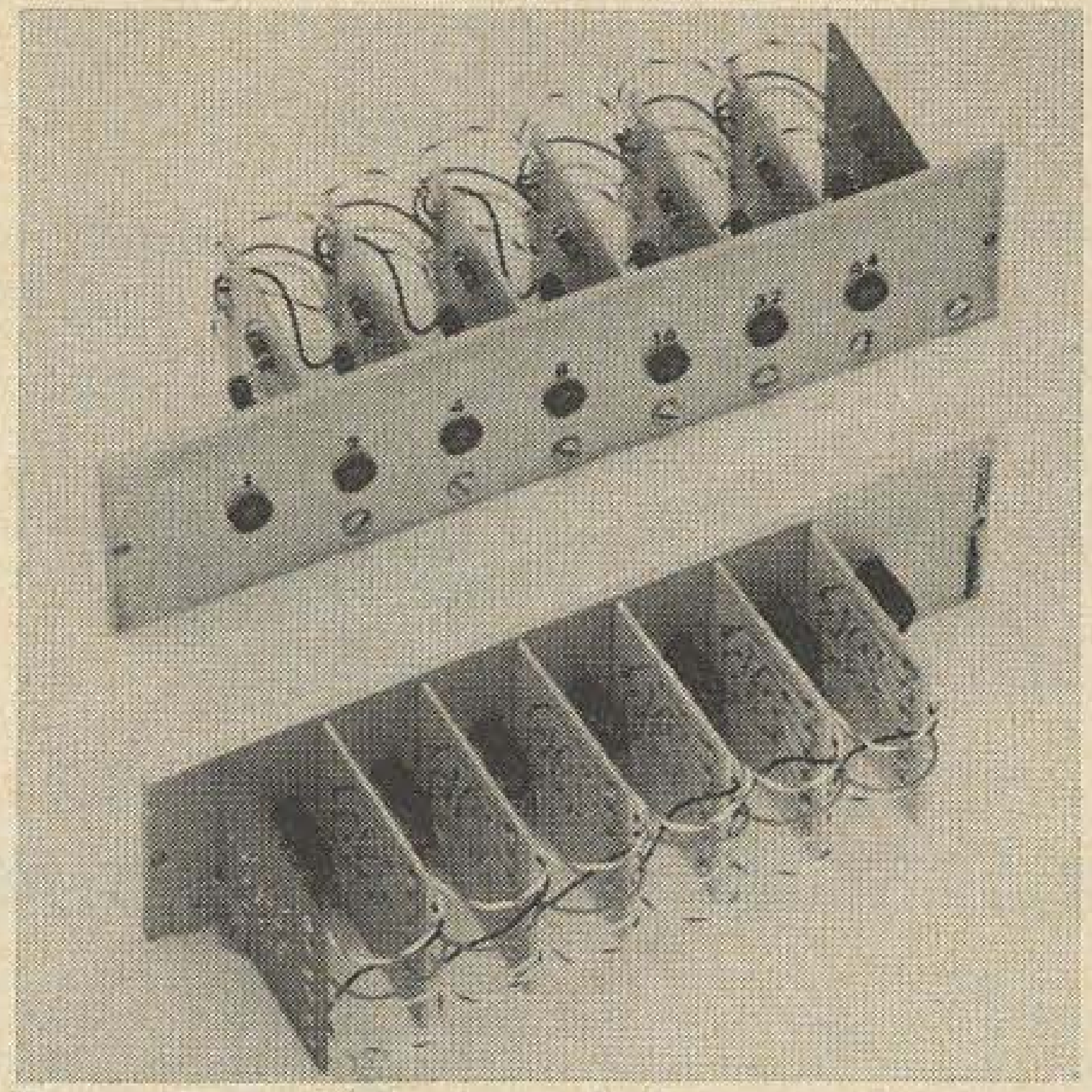
4844 Fullerton Ave., Chicago, Illinois 60639

LESS THAN $2.00 PER STAGE



Low Cost Integrated Circuit Counter

Has many uses such as frequency counter, electronic stop watch, frequency meter, event counter, etc. This unit is a binary counter, the first light reads -1- each lite (stage) you add doubles the count.

Example:

No. of stages	Lite no.	Count
1	1	1
2	2	3
3	4	7
5	16	31
10	512	1023
15	16,384	32,767

No limit to the stages you can add. The total count is twice the value of the highest numbered light minus —1. Each kit contains one complete stage with instructions for assembly in minutes.
Diagrams for power supplies included.
Printed circuit board measures 2" square*

Kit for stages

$2.49 ea. ....2 to 9 — **$2.29** ea. ....10 or more **$1.99** ea.
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Photo shows sample mounting of 7 stages.
Additional information upon request.

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2 x 2	10¢ ea	12/$ 1.00
3 x 6	25¢ ea	10/$ 2.25
4 x 6	35¢ ea	10/$ 3.25
12 x 12	$1.95 ea	10/$17.00

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Fairchild I.C.'S

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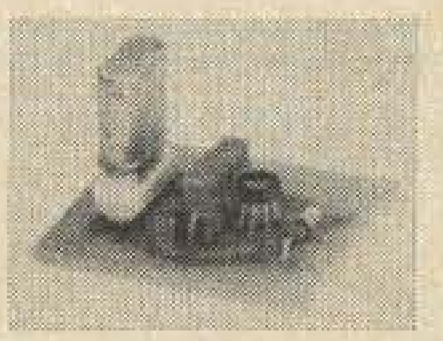
UL923 J.K. Flip Flop with spec sheet **$1.75 ea. 10/$14.95**

CRYSTAL OSCILLATOR KITS



using I. C. UL 914 Stable, harmonic-rich output osc. range 100 KC to 10 MC - Kit includes Fairchild I.C. UL 914, crystal sockets, resistors, capacitor, & PRINTED CIRCUIT BOARD, with instructions for assembly ....**$2.00** per Kit.

