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January 1970

75¢

AMATEUR RADIO 73

Transceiver Companion
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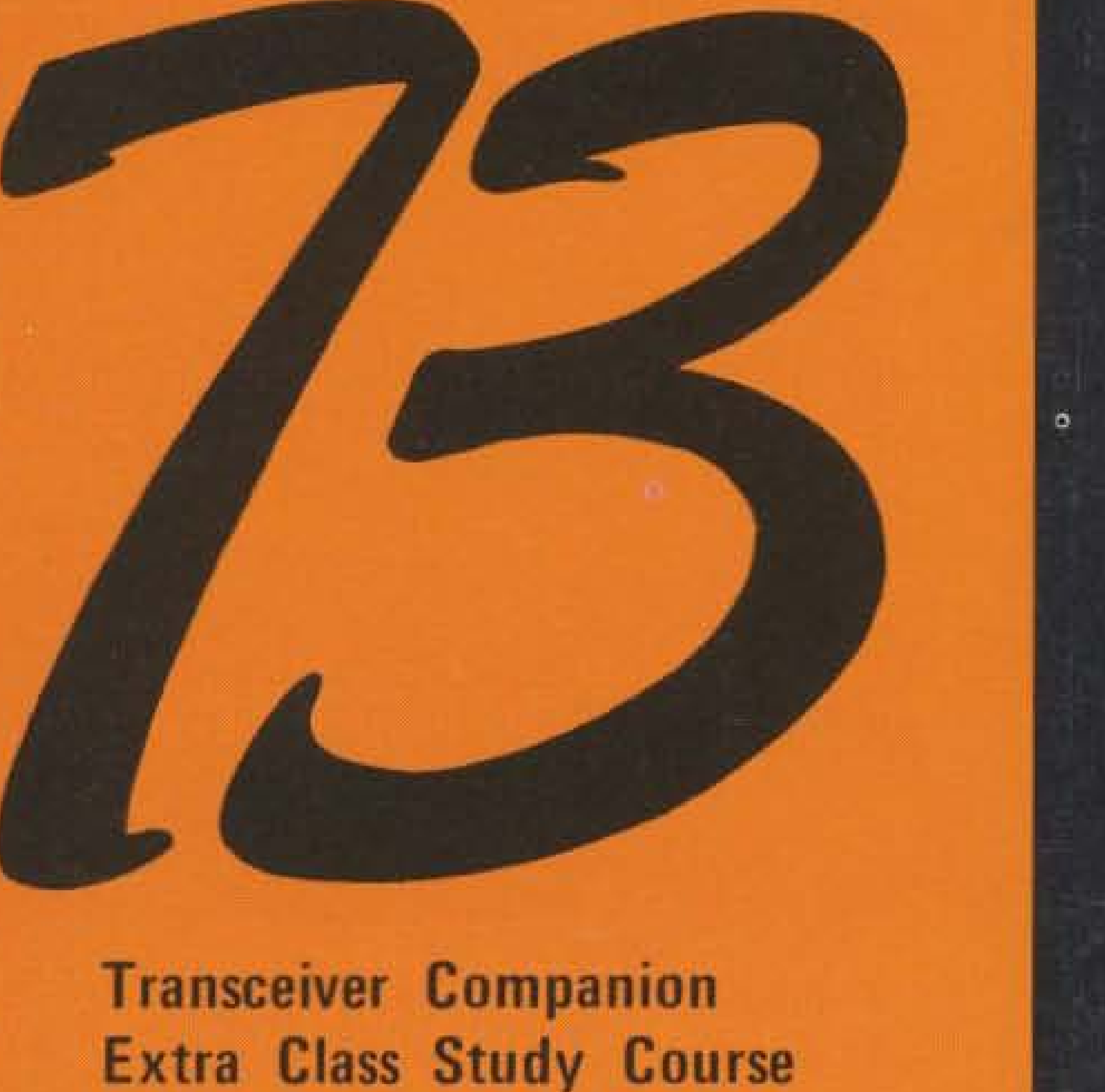
336 2 meter elements at W2NSD/1



Amateur Slow Scan Color TV Approaches Perfection Slo-o-o-o-wly

73 MAGAZINE

#112, January 1970

Features

STAFF

Contents

73 Magazine is published by 73, Inc., Peterborough, New Hampshire 03458. Subscription rate: $12.00 for three years, $6.00 for one year. Second Class Postage paid at Peterborough, New Hampshire, and at additional mailing offices. Printed at Pontiac, Illinois, U.S.A. *People generally fall into one of two groups: the Construction Workers or the Wrecking Crew. Which are you?*

...de W2NSD/1

Wayne Green

Last month we carried Ken Sessions on the masthead as the FM editor. This probably needs some explanation. Ken (K6MVH), as you may know, has been the editor of the FM Journal for the last year, working in conjunction with Mike (WA8UTB), the publisher. It is easy to go overboard on this sort of thing, as the publishers of many past amateur radio magazines will attest. At any rate Mike and Ken agreed to split up, with Mike continuing the magazine as long as he could alone. Ken wrote to me and offered to run an FM department for 73.

Having just returned from a splendid demonstration of the joys of FM and the excitement of the repeater systems while visiting with Tom Nelson W6QGN, I jumped at the offer.

Ken, in the meantime, had pulled up stakes and moved from California to a job editing Electronic Packaging and Production magazine in Chicago. I called him a few times about some FM articles we had in the works and my good impression of him gained at the Saroc convention back in January was reinforced. Would he be interested in coming with 73? I didn't have much money to offer, but I did have a job that is about as much fun as a job can be for a dedicated ham, and New Hampshire is a fabulous place to live. So I called Ken and though it meant a substantial cut in salary, he quickly agreed to make the move. Since he had been working at EPP for just a few months they were a bit put out by the sudden change.

A couple of weeks later, Ken, his wife and seven children (count 'em–7) and a van load of ham gear (and furniture) arrived. Fortunately I was able to locate a nice home for him less than a mile from the 73 headquarters.

Ken will be running the editorial end of 73, while I tend to increasing the circulation, getting around to a few conventions, talk to a few clubs, maybe get off on a short DXpedition or two, work on plans for 73 to eventually go public, get Radio Today into gear, help with the new junior op that is due about the time this goes to press, work on plans for several other new magazines, and perhaps run ski classes for the 73 staff on bright snowy mornings.

Exit the Youth Forum

The Youth Forum in the October issue didn't work out too well, everything considered. This was the brainstorm of Ralph Irace WA1GEK, a 17 year old with more than the average amount of drive.

Ralph turned up here last July and wanted to do something about getting more teenagers interested in amateur radio. He felt that both 73 and Radio Today could help with this and he wanted a job with us. Being extremely shorthanded, I agreed to give him a trial proofreading articles as an editorial assistant. After a few days it was obvious that this was a mistake. His moods were mercurial, running from virtual catatonia to great agitation. Frankly, he scared most of the girls here and my wife was truly frightened. I laughed at her preposterous worries. I suppose that I should have known, for I laughed at her when she tried to warn me about Don Miller.

At any rate, after a couple of weeks Ralph went away. Shortly thereafter I received a fantastic letter from him saying that he had made copies of many of the documents here and would use them against me unless I came to terms with him. Since there is absolutely nothing here to hide, none of us could figure what could be in his mind or why he thought copies of old bills and letters would be of value to us or our competitors. I ignored him.

In late October, while I was out in California at the Bay Area hamfest, someone broke into the 73 offices and stole my two rifles, plus who knows what else. Our list of missing items is a long one. I reported the theft and dismissed it from my mind.

Then Dave Mann (Leaky Lines) sent me a clipping from the Hartford Times saying that Ralph Irace was being held for murder. According to the clipping, Ralph and a friend were returning from Florida in early November. The police discovered the body of Wayne Rubenstahl shot three times with a .30 caliber rifle on highway I-91 in Lumberton, N. C. The police there put out a warrant for Ralph's arrest for murder and he was arrested in Richmond, Virginia. The police said they were at a loss for a motive for the murder.

I was dumbfounded.

As I thought about it, I became suspicious, so I called the police in Lumberton to check on the murder weapon. I explained about my two stolen 30 caliber rifles and gave them the serial numbers. Yes, they had the guns and one had been used in the killing.

We have no plans for continuing the Youth Forum that was published in the October issue . . . at least not under the same byline.

I have promised to let Lin check on all employment applications for 73, even those on a short trial, in the future. If her intuition says no, no it is. I know when I am licked.

(continued on page 97)

For The Experimenter!

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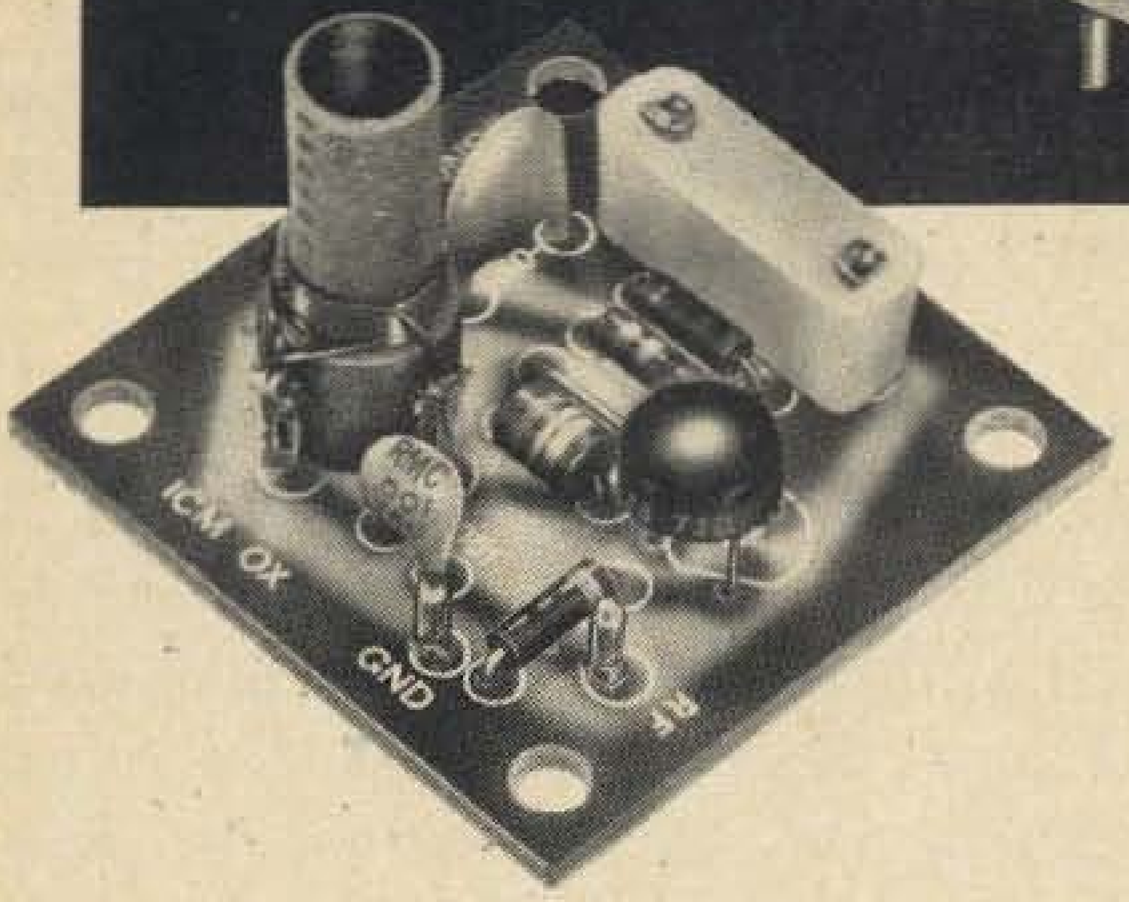

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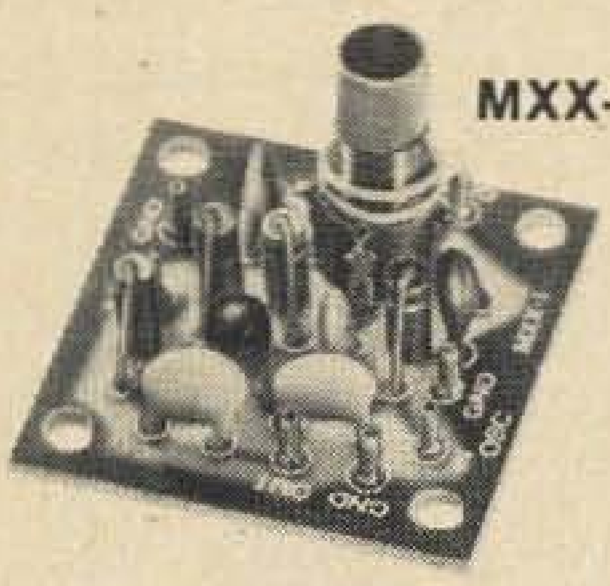

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Single Sideband AM-FM Modulation System

Much has been said pro and con about single sideband in its present form. It is an admitted fact that SSB takes up far less of the radio spectrum than AM or FM. Still when you tune in an AM or FM signal with a proper receiver there is a difference. With SSB as it is now, tuning the receiver is critical and stability of the receiver is very important. When the carrier is sent along as in AM or FM the tuning of the receiver is no problem.

Being an old time amateur and liking AM for so long, when SSB came along I could not warm up to it at all. I always liked to hear all that was going on even if it was on an adjacent channel, beat note and all. It was somewhat like being in a room with a lot of people talking at the same time with all the noise added. Today the adjacent channel is all monkey chatter which is almost as bad as the heterodynes. Sometimes you like to know what your neighbor is saying, good or bad. Tuning a few hertz off and not being able to understand, yet hearing the signal either nasal or guttural is not best for me. Also, how are we going to make use of this SSB in the UHF and microwave regions? You would need the stability of an atomic clock at both the transmitter and receiver. FM has made the deepest penetration into these frequencies. Narrowband FM is being used for most mobile communication, and many improvements have been made over the years.

By now I guess you can gather from the above that I am not happy with SSB as it is and I am not about to chuck the old AM rig that is gathering dust in the basement shack. I am dreaming about the ideal system where the carrier would be sent along with a bandwidth no wider than that required for a single signal the same as CW. If someone sneaks alongside I don't want to hear anything other than his own speaking voice.

So now, to get started and narrow things down, I decided to start playing around with filters. Crystal filters are excellent and everyone uses them, but I wanted a filter that I could tune. Just for kicks I decided to build around 30 mhz. Crystals having a fundamental at 30 mhz are pretty hard to come by, so I decided to investigate the resonant cavity type filter as they are quite easy to make. My first thought was the re-entrant type cavity, so I started to look for one. Down on Newbridge Road there is a water tank about 25 feet in diameter and 100 feet in the air. It looked like it would resonate at 30 mhz. This turned out to be wishful

A sight for sore eyes on the Long Island Expressway.

thinking as it was pretty solidly mounted and I assume that the water department would be a little reluctant to let me borrow it for my experimenting. There is one in Garden City that is nearly round and the spherical type is known to have a Q of around 53,000. Well my hopes started to shrink and I finally succumbed to a smaller cavity like a 55 gallon drum. It was quite a sight seeing my little Bianchina 500 Fiat going down the highway with a 55 gallon drum lashed on the back. I ended up with quite a collection – three 55 gallon, one 30 gallon and one 14 gallon.

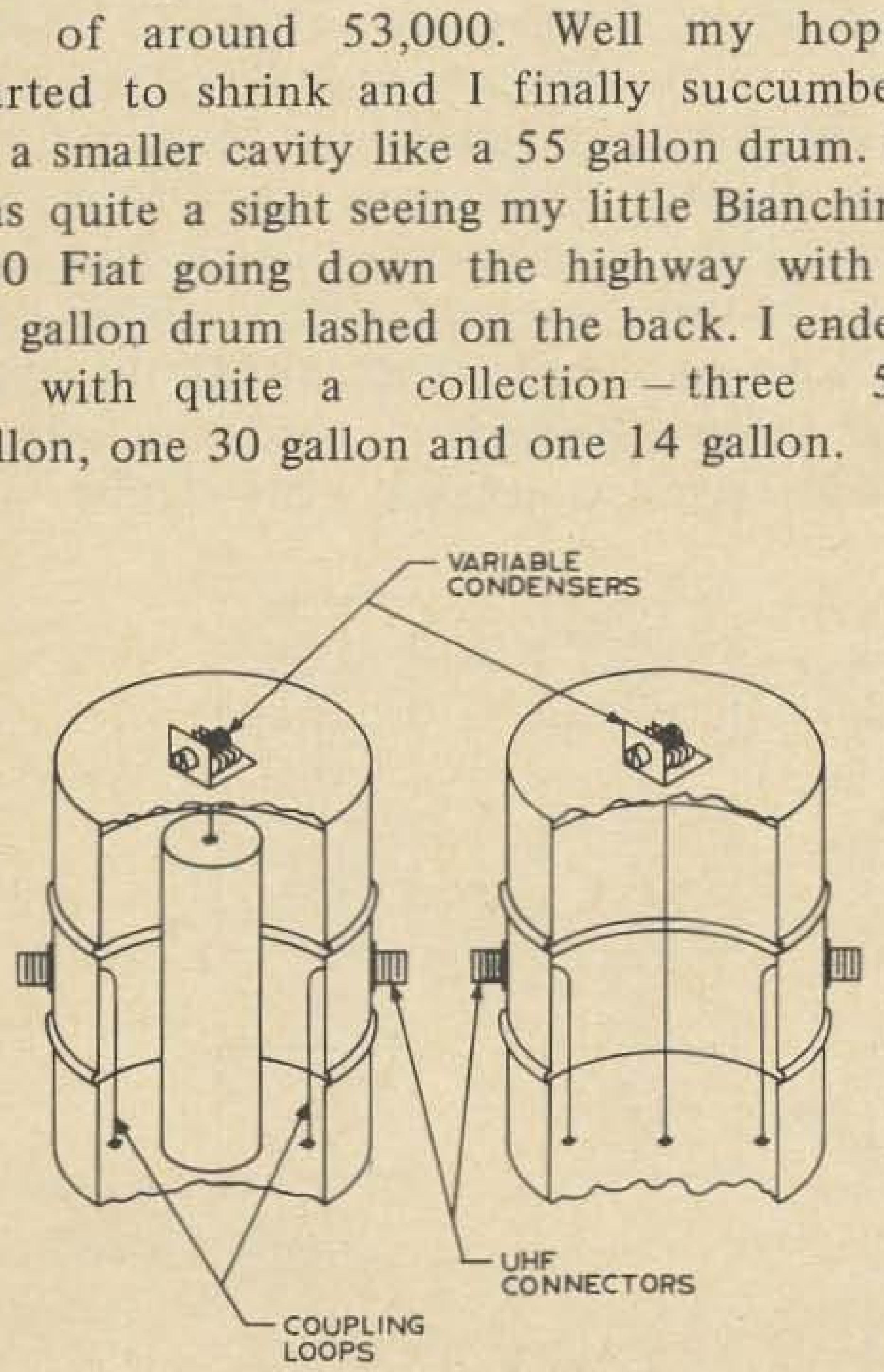


Fig. 1. Drum cavities.

I experimented with two types of re-entrant arrangements. One was made as shown in most textbooks, with a large re-entrant post and capacity loaded and the other with a single wire through the middle of the drum as a re-entrant element. Both of these cavities had a self resonant mode around 200 mhz. With a 100 pf variable capacitor, resonance at 30 mhz was found at about 65 pf. The cavity with a single wire as the re-entrant element had a higher self-resonant frequency as it required less capacity loading.

With the equipment in the shop it was impossible to make accurate Q measurements; to make even comparison measurements a good VTVM was needed, so I had to tap the piggy bank for a VTVM kit. I found this to be a very worthwhile investment and every ham shack should have one. Making comparisons of the characteristics of the two different type cavities showed that the one as shown in the textbook with the large re-entrant element had very little insertion loss, but did not have as sharp a band pass as the single wire job. The size of the coupling loops into the cavities was arbitrarily chosen and no great attempt was made to get a perfect impedance match to both input and output.

There are many things one can do to improve the Q of cavities, such as silver plating the inside or changing the shape and, for stability, temperature control or use of materials unaffected by temperature, etc. Considerable research on resonant cavities has taken place and by searching into past publications one can learn a lot. I was anxious to put them to use and, as far as the other sizes (30 and 14 gallon drums) were concerned, my research ended by finding resonance using the single-wire center element. The 30 gallon drum resonated around 40 mhz and the 14 gallon at 200 mhz using a 50 pf variable capacitor.

Not having a stable signal source on 30 mhz, I decided to build a transmitter that would have a 30 mhz output and when finished with my experimenting, successful or unsuccessful, I would at least have a usable rig on 10 meters. The rig would be FM and as stable as possible.

Having many old-fashioned tubes kicking around, I decided to build a rig as described in an old Radio Handbook (Editors and Engineers Limited. Eighth Edition). The tube lineup is a 6N7 audio amplifier, 6SJ7 reactance modulator, 6F6 electron coupled oscillator, 6K8 oscillator-mixer, and a 6H6 discriminator.

Starting with broadcast components in the electron coupled oscillator, the first frequency is 1.1725 mhz with a 2.345 mhz output. A tripler multiplies the frequency up to the 7 mhz frequency and some of the output signal is mixed with a crystal controlled oscillator. The output of the mixer produces a 465 khz signal, which is fed into a discriminator, thus producing a dc voltage that is used to stabilize the electron coupled oscillator.

Another output of the 7 mhz tripler is then fed into doublers that multiply the frequency up to 30 mhz. (Modern tubes were used for this.) The signal ended up with a 6AQ5, giving enough output to light a small neon. I encountered the usual parasitics and other things and had to back-track many times. Also, listening to the 28 mhz signal, I found it to have considerable 60 hertz hum with no audio going into the reactance modulator. The electron coupled oscillator called for a coil in the filament lead of the 6F6, and the AM broadcast frequencies require quite a few turns. There was a filament voltage drop and, with low voltage on the filament and ac in the coil, some modulation of the carrier was taking place. I decided to put dc on this filament; with good filtering the hum on the carrier decreased substantially.

Now I had an FM signal generator ready for the drums. I connected the output to the input of one of the drums and, using a sensitive meter with a crystal rectifier, I was able to observe the changes of reading as I tuned through resonance. The single wire re-entrant drum tuned very sharply and I was pleased. When tone modulation was applied, the reading went down just as it should. Using an on-off tone at about 2500 hz I found I could tune to both the upper and lower sidebands. I also found that I could get wideband modulation and

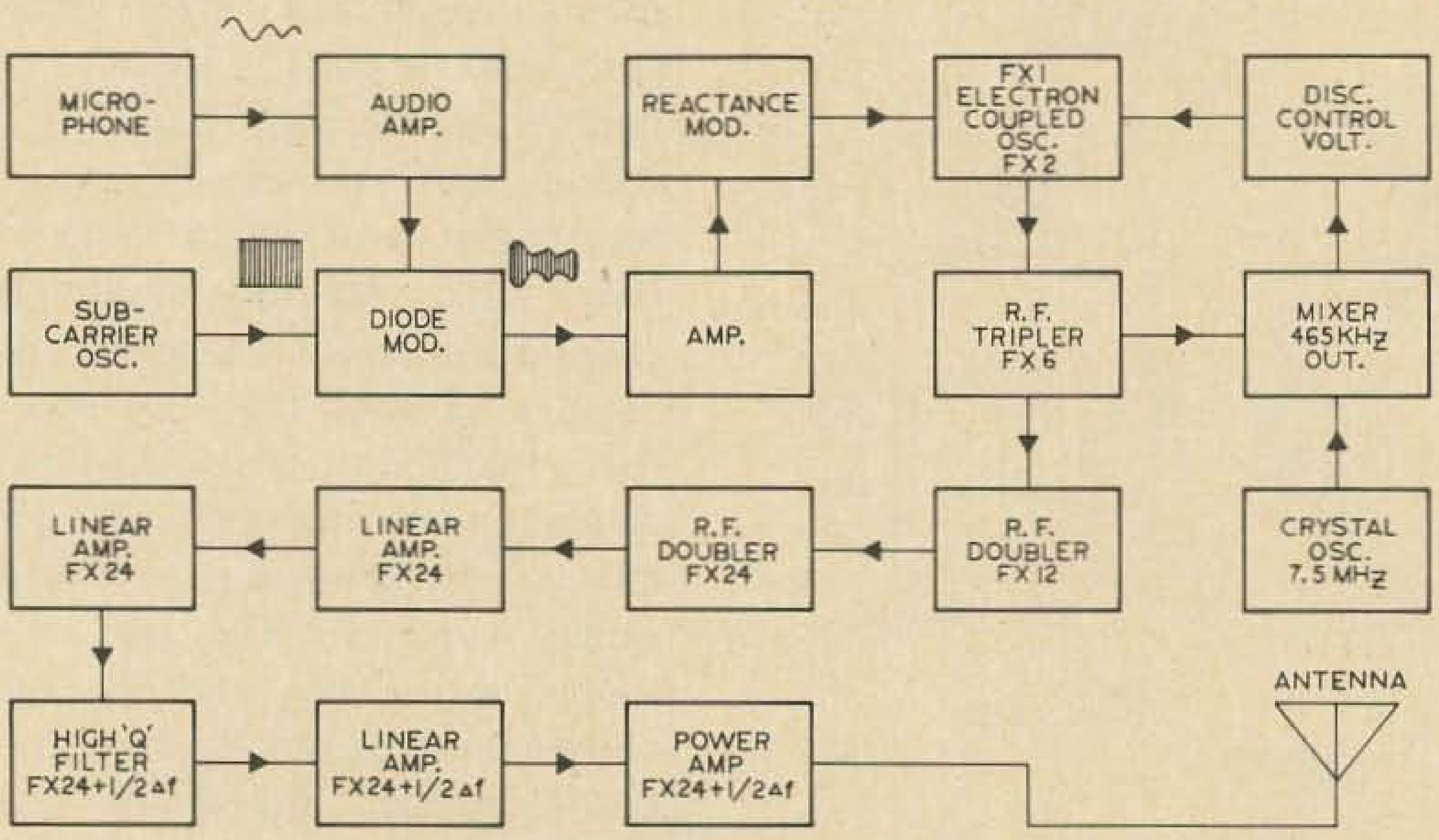


Fig. 2. Modulating circuit.

detected sidebands as much as 200 khz away from the center frequency of the FM signal.

I also found that I could peak the final amplifier to the upper or lower sideband and get an increased signal reading depending where resonance of the drum was tuned. The maximum sideband signal also varied with changes of audio level or deviation. The tone of the on-off oscillator was good when I listened on my old AM receiver and it was quite easy to locate the carrier center with no audio. With very little shielding of the chassis and the bottom plate off there was plenty of rf floating around the shack.

Well now, what will happen with voice and music fed into the system with all this deviation and how much intelligence will get into the filter? I coupled a microphone into the unit and turned up the gain and listened on the AM receiver. All that I could hear was a lot of pops of the high level audio peaks and it sounded very similar to our present sideband without the carrier added. By increasing the deviation there were a greater number of pulses due to more rf getting into the filter, but it sounded pretty awful. None of the low amplitude audio was getting to the filter and at this point I thought of using volume compression and clipping. I saw an article in 73 on a compression amplifier and immediately built one. The output of this was fed into the unit and after a few more days of tuning, testing, and listening to a little less awful sounding signal I proceeded to the local liquor store and bought a bottle of scotch and drank it. This didn't help so I decided to try clipping. I incorporated it in the compression amplifier, using a couple of diodes for the clipping. Now, this made an improvement and with all the distortion created by very heavy clipping I finally was able to understand voice modulation. Music sounded like 2000 cats on an equal number of different sized tin roofs.

After analyzing the situation I found that those low amplitude audio inputs would never make it, or would only when all others were deviated into the microwave region on the upper sideband or back into the audio range on the lower sideband. Then there wouldn't be much left anyway because the carrier would be spread out as if hit by an atomic bomb.

Those low amplitude audio signals needed a little push. Why not introduce a subcarrier that would push those little signals out to the filter, just far enough that they could be heard? The frequency of the subcarrier would be above the audio range and would not be heard. I started immediately to build an oscillator out of transistors and ended up with an oscillator on about 35 khz. I fed this directly into the grid of the reactance modulator mixing it with the audio. Making all the necessary adjustments I listened, but those low audio signals just didn't come through. I then decided to look at the audio going into the reactance modulator on an oscilloscope; sure enough, it was riding up and down with the carrier and not modulating like old fashioned AM should. We needed a better arrangement. I decided to put a diode modulator to work and get good AM modulation of the subcarrier.

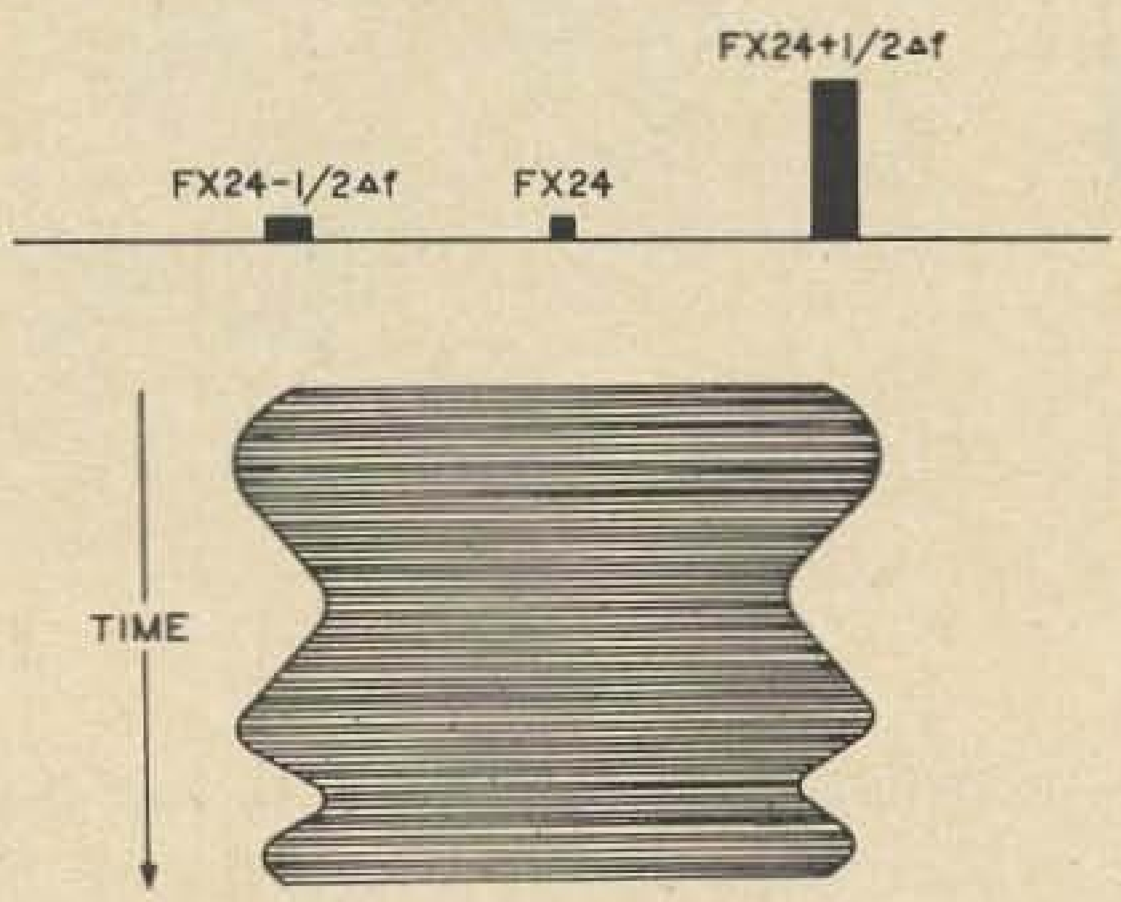
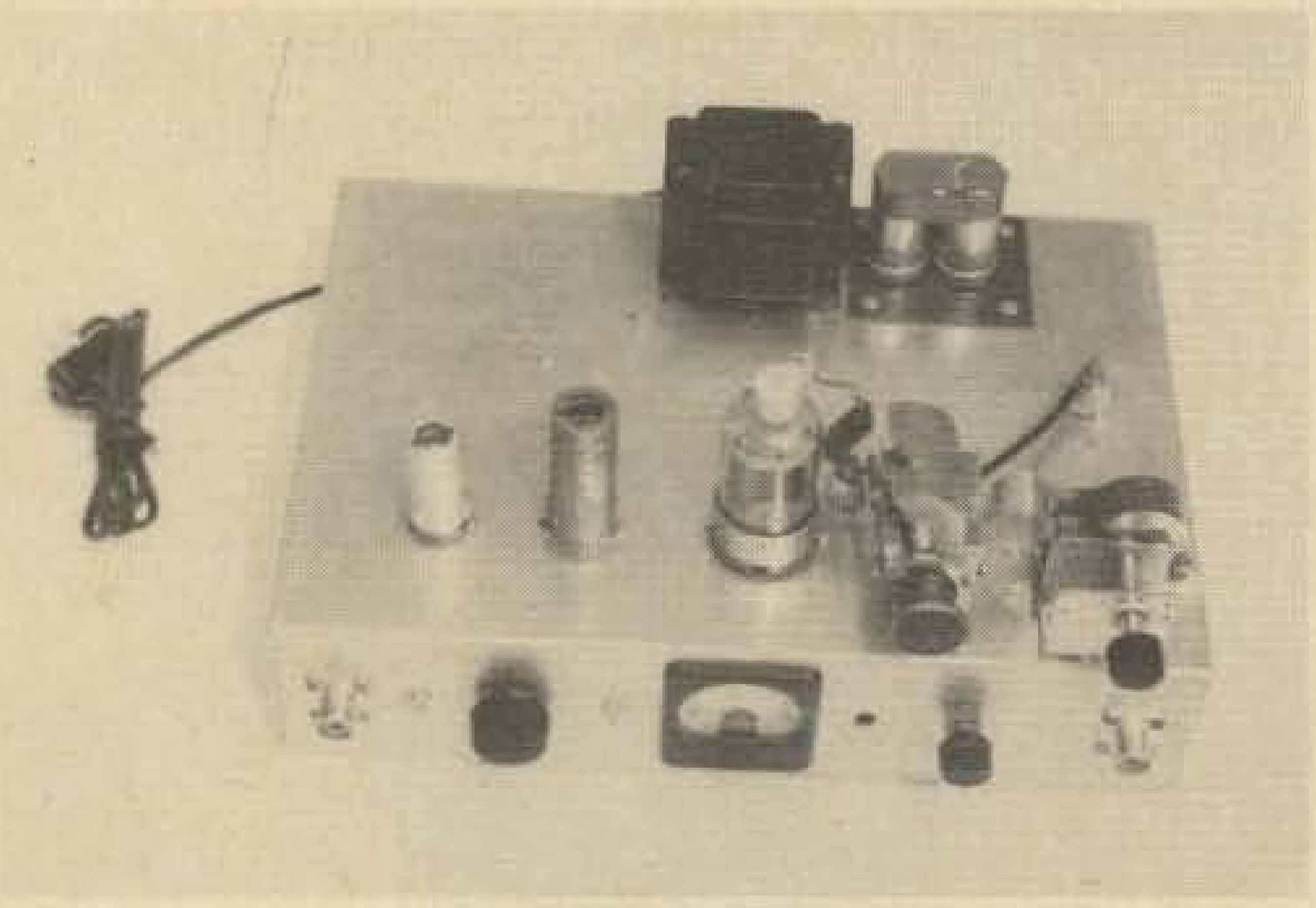


Fig. 3. Carrier, sub-carrier & audio modulation.

This arrangement made a tremendous improvement—so much that not only could I understand what a person was saying but I could also make out the music. The AM receiver I have was not up to receiving this type signal too well, so I needed something a little better. I found an old 30 mhz i-f strip out of a surplus radar in my junk and started to work on it. The strip needed a going over as one of the rf amplifiers oscillated when plate voltage was applied. I installed a ratio detector after the last rf stage and after a few additional problems I got the strip to work. I lowered the supply voltage, as the strip had quite a bit more gain than I needed to make tests. Using a small transistorized audio amplifier and speaker, I started to listen to the output of the filter. It sounded pretty good.



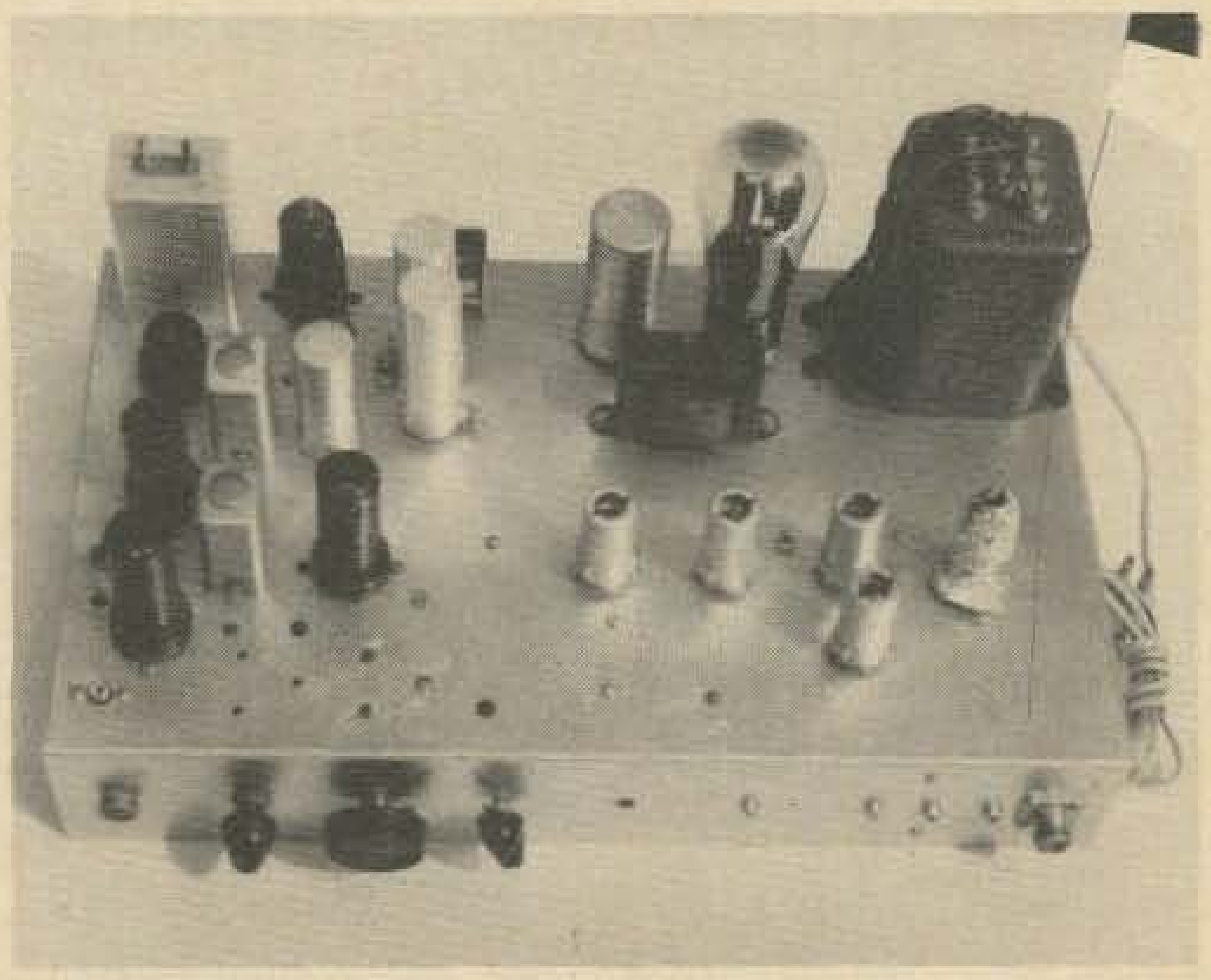
Linear amplifier.

Now what would happen if the output of the filter were coupled into a final linear amplifier? I decided to build a linear amplifier with a circuit using a 12BY7 driving a 6146. This linear amplifier was built on a separate chassis using two well-regulated power supplies, one low voltage and one high voltage.

After the usual problems with neutralizing and parasitics I found there was insufficient gain and another stage of amplification was required. Also I might point out that for the filter I now had two 55 gallon drums hooked in tandem. This introduced considerable insertion loss and the amount of power output was small, but contained the sharp band-pass characteristics that are needed. Using a 6AU6 to drive the 12BY7 brought the filter output up and drove the power up to a good level. With this additional power I was now able to take the receiver some distance from the equipment and listen to the quality. After listening I became very encouraged and was pretty well convinced that I had a different means for getting a sideband signal that would be pleasant to listen to.

In that this type of modulation as far as I know is not on the FCC list I have not put the system to test on the air. With the proper FCC approval I will give it a try, but in the meantime will continue to use the dummy load for tests.

In that the first unit constructed grew like Topsy, future plans are to build another chassis using better components and newer layout. There is considerable room for experimentation with the system and I also have plans to try using two arrangements having two different subcarriers so as to get a compatible stereo output. This will require a different or double detection receiver.



Main chassis.

Many improvements can be made for band switching with tunable filters. One disadvantage for amateur use is that the filter is at the fundamental frequency transmitted and it has to be good as it is the frequency determinant and must be stable.

In that the system contains both AM and FM and a filter I guess that the best name for it would be Frequency Aperture Modulation, or FAM.

. . . W2BSP ■

Leaky Lines

Writing a monthly article for a magazine like this is not a lead-pipe cinch. It can be sheer drudgery, tedious and monotonous, because of the limited subject matter. By precedent it has been established, more or less, that publications oriented toward specific activities should confine themselves to those alone.

One's intellect, however, fairly shrieks for variety, above all. For the disciplined, principled view, which always characterizes small and large crusades, demands constant iteration and reiteration. The moral obligation to maintain a concentrated pressure in order to effect a desired change (and it *is* an obligation) demands allegiance to the idea . . . completely and wholeheartedly. Yet, there do exist other things, other matters of fascinating interest, even though they may be less appropriate, or may appeal to be lighter, when weighed in the scale of comparative importance.

It is sometimes necessary to take a look around and consider these lighter topics, in order to preserve a certain quotient of balance in the total equation of existence. For, one-sided, overfervent, hyperintense crusades create one-sided, overfervent, hyperintense bores . . . people who, despite the correctness of their views, succeed generally only in repelling the very ones they are most anxious to convince and convert.

Just to demonstrate that three prohibited examples out of this group, all of which have been pronounced "taboo," may be discussed without provoking anything more alarming than the gray matter, I wish to concern myself with them in this installment of my personal journal. For many years the timid and timorous have studiously avoided any open dialog upon these matters, lest they offend the sensibilities of that huge mass of shadowy, faceless and nameless creatures called "the public."

But this "public" is not merely an amorphous glob of inorganic goop, without volition or the ability to distinguish between common sense and idiocy. The "public" is composed of individuals, in each of whom resides, if only dormantly, the intelligence to determine for himself the dimensions and limits of decency, propriety, and virtue.

And so, despite the upraised hands and horrified tongue-clucking of all the alarmists who ceaselessly warn of impending doom and disaster, I shall make a few observations and speculations concerning these three unmentionable subjects: Politics, Religion, and if you'll pardon the expression, Sex!!!

Now this, as if you didn't know it, is an election year. And in such periods we seem always

(continued on page 93)

The Transceiver Companion

Peter A. Lovelock W6AJZ
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Santa Monica CA 90403

The transceiver companion is not just another control console; in fact, its application isn't limited to transceivers, and it might well find a place with any receiver-transmitter combination. It started out as a desire to integrate all the associated accessories which surrounded the transceiver in the corner of our apartment living room.

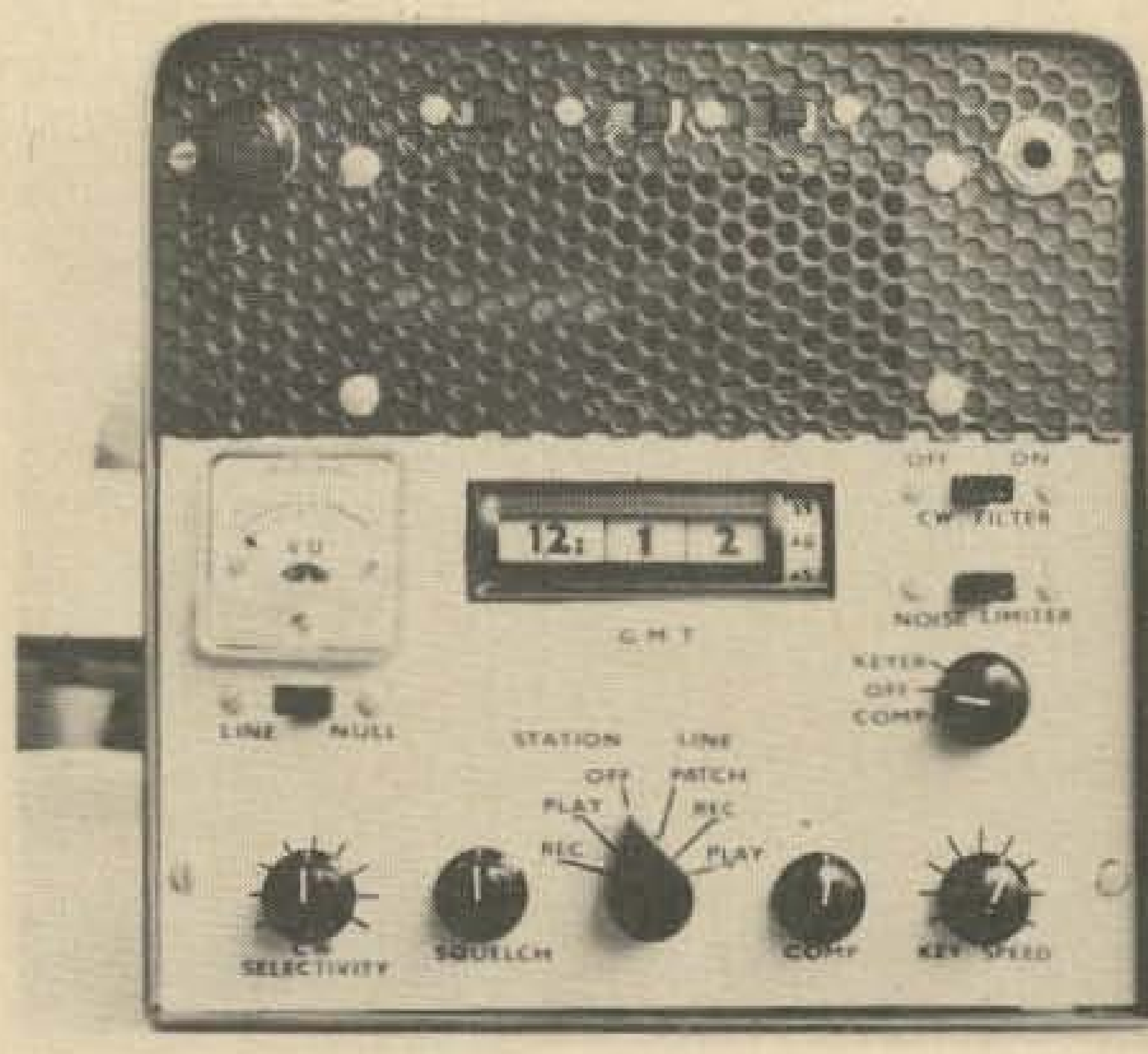
What with a compressor preamp, electronic keyer, phone patch, tape recorder, CW filter, clock and speaker with associated cables, the corner was getting messy and the XYL unhappy. Besides, there was a problem of plugging and unplugging for each mode of operation, and the tape recorder would be more useful if . . . . . !

Thus the transceiver companion evolved to integrate the necessities of a fixed station transceiver, with the one exception of the tape recorder itself. But it took care of utilizing the recorder for various purposes without touching a connector.

Actually this article presents ideas for consolidating the ham station accessories adaptable to the individual constructor's needs. My companion was designed to provide associated functions for my Galaxy V Mark 2, though with a mind to eventual equipment replacement, and the flexibility to work with something else.

So if you use some other equipment and your operating habits dictate other accessories than described, you may well be able to build a companion of your own. It may not even look the same, for you will likely as not want to utilize a housing to match your other equipment. And how many hams exactly copy any construction article?

The heart of the transceiver companion's flexibility is the use of plug-in, computer-



type boards, for all the transistor circuits incorporated. You can buy such boards ready made, or build them yourself. They permit great ease for trying out different circuits, or substituting that better one when it comes along with a minimum of construction change. And they are real great for testing and troubleshooting, or incorporating the occasional modification.

Thus, the companion isn't a static piece of equipment doomed to eventual obsolescence.

Besides the transistorized circuits, other accessories are incorporated in more conventional form. Right now my transceiver companion incorporates the following which, apart from the tape recorder, mike and separate power supply, is everything I use with the transceiver:

(1) speaker, and headphone jack.

(2) low-pass speaker filter to eliminate SSB monkey chatter.

(3) phone patch/tape recording and playback facility with selectable mode.

