AMATEUR RADIO 73

November 1968
73¢

Computer Card
Transmitter
Crystal Filters
Trouble Shooting
Solid State
I.C. Counter
Pulsars
Thermistor
24 Articles In
This Issue

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73 MAGAZINE

November 1968
Vol. XLVII No. 11

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Cover: A typical ham workbench in operation. Photo by Fred Meyer

Next Month: Transceiver review, Ham gifts under $20

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Departments

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Editorial Liberties

I keep getting the word from the Subscription department that there are numerous requests for *73* to print a picture of the Editor. Actually, my picture appeared on the cover of the October 1967 issue. I'm the one working on the antenna. For those who may have missed it, copies are available for 73¢.

This is the second month without a "Letters" column. This is not due to lack of space, but lack of mail. Normally, the only people who write are those who disagree or have complaints. Most of these give constructive criticism and have something worth printing. In the past couple of months, the only letters I have received have been nice ones with compliments about the quality of the magazine. If I printed only the nice letters, you would think I was hiding the bad ones. Tell me what you want....this is the only way I can improve *73*.

Under the "Big Deal of the Year" department comes the news that Kentucky, the last state without call letter license plates, has passed the following legislation:

"188.176 Amateur radio licensees may attach plate showing call letters to license plate.

"An owner of a motor vehicle who is a resident of this state and who holds an unrevoked and unexpired official amateur radio station license issued by the Federal Communications Commission may attach to his motor vehicle license plate an additional license plate inscribed with the official amateur radio call letters of the licensee, provided the additional plate is attached in such manner as to not interfere with the view of the motor vehicle plate. (1968 H 226. Eff. 6-13-68)"

The amateurs of Kentucky must be *thrilled*!

A couple of states issue two sets of plates and the call letter plates may only be attached if a mobile rig is installed in the vehicle. If you take the rig out, you must change the plates. There may be some merit in this in times of emergency where identification is required to enter a disaster area. Only the cars capable of being useful would be permitted to enter the area. The call letter plates would serve as identification. However, not all the police know about call plates. I was once stopped by a police officer in Glendale, Colorado. I had Colorado plates with my call WØHJL. He came to my car window and, in a sarcastic tone, asked, "OK, lady, where did you get the license plates, out of a cereal box?" Between convulsions of laughter, I explained the situation. After seeing my registration and my ham ticket, he had a very red face.

In a few countries, hams are permitted to hold a call only upon proof that they have an *operating* station. If the station is dismantled, the license must be relinquished. It is held for a reasonable length of time, then becomes eligible for reissue. When the amateur gets another station on the air, he may get his license back without taking a new examination (if still within the expiration time limits) but may be assigned a new call. There may also be some merit in this system. If amateur radio exists, as we are told, only because of our involvement with Public Service, should a ham hold a license if he is not in a position to render such service?

I'd be willing to bet that less than 50% of the hams listed in the *Callbook* are active amateurs with operational stations. In many areas, we have used up the W, K, and WA calls. In two areas, we have used up the WB calls and are into the WC calls. If only the amateurs with operational stations were permitted to hold a license, we could all have W or K calls.

Each year the *Callbook* gets fatter and fatter, and the price goes higher and higher. If the inactive hams were eliminated,the U.S. callbook would be about the size of the DX book, and the price would go down.

November 22 is rapidly approaching. Although I don't usually plug products in the editorial column, a new company has come out with a crystal calibrator divider which makes your 100 kHz crystal put out a tone each 25 kHz. It is a miniature printed circuit board requiring the soldering of four wires and will let you know where you are at all times. It comes from Paxitronix and their ad appears on page 124. This little gadget costs under $6 and is a necessity for the ham who didn't take the higher class exam in time.

. . . Kayla W1EMV

de W2NSD/1

The latest Callbook lists about 6500 Extra Class licensed amateurs. This does not have the look of a mass move to me. A look at the previous two Callbooks confirms my suspicion. The Summer edition showed an increase of 229 Extra Class licenses over the Spring issue and the Fall issue went up by 332 more. Perhaps the November 22nd change in the frequency allocations will make the cheese more binding and we will see a more decided trend toward the higher classes of license.

License Class	Spring '68	Summer '68	Fall '68
Extra	5875	6104	6436
Advanced	39040	39406	39638
General	116005	116822	116513
Conditional	42825	42963	41626
Technician	63693	64870	63505
Novice	12467	11820	13124

There is not any great noticeable rush for the Advanced Class license either, as you can see. 366 in the second quarter and 232 in the third quarter seems to me to indicate either advanced apathy or else a sit-out strike. I expected a little heel dragging about this "incentive program", but not almost total rejection of it.

Perhaps others feel as I do. Ham radio has been my major hobby for thirty years now and by virtue of my having gotten my license many years ago I have the Advanced Class ticket. I get on the air with my little transceiver (with linear) whenever I can, and generally enjoy talking with friends all over the world. The QRM gets to me now and then. Though I've lost all track of how many countries I've worked and my main connection with DXCC is as its critic, I do love to work DX. But . . . somehow I dislike being punished into doing something rather than being rewarded into it. Ask me and I'll do almost anything . . . tell me and I'll resist with all my strength.

Doubtless this resistance to authority is some sort of psychological defect in my makeup. Yet it is so deep that I accept it as a philosophy and I feel that this is a better way to run a country. It is tied in with freedom in my mind and government edict is the antithisis to freedom for me. This seems to me to be the one basic difference between a totalitarian government and a democratic government.

This is why I resisted as much as I could when the ARRL proposed the incentive licensing changes. I felt that we could achieve whatever aims they had . . . and these were *never* stated, by the way . . . by offering rewards rather than punishment. As I pointed out at the time, we have wide areas of our bands that are virtually going to waste which could have been offered to the Extra Class licensees to make that ticket sweeter. There would have been little problem in opening up an extra 50 kHz on the five major bands for Extra phone. This would have given us bands rather than taking them away.

Unfortunately for all of us the ARRL managed to get its way in spite of overwhelming protests and on November 22nd we can tune our re-apportioned bands and see how it works out. The Extra Class segments are going to be pretty thinly occupied, obviously.

Here are the new allocations.

	Extra CW	Extra Phone	Advanced
80M	3500-3525	3800-3825	3825-3850
40M	7000-7025	7200-7225	7200-7225
20M	14.00-14.25	14.2-14.235	14.2-14.235
15M	21.0-21.025	21.25-21.275	21.275-21.3

That gives the Extra Class a 25 kHz exclusive band on the low end of 80-40-20-15 for CW and 25 kHz of exclusive phone frequencies on the low end of the 80 and 15 meter phone bands. The Advanced Class can join the handful of Extras for 25 kHz on 80-40-15, and 35 kHz on 20 meters. The General Class will have to move out of the lower 50 kHz of the 80M and 15M phone bands, the lower 25 kHz of 40 meters and 35 kHz of 20 meters. Sorry about that, but that's what happened to us.

The new regs will probably result in a field day for a band of self appointed righteous "police" who will be eagerly looking up every call heard on these bands in the Callbook to see what class license they have. Then, when they find someone out of his band they will break in with great glee to demand that he get up where he belongs. If you hear anyone doing this please break in yourself and tell him that Wayne Green says

(*Turn to page 114—it's really there!*)

The SBX-9 Exciter-Driver and the SBA-50 Mixer-Amplifier provide the perfect combination for 50-54 MHz SSB operation. Performance, versatility and reliability are incorporated into this new SSB pair. A tremendous value at a low price!

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12BY7A Amplifier
6360 Linear power amplifier

Drive: Requires 9MHz sideband signal from SBX-9

Output: SSB single tone 10 watts

Controls: On-Off Power
PA Grid Tune
PA Plate Tune
PA Load Tune
Metering Switch

Metering: Oscillator
9MHz Drive
Buffer Grid
PA Grid
RF Out

Crystals: Three positions, uses 3rd overtone 41-45MHz range. Crystal frequency = final frequency —9MHz

Misc: Accessory socket provided for connecting keying circuit to SBX-9. Comes with three crystals. Specify frequency when ordering. For operation on 117 vac 60 cycle power.

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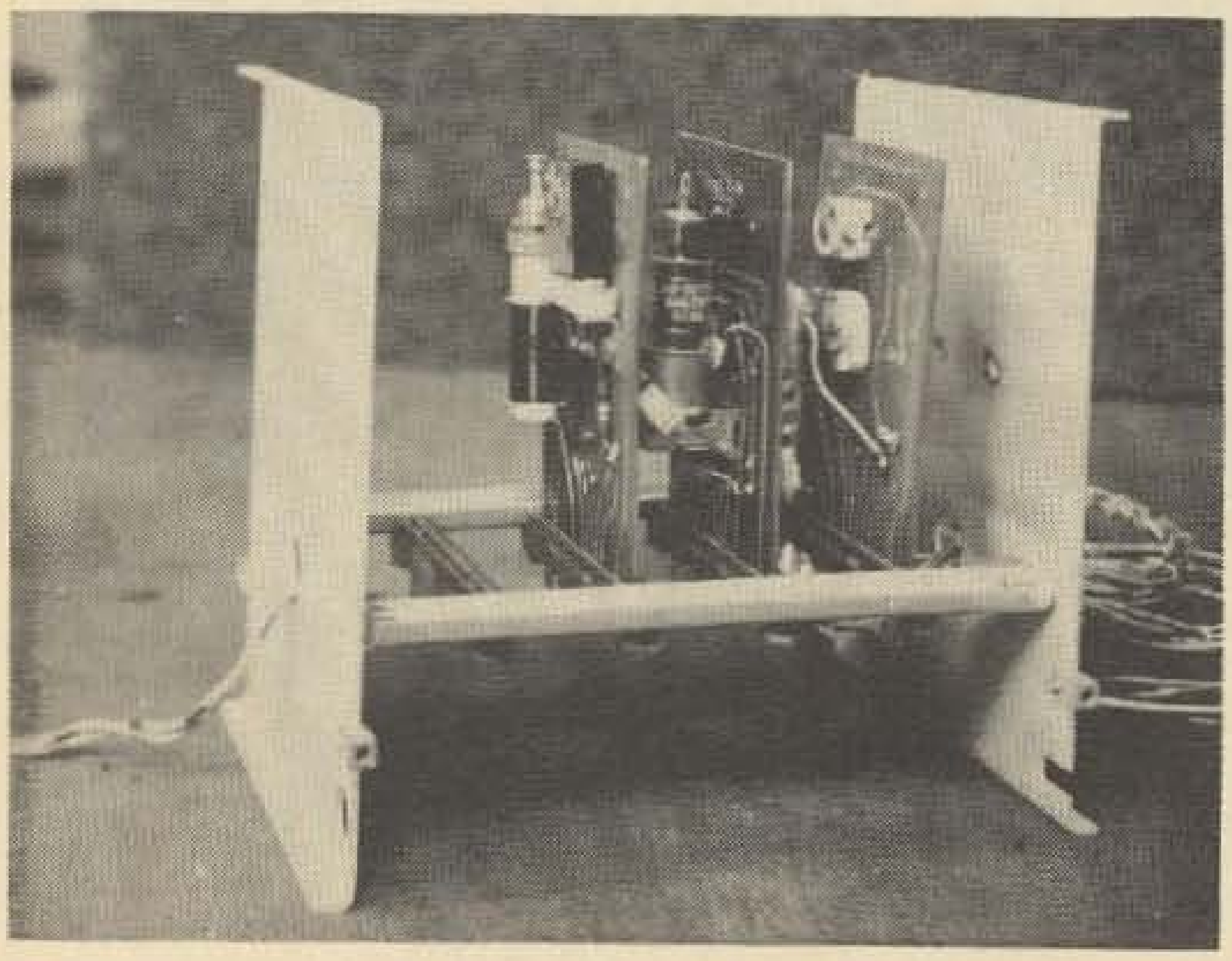
Computer Card Transmitter

A Simple Hybrid Rig for 80 Meters



Front view of the Computer Card Transmitter.

This simple rig for 80 meters was designed for the ham who can't leave well enough alone. It consists of three sections, all constructed on surplus plug-in computer cards to facilitate experimentation and modification. Each section may be removed, modified, and worked on at will without touching the other sections, and by using additional plug-in cards, new circuits may be designed and tested while keeping the old cards intact. Thus an operating version of the rig is always available while new changes and designs are being tested.

This rig has also been designed for the ham who has always stayed away from transistors fearing that they are too complicated. The transistor oscillator described in this article is very simple to build, uses three $1 transistors, and will work first time if the instructions in this article are followed. The oscillator itself should present no problems even for the inexperienced ham.

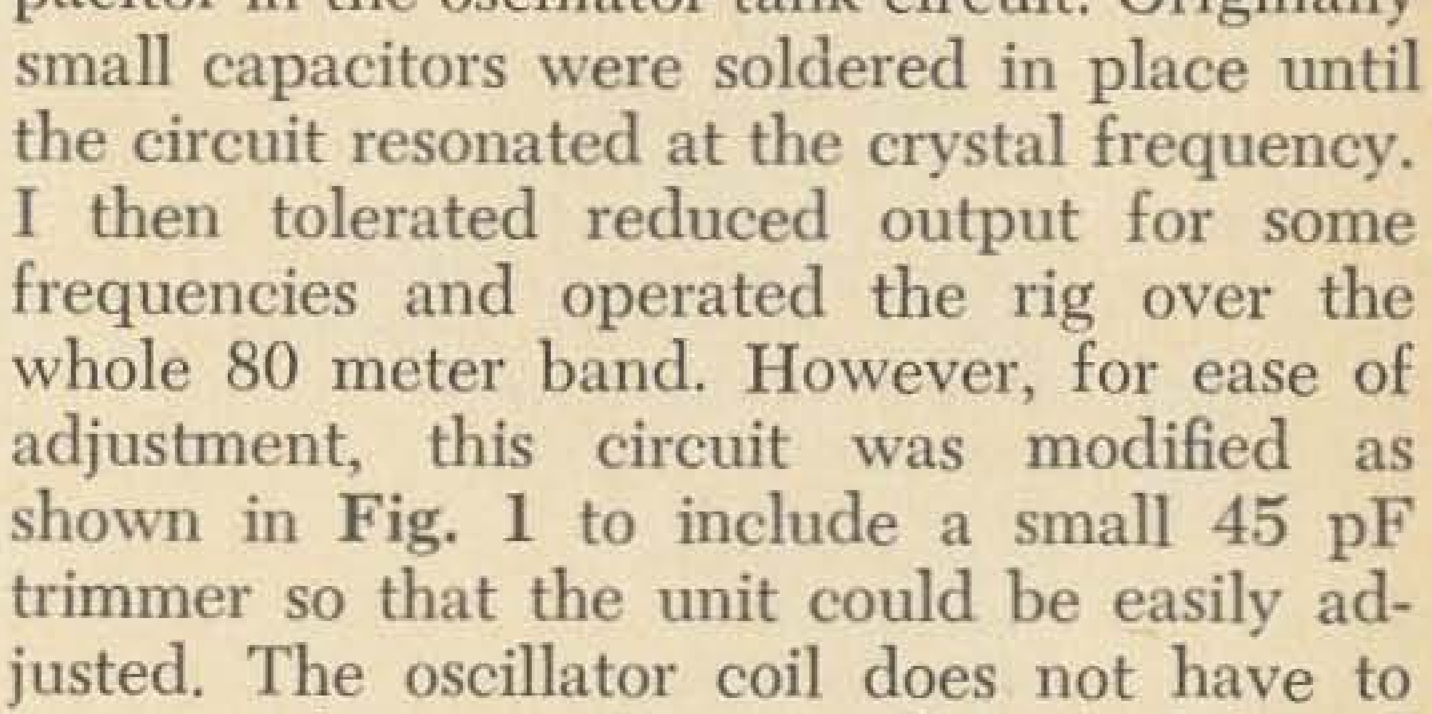
This rig has been designed for 80 meters because out of sheer laziness, I haven't gotten around to winding the coils for the other bands. I will leave the other bands to the builder who may experiment to his heart's content by using other plug in boards.

For information on construction on surplus plug-in computer cards see my article "Computer Card Construction" in 73 magazine earlier this year.

The oscillator

The oscillator is somewhat standard and should give even the inexperienced builder no trouble at all. It oscillates readily and because it uses a slug tuned coil will resonate over a range of plus or minus 75 kHz from some center frequency without retuning. If reduced output from the final can be tolerated, it can be operated over the entire 80 meter band without retuning.

The original circuit had no variable capacitor in the oscillator tank circuit. Originally small capacitors were soldered in place until the circuit resonated at the crystal frequency. I then tolerated reduced output for some frequencies and operated the rig over the whole 80 meter band. However, for ease of adjustment, this circuit was modified as shown in **Fig. 1** to include a small 45 pF trimmer so that the unit could be easily adjusted. The oscillator coil does not have to be wound on a slug tuned coil if broad band operation is not desired.



Q1 = 2W NPN 100 MHz SILICON TRANSISTOR RADIO SHACK PART NO. 276-507 (SIMILAR TO 2N696, 2N697, 2N1613)

L1 = 58T NO. 26E CLOSEWOUND ON 1/2" DIA SLUG-TUNED FORM (MILLEN 69046). B+ CONN. OPPOSITE MTG END. TAP 19T FROM B+ CONN. LINK IS 4T NO. 26E CLOSEWOUND AT CENTER

Fig. 1. Oscillator card with broad band operation.

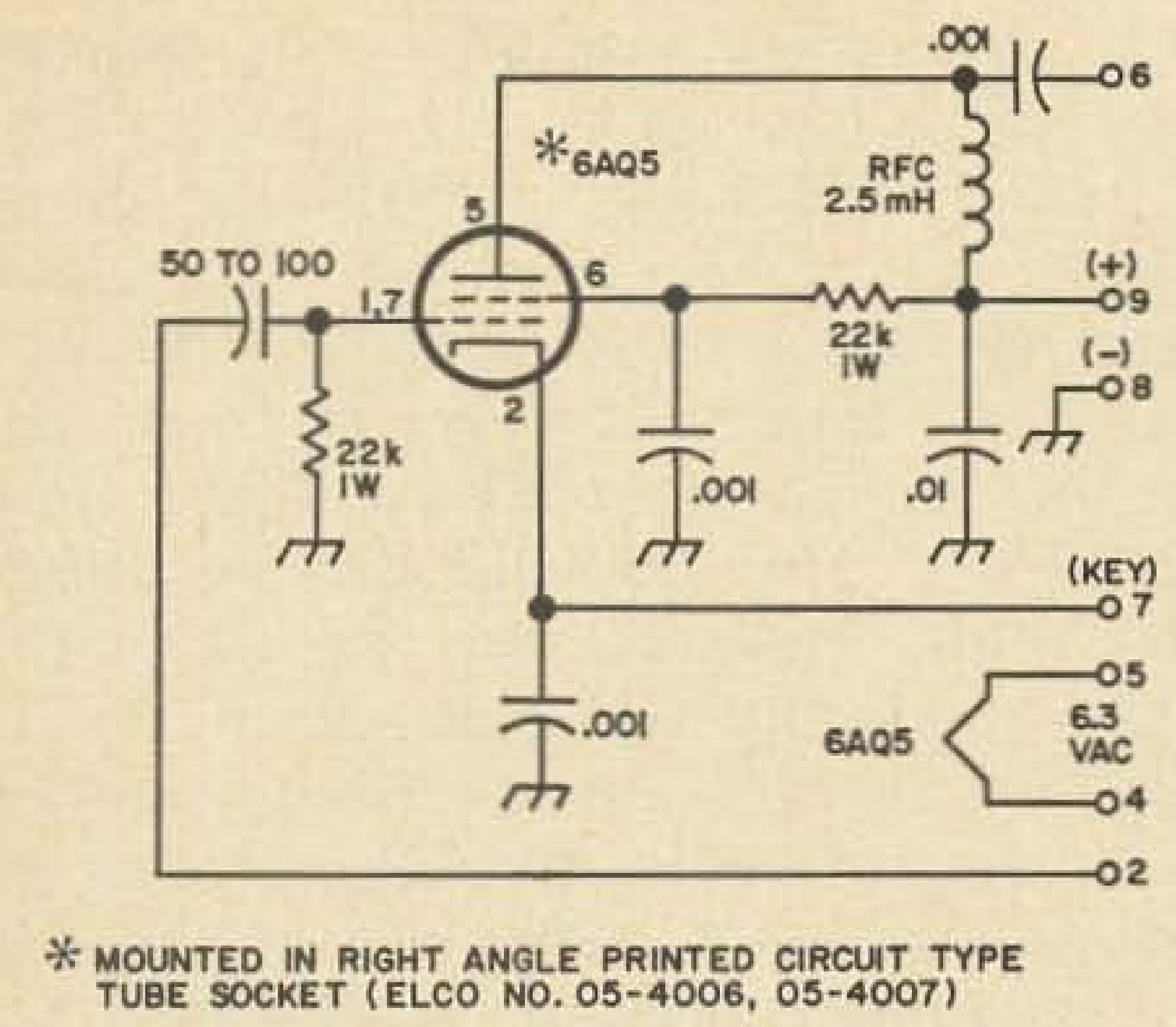


Fig. 2. Diagram for the final amplifier card.

The oscillator will become a bit unstable and may cease oscillation as resonance is approached. For this reason, the oscillator is considered to be properly tuned when maximum drive is obtained, or when the oscillator current is about 40 mA.

It is possible to tune the oscillator by varying the movable slug; however, this method is not recommended since it varies the feedback and causes current fluctuations which are hard to interpret. The slug tuned coil is used only to provide a broadband oscillator circuit.

The tap on the oscillator coil has been adjusted for optimum operation; however, for experimentation purposes, the position of this tap may be varied. The circuit will oscillate quite readily when the collector of the transistor is connected directly to the crystal end of the tank coil; however, at this position, the oscillator will produce very little drive and draw little current. As a matter of fact, if you wish to use this circuit as a spotting oscillator to find certain frequencies, connect the collector to the crystal end and use 6 volts or less for voltage. As the position of the tap is advanced from the crystal end toward the battery end, the oscillator will draw more current and deliver more drive until a point is reached where the circuit becomes unstable and eventually ceases to oscillate. As mentioned before, the circuit as shown will work without difficulty and will produce enough drive to push the final to 14 or 15 watts, thus it should be used at it is.

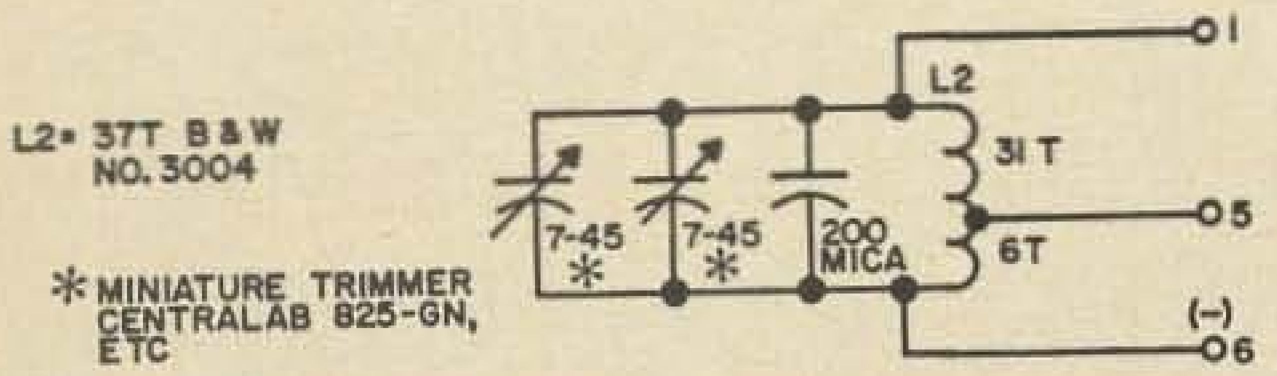
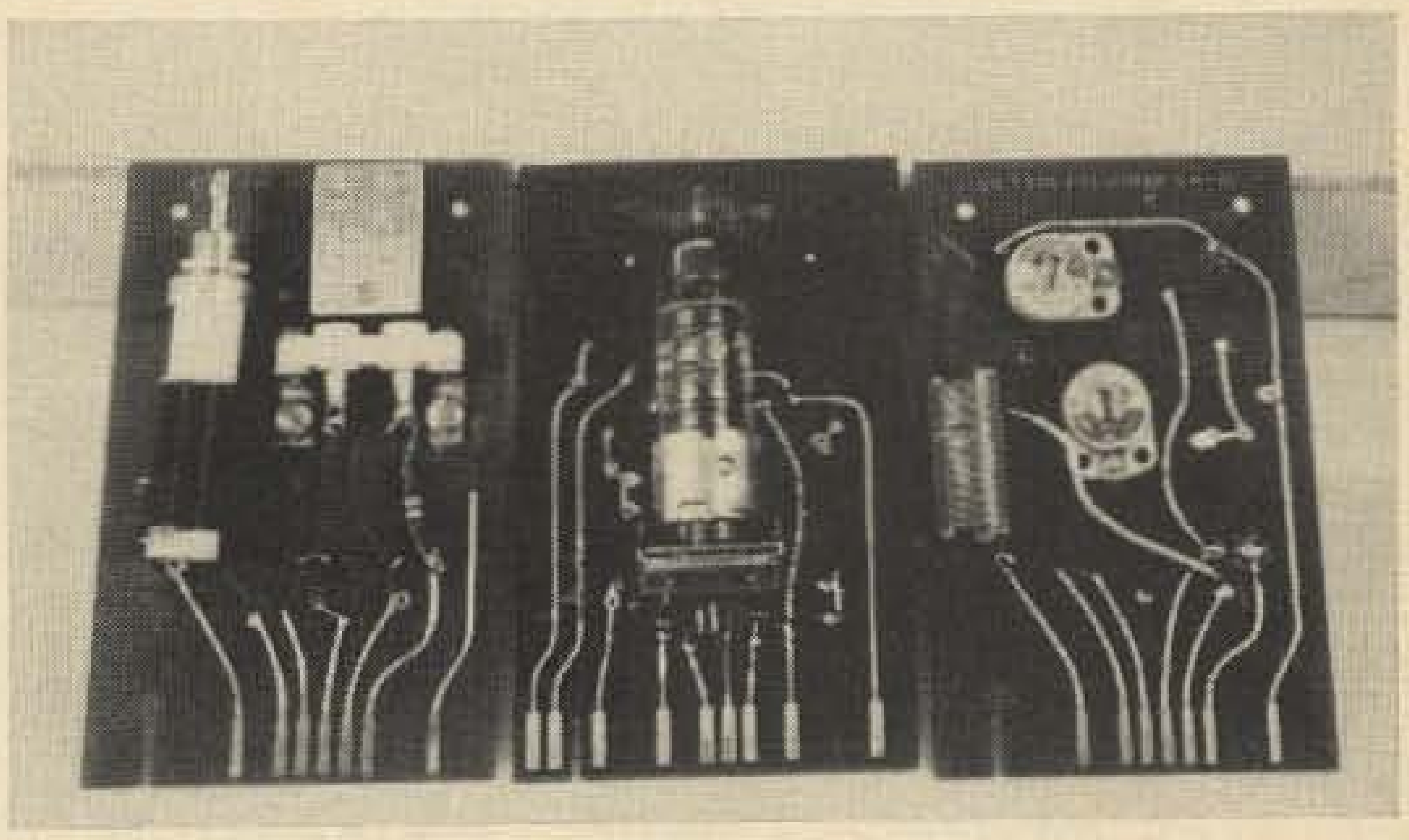


Fig. 3. The tank circuit card diagram.

If you will notice on the circuit in **Fig. 1**, a low impedance link is shown on the oscillator coil. This link is not used at the moment but will be used in the second version of the transmitter which has a transistor final amplifier. This second version is currently being designed.

There are no precautions to worry about when building this unit other than not to get the transistor too hot when soldering it into the circuit. The best idea is to use a small transistor socket and solder it into the circuit. The oscillator, when it draws 40 mA at 18 volts, runs about ¾ watt. To prevent damage to the transistor a small heat sink should be used. I used a small surplus finned heat sink. Similar sinks can be obtained from Allied Radio. The sinks are made by Wakefield-Engineering and are numbers NF205 and NF207.



Front side circuit boards.

The final amplifier

The final amplifier circuit is nothing out of the ordinary, and there is little to say about it. I had originally planned the final to be transistorized too, but I ran out of transistors and decided to use a tube. The tube socket specified on the schematic must be used to permit the tube to be mounted parallel to the computer card. When mounted this way, it sticks out from the card for less than an inch. When fully loaded, the final should draw between 40 and 50 mA at 300 volts giving a power input of a little less than 15 watts.

The tank circuit

The tank circuit was originally designed for single frequency operation as the trimmer capacitors were mounted right on the tank circuit card. This proved to be incon-

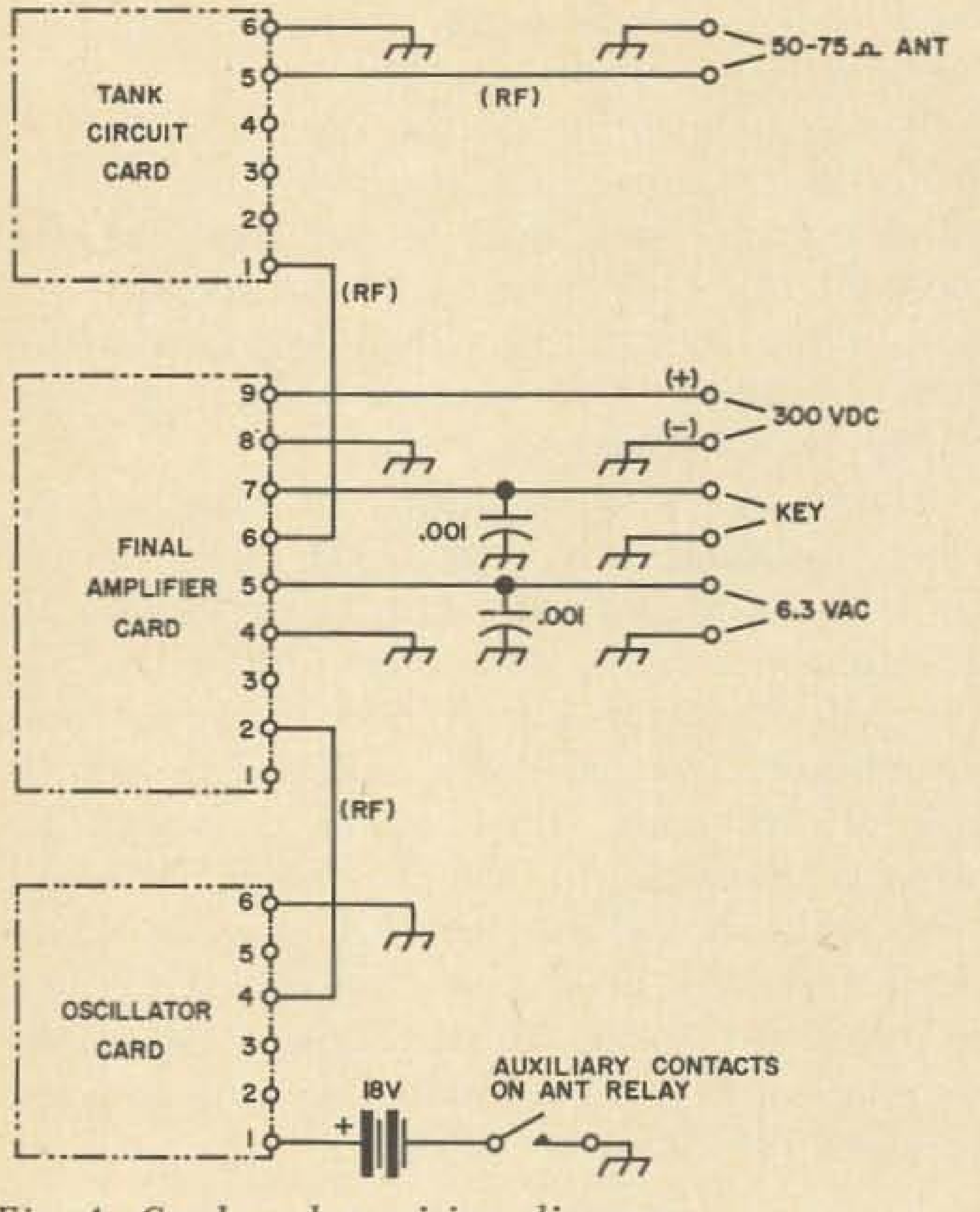


Fig. 4. Card socket wiring diagram.

venient, however, as I use this rig for the entire band. Thus, one trimmer capacitor was eliminated and a 100 pF capacitor which was mounted on the card rack was used instead. By varying both capacitors the tank will cover the entire band.

The output of the rig was designed for 50-75 ohm cable, and seems to work well into a load of this impedance. If you desire, you may change the output circuit to anything which happens to suit you merely by building a new circuit on another plug-in card and then swapping cards.

Tune up and operation

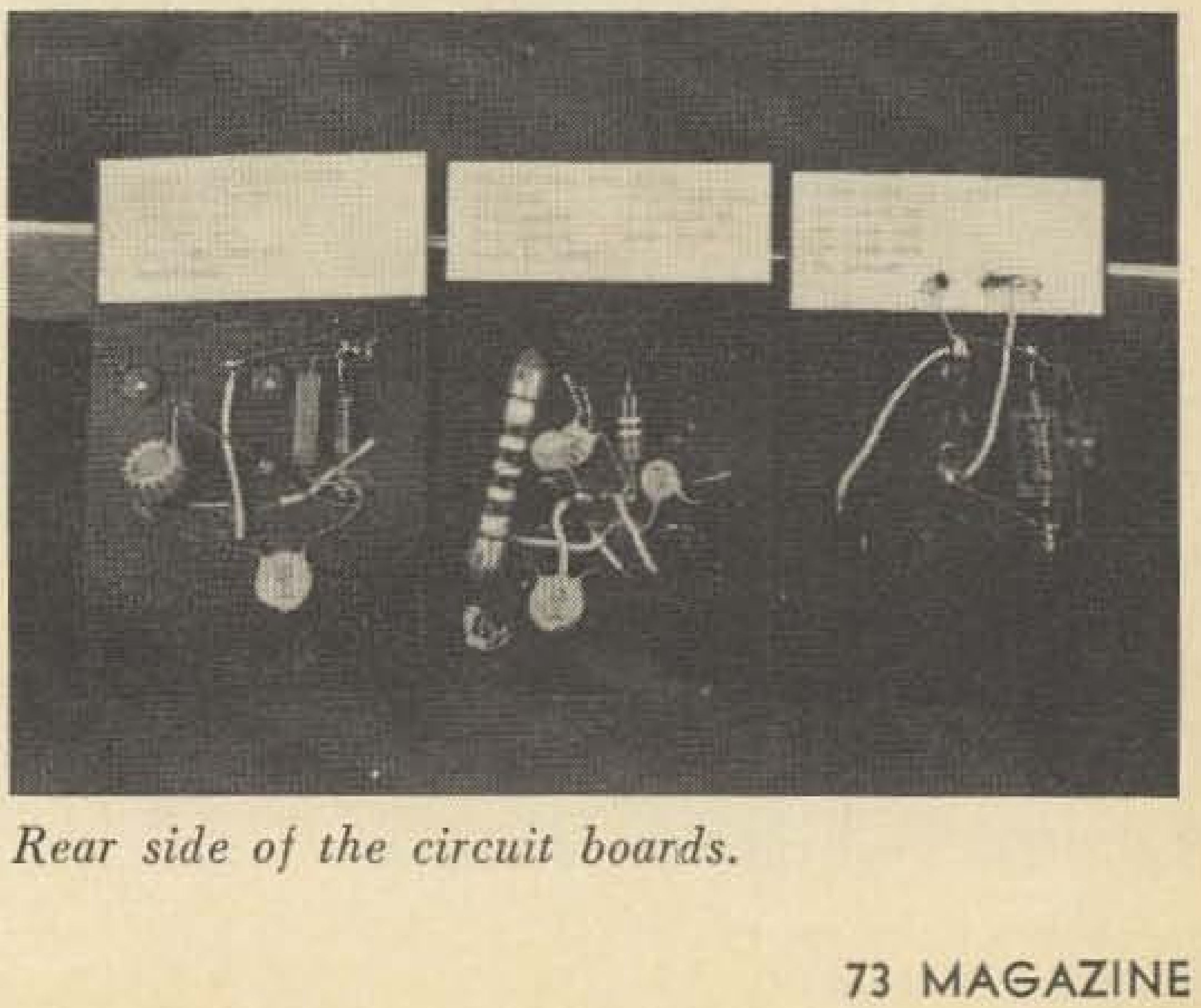
In my particular setup, the transistor voltage is supplied by three 6 volt lantern batteries. You may use any dc supply which delivers between 18 and 24 volts.

For testing purposes, connect a 5 or 10 watt lamp to the output to be used as a dummy antenna. Screw the movable slug on the oscillator coil all the way in and be sure that the heat sink is on the transistor. Connect a key to the key circuit and place a 100 mA meter in the battery circuit of the oscillator, but use only 6 volts or so on the oscillator. Turn on the station receiver and check to see that the oscillator is functioning. If it is not, vary the trimmer until it does oscillate. If trouble should be encountered, check to see that the battery polarity is correct and that the transistor is properly connected in the circuit. When oscillation is obtained, increase the battery voltage to 18 to 24 volts. Adjust the oscillator trimmer capacitor until oscillation ceases or the current drops to below 20 mA. Back off on this capacitor until the oscillator draws about 40 mA. The oscillator is now properly tuned. At this time, remove the meter from the battery circuit and place it in the key circuit. Adjust the capacitors in the final tank circuit to give minimum current with 300 volts applied to the plate of the final. When minimum current is obtained, the bulb should light dimly.

An alternate way of tuning up is to connect all voltages, place the meter in the key circuit and adjust the final for minimum current. Then, while observing the light bulb on the output, adjust the oscillator so that maximum brightness is obtained. At this point the oscillator current should be between 30 and 60 mA.

To put this rig on the air, connect a 50 or 75 ohm antenna or tuner to the output, place a 100 mA meter in the key circuit and tune to resonance. Then put the meter in the oscillator circuit and adjust the trimmer for about 40 mA.

This rig produces a clean signal with about 15 watts input. It should pose no constructional or operational problems that I know of; however, it does have one small quirk of which the builder should be aware. That is, that with 18 volts on the oscillator circuit, the grid drive is marginal and under some conditions, depending upon the transsistor, crystal, etc., the grid drive may be just under optimum. This condition will be very obvious if it occurs since if an *rf* choke, meter or other small inductance is placed in the key circuit, the output from the final will increase. This occurs because under con-



Rear side of the circuit boards.

ditions of insufficient grid drive, the final becomes unstable and begins oscillating by itself, but locking to the frequency of the crystal oscillator. The rig can be used under this circumstance for CW operation, but if you should plate modulate this rig it would be wise to use 24 volts on the oscillator to be assured of sufficient drive.

Do not be alarmed if the transistor runs hot to the touch. With the heat sink as specified in the oscillator section, the unit will get very warm but will not reach a dangerous temperature. Without a heat sink, however, the transistor will be damaged.

After you finish this little rig and decide that its time to start modifying it, keep in mind that since the three sections are built on plug-in boards there is no reason to modify or change your original circuits. Keep your original circuits intact and make all changes on separate circuits built on other plug-in cards. By doing this you will always have an operating version and you will always be able to make comparisons to your original circuits to see if you have made improvements or not.

. . . K1EUJ

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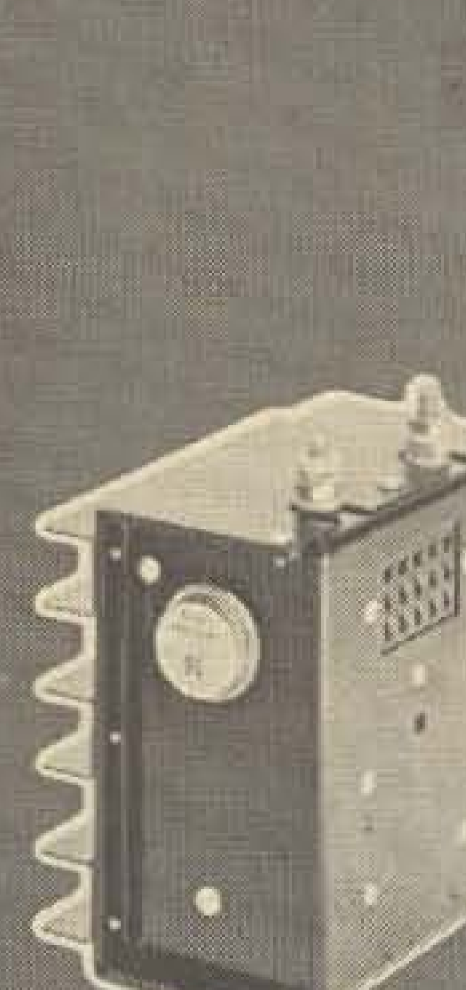

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SWAN SPEAKS YOUR LANGUAGE . . . ASK THE HAM WHO OWNS ONE

Crystal Filters

Heart of Single Sideband

Frederick M. Clepper, W3RET
McCoy Electronics Company Division
Oak Electro/Netics Corporation

Today, nearly all commercial SSB equipment utilizes quartz crystal filters. Ease of initial alignment, circuit stability and the "crystal clear" resultant signal are all characteristics of the filter approach to SSB generation. It hasn't always been this way, however.

Immediately following World War II—a time when most amateurs were eager to return to the airwaves—SSB was in its infancy. By mid-1947 only a handful of amateur stations were emitting the "Donald Duck" sounds on the lower frequencies. As one might expect, much controversy arose during these early sideband years and heated on-the-air discussions of SSB versus AM tended to prevail throughout the 1950's.

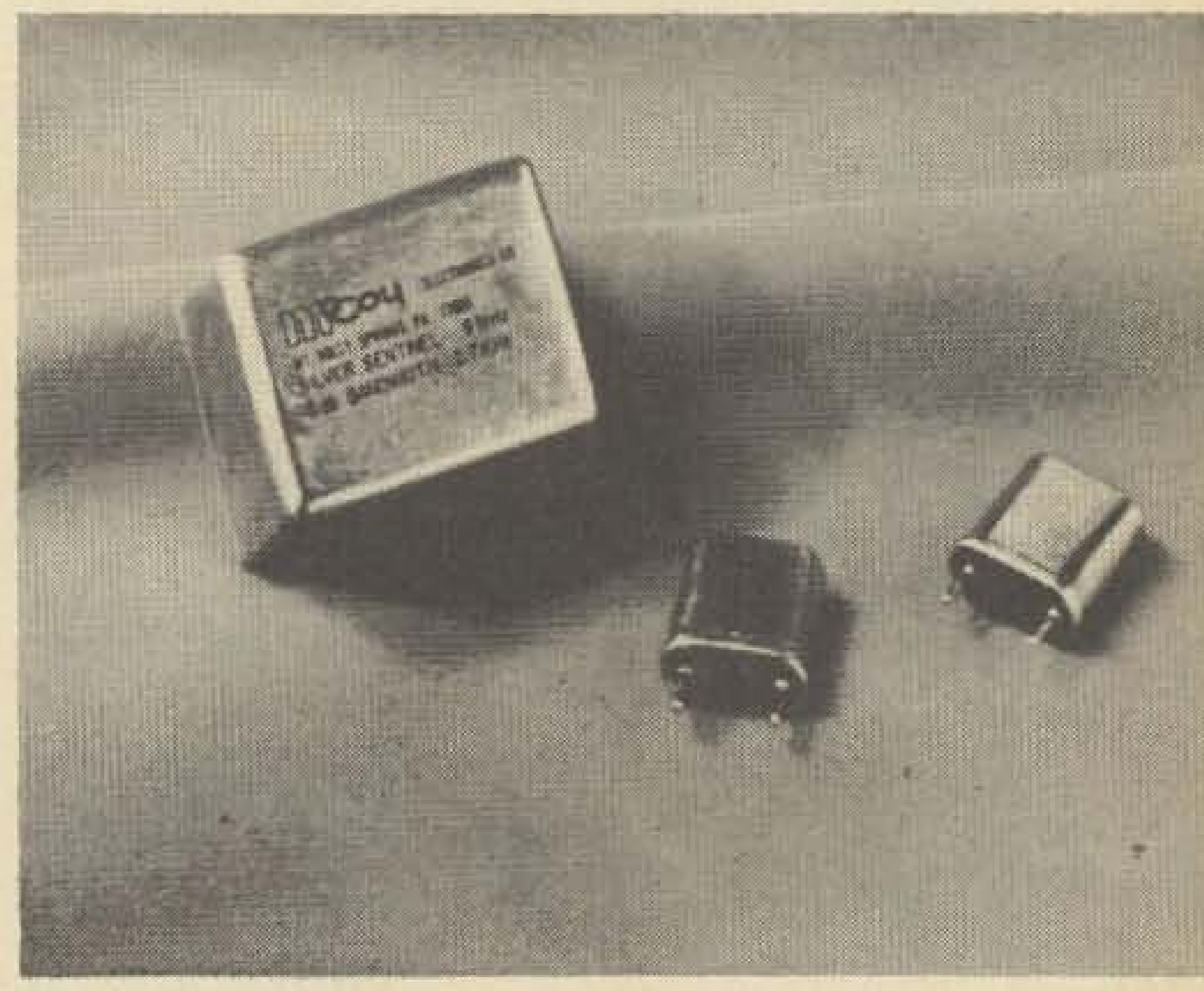
The technological approach then was to employ phasing-type designs commercially available with Barker & Williamson phase shift networks; this tended to make the carrier suppression job somewhat less tedious.

Crystal technique emerges

While this was happening crystal filters began to come into their own in communications receivers. It wasn't long before the advantages offered by the highly selective quartz elements became generally known by radio operators the world over.

Some of the more technically oriented amateurs of the early fifties discovered that military surplus low-frequency crystals could be used in construction of homebrewed SSB filters. It wasn't long before construction articles appeared in the amateur and trade press—significantly advancing the state-of-the-art—as a direct result of the staunch efforts of these pioneers. A quick examination of crystal operational characteristics reveals why this occurred.

Piezoelectric quartz, chemically silicon dioxide, possesses the ability of converting both electrical impulses into mechanical vibrations and mechanical vibrations into electrical impulses. It is through this means that



McCoy's Silver Sentinel quartz crystal filter, shown with the oscillator crystals supplied with all units.

quartz crystals can be used to control frequencies of radio transmitters and receivers. It is also by virtue of the piezoelectric effect that networks using quartz crystals can effectively pass or eliminate narrow bands or discrete frequencies in the radio spectrum.

Two basic filtering systems are being applied now to amateur equipment: 1) the switched filter method and 2) the switched carrier method.

The switched filter concept consists of two asymetrical or pure SSB filters switched above or below a common carrier frequency. **Fig. 1**, a simplified presentation of showing relative positioning of filters with respect to the carrier frequency, illustrates this point. The USB and LSB notations apply only to original frequency of sideband generation. Sideband inversion may result from hetrodyning to other than the original frequency.

The switched carrier concept is designed around an extremely selective, symmetrical bandpass filter. In this approach carrier frequency is switched between the upper and lower filter cut-off frequencies. **Fig. 2** is a presentation of the relative positioning of carrier with reference to the filter.

Switched carrier systems recently achieved wide acceptance in both receivers and transceivers. The advantages of this system include: 1) better out-of-band attenuation on both sides of the filter, 2) better stability

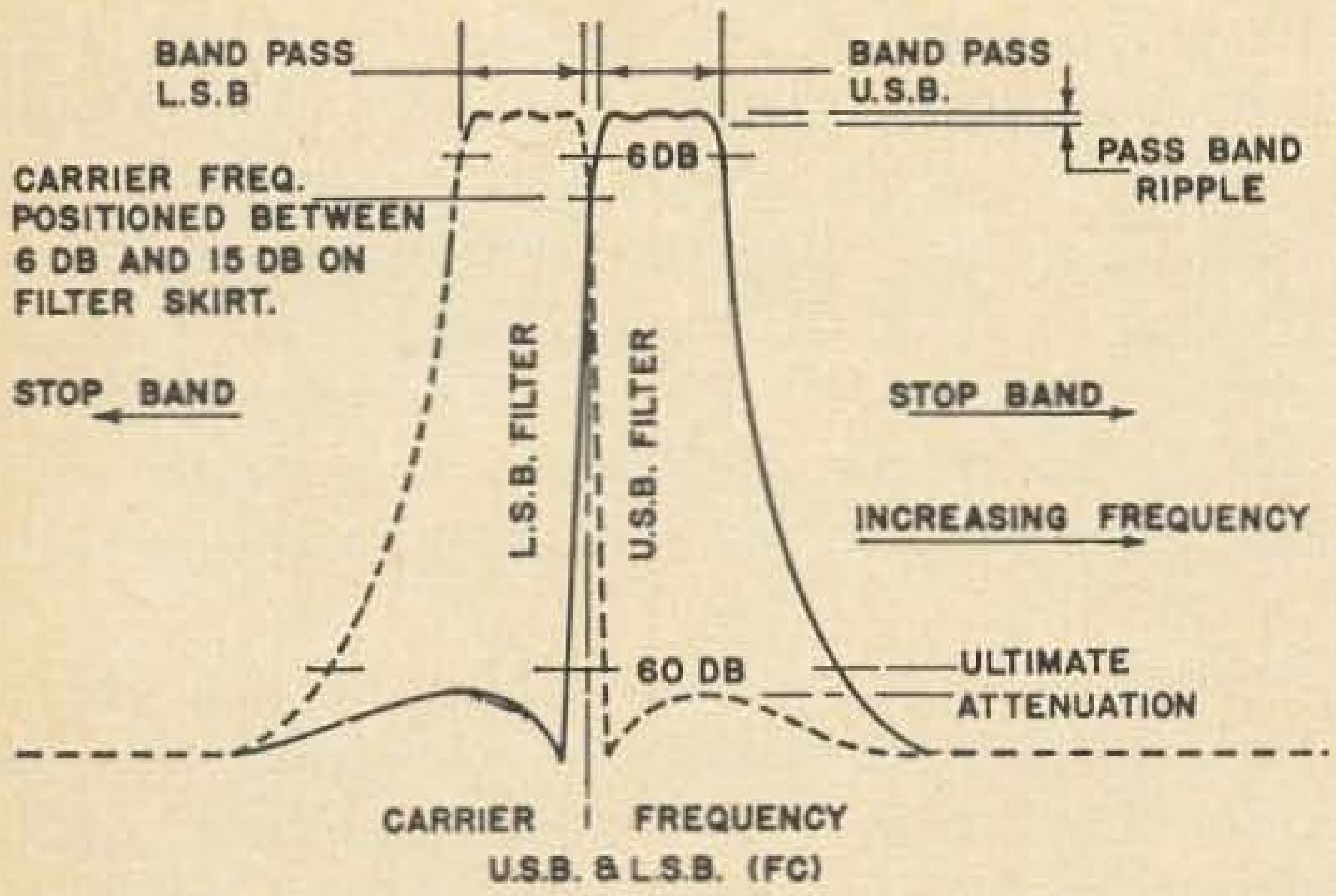


Fig. 1. Typical matched usb and lsb filters used in switched filter systems.

by eliminating the filter tracking problem of matched filters, 3) lower filter procurement cost, 4) less chassis space required and 5) oscillator crystal switching is operationally less critical than filter switching.

What to look for

An effective SSB filter must possess several distinct characteristics:

1) *Bandwidth.* The bandwidth of a filter is usually specified at −6 db. A typical SSB filter has a bandwidth of 3 kHz. Recent studies have indicated that a 2.1 kHz bandwidth is adequate for 100% intelligibility of the transmitted human voice. When one considers the adjacent channel or on-channel QRM on most ham bands, a 1.8 kHz bandwidth may find future acceptance.

2) *Shape factor.* Shape factor is usually specified as the ratio of the 6 db bandwidth to the 60 db bandwidth. An effective SSB filter should have a shape factor of 1.5:1 or less. For example, if a given filter has a 6 db bandwidth of 2.1 kHz, the 60 db bandwidth should have a maximum of 3.15 kHz. This specification is usually referred to in terms of the symetrical bandpass filter

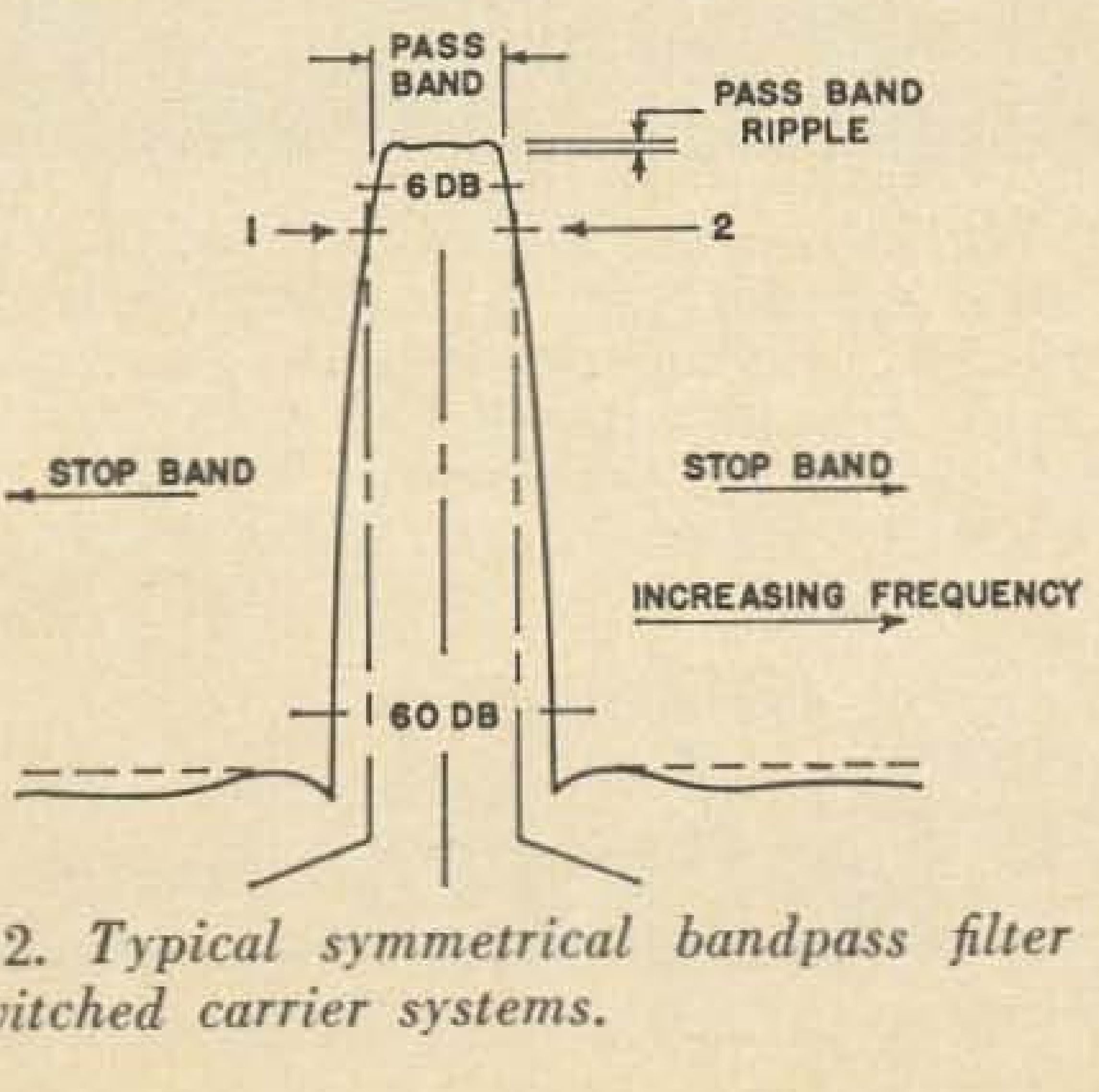


Fig. 2. Typical symmetrical bandpass filter used in switched carrier systems.

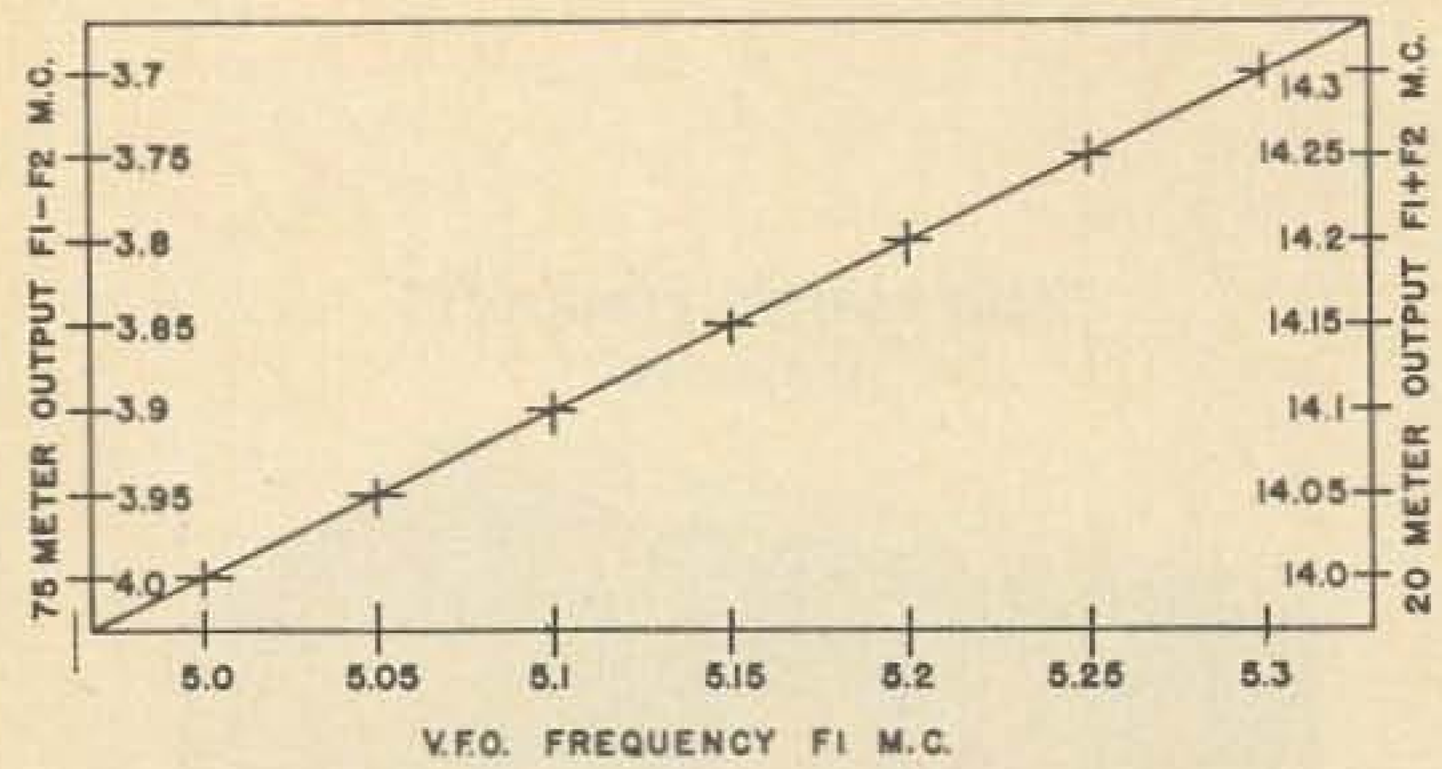


Fig. 3. Twenty and 75 meter frequency translation relationships to 5 MHz vfo.

used in the switched carrier technique. See **Fig. 1.** Pure SSB filters are most selective on only one skirt. In this case, discrete cutoff frequencies and their relative attenuations are usually specified.

3) *Ultimate attenuation.* The amount of attenuation given to signals appearing outside the selective skirt of the filter is normally referred to as ultimate attenuation. Generally −40 db is considered adequate as a design minimum. −50 db to −60 db ultimate attenuation is preferred.

Ham filter "Standards" arrive

In 1957, a 9.0 MHz symmetrical bandpass filter for amateur SSB use was introduced by McCoy Electronics Company. This filter was supplied with matching oscillator crystals for both upper and lower sideband operation and designated as type SSB-9. It was designed for a 6 db bandwidth of 2.7 kHz and a shape factor of 1.8:1, 40 db to 6 db.

The frequency of 9.0 MHz was chosen for this filter "first" because of the ease in hetrodyning to 20 to 75 meters with only a single conversion stages. **Fig. 3** is a graph of the 20 to 75 meter frequency translation relationships with a vfo operating in the 4 MHz range.

Popular demand for a filter of the SSB-9 type prompted design of a second generation filter series. The "Silver Sentinel" (McCoy type 32B1) and the "Golden Guardian" (type 48B1) evolved from the original SSB-9 designs.

The popularity of 9.0 MHz SSB filters has today spread throughout the world. VHF operators generally contend that high-frequency crystal filters were primarily responsible for the growth of SSB on the 50, 144 and 220 MHz bands. Manufacturers of amateur and commercial radio equipment have recognized the value of high quality crystal filters and are today producing amateur equipment capable of meeting rigorous commercial standards.

More than twenty years have elapsed since the birth of amateur SSB. Advances in state-of-the-art continue to tax the imagination. Amateur radio enthusiasts have played a major role in this progress and should be proud to have pioneered these advances.

. . . W3RET

The Ham of Distinction
uses
McCoy single side band filters

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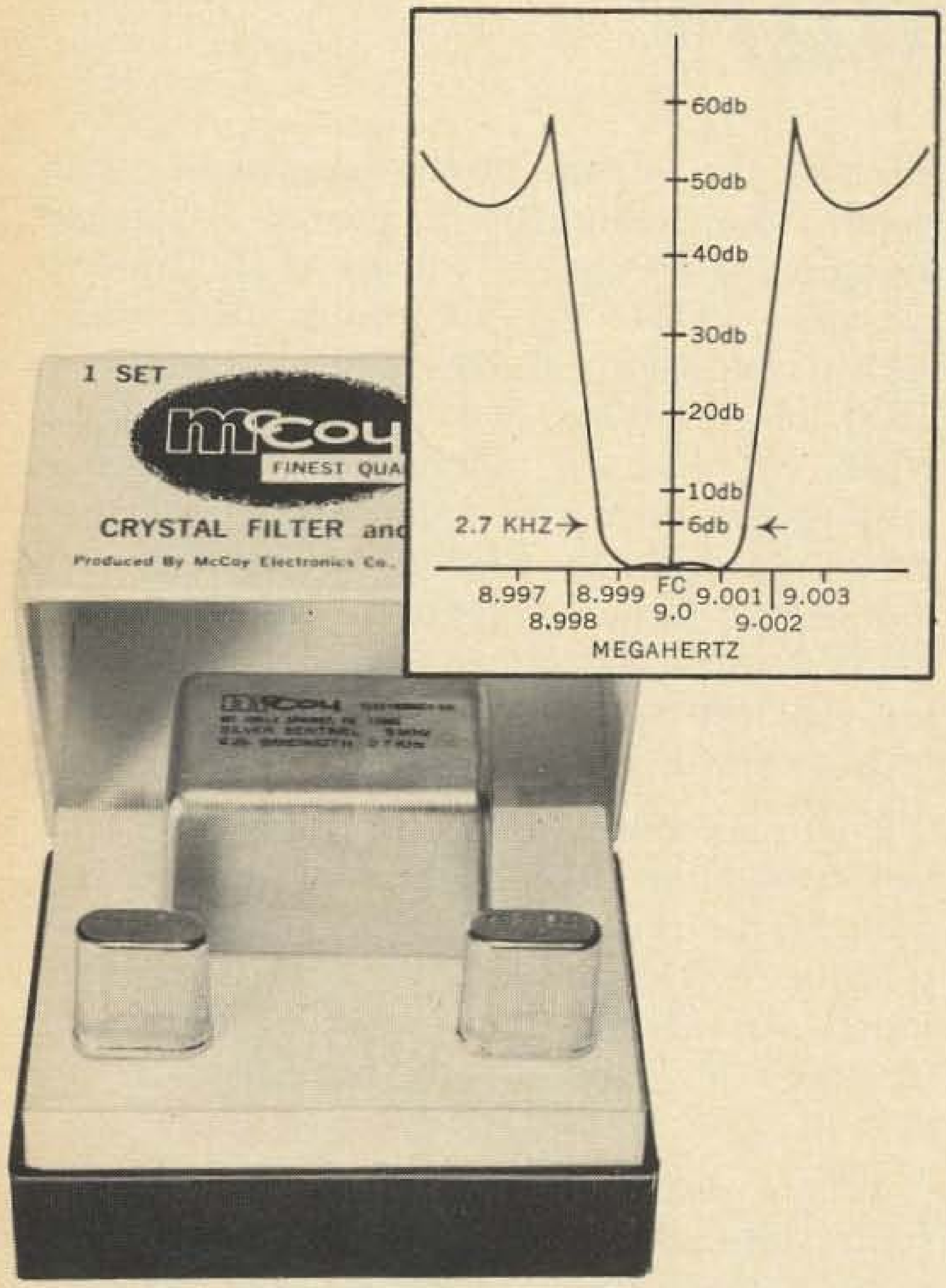
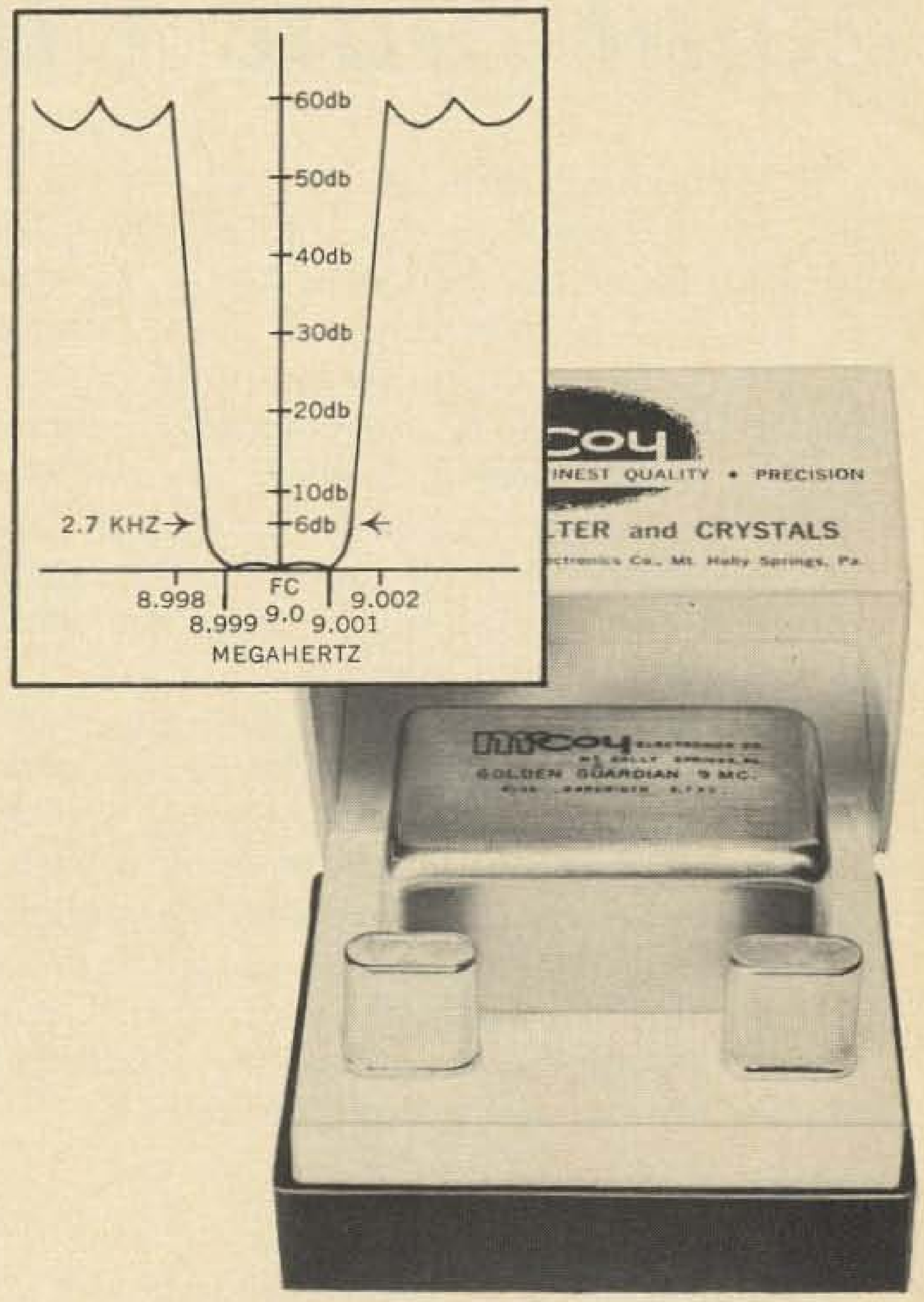


Silver Sentinel 32B1

Shape Factor: 6:20 db—1.3:1, 6:50 db—1.8:1 In/Out Impedance: 500 Ohms Ripple: 1 db max. Unwanted Side Band Rejection: over 40 db. Size: 1¾" x 1¼" x 1"

32B1 $32.95



Golden Guardian 48B1

Shape Factor 6:20 db—1.18:1, 6:50 db—1.53:1 In/Out Impedance: 600 Ohms Ripple: 1 db max. Unwanted Side Band Rejection: over 55 db. Size: 2 7/16" x 1 19/32" x 1"

48B1 $42.95

Both filters contain McCoy precision crystals and are supplied with two oscillator crystals. By switching crystals either upper or lower side band operation is possible. Both are available from stock. (Send check for cost plus $1 postage east of the Mississippi, $2 west.) Write McCoy or contact your distributor. Applications, notes and bibliography available on request.

McCOY ELECTRONICS COMPANY
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Troubleshooting Solid State Circuitry

Charles Jones K3PBY
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"If something can go wrong, it will!" This saying hangs on the wall of my shack and also above my bench at work. To anyone involved in electronics it is a familiar happening. Some construction projects don't work at all after they are completed; others work in a half decent fashion; or a circuit decides to lay an egg after months of perfect operation, It's all part of the game we've all been through. Winning the game can be pretty tough though.

In this article I will try to give you some "down-to-earth hints and techniques to make the hard game of troubleshooting a little easier for you to win. I do not think it useful to explore the aspects of debugging vacuum-tube circuitry since most of us are familiar with these procedures. Instead, I will concentrate on methods of locating difficulties which arise in solid state circuitry.

Voltage Measurements

The output and input impedances of transistors often are much lower than for vacuum-tubes, therefore a more sensitive voltmeter must be used when you are working on transistor circuits, to read the lower voltages. And a 1000 ohms-per-volt VOM about useless for transistor work because its current requirements will upset many transistor circuits.

To see how important it is to use a sensitive voltmeter when making measurements in a transistorized circuit, take a look at the circuit of **Fig. 1.** Suppose we want to measure the voltage at the base of the transistor. Our schematic indicates it should measure 1.35 volts. If we use a 1000 ohms-per-volt VOM at 2.5 volts full scale, with a sensitivity of the meter resistance is 2500 ohms. What we are actually doing when we make a voltage measurement is putting the meter in shunt with the circuit being checked. In **Fig. 1** we see this will reduce the base resistance to an equivalent value under 2500 ohms. Right away we can see that the signal and DC voltages at the transistor will be very upset.