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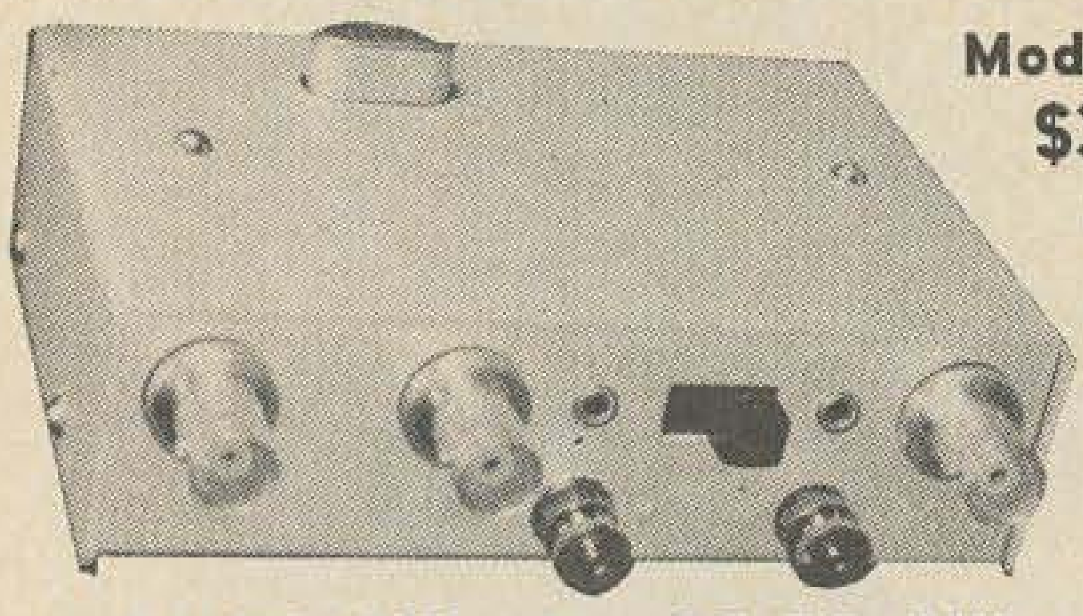
6 METER
CONVERTER



Model 407
$34.95
ppd.

50-52 MHz in. 28-30 MHz out or 52-54 MHz with a second crystal

A full description of this fantastic converter would fill this page, but you can take our word for it (or those of hundreds of satisfied users) that it's the best. The reason is simple—we use three RCA dual gate MOSFETs, one bipolar, and 3 diodes in the best circuit ever. Still not convinced? Then send for our free catalog and get the full description, plus photos and even the schematic.

Can't wait? Then send us a postal money order for $34.95 and we'll rush the 407 out to you. NOTE: The Model 407 is also available in any frequency combination up to 450 MHz (some at higher prices) as listed in our catalog. New York City and State residents add local sales tax.

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Propagation Chart

December 1968

ISSUED SEPT. 1

J. H. Nelson

EASTERN UNITED STATES TO:

GMT:	00	02	04	06	08	10	12	14	16	18	20	22
ALASKA	14	14	7	7	7	7	7	7	14	21	21A	21
ARGENTINA	14	14	14	7	7	7A	14A	21A	28	28	28	21
AUSTRALIA	21	14	7B	7B	7	7	7B	14B	14	14A	21A	21A
CANAL ZONE	21	14	7	7	7	7	14A	21A	28	28	28	28
ENGLAND	7	7	7	7	7	7A	14A	21A	28	21	14	7
HAWAII	21	14	7	7	7	7	7	7 B	14A	28	28	28
INDIA	7	7	7B	7B	7B	7B	14	21	14	7B	7	7
JAPAN	14	14	7B	7B	7	7	7	7	7B	7B	7B	14A
MEXICO	14	14	7	7	7	7	14	21A	28	28	21A	21A
PHILIPPINES	14	14	7B	7B	7B	7B	7B	14B	14	14	7B	14
PUERTO RICO	14	7	7	7	7	7	14	21A	21A	21	21	21
SOUTH AFRICA	14	7	7	7	7B	14	21A	28	28	28	21A	21
U. S. S. R.	7	7	7	7	7	7B	14	21A	21	14	7B	7
WEST COAST	21	14	7A	7	7	7	7	14	21A	28	28	28

CENTRAL UNITED STATES TO:

ALASKA	21	14	7	7	7	7	7	7	14	21.	21A	21A
ARGENTINA	21	14	14	7	7	7	14	21A	28	28	28	21
AUSTRALIA	28	21	14	7B	7	7	7	14B	14	14A	21A	21A
CANAL ZONE	21	14	14	7	7	7	14	21A	28	28	28	28
ENGLAND	7	7	7	7	7	7	14	21	21A	21	14	7B
HAWAII	28	21	14	7	7	7	7	7	14	21A	28	28
INDIA	7A	7A	7B	7B	7B	7B	7B	14.	14B	7B	7B	7
JAPAN	21	14	7B	7B	7	7	7	7	7	7B	14	21
MEXICO	14	14	7	7	7	7	7	14	21A	21A	21	21
PHILIPPINES	21A	14	7B	7B	7B	7B	7	.7	14	.14	7B	14A
PUERTO RICO	21	14	7	7	7	7	14	21A	28	28	28	21A
SOUTH AFRICA	14	14	7	7B	7B	7B	14	21A	28	28	21A	21
U. S. S. R.	7	7	7	7	7	7	7B	14	14	14	7B	7B