(4) digital clock.

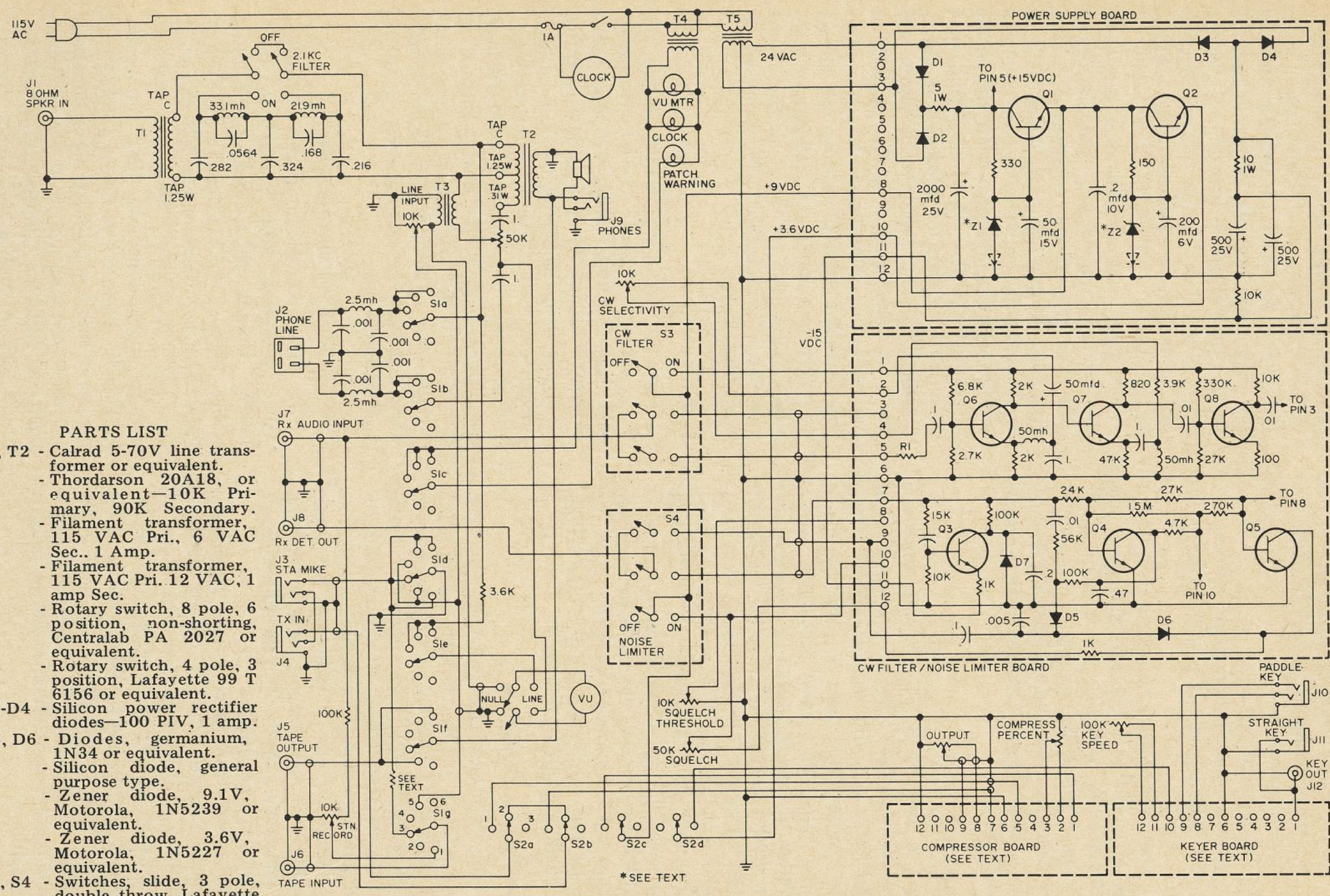


Fig. 1. Schematic.

PARTS LIST

- T1, T2 - Calrad 5-70V line transformer or equivalent.
- T3 - Thordarson 20A18, or equivalent—10K Primary, 90K Secondary.
- T4 - Filament transformer, 115 VAC Pri., 6 VAC Sec.. 1 Amp.
- T5 - Filament transformer, 115 VAC Pri. 12 VAC, 1 amp Sec.
- S1 - Rotary switch, 8 pole, 6 position, non-shorting, Centralab PA 2027 or equivalent.
- S2 - Rotary switch, 4 pole, 3 position, Lafayette 99 T 6156 or equivalent.
- D1-D4 - Silicon power rectifier diodes—100 PIV, 1 amp.
- D5, D6 - Diodes, germanium, 1N34 or equivalent.
- D7 - Silicon diode, general purpose type.
- Z1 - Zener diode, 9.1V, Motorola, 1N5239 or equivalent.
- Z2 - Zener diode, 3.6V, Motorola, 1N5227 or equivalent.
- S3, S4 - Switches, slide, 3 pole, double throw, Lafayette 99 T 6166 or equivalent.

(5) transistorized noise limiter and squelch.
(6) variable selectivity audio amplifier for CW operation.
(7) electronic keyer.
(8) microphone compressor/preamp.
(9) power supply for transistorized circuits.

The entire unit is housed in an 8 inch x 8¼ inch x 8 inch cabinet, taking up just 1/3 cubic foot of space.

Fig. 1 shows the complete schematic of my transceiver companion, and the following is a description of the elements enumerated above:

Speaker

A 6 inch by 2 inch, 8 ohm voice coil speaker was selected because of the excellent response range and convenience of fitting this configuration into the available panel space. This type speaker is available from a number of sources (including a replacement for several popular brand table model TV sets). However, TV manufacturer replacements run around $7.50, while imported makes cost from 89 cents to $1.98. Usually the lower the price, the smaller the magnet and the lower the efficiency. Some imported makes have 3.5 ohm voice coils, requiring use of the 4 ohm tap on T2. (See recommended parts list.)

Low-Pass Speaker Filter

The switchable 2.1 khz low pass filter is a Chinese copy of that described by W3NQN (*QST*, Technical Correspondence, November, 1967). Transformer T1 elevates the transceiver output impedance to the 500 ohm impedance of the filter. T2 matches the filter to the 8 ohm (or 3.5 ohm) speaker. T2 also serves double duty as a component of the hybrid phone patch circuit described below.

This excellent filter circuit provides a maximum attenuation of -60 db at about 2.6 khz, and no less than -40 db at all frequencies above that. It is considerably superior to constant K and m-derived filters in the sharp cutoff above 2.1 khz, which knocks out high pitched "monkey chatter" and heterodynes without affecting speech intelligibility.

The filter on-off switch is therefore not essential as it may be left permanently in circuit. However, since I anticipated using the speaker for other monitoring purposes, the switch was included to permit optional full response range. In addition, it provides a convincing demonstration of the effectiveness of the filter, which has to be heard to be believed.

The filter coils are made from surplus 88 mh toroids by removing turns until the exact values are measured on an impedance bridge. Similarly, the odd capacitor values are built up from standard value units in parallel and measured on the bridge to obtain the precise values shown. Not every ham has possession or access to a high precision bridge, unfortunately. Use of approximate values will result in degradation of performance from the optimum. Therefore, I can't overemphasize the value of borrowing a bridge, or prevailing upon some engineer or technician friend who has one at his disposal, if you plan to use this filter. The results will be worth the effort.

Digital Clock

This was obtained by extricating the works from the plastic case of my former desk clock (Tymeter twenty-four hour clock, Lafayette catalog 40 T 9102). The entire clock movement is assembled on a casting, mounted by two screws to a bottom plate. The plate was removed and discarded, and the tapped holes in the casting utilized to mount it to the companion chassis foundation. Two miniature pilot lamp holders were attached to the numeral mask to provide illumination.

Phone Patch/Recording Switcher

The phone patch is a duplicate of that designed by Katashi Nose, KH6IJ ("An Inexpensive Hybrid Phone Patch," *73*, November, 1965). This circuit permits the use of low-cost transformers and a 50k balancing pot, with impedances widely in variance with the conventional 600 ohms. This results in fantastic losses, but as KH6IJ pointed out, the loss in gain is appropriate when matching a 0 db level phone line to a -55 db mike input. In fact, the "imperfections" of this circuit serve to reduce hum and rf susceptibility, and it works like a charm at a fraction

of the cost for the components of a high grade circuit.

As mentioned above, T2, which is a center-tapped transformer providing two arms of the bridge, also serves the dual function of matching the output of the low-pass speaker filter to the speaker. When this was tried experimentally, it was feared that switching the filter would cause a change in the null balance, but this proved unfounded, and T2 serves its dual role beautifully.

T3, the two 1 mfd capacitators and the 10k potentiometer (TX input level), make up the balance of the patch components. A refinement to the original circuit was the addition of a VU meter which, by means of a DPDT slide switch, can be selected to read transmitter input level for null adjustment (null position) or output level to the phone line (line position). I personally consider the use of a VU meter essential to prevent feeding too high a level to the phone line, which is all too easy if "ear" measurement is depended upon.

Null adjustment is described at the end of this section.

J7 and J8 provide for permanent connection to the mike input and speaker output of a suitable tape recorder. (I use a small transistorized recorder, with high impedance mike input, 8 ohm speaker output.) Phone patch/recording/playback mode switching is provided by S1a-g which is a 4 deck, 8 pole, 5 position, nonshorting rotary switch wired to provide the following functions:

Position 1 - Record from receiver.
Position 2 - Playback to transmitter.
Position 3 - Off (usual position during normal station operation).
Position 4 - Phone patch.
Position 5 - Record from phone line.
Position 6 - Playback to phone line.

While position 3 is denoted as "off," it will be noted that the station mike is connected to the tape recorder input in this position. Therefore, activating the recorder in position 3 will permit recording of transmissions made. If PTT can be deactivated, the station mike can be used for making any recording, such as directional CQs, which can then be played back as often as required to the transmitter input by switching the mode switch to position 2. Alternatively, another station's transmission may be recorded (mode switch in position 1) and then played back for his edification (position 2) or held over for later telephone relay to some third party (position 6).

The mode switching permits flexible utilization of the tape recorder without having to plug or unplug a single connector for any mode.

With a high-impedance recorder input, no loading or gain loss from the station mike is experienced when simultaneously transmitting and recording with mode position 3. However, some transistorized recorders have input impedances which are intermediate, even though they function with a crystal mike. Such recorders may load the mike line and cause significant loss of gain to the transmitter input. In such cases a resistor of 50k to 250k should be inserted in the wire between sections d and g of S1, until no noticeable loss of level to the transmitter can be observed. Tape recorder input level can be compensated by its own gain control.

In mode positions 4, 5, and 6, all of which involve connection to the phone line, section c of S1 activates a warning light mounted in the top left hand corner of the front panel, to remind the operator to return the mode switch to a nonphone line position at the conclusion of this type of operation.

Two 10k pots mounted at the rear of the companion provide preset level adjustment for station receiver output to the recorder, and phone line input to the transmitter and tape recorder.

To adjust the hybrid phone patch balance, first call an obliging friend and have him hold the line. Switch mode to position 4 and VU meter to *line* . Feed a steady signal from the receiver (such as the beat note from crystal calibrator, tuned to approximate a 1 khz tone), and adjust the receiver gain control for a VU reading of 0 db. Switch VU meter to NUL and slowly adjust the 50k balancing pot for null (zero) reading on the VU meter. This first null may appear somewhat broad. Actually the null position of the pot is quite sharp, but the null is about -40 db, while the VU meter range is limited to about 25 db. It will now be necessary to temporarily crank up the receiver gain in order to feed enough level to the meter to find the exact null adjustment. This must be done as quickly as possible since it means feeding more than the normal level to the line. Once set, the null pot requires no further adjustment unless the companion is connected to a different line—such as when changing QTH. However, it's worth rechecking once in a while, in case the company has modified something at the other end of your line which would affect the balance.

The VU meter must always be switched to line position when using the phone patch, and the receiver gain control adjusted so that VU meter readings do not exceed 0 db on voice peaks. If the switch is left in null position during operation, the VU meter will load the transmitter input and result in severe loss of gain from the phone line. However, during normal, nonpatch operation the null position may be used to provide visual monitoring of the receiver output, since the hybrid circuit is unbalanced when the phone line is disconnected. Thus, actual signal versus noise reports may be given to stations in addition to the traditional S-meter readings. The meter is automatically disconnected in the line position, when the mode switch is in position 1, 2, or 3 to prevent possible damage from high signal levels at the unloaded phone-line switch connections.

In the event your transceiver doesn't permit taking audio from the detector stage, as required by J4 in **Fig. 1**, an alternate circuit which will permit recording from the receiver is shown in **Fig. 2**. This involves the addition of a small transformer, T6, with an 8-ohm primary and 500-ohm secondary impedance to match the tape recorder output to the patch line terminals when the mode switch is in position 2.

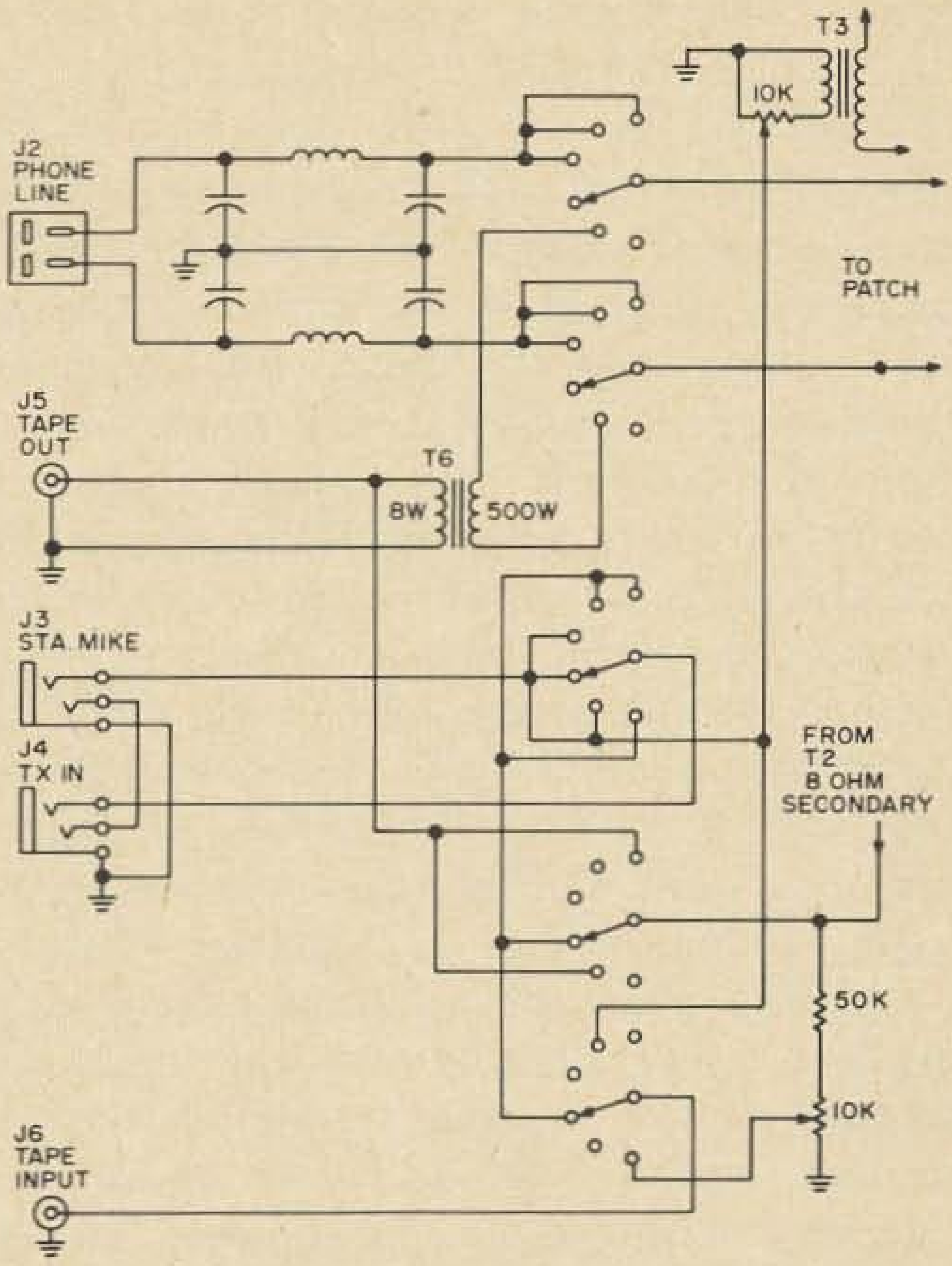


Fig. 2. Alternate circuit for station recording and playback. T6—Miniature transistor output transformer, 600 ohm pri, 8 ohm sec.

Noise Limiter and CW Filter

In order to use the noise limiter and CW filter it is necessary to be able to take audio output directly from the product detector and feed input to the audio amplifier of the transceiver. The Galaxy V Mk2 and the Mk3 transceivers have such a provision built in to accommodate an audio filter manufactured by Galaxy. If your equipment has no such provision it can easily be incorporated by mounting a dual RCA type phono jack on the rear of the unit and wiring the detector output to one jack and the amplifier input to the other, using shielded cable. If you don't care to make such a modification you obviously can't make use of this section.

Both noise limiter and CW filter are constructed on a single plug-in board (see construction section).

The noise limiter is a transistorized version of the popular TNS circuit, comprising Q4 and Q5, and was adapted from a circuit by Tom Kneitel K3FLL ("103 Simple Transistor Projects," John F. Rider Publishing, Inc.). Q3 is an audio derived agc circuit furnishing fast attack, delayed release negative bias, to replace the more common carrier derived avc from an AM detector which this circuit requires to "gate" the squelch action. As with its tube predecessor, this circuit provides a squelch feature by varying the load resistor value in the collector of Q5. The load resistor is a front panel control, 50k potentiometer labeled SQUELCH. The 10k pot connected to the base of Q5 is for preset adjustment of squelch threshold, and is mounted on the rear bracket. Setting of this control depends upon the exact characteristics of the transistors used, and the input signal level to some degree. To adjust it with signal applied from the receiver, the squelch threshold control should be advanced from zero circuit resistance to a point where no further increase in signal level is observed. Any further advance of the control will result in overdriving the transistor bases with resultant distortion and degradation of noise-limiting action. The adjustment is best made with random noise, and setting slightly below the point of maximum signal may improve noise limiting. At the optimum setting of the squelch threshold control, squelch action will occur at about the midpoint setting of the front panel squelch control.

It should be noted that, for the circuit constants shown, Q4 and Q5 and the diodes D5 and D6 *must* be germanium types. Silicon types will not function with the resistor values shown. Q4 and Q5 may be any audio-type, germanium NPN transistors with an h_{FE} of about 100.

The selective CW filter comprised of Q6, Q7, and Q8 is adapted from a circuit by Jim Fisk W1DTY (*73 Transistor Circuits,* published by 73 Magazine). Q6 and Q7 have a controllable feedback loop between their emitters, which is correctly phase shifted by the series tuned circuits in parallel with the emitter resistors, so that feedback takes place only at a frequency determined by the tuned circuits. The 1 μf, 3v ceramic capacitors and 50 mh coils used in my unit provide a resonant frequency of 700 hz. These values were used because they were available, but other combinations of L and C may be substituted, providing they resonate at a desired audio frequency. However, as the value of L in increased so is the impedance of the circuit, and the feedback control potentiometer will also have to be increased.

The 50 mh coils I used are surplus miniature shielded toroids, and regardless of the value of the coils, toroids are strongly recommended to avoid stray coupling, which will degrade the selectivity of this circuit. The use of high value ceramic capacitors requires matching the values of the components used to ensure that both circuits are resonant at the same frequency, since ceramic capacitors have wide tolerance ranges. If test equipment is not available to match the capacitors, you can try padding each capacitor with smaller value capacitors until regeneration (audio oscillation) occurs with the lowest setting of the 10k potentiometer.

The CW selectivity control varies the amount of feedback between Q6 and Q7 and thus changes the bandwidth. At a point just before oscillation occurs, selectivity becomes extremely sharp with the characteristic ringing of a crystal filter, so that only the slowest speed CW can be copied. The 3.9k resistor in series with the selectivity potentiometer should be decreased or increased experimentally until the circuit is just on the threshold of oscillation when the selectivity control is advanced fully clockwise (zero resistance).

Resistor R1 is provided to attentuate the output of the product detector, which in the case of the Galaxy V was too high for the input of Q6. The value will have to be determined experimentally for the receiver used, but in the case of the Galaxy it is 100k.

The original Fisk circuit included an emitter follower ahead of Q6 to provide input isolation. This stage was found to be unnecessary with the high input level from the Galaxy V product detector, since the 100k series attenuating resistor required to drop the level to Q6 furnished a sufficiently high input impedance to prevent loading the detector stage. If this circuit is to be used with equipment requiring an isolated input, the emitter follower input circuit may be required, and **Fig. 3** shows this optional circuit.

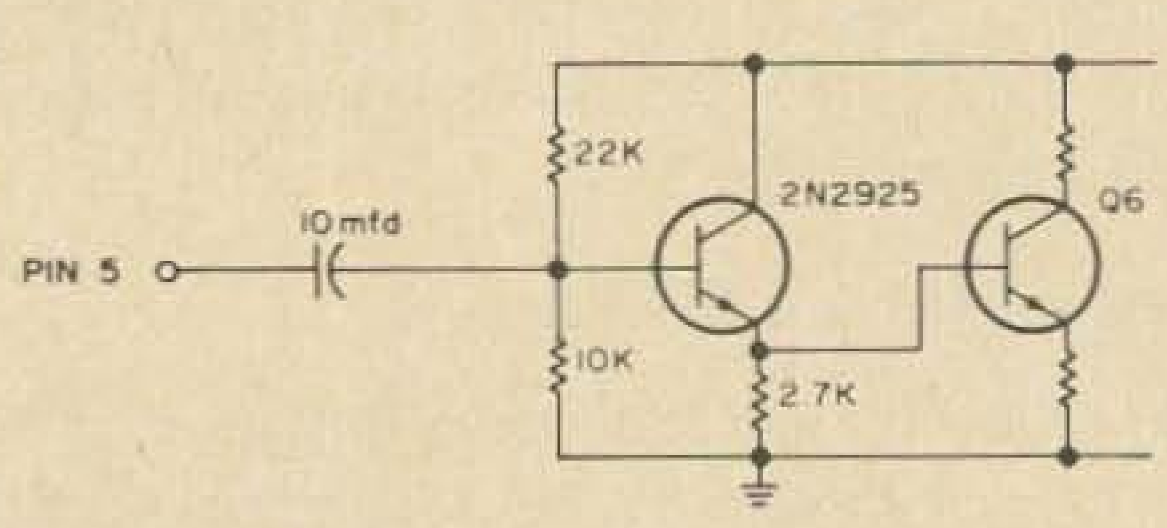


Fig. 3. Alternate input emitter-follower stage for CW filter.

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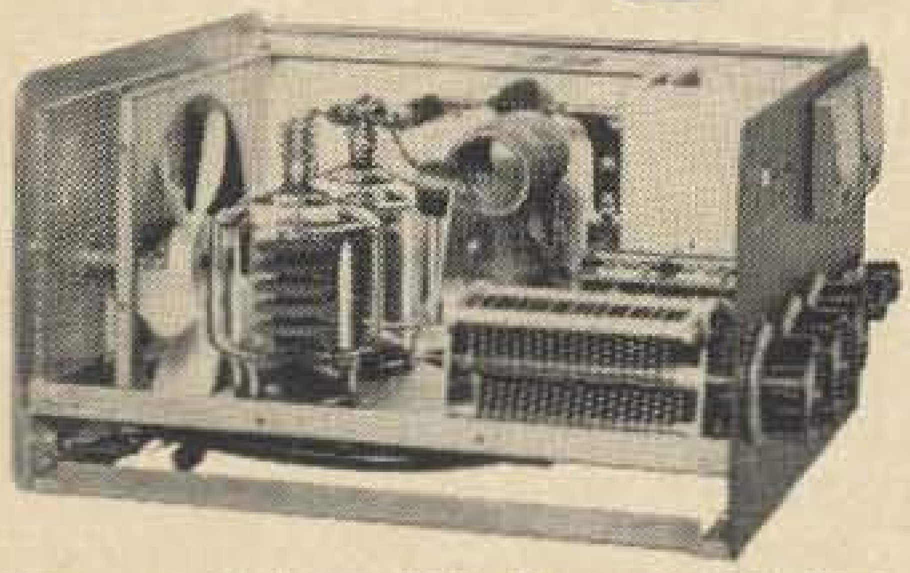

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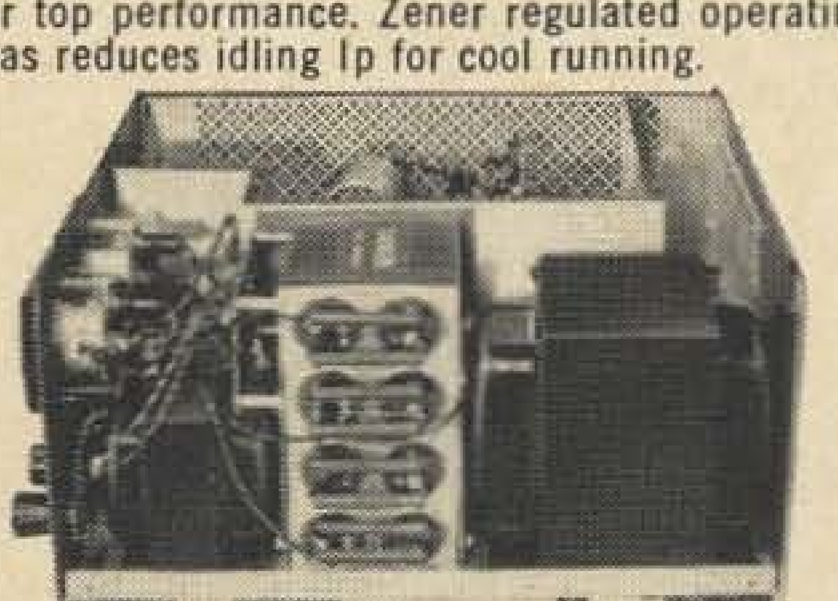

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Since the output of Q7 across the 820 ohm load is quite low, Q8 is a simple stage of gain to raise the level to that required for the transceiver audio input.

Jacks J3 and J4 connect to the product detector output and audio stage input via shielded cables. Both the noise limiter and CW filter circuits are switched in and out of circuit by two 3-pole double-throw slide switches mounted on the front panel. One section of each of these switches provides the +9v regulated power required by both circuits. It will be noted that the switches are wired in combination so that the noise limiter is ahead of the CW filter when both are used simultaneously. This is important, since high impulse noise peaks, such as ignition, switching transients, etc., can cause extreme ringing when the CW filter is adjusted close to maximum selectivity. Removal of such pulses can make possible the copying of weak signals through QRM which would be rendered intolerable by high noise impulses.

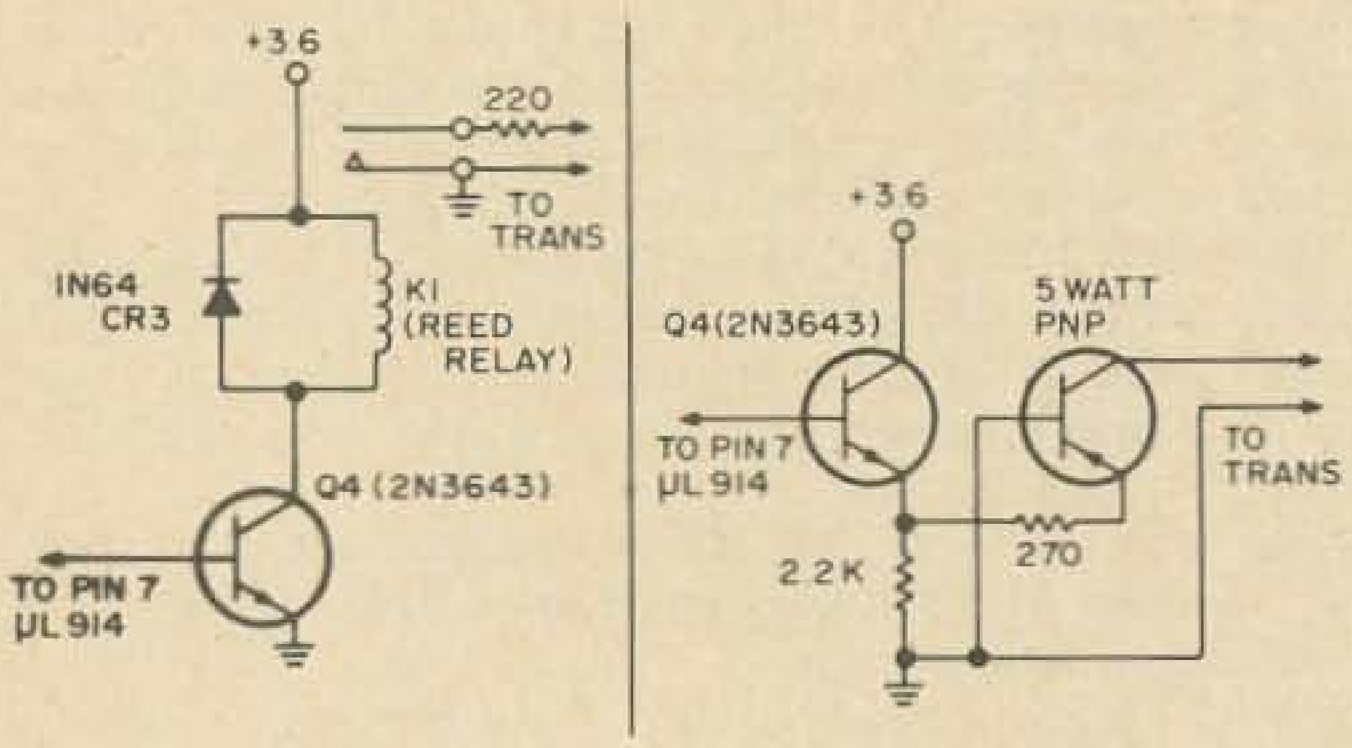


Fig. 4. Power transistor switching output modification for K3CUW keyer.

Electronic Keyer

The keyer board incorporates the circuit of the Micro-TO Keyer by K3CUW (*QST*, August 1967, and *ARRL Handbook*, 1968). Consequently, the complete circuit is not included on the schematic, although external connections to the board are shown. The sidetone oscillator in K3CUW's keyer was excluded since my transceiver has built-in provision, but the board has plenty of room to include the oscillator if required. The only other deviation from K3CUW's circuit was the use of a power transistor, instead of a reed relay, for direct keying of the transmitter. Fig. 4 depicts the incorporation of the power transistor to the Micro-TO Keyer. Just about any PNP 5 watt power transistor will function in this circuit, which is intended for grid-block or low power stage keying.

Compressor Amplifier

A number of circuits have been tried out on this board over the past year, and if you find a compressor useful in your operation, the bibliography may prove helpful. Unfortunately, for proprietary reasons the actual circuit now in use cannot be reproduced here but typical controls and connections to the board are included on the schematic.

Switch S2 is a 4 pole triple throw, nonshorting rotary switch, which switches in either the electronic keyer or the compressor amplifier. A single switch, with center position off, was utilized, since quite obviously simultaneous operation of keyer and compressor is never required. In the off position power is removed from both keyer and compressor, and the microphone is connected directly to the transmitter. When the switch is in keyer position, the microphone is disconnected from the transmitter to avoid unintended modulation.

Power Supply

The internal power supply, which furnishes all the voltages for the various circuits, comprises T5 and the regulated power board. T5 supplies 24 vac, center tapped ground to the board. A full wave rectifier consisting of D1 and D2 and associated filtering components supplies +15v to the voltage regulator circuits of Q1 and Q2. The regulator transistors furnish +9v and +3.6v respectively. The +9v supply is used for the CW filter, noise limiter and compressor circuits. +3.6v is used for the electronic keyer. Q1 and Q2 are arranged in series to give particularly stable regulation of the +3.6v, since the keyer current requirements are quite heavy during "key down," and any voltage fluctuation causes keying speed variation.

A word about the zener diodes Z1 and Z2 is in order. If 9.1 and 3.6 volt zener diodes are used in these positions, the output voltages will be the zener voltages less the 0.6 volt base to emitter drop in Q1 and Q2, resulting in outputs of 8.5 and 3.0 volts. But zeners, like any components, are subject to tolerances so the voltages may be slightly higher or lower. While the +9v circuits aren't too critical, the +3.6v required by the keyer is, and should be adjusted as closely as possible. Too low a voltage will result in inability to obtain the lowest keying speeds, while the voltage should not exceed much over 4 volts to avoid damage to the integrated circuit components. Voltage adjustment can be attained by selecting zener diodes with high tolerance values. However, an easier method is to add forward biased silicon or germanium diodes in series with the zeners. The drop across the diodes will add to the zener voltage -0.6 volt for silicon diodes and 0.3 volt for germanium diodes. Having first assembled the circuits with the zener installed alone, measure the output and note the drop below the desired output. Then add silicon or germanium diodes as required to bring the voltage up to the proper value. Since the voltage drop across the forward biased diodes in constant within their current limitations, they have no effect upon the zener regulating capability. Both zener and regular diodes should be rated at 1 watt.

D3 and D4 provide full wave rectification to supply -15v unregulated, utilized by the agc control circuit Q3 for gating the squelch.

+15v unregulated is also available at pin 5 of the board, though not currently utilized in my companion.

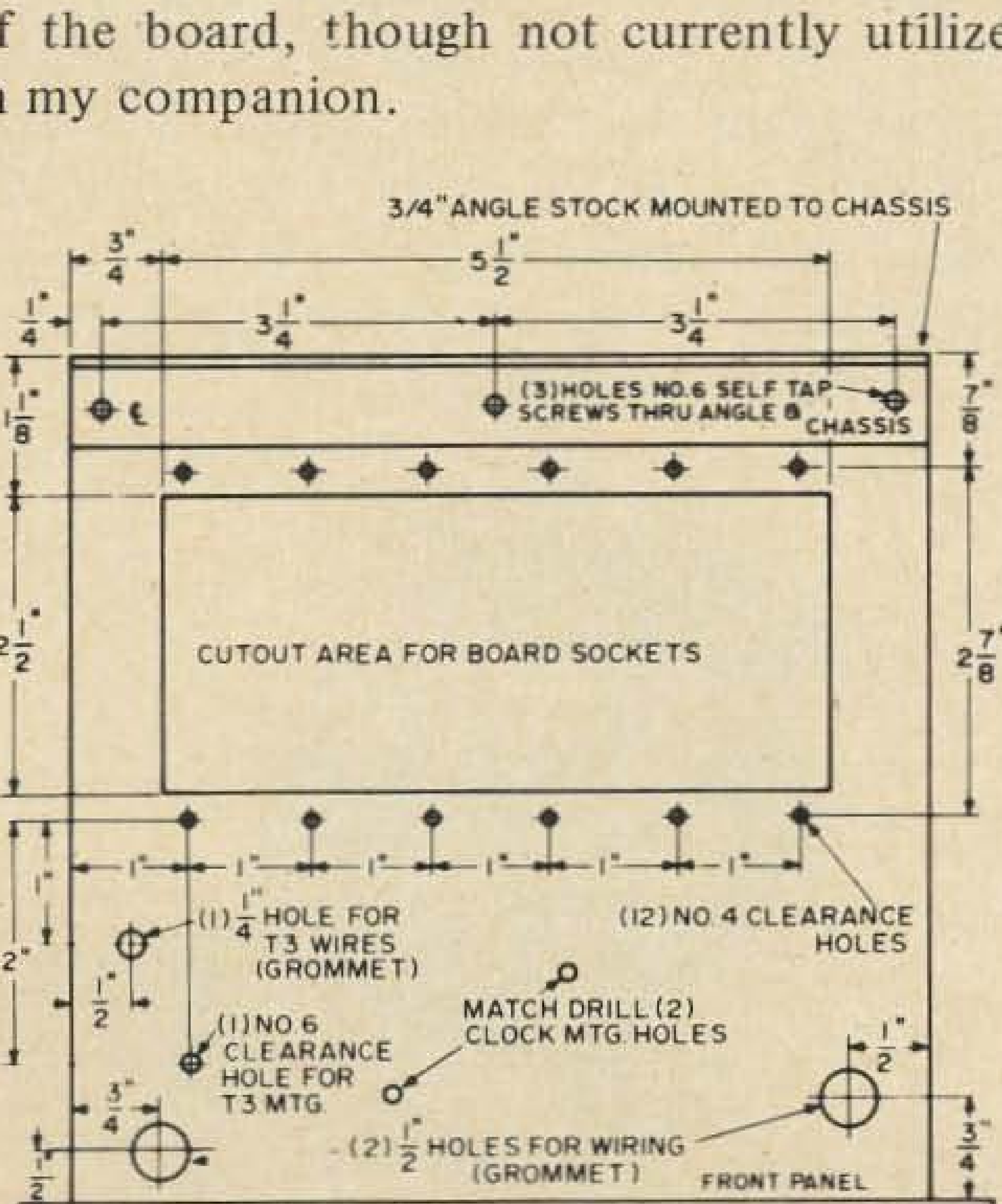
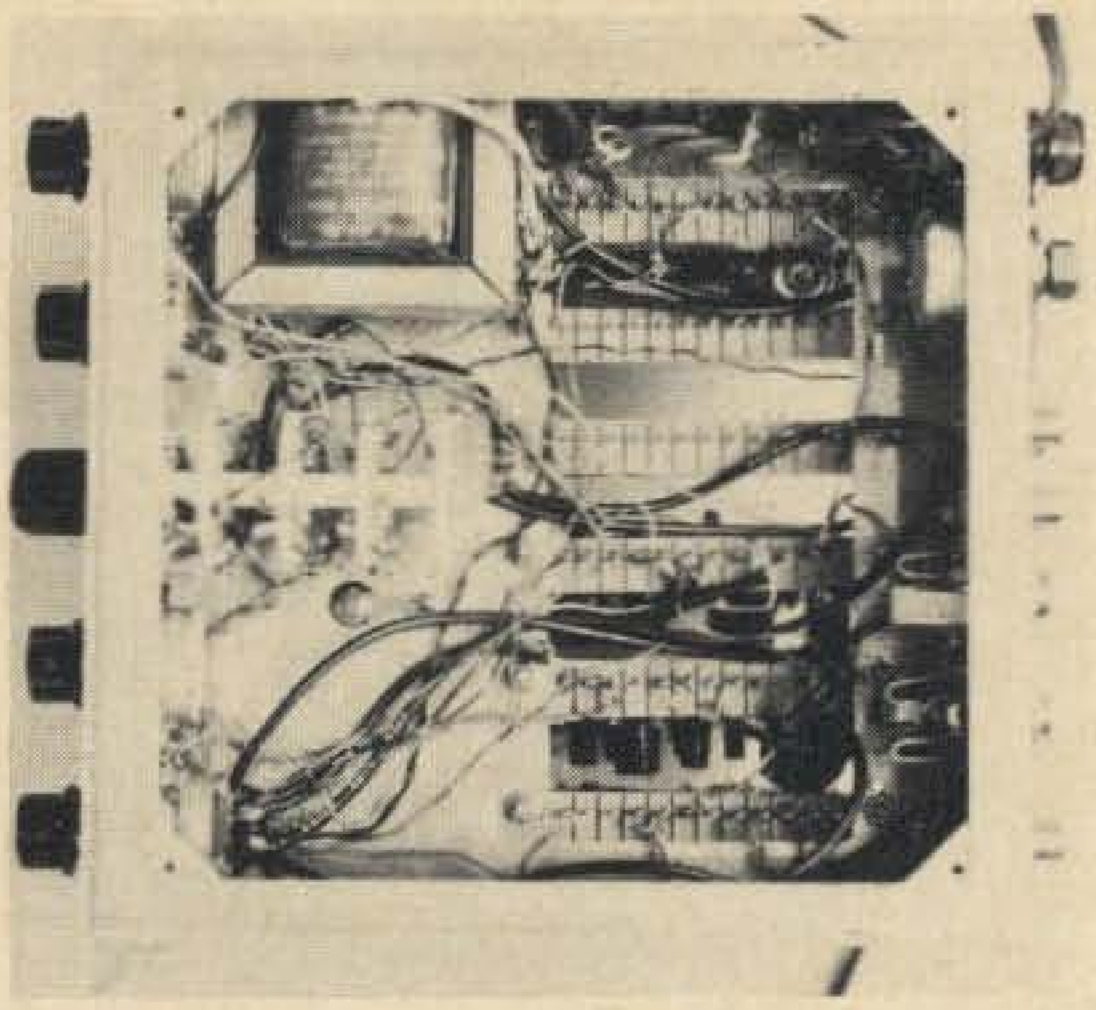


Fig. 5. Chassis layout.



Construction

For those who may want to duplicate my transceiver companion, **Figs. 5 and 6** show the chassis and front panel layouts with major cutouts and hole dimensions and locations. Not all component mounting holes are shown due to the likely substitution of components with dissimilar mounting requirements.

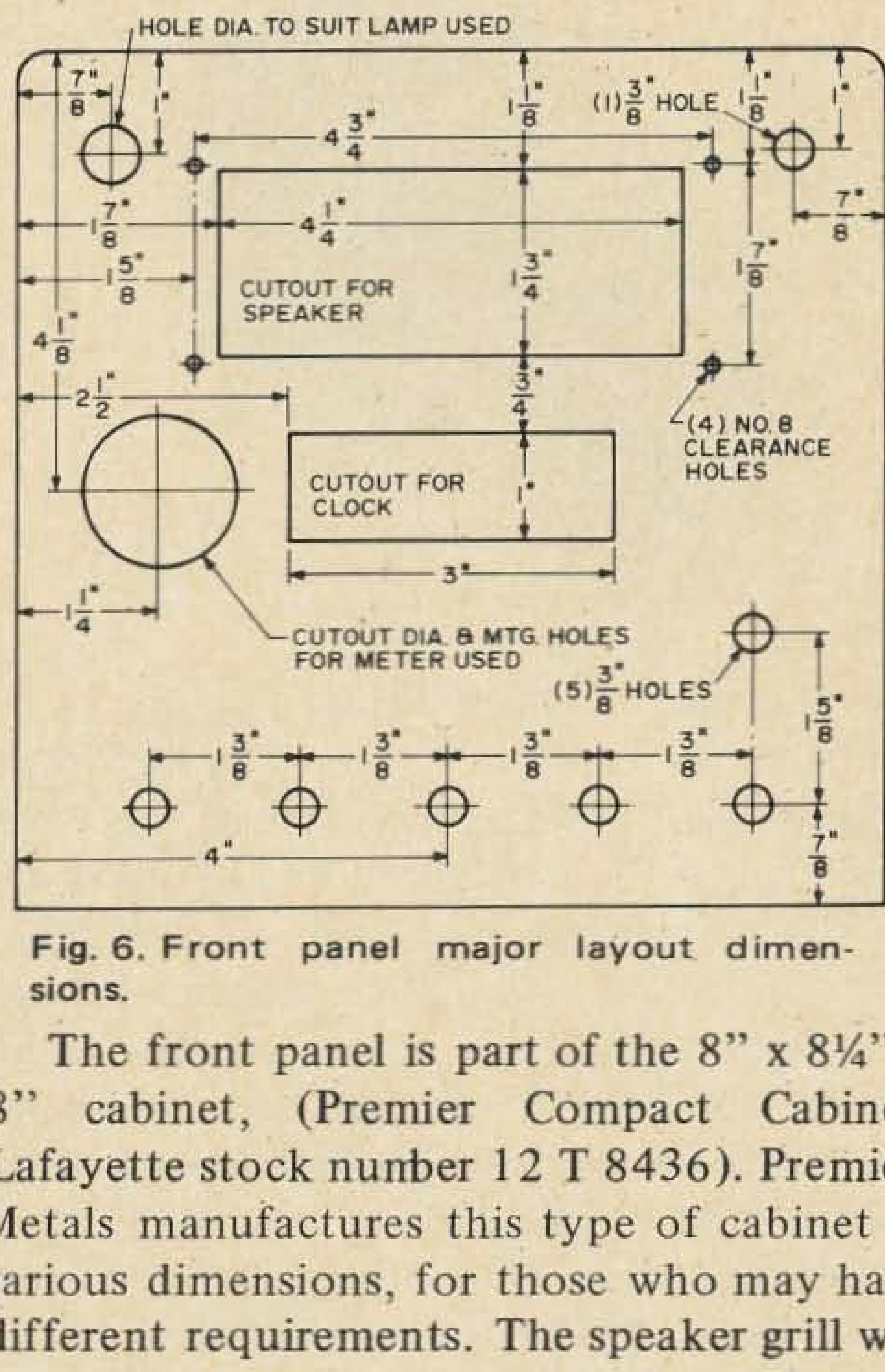


Fig. 6. Front panel major layout dimensions.