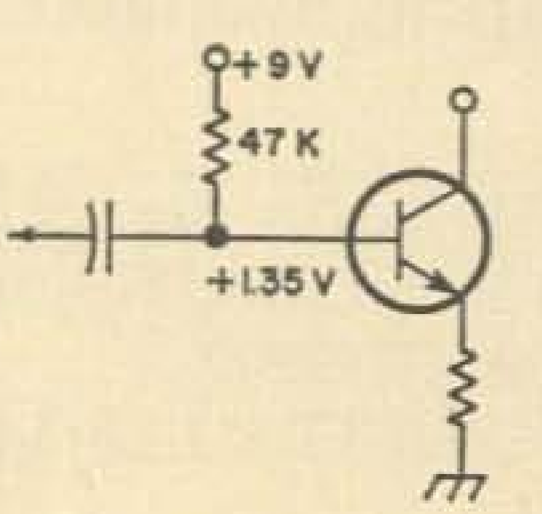

Fig. 1. See Text.

But if we use 20,000 ohms-per-volt VOM, this would be 50,000 ohms on the 2.5 volt range. This is a little better since the more sensitive VOM does not load the circuit as much. An 11-megohm would be best since it would have practically no effect on the circuit being tested.

When making voltage measurements in a solid state circuit, keep in mind that low meter ranges are required for low voltages. as an example consider a vacuum-tube circuit in which the plate voltage is supposed to be 300 volts. If for any reason there is a 10 percent decrease in plate voltage, we find 270 volts, a very visible change on a 350 Volt full scale range.

Now let us assume a transistor collector circuit in which we are looking for a potential of 6 volts. If this has dropped 10% we would find 5.4 volts. The percentage difference in both cases is the same and for the vacuum-tube circuit it would be very easy to detect a 30 volt difference. But a difference of 0.6 volt would be difficult to recognize, when working with low voltages on a high range scale. It is always good practice to choose a range where the meter needle will swing above the mid-scale point. This will help to make slight deviations in voltages more apparent.

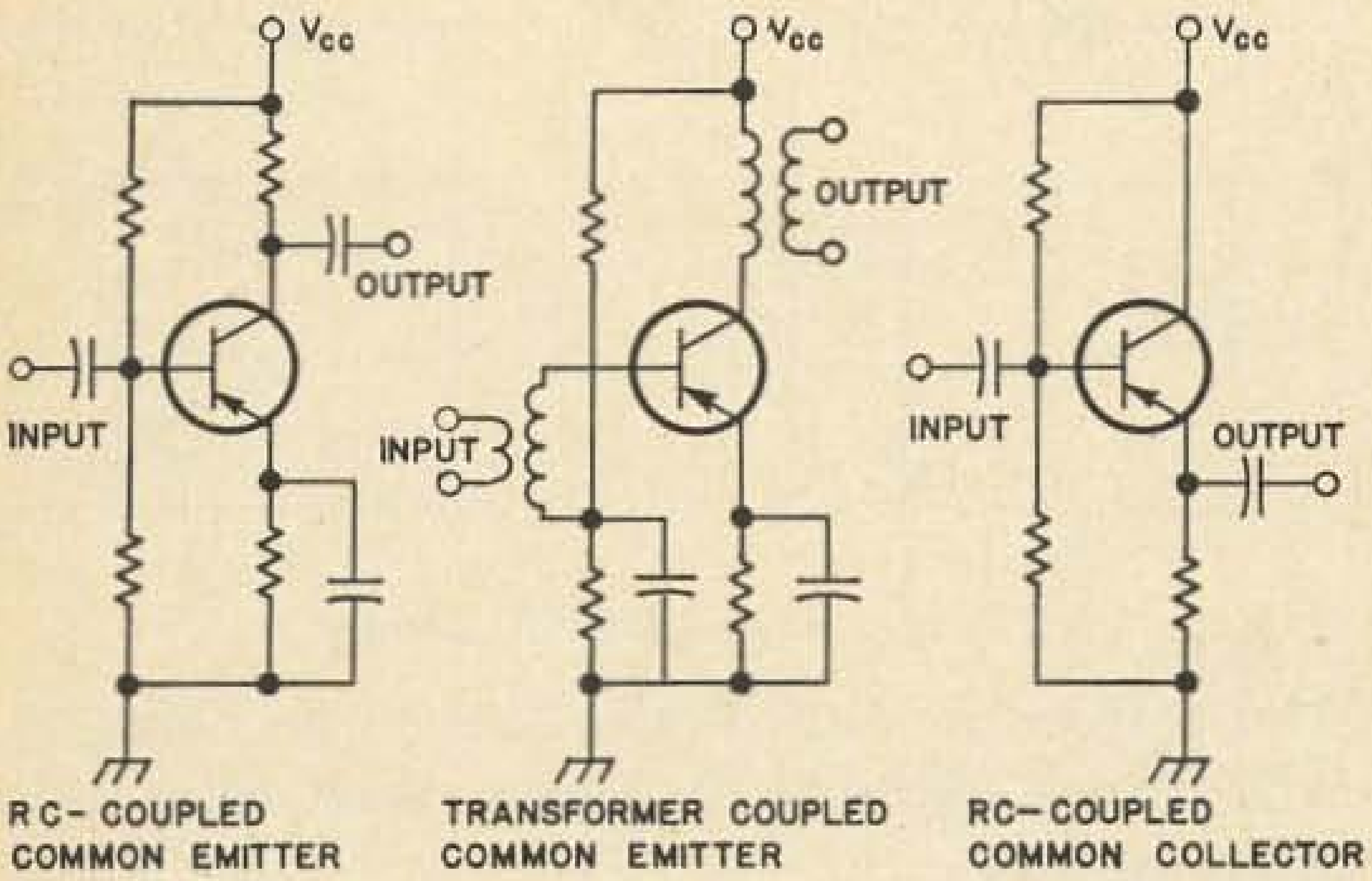

Fig. 2. Three common types of transistor amplifier circuits.

Voltage checking of transistor amplifiers is generally rather simple because they usually include an emitter resistor as part of the temperature stabilization network. By making voltage measurements across the emitter resistor we can quickly determine if the associated transistor and its circuit are functioning normally.

When checking the emitter resistor of an NPN transistor, we connect the positive lead of the voltmeter to the emitter lead and the negative lead to the common ground return point. For a PNP transistor the test leads must be reversed. Be careful in making voltage measurements across emitter resistors; it's easy to get fooled. You may be on the wrong range of your voltmeter. For example, if there is a defect in some component causing the voltage across the emitter resistor to be extremely low (0.2 volt or so), and you are on the ten volt scale of your voltmeter, it would be very easy to conclude that the emitter resistor voltage is zero.

The amount of voltage that you measure across the emitter resistor is a good indication of the trouble present in the circuit. For example, if you measure a potential of zero volts across the emitter resistor, it is likely the emitter resistor is open or disconnected. But take a good look to be sure the resistor is in good condition, and check the soldered joint.

Emitter resistors will seldom fail simply because they are tired. Usually some circuit malfunction causes them to overheat and open. A transistor collector-to-emitter short is one possible cause of a burned out emitter resistor. If you do find an open emitter resistor, or one which is greatly changed in value the associated transistor should be checked before the resistor is replaced.

Applying voltage of incorrect polarity to the circuit may also burn out the emitter resistor. If the circuit does not operate properly after you have corrected the supply polarity you should check each stage for an open emitter resistor after checking the transistor.

When measuring the collector-to-emitter voltage, be sure to use the correct meter polarity, depending on the type of transistor under test. The voltage you find should be around 50 percent of the collector supply voltage, or higher.

Because the base-emitter voltage is usually a few tenths of a volt, few circuit defects will cause the base voltage to be far from normal when measured with respect to the ground. Unless the base of the transistor is disconnected from its voltage divider network, or the network itself is defective, the base voltage can not change by a very large amount. Small variations in base voltage normally don't cause the circuit to become completely inoperative, unless the base-to-emitter current is abnormal.

Real Circuits

The three most common types of transistor amplifier circuits are illustrated in **Fig. 2.** For each circuit, it is easy to estimate the emitter, base and collector voltages to be expected if the transistor and other components are good.

If a high-beta transistor is used in the RC-coupled stage of **Fig. 2A,** the base current may be neglected in comparison with the bleeder current in the bias network consisting of resistors R1 and R2. The voltage at the base of the transistor can be calculated by solving the following equation:

$$\text{base voltage} = \frac{R2}{R1 + R2} \text{ x's collector voltage}$$

In the normal low-level amplifier stage with a quiescent collector current of approximately 1 mA, the base-emitter voltage is of the order of 200 millivolts in a germanium transistor, or 700 in V in a silicon transistor. The emitter voltage can be estimated by subtracting this voltage drop from the base voltage.

The emitter current is equal to the emitter voltage divided by the value of the emitter resistor, and the collector current will be about the same. The same analysis applies to the circuits of **Fig. 2B-C.**

Current Measurements

Direct current measurements sometimes provide useful clues to the operation of a circuit than voltage measurements. To make current tests, however, the circuit must be broken to insert the milliammeter. For this reason, current measurements are often used only as a last resort.

We can measure the emitter current by connecting dc milliammeter in series between the emitter resistor and the emitter electrode. To do this, remove the transistor from its socket, disconnect the emitter resistor from the emitter electrode and insert the milliammeter leads. If the transistor is soldered in to the circuit, simply disconnect the emitter resistor from its ground return and connect the milliammeter from the ground return to the open end of the resistor. You can also calculate the emitter current by measuring the emitter voltage and the resistor value.

Finding Open Circuits

When the emitter circuit of a transistor is open the collector current circuit is broken. The floating emitter lead will assume the same voltage as the base terminal, if the BC diode is not shorted. The-emitter-base bias voltage will be zero volts, and the base voltage to ground will be fairly normal.

If the base circuit of a germanium transistor opens, the transistor may go into thermal runaway. A silicon transistor will simply stop conducting under normal conditions, but may also go into the thermal runaway if operating temperatures are high.

When the collector circuit opens, the collector and emitter electrodes will assume the same potential, provided with normal base bias, the transistor has gone into saturation. Another condition which will cause the emitter and collector electrodes to have the same voltages is a shorted transistor. This is more likely to happen with power transistors.

Various Tests and Measurements

Always test a transistor or diode before inserting it in a circuit. It may be defective.

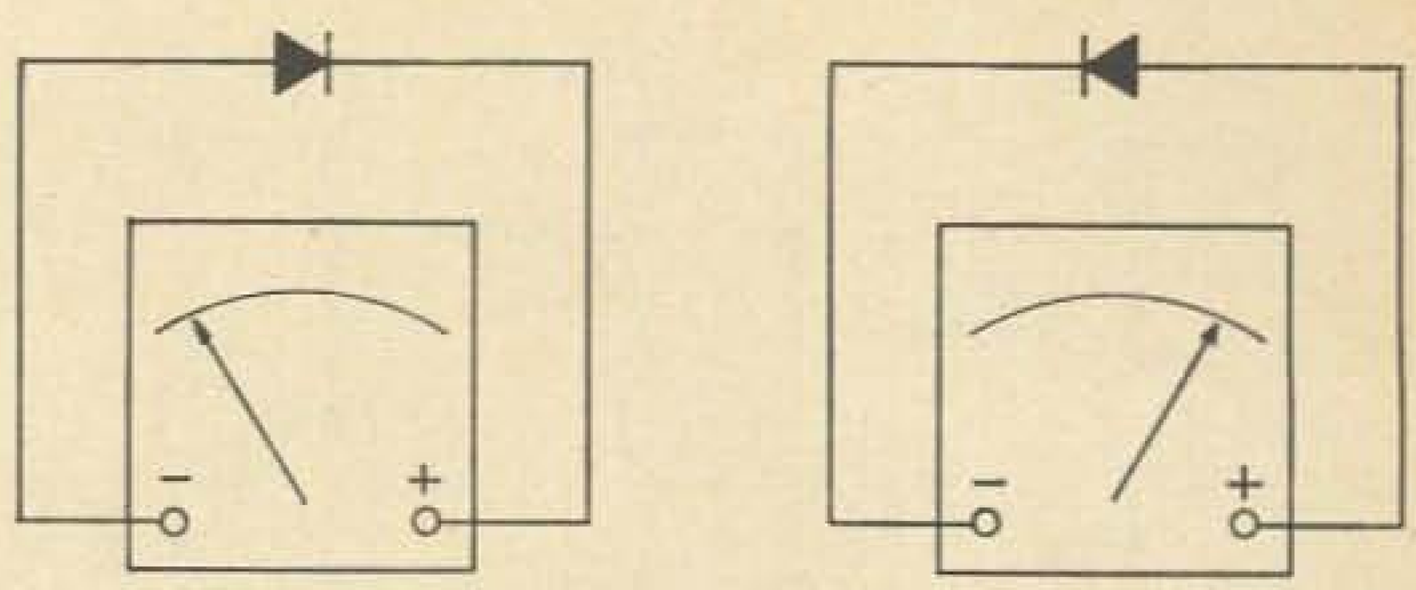

Fig. 3. Checking semiconductor diodes.

And transistors and diodes should be checked when they are suspected as a cause of equipment failure.

Semiconductor diodes are easy to check with an ohmmeter. Diodes should measure 25 to 500 ohms forward and about 250k ohms or more in the reverse direction (**Fig. 3**). If the diode is tested in the circuit the forward resistance should be about the same. But in most circuits diodes will only measure around 5k ohms in the reverse direction, due to added parallel circuit resistances. If you suspect that the diode is defective make a final check on the reverse resistance with one end of the diode disconnected from the circuit.

You can also make rough checks on transistors with your ohmmeter. If the transistors are not in sockets or cannot be easily removed from the circuit you do not have to disconnect them.

A transistor is basically a pair of diodes placed back-to-back. We can take advantage of this fact for testing, simply by measuring the forward and reverse resistances of the transistor electrodes.

The first step is an ohmmeter test with the collector-base electrodes reverse biased. This is easily done whether the transistor is an PNP or NPN type. Try both directions across the collector and base to find which gives the highest resistance reading. When you have located it, hold the meter leads to the collector and base terminals in place.

Next, observe the resistance reading and then short the emitter to the base; the resistance reading should not change. Remove the ohmmeter lead from the base electrode and connect it to the emitter lead. Now short the emitter to the base; the resistance reading should increase.

If a transistor does not respond as described, it probably is defective. However, weak units, or those which have leakage between elements, might test satisfactorily. These basic tests only indicate when a transistor is completely inoperative.

Conclusion

Troubleshooting solid state circuitry is sometimes very different from troubleshooting vacuum-tube circuitry. A few points are outlined in our discussion where the testing calls for special precautions or techniques, and some other debugging procedures are much the same. Locating solid state circuit problems should not present much difficulty to the radio amateur who is familiar with basic troubleshooting procedures and solid state theory.

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Bibliography

Leonard Lane, *How To Fix Transistor Radios and Printed Circuits—Vol. 2*, New York, Gernsback Library, 1959.

A Real "Big Switch"

When you hear a ham make a comment about pulling the "big switch" in most cases he means he will spend the following several minutes turning off an assortment of receivers, transmitters, scopes, calibrators etc. Some few of us actually cut the main breaker, but that too has disadvantages, there being some items which should remain on 24 hours a day. (including some rigs)

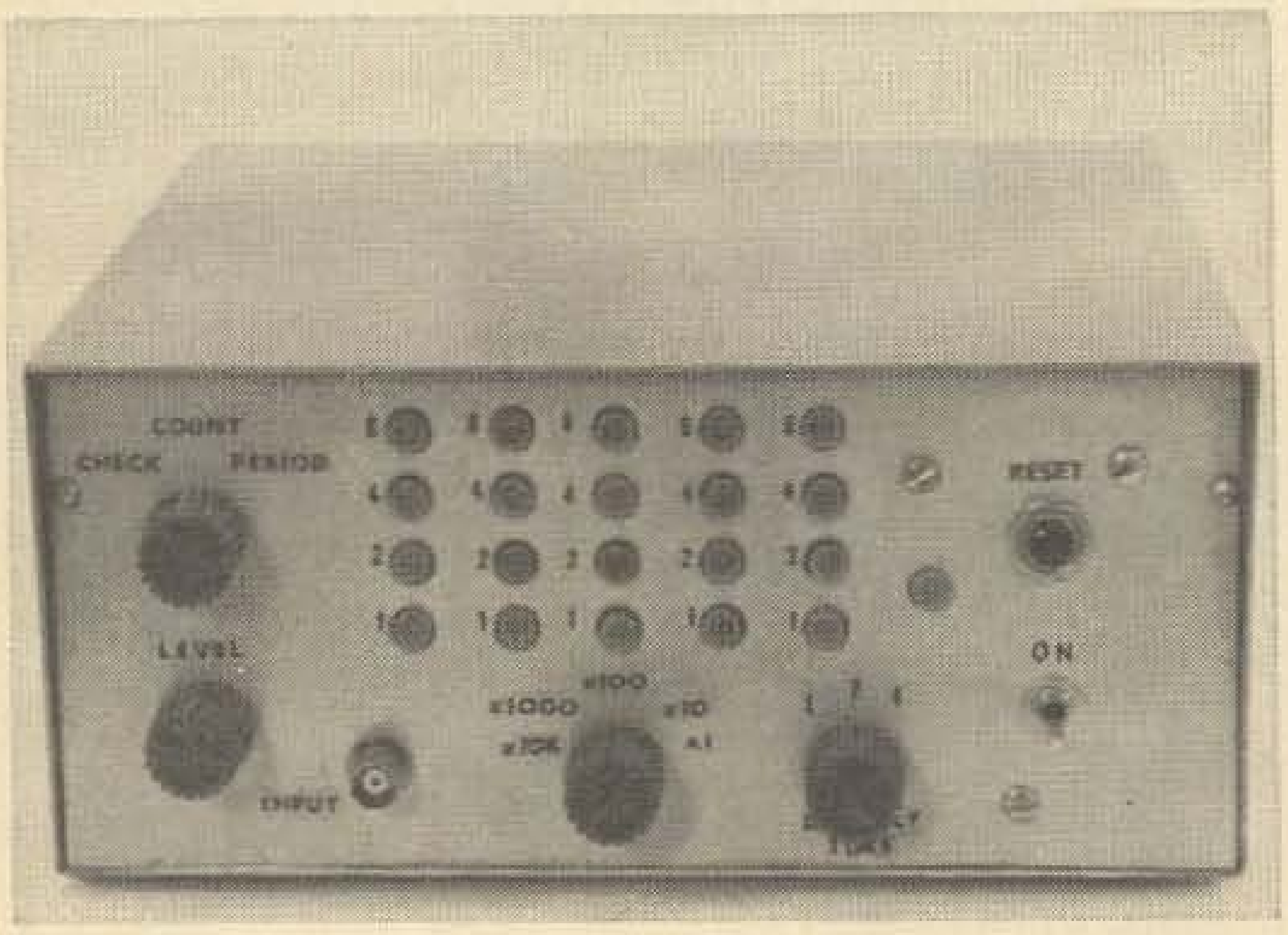
There are several ways of approaching this problem, the simpliest being two "convenience outlets" mounted on the main rig power supply. One is attached directly to the incoming power line. This circuit is used for clocks and other items which are left on all the time. The second outlet is wired across the primary of the power transformer so that it is energized with the rig. This setup should only be used for devices drawing small amounts of current lest the fuse or switch give up under the extra burden. For higher power, install the outlets as described, but in an external box install a heavy duty 117vac relay and as many outlets as required by the equipment to be controlled. The power for the relay coil only is derived from the rig, a separate heavy duty line cord being connected in series with the normally open relay contacts and the outlets.

We now have a method of turning off power to the station by means of a single switch–the one already on the rig. You can comment about pulling the "big switch" and be overstating the facts only very slightly.

. . . WAØABI

Integrated Circuit Frequency Counter

Wes Votipka WB6IBS
Consumer Applications
Fairchild Semiconductor
313 *Fairchild Drive*
Mountain View, Ca. 94041



A simplified frequency counter that can be used in checking the drift of a variable frequency oscillator can be easily built at a minimum of cost thanks to the large availability of low-cost integrated circuits.

The simplicity of design using the integrated circuit binary system uses no transformers with their associated turns ratio and impedance ratio to worry about or wind; there is no filament to run, shield and bypass at each end; and there are no ground loops that always seemed to be included in equipment built in the past.

The basic block diagram for the digital frequency counter is shown in **Fig. 1.** A standard frequency is needed as a reference; a pulse shaping network for the input signal; a counting and display system; a power supply and a control (program generator) to sequence everything properly.

The final design must meet these requirements:

1. Count frequency to at least 10 MHz.
2. Have reasonable accuracy, .001 per cent or better.
3. Use low cost and readily available integrated circuits.
4. Line operated regulated power supply with options for use with auto battery.
5. Should have a five-digit readout with panel lights because Nixie tubes are too expensive and require additional integrated circuits for decoding for a decimal readout.
6. Variable readout display time.
7. Period count for additional flexibility.
8. Self check feature.
9. P. C. Board for repeatability and trouble free wiring.
10. A general description of the circuit complete enough for the interested person to get an understanding of the logic operation and design to assist him in modifying the counter to use whatever integrated circuits he might have available.

The integrated circuit frequency counter to be described meets all of the above requirements and exceeds the minimum frequency specifications in that it has a direct readout to 20 MHz. The total cost of new, off-the-shelf, integrated circuits is approximately $120.

First, it's best to examine the basic parts of a counter to see how they work, and then connect them to make them count. The basic unit (counter module) must contain some means of sensing a change at its input. The module should be able to store or hold this information so that it can displayed on a readout device. The unit chosen for this function is a flip-flop, a device that has only two output states, a "one" and a "zero." **Fig. 2** is the schematic of a μL 923 JK Flip-Flop.

Fig. 3 is the logic symbol of the device

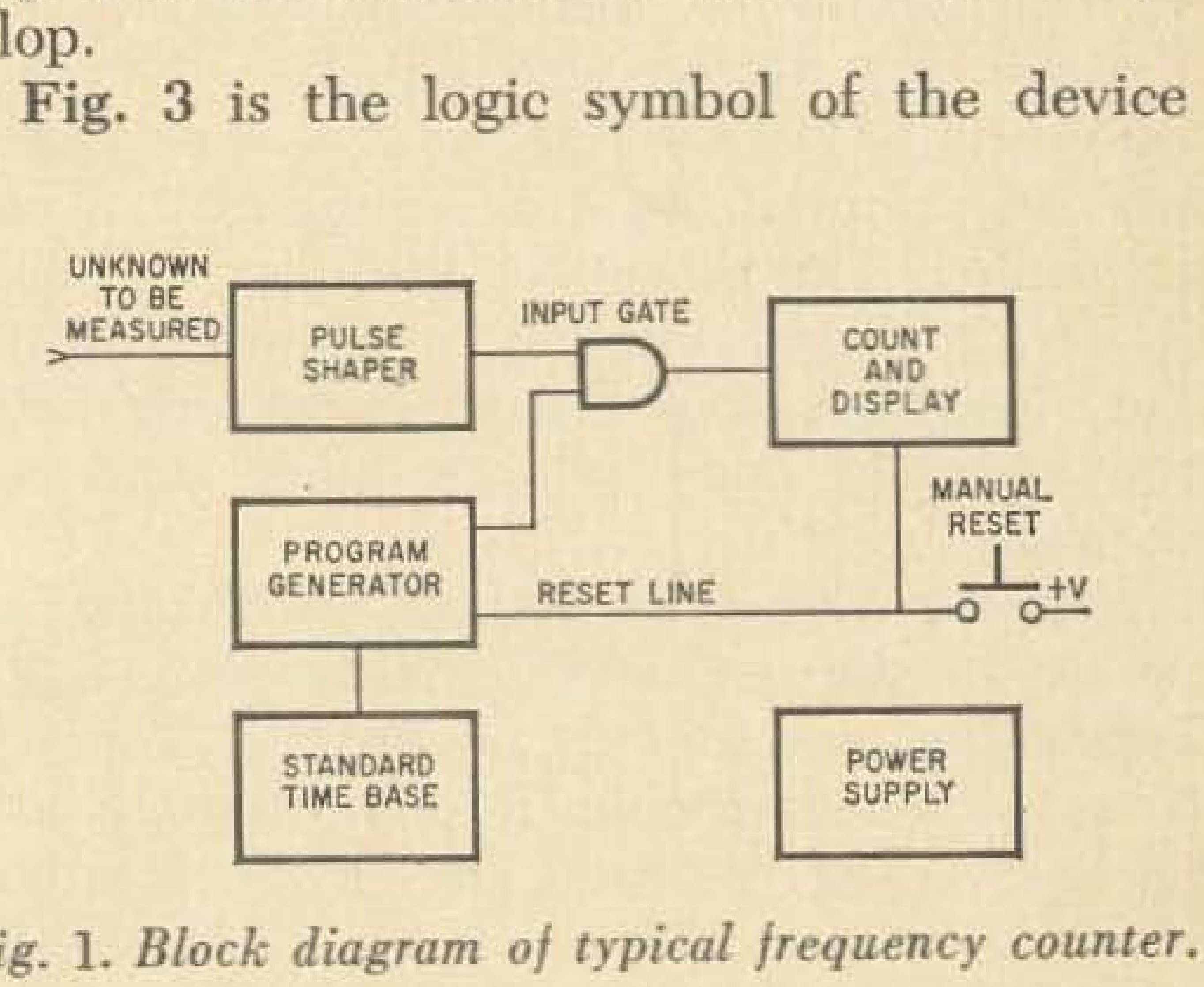


Fig. 1. Block diagram of typical frequency counter.

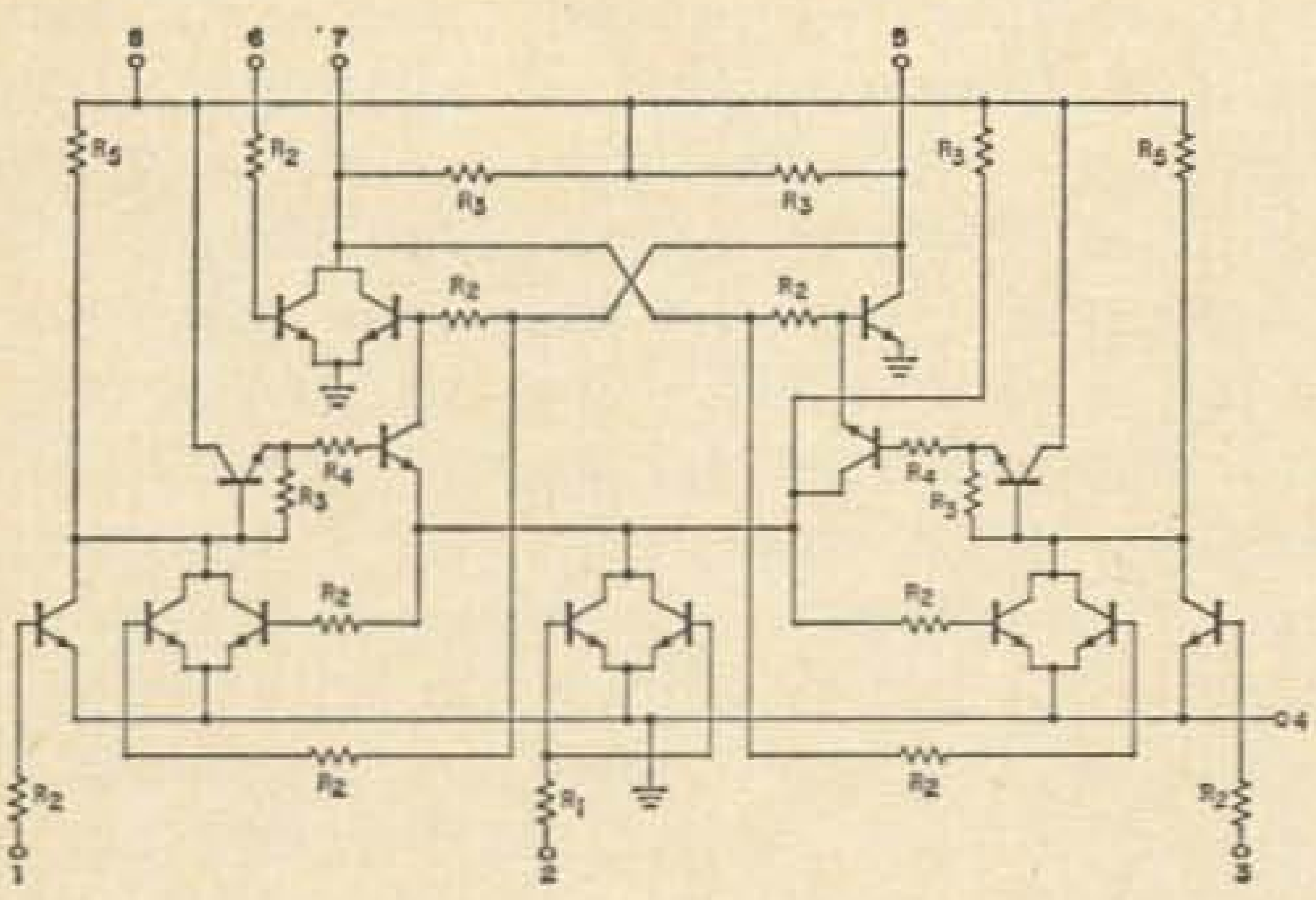


Fig. 2. The schematic of a uL 932 JK Flip-Flop.

with the truth table for the μL 923 outlined in **Fig. 4.** A lamp is used in series with a transistor connected to ground as a lamp driver and when connected produces the counter module shown in **Fig. 5.**

When connected in this manner, the transistor would draw excessive base current, so 470-ohms resistor is added in series with the base to limit the base current to a safe value. The lamp will now light every other time the input switch (S1, in **Fig. 5**), is closed. When five of these are connected together (as shown in **Fig. 6**) there will now be a counter that can count, hold and display up to a total count of 31. On the next input all lamps go out and the count starts over.

This idea can be carried on as far as one cares. That is twelve of the basic modules connected as such would give a total count of 4,095. In the above example the individual must decode the lamps that are lit. Assume all lamps are out, on the first pulse lamp No. 1 lights, on the second pulse it goes out and lamp No. 2 lights, on the third pulse both 1 and 2 are lit and so on. The secret is to add the value of the lighted

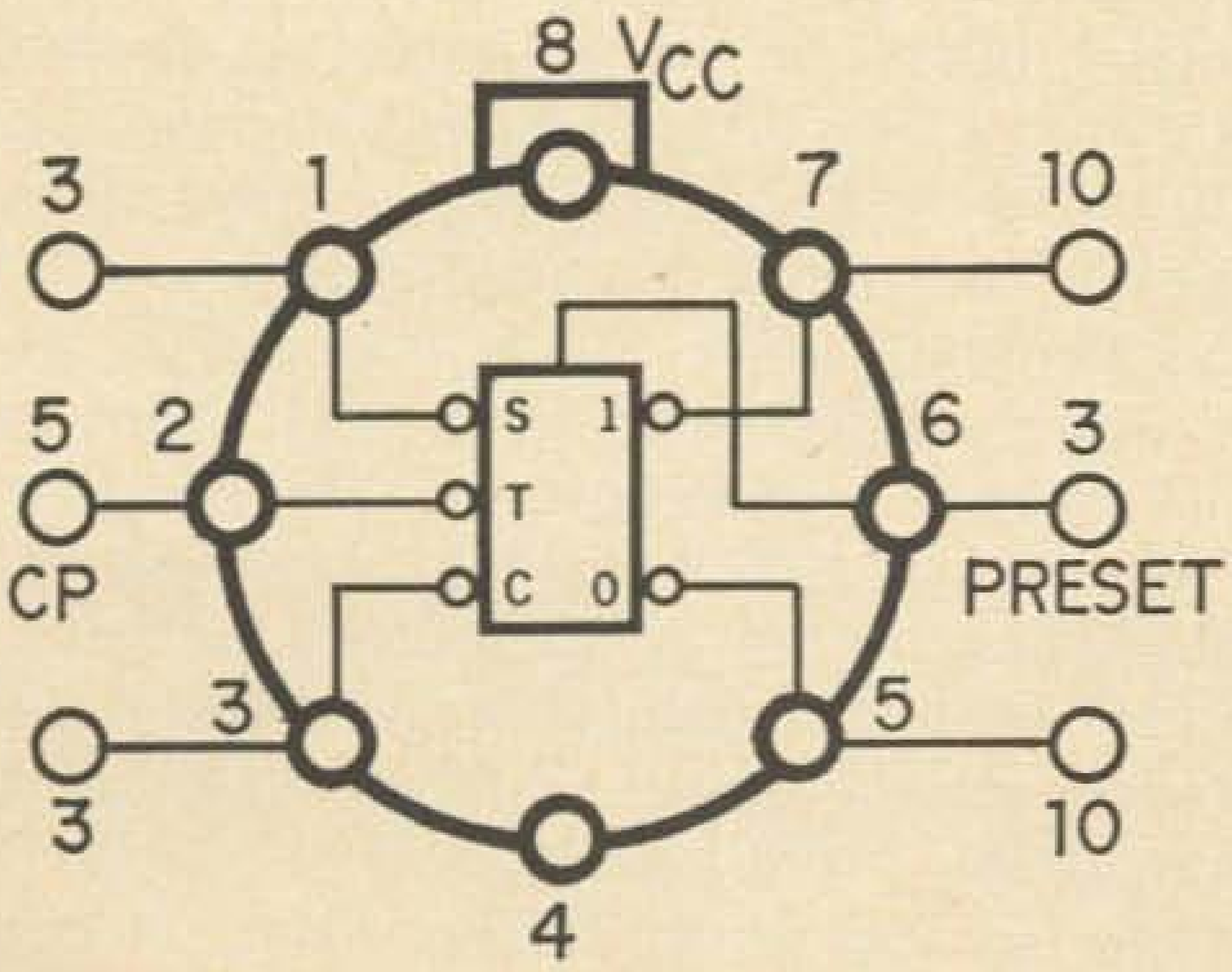


Fig. 3. The logic symbol of the uL 923.

lamps to arrive at the correct count. While this binary system works well, most people have been taught to think in the decimal or base 10 system, therefore a counter is needed to display the number 9 count then on the next input for all the lights to go out. This can be done as in **Fig. 7A.**

In order to accomplish this 4 flip-flops and a μL 914 are used (**Fig. 7B**) with dual two gate input connected to form a decade (or divide by 10) counter.

FUNCTIONS

SET (1)	CLEAR (3) t=n	OUTPUT (7) t=n+1
H	H	X^n
H	L	H
L	H	L
L	L	$\overline{X^n}$

H = HIGH

L = LOW

X IS THE OUTPUT STATE AT TIME n

A HIGH ON PIN 6 WILL PRESET OUTPUT PIN 7 LOW

Fig. 4. Truth table.

Truth Table

		Lamp Number			
Decimal	Input	#1	#2	#3	#4
0	0	0	0	0	0
1	1	*	0	0	0
2	0	0	*	0	0
3	1	*	*	0	0
4	0	0	0	*	0
5	1	*	0	*	0
6	0	0	*	*	0
7	1	*	*	*	0
8	0	0	0	0	*
9	1	*	0	0	*

The above truth table is the proof of this connection. By connecting five of these decades together one has the ability to count to 99,999.

The maximum speed of the μL 923 is 2 MHz, and a μL 926 has a maximum speed of 20 MHz, with one decade using μL 926s and four decades using μL 923's ability to count to the maximum rate of the μL 926 is reached—in other words a 20 MHz counter.

For a reference a stable time base is required. A good choice is a 100 kHz crystal.

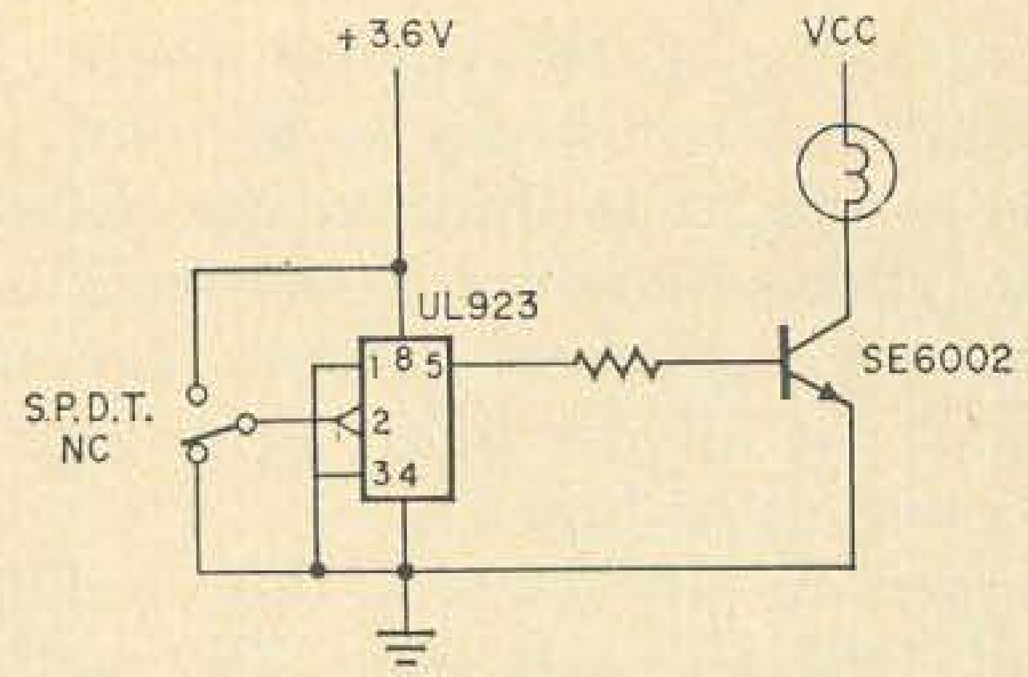


Fig. 5. A lamp used in series with a transistor connected to ground as a lamp driver produces the counter module shown.

Fig. 8 shows the 100 kHz crystal oscillator used.

The μL 914 is connected as a multivibrator with the crystal connectel in one of the feedback paths. The output of the crystal oscillator has to be reduced to lower frequencies to be useful. The μL 958 decade divider is used here in the interest of space. The μL 923 decade divider of **Fig. 7** could be used as well if space is not a prime consideration. The logic diagram of the μL 958 is shown in **Fig. 9.**

Five of these decade dividers are required in this system in addition to three μL 923 flip-flops to give the required timing pulses.

The next circuit to be considered is the input-pulse shaper and gate. The pulse shaper is required to convert the input waveform to a square wave with rise and fall time faster than 200 milliseconds. The Schmidt trigger meets this requirement. The input to the Schmidt trigger is rather high (1.7 V) so it must be preceded by an amplifier. The complete input circuit is shown in **Fig. 10.**

The 5K pot serves as the input sensitivity control. The diodes D1, D2, and D3 are required as level shifting devices and can be any silicon devices such as the FD 100.

The program generator is the most complicated part of the counter circuitry. **Fig. 11** is a diagram of this unit.

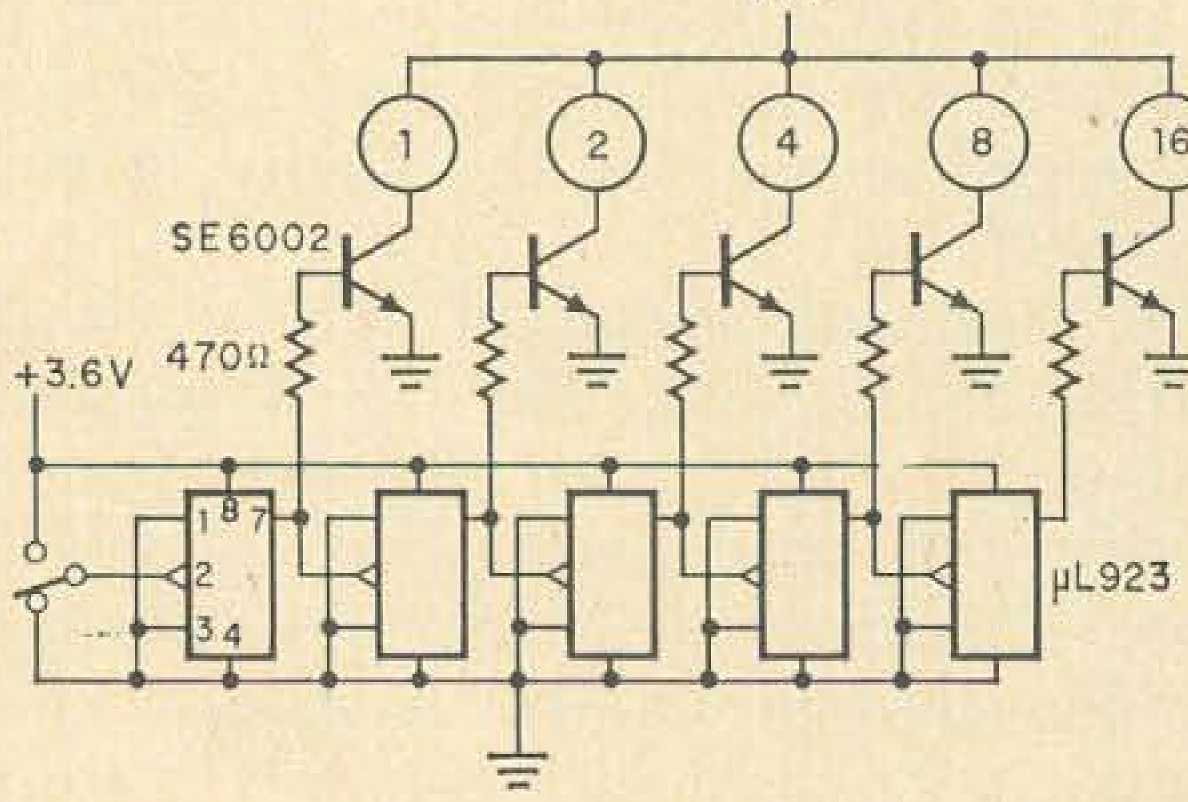


Fig. 6. Five counter modules connected together can count, hold and display a total count of 31.

To describe its operation, assume the manual reset button is pushed, all lights in the counter go out indicating no count is started and it is ready to count. The first positive going pulse (from the time base generator) on pin 2 of gate G1 drives its output pin 7 in a negative direction toward ground. This negative pulse causes flip-flop 1 to change state from a high at pin 5 to a low at pin 5, the low on pin 5 allows the input gate in the pulse shaper to pass the pulses to be counted to the counter. At the end of the first pulse G1, pin 2 is no longer held at a high level (approximately +3 V) and returns to ground allowing pin 7 to go high. As the μL 923 flip-flops do not toggle on a positive going pulse, flip-flop 1 does not change state and the pulse shaper gate is enabled (held open) to allow pulses to pass. When the second pulse from the time base

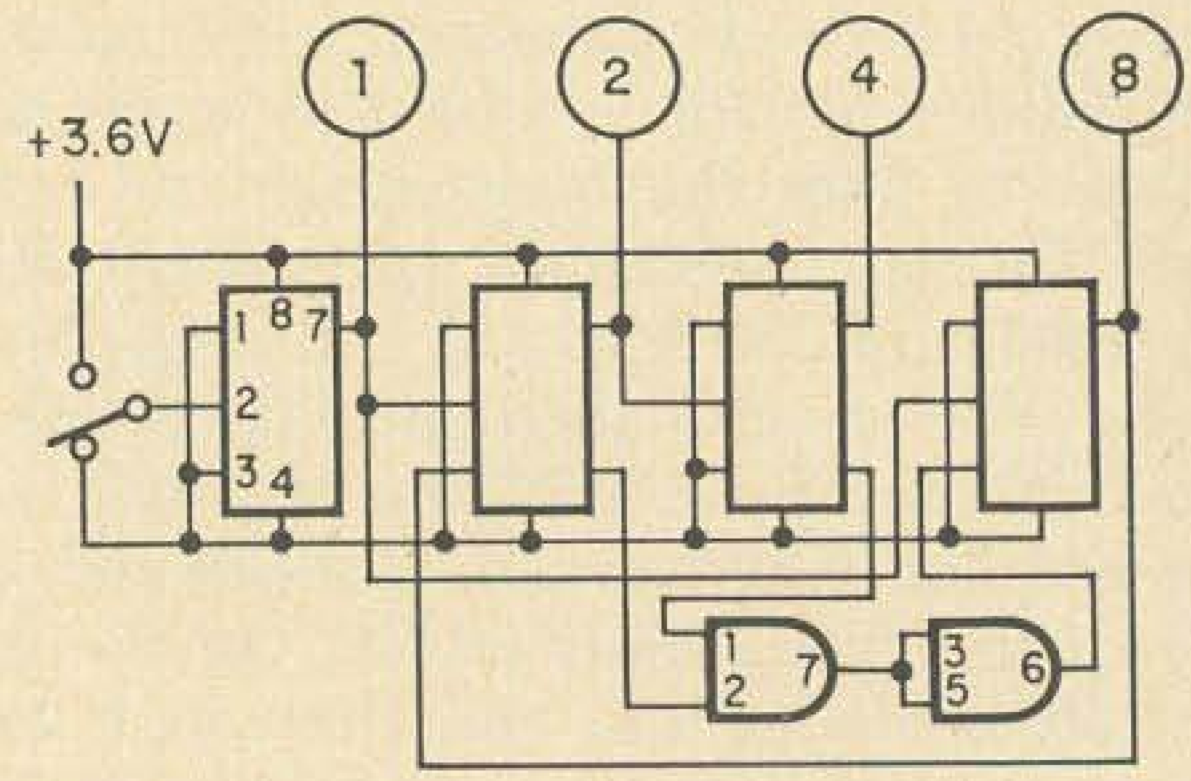


Fig. 7A. See text

generator arrives at the input to G1, it again drives G1 pin 7 low which causes flip-flop 1 to change state. When this happens flip-flop 1, pin 5, is high therefore the pulse shaper gate is blocked and no more pulses are allowed into the counter. At the same time pin 5 goes, pin 7 is driven negative. These actions cause flip-flop 2 to change state with flip-flop 2, pin 7 going from low to high. The high on pin 7 is applied to pin 2 of G1 which inhibits or blocks its input, therefore the count is now displayed until a reset pulse is initiated. G2 and G3 are connected as a one-shot to control the gate lamp and D1, the gate lamp driver. This lamp is lit when the pulse shaper gate is enabled (opened) to let pulses into the counter. The lamp stays lit for approximately 200 milliseconds. The flashing gate lamp is an indication that the counter is either ready or is counting depending on the presence of a signal at the input to the pulse shaper.

Gate G4 and driver D2 are also connected as a one shot to automatically reset the total

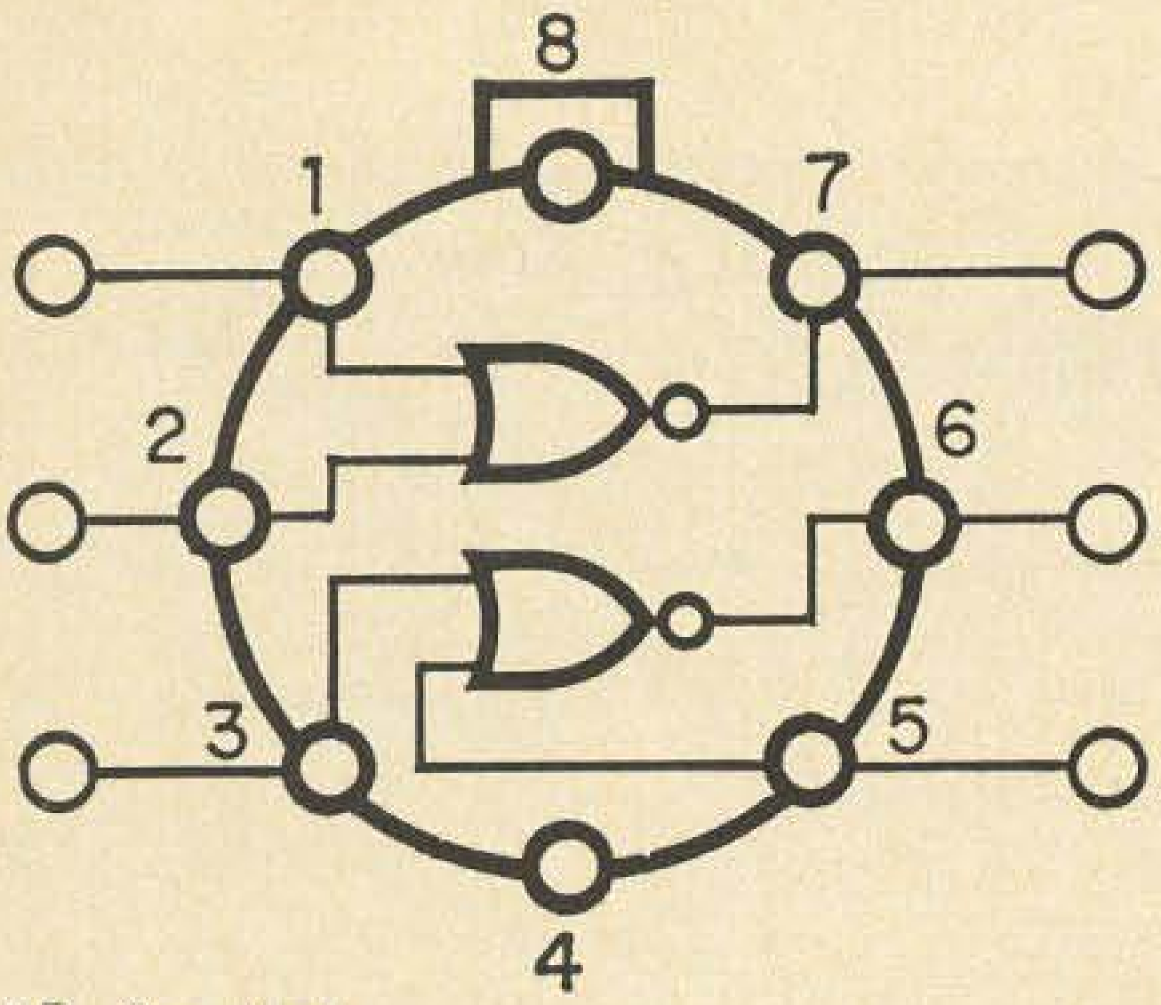


Fig. 7B. See text.

frequency counter depending on the position of the display time switch. In this design the display time is one, two and four seconds. The actual display time is the time selected by the display time switch less a two-pulse time selected by the time base switch. As an example assume the time base switch is set on 1KC (1 millisecond) and the display time is 1 second. The count will be for one millisecond and the display for 999 milliseconds. This is very close to the time selected by the display time switch, but if the count is for one second as would be used to count very low audio frequencies then the display time switch should be set for either two or four second display for a reading because in the one second display time position the counter will count for one second and then immediately reset at the end of one second period, resulting in a continuous count and no display time for readout.

Persons interested in building the complete counter or only part of the circuit should start with the basic counter module of **Fig. 6**, which can be expanded to as many flip-flops and lamps as needed for other applications.

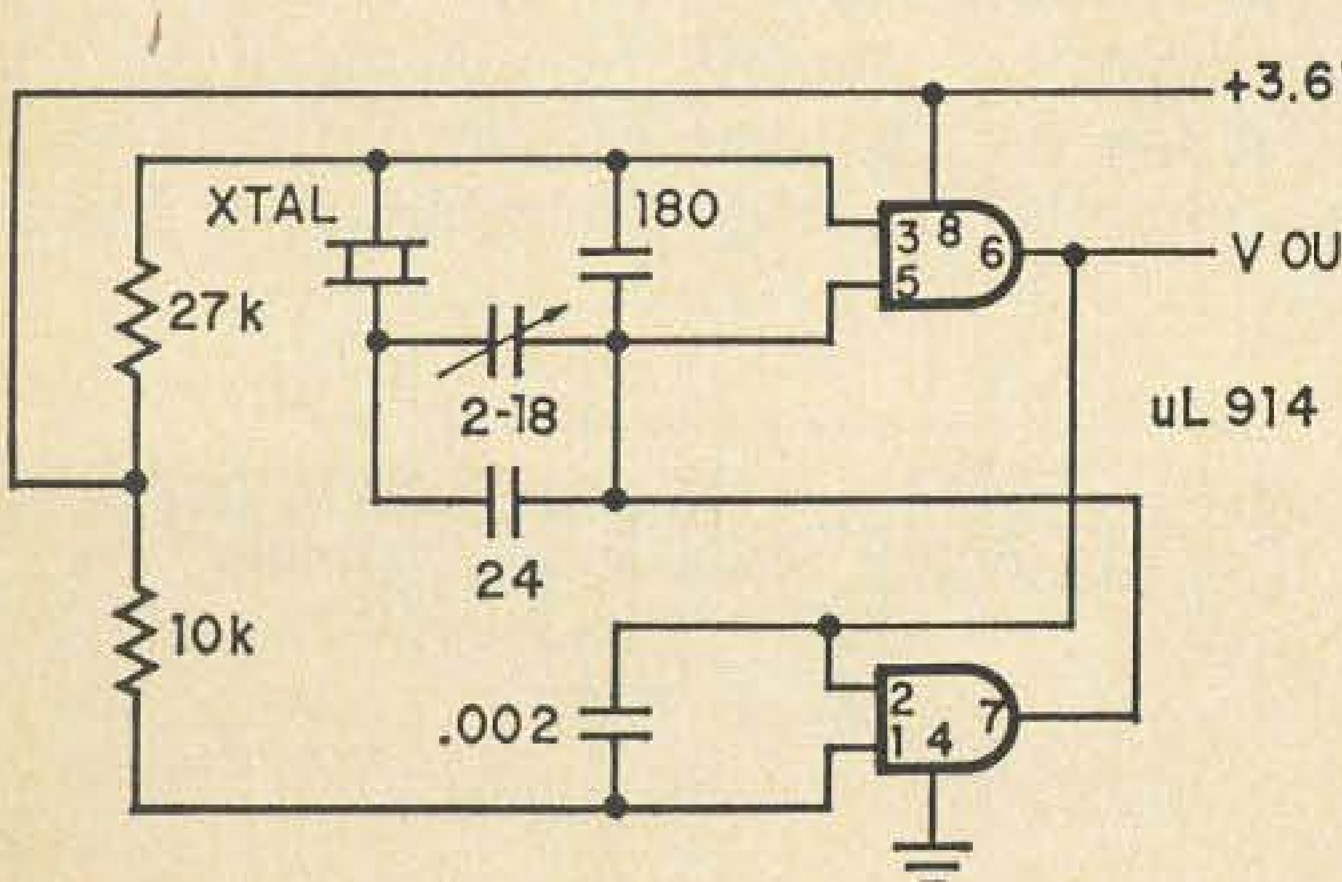


Fig. 8. The 100 kHz crystal oscillator.

The average toggle or push button switch is too noisy for this application so one should not try to use one to control the basic counter module. The one shot portion of the gate lamp circuitry of **Fig. 11** is shown in **Fig. 12** and should be used in place of the switch to drive the basic counter module.

The standard coding used on the μL 900, μL 914 and μL 923 is that pin 4 is ground and pin 8 goes to +3.6 V. On the μL 926 pin 5 is ground and pin 10 goes to +3.6 V.

Another point to remember is that all unused input pins must be grounded for noise immunity. As a point to remember it should be noted that all pin numbering is done from the top. Remember when working from the bottom of the board they are still numbered like the tubes we are familiar with.

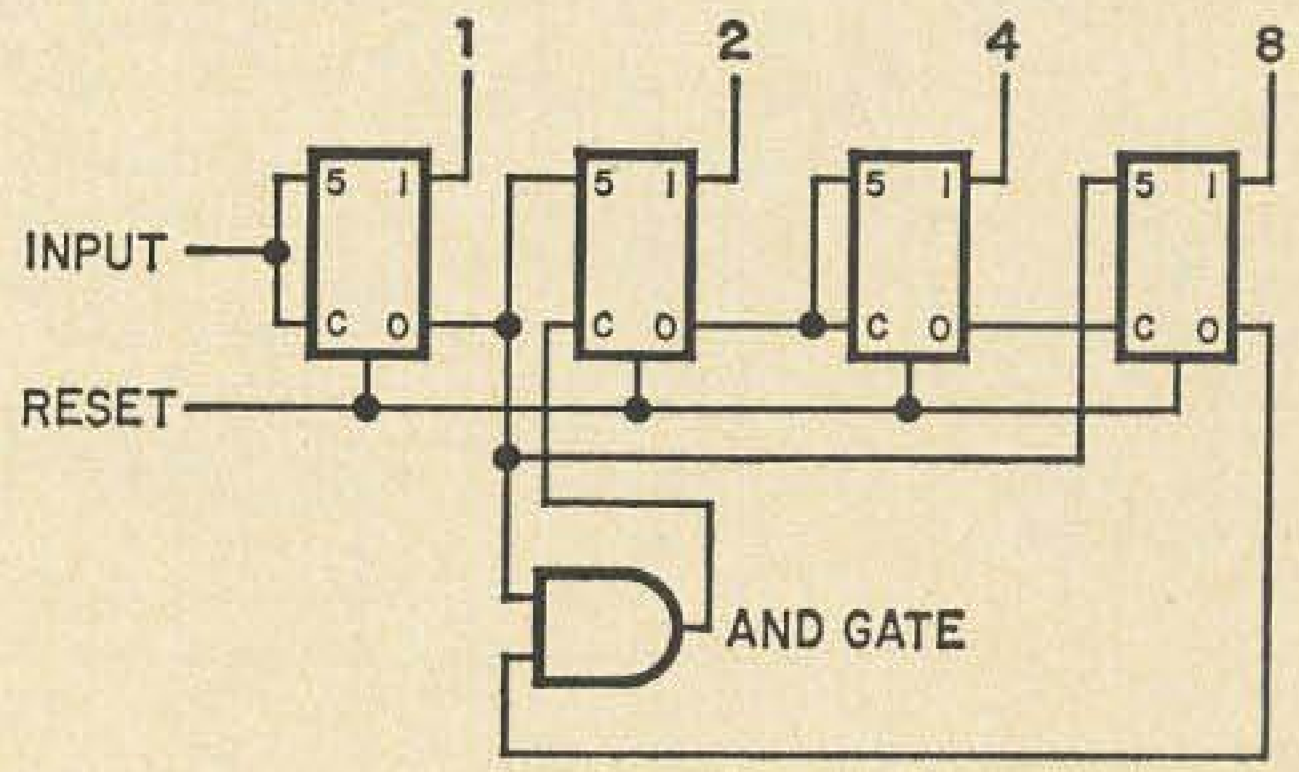


Fig. 9. The logic diagram of the uL 958 decade divider.

After becoming familiar with the wiring and operation of **Fig. 6**, change the layout to the wiring of **Fig. 7** to check the proof of the truth table. This table is an informative display and is the key to the readout of this frequency counter.

Several of the basic counter modules may be joined by connecting pin 1, the carry output, of the first module to pin 2, the count input, of the second unit. These connections should be repeated as additional modules are added to the existing ones. By jumping pin 6 of all of the μL 923s together and adding a spring-loaded normally opened switch in series with this line to the +3.6 V line, all units may be set to "O" by momentarily pressing the switch to turn off all the lamps.

The next thing to build is the 100 kHz crystal oscillator shown in **Fig. 9.** The operation of the oscillator depends on the tolerance of the .002 μF capacitor and this value may need to be adjusted slightly to insure crystal control of the oscillator. With the crystal out of the circuit the output at pin 7

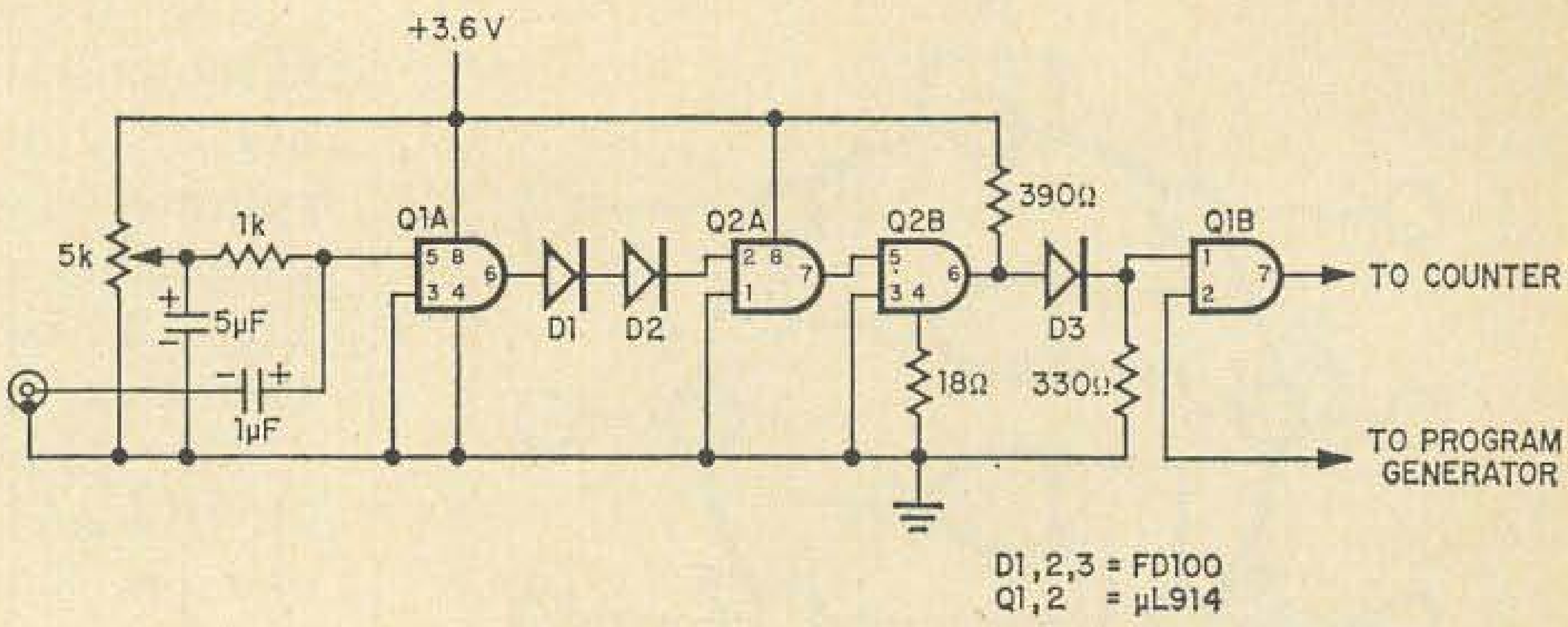


Fig. 10. The complete input circuit to the Schmidt trigger.

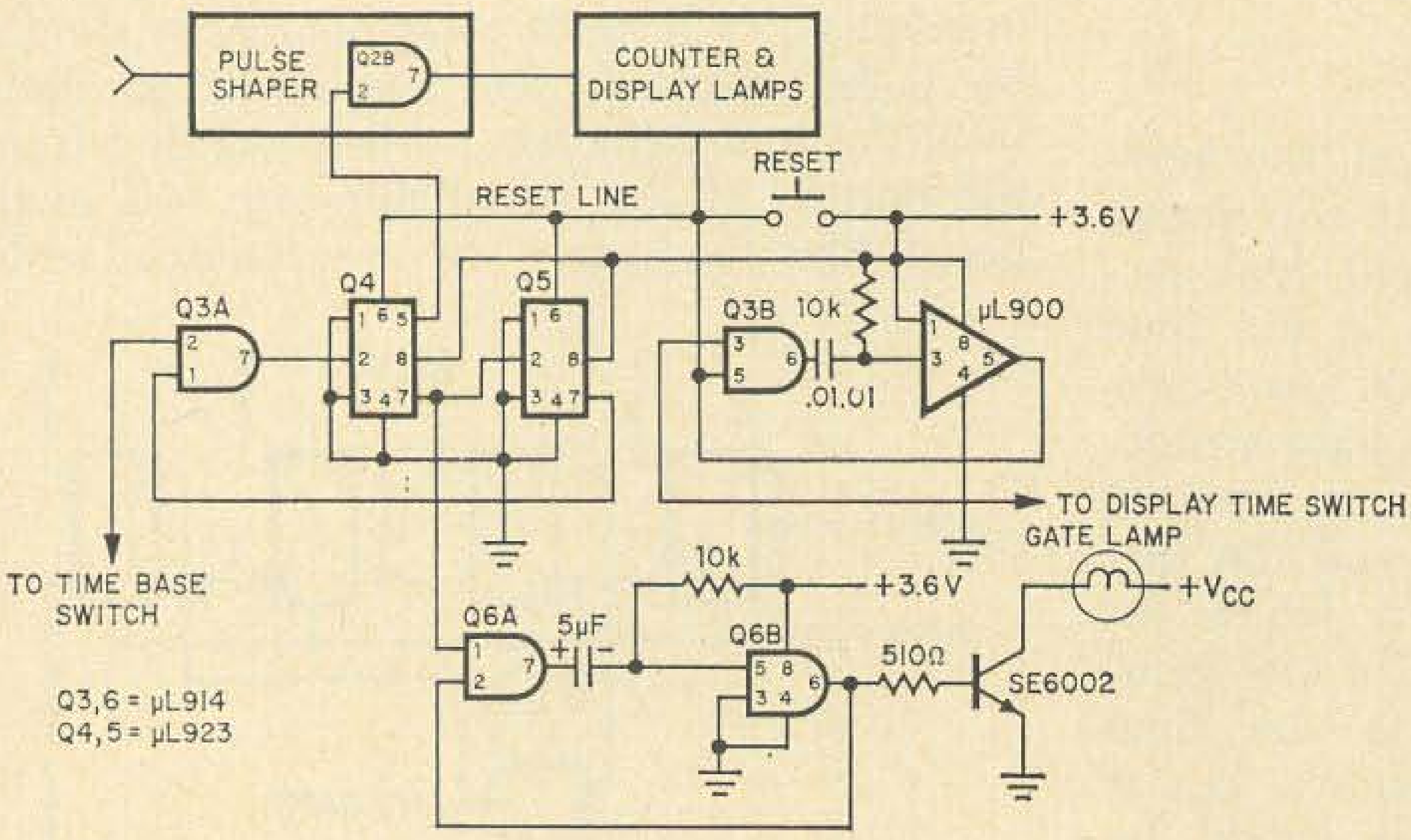


Fig. 11. Diagram of the program generator.

should be a square wave with a free running frequency of about 150 kHz. This can be checked on the station receiver. The next step is to put the crystal back in the circuit and adjust the trimmer to zero beat with W.W.V. when slightly coupled to the antenna. A μL 914 should be used as a buffer amplifier to prevent loading of the oscillator as shown in **Fig. 13.**

There are several alternatives to consider in place of the μL 958 decade dividers if one is not limited by space requirements. One alternative would be to use the basic counter module of **Fig. 7A.** Another would be to use the minimum hardware type decade divider shown in **Fig. 14.**

A digital type divider should be used in the time base section as there has not been as yet developed a reliable, low-component count, regenerative or step type divider that can compare with the digital type for temperature, component tolerance and frequency stability.

Fig. 15 is the schematic of the complete integrated circuit frequency counter.

The function switch S1 selects the mode of measurement. In position 1 check the output from Q10, the first decade divider, a 3 V P-P pulse is applied to a resistive voltage divider and coupled through a .01 μF capacitor to the input of the pulse shaper. The level is set at approximately 53 millivolts to allow a setting of the sensitivity control to the most sensitive position for future measurements.

Position 2 "FREQ" is used for most frequency measurements. Some adjustment of the sensitivity control may be needed to handle very small or very large signals. Some consideration should be given the dc level applied to the input jack. The 1 μF, 50v input capacitor should be changed in the event the unit is used exclusively with tube type circuits. However an external dc block-

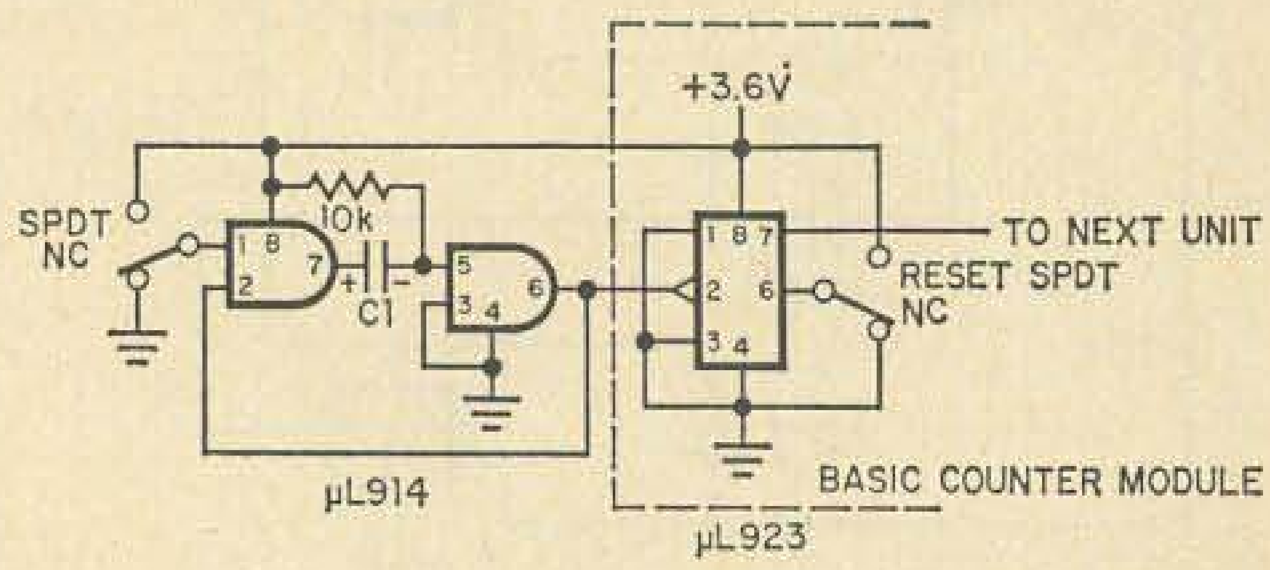


Fig. 12. "Noiseless' switch used to control the basic counter module.