WESTERN UNITED STATES TO:

ALASKA	21	14	7	7	7	7	7	3A	14	21	21	21A
ARGENTINA	21	14	14	7	7	7	7B	14A	21A	28	28	21
AUSTRALIA	28	28	21	14	14	7	7	7	14	14A	21	21
CANAL ZONE	21	14	14	7	7	7	7	14A	21A	28	28	28
ENGLAND	7B	7	7	7	7	7B	7B	7B	14A	21	14	7B
HAWAII	28	28	21	14	14	7	7	7	14	21A	28	28
INDIA	14	14A	7B	7B	7B	7B	7B	7	14B	7B	7B	7B
JAPAN	28	21A	14	7B	7	7	7	7	7	7B	14	21A
MEXICO	21A	14	7	7	7	7	7	14	21A	28	28	28
PHILIPPINES	21A	21A	14	7B	7B	7	7	7	14	14	7B	14A
PUERTO RICO	21A	14	7	7	7	7	7	14A	21A	28	28	28
SOUTH AFRICA	21B	14	7	7B	7B	7B	7B	14	21A	28	21A	21
U. S. S. R.	7B	7	7	7	7	7B	7B	7B	14	14B	7B	7B
EAST COAST	21	14	7A	7	7	7	7	14	21A	28	28	28

A - Next higher frequency may be useful this period
B - Difficult circuit this period

Good: 1-5, 11-14, 16-21, 23, 24, 26-29, 31

Fair: 6, 8-10, 15, 25, 30

Poor: 7, 22

Caveat Emptor?

★ **Price—$2 per 25 words for non-commercial ads; $10 per 25 words for business ventures. No display ads or agency discount. Include your check with order.**

★ **Deadline for ads is the 1st of the month two months prior to publication. For example: January 1st is the deadline for the March issue which will be mailed on the 10th of February.**

★ **Type copy. Phrase and punctuate exactly as you wish it to appear. No all-capital ads.**

★ **We will be the judge of suitability of ads. Our responsibility for errors extends only to printing a correct ad in a later issue.**

★ **For $1 extra we can maintain a reply box for you.**

★ **We cannot check into each advertiser, so Caveat Emptor . . .**

TELETYPE MOD. 14 reperforator with automatic tape take up rewinder new, unused, $69.95 . . . 4-400's $14.95 . . . transformers: Plate 5KV-1.6ADC $59.95 . . . Modulator 811A's $35 . . . Filament 12.6DCT-10A $4.95. Ideal for transistor supply, battery charger . . . catalog 10¢. Fertik's, 5249A "D", Phila., Pa. 19120.

RF MULTIMETER measures ten millivolts to three volts rms and VSWR down to 1.05:1 as high as 2GHz. RADEVCO, Box 8450, Baltimore, Maryland, 21234.

VIBROPLEX or semiautomatic key wanted. Write Box 691, Savannah, Georgia, 31402.

MERRY XMAS AND HAPPY NEW YEAR from WØCVU. See you at Des Moines, Iowa. June 20-22, ARRL 1969 National Convention.

CHRISTIAN HAM FELLOWSHIP being organized for Christian fellowship and gospel tract work among licensed amateurs. Christian Ham Callbook for $1 donation. For details write Christian Ham Fellowship, 5857 Lakeshore Dr., Holland, Mich. 49423.

WANTED: GONSET #3269, 100KC calibrator, or circuit diagram, used in G-76. Swap: Ranger II and 6 Meter SSB gear for G-76 or Gonset 2 meter gear. J. Gysan, 53 Lothrop St., Beverly, Mass. 01915.

ON AIR NOW: Apache, SB10 SSB, SWR, All Heath, all in like-new condition. $159.50 FOB. Newton, Mass. K1ZYG.

WANTED: McElroy XTR-442-C automatic tape keyer and tape perforator. John R. Hinegardner WØBFB, Mitchelville, Iowa. 50169. Phone 515-967-2898.

AMATEUR and CLOSED-CIRCUIT TV Technical Literature, Plans. Kits

5 TUBE VIDICON TV CAMERA CONSTRUCTION MANUAL-16 page booklet gives complete details for building, testing and operating your own "live" TV camera. Simplest tube type TV camera circuit known! Designed to use maximum number of readily-available components normally found in amateur junk boxes. ONLY $3.00**

TRANSISTOR VIDICON TV CAMERA CONSTRUCTION MANUAL-31 page manual gives step-by-step instructions for building a high quality fully transistorized camera. Thousands of hours of lab and field testing have gone into this circuit thus making it the perfect choice for the serious constructor. Order stock #XT-VCM Only $5.00**

TELEVERTER FLYING SPOT SCANNER TV CAMERA CONSTRUCTION MANUAL This 22 page step-by-step manual contains complete details for building an unusual flying spot scanner type camera suitable for televising 35mm slides. The unit is very easy and economical to build since it makes use of a standard TV set to provide the scanning circuitry. ABSOLUTELY NO WIRING MODIFICATIONS are required on the TV set. Requires only 4 tubes plus photomultiplier. Order Stock #TV-1 $2.50

MONOSCOPE CAMERA CONSTRUCTION PLANS-Ideal camera for testing and servicing work where a "standard" fixed video signal is required. No lens system, external lighting or test charts are required since the pattern is built inside of the tube. Straightforward 4 tube plus monoscope circuitry. Order Stock #LPS-1 Only 50¢