The front panel is part of the 8" x 8¼" x 8" cabinet, (Premier Compact Cabinet, Lafayette stock number 12 T 8436). Premier Metals manufactures this type of cabinet in various dimensions, for those who may have different requirements. The speaker grill was fabricated from a piece of perforated metal stock. Bottom part of the front panel was finished with two spray coats of light gray lacquer. Lettering and dial markings were applied with Letraset instant lettering, and the entire section given two finish coats of clear acrylic lacquer to protect the lettering. Top portion of the panel and the grill were

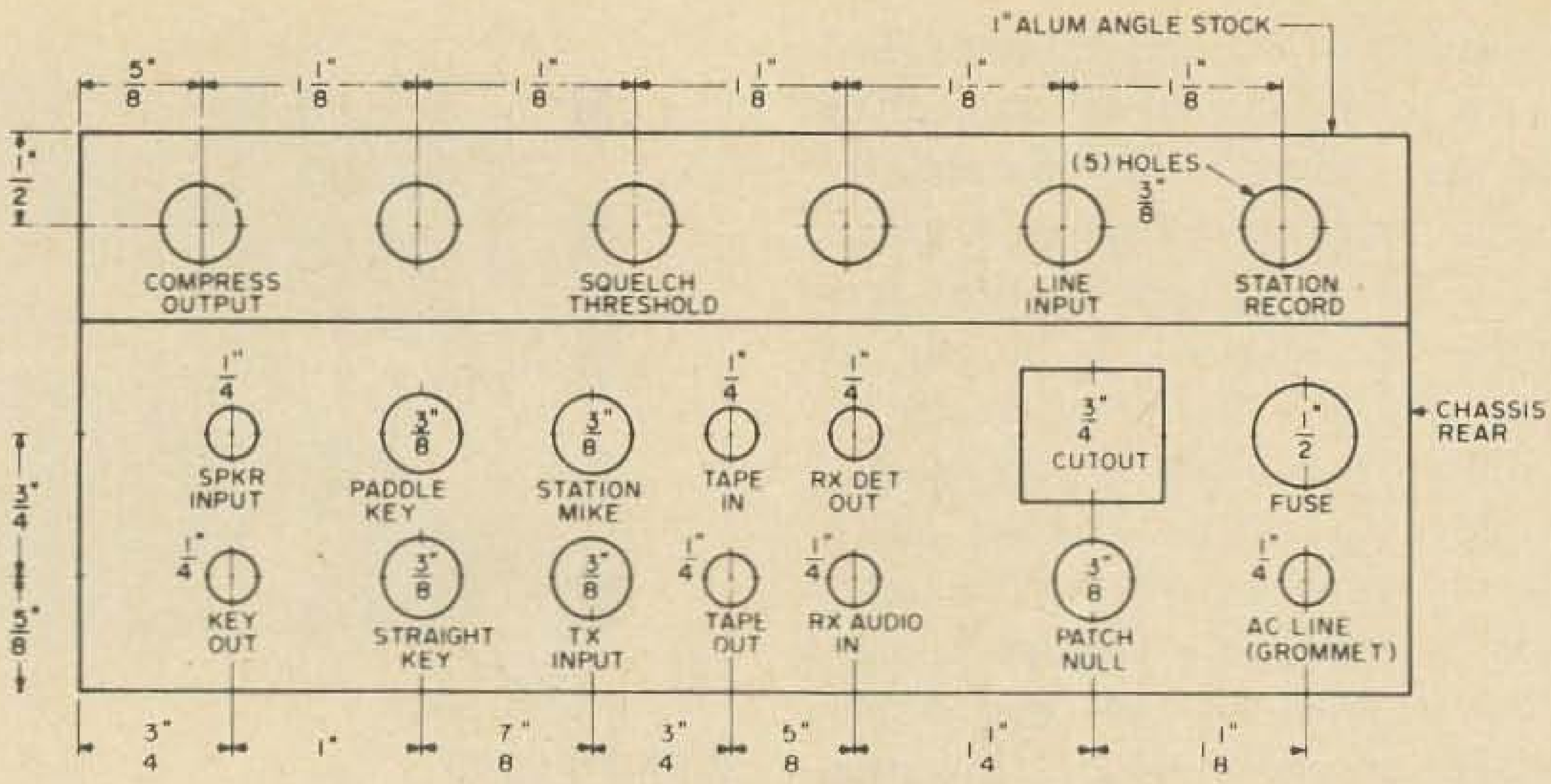
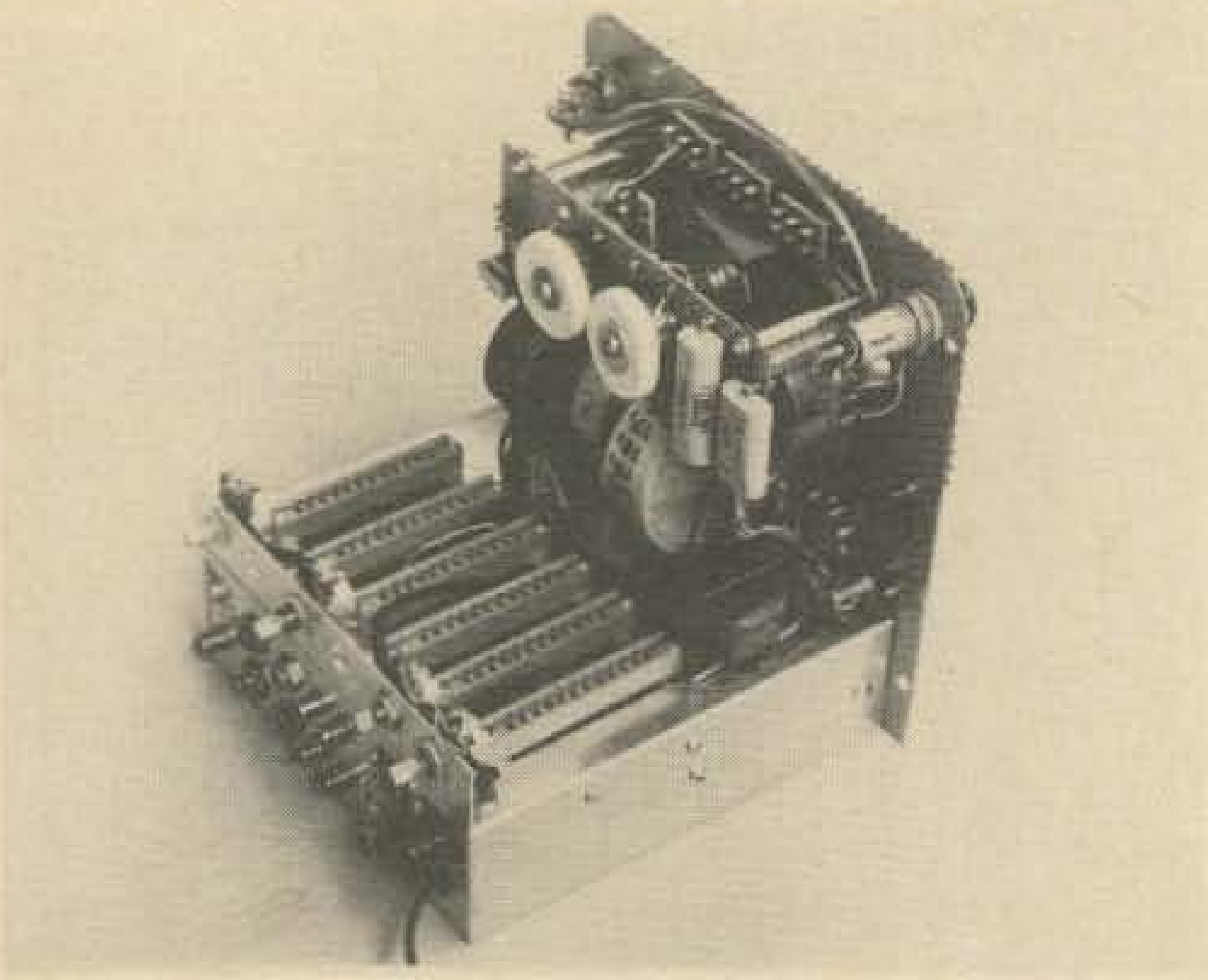


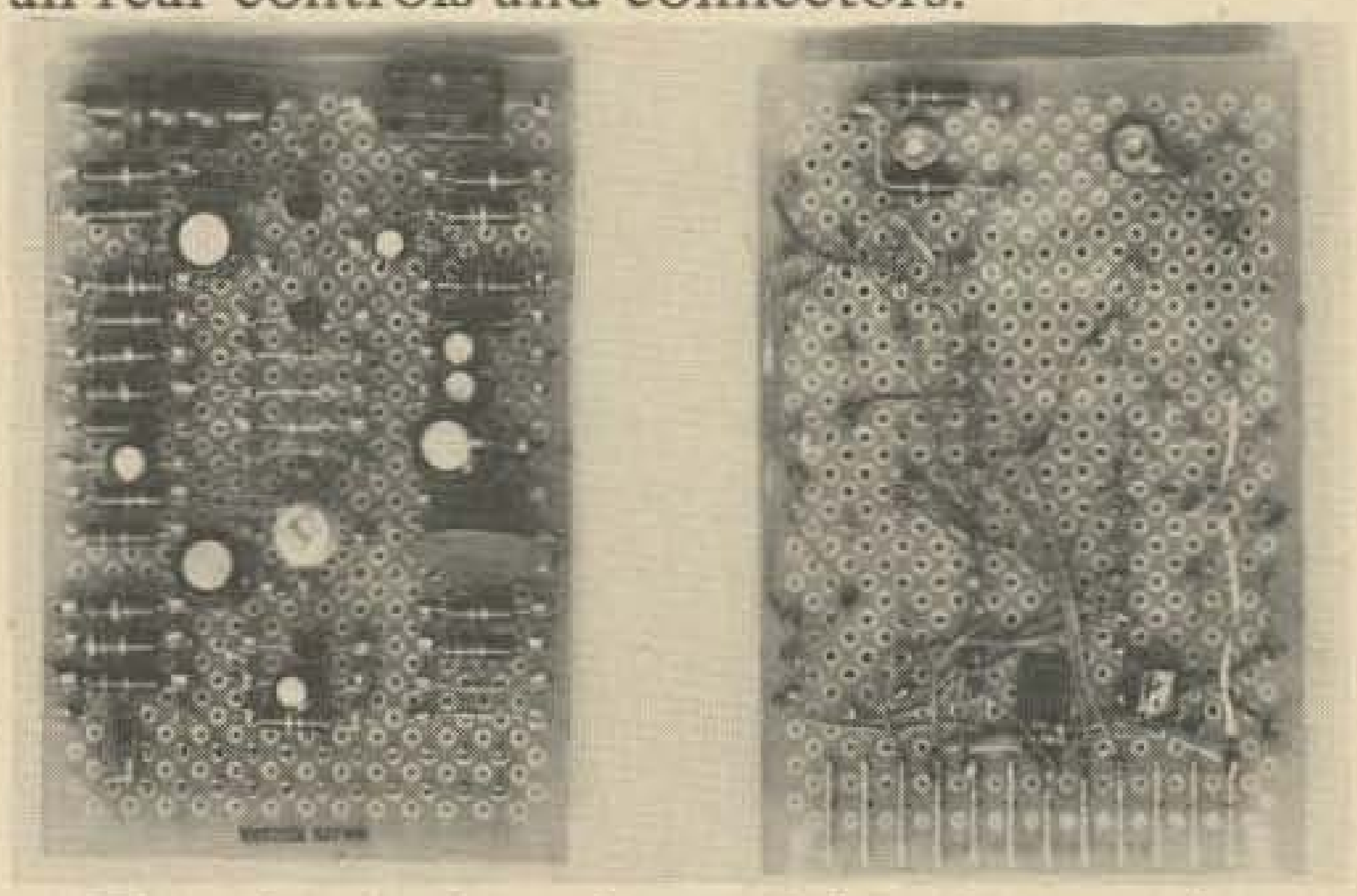
Fig. 7. Rear controls and connectors.

sprayed with two coats of black crackle, so, that the speaker opening was "lost" in the overall black finish. The front panel is secured to the 7 x 7x 2 inch foundation chassis by the lower front control nuts.

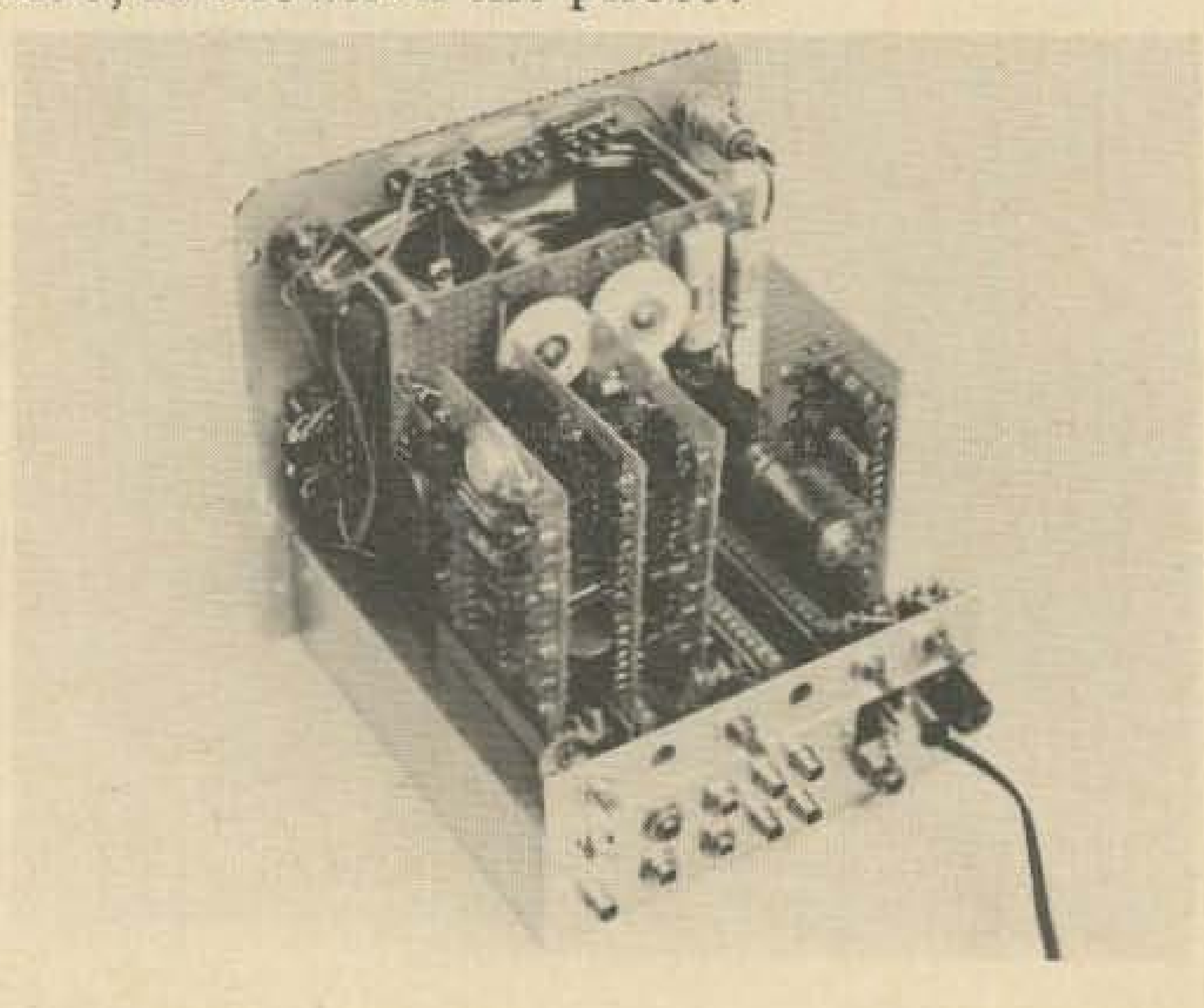


Toroid coils and capacitors for the 2.1 khz low-pass speaker filter, together with transformers T1 and T2, are mounted on a piece of perforated phenolic measuring 5½ x 2¼ inches. This board is mounted by standoffs to the front panel through the speaker mounting holes. The 2 inch standoffs are assembled from two 1 inch spacers commonly used for expanding three-hole binders, and available from industrial stationery stores. The spacers have 8/32 studs at one end and 8/32 tapped holes at the other. Hole ends of the assembled standoffs are used to secure the speaker to the front panel with ¼" 8/32 flathead screws. Stud ends of the standoffs are used to mount the board with 8/32 nuts.

Rear mounted "preset" controls are mounted on a bracket fabricated from 1" aluminum angle stock, fastened to the top-rear of the chassis. **Fig. 7** shows locations of all rear controls and connectors.



The plug-in boards used for the transistorized circuits and power supply are Vector type 837 WE, 4¼" x 3". These boards are equipped with twelve connector pins. The WE suffix denotes epoxy glass material. While they are also available in epoxy paper material (type 837), the slight extra cost of the glass material is considered well worthwhile, since it is impervious to heat, permitting stripping and reusing boards for new circuits. Flea clips are used for mounting the components to one side of the boards, while interconnections are wired on the opposite side, as shown in the photo.



Sockets are provided for six boards (sockets are Vector R612-1), with sufficient spacing to allow for component clearance. At present only four boards are utilized in my companion, leaving two vacant sockets for the addition of up to 50% more circuitry when the need arises.

Since a board-socket combination costs around $4.30, the budget-minded may want to make their own, which can be cut from suitable perforated stock sheet with .062 holes, and mounted to an appropriate male connector.

The sharp-eyed may note from the photos that two of the top-mounted panel slide switches are unwired. Well, together with the two unused Vector sockets, and the vacant control holes in the rear bracket, there is still room for expansion. And if additional front panel controls are required, with space getting at a premium, there are always those dual pots with concentric shafts, used in TV receivers.

Anyway, I think my companion will be around the shack for quite some time, even though it may pass through a continuing process of evolution.

. . .W6AJZ ■

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"The Audio Booster," Jim Kyle K5JKX/6, *73 Magazine*, October, 1960.

"An Audio Peak Limiter for Voice Transmission," Sydney H. Moate W6ZEM, *QST*, August, 1965.

Fred Johnson ZL2AMJ
15 Byron Street
Upper Hutt, New Zealand

A Simple Bench Power Supply

This power supply provides the choice of four popular output voltages, three current overload limits, and has an overload indicator, yet requires very few components. This principle of current overload protection can be easily adapted to existing power supplies. The size of heat sink required for a series regulator transistor can be reduced if this overload principle is used.

It soon became apparent after building a rather complicated bench power supply that this was not the end of my power supply requirements. This complex supply provided 0 to 20 volts at 500 ma maximum with full regulation and overload protection and is ideal for development projects. Unfortunately, when it is being used on the "latest" project it cannot also be used to supply other devices in use in the shack. It was apparent that a small supply with choice of fixed output voltages (3, 6, 9, or 12 volts) and moderate current capacity (200 ma) would fill the need. Overload protection was desirable to ensure that an unexpected overload or short-circuit could not harm either the supply itself or other equipment. The specification for this new supply therefore became:

Output voltage:	3, 6, 9, or 12 volts (switched)
Output current:	200 ma maximum
Internal impedance:	Less than 5 ohms, preferably about 1 ohm.
Ripple:	To be less than 10 mv peak-to-peak.
Overload protection:	To reduce the output voltage to a low level in the event of excessive load currents or short-circuits on the output terminals.

A further requirement that the transformer used should not be a "special" meant that one with a 6.3 volt secondary would

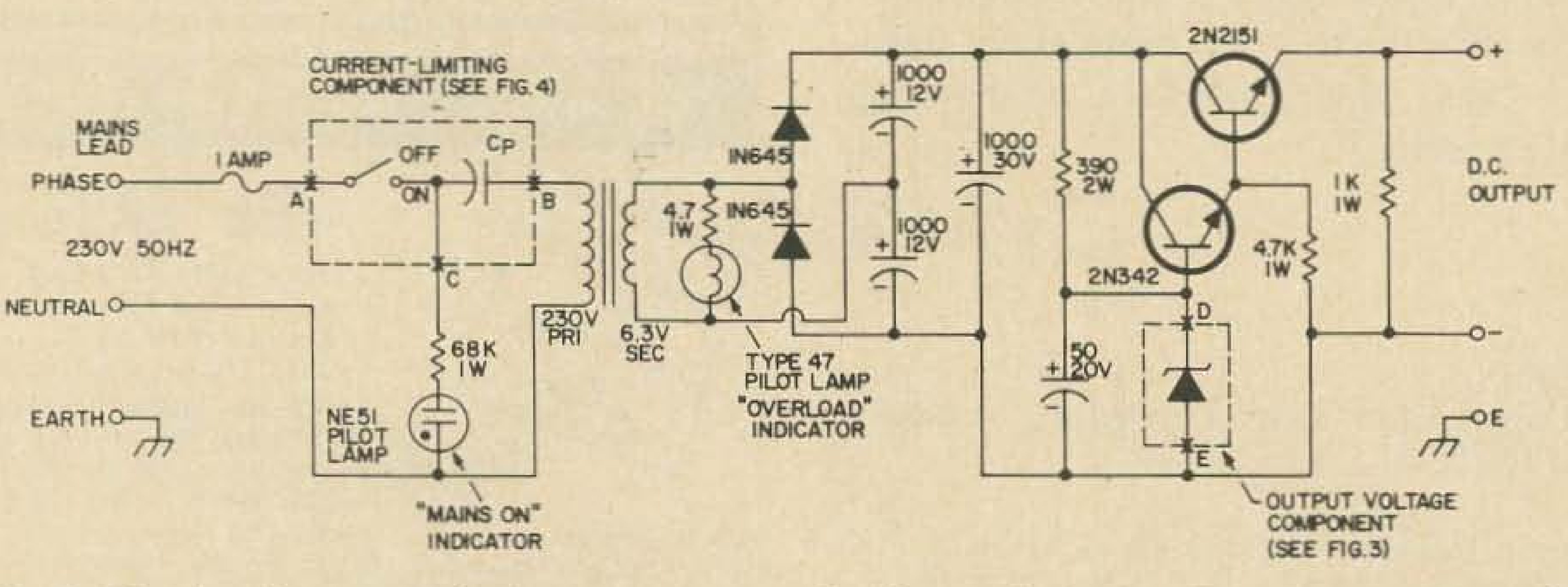

Fig. 1. Circuit diagram of the regulated power supply. The components in the dashed squares are simplified examples for purposes of explanation. A 230 volt supply is shown but the system can be easily adapted for 110 volts (see text). The "overload" indicator extinguishes when excessive output currents are drawn.

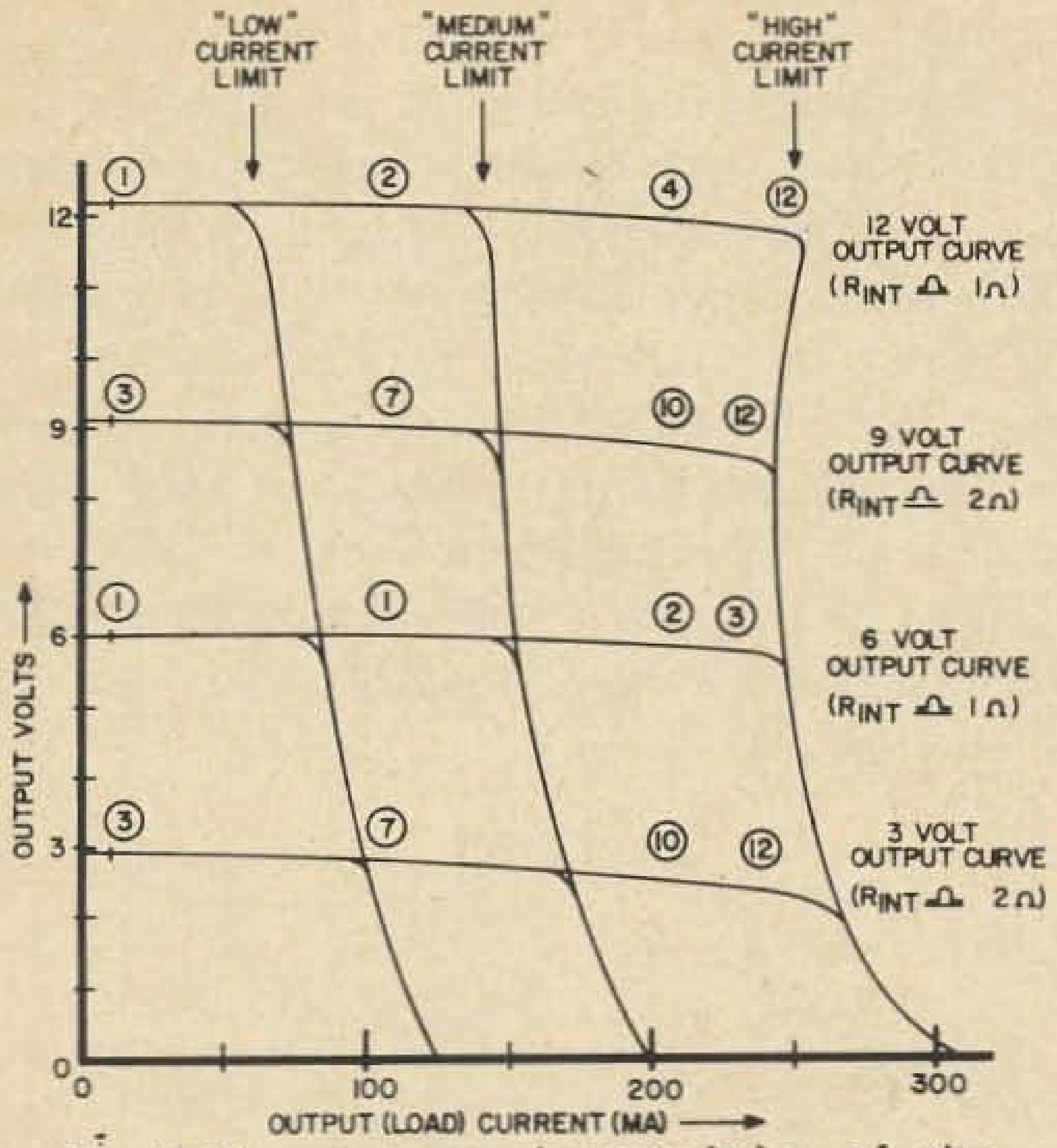

Fig. 2. The output characteristics of the power supply. Note that four output voltages (3, 6, 9 and 12 volts) and three current limits (at 50 to 100 ma, 130 ma, and 240 ma approx.) are available. The maximum current limit may be increased (see text). The figures in circles represent peak-to-peak ripple voltages (in millivolts) at the load points shown, measured with an oscilloscope. Output impedance is about 2 ohms (at worst) on the flat part of the curves.

have to be used. This meant that some form of voltage doubler would be required to get a 12 volt output. This, however, represents a saving of two rectifier diodes over the four generally used in bridge circuits so in some ways is an advantage—provided the output ripple can be kept within the limits acceptable.

This, then, was the background to this project. The resulting circuit diagram is shown in **Fig. 1** and the dc output characteristics shown in **Fig. 2**. Note that the input supply voltage is 230 volts at 50 hz. This is the domestic supply used in New Zealand and has been retained in this circuit in order to show the overload protection arrangements. Some component values will have to be changed when 110 volt primary transformers are used. As access to 110-volt 60 hz systems are just about impossible in ZL-land, details will be given later on the methods used to select component values for other systems of power distribution. It is hoped that some enterprising U.S. ham will investigate this with local components and write and tell this magazine about it, giving part numbers and component values.

The Circuit

The regulator circuit is basically a transistor series regulator with a zener diode as voltage reference. Two transistors are used in a compound circuit as cascaded emitter followers to ensure a low value of output impedance and to prevent any wide load variations from causing excessive changes to the zener diode operating conditions. A zener diode reference voltage is selected by means of switches to provide the output voltage required. The switching used is shown in **Fig. 3**. Two toggle or slide switches select the required zener reference diodes. Note that three diodes are used to provide four reference voltages.

The zener diode reference voltage has to be slightly greater than the resulting power supply output to allow for the base-emitter voltages of the two transistors. The transistors shown are NPN silicon types but many other types could be substituted, silicon or germanium. If PNP transistors are used, all diodes and all electrolytic capacitors will have to be reversed to provide voltages of the opposite polarity. If other transistors are substituted they should have as high a current gain as possible consistent with the current they are expected to handle.

I built the supply in an aluminum box 5 inches by 4 inches by 3 inches and the 2N2151 power transistor is bolted to the case but insulated from it by mica washers. A heat sink is not really required owing to the modest current output of this particular supply. More will be said about this later. Other constructional details will not be given

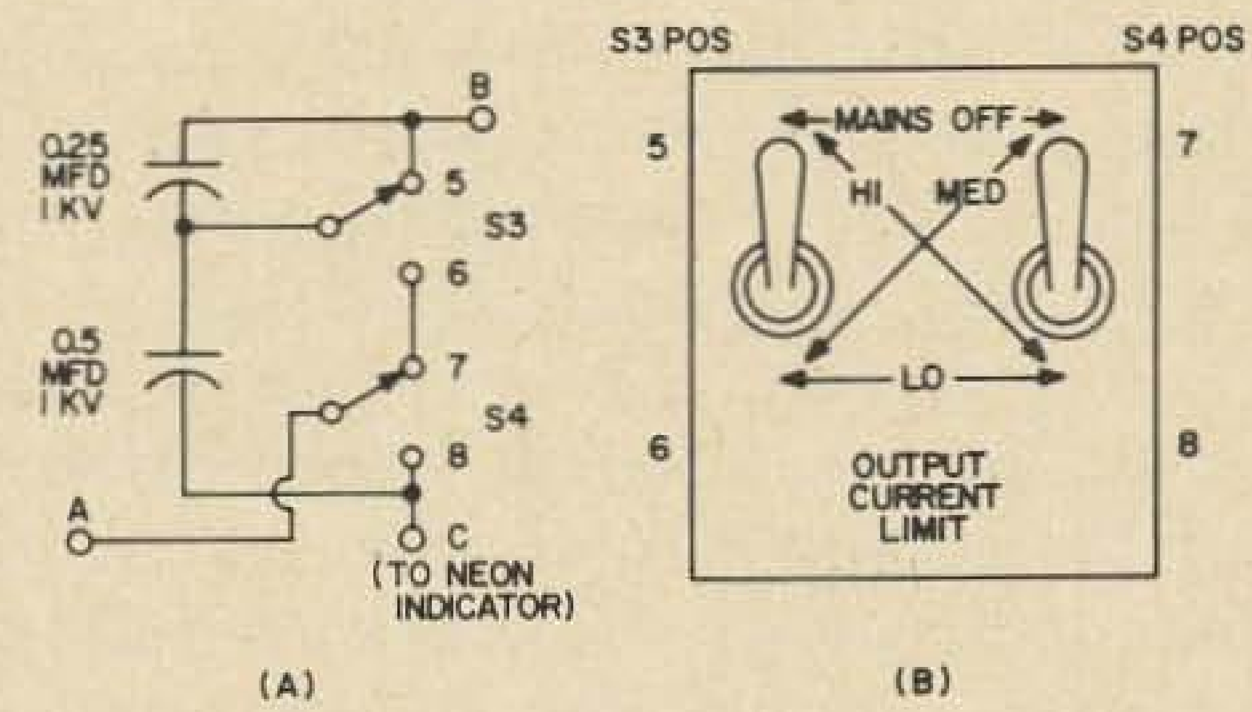

Fig. 3. The output voltage switching arrangements. Two SPDT switches select the required zener regulator diode. Switch positions in (a) are also shown in (b) which shows the panel labeling. Note that for 3 volts (as shown) the 3 volt zener is in parallel with a 6 volt zener—which of course will not be operating.

for there is nothing at all critical about the layout.

The 390 ohm resistor was selected to ensure that the zener diodes do not dissipate more than their 400 mw under any conditions. In fact they are considerably underrun. Other zener types could be substituted to provide other output voltages if required, but if this is done then some adjustment of the 390 ohm resistor may be necessary. The zeners may be individually selected if enough are available, to provide accurate output voltages.

The voltage doubler is conventional and again a wide range of diodes could have been used in place of the ones shown. A pilot light using a type 47 lamp is connected to the secondary of the transformer. A 4.7 ohm resistor is used to protect the lamp from the rise in secondary voltage on no-load, but this will be discussed later.

Overload Protection

The regulator system is capable of regulating the output against wide changes of input voltage from the main supply and it is this characteristic that is used in this unit to give overload protection. From the secondary of the transformer to the output, the regulator is of quite common design. Such a regulator will normally regulate up to the rated current limit of the series regulator transistor and other components, but will have little or no immunity against overload. Excessive load currents will generally cause overheating in the regulator with ultimate failure of one or several components. Many different techniques have been devised to protect this type of supply from overload. The most elaborate methods use some form of trigger circuit to electronically switch off the supply after a certain load current has been reached. This entails a reset procedure to restore the output after the cause of the overload has been removed. Another type of overload system ensures that the output voltage is abruptly reduced to a low and safe level after a certain load current has been reached. This type of protection is usually self-resetting in that once the cause of the overload has been removed, the supply will immediately return to its normal output voltage. It is one form of this type of protection that is used in this small power supply.

The simple addition of a capacitor in series with the transformer primary provides a convenient current overload protection with some other advantages. This capacitor is shown as C_p in **Fig. 1**. The effect is to cause the "vertical" voltage drop as shown on the characteristics in **Fig. 2**. It may seem at first to be a highly unlikely result so an outline of the action will soon be given. The high-current overload does double back as shown on **Fig. 2**.

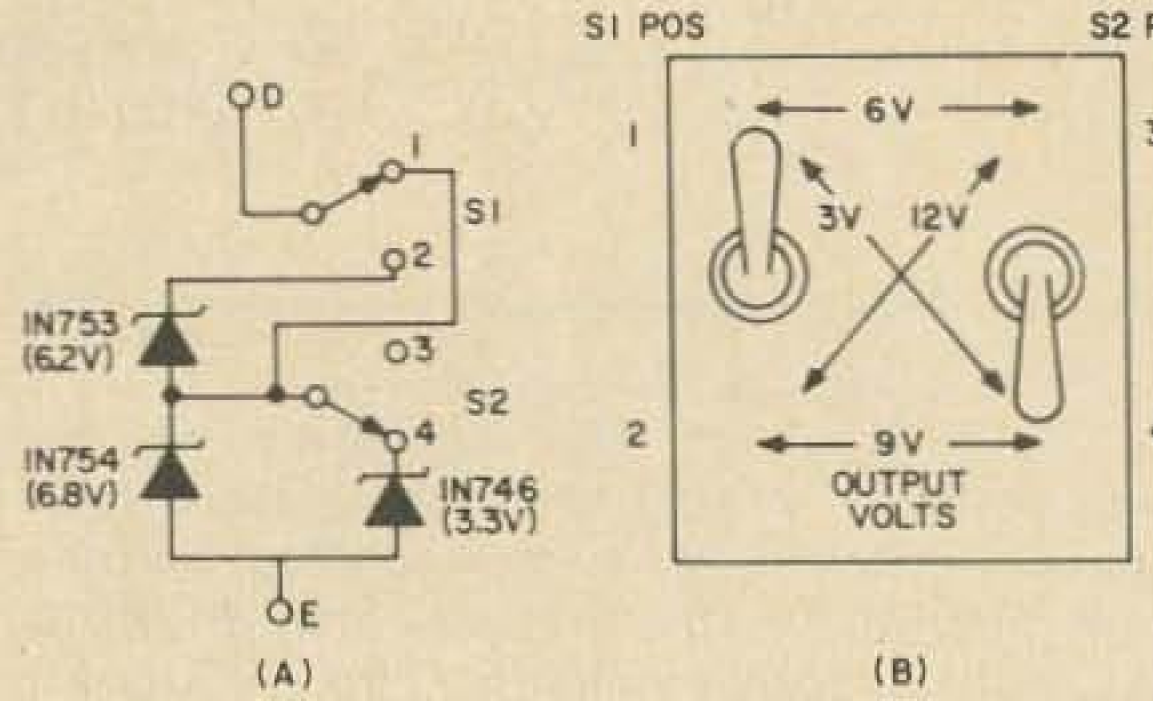

Fig. 4. The current-limiting switching arrangements. Two SPDT switches provide "off" and choice of three output current limits by selecting one of two capacitors, or both in series. The neon operates whenever the supply is "on," irrespective of which current limit range is in use. Switch positions are shown on both diagrams for ease of reference.

The switching arrangements for the current overload are shown in **Fig. 4**. Two SPDT toggle or slide switches (similar to the zener-switching ones) provide a "mains off" facility and the choice of three overload current limits. Two capacitors are used and these are connected individually and in series to provide a range of three capacitance values.

The Indicators

The neon pilot lamp is used to indicate that the supply is on. In one set of switch positions the neon is fed with 230 volts through the 0.5 μf capacitor. This capacitor has a reactance of 6400 ohms at 50 hz so has negligible effect when in series with the neon current-limiting resistance. This form of connection is necessary to ensure that the neon glows when the switches are in all three current-limiting positions, and yet is extinguished when the switches are in the "mains off" position.

It may seem strange that two pilot lights are necessary. The neon shows when the

power is on while the other lamp shows when an overload has occurred. The type 47 lamp extinguishes when an overload has been applied. While both lamps are lighted the supply is delivering its rated voltage. If the type 47 goes out then an overload has occurred. This arrangement works irrespective of the voltage output setting or the current overload range that is being used. With no voltmeters or ammeters used in the output (they were not considered necessary for the application in which this supply is used) this twin-lamp system has proved to be quite effective.

Overload Circuit Operation

The action of the series capacitor in the primary can be explained when it is realized that the input impedance of the primary of the transformer (when the dc output is on open-circuit) can be regarded in its simplest form as an inductance in series with a resistance. The inductance value is made up of transformer leakage reactance and some primary inductance while the resistance is made up of resistances representing the transformer losses and the load presented by the regulator components. The primary circuit is thus a series-tuned circuit, consisting of Cp, and the transformer inductance and resistance. This tuned circuit must not be at resonance at the mains frequency or excessive primary current would flow. The resonant frequency is made higher than the mains frequency and a change of Cp has the effect of changing this resonant frequency.

The primary current (with no load on the output terminals) is increased considerably with the inclusion of Cp. The current flowing is not in phase with the supply voltage so the power dissipated in the primary is small. The voltage across the transformer primary is increased to about 300 volts when the 0.5 μf capacitor is in circuit. This in turn means that the output of the voltage doubler is increased to about 20 volts dc when the supply is on "no load." The series transistor regulator accepts this 20 volt input and reduces it to 12, 9, 6 or 3 volts at the dc output terminals, even on no-load. When a load is connected to the regulator dc output terminals it has the effect of changing both the inductance and resistance values seen at the transformer primary. The resistance value increases as the load increases while the inductance value decreases. The resonant frequency of the primary tuned circuit therefore rises and the impedance presented to the mains input increases, causing a decrease in primary current. The Q of this series tuned circuit thus falls. The output of the voltage doubler and the 20 volt dc level at the input to the regulator drops. At some value of load current this dc voltage will have dropped to a point where the regulator can no longer operate satisfactorily and the output dc voltage now takes a downward plunge. The exact mechanism causing this steep fall is rather complex for the current and voltage waveforms at the transformer primary become distorted even though core saturation has not been reached.

At the overload point at the top of the downward plunge of the voltage curve, the type 47 pilot lamp goes out, showing that the transformer secondary voltage has dropped to a low level. With an overload current at the dc output terminals, the voltage at the output of the voltage doubler has dropped to about the same voltage as that at the dc output terminals, and with a short circuit, it drops to zero volts.

The overall result is most effective and especially is this so when component economy is considered.

The voltage rating of the capacitors must be high because under no-load conditions the voltage across the capacitor rises to about twice the mains voltage. The voltage rating should be 1 kv for 230 volt systems and 500 volts for 110 volt systems to be sure that the component will not fail.

Determining Component Values

This current-limiting technique has been applied to another power supply and it was found that a 4 μf series capacitor (1kv oil-filled) produced as steep a falloff as the 0.5 μf on the supply described. The value of capacitor to use for a particular value of current limiting is just about impossible to calculate for little is usually known about the transformer input impedance for the resulting dc load. The capacitor value is best determined experimentally by substituting value after value (starting off with a 0.1 μf for 230 volt systems and a 0.25 μf for 110 volt systems) and plotting the output characteristics using an ammeter, voltmeter, and adjustable load resistor of suitable value. Increase the capacitor values in say, 0.25 μf steps until the desired cutoff current is reached.

One point must not be overlooked. If you try this with an existing supply (as I hope you will) make sure that the voltage ratings of any filter capacitors are not exceeded. Remember that the dc voltage output of the rectifier is increased by approximately 50% when the supply is on no-load. The primary voltage is increased by a like amount, but this is not as serious as it appears to be for the power factor is far from unity and little increase in transformer operating temperature (if any) will result. An ac voltmeter across the primary can be used to keep this under observation while substituting capacitor values. Remember that excessive primary currents can be drawn if the primary approaches resonance, so start off with the values of capacity quoted and increase it in small increments until the desired limit is reached, keeping an eye on filter capacitor voltage ratings. Remember too that you are playing with mains power so play it safe.

Other Advantages

Two other unexpected benefits also accrue from this series capacitor current-limiting arrangement. When first switching on, all the filter capacitors are discharged and the diodes would normally pass a very high current during charging. With this series capacitor in circuit, this charging current appears as an overload current and the initial charging current is limited. A resistor in series with the transformer secondary to limit the switch-on charging current as often used is now not necessary. The second added advantage concerns the size of the power transistor heat sink (if used). Because the dc input voltage to the regulator falls as the load current increases, the power dissipated in the series regulator is not as high as would normally be expected, and large dc output currents can be handled before a heat sink becomes necessary—this alone is an economy in space.

A change in mains frequency will have the effect of changing the current-limit level but this is unlikely to be bothersome if you draw your power from a large distribution system. A change of input mains voltage has a very small effect on the limit level and can be overlooked.

Ripple voltages, measured with a Tektronix 545B oscilloscope are shown in circles on Fig. 2 (millivolt peak-to-peak values), at various load levels. The lower output impedance and inferior ripple of the 3 volt and 9 volt curves can be attributed to the use of the 3 volt zener with its high dynamic impedance.

This supply has met my requirement quite satisfactorily and is giving good service.

Acknowledgment

I wish to thank Louis W5KFV for providing many of the components used in the development of this and many other projects.

. . . ZL2AMJ

Slow Scan Color Transmission

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Introduction

In 1861, James C. Maxwell demonstrated the principles of three-color photography. Maxwell analyzed a landscape scene through red, green and blue filters, and from the black and white negatives so produced, made three positive lantern slides. Then, by projecting the black and white lantern slides back through red, green, and blue filters, and superimposing the three pictures, he produced a color picture of the landscape. The principles of tricolor analysis and synthesis first demonstrated by Maxwell are still used today in the field of color photography, color printing, and color television. For example, the first close-up color photographs of the moon's surface were produced by a Surveyor satellite suitably equipped with a black and white television camera and color separation filters. More recently, the color photographs of the earth taken by an Application Technology Satellite (*Scientific American,* 1969) are but another example of color photography by means of color analysis and synthesis.

The application of color analysis and synthesis techniques to amateur television follows as a logical step in the development of this communication mode. In particular, the technique is here applied to the field of slow-scan television, giving the amateur a capability for the long-distance transmission of color information.

Color Principles

In 1801, Thomas Young put forth a hypothesis that human color vision is based on a three-part color analysis, in the eye, of the light received from an object. Young's investigations were extended by Helmholz and others, who showed through mixing experiments that almost all colors could be matched by a mixture of three colors. The three colors used in the matching process are not specified; but then, there are no three unique components that must be used for color matching. It can be shown, however, that red, green, and blue components permit matching the greatest spectral range of colors (without using negative quantities of a component), and for this reason, red, green, and blue are considered as the *primary colors.*

James C. Maxwell, in 1861, demonstrated that the above principles could be used to reproduce a colored scene, and thus laid the foundation for current three-color photography, printing, and television. Maxwell exposed three separate photographic plates to a landscape scene through red, green, and

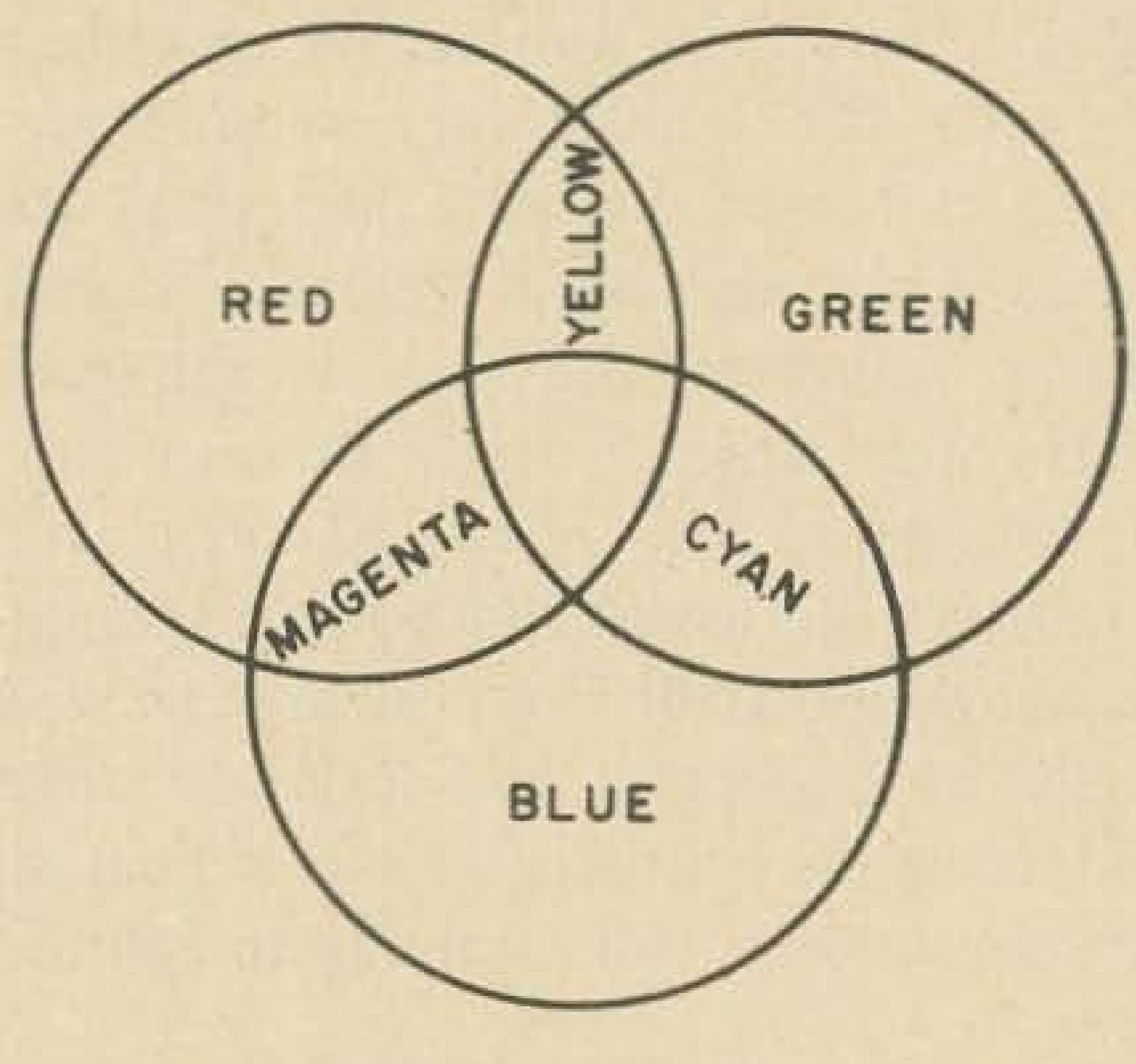


Fig. 1. Color mixture by addition.

blue glass (filters). The photographic emulsion exposed behind the red filter, when developed, showed, in terms of silver densities, the amount of red light reflected from the scene. Areas of the landscape which reflected greater amounts of red light yielded greater densities on the corresponding parts of the black and white negative. Where a lesser amount of red light was reflected, a lesser density was obtained. Similar statements apply to the negatives made with the green and blue filters (substitute "green" and "blue" for the word "red" in the above sentences). Colors formed from two or more colors were recorded on two or more negatives in proportion to the amount of each primary color reflected. Thus, the set of three black and white *separation negatives* recorded the *tricolor analysis* of the scene.

To reproduce the landscape analyzed by tricolor analysis, Maxwell first produced a positive transparency from each of the three separation negatives. These positives were then placed in magic lanterns, and a colored filter corresponding to a given positive's separation filter was placed in front of each lantern. That is, a red filter was placed in front of the lantern containing the positive made from the "red" negative, etc. With the intensities of the lanterns properly adjusted, a reproduction, or synthesis, of the landscape appeared on the screen. Although the reproduction was poor by today's standards, the basic principles of three-color photography had been established.

Maxwell reproduced his image by *additive color synthesis,* wherein three colored light images are added together to obtain a

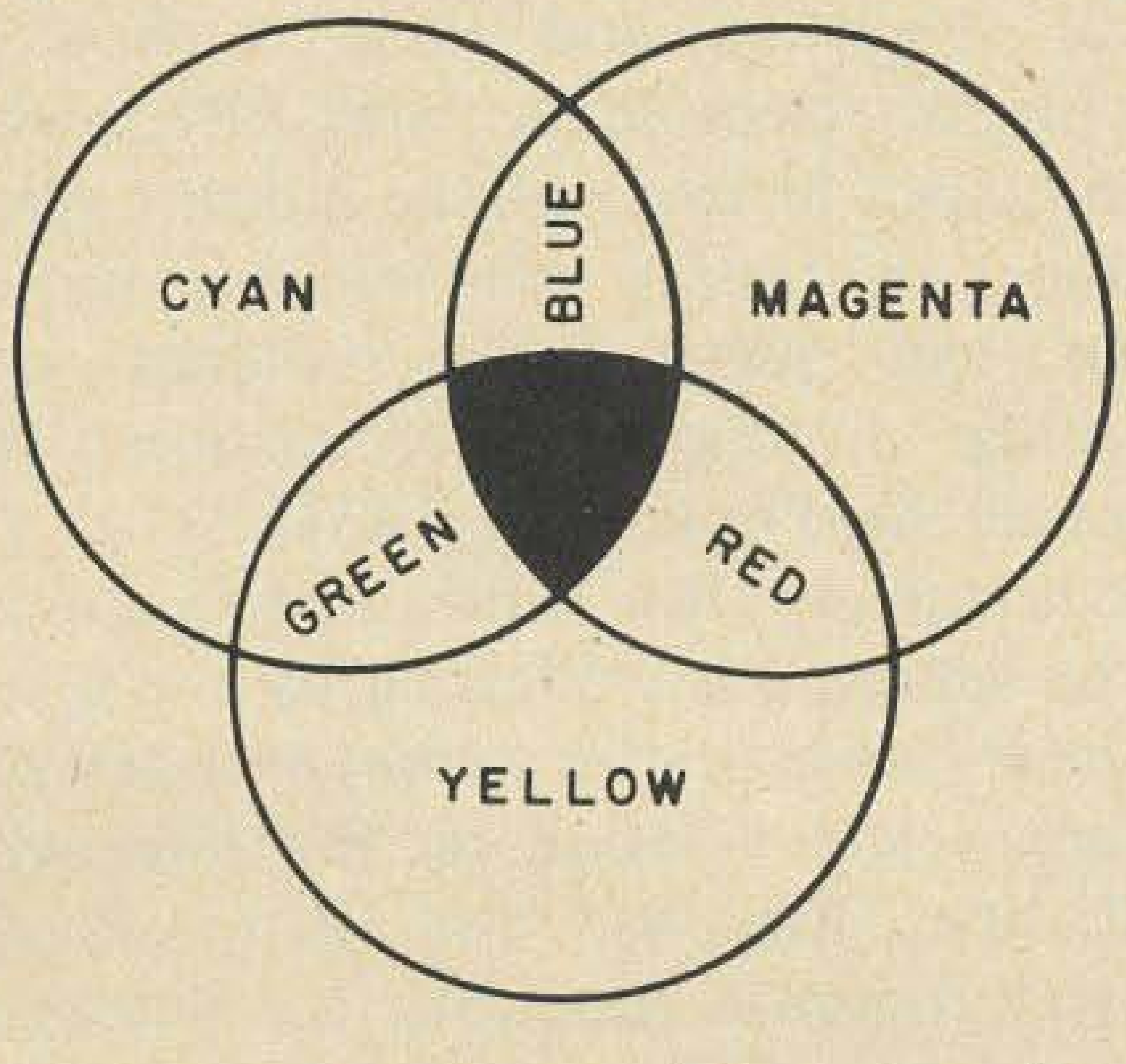


Fig. 2. Color mixture by subtraction.

suitable mixture. This process is illustrated in Fig. 1, where white-light sources are projected onto a screen through three primary color filters. Besides the areas where the primary colors are observed, and where all three colors are superimposed (white), three additional colors are observed. These are: cyan, (white light minus red); magenta (white light minus green); and yellow (white light minus blue). This suggests that color mixing may be performed using the colors of cyan, magenta, and yellow; that is, by subtractive mixing.