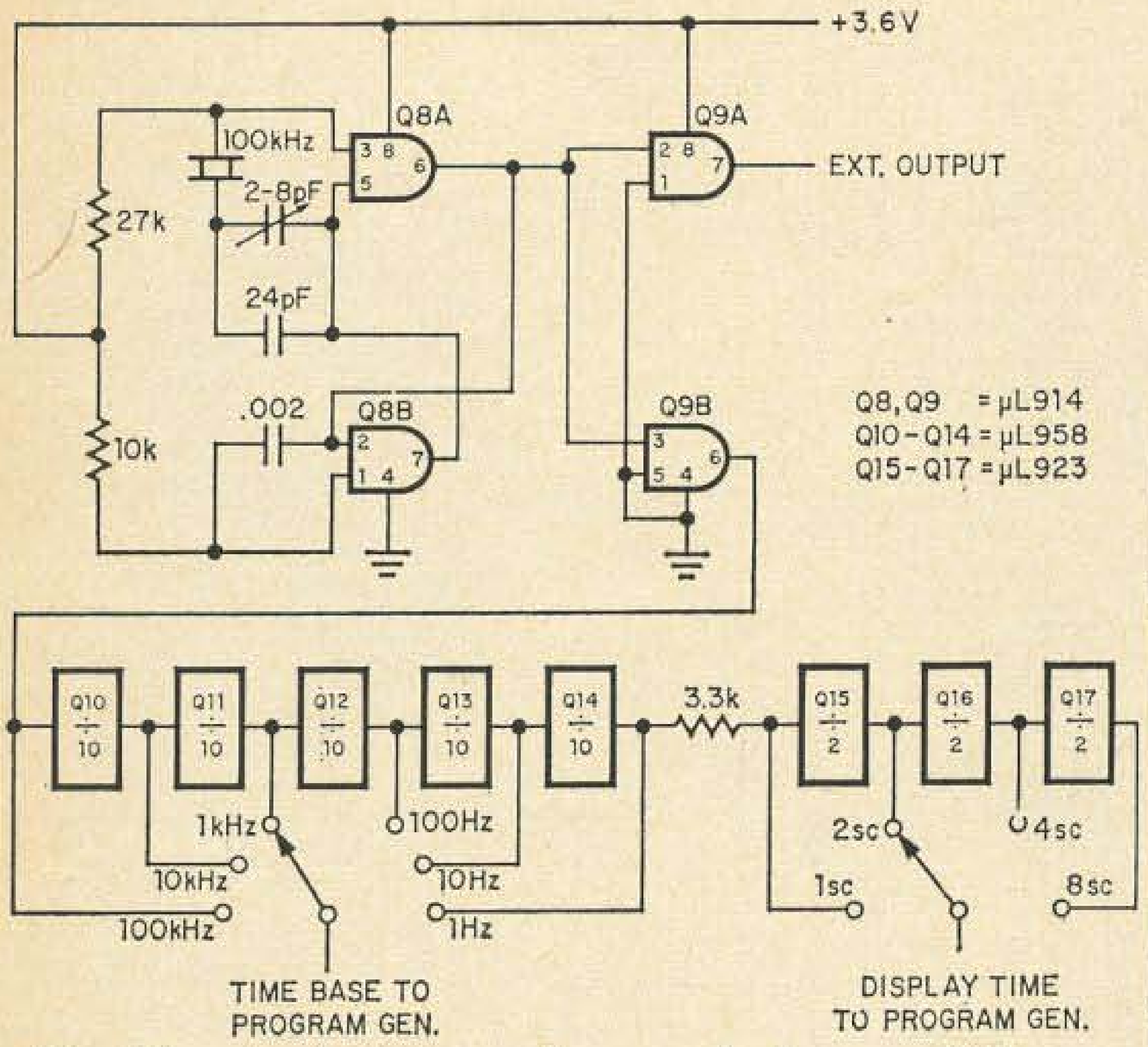


Fig. 13. A uL 914 used as a buffer amplifier to prevent overload of the oscillator.

ing capacitor may be used, and should always be used when in doubt.

Position 3 "PERIOD" is the most versatile one. In this mode the input to the pulse shaper and the program generator portions are reversed. A pulse applied to the input jack opens the gate Q 1B allowing the pulses, selected by the time base switch S2, into the count register. These pulses are accumulated in the register until the next pulse arrives at the input jack which inhibits (turns off) the gate Q 1B. The accumulated count is now displayed for readout.

The reciprocal of the readout is the period of time between the input pulses.

$$\text{TIME seconds} \qquad \frac{1}{\text{Readout}}$$

As an example a readout of

$$1000 = \frac{1}{1000} = 1 \text{ millisec.}$$

$$200 = \frac{1}{200} = 5 \text{ millisec.}$$

$$25 = \frac{1}{25} = 40 \text{ millisec.}$$

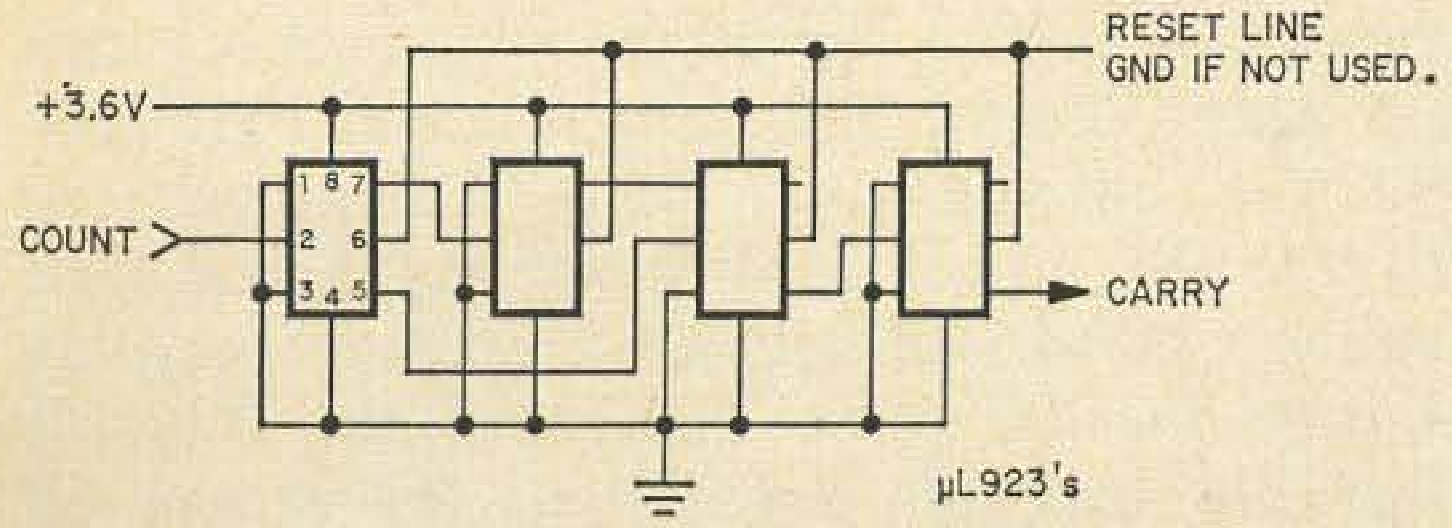


Fig. 14. The block diagram of the standard time base generator.

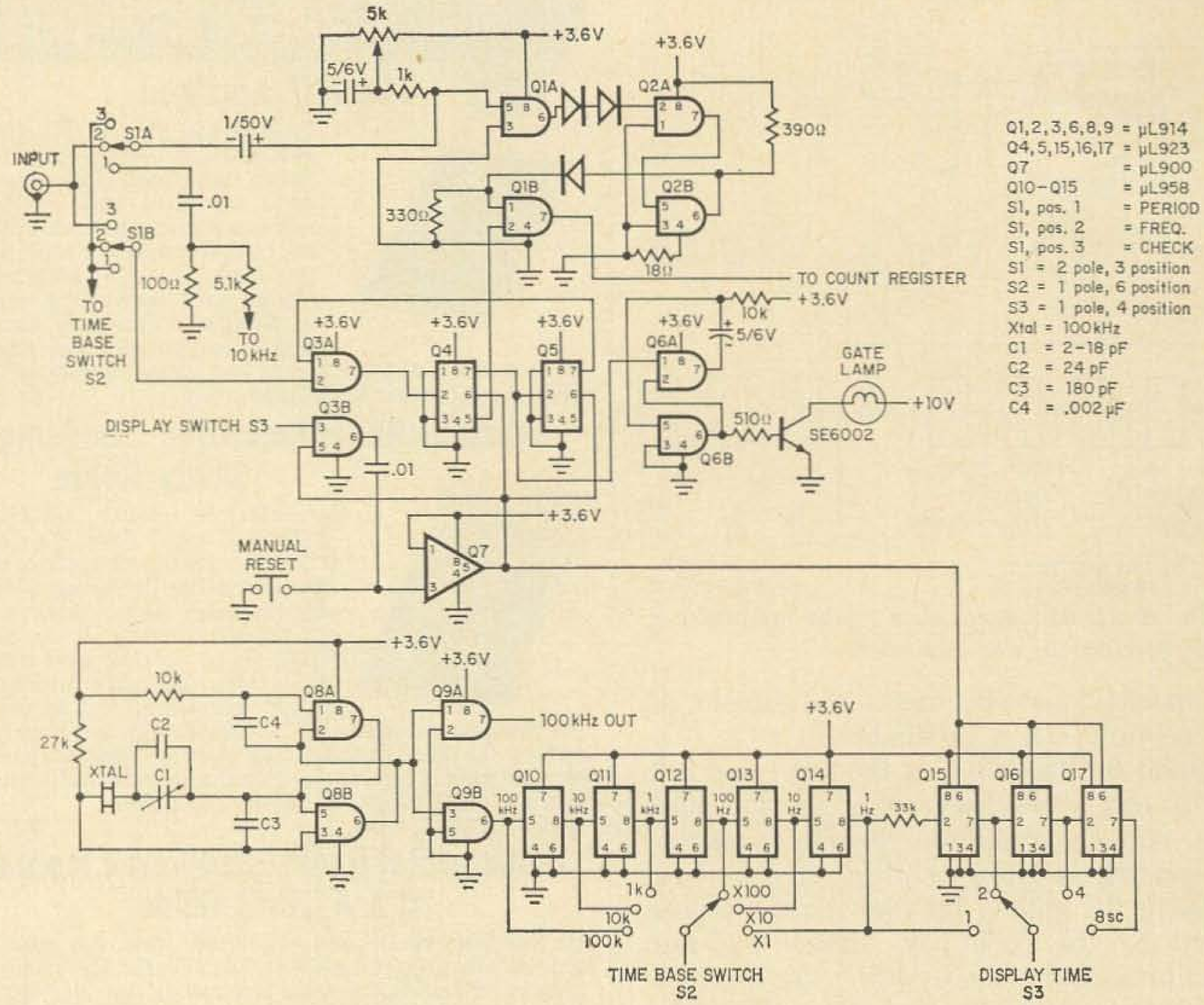


Fig. 15. The schematic of the complete integrated circuit frequency counter.

One use of the PERIOD position is to measure frequency or occurrances too slow to count reliably. The doppler frequency of Oscar as it passed overhead may be measured in this manner. Other uses could be as a digital readout automobile tachometer, timing clock at the drag strip and a chronograph to measure the speed of a bullet.

A voltage-to-frequency converter now in the prototype stage looks promising. With a conversion factor of 100 Hz volt the unit becomes a digital voltmeter with possible uses as a digital volt, ohm, milliamp meter and a digital thermometer by the addition of a thermistor.

Another idea in the prototype stage is a high frequency divider or scaler that will allow a direct readout to 100 MHz.

While all of the possible uses of the basic integrated circuit frequency counter have not been covered it's easy to see how a person can get involved in something like this where its uses are limited only by one's imagination.

The power supply schematic is shown in **Fig. 16.** The connections of the secondary may appear strange, but connected in this manner it provides the required outputs, where a conventional connection for these outputs require a dual winding on the secondary. Diodes D1, D4 and C2 form a capacitor input bridge circuit with C2 charging to the peak value of the secondary voltage, approximately 6.5 volts underload. Diode D5 and C1 form a half-wave capacitor input supply with approximately 12.5-volt output underload. R1, D6 and Q1 forms a series regulator for the 10-volt line to the lamps. C3 is needed to suppress the noises generated as the lamps are switched off and on. Q2, Q3 and D7 form a series regulator for the 3-6-volt line. R2 is connected between D6 and D7 with D6 as a constant voltage point. R2 acts as a constant current source for D7. The output of the 3.6-volt line has excellent regulation. C4 is needed for additional noise suppression.

For operation from an auto battery the

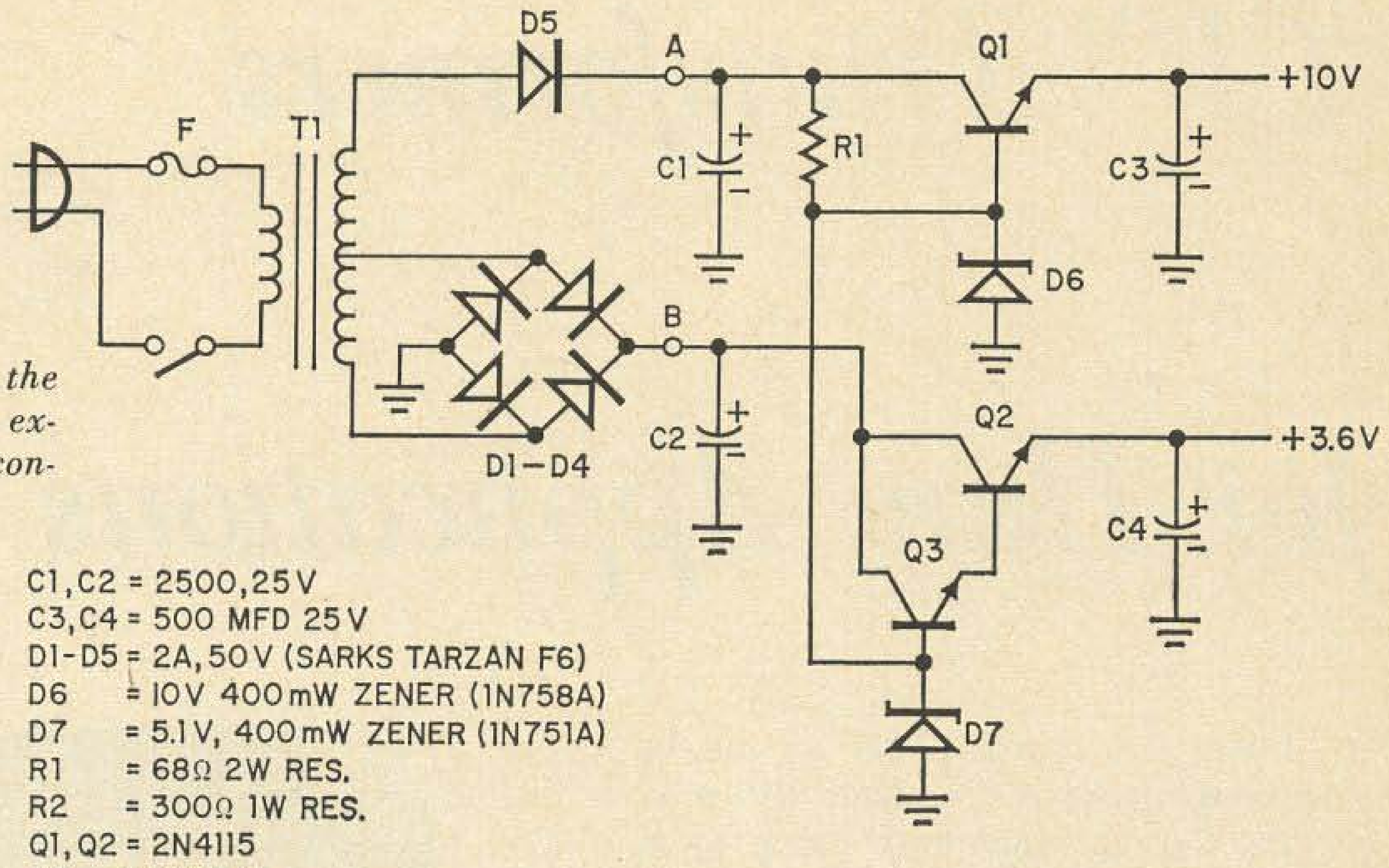
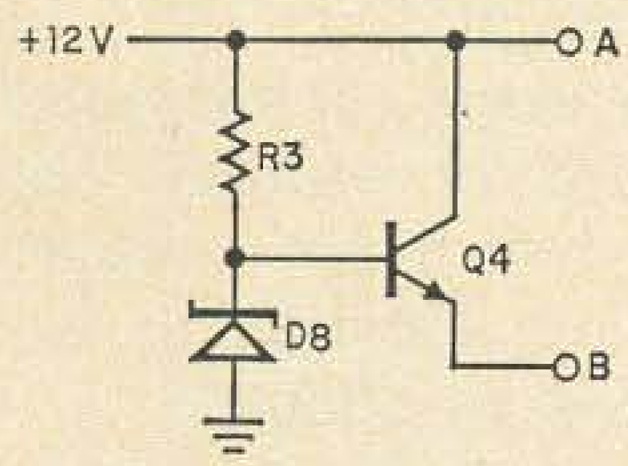


Fig. 16. Schematic of the power supply. See text for explanation of the unusual connections of the secondary.

C1,C2 = 2500,25V
C3,C4 = 500 MFD 25V
D1-D5 = 2A,50V (SARKS TARZAN F6)
D6 = 10V 400mW ZENER (1N758A)
D7 = 5.1V, 400mW ZENER (1N751A)
R1 = 68Ω 2W RES.
R2 = 300Ω 1W RES.
Q1,Q2 = 2N4115
Q3 = 2N3568
F = 1 AMP
T1 = 115V PRI 12.6V, 2.5A TRIAD F26X

power supply is broken at points A and B and the auto battery adapter is connected to these points.

The photos show the mechanical layout used in the model. The enclosure, the front panel and sub chassis is formed of copper clad board. The sub chassis is soldered to the front panel after the holes are drilled for the switches and lamps. All components of the power supply are mounted on the aluminum channel, which is bolted to the front panel and the enclosure bottom, resulting in a very light but rigid assembly.



R3 = 300Ω 1W RES.
D3 = 6.8V ZENER (1N754)
Q4 = 2N4115

Fig. 17. Auto battery adaptor.

The dimensions of the enclosure are 4″ high, 9″ wide and 9″ long, with a net weight of 5 pounds. While there may be manufactured frequency counters on the market with better appearance, better readout systems, higher count ability and oven controlled crystals, their cost puts them out of reach of the serious experimenter. This unit shows what can be done, without a large engineering effort, to utilize readily available ICs in a project of this magnitude.

A complete set of etched and drilled boards are available from the author for $22.50 plus 50 cents postage in the U.S.

. . . WB6IBS

"CV" Transformers

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Sola Basic Industries

for Ham Applications

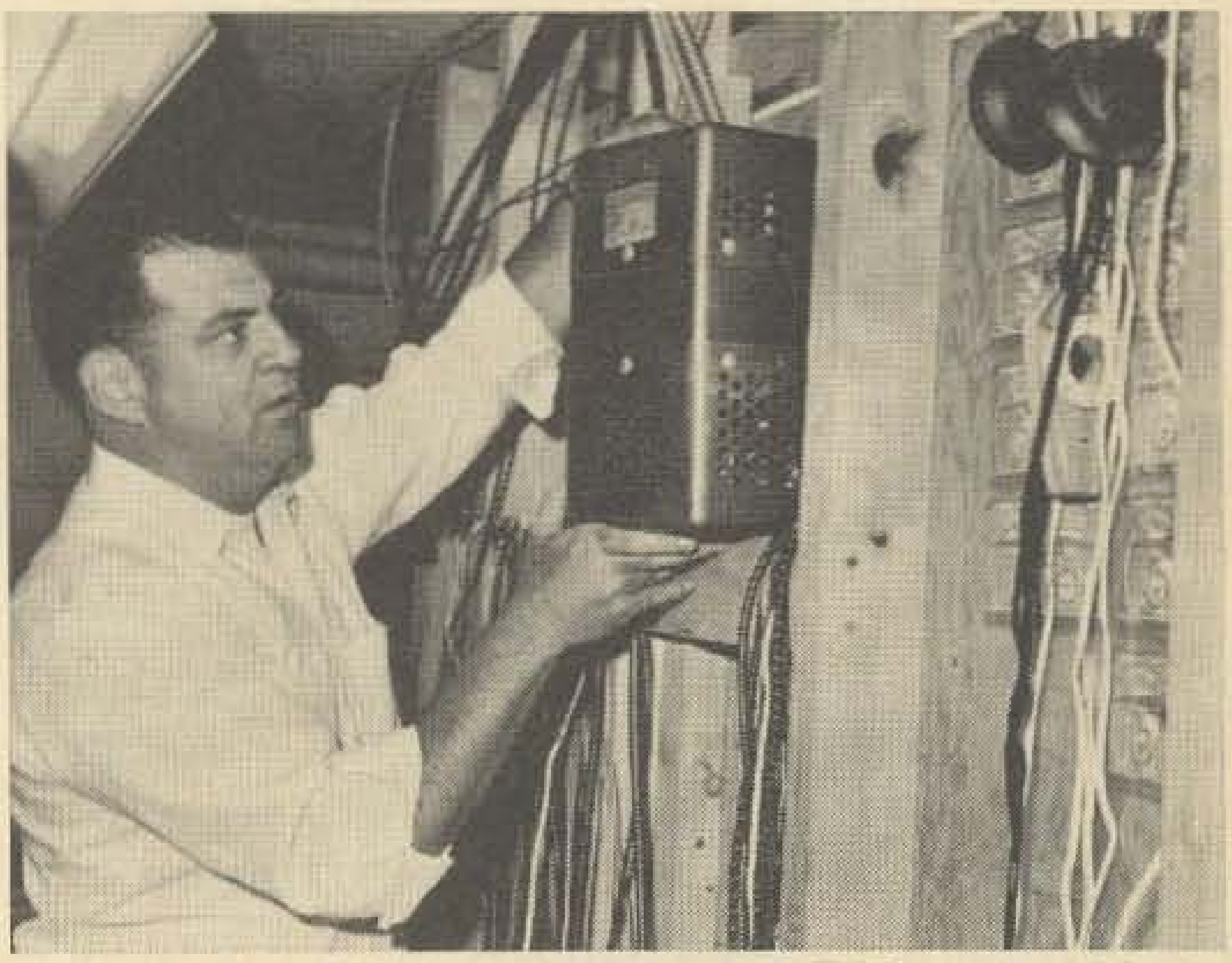
Over the years many of us have encountered problems caused by power line voltage fluctuations, and most of us have simply assumed that line variations are something with which we have to live.

In nearly all private homes today are literally scores of electrical appliances which are used intermittently, thus causing load variations. These electrical loads include furnaces, washing machines, dryers, air conditioners, not to mention XYLs' irons, toasters, vacuum cleaners, refrigerators and hair dryers. When these items are considered in their normal on/off circuit enivironment, it is small wonder we amateurs notice ham shack lamps flickering from time to time.

If a recording voltmeter were installed for 24 hours in the ac line feeding the station, most hams would be amazed at the voltage changes. They would consist of spikes, dips, surges and high-low variations, well removed from the nominal voltage for which amateur equipment was designed. If the QTH is an older building, an apartment, industrial area or farm, this condition usually becomes even more pronounced.

Although most amateur electronic equipment has some built-in regulation for vfo's and various oscillators, line variations still exist which can have a serious effect on filament emission and plate voltages. High voltage (above the nominal) shortens tube and equipment life by overstressing components. Low voltage results in less than peak performance while transients can cause disruptive action and possible frequency shift.

Amateurs can correct these variation problems—without requiring that they own their own utility to accomplish it—by examining the various types of line regulators now available. These include electronic, in-



Author WA9CQN mounting Sola Electric 500 va constant voltage transformer on wall near outlet box supplying ac power to radio room.

duction, electro-mechanical, electronic mechanical and static-magnetic. The static-magnetic constant voltage transformer is one of the best means of voltage regulation. It provides close regulation without the need of complicated circuit components. Additional advantages are as follows:

1. Maintain ± one percent regulation with transient or continuous primary variations as great as ± 15 percent.
2. Self protection is provided against short circuits in the load.
3. Both physical and electrical isolation is provided between input and output circuits. No manual adjustments are required because there are no moving parts; completely automatic continuous regulation is provided.
4. Response time is usually less than 25 milliseconds at 60 Hz plus preventing irratic VOX or relay operation.
5. Has inherent built-in characteristics of current limiting to protect the load.
6. Comes in a variety of step-up or step-

down designs ranging from 15 va to 10 kva.

How transformer works

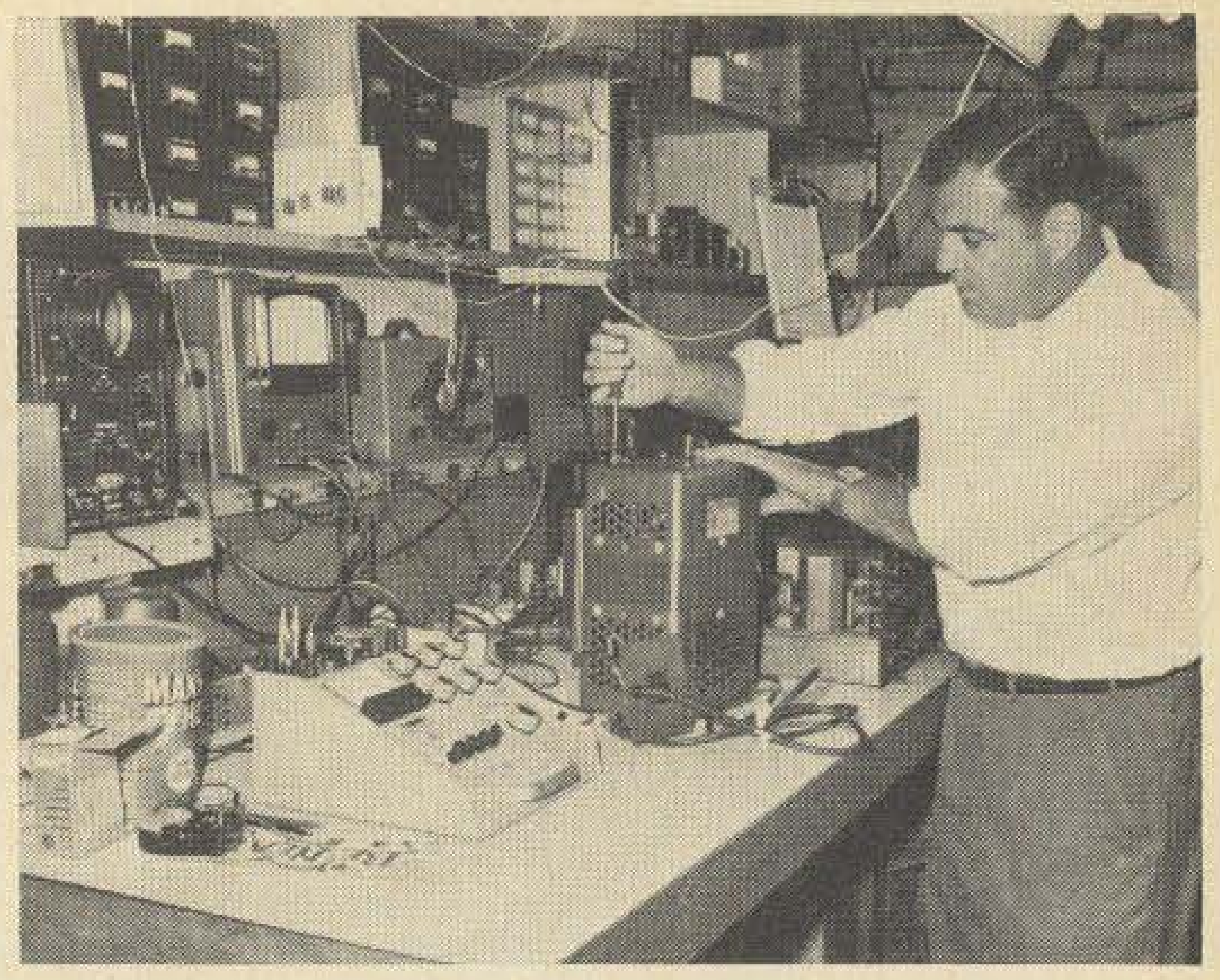
A constant-voltage transformer has a magnetic core structure different from conventional transformers. It has a magnetic shunt with a fixed air gap interposed between the primary and secondary windings. The secondary winding is shunted by a fixed ac capacitor. Upon application of primary voltage, the secondary voltage increases to the point at which that portion of the magnetic core directly under the secondary winding approaches saturation due to the capacitative load connected across the secondary winding.

As the core approaches saturation, it cannot carry much additional magnetic flux. The increase in secondary voltage is less than any proportional increase in primary voltage. Thus, a condition of relative stability of secondary voltage is reached. Over the range of specified primary voltage, the core under the secondary changes very little for this range of primary voltage. Due to the magnetic shunt between the primary and secondary windings, that part of the core under the primary is not saturated.

To equalize the small effect of increasing primary voltage on the secondary, a compensating coil is wound over the primary coil and is connected in series with the secondary load circuit—but out of phase with the secondary. Result is that as primary voltage increases beyond the design voltage, the voltage in the compensating coil also increases. Since it is out of phase with the secondary voltage, however, it subtracts (from the secondary voltage) an amount equal to the slight increase induced in the secondary winding by the increase of primary voltage. Likewise, when the primary voltage decreases, the compensating coil voltage decreases in proportion to the primary voltage, and subtracts from the secondary voltage. The design is such that the vector sum of the compensating coil voltage and the secondary voltage is practically constant throughout the design range of input voltage.

Using the CV

When the constant voltage transformer is overloaded in excess of its rated load, a point is reached where the output voltage drops to approximately zero. Due to the magnetic shunt in the transformer, its output current is limited. With excessive load current, the effect of the ac capacitor is lost; secondary flux opposes primary flux to de-magnetize the secondary core leg, and the output voltage collapses, limiting short-circuit current to approximately 150 percent of full load.



Here Bill is removing Sola CV transformer to facilitate connection of adapter (seen with cabling attached in front of CV) for use with standard ac line plugs. Use of adapter precludes necessity for permanent installation, cable hookups, etc.

From this it begins to become clear why the addition of a constant voltage transformer is such an asset to the ham shack. The same transformer can be used additionally to supply constant voltage to the workshop thus insuring that the readings and indications obtained from test equipment remain constant.

Most electronic supply houses carry a fairly complete line of constant voltage transformers. In case of a special requirement, they can also order to individual specifications.

Since most CV transformers are rated for resistive loads (unity power factor), care must be taken in selection of proper rating. Charts are available to show how much to derate the transformer if power factor is less than unity. Normal constant voltage transformers also have some harmonic content in the output. If the equipment in question requires a wave shape close to a sinosoidal, a harmonic-neutralized constant voltage transformer should be specified.

Stabilize that station voltage, cut maintenance costs and increase your equipment's component life.—today! . . . WA9CQN

A Space Communications Odyssey

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The Star Trek episode concerning the adventures of three radio operators named Tom, Dick, and Harry which I am about to relate could some day be true. It is based on the well-known principles of the special theory of relativity applied to fast-moving rocket ships plying the depths of interstellar space. Before proceeding with an account of the unusual events experienced by the three radiomen, permit me to introduce some elementary concepts of the theory which arise when high speeds are encountered.

One of the pillars on which relativity theory rests is Einstein's dictum that:

> The velocity of electromagnetic radiation in space is the same for all observers[1] regardless of their individual motions; furthermore, no object can travel faster than this radiation, 186,300 miles per second.

According to Einstein, if v_A and v_B represent the space velocities of two observers, A and B respectively, their relative velocity, v_{AB}, is

$$v_{AB} = \frac{v_A + v_B}{1 + \frac{v_A \cdot v_B}{c^2}}$$

where c equals the velocity of electromagnetic waves. This formula results from the linking together of the fourth dimension, time, with the three dimensions of space. If A's and B's velocities are insignificant in comparison with the velocity of light or radio waves, which is normally the case on earth, formula (1) reduces to the usual expression, $v_{AB} = v_A + v_B$. Thus if two planes are traveling in opposite directions at 500 miles per hour, their speed relative to each other is 500 + 500 = 1000 mph. On the other hand, if two bullets could be fired in opposite directions at speeds of 100,000 miles per second and 150,000 miles per second respectively, their relative velocity, v_{AB}, is *not* the sum (= 250,000 mps) but 145,350 mps as calculated from formula (1). Let us consider the extreme situation. If two beams of light are transmitted simultaneously in opposite directions from the same point, they will recede from each other at the relative velocity of 186,300 mps (= c) and not at 372,600 mps (= 2c) according to formula (1). There is no way of traveling faster than the speed of light.

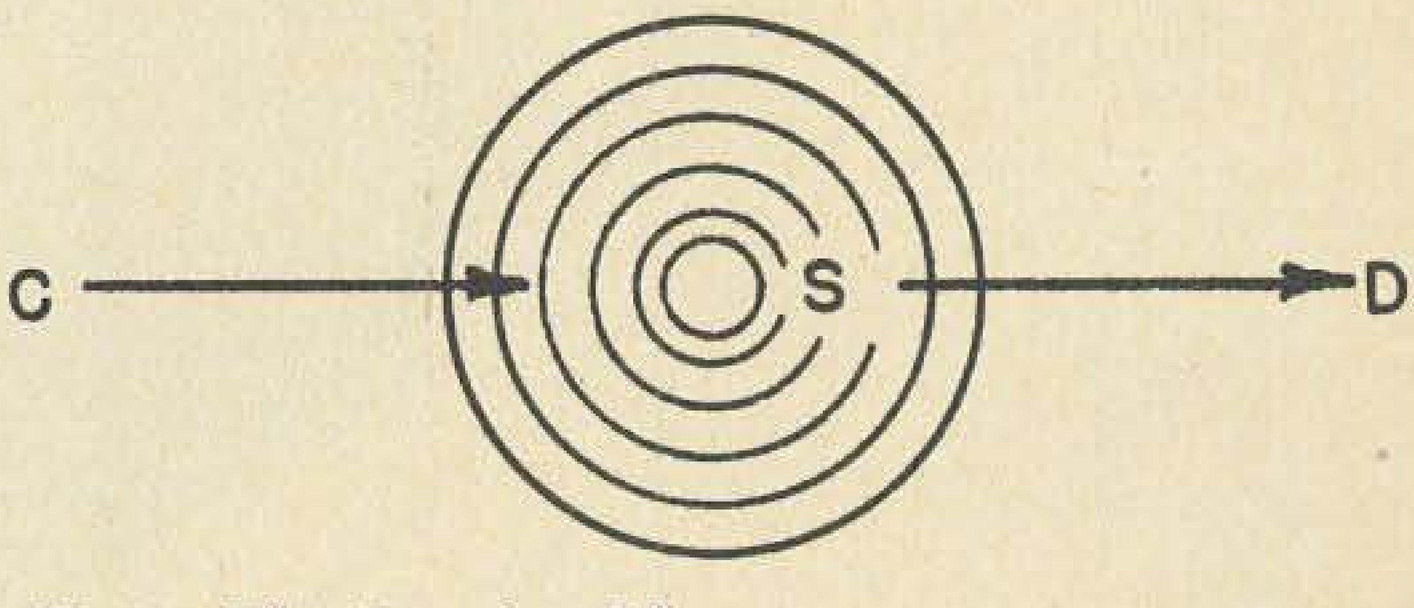


Fig. 1. The Doppler Effect.

Another well-known result of relativity is that time is *slowed* by the Lorentz contraction factor, $\sqrt{1 - \frac{v^2}{c^2}}$, where $\frac{v}{c}$ is the observers velocity relative to that of light. This slowing down of time for a fast-moving observer is called time dilation. It is unimportant for all ordinary speeds $(\frac{v}{c} \sim O)$ but must be reckoned with at speeds which are significant fractions of the velocity of electromagnetic waves. Another way of stating this result is: the faster one travels relative to the speed of light, the slower his clock runs. This affects all physical phenomena, such as electromagnetic or atomic, in which the time element enters as a factor.

There is one more phenomenon to consider before leaving the earth for a flight to the stars, viz., the Doppler Effect. If observer C is moving toward a fixed source, S, which is radiating on a frequency, f_o, as shown in **Fig. 1**, he will encounter more wave crests passing him each second than if he were standing still. If observer D is moving away from the stationary source, S, he will in turn record fewer wave crests

[1]An observer may be defined as a person who clocks the time of an event or happening in his moving frame of reference.

passing him each second. C will have to tune his receiver to a slightly higher frequency and D to a slightly lower frequency in order to receive the signal from S, the amount of frequency shift being proportional to the observer's velocity. In reality, it is immaterial whether the source is in motion, or the observer, or both. For ordinary velocities the Doppler formula is given by

$$f_r = f_o(1 - \frac{v}{c}) \quad \text{receding} \tag{2a}$$

$$f_a = f_o(1 + \frac{v}{c}) \quad \text{approaching} \tag{2b}$$

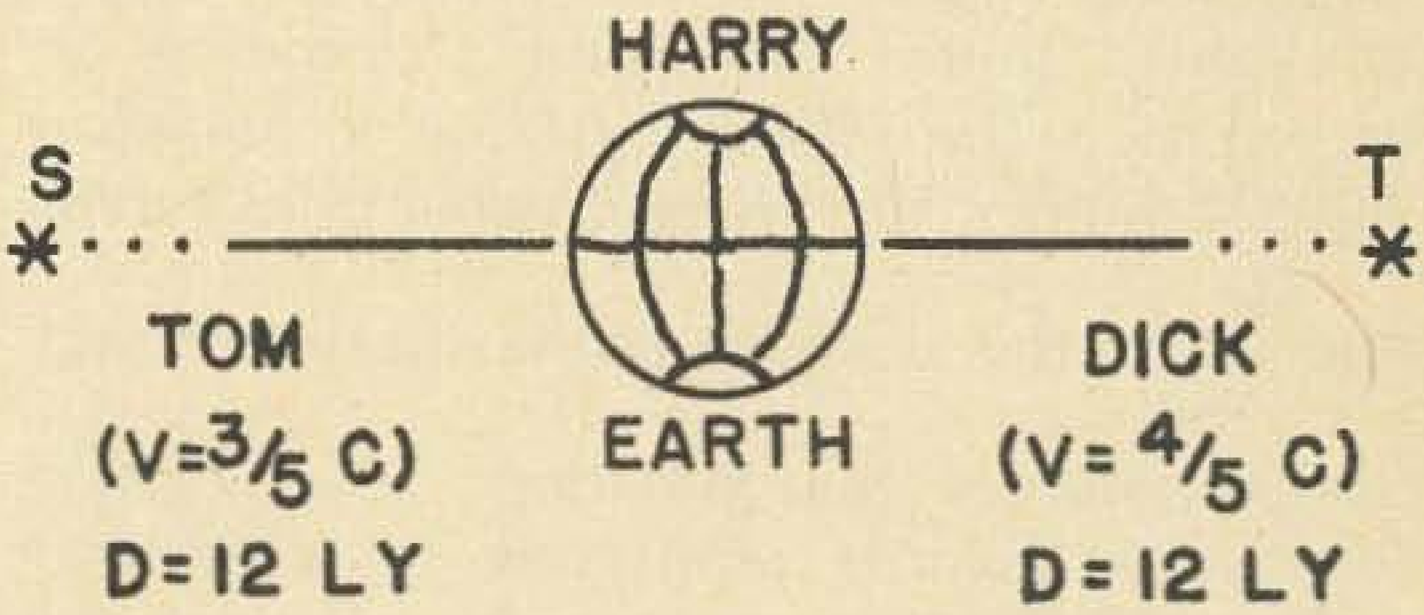
where f_o is the station's transmitting frequency, f_r is the received frequency which is slightly lower than f_o for a receding observer, f_a is the received frequency which is slightly higher for an approaching observer, and $\frac{v}{c}$ is the velocity of the observer relative to that of the radiation. The Doppler formula is widely employed in astronomy and in physics in the study of radiating moving bodies. Use is also made of the Doppler Principle to provide velocity and distance determinations in aircraft, lunar softlanders, and in the tracking of space vehicles by means of Doppler-radio or Doppler-radar techniques.

When the speed of approach or recession is appreciable, the Doppler expression above must be modified according to relativity theory by dividing the frequency f_r or f_a by the factor $\sqrt{1 - \frac{v^2}{c^2}}$ because the observer's clock is running slow by this amount thereby increasing his count of wave crests per second. As an illustration of the Doppler Principle, imagine a rocket vehicle leaving the earth at a velocity of 10 miles per second. If the rocket's transmitting frequency while on the launch pad is 100 MHz, its received frequency on earth during flight will be 99.9946 MHz from formula 2a. However, if it were possible for the rocket to leave the earth at a speed of 10,000 miles per second, the received frequency would now be 94.7700 MHz which is obtained by dividing $100\ (1 - \frac{v}{c}) = 94.6323$ MHz by the contraction factor, $\sqrt{1 - \frac{v^2}{c^2}} = .99712$

where v = 10,000 mps and c= 186,300 mps.

We are now ready to see what happens to a radio operator departing from the earth at high speed for a round-trip journey in a rocket ship to a distant star. Tom is planning to leave the earth on a round-trip flight to star, S, 12 light years distant at a rocket speed of three-fifths the velocity of light ($v = \frac{3}{5}c$). At the same time, Dick will leave the earth in the opposite direction on a round-trip voyage to star, T, also 12 light years distant at a rocket speed of four-fifths the velocity of light ($v = \frac{4}{5}c$). The third man, Harry, will remain on earth and attempt to communicate with each traveler by means of UHF transmissions. Although all three radio operators will transmit on the same frequency, they will receive on different frequencies due to their unequal motions (Doppler Effect). Tom and Dick agree to transmit brief daily messages to Harry who will reciprocate by sending brief daily reports to Tom and Dick. Before take-off the three men synchronize their clocks. To avoid undue complications in the recording of the travelers' clock times, we will make the reasonable assumption that the periods of acceleration at the beginning of the outward and return paths and the periods of deceleration on approaching the star or the earth are exteremely brief in comparison with the length of time spent in moving at constant velocity. We can predict from relativity theory, employing the time dilation factor, that Tom will be gone for 40 years and Dick for 30 years according to Harry's clocktime. However, Tom will claim that he has been away for 32 years by his clocktime while Dick will assert he has been gone for only 18 years by his clocktime. To clarify these conclusions, consider Tom's situation. It takes a light ray 24 years to make the round trip between the earth and star, S. Tom, traveling at 3/5 the speed of light, will accomplish the feat in $\frac{24}{3/5} = 40$ years judged by Harry's clock. But since Tom's clock runs slow by the factor $\sqrt{1 - \left[\frac{3}{5}\right]^2} = 4/5$, Tom's round-trip time will be $4/5 \times 40 = 32$ years according to Tom's clock.

Let us now consider the rate at which Harry's daily messages will be received by Tom and Dick in their rocket ships. It will not be once per day! Relativity theory informs us that the receipt of information transmitted from earth at a constant repetitious rate by either light or radio signals by an observer rapidly receding or approaching the earth is dependent on the frequency or rate with which the signal is being transmitted, on the Doppler Effect, and on the time dilation factor. Although the formulae expressing these relations can be understood by anyone who has had at least one year of algebra, the reader will be spared the inconvenience of verifying the calculations and the conclusions will be simply stated. This is what will happen.



Employing the data; distance = 12 LY, $v = \frac{3}{5}c$ for Tom and $v = \frac{4}{5}c$ for Dick, and the signal rate one brief message per day,) one obtains the following results: Harry will be transmitting daily messages to Tom going out and coming back on frequency, f_o, for 40 years and to Dick on the same frequency out and back for 30 years as measured in Harry's time. During the outward portion of the trip, Tom will receive Harry's daily messages every other day on one-half the operation frequency, $\frac{1}{2}f_o$, for 16 years and on the way back twice daily at double the operating frequency, $2f_o$, for 16 years according to Tom's time. Dick will receive Harry's daily messages once every third day on one-third the transmitting frequency, $\frac{1}{3}f_o$, on the way out for 9 years, and on the return journey three times per day at triple the transmitting frequency, $3f_o$, for 9 years according to Dick's time. Note the slower outward rate of the received messages and the lower, shifted frequency of the reception of Harry's signals by both Tom and Dick as they rapidly recede from the earth and the faster return message rate and the higher, shifted frequency of the reception of Harry's signals by Tom and Dick as they rapidly approach the earth. The preceding results are the natural effects of the relativistic Doppler Effect and the time dilation effect becoming important at high speeds. This is easily confirmed by referring to expression (2) and dividing it by the contraction factor, $\sqrt{1 - \frac{v^2}{c^2}}$, to allow for the slower rate of the travelers' clocks. For example, in Tom's case, when he is moving away from the earth, he will receive Harry who is transmitting on the frequency, f_o, on

$$\text{a lower frequency} = f_o \frac{(1 + 3/5)}{\sqrt{1 - (3/5)^2}} = 2f_o.$$

The same ratio, $\frac{1}{2}$ or 2, also holds for the rate at which Tom receives Harry's brief daily messages which may be likened to signal flashes of radio or light bursts occuring once each day on earth.

What about Harry's receipt of messages from Tom and Dick both of whom agreed to transmit brief daily reports to him on frequency, f_o, during their respective round-trip journey to star S and star T? It should be observed that Harry will receive Tom's and Dick's daily transmitted messages at the slow rate during most of the time. In other words, the outgoing slower rate of received messages on earth from Tom and Dick covers a longer interval of time for Harry than the incoming faster message rate because there is a time lapse of 12 years before the last of the outgoing transmitted signals reach the earth traveling over the distance of 12 light years after the rocket ship has turned around and is headed back to earth and by the time the new received faster signal rate reaches the earth, the ship is well on its way toward the earth. The record of Harry's communications log is startling but nevertheless true; as will now be shown.

Harry will receive Tom's daily reports on one-half the transmitting frequency, $\frac{1}{2}f_0$, every other day during Tom's outward journey and the first part of the return trip for $20 + 12 = 32$ years and during the remainder of Tom's return trip on double the frequency, $2f_0$, twice daily for $20 - 12 = 8$ years as measured in Harry's time. On the other hand, Harry will receive Dick's daily reports during Dick's outward trip and most of the return trip on one-third the operating frequency, $\frac{1}{3}f_o$, every third day for $15 + 12 = 27$ years and on triple the transmitting frequency, $3f_0$, three times per day during the remainder of Dick's return voyage for only $15 - 12 = 3$ years according to Harry's time. The total number of messages received by Harry is the same going out and coming back.

Suppose all three radiomen are 20 years old at the time the journeys begin. Dick will return to earth first and find that Harry is now 50 years old while he is only 38 years old. When Tom comes back to earth, he will fiind that Harry is 60 years old while he is 52 years old. When Tom and Dick meet again on earth, Tom will be only 4 years older than Dick because Dick returned sooner than Tom by 10 earth years. By this time the reader must be aware that to stay eternally young he should travel with the speed of a lightning bolt but he will never be able to communicate with his fellow man on earth because his received Doppler-shifted frequency will be either zero or infinity.

. . . K6BW

Surprise in the Skies

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What are pulsars? Radio astronomers and other scientists all over the world are trying to work out the unexpected mystery posed by four sets of strangely regular, short, sharply pulsed radio signals from space. Several months of effort have resulted in an impressive number of contributions to the scientific literature, but the possible sources suggested so far have not successfully accounted for the signals actually observed. At this writing (July 3, 1968) it appears nobody knows what pulsars are, and new measurements, just published, will probably obsolete much careful thinking. Hardly tongue-in-cheek, I suggest "posers" might be a better title for the sources of these remarkable signals from space.

Although pulsar signals are very powerful at their point of origin, their distance of many tens or a few hundreds of lightyears attenuates the signals so that a good receiving system is needed to hear them. F. S. Harris (Is that *Sam* Harris?) has heard them at Aricebo Observatory in Puerto Rico using a 50-foot paraboloidal reflector on 144 MHz. From this it appears any ham who can try moonbounce work might be able to hear pulsars. This raises an interesting thought.

Why couldn't pulsars have been discovered by an amateur operator? Too bad they weren't. It would have done a lot for ham radio. Well, to find out something about pulsars let's start with a few notes on radio astronomy.

Radio astronomy

Radio astronomy originated before WW2 as an amateur electronics hobby rather than an amateur radio hobby. But it did not become a recognized scientific field until after WW2, when scientists using the radar and radio techniques developed for military applications, began to point their antennas out toward space to find out what they could hear.

It turned out they could hear a lot, and soon they were busy mapping the sky for radio brightness. Investigations in this field began to answer questions about our sun's location in space, and provided information about the shape of our galaxy and the distance to its center. Radio astronomy complemented optical astronomy very well since radio signals could penetrate the huge dust clouds found in many parts of the sky and particularly toward the galactic center.

Just as the optical telescope is one of the prime tools of the optical astronomer, the radio astronomer works with a radio telescope. But a radio telescope is simply a very large radio antenna with strongly directional characteristics, rather than an array of lenses and mirrors. A very good radio receiver completes the research installation, which may be very simple.

I was surprised to discover there are a number of amateur radio astronomers in England. I haven't come across any mention of American amateur radio astronomers, but I think this special form of engineering electronics might be interesting to hams who would like to try some new ideas.

As the radio astronomy field developed it became important in its own right. Workers found many surprises including radio stars which could be observed by radio but were invisible to any optical system. Some other stars were found which were visible both by radio and light observation, and one of these is the very interesting Crab Nebula, a remarkable sight centered on a star believed to have exploded into a supernova in our year 1054 AD. Other radio observations were made at various distances ranging from the planet Jupiter, right in our own backyard as such things go, out to several times the range of the visible universe.

Later, astronomers discovered the enigmatic sources called quasars, whose nature and distances are still uncertain. Opinions as to the nature of quasars have ranged from primitive galaxies in a very early stage of development to a radical suggestion they might be huge spaceships traveling in our own galaxy at relativistic speeds. Some observed facts suggest quasars are right here

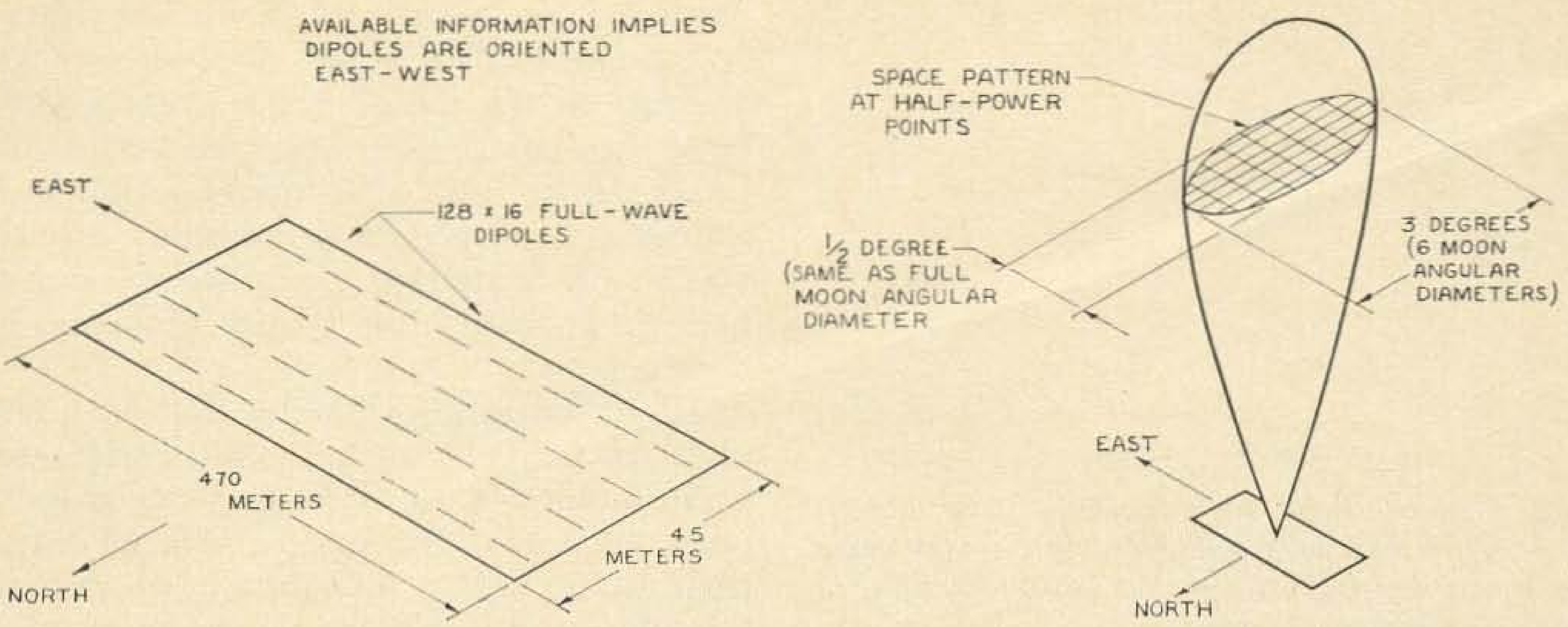

Fig. 1. The antenna system at Cambridge, just completed, which located the only four known pulsars. Electrical switching can sweep the beam lobe N-S and E-W across the sky.

in our own galaxy but the weight of the evidence indicates they are very far out and may be some of the most distant objects observable by both optical and radio means.

As the radio astronomers have built more effective radio telescopes they have continued to find interesting new facts, challenges, and problems. Radio astronomy has provided much useful information for cosmologists thinking about the nature and age of our universe. Some quiet, steady and nearly undetectable radio noise that comes in equally from all directions appears to be the still-echoing whisper remaining from the furious thunder of creation an estimated 26 billion years ago. This observation has received some attention over several years but it is not regarded as a very important matter.

While I was researching this article I came across a very interesting letter published by one radio astronomer who thinks a recent radio survey may have seen halfway around the universe. Some extremely faint, distant radio objects observed in a certain direction just might be, he suggests, the same ones we discover by looking in the opposite direction. He supplied a list of five prime possibilities and another five less likely candidates. If this is correct then we have some very useful information for testing theoretical investigations into the age and size of the universe.

Pulsars

One requirement for the continued develpement of radio astronomy has been better antennas and receivers. Another has been improvements in methods of detecting weak signals, and some of this work has appeared in the amateur radio field in moonbounce and space communications work. In a remarkable boundary-jumping effect, one valuable radio astronomy result has been the development of improved methods for studying human brain function. This has some very important and useful medical applications.

It was a natural development in 1967 for Cambridge University, in England, to be building a new and better radio telescope. The new instrument's antenna consists of a 128 x 16 planar array of full-wave dipoles with tiltable plane reflectors. The system's long axis extends in an east-west direction as shown in **Fig. 1.**

This system was designed to operate at about 81.5 MHz. Its beam direction is changed by switching in time delays from different sets of elements, so that without moving the antenna its lobe can be pointed at different parts of the sky. The antenna can be used with up to four receivers simultaneously to look in four different directions, a mass-production arrangement appropriate for achieving the maximum use from a rather expensive installation.

The new radio telescope was finally put into operation in July, 1967. Its operators started making regular routine sky surveys, a simple business of mapping the sky's radio brightness time and time again, looking for changes, and anything unusual, of interest. They observed some sporadic interference of unknown source and finally, in November of 1967, they started looking for the cause.

An answer appeared shortly. The appar-

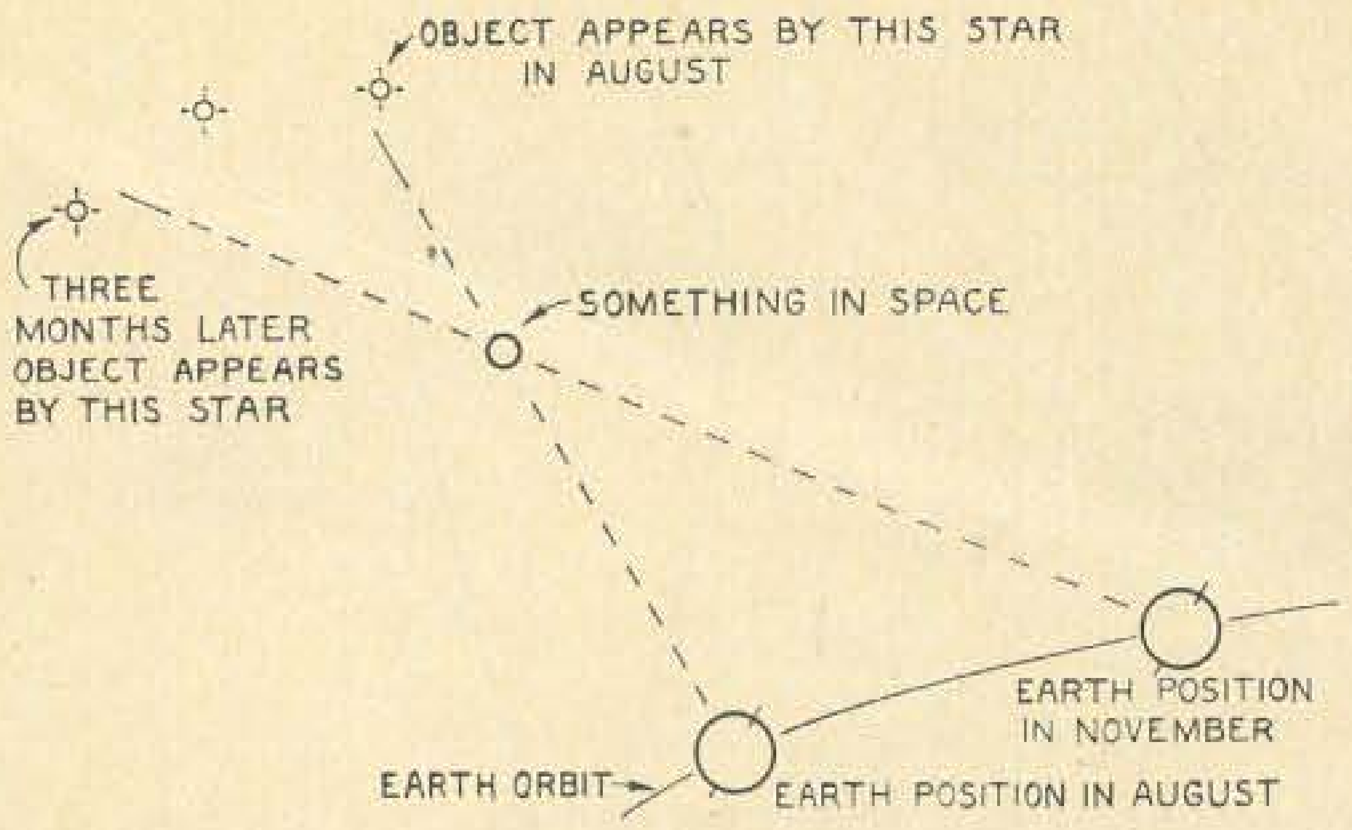

Fig. 2. Why the radio sources would seem to move in the sky if they were relatively close to the earth. This is the same geometry that causes parallax in reading instrument scales.

ent interference was a steady stream of pulsed signals coming in from space. An investigation of past records and some additional tests showed the astronomers that they had discovered four strange radio sources in space, generating signals unlike anything known to come from any previously studied sources.

It was reasonable to suppose these signals resulted from some unannounced space-research activity. A space probe? *Four* space probes? Unlikely, and it could not be some reflection from the moon or some other body, of radiation originating on the earth, because the sources of the signals did not seem to move about in the sky as the earth moved through space.

See **Fig. 2.** If the source were nearby, the earth's orbital motion in space would cause a nearby object to move across the sky relative to the stars. After reviewing their records and doing careful additional research, the astronomers concluded their newly discovered signals had to be coming from some unknown source too far away to have any connection with human activities. Finally, on Feb. 24, 1968, their results were published under the unobtrusive title "Observation of a rapidly pulsating radio source." I've listed it in the Bibliography.

That paper has undoubtedly upset a number of carefully planned research efforts. Starting from zero, there have been at least 35 additional papers published since, which probably sets some kind of a scientific record. The great observatory at Jodrell Bank promptly turned its 250 foot diameter paraboloidal reflector towards the signal sources and provided additional verification at frequencies other than 81.5 MHz. And a furious effort at Aricebo Observatory in Puerto Rico produced no results at first, but after its operators installed a new Sears-Roebuck TV antenna at the focus of the great 1000-foot bowl the signals were observed very strongly there. In a couple of months the strange signals had been named "pulsars," an abbreviation of "pulsating radio stars," and they had made the front pages of some large newspapers.

There was some thinking that such sharp, regular, unlikely signals must originate in some intelligent purpose, and newspaper reports suggested the matter was all but settled. More sober thoughts have prevailed, though, since compelling facts indicate that like all the other signals observed so far from distant space, these have some natural origin. What is that origin? There are many suggestions but nobody knows.

The picture—so far

I've heard tape recordings of pulsar signals, and they certainly sound like something originated by life. They are a steady, regular rasping beat that sounds more sensible than the jamming transmitters and other signals that may be heard on shortwave receivers. The pulses give a tremendous impression of power, stability, and intelligent purpose. They sounded to my ear as if there *must* be somebody out there deliberately triggering them off. It is easy—too easy, to believe that if we are smart enough we can work out who it is and what they are trying to do.

The work on pulsars has been so intensive a recent report in Scientific American magazine appeared under the title "The Pulsar Industry." Pulsars seem to be the number one order of business for many scientists all around the world, and their work as described so far has tended to fall into three general classes.

First, the astronomers have tried to obtain better recordings and measurements of the pulsar signals. They have been making very careful records of timing, signal strength, and the varying polarization of the incoming radio signals. These are rather hard to hear because they are weak, and the best equipment possible is required. Many observational reports have appeared, providing new facts useful to workers thinking about what kind of sources could be generating the pulsar signals.

The second area is theory research, in which workers thinking about possible sources try to work out what these sources should sound like if they operate according to familiar rules already understood. This work is a continual process of developing possible models, calculating the consequences, and seeing how well the results square with observations. So far as pulsars are concerned the work has not been very successful in finding an answer although a wide variety of interesting proposals have been studied.

And finally, some researchers are trying to obtain new information by discovering light signals from the pulsars. If the pulsars emit radio flashes, the reasoning goes, perhaps they emit light flashes also, and if we can identify which star is doing the flashing maybe it will turn out to be a kind of star we already know something about.

Results so far indicate pretty definitely that all four pulsars are the same kind of radio event, with some individual variations. All four have similar pulses with a similar 12-millisecond time schedule in the pulse structure except for one whose pulse is similar to the first part of the more complex pulse emitted by the other three pulsars.

The first pulsar discovered was CP1919. It is slightly the strongest, and it has received the most scientific attention. This is the pulsar F. S. Harris has observed at Aricebo using a 50-foot paraboloidal reflector. Its power level is sometimes as great as 200 x 10^{-26} watts per square meter per Hz peak, and its signal is a three-part pulse about 36 milliseconds long. This is a model pulsar pulse, consisting of parts A, B, and C in **Fig. 3.** Its period is about 1.337 seconds, and its amplitude shows wide variations which are believed to originate in the source rather than propagation effects.

This is the pulsar that was investigated in a search for optical flashes. At least three observatories performed tests. A European observatory tried a rocking camera arrangement timed to the pulsar signals so that a flashing star would leave a distinctive image different from the steadily shining stars in the area believed to contain the pulsar. This test was not successful, and attempts were made in America using elaborate cooled-photocell and computerlike analysis systems. These were not successful either. Although reports of success have appeared in the papers and were circulated at the Pulsar Conference in N.Y.C. at the

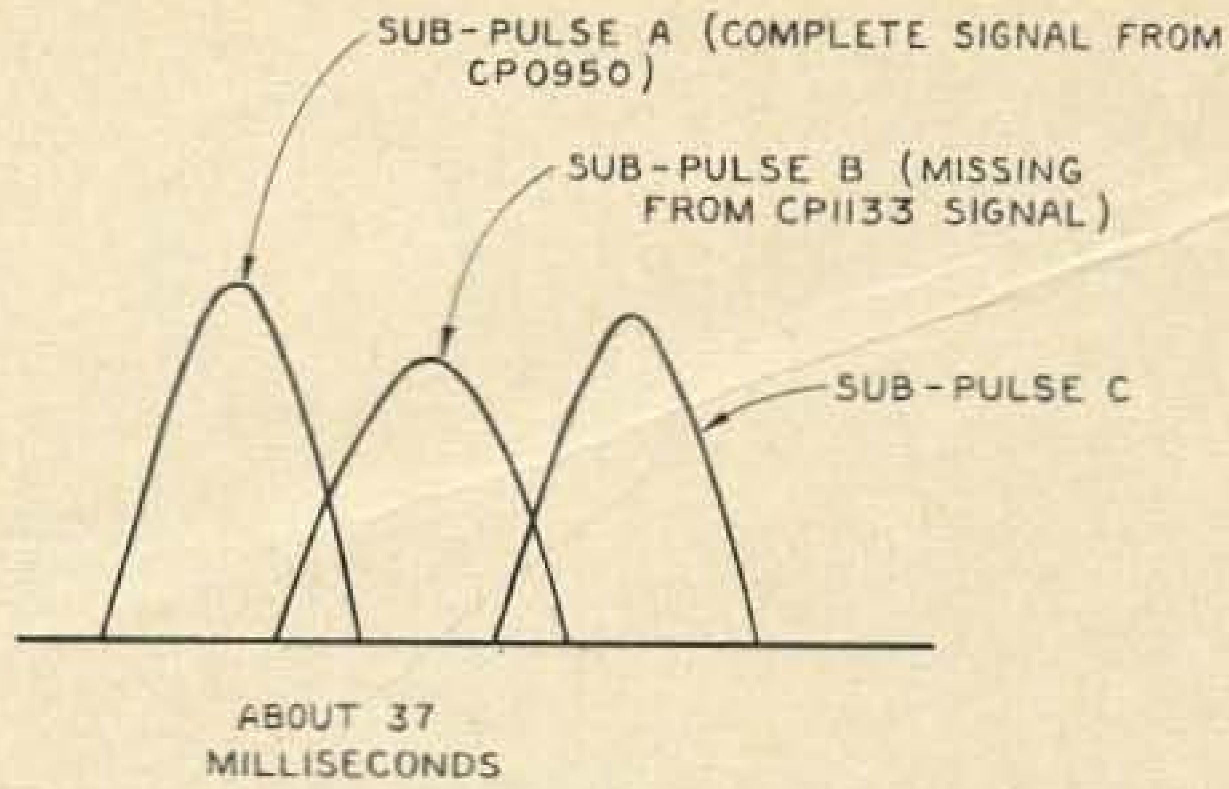

Fig. 3. All Four pulsars generate signals that are some variation on this scheme. And they all have the same timing.

end of May, so far nothing has been sighted in the sky that could be identified as a pulsar.

The latest research reports, just out at this writing, indicate the pulsar signals are more complex than shown in **Fig. 3.** New work with a faster system at Aricebo have shown the pulse shapes of **Fig. 3** are only average results. The pulses are really composed of many spiky microsecond pulses of much greater amplitude. The tough problem of pulsar signal sources has just become a bit tougher. But amateur radio gear is likely to see the signals as they are described here.

Pulsar CP1133 has a peak power level similar to that of CP1919 but a period of 1.188 seconds. It emits a doublet pulse consisting of a normal initial pulse, followed after a 12 millisecond delay by a normal terminal pulse. Look again at **Fig. 3,** this is sub-pulses A and C. The central pulse is usually missing but has been observed occasionally.

Pulsars CP0834 and CP0950 are considerably weaker, with peak powers at reception of around 60 x 10^{-26} watts per square meter per Hz. CP0834 pulses once per 1.274 seconds with a pulse shape similar to that of CP1919, and CP0950 pulses once per 0.253 seconds with a short single pulse similar to sub-pulse A of **Fig. 3,** about 20 milliseconds long. Perhaps at its relatively short period it just doesn't have time to carry out the complete sequence. It just is not believable that a sunlike object should emit almost four sharp, distinct pulses per second —until you actually hear it.

Pulsars present a real scientific problem that is likely to be important in the future. It is a tough problem, too, but the response to this challenge has been very strong. My guess is that the questions will be worked

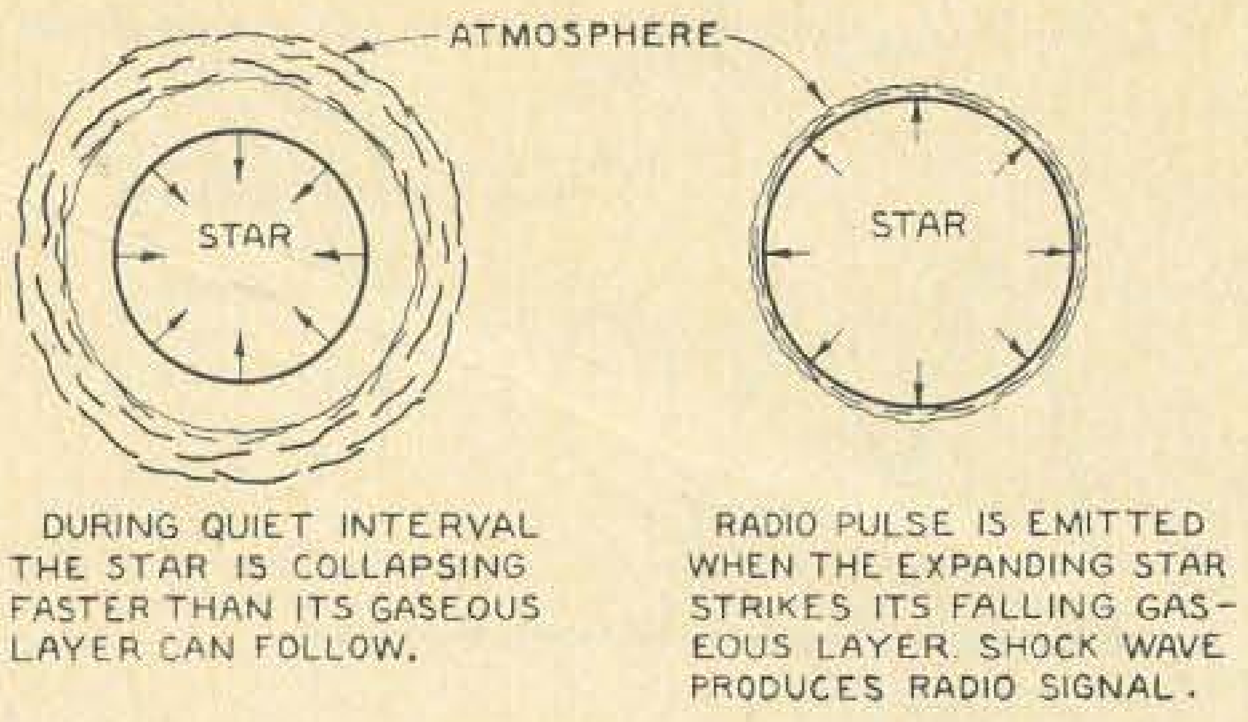

Fig. 4. A Sufficiently massive oscillating star could collapse inwards leaving a gas shell behind, and then expand outwards again striking the shell. Resulting pressures and ionization would generate radio signals.

out within a year or so, and here are some of the many possible sources astronomers are working on now.

Pulsars could be white dwarf stars or neutron stars, oscillating radially with periods equal to those of the observed radio signals. Some previously worked out computations seemed to indicate white dwarf stars could not oscillate fast enough, and neutron stars would oscillate too rapidly, to cause the pulses actually measured. These objections have been countered with new calculations and suggestions about possible overtone vibrations. See **Fig. 4.**

Another possibility is that two neutron stars are orbiting very rapidly around each other. The atmosphere and gravity fields of each star in turn could serve as a lens to focus the other star's radiation in our direction for a brief interval when the stars were on a direct line toward our sun. This mechanism has been written off because it would generate pulses with cyclic differences that have not been observed.

Certain events known in our solar system generate signals having some characteristics of pulsar signals. Our planet Jupiter emits radio bursts apparently timed to the orbiting of its sattellite Io, but a recent scientific paper concludes any satellite orbiting a star fast enough to trigger the observed signals could not exist. Too many contradictory requirements. There does not seem to be any work out that attempts to relate pulsar signals directly to events observed on our sun but a possible similarity has been suggested.

A key observation is the pulsar signals' steady rate. The time stability of the signals compares very favorably with the best atomic clocks anybody has been able to build. This suggests the pulsar signals must be triggered off somehow by a huge, massive rotating body.

The possibility it is an ordinary star have been ruled out. Theoretical astronomers have been thinking for several years about what happens to stars after they have exploded—and stars do explode sometimes, violently. The explosion is called a nova, or if it is a really large one, a supernova. After the explosion, according to calculations, much of the star's material will remain but its nuclear fuel will be nearly exhausted and the star cannot maintain its original size. It collapses inward, and a mass substantially greater than that of our sun may be packed into an intensely hot, rapidly rotating body a *few miles* in diameter. It becomes a white dwarf star (a few of these have been observed) or a neutron star. Present thinking tends to the idea that when pulsars are understood there will be some direct connection with an old nova, probably collapsed into a neutron star.