ONE WATT 432 Mhz TRANSMITTER-MODULATOR PLANS-Complete details for building a simple 5 tube ham TV transmitting station. Stock #LPS-2 Only 50¢

432 Mhz TV CONVERTER PLANS-uses 6CW4 RF amp, 6AF4A osc and 6BQ7A i.f. amp. No difficult plumbing required. Easy to tune up. Order Stock #LPS-5 Only 50¢

420-450 Mhz TV ANTENNA CONSTRUCTION PLANS-12 ele. Yagi. #LPS-3 25¢

CAMERA DEFLECTION COILS-Technical data sheet explaining phasing and testing of vidicon and image orthicon yokes. Ideal for do-it-yourself yoke builders. Prevent costly damage to camera tubes by using these simple techniques. #LPS-6 25¢

NEGATIVE-POSITIVE VIDEO INVERTER CONSTRUCTION PLANS-Complete details for building an adaptor that can be inserted between the output of any video TV camera and the video monitor to reverse the polarity of the video signal but not the sync-blanking pulses. Perfect for observing negatives, etc. Stock #LPS-8 $1.00

BASIC LENS THEORY FOR APPLIED TV-A short course in basic lens theory designed to assist the user in the selection and operation of lenses for TV cameras. Especially valuable to those designing their camera from available parts. LPS-4 50¢

GLOSSARY OF APPLIED TV TERMS-120 different TV terms defined. Very valuable for those just getting started in the Applied TV field. Stock #LPS-7 Only 50¢

SET OF TEST PATTERNS-6 individually printed patterns. Stock #TCS-6 $2.25

STATION I.D. ILLUSTRATIONS-Set of 12. High contrast line drawings. #IDS-12 $3.50

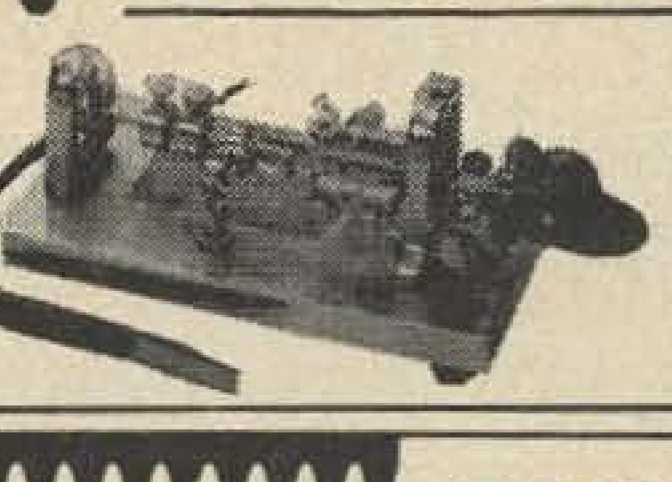
WARNING: THESE PREMISES ARE PROTECTED BY CLOSED-CIRCUIT TV-8½ x 11" warning signs. Large black letters on colored card stock. Stock #SS-1 3 for $1.00

**Full price of these manuals refundable with later kit purchase.

WRITE for your FREE catalog fully describing our line of TV camera kits and parts.

13th & Broadway North, **ATV RESEARCH** Dakota City, Nebr. 68731

VIBROPLEX



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Accurately! Four wires connect IC-3 Divider to your 100KC calibrator to give 25KC marks. Circuit board 1¼" x 1½". Specify supply voltage — 3-300, 10 ma. (Lowest is best.) Send for IC-3, $5.95, + 30¢ postage.

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CRYSTALS—low frequency types available at $2.50 each postpaid USA in hermetically sealed HC6 or HC13 metal holders with 2½ inch wire leads. Frequency in KC: 2.000, 4.0457, 6.4000, 16.000, 32.000, 75.000, 96.000, 100.000, 128.000, 218,000. Form page brochure available for stamp. QUAKER ELECTRONICS, HUNLOCK CREEK, PA. 18621

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LARGEST SELECTION in United States AT LOWEST PRICES—48 hr. delivery

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Thousands of frequencies in stock. Types include HC6/U, HC18/U, FT-241, FT-243, FT-171, etc.
SEND 10¢ for catalog with oscillator circuits. Refunded on first order.
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ELDICO SSB Adapter SBA-1 with book, converts any receiver with 455 kc IF to SSB; select either upper or lower side band: in neat cabinet **$127.50**

Silic. Rect. 8000 PIV 400 ma. Pair $5.30
R-23/ARC-5 Command rcvr 190-550 kc. Shpg. wt. 9# .. 14.95
A.R.C. 12 #22 Command rcvr 540-1600 kc. 9# 17.95
LM-14 freq. meter, .01% 125 kc-20 mc. 15# 57.50
TS-323/UR freq. meter 20-480 mc. .001% 169.50
TS-175 Freq. Meter. 85-1000 Mc, .04% $125.00
CLOSING OUT Radio Receivers 38-4000 mc at **CRAZY LOW PRICES!** Ask for APR-4Y/CV-253 sheet.

R-392: Compact version of R-390. Tubes work on 24v 3A. Same digit tuning. W/pwr sply & book 525.00

WANTED: GOOD LAB TEST EQUPT & MIL COMMUNIC.

WE PROBABLY HAVE THE BEST INVENTORY OF GOOD LAB TEST EQUIPMENT IN THE COUNTRY. BUT PLEASE DO NOT ASK FOR CATALOG! ASK FOR SPECIFIC ITEMS OR KINDS OF ITEMS YOU NEED! WE ALSO BUY! WHAT DO YOU HAVE?