Fig. 2 shows a subtractive mixture of colors produced by projecting a single white light source through an overlapping set of staggered subtractive filters (i. e., cyan, magenta, and yellow filters). Besides the three subtractive colors observed on the screen, we can see areas of red, green, and blue. Where all three subtractive filters overlap, no light (black) is projected. Thus in Maxwell's experiment, let us dye the positive silver image prepared from the red filter separation negative cyan. Similarly let us dye the positives prepared from the green and blue filter-separation negatives magenta and yellow, respectively. If we now place all three dyed transparencies in the same projector, we obtain a color picture (without having to use any filters in front of the white light projector) by *subtractive color synthesis.* Our present color photography and color printing methods employ the principles of subtractive color synthesis, and it is this technique we used to synthesize the first color picture transmitted by slow-scan television.

Method

The general method employed to analyze and synthesize the slow-scan color television picture is shown diagrammatically in Fig. 3. The subject here, a black circle containing red (R), green (G), and blue (B) circles, is first illuminated with white light. The subject is then viewed (in sequence) through red, green, and blue filters by an SSTV flying-spot scanner or vidicon camera, and the three black and white pictures obtained – which might be called the separation pictures – are recorded on a conventional audio tape recorder. Once taped, the pictures may be transmitted over the air or on the telephone lines; the tape can also be forwarded through the mail. Whatever the means of transmission, the pictures are eventually played back at the receiving end, whereupon three black and white photographs, corresponding to the three separation pictures, are taken of the monitor's display. Note that no filters are required at the receiving station; the three black and white pictures transmitted already contain the necessary tricolor separation information.

Once the monitor's output has been photographed using a conventional camera (time exposures are taken of the three separation pictues), the film is developed. This yields a set of separation negatives from which are prepared three positive prints. Halftone negatives are now made from the three positives, and these negatives processed using the Color-Key printing technique. If the three processed Color-Key films are now superimposed on a white background, the resulting color image is a reproduction of the originally televised color subject.

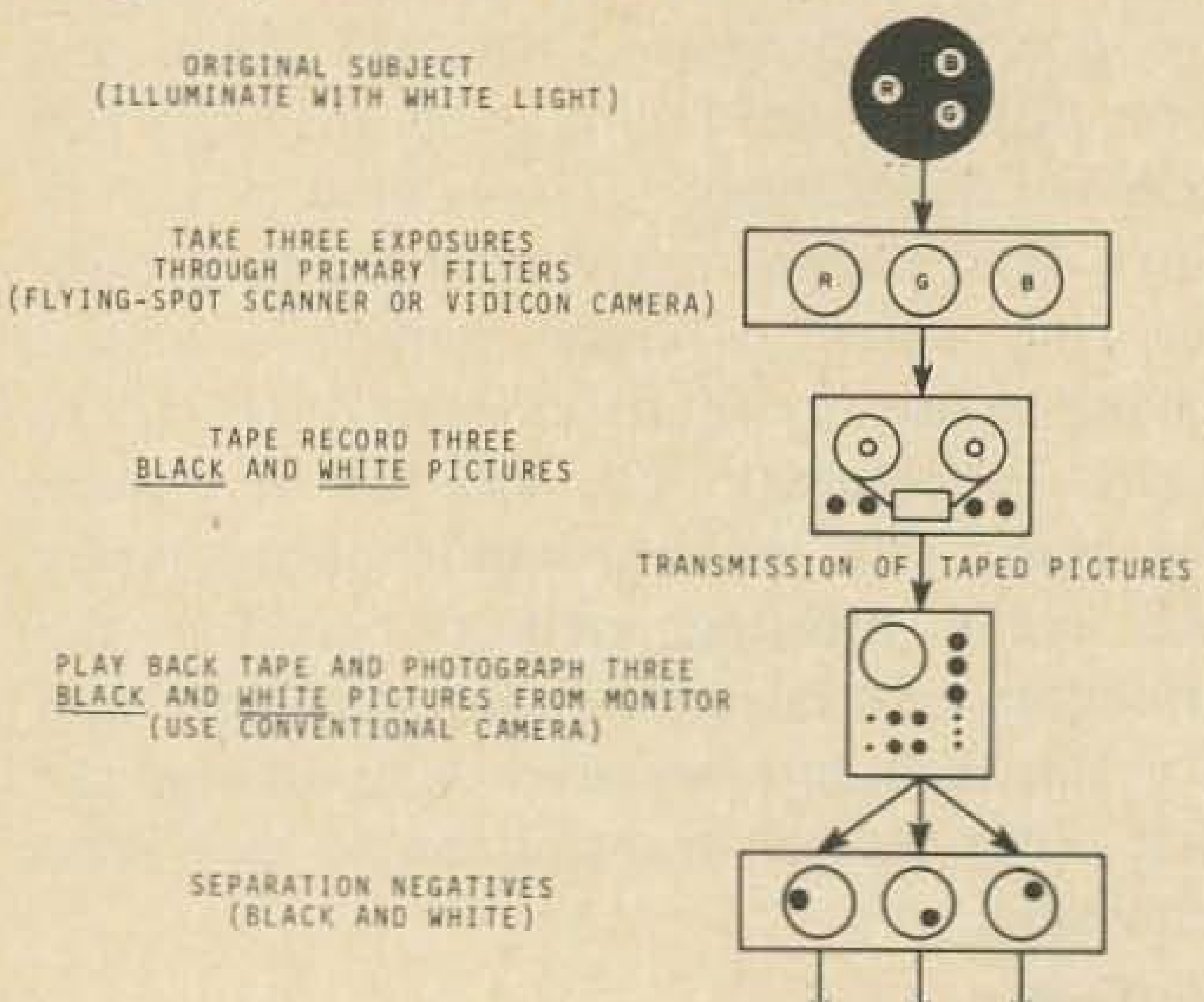
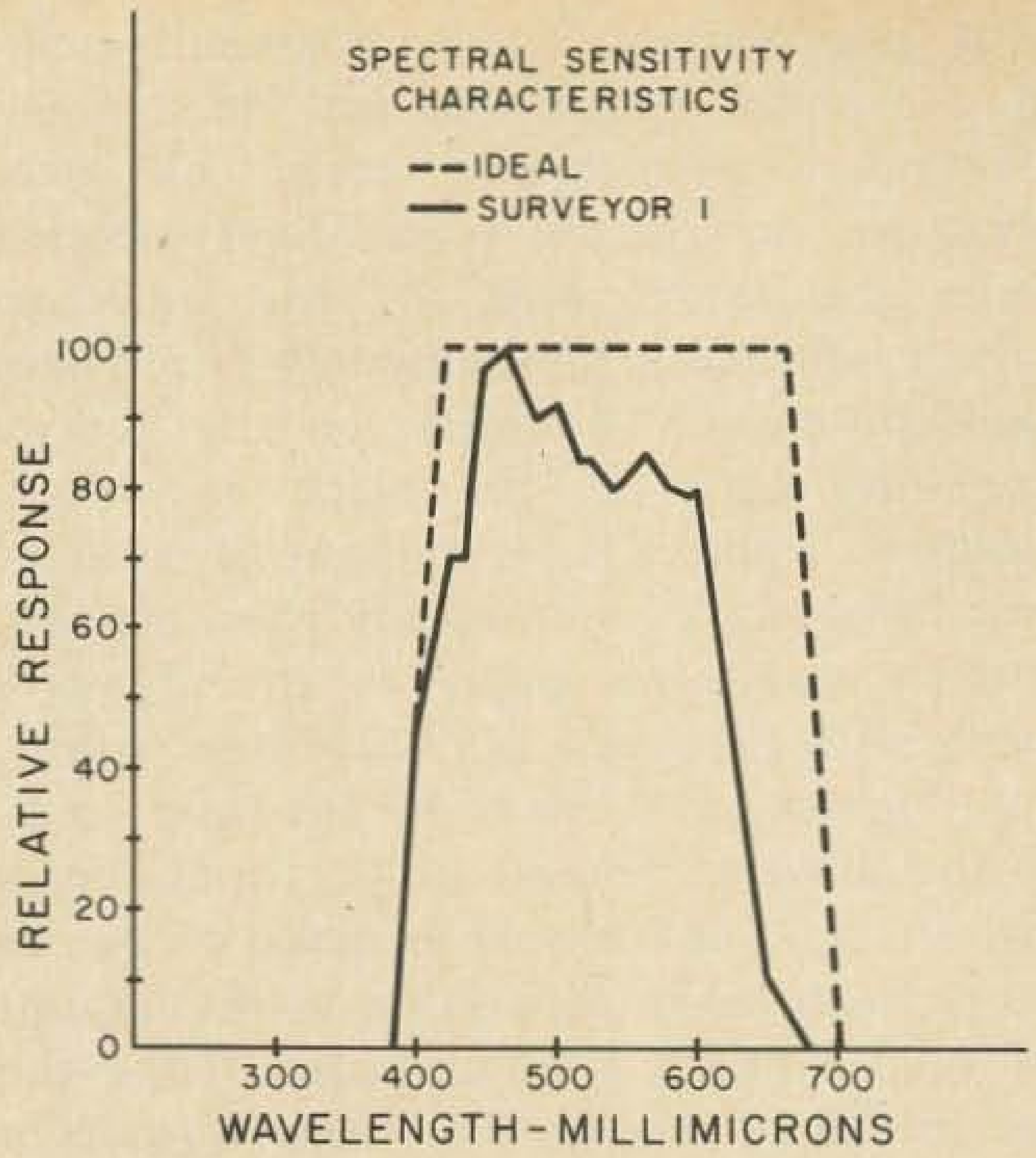


Fig. 3. Color reproduction by means of color analysis and synthesis. This was the method used by W4UMF and Mr. Tarr to reproduce the first color picture transmitted by amateur SSTV.



MODIFIED AFTER: SURVEYOR I: PRELIMINARY RESULTS, SURVEYOR SCIENTIFIC AND EVALUATION AND ANALYSIS TEAM, SCIENCE, VOL. 152, 24 JUNE 1966.

Fig. 4. The ideal total-system response for color analysis work. This response is shaped, using single-color filters, to produce a response which matches the standard color-matching functions. The total-system response for the camera aboard Surveyor 1 is shown for comparison.

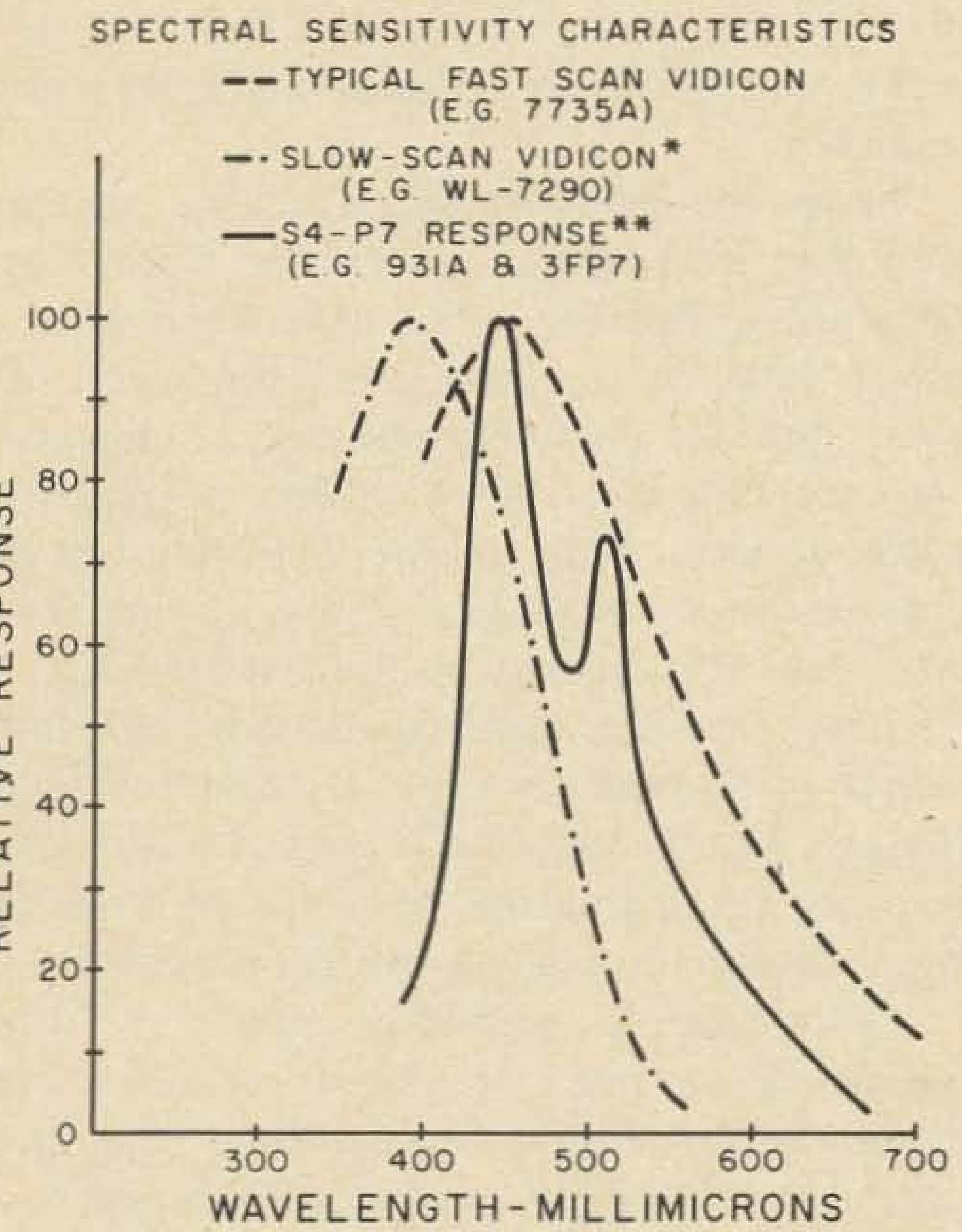
Having outlined the basic principles of color analysis and synthesis, and the application of these principles to the transmission of color pictues by slow-scan television, let us now turn in detail to the techniques employed.

Color Analysis

Ideally, one would wish that the response of his television system be similar to that shown by the dashed line in Fig. 4. The response is seen to be flat over the entire visible spectrum, and thus, it should be possible to select single-color filters which, when placed in front of the imaging system, produce an overall camera-filter response which can match the standard color-matching functions (Commission Internationale de l'Eclairage, 1931). That total system response functions close to the ideal can be achieved is evidenced by the spectral response curve of the Surveyor 1 television cameras (clear position on the filter wheel, solid line, Fig. 4). Overall camera-filter spectral response functions for Surveyor 1 can be found in the report of the Surveyor

Scientific Evaluation and Analysis Team (1966), and for Surveyor 3 in Shoemaker, et al. (1968).

As television cameras with "ideal" spectral response curves (like those of the Surveyor cameras) are necessarily expensive, we should not be surprised that the imaging systems employed by amateurs use tubes with response curves far from the ideal. **Fig. 5** shows the response curves for three classes of imaging systems used in amateur slow-scan television work. Flying-spot scanners (e. g., see Hutton, 1967) typically use 931A photomultiplier tubes (S4 response) together with a P4 or P7 CRT raster source. Slow-scan vidicon cameras, on the other hand, generally employ image tubes like the Westinghouse WL-7290. Only recently, Taggart (1968) and Hutton (1969) have demonstrated the use of conventional fast-



*REF.: SLOW-SCAN VIDICONS; LIGHT INTEGRATION & STORAGE, NARROW-BAND VIDEO TRANSMISSION, WESTINGHOUSE, APRIL, 1968.

**REF.: AVERAGE RESPONSE; S4 SENSITIVITY (2870° K TUNGSTEN SOURCE) TIMES AVERAGE P7 SPECTRAL-EMISSION CHARACTERISTIC, RCA HB-3 TUBE MANUAL.

Fig. 5. Three classes of image-tube response used in amateur SSTV systems. The response of a conventional vidicon is preferred for color analysis work, followed by the response for an S4-P7 flying-spot scanning system.

scan vidicons (e. g., 6326, 7038, 7735A, etc.) in the slow-scan mode. Thus, we essentially have three classes of image-tube response to choose between. Of these, the conventional vidicon's response is superior, followed by the spectral response of the S4-P7 flying-spot scanning system. The slow-scan vidicon, however, peaks in the violet, and experiments at W4UMF have shown that its extremely low output in the red (visible wavelengths greater than 610 millimicrons) eliminates it as a possible image pick-up device for direct color separation work.

Robert Tschannen's (W9LUO) dual-931A flying-spot scanner was used for the color analysis phase. This scanner, similar to that described by Hutton (1967), employs a 15 hz horizontal frequency and an 8-second frame period (120 lines). The total-system spectrum response function was shaped for color separation by inserting red (Wratten No. 25) and blue (Wratten No. 47) filters in front of the photomultiplier tubes. No filters were used in producing the green separation picture. While the green separation picture therefore contained, in reality, blue-green information, this color bias was compensated for in the production of the Color-Key print.

The subject chosen for the initial color separation tests is shown on the cover, bottom left. Anyone who has ever tuned a color TV set or viewed a color slide can attest to the fact that the faithful reproduction of skin tones is essential to good color imaging. Thus, it was felt that a subject such as that chosen would provide a good test of the techniques to be employed.

To correct for the non-uniform spectral response of the system, the following procedure was used in preparing each of the separation pictures. With a given set of color filters in place (or no filters, in the case of the green picture), a white card was substituted for the subject picture, and the phototube outputs set to a predetermined level. This level, which was the same for all three white-card separation pictures, was sufficiently high to produce a white picture on the slow-scan monitor. Following equalization of phototube outputs, the subject picture was placed in the scanner, and 8 separation-picture frames were recorded on magnetic tape. Every effort was made to replace the subject picture in the same position following each equalization adjustment; an attempt was also made to maintain a common size for the scanning raster. The necessity of alternately changing picture and card for primary output adjustment could account for some of the misregistration seen in the synthesized picture. It is to be noted that slight defocusing did occur on the red separation picture. This is a result of having to drive the raster source CRT quite hard before obtaining the desired output equivalence.

The recorded pictures were mailed to W4UMF for color processing. The question of whether these pictures should have been transmitted by SSB on 20 meters, via the phone lines, or by tape through the mail is purely academic; tests conducted during the past two years have proven all three transmission modes capable of yielding high-quality SSTV pictures.

Color Synthesis

To produce the required separation negatives, the taped separation pictures were played back through a 3" monitor, and photographed on black and white 35mm film. The camera used was a Bell and Howell-Canon single-lens reflex with a 35mm f/1.8 lens. A close-up lens was also attached. The camera was tripod mounted, and a remote shutter trigger employed to minimize changes in the camera's position. While small lateral and vertical changes in the camera's position can be corrected for in printing the Color-Key picture, changes in the distance between the camera and monitor will produce variations in picture magnification. Such variations in image size are difficult to compensate for, and can result in significant color fringing.

Use of 35mm film necessarily required that the separation negatives be enlarged prior to printing. This suggested that fine-grain film be employed. The film chosen was Kodak Panatomic-X.

The Panatomic-X film has an ASA rating of 32. Because of this rating, and the low light level of the CRT flying spot, it was necessary to experiment with aperture settings. Aperture settings of 1.8, 2.8, 4 and 5.6 were used in obtaining the 3-picture sets.* All pictures taken were 8-second (one frame) time exposures. The black background of the original subject was used as a guide for proper adjustment of the monitor. That is, the brightness for each picture was set such that the CRT beam was just extinguished in the black portion of each frame.

The exposed film was processed in accordance with the film manufacturer's specifications. This not only assured us of obtaining proper silver densities in the negatives, but should also permit duplication of the results obtained to within narrow limits.

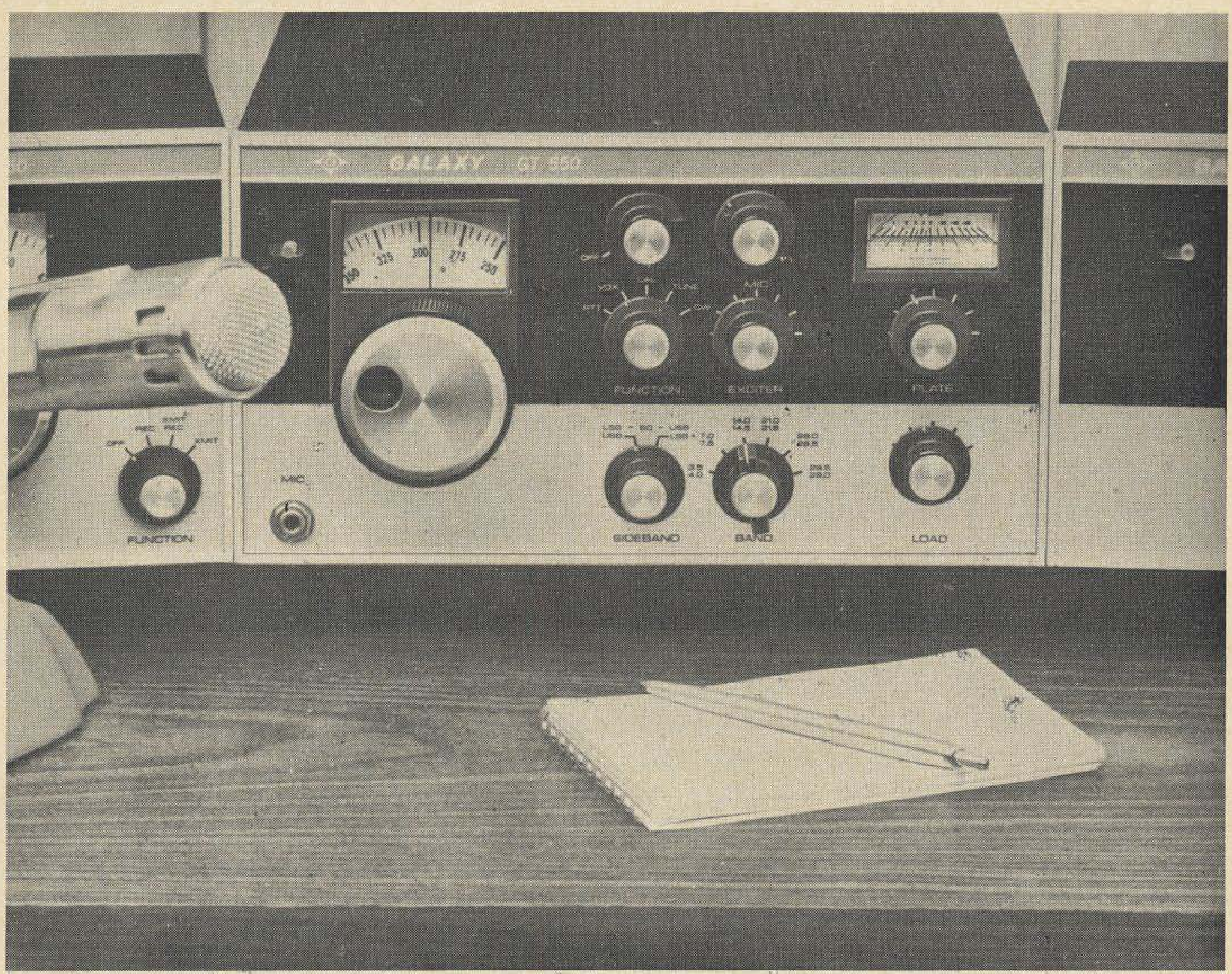
The 35mm separation negatives photographed from the monitor were quite contrasty. This was due in large part to the lack of tonal gradation in the pictures displayed on the monitor. As the P7 cathode-ray tube is capable of reproducing only 4 or 5 shades of gray, some tonal adjustments had to be made in the synthesis process. These adjustments will be discussed in detail later in this section.

From the 3-picture sets available, separation negatives were chosen for Color-Key processing. The choice of negatives was not too critical, as one can exert some control over picture characteristics (i. e. density, contrast, etc.) in a separable subtractive color process such as the dye transfer or Color-Key process. The white flaring was introduced in the analysis process (glare).

The Color-Key method for color printing was used to synthesize the tricolor-analyzed picture. For a complete survey of Color-Key printing the interested reader is referred to the literature on color printing processes.

Color-Key is primarily used by lithographers to produce proofs of separated negatives for multicolor printing. The process can be used by anyone with access to a high intensity lamp. In addition, materials are available in most areas of the country, which is not true of other processing mate-

*The monitor at W4UMF employs a 3RP7A CRT, with an accelerating voltage of 1600 volts. Most monitors use 3FP7A, or 5ABP7 CRT's, which generally employ accelerating voltages closer to 3100 volts. If tubes of the latter type are employed, and Panatomic-X film is used, it is suggested that stops between 2.8 and 8 be tried. If a film such as Plus-X is used with a high accelerating voltage CRT (~3100 volts), f/stops between 8 and 11 should produce good 8-second time exposures.



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rials investigated (e. g., dye tranfer materials). Color-Key is easily handled in subdued light and has a one-step developer which is applied with a cotton swab.

Because of its lack of tonal range, Color-Key must be exposed using a halftone or screened negative.

The Color-Key process uses three sheets of film, each dyed one of three colors: cyan, magenta, and yellow. The halftone negative for the complement of each Color-Key dye is exposed and developed separately. The resulting Color-Key positives are then aligned, one on top of the other. Viewing through the composite film *should* produce a color reproduction of the original color scene. We use the word "should" because of the problems encountered.

It was mentioned earlier that the negatives photographed from the monitor were of high contrast. As such, the glossy photographs were also without tone gradation, and thus, the halftone negatives had relatively little tone variation. The reason for this follows. Let us examine the synthesis process in detail. Consider that black and white picture on the monitor which had been analyzed through the red filter. The picture had white areas on the screen where the skin tone was on the original. As the skin tone (large percentage of yellow-red) would pass through a red filter, the face should have appeared light gray. The green area of the dress, composed of cyan and yellow, was not entirely passed by the red filter, and should have appeared dark gray on the screen. This area however, was displayed as black. This shift to higher contrast is a product of the monitor's CRT limited dynamic range. Thus, it was not possible to accurately reproduce the tones of the original picture. Similar statements apply to the green and blue separation pictures as observed on the monitor. As such, we were required to use some color correction to reproduce the tone values between white and black.

After all the Color-Key positives were made, it was determined that more magenta and yellow was needed to reproduce a realistic skin tone. Adding these colors would also make needed corrections in other areas of the picture to correct for the blue-green bias in the original SSTV separation pictures. Color-Key sheets containing dot patterns of 50% color value at 85 lines per inch were added. This corrected the color to within reasonable limits over the entire picture. No attempt was made to correct particular areas of the print; all areas were treated uniformly.

Results

The processed color print is shown on the cover, at the right. In judging the quality of the reproduction, we should be aware of the inherent resolution limitation (120 lines) of the slow-scan system, and the limited dynamic range of the monitor's CRT. To the extent that the Color-Key print approximates the color of the subject, however, we class the quality of the synthesized color print "fair."

Comments and Conclusions

In the case of the picture processed above, the original color photograph was available to be used as a guide in the synthesizing process. To eliminate the need for viewing the original color photograph during color synthesis, it is suggested that a small color-bar set be included in pictures to be analyzed. Upon synthesis, accurate reproduction of the color bars will insure proper color balance in the subject.

We have demonstrated the feasibility of transmitting color pictures by slow-scan television, using the method of color analysis and synthesis. In particular, picture reconstruction was performed using a separable subtractive color process – the Color-Key process. Though the color analysis phase of the test and the production of the separation negatives may seem heuristic in character to the critical experimentalist, the procedures described nevertheless do work. We would hope that more experimentation will be done using the Color-Key process as this process can produce excellent results given separation negatives of good tonal gradation.

That prints made using the Color-Key process are considerably more expensive than conventional color prints, and that an experienced amateur photographer is more apt to obtain the desired results when using this process, would seem to limit the application and use of the color transmission method described. However, given today's technology in quick-processing films (e. g., Polaroid Polacolor), and a continued experimental effort on the part of the amateur-photographer, it is expected that technically and economically more appealing synthesis techniques will be developed shortly for the color transmission by slow-scan television.

. . . W4UMF & Tarr

Acknowledgement

The assistance of Mr. Robert Tschannen, W9LUO, in preparing the separation SSTV pictures, is gratefully acknowledged. The authors further thank Mr. Tschannen for many stimulating discussions on color separation, and for his critical reading of the manuscript. The authors also thank Mr. Charles Cowden, K6BL/4, and Capt. David Veazey, W4ABY, for providing 20 meter liaison communications between W9LUO and the authors.

Mention of trade or brand names is solely for identification and does not imply endorsement of products mentioned, nor does it imply nonendorsement of unnamed products.

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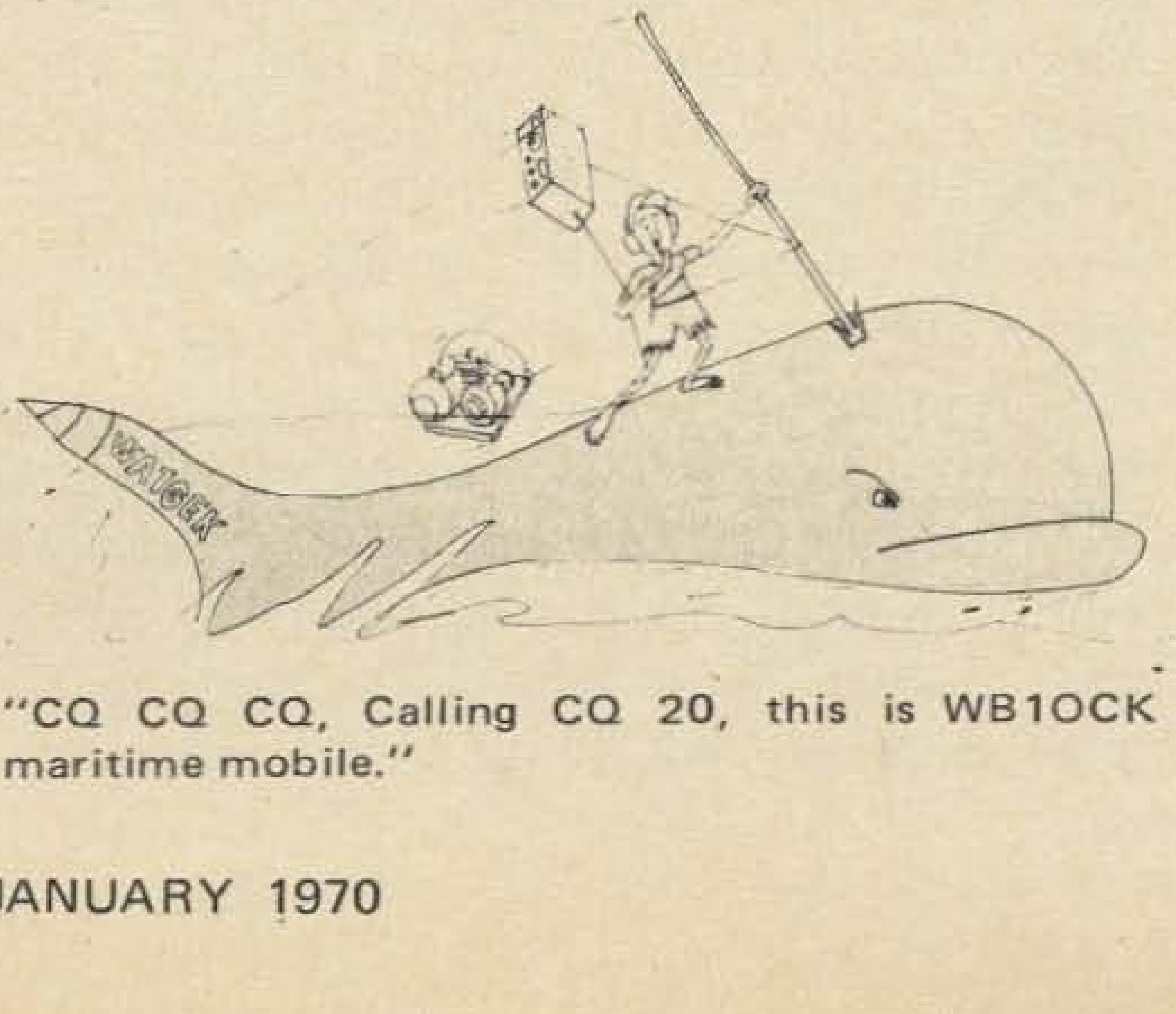

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Fascinating Fundamentals

Volta and His Pile

Although this article is about Volta and the invention of the electric cell, it would be incomplete without at least a mention of another Italian, Luigi Galvani. Both these men stumbled over the same principle, and both men misinterpreted it, although Volta's interpretation was most nearly accurate. Galvani's main field of operation was electric detectors. After his wife was scared out of her wits by a pair of frog's legs that jumped without having the rest of the frog attached, and after she suggested to her husband that the phenomenon just might have something to do with his electric machines, Galvani "discovered" this very sensitive method of electric detection.

Galvani worked for a number of years with his frog legs, and during the course of his experimenting, he completed a circuit to a pair of legs by way of a copper wire and an iron fence. He observed that the legs would jump when connected through two different metals, but not when only one kind of metal was involved. Not being concerned with electric generation, he continued his experiments in the field of detection.

This was in the latter part of the eighteenth century, and in those days, the only source of electric power was from electrostatic machines. Just a few decades before, Franklin had discovered atmospheric electricity through his famous kite, but this had proven to be a difficult source to control. Nobody had, as yet, said so, but the thing most needed to further the progress of electricity was a source of continuous current.

Galvani had been convinced that his connection of the frog legs to the metal strips had shown evidence of what he called "Animal Electricity." Volta thought differently. He felt sure that the source was not in the animal tissues, but rather in the connection between the two metals. He came awfully close. For quite a while he experimented with a great many combinations of metals, and eventually came up with a list so arranged that any metal shown would generate a positive charge when contacted with any metal below it. His one misconception, and it was a minor one, was that it was the CONTACT between the two pieces that produced the charge.

Volta had tried to improve the connection between the metals by moistening them with brine. In time he found that the same result could be had if the two pieces were altogether separated. He still believed, however, that it was only the connection between the metals, and not a reaction with the brine that produced electricity. Soon he was making stacks of his cells piled one on top of the other. This, naturally, produced a more powerful charge and, while its power was nowhere near that of the static machines, it never had to be recharged. Here,

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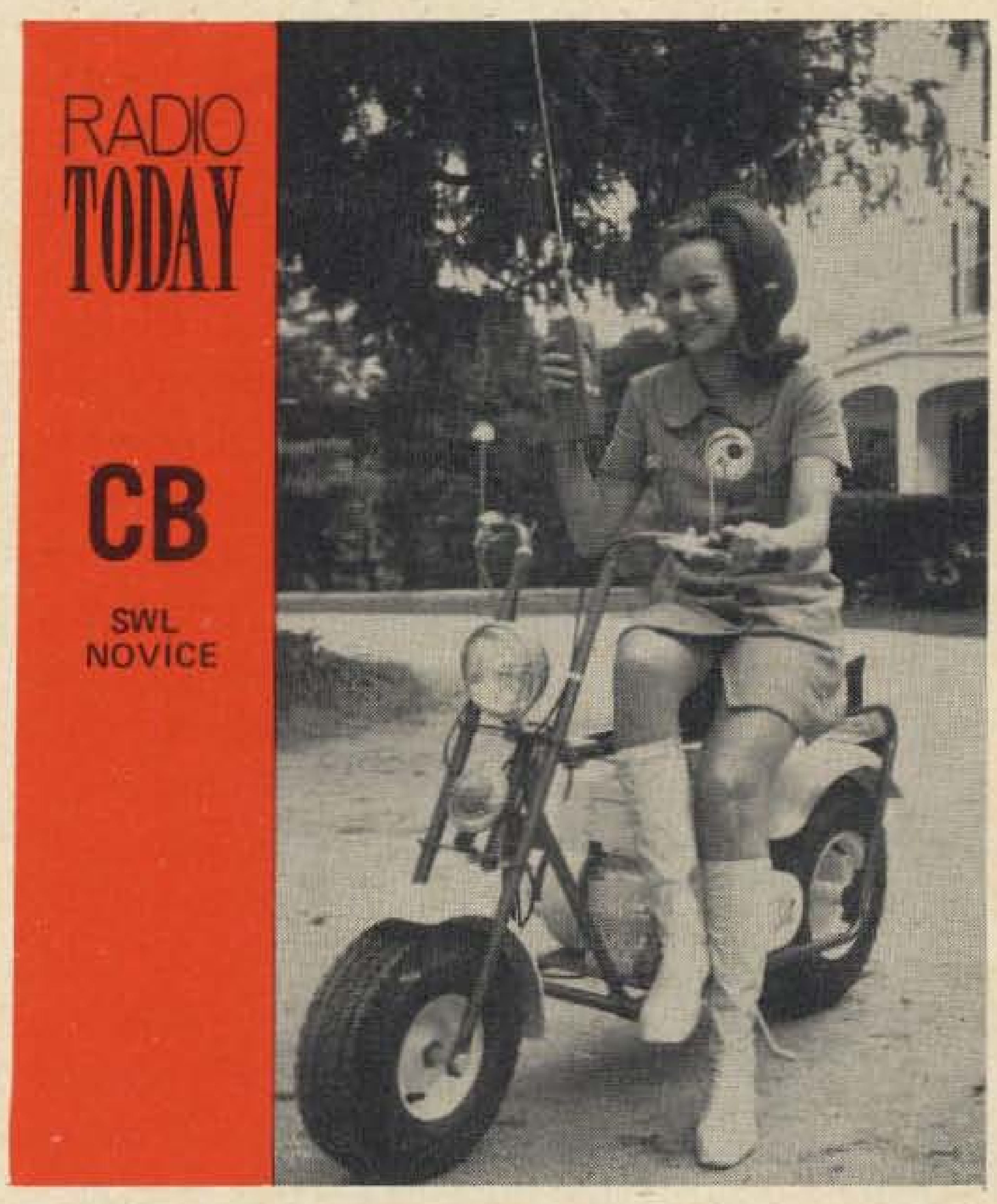

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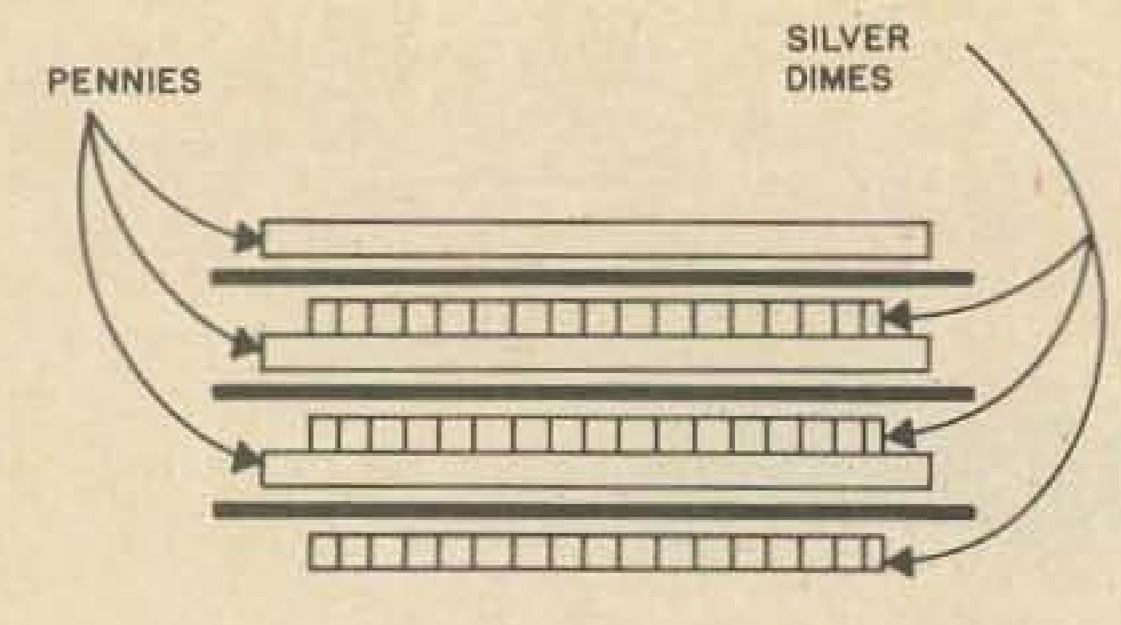


Fig. 1. Volta's pile (also called the spit-on-a-dime battery). Blotters should be moistened. This always used to be made with the older silver dimes. I don't know how well it will work with the new ones.

then, was a source of continuous current. Volta published his conclusions in a letter which was read to the Royal Society in England on June 26, 1800. On that day, electricity took a giant step forward. In the next half century, many improved cells were developed by such men as Faraday and Davy, but it was Volta who started it.

Volta's one misconception, that electricity was being generated by the action of the two metals with each other, was not too far off. Actually, it is the action of the two metals AND A CHEMICAL. In the table, we see the potentials which can be produced with a few common metals and various solutions. To determine the potential you will get, take the DIFFERENCE between the potentials of the two metals you will use. For instance, with a sulfuric acid solution, zinc has a potential of 0.0, and copper, 1.007. If you immerse a strip of copper and a strip of zinc in a jar of sulfuric acid, there will be a potential of 1.007 volts between them. Lead, however, has a potential of 0.513. A cell made of copper and lead will produce only 1.007-0.513, or 0.494

Solution	Sulphuric Acid	Lye	Salt
Metal			
Zinc	0.0	-0.321	?
Lead	0.513	0.318	0.512
Tin	0.513	0.002	0.503
Copper	1.007	0.802	0.809
Silver	1.213	0.958	1.013

Table 1. When immersed in any of the solutions shown, any two of these metals will produce a voltage equal to the difference of their potentials. For instance, Zinc and Silver in a solution of lye: E = 0.958 (-0.321), or 1.179 volts.

volt. Try it yourself. All you need is a peanut butter jar (empty), some metal, and some acid. You can get the acid at any gas station. Just ask for some battery acid.

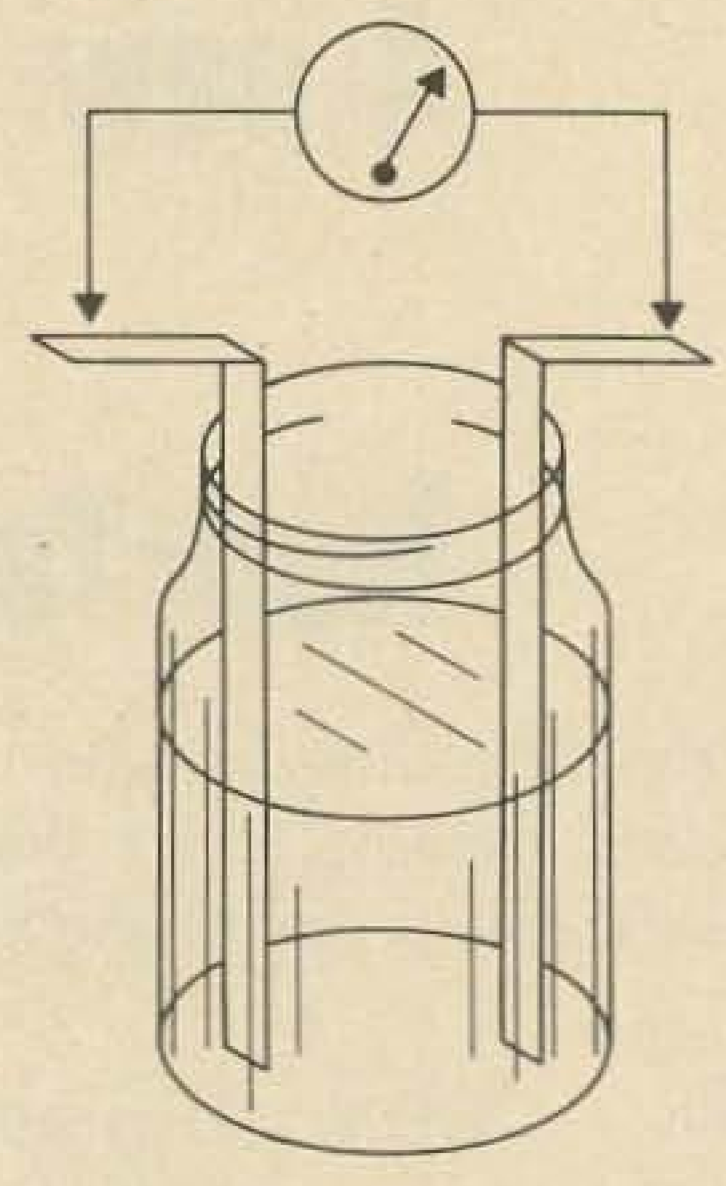


Fig. 2. A simple jar cell. See table for solution and metals.

I once made a demonstration cell by filling a tin can with a solution of vinegar and immersing a copper pipe. Between the copper and the tin, there was about half a volt, and if I had used sulfuric acid instead of the vinegar, that would agree quite well with the table.

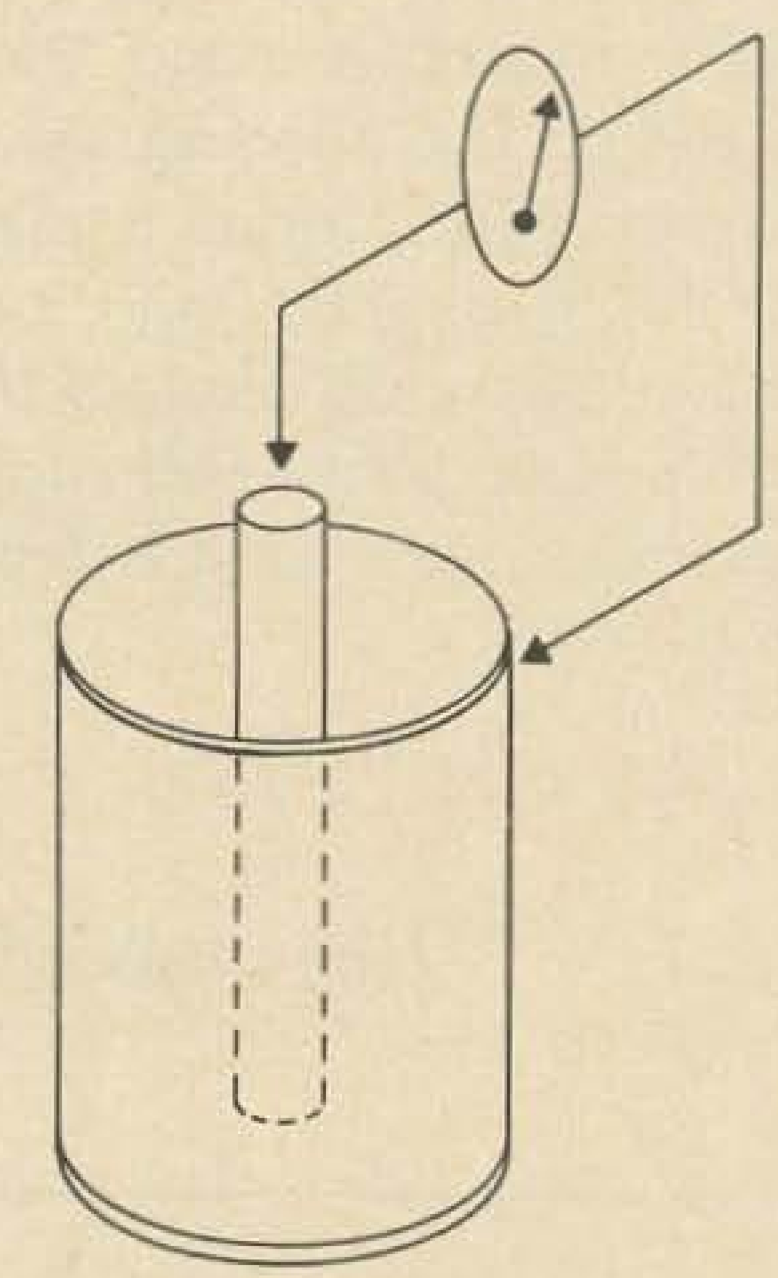
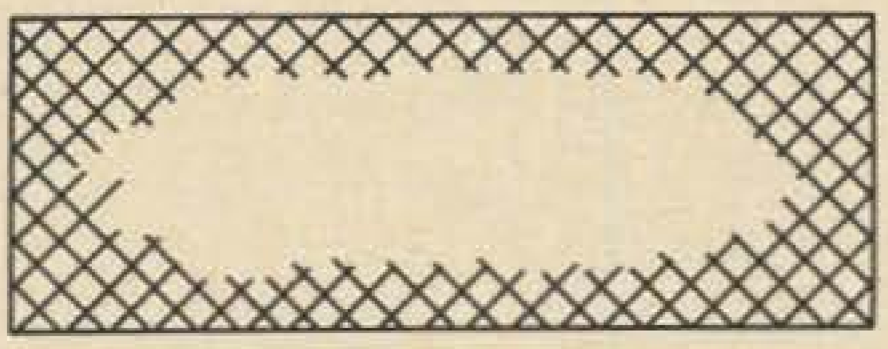


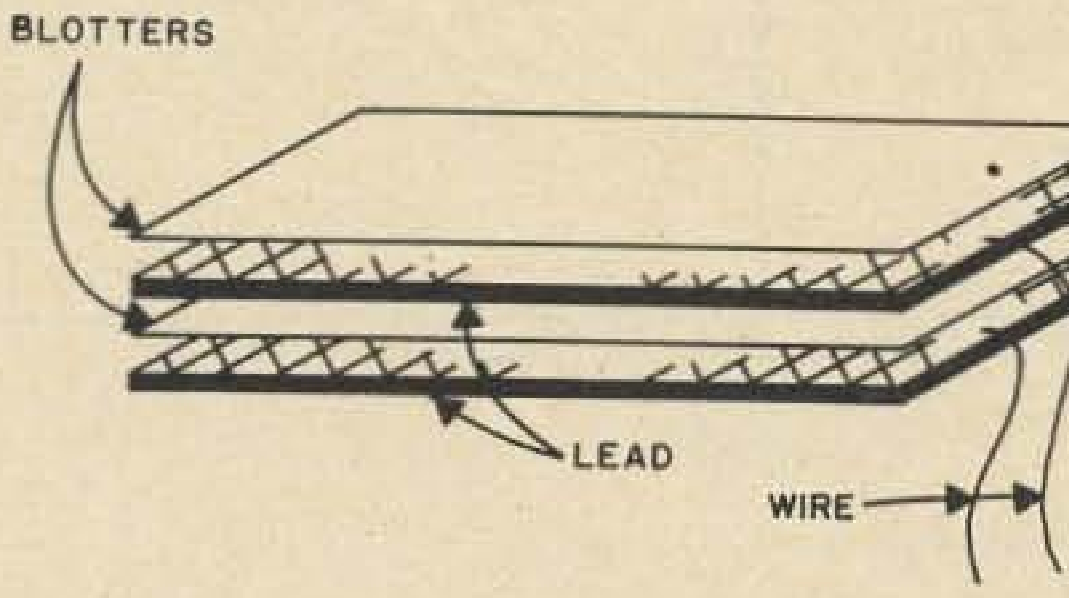
Fig. 3. The "can-full-of-vinegar" cell.