Can we hear pulsars?

I don't really know. I worked out some figures that indicated Aricebo couldn't hear them. Obviously there was an error in there somewhere, and I think it is in the receiver department. Nothing appears in any of the scientific reports as to how good the radio astronomers' receivers really are, but evidently they are considerably better than the usual engineering equations assume.

Since F. S. Harris heard CP1919 with a 50-foot reflector, it appears pulsar signals are in the moonbounce range of difficulty. I worked out his antenna gain must have been around 22 db and probably not over 26 db. There are many moonbounce antennas built offering higher gains than that. One in Australia, described in the July issue of 73 Magazine on page 66, is rated at 34 db gain, but it is a huge double rhombic and probably cannot be pointed at any pulsars.

Some ham ought to be able to hear pulsars, I think. I hope he tries.

. . . W1EZT

Bibliography

If you're interested in more detail on pulsars you probably can find it in a nearby library. The librarian will be glad to help you out and can obtain books and magazines for you in a few days from other libraries if they are not on the shelf. Here is what you look for, and you can find the rest of the 36 papers so far by using bibliographies at the ends of the papers, and looking in other copies of the magazines.

1. Craft et al: Submillisecond radio intensity variations in pulsars. Nature *218* 1122 (June 22, 1968). This is the latest at the time of writing.

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Using Thin-Wire Antennas

A thin-wire antenna can often provide an antenna "solution" in situations — either permanent or portable — where an obvious antenna is not desired. Various special considerations to observe when using thin-wire antennas are explored.

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Many amateurs who live in apartment houses, or even in private homes, are faced with the situation that a conspicuous outside antenna cannot be erected. One solution to this problem is to use an indoor antenna and accept the signal loss caused by absorption due to the building structure. Such antennas can be reasonably useful depending upon specific circumstances—height, building construction, etc. They also can cause tremendous problems, such as coupling *rf* into power lines and other wiring circuits. Working on the basis that almost any type antenna placed outdoors will work better than an indoor type, one is faced with the problem of constructing a reasonably inconspicuous antenna. No antenna can probably be completely inconspicuous to someone who knows what to look for, but at least the average person will regard any piece of wire that is visually inconspicuous as being inconsequential both from an aesthetic and interference viewpoint. Many approaches may be tried to produce an inconspicuous antenna, but probably the simplest and least expensive uses extremely thin wire in lieu of conventional large antenna wire.

This article explores various considerations which one should observe when constructing a thin-wire antenna in order to obtain the most efficient performance.*

* what constitutes 'thin-wire" or a reasonably inconspicuous size depends upon specific circumstances, but generally a wire size of AWG #18 or smaller is meant.

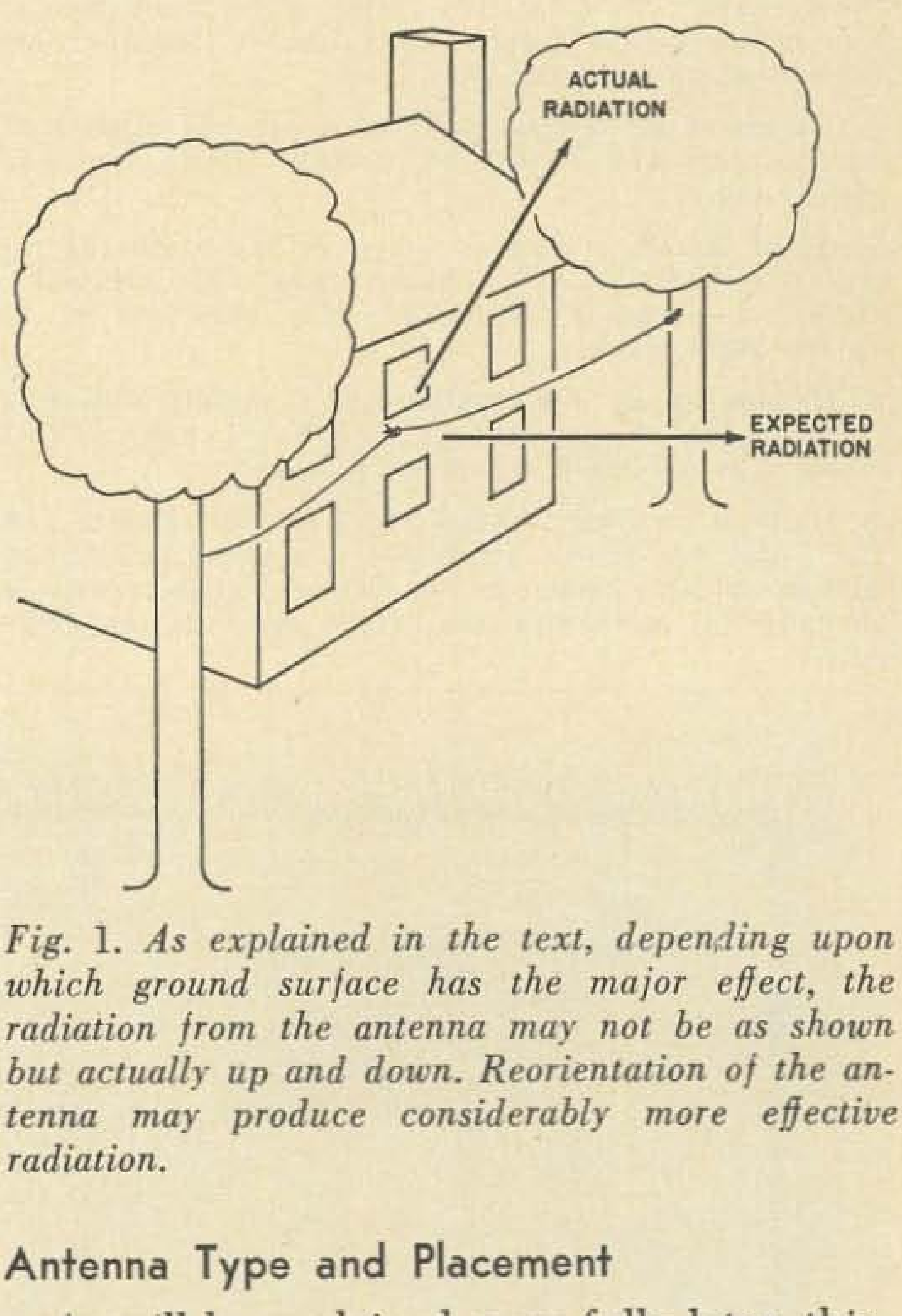

Fig. 1. As explained in the text, depending upon which ground surface has the major effect, the radiation from the antenna may not be as shown but actually up and down. Reorientation of the antenna may produce considerably more effective radiation.

Antenna Type and Placement

As will be explained more fully later, thin-wire antennas, because of their very nature, can develop very high voltage points with even only moderate transmitter power. Therefore, one of the great problems which may develop with such antennas, is *rf* in the shack when a single wire type is used with a ground connection to a plumbing or heating system. An unbalanced antenna should be avoided if at all possible and some form of balanced antenna used—a dipole or V—even if it means that each leg of the antenna will be shorter than that obtainable with a single long wire. A transmission line should be avoided if possible, and both legs of the antenna coupled directly to the terminals of an antenna coupler located near a window or on a balcony. If a transmission line is used because a considerable height advantage can be achieved by remote location of the antenna, one is faced with the conflict that the less conspicuous the transmission line, the greater its attenuation. A generally acceptable compromise is to use 72 ohm receiving twinlead, which is relatively small and has acceptable losses if runs of 50 feet or less are used. Another possibility for a really small coaxial transmission line is RG174 A/U, which is a 50 ohm cable only 1/10 in diameter. Again, its losses are tolerable only in runs of about 50 feet and its power handling capability is no more than 50 watts.

The placement of the antenna should avoid coupling to surrounding lossy surfaces. The worst condition probably exists when an antenna is run close to and parallel to a building surface. Ideally, the antenna should be placed at right angles to the building surface, or if parallel to it, at least as far away as is consistent with keeping the installation inconspicuous. There is certainly more art than science involved in the placement of such antennas in a complex building structure, but the above two rules seem to consistently apply.

Antenna directivity is another factor which defies any exact rule-making. Normal dipole radiation is, of course, at right angles to the line of the antenna. But, when the antenna is extremely close to a ground surface, considerable low-angle radiation in line with the antenna may occur.

Another problem is in determining what the ground surface is for an antenna. When it is mounted away from a building wall of considerable area in terms of wavelengths, the building wall may form the ground surface for the antenna, rather than the earth surface. For instance, in **Fig. 1**, if one considered the earth surface as the ground surface, radiation should be expected in the direction shown by the arrow. However, the building surface may well act as the ground surface and one may simply be radiating most of the signal straight up and down. The solution, of course, would be to rotate the line of the antenna by 90 degrees, so that the radiation is bi-directional with the building surface acting as the ground surface. This rather simple re-orientation of an antenna can produce a very dramatic

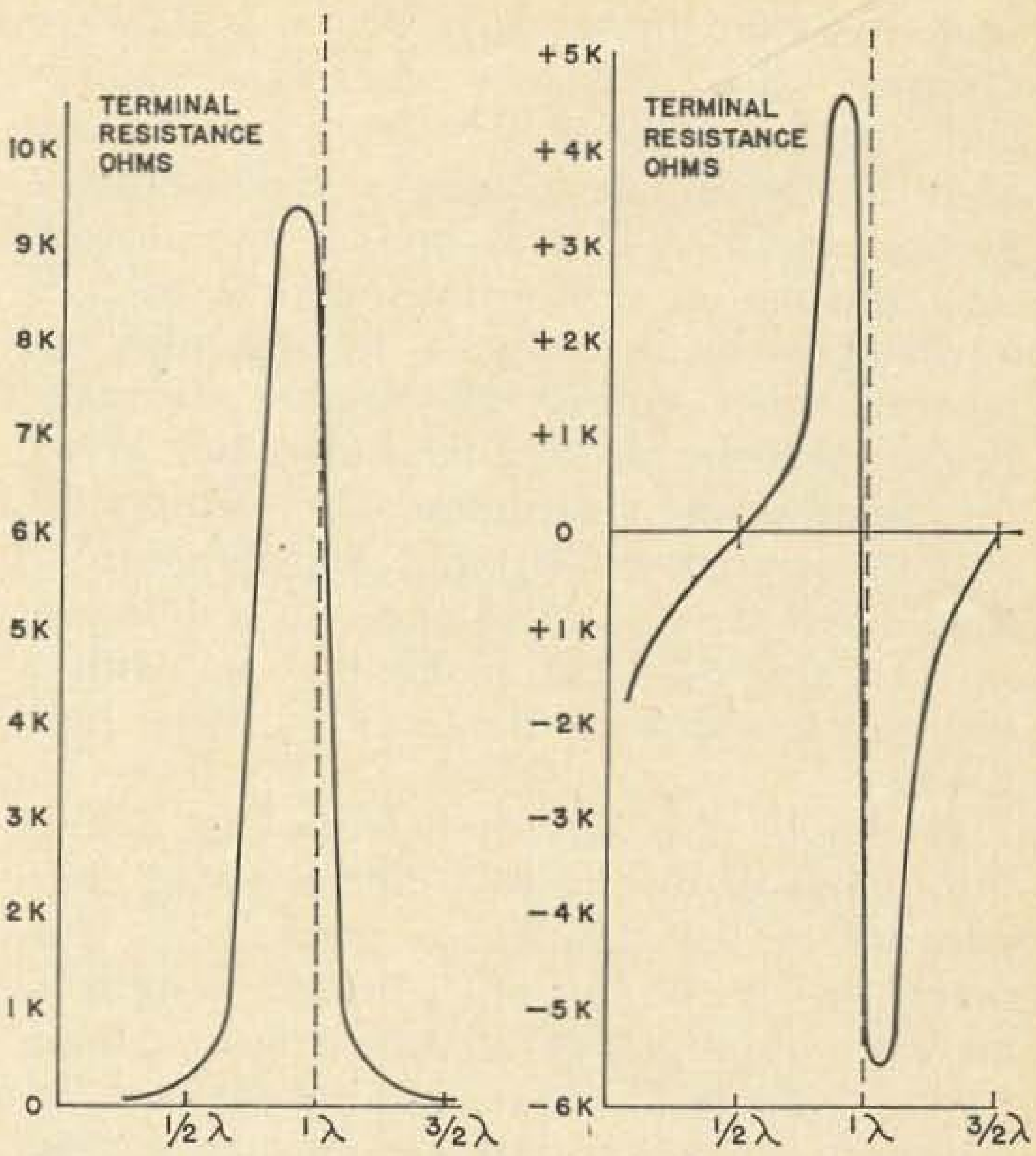

Fig. 2. Free-space resistance and reactance values for a dipole having a wire diameter of λ/100,000 (approximately AWG #26 wire used on 40 meters). Of interest is the fact that when the dipole is an even multiple of a wavelength long (physically), resonance as defined by zero reactance actually occurs at a slightly shorter length. The curves basically repeat for longer length antennas except that the peak amplitudes slowly decrease.

improvement in performance in many apartment situations.

Antenna Impedance and Coupling Methods

Fig. 2 shows the resistive and reactive terminal values of a dipole antenna as its length varies between essentially 0 and 1½ wavelengths long overall. The curves are shown for an antenna having a wire diameter of λ/100,000, or about AWG #26 wire used on 40 meters—which certainly qualifies as a thin-wire antenna. With slight modification, the resistive and reactive values repeat as the antenna is made longer in terms of wavelength.

The values shown are based upon a dipole in free-space and although it is not desired to make a complex subject even more involved, it should be realized that proximity to a ground surface will modify the values shown, particularly the resistive component. The reactance of a ½ wave dipole in open space, as read from the graphs, would be zero, and the resistance about 70 ohms. As the antenna is placed nearer a ground surface, however, particularly below 1/10 wave distance, the resistance decreases rapidly and can easily be only a few ohms, as for a 40 meter dipole placed a foot above a ground surface. This is one of the reasons why the use of a transmission line to feed a remotely located dipole is generally not recommended unless the height advantage gained thereby is very considerable. Without appropriate instrumentation, it is difficult to determine the input impedance of a dipole remotely located close to a building surface and one will likely end up with a transmission line operating at a very high SWR.

It should also be noted from **Fig. 2** that the swings of the resistive and reactive components of the dipole are particularly dramatic when the overall antenna length is an even multiple of a wavelength. Therefore, if one had an antenna which was being used on several bands so that on various bands its length was an even multiple of a wavelength, major readjustments of an antenna coupler might be required for minor frequency excursions within a band in order to resonate the antenna system. Because of this consideration, as well as other factors discussed next, it would be better to choose a length for a multi-band antenna so that the terminal impedance remains within reasonable limits on all bands. For instance, if one chooses an antenna length of ⅜ or ⅝ wave on the lowest frequency band to be used, the impedance values on higher frequency harmonically related bands should be well within the range covered by a simple transmatch type antenna coupler. If a basic length of ¼ or ½ wave were chosen, however, it is unlikely that a transmatch coupler could accommodate the impedance range of various harmonic frequencies.

Voltage and Current Considerations

Besides the problem of choosing an antenna length which a conventional coupler can handle, there are also insulation and wire size considerations which affect both the antenna and the coupler. If one operated a basic ½ wave antenna on its second harmonic, the terminal impedance would be from 7 to 9 K ohms, as shown in **Fig. 2.** With a 100 watt transmitter this would produce over 700 volts of *rf*, and over 1600 volts of *rf* with a 300 watt output transmitter. The voltage distribution on such an antenna would be as shown in

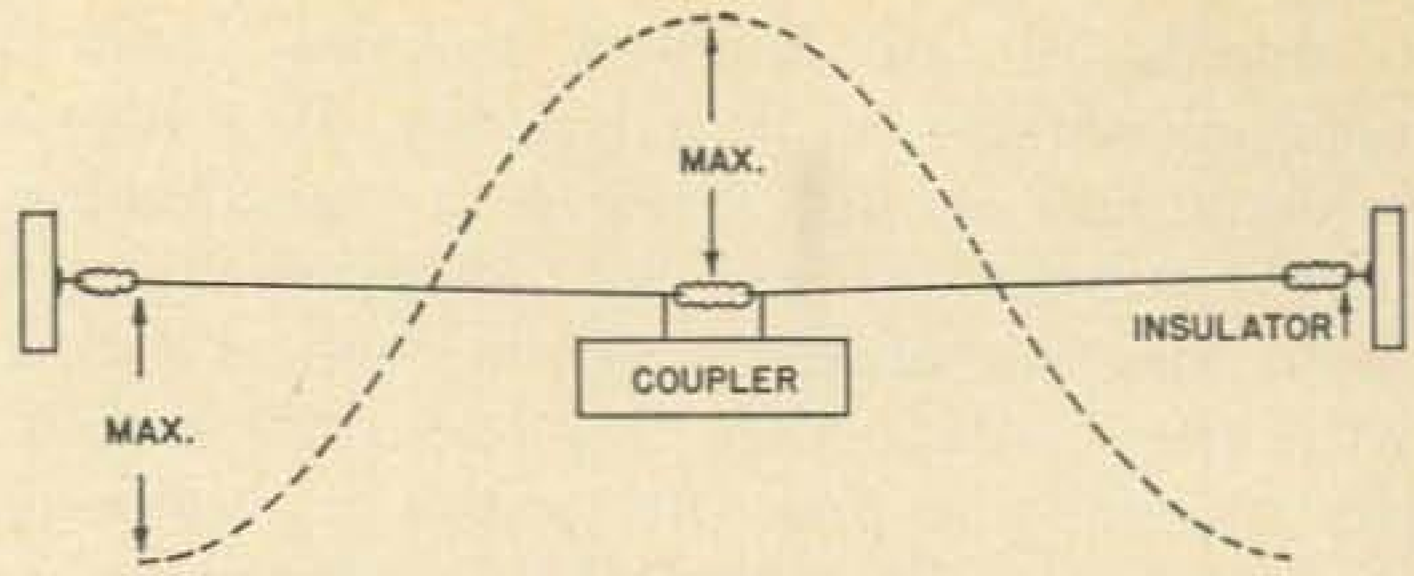

Fig. 3. Voltage distribution along a ½λ dipole operated on its second harmonic.

Fig. 3. The voltage peaks occur at the dipole terminals and at the far ends. Thus, the components within the antenna coupler, the feedthrough insulators connecting the antenna to the coupler, and the end insulators all have to be rated for a relatively high voltage if arc-overs (within the coupler) and losses due to long leakage paths are to be avoided.

The consideration that must be given to the effects of current flow can be seen if a ½ wave dipole is considered operating on its fundamental with a terminal impedance of 50-70 ohms. At the terminals a 100 watt transmitter (CW) will produce about 1.2 amperes. A 300 watt transmitter can produce almost 2.5 amperes. Obviously, very small wire sizes will not handle such currents although in reality one can get away with using thin wires far beyond their "handbook" current rating because of the intermittent nature of most transmission modes. Nonetheless, AWG #22 wire cannot handle more than 1 to 1.5 amperes and AWG #18 about 2.5 amperes. When one considers really thin wire–down to AWG #30 sizes–the current ratings go down to a few hundred milliamperes.

All the possibilities which involve voltage and current maximums in harmonically operated dipoles can become quite complex. But the above simple examples demonstrate another disadvantage of constructing multiple half wave antennas of very thin-wire. If the antenna is constructed to avoid operation on ½ wave multiples, the terminal impedance will not vary over such wide excursions. The voltage and current maximums will be less and both insulation requirements and wire size requirements will be reduced. The reactive component of the dipole impedance produced by such operation can be easily tuned out with a conventional antenna coupler.

Wire Selection

A wide variety of wire types is available for construction of a thin-wire antenna. Exactly which type one should use depends upon a specific installation—the length of the antenna, the tension that will be placed on the wire, and how far one wants to go to be inconspicuous while still retaining a wire size adequate to handle the transmitter power. Insulated magnet wire, made of tinned copper, is available in sizes down to AWG #40. One should use the type with a double polyester film coating, but, even then, the smaller sizes will stretch considerably with only slight tension. So-called indoor antenna wire (Belden 8014) is the stranded equivalent of AWG #25, but has considerably better tensile strength. Boinbach high-temperature miniature wire (7524-7534 series) is available in AWG 24-34 sizes and is similar to magnet wire except that it is available with a variety of colored thermoplastic films—in case one really wants to make an effort to have the antenna blend with a background color.

The smallest size in which 40% copperweld wire is available is AWG #18 (Saxton 5300). It is the best choice if such a size is acceptable. Piano wire is available in smaller sizes, but may corrode in certain environments. Its springiness also can make it difficult to handle. Clear plastic fishing line functions nicely as a combination insulator and tie line for the antenna ends.

Summary

Thin-wire antennas can perform very well when properly installed, and can provide an antenna solution in situations where a conventional installation cannot be used. The considerations involved in using a thin-wire antenna successfully differ somewhat from those when using conventional antenna construction and this article has tried to highlight the main considerations to watch.

In summary, a balanced form of antenna should be used, if at all possible, which is directly coupled to an antenna tuner. The antenna length should be chosen to avoid impedance extremes on harmonic operation and a high current loop at the tuner terminals on fundamental operation. A tuner should be used which can properly couple to a balanced form of antenna—a transmatch tuner, for instance, and not a pi-network tuner. . . . W2EEY/1

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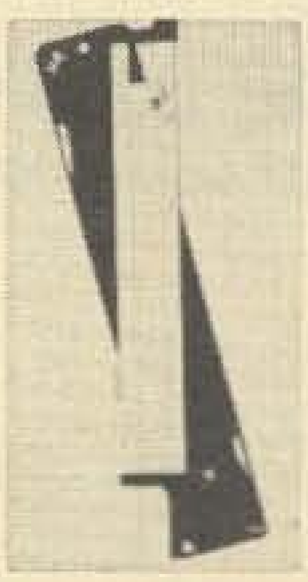

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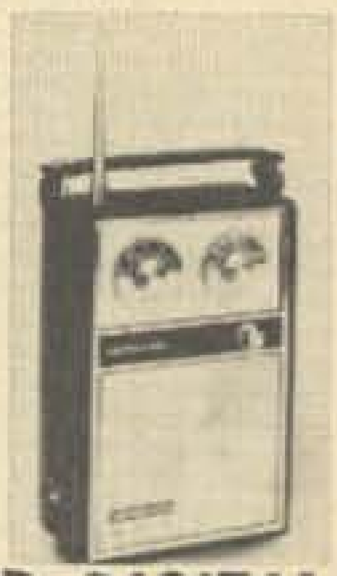

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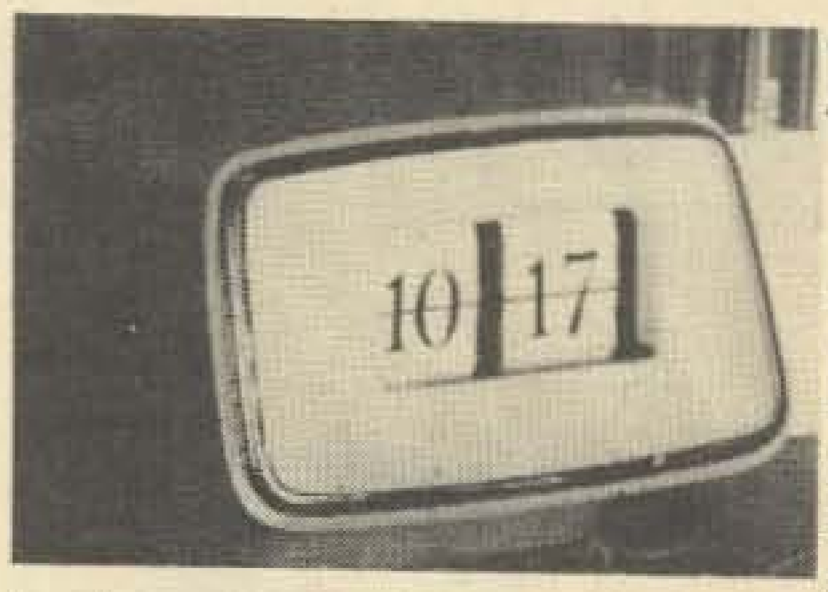

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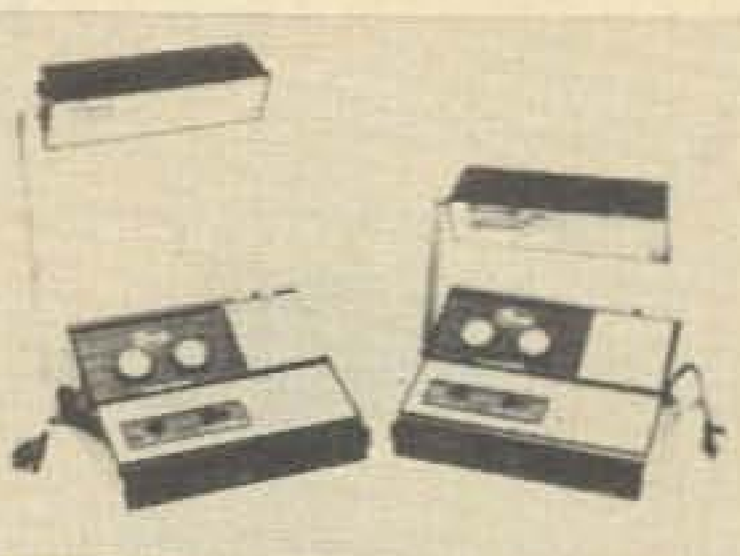


$35 HI-INTENSITY LAMP-RADIO AND CLOCK!

Free with 8 subs or $18 with 2 subs. Clock operates radio, etc. Fine for desk.

HAMMOND 18" LIGHTED $25 WORLD GLOBE

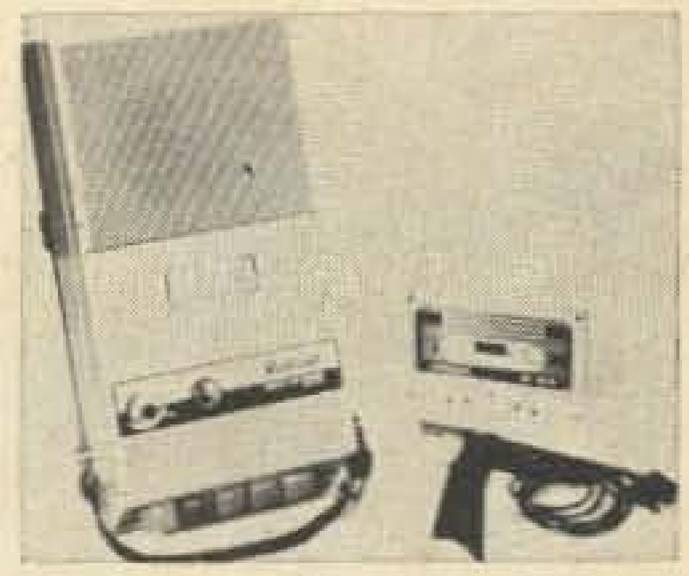
Free with 6 subs or $12 with 2 subs. Get two, one for jr op. No pins.

NAME & CALL PLATE

Free with 1 sub. Up to 20 letters and spaces on 10" desk plate. Walnut with white letters.

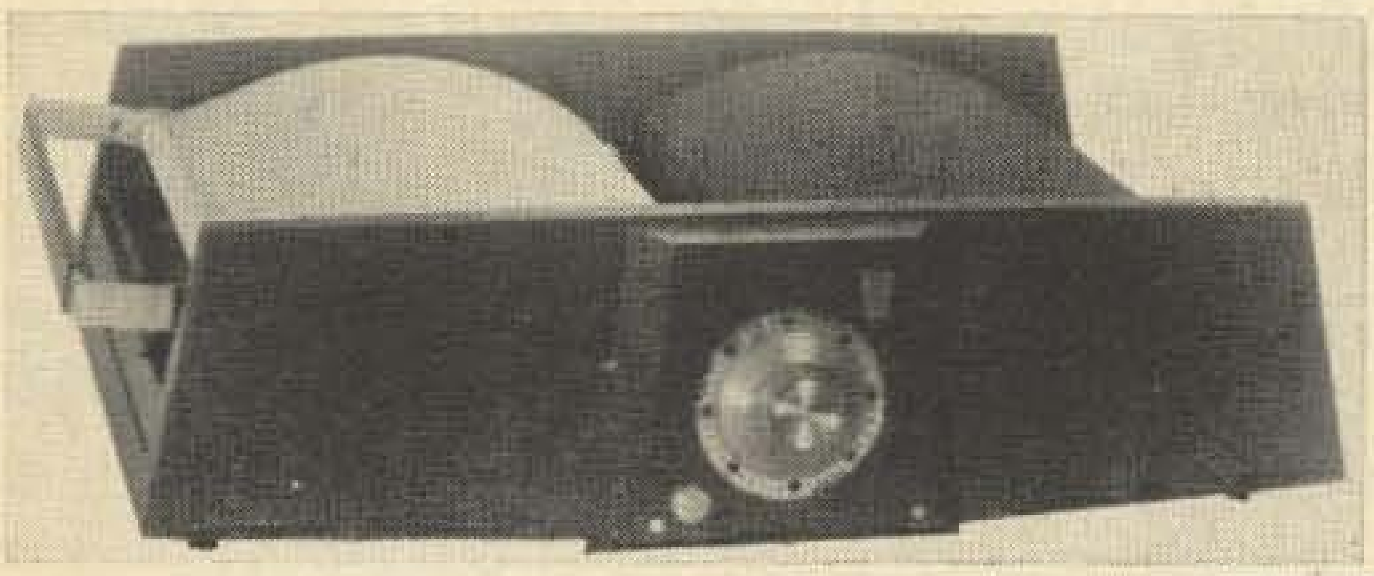
AM-FM TELECHRONE CLOCK RADIO

Free with 12 *subs or* $30 *with* 2 *subs. This really beautiful clock-radio usually sells for* $65. *Has buzzer, radio alarm, slumber button, and delayed snooze turn off. Give yourself—one . . . or the XYL.*



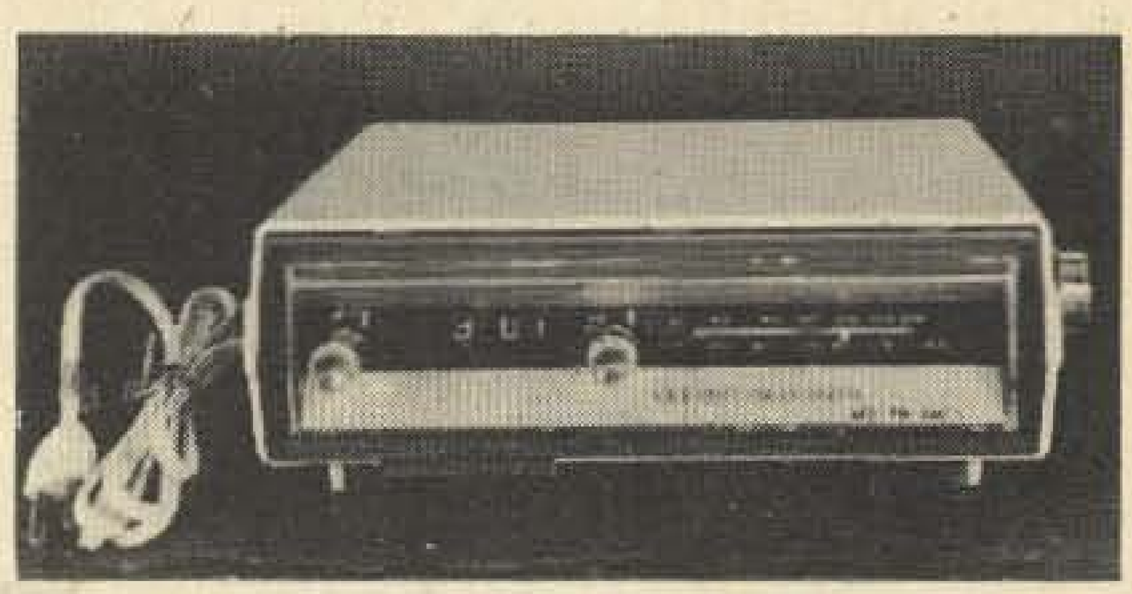
$50 CASSETTE TAPE RECORDER

Free with 12 *subs or* $30 *with* 2 *subs. We tested a dozen recorders before we found this darb. Really works. Record birds, rare DX, family squabbles, jokes, singing. Sneekily small.*



COPYMATE PHOTO COPIER MACHINE

Free with 10 *subs or* $24 *with* 2 *subs. This does every bit as good a copy job as a well known* $400 *copier and uses same inexpensive paper. Comes with paper all set to go.*



DIGITAL CLOCK AM-FM RADIO

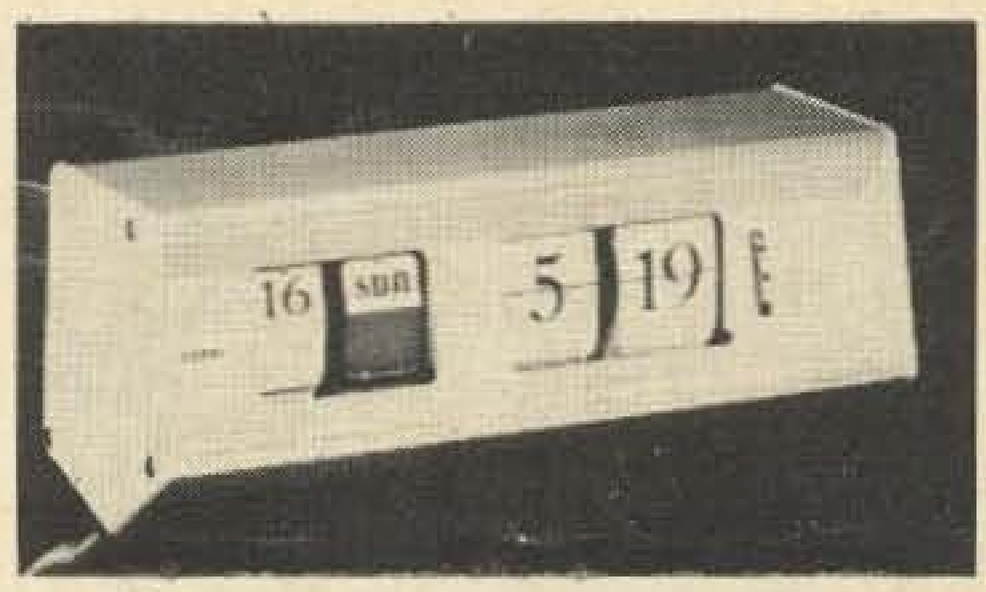
Free with 9 *subs or* $20 *with* 2 *subs. This is the only digital clock radio we've ever seen. Fine FM radio built in with sleep alarm, buzzer, whole schmear. Like the unusual and new?*

OPERATING DESK

Free with 9 *subs or* $23 *with* 2 *subs.* $35 *desk just right size for modern transceiver ham station. Shipped FOB factory in Michigan.*

RAND-MCNALLY MAGELLAN WORLD GLOBE

$15 *globe free with* 3 *subs or* $8 *with* 1 *sub. You can't beat a deal like that.*



CASLON 601 DIGITAL DATE-DAY CLOCK

This $50 *Ferrari of desk clocks is free with* 12 *subs or* $32 *with* 3 *subs. Brushed aluminum. The last word in operating aids.* 24 *hour clock, naturally.*

$160 ENCYCLOPEDIA SET

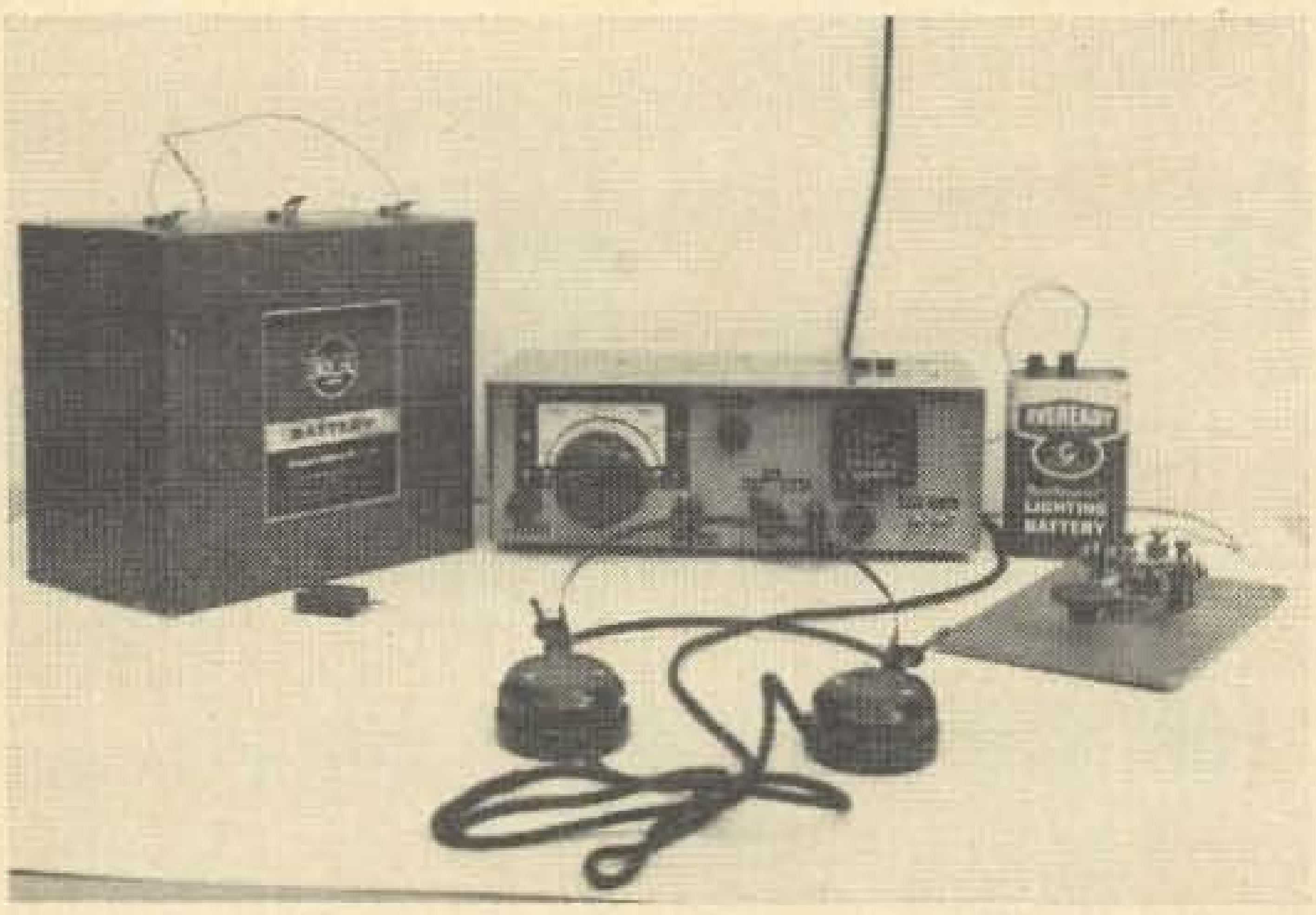
Free with only 20 *subs or* $52 *with* 8 *subs. This is a first rate encyclopedia. This one is FOB the publisher. Tap your fellow club members for* 73 *subs and win this mass of books.*

Send each gift subscription on a separate 3 x 5 *card with name, call, address and zip. All must be new one year* $6 *subscriptions to start with the November issue. You want to renew your own subscription? OK, if you include the label from your wrapper. On another card write your name and addess and indicate which prize you wish. Allow up to eight weeks for delivery in case we are back ordered from the factory. Prizes will be sent postpaid unless otherwise stated. This offer is good for the USA and APO only and expires December* 31, 1968.

73 MAGAZINE, PETERBOROUGH NH 03458

7 *MHz Transistor Transmitter*

Lee Krutz WA6JND
1134 *Royal Ann Drive*
Sunnyvale, Calif. 94087



In a number of years of hamming on a relatively mild scale, the author has never contacted another station who, at the moment, was running transistorized homebuilt gear. This seems odd indeed, especially in view of the fine transistors available today at reasonable cost and indicates that the activity is not as great as it might be.

Some experimentally inclined hams may have shied away from transistorized transmitters because they are frequently multistage affairs requiring specialized equipment and techniques for tuning. This article is directed particularly to those who may want to jump in and get their feet wet for the first time.

By way of background, a transmitter circuit similar to that used here was first tried in the spring of 1960 with excellent results. The transistors used were a pair of RCA 2N247 drift transistors with inputs limited to a hundred milliwatts or so. This was fine for a short while when the spirit that years ago speculated, "what is the ultimate power input a 6L6 will take", again prevailed, and before long the little rig was running at more than a watt input. To prevent the breakdown in the transistors, which occurred if the key was held down more than a second or two, from being catastrophic, four #47 pilot bulbs in series with the 22½ volt collector supply were used. This power limiting device allowed several trips into the breakdown region before the transistors lost their desirable characteristics. Later drift transistors of the 2N640 type proved a little more rugged and several survivors were used in this project.

The transceiver (actually transmitter-receiver) presented here consists of an 8 to 10 watt input crystal controlled transmitter link coupled through a send-receive switch to the antenna. A device is included to protect the *rf* transistors from burnout. The receiver follows traditional *trf* design with an *rf* amplifier and reflex regenerative detector followed by two stages of audio amplification. A keying monitor and spotting oscillator are included as operating conveniences. The transceiver went through several variations in the course of its evolution. A speaker driven by a class "B" audio amplifier was originally incorporated. The fluctuating current drain of this stage caused instability in the note of the received signal and was abandoned in favor of single-ended class "A" stage driving a headset. The speaker was never missed, however, since CW operation and the use of headsets is somehow synonymous. The first three stages of the receiver were enclosed in a separate shielded box with the idea that the transmitter could be monitored directly. The shielding proved inadequate and the keying monitor and spotting oscillator were added as a substitute. If the job were to be done again, the shield box would be eliminated entirely with the *rf* stage located under the chassis next to the send-receive switch with the balance of the receiver above the chassis.

One of the cheapest and most convenient sources for powering portable transmitters of this power level are any of the large 45 V "B" batteries such as the Burgess 21308SC or the RCA VS 127W or VS 157W series. They are capable of normal 300 mA discharge rates and one of these will furnish a whole summer of trouble-free operation at a cost of about $6.00 to $7.00. These types may not be readily available on the dealer's shelf as the demand seems to be low, but this is really a break in your favor since the one you order is much more likely to be fresh.

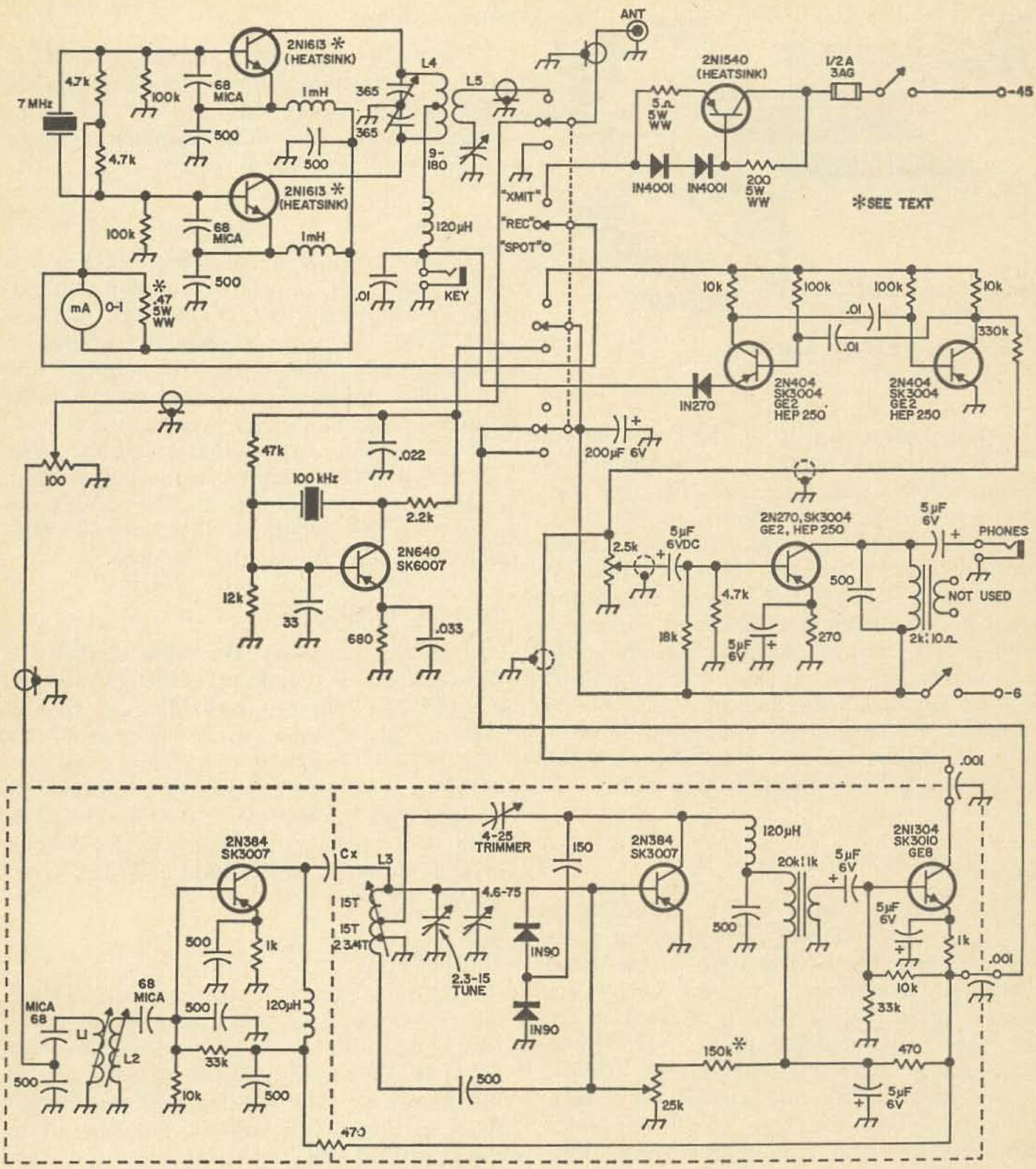


Fig. 1.

Receiver

The first three stages of the receiver are built on perforated vector board with ¼-inch pitch holes mounted inside a small LMB "Jiffy Box". An aluminum barrier is mounted on the vector board on both sides to shield the *rf* stage from the Detector stage.

RF Stage

The antenna in receive position comes through the "receive-transmit-spot" function switch to R-10 which is the *rf* gain control.

*L*1, *L*2 30 *turns* #32 *enameled wire close wound on* ¼" *slug tuned form. J. W. Miller* 46*A*000*CPC or CTC* 2206-2-3

*L*3 32¾ *turns* #32 *enameled wire close wound on* ¼" *slug tuned form. (same form as above)*

*L*4 11 *turns* 1" *diameter* 16 *TPI. AirDux or B & W.*

*L*5 4 *turns hookup wire wound around the center of L*4.

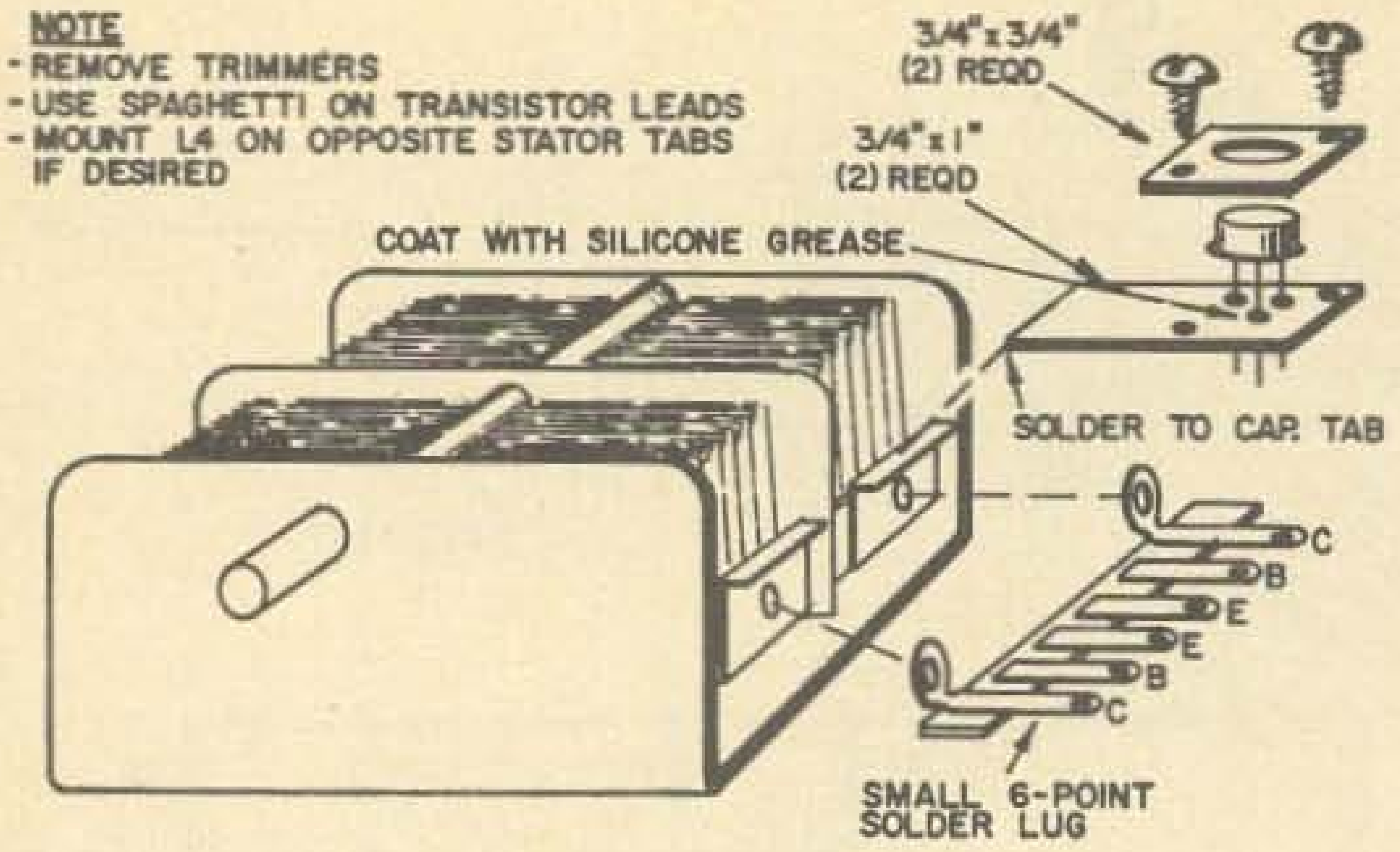


Fig. 2. Details of the heat sink.

L-1 and L-2 terminals fit the hole pattern of the board and result in a coil spacing of ½-inch which seems adequate. The two resonant circuits form an elementary bandpass filter that does not require tuning to cover the 200 kHz of the CW portion of the 40 meter band. The *rf* amplifier is straightforward and no attempt is made to adjust the gain of this stage because changing the parameters of the transistor would result in some pulling of the detector. Cx is a 1 pF capacitor but a gimmick consisting of several twists of hookup wire would be even better in that it would be adjustable.

Detector

The detector tuned circuit, consisting of L-3, C-8 and C-9, will give a tuning range just covering the CW portion of the band. The dial assembly is a National Velvet Vernier removed from a BC-375 tuning unit and equipped with a plastic pointer. The Reflex regenerative detector functions as follows:

RF signals in the tank circuit are coupled through C-7 to the base of the transistor. Resistors R-4 and R-11 provide an adjustable bias network for the transistor and functions as the panel regeneration control. The *rf* signal is amplified by the transistor and is fed to the voltage doubling detector C-11, D-2 and D-1, C-7 and reflexed back into the same base as an audio signal. RFC-2, C-12 isolates the rf signal and couples the amplified audio signal through T-1 to the following stage. Resistor R-4 may have to be altered to give a proper range of adjustment to the regeneration control and an operating point whereby the bias adjustment versus feedback settings of C-10 will be found that is optimum for any particular transistor used.

Audio Stages

The audio stages are straightforward and if the prospective builder does not require high output levels, the headset could be coupled to the first audio amplifier in place of the Volume control, R-12.

Monitor

A keying monitor, consisting of Q 5 and Q 6 connected as a free running multivibrator, is incorporated. Values of C-29, 30 and R-30, 31 were chosen to produce a pleasing note. The output is coupled into the audio amplifier and R-33 attenuates the signal to a value closely matching the received signal under normal conditions. The emitter of Q-5 is coupled to the key through isolating diode D-3 which is required because of the relatively high voltage employed in the transmitter section.

Spotting Oscillator

A single transistor calibration oscillator is provided and it's output is sufficiently low to prevent blocking or overloading of the receiver. The calibrator uses the transmitting crystals. For simplicity, no means were provided to switch the crystal from transmitting to spotting, consequently it is necessary to plug the crystal into either the transmitter crystal socket or the calibrator socket as required.

Transmitter

The transmitter is a push-pull crystal oscillator operating at approximately 8 to 10 watts input. It operates quite reliably with all forms of surplus crystals of the pressure holder variety. The small plated crystals will work in this circuit and are not harmed by the drive but will give a "yoop" to the dash-note due to crystal heating. The transmitter transistors, Q-8, Q-9, are forward biased by resistors R-20, R-21, R-22, and R-23 to approximately 50 to 60 mA with the crystal removed. If operating properly, the transistors will not break into oscillation with any setting of the transmitter tuning control. When a crystal is inserted into the socket, the current will rise sharply. A nice dip should occur at resonance much like that observed in vacuum circuits. The transmitter is link coupled to the antenna and a tuner is recommended for harmonic suppression whenever the transmitter is used into anything other than a loaded whip. The small milliameter is a surplus unit and in conjunction with R-24 gives a full scale reading of approximately 250 mA. The transmitter is usually loaded to 200 to 230 mA, and at this input the transistors do not get appreciably warm during normal transmissions although under continuous key down conditions, it will get quite warm.

Practically the whole transmitter can be built onto a two gang broadcast tuning capacitor of the TRF variety with the transistor heat sink tabs soldered onto the stators. The effectiveness of the stator as a heat sink will become immediately apparent when trying to make this solder joint. In short, use a large iron. The attached sketch shows the mounting of the transistors and the terminal strip on which most of the transmitter components can be mounted. Almost any NPN silicon planar transistor having a 25° C. case rating of 2 watts or more may be used.

Current Limiter

A current limiter is provided for the protection of the transmitter transistors. It is characterized by low internal voltage drop as current increases until at the "knee" or transition point, the internal voltage drop rises to prevent further increase of current. As designed, this "knee" occurs at around 250 mA and when the load is short circuited, will pass only slightly more than 300 mA. A device such as this is absolutely necessary when operating transistors in an overloaded condition where secondary breakdown is likely to occur. The limiter action is instantaneous and prevents the breakdown from being catastrophic. The limiter operation is as follows: R 35 heavily forward biases the limiter transistor which passes current through R 34 to the load. When the voltage across R 34 approaches 1.2 volts which is equal to drop across diodes D 4 and D 5, the internal resistance of the limiter rises to prevent a further increase in current. The sharpness of this transition is a function of transistor gain. The limiter transistor is heat sinked to the chassis although it generates no heat during normal operation. Should a short or breakdown occur in the transmitter, however, the dissipation would be quite high. A fuse has been included although it has never been replaced.

Conclusion

The unit as described has been used for about 4 years now and has bounced around in the back of a VW camper for a good number of miles. Typical operation during daylight results in solid contacts at distances up to 600 miles using a whip antenna. The entire unit is constructed in an LMB W-1B chassis/cabinet combination, and the construction was accomplished without any crowding whatsoever. There does not seem to be much point in miniaturizing beyond a certain point, since operating convenience dictates reasonable size knobs, dials, etc., even though the electronic portions could be duplicated in a much smaller volume.

As an afterthought the prospective builder may want to investigate the use of the new plastic power transistors with tab mounted collectors. These include the GE 2N4057, TI TIP-14, or Motorola MJE340. The increased dissipation rating of these power units plus the fact that some are rated to 200 volts suggests that several times the power could be run by simply rectifying the 115 V mains. Including this simple 130-140 Vdc power supply within the case would result in a really small rig for its power. The prospective builder had better incorporate a 60 mA pilot lamp in the crystal lead for protection however, as was the practice in the day of the old Tri-tet oscillator.

. . . WA6JND

Double Conversion of the BC-348-M

T. V. George VU2TV
3205 Sector 27D
Chandigarh, India

Hams in most of the world are lucky enough to be able to select their receiver from a vast variety of factory-made equipment, but in places like India, where there are relatively few amateurs, it is difficult to obtain even surplus communications equipment. As a result, you aren't apt to find many Indian hams with modern equipment. The only choice left is to make the most of the surplus equipment that is available.

Most of the surplus receivers available to us were quite suitable for operation during the 40's, but with modern operating techniques and the number of stations on the air, they are not suitable for present day operation. In this article I will present a few ideas on how to make the old BC 348 a moderate receiver for present day use.

It is converted into a double-conversion receiver with selectable upper and lower sideband. The second *if* of 85 kHz (obtained from an old BC-453) maintains good selectivity for normal operation. The front panel controls include main tuning, band switch, *rf*, *if* and audio gain controls, upper or lower sideband selection, antenna trimmer, BFO, calibration check, ANL, AVC on/off-fast/slow, AM or CW/SSB, tone and transmit/receiver.

Circuit

The ECC189 in the first *rf* amplifier is connected in the cascode configuration to utilize its low noise and high gain properties. The second *rf* amplifier is a 6BA6 with an *rf* gain control in the cathode circuit. Delayed AVC is applied to the grids of these tubes rather than through the *rf* coils as in the original circuitry of the BC 348. The first mixer and local oscillator are the same as originally designed, but the mixer was rewired on a new *rf* module along with the *rf* amplifiers. The regulated voltage to the oscillator is from the original neon bulb regulator.

A 6BA6 is used in the first 915 kHz *if* stage. The cathode bias is varied along with the first 85 kHz *if* amplifier with the *if* gain control. A 6BA6 in the second mixer converts the 915 kHz signal down to 85 kHz. The BC 453 *if* transformers are peaked at 85 kHz for maximum selectivity. These transformers are lightly loaded by tapping down on the winding, thereby maintaining the high Q necessary for good selectivity. A 12AT7 twin triode serves as two crystal oscillators—one at 1000 kHz. the other at 830 kHz. Upper and lower sideband selection is obtained by switching the proper oscillator into the mixer circuit.

Two 6BA6 85 kHz *if* stages provide the necessary amplification. Also gain can be realized from these stages, their primary function is to provide good selectivity. Their gain is controlled by varying the cathode biase with the *if* gain control.

The product detector in this dual conversion BC 348 consists of a heptode converter with a variable Hartley oscillator for the VFO. The incoming 85 kHz signal is applied to one grid and the local Hartley oscillator to the other—the product of the two signals is obtained across the plate load. If both signals are at nominal zero beat with each other, the oscillator signal replaces the missing carrier in a SSB signal. If the oscillation is off by 1 kHz, the result is a 1000 Hz audible note for CW reception.

In the AM mode a 6AL5 series rectifier demodulates the incoming AM signal. The detected AM signal is connected to either the series noise limiter, another 6AL5, or directly to the audio amplifier through the mode switch. The series noise limiter derives automatic bias from the incoming signal. The clipping level is controlled by the average carrier level. This type of limiter is only effective for AM signals and optimum operation is obtained at 30 to 40% modulation. It maintains best signal-to-noise ratio regardless of signal strength.

A 6AL5 provides shunt-type delayed AVC. The 6AL5 cathode is maintained at a fixed level by a voltage divider; this voltage allows

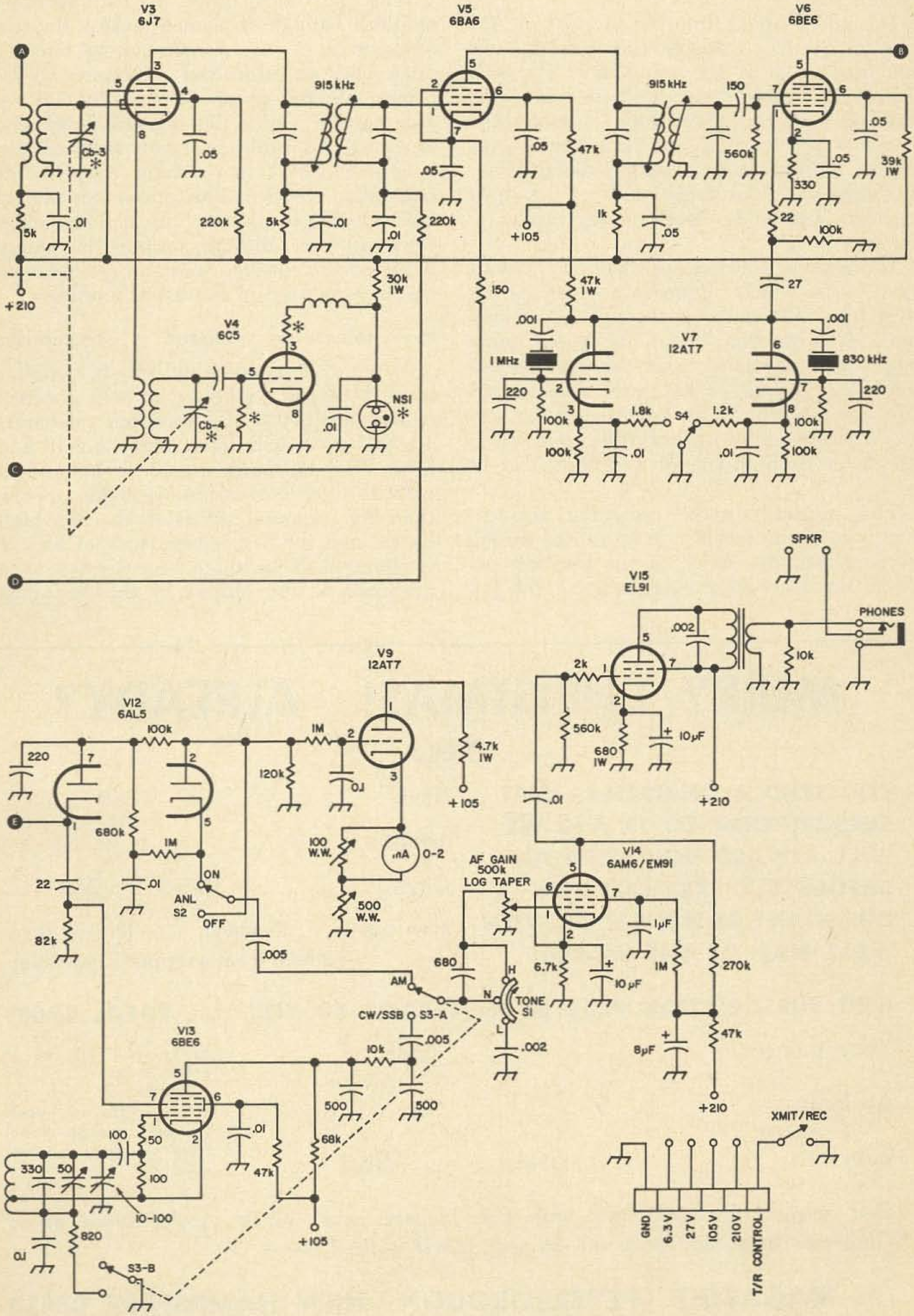


Fig. 1. The complete diagram showing modifications.

the signal to reach a predetermined level before the tube conducts and provides AVC voltage.

The audio signal from the product or AM detector is fed through the tone control switch to an EF91 audio amplifier. The tone control has three fixed position—high, normal and low. The EL91 audio output stage is a low power tube with low heater current to reduce the heat within the receiver. In communications work with a high-gain receiver, high audio level is very rarely required.

The S meter function uses half of a 12AT7 twin triode which obtains a varying carrier level from AM detector through an rc network. This section has a regulated plate supply and the meter is in the cathode circuit. The varying carrier level changes the tube current which can be read on the meter. With the aid of resistors VR-5 and VR-6, the meter calibration and sensitivity can be set.

The transmit/receive switching arrangement allows the receiver to be muted during transmit periods. When in the transmit position, the relay RL1 energizes and the following changes take place. 1. The antenna is grounded to avoid any high potential appearing at the *rf* grid. 2. The second *rf* amplifier cathode is poened making the stage inoperative. 3. The *if* gain control circuit is open and an additional resistance (VR-4) comes into the circuit. This additional variable resistor varies the sidetone level available while transmitting. In my receiver, there is also a 100 kHz oscillator to make dial calibration checks. The power for the circuit was obtained from the cathode output stage. In the calibrate position the antenna input is disconnected and the oscillator output is connected to the 1st *rf* amplifier.

How selectable sideband is accomplished

When a signal of 10,000 kHz is modulated by 1 kHz audio, the signal will consist of carrier at 10,000 kHz, an upper sideband at 10,0001 kHz, and lower sideband at 9,999 kHz. The incoming signal is heterodyned with the 1st conversion oscillator at lower than the incoming signal on the two higher bands, and the first *if* frequency of 915 kHz is obtained. Now, three new frequencies are available at the output of the first mixer.

The carrier at 915 kHz, the upper sideband at 916 kHz, and lower sideband at 914 kHz. These signals are heterodyned with the second conversion oscillator in the second mixer stage. The second conversion oscillator is crystal controlled at 1000 kHz and 830 kHz. The selection of one of them is done by switch S-4. As the second *if* is tuned to 86 kHz, the 830 kHz oscillator would give upper sideband (916 kHz of first *if*) and the 1000 kHz oscillator would give lower sideband (914 kHz of the first *if*). In the frequency conversion process the carrier still remains at 85 kHz. It should be remembered that the above conversion holds good only for band 5 and 6, where the first conversion oscillator is lower than the incoming signal. The operation of USB and LSB switching will be just the reverse in the case of the lower bands 1 to 4. Here the first conversion oscillator is higher than the incoming signal. An effective selecting of the sidebands can be established by reducing the bandwidth of the 2nd *if* frequency. This can be accomplished by making use of tapped points in the 85 kHz *if* transformers and by pulling up the secondary coil for loose coupling.

The circuit diagram does not include the power supply for the receiver. A suitable power supply unit can be built externally and connected to the receiver as shown.

Construction

The construction of the complete receiver is divided into three modules, each being externally wired and interconnected after they are placed in the original chassis. The wiring of the original receiver was completely removed except for the avc packs on which only the avc feed was changed. For ease in wiring, the original chassis frame between the inverter unit and the *if* assembly was cut away. The first module consists of *rf* amplifiers and the first mixer. This stage of wiring is easy as there are only a few components. After wiring, this module can be put in its original place. Access to the tube base connection is possible through the front panel opening. The second module consists of the detectors, *af* ampliers, and first *if* (915 kHz) amplifier. The third module contains the second mixer, 86 kHz *if* and the S meter tube. Most of the components of this module are placed on circuit boards and mounted close to the respective tubes.

Many of the components of modules 2 and 3 are circuit-boarded and the arrangement of components does require some constructional experience. The frame between the coil pack and modules 2 and 3 will accommodate all the supply distribution among the modules. To insure better chassis continuity, a metal braid interconnects the modules. The top view of the receiver does not show the 830 kHz crystal as the photo was taken prior to the wiring of the crystal. The output transformer takes the original place in the BC-348.

After construction, the alignment procedure is normal. Care should be taken while aligning the 2nd *if* stage that it is exactly peaked for 86 kHz, as this would determine sideband selection.

I am sure this unit would equal most of the moderately priced receivers on the market. Of course, for many of our ham friends who can buy one for cash, it may sound a waste of time to build his own receiver, but this is not the case in India where almost everything in the shack must be home-brew.

. . . VU2TV

The Gentrac

P. A. Lovelock
235 *Montana Ave.*
Santa Monica, Calif. 90403

Ever been frustrated by a pyramid of test gear and that inevitable octopus of tangled leads and power cords, while trying to align or trouble shoot your receiver. Or perhaps, like me, the minimal closet space of modern apartment dwelling has prevented you from harboring much in the way of test equipment. In either event, you can use a Gentrac.

Originally conceived as a 'do-all' test set for receiver work, the Gentrac also possesses useful capabilities for transmitter and audio circuit testing in a single, transistorized package which can be used anywhere.

The Gentrac incorporates two individual units from which its name is derived:

1) A multi-purpose generator, furnishing the most needed signals for communications work
2) An *rf/af* signal tracer and output meter.

Only two test leads are required; one for generator output and the other for tracer input, eliminating the usual cats cradle that confounds the more conventional set-up.

Here is what the Gentrac has to offer:

Generator Specifications.

100 kHz and 1MHz calibrated markers up to 200 MHz Crystal controlled oscillator output in the range of 100 kHz to 30 MHz on fundamentals; up to 200 MHz on harmonics.

Audio sine and square waves over the voice frequency range of 250 to 2,500 Hz.

Broadband "white" noise.

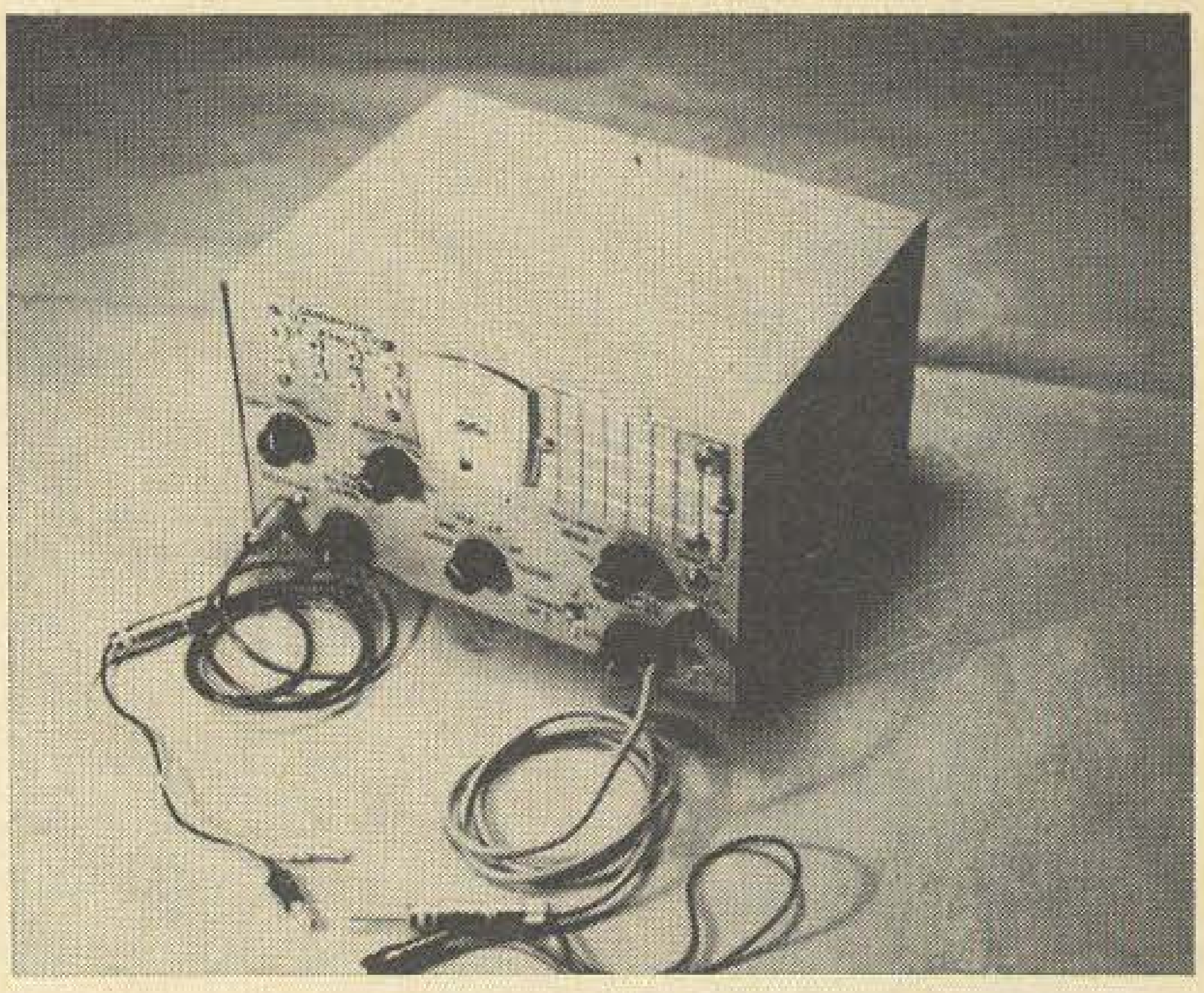
Modulation of *rf* output by 250 to 2,500 Hz sine wave, or unmodulated.