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BUSINESS OPPORTUNITY

Young man wanted to learn management of surplus electronics firm in New York-New Jersey area. Small investment or none. Participate in profits and ownership. Equipment and know-how supplied, all that is needed is a good ham background and an earnest desire to learn and work. Call 201-824-1244.

MOTOROLA FM EQUIPMENT SCHEMATIC DIGEST

91 pages (11½" x 17") of schematics, crystal information, alignment instructions, service hints and specialized information. $3.95 post paid.

TWO-WAY RADIO ENGINEERS, INC.
1100 Tremont Street
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NCX-200, USED ONLY FIELD DAY, $300, in original box. Will include heavy home built supply free. FOB. WAØNDV, 611 No. Hartup, McPherson, Kansas 67460.

CRYSTALS—Low frequency types. Available at $2.50 each postpaid USA in hermetically sealed HC-6 or HC-13 metal holders with 2-2½" wire leads. Frequency in kilocycles. 2.000 4.0457 6.400 16.000 32.000 75.000 96.000 100.000 128.000 183.000 218.000. 4-page brochure available for stamp. Quaker Electronics, Hunlock Creek, Pa. 18621.

DISCOUNT PRICES. All equipment listed is new, factory sealed cartons, full manufacturers warranty. Our policy: new equipment at low prices. Swan SW-500C $468, SW-350C $378, Swan 14-117 AC-DC P/S $115, Hygain TH6DXX (Reg. $159) $135, TH3MK3 (Reg. $125) $112, CDR Ham-M rotator with indicator $99.95, Tri-ex W-51 self supporting crank up tower (Reg. $362) $299.95 prepaid, Mosley TA-36 (Reg. $153) $137, TA-33 (Reg. $121) $109, Hammarlund HQ-180A (Reg. $480) $432. Many factories prohibit discount advertising; write or call for discount price catalog on brands not listed in this ad. Time payments available. Bryan Edwards Electronics, 1314-19th St., Lubbock, Texas. 806-762-8759.

WANTED: Magazines, VHRer & ATV. K6KTP, Berry St., Lemon Grove, Calif. 92045.

HQ100 WITH SPEAKER and xtal BFO very good at $110; DX40 oldie but goodie at $40; Knight V44 $15. N. Dowling, 733 Mohawk, Lynchburg, Va. 24502.

HQ-140X, VALIANT I, B&W51SB. Good condition. With manuals. $235.00. Shipping collect. John Rains, 3200 Long Blvd., Nashville, Tenn 37203.

WANTED: Must have manual and/or instruction book for Heathkit DK-40 XMTR, will pay cost. Philip Napora, 474 Tonawanda St., Buffalo, N.Y. 14207

NEGATIVES MADE for use with photoresist P.C. boars. As described in Aug. 73. 4x5 in. $2.00. D. Goodman, Bx 94, Catheys Valley, Calif. 95306.

FOR SALE: Motorola FMTR 80D, 52.525 Mc with AC supply, accessories, no speaker. $95. FOB. C. G. Reinsel W3WUA. Box 25, Bigler, Pa. 16825.

COMMUNICATIONS TECHNICIAN position desired, 16 years experience, first class phone and advanced class amateur. Family, willing to relocate. Write for resume. 73. Box 1168, Peterborough, N.H. 03458.

SELLING MY old radio books, magazines, catalogs, and parts. Send stamped, addressed envelop for price list. W6CID, Elmer A. Piercy, Box 666, Victorville, Calif. 92392.

SWAN 250 6 METER Transceiver with power supply, $250. Vanguard TV camera, $175. Lafayette HA-6, $65. P. Franson WA7KRE, 7312 E. Oak St., Scottsdale, Arizona 85257. 602-947-6052.

NEEDED: Electronic maintenance and operation men for color TV station control room work. First class ticket required. Salary range, depending on experience, $600-$700 a month. Call collect 313-239-6611 or write Chief Engineer, WJRT-TV, Flint, Mich. 48503.

AMATEUR RADIO CERTIFICATE: Display impressive 8½" x 11" personally endorsed certificate in your shack. Send $1.00 to Amateur Radio Certificate, Box 244, Miami (Kendall Br.) Fla. 33156.

WRL'S USED GEAR has trial—terms—guarantee! 900A Sidewinder—$219.95; Galaxy 5—$289.95; Galaxy 300—$159.95; HW22—$89.95; HT40—$49.95; HX500—$289.95; 51J3—$449.00; 75A1—$169.95; NC155—$119.95; NC190—$139.95; SB300—$249.95; RME6900—$149.95; and hundreds more. Free Blue-Book list. Write WRL, Box 919, Council Bluffs, Iowa 51501.

DRAKE 2-A FOR SALE, $100. Want SK-506 chimney and APX-6 in any condition. LA35G1W4, K. Midtseter, 1490 NW 58 Terrace, Ft. Lauderdale, Fla. 33313.

FOR SALE: Yaesu FTDX 400—$325. Heath HR 20—$70. SB 175—$50. With all manuals. WB4APZ, 1900 8th Ave., Immokalee, Fla. 33934. (813-OL7-3288).

NATIONAL 200, AC-200. Absolutely mint condition. In original cartons. $320 or best offer. Terry Taylor, 1459 Jaywood, Creve Coeur, Mo. 63141.

SALE: Comdel Speech Processor (CSP-11) excellent condition, $75 PPD. WB6YVW, 1755 N. Wilcox, Hollywood, Ca. 90028.