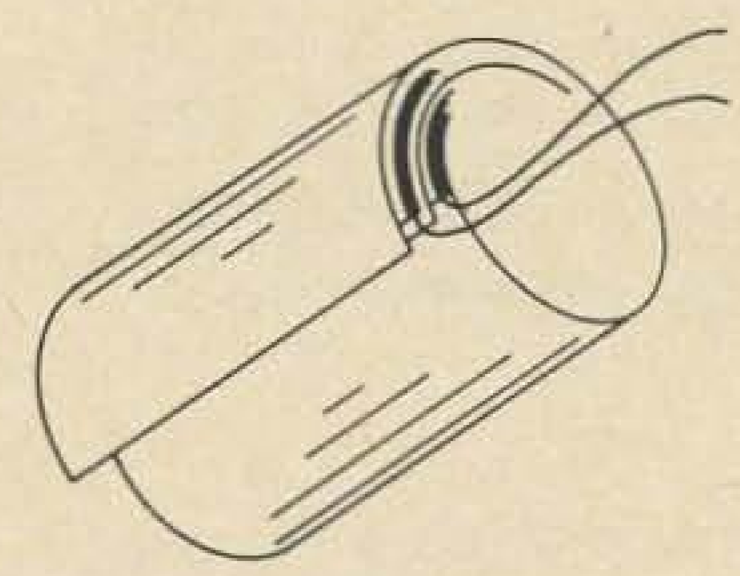
A storage battery is one in which the chemicals can be renewed by sending a current through it in the reverse direction. Take two strips of lead, and score criss-cross lines on them with a scriber. Then roll them together between two pieces of blotter, making sure that they do not touch each other. Put the whole thing into a jar and add some battery acid. Now "charge" it by connecting it to a two or three volt dc source. After an hour or so, remove the source and you will find you have made a 2 volt storage cell.

. . . W2FEZ ■

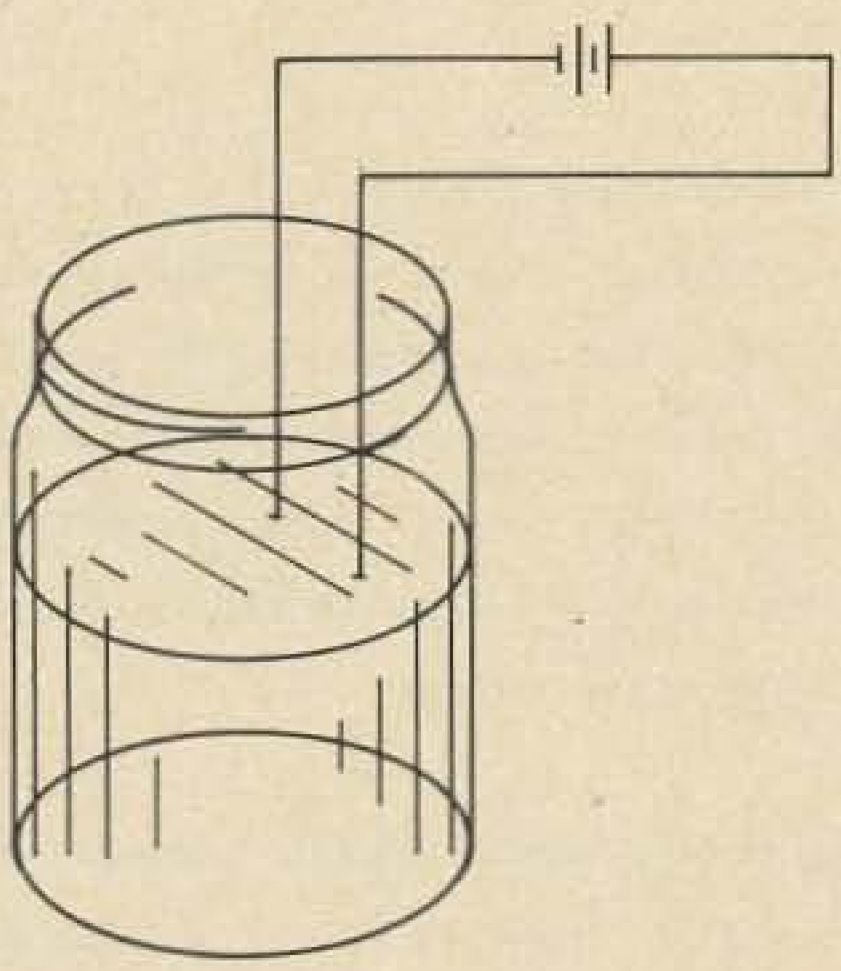


Score the lead like this.





Roll them up.



Put them in a jar and charge them.

Fig. 4. A simple storage cell. Make sure the lead pieces do not touch each other. Fill the jar with battery acid obtained from a local gas station. Once it has been charged the first time, mark the polarity and always observe it in future chargings.

The Manuscript Game

2084 Blair Street
Williamsport, Pa. 17701

November 12, 1969

73 Magazine
Wayne Green

Dear Wayne,

Since I have enjoyed reading the material you have written over the years, I have made up a little antenna story for you. I hope you enjoy reading it.

If by chance it has publication value, there is an automatic discount for rewriting of 27%.

The commercial price is therefore your choice of 73¢, $7.30, $73.00, or $730.00. I positively will not accept more.

James M. Fisher, W3KNG

1.

The 20 Meter DX Copper Ball Antenna

On a recent trip through a large hardware store, it was discovered that there is a plastic toilet float on the market. This may mean the eventual demise of the classic copper toilet float. In case this could happen, it was thought advisable to describe the old "toilet ball" 20m DX antenna before parts for this famous old antenna are no longer available.

The origins of this trusty old skywire, if documented, are not available to this author. Like legends, the design has filtered down through word of mouth. However, a tip of the hat to the inventor, wherever he may be. It's a good one.

It was developed when 20m first became a ham band, long before the beams of today were in use. Basically, it is a very simple antenna to build and use, and will perform as well as any dipole. The components themselves are inexpensive, and no elaborate towers or rotators are required. It has no apparent directive pattern. Using this antenna on 20m CW, and the modest power developed by modern transceivers, barefoot, it is easy to work around the world.

The theory behind the design is very simple: Half the transmitted energy is concentrated on the outside of a copper toilet float, and half is loaded into a 32 ft. wire counterpoise. The ball develops a fierce concentration of an electrostatic field, and really shoots this energy out, covering the entire world (which, incidentally, is also globe-shaped).

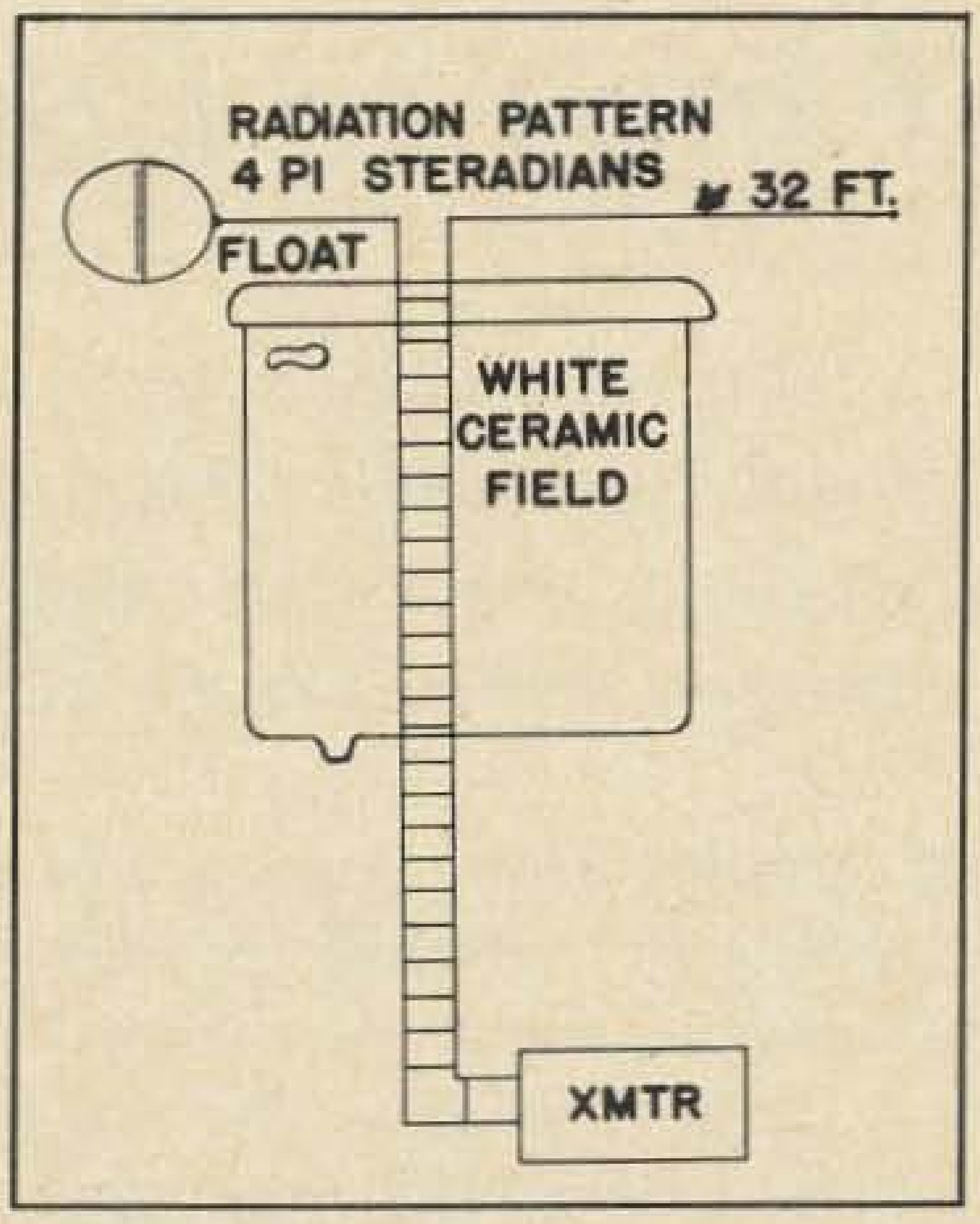
2.

The counterpoise, loaded primarily with the electromagnetic component of the transmitter's output, nicely provides background fill for the ball's radiation, giving depth and smoothness to the signal. The ladder line feed not only separates the electrostatic and electromagnetic fields to their ball and counterpoise, but actually convert the low impedance energy in the coaxial cable to the hot juice needed to make the ball sizzle.

Construction is not difficult. The insulators around the ball mount should be ceramic, and if you are going to use a kW, they should be a minimum of 4 in. long. The counterpoise should run in fairly clear space, several feet from trees or buildings, if possible. The ladder line should be mounted by regular TV standoffs, except for the top three feet, which should be either in the clear or on good white ceramic. The entire ladder should be guarded from contact by children or pets.

The whole shebang, ball and counterpoise, should be about 16 ft above ground. Build it and have a BALL!

. . . James M. Fisher W3KNG



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PETERBOROUGH, NEW HAMPSHIRE 03458

Dear Jim,

Thanks for letting us have the first opportunity to publish the article on the copper ball antenna. Some of the 73 staff became so inspired by your write-up that they built up a couple of the devices for the station here.

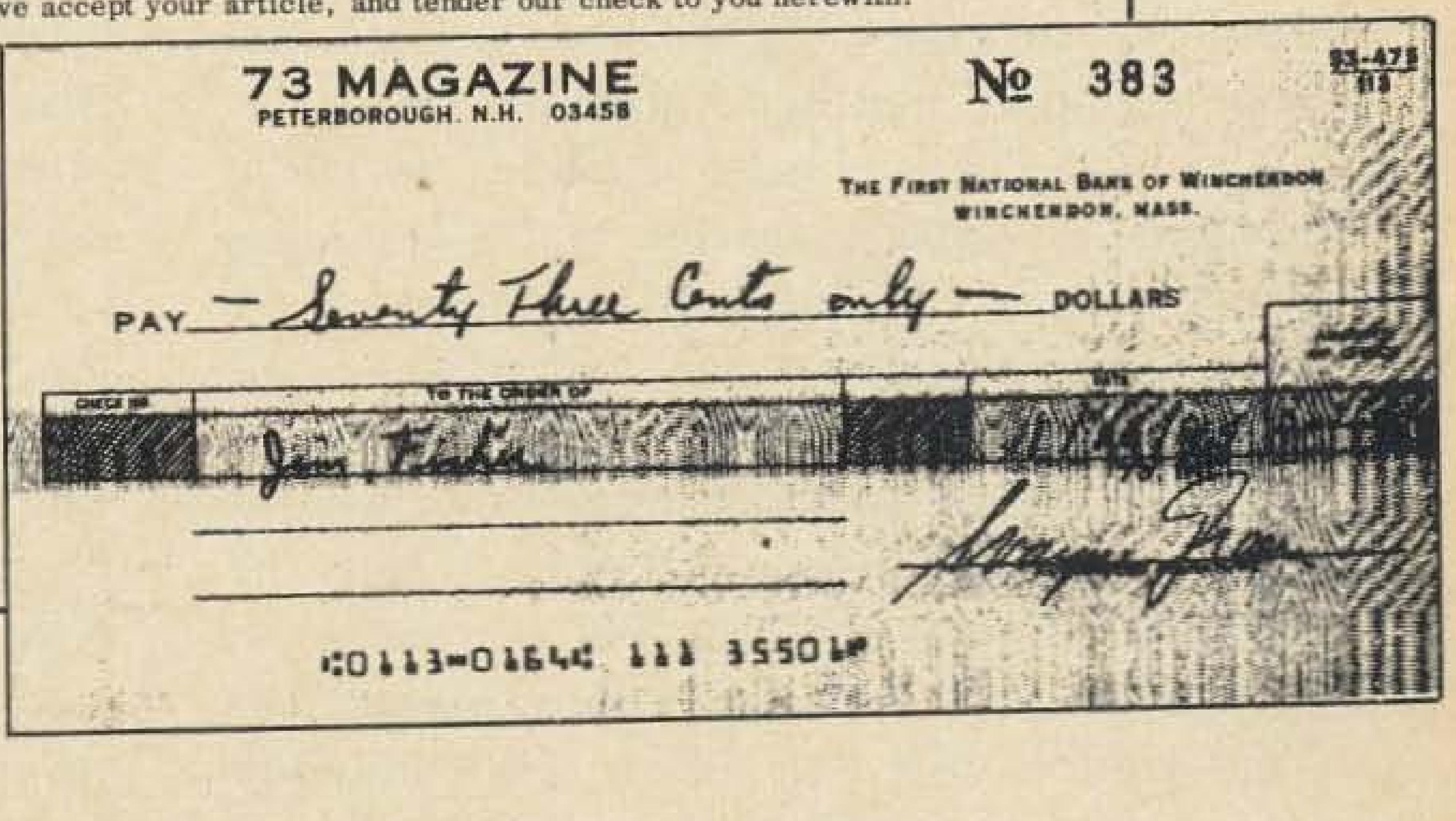
Needless to tell you, we've had phenomenal success with DX, even to the extent of working contacts in areas thus far uncharted.

Some inconvenience has occurred as a result, however. The nearest service station is several miles away, and its restrooms are damp and cold. Hardly a substitute for the nice ones we had on the premises before your article came in.

At any rate, we accept your article, and tender our check to you herewith.

73,

Wayne Green



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Base - Tuned Center - Loaded Antenna

No, the title is not incorrect. An antenna can be center-loaded without having the reactive element physically present at the center of the antenna. Transmission line transfer of the reactive element is the key.

There is certainly nothing new about base inductive loading of a vertical antenna. The method is convenient and often allows easy construction of an antenna. The disadvantage, of course, is low efficiency when the antenna is shorter than ¼λ long at the operating frequency. As shown in **Fig. 1**, the high current flow at the base of the antenna means that the greatest current flow takes place through the coil's relatively small conductor. Various solutions have been tried to get around the problem of distributing the current flow in an antenna such that the reactive elements necessary to bring the antenna system into resonance do not also produce the greatest losses. The helical antenna was one solution. By distributing the inductive loading along essentially the entire length of the antenna, the average current flowing through the base section of the antenna was reduced. Center lumped inductive loading (**Fig. 1**) has become the most popular method, however, since it allows the heavy base current to flow through the bottom section of the antenna, which is not loaded, and because of its constructional advantages, particularly for mobile antennas.

The method is not always practical for fixed station situations, however, where the antenna center may not be accessible to change coils for various bands. Usually, the fixed station operator who is constrained to using a vertical antenna on several bands has had to settle for base loading and could simply take the approach of making the base loading inductor as hefty as possible in an effort to reduce its losses. This article explores a method by which the efficiency of such an antenna can often be considerably improved by a form of pseudo-center loading using a transmission line to transfer the reactance of a loading element located physically at the base of the antenna electrically to its center.

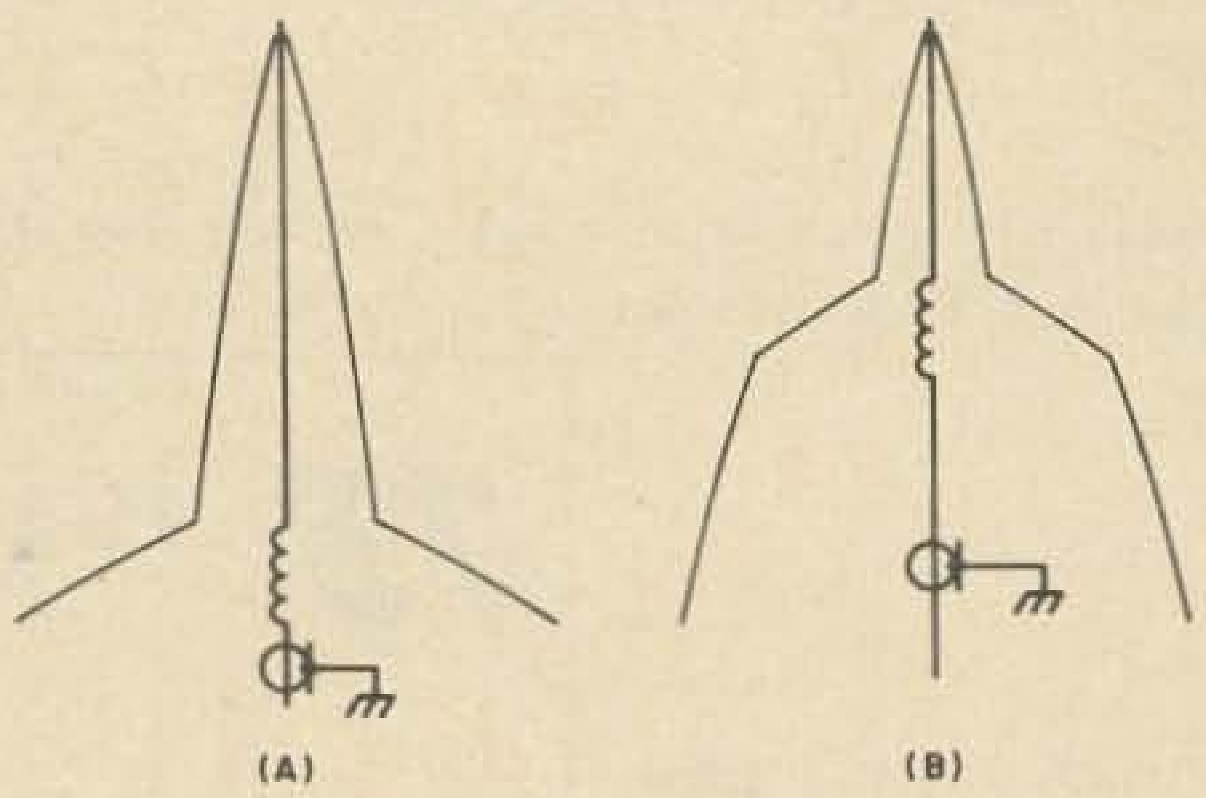


Fig. 1. Improved current distribution of center-loaded antenna (B) over base-loaded antenna (A) allows highest currents to flow where ohmic losses are low.

A note should first be made concerning the function of the loading inductor in a center loaded antenna. The inductive reactance is necessary to make the electrical length of the antenna equal a ¼λ so that the base impedance will match a coaxial transmission line and the antenna will accept a transfer of power from the transmission line. Unless the loading inductor is extremely long or wide, it does not radiate any appreciable signal. The radiating is done by the rest of the antenna. If the copper losses in the inductor are not kept low, the inductor will act in a manner similar to a dummy load and simply produce heat. The inductors used for the center loading of short mobile antennas are usually not shielded because weather protection can be obtained by epoxy coatings and a shield must reduce the inductor's Q or efficiency. The coil, however, could be shielded with a large enough enclosure so that the effect upon the Q would be small and antenna performance would not be affected thereby.

So, if the antenna saw the proper value of loading inductance at its center, regardless of where the physical inductor was placed, it would operate the same as it did with the physical loading inductor at its center.

Reactance Transfer

One method that can be used to transfer a remotely located reactance to the center of an antenna is via a transmission line. Transmission lines can actually be used not only to transfer reactances but also to simulate them. The latter feature is commonly used when stub matching is employed to simulate the necessary inductive or capacitive reactance to correct a mismatched transmission line condition. By a combination of using a lumped reactance at the end of the stub and the effect of the stub itself, almost any value of inductive or capacitive reactance can be created. The reactance so produced can have quite high Q and a low power factor depending upon the quality of the lumped reactance and the losses of the transmission line. By using the proper length and/or termination for a transmission line, it can also reflect an open or short circuit and be used as a remote switch.

Fig. 2 shows how a length of transmission line also can act as either a capacitive or inductive reactance. The chart shows how a short circuited stub can increasingly act as an inductor until it is ¼λ long and then start simulating a capacitive reactance beyond ¼λ. If the stub were open-circuited, the

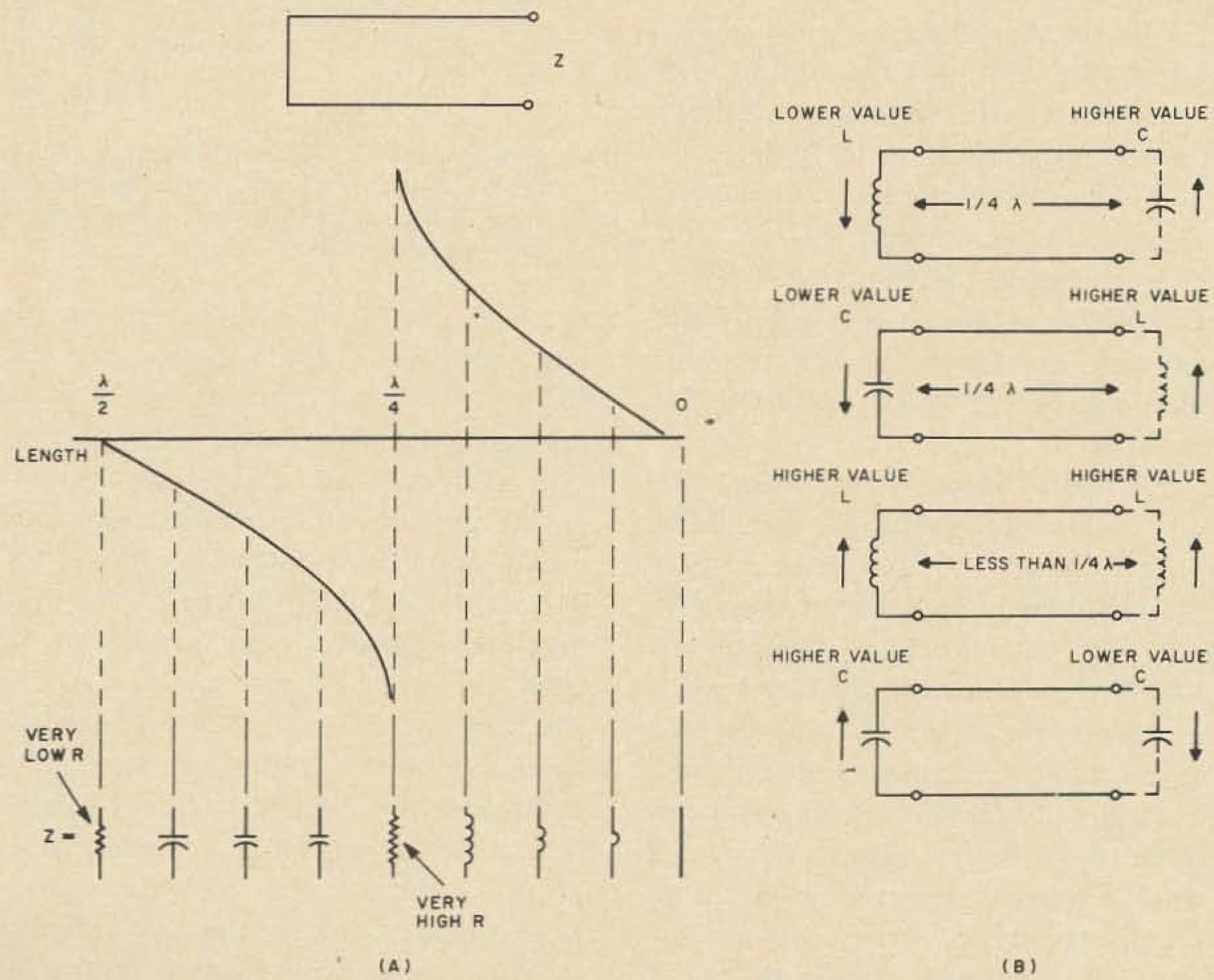


Fig. 2. (A) illustrates how length of transmission line can simulate a series of reactances depending upon its length. (B) shows some of the transfer reactances possible when a lumped reactance is used on the end of a stub. A line exactly ½λ long will transfer exactly the same value as the lumped reactance.

opposite reactive condition would apply. That is, capacitive reactance would be produced until the stub were ¼λ long and then at exactly ¼λ length it would act as a short circuit.

For those who don't mind a bit of math, the reactance produced by the stub when up to a ¼λ long is:

X_L (short circuited stub) = Z tan (2π L/λ)

X_C (open circuited stub) = Z/ tan (2π L/λ)

Z is the impedance of the transmission line used to make up the stub and L/λ is the line length in wavelengths. The physical line length is affected by the velocity factor (usually .66 for coaxial lines) and shorter by that factor than a free-space wavelength.

Although the reactance values repeat as the stub is made odd multiples of a ¼λ long, such long lengths should be avoided if possible. The highest Q will be obtained when the stub length is less than ¼λ. Once one knows the reactance produced by the stub, one can calculate or look up a reactance graph to determine how many microhenrys or picofarads are produced at any particular frequency.

Also, to obtain the best Q, a cable of the lowest loss possible should be used and also one with an inner conductor radius to inner radius of outer conductor ratio of 3 to 5. Not all cables can satisfy the latter criterion, RG/59 cannot, for example. RG/58 and RG/14 both are usable and the latter cable is particularly useful, although it is a bit large (.55" diameter) to satisfy the requirement for low loss and the proper geometry for high Q as a stub.

Short or open-ended stubs alone are limited in ability to produce simulated values of capacitance or reactance simply because of the fixed impedance of the cable used. Replacing the short or open-ended termination with a lumped reactance will, however, extend the range to any desired value. The terminal reactance produced by a stub with a lumped reactance at one end can be calculated or found by a Smith chart plot for various stub lengths. Reference should be made to an antenna or transmission line manual for the method. However, as a general indication of what effect lumped constant termination will have in order to experimentally determine the required reactance, Fig. 2 can be used as a guide.

Practical Application

Fig. 3 shows how the principle outlined for transfer of the center-loading reactance can be applied. By using the proper value of loading reactance, the overall antenna is resonated either as a ¼ or ¾λ vertical, and so its feed point impedance will match a 50-ohm transmission line directly. The coaxial line used to transfer the base reactance is placed inside the lower element of the antenna. The reactive components themselves can be placed in a shielded enclosure, if desired, but note that both sides of the

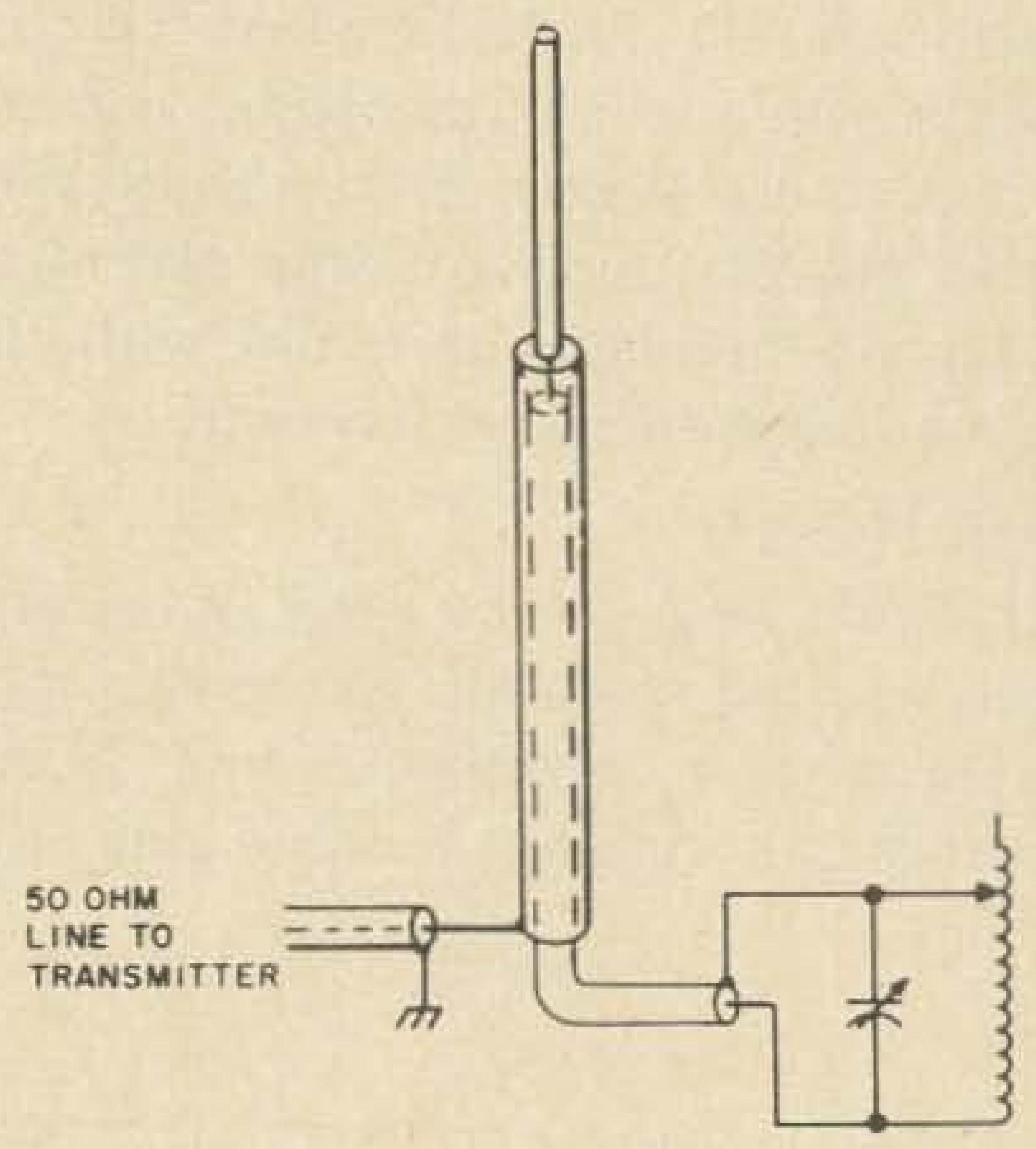


Fig. 3. Coaxial line placed inside lower antenna element to effect reactance transfer from base to junction of upper and lower antenna elements.

coaxial transfer line must remain insulated from ground. There will be some radiation from the coaxial transfer line although the portion enclosed in the lower antenna section will not cause any problem. The exposed portion can cause various problems, including pattern distortion of the vertical if it is made too long. Basically, the method of reactance transfer was meant to function with the physical reactance at the base of the antenna and not 100 feet away. Therefore, the dimensioning of the antenna sections and the length of the coaxial transfer line must all match to achieve proper operation of the antenna on various bands and positioning of the base reactive elements.

With some care, many combinations can be found that will work. One combination that was experimented with used a standard 10 foot TV mast as the antenna lower element and a smaller diameter 5 foot tube, insulated from the lower element, as the top element. inside the ten foot section. Since ½λ of this cable on 10 meters was 10.8 feet, it provided a very convenient length to the base of the antenna. Either a B & W stock 3905-1 coil (6 TPI, 2½" diameter) or a 500 pf variable capacitor was used to resonate the antenna, depending upon the band and the antenna's mode of operation.

On 10 meters, some slight inductance was used at the base to make the antenna operate in a ¾λ mode in order to match the transmission line to the transmitter. On 15 meters, capacitive reactance was used to make the antenna operate in a ¼λ mode. On 20 meters some very slight capacitive reactance was also required. On 40 and 80 meters, the transfer line length is quite short in terms of wavelength and additional inductive reactance at the base was used.

Tuning of such an antenna can initially be done using an SWR meter in the transmission line to the transmitter. One should try both the inductive and capacitive element at the base on each band, varying their value until the SWR is brought down as close to 1:1 as possible. Generally, the minimum amount of reactance that will achieve resonance should be used since additional reactance means additional losses. Some confusion will occur on the higher frequency bands because the length of the transfer line and antenna may allow various combinations of base reactances to resonate the system. The only solution in such a case is to use a field strength meter or, preferably, check signals with a distant station to determine which reactance value produces the best radiated signal. Once the proper reactance values are found, they can be bandswitched, if desired, although the tuning does become critical on some bands; a better solution might be to switch the inductor and capacitor (with various taps on the former) and use a simple tuning chart on each band to locate the correct settings.

With a vertical antenna, the transfer of the loading to the base does not affect the fact that either a radial system or good ground connection must be provided if the antenna is always operated in a ¼ or ¾λ mode for direct match to a 50 ohm transmission line.

Summary

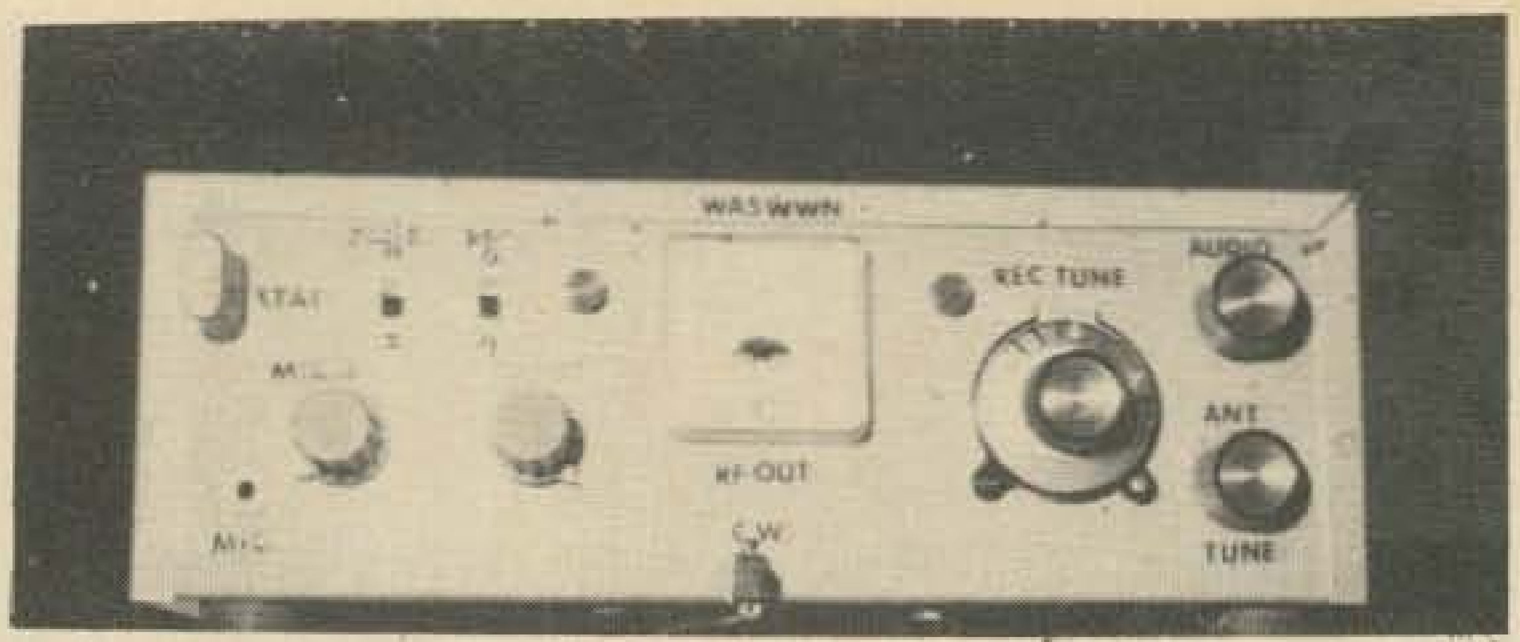
The method presented for transfer of the center loading in an antenna to a more convenient location presents various interesting antenna construction possibilities aside from the one described.

If a location is used where no adequate ground connection is possible, it would seem possible to use the reactance transfer idea to resonate the antenna in a ½λ mode. The base of the antenna would then be at a high impedance point and an antenna coupler would be necessary to couple to a coaxial transmission line. Another approach to make an antenna with less ground dependence would be to form a dipole antenna, center loading each element via a reactance transfer cable to the center of the dipole.

Removing the physical reactance a distance away from the base of the antenna presents the problem of line radiation which was mentioned. A possible solution to this problem may be the use of triaxial cable with the outer shield grounded and the inner shield and inner conductor used for the reactance transfer. How long the cable could be while still retaining good loading Q and without having the tuning become too critical are questions that only trial and error experimentation can answer.

. . . W2EEY/1 ■

Charles O'Grady WA5WWN
1212 Prelude Drive
Ft. Worth TX 76134

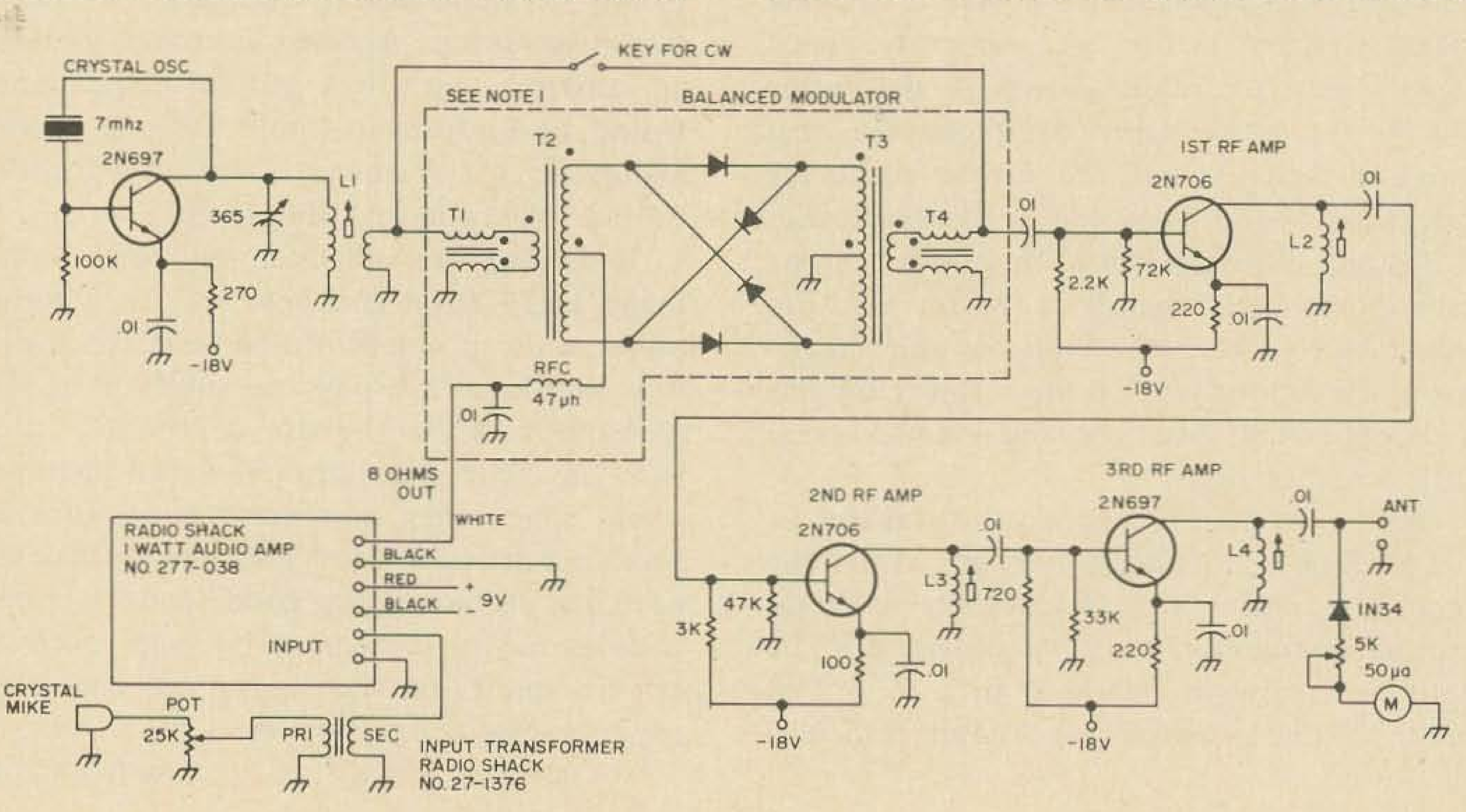


Quazar QRP 40 Meter DSB Transmitter

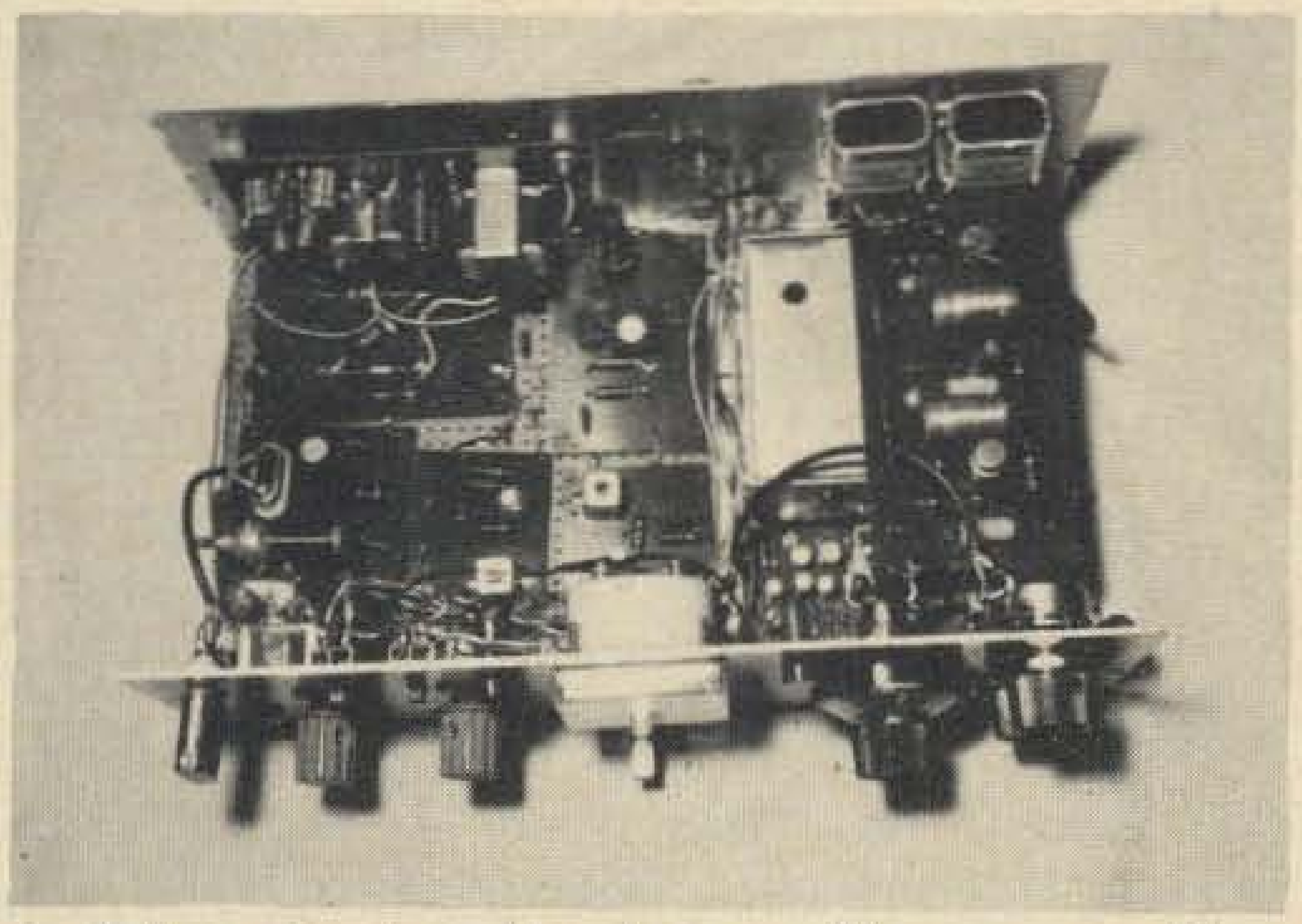
For several years now I have been trying to make a QRP sideband rig and finally achieved this with the aid of the March 1969 issue of 73 and the article written by WA1FRJ. I had gone through about five different balanced modulators over a period of the past two years and could not achieve any satisfaction until using his method with the toroids. Keeping 18 volts on the transmitter, no carrier is noted. A 20v and above carrier can be observed on the rf output meter that is incorporated in the transmitter output. The diodes in the modulator do not seem to be too critical, but keep the forward resistance of each diode as close as possible. I used the usual junk box diodes from a printed circuit board I bought for 29¢ and with no designation on them (same goes for the direct conversion receiver I built out of another article). Possibly the hot carrier diodes may work better but I have achieved good results with WA5NTN who is about a mile from me and has worked patiently in testing the transmitter for the past three months.

The rig works good on CW, too. I have made quite a few contacts and several contacts over 200 miles. With a little patience one could do quite a bit better I'm sure.

Construction notes: Parts layout does not seem to be too critical. Each section of the transmitter was built on a separate module and tested individually in line as it was constructed. I used 1/16 inch circuit boards and breadboarded the components on each board and made the connections on the under side. This allows positioning of each



module where it best fits in the desired cabinet. The coil winding data on the rf amplifiers was just a guess and it turned out that each coil could be peaked to maximum. The audio amplifier is a one watt unit and was purchased at Radio Shack. It seemed easier to buy than build the unit. And the output impedance matches the balanced modulator well.