Generator output low impedance, and continuously variable over a 60 db range for all signals.

Tracer Specifications.

Input impedance: selectable 1 megohm or 10 kohm.

Input Sensitivity (gain): selectable 150 μV or 3 mV.



AF input: Direct. *rf* input; with external probe.

Output: Selectable to internal speaker and/or VU meter

Circuit Description—Generator.

A schematic of the generator is shown in **Fig. 1.** For convenience the circuit has been divided into six basic sections by dotted lines, and labeled G1, G2, G3, G4, G5 and GO, being the individual Oscillator and output circuits as follows:

(G1 *Marker Generator.*—Q1 is a dual controlled oscillator, selectable for 100 kHz and 1 MHz output. Capacitors C2 and C3 permit accurate frequency adjustment. Q2 is a hormonic amplifier for the 100 kHz output only, providing markers well up into the VHF range.

(G2) *H.F. Generator.*—Q3 and Q4 comprise an untuned crystal oscillator functioning over the range of 3 to 30 MHz.

(G3) *L.F. Generator.*—Q5 is an untuned crystal oscillator functioning over the range of 100 kHz to 4 MHz.

(G4) *A.F. Generator.*—Q7 is an RC coupled, phase-shift oscillator, with good quality sine-wave output, continuously variable over the 250 to 2,500 Hz range. This oscillator also drives Q8 and Q9, which comprise a square-wave amplifier, for providing square wave output.

(G5) *Noise Generator.*—Diode D2 is a conventional noise generator, utilizing either a 1N21 or 1N23. The diode current regulator resistor R6a, is a potentiometer section ganged to the output attenuator R6b, Thus, while the output attenuator is not used with the noise generator, the noise

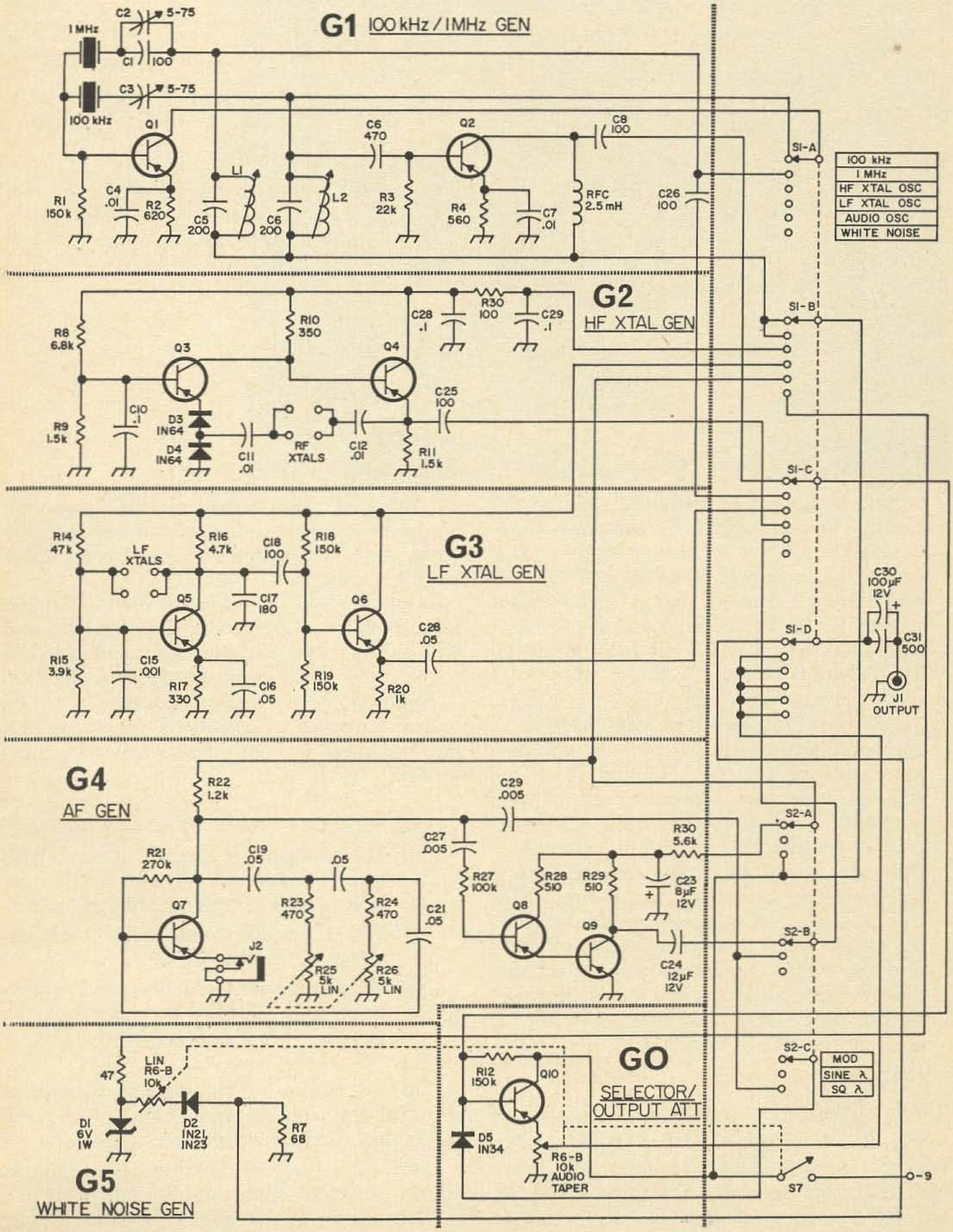
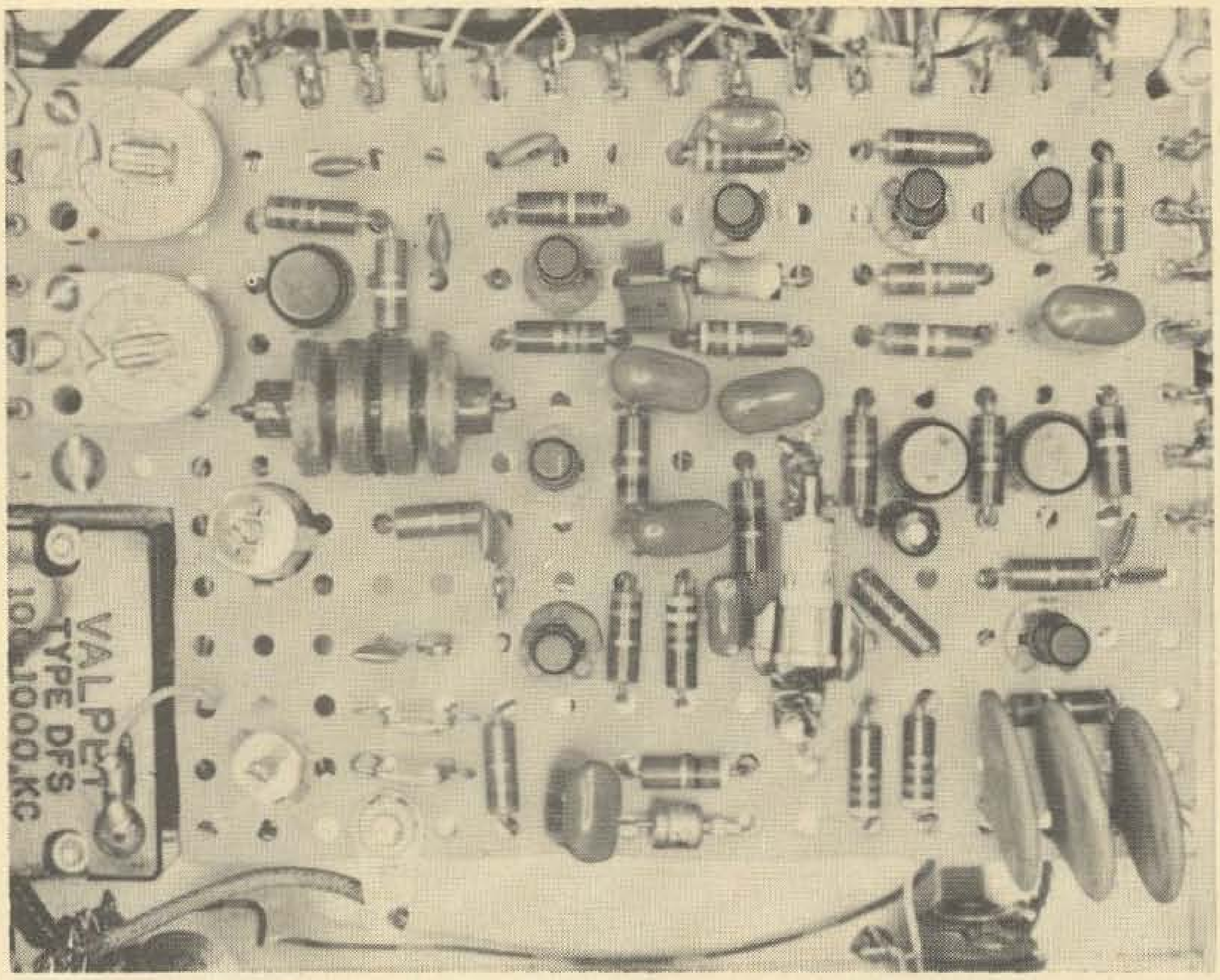


Fig. 1. The schematic of the generator.



Generator section component board layout.

output is adjustable with the same panel control. Voltage supply for the noise diode is stabilized by a 6V Zener diode (D1), so that noise output is unaffected by normal battery variation, and permits control setting to be used as a direct reference when making relative noise measurements. This eleminates the need for the usual diode current meter for reference purposes.

(*GO*) *Output/Attenuator Stage*. Q10 is an emitter follower which is the common output stage for G1, G2, G3 and G4. This stage provides low impedance output with negligible loading on the individual generator circuits. The output attenuator R6b, also functions as the emitter resistor for Q10. The generator mode switch, S1a, b, c and d selects the appropriate generator signal to be fed to the base of Q10, and also switches generator supply voltage. Sine wave modulation of Q10 is provided by the diode-modulator D5, when the *af* mode switch S2, is switched to the "MOD" position.

'Circuit Description—Tracer.

Fig. 2 is a schematic of the tracer section, which is comprised of a commercially available transistor amplifier (Realistic type No. 27-1557 or equivalent), together with the associated patching and switching functions. In addition an outboard emitter follower stage is incorporated to allow for selectable high impedance input, as well as the normal 10 k input impedance of the amplifier. Switchable speaker and VU meter provide aural and visual monitoring of the tracer amplifier output.

Input #1 (J3) is normally used for tracer input operation, and is switched for high and low gain by S5, and for high and low impedance by S4, both on the front panel.

Input #2 (J4) provides direct coupling to the transistor push-pull output stage, and may be used for one of the following purposes:

(a) Substitute output stage and speaker.

(b) Direct input to the VU meter (with tracer amplifier switched off) for measurement of high level signals.

(c) Tracer amplifier output for high impedance phones.

(d) Output for oscilliscope to observe low-level *rf* or *af* signal picked up by the tracer.

(J5) permits using the internal speaker as a substitute with an external amplifier, and disconnects it from the tracer amplifier.

(J6) is output for low impedance headphones, disconnecting the internal speaker.

Decoupling of the internal battery supply is accomplished by a 27 ohm resistor and 500 mfd capacitor, to prevent interaction between the generator and tracer when used simultaneously.

Construction.

The entire generator circuitry, excluding front panel controls and crystal sockets, is mounted on a 5¼" x 3½" piece of perfboard (0.093" holes). Layout of the components is shown in the photo.

Good grade, mica-filled sockets were used for transistors. Alternatively transistor leads may be permanently soldered to flea clips staked in the perfboard.

The generator board and tracer amplifier are mounted in the 4½"h x 8"w x 6"d aluminum mini-box by means of standoffs. The stand-offs used by the author are assembled from ½" and 1" spacers, normally intended for expandable three-hole binders, and obtainable from any good stationary store. These spacers have 8-32 threaded studs at one end and threaded inserts at the other end, accepting 8-32 screws and nuts for attachment to the boards and box. The spacers may be connected together to assemble the desired length. Two 1" and one ½" make up each of the four spacers to mount the generator board. Four ½" spacers support the tracer amplifier and two 1" spacers attach the input emitter-follower stage to two of the tracer amplifier mountings.

The crystal used in the (G1) Marker Generator is a Bliley dual 100 kHz/1 MHz unit which was available in the authors junk box. In the event difficulty is encountered in obtaining this unit, individual crystals may be mounted in the same board space. All the generator circuits were adjusted to permit common usage of the GE2 and GE9 transistors, since these are commonly available just about anywhere. However other suitable transistors may be substituted and the individual constructor may want to experiment with what is available. Substitutes for the GE2 may be any audio frequency PNP transistor with an hfe of about 70. Substitutes for the GE9 should be high frequency PNP types, preferable good to 100 MHz minimum, with an hfe around 100.

Location of controls is shown in the front panel photo. One each HC6/U and FT243 type crystal sockets are mounted on the front panel for both the HF and LF generator, in order to allow almost any crystal to be plugged in.

The Gentrac is powered by a Burgess type D6, 9V battery, or equivalent type. Smaller

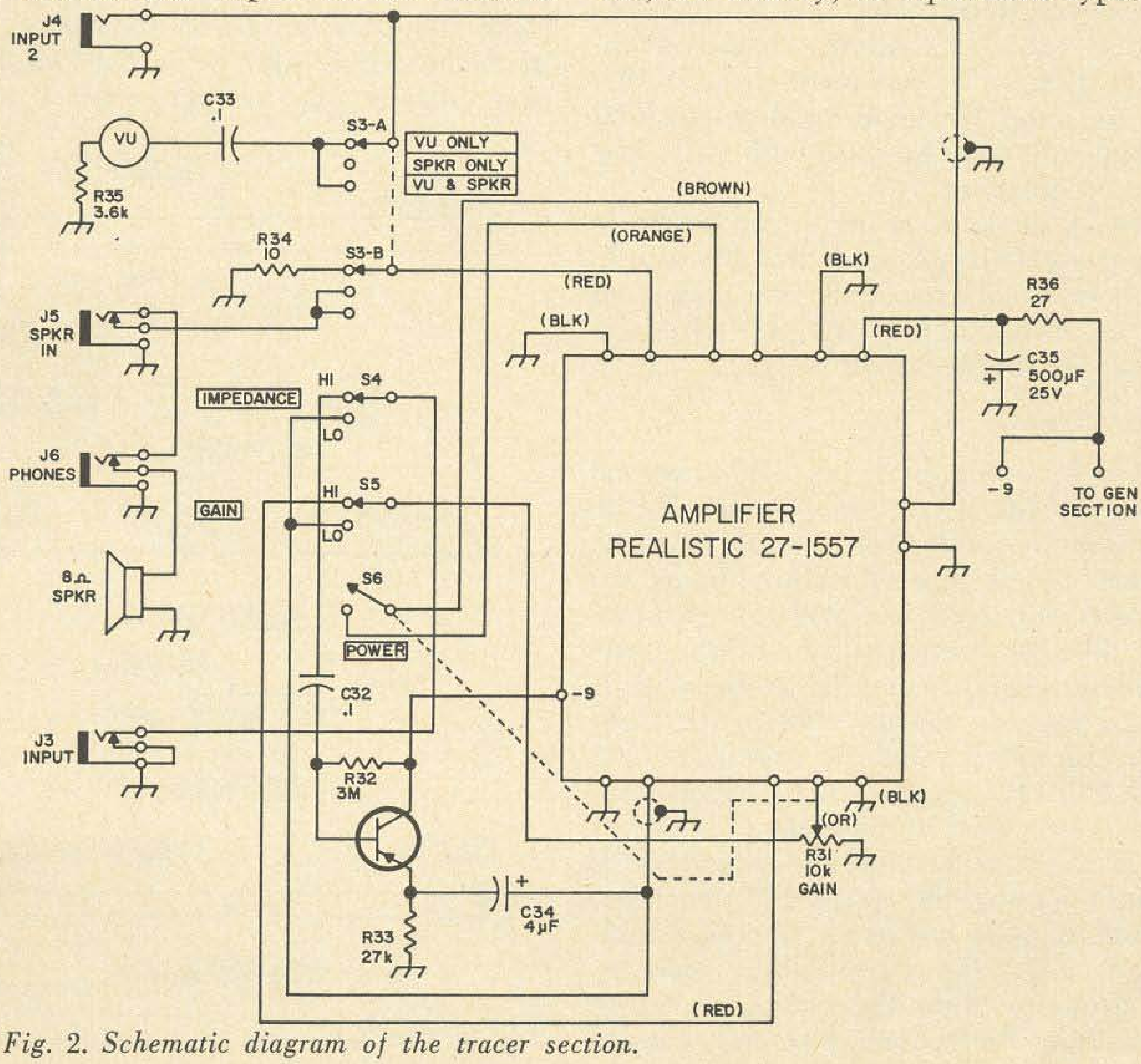
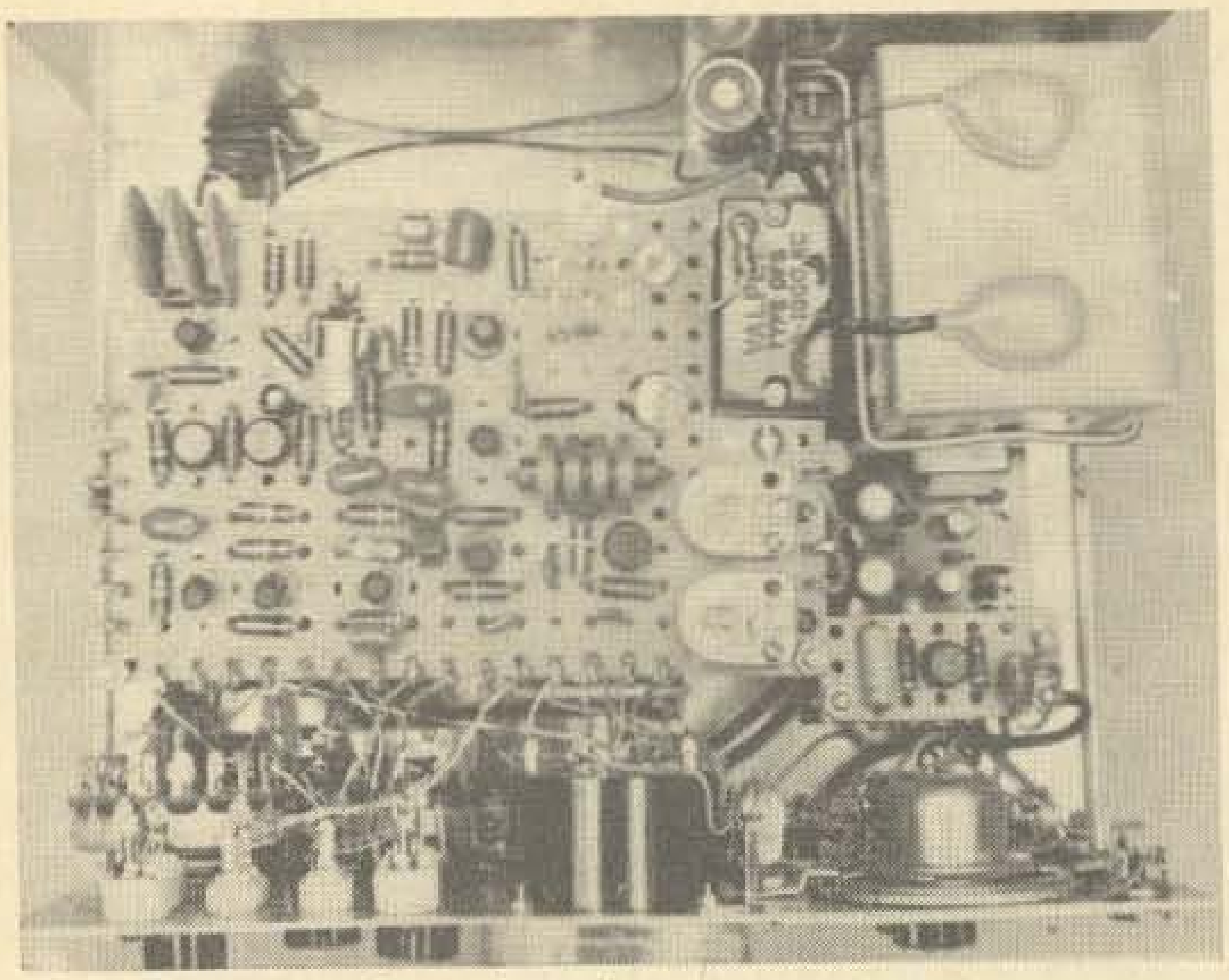


Fig. 2. Schematic diagram of the tracer section.



The Gentrac—Interior view.

9V batteries are not recommended for reliable operation, particularly since the drain of the noise generator is substantial. The battery is secured to the back of the mini-box by a wire-clamp fabricated from a wire clothes hanger. The springiness of this wire holds the battery securely while permitting it to be removed when required.

The two test leads and *rf* test probe are assembled as shown in **Fig. 3.** Any small diameter shielded single conductor cable may be used for the tracer cable. For the generator output cable, miniature coaxial cable (type RG 174/U) is recommended. If this is hard to come by good quality shielded single conductor may be used with some loss at higher frequencies.

The 1N34 diode used in the *rf* probe is of the larger glass type, since this fits snugly in the phono connector, with one glass seal forming an insulator between the wire-lead probe and the connector housing.

Using the Gentrac.

The first question may be, "Why crystal oscillators for the generator". Obviously the Gentrac does not substitute for a precision, wide range signal generator. But just as obviously a crystal oscillator will give a more accurate discrete frequency signal than a low cost, tunable signal generator. A handful of low priced crystals will do a lot in the Gentrac. For example a couple of crystals at 262 kHz and 455 kHz for use in the LF generator, will cover most *if* alignment needs. A 10.7 MHz crystal in the HF generator is handy for aligning the *ifs* of FM receivers. Ham band crystals are good for 'band finding' when calibrating a home-brew receiver, prior to accurate calibration with the marker generator. Specific frequency crystals can be obtained for special purposes, such as the *ifs* of transceivers at 5.0, 6.0 and 9.0 MHz, and will make possible accurate alignment with assurance and repeatability not possible with the average tunable signal generator.

Referring to the front panel photo, use of the controls is fairly apparent. The generator is turned on by advancing the output control from fully counterclockwise. Generator Mode switch selects the desired signal. In the HF and LF modes a crystal is plugged into the appropriate socket. The crystal oscillators require no adjustment or tuning and will work with any active crystal within their range. In the *AF* mode the Audio Freq. control is adjusted to the desired frequency. Accurate calibration of this control was not attempted on the authors unit since approximate frequencies in the audio range (e.g. 400 Hz, 1,000 Hz) are usually adequate.

However a few adjustments are required when first setting up the Gentrac. The Marker Generator requires zero-beating the 100 kHz and 1 MHz outputs against WWV, by adjusting C2 and C3. After this L1 and L2 should be tuned for maximum output. You can use the tracer with the *rf* probe plugged into the generator output and observe the peak on the V.U. meter, but the *af* mode switch must be in the "MOD" position. Adjust the output control and the

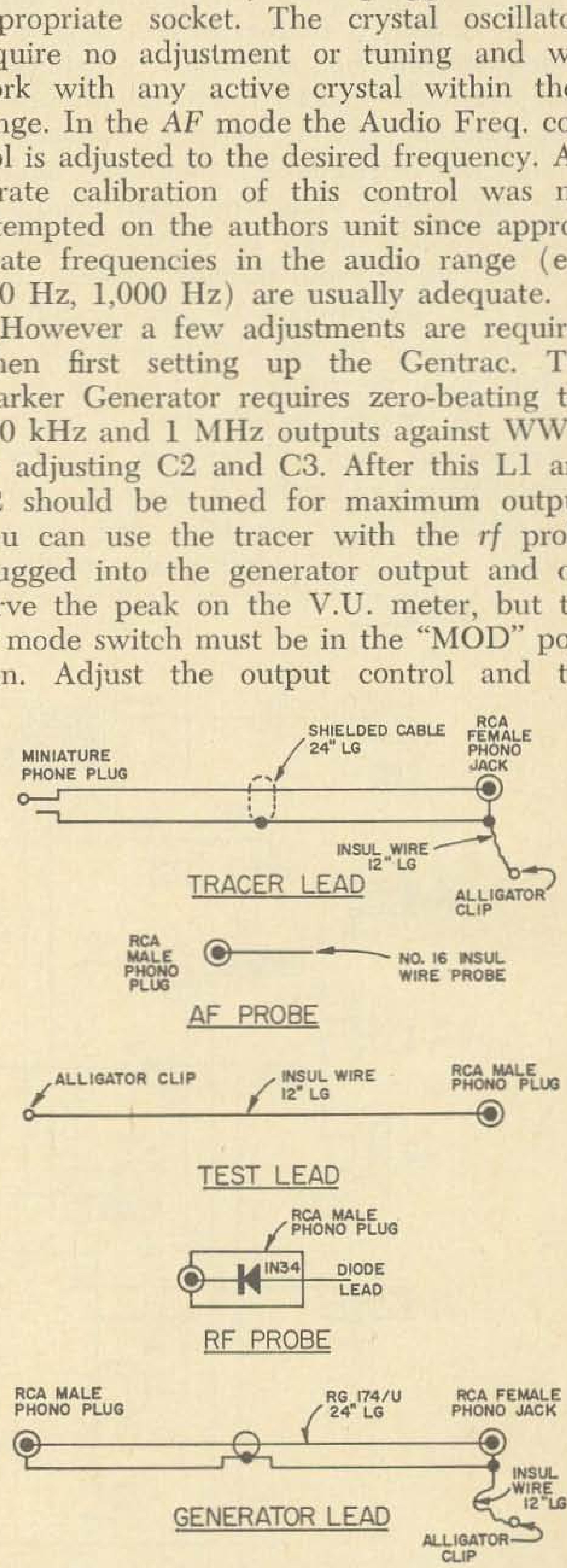
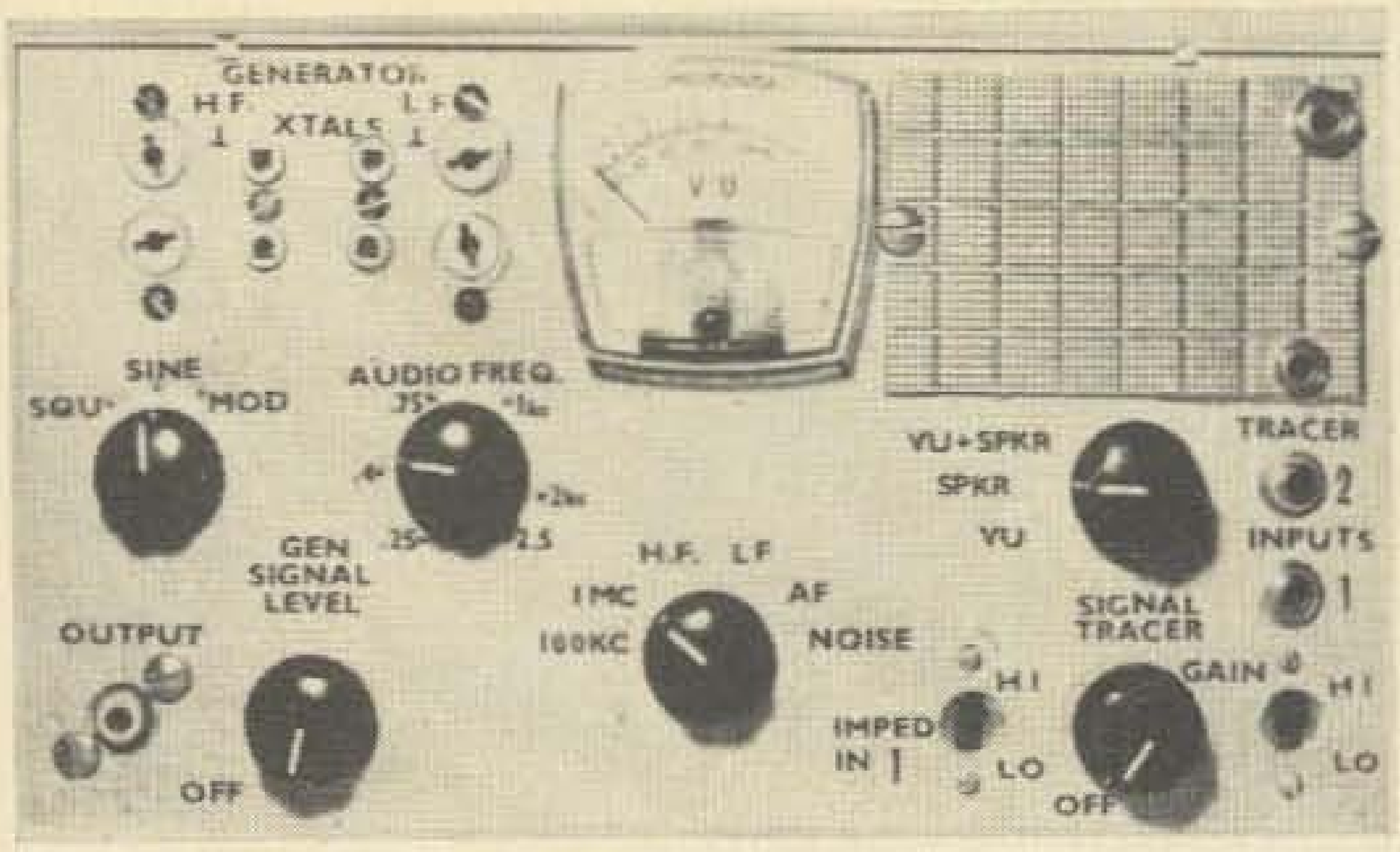


Fig. 3. Test leads and rf test probe construction.



The Gentrac front panel

tracer gain for a suitable reading. The approximate *af* frequency markings for the AUDIO FREQ. control may be spotted by hetrodyning the output against a borrowed audio generator, or a frequency test record on the Hi-Fi system.

A typical application for the Gentrac in aligning a communications receiver is as follows:

1) *if Alignment*—Generator Mode switch to LF and 455 kHz crystal in LF socket. *af* Mode switch to "MOD". AUDIO FREQ. control at .4 (400 Hz). Connect generator output cable to converter stage grid, and tracer input lead to receiver audio output. Tracer input switches to Low Impedance and Low Gain. Tracer output set to VU. Set generator output and tracer input controls for suitable VU reading and peak *if* transformers.

2) *Dial Calibration*—Generator Mode switch to 1 MHz. Generator output to receiver antenna input, and adjusted to suitable level. Adjust receiver trimmers for markers at 1 MHz dial markings.

3) *RF Alignment*. Generator Mode switch to NOISE. Generator output to receiver antenna input. Tracer input to receiver audio output. Generator level control full clockwise. Tracer gain control set for suitable VU meter reading. Peak *rf* and converter stage trimmers for max noise level on VU meter.

Many other uses for the Gentrac will suggest themselves. The tracer is conventionally used for locating signal loss or distortion, using the appropriate probe, when receiver trouble shooting.

With a telephone pickup coil plugged into tracer input #1, you can have a handy telephone amplifier. And for a little code practice, patch the generator output to the tracer input, plug a morse key into J2, and set the Generator Mode switch to *af*. When used as a practice oscillator square wave output may prove less fatiguing than sine wave, and you can adjust the *af* frequency to your own liking. Incidently J2, which keys the *af* oscillator, is mounted on the back of the minibox, and may be excluded if not required.

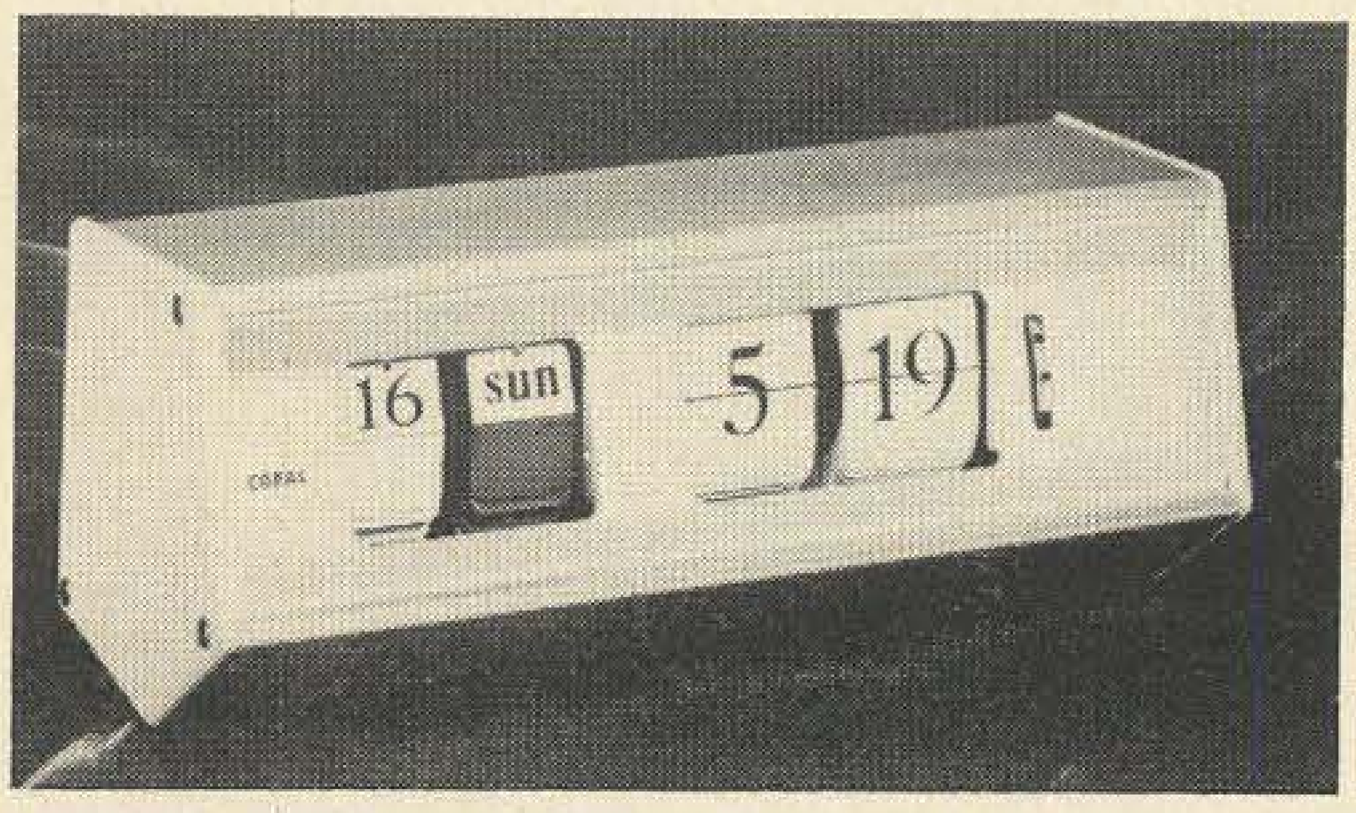
. . . W6AJZ

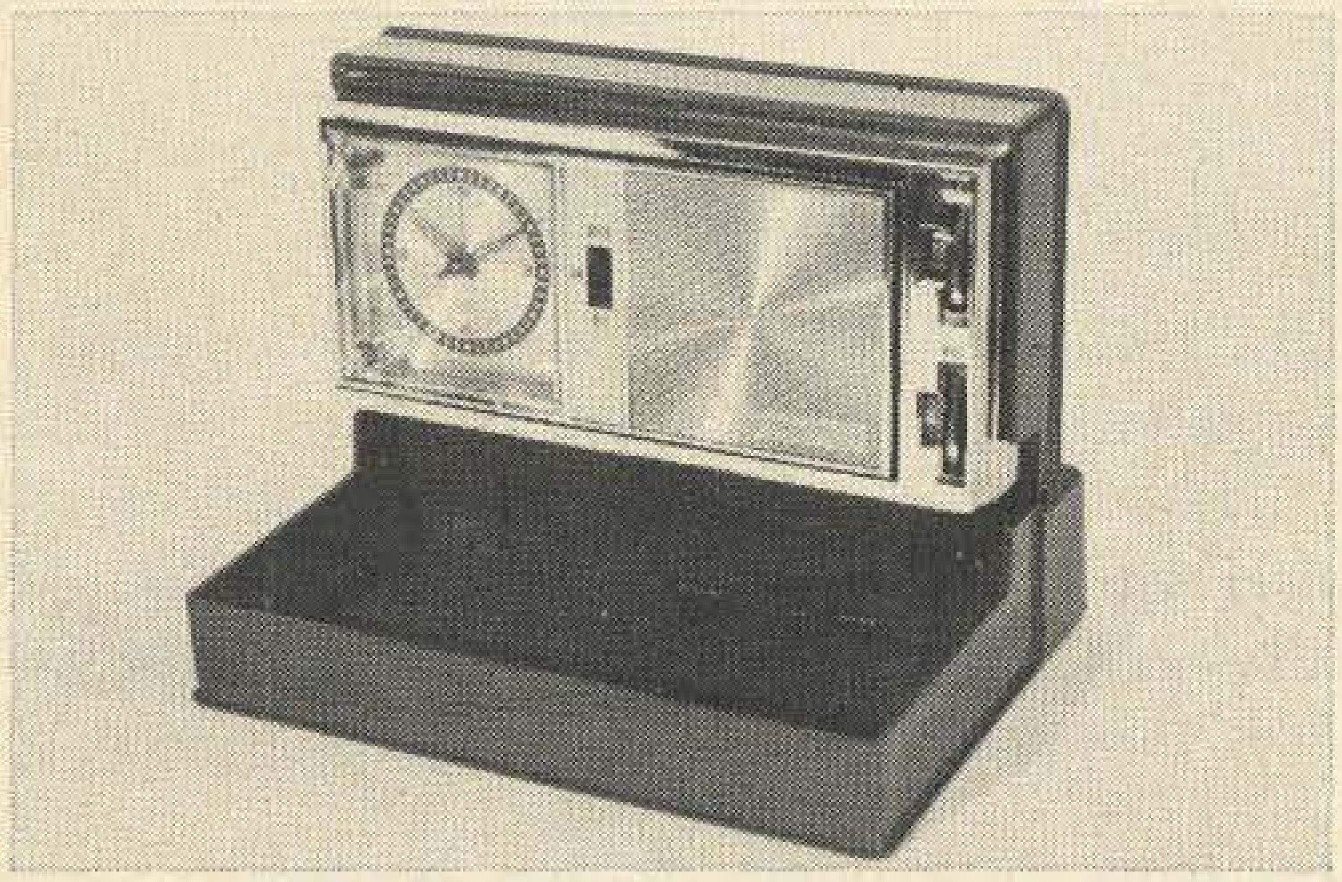
Organizing a Resistor Collection

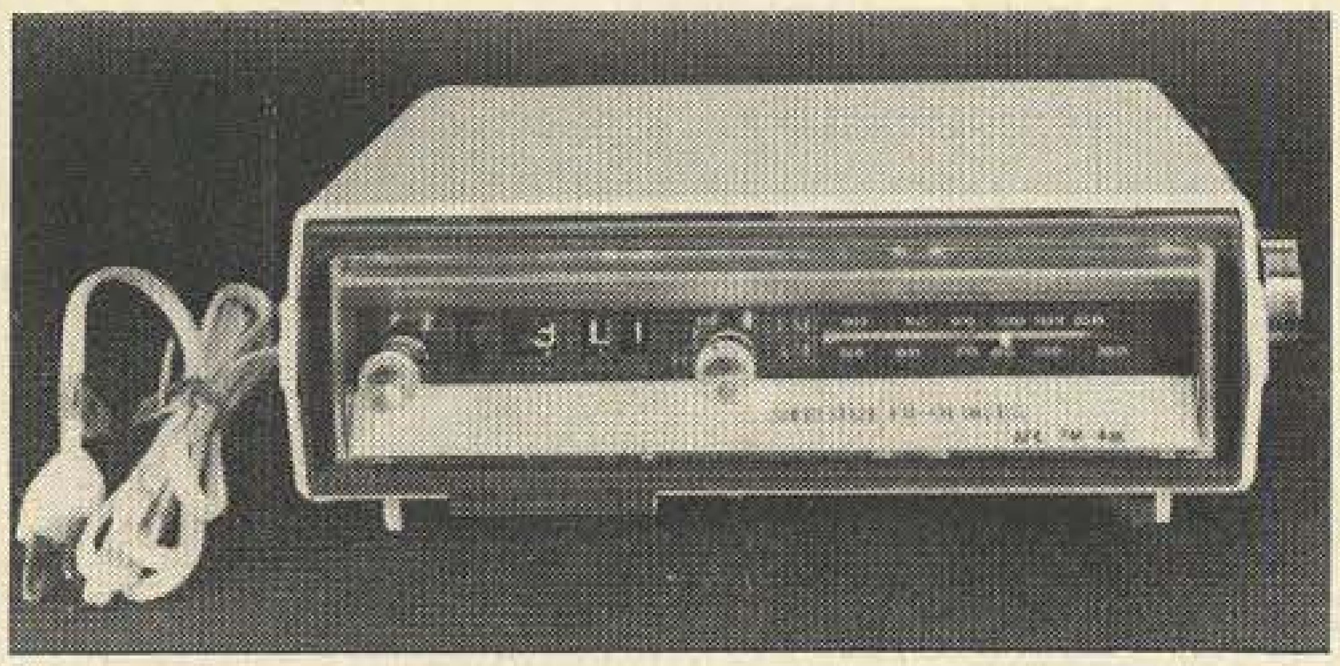
A simple, yet effective way to organize your supply of resistors is found in last years parts catalogs. For years I had all of my resistors thrown in a box, each time I needed a particular value I had to rummage through the entire box to find it. The answer to this problem lies in a small cabinet with twelve drawers. Thumb through last years catalogs to the resistor section. Cut out the table of standard values. I used the IRC 10% table from Allied Radio's catalog. The 5% table would provide a more complete listing, but it may be too large to fit the drawer fronts. You will note that the table is divided into twelve columns, cut these apart and glue or tape them to the fronts of the drawers. This simple system saves 90% of your resistor locating time, looks neater, and helps you keep a balanced supply on hand.

William P. Turner WAØABI

"He's left me before—but this time I think he means it."







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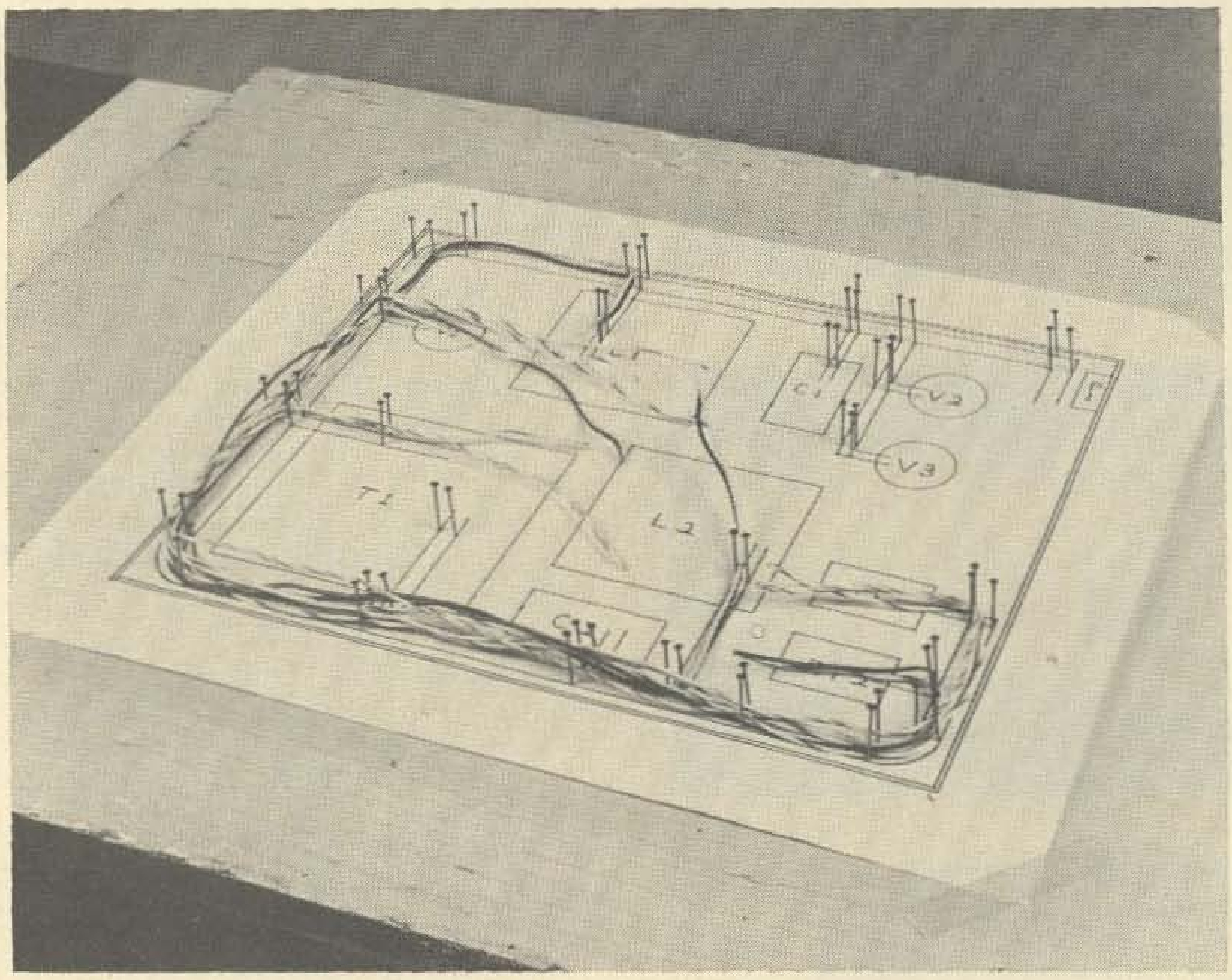


When building any complex piece of electronic equipment, you will usually find that the majority of the wiring consists of power and control wiring of one kind or another. This wiring is usually completely uncritical as to length and placement, so ordinarily not much thought is given to its installation. Any method of wiring may work well electrically, but later on, when it is necessary to trouble-shoot the circuit and make repairs, you may find that you have built-in some unnecessary troubles.

If you wire directly from point to point, always using the shortest possible wire, the wires will cross each other at many odd angles and will very likely pass over other components. This makes access to these components difficult. Also it is hard to find a clear path for the signal wiring when power leads are everywhere.

A much better plan is to run the non-signal wiring around the sides of the chassis, bound together into a neat bundle, with leads breaking-out at right angles near each component. A wiring harness like this is most easily made outside of the chassis. A little time should be spent in preparing a wire chart and a full-size layout of the chassis. This will speed the construction of the cable and make errors unlikely; also, you will have a complete record of where each wire goes in the circuit.

The wire chart and chassis layout

To make a wire chart, rule off five vertical columns on a sheet of paper, and mark them with these headings: Wire No., Size, Color, From, and To. Under Wire No., number the wires consecutively; under Size, put the gauge of the wire; under Color, use the standard color code (a red wire would be 2, a white-blue-green wire 965, etc.); under From and To, put a description of the components or terminals to which the wire is to be connected.

Now draw a full-size layout of the chassis. This need only be a simple outline of the chassis, with the approximate location of all the major parts drawn in. Decide where you want the main body of the cable and the breakouts to the components to run, and sketch them in. Use this layout, together with the schematic, in making the wire chart.

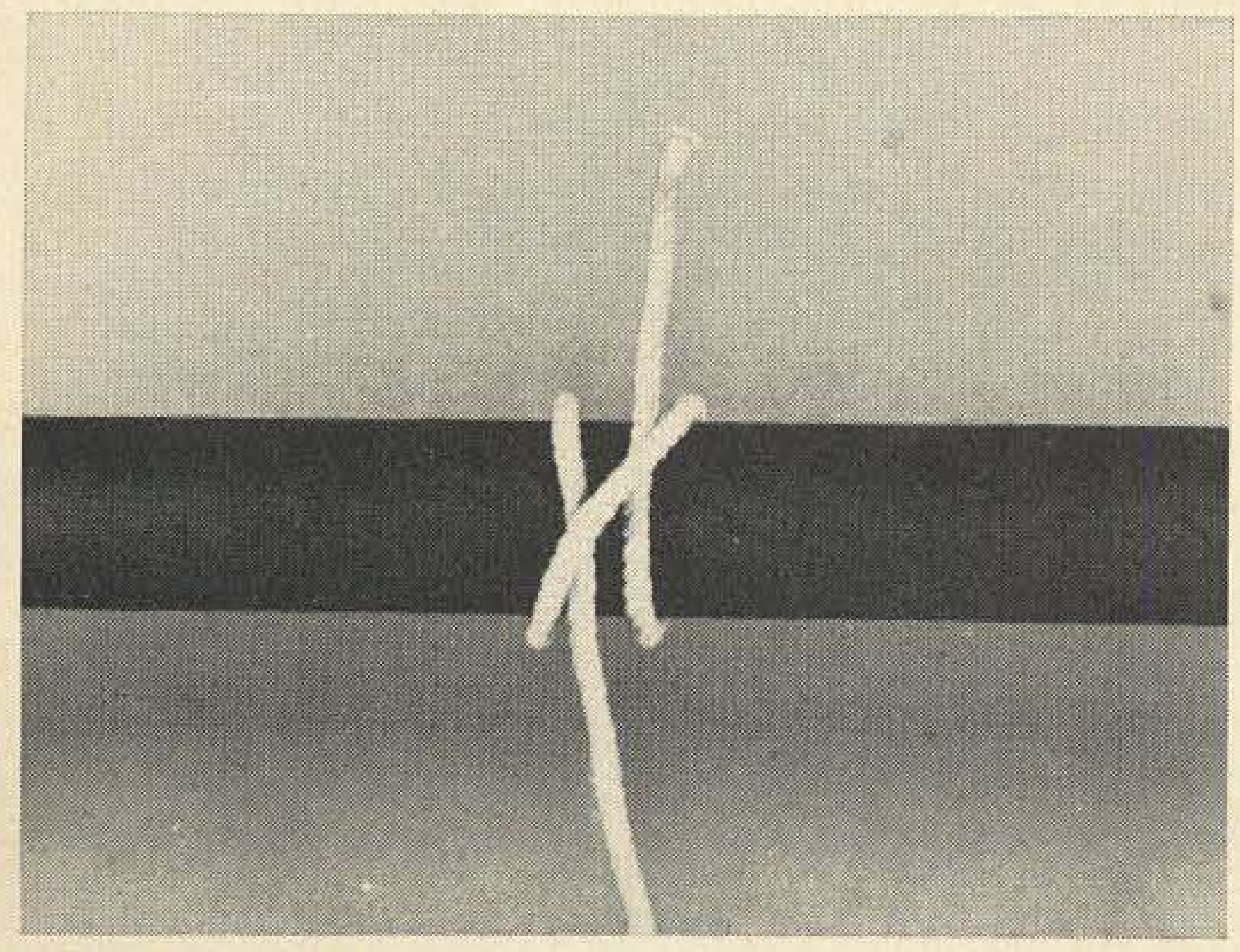
Start from one side of the circuit diagram and begin filling in the wire chart, marking through each wire with a colored pencil as it is put down on the wire chart. For example, say you start with a white, 18-gauge wire from the power switch to the primary of the power transformer. You would put down something like this: Wire No. - 1, Size - 18, Color - 9, From - S1, To - T1, terminal #1. Then mark the schematic to show which part of the wiring is now on the wire chart. A fairly large-size copy of the circuit diagram is helpful.

The chassis layout is useful when several components are connected to the same wire. The order in which the components appear on the schematic may be considerably different from their relative locations on the chassis. Reference to the chassis layout when making the wire chart will prevent excess wiring in the cable, caused by the same wire doubling back on itself to get to a previously-skipped component.

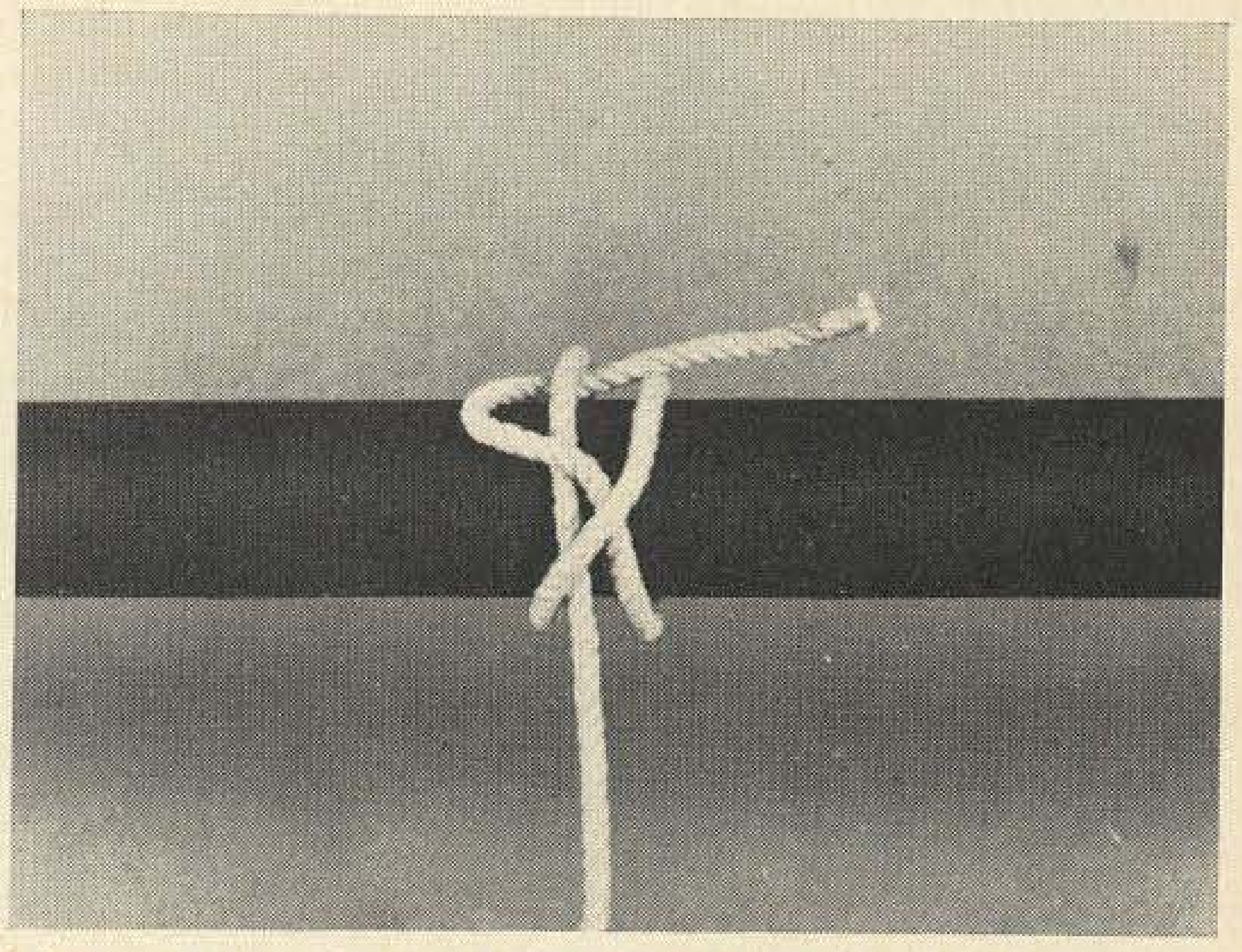
Use wires of as many different colors as possible. Assortments of small quantities of wires in various colors and sizes are available at bargain prices from most of the large mail-order parts distributors. You can use the colors according to some code of your own making, or just use them consecutively, and when you run out of colors start over again.

Making the harness

To make the harness, first tape the full-size chassis layout to a piece of wood. Drive some small nails along each side of the sketched-in cable. Place the nails in pairs



The clove hitch.



An extra tuck is added to the clove hitch to prevent its loosening.

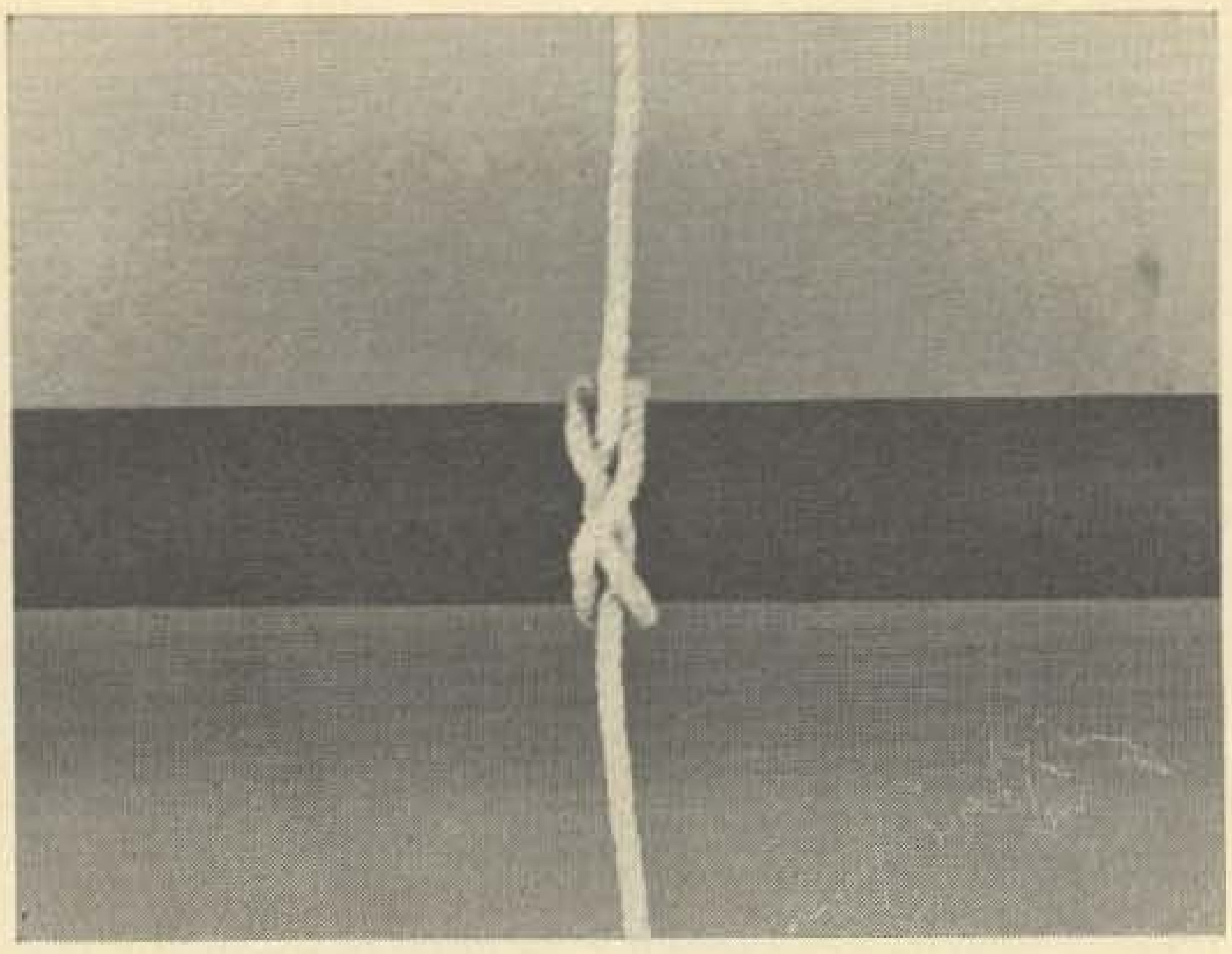
and space them about one-half inch or so, depending on the number of wires in the cable. Refer to the wire chart and begin to lay the wires in place. Put a check mark beside the wire number on the chart as each wire is put in. Be sure to leave sufficient length at the ends of the wire to allow making the connections. The wires may be stripped and tinned at this time, but a neater job will result if you leave this until after the cable is put into the chassis.

Lacing

When all the wires are in place, you can start binding them together. There are a number of different types of wraps, ties, and bindings that can be purchased, but in my opinion the neatest and simplest method for a small project is to tie the cable together with cord. Special lacing cord is available, and the flat nylon braid type will do a very attractive job. Any type of heavy twine will do about as well however. It should be large enough in diameter that it won't cut into the insulation.

The wires may be laced together, or simply tied at intervals. I prefer to tie them, as it is more secure and takes little more time than lacing. Lacing is recommended, however, when long runs of cable are made up. Tie the cable every few inches along the main body, and place a tie on both sides of each breakout.

A good knot for fastening the wires is a modified clove hitch, or ordinary clove hitch with a square knot tied over it to lock it. If maximum security is desired, put a drop of glue on each knot. For the nicest-looking job, the knots should be under the cable,



The completed modified clove hitch.

where they will be out of sight. The easiest way to do this is to first make enough temporary ties to hold the harness together. Then carefully remove it from the jig and turn it over. Finish the ties with the harness upside-down, and the knots will come out on the bottom when the harness is turned rightside-up.

The harness may now be mounted in the chassis. Hold it in place with a few cable clamps. Metal and plastic clamps are available in many different sizes. The plastic types are not as likely to cut into the cable, and will not cause a short circuit even if they do.

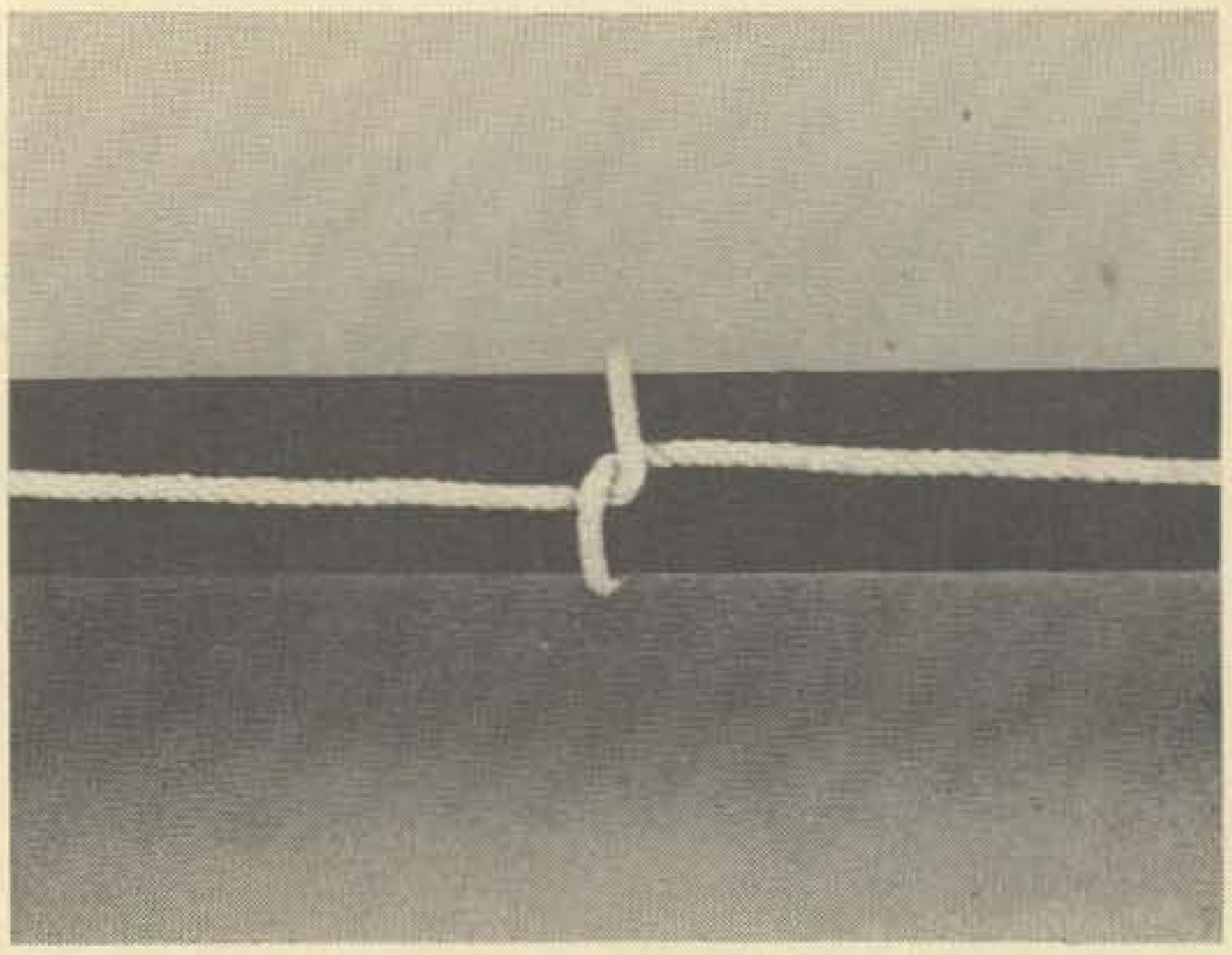
Route the leads to each component and cut them to length. Leave a little extra lead length at the end of each wire. This is called a service loop, and is very helpful if the connection must be taken loose and resoldered when replacing a component. It also keeps the wire from putting any strain on the connection. It is best to run the wire straight, and then make the loop right at the connection.

Tinning and soldering

All stranded wire must be tinned after stripping. This takes only a few seconds, and if it isn't done, the ends of the wires will fray and spread in all directions when the wire is wrapped around a terminal. Heat the wire before applying the solder, so that when the solder is applied it will quickly flow between the strands.

Strip enough of the wire so that when the connection is made, the insulation will be back about 1/16" or so from the connection. This will help to prevent burning the insulation when soldering. Don't put a sharp bend in the wire within ½" of the connection, as the heat of soldering may cause the insulation to pull away from the wire.

The above applies to the use of most plastic or rubber insulated wires. Teflon insulation is not affected by soldering iron heat, and cannot be burned or melted accidentally. Although Teflon-insulated wire is expensive (about 4 or 5 times the price of vinyl insulation), it is very useful when many wires must be soldered in very close quarters. Besides being heat-resistant, the electrical and mechanical properties of Teflon are excellent.



The proper method of lacing.

If you wish to replace a wire in the harness for some reason, you can do so by soldering a new wire to one end, and by pulling the other end the new wire may be drawn into the harness. Make a small lap-type solder joint, and smooth off any rough edges before pulling it through.

The information given here should not be taken as the last word on the subject. However, the use of this outline, together with ideas of your own, should make it possible for you to do a very professional-looking wiring job on your next project.