THE WHEATON COMMUNITY RADIO AMATEURS (WCRA) will hold the 7th annual Mid-Winter Swap and Shop Sunday, February 16, 1969 at the DuPage Count Fair Grounds, Wheaton, Ill. Hours—9:00 a.m. to 5:00 p.m. $1.00 donation at the door. Refreshments and unlimited parking. Free coffee and doughnuts 9:00-10:00 a.m. Hams, CBers, electronic hobbyists, friends and commercial exhibitors are cordially invited. Contact Bill Lester, WA9FGP, Box 1, Lombard, Ill. 60148 for information.

WANTED: Teletype equipment & parts. Also R-390A, U-R, R-220, etc. Cash or trade for new amateur equipment. All-tronics-Howard Co., Box 19, Boston, Mass. 02101. (Tel. 617-742-0048).

MICRO-MICRO-TO-KEYER: Perfect code from one cubic inch, microcircuit digital electronic keyer module designed for mounting inside any transmitter. Speed range 4-40 WPM. Grid block keying only allows price of $19.95. Includes mounting hardware. Unconditionally guaranteed. Micro-Tech Labs. PO Box 884 (I.A.B.), Miami, Fla. 33148.

ESTATE LIQUIDATION: Telrex combination beams 10M-518 over 15M-525 over 20M-505. Self supporting tower 50 ft. and H.D. rotator cost over $1000. Asking price $200 and you take down. Mint condition. Arthur W. Lee, Rt. #1, Box 23A, North Monmouth, Maine 04265; Tel. 207-933-2869.

ESTATE LIQUIDATION: Collins 75A4 receiver serial 3316 and matching speaker two filters F455-J-08 and F445-J-31; Collins KWS-1 SSB-AM transmitter serial 953. New final tubes, mint condition. $650 for both. Arthur W. Lee, Rt. #1, Box 23A, North Monmouth, Maine 04265; Tel. 207-933-2869.

SELL: COLLINS KWS1-1721 $795, 75A4-4325 $450, both $1150, prefer local sale, like new, ship cod original packing. Barnett, 1310 Navajo, Florissant, Mo. 63033.

"NORTHERN CALIFORNIA HAMS." Best deals—new and reconditioned equipment. Write, call or stop for free estimate. The Wireless Shop, 1305 Tennessee, Vallejo, Calif. 707-643-2797.

WANTED: Back issues of 73 Magazine, November 1960 through March 1961. C. W. Janes K2KS, 2 Windsor Gate, Upper Saddle River, N.J.

GATEWAY ELECTRONICS

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Facsmile Machine—complete with simple instructions for auto-start and auto-phase. Can be operated back to back or via radio. Machines in excellent condition and in working order when removed from service. 115 Volt AC 60 cycle. Shipping wt. 25 lbs. .... **$ 19.50**

Automatic Ice Maker—for refrigerator—new with instructions and water valve .. **$ 14.95**

Sealed Mercury Wetted Polar Relay (direct replacement for model 255) No adjustments required .... **$ 4.95**

40-0-40 uA Weston Meter .... **$ 2.95**

7200 VCT@IA Transformer 110/220 volt primary 60 cycle. Shipping wt. 110 lbs. **$ 25.00**

Jennings Vacuum Variable (UCS-300) with motor drive 10-300pf new .... **$ 35.00**

X-Y Plotter — Pace Electronic Associates Inc. Variplotter **$395.00**

Minimum order $5.00. Sorry, no catalog at this time. Write for specific items. Watch for our future ads in 73. Stop in and see us when you're in St. Louis.

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UNIT CHASSIS
WRITE
DEVICES
BOX 136, BRONX, N.Y. 10463

CQ de W2KUW

All tubes bought • Electronic items wanted
Topping all offers

TED DAMES CO.

308 Hickory St., Arlington, N.J. 07032

ARC-1 Transceiver 100-156 Mc, 25 Watts AM, with tubes, schematic, conversion info for 2-meters. Used, good. 50 lbs. $20.00
ARC-1 only, less tubes, $12.00
BC-221-AK with AC Power, Calib. Book & Xtal. $95.00
TS-174, 20-250 Mc. Freq. Meter, on rack panel with AC Power, Calib. Book & Xtal. $95.00.
Brush BL-202 2-channel oscillograph, Used, Exc. $90.00
Sorensen 3000S AC Line Voltage Regulator, 3000 V.A. Used, Exc. $125.00
Non-Linear-Systems 451 Digital Voltmeter. P.U.R.
Send 10c for flyer listing surplus equipment, test equipment, new and used ham gear.

JEFF-TRONICS

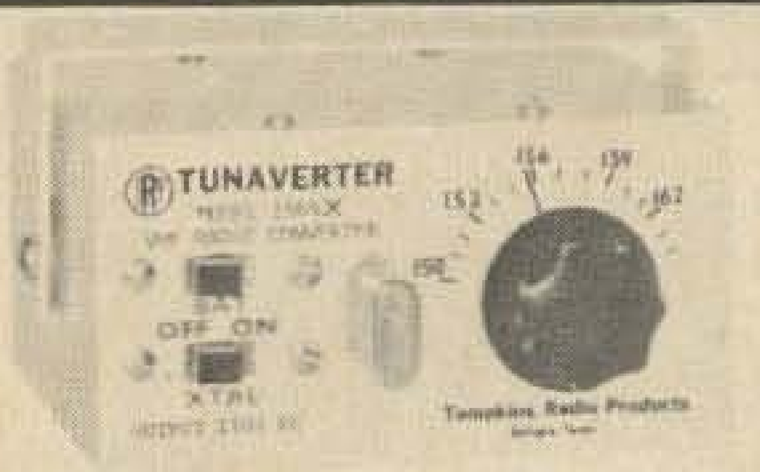
4252 Pearl Rd. Cleveland, Ohio 44109

NOW TUNAVERTER® X

WITH NEW ELECTRONIC SQUELCH ACCESSORY FOR NOISE FREE MONITORING OF . . .