When tuning the transmitter, a one time tuneup procedure is used. Have the antenna connected and tune up each stage in succession. No external tuning is provided.

. . . WA5WWN ■

Edward Lawrence WA5SWD/6
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Simple Compact Six Meter Bandpass Filter

(TVI eliminator, or how to keep your happy home happy)

Would you like a good filter that really works, low loss, doesn't need to be retuned if you QSY 50 khz? Well, this one can be built in less than an evening. Then you can hook it up and forget it. Total cost with all new parts is only $4.42.

When I started on six meters in 1963, I naturally had my share of TVI. So I built the low pass filter for six meters from the *Radio Amateur's Handbook*[1]. This did help but didn't eliminate all the complaints. Also it had about 2-3 db loss besides. So I really wasn't too happy with it but suffered the loss in order to stay on the air.

Then, about two years ago, I requested and received several Amperex Application Reports[2]. One of these was Report No. S-124, "Designing Varactor Triplers."

Sounds far out? I thought so too until I looked in the back and saw information for three bandpass filters with low insertion loss and good skirts. The filters are for 50 mhz, 150 mhz, and 450 mhz.

The 50 mhz filter had 0.4 db insertion loss at just under 50 mhz but the nose of the curve was very sharp and appeared to be about 1 mhz wide at 1 db down. So I constructed a filter based on this information, but with less spacing in order to slightly overcouple and broaden the nose of the curve while still keeping good sharp skirts. The result was a filter with a minimum loss of 0.3 db, less than 1 db loss from 50 to 52.5 mhz, and better than 40 db down 10 mhz away.

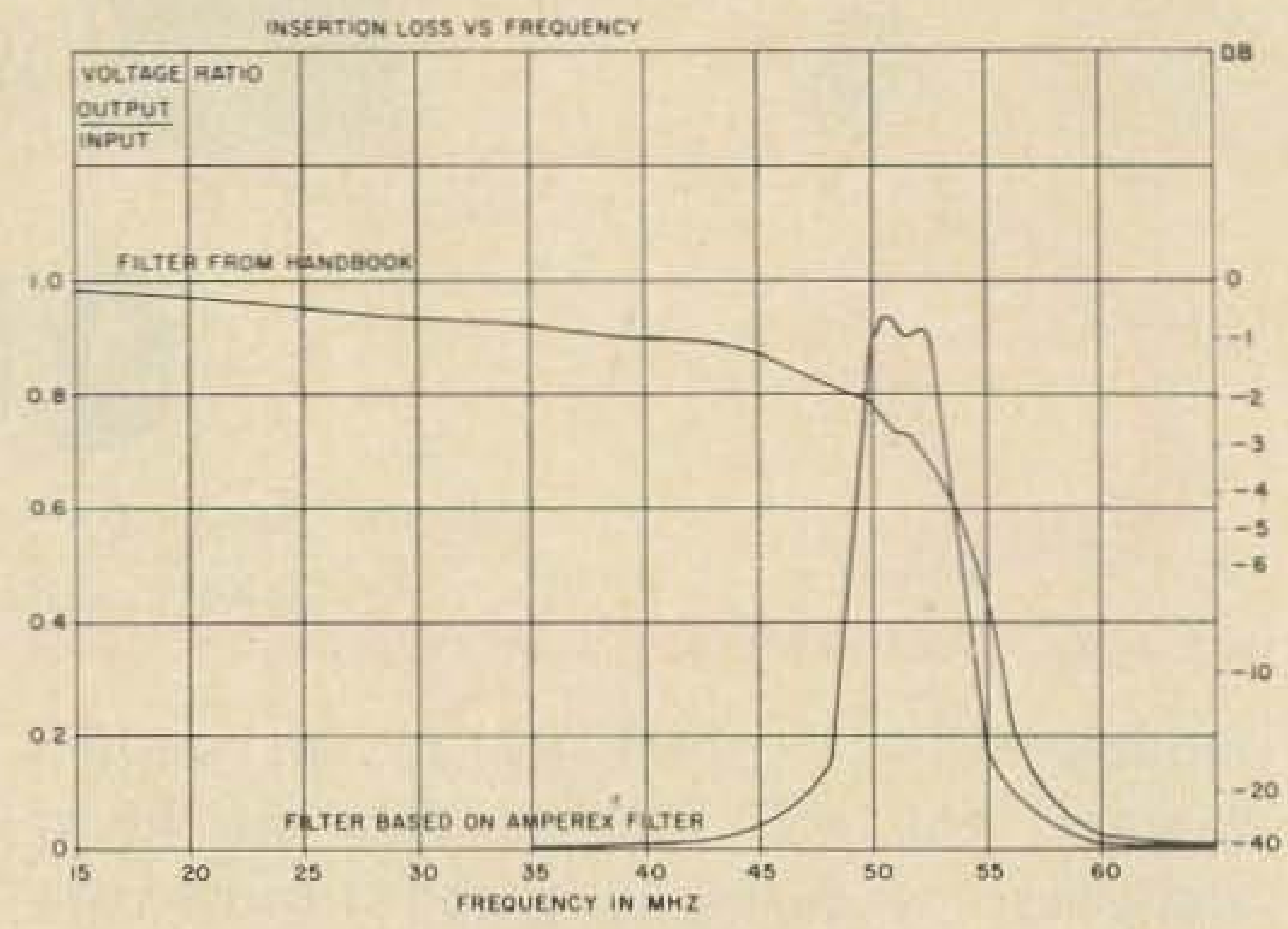


Fig. 1. Graph of filter response.

I plotted the response of both filters in **Fig. 1**, so you can compare the characteristics. Both filters were peaked for best response and lowest loss at 50.5 mhz. (Note: The low pass was constructed in a steel Minibox which might have added some loss at the higher frequencies.)

The filter is built in a Bud Minibox, CU3003A with all parts mounted on the "U" portion. This is 2½ x 2½ x 4 in. The coils are 7 turns no. 12, 5/8 I.D. One is wound lefthand, and the other righthand. The turns should be evenly spaced and be 1 5/6 in. from the top turn to the bottom turn. Solder directly to the coax connector at exactly one turn from the bottom. For powers up to 500 watts, use Johnson 148-4 capacitors. Above that, use something with a higher voltage rating. Mount the coax connectors at a 45 degree angle to the edges of the box and use a solder lug on the lower screw to ground the lower end of

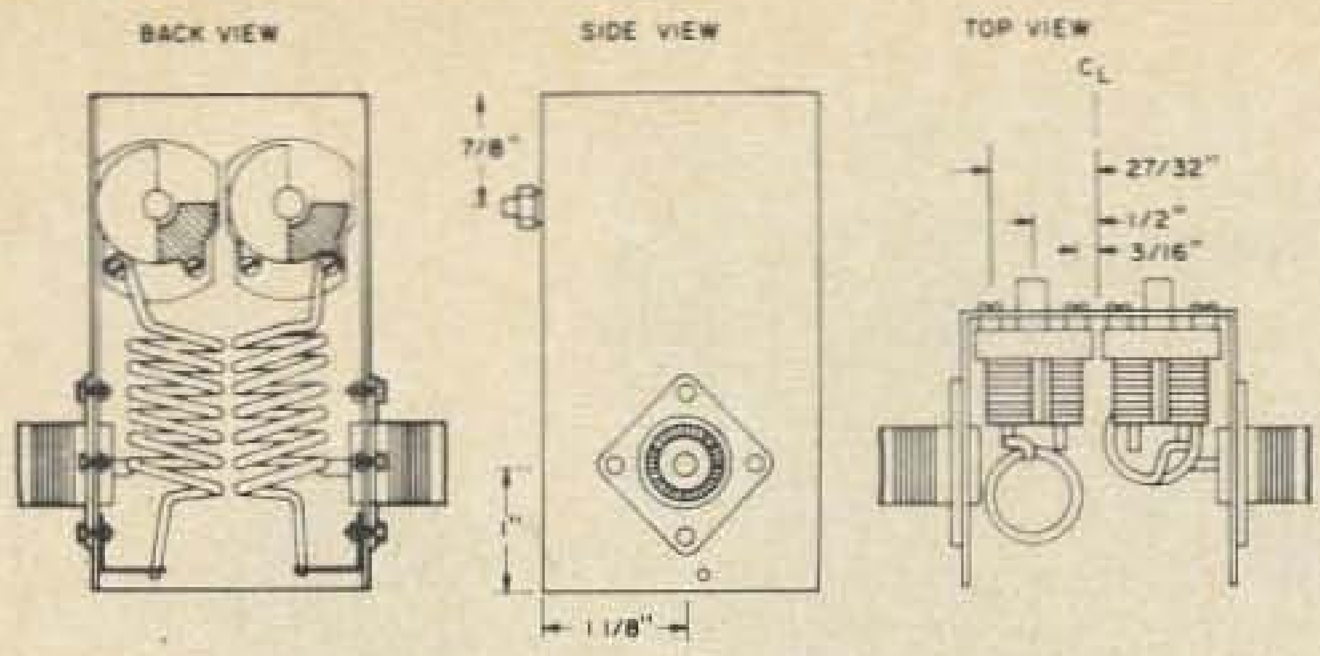


Fig. 2. Filter dimensions and construction.

the coil. When you are finished, the coils should be spaced 1 inch apart. Position as shown in Fig. 2.

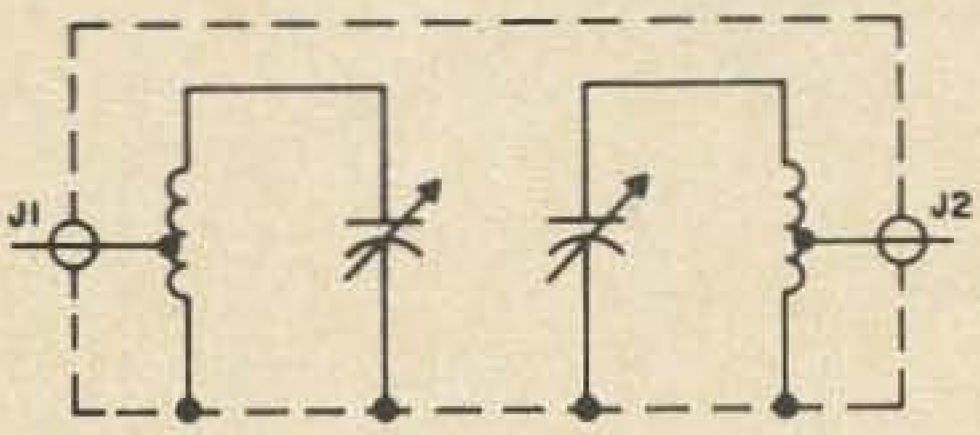


Fig. 3. Schematic.

To tune the filter, insert it in the transmission line, set your receiver to 50.5 mhz, and tune for maximum noise or signal. Then transmit and notice the reduction in TVI. I think you will be quite pleased. Look for me the next time 6 is open, because otherwise I can't get out of this valley. Out here, the dial impulses from the telephone tear up the TV more than my 45 watt homebrew with the filter installed.

. . . WA5SWD/6 ∎

Notes

1. *Radio Amateur's Handbook*, page 567, 1965 Edition.
2. Amperex Electronic Corporation, Providence Pike, Slatersville, RI 02876

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.

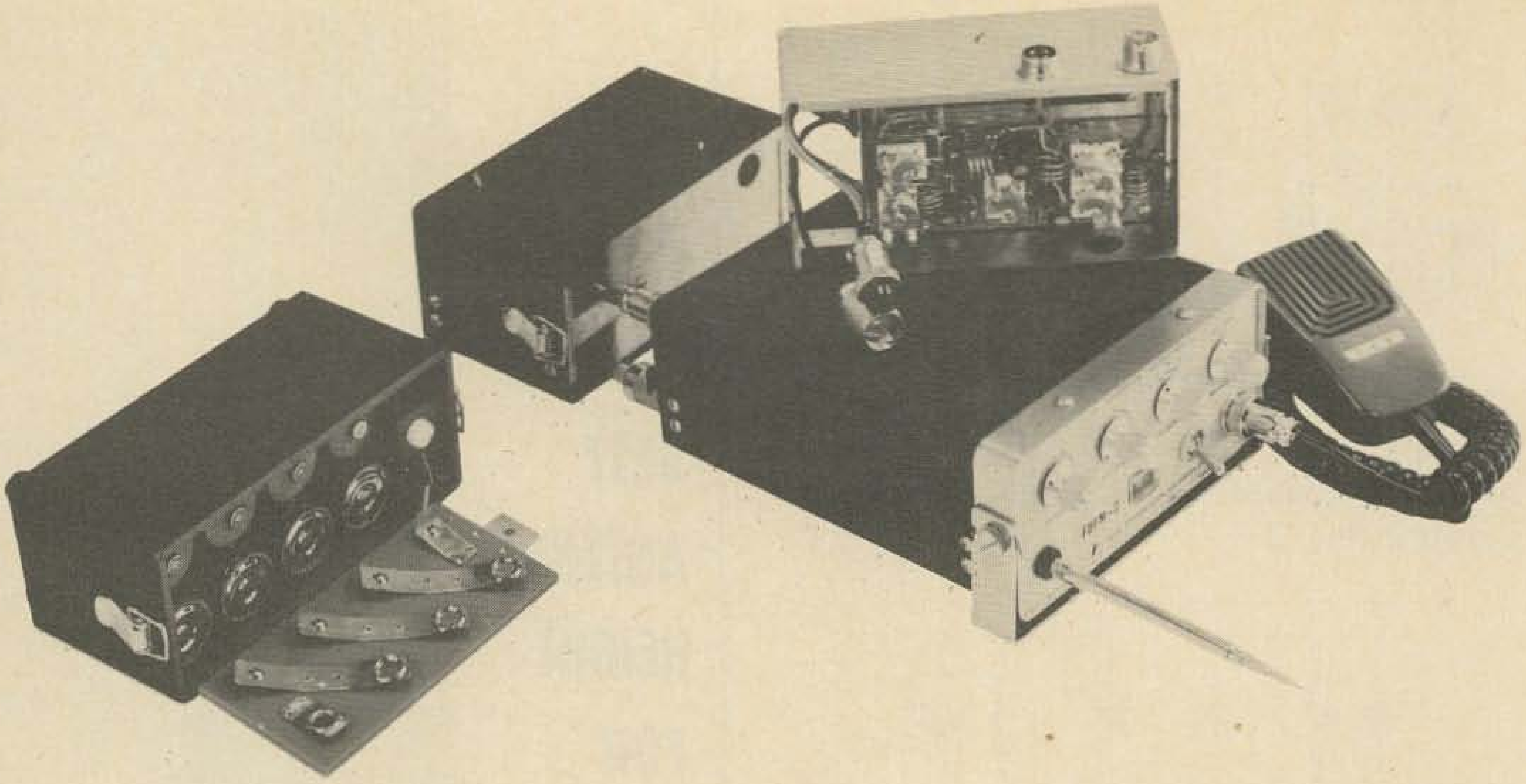


Fig. 1. Varitronics FDFM-2 uses modular approach. Snap-on elements change basic low-power transceiver from mobile to portable, to high-power base station.

Low Cost Electronics: Japan's FM Invasion

Two years ago the door to FM operation on the VHF bands was narrow indeed. The only way an amateur could get started was by converting FM units that were designed for two-way use in the neighboring commercial spectrum. As a result, most amateur FM operators were either endowed with special technological skills or were close friends of individuals who were thus endowed. A survey of operators conducted by FM Magazine in late 1967 showed that 72% of all active FM'ers were associated in some way with the commercial radio service—as technicians, First- or Second-Class Commercial licensees, or as two-way users.

Today, a similar survey would likely show a reversal of that trend. Thanks to enterprising American businessmen and clever Japanese engineers, VHF amateur FM has become one of the least expensive and easiest-to-open doors to ham radio.

The Inoue line of amateur FM units, distributed in the U.S. by Phoenix-based Varitronics, Inc., serves as an example of applied Japanese knowhow. Designed modularly so they can be used in every conceivable application for a variety of individual interests, the units are high power or low; portable, mobile, or fixed; crystal controlled but multiple channel.

The basic unit, shown with three snap-on modules in **Fig. 1**, is an underdash-mounting, six-channel, low-power mobile unit that is ready to go when a 12V source and an antenna are connected. In this service, the transmitter puts a little over a watt into the antenna. And if a watt is insufficient, the module shown behind the transceiver will up the output to better than 20W. The modular class C amplifier mounts flush with the rear of the basic unit and is held on by a suitcase-type snap on each side. (The transistorized amplifier is shown disassembled atop the transceiver.)

Fig. 2. Base station module, built in case of same configuration as transceiver, permits high/low power switching and operation from 115V power source.

The narrowband 12-channel Standard FM transceiver comes equipped with simplex crystals for 146.94 MHz. Designed for portable or mobile operation, unit packs a 5W punch and draws only 100 mA in standby mode. Frequency error rated at 0.0005%, with a receiver sensitivity of 0.3 μV. (Standard Communications Corp., Torrance, California.)

A battery module (lower left in photo) converts the unit to a hand-held transceiver. The battery pack uses eight D-size flashlight cells in series and provides enough sock to keep the radio going for about 15 hours of typical intermittent duty. In portable use, the transceiver stands up on end so that the telescopic whip (protruding from the face of the pictured unit) can be extended vertically. The whip antenna is a screw-on type and is removed for mobile or fixed-station use.

So that the Varitronics FDFM transceiver will be capable of gobbling up every possible morsel of business in the many-faceted FM market, the company is distributing a power supply/amplifier module designed around the same case as the basic transceiver. This unit, shown in **Fig.** 2, contains a converter that supplies 12V dc from an ac source of 115V, as well as a modified version of the class C amplifier. A panel switch permits optional use of the amplifier.

The prevalence of repeaters on 2 meters has opened a whole new vista in useful products for communications. Consider, for example, the limited usefulness of a low-power VHF hand-held transceiver. For point-to-point operation, the range and utility would be restricted to near impracticality except at hamfests, transmitter hunts, and other close-in gatherings. But one of the key features of a repeater is its ability to extend the coverage of even the lowest-powered transmitters and the least-sensitive receivers. Now a number of firms are cashing in on this feature by importing a variety of miniaturized communications devices.

The "Handicom" is one such unit. Designed specifically for use with repeaters, the tiny two-channel transceiver (**Fig. 3**) boasts a receiver sensitivity of 0.4 μV for 20 dB of noise quieting and a transmitter output

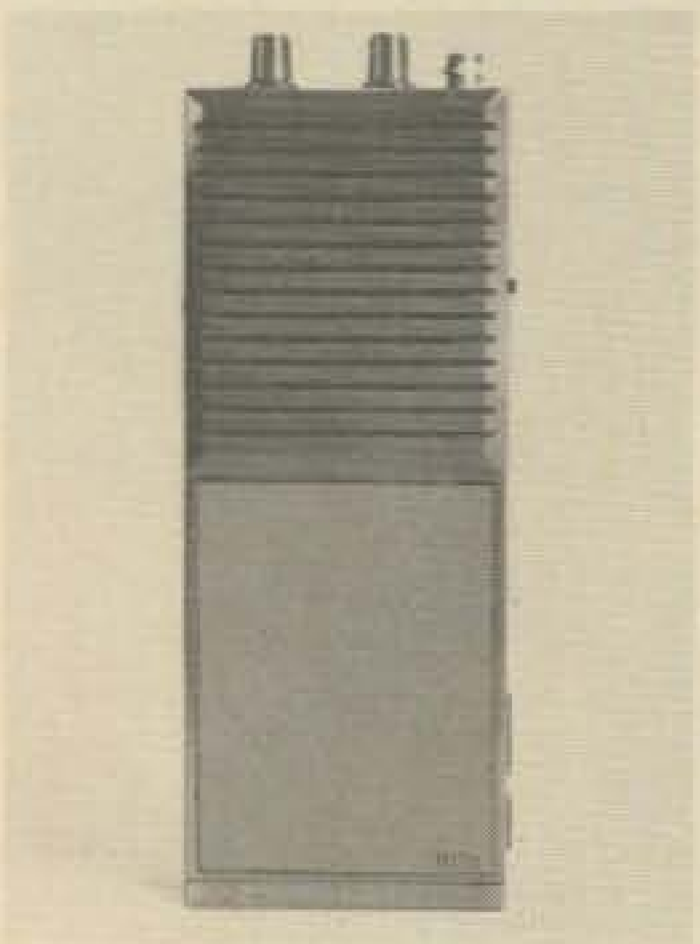


Fig. 3. Handicom transceiver is self-contained 1.6W hand-held unit with sensitive superhet FM receiver, designed especially for operation with repeaters. Comes with two-channel capability so point-to-point operation can be assured when repeater is not in range.

Fig. 4. Allied VHF monitor receiver is one of the first to include the FM portion of the 2-meter spectrum as part of its regular tuning range.

power of 1.6W. The Handicom, distributed by Telco (Pomona, California), comes equipped with rechargeable batteries, charger, integral meter, removable whip, and all the other accessories typically furnished with Japanese-made radios.

Even some of the giants are finding amateur FM a lucrative market. Allied Radio is pushing a low-cost monitor receiver that tunes from the commercial band all the way down to the bottom of the amateur FM spectrum (146.0 MHz). The Allied unit, **Fig.4**, has a self-contained 2-1/2 in. speaker, a swivel telescoping whip, plus provisions for an external antenna and a 115V ac adapter.

. . . K6MVH

Easy Tuning of the Beam

Any time a beam antenna is erected, we run into the problems of how to get to the elements and matching device to tune the beam. **Fig. 1.** shows a method for tilting the boom so the elements are readily available to a man on the tower. Rotation of the boom might be necessary and this is accomplished by loosening the clamps.

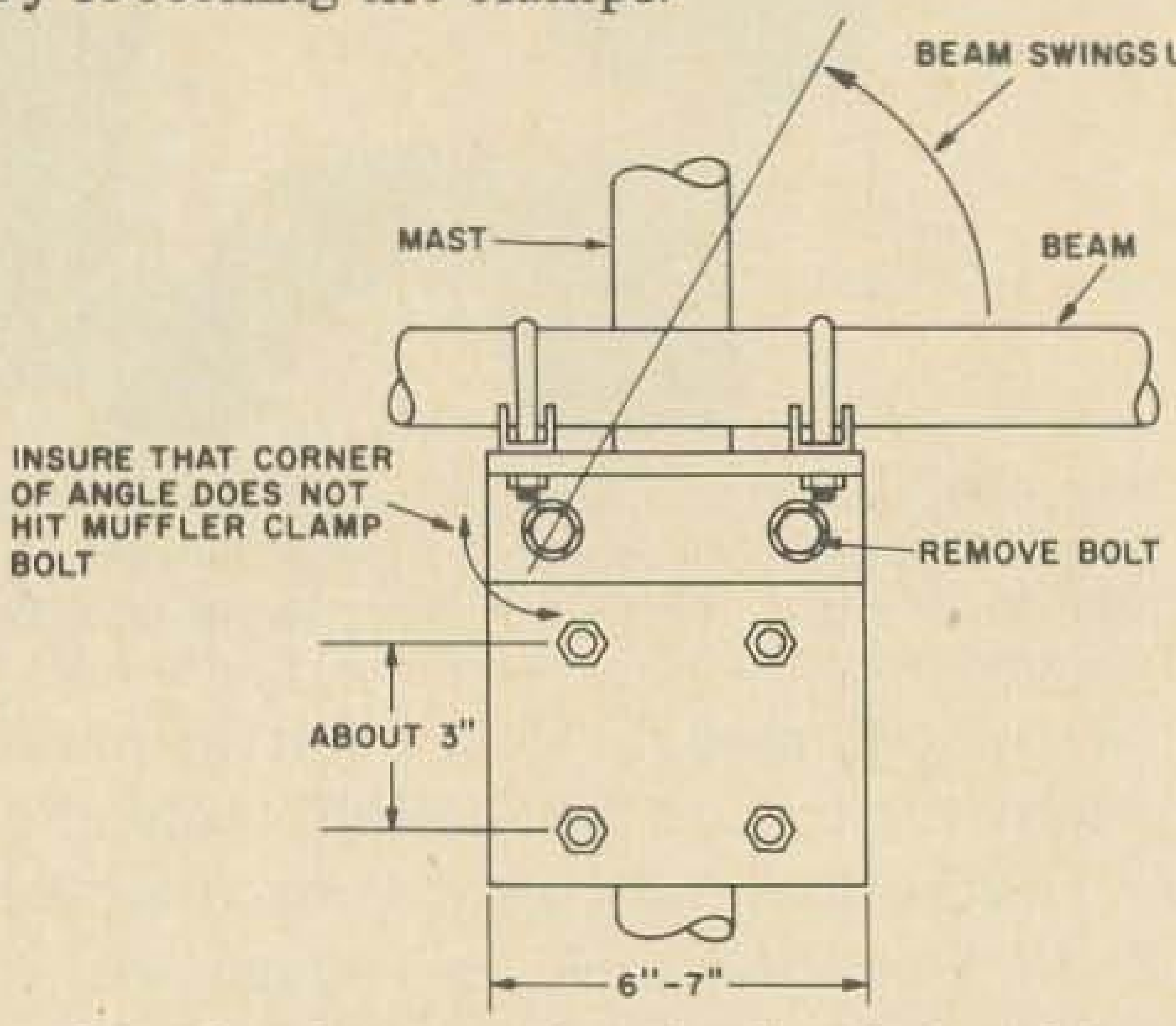
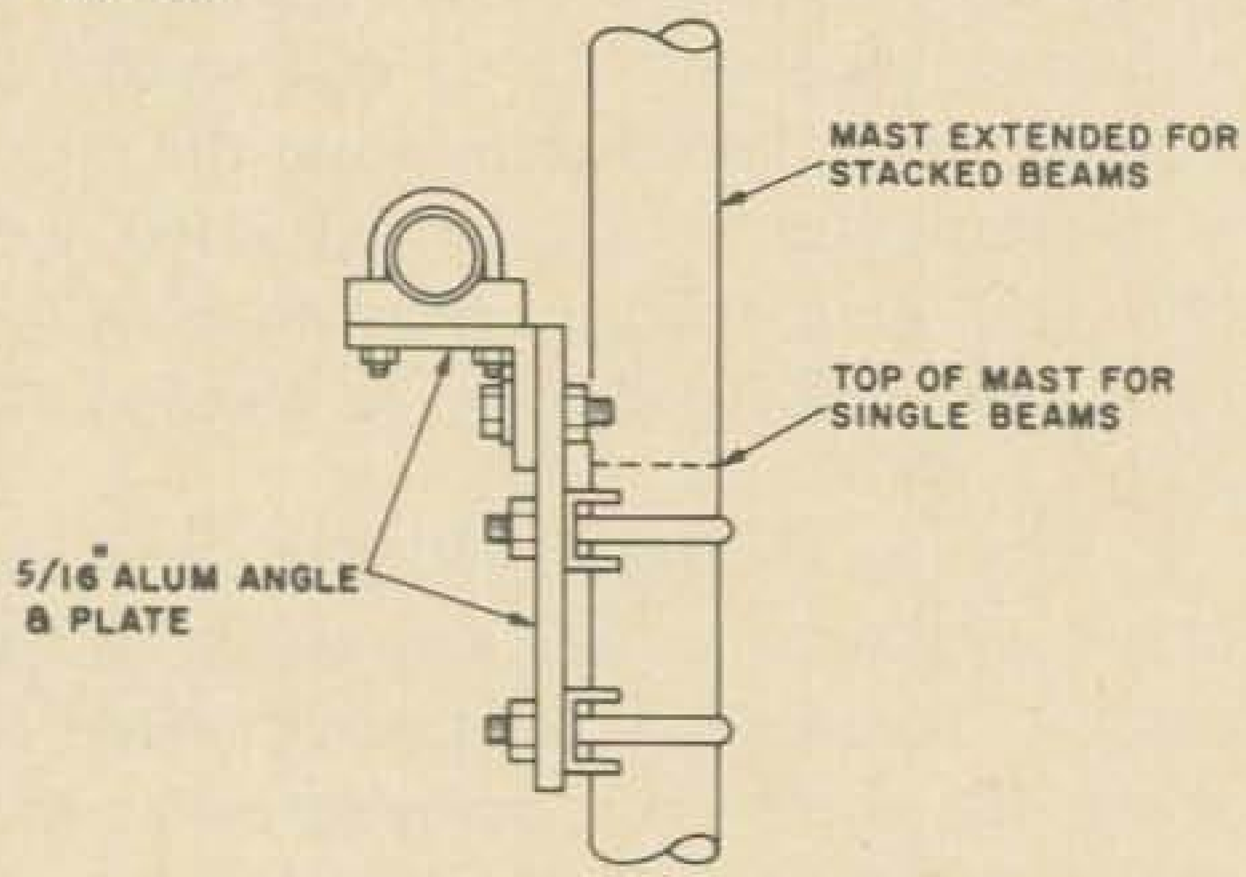


Fig. 1. Construction details of the tilting device.



With one man stationed on the tower, a rope tied to the boom, and the bolt removed, he can bring the elements and matching device within easy reach. Since the beam is off center, it will right itself by letting up on the rope.

...P.L. Simandl, K9SQV

Dial Drive Repair

"The Heathkit SB series of ham kits are, in general, a fine piece of electronic equipment." This is the kind of statement you can hear on almost any ham band where you might listen. There is, however, one bad comment one does hear once in a while: "That darn dial drive." (It must be pointed out that the dial drive is a real joy to most: however, to some...) I became one of the few after building two kits (an SB-300 & SB-400) with no problems. As is normal with such endeavors, it was a kit I was building for a friend that "went amuck." The problem was that no matter how hard I tried to align the thing, the drive would operate for a short time, and then, for no reason, just quit.

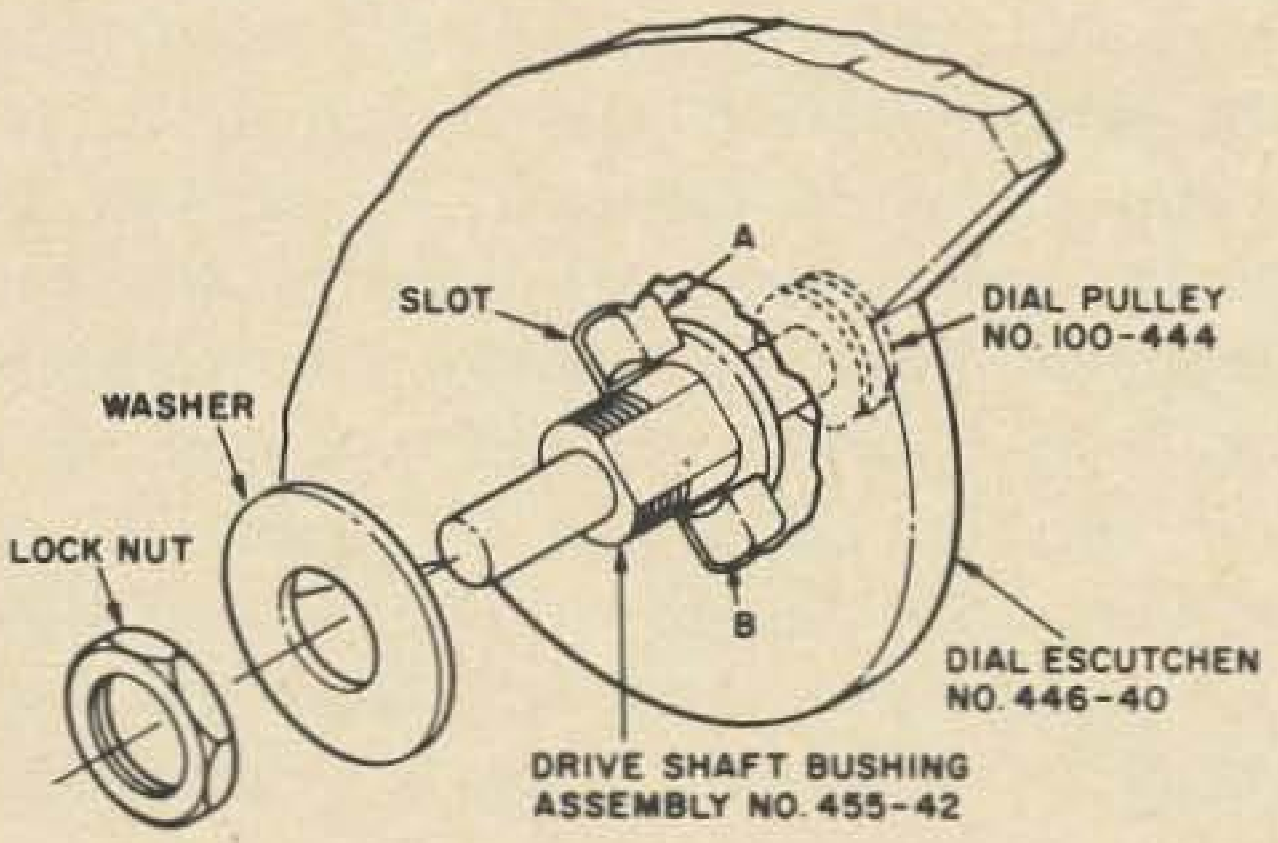


Fig. 1. Cut away drawing showing added "shims" (A&B).

It seems the problem is in the fundamental design. Once the "Dial pulley" (Heath part 100-444) is pressed down and locked in place with a lock nut, sometimes the unit just "walks" up on the slot in the escutchen and slips. (The plastic material used to make the escutchen prevent the builder from making it too snug.)

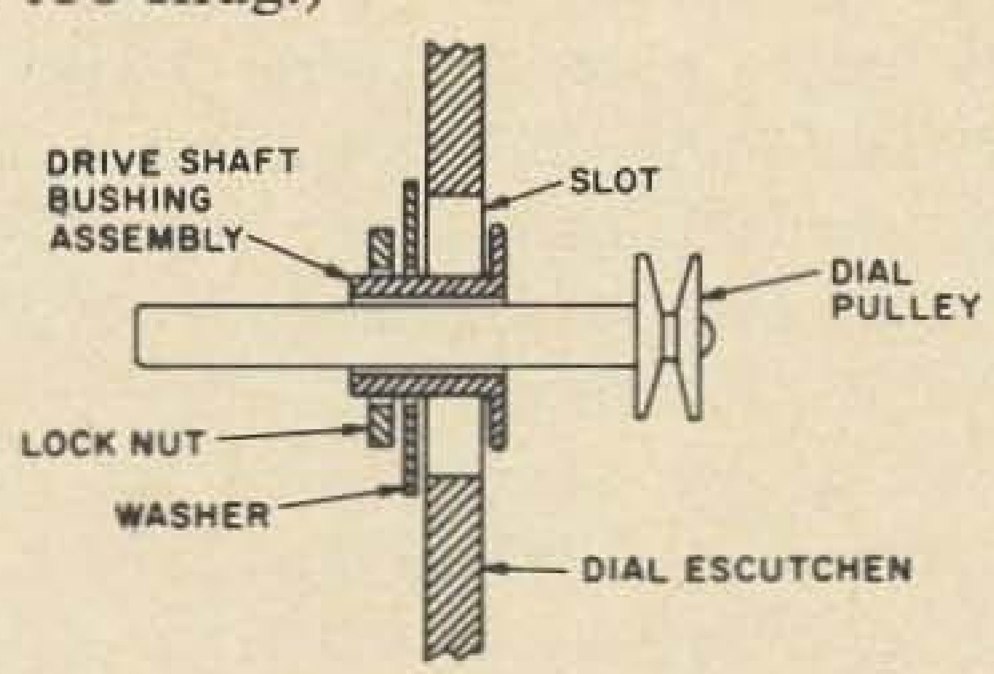


Fig. 2. Profile (No shims).

To eliminate the problem, I simply made two wood shims (one above and one below the "dial shaft bushing assembly") as shown in Fig. 1. This simple addition removes all the stress from the plastic escutchen and allows the dial to operate 100% of the time with the lock nut only "finger tight."

Phil Writer, W6TRU

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Mobile CW

After operating CW mobile in one of the heaviest auto populated sections in the U.S.–the Los Angeles freeways–for over a year and receiving comments from, "how brave you are" to "what an idiot," unspoken but unmistakable, I decided to write about some of the tricks that make mobile CW a real ball.

First, mobile CW is hopeless unless you are a true CW man. You must be motivated to communicate by that wonderful pure code and give up the "by gollies" and "fine business, here" jazz of SSB. Mobile will never convert you to a CW man, but a CW man can be converted to mobile.

Second, you must be prepared to accept the frustration of having your report or the DX call blanked out by the ignition QRN from that miserable little VW who is staying right behind you staring at that big whip. Murphy's law reigns paramount here. When you have been waiting for 30 miles to hook that JT1 just invariably when he calls you, on comes the ignition or power line QRN. You will begin to notice that all the major roads and freeways follow the path of the highest QRN. I am sure they put in the power poles first and built the roads next to them. Also, you will find yourself looking for different ways to drive to work to avoid what I call "QRN Alley" or else you time your QSO so you send in the high QRN areas and receive in the low–tricky, but possible.

The basic solution is simple. Acquire the patience of Job and train your ears (what the headshrinkers call "the cocktail party syndrome" where you can pick out one voice and copy it solid over other masking voices) to copy through S5-S7 QRN and develop the tricky use of audio filters, rf, and audio controls. The code can sound mighty strange by the time it gets through all those windows, but it can be copied solid. As a bonus, your home receiver will sound so very nice and quiet to you that you keep checking to see the antenna is connected–sort of like after you lift heavy weights for a long time then light weights seem very light. All this is for free.

Third, you must be prepared for strange looks, staring kids, and slow shaking of heads as people pass you on the freeway. Especially when your car is a white Cadillac, the whip sticking way up high as it is mounted on the center of the car just back of the rear window forward of the trunk deck, earphones on, and then have a beard–like me. I have a speaker mounted by my left ear, but as I like to chase DX even mobile, I use phones–in fact, I 'most always use phones as a hangover from the "every signal is weak" old days. If you are shy–forget it.

This article describes what could best be called a "human factors approach." It is not a construction article, as many excellent ones have already been written, but it shows one way to integrate the amateur, the driver, the car, the freeway, and the rig all into one smoothly operating loop to dramatically lessen the hazard of operating CW while driving.

My basic "human factors" design requirement for CW mobile operation was the rig and all controls had to be operated without the driver ever taking his eyes off the road. To do this, all controls must be close enough to the driver and capable of operation without reaching *or* looking to reach.

As each mobile installation is different, the first step is to make what the aerospace industry calls a "mock-up," or a simulation of the rig, controls, and mounting in the car. This can be done by supporting the rig, controls, SWR unit, etc., with wood blocks, rope, books, beer cans, etc., and using stiff cardboard and tape to simulate the structure of mounting of the final installed operating position of the rig, the key or paddle, and

SWR unit in the front seat of the car.

Then, the second step is to shut the doors, move the seat to the driving position, start the car and operate all the car controls like the lights windshield wipers, steering wheel adjustment, air conditioner controls and outlets, ashtray, glove compartment—don't miss a one. Obviously, in all cases they should not be completely obstructed by the rig or supporting mounts. In specific cases, a compromise can be made. In my installation the governing factor was the dashboard ashtray. I compromised on using half of it. I pull it out until it hits the rig and that gives enough clearance to use the lighter and half of the ashtray. I don't smoke while driving, but girls do!

The third step is to simulate a complete QSO operating all the rig controls and key with your eyes doing just the normal (?) scan of odometer, fuel and temperature gauges, rear mirror, side mirror, and the blonde in the next car. In no case look at the rig—except for the first quick glance to see if you are in the band. To do this with a flick of the eye, mark on the dial in black with tape or paint a ½ inch bar at each band edge so as long as you are centered between the black bars you are safe. Now, make the final adjustments to the "mock-up" so the basic design objective is met; i.e., operation of *all* controls without looking or stretching to reach them.

Great—if you feel silly after this little experience, then you did it just right, but you would be amazed at how much time and money is spent and how seriously such simulation is done in the aerospace industry.

My installation, which resulted from the "mock-up," was a little wooden desk made from soft pine. The desk bottom is contoured to fit over the floor hump and is secured to the car floor with angle brackets. The art of drilling through the car floor into a clear space for nuts and washers underneath is sheer black magic. However, some judicious measuring from the car edges or other reference point helps not drilling through the muffler or a brake line.

The desk is made so the Swan 500 sets into a recess on top placing the front panel on a slanted plane easily reachable and seeable from the normal driver's position. The rig is held down in the recess with one bolt and a wing nut.

The desk has a small "L" shaped flat top going in front and along the left side of the rig. The front portion holds a paper pad and the left hand side of the "L" has the vertical plane of the right edge of the steering wheel. Thus the driver's hand just slips off the wheel onto the desk and the fingers drop on the key and paddle with an arm rest. The hand key and the keyer paddle are mounted in the same position on the desk. The keyer paddle is mounted vertically at an angle above the hand key so the paddle finger plates are forward and above the hand key knob—just far enough away so the fingers can handle the hand key without hitting the paddle plates. In this manner when your hand falls off the wheel, your fingers are on both the paddle and the band—so without looking you can move your fingers to work whatever key you want. Both keys are installed so if the keyer flunks the course, you still are on the air with a hand key to get in practice for the Extra Class exam. The SWR unit is mounted on the top and back of the Swan 500 where it is visible by glancing over the top of the rig toward the car floor.

All other controls, like the keyer speed control, speaker switch, etc., should be on the left side of the steering wheel to balance up the human factors programming of the rig operation on the right side. An added refinement is to duct some cool air from the air conditioning ducts into the final tube compartment of the rig. After an hour's operating even the dial on the Swan 500 would be hot to touch. After building a plenum chamber on the outside of the enclosure right next to the final amplifier tubes and installing a duct from the air conditioning system, the whole rig is cool. This lets the power output stay up and must prolong component life. Even the use of ambient air from the blower alone has significant effect. So far, no one has commented on the fact I disconnected the entire car's right hand air conditioning for this worthy purpose! It is an interesting and uncomfortable example of thermodynamics to feel how much heat can be transmitted into the front seat area from a little black box burning up those watts not going into the antenna.

If you have been faithful to the design objectives, you now have a "human factors" designed mobile installation. You should be able to turn on the rig, tune and establish control without looking or reaching so your head bobs down. In the real world you will find many clear opportunities to look while stopped in freeway jams, but you will be amazed at how quickly you can scan everything you need to see.

One word of warning while driving: By all means avoid the trap of looking at the rig and trying to troubleshoot if it doesn't work. The feeling is almost irresistible to try to get it working again—right now. Don't do it! Shut off the rig and listen to AM/FM until you get home or else get off the freeway and stop. It cost me $450 over the deductible insurance one rainy night on the freeway trying to get the rig working. It started working just as I slid off the side and down the embankment—a sadder, but wiser CW mobile type. Human factor engineering helps, but it can't think for you.

. . . K6RA■

Getting Your Extra Class License

STAFF

Part XII: Semiconductors

Just a little more than two decades ago, a trio of Bell Telephone Labs researchers put together a device which had all the external characteristics of a resistor—with one thing added: it would transfer a signal from one circuit to another, and if the circuit was properly put together it would amplify the signal in the process.

The learned gentlemen coined a name for their device by combining the words "transfer" and "resistor" into "transistor." Today, it's hard to realize that the transistor was unknown 25 years ago, and even 15 years back was pretty much a laboratory curiosity. Now, of course, it's just about the usual thing to find transistors in almost any receiver, and not too unusual to find them in low-power-level stages of a transmitter as well.

Semiconductors—of which the transistor is only the most widely used example—are such an important part of the art of electronics today that the Extra Class examination includes a number of questions dealing with them. Those questions are our subject this month.

The official FCC study list of questions includes five specific questions dealing with semiconductors in its total of 90 questions covering the entire knowledge required for would-be holders of the Extra Class ticket. These questions are: 15. Define the alpha cutoff frequency of a transistor. How is this parameter of use in circuit design?

38. How are the emitter, base and collector of a transistor biased for amplifier operation? How are they biased for cutoff (open circuit) and saturation (short circuit)?

39. How do NPN type transistors differ from the PNP type? How does their bias differ?

52. What is the phase relation between the input and output signals in the common-emitter, common-base, and common-collector transistor circuits?

84. Compare silicon and vacuum tube diodes. What is meant by the "forward voltage drop" of a conducting silicon diode?

Question numbers, as always, are those assigned in the Commission's study list.

We'll follow our usual procedure. Rather than answering these five extremely specific questions, with equally specific replies, we'll reword the questions into less specific queries which cover the same material but much more as well. Then we'll hunt for answers to our more general questions, and along the way come up with the answers to not only the specific study list questions, but most of the similar ones which may appear on the actual exam.

All our questions deal with semiconductors, so let's make our first general question simply "Why Is A Semiconductor?" The answer to this will provide answers to both questions 39 and 84, as well as a foundation for our subsequent questions.

From there, let's find out "How Do Transistors Amplify?" This will provide partial answers to questions 38 and 52, as well as to the second part of question 39.

When we know how transistors amplify, then we can ask "What Factors Affect a Transistor's Amplification?" and that will bring us into the answer for question 15. To wind up our examination of transistors, we'll ask "Is Amplification All?" and that will get us an introduction to the world of semiconductor switches. This subject in itself could fill several large volumes, but affects only a part of question 38 on the study list.

For our final question, we'll drop transistors and ask "How About The Rest Of The Family?" Here, we'll take very brief looks at some other members of the semiconductor clan and compare them with their more historic equivalents.

As always in this study course, we run the risk of oversimplifying complex subjects when we attempt to compress an entire field of study into one or two articles. This time, the risk is higher than usual—because semiconductors came to us from physicists rather than from more mundane experimenters, and the whole basic theory is deeply intertwined with the physics of subatomic particles.

Fortunately, nobody needs to be an atomic physicist to get a fairly clear understanding of how semiconductors work. This was made abundantly clear more than 10 years ago with the publication of Department of the Army Technical Manual TM 11-690, "Basic Theory and Application of Transistors." In that 253-page volume, only one chapter required any knowledge of mathematics—and that chapter could be skipped without any harm at all, because its purpose was to provide the algebraic proof that the "equivalent circuits" used by transistor-circuit design engineers actually do represent transistors accurately. And the math required to get through that single, optional chapter was hardly any more complicated than that necessary to apply Ohm's Law!

We have leaned heavily upon the approach and examples used in TM 11-690 in preparing the first 4/5 of this installment, because the basic theory has not changed and 11-690 does provide an accurate picture of it without introducing errors because of oversimplifying. The final discussion, though, involving "the rest of the family", is based upon a number of other sources, because the kinds of semiconductors known have increased hugely in the decade since 1959.

Why Is A Semiconductor?

To have any understanding of how a transistor operates, we must have a fairly clear idea of what a semiconductor is and why it can operate. But to get that idea clear, we must first turn our sights to something even more basic—the theory of the structure of matter.

We already know quite a bit about this theory, although we may not know it by name. It's the theory which tells us that electrons exist!

Let's start out assuming that we know nothing about it, though, and begin at the very beginning by defining "matter" as "any substance that has weight and occupies space." This includes all gases, liquids, and solids.

Chemists tell us that all matter is composed of either "elements" or "compounds," with most of it being "compounds." An element is a substance that can neither be broken up into other substances by chemical action, or made from other substances. A compound is any substance which is not an element. Such things as copper, aluminum, oxygen, and hydrogen are elements. Water, rust, and salt are compounds. Water is a compound of two parts hydrogen and one part oxygen, but its chemical properties are very different from those of either of its elements. Salt is made of equal proportions of the metallic element sodium and the gaseous element chlorine, both of which are highly poisonous in their pure form—but salt is essential to life.

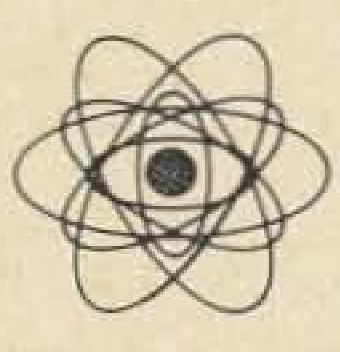
Whether a substance is an element or a compound, it is made up of many "molecules." The molecule is the smallest particle of any substance which can exist by itself and still retain its chemical properties. The molecule is composed of atoms, which are the smallest particles of *elements* that can take part in chemical actions. A molecule of water contains two atoms of hydrogen and one atom of oxygen. A molecule of gaseous hydrogen contains two atoms of hydrogen. A molecule of salt contains one atom of sodium and one of chlorine.

Since there are at least 102 elements, 92 of which occur in nature and the rest of which are man-made in nuclear experiments, there are at least 102 different kinds of atoms. At one time it was thought that the atom was the smallest particle of matter—but the advent of our electronics art brought that belief to an end. To explain the action of electricity and vacuum tubes, the physicists had to move on into the world of subatomic particles.

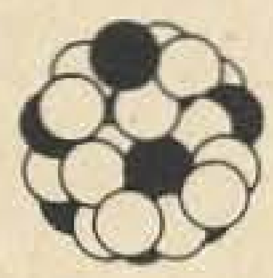
By now, they have moved still another step smaller into "subnuclear" particles as well, but we don't need to carry things that far. Our purposes will be adequately served when we meet the three major subatomic particles: the electron, the proton, and the neutron.