. . . K5LLI

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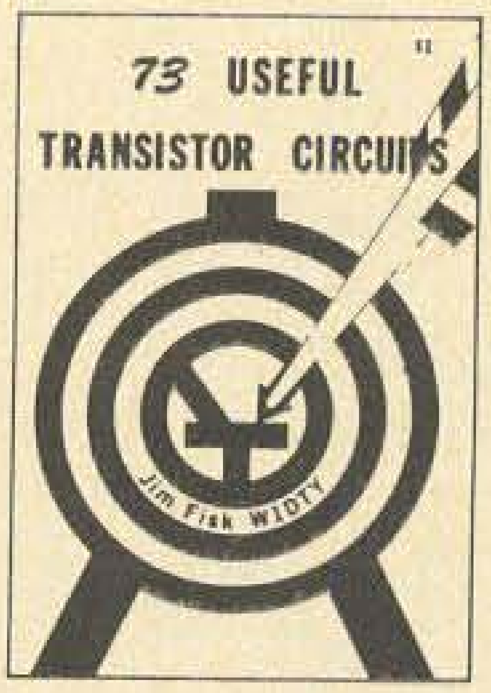

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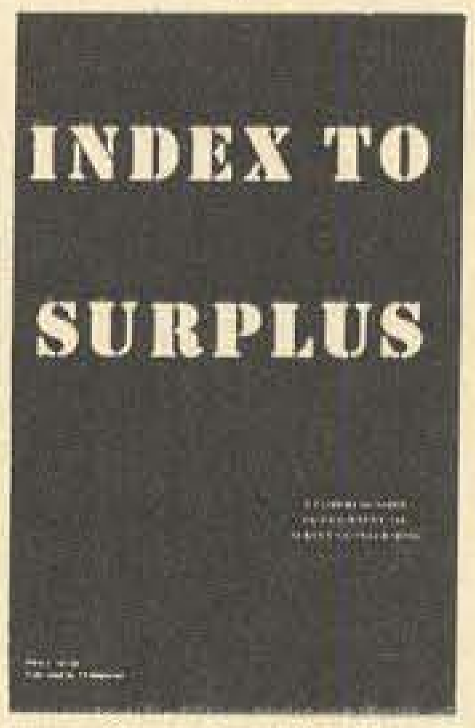

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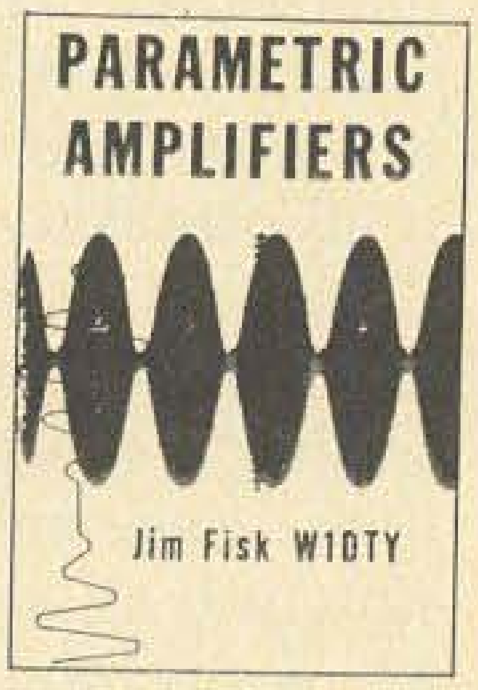

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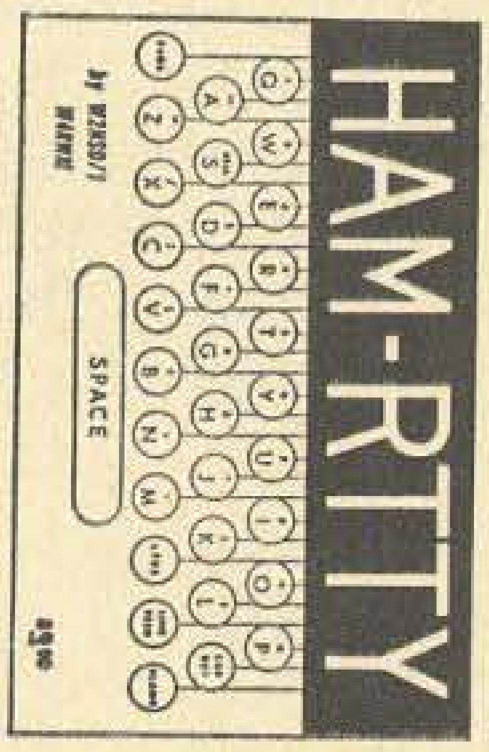

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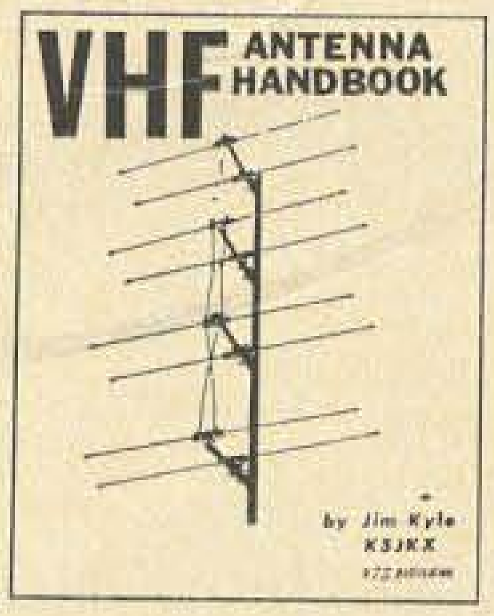

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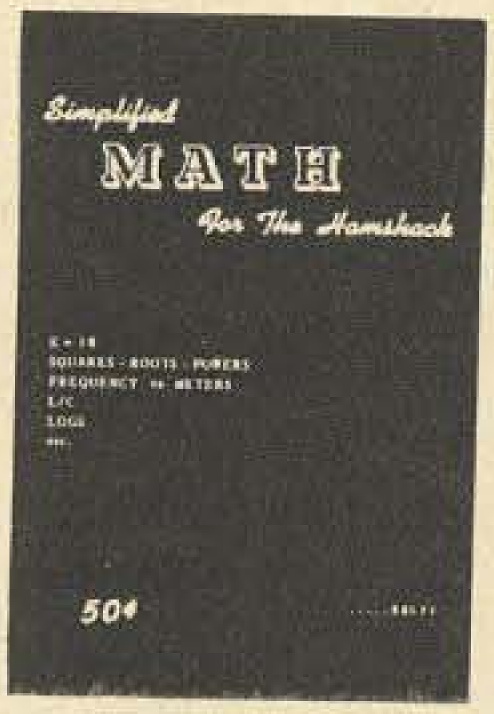

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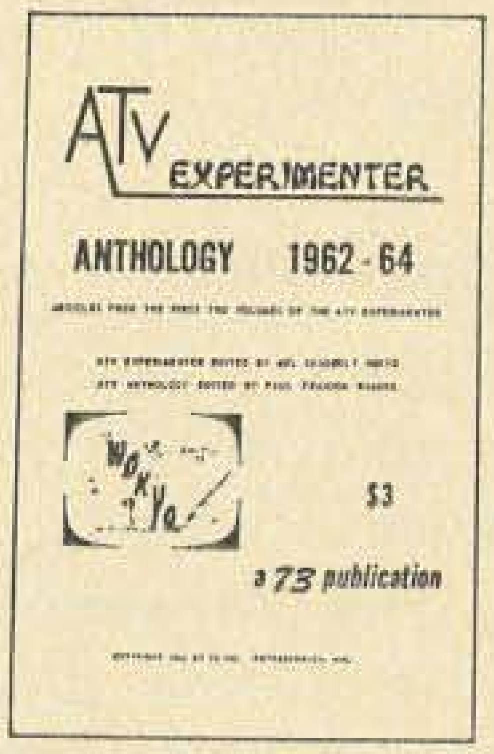

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73 Magazine

Peterborough, N. H. 03458

Copper Wire

Jim Ashe W1EZT
P.O. Box 343
Peterborough, N.H. 03458

Wire is so closely associated with electronics that it comes as a surprise to think there is an electronic component called 'wire.' Yet that is a very good way to think of the stuff that comes on spools, is measured in feet, available almost anywhere, and whose correct application is necessary for building reliable gear.

Looking inside a wire, we usually find copper. Copper is a very important metal, and electronics as we know it could not exist without that easily obtained, malleable, ductile, solderable, copper-colored stuff we call copper.

Copper wire in electronics

Copper is second only to silver in its good current carrying properties, and it is far less expensive. The difference in current conductivity between copper and silver is considerably less than seems to be generally believed, amounting to about 6% at dc. The difference is smaller at *rf*. See **Fig. 1** for relative resistances of some metals often seen in electronic chassis.

Copper has one unwanted property: it tends to work-harden. A piece of soft copper wire, once bent, never returns to its original soft state. It becomes harder and more crystalline, and prone to brittle fracture. Under conditions of vibration, #22 and smaller wire has a tendency to crystallize and finally break. And some insulation, stripping tools will nick a copper conductor, increasing chances of breakage at the nick, which is partly hidden by the insulation.

The tendency to break, noted in solid conductors, is greatly reduced by making the conductor of many fine strands. See **Fig. 2**. Reliability under vibration is greatly improved and the conductor is better able to withstand the stress of unsoldering and resoldering, although less convenient to work with. Flexible power cables are made of stranded copper wire.

Metal	Resistivity Compared to Copper
Silver	0.95
Copper	1
Gold	1.4
Aluminum	1.6
Iron	5.8
Tin	6.7
Solder (63/37)	9.3

Fig. 1. Resistances of several metals compared to copper. For example, if a certain piece of copper wire had a resistance of 1 ohm, a piece of iron wire with the same length and cross-section area would have a resistance of 5.8 ohms.

Some metals will react violently when exposed to air or water. Copper is very well-behaved, and stays clean and shiny for some time upon exposure to air. But it eventually becomes darkened by an oxide coating, after a few months. This can be very important in *rf* applications, and will be explained later. Copper will react quickly with body greases and acids commonly present on the hands, so that a shiny clean surface will take permanent fingerprints. And copper will react slowly with some chemicals to form a greenish nonconducting film or scum. Cleanliness is important when working with copper.

Electronics applications for copper wire fall under two general headings, dc and *rf*. At dc and power frequencies, conduction is distributed through the entire volume of the copper wire. Current flows in the center of

Wire-Size	Stranding
12 AWG	19x25
14	19x27, 41x30
16	19x29, 26x30, 65x34
18	7x26, 16x30, 19x30, 41x34, 65x36
20	7x28, 10x30, 19x32?, 26x34, 31x36
22	7x30, 16x34, 19x34?
24	7x32, 19x36?, 45x40?
26	7x34
28	7x36
30	7x38

Fig. 2. Stranding of some popular wire sizes. The finest stranding is most flexible. This table was built up from an industrial electronics catalog, and several errors were found. The values followed by a question mark may be wrong.

Wire Size	mV/amp-ft. 20 deg. C	mV/amp-ft. 75 deg. C
12 AWG	1.6	1.9
14	2.5	3.1
16	4.0	4.9
18	6.4	7.8
20	10	12
22	16	20
24	26	31
26	41	50
28	65	79
30	103	126

Fig. 3. Wire resistance stated the most convenient way for several popular wire sizes. Resistance rises as the wire becomes warmer.

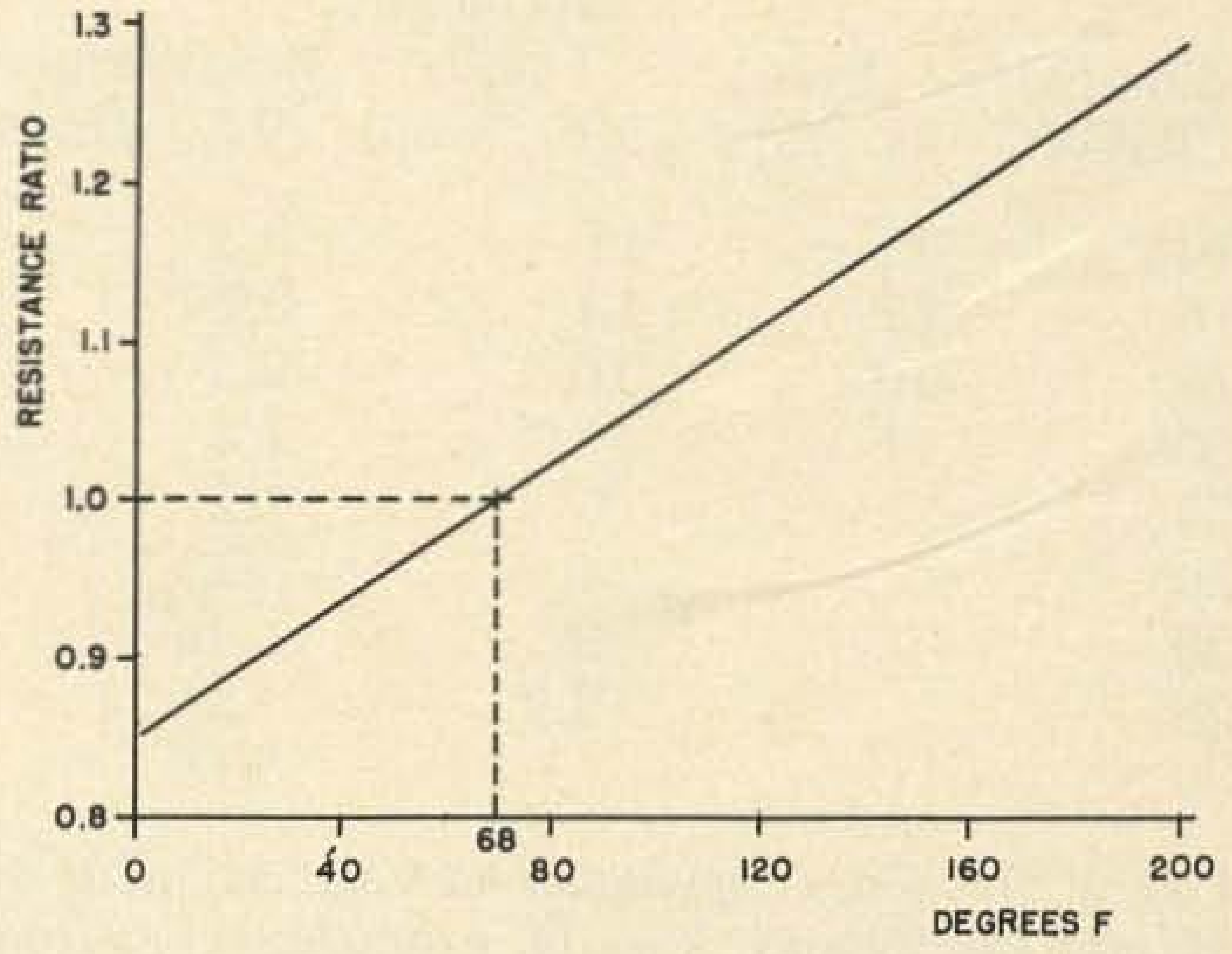

Fig. 4. Ratio of hot resistance to room temperature resistances for determining transformer operating temperature.

the conductor as well as the outside. But at *rf* the current is confined by magnetic effects to the conductor surface, which is why hollow conductors are often used in power *rf* gear. It is not economical to purchase copper when it will not carry current, and sometimes the space is conveniently used to carry cooling water. The frequency dividing line between dc volume conduction and *rf* surface conduction is not sharp.

dc and power wiring

Conductor cross section is the area available to carry current. To determine a conductor cross section value, imagine you have cut squarely across the conductor, and estimate the number of square inches, centimeters, or what have you, of area exposed. Circular mil measure is sometimes used, but is not required for electronics work. The conductor cross section has no direct bearing on how much current the conductor can carry, since tests at 15,000 amps/square mm (about #17 wire) show no indication of an intrinsic limit. The maximum or operating current is determined by one of two factors: excessive voltage drop, or excessive temperature rise.

Various tables in handbooks and physics tests may be used to calculate resistance values, but for most applications there is an easier approach. Resistance is commonly specified directly for various wire sizes in ohms per 1000 feet. This can be read as milliohms per foot, and a key trick in using this value is to read it as millivolts drop per amp-foot. See **Fig. 3**. In this way, calculations can often be completely avoided. You have to remember to allow for the current return path too, in estimating the voltage available at the end of a conductor or run. Good technique is to measure the result in the finished gear.

Wire resistance increases as temperature rises. See **Figs. 3** and **4.** The increase is not significant for most electronic applications, being in the order of 2% per 10 degrees F. This small change in a small resistance is rarely significant, but may become an important factor in transformer operation.

How hot does a given transformer actually become in normal operation? Straightforward resistance measurements can provide an answer. If the room temperature resistance of a winding is known. **Fig. 4** may be used to estimate operating temperature from the hot resistance of the transformer winding. If a very enclosed experimental device has been through two or three transformers even though they do not seem to be overloaded, this can be a very informative test.

Transformer temperatures are important in another way, too. A transformer can go into thermal runaway, if conditions are right. In normal operation the transformer power dissipation is directly proportional to its temperature rise, and the resistance also increases directly to the temperature rise. In this conditionally stable situation, transformer operating temperature is related to load. If another factor comes in, such as internal leakage that increases significantly with temperature, or circuit load requirements that rise with temperature, a thermal runaway situation is possible. Since it does not

		Application	
Wire Size	Free	Cable	Transformer
12 AWG	41 amps	23 amps	9.3 amps
14	32	17	5.9
16	22	13	3.7
18	16	10	2.3
20	11	7.5	1.4
22		5	1.2
24		4	.73
26		3	.46
28		2.2	.29
30			.18

Fig. 5. Suggested maximum current for wire in various applications. Wire in a transformer is least able to dissipate heat, and is rated at the least operating current.

go too fast, perhaps it can be detected by plotting transformer temperature over time, with a cooling off period between tests. This goes slowly, but it may explain catastrophic failures that otherwise simply do not make sense.

When voltage drop in wiring is not a consideration, which is most of the time in amateur and experimenter electronics, the choice of wire size is determined by temperature and insulation considerations. Temperature is important, because insulation failures are generally keyed by excessive temperatures.

Conductor operating temperature is that of the general environment, plus a bonus rise depending upon the current and ease of dissipating excess heat. See **Fig. 5**. Very enclosed wire in a transformer is rated at a much lower current than the same size wire in free space. If special insulation permits higher operating temperatures, the wire current rating is increased.

The place formerly held by rubber as an insulating material is now taken by thermoplastic insulations. These are usually a vinyl chemical compound, much better behaved and longer lasting than rubber, but thermoplastic. That is, they soften and melt if they become too warm. Typical maximum operating temperatures are near the boiling point of water, about 175-200 degrees F. Teflon insulation, now entering the electronics consumer market, is good for much higher temperatures, and special teflon-glass insulation works at temperatures near red heat. Teflon and teflon-glass insulations also have excellent *rf* properties.

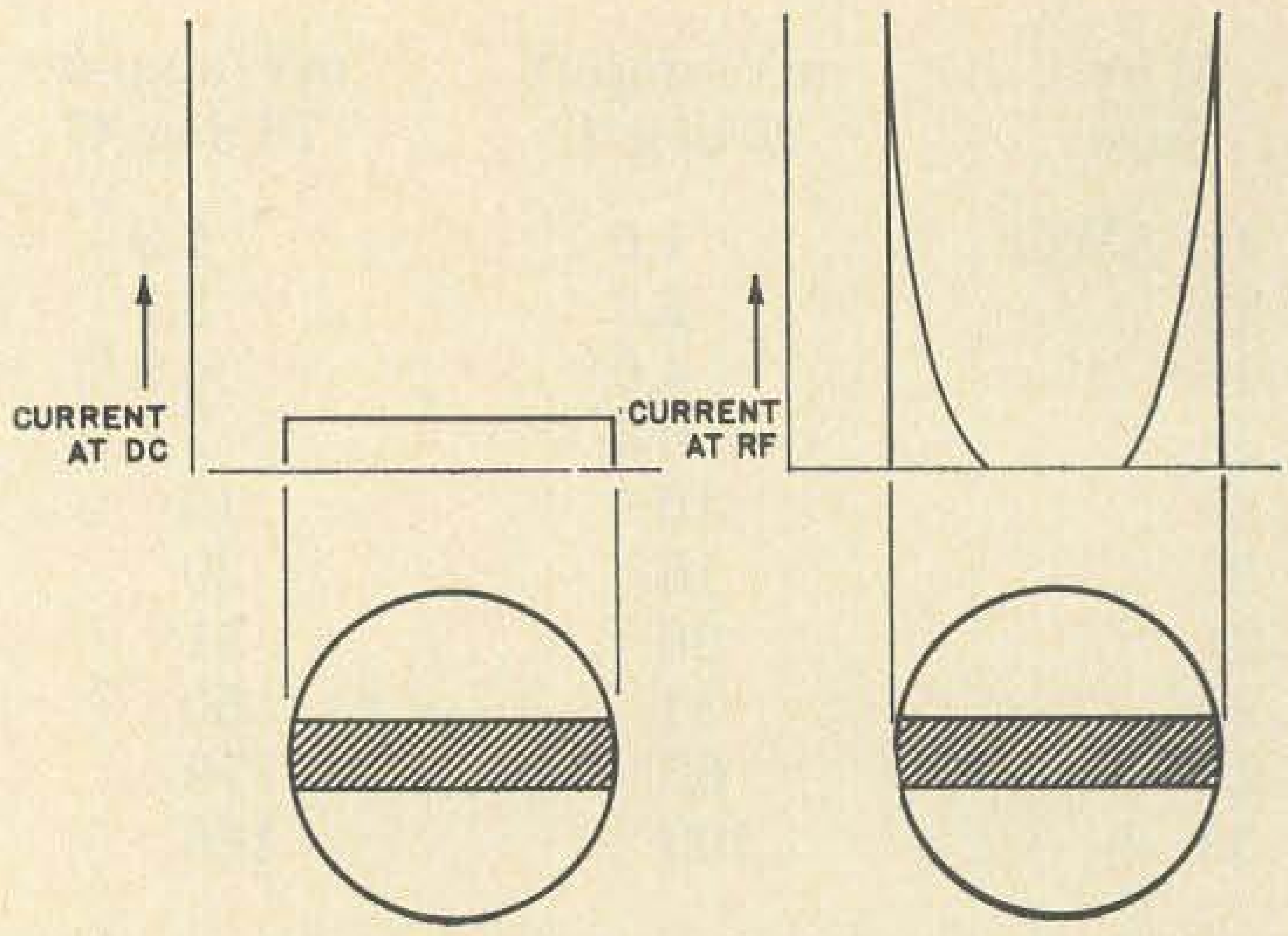

Fig. 6. If we could cut a thin slice from a wire carrying current at dc and RF without disturbing the current distribution, we would find a very basic difference in the way the current flows through the wire. In the RF case, there may be no current at all in the center of the wire.

Wiring at *rf*

There is a vague dividing line between *rf* and dc applications in wiring. It depends upon the application, permissible losses, and wire size, but is generally reckoned to be in the range of 50 kHz to 1 MHz.

If two adjacent wires carry dc or ac current in the same direction, they will be pushed away from each other by their similar magnetic fields. Imagining that a single large conductor carries many tiny current paths, we see that something like this might occur in single conductors. This actually is the case, and its result is called 'skin effect.' See **Fig. 6**.

Because only a small part of the wire actually carries the current its resistance appears greater than at dc, in proportion to frequency as shown in **Fig. 7**. Resistance at *rf* is always greater than dc resistance, and

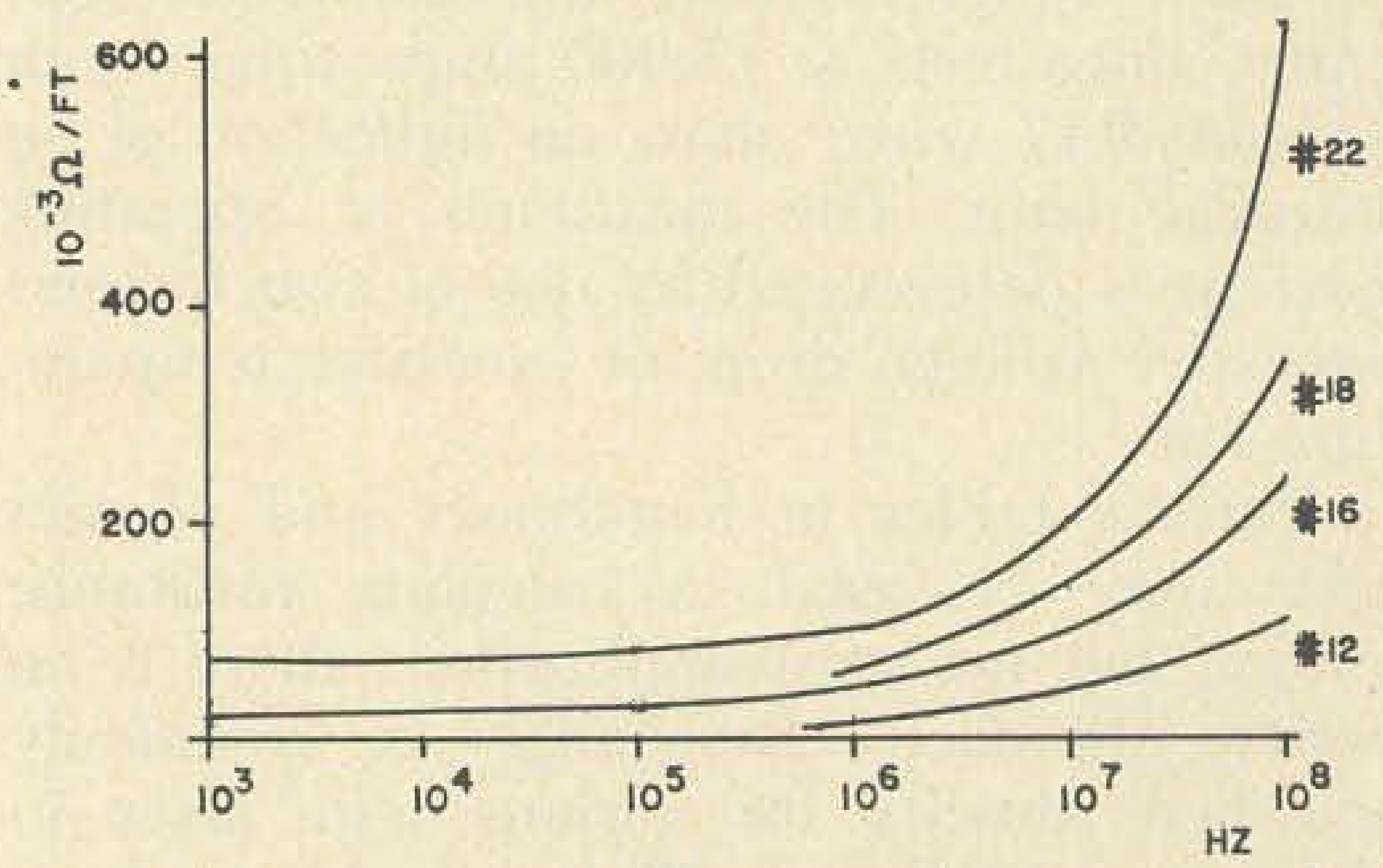

Fig. 7. Resistance of some popular sizes of shiny copper wire rises as frequency is increased. The largest wire always has the least resistance. Flat wire would show a much smaller frequency resistance dependence.

this explains why dirty or corroded *rf* conductors will not perform as well as clean, shiny ones.

In the process of working out this chart, some interesting facts appeared. Tinned conductors are not as good as shiny copper conductors, and there is little to be gained by silver plating. Because the tin is applied to the wire surface and has a much higher resistivity than copper, *rf* losses are relatively high. And since *rf* resistance resulting from skin effect varies as the square root of resistivity, silver plated conductors are but slightly better than shiny copper ones. The difference appears with aging, and may be minimized by a protective coating over the copper surface once construction is completed. This note should be especially useful to radio amateurs with old, dull open wire transmission line extending to expensive or carefully built VHF antennas.

This skin effect data also indicates how best to make good, high-Q *rf* and VHF coils at least expense. New copper wire is indicated and it should have an enamel or preferably a formvar coating. Silver plating is not required, and if possible the wire is flat rather than round. Both types of wire are commonly available from motor repair shops, which usually carry on a rewinding business in a back room.

Other copper materials for *rf* work are roofing copper, easily formed and cut into straps, and copper coated PC boards. The very best in this department is the two-sided glass-epoxy boards in 1/16 and 3/32 inch thicknesses, which probably have better mechanical and temperature characteristics than heavy metal.

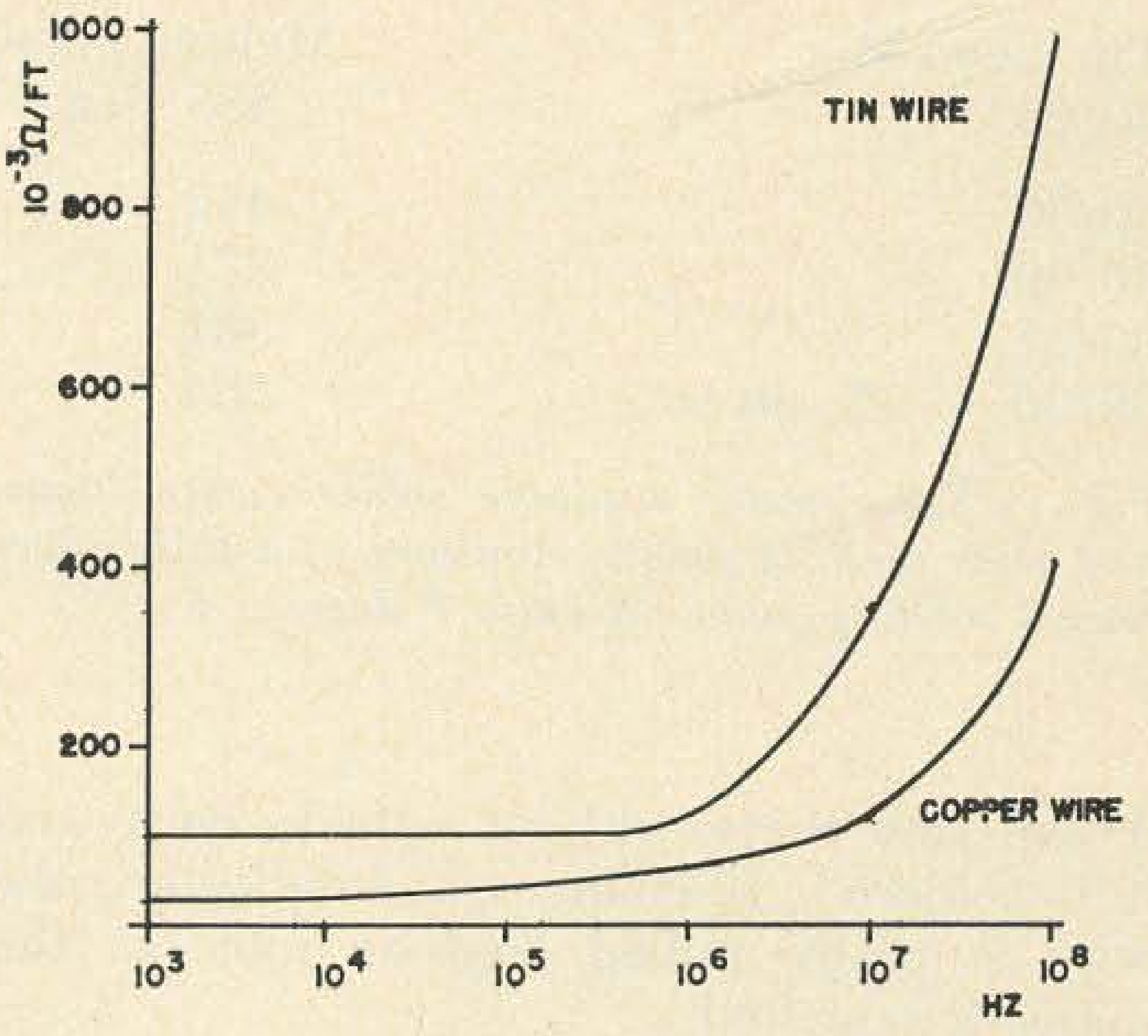

Fig. 8. Actual resistance of a tinned copper wire will be greater than shiny copper wire but less than solid tin wire, except at highest frequencies. It depends upon the thickness of the tin coating.

Insulation

Insulation restrains the current to its intended path, and rarely has a mechanical function. Insulation should always be viewed with suspicion, and tested where its quality or reliability may be in doubt. This applies to all surplus wire. And some insulations show very high losses at *rf*.

Insulation failures may involve many factors. Oxidation is a natural enemy of rubber insulations but does not seem to affect the more popular vinyl insulations. Fungus may be important in very warm, humid regions, and sometimes oils and greases give trouble. Abrasion may cause failures in mobile applications, and manufacturer's specifications on voltage rating should be followed. But the most significant factor in amateur and experimeter applications is temperature.

Temperature melts some insulations, and accelerates aging of others. It has a drastic effect upon insulation resistance. The MIT Radiation Lab Component Handbook lists an insulation resistance change by a factor of 48 in 20 degrees C. temperature change. This could be very significant in some critical circuits, and in transformers.

The common insulations used in electronics are the vinyl and polyvinylchloride types, enamel and formvar, and rubber. The vinyl insulations are most generally used and teflon is coming up fast due to its popularity in computer applications. Teflon has nearly perfect properties. Formvar is very good for coils and VHF circuits, and rubber is still used sometimes in power cords. Avoid rubber.

Installing wiring

It is not true that wire joints must be mechanically strong before soldering. This rule may have application in military and aerospace construction, but few amateur and experimenter applications involve such extreme requirements of vibration resistance and reliability. For lab and other light-duty applications a solder-only joint is perfectly reliable. The lead is brought to and into the lug, connector, or whatever, arranged so that

Tin/Lead Mix	Melting Point
40/60	455 deg. F
50/50	412
60/40	371
63/37	361
62/36 + 2% silver	354

Fig. 9. Some easily available solder compositions, and their melting points. Addition of a little silver lowers melting point an extra 7 degrees F.

it will stay there without outside help, and it is soldered. If changes are indicated, the wire is easily pulled free as soon as the solder is remelted.

Acid-core solder deserves special mention. Its reputation is not a product of special mention. Its reputation is not a product of sales interests. The acid is corrosive in plumbing applications, and has no place in the electronics lab. Kit manufacturers void their guarantee for any gear exposed to acid core solder for this reason. Paste fluxes too, are at least very messy and sometimes corrosive. Do not use them.

The popularity of soldering guns seems to be a result of good advertising. There is certainly nothing to recommend them to the serious worker. They heat quickly, but waste time at each application of solder. Since there may be hundreds or thousands of joints in a large project, soldering guns do not save time. And because of the small mass of hot copper at the tip, guns must use high power to maintain soldering temperatures. A long application of the gun to a joint may result in temperature excursions several hundred degrees hotter than required. Guns are clumsy, too, and mechanically inefficient. If their popularity is not due to good advertising, another plausible explanation is a repressed cowboy urge in the gun addict.

Soldering irons traditionally run too hot. Some otherwise excellent irons are notable in this respect. Any iron may be tamed by providing its power through a variable resistance, an SCR controller, or a variac. The variac is preferable, since the iron can be overvolted for occasional heavy-duty applications. This does not seem to harm the iron, if not overdone.

Solder is a tin/lead alloy, melting at a lower temperature than either pure metal. The melting point depends upon the ratio of tin to lead, being lowest in the 63/37 mix (63%, 37% lead) sometimes called eutectic solder. Low melting points in electronics applications are very desirable, and sometimes a little silver is added to lower the melting point a little further. See **Fig. 9.** Low melting point solders are more expensive than the 50/50 or 40/60 alloys, but reduced temperatures and faster soldering minimize heat effects on fragile electronics components.

Insulation removal with a sharp knife is too slow for modern electronics work. There are many strippers on the market, and the more elaborate ones are complicated mechanical monstrosities completely unsuited for serious electronics applications. Maybe they are appropriate for wiring houses rapidly. Of the simpler tools, the nicest is Miller's Model 100 Stripper, which should be cut down to fit small spaces. The stripper is also available with a return spring, but the spring serves largely to reduce feel so you cannot tell if you are cutting insulation or wire. In many stores the spring variety is the only one available. The spring is easliy removed and discarded.

A pair of fingernail clippers may be converted into a convenient stripper by grinding or filing a careful notch square to the jaw. Cut in until a hole appears, just large enough to clear the wire as determined by trial. See **Fig. 10.** There is enough space for two or or three notches for different wire sizes. Don't try to put a notch in the middle because there is a metal post inside.

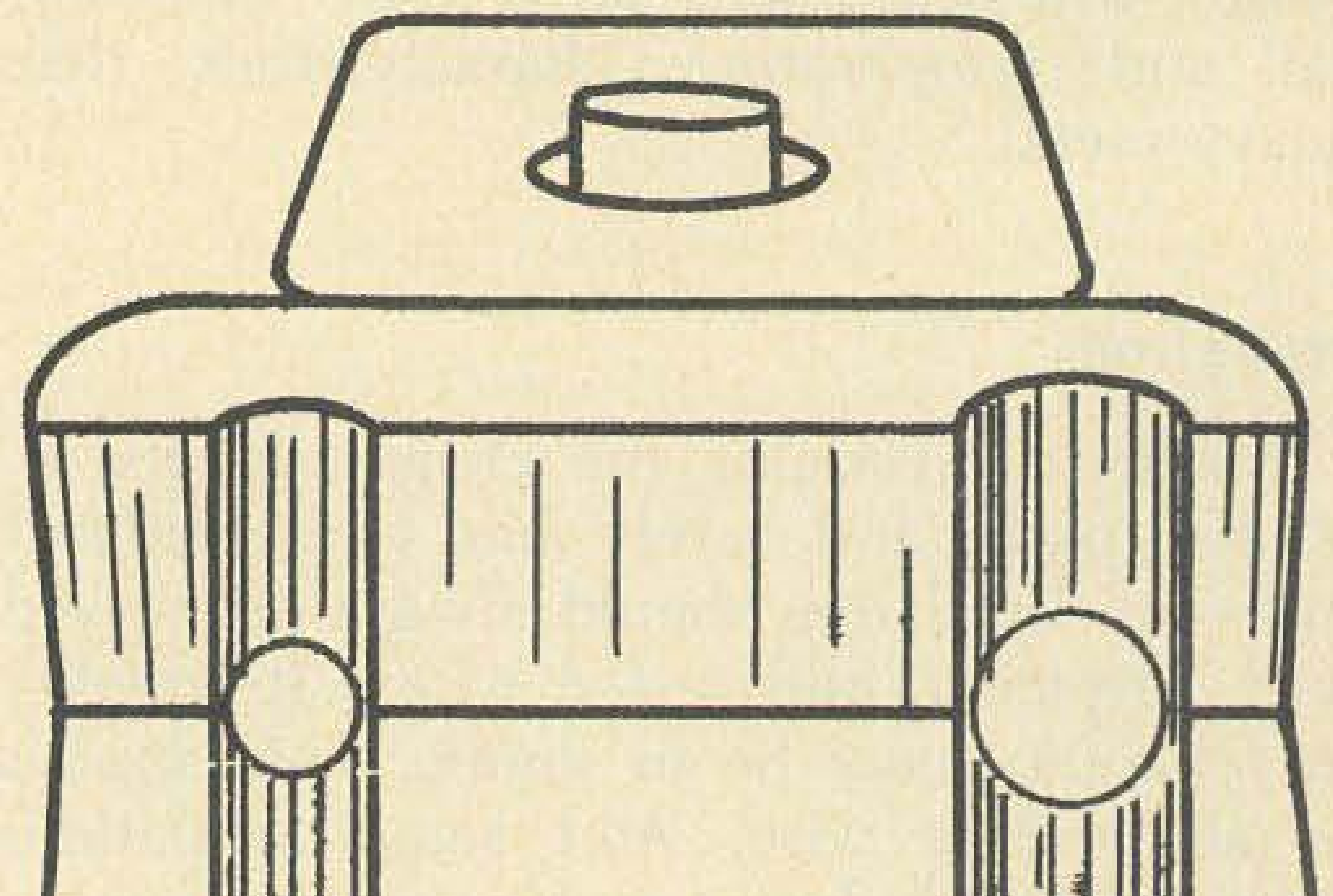

Fig. 10. How to notch a pair of fingernail clippers to make a handy wire stripper. A post through the center of the clippers will block a notch placed there, unless very short sections of insulation are to be removed.

The very best wire strippers are the thermal variety, which melt rather than cutting through the insulation before pulling off the unwanted end. These strippers do not score the wire, and cannot cut or notch it. Recommended for reliable applications. See catalogs near soldering irons. Oryx makes a nice stripper, which is listed in some of their catalogs.

In the matter of actually wiring a chassis, there is a lot to learn but not very much to say. Wiring goes in power wiring first, then miscellaneous innerstage and control wiring, and finally signal wiring. That puts the part that receives most attention on top. In the case of printed circuits, there is very little wiring, but some care is required to avoid a hazard of broken wires at board connections.

. . . W1EZT

Cheap *rf* Weatherstrip

A highly satisfactory substitue for *rf* weatherstrip may be made from common shielding braid. The garden variety sponge rubber weatherstrip found at your local hardware store is used to make it resilient. Surgical tubing filched from a friendly MD or nurse will also work well.

The mating surfaces of the crevice to be sealed are first drilled for small sheetmetal or machine screws. A length of braid is measured to fit the outline and a slightly shorter length of rubber inserted within this braid. The braid is then formed to the proper shape and the ends overlapped ¼" or so. Solder the braid together in one spot only. We don't want it to be so stiff that it won't conform to irregular surfaces.

Clean the areas involved with sandpaper or steelwool so as to present a good conductor. Put the seal in place and fasten the parts together. It is not necessary for the screws to go through the braid.

Various sizes of braid are commonly available at supply houses, I have found the ¼" and ½" sizes to be most practical. It is much easier to insert the rubber if the braid is first squeezed to the shortest possible length.

Seals between surfaces which already mate fairly well may be made without the benefit of the rubber insert.

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Who Says You Can't Take It With You?

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Schoolbooks, sliderule, and a mobile rig, all go toward making college interesting. Especially the mobile rig.

Amateur radio licenses are being earned by younger people every year. For those youngsters in a "ham family," having a license can be beneficial, because eventually they will be going to college.

Being away at college need not interrupt Junior's ham radio career. By planning ahead, his equipment can be selected so he can take it with him.

With the advent of the two and three car family, it can be supposed that he may have a car of his own. Consider the advantages of having a mobile installation.

Phone bills get awfully expensive in no time at all (remember the half hour phone call when you had your first fight with your room mate?); traveling to and from college would be more enjoyable with someone to talk to (plenty of people on 40 meters!); and besides, adventure is involved, and mobiling is just plain old fun!

Since Junior may be changing residences during his college years, and ham radios aren't allowed in most college dorms, the obvious solution to keeping his license current is to put the rig in the car.

Several medium powered transceivers can be had for a nominal sum, and with a little ingenuity, some money can be saved by building your own mount or perhaps buying an easy-to-put-together kit.

Most transceivers have ac supplies available so they can be used indoors as a portable station. This can be handy if Junior decides to live by himself in a rented house or apartment. (Be sure to get the landlord's approval if you operate in an apartment house!)

The author selected a Galaxy III from the used gear market and got a New-tronics "Hustler" collapsible whip to go along with it, providing operation on 80, 40, and 20 meters.

A dc supply capable of handling the full 300 watts PEP of the Galaxy was purchased new, bringing the total cost to just over

The compactness of mobile transceivers allow them to be used right alongside the typewriter, taking up about as much space. The power supply is placed on the floor. Tired of studying? Take a QSO break.

A quick QSO on the way to classes makes the trip a pleasure. Plenty of time to work a few DX stations.

$300. An industrious young ham can earn this much in a Summer.

Instead of buying the commercially made mount for the transceiver, give a little thought to making your own. It's relatively simple to do, and all that's needed is an electric drill, a few feet of flat strap steel, and a few nuts and bolts. Let the junior op make the mount while the OM works a little DX.

The first contact the author made, after installing the Galaxy, was with Pennsylvania. Not too bad, but the second QSO was with New Zealand. And the third was Australia. Both signal reports from the South Pacific were S9 plus!

KC4USB in Little America (see "Operations Deep Freeze— 1957-1967," March 1968 73) gave the Galaxy an S5 rating. And Antarctica is about as far away as you can get from anywhere!

So if Junior is basically a DX man, he can continue his drive (no pun intended) towards DXCC with the mobile rig. And if he should encounter problems while crossing long deserted stretches of highway, he can always call for help. The West Coast Amateur Radio Service net is on 7.255 Mc, and they give priority to mobiles. Need help? Just call.

The young collegian will want to find a group of friends with similar interests, and he need look no further than the campus amateur radio club.

W6BHZ is the call of the Amateur Radio Club at California State Polytechnic College, San Luis Obispo, California. The author joined the club when he first got to school, and subsequently met JA8SB, whom he had QSO'd in 1962. Small world.

If you can't afford a mobile or portable station, then consider joining the campus amateur radio club.

Yes, mobiling may be the key to keeping Junior active while in college. If his date turns out to be a cold fish, he can always try to find a tantalizing Tahitian YL who's willing to QSO.

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Frequency Allocations Chart

	PHONE ALLOCATION			CW ALLOCATION	
	Extra Class	Advanced Class	General Class	Extra Class	Advanced and General Class
Current	3.8 - 4.0	3.8 - 4.0	3.8 - 4.0	3.5 - 4.0	3.5 - 4.0
	7.2 - 7.3	7.2 - 7.3	7.2 - 7.3	7.0 - 7.3	7.0 - 7.3
	14.2 - 14.35	14.2 - 14.35	14.2 - 14.35	14.0 - 14.35	14.0 - 14.35
	21.25 - 21.45	21.25 - 21.45	21.25 - 21.45	21.0 - 21.45	21.0 - 21.45
	28.5 - 29.7	28.5 - 29.7	28.5 - 29.7	28.0 - 29.7	28.0 - 29.7
	50.1 - 54.0	50.1 - 54.0	50.1 - 54.0	50.0 - 54.0	50.0 - 54.0
November 22, 1968	3.8 - 4.0	3.825- 4.0	3.85 - 4.0	3.5 - 4.0	3.525 - 4.0
	7.2 - 7.3	7.2 - 7.3	7.225 - 7.3	7.0 - 7.3	7.025 - 7.3
	14.2 - 14.35	14.2 - 14.35	14.235 - 14.350	14.0 - 14.35	14.025 - 14.35
	21.25 - 21.45	21.275- 21.45	21.3 - 21.45	21.0 - 21.45	21.025 - 21.45
	28.5 - 29.7	28.5 - 29.7	28.5 - 29.7	28.0 - 29.7	28.0 - 29.7
	50.1 - 54.0	50.1 - 54.0	50.1 - 54.0	50.0 - 54.0	50.0 - 54.0 (A)
					50.1 - 54.0 (G)
November 22, 1969	3.8 - 4.0	3.825- 4.0	3.9 - 4.0	3.5 - 4.0	3.55 - 4.0
	7.2 - 7.3	7.2 - 7.3	7.25 - 7.3	7.0 - 7.3	7.05 - 7.3
	14.2 - 14.35	14.2 - 14.35	14.275 - 14.35	14.0 - 14.35	14.05 - 14.35
	21.25 - 21.45	21.275- 21.45	21.35 - 21.45	21.0 - 21.45	21.05 - 21.45
	28.5 - 29.7	28.5 - 29.7	28.5 - 29.7	28.0 - 29.7	28.0 - 29.7
	50.1 - 54.0	50.1 - 54.0	50.25 - 54.0	50.0 - 54.0	50.0 - 54.0 (A)
					50.25 - 54.0 (G)

The Thermistor

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An Electronic Device With Non-Electrical Applications

I remembered Ralph Hanna's article in the May, 1967 73, and when I was recently called upon to do a research paper, the thermistor came to my mind. Considering the electric characteristics of the thermistor, you might decide that it is a pretty dull animal, and leave your investigation at that. However, as I found out, there are some pretty unlikely and surprising applications of this device, as we shall seee. But first of all, we should find out what a thermistor really is.

General description

A thermistor is a semiconductor device with a negative temperature coefficient of resistance, opposite to most metals. The resistance follows an exponential variation with temperature which is given by the following relation:

$$R = R_o \exp\left[\beta\left(\frac{1}{T} - \frac{1}{T_o}\right)\right]$$

R_o is the resistance at T_o, and β is an experimental constant that can have a value between 3500 and 4500 degrees Kelvin. What this all means is that a graph like the one in **Fig. 1** will result. This shows how the resistance of a thermistor can vary with temperature; R is the resistance and T is the temperature. In practice it is best to determine this relation experimentally rather than try to depend upon mathematical calculations.

Physically, thermistors are made by compressing mixtures of compounds, usually oxides of manganese, cobalt, calcium, uranium, iron, zinc, titanium, aluminum, and magnesium. This starts out in a powder form, and the material can be formed into rods, beads, or discs, by a process called sintering. This is merely a process of forming a blob of material under high pressure and temperature.[2] Wire leads can be attached to the

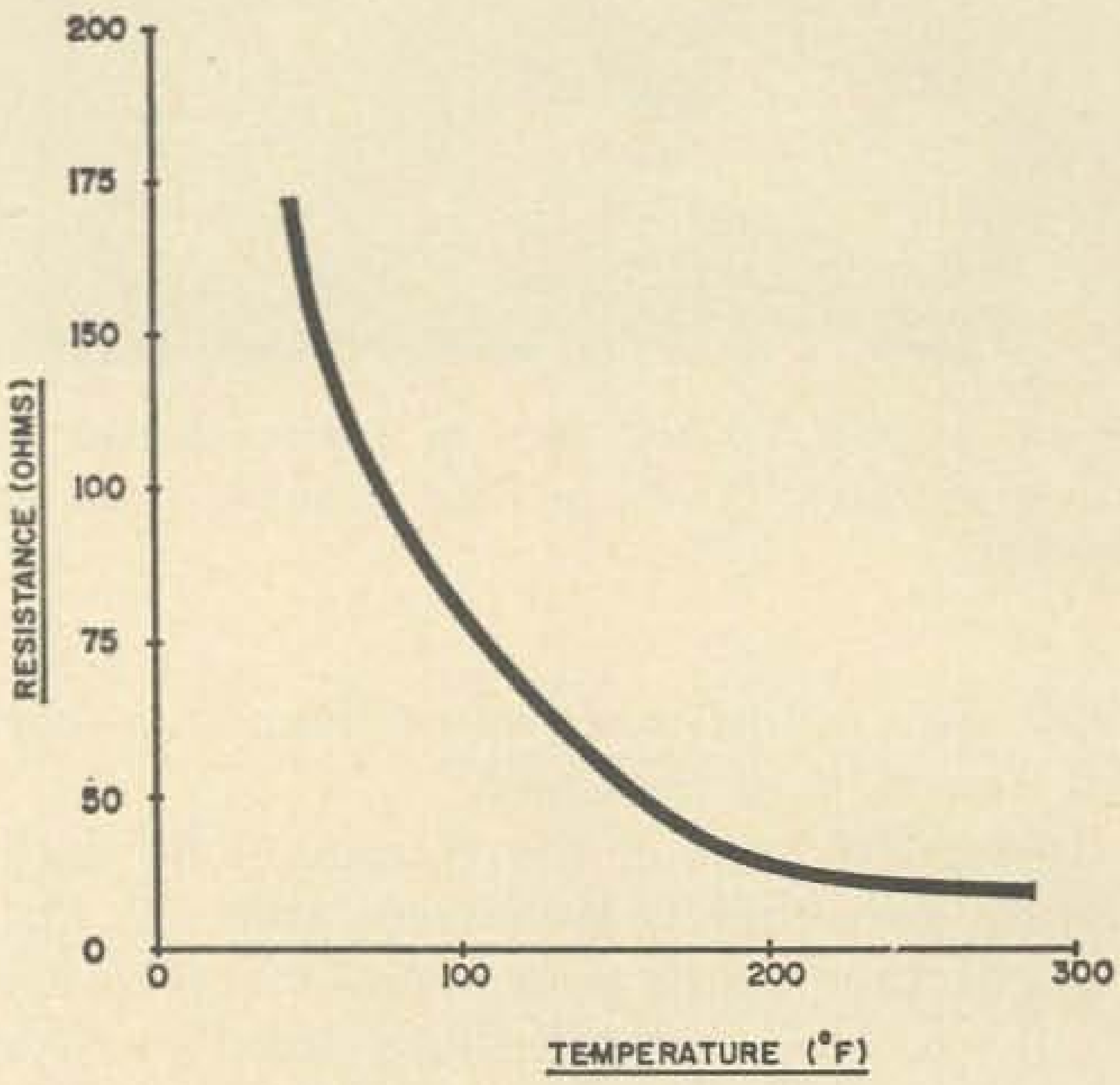

Fig. 1. Graph showing how resistance can vary with temperature.

thermistor, and sometimes it is enclosed in an envelope of some kind, glass for example.

General advantages and disadvantages

For all uses in general, thermistors have certain advantages and disadvantages over other devices. Advantages include small size 0.006 to 0.1 inch in diameter, and their low specific heat allows them to draw virtually no heat from the object being measured. Temperature differences as small as 0.0001 degrees F have been measured.[2] Their high resistance permits adequate impedance matching with associated equipment, and reduces effects of lead wire resistance changes on temperature readings.

This is not all for free, however, and we must be aware of a few disadvantages of using thermistors. One problem is the nonlinear resistance–temperature relation which requires many calibration points, raising costs. When a thermistor is compared to a well made platinum resistance–temperature sensor, the thermistor will show poorer calibration stability. Another disadvantage

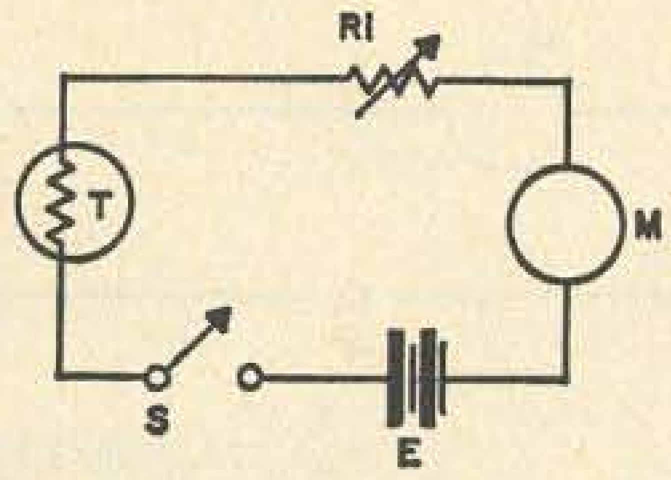

Fig. 2. Simple application of the thermistor. Current meter type of temperature measurement.

is that most thermistors of the oxide type show aging effects in that resistance increases with time. This problem can be solved by preaging which is accomplished by exposing the thermistor to a temperature that is higher than the temperature at which it is to be used. This will enable you to do very precise work. Also, enclosing the unit in glass will reduce chemical effects on aging.

A few uses and applications

R. F. Turner[3] lists and describes many applications for the thermistor, some of which seem rather unusual. First we shall discuss basic methods of measuring temperature, and later take a look at a flow meter and vacuum gauge that can be made with thermistors.

The biggest advantage of the thermistor in temperature measuring is remote electrical readout. If you would like to tell the operator on the other end of a QSO what the local temperature is without going outside, a thermistor thermometer is a great convenience. Similarly, if you would like to monitor the temperature in the final of your transmitter without opening it up and feeling around, then read on.

Fig. 2 shows the simplest application of the thermistor. T is the thermistor, E is a source of voltage, R_1 is the calibration control, and M is a milliammeter or microammeter. R_7 is set and the meter scale is calibrated in degrees. A well regulated constant voltage source is required, and a zener diode from Poly Paks, or some other low cost source will meet this requirement. Make the meter as sensitive as possible to limit the current flow in the thermistor because the thermistor will dissipate power just as any resistor will, and the heat resulting from this will effect the resistance. I noticed no problems of this type while using a fifty microamp meter, and this may be all that is necessary for your application.

Fig. 3 shows an ohmmeter measuring the resistance of the thermistor. This is the way that most experiments start. A chart can be made to relate meter reading to temperature, but this is not very convenient.

Fig. 4 shows the most commonly used circuit. R_1, R_2, R_3, and T make up a Wheatstone bridge. R_2, which is calibrated in degrees, is adjusted so that no current flows in the meter, and a very accurate reading can be made. This is not so convenient as just looking at a meter, but it is the best method for very precise measurements. I prefer the ordinary current meter method, first described, for my own uses, because it is very simple, and it works. None of these methods is beyond the ability of the average amateur and should provide interesting experiments, if you are looking for a gadget that is rather interesting, simple, and useful.

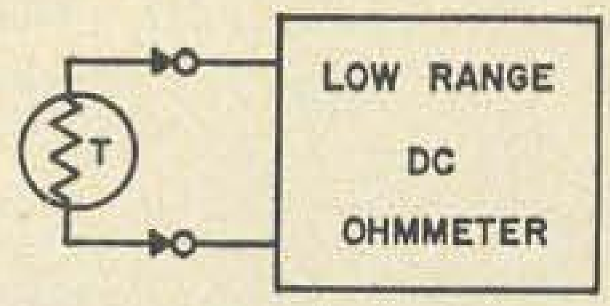

Fig. 3. The thermistor as a low current ohmmeter.

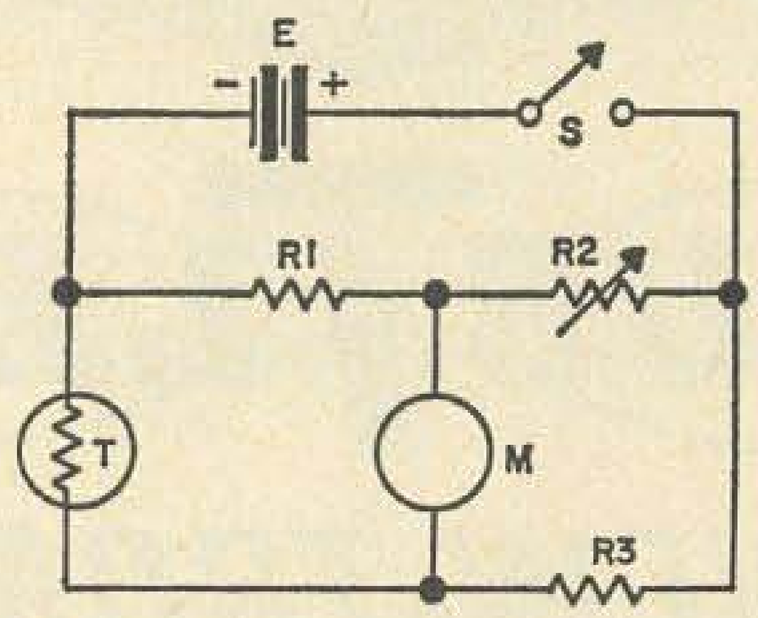

Fig. 4. Bridge type temperature measuring device.

Another device that can have applications for the amateur is a flow meter. **Fig. 5** from Turner shows a typical circuit of a flow meter that can be used to measure either liquid or gas flow. Heat will dissipate more rapidly from an object when it is in a flow than when it is in static surroundings. A bridge circuit is used to measure the difference in resistance between T_1 which is out of the flow, and T_2 which is out of the flow, but in the same medium. In this case the bridge is balanced initially with R_2, with the flow still. R_3 may have a scale calibrated in rate of flow. This method is much simpler than a mechanical method, is free from wear and vibration, and results in almost no pressure loss. Perhaps the more adventuresome experimenter could devise a

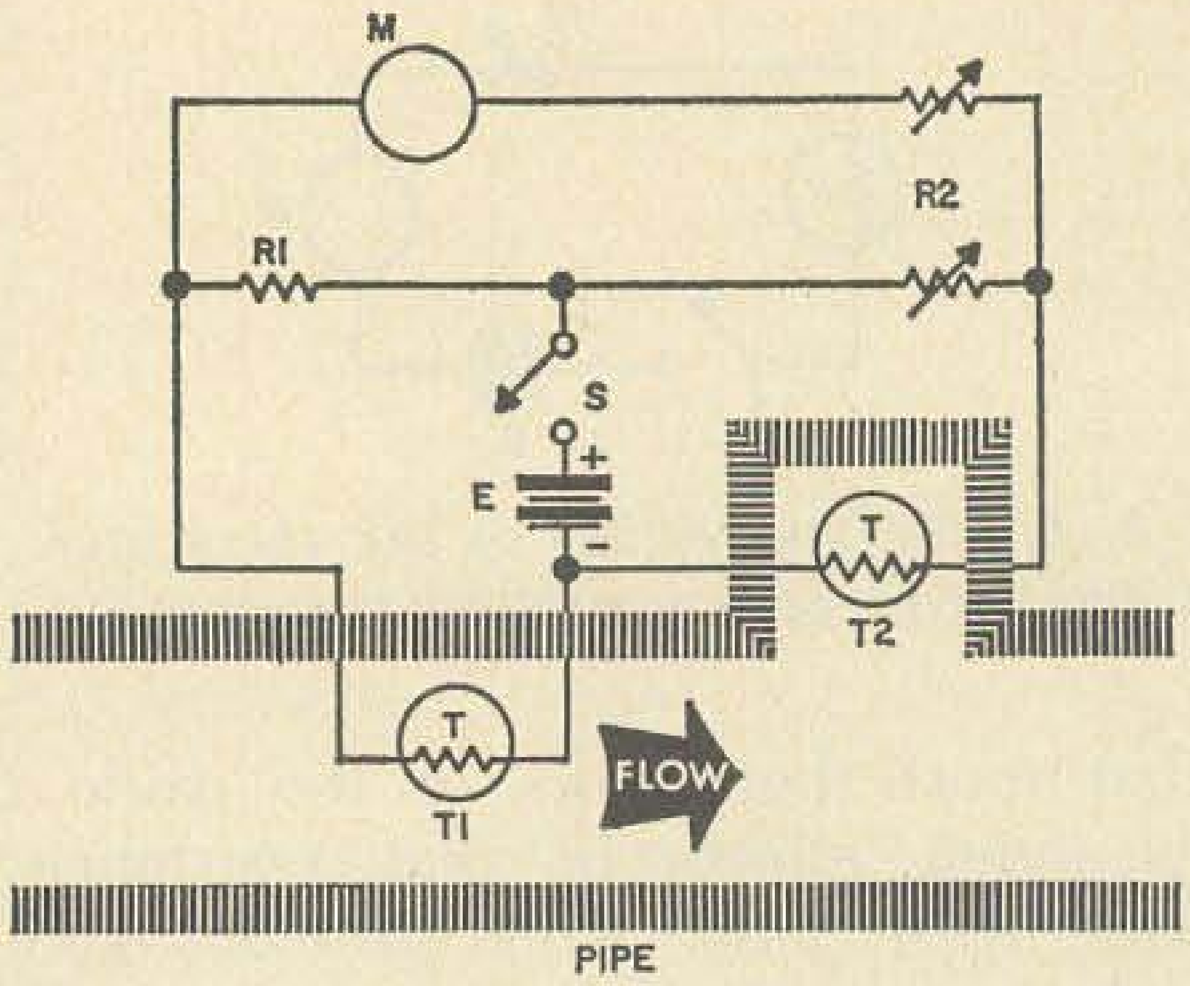

Fig. 5. Typical circuit of a flow meter to measure either liquid or gas flow.

method to monitor the cooling air flow to his 4CX250B's while at the same time measure their temperature.

As you might imagine, the ruggedness and low cost of the thermister allows it to be used where some of the mechanical counterparts could never go. Also, the convenience of electrical readout, recording and transmission of data allows us to sit comfortably in front of a control panel while taking measurements. So, the next time you discover a thermistor while rummaging through your junk box, pause for a moment and consider the many and varied applications that it can have.

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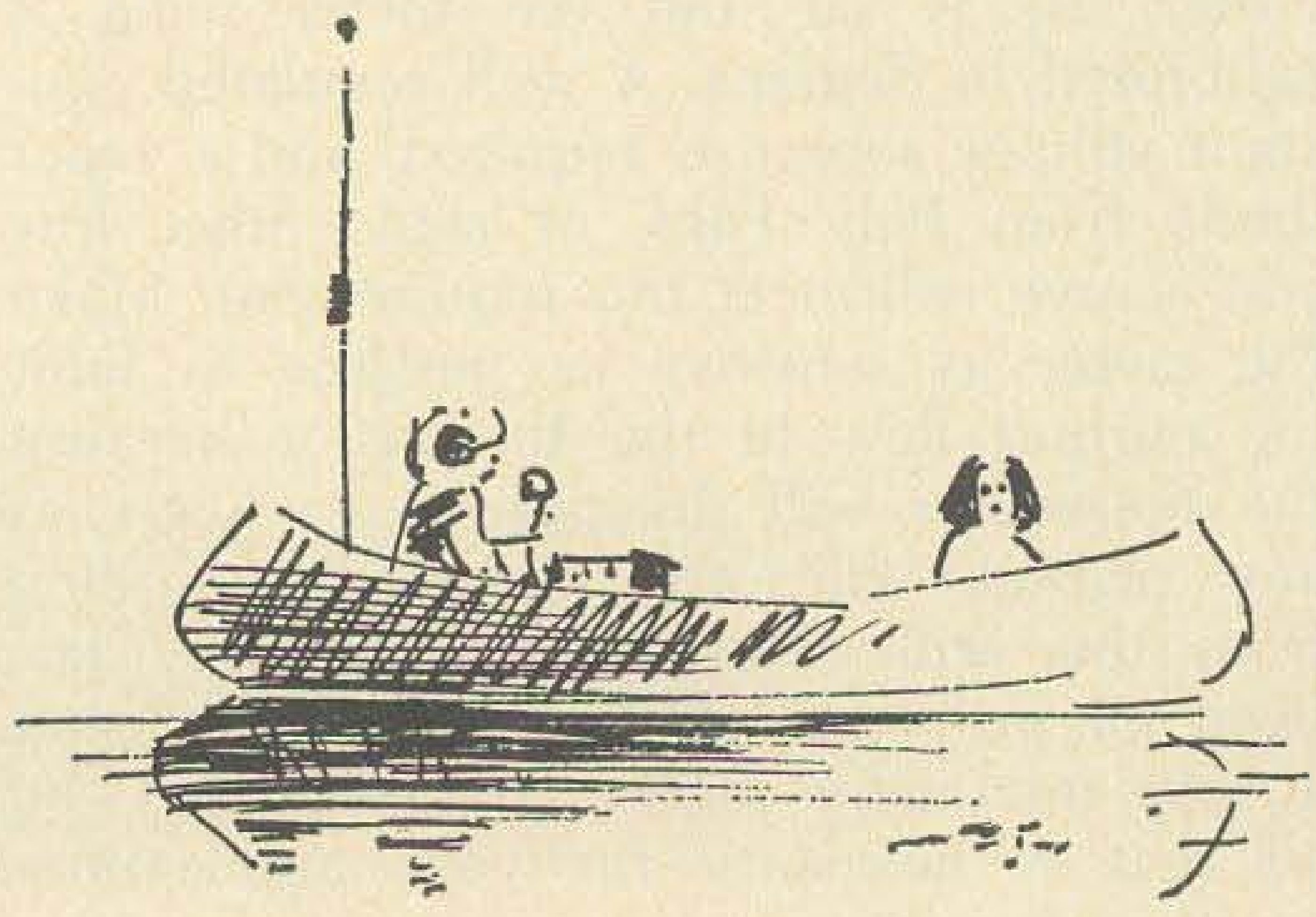


Printed Circuit Layout Template

After spending countless hours measuring the mounting centers required for the various components involved in laying out a printed circuit board, I decided to do something about it. I found a scrap of aluminum rack panel in my junkbox and converted it into a handy template. The plate I used was ⅛ thick and measured 3" by 9". On this area I laid out the mounting centers for ¼, ½, 1 and 2 watt resistors; single and dual low voltage electrolytics, disc ceramics; inline, triangle and diamond transistors; 7 and 9 pin tube sockets; and several types of small transistor transformers. Holes were then drilled to approximate the foil areas required and the plate marked with each component name.

Now, instead of measuring each component, I just slip it into the template holes to check for fit and transfer and dimension to the board or mockup. While not all components are listed, there are always usable holes. For example: top hat rectifiers fit the 1 watt resistor holes, while epoxy types fit the ½ watt holes. Note: Tube and transistor socket numbering should refer to the bottom view. There will be plenty of space remaining for future additions.

William P. Turner WAØABI

"I want something that will go well with news that I spent all the grocery money for a wide-band oscilloscope."

Using a SCR in a Teletype Series Wound Motor

Robert Suding W8NSO
814 Nichols Dr.
Pontiac, Mich.

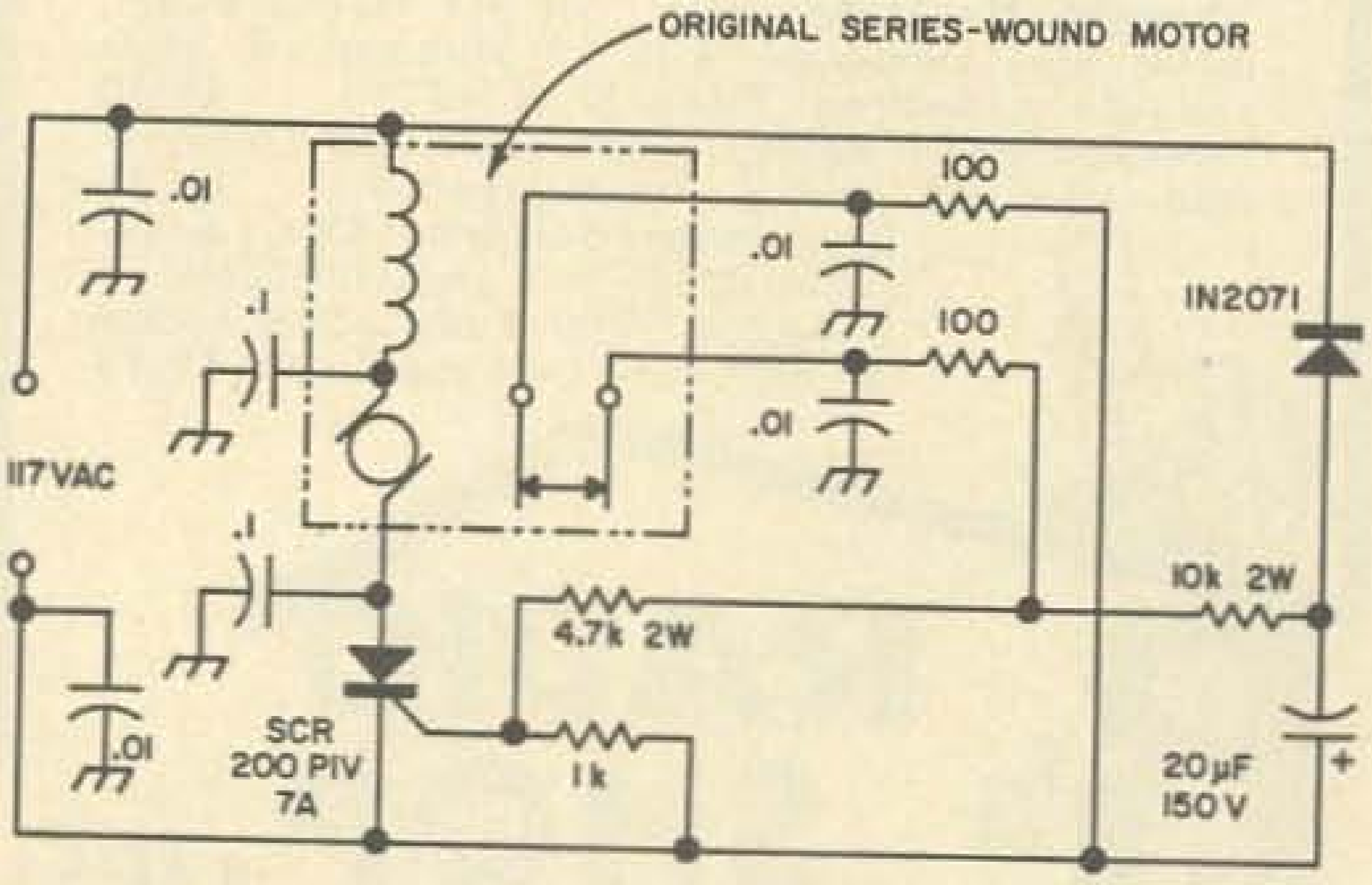


Fig. 1. Using a SCR in a teletype series wound motor.

In the interest of greatly reducing the spark and resulting interference from a motor that is commonly found in a Teletype machine, I used the circuit shown.

The resulting current across the governor contacts is reduced from about 1 amp down to about 10 mA. The noise that might be generated by this is completely inaudible now.

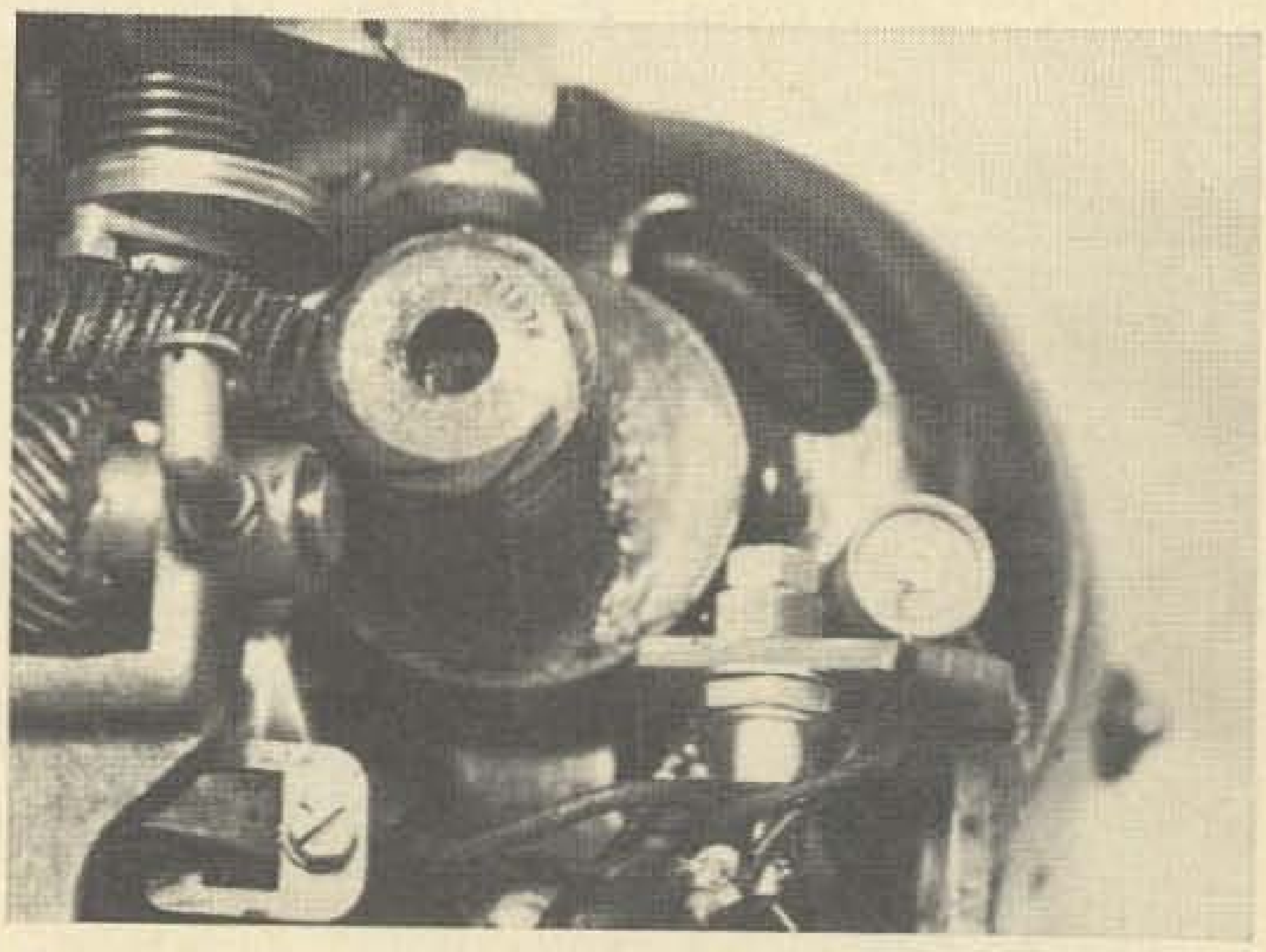
The SCR is one that I picked up at one of the mail order establishments advertised in "73".