POLICE - FIRE - C. DEFENSE AIRCRAFT - AMATEUR CALLS,

ON YOUR BROADCAST RADIO!



Tunable plus Crystal controled (selectable with switch) solid state converters to change your auto and home radios into excellent, sensitive, selective, calibrated VHF receivers!

CRYSTAL & TUNABLE. = VERSATILITY!
CHANGABLE CRYSTALS
AND NEW ADJ. SQUELCH = USABILITY''

- 9 volt battery powered
- Includes coax, mount
- New FET transistor osci.
- 1 year guarantee
- Size—2½" x 3½" x 4¼"
- 100% American Made

Models for AM & FM Tunable & Crystal!

BAND	MODEL	COVERS	OUTPUT	PRICE EACH
CB & 10 M	273 X	26.9-30 mc	1500 kc	
6 meters	504 X	50-54 mc	1500 kc	
Pol.ce, fire,	1450 X	144-150 mc	1500 kc	$32.95 ppd.
Weather, etc.	348 X	33-48 mc	1500 kc	Less Crystal
2 meters	1564 X	150-164 mc	1500 kc	
Aircraft	1828 X	118-128 mc	1500 kc	

Models for AM & FM Tunable only

Marine	Marine	2.0-2.85 mc	550 kc	$19.95 ppd.
SW & WWV	SWL	9.5-16 mc	1500 kc	$19.95 ppd.

SQUELCH FOR YOUR TUNAVERTER!!

Noise free monitoring with adj. electronics squelch! No wires to Radio or Converter! Just plug in coax! For all 1500 kc outputs, 9 or 12 V. 1 x 4 x 2 inches.

Model ST mounts on bottom of Tunaverter ......$17.50 ppd.
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Coupling Loop & Ext. Antennas for use with home and Transistor Radios ....$3.95 ppd.
Mobile Battery Eliminator, 12V to 9V ....$4.95 ppd.
Crystals—State Eaxact listening Freq. ....$5.10 ppd.

Order from: AIR MAIL add $.85 ea.

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YOUR SURPLUS WANTED BY THE FASTEST GUN IN THE EAST

No horsing around, we pay fast . . . in 24 hours . . . and we pay more. We'll swap or trade new equipment too . . . We quote fast too. We also pay for shipping, insurance, etc. You call fast, now, collect, for fast quote.

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FT243, DC34, CRIA/AR, FT241, HC6/U and other misc. crystals

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Go VHF the easy VHF Associates way. Send for descriptive Technical Bulletins describing our complete line of TRANSISTOR RECEIVING CONVERTERS and VARACTOR FREQUENCY MULTIPLIERS for 50, 144, 220, 432 and 1296 MHz.

VHF ASSOCIATES, INC.
P.O. Box 22135, DENVER, COLORADO 80222

ESTATE SALE: 110 ft. Telrex Big Bertha tower with three stacked 6 element beams on 20, two 5 element beams on 15, two 4 element beams on 10, one 3 element beam on 40, Spiral on 6, 20 elements on 2 meters. All Telrex. Must be removed from present location. Original cost $12,000. Make offer. 73 Magazine, Box 69, Peterborough, N.H. 03458.

DAYTON HAMVENTION April 26, 1969: Sponsored by Dayton Amateur Radio Association for the 18th year. Technical sessions, exhibits and hidden transmitter hunt. An interesting ladies' program for XYL. For information watch ads or write Dayton Hamvention, Dept. S, Box 44, Dayton, Ohio 45401.

RTTY GEAR FOR SALE. List issued monthly, 88 or 44 MHy torroids 5 for $1.50 postpaid. Elliott Buchanan & Associates, Inc., 1067 Mandana Blvd., Oakland, California 94610.

WANTED: Military, commercial, surplus Airborne, ground, transmitters, receiver, testsets accessories. Especially Collins. We pay freight and cash. Rico Electronics, Box 156, Annandale, Va. Phone 703-560-5480 collect.

3000 V @ 3μF brand new GE Pyronal oil capacitors $3 each. Can mail, 3-lbs each shipping wt., FOB. P. Wandelt, RD #1, Unadilla, New York 13849.

DANGER

73 Transistor Circuits has driven hundreds of amateurs right out of their minds with joy. Do not send $1 for this dangerous book. Do not send it to: 73 Magazine, Peterborough NH 03458.

Your ad in this space will reach 65,000 paid readers (an *honest* Figure!). Plus all their friends who are too chintzy to buy their own copy.

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03444
Phone 603-924-3873

"FLAT PAK" INTEGRATED CIRCUITS!!

Solid State KING

BRAND NEW! $1.49 ☐ **DUAL 914★**

We include **30 Basic IC Projects** RADIO-ELECTRONICS January & JULY 68

RTL Logic −55° C to +125° C Electronics World:

★ First time anywhere two identical IC's in one package.