Nobody has actually seen any of these, so what follows is only theoretical. The theory, however, has withstood the test of time since 1889, and has fit all observations, so we assume that it is an adequate picture of the atomic structure.

If we could enlarge an atom some 100 million times, it would appear to be about the size of a penny. We could then distinguish its two major parts (**Fig. 1**), which are a central nucleus and a cloud of electrons orbiting around the nucleus much as the planets of our solar system orbit the sun.



ATOM MAGNIFIED 100 MILLION TIMES



ATOMIC NUCLEUS X 1 BILLION

Fig. 1. Atom is smallest unit of any element. Views shown here are those described by current atomic theory; nobody has ever seen either so they may not be correct. Top view shows major parts of atom—central nucleus and orbiting clouds of electrons surrounding it. Electrons orbit in "shells" which represent definite energy stages. Nucleus is composed of neutrons and protons as shown in lower view.

At a billion time enlargement, we could see that the nucleus resembles a bunch of grapes, and contains two different kinds of particles. This part of the atom provides nearly all its mass. Both kinds of particles in the nucleus weigh the same—1850 times as much as the electron. One of the particles is charged while the other is neutral; they take their names (proton and neutron) from this fact. The proton has a positive electrical charge.

The positive charge of each proton is balanced by an equal negative charge on the electron. It's still an open question just what an electron is; some feel that it's merely a unit of electrical charge while others feel that it's more than that. For our purposes either idea is all right, so long as we remember that the atom is balanced electrically.

The electrons are held in their orbits by a balance of opposing forces, including electrical attraction and repulsion. The orbiting electrons shield the nucleus so that it cannot take part in ordinary chemical reactions, but the number and kinds of particles in the nucleus determine the mass of the atom and how many electrons it has, and so are the factors which make one element different from any other element.

In some respects, the cloud of electrons in any one atom is something like an onion. If you keep peeling an onion, you'll never get below the skin—and when you finish you'll find you have nothing left.

Similarly, the orbits of the electrons in each atom are arranged in layers sometimes called "shells." Each shell represents a balance of forces at a specific distance from the nucleus, and each shell can hold only a specific number of electrons. The first (innermost) shell can hold only two electrons. The second shell can hold only eight. The third is limited to 18 electrons, and so forth. If an atom has only one or two electrons, it will have only one shell. If it has 3 to 10 electrons, it will have two shells. With 11 to 28 electrons, three shells are necessary. The outermost shell need not be filled.

Because of repulsion between like charges (and all electrons are negatively charged), the outermost shell (Fig. 2) is the only one able to participate in chemical reactions. Chemists call it the "valence shell," and know its electrons as the "valence electrons," for this reason. The number of valence electrons in any atom determines how that atom will combine with other atoms to form molecules. For instance, hydrogen has only one electron, but the first shell can hold two electrons. Because of this, hydrogen atoms combine to form hydrogen molecules of two atoms each, with each of the atoms in each molecule sharing its electron with the other. Both positions in the shell are now filled, and additional chemical combination is difficult.

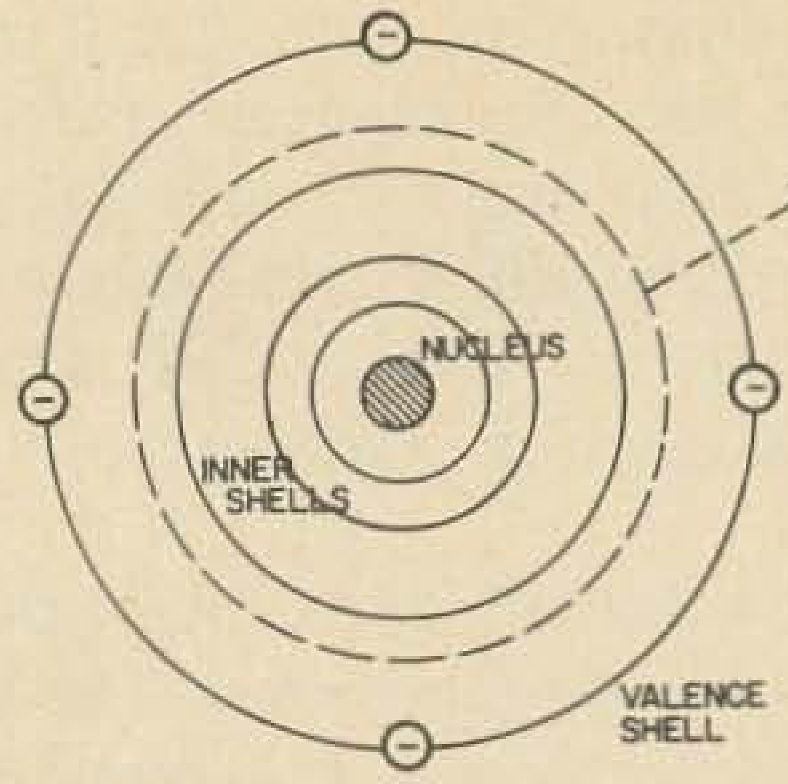


Fig. 2. General structure of atom as it applies to semiconductors is mapped here. Nucleus, in center, is surrounded by electron shells. Outermost shell, termed "valence shell," is only one involved in crystal structure or chemical actions. Nucleus and all inner shells, combined, are called "core" of atom. In crystals, atom cores are fixed into position but valence electrons are free to move to limited degree.

The various kinds of matter may be divided into groups in many ways. We have already seen the physicists' grouping into gas, liquid, and solid. Chemists group things as elements or compounds; they also group by "organic" and "inorganic" structure, in which organic structure includes all compounds containing the element carbon, and inorganic structure is everything else. We will be concerned only with matter of inorganic structure from here on; this eliminates anything which was once part of a living organism.

Another grouping, which is why we've gone through all this in the first place, is into the categories of "conductors," "insulators," and "semiconductors." This actually isn't a very good set of words to use, because no perfect conductor or perfect insulator exists. Everything, actually, is a semiconductor—but some things are more, and some things less, "semi" than others.

Copper, silver, and gold, for example, are considered good conductors because they offer extremely low resistance to the flow of electric current. Air, glass, and mica, on the other hand, are considered insulators because they offer extremely high resistance.

The resistance of any substance is directly related to the valence electrons in the molecules of that substance. If the electrons are relatively independent of any one nucleus, they can migrate easily through the material—and that material is a good conductor as a result. If, on the other hand, the electrons are tightly bound into place and there are

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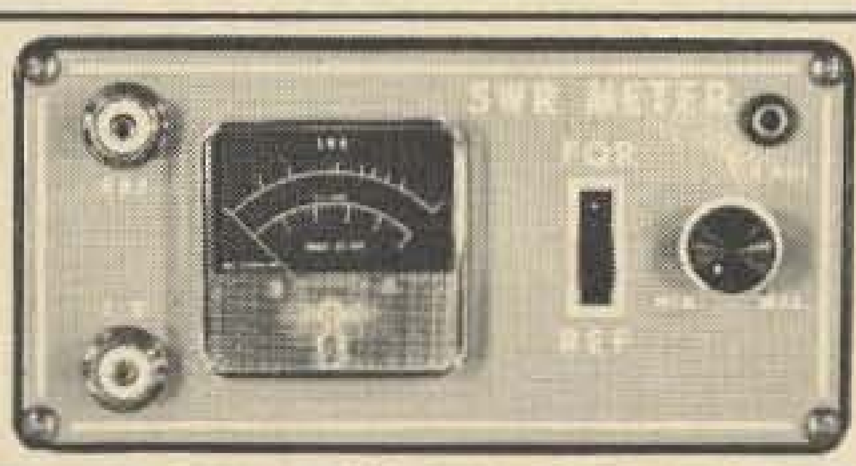

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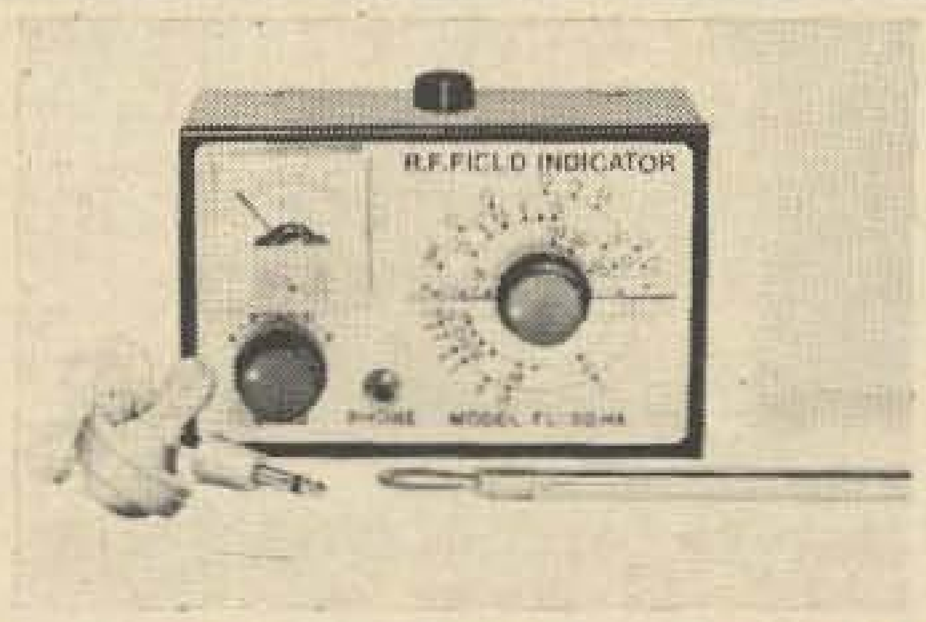

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few "free" electrons able to move, then the resistance will be high and we have an insulator.

Our common semiconductors, germanium and silicon, are actually fairly good insulators in their absolutely pure state. They gain their semiconductor properties because of carefully controlled impurities which provide a few free electrons or their equivalent—but before we can see how this is done we must turn from chemistry to physics and look at the structure of crystals.

Most solid inorganic substances are made up of crystals. In many cases the individual crystals are too small to see except through a microscope, but in some cases the crystals are large. A quartz crystal in its natural state (before cutting) is a single large crystal. So is a diamond, or the ruby rod in a laser.

X rays have been used to examine the internal structure of crystals, and from the pictures obtained we have been able to construct models of this internal structure. These models reveal the not-too-surprising fact that the structure of the crystal is determined by the characteristics of the atoms which compose it (not necessarily the molecules), and the somewhat less expected point that each atom is related not to just one adjacent atom or two, but to a number of adjacent, equidistant atoms.

The specific arrangement of atoms in any crystal depends on the size and number of atoms present and on the electrical forces between them. All other characteristics of the crystal depend on these forces between the atoms.

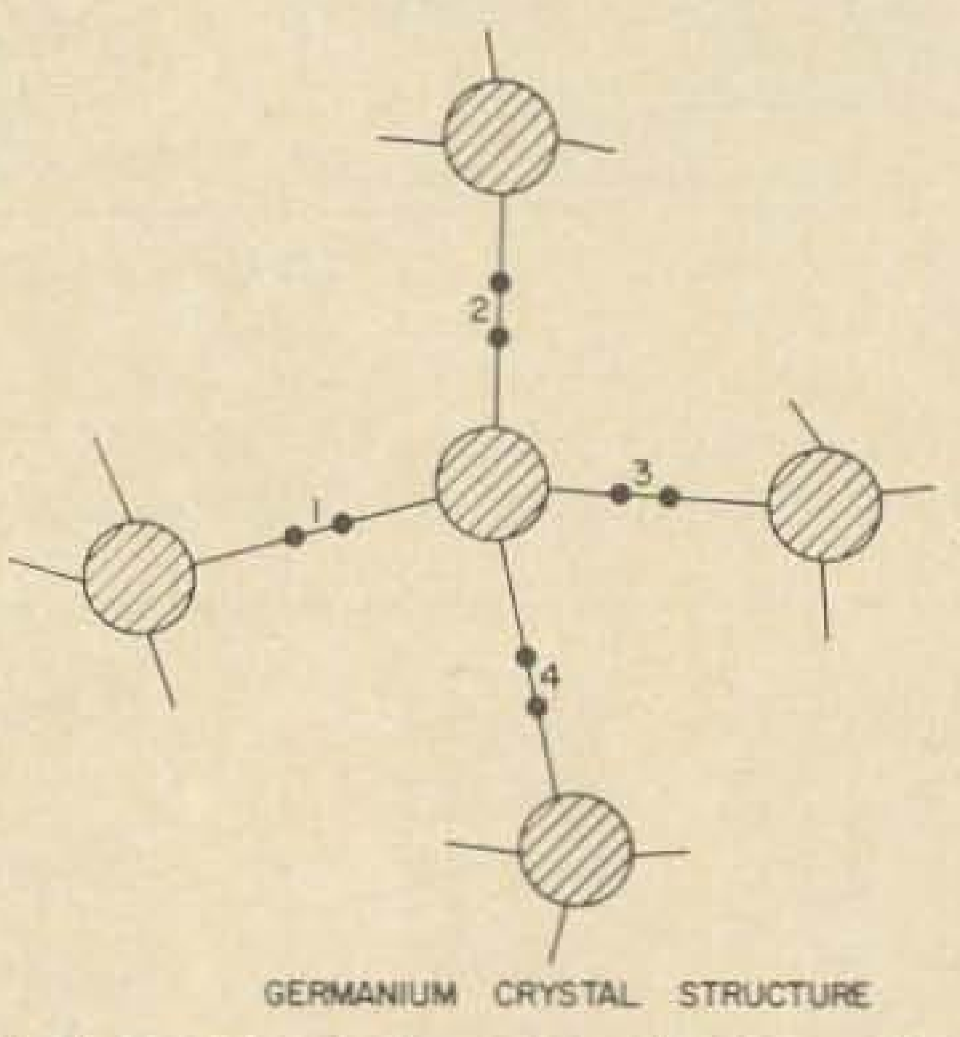
For instance, to turn to carbon crystals momentarily, the carbon atoms in a crystal may take either of two different arrangements. One of them produces a structure which is soft and opaque; we use it (graphite) as a lubricant and to write with. The other produces a structure which is the hardest substance known, and is transparent. Only another diamond will cut a diamond. And the difference between a diamond and a pencil lead is just the difference in arrangement of atoms of the same element.

The structure of a crystal is determined by the valence electrons of the atoms in the crystal. In a crystal, the rotation of one valence electron of a given atom is coordinated with the rotation of one valence electron of an adjacent atom. Such a coordinated rotation of two valence electrons (one from each of two adjacent atoms) is called an "electron-pair bond" by physicists, or a "valence bond" by chemists.

The electron-pair bonds cause the nucleii of the two atoms involved to be attracted toward each other, while the positive charges on the nucleii repel each other. When these forces of attraction and repulsion balance, the crystal structure is in "equilibrium."

Once a valence electron is involved in one electron-pair bond, it cannot participate in any other such bonds, nor may it drift through the substance as a free electron. Thus, in a crystal, each valence electron of each atom can form an electron pair bond with an adjacent atom.

The first element widely used as a semiconductor, and still one of the most popular, was germanium. This element has four valence electrons in each of its atoms, and so each atom in a crystal of germanium is linked by electron-pair bonds to four adjacent atoms. The resulting crystal structure looks something like the sketch in **Fig. 3**, with one atom at the center of a pyramid and its partners at the corners of the pyramid.



GERMANIUM CRYSTAL STRUCTURE

Fig. 3. Germanium and silicon, the two most widely used semiconductor materials, each have four electrons in their valence shells and so form crystals in which each core is joined to four other cores by electron-pair bonds. Other materials may also fit into the structure, with electrons either missing from bonds (holes) or left over (free). This produces P-type and N-type material, respectively.

We have already seen that crystals may be small or large. The crystal structure we have just examined is that which exists *inside* the crystal; at the edges, of course, there are no adjacent atoms to link to. Because of this, materials which exist as many small crystals (such as most metals) behave considerably differently from those which exist as a single large crystal. In particular, a polycrystalline (many-small-crystals) substance is likely to be a good conductor because the valence electrons in the outside atoms of each crystal are free to drift through the materials, and a single-crystal substance is likely to be a good insulator because almost all its valence electrons are fixed in place as partners in electron-pair bonds.

What we call semiconductors are always single-crystal substances. If every atom in a crystal of germanium is actually a germanium atom, then the crystal acts as an insulator. However, if a very few (about one in ten million) atoms of some other substance with either fewer or more than four valence electrons are in the crystal, the valence electrons will not all be fixed in place.

A number of such other substances are able to fit into the structure of the germanium crystal. Arsenic, phosphorus, antimony, and boron, all of which have five valence electrons rather than four, will fit in. So will aluminum, gallium, and indium, which have only three valence electrons.

The substances with five valence electrons are called "donor" materials because they "donate" an excess valence electron to the crystal. A crystal containing donor impurities has a surplus of electrons and so is inherently negative in charge; it is called "N-type" germanium.

The substances with only three valence electrons are called "acceptor" materials because they "accept" only three electron-pair bonds and leave a "hole" which may be filled by any stray electron. This absence of enough electrons to fill all the possible bonds in the crystal results in a positive-charge characteristic, and such a crystal is called "P-type" germanium.

It's important to remember that the crystal *as a whole* is electrically balanced in either case, because the donor or acceptor atoms were electrically balanced before they became part of the crystal structure. The "positive" or "negative" imbalance we spoke of in the preceding two paragraphs refers only to "free" particles which are able to drift within the crystal. N-type crystals have electrons which are free to move without disturbing the crystal structure, while P-type crystals have "holes" which may be filled by electrons introduced from outside. Of course, whenever a hole is filled, the crystal itself has too many electrons for balance and must get rid of one, which produces a hole somewhere else, so that the original hole appears to drift through the material just as would the free electrons in N-type material.

Either P-type or N-type germanium is a better conductor than pure germanium would be, because the impurities provide either free electrons or free holes which can carry electric charge through the material. The free electrons or holes are called "charge carriers" or just "carriers" for short.

Now that we have seen how charge can move through the structure of a semiconductor crystal in the presence of impurities, we're ready to look at the reasons a semiconductor can work as it does. First, let's look at a diode.

If we take a crystal of N-type germanium and connect a battery in series with it, a current will flow. It is carried through the crystal by the free electrons in the crystal structure.

If we use a crystal of P-type germanium instead, the same thing will happen, with the holes carrying the current through.

If we disconnect the battery from both crystals, no current will flow. The atoms inside each crystal would be vibrating because of heat energy which is always present, and the carriers in each crystal would be "diffusing" at random throughout the structure, but nothing would escape from the edges of the crystal.

Now let's join these two separate crystals to form a single crystal, which is N-type at one end and P-type at the other end.

We might expect the holes in the P-type to move toward the junction, in their random diffusion, and there meet the electrons from the N-type, combine into a filled electron-pair bond, and thus eliminate all carriers from the crystal.

This process actually starts to happen

when we form such a crystal—but it stops itself soon after it starts, and long before all the carriers are eliminated from the crystal. When a hole from the P-type and a free electron from the N-type join to form a new electron-pair bond at the junction, this leaves a nucleus short one electron in the N-type material, and a nucleus with one electron too many in the P-type region. The charge across the junction is no longer balanced. The next free electron which diffuses toward the junction is repelled by the excess negative charge now present in the P region, and cannot get to the junction to join with a hole.

So long as any point exists at the junction where holes and electrons can meet without repulsion, they will do so—but as soon as every electron-pair bond across the junction has been filled, no more carriers can cross the junction because of the "barrier" established by charged nucleii just outside the junction area. This barrier area is known as the "depletion region" (**Fig. 4**) and also as the "space charge region." It has definite physical width.

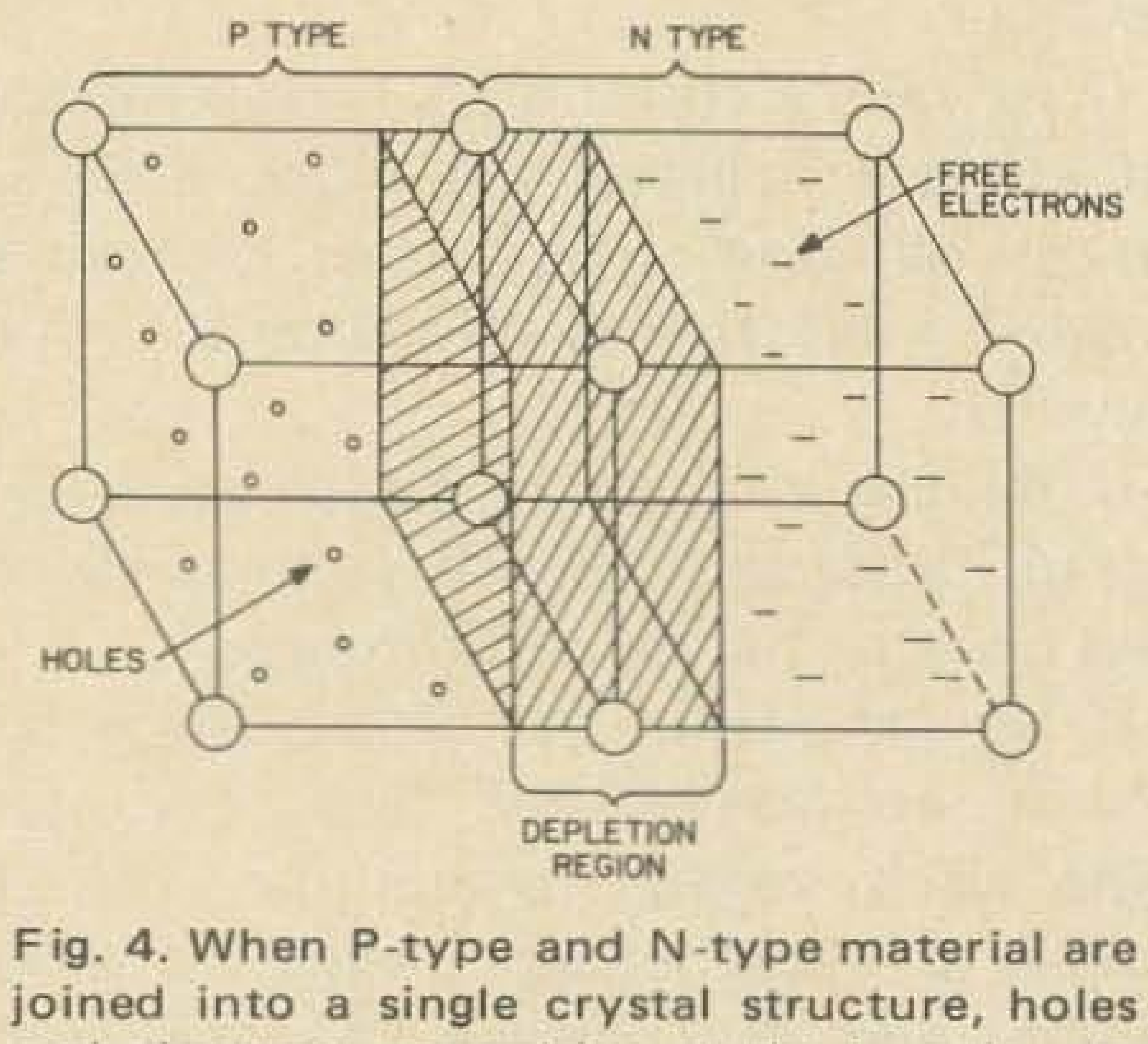


Fig. 4. When P-type and N-type material are joined into a single crystal structure, holes and electrons recombine at the junction to form a barrier or depletion region, shown shaded here. Holes are concentrated at P-type side of barrier and free electrons are at N-type side. Crystal as a whole is electrically neutral, however.

The unbalanced nucleii which establish the barrier are (or may be considered to be, which amounts to the same thing) near the outer edges of the depletion region; since all the electron-pair bonds within the depletion region are filled, this area acts as an insulator—and we have, in effect, a charged capacitor *inside* the crystal.

One way of defining voltage is in terms of the amount of charge in a capacitor. Normally, this is a sort of "reverse English" manner of defining voltage—but in this specific case it lets us think of the barrier in terms of voltage, and this equivalent voltage defined by the charge surrounding the depletion region is known as the "height" of the barrier.

For any particular junction, the height of the barrier depends upon many things. Some of these things are the amount of impurities present in the crystal structure, the temperature (which determines how much bouncing about inside the crystal the carriers may do), and the amount of light reaching the crystal (which provides energy, just as does heat). The most important, though, is the material of which the crystal is made. The barrier in any germanium crystal junction runs between 0.2 and 0.3 v in height, while that in a silicon junction runs between 0.6 and 0.7 v height, in the absence of any external forces.

It's important to remember that the barrier comes into existence when the junction between N-type and P-type material is formed in a single crystal. It's always there. Whenever we have a junction, we have at the junction a depletion region and a barrier. The barrier height depends upon the crystal, but is somewhere around half a volt in most cases in the absence of external forces. Now let's see what happens when we connect *this* crystal to a battery.

Let's try it first with the positive pole of the battery hooked up to the N-type end of the crystal. The battery provides electrons at its negative terminal and forces them into the P-type end of the crystal. This fills even more holes in the P-type material, while the positive terminal of the battery is drawing electrons out of the N-type end of the crystal and so is taking out even more free electrons than were already used to form the depletion region.

As free electrons are drawn out of the crystal toward the positive pole of the battery, the random diffusion within the N-type material tends to move them away from the barrier to fill the gaps. Similarly, the holes in the P-type material move away from the barrier to replace the holes filled by electrons from the battery. The net result

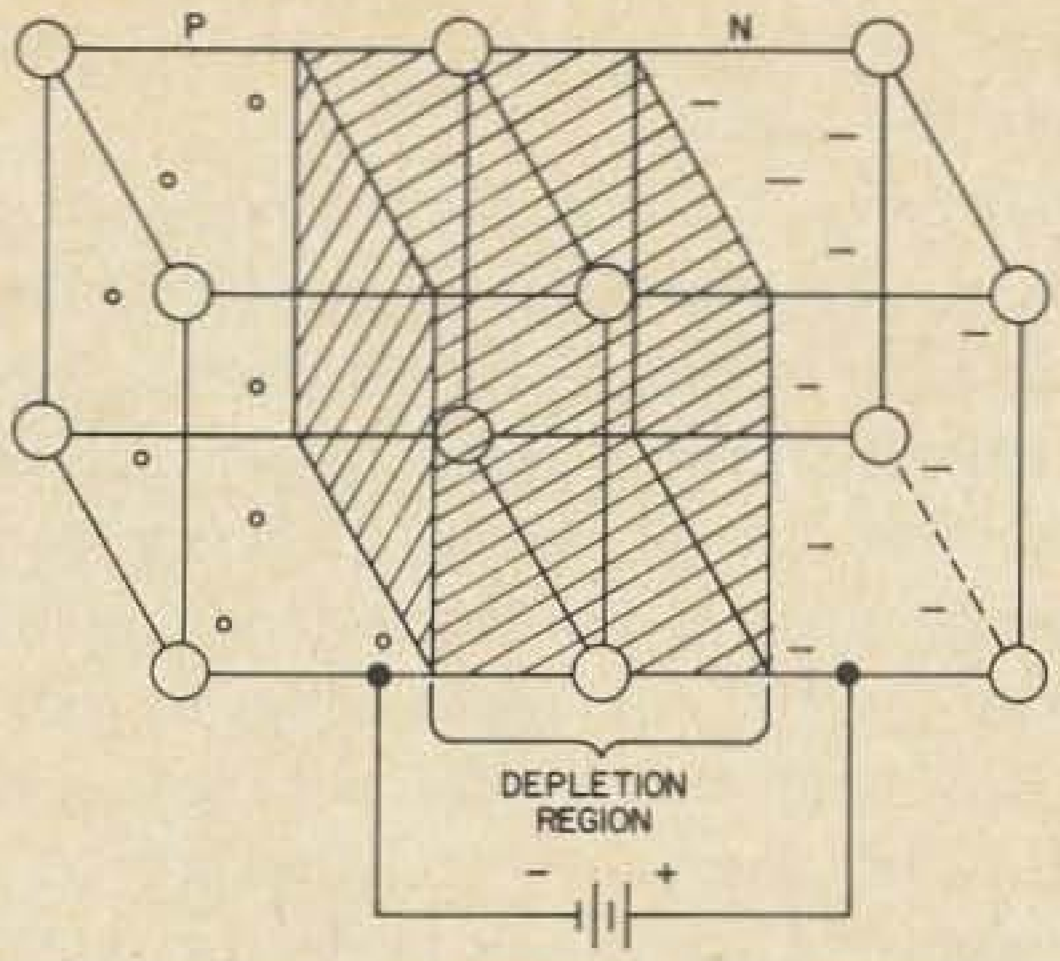


Fig. 5. Battery connected as shown here supplies more electrons to fill holes in P-type end of crystal, and withdraws free electrons from N-type material. Result is widening of depletion region until voltage across barrier equals voltage of battery, or until crystal structure breaks down if voltage is too great. Condition is known as "reverse bias."

is that the depletion region becomes physically wider—and the barrier becomes higher. This process continues until the height of the barrier exactly equals the voltage of our battery. When this occurs, no current can flow, because the voltage of the battery is exactly balanced out by the height of the barrier at the junction.

Under these conditions (**Fig. 5**), our junction is an insulator.

If we reverse the connections to the battery, though, things change. Now, every time a free electron and a hole combine at the junction, they are replaced by a new electron put into the N-type end of the crystal from the negative pole of the battery and a hole created in the P-type material by the battery's taking away an electron. This *reduces* the width of the depletion region

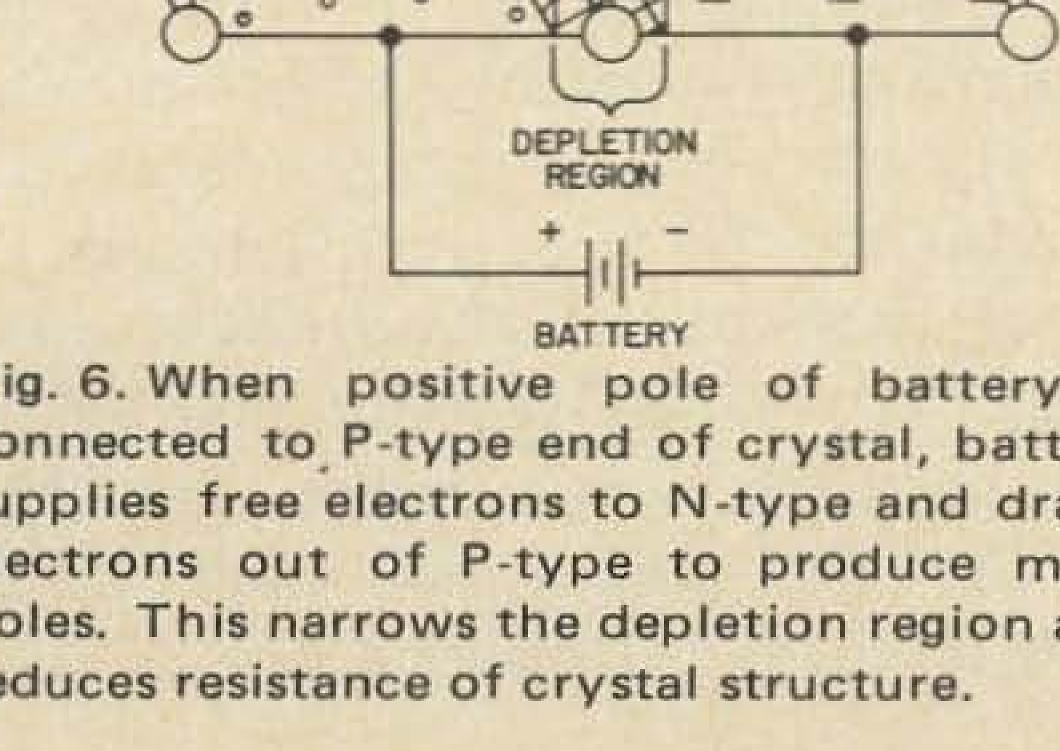


Fig. 6. When positive pole of battery is connected to P-type end of crystal, battery supplies free electrons to N-type and draws electrons out of P-type to produce more holes. This narrows the depletion region and reduces resistance of crystal structure.

(Fig. 6) and the height of the barrier. It does even more—when the barrier is completely overcome, it makes the crystal into an excellent conductor.

The junction, then, is effectively a polarity-sensitive switch. For current flow in one direction, it is an open circuit, but if current attempts to flow in the reverse direction it turns into a conductor.

Such a device is, by definition, a diode and a rectifier. If we apply ac, instead of using our dc battery, the polarity will reverse every half-cycle. Those half-cycles which oppose the barrier are blocked, but those which reduce the depletion region width go through unchallenged—and the output is pulsating dc.

We call the open-circuit condition "reverse bias" and the closed-circuit condition "forward bias," the "voltage drop" of a junction diode is simply the barrier height, because even in the forward-bias condition the applied voltage must overcome the barrier before the depletion region's width drops to zero and closes the switch.

It is possible to force current through a reverse-biased junction diode; if the applied external voltage is so great that the entire crystal is used by the depletion region, for instance, any increase in voltage cannot be overcome by additional expansion of the depletion region. In such a case, the crystal structure actually breaks down and current flows unchecked. If the current is limited by something outside the crystal so that excessive heat cannot be generated, the breakdown heals automatically when the overvoltage is removed; if nothing limits the current, the crystal material is usually vaporized by excessive heat. Zener diodes make use of this reverse breakdown, but in most cases it's something to avoid; that's why diodes are rated for "peak inverse voltage" or "PIV"—that's all they will stand in reverse!

Most rectifier diodes now in use are of silicon rather than germanium, but they work in just the same way. The reason silicon is used is that it is much less temperature-sensitive than germanium, and has higher resistance when reverse-biased. The reverse resistance of a good silicon diode may be greater than 10 megohms, while the resistance in the forward direction is usually less than 500 ohms.

A part of the voltage drop associated with a silicon diode is simply the result of Ohm's Law, because of the 500-ohm forward resistance. However, the forward resistance varies with the amount of current flowing, so that the voltage drop is hardly ever more than a volt (the barrier in most silicon rectifier diodes averages 0.65 volts without current flowing). In fact, it's necessary to put current-limiting resistors in series with silicon diodes to keep them from destroying themselves in normal operation, because they will permit extreme current flow in the forward direction. These resistors are usually 47 ohm 1/2-watt units, which serve the purpose adequately in most cases.

The action of the silicon is a direct result of the crystal structure including the junction between P-type and N-type silicon. This is different from a vacuum diode, which boils electrons off a heated cathode and permits them to flow to the plate whenever the plate is more positive than the cathode. The major differences which result from the different action are:

1. The vacuum diode requires power to heat the cathode while the silicon diode does not.

2. The vacuum diode requires an envelope to maintain its vacuum; the silicon diode is a single crystal and can be quite small.

3. More force (external voltage) must be applied to move electrons across the distance between cathode and plate in a vacuum diode than is necessary to move charge across the junction in a semiconductor, because of the 10-million-to-one variation in the distance (atomic in the case of the junction, easily visible in the vacuum diode).

4. The heater in the vacuum diode eventually burns out; the semiconductor diode has no known failure mechanisms which are inherent in the unit itself, and most failures are caused by failures of other items in the circuit. No semiconductor has ever been known to "wear out" with use.

Most of these differences are also applicable when comparing vacuum tube amplifiers to transistors—but that's our next subject. At this point, we have a fair (although incomplete) idea of what a semiconductor is and why it can act as it does, and it's time to move on to study the transistor.

How Do Transistors Amplify?

We have just seen how the polarity of voltage applied to a single semiconductor junction between P-type and N-type semiconductor material controls the width of the depletion region which exists at the junction, and so controls the resistance of the junction. This is enough to give us diode action, but something more is necessary in order to get amplification.

Let's sandwich a slice of P-type material between two pieces of N-type material in a single crystal and see what happens. Each N-P junction is immediately surrounded by a depletion region; since we have two N-P junctions, one on each side of the P-type region in the crystal, we have two depletion regions.

Either of these junctions alone will act just as does the single junction of a diode. For instance, if we forward-bias the leftmost junction in Fig. 7 and leave the right-hand junction disconnected, the depletion region becomes narrower. If we apply reverse bias, the depletion region widens.

But since both junctions are in a single crystal structure, something more complicated happens if we apply bias voltages to both. If the thickness of the P-type portion

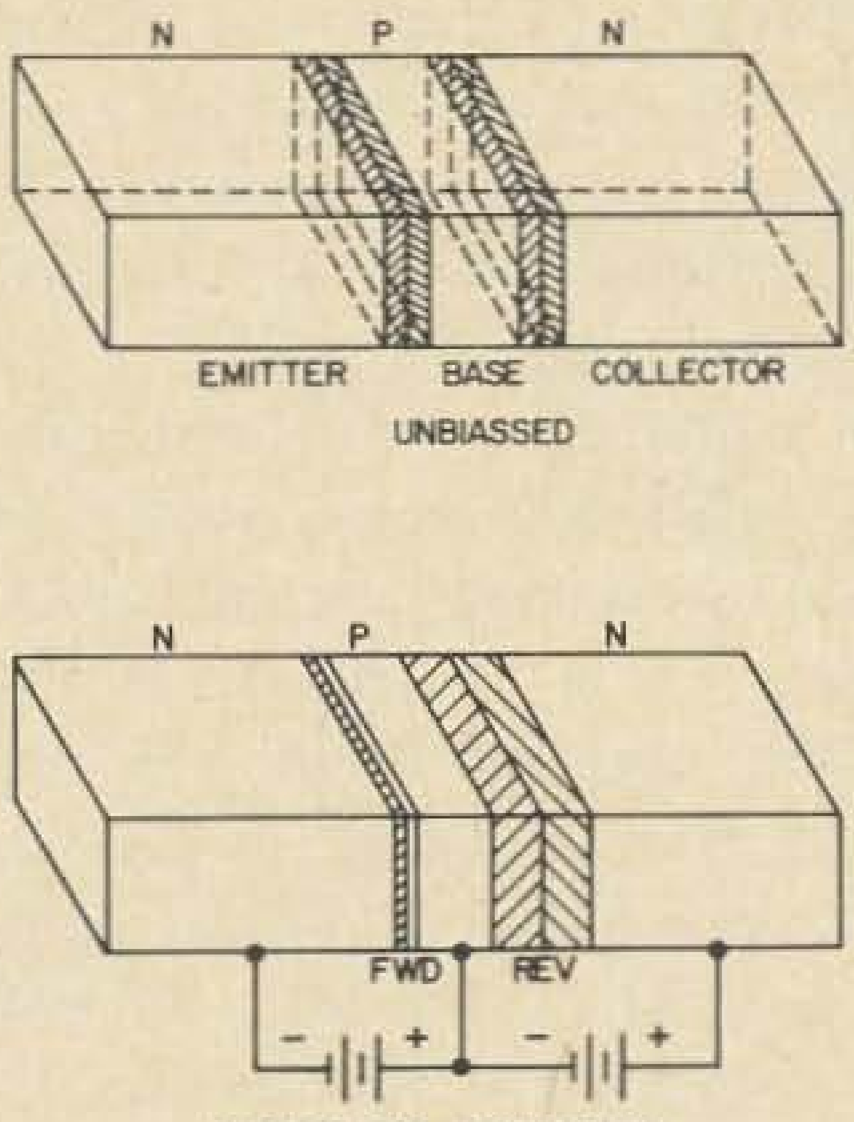
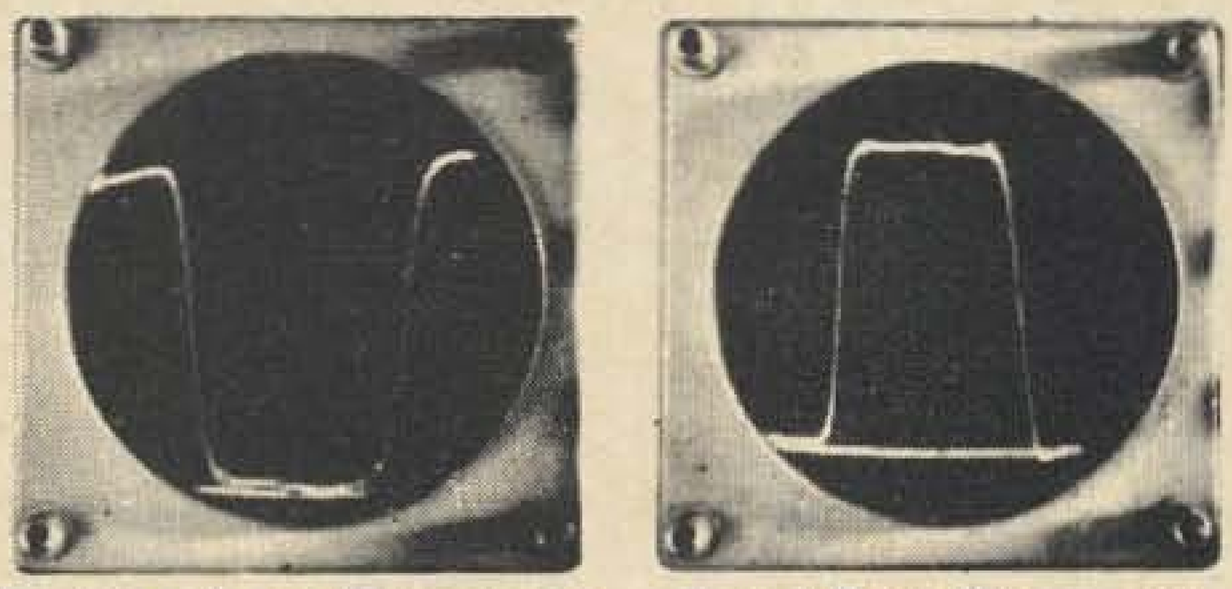
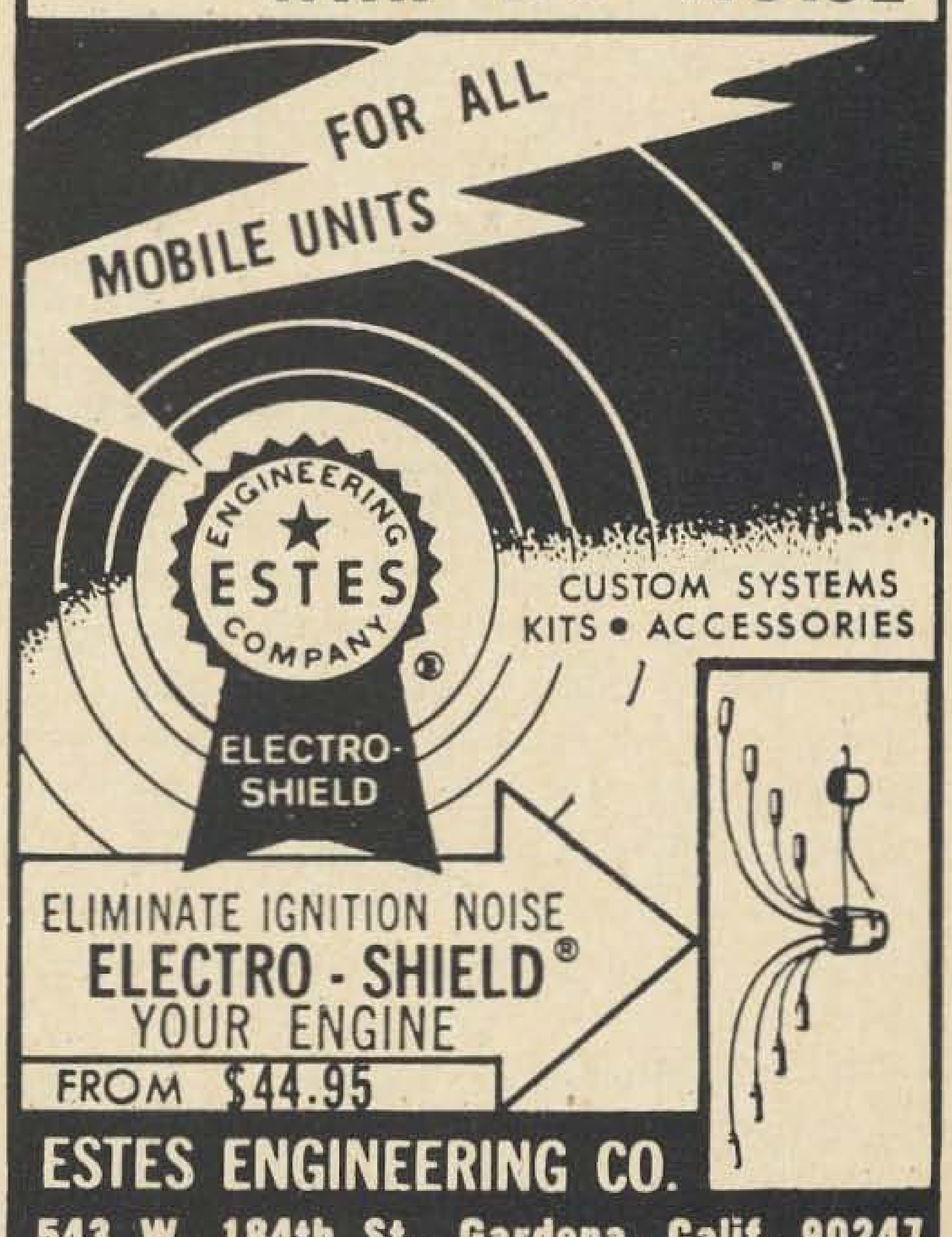


Fig. 7. Placing two junctions in a single crystal structure produces two barriers and two depletion regions, as shown at top. When bias voltage is applied as in bottom view, one junction is forward biased with small depletion region and other is reverse biased with large depletion. This makes amplification possible.





of the crystal is small enough, and we forward-bias the one of the two N-P junction, many of the electrons which go into the N-type material shoot right on through the P-type region without meeting any holes, picking up enough energy on the way that they shoot right through the barrier of the other junction into the other N-type region. There, they may meet holes—or, if polarities are correct, may flow right on out into an external circuit.

In order for these shot-through electrons to be able to continue into an external circuit, the right-hand N-type material must be connected to a more positive voltage than is the P-type material in the center. This, however, amounts to reverse bias on the right-hand P-N junction.

And as we saw when examining action of a single junction, a reverse-biased junction has extremely high resistance.

The left-hand junction, being forward biased, shows a very low resistance. Yet it is the electrons injected into this low-resistance circuit which shoot through and affect the current flow in the high-resistance reverse-biased circuit. This is a *transfer* of signal from a low-resistance to a high-resistance circuit, with very little loss of current, and such a transfer amounts to a power gain (1 mA in a 10-ohm circuit is 10 microwatts; the same 1 mA in a 10,000-ohm circuit is 10,000 microwatts, or 1000 times more power).

This is, about as precisely as we can put it without resorting to pages of higher math, just how a transistor operates. What we see in Fig. 7 is an NPN transistor; the N-type material at the left is the emitter, the P-type region in the center the base, and the N-type material at right is the collector.

The names applied to the elements of the transistor may make a little more sense now. The emitter emits electrons, under the influence of the forward bias between itself and the base. Actually, the electrons are pushed out by the battery which establishes the forward bias. They shoot right through the base region into the collector, which collects them.

The amplification comes about because the emitter-base circuit is at low impedance while the base-collector circuit is at high impedance, and the flow of electrons all the way through from emitter to collector is a series circuit in which constant current flows.

Not all the electrons make it through the base region, of course. A few of them must recombine with holes in the base, to maintain a current flow in the base circuit and keep the emitter-base junction forward biased. Almost any transistor, though, will let at least 95 percent of the electrons which leave the emitter reach the collector. High-gain transistors permit only a very small fraction of one percent of the emitted electrons to be trapped by the base.

In the early days, a factor called "alpha" was used to rate the gain of transistors, and it was, specifically, the ratio between the number of electrons reaching the collector and those which left the emitter.

It wasn't measured by counting electrons directly, of course. Instead, current in the emitter circuit and current in the base circuit were measured and compared. An alpha of 0.99 meant that for every 100 mA in emitter circuit, 1 mA flowed in the base circuit and the remaining 99 went on through to the collector circuit. Alpha always ranged between 0 and 1; a very high gain unit might reach 0.9999999999, but it could never quite get to 1.0 because if it did, no current would be left to flow in the base and keep the transfer action going.

Partly because of this bit of mathematical confusion, and more because of a change in the preferred type of circuits as designers gained experience with the transistor, a different rating called "beta" by most and "H_{fe}" by some came into widespread use, and today most gain comparisons are made on the basis of beta rather than alpha.

The beta of a transistor is the ratio between the current flowing in the base circuit and that flowing in the collector circuit. Our preceding example, for instance, with 1 mA in the base and 99 mA in the collector, would result in a beta of 99.

Beta and alpha are mathematically related by the fact that all the current reaching either the base or the collector normally goes through the emitter; if you know alpha and need beta, simply divide the alpha figure by the difference between 1 and alpha (to apply this to our example, 0.99/(1-0.99) or

0.99/0.01) and the result is beta.