When there is no voltage coming into the gate of the SCR, the motor speeds up. When there is a slight negative voltage coming into the gate, the motor then slows down. Using this theory, I then made up a little negative supply; the IN2071 and the 20 mfd/150 volt condenser. The output of this is then applied to a voltage divider consisting of 14.7 K (10 K and 4.7 K), and the 1 K resistor between the gate and the cathode of the SCR.

When the motor is either starting up or going too slowly, the governor contacts are closed, which makes the SCR receive no negative voltage, thus giving the motor more voltage. When the motor has attained its proper speed, the contacts open, and the SCR's gate receives a slight negative voltage, thereby decreasing the speed of the motor.

Though I experience no trouble with interference, you may find that you can further reduce any which may show up in your case by substituting small 2.5 mH chokes in place of the 100 ohm resistors. For the perfectionists, put an Ohmite Z-7 choke, bypassed to ground, in each lead coming out of the motor.

. . .W8NSO



Rear view of a model 14 teletype with the SCR mounted at the lower right. It is mounted on the small bakelite board with the condenser on the top.

The New Hi Voltage Transistors

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With the development of new transistor design and fabrication techniques, many good high voltage transistors have become available. In an attempt to improve transistors a compromise must be made between bandwidth and breakdown voltage. For high-frequency types the base region has been made thinner. Unfortunately this means we get low breakdown voltages (BVcbo, BVceo etc.). Only recently have high voltage, high frequency transistors been sold at experimenter prices. These units find application in line operated receivers, high power transformerless complementary symmetry (and quasi complementary) amplifiers and high voltage regulated power supplies. At the present time most high voltage units are NPN type (silicon). Below is a list I have compiled which shows some of the transistors being sold now. This list is not meant to be complete, only a guide and representative sampling. All units are NPN unless noted otherwise. Power dissipation is usually given at 25 degrees C. Above this temperature the transistor power dissipation must be derated. Where gain bandwidth product (f_t) is not given the transistor will usually be a low frequency unit. Prices may vary. Check your catalog.

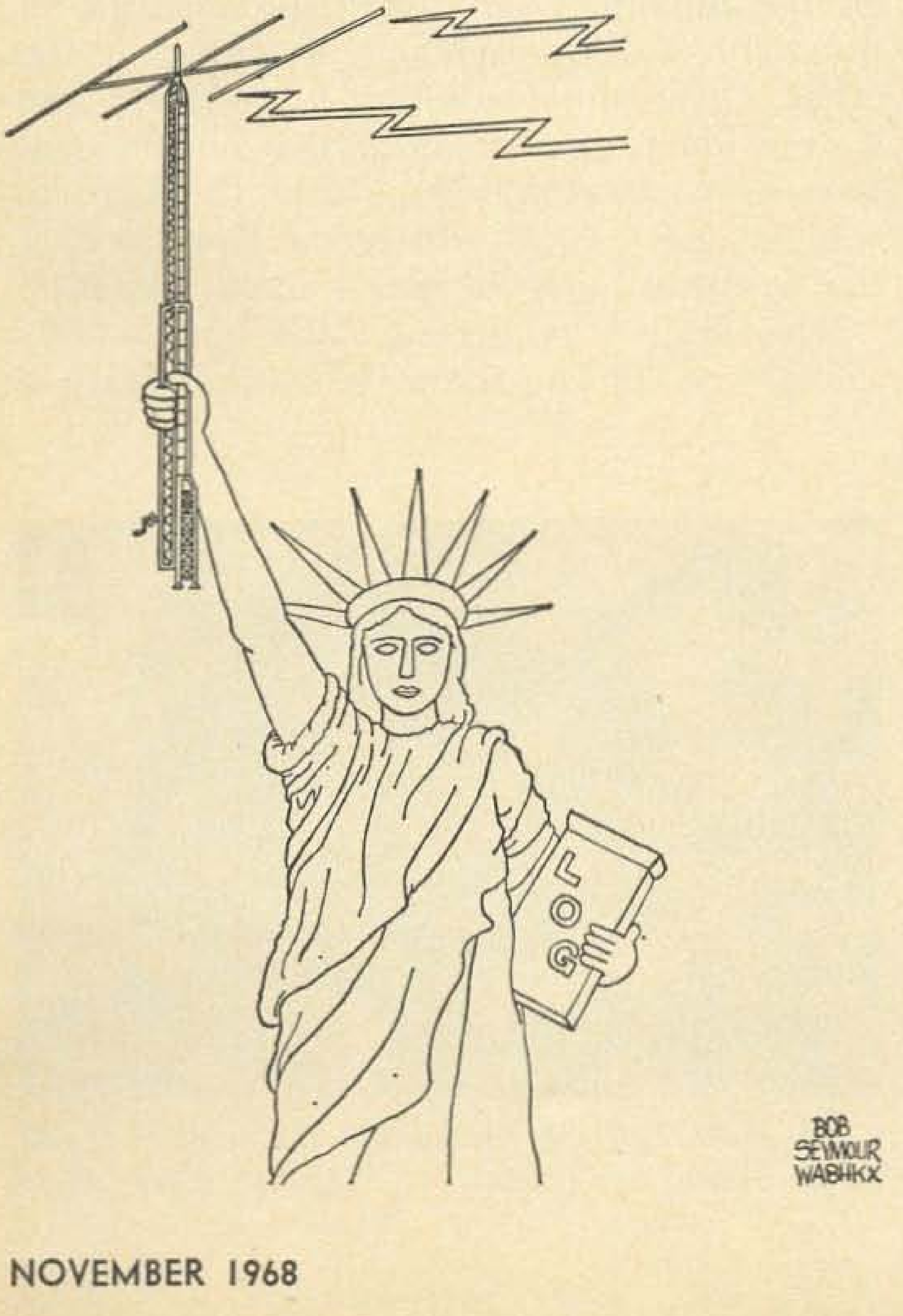
Index to manufacturers:

RCA	Radio Corp. of America
GE	General Electric
MOT	Motorola
MS	MS Transistor Corporation
TR	Transitron
RAY	Raytheon
STC	Silicon Transistor Corp.

transistor	BVcbo	f_t (mc)	power (w)	case	I_c (A)	price	mfr	type
2N3439	450	20	5	TO-5	1	3.71	RCA	
2N3441	160*		25	TO-66	3	2.89		
2N3583	250	10	15	TO-66	2	3.30		
2N3584	375	10	7.5	TO-66	2	6.60		
2N3585	500	10	5	TO-66	2	13.20		
2N3730	200		10	TO-3	3	1.24		PNP
2N3731	320		5	TO-3	10	1.62		PNP
2N3773	160		150	TO-3	30	7.84		
40313	300		35	TO-66	2	2.23		
40318	300		35	TO-66	2	2.10		
40321	300		5	TO-5	1	1.32		
40322	300		35	TO-66	2	2.15		
40327	300		5	TO-5	1	1.24		
40328	300		35	TO-66	2	2.18		
40408	90*	100	1	TO-5	0.7	1.08		
40409	90**	100	3	TO-5	0.7	1.14		
40410	90**	100	3	TO-5	0.7	1.64		PNP
40411	90**	0.8	150	TO-3	30	4.79		
40412	250**		10	TO-5	1	1.06		
40422	300	25	8	TO-66	0.150	1.03		
40423	300	25	3.8	TO-66	0.150	1.11		
40424	300	25	8	TO-66	0.150	0.98		
40425	300	25	4	TO-66	0.1	1.06		
40440	200		5	TO-66	10	1.32		PNP
40444	120	60	140	TO-3	20	14.55		

MJ420	275	30	2.5	TO-5	0.5	1.80	MOT
MJ421	350	30	2.5	TO-5	0.5	1.85	
MM2258	120	1.5	5	TO-5	0.5	3.90	
MM2259	175	1.5	5	TO-5	0.3	4.20	
MM2260	175	1.5	5	TO-5	0.3	4.50	
2N4054	300		4		0.1	1.56	GE
2N4055	250		4		0.1	1.44	
2N4056	200		4		0.1	1.20	
2N4057	150		4		0.1	1.08	
MST-20	200		2	TO-5			MS
MST-40	400		2	TO-5			
MST-60	600		2				
MST-80	800		2				
MST-100	1000		2				
DTS-413	400		75	TO-3	2	3.95	DELCO
DTS-423	400		100	TO-3	3.5	4.95	
2N1052	200	8	5	TO-5			TR
2N1053	180	8	5	TO-3			
2N1054	125	8	5	TO-5			
2N1055	100	3	0.15	TO-5			
2N1613B	120	60	1	TO-5		0.79	RAY
2N1711B	120	70	1	TO-5		1.65	
2N1893A	140	100	0.8	TO-5		2.45	
STT2400	150	25	10	TO-5	7.5		STC
STT2401	140	25	10	TO-5	7.5		
STT2403	120	25	10	TO-5	7.5		
STT2800	150	25	40	TO-59	7.5		
STT2802	140	25	40	TO-59	7.5		
STT2803	120	25	40	TO-59	7.5		

. . . K3VKC



Cord Untangler

You say you got the line cord tangled with your number nines and pulled the VTVM off the bench? You say you are having trouble plugging 11 cords in 4 outlets? Yes, Virginia, there is a way out.

Drop by your local TV parts emporium and buy out their stock of "cheater" receptacles. Install one on each piece of equipment. This should be done neatly, of course.

Naturally you have a supply of cheater cords liberated from defunct TVs. Plug one into each of several outlets and thereafter merely attach cords to the equipment currently in use. PRESTO! No cords to wind up, tangle, or generally get in the way.

I would like to take full credit for this high calibre idea, unfortunately KØRIR beat me to it.

P.S. Works great on projects too—the cord doesn't get in the way of redesign efforts.

William P. Turner WØABI

Project Facsimile Antarctic

. . . . . . *Part II.*

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Winner's photo being posted on bulletin board. Official Navy photo

With the long dark Antarctic winter drawing to a close, plans were made with the men at McMurdo Station to hold a beauty contest as a final part of the morale operations of Project Facsimile Antarctic[1] for 1968. The only difference in this contest is that the girls would not be in the flesh at McMurdo Station but the selection of the winner would be made by facsimile pictures transmitted from the Project Facsimile Antarctic station WA6URW. The winner of the contest to be named "Miss Antarctica of 1969".

The Miss America Pageant officials in Atlantic City, N.J. were contacted and interested in assisting in this final morale offering. Pictures of the 1968 contestants of the Miss America Pageant were sent to the headquarters of Project Facsimile Antarctic and from there they were to be transmitted by facsimile to McMurdo Station. Through July and August, the pictures of the fifty contestants were transmitted with the vital statistics of each girl. A number was placed on each picture instead of giving the state of the contestant to avoid selection of a winner other than by beauty.

As the pictures were received at McMurdo Station, each one was hung on a large bulletin board in the mess hall. From the time that the first picture arrived until the last there was plenty of excitement at "chow" times when the men had elimination balloting to select at least ten semi-finalists. There were problems galore trying to select these ten semi-finalists as each group of men had their favorites. With pictures of fifty pretty girls and and two hundred and fifty Navymen, it was really going to be a tough job selecting a winner.

On the night of the final selection of Miss Antarctica, everyone was excited. There on the bulletin board were the pictures of ten semi-finalists, each one as pretty as the other. Once more balloting was started and it was touch and go until five of the contestants were eliminated. Now the big job was to select Miss Antarctica from five of the prettiest girls in the United States.

The hour was getting late but nobody thought of "hitting the sack" as they wanted

Casting the ballot to determine the winner of the "Miss Antarctica" title. Official Navy photo a winner before this night was over. Again with balloting in 40 degree below zero weather, votes were tabulated and the selection was reduced to three finalists. Picking a winner was getting tougher and tougher but it had to be done. Once more the ballots were passed around and everyone took one more look at the pictures and the vital statistics (36-24-36) of each girl. This was to be the last ballot and one of these girls was going to be the winner, so each man was given plenty of time to make sure of his selection. The voting began and inside of thirty minutes a winner was selected. The tabulation of votes showed that Miss Rhode Island, a hazel eyed brunette, was selected as the winner of the Miss Antarctica Contest with Miss Florida as the first runner-up and Miss Colorado running third. At the time these selections were made, the men only knew these girls by the number on the pictures, but when they received the names of the states the girls came from, via radio, the mess hall at McMurdo was full of excitement. You can picture the men in certain groups boasting that they too came from the same state as Miss Antarctica. She was now their pinup girl.

At the Miss America Pageant in Atlantic City, Miss Rhode Island will be presented with a trophy inscribed as the first Miss Antarctica. Pictures will be taken of her at the pageant and, when received at Project Facsimile Antarctic headquarters, will be transmitted by facsimile to the Navymen at McMurdo Station so as to give them a final picture for the Miss Antarctica Beauty Contest.

With the Antarctic summer and the mail planes arriving shortly at McMurdo Station, Project Facsimile Antartic will have completed a successful morale operation for the "wintering over" Navy personnel who have been isolated, except for radio amateur phone patches and our facsimile operations, since March 1st, 1968. The officers and men at McMurdo Station have enjoyed receiving pictures of their families and participating in the beauty contest. Many are the "thanks" from these men and their families for the morale boost culminating from the operations of Project Facsimile Antarctic.

Although little used at present in amateur radio, facsimile has many interesting features to make it popular for those who like to experiment. . . .K6GKX

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Are You Really Ready for the Next Emergency?

On Wednesday, May 15th, several tornadoes swept across the midwest giving Amateur Radio another unsought opportunity to be of service. Twin tornadoes hit two Iowa cities almost at the same time. Charles City, Iowa came under attach at 4:47 P.M. and Oelwein, Iowa, 60 miles southeast, was nearly wiped off the landscape ten minutes later at 4:57 P.M. Each town had been hit by a different tornado and each funnel then squirmed on to wreck smaller communities of Elma, Maynard and a number of farms in two separate paths across the northeast corner of the State.

Five minutes after Charles City was hit Chuck Angel WAØINC, AREC director in Waterloo, Iowa, was busy alerting the local 2-meter FM network of amateurs. Several Waterloo mobile operators were soon headed, for Charles City, including KØCQH, WØDDW, WAØGZF, WAØINC, WAØIYT, WAØKZP and WAØUKK from Waverly, Iowa. When word flashed across 75-meters that Oelwein also had been hit, WØDDW, KØEDI and WAØFYG stopped short of Charles City and headed back southeast toward Oelwein, now further away than when they left their homes.

Have you ever wondered what you'd do in a similar situation? What equipment should you take? Where should you report and to whom? What is the first and most important communication service you can and should provide in such an emergency?

Perhaps a comparison of these two violent disasters, separated only by minutes and a few miles, will provide some of the answers and help you to be better prepared when it's your turn to act.

The first tornado, the one which hit Charles City, churned directly down Main Street wrecking most of the business section including several Public buildings, churches and schools, an 80-unit low-cost housing development and 150 square blocks of the town's residential area. All telephone and electrical lines were either torn down or cut off and the power company was wrecked. The water supply and gas supply was disabled and only a few places had portable generators which could be activated.

AREC Director Angel took his four Mobile Units to the Courthouse for instructions, then set up a communications system between the Courthouse, the Hospital and the National Guard Armory, leaving one unit free to go wherever needed most. With a number of dead already counted and several hundred injured awaiting discovery or waiting to be treated at the Hospital, the first and most important job for the Amateur operators was to call for Blood and for more Doctors, Nurses and Ambulances.

In a matter of minutes contact had been

made on 75-meters with Doc KØZZR, in Minneapolis and this Red Cross-affiliated station offered to obtain blood and a DC-3 to transport the blood to Charles City . . . If the airport of this 10,419 population town could handle such a plane . . . and IF the field could be lighted for a landing.

Off goes the spare Mobile Unit to find out and it didn't take long to radio back the good news that the airport had escaped the funnel-cloud. . .could handle a DC-3. . . and had its own lighting intact.

Next came an urgent call for drugs needed at the overcrowded Hospital and again 75-meters proved adequate (in spite of the QRN from the still-raging rain and windstorm). An operator in Dubuque, Iowa, WØYLS, offered to help. It took nearly an hour to decipher and relay the huge list of strangely-titled drugs in all that noise and confusion. Even so, within 3 hours after the storm hit Charles City, an airplane with the much-needed drugs was standing on the runway ready to take off as soon as clearance could be obtained.

Next came the order to assist the National Guard and local authorities who were trying to get things organized midst the terrible confusion which always prevails immediately after the sudden shock of disaster. ARED Director, Chuck Angel, hooked his all-band Transceiver to his small portable generator at the Courthouse, strung out a portable 75-meter dipole at 5-feet elevation and proceeded to act as NCS for the other Mobile units on-the-scene as well as dozens of Amateurs all over the country who were calling in, anxious to help get the traffic out during those early hours of the emergency.

Several hours later, after power had been restored in one part of the city, Charles City resident, KØYVU (Al) got his kilowatt SSB rig on-the-air and started the routine handling of incoming and outgoing health and welfare traffic which always comes too soon. Eventually, Al was joined by stations and operators from all over northern Iowa and southern Minnesota and nearly 1,000 messages were handled during the ensuing three days and nights.

Although 11 persons died in Charles City that night and more than 360 were injured, the death toll might easily have been greater had it not been for the quick response of those Waterloo Amateur Radio operators and the quick-thinking leadership of WAØINC.

Oelwein, Iowa, was a town of just 8,500 people but tornadoes play no favorites and a freak "three-funnelled" tornado formed at the southern outskirts of Oelwein, then swept right down Highway 150 through the main business district and on through 90 square blocks of residential area. Three people died instantly in Oelwein and two more were killed minutes later in Maynard, Iowa, as the triple-tongued tornado careened on toward the next town in its path. More than 300 additional residents of Oelwein were injured as the power company, telephone office, fire station, several churches and nearly all downtown buildings were severely damaged or completely flattened.

Local Police and the Highway Patrol had set up headquarters in the basement of the damaged Telephone Office when KØEDI and WØDDW arrived, having followed a bulldozer into the downtown area. While climbing over piles of brick, broken glass and boards full of sharp nails, we all wished we'd thought to wear heavy, hard-soled shoes. The town was totally dark except for the flashlights of searchers and the headlights and flashing red lights of emergency vehicles.

Neither KØEDI nor WØDDW had a portable generator but an Oelwein high school student, Burke Miller WAØPZR, soon borrowed his Dad's portable generator from a sign-company truck and managed to get his station on-the-air, using a make-shift antenna.

Lieutenant Kuch of the Highway Patrol sent the Mobile operators to the Hospital, located on the fringe of the most seriously damaged area, to determine what might be needed by the already overworked, doctors, nurses and other volunteers at the. Hospital. Fortunately, or unfortunately, this small three-story Hospital had been nearly full of patients before the storm struck so many of the most seriously injured tornado-victims had to be transported out of town to other hospitals in Independence and Waterloo, thirty miles away. No additional Doctors or Nurses were needed and the injured who remained at the Oelwein Hospital did not require any additional supply of either blood or drugs.

Hospital Supervisor, Sistor Mary Maureen, asked if the Amateur Operators could send information to relatives of some of the injured, many of whom were visiting in the town or simply passing through when the tragedy came.

For nearly an hour WØDDW and WØFYG went from bed to bed (many of them hastily set up in hallways) gathering messages which the storm's casualties wanted sent to relatives in Oelwein or elsewhere around the country.

By the time the "local traffic" had been disposed of, more Waterloo amateurs arrived on the scene. WØEFM, Ev Frank and his wife, Kay WAØAOU, came equipped with a heavy-duty portable generator, a Transceiver and a full-size 75-meter antenna. KØDFH, KØDCV, WAØFYG and WØDDW helped Ev get the antenna connected to the top of a flagpole at the Red Cross Disaster Center, in the Sacred Heart Church, and soon WØEFM/Ø had begun a 74-hour continuous traffic-handling operation.

Although the hastily-erected antenna enabled WØEFM/Ø to communicate directly with stations from coast to coast it soon became apparent that an outside Net Control Station was a "must". KØLVB in Marshalltown seemed to have everything needed at the time. . . a good, strong signal plus the experience of an NCS on two SSB Traffic Nets in Iowa. Besides all this, Greg KØLVB had a personal interest in the Oelwein operation since his parents and two brothers lived there on the fringe of the most heavily-damaged area.

More than 560 outgoing and 490 incoming messages were passed through WØEFM/Ø between 0200Z May 16th and 0100Z the 19th of May (Saturday night). Two copies of each message were prepared as they were sent or received so the job of checking later would be easier. Local Citizen's Band operators set up a station alongside the Amateur station of WØEFM and volunteered their services in checking the "health and welfare" inquiries which by now were pouring in steadily.

During the first few hours several of the C-B operators provided a very important service and WØEFM/Ø was able to report the condition of several dozen families in the stricken area to stations "standing-by" on 3975 kHz. Soon, though, the CB volunteers ceased coming back for more traffic and for the next two and one-half days and three nights the amateurs were forced to seek the help of local high school students and additional mobile-equipped amateurs to run down the now-piled-up "Health and Welfare" inquiries. During all this time the CB Transceiver across the room continued to roar with the voices of dozens all screaming to be heard above the din of "Ten-Four". . . "What's your Ten-Twenty?", etc. . . as the sight-seeing began with the aid of an automatic "pass" into the restricted area. . . a Mobile Whip.

Some of the amateur operators were arrested on one occasion while attempting to obtain information about a family whose home was totally destroyed. No official "passes" had been issued and they were driving a car which had no Mobile antenna. The Officer told them to "Get back to the church or go to jail!" Ev Frank WØEFM, whose generator and radio equipment was providing the only communication to and from the town at the time, was ordered off the streets while travelling from one Red Cross shelter to another without a "pass". He had an antenna on his automobile but the rig was not in the car. It was pouring out messages from the Disaster Center.

WØEFM's portable generator provided the emergency power for station operation as well as lights for the Sacred Heart church basement where the Red Cross was busily caring for hundreds of volunteer workers and homeless victims each day. At least two amateur operators were busy manning the transmitter all day and all night. One could manage an hour or so of rest while the other worked along during the wee hours when message-handling slowed down, but it was difficult to sleep in the cold basement. The day of the storm had been an unusually hot Spring day but the cold front which produced the violent weather also brought a sudden drop of 40 degrees in temperature and no one had thought to bring along warm clothing, or blankets, or even a pillow to lean on for comfort.

By any measuring stick you'd care to use both the Charles City and Oelwein emergencies stand tall as monuments testifying to the dedicated responsibility for which America's radio amateurs are well known. As is usually the case, they were taken by surprise, caught off-guard, and not as well-prepared as we'd all like to be in such a situation. But, in both cases, they did respond quickly. They handled the priority traffic first and they stumbled, however accidentally, into some of the prime necessities of emergency operation.

Naturally, your group will never face this same situation, regardless of the crisis which may arise in your area, because you're probably totally prepared. . . with a club-owned generator of adequate size, practice-sessions in connection with your AREC and RACES net-gatherings (as opposed to simple checking in and rag-chew afterward), Identification Cards for all Club Members, ready-made portable antennas complete with spare co-axial feedline, nylon rope, extra connectors, fully-equipped toolbox including a 12 volt soldering iron or two, extra microphones, stand-by transceiver, a well-established system of handling messages in an emergency. . . known to all or pre-printed so the instructions can be handed out to all participants at the scene of the emergency, an efficient system for alerting key-members of your group when the time comes, and most important of all . . .a definite plan for doing the whole job with amateur radio operators so you don't have to depend on any other group.

Just one more thing—if your Club can afford it, get yourselves a big, big sign which says:

"EMERGENCY COMMUNICATIONS
BY AMATEUR RADIO
OPERATORS. . . . . . . .HAMS!"

It's pretty sickening to pick up the papers your XYL saved for you to read after you'd been gone for three days and nights only to find a picture of a fellow "ham" in front of a TR-4 in the Disaster Center with a caption which reads:

"Citizen's Band Operator Provides Emergency Communications from the Disaster Area."

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Getting your Higher Class License

Part VIII — Transistor Principles

Just a little more than 20 years ago, a team of physicists at Bell Telephone Laboratories stuck some wires onto a solid crystal and came up with a device which acted like a cross between a transformer and a resisor—and which in the two decades which followed has revolutionized all phases of electronics.

Despite the widespread application of the transistor, however, its operation and use has been almost ignored in the FCC examinations up until the latest versions. The new Advanced Class exams include a number of questions on semiconductors, and this month's chapter of our Advanced-Class study course will concentrate on this area.

Only three of the questions in the official FCC study list for the new exams deal directly with semiconductors. These, which we will go into this time, are:

32. Power dissipation in what part of a transistor warrants careful observation of power ratings?

40. Compare transistors and tubes. What are the advantages and disadvantages of each?

46. What is the vacuum tube counterpart of (1) a grounded base circuit; (2) grounded emitter circuit; (3) grounded collector circuit?

Lest you think that three questions is too small a number to spend an entire instalment on, read them again—and notice that two of the three require a rather comprehensive knowledge of transistor principles for adequate answers!

As we have done in the past, let's re-phrase the official questions into another group which can be examined in a more orderly sequence.

The first question in any dealings with a transistor must be "How does a transistor work?" You don't have to have a solid-state physicist's knowledge of the "how", but any use of the devices becomes much easier when you have some idea what's going on inside.

Almost all transistor specifications are given in terms of a "black-box analysis" which boils down to one of the three basic circuits listed in FCC question 46. That makes our second question for dissection become "What are the basic transistor circuits and how do they differ?"

An adequate comparison of transistors and tubes requires a knowledge of both the advantages of the transistor in relation to the more familiar tube. Our third question thus is "What are the transistor's advantages?" and the fourth is "What are its disadvantages?"

Finally, the power-rating question (No. 32 in the FCC list) is only one of a number of possible similar questions dealing with critical points in the application of transistors. To be prepared for all these questions, let's find out "What are the critical factors in using transistors?"

For those among you who *are* physicists, let's spell out in advance that this is a *practical* explanation of all these questions and as such, necessarily runs the risk of becoming oversimplified at some points. You aren't going to get very involved with "holes" or "minority carriers", and the matrix algebra so commonly encountered in any examination of transistor circuit approximations is going to be conspicuous by its absence. Many good books have already been written on solid-state physics, and we've studied quite a few of them in preparation for this article. But *this* article aims to give sufficient understanding of what goes on to satisfy the exam requirements, and possibly to whet interest in pursuing the details later.

Okay? Let's get on with it.

How Does a Transistor Work? Back in those dear dead days before semiconductors, most of us learned that vacuum tubes amplifying by deflecting and/or rejecting elec-

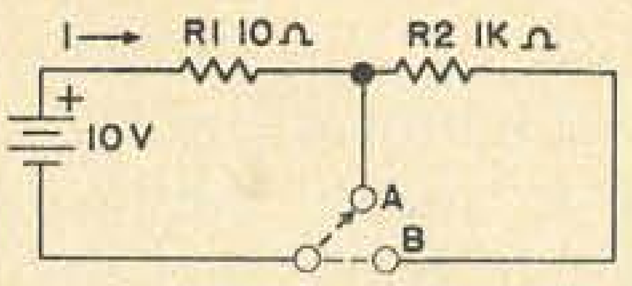


Fig. 1. This simple switching circuit shows the basis of transistor action; details are explained in the text.

trons in transit from cathode to plate, and that this action was brought about by the electrical charge on the tube's grid. The electrons were boiled off the cathode by the heat of the filament, and the tube had to have a vacuum because otherwise the grid couldn't accurately control the electron flow.

All of this is still true. So, how can a solid chunk of something very like sand do any amplifying when it has neither cathode, grid, nor plate, no vacuum in it, and no electric-charge effect worth talking about?

The answer is hinted at in the name of the device, which is a blend of "trans" meaning "through" and "resistor". The transistor is a special type of variable resistor, in which current injected (or withdrawn) from one terminal apparently goes "through" and affects current flow between the other two terminals. Incidentally, the familiar vacuum tube can be thought of in the same manner, as a variable resistor whose resistance is varied by grid voltage—and then the operating similarities between tubes and transistors become obvious. They operate in functionally the same way, except that transistors are operated by current while tubes operate by voltage.

Fig. 1 shows a simplified approximation of what a transistor does in a circuit. Placing the switch in position A, with the voltage and resistances shown, would cause one amp of current to flow through R1, with a resulting power dissipation of 10 watts. If, when we throw the switch to position B, we could keep that same one amp of current flowing through the circuit composed now of R1 and R2 in series, we would increase the power dissipation by a hundred times. This would be a form of power amplification—and in effect, this is what a transistor does.

The transistor consists of two adjacent junctions, between different types of semiconductor material known as "n" and "p" type. You can think of it as a thin slice of ham between two thick slices of bread if you like.

In a single junction, current can flow much more easily in one direction than in the other. When negative polarity is applied to the "n" side of the junction and positive to the "p" side, current flow is easy; when polarity is reversed, current flow is difficult and apparent resistance is high.

The "easy" current flow is a combination of two processes known as "injection" and "collection". The material on one side of the junction "injects" electrical charge into the junction region, and that on the other side of the junction "collects" this charge.

To get from one side of the junction to the other, the charge must "diffuse" through the junction region. In a single junction the diffusion will be either aided or hindered by the types of material involved and the polarity of the charge. This is what makes the current flow easy in one direction—when both materials aid the flow—and difficult in the other—when both oppose.

Such a single junction is widely used, for many purposes. The familiar crystal diode is one example of such a junction. The silicon power rectifier is another.

When we place the second junction adjacent to the first to turn the diode into a transistor, a number of additional happenings come into the picture. The basic processes of injection, diffusion, and collection remain the same. To obtain transistor action, though, one of the two junctions must be biased in the forward or easy-current direction while the other must be biased in the reverse or high-resistance direction. The single slab of material in the middle, which corresponds to the ham in the sandwich and is common to both junctions, controls the action.

Not all of the charge injected into this middle region or "base" by the forward-biased junction from the "emitter" material is collected by the base. Like the stream of electrons in the vacuum tube which flow past the grid to the plate, some of the injected charge passes right on through the base into the second reverse-biased junction. However, this charge is of the proper polarity to tend to forward-bias—or at least reduce the amount of reverse bias on—this second junction.

And when the amount of reverse bias is reduced, the resistance across this second junction reduces right along with it.

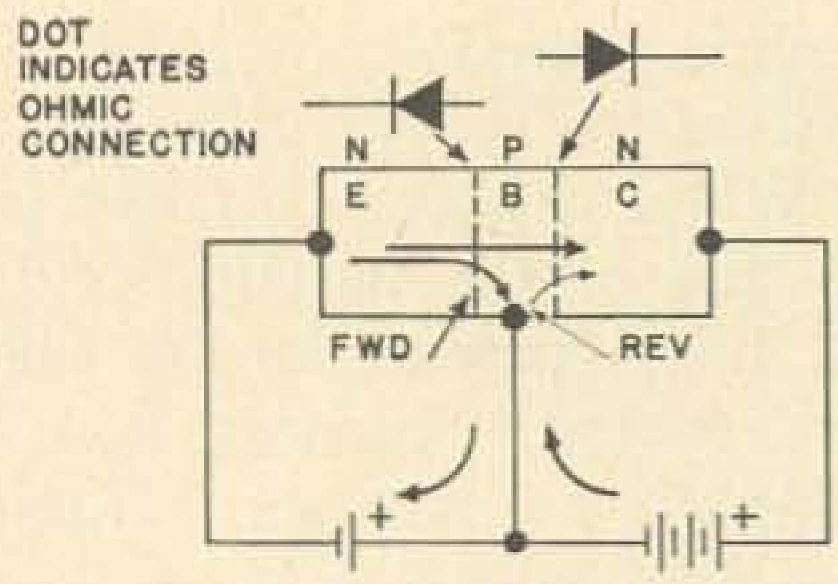


Fig. 2. Forward-biased emitter-base junction permits electron flow. Most electrons from emitter, however, pass right through the base region into the collector material, and this reduces the amount of reverse bias on the collector-base junction. The result is a variation of resistance in the collector circuit, which amounts to amplification.

In this manner, the current flow in the forward-biased base-emitter junction causes a reduction in resistance at the reverse biased collector-base junction.

If current injection in the base-emitter junction is increased by any means, the amount of charge which spills through the base to be collected at the collector-base junction will also increase. Similarly, if current in the base-emitter junction is reduced, the spill-through charge will also reduce.

Thus any variation of current in the base-emitter circuit will affect the resistance in the collector-base circuit as well.

Since current flows easily in the base-emitter circuit, this is a relatively low resistance circuit. Resistance in the collector-base circuit is much higher because of the reverse-biased junction. Because of the large ratio of the resistances in the two circuits, a small signal in the low-resistance circuit becomes a large signal in the high-resistance circuit—and we have amplification of the signal.

Fig. 2 shows how this action works in one of the three basic circuits—the common-base or "grounded base" arrangement. This circuit is of historical interest because it was the first to be used; most of today's applications use one of the other two circuits for several reasons.

As we have seen, the amplification in a transistor happens because of a difference in resistance between the input and output circuits, and the fact that the semiconductor material permits the current in the input circuit to affect the resistance of the output circuit.

It should be obvious at this point that the charge injected into the junction area from the emitter material divides between the base and the collector. While it might look as if most of the current flow would be in the base-emitter circuit and only a small part of it would be in the collector circuit, it doesn't work out quite that way. Most of the charge injected from the emitter passes right on through the base and is collected by the collector; only a small part is diverted by the base.

The ratio of collector current to emitter circuit is known as "alpha". Since the emitter current is the total of both the collector current and the base current, alpha is always less than 1. Just how much less is one of the major design features of any particular type of transistor, since alpha is the primary factor affecting the gain in any circuit. It is determined by the nature and relative sizes of the "n" and "p" materials which make up the semiconductor crystal. Early transistors had alpha factors in the neighborhood of 0.9; modern units range as high as 0.995.

This doesn't mean that the effective gain of a transistor must be less than 1 at all times. A more realistic measure of the effective gain provided by any one unit is the "beta" factor, which is the ratio of collector current to base current.

The "beta" and "alpha" factors are closely related. The closer alpha is to 1.0, the higher will be the beta. This is easiest to see by an example. Suppose we have a transistor hooked up in a circuit so that emitter current is 10 milliamps. If the alpha factor for this one particular transistor is 0.9, then the collector current will be 0.9 times 10 milliamps, or 9 mA. The base current will be the remaining 1 mA. The beta, however, being the ratio of collector to base current, will be 9/1 or merely 9.

If we put in another transistor and adjust the circuit to again have 10 mA in the emitter circuit, but find that the collector current is now 9.9 mA, then the alpha for the new transistor is 9.9/10.0 or 0.99. The remaining 0.1 mA is the base current, so beta is 9.9/0.1 or 99.

If we now try a third transistor with a known alpha of 0.995, we will find that for 10 mA of emitter current the collector current is 9.95 mA and the base current is only 0.05 mA. Beta, in this case, is 9.95/0.05, or 199. Transistors with beta ratings of 050 are not uncommon these days.

To relate alpha and beta by calculation takes only a small amount of arithmetic. Beta is equal to (alpha) divided by (1-

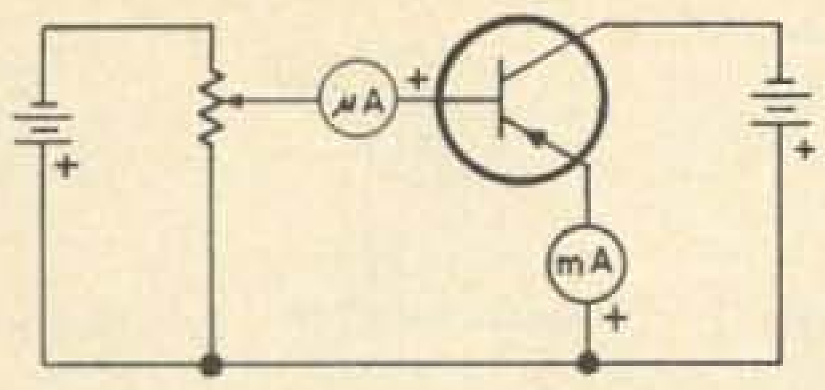


Fig. 3. Alpha factor of a transistor can be measured directly in this test set-up. Text explains technique.

alpha), while alpha is equal to (beta) divided by (beta +1). If you know either, the other can be easily determined by these relationships. Either or both can also be measured quite readily by the test setup shown in **Fig. 3.** It works exactly as our examples above were phrased; the transistor is connected and base bias adjusted for an emitter current of exactly 10 mA. The base current needed to produce this emitter current is then also measured, and subtracted from the emitter current to determine collector current accurately (beta of most modern units is so high that collector current cannot be measured with enough accuracy, directly). Beta is then calculated by dividing the collector current by the base current.

The inexpensive transistor testers so widely available use a simplified version of this scheme. Most of them use a battery and a large resistor to provide an approximately constant-current source of some 100 microamperes in the base circuit, and measure collector current with a meter calibrated directly in beta. If the base always gets 0.1 mA, then 1 mA on the meter represents a beta of 10, 2 mA is a beta of 20, and so forth. To check high-gain units, base current is reduced to around 10 microamps; 1 mA in the collector circuit then represents a beta of 100, 2 mA is 200, and so on.

Fig. 4 shows how this type of tester works. Despite its simplicity, it is as accurate as most tube testers.

Because the transistor works by a resistance relation, its input and output circuits are more closely connected to each other

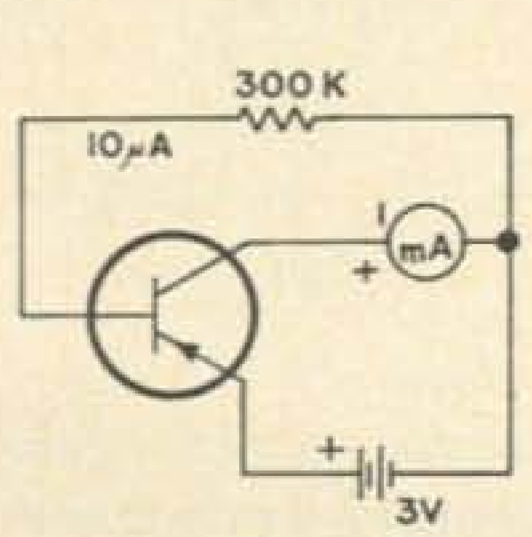


Fig. 4. This much simpler test circuit can read beta of a PNP transistor directly from meter. To use it with NPN units, reverse battery and meter polarities.

than are those of tubes. Alpha, beta, total circuit gain, and many other characteristics are affected by both the input and output components external to the transistor. We'll get into this deeper in the next question—the major point right now is that accurate prediction of how a transistor will perform in all possible circuits is not practical.

Because of this, the manufacturers rate them under a small set of rigidly specified input and output conditions. These are (1) input shorted and output open circuited; (2) both input and output shorted, (3) input open-circuited and output shorted, and

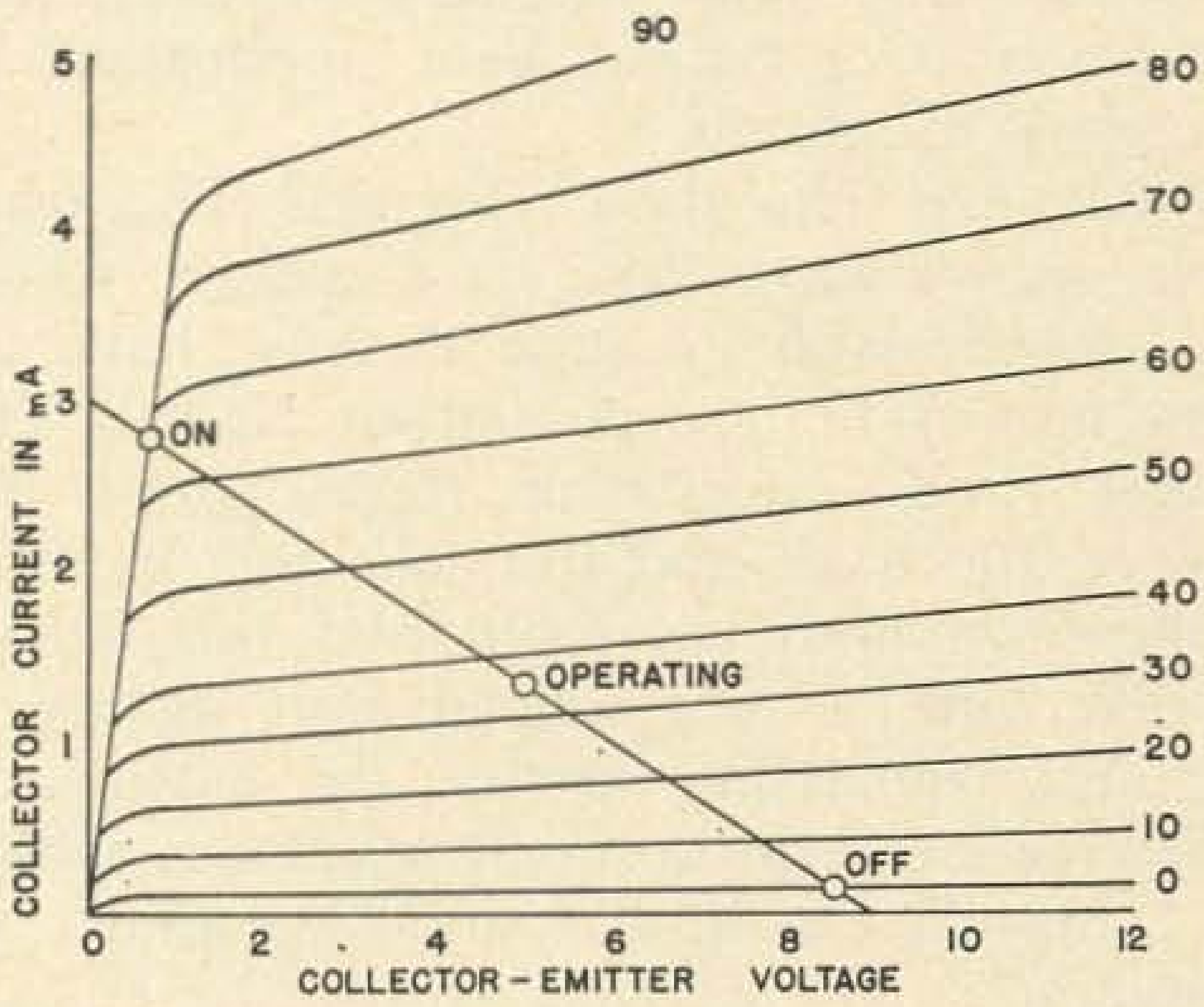


Fig. 5. Characteristic curve of a typical transistor is similar to that of a tube. Each curve in this family represents the collector voltage-collector current relationship for a single value of base current. Diagonal line is "load line" for 3000 ohm collector load resistor; Point labeled "operating" is bias point to operate as an amplifier with this load resistor. "On" and "Off" points illustrate switching action explained in the text.

(4) both input and output open. Of these, the first and third are most applicable to most circuits. The second applies only in a few special circuits, while the fourth is almost never used and can even destroy many types of transistors.

The characteristics of any particular type of transistor are measured under these specific conditions, and published as charasteristic curves similar to those available for tubes. The conditions for each curve are always noted, but sometimes the notations are in engineeringese. **Fig. 5** shows a typical characteristic curve. These curves are used to predict transistor performance in the same way that tube curves are used to predict how a type of tube will perform in any planned circuit.

The curve in **Fig. 5** shows how gain is affected by the amount of base bias supplied to the unit; the wider apart the horizontal lines are, the greater the beta and the higher the gain. With either too much or too little bias, gain falls off rapidly; operating conditions are rather critical.

With almost no bias, the gain falls to zero and current is virtually cut off. With excessive bias, the gain again falls to zero because the collector-base junction's resistance is as low as it can get. These two points, labelled "off" and "on" respectively in **Fig. 5**, are widely used in digital circuits—at these points, a transistor is a better switch than most ordinary switches. The TO keyer is a typical ham application of this type of circuit.

What Are The Basic Circuits? The transistor, as we have seen, is a gadget which can amplify—and as such it must have an input circuit and an output circuit. The gadget itself consists of three parts: the emitter, the base, and the collector. In most applications both the input and the output circuits work a "hot" signal lead against a "ground" connection so that the entire amplifier has only three signal terminals, which are "input", "output", and "ground" or "common".

This is not unique to transistors. With vacuum tubes we have the grounded-grid circuits and the cathode-follower or grounded-plate, as well as the conventional grounded-cathode arrangement.

Since the transistor has three internal components, we can choose any *one* of these three as the "common" or grounded element. This leads us to the three basic circuits for transistors—the common-emitter, common-collector (or emitter follower), and common-base (grounded base) circuits.

The word "grounded" is sometimes used to replace the compound adjective "common-" in the circuit names; the FCC study list uses "grounded" but most present writings appear to prefer the "common" phrasing.

Fig. 6 illustrates these three circuits, stripped to their basics. You can see that in every case, input signals are applied to the base-emitter circuit and output is taken off in the collector-base circuit—but the three circuits differ drastically in their characteristics because of the different ways in which they relate input and output circuits to each other.

For instance, in the common-base circuit

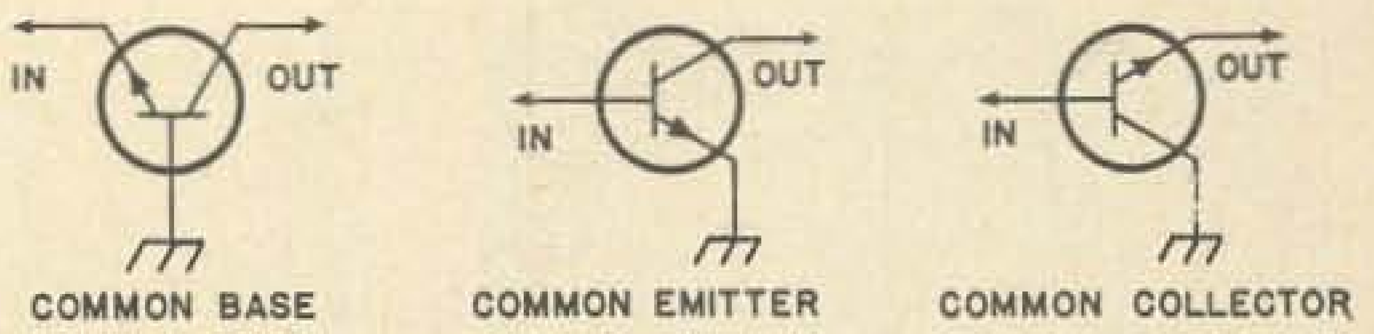


Fig. 6. The three basic transistor circuits are shown here. While all are related, characteristics of each differ from the others.

shown in **Fig. 7** the input and output circuits are about as isolated from each other as it is possible to get with a transistor. The only point in the entire circuit at which both input and output currents are present is the transistor base (including its leads back to ground). The input circuit consists of the base-emitter junction and bias arrangement. The output circuit consists of the collector-base junction and its bias and load arrangements.

In this circuit, the input circuit sees a forward-biased junction and so exhibits very low impedance. The output circuit, on the other hand, contains a reverse-biased junction and so is of very high impedance. The circuit corresponds to the vacuum-tube grounded-grid amplifier, and offers the same advantages of high-frequency operation with good power gain.

The common-collector circuit shown in **Fig. 8**, on the other hand, makes the output circuit an integral part of the input circuit so that the output tends to completely "buck out" the input signal. The input circuit consists of the base-emitter junction, the load resistor in the emitter lead, and the power supply (with the common point passing through the power supply). The output circuit consists of the forward-biased base-emitter junction (which acts for it as a low-valued resistor), the base-collector junction, and the emitter load resistor.

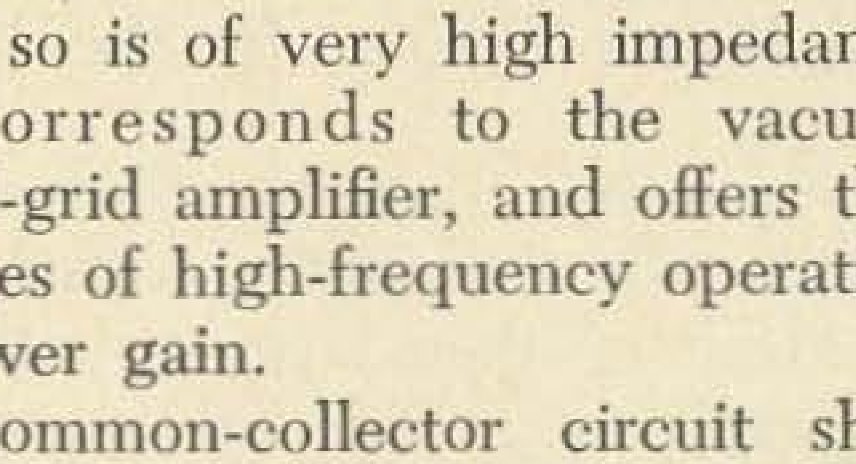


Fig. 7. Common base circuit was earliest. It has voltage gain, but no current gain. Input impedance is low and output impedance is high. Transformer input shown here can be replaced with coupling capacitor as in subsequent figures. Similarly, output load resistor can be replaced by transformer primary.

Since actual active input must be applied between base and emitter, while the output appears across the emitter resistor, the actual active input to the transistor in this circuit is much smaller than the applied input signal. In fact, the signal seen by the transistor is equal to the applied input signal *minus* the resulting output signal. If a 1-volt ac signal is applied and a 0.9-volt ac signal is produced at the output, the effective input to the transistor is only 0.1 volt and the transistor itself is performing at a gain of 9 although the circuit's gain is only 0.9.

With the effective input reduced by an amount proportional to the transistor's current gain (beta), the current flow in the input circuit is reduced by that same factor. Since we did nothing outside the circuit to reduce the applied input signal, this has the effect of multiplying the input impedance of the transistor by its beta and so the common-collector circuit has high input impedance.

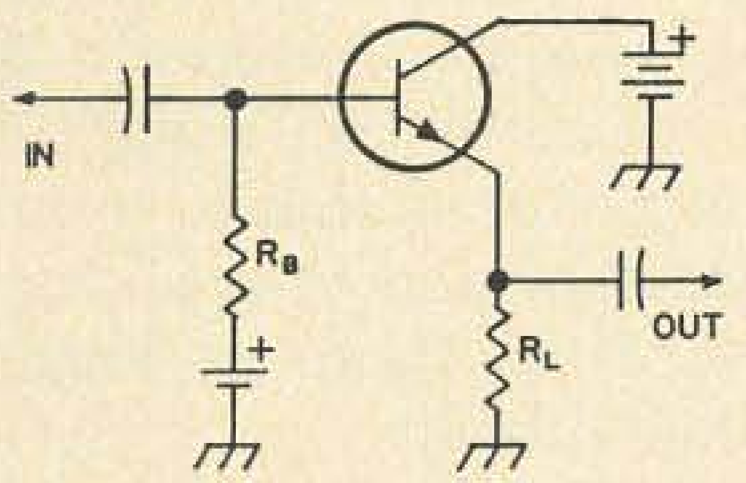


Fig. 8. This is common collector circuit. Both input and output current flows through load resistor R_L and the result is high input impedance, low output impedance. Voltage gain is less than 1, *but current gain can be high.*

The bucking-out action we have just examined affects *voltage* in the output circuit but does nothing to hold down the *current*. The output current is as great as our load resistor and operating point will permit, but the voltage associated with this current is reduced by the buck-out. This causes output impedance of the circuit to be divided by transistor beta; the result is very low output impedance.

The common-collector circuit, then, corresponds to the vacuum-tube cathode follower. It has high input impedance together with low output impedance, and voltage gain is always less than 1. With high-beta transistors, though, voltage gain can be almost up to 1. It will be, to a first approximation, equal to the transistor's alpha factor —which can exceed 0.995.

The remaining basic circuit is the common-emitter arrangement shown in **Fig. 9.** This one acts in a manner midway between the other two. The input circuit—the base-emitter junction and its bias arrangement—is relatively unaffected by the output circuit, but in the output circuit the base-emitter junction is placed in series with the collector-base junction. This reduces output impedance by a bucking-out action, but the buck-out is much less than in the common-emitter since only a part of the output signal appears across the base-emitter junction while in the common-emitter the entire output signal appears in the input circuit.

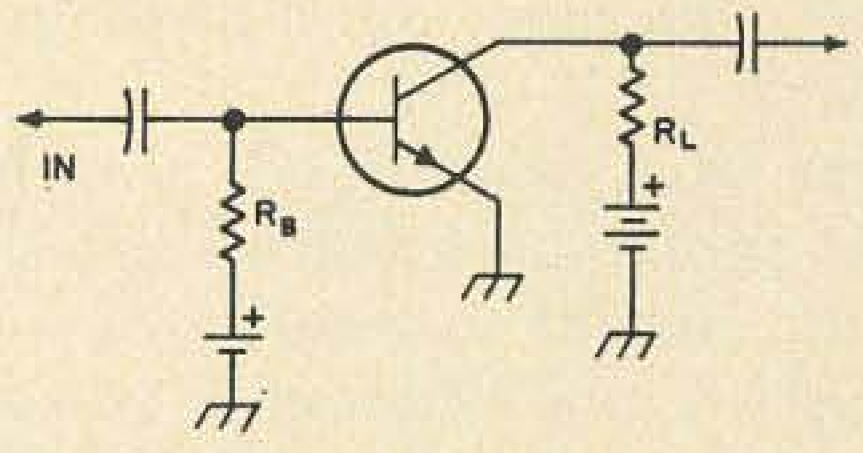


Fig. 9. Common-emitter circuit shown here is most widely used. It has both current and voltage gain, and so is only transistor circuit exhibiting appreciable power gain as well. Both input and output impedances are moderate.

The fraction of the output signal which does appear in the input circuit tends to increase the input impedance in much the same manner as in the common emitter. Again, the effect is much smaller.

Both the common base and the common collector circuits represent extremes—input /output isolation in one case and total interaction in the other. The common emitter circuit represents a compromise between these two extremes, and all its characteristics are intermediate between those of the other two. Voltage gain is moderate; not so high as in the common base but much higher than the common collector. Current gain, which is less than 1 in common base but almost equals beta in common collector, is also moderate. Since power is the product of voltage times current and the common emitter circuit is the only one in which both voltage and current gain exceed 1, it has the greatest power gain of the circuits.

Input/output isolation is only moderate in this circuit, which limits the frequency response and makes accidental feedback a possible problem. However, the common-emitter circuit, like the vacuum-tube grounded-cathode circuit to which it corresponds, is the most widely employed in practical applications because of its power gain and preponderance of advantages over disadvantages.

You may have read elsewhere of the peculiar problems involved in adapting vacuum-tube circuits to transistors. Most of these problems are not inherent in transistors themselves, but are the product of the fact that the first transistor circuit used was the common base version. The same problems are present in grounded-grid vacuum-tube circuits—they're the problems of adapting one type of circuit to another type, not those of changing from one kind of component to another. The fabled "low impedance" of transistors, in particular, is apparent only in common base. With run-of-the-mill transistors, impedances equal to those of tubes can be obtained by proper blendings of the circuit types used. Common-collector circuits with high-gain transistors can have as much as 10 megohms input impedance; few vacuum tubes can stand that much grid resistance without developing "contact potential" bias problems!

What are the Transistor's Advantages? In the 20 years that transistors have been on the scene, they have virtually replaced vacuum tubes in many applications. Obviously, then, they must have some advantages over tubes. What are they?

The major advantages of the transistor as compared to the tube fall into three categores—size, power requirements, and reliability.

The size advantage enjoyed by the transistor is obvious to anyone. Typical transistor sizes are much smaller than those of tubes with comparable characteristics. The action of the transistor occurs within the atoms which make up a single crystal of semiconductor material—that of the tube occurs in a stream of electrons flowing from one physical element past another to a third. Today's integrated circuits were made possible by the transistor's capability of being reduced to truly microscopic size; the smallest tubes are still easily visible.

Power requirements for a transistor are much less than those for a tube of comparable abilities. The largest part of the power reduction comes about because the transistor needs no heater to make it work. Most tubes, also, require much higher operating voltages than do similar transistors, even though some tubes do operate at low voltages and some transistors are capable of operating at vacuum-tube voltage levels.

With no heater, the transistor also runs much cooler than does a tube. Even a power transistor normally is cooler to the touch than is an ordinary low-power tube. This reduction of heat in the circuit adds to the size advantage by permitting transistors to be packed into more compact spaces, and is in itself an advantage since no special cooling is required in many applications.

The most spectactular advantage, however, is in the area of reliability. A tube operates by boiling off electrons from its cathode. Eventually, the tube wears out and must be replaced. Even before this happens, the tube is likely to become gassy—or to be burned out or broken.

The transistor, on the other hand, operates by the injection of electrons into a crystal. No boil-off is involved, and there is nothing in the basic action to cause the device to ever wear out. The transistor *can* become contaminated, which corresponds to the tube going gassy, and it *can* be burned out—but if manufacture is controlled with enough care, contamination is not likely, and if the circuit is properly designed and operated, burnout is equally unlikely to occur. The result is that a transistorized circuit can be expected to perform properly for from 10 to 1000 times as long as a similar circuit using tubes.

So far as breakage is concerned, this is easy to demonstrate. Just put a tube and a transistor side by side at the edge of a table, and sweep both over the side onto the floor. After picking up the broken glass from the tube, test the transistor. It will probably be working perfectly.

The reliability of the transistor is what has made the digital computer industry, to cite but one example, possible. Premium tubes have a life expectancy of around 50,000 hours. If a circuit requires 100,000 tubes, the law of averages tells us that we can expect a burnout on the average of once every half-hour. This means that the longest period of operation we can expect from this complicated gadget is 30 minutes.

Similar quality transistors, however, have an estimated life expectancy of over 8,000,000 hours (the reason that it's estimated is that nobody has been able to run a test long enough yet to be sure that the figure is accurate). If those 100,000 tubes are replaced by transistors, then failure can be expected only once in 80 hours. The reliability of the device has been improved by

160 times—and any device that complicated can do any job expected of it in less than 80 hours.

While the figures may sound a bit extreme, many modern industrial devices contain tens of thousands of transistors. Such devices simply were not practical during days of tubes. This is, then, the major advantage enjoyed by the transistor.

What are the Disadvantages? We have seen that the transistor's advantages over the tube are primarily those of size, lower heat, less power required, and greater reliability. Why, then, have they not replaced all tubes?

Transistors do have some disadvantages. The greatest of these are in the area of high-frequency capability, and power handling. Both are being overcome, but it's a safe bet that in applications which involve both high power and high frequencies, tubes will be preferred for many years to come.

The first transistors were limited to low-frequency use. In fact, they did not perform adequately even over the audio-frequency range, and use at *rf* was impossible. The limit was pushed gradually higher until broadcast-band operation became practical —and kept going higher. Today, inexpensive transistors which perform nicely at 50 and 144 MHz are available. In fact, they outperform tubes at VHF frequencies today, having noise figures which are much lower than those of even premium tubes.

The first transistors, also, were limited to very low power. Even in the *af* region, they were unable to develop enough power to drive a loudspeaker. Like the quest for higher-frequency operation, the search for additional power moved forward. Audio power transistors became available, and some years later *rf* power transistors hit the scene. Today it's possible to build a 100-watt 6-meter transmitter using nothing but transistors.

However, the disadvantages are still present. That 100-watt transistorized transmitter is going to cost you more than would a kilowatt with tubes—and if you want a full gallon the tube is still the only practical choice at 6 meters. At any higher frequencies, the power capabilities are much less.

So, while it is *possible* to use transistors instead of tubes for power applications at *rf*, it's still much more expensive—and this is in itself a disadvantage.

There are some electrical disadvantages too. A transistor is, by its very nature, a voltage-variable capacitor as well. In high-frequency circuits, this capacitance can hamper action of the circuit. The transistor is a triode type of device, and so far it hasn't been practical to introduce elements which correspond to the tube's screen or suppressor grids. This prevents the transistor from being used in circuits which make use of these elements. Isolation between input and output circuits is much greater with tubes than with transistors.

Tubes are operated by voltage changes while transistors operate by current variations—and this means that a transistor must impose some load upon its input and output circuits while a tube can be made essentially a non-loading amplifier.

The net result is that, while the transistor's advantages make it the preferred choice for many types of uses, its disadvantages rule it out for many special applications.

What are the Critical Factors When Using Transistors? The basic differences between tubes and transistors come out most clearly when a designer attempts to put a transistor into a circuit. Because of these basic differences, transistor circuits have a number of critical factors which can be almost ignored when using tubes.

The two major critical factors are voltages and heat. The active area of a transistor may be no more than a few atoms in thickness. Since it is so thin, any applied voltage which is too high can cause "punch-through" which is similar to the puncturing of a capacitor. When punch-through happens, the result is a dead short at that point. Transistor action ceases and the device turns into a low-value resistor.

Punch-through can be either temporary or permanent, depending upon the power available at the puncture region. A temporary punch-through is of little consequence—as soon as the over-voltage is removed the problem is over. If, however, enough power is available, the transistor material is melted at the punched-through spot and the damage becomes permanent.

Since the material involved is so very small, it doesn't take much power to be "enough". A few milliwatts is more than adequate in most cases. For this reason, transistors should always be protected against over-voltage. The over-voltage may be in either the power supply or in the

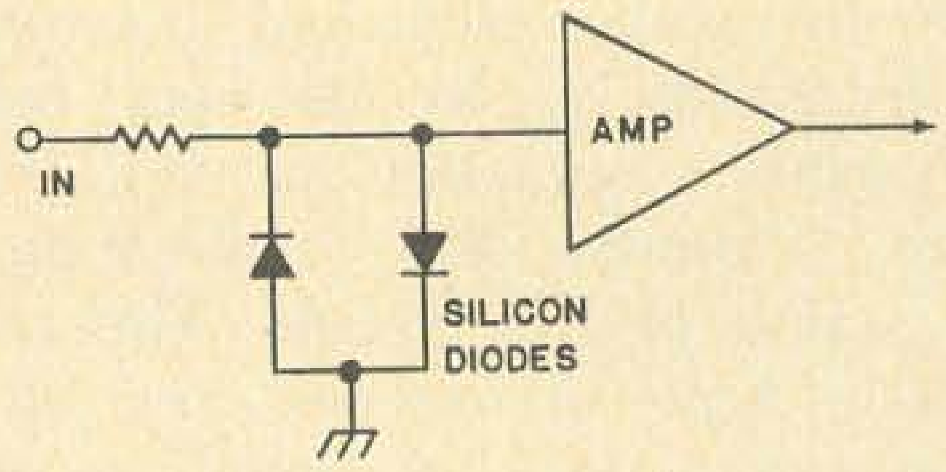


Fig. 10. Amplifier can be protected against excessive input signal voltage as shown here. Diodes are essentially open circuits at voltages less than threshold (about ½ volt) and have no effect on small signals. Above the threshold, diode becomes short-circuited and cuts off overvoltage signal.

signal circuits—a voltage peak in the applied signal is one of the most frequent causes for punch-through. The remedy is to incorporate voltage-limiting ahead of the transistor so that no input signal can exceed safe limits. **Fig. 10** shows such a safety feature; the parallel diodes limit input voltage to a maximum of half a volt and the rest of the amplifier is then designed to handle any voltage which can result from a half-volt input signal.

Over-voltage spikes on the power supply lines may be prevented by extensive decoupling, or by regulation of the power supply. A good battery is one of the best power sources since it is inherently regulated.

Heat is a critical factor for several reasons. If a transistor heats, its normal operating conditions are altered. The energy present as heat has the safe effect as an increase in input signal and power-supply voltages, and all characteristics change.

In addition, when the inside gets hot enough, the crystal structure which is basic to transistor action begins to melt and change. This change in the crystal structure destroys the transistor and turns it into a useless hunk of semiconductor material.

In fact, the damage done by over-voltage is actually done by the heat which results from the over-voltage condition.

Some heat is always present in a transistor, since it does its amplification by changing the resistance of the collector-base junction. Current is passing through this resistance, and whenever current passes through a resistance heat is generated.

This resistance is primarily in the collector-base junction, so that the heat of the junction is the primary factor. Transistors are rated for power capability on the basis of their ability to withstand this heat, and to carry the heat away from the junction as it is generated. Power transistors have larger collectors, which are designed to carry the heat away more rapidly—and to operate at their maximum power ratings even these must be connected to "heat sinks" which help carry the heat away.

If the heat generated in the collector-base junction is not carried away fast enough, it acts to change the transistor's internal operating conditions just as would an increase in applied voltage. More current flows—and the more current, the greater the heat. As heat increases, still more current can pass. The condition is known as "thermal runaway" and leads to rapid destruction of the transistor. Once a transistor enters the runaway condition, nothing can stop it until it is using all the current available to it or has melted itself.

When the junctions get hot enough, the base loses all control of operating conditions, this is the true "runaway" condition since no control is possible from the input circuit. The only control available is to prevent runaway from occurring.

The primary preventive measure we can use is to keep the transistor cool. This means using large enough heat sinks and assuring that enough air is available to keep the temperature within limits.

A secondary preventive measure is available by using an emitter resistor as shown in **Fig. 11.** Under normal operating conditions, the voltage appearing across the resistor is a part of the normal bias arrangement. When the transistor heats and "leakage" current (that current due to heat and not controlled by the base) increases, the voltage across the resistor increases and thus *subtracts* from the original bias voltage. This reduces the controlled current flow; if the reduction is sufficient, then heating will

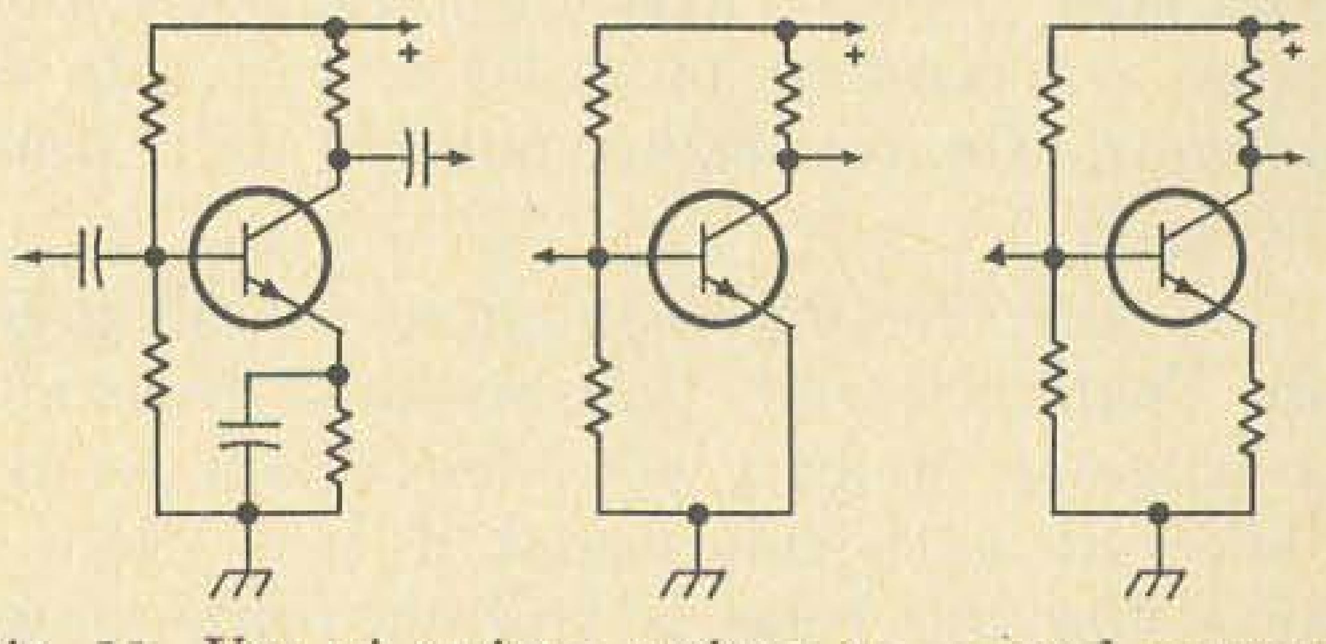


Fig. 11. Use of emitter resistor to control runaway depends upon its effect on base-emitter junction bias. At far left is full circuit; at center is that part of the circuit seen by ac signals, while that part at right is effective to dc levels. Drop across emitter resistor increases as transistor heats, reducing bias and cutting down on dc current flow. This limits maximum current.

be reduced and so will the leakage current. If, however, the runaway condition is reached, the reduction will have little effect upon the current.

The final preventive measure, which cannot be applied in many circuits, is to limit the amount of current available to the transistor so that it can never obtain enough current to melt itself under runaway conditions. Unfortunately, the circuits most likely to run away are those which must handle high power—and limiting the current also limits the power which can be produced by the circuit.

Any attempt to operate a transistor at a power level higher than that for which it is rated is almost certain to result in runaway. Additional heat sinks won't help, because a heat sink can only carry away the heat which gets to the outside of the transistor. If heat is produced *inside* faster than it can get out, then the junction itself will keep getting hotter and runaway will occur.

Most power transistors are rated under at least two conditions—without heat sink, and with "infinite" heat sinking. The first rating is usually identified in that manner; the second may be called "absolute maximum power". The first rating determines the power which may be applied to the transistor with no heat sink at all. The second tells us how fast the heat can get out; exceeding this second rating just about guarantees us a melted transistor.

Another factor involved in using transistors, which is less critical than the others, comes about because transistors come in two "flavors"—PNP and NPN—while tubes come in only one, which corresponds to the NPN transistor. The two types of transistors require supply voltages of opposite polarity. A PNP transistor requires that its collector be negative with respect to the base, and that the emitter be positive to the base, in order to operate. The NPN unit is just the reverse.