EPOXY SILICON TRANSISTORS

- ☐ 3-FK-4046, 1W, 0.5A, npn, 250MC $1.00
- ☐ 3-2N3568, 350MW, 200MC, 200BVC, NPN $1.00
- ☐ 4-2N3563, NPN, 600MC, 200MW $1.00
- ☐ 3-2N3683, NPN, 1000MC, 5MA, 200MW .. $1.00
- ☐ 3-14 WATT, B-5000, npn, 3A $1.00
- ☐ 4-2N4313, PNP, 600MC, 200MW $1.00
- ☐ 4-2N3565, 500HFE, npn, 200MC $1.00

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- ☐ 900 Buffer $1.49
- ☐ 903-903* 3 Input Gate $1.69
- ☐ 904-904* Half Adder $1.69
- ☐ 914-914* Dual 2 Input Gate $1.49
- ☐ 923 JK Flip Flop...............................$1.69
- ☐ 923-923* JK Flip Flop $1.98
- ☐ 927 Quad Inverter $1.69

*First time anywhere two identical IC's in one package, example 923-923 contains two separate JK flip-flops in one package. 914's and 923. We include 50 uses. ** Licensed. ¼" x ¼"

FAIRCHILD IN-LINE INTEGRATED CIRCUITS

Tested, with data sheets

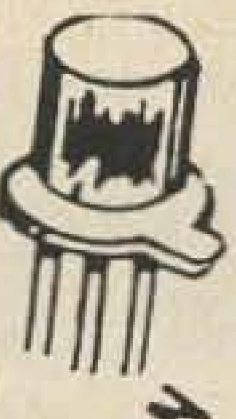
- ☐ 930 DUAL 4 INPUT GATE & EXPANDER $1.00
- ☐ 933 DUAL INPUT EXPANDER $1.00
- ☐ 944 DUAL POWER GATE $1.00
- ☐ 946 QUAD 2 INPUT NAND/NOR GATE $1.00
- ☐ 952 DUAL 2 INPUT INVERTER GATE $1.00
- ☐ 953 2-2-3 INPUT AND GATE $1.00
- ☐ 954 DUAL 4 INPUT AND GATE $1.00
- ☐ 955 8 INPUT AND GATE W/2 INPUTS $1.00
- ☐ 956 DUAL INPUT BUFFER $1.00

100's of other IC's including: Flip-Flops, Registers, Adders, etc. Write for listing.

LINEAR AMPLIFIERS *with circuits & data*

- ☐ 702C WIDE BAND DC $3.98
- ☐ 703H RF-IF-FM $1.49
- ☐ 709C HI-GAIN OPERATIONAL $3.98
- ☐ 710C HI-SPEED DIFF. COMP. $3.98
- ☐ 711C DUAL COMPARATOR $4.98

400 mc 5 for $1 NPN 2N706 ☐ SILICON



Watts	V_{cb}	H_{fe}	ma
.5	30	TO-300	150

$10 ORDERS CHOOSE ANY $1 ITEM Free

100 MICROAMP PANEL METER

CLOSEOUT! $2.88

SILICON POWER STUD RECTIFIERS

PIV	3A	6A	12A	55A
50	☐ .06	☐ .16	☐ .20	☐ .50
100	☐ .07	☐ .22	☐ .25	☐ .75
200	☐ .09	☐ .30	☐ .39	☐ 1.25
400	☐ .16	☐ .40	☐ .50	☐ 1.50
600	☐ .20	☐ .55	☐ .75	☐ 1.80
800	☐ .30	☐ .75	☐ .90	☐ 2.30
1000	☐ .40	☐ .90	☐ 1.15	☐ 2.70

1 AMP TOP HAT AND EPOXIES

PIV	SALE	PIV	SALE	PIV	SALE
50 ☐	.05	800 ☐	.19	1800 ☐	.87
100 ☐	.07	1000 ☐	.31	2000 ☐	1.05
200 ☐	.08	1200 ☐	.44	3000 ☐	1.60
400 ☐	.11	1400 ☐	.62	4000 ☐	1.90
600 ☐	.16	1600 ☐	.72	10000 ☐	4.80

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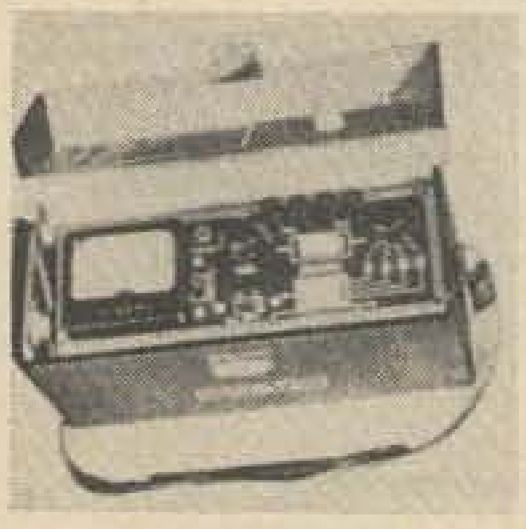

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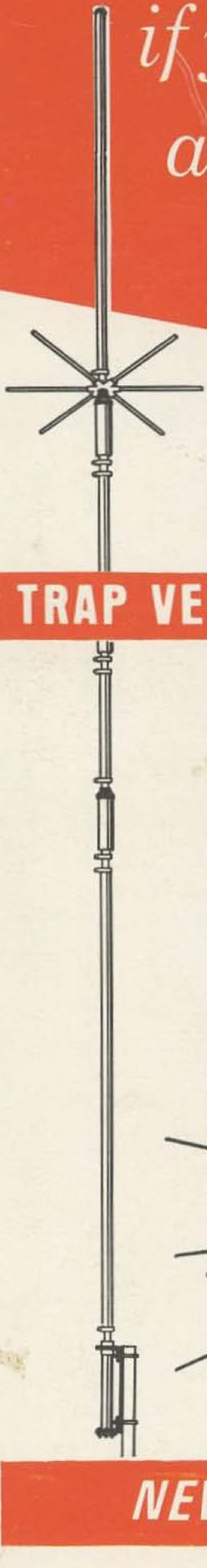

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