It's rather easy to apply wrong-polarity power to a transistor circuit; what happens then depends largely upon the circuit itself. If only one of the junctions gets the wrong polarity, the transistor may be instantly destroyed. If, however, both get reverse polarity the circuit may even operate after a fashion—but the actual collector will be serving as an emitter and vice versa. Some care should be taken when connecting power since it is possible to damage the transistors, but this danger has been overrated in the past. The reason for its emphasis in earlier days was that separate power supplies were usually used for input and output circuits, and if only the output circuit polarity should be reversed instant destruction was the result. Modern circuits usually use only one power source for all circuits, and reversing of that source normally causes no damage.

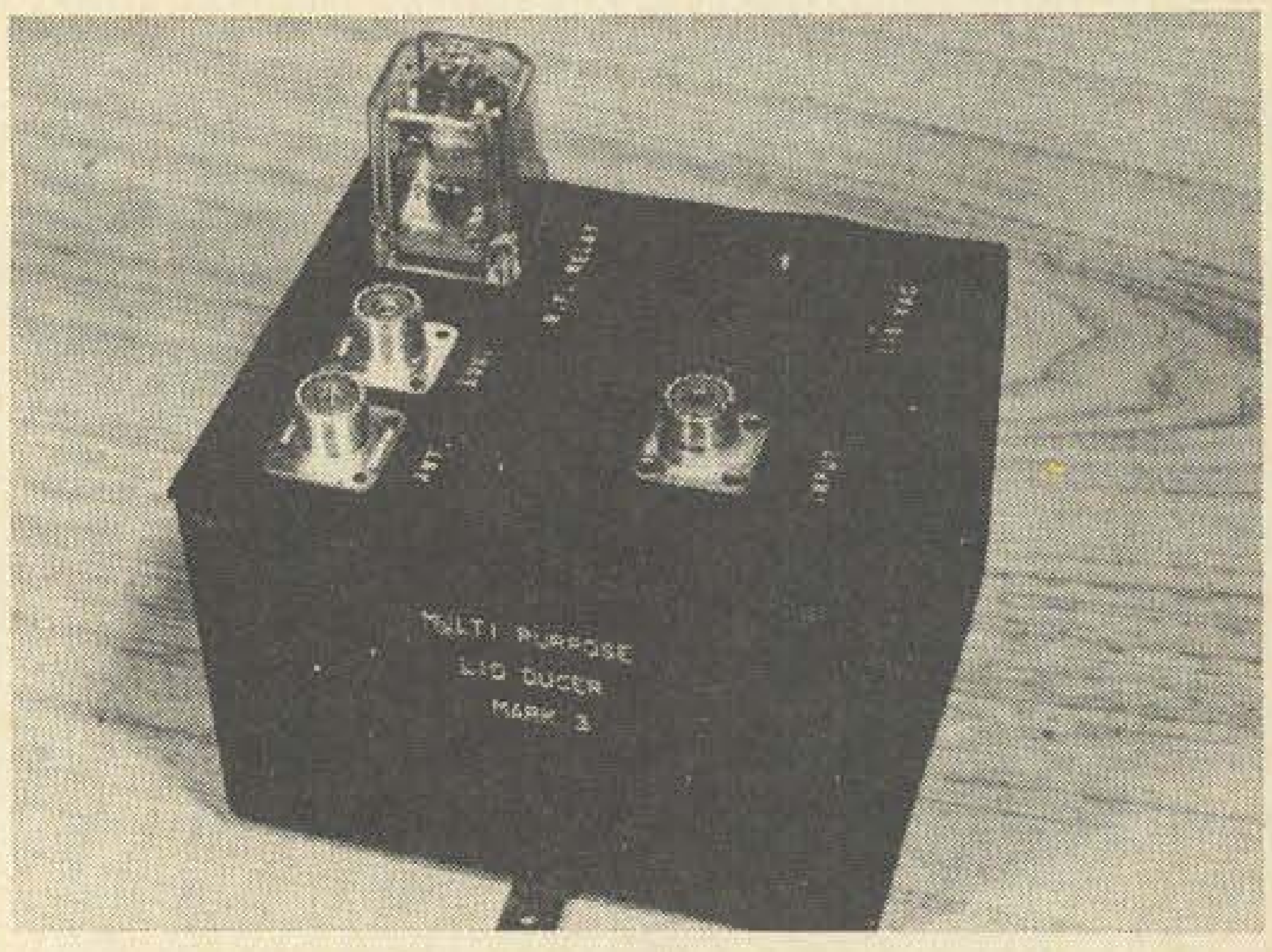
Next Month. Only a few questions remain to cover the FCC study list. Next time around we'll cover half of them, looking at power supplies, transmitter adjustment, and some find points of *rf* tube design. ■

RENEWAL CODE

The two numbers under your call on the address label are the expiration code. We have tried to make it simple. The first number is the month that we send you the last copy on your subscription and the second number is the year. 78 would be July 1968, for example.

Ipecac Works on Lids

Robert A. Manning K1SYD
915 *Washington Rd.*
P.O. Box 66
West Rye, N.H. 03891



Inside the cavern, the noise was deafening and minor skirmishes broke out from time to time between delegates. One teenage Extra class was severely skewered with a Hustler 20 meter mobile resonator, deftly wielded by an irate Technician, who had taken issue with the youthful Extra for using his 6 meter halo as a basketball hoop. Although the auditorium sounded somewhat akin to 75 meters during sweepstakes weekend, the chairman did manage to restore a semblance of order. Using the normally oversized jawbone of a rag chewer (long since departed) as a gavel, he pounded on the skull of a Citizen Bander (the exact animate or inanimate state of this resoundingly hollow cranium could not immediately be determined. However, I assumed that its former owner too had long since departed this mortal soil, since its oral orifice remained motionless).

Calm, thusly restored, I found myself seated between a YN3 DX hound, who occasionally muttered, "CQ-DX," a Mexican BPL mumbling constantly about listing messages for Garcia and directly behind a WN2, who made several attempts to plug an 80 meter crystal into my nostrils.

I had, by default, been chosen to go to the Carlsbad Caverns to attend this, the first universal conclave of IPECAC (International Party for the Elimination of Cads and Acrimonious Cuckoos). The original delegate, an antenna experimenter, had been working on a remotely controlled sliding bazooka balun connected to a counterweight through a pulley. An unfortunate miscalculation caused the mechanism to misfire, dropping the counterweight which, because the experimenter neglected to let go, snatched him unceremoniously off his feet, up 54 feet of tower, through the 2" O.D. bazooka, and the even smaller pulley, then dropped him, 9 feet taller and considerably thinner, back to the cement base. His health is good, his bones are mending, but he was unable to attend due to a predictable difficulty in obtaining clothes to fit.

IPECAC is comprised of amateurs from all nations and all special interest groups and is dedicated to reducing or completely eliminating 'lids' and acts of lid-man-ship. For years it has been the considered opinion of these amateurs that 'lids' were not merely pests, but the largest problem facing amateur radio; larger even than the problem of the "SPONCH," that nasty subliminal creature, developed and nurtured by Vidiots (Video Idiots), who creeps up your mast and at that precise moment that you are, after years of patience and effort, about to make that all-important contact needed to complete W.A.C., W.A.S. or DXCC, sucks up all your radiated power. The "SPONCH" is the real cause behind the many laws not in effect pertaining to amateur radio that state, in effect, that the least desirable occurrence is most apt to happen at the least opportune moment. Oft times, the "SPONCH" will sit at the apex of your "V" gleefully waving a lightning rod during the one thunderstorm of the year when you forgot to ground your antennae.

While IPECAC is now universal, the originators—or founding fathers—came from a small group of net control stations who, in trying to work through QRM caused by 'lids,' had suffered some tangible harm. One common occupational hazard called, "Merging Ears" or "The Flounders" has claimed many a victim. It is caused by, over a period of time, increasing the tension between earphones and against the ears which gradually compresses the head. One such net controller recently amazed a Ham gathering by revealing an uncanny ability to look through a keyhole with BOTH eyes; Another discovered that his nostrils were now wider apart than his eyes and one ill-fated YL, dressing up for an eye-ball QSO, was startled to learn that she could accommodate only ONE earring.

Besides this, and other, physical impairments resulting from contending with 'lids' there is usually a great deal of mental stress involved. Reactions differ, but a good example is that of one infuriated operator, who physically attacked his rig, driving a #2 phillips screwdriver straight through the plate meter—not only ruining the meter, but arc welding the T/R switch to the load capacitor and placing himself in distinct danger of being instantaneously burned to a cinder.

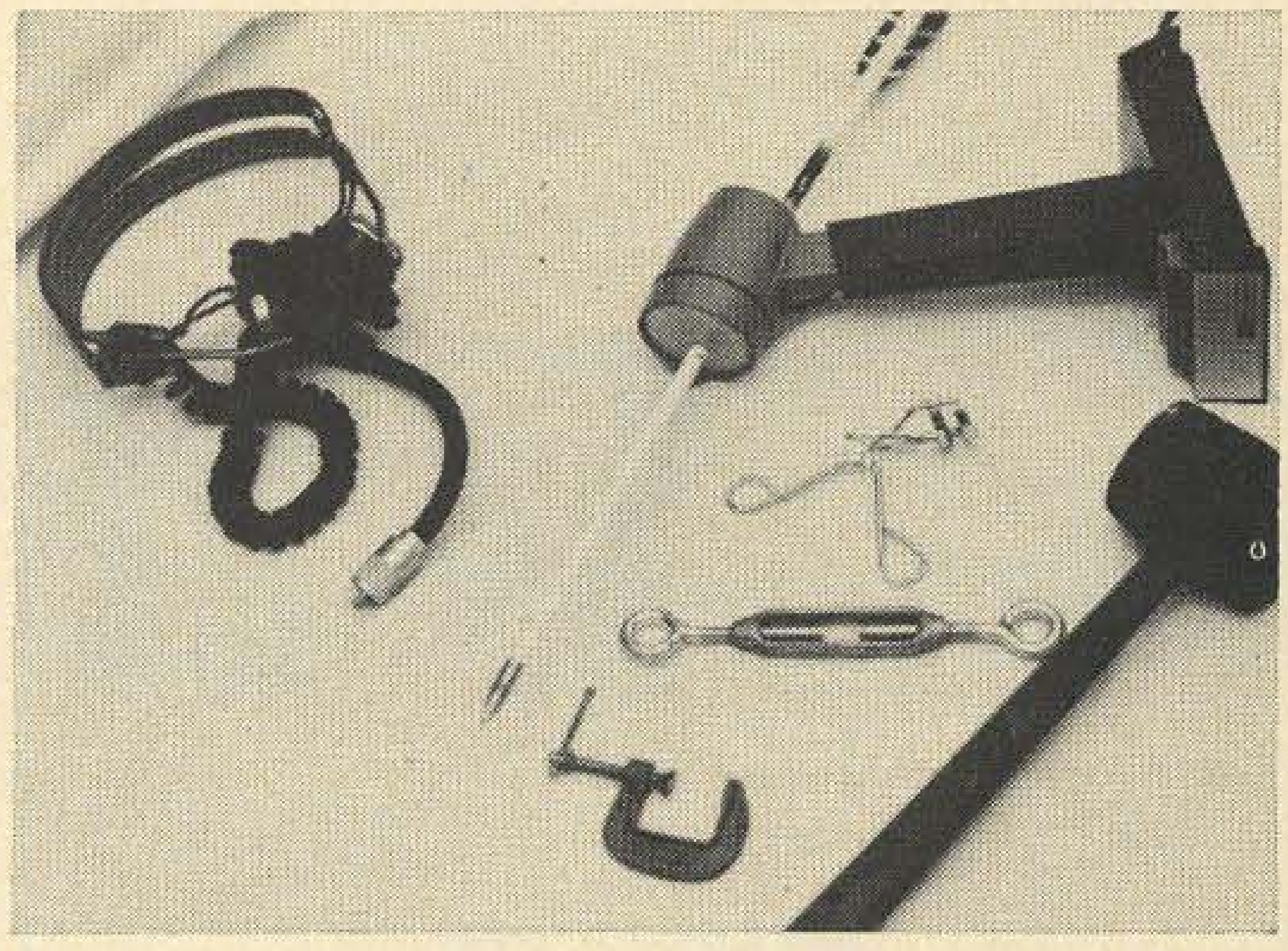
The straw that finally broke the camels back, however, and caused the unification of all anti-lids and the formation of IPECAC was the epic drama of a very well known and well liked ham. One afternoon, after battling lid after lid, he raced, in a fit of pique, into his yard armed with a double bladed axe and proceeded to chop down his antenna structure, forgetting momentarily that his equipment was VOX operated. When the structure finally came tumbling down, the ensuing thunderous clatter activated the VOX and the resulting RF output fused a 4 element quad, two yagis, a multiband inverted "V" and the operator together into one hopelessly tangled jumble of loose ended junk. The operator was transfixed in an anatomically impossible position at the center of a vortex of what appeared to be a stilted midget battling a horde of colossal aluminized praying mantis. Fortunately, Andy Wharhol happened along and affixed his signature to the mass. It is, as a lasting memorial and mute testimony epitomizing the need for lid elimination, now on display in a New York Op Art Gallery entitled, "Man and his orderly life plan."

Since, all too often, a member of one special interest group may erroneously label a member of another special interest group a 'lid' simply because their interests differ, one of the purposes of this conclave was to clarify exactly what a 'lid' was, and is.

A 'lid' (believed by many to be a contraction of **L**'il **ID**iot) can be simply defined as an operator who, intentionally or unintentionally, operates in a manner prejudicial to the enjoyment of others or conducts himself in a manner that projects an ungentlemanly – or poor ham – 'image' – in short, like the fella who smokes in bed, a lid is prone to make an ash of himself.

From all reports, lids are definitely on the increase, which precipitated the secondary mission of IPECAC—to find an alternative to the Wouff Hong. This instrument is too rarely used to prove a very effective deterrent, yet its occasional use renders it a ridiculous and purposeless outrage. For as it is now applied, the Wouff Hong is nothing but an arbitrary discrimination against an occasional, and most times, dim-witted victim.

Some members of IPECAC were thoughtful enough to bring along samples of their ingenius Wouff Hongs (see photo).



In the upper left hand corner is the Nordic /Germanic "SVENKA"—the earphones are connected directly to the *rf* output (a rather sneaky method of creating L.C.'s). The two screw type devices in the lower center are the "ANTI BUTTON PUSHING THUMB DISABLER" from Britain and the "WAGGING TONGUE LIMITER DINGUS" from Australia. The lower right hand corner contains the Russian "GRONSKY"—a heavy rubber mallet employed in, on, round and about the head and shoulders by a Neanderthal type from the upper Ural regions. Just right of center is the ingenious "PERUVIAN FINGERNAIL PINCHER"—and last is the somewhat crude, but highly effective, "PFFFFFFFT" used by almost all the Pygmy nations—it is sometimes dipped in curare for a "total" effect.

During the evenings, IPECAC members behaved as most conventioneers—squirting boutonniers—hand buzzers—bags of water off the stalagtites and the ever popular, "Girlie in the cake" who, in this instance, burst out of an electrolyte cake, moulded n the form of the new FCC Headquarters, clad in two IRC coupons, a W1AW QSL card strategically placed, and various other items inherent to amateur radio. I guess I'm not much of a Stag Party man, because when she stepped on a glazed whipped cream figurine of Ben F. Waple, slipped and broke her "S" meter, I was secretly pleased.

There was only one real 'incident' during this skip distance revelry; one of the Russian certificate hunters came to the alcoholic conclusion that the olive in his martini was a concealed microphone and before anyone knew what was happening, he'd wired up a resonant Vic Tanny reject, worked 23 States, 3 Continents and placed second in the Fargo, North Dakota QSO Party.

In defining a 'lid' the IPECAC congress conceded that over 90% of all acts of lidmanship were perpetrated by 'good' amateurs in a moment of careless thoughtlessness and/or ignorance. This decision inspired the belief that gentle reminders would adequately replace the extreme applications of Wouff Hongs.

Consequently, a group of experimenters made up of three nationalities—Americans to conceive ideas, Russians to claim the ideas and Japanese to mass produce the item at ¼ of the cost while the other two groups argued—worked throughout the nighttime revelries to perfect what came to be known as the Lid Reducer—or "Lid-Ducer." —While the Mark #3 prototype "Lid-Ducer." shows promise, it is very loose in design and could stand some refining. However, the basic precept is sound and could/should become a standard incorporated feature in all amateur radio equipment.

When the Lid-Ducer was unveiled for IPECAC, most members wanted a practical demonstration. Volunteers were as rare as Rhode Island stations during a contest. A safari of scroungers (a common ethnic group among amateurs) was dispatched to recruit a volunteer. They returned with a 'jiggler'—you all know what a 'jiggler' is—he's the 8 handed fumble fingered jerk who invariably stumbles into your shack while you've got six hundred dollars worth of parts laid out on your bench and, despite repeated warnings, both oral and written, has an uncontrollable urge to jiggle a switch, fiddle

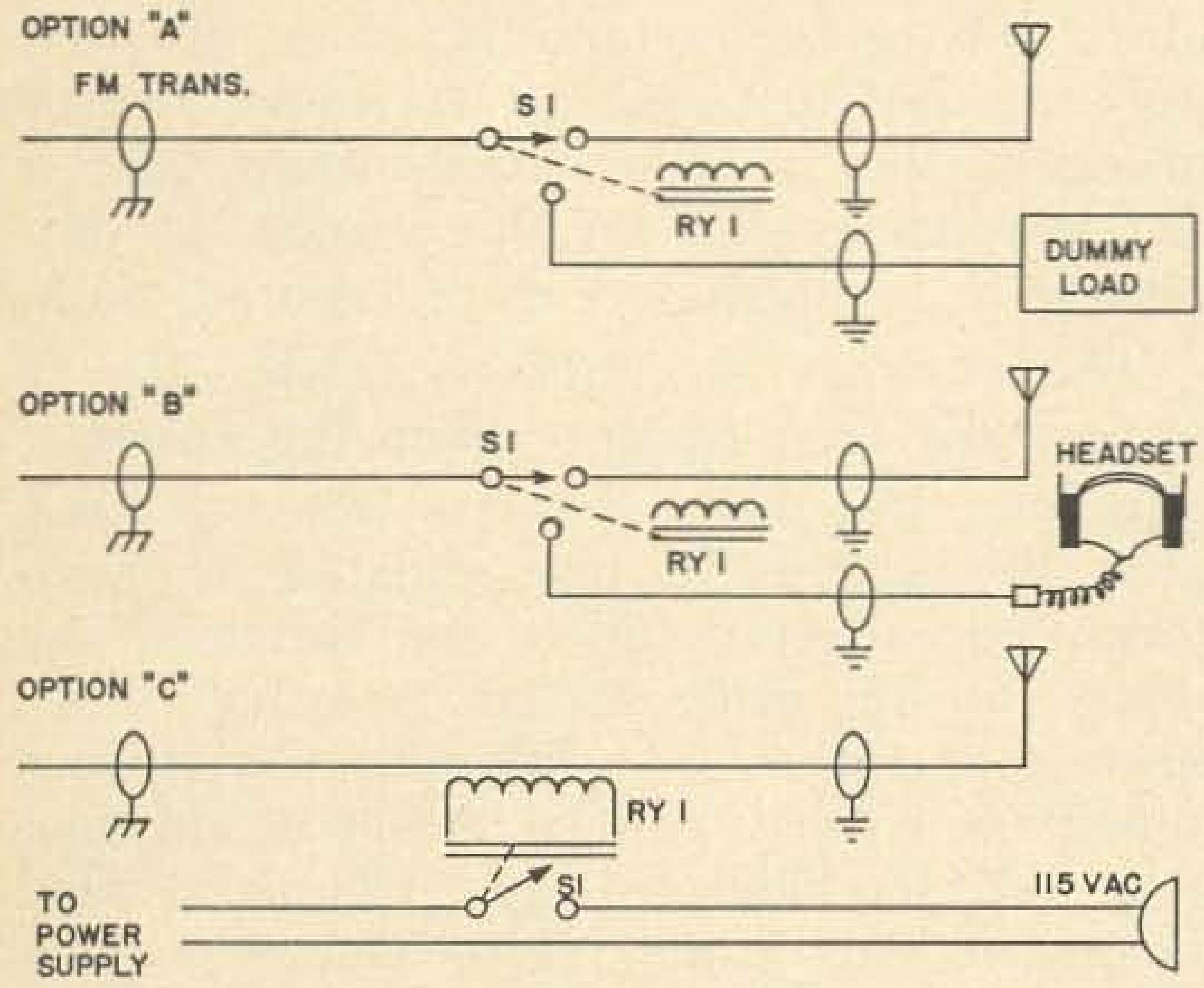


Fig. 1. 3 varieties of Lid Ducer.

with a knob stretch a coil or juggle two 4CX-1000's. The safari laid an ingenious trap; they spread a table with knobs, probes, tubes and switches—then placed a 3 foot sign over the array reading, "DO NOT TOUCH UNDER ANY CIRCUMSTANCES!"—barely 5 minutes had passed before a shifty eyed, change jingling miscreant bumbled up, peered sneakily over his shoulder and jiggled a knob. This triggered a snare trap and they had their volunteer.

Because of a mass traumatic shock, the exact details of the demonstration are not clear in anyone's mind. We had selected the Nordic "SVENKA" option for the test. Unfortunately, the equipment used had a 'home brew' California amplifier which, unbeknownst to us, employed one hundred and thirty two 6146's in parallel. When the relay activated itself, all hell broke loose. The California kilowatt delivered full strength through the SVENKA not only zapping the volunteer, *rf* cooking his spleen, and performed an on-the-spot frontal lobotomy but the resulting pyrotechnics set off a chain reaction of UFO sight reports covering a three State area. In his mentally vacant and stagnated state, there was little else to do with the volunteer but send him to Foam Rubber City (Bonita, California) located somewhere between Oz, Disneyland and the Twilight Zone. We learned later that, with his newly acquired attribute of catatonic mindlessness, he was immediately scooped up and put to work eking out a meager living as the editorial chief of a block printed mimeographed ham pamphlet published in that city.

A photo and schematic of the Lid-Ducer, Mark #3 prototype and its three optional uses are shown elsewhere. It would, out of necessity, be a sealed unit when placed into equipment—but for the purpose of simplicity—it is illustrated as a separate unit.

The circuitry is cimplicity itself. The *rf* is normally coupled directly to the antenna. However, the relay is set to activate itself after 60 seconds of unmodulated or uninterrupted carrier is fed to the antenna. The relay can be programmed to react to almost any stimuli. The stimulus setting and timed reset delay can be preset at the factory and modified by the FCC as needed in lieu of issuing 'pink slips.' Once the stimulus activates RY1, S1 is thrown to the alternate position, which can either be coupled to a device similar to the Nordic SVENKA—possibly modified with an enema probe—or to a more conventional dummy load.

The Lid-Ducer should prove to be an effective reminder to that 90% of lids who are lids only because of a moment of thoughtlessness. Their punishment would be instantaneous and cost a minimum of 10 minutes of on-the-air time for each act of lid-man-ship.

One feature of IPECAC—an ultra extremist group—held out for more stringent measures—especially for that remaining 10% of 'lids' who perform lidmanship as an active avocation. They advocated 'the' ultimate weapon i.e., enforced listening to the 11 meter band for varying amounts of time depending upon the offense. Since we all know that no amateur of any repute could possibly endure more than a few minutes of this hideous torture without running, covered by microphones, amplifiers, 28 MHz crystals, pre-amps and squelch knobs, into the street screaming, "10-4 there, 10-4 there, wheeee—I'm the Eastern Mass Hunchback—I'm the Arkansas mugwump—and a whole bunch of 10-20's" this seemed to be not only an unjust, but inhumane punishment.

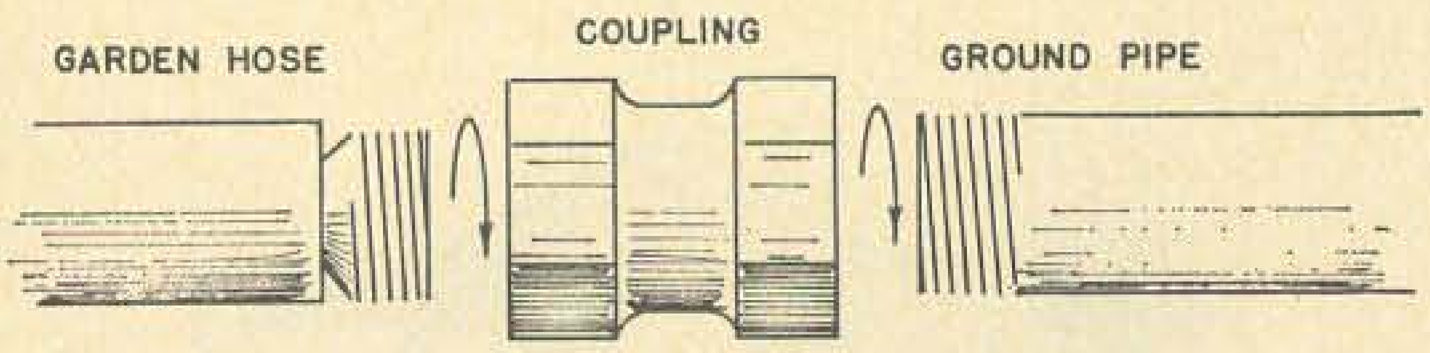
Unfortunately, before any further decisions could be reached, the meeting was brought to an untimely close when 2 MARS members and a CW man located an "OO" secreted behind some stalagmites surreptitiously listening on split phones to time ticks and loran signals while folding roadmaps and timing the speaches of various delegates. A mob formed, tied the "OO" with a random length of RG58U and carried him from the cavern while he bellowed, "Long Live George Hart" and sang section 97.87 (in free verse) to the melody of "I Believe." They drove him off in an Edsel that, because of the cars design and the number of antennas attached to it, closely resembled a gigantic and quite recently goosed porcupine.

The next session of IPECAC is tentatively scheduled for the weekend of Arbor Day and is to be held in Atlantis. This will necessitate Maritime Mobile operation—section 97.97. applies. Entertainment thus far booked includes Senator Everett Dirkson giving his sterling rendition of The Communications Act of 1934 (in its entirety) and Jim Fisk tap dancing and doing the Frug to Conelrad signals.

. . . K1SYD

Instant Drilling Rig for Grounds

David B. Cameron WA4VQR
324 S. Riverhills Dr.
Temple Terrace, Fla. 33617



As most hams know, a good ground is necessary for safety and the effective use of some types of antenna systems. In some areas water pipes or the grounded side of power lines make good grounds, but in areas where these cannot be used the ham must install his own. Being a person of little brawn and even less desire to use it, I couldn't envision myself banging away on a metal rod John Henry style. I found, instead, a much easier and more effective way of drilling.

The gold and sulphur mines have been using the hydraulic method for years; I merely put it on a small scale. All that is needed in the way of parts is a large garden hose, a piece of ¾" iron pipe, which becomes the ground rod, and a coupling to connect the two. This is a special pipe to hose, female to female fitting. Any pumped source of water will do for power, but if you have a good sprinkler or well pump that you tie into, you may get more volume (if you have small pipes in your house, the house water supply may act like a high voltage power supply that drops when too much load is placed on it). Attach the hose to an outside sill cock or other outlet, link it to the pipe with the coupling (**Fig. 1**), punch the pipe through the grass, and turn the water on full blast (watch out for that first spurt, it's a lulu).

Keep some downward pressure on the pipe, but let the water do the work. It will dig quite rapidly in sand, as several inches a second, and somewhat slower in dirt or clay. The sand, dirt, and bits of rotted wood that come up around the pipe with the water are a constant monitor of the composition of your land at various depths.

If you hit a small rock, treasure chest, or other obstruction, give the water a chance to dig around it and then start punching at it with the pipe. If it is too large to move or break, you will have to stop there or try somewhere else. This will vary with the geology. A last note of warning: all that dirt had to come from somewhere. If all goes well you will only eat a hole about one inch in diameter and stopping off for a few minutes in one spot won't do much damage, so you can tell the XYL to quit worrying about the house disappearing. But if you get stuck at the one foot level for ten minutes with dirt still bubbling out, the next thing that you can expect to go down is the turf you're standing on!

. . . WA4VQR

Propagation Chart

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

CENTRAL UNITED STATES TO:

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

WESTERN UNITED STATES TO:

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

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

Good: 1, 2, 4-6, 9-12, 14, 16-18, 23-25, 27-30
Fair: 3, 8, 13, 15, 21, 22, 26
Poor: 7, 19, 20

A Report on the WTW

DX activity during the months of July and August I suppose is at its lowest ebb, or at least this is indicated by the reports I have received here recently. Many WTW-Tally sheets have been sent out so I assume the boys are "getting ready" for the Fall season which is just around the corner.

I have hopes that right after the first of the coming year (1969) I will be at some good DX spots to give those needing certain countries on certain bands some assistance. Looks like another DXpedition is in the works now, had a good eye-ball QSO with Ack-W4ECI over in Birmingham, Alabama and Ack says—"If there is enough interest, we will do it again" (Ack was formerly the man back in the States who did all theorganization work, handling QSL's, etc.—on one of my DXpeditions and if I go again he will be the one to do this work. —He wants those interested to write him and tell him what they think) So fellows I strongly suggest that each of you get all your antennas in good working order and on all bands—from 160 through 10 meters, because I will be using all of them. I have an idea you will see some fellows qualifying for WTW on each band (6 bands actually) before this one is all over with this time. Before the real cold WX hits you get those antennas up so you won't have to face the elements when I get going—We hope possibly right after the first of the coming year. We are talking about some "big plans" for this DXpedition.

Only two have qualified for WTW since the last report.

WTW-100, 14MHz phone—W3SEJ received WTW certificate Nr. 58.

WT-100, 14MHz phone—W2NSG received WTW certificate Nr. 59.

Add to the honor roll listings the Call W4BYB with 151 countries on 7 MHz band CW. Also add to the 14 MHz listings 122 countries for WB2NSG—phone mode.

Please send me your claimed score for listing in the Honor Roll, would like to get your latest count for the gang to see. QSL's are not necessary, until you get up to the next WTW certificate, thats when we will want to see them. When you tell us you have 199 countries that's ok but when you get to 200 —we then want to see the cards!

There is no delay here in issuing certificates now, have a good file system working and your cards are returned pronto. I am sure all the various QSL check points can say the same.

Have received a number of letters from XE stations who are ready with their cards but are afraid to trust them in the mail—So we are looking for some good reliable Club in XE land to be our check point for QSL cards—any takers? The same goes for Europe, because I have heard from a few stations over there who tried out our European check point and I guess they have changed their mind—How about one of you good European clubs volunteering this little task for us?

Remember fellows send along with your application for WTW certificates $1.00 plus enough to return your cards via what-ever way you want them returned or else they will be returned by 3rd. class mail with the chance they may become lost along the way plus the delay in delivery involved. The best (at a reasonable rate, in my book) seems to be via "Certified mail". No need to insure them either way because my understanding is the fact that your cards have no value whatsoever to anyone except you, and if a value is placed on them in Dollars and Cents and they get lost—You will not receive anything.

Up to this time we have not issued any RTTY WTW certificates, so if any of you fellows Qualify for this band ship us your card and get the first RTTY WTW certificate. The same goes for bath 160 meters and 80 meters on either CW or phone.

Some of you new comers to DXing take my advice, "work all the DX you can now" because these superb conditions won't last too much longer. I understand the sun spot count has now passed its peak and when they get down low in a few years from now all this FB DX will not be heard at all. During these low sun spot times 10 may be stone dead, and many times 15 the same, 20 going dead at sundown, and even 40 meters may go out after midnight—maybe even 80 will do the same at times. So again I say—get in there and get the DX while you have the conditions with you like they are right now—The bands can get very very bad in a few years now.

I have plenty of WTW tally sheets on hand, 25c will bring you two sets of them. Drop me a line fellows—and don't forget send in your "claimed scores" for the WTW Honor Roll.

. . . W4BPD

Gus Browning W4BPD
Cordova, So. Carolina

Technical Aid Group

Please refer any questions of a technical nature to one of the following members of 73's Technical Aid Group. These are dedicated amateurs who really want to be of help and do so without compensation. Be sure to state your problem clearly and enclose a S.A.S.E. for a reply.

John Allen, K1FWF, high school student, 51 Pine Plain Road, Wellesley, Mass. 02181. HF and VHF antennas, VHF transmitters and converters, AM, SSB, product data, and surplus.

Bert Littlehale, WA1FXS, 47 Cranston Drive, Groton, Conn. 06340. Novice transceivers, test equipment and homebrew projects gone wrong.

Bob Groh WA2CKY, BSEE, 123 Anthony Street, Rochester, New York 14619. Specializes in VHF/UHF solid-state power amplifiers, but will be glad to make comments on any subject.

G. H. Krauss, WA2GFP, BSEE, MSEE, 70-15 175 Street, Flushing, New York 11365. Will answer any questions, dc to microwave, state-of-the-art in all areas of communications circuit design, analysis and use. Offers help in TV, AM, SSB, novice transmitter and receivers, VHF antennas and converters, receivers, semiconductors, test equipment, digital techniques and product data.

Charles Marvin W8WEM, 3112 Lastmer Road, RFD #1, Rock Creek, Ohio 44084. Will help with any general amateur problems.

Stix Borok WB2PFY, high school student, 209-25 18 Avenue, Bayside, New York 11360. Novice help.

Clyde Washburn K2SZC, 1170 Genesee Street, Building 3, Rochester, New York 14611, TV, AM, SSB, receivers, VHF converters semiconductors, test, general, product data.

Richard Tashner WB2TCC, high school student, 163-34 21 Road, Whitestone, New York 11357. General.

J. J. Marold WB2TZK, OI Division, USS Mansfield DD278, FPO San Francisco, California 96601. General.

Ira Kavaler, WA2ZIR, BSEE, 671 East 78 Street, Brooklyn, New York 11236. SSB transmitting, color TV, computer programming and systems, digital, radio and remote control, rf transmission lines, dipole design, audio amplifiers, linear and class C rf amplifiers.

Fred Moore, W3WZU, broadcast engineer, 4357 Buckfield Terrace, Trevose, Pa. 19047. Novice transmitters and receivers, HF and VHF antennas, VHF converters, receivers, AM, SSB, semiconductors, mobile test equipment, general, product data, pulse techniques, radio astronomy, bio-medical electronics.

Walter Simciak, W4HXP, BSEE, 1307 Baltimore Drive, Orlando, Florida 32810. AM, SSB, Novice transmitters and receivers, VHF converters, receivers, semiconductors, mobile, test-equipment, general.

James Venable K4YZE MS, LLB, LLM, 119 Yancey Drive, Marietta, Georgia. AM, SSB, novice gear, VHF, semiconductors, and test equipment.

J. Bradley K6HPR/4, BSEE, 3011 Fairmont Street, Falls Church, Virginia 22042 General.

Wayne Malone W4SRR BSEE, 8624 Sylvan Drive, Melbourne, Florida 32901. General.

Bruce Creighton WA5JVL, 8704 Belfast Street, New Orleans, Louisiana 70118. Novice help and general questions.

Douglas Jensen, W5OG/K4DAD, BA/BS, 706 Hwy 3 South, League City, Texas 77573. Digital techniques, digital and linear IC's and their applications.

Louis Frenzel W5TOM, BAS, 4822 Woodmont, Houston, Texas 77045. Electronic keyers, digital electronics, IC's commercial equipment and modifications, novice problems, filters and selectivity, audio.

George Daughters WB6AIG, BS, MS, 1613 Notre Dame Drive, Mountain View, California. Semiconductors, VHF converters, test equipment, general.

Glen H. Chapin, W6GBL, 3701 Trieste Drive, Carlsbad, Calif. 92008. HF and VHF antennas, novice transmitters and receivers, VHF converters, semiconductors, receivers AM, SSB, general, surplus.

Tom O'Hara W6ORG, 10253 East Nadine Temple City, California 91780. ATV, VHF converters, semiconductors, general questions.

Steve Diamond WB6UOV, college student, Post Office Box 1684, Oakland, California 94604. Repeaters and problems regarding legality of control methods. Also TV, novice transmitters and receivers, VHF antennas and converters, receivers, semiconductors, and product data.

Orris Grefsheim WA6UYD, 1427 West Park, Lodi, California 95240. TV, HF antennas, SSB, VHF antennas and converters receivers, semiconductors, and general questions.

Hugh Wells, W6WTU, BA, MA 1411 18th Street, Manhattan Beach, Calif. 90266. AM FM receivers, mobile test equipment, surplus, amateur repeaters, general.

Carl Miller WA6ZHT, 621 St. Francis Drive, Petaluma, Calif. 94952. Double sideband.

Howard Pyle W7OE, 3434—7th Avenue, S.E., Mercer Island, Washington 98040. Novice help.

PFC Grady Sexton Jr. RA11461755, WA1GTT/DL4, Hedmstedt Spt. Detachment, APO New York 09742. Help with current military gear, information from government Technical Manuals.

Sgt. Michael Hoff WA8TLX, Box 571, 6937th Comm. Gp., APO New York 09665. Help with all types of RTTY both commercial and military. Also data techniques. Covers conversion of military RTTY equipment.

Eduardo Noguera M. HK1NL, EE. RE, Post Office Box Aereo 774, Barranquilla, Columbia, South America, Antennas, transmission lines, past experience in tropical radio communications and maintenance, HF antennas, AM, transmitters and receivers, VHF antennas, test equipment and general amateur problems. Can answer questions in Spanish or English.

D. E. Hausman, VE3BUE, 54 Walter Street, Kitchener, Ontario, Canada. Would like primarily to help Canadians get their licenses. Would be able to help with Novice transmitters and receivers.

Frank M. Dick WA9JWL, 409 Chester St., Anderson, Indiana 46012. Will answer queries on RTTY, HF antennas, VHF antennas, VHF converters, semiconductors, mobile, general, and microwave.

Gary De Palma, WA2GCV/9, P.O. Box 1205, Evanston, Ill., 60204. Help with AM, Novice transmitters and receivers, VHF converters, semiconductors, test equipment, digital techniques and all general ham questions.

Arthur J. Prutzman K3DTL, 31 Maplewood, Dallas, Pennsylvania 18612. All phases of ham radio. Can assist with procurement of parts, diagrams, etc.

William G. Welsh W6DDB, 2814 Empire Ave., Burbank, Calif. 91504. Club licensing classes and Novice problems.

Ralph J. Irace, Jr., WA1GEK, 4 Fox Ridge Lane, Avon, Conn. 06001. Help with Novice transmitters and receivers and novice theory.

Iota Tau Kappa Radio Fraternity W7YG, Multnomah College, 1022 S.W. Salmon St., Portland. Oregon 92705. This group of radio amateurs will answer any technical questions in the field of electronics.

Ted Cohen W4UMF, BS, MS, PhD. 6631 Wakefield Drive, Apt. 708, Alexandria, Va. 22307. Amateur TV, both conventional and slow scan.

Roger Taylor K9ALD, BSEE, 2811 West Williams, Champaign, Illinois 61820. Antennas, transistors, general.

Michael Burns Jr. K9KOI, 700 East Virginia Avenue, Peoria, Illinois 61603. AM, SSB, receivers, transmitters, digital techniques, novice help, general.

Jim Jindrick WA9QYC, 801 Florence Avenue, Racine, Wisconsin 53402. Novice transmitters and receivers, general.

John Perhay WAØDGW/WAØRVE, RR #4 Owatonna, Minnesota 55060. AM, SSB, novice transmitters and receivers, HF receivers, VHF converters, semiconductors, mobile, product data, general. Has access to full specifications on almost all standard components presently catalogued by American manufacturers.

Ronald King K8OEY, Box 227, APO New York, New York 09240. AM, SSB, novice transmitters and receivers, HF receivers, RTTY, TV, test equipment, general.

Charlie Marnin W8WEM, 3112 Latimer Road, RFD 1, Rock Creek, Ohio 44084. General technical questions.

Michael Winter DJ4GA/W8, MSEE, 718 Plum Street, Miamisburg, Ohio 45342. HF antennas, AM, SSB, novice gear, semiconductors.

David D. Felt, WAØEYE, television engineer, 4406 Center Street, Omaha, Nebraska 68105. Integrated circuits, transistors. SCR's, audio and rf amplifiers, test equipment, television, AM, SSB, digital techniques, product data, surplus, general.

Tom Goez KØGFM, Hq Co USAMAC, Avionics Division, APO New York, New York 09028. HF antennas, mobile, airborne communications equipment, particularly Collins and Bendix gear, AM, FM, or SSB—HF, VHF, UHF, general.

Robert Scott, 3147 East Road, Grand Junction, Colorado 81501. Basic electronics, measurements. ■

MOVING?

Every day we get a handful of wrappers back from the post office with either a change of address on them or a note that the subscriber has moved and left no address. The magazines are thrown out and just the wrapper returned. Please don't expect us to send you another copy if you forget to let us know about your new address. And remember that in this day of the extra rapid computer it takes six weeks to make an address change instead of the few days it used to when we worked slowly and by hand.

that he is sick and needs immediate mental treatment and to leave this particular policing to the FCC. A bunch of "band police" with verbal billyclubs can clean out the band in short order, but if we let the fellows take their own time the results will be same in the long run and we will keep ham radio being fun and not a source of resentment and frustration.

Looking At The Editorials

Yes, I read the other magazines.

The September CQ editorial is still grumbling over the Electronic Industries Association proposals to the FCC, in a backhanded way calling them self-serving to the manufacturers. They seem to be overcritical of EIA, possibly because they were kicked out of the organization. The EIA has great possibilities for benefitting amateur radio. It is the first substantial effort to provide and coordinated channeling of the manufacturers in the ham industry. The EIA is doing a fine job in the CB field and I think we can look forward to similar progress in ham radio.

The one think that has been desperately needed for amateur radio for many years now, is a coordinated and extensive promotional effort. I have been writing about this for a long time now, trying to get the ARRL Directors to become aware of the importance of strengthening amateur radio through a recognition of it and a steady growth of our numbers. I haven't gotten very far with the League. They feel that there should be fewer amateurs and they are working to that end. The EIA believes amateur radio will be strong only if it is growing and is working on plans for our long needed PR campaign. Hooray.

Ham Radio magazine threatens that if you don't hurry up and start using our VHF and UHF bands that they most surely will be taken away. This is the old ARRL theme . . . threats. I wonder how many of us are moved by this argument to go to the trouble of getting on a VHF band? Hells bells, the threats of cancer have done little to slow down cigarette smoking and death by cancer is a lot more formidable than losing the 220 MHz band.

The threat to these bands is a real one, doubtless. But threats like this are just a waste of magazine space and the reader's time. If we want to get activity on the VHF bands we can do it. The magazines can encourage VHF operators to write articles telling everyone else how much fun they are having and giving circuits for easily built gear to get them on the bands. If Ham Radio or ARRL wants fellows to operate in these bands why don't they offer manufacturers half price or free ads for VHF equipment in order to encourage more companies to make gear for these bands?

The VHF bands are relatively vacant because our magazines have not done a selling job. A VHF column and an occasional construction article are not enough. If we want to move to the VHF bands we need PR for VHF. Tell me, what VHF awards are available from the ARRL?

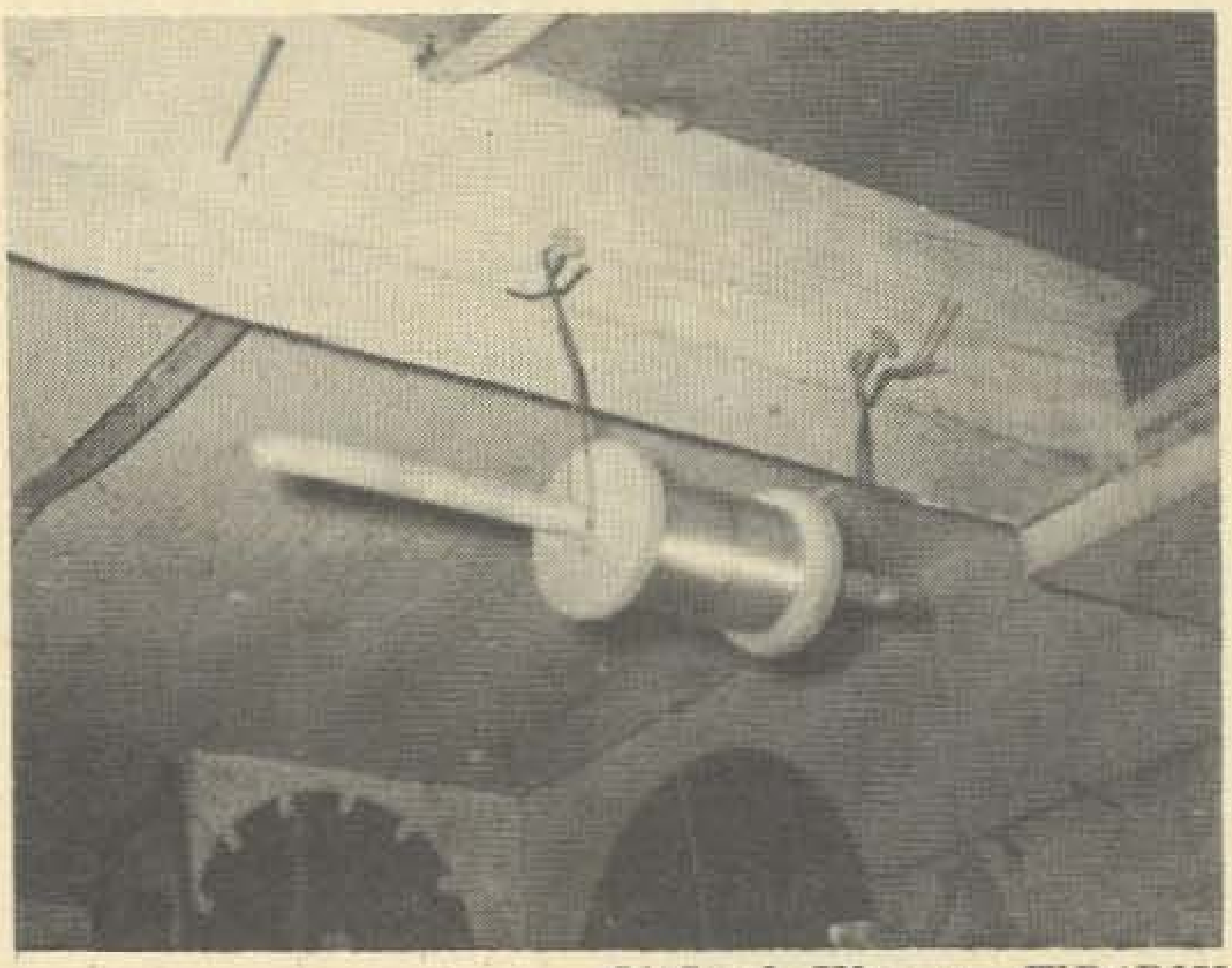
This gets back to my basic philosophy of getting people to do things by using the carrot instead of the nightstick. Ask them instead of telling them. Imagine how those years of going to school would have been if the schools had made them fun and enjoyable and you had gone there out of choice instead of being arrested if you didn't. School can be fun. Teachers can make learning enjoyable, but because they don't have to in order to attract students the whole process is a mess.

We will, hopefully, have some new ARRL Directors in office this fall and perhaps some of them will turn out to be more interested in the future of amateur radio than their own prestige of office and will buck the organized inertia at headquarters and get the League to spend some of that $1 million hoard on PR for amateur radio. We need a good experienced PR office to get ham stories into the newspapers, on the wire services, and into national magazines. We do plenty that could be publicized, but few people ever hear about it. We have some excellent ham authors and cartoonists that could be organized for the effort. One or two good articles in Playboy every year, the Saturday Post, Look, etc., and we would not only be known but we would find our radio clubs bursting with fellows eager to learn and become hams.

It is really up to you. You have to take it on your own self to get after your director and to get your friends after the director. Talk about this on the air and get everyone you talk with to call his director. It only costs a little to phone him at night and put the screws on him. A handful of phone calls to each director could change the future of our hobby.

. . . Wayne

The Solder Saver



Clifford Klinert, WB6BIH
520 Division Street
National City, Calif. 92050

Soldering is still the most commonly used method of connecting electronic components, and can be a source of frustration for any electronics experimenter or builder. Aside from the problems involved with cold and dirty solder joints that are encountered in learning the art of soldering, one problem is still common to even some of the most professional and experienced builders—finding the solder. Many frustrating minutes can be lost while hunting for the roll of solder that had been placed on the workbench only a moment ago. This is especially annoying when the experimenter is just on the verge of a startling discovery or a victorious success in some phase of electronics. Is the solder hiding under the page of a book? Or has a component or piece of test equipment been inadvertently placed in front of the roll of solder?

In the interest of reducing frustration and maintaining sanity, the simple device that is described in this article has been developed. In this case, a solder dispenser has been constructed by using a short section of TV antenna element for a shaft, and suspending it from the ceiling of the workshop with two short pieces of wire. The wires are fastened to the ceiling with two nails and connected to the shaft by passing it through two holes in the tubing. A spool of solder can be placed on the shaft before mounting the completed assembly.

This idea works well with small size solder as is shown, and has also had good success with the larger sizes that are most commonly used with electronic wiring. The increased organization that this simple device has added to an already overcrowded workbench greatly increased the efficiency and reduced fatigue in electronic project construction. It can help you too!

. . .WB6BIH

Wind Loading On Towers

Bob Eldridge VE7BS
805 *East 20th Avenue*
Vancouver 10 *B C*

The great enemy of towers is wind, and towers are rated in terms of the drag in pounds per square foot of surface area presented to the wind.

Cylindrical section structures produce less drag per square foot with a given speed of wind, so lighter material can be used. Flat strap structure produces about 50% more drag and angle iron about 16% more than flat strap. The figures used for calculation of wind drag are fairly simple:

Pressure on cylinder $Pc = .0026V^2$
Pressure on flat surface $Pf = .004V^2$
Pressure on angle surface $Pa = .00464V^2$
Where V is wind velocity in mph.

For example if you expect winds of up to 100 mph, then a tower of round section should be at least a "27 lb tower", of flat section a "40 lb tower", and of angle a "45 lb tower".

This does not include any allowance for ice. If you live in a location where you may get icing on the tower as well as high winds, you had better seek some expert advice on towers before you buy one—if one falls down you may have a lot more trouble than just the broken tower!

Incidentally, while talking about ice, it helps a lot to paint a tower black (and any "plumber's delight" antennas too). When the sun comes out the metal then soaks up the radiant heat from old King Sol and melts the ice from within.

Don't try to cut down too much on the real estate occupied by the guys. The closer you bring the anchors to the base of the tower the more strain you put on the tower, and the more downward pressure you exert on the base. A tall pole on a small roof has been known to go clean through the roof at the base in a high wind. . . . VE7BS

Please Use Your Zip Code When Writing 73

The Care and Feeding of a Ham Club—part V

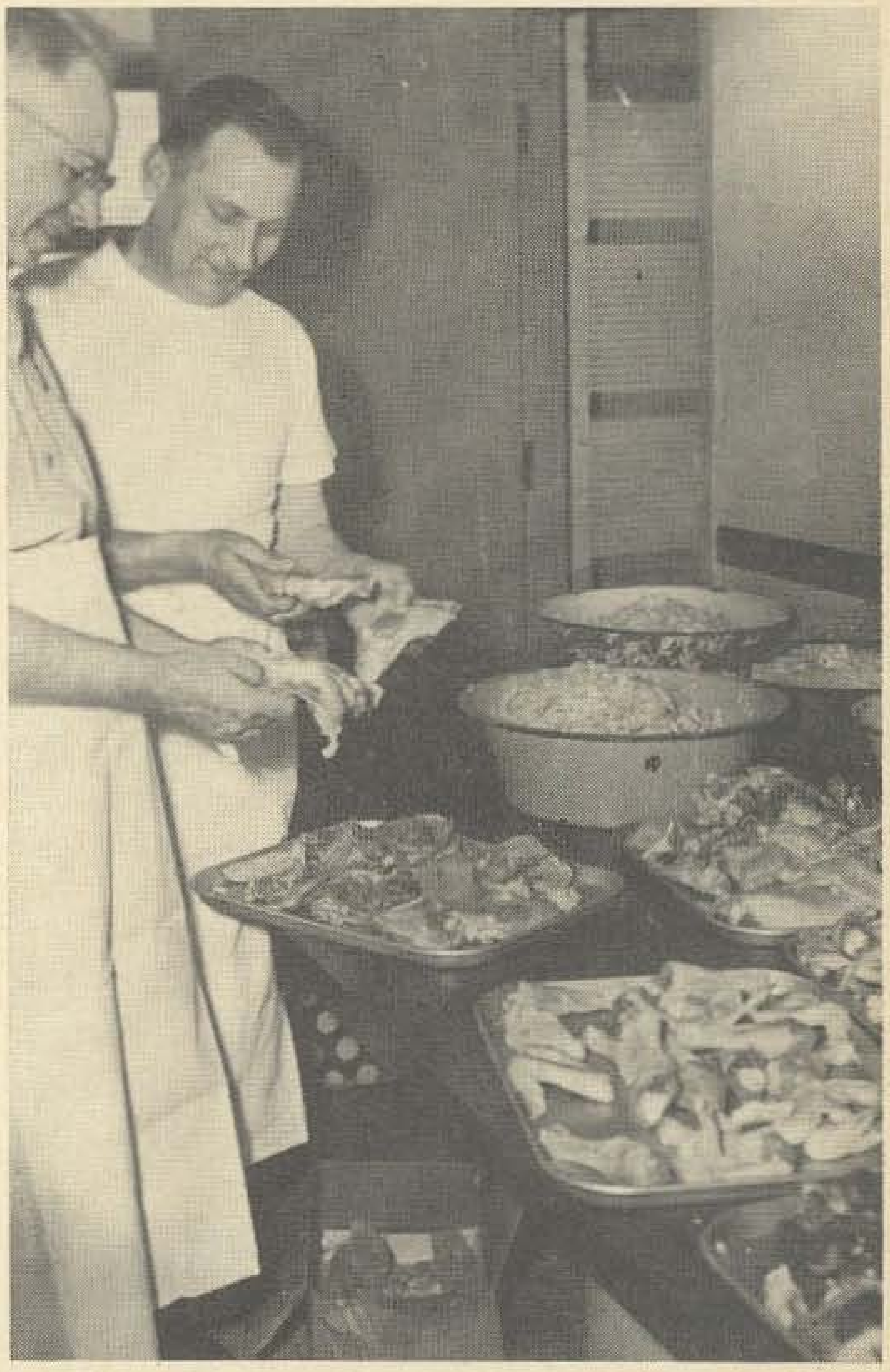
More Money Talk

Carole Allen W5NQQ
308 *Karen Drive*
Lafayette, La. 70501

Sooner or later every club has to face the fact that dues and small donations just aren't enough to pick up the tab for a 50 foot tower, new rig, or generator. What then? Raise money, of course—but it's easier said than done. The first decision a club has to make is whether sufficient funds can be raised within the club by members making larger donations or if the public should be approached. The latter scheme, if properly handled, can do at least two jobs at once. If the club decides to tackle an interesting project, the result may well be a bulging budget as well as a more closely knit group.

A money-making project can be chosen from one of dozens of ideas and should be voted on by a majority of members. How about trying a bake sale with the ladies contributing cakes, pies, and other goodies? After the local health authorities issue the necessary certificate approving the sale of food, the pastries can be displayed in a downtown business place and sold to shoppers who are tempted and stop in. Since most of the food for a bake sale is donated, all but packaging expenses and perhaps rent for the window area will be clear profit.

Although ice cream socials, chili and ham suppers, and public shrimp boils are major undertakings, they can be handled well by a large club with families that pitch in and work together. Naturally, a committee would have to be appointed with dozens of workers to plan the event, set up tables, prepare food, sell tickets, serve, clean-up, and perform the many behind-the-scene jobs.



If the club needs more money than dues can provide, a special project will be needed. Here, the fellows pitch in to fry chicken and make cole slaw for a chicken dinner. If everybody in the club works together, money-making schemes can be fun as well as successful.

As all super-salesman will agree, one of the secrets of selling is to give service to the public, and a community car-wash can be a big success. Check first with local officials to make sure no ordinances will be broken; then pick a likely spot (and consider yourself lucky if you have a filling station owner in the club). The main expense will be the water bill and maybe a couple of chamois skins and sponges. A few large signs placed on the boulevard and some advance publicity will bring in enough cars to keep members busy washing and polishing. If a lot of hams pitch in, no one

A radio exhibit in an uptown store will draw a lot of public interest and may bring in some contributions for a worthwhile project if properly presented on posters. Shown is a window showing the activities of local amateurs.

will be too bushed at the end of the day. Campus clubs will find this idea a good one, for all that's needed is a spare Saturday, a sunny day, and some unharnessed energy.

If you live in a large city or a community that doesn't support car-washes, socials, and suppers, explore the possibility of getting help from a service organization. Many groups are always looking for a worthwhile project to sponsor, and since hams are known for their unselfish public service, their bid is almost certain to receive consideration and maybe approval. A service club might be approached for a generator, transmitter, or one certain piece of gear which can be named in their minutes and presented for a vote. The only hitch might be that a club member will be asked to present the plea in person and also to come back and give a radio demonstration about once a year, but who minds having a few strings attached to a big fat donation.

C. C. Kessler, K9SBP, of the Jersey County (Illinois) ARC says that although their club has very little expense, "We bought a large coffee maker and graveled the road to the shack after holding a White Elephant sale and selling candy we purchased on a wholesale arrangement."

Another possibility to look into is setting up exhibits at bazaars, fairs, homecomings and community celebrations. Nothing but a kissing booth attracts more attention than a ham radio display, so why not do a little soliciting at the same time? It doesn't hurt to ask, and if the town learns that their hams need help, contributions may come rolling in. But, look out if someone gets the bright idea that charging a less-than-

A bake sale with the ladies of the club donating the "goodies" is usually an excellent way to raise funds.

phone-toll fee for relaying greeting messages will fill the piggy bank, better remind 'em that the FCC just doesn't think it's cricket.

EXTRA, EXTRA, read all about it!

Not everyone does well "with pen in hand" or even wants to, and for this reason, editing the club newspaper can't be assigned to just any Tom, Dick, or Harry. Collecting material, writing, re-writing, and finally printing a paper takes a lot of work; and editors will tell you that they donate the hours involved as a labor of love.

Published to inform, remind, and entertain, a newspaper means just as much to a radio club as the Daily News to the city. And U.S. hams can be poppin' proud of many of their club publications. Outstanding with circulations in the hundreds are the *Auto-Call* printed by the Washington, D.C., area hams; the *SRA Bulletin* published by Spokane, Washington, amateurs; The Dallas, Texas *Monitor*, the Indiana Radio Club Council *Bison* and many others.

In addition to these major publications are countless small but top-notch papers such as the Montgomery County (Illinois) *Ham Hash* printed monthly with Bobbi Pattie, K9GOL, in charge.

"Our format is simple but varied," she commented. "The first page holds the heading, date, volume, number, etc., followed by last month's minutes which the secretary writes as to-the-point as possible. The Emergency Coordinator has a column of operating hints, ARRL bulletins, and sometimes a schematic for novices. The 2-meter net secretary submits "The Net Notes" which is a run-down of high frequency happenings, and another YL writes a scoop column entitled "K-9 Barks and Remarks" covering local "gossip" such as new gear purchased, DX worked, hamfests attended, and you-name-it. I sort through this material, add some comments, jokes, and sayings, and then get ready to roll the presses."

The *Rams News,* formerly edited by Leon Nielsen, W6QHP, is a four-page paper distributed to the Radio Amateur Mobile Society of Sacramento, California. "We print features such as "RAM of the month," said Leon, "which is an entertaining biography of a new ham or veteran club member."

A run-down of picnics, parties, and transmitter hunts coming up is a popular feature and keeps everyone well-informed on what is planned, when and where. Another column known as "Glenn's Swap Shop" lists surplus gear for sale and the name of the OM who wants to sell it.

Another way to prepare in advance for "off-days," is to ask several club members to write a short column on "Why I Became a Ham" or some other provoking question. The columns can be made a monthly feature or filed away until editorial going gets rough.

After writing, editing, sorting, and assembling, the editor can't quit until the paper is printed, too. If your club has access to an off-set press or is lucky enough to have a professional printer in its ranks, that's great. The alternatives are mimeographs, hectographs, or a similar duplicating process that can be begged, borrowed, or bought inexpensively. Needless to say, the best machine the club can afford is none too good.

The best place for a new ham to find encouragement in getting his ticket and also learning to operate is in a club. Shown above is Brent Greenwood, K9RHL, getting tips from veteran Dale Stretch, W9KHQ.

The last step is distributing the monthly masterpiece, and this can be done in at least two ways. If the club owns an addressing machine or has some willing members who will address and stamp, papers can be mailed to everyone. Another method is to distribute copies at each meeting and then mailing them only to absentees.

Regardless of the way you write, print or distribute, and even if you don't win a Pulitzer prize, editing a newspaper provides a real feeling of accomplishment. And just in case you get the idea all the work isn't appreciated, just try skipping an issue some time.

The Radio Club as a Helping Hand!

"If it wasn't for the club," many a ham has said, "I wouldn't have my license today." A statement like this should be the goal of every group worth its weight in crystals.

Although a lot of cities offer courses in electronics in special schools and colleges, and a growing number of educators are putting radio and theory classes in their curricula, local clubs remain the best place for a novice to find encouragement and help in getting their tickets.

Needless to say, the ham who tackles teaching should know what he's talking about and also how to present the material and explain it clearly. Excellent teaching aids such as movies and film strips can be rented or purchased by the club and will be appreciated by both students and teachers. Another fine investment for the club is a code machine with a supply of tapes providing hours of perfect code. With this equipment on hand, a lot of veterans who feel the need to brush up at the key will sit on in the classes, too.

An excellent class project is group construction of a simple piece of gear such as a transmitter. Students will learn to handle tools, solder, and identify components. They'll also experience that wonderful feeling of putting something together. Here again, the club can save the day for the guy or gal who can't afford a kit or parts by financing the project for him.

Even after classes have closed and a new crop of novices have been licensed, the club still has a fine chance to be a friend in need. Transmitters and receivers don't grow on trees, and sometimes a ticket arrives before the rig does. A new ham and his family, too, will long remember the club station he borrowed for that first QSO. And if your members have a lot of surplus gear lying around, why not build up a low-power rig and receiver to loan to needy novices.

Local CW and Phone nets run by kind-hearted club members are excellent for knocking the rough operating edges off new hams. Correction from a friend who says "Don't talk so fast when you check in," or "Give your own call letters last not first" is hundred times easier to take than launching forth on the big wide ham bands and picking up the "Lid" label.

Club meetings themselves will aid both the novice and the technician through talks by experienced amateurs and bulletins including information on transmitter tuning and antenna adjustment. After the "new" has worn off the novice tickets, additional code and theory classes will get the fellows and gals started on their way toward the General Class license.

Last but not least, a new ham appreciates his club affiliation all over again when he stirs up that first nasty case of television interference. Stepping in with cool tempers and voices of experience, the TVI committee and a new ham's club membership never look so good. Like the chicken and the egg, it's hard to say whether the novice or the radio club came first, but who cares—they go together very well.

. . . W5NQQ

New Books

Basic Mathematics for Engineers by D. J. Hancox, South Birmingham Technical College, Edgbaston, Birmingham, England which was published by McGraw-Hill in England in 1966, is being made available for the first time in the United States beginning September.

This volume will serve as an invaluable reference for the engineer in his daily work, as a basic review for those who may have studied calculus sometime in the past, and as a helpful guide for anyone preparing for the professional engineering examinations.

The ten chapters of the book cover the following: Indices and logarithms—the laws of indices and logarithms transposition of formulae and natural logarithms; equations—quadratic and simultaneous equations, quadratic and linear with problems; determination of laws and graphical solutions of equations—graphs of linear, quadratic and cubic equations including circle ellipse and parabola, and examples of curve sketching; series—the arithmetic and geometric progressions, the binominal series for any index and the exponential series; trigonometry and mensuration—trigonometry summarized with identities and graphical problems; differentiation—from first principles, function of a function, product and quotient rules; application of differentiation—velocity and acceleration, rates of increase approximations and maxima and minima problems; integration—indefinite integration as reverse of differentiation as applied to algebraic, trigonometric, and exponential functions; application of integration—definite integration as applied to areas, volumes, mean values, root mean square values, variable forces, centroids (including Pappus Theorems), second moments of area; complex numbers—the Argand Diagram, addition, subtraction, and multiplication, and division of complex numbers. The slide rule and calculations are included as an appendix.

D. J. Hancox is a Senior Lecturer in the Department of Mechanical and Production Engineering at South Birmingham Technical College. He was formerly an aerodynamicist with A. V. Roe and Co.

Further information on *Basic Mathematics for Engineers* may be obtained from the McGraw-Hill Book Information Service, 327 West 41st Street, New York, New York 10036.

Happiness is Being a Novice

Being a Novice is:

FCC Form 610.

Meeting the postman with a hopeful smile each day for two months: Staring night and day at dormant equipment.

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The first page of your log; solid CQ's.

Trying to fit your license into your wallet.

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1. Three bottles of *Unguentine* in one week.
2. Your first soldering *gun*.

Following the picture in the magazine instead of the schematic.

A "free" ham map of the U.S. for only 25¢.

QRS

Touching the terminals of your antenna switching knife switch.

Buying a relay.

Mail from the ARRL every month asking you to enclose your dues in the *postcard* provided.

Finding out that that red lead *is* hot.

Your mother answering the telephone, "oh, yes, he's here, he's working on his transistor."

Restringing your dial cord; every three days.

Trying to solder a PL-259 without a reducer.

40 on Saturday.

Trying to find a schematic for a Q multiplier for 1650 kHz.

Alternately drooling over new equipment and frowning at your wallet.

Praying for no QRM on W1AW tonight.

A General saying, "don't worry, it only took me four trips."

Asking what your dealer will give you for the R-55A.

Trying to take his answer good naturedly.

Just one more wpm.

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FCC FORM 610.

Meeting the postman with a hopeful smile each day for two months.

David Colker WN31NL

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★ **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 . . .**

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HAMMARLUND HQ-145C, calibrator, $110. Clegg Apollo 700-watt six-meter linear, excellent, $175. HamScan, $40. Ship collect. McCormack, 5008 Carlyn Spring, Arlington, Virginia 22203.

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PRINTED CIRCUIT BOARDS (less parts): Xtal controlled 15.75kHz, 60Hz, $4.50; 3.6V Power Supply, $2.50. Postpaid. Free list. Dirck Spicer, 11 Ridgeland Road, Wallingford, Conn. 06492.

GALAXY AC 400 supply $60, Speaker Console $14, Vibroplex Original $15, Turner 454X mike $11.50, W2AU Quad and 4:1 Balun $57. Write Ray Thompson, 337-52nd. St., Des Moines, Iowa 50312.

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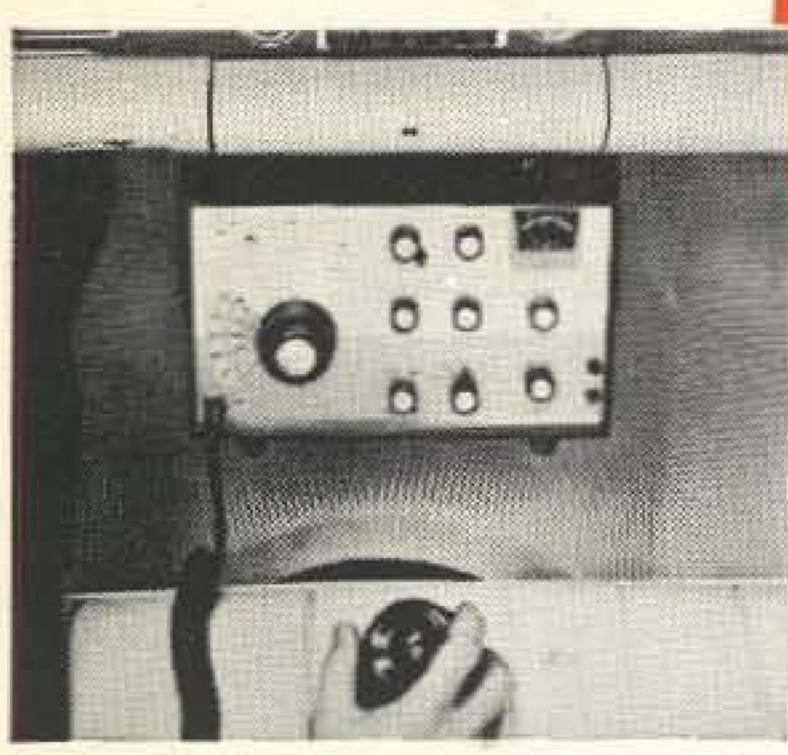

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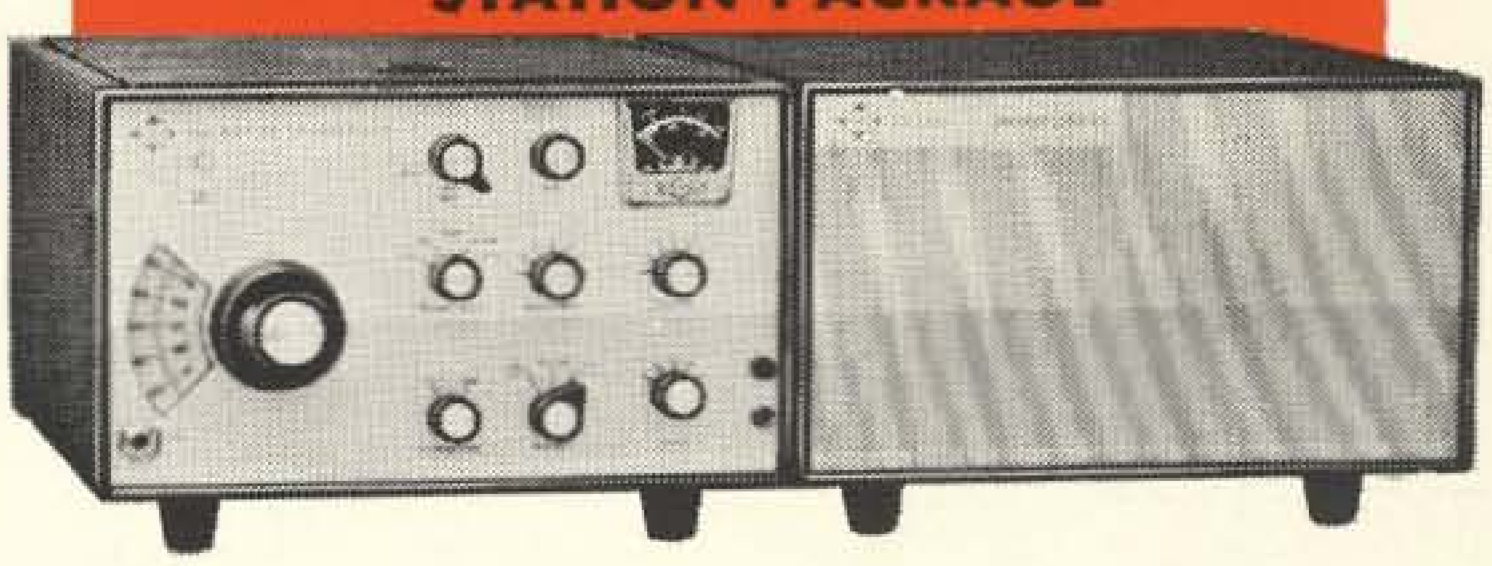

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