Actually, a small amount of leakage current may flow, so that these and other mathematically based relations do not always hold true in practice—but they're usually plenty close enough for our purposes.

The NPN transistor we have just looked at operated with polarities very similar to those of vacuum tubes, except that the base (which corresponds to the grid of the tube) is positive rather than negative with respect to the emitter (which corresponds to the tube's cathode).

Transistors differ from tubes in one major respect, however. Tubes can only employ electrons as their carriers, because holes cannot exist in a vacuum (they are an inherent part of crystal structure and cannot exist outside that structure). Since the transistor uses crystal structure to achieve its effects, it can just as easily sandwich a slab of N-type material as a base between two slices of P-type, and we then have a PNP unit instead of NPN.

The PNP unit operates exactly as does the NPN, except that holes replace the electrons as the charge carriers, and all the bias-voltage polarities must be reversed.

The existence of both NPN and PNP transistors makes many circuits possible which cannot be done with tubes. For example, a single-ended input signal can drive a push-pull amplifier direct without any need for phase inverters or center-tapped driving transformers, if one half of the push-pull stage used an NPN transistor and the other half is PNP (providing that bias is properly set).

When we compared junction diodes and vacuum diodes, we found a number of differences which also apply to a comparison of transistors and triode vacuum tubes. Here are a few more:

1. The main current flow in a vacuum tube is from cathode to plate; in an NPN transistor, the main current flow is from emitter to collector. In the tube, the current passes through the grid; in the transistor, it passes through the base. Thus the emitter of the transistor corresponds to the cathode of the tube, the base to the grid, and the collector to the plate (Fig. 8).

2. In most applications of tubes, no

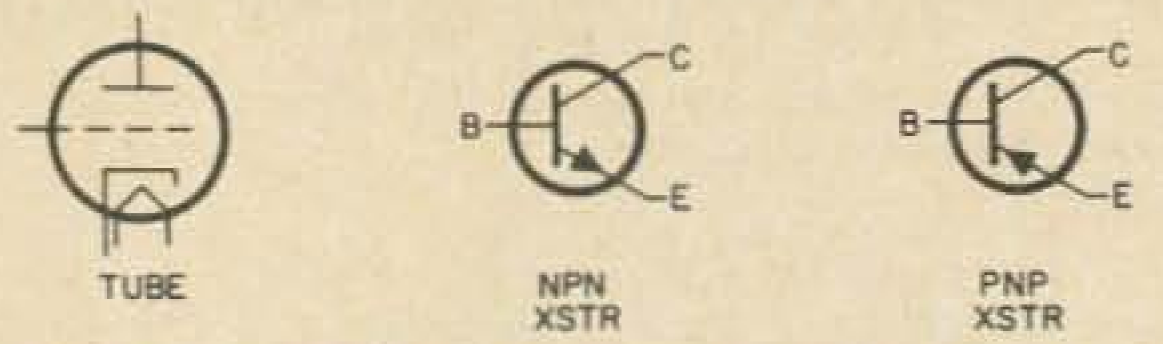


Fig. 8. Schematic symbols for both NPN and PNP transistors as compared with symbol for triode tube. Type of transistor is indicated by direction of arrowhead on emitter lead; the arrowhead points in the direction of positive current flow. Symbol corresponds closely to that for semiconductor diode, in which arrowhead also points in direction of positive current flow (as opposed to negative electron flow).

current flows in the grid-cathode circuit, so that the grid of the tube is a very high impedance. In most transistor applications, the base-emitter junction must be forward-biased and current flows; the circuit is a low impedance. Thus the input resistance of the tube is usually much higher than that of a transistor.

Since the emitter, base, and collector of the transistor do correspond to the cathode, grid, and plate of the triode tube, transistors can be hooked up as amplifiers in circuits (Fig. 9) which correspond to the three types of vacuum-tube amplifiers: conventional grounded-cathode, grounded-grid, and cathode follower.

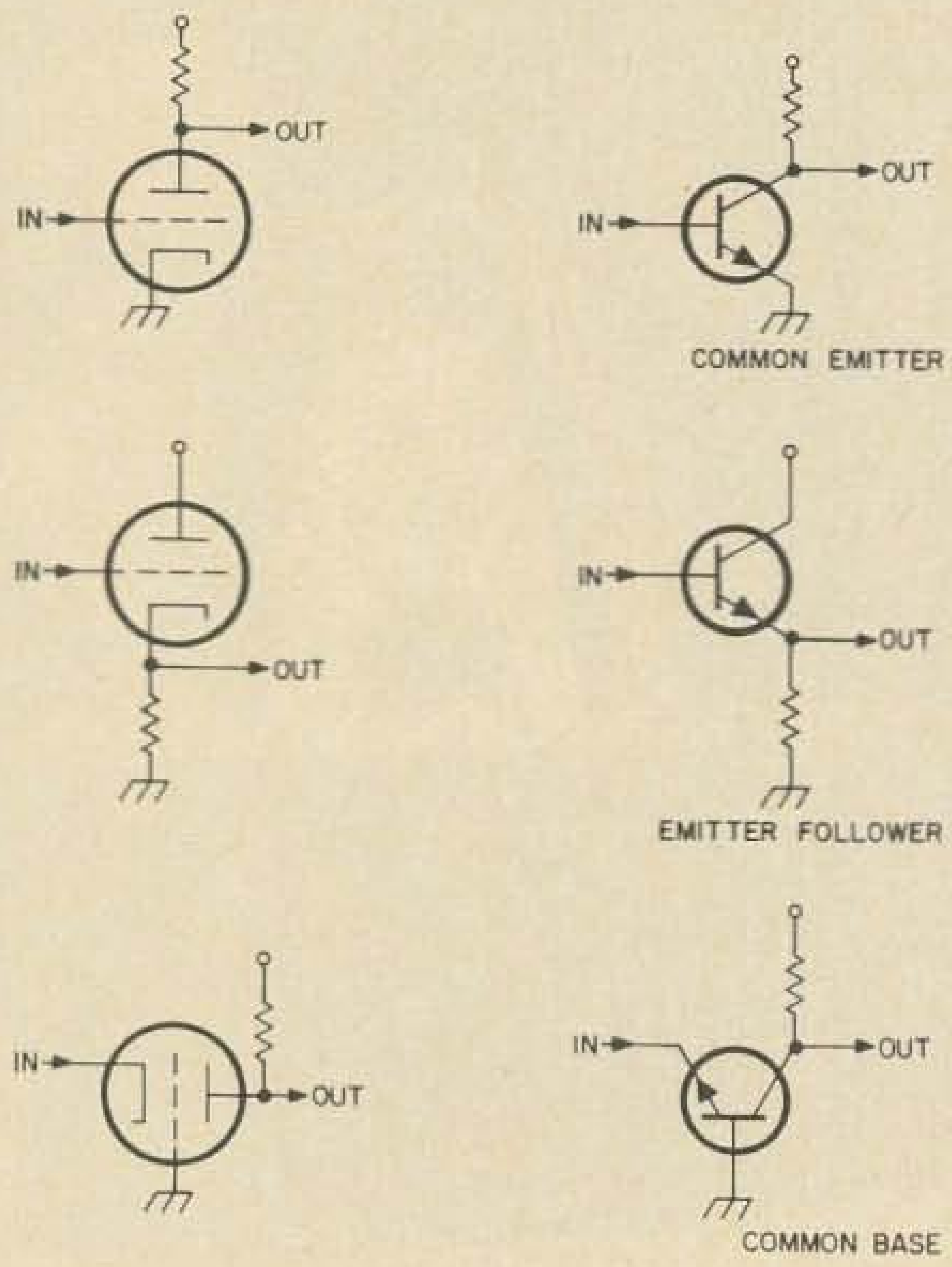


Fig. 9. The three basic types of transistor amplifier circuits are shown here as compared to the corresponding vacuum-tube circuits. Only signal paths are shown; each transistor circuit requires bias arrangements also as shown in Fig. 10 for the common-emitter case.

The corresponding transistor amplifier circuits are known as the common-emitter, common-base, and emitter follower or common-collector. The common-emitter circuit is most frequently employed now, and corresponds to the grounded-cathode tube circuit. The emitter follower or common-collector circuit is frequently used to increase input resistance of transistor circuits.

Characteristics of each of these transistor circuits are roughly similar to those of the corresponding tube circuit, keeping in mind the inherent lower input resistance of transistors.

Like the grounded-cathode tube circuit, the common-emitter transistor amplifier offers moderate input resistance and reverses the phase of the signal between input and output.

The emitter-follower, like the cathode follower, has high input resistance and a voltage gain of less than one. Phase of the output signal is the same as that of the input.

Any transistor circuit, whether common-emitter, common-base, or common-collector, must be biased properly in order to amplify. The bias voltages establish the required reverse bias of the collector-base junction and forward bias of the base-emitter junction. The collector bias voltage corresponds directly to the B+ or plate supply voltage of the vacuum-tube circuit, but the base bias voltage differs from the grid bias of a vacuum tube because current normally is allowed to flow in the transistor's base circuit.

For proper amplification, base bias is somewhat critical–but no more so than is the grid bias of a tube. If too much current is permitted to flow in the base circuit, the transistor will act as a switch rather than an amplifier; if insufficient current flows, the transistor will be cut off (little or no collector current). The overbiased condition is known as "saturation," and the underbiased conditions as "cutoff." For proper amplification in most circuits, bias should be adjusted to a value halfway between cutoff and saturation; this will permit the largest possible input signal swing between these limits.

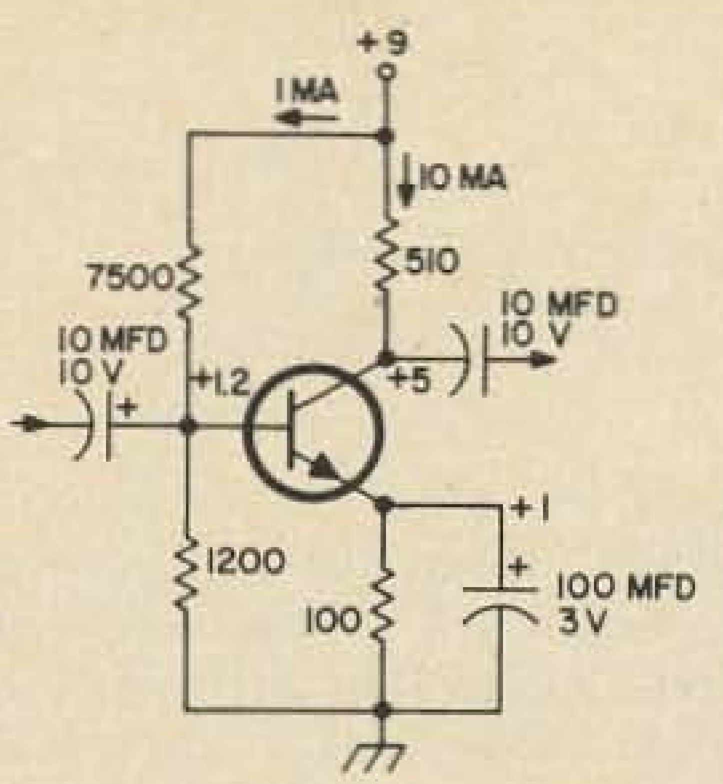


Fig. 10. Emitter bias circuit as applied to a common-emitter audio amplifier circuit using an NPN transistor. Emitter resistor's value is chosen to give a convenient amount of voltage drop when desired emitter current flows, and voltage divider supplying bias to base is then set to provide this same voltage plus barrier offset (about 0.2 volt for germanium transistors or 0.6 volt for silicon). Emitter current will stabilize at desired value. Change in supply voltage requires only changing of base voltage divider to keep base voltage constant.

In a vacuum tube, amplification can be controlled by varying the grid bias. Changing the base bias of a transistor has much less effect upon the amplification, although a limited control is possible by this means.

Bias can be supplied from separate supplies, but it's more common to use a resistive voltage divider to put the base at some voltage between the collector-supply level and ground, and include a moderately small resistor in the emitter circuit as shown in **Fig. 10**. This corresponds to the "cathode bias" arrangement used frequently in tube circuits; it makes the bias automatically self-compensating to just that amount which will permit a desired level of emitter current to flow. While **Fig. 10** show this in a common-emitter circuit, the same bias arrangement can be used for any of the three types of circuits by moving the ac grounds and signal input/output points while leaving the dc portions of the circuit unchanged.

What Factors Affect a Transistor's Amplification?

Now that we've met the transistor as an amplifier, it's time to take a deeper look at the factors which affect the transistor's performance in this role.

Among these factors are the signal frequency, the construction of the transistor, the circuit constants, and many others. Let's look at the transistor's construction first, because in practice we have no control over this except to choose a particular type of transistor which has the type of construction we desire.

The transistor which we used as an example (**Fig. 7**) was a single crystal of semiconductor material with the base sandwiched between the emitter and collector. We drew it in the shape of a long narrow slab to make the explanation easier to follow visually—but very few actual transistors use this shape. In practice, the designer of a transistor must juggle such factors as the width of the base region, the capacitance across each junction, the thickness and volume of the collector (which sets the power rating of the unit), and the area of the emitter junction. Most of today's common transistors, as a result, resemble tiny ham sandwiches; they are spread out over a wide area but are not very thick. The collector is the largest part, with the base on top of that and the emitter covering the base; both emitter and base are normally very thin.

The width of the base sets a limit on signal frequency, because any carriers which remain in the base region for an appreciable fraction of a signal cycle cannot be controlled by the signal (it will be pulling them part of the time and pushing them the rest of the time). Early transistors were limited to audio frequencies because of this, but modern units are capable of amplifying well into the rf range and many "ordinary" transistors operate nicely up to 5 or 10 mhz. For higher frequencies, different construction techniques are used; transistors which operate in the ghz frequency range are available although expensive.

Base width also determines to some degree the amplification ability of the transistor; a thick base can capture more carriers than can a thin one, which means that fewer carriers will go on through to the collector. This increases the base-current/collector current ratio, which reduces both alpha and beta.

Circuit constants affect transistor amplification in the same manner as they affect tube amplification; a high value of load resistor will give increased voltage gain, if enough current can be made to flow through it. Increased forward bias will permit greater current flow. However, each type of transistor has an optimum operating point which provides maximum amplification consistent with linearity. You can get higher gain, but at the cost of possible distortion.

Is Amplification All?

The most familiar use of transistors, to most of us, is in amplifiers or amplifier-related circuits such as oscillators or active filters. However, as we've already glimpsed, the transistor also has the capability of acting as a switch if the base bias is varied between saturation and cutoff—and in fact, the most common use of transistors today is not in amplifiers at all, but as the switching element in digital computers.

A switching transistor and an amplifier transistor are essentially the same, except that the switching unit is designed to emphasize its switching properties and is not tested for use as an amplifier. Despite this, most switching transistors make highly acceptable amplifiers if you're willing to develop your own circuit constants for them.

When a transistor is saturated, that is, when so much base current is supplied that no additional change of collector-emitter resistance can occur, it is a better switch than many mechanical switches. The voltage drop from collector to emitter under these conditions is usually much less than 0.1 volt (as compared to the 0.25-volt drop between base and emitter at the same time).

In cutoff, however, almost no current flows through a silicon transistor, and very little through a good germanium unit.

By removing the base-bias network from a common-emitter amplifier circuit and bringing the base lead out (through a current-limiting resistor) as the input terminal, we have the basic transistor switching circuit shown in Fig. 11. If voltage is applied to the input with a polarity that provides forward bias to the base-emitter junction, current can flow in the load circuit. In the absence of input voltage, or with reverse-bias polarity, current flow in the load circuit stops.

Placing a resistor in the load circuit, and then connecting two such switching circuits back to back as in Fig. 12, gives us a

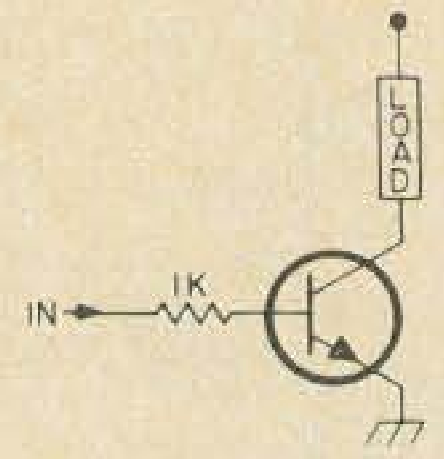


Fig. 11. Basic transistor switch circuit is simplicity itself. Transistor is connected in series with the load to be switched, and control voltage is applied through a resistor to the base, to assure cutoff in the absence of control voltage input, but in many cases the zero-bias leakage current is small enough that no more components than shown here are necessary.

"memory" circuit. If we ground terminal 1, this will cut off transistor Q1 and halt the flow of current through R1. With no current flowing through R1, the collector of Q1 will rise toward the supply-voltage level. This provides forward bias to Q2, driving it toward saturation and permitting current flow through R2. When Q2 saturates, the voltage at its collector is virtually ground level and we can now remove the ground from terminal 1 because Q2 has turned into a permanent ground at the same point in the circuit.

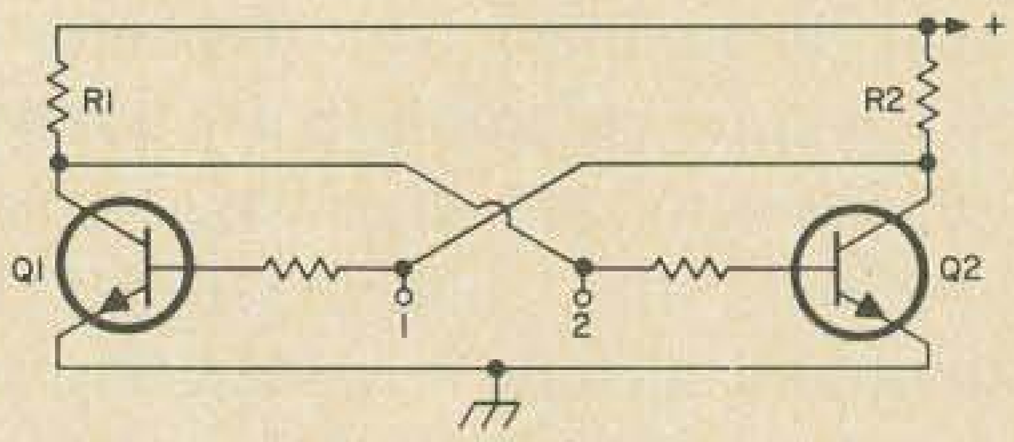


Fig. 12. Two simple transistor switches (Fig. 11) with resistors for loads, and cross-coupled to each other back to back, form a simple memory circuit which is actually used in some digital computer designs, and which is the heart of most of the more complicated flip-flop circuits. This version is known to computer designers as the "DTL flip-flop" (direct transistor logic). Operation is explained in the text.

This circuit will "remember" that condition until we ground terminal 2, no matter how long we wait. When we ground terminal 2, we remove the voltage from the base of Q2 and thus cut it off. The voltage at Q2's collector rises, driving Q1 into saturation. When Q1 saturates, it holds Q2 cut off. The circuit is now remembering a new condition.

This circuit, called a "flip-flop" by most computermen in this country and known to engineers as a bistable multivibrator, is the heart of most computers. In practice, more elements are needed in order to speed up action, etc.—but the simple sample circuit here will work as described.

While the transistor's use as a switch is its most common application, and its use as an amplifier is the most familiar to most of us, there are still other uses.

One of the more interesting is its use as a current-controlled resistor.

Both amplification and switching action in the transistor come about, as we have seen, by a change in the resistance of the collector-to-emitter circuit caused by a change in the current flow in the base-emitter circuit. We can, then, simply use the collector-to-emitter circuit as a variable resistor, and change its resistance by changing the current flow in the base circuit.

This offers, as one example, a simple automatic gain control technique. The agc control voltage is converted to current by a series resistance and applied to the base of a transistor; the transistor is in series with a fixed resistor which forms a voltage divider for the signal being controlled.

If control voltage and consequent base current are high, the transistor's resistance is low and the voltage divider has low output. If control voltage and base current are low, the transistor's resistance is high and the voltage divider has little effect.

The circuit, diagrammed in **Fig. 13**, can be applied to many other uses. It has been used, for instance, as a motor speed control—but in such a use the transistor must

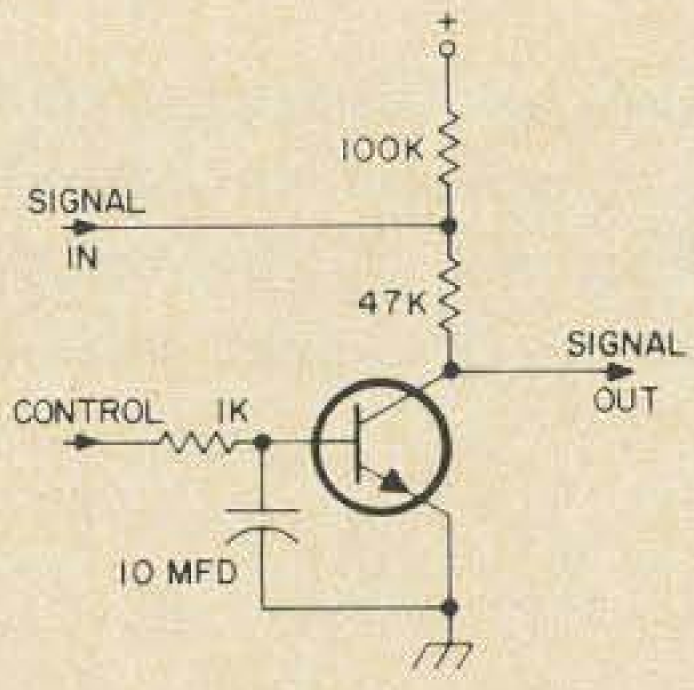


Fig. 13. Transistor may be used as current-controlled variable resistor to provide AGC circuit as shown here. Application of positive control current or voltage reduces collector-emitter resistance of transistor, reducing output voltage. Reduction of control current increases transistor resistance, raising output voltage. Topmost resistor is to isolate signal from low impedance of power supply. Values are only suggested; in any specific application they would have to be tailored to the needs of the circuit.

dissipate large amounts of power (in the agc application, almost no power is involved).

What About the Rest of the Family?

We've examined junction diodes and junction transistors, both silicon and germanium types. We have by no means seen all the semiconductor family. We have completely skipped over the point-contact diodes and transistors, partially because they are little used today but primarily because modern theory indicates that they are actually junction devices in which the junctions are created at the points of contact during use (which means that they operate in essentially the same manner).

Some of the other semiconductor devices operate in totally different fashion although based on the same basic events in a crystal structure, and some bear the same relation to transistors that transistors bear to diodes—an apparent combination, modified by the fact that the whole combination is in a single crystal.

The silicon controlled rectifier (SCR) is one of these combination devices. It can be simulated by a hookup of PNP and NPN transistors as shown in **Fig. 14**—but only if both transistors have essentially zero leakage current. It is a switching device only; when "off," almost no current flows through, and when triggered "on" by a small signal in the gate circuit, a large flow of current can flow with no more voltage drop than an ordinary silicon diode.

Fig. 14 indicates that such a device should be able to be turned either "on" or "off" by control signals; most SCR's only turn "on" by control signals, and must be turned "off" by other means. A similar device based on the same principles, known as the silicon controlled switch (SCS), has both "on" and "off" capabilities.

The four-layer diode is similar in characteristics to the SCR but has only two terminals; the "turn-on" signal is generated inside the crystal structure by the applied voltage. The result is that the device is an open circuit for voltages below a critical "threshold" value, and a closed circuit for voltages above that value.

The unijunction transistor, originally called the double-base diode, is a completely different device. It has only one junction, and injection of current into this junction affects the current flow through the main mass of semiconductor material. This device does not amplify, but is excellent as a switch in timing circuits similar to neon-bulb oscillators.

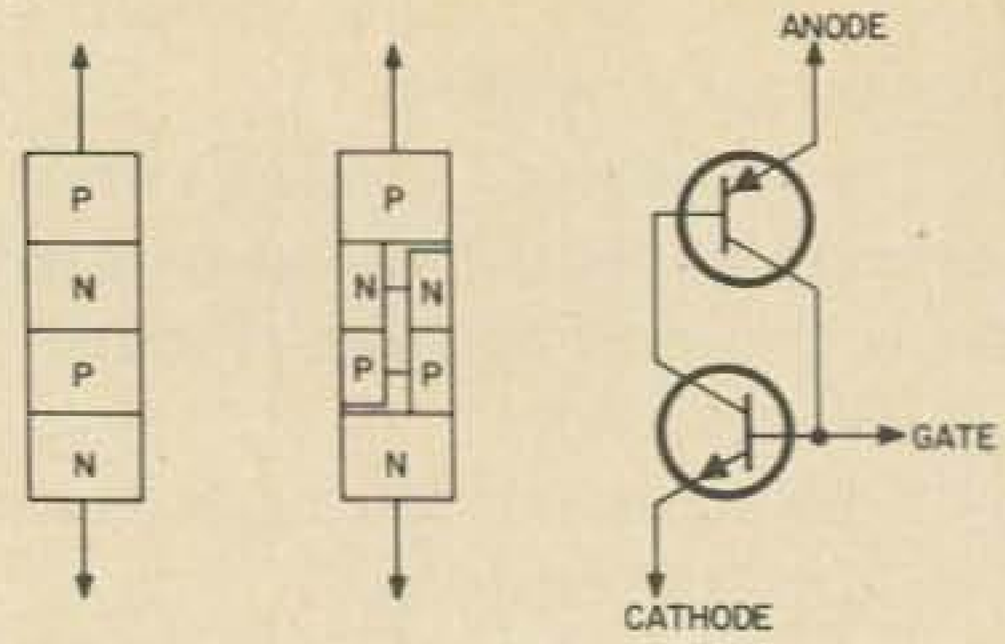


Fig. 14. Actual structure of SCR is four-layer PNPN sandwich as shown at left, but operation is very similar to that of two perfect transistors as shown in center, hooked up as shown in schematic at right. If both transistors have almost zero leakage, circuit at right will work; in SCR, leakage is held to minimum by action within the crystal structure.

The field-effect transistor is something of a cross between the ordinary transistor and the unijunction. **Fig. 15** shows how it works in principle. Only one junction is involved, and it is always reverse-biased. The amount of reverse bias varies the depth of the depletion region in the main mass of the material, which varies the resistance between the source and drain terminals. The FET has operating characteristics very similar to those of a vacuum tube—input resistance is high and no current flows in the input circuit.

Voltage-variable capacitors and varactors are simply specially processed junction diodes, making use of the variation of the depletion region thickness with variation in

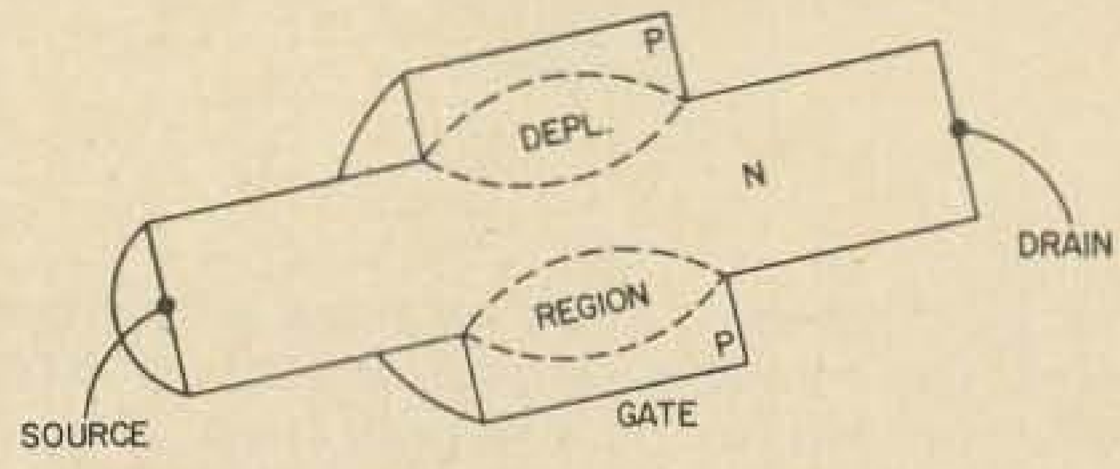


Fig. 15. Cutaway view of theoretical field-effect transistor shows how depletion region created by reverse bias of the gate material (in this example, a ring junction all the way around the main semiconductor) "pinches" down the available current path and so increases the device's source-drain resistance. Actual FET's are considerably more complex than this simple model.

bias voltage to change capacitance across the junction.

Zener diodes and tunnel diodes are also specially processed junction diodes. A zener diode is built to maintain a constant breakdown voltage in the reverse-bias direction and serves the same function as a vr tube. A tunnel diode contains much higher levels of impurities and apparently operates in precisely zero time (the physics of it are still somewhat unclear to most students); the effective result is the establishment of theoretically impossible negative resistance, which in turn makes any resonant circuit capable of oscillation.

The "integrated circuit" is today's frontier of semiconductor study; any one integrated circuit contains transistors, diodes, resistors, capacitors, and conductors, all of which may be grown into a single crystal structure. When each individual component of an IC is examined by itself, it is found to be identical to that same component in any other application—the IC is more a means of packaging complete circuits in very small spaces than it is a separate member of the semiconductor family.

This is not all the list by any means; semiconductor technology is moving so rapidly today that no list could ever be complete, because new types would be invented in the time between writing the list and its publication. However, these are most of the members of the family that you're likely to meet soon in the radio world—and this is enough of their basic theory to provide answers to all the semiconductor questions on the Extra Class examination.

. . . Staff

More Wax

Besides emergency fluxes and lubricants, wax can be used to set those set-and-forget controls, like the regeneration pots on the Heath Lunchboxes, and bias settings. Hold the candle (lit!) half an inch over the control and let wax drip into and around it for about half an inch around it. You can also tell if someone has been tampering with the rig.

...WA3HWI■

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A Preamplifier for the CB and Ten-Meter Bands

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27 Rorer Avenue
Hatboro, PA 19040

Did you ever want to listen in on the CB or 10 meter bands and find your receiver sounded completely dead? Perhaps it is too noisy and the signals are there but you cannot hear them, or maybe it simply is not sensitive enough.

What you need is a high-frequency preamplifier, and a nice surplus item can be converted very easily to boost your receiver's performance.

The Conversion

Begin with a No. MFP-50 10 meter preamplifier. This comes unconverted at around $5 plus postage.

The conversion consists of installing two BNC connectors and appropriate power connections; adding a link input circuit, and tuning up. You may need to build a power supply. Here is the conversion process:

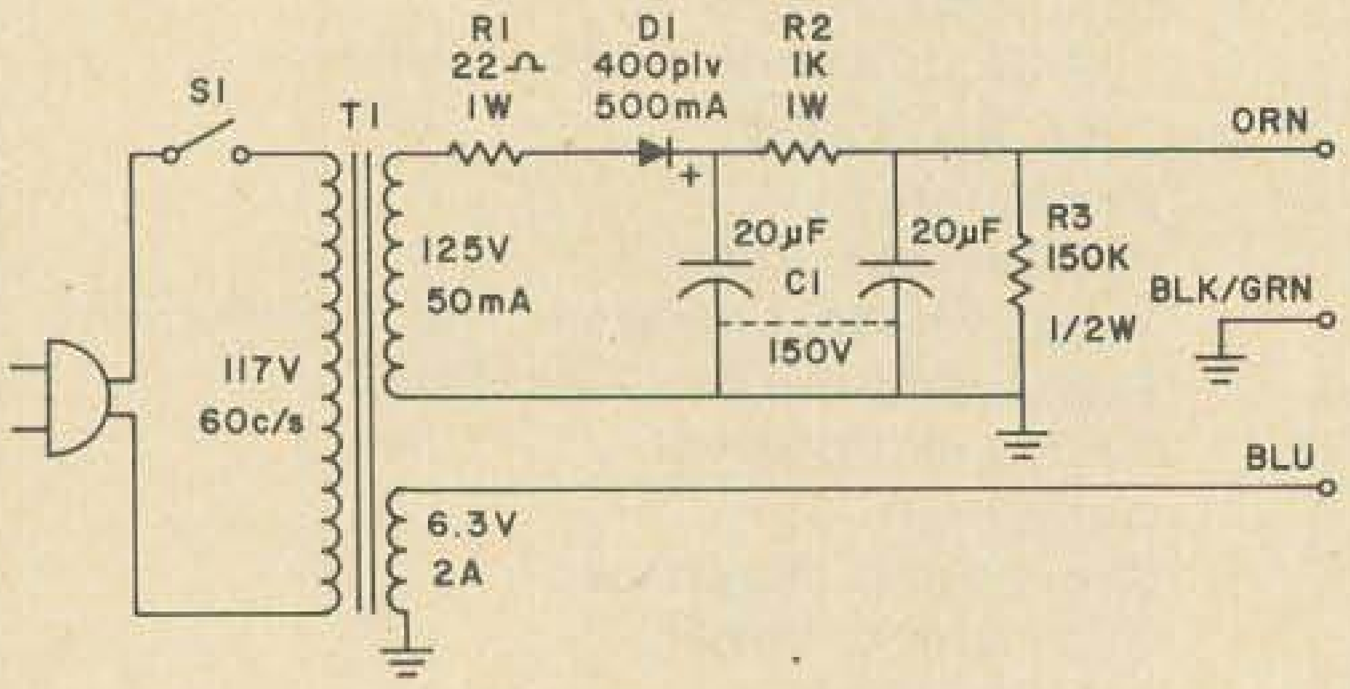

Fig. 1. Power supply circuit. Parts list: C1-dual–20µf, 150 volt electrolytic; D1–400 piv 500 ma silicon rectifier; R1–22ohm 1 watt resistor; R2–1000ohm 1 watt resistor; R3–150K ½watt resistor; S1–SPST toggle switch; T1–Power transformer, Allied 54C 1411, primer 117 volts ac, secondary 125 volts ac, 50ma, 6.3 volts ac 2 amps.

Step 1. Remove connector from 6 inch cable and add extension cable or other provision for connections to power supply. Connections are: Black, chassis ground. Blue, 6.3 volts at 0.45 amps heater ac. Orange, 120 volts dc screen and anode supply, about 30 ma. Green, chassis ground. Brown, not used.

Step 2. Replace black bakelite plug under the chassis with a BNC connector, and label this "Input." Remove coil form L1301.

Step 3. Wind 6-8 turns of No. 20 enameled wire around coil T1302, grounding one end and connecting the other to the BNC connector previously installed.

Step 4. Replace connector J1301 with a BNC connector, and label this "Output."

Step 5. Remove the two pi-wound chokes, one at each end of the chassis along with the red wire that connects the two chokes.

Step 6. Complete the power connections and install the preamplifier in your receiver's antenna circuit. Turn it on, let it warm up, and then peak TI301 and TI302 in the center of the 10 meter band. You may need to use solvent to soften the cement holding the slugs in place, or you will chew up the slot on the coil slug.

Results

This preamplifier should make any surplus or cheap ham receiver come alive on 10 meters. It is quite broadbanded, shows a possible 30 dB gain, and has a very low noise figure. Any questions will be answered if an S.A.S.E. is enclosed. Gud Luck!

. . . WA3HMW

Proper Use of Silicon Rectifier Diodes

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One or two of these tiny components, closely resembling resistors, can do the same job as a large vacuum tube of not too many years ago. They cost less than the tubes, and are more effective. But if abused they can depreciate to zero value in part of a millisecond. What are they?

They are silicon diodes, available on the commercial or surplus markets at very economical prices. Their basic electrical property is very simple: in the forward direction they will pass up to several amperes (for a small silicon diode) at a constant voltage drop under 1 volt. And in the reverse direction they will pass a tiny current. The details of these properties are different for various types and for individual specimens of a given type of diode. Rectifier diode failures in practical applications are directly associated with these two properties of forward conduction and reverse resistance.

The Forward Current Rating

When a diode is in forward conduction, which normally is during the part of each half-cycle when the voltage applied to the diode exceeds the voltage appearing across the filter input terminals, the combined voltage across the diode and the current through it indicate a certain amount of heat energy is released in the diode. In normal operation the diode gets warm.

If the current becomes large enough, the diode may be heated to a point at which it is either unable to resist the reverse voltage appearing during nonconducting parts of its operating cycle, or to a point at which the semiconductor doping atoms begin to migrate to new sites. Either condition is likely to prove fatal, since a breakdown condition or doping atom migration increases diode temperature and resistance.

Once the failure process starts, it develops regeneratively to a catastrophic end. This is why manufacturers are very specific about forward surge and inverse specifications. A key point in forward rating specs is that the diode does have a certain internal resistance, and heat dissipated in this resistance increases as the square of the current. Surges, such as tend to occur when turning on a capacitor-input supply, immediately after an accidental short, or during sideband or photoflash operation, may destroy diodes. See **Fig. 1.** If your power supply consumes diodes at an unreasonable rate, this possibility deserves investigation.

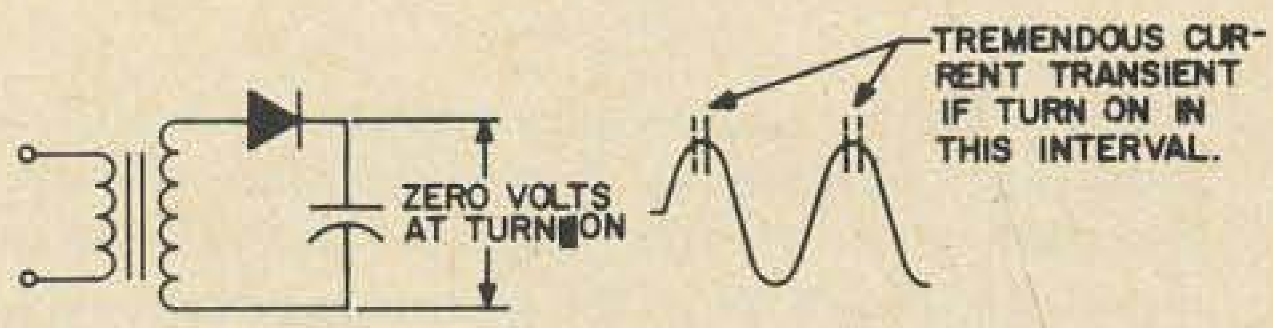


Fig. 1. If a power supply is turned on at the instant the supply voltage is at its peak, the transformer sees a short-circuit and may be required to deliver tremendous amperages through the rectifier diode circuit.

PIV Rating

When a diode fails, the typical conclusion is that its PIV has been exceeded. This conclusion *may* be correct. If the diode's forward current ratings have been given due respect, the possibility of inadequate PIV rating becomes quite likely.

There is an instant during each operating cycle when, if there is any kind of filter, the filter voltage and the applied ac voltage combine to apply a maximum reverse-

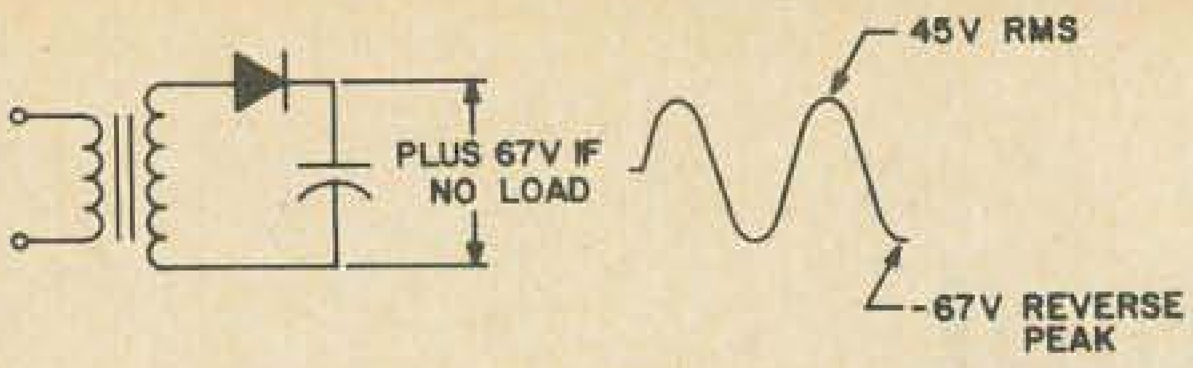


Fig. 2. There is an instant during each cycle in normal supply operation when the diode is facing into full capacitor voltage, with the transformer in back of it exerting an opposite voltage. This is the instant when diode failure from PIV stress is most likely.

voltage stress to the diode. See **Fig. 2**. If the diode is unable to resist the stress it goes into conduction. This is not necessarily fatal, and zeners normally operate in a breakdown mode.

But since there is plenty of power available from the transformer and stored in the filter, a large reverse current flows. The diode becomes very hot, doping atoms migrate, and the junction loses its rectifying properties. It conducts about as well as a piece of wire in either direction. It has failed.

Manufacturer's PIV ratings tend to be realistic, and the ratings of surplus diodes may be optimistic. That is, these ratings are exceeded only with expectations the diode may fail any cycle now – and at 60 hz the failure is generally not very far off.

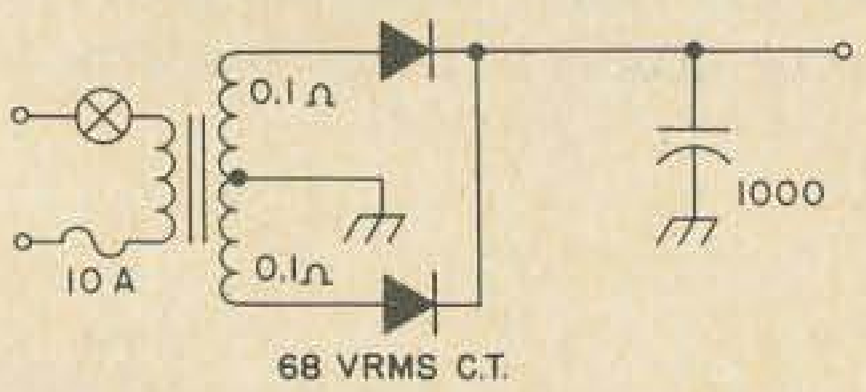


Fig. 3. Real transformers typically have low secondary resistances, if they are high-current transformers, or designed to deliver large amounts of power. This simple circuit will generate current surges on turn on in the hundreds-of-amperes range.

Practical Applications

In Fig 3. is shown a simple power supply for 48V with a large filter capacitor. After several days of operation, it fails. Why is this?

Looking at the schematic, perhaps you think of forward-current overload. This possibility deserves attention, since nothing in the schematic seems provided to limit the forward current upon turn-on, and the fuse is very large. But could the forward current ever be disastrously high?

Suppose the supply is turned on just at the instant the transformer secondary voltage swing is at its peak. At this time the emf is around 75 volts, and it will feed into an empty filter capacitor. This is a short, for practical purposes.

Circuit resistance being around 0.1 ohm here, a surge current of 750 *amperes* might be expected. That's why the primary fuse is so large! A scope test would show real surges of only a few hundreds of amps since the real transformer probably cannot deliver really heavy surges. But it *can* blow 1-amp fuses, and that's what the schematic specifies.

One answer to this problem is a series surge resistor, which is shorted during normal circuit operation. A 1-ohm resistor pares these surges down to 75 amps maximum, and if regulation is not too important, the shorting provision may be omitted. Another answer is a thermistor, which offers a relatively high cold resistance, but as it becomes warm its resistance drops to a low value.

Now let's examine the string of diodes appearing in **Fig. 4**. These diodes are healthy and the supply has been turned on without any harm because you have carefully provided a primary resistor to limit the turn-on current surge. When the voltage across the filter capacitors reaches about two-thirds of full value, a relay shorts the limiting resistor for normal operation. Now, having finished your work, you turn off the supply.

But you notice it makes a rather heavy "thunk!" Feeling suspicious, you turn it back on again, and within seconds the limiting resistor is emitting clouds of smoke. The fuse blows. What went wrong?

Looking at **Fig. 4**, we observe the diodes do not all have the same PIV ratings. Here we have the measured, not the advertised, breakdown voltages. At the moment we turned off the supply, the turn-off transient overvolted the string, and pushed the other string into conduction. Otherwise it would have been a much larger transient, suggesting to us that half-wave rectifier diode strings must be more conservatively designed than full-wave systems.

When the string was overvolted, one or two of its diodes went into reverse conduction, increasing the stress on the remaining diodes. They collapsed like a row of dominoes. The initial breakdown was followed by a powerful reverse current surge as the filter capacitor discharged back through the transformer, producing that "thunk" you noticed. Possibly the surge overvolted the other diode string, and that failed too.

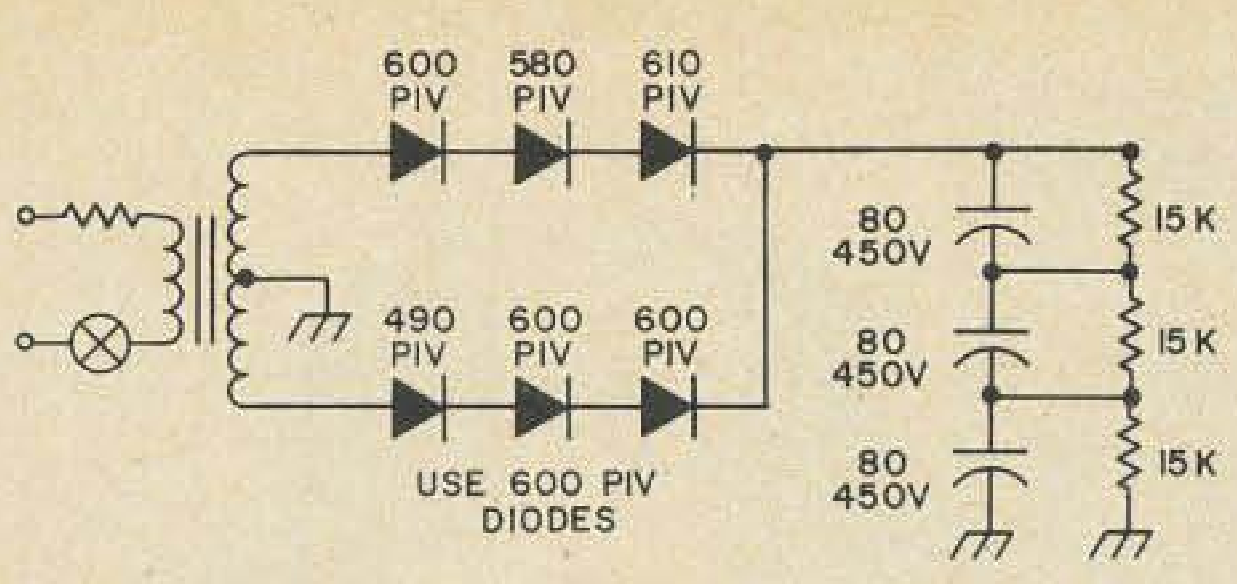


Fig. 4. This circuit may not show very good diode life. Diode PIV s shown are measured; the nominal specification is given in the corner of the drawing, and would be used in ordering diodes.

To avoid this accident, replace the original string with a more conservative arrangement as shown in **Fig.5**. The sum of all the PIVs might be twice the estimated maximum inverse voltage the circuit can generate, and a factor of 2.5 is good practice.

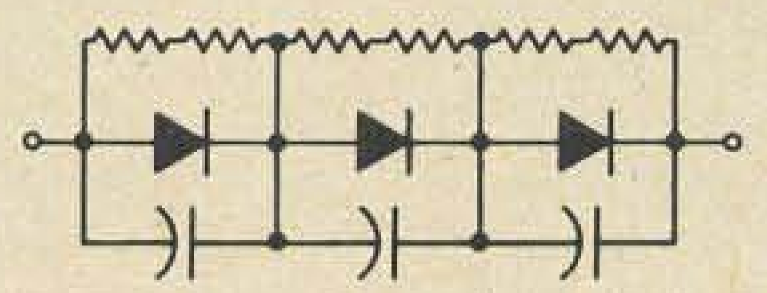


Fig. 5. Revised diode string for improved reliability. The PIV spec has been increased from 600 to 800 volts, and an RC network added to equalize DC and transient voltage stress along the string. Note the network must be connected to every junction between diodes, not just at the ends.

Further good practice is to place resistors and capacitors in parallel with the diodes. The resistors act as a divider to equalize voltage stress along the string for dc and low-frequency ac voltages. The capacitors do the job for the high-frequency transients. This string is now quite dependable.

Full wave CT choke input	No derating necessary
Full wave CT capacitor input	Use only 70% of the current rating
Full wave bridge capacitor input	Use only 50% of the current rating
Full wave bridge choke input	Use only 70% of the current rating
Full wave doubler circuit	Use only 20% of the current rating
Simple half wave circuit	Use only 40% of the current rating

Fig. 6. List giving the approximate current deratings for various types of power supplies.

Other Suggestions for Supply Design

Manufacturers' transformer current ratings are sometimes rather optimistic, or rely upon test conditions not known to you. For a specific application, good practice is to make up a breadboard circuit that will load the transformer in the same way as normal operation in the proposed circuit. That is, if 100 ma load is expected, and a 1000 uf filter capacitor, this is quite different from a resistive load. Making up a complete rectifier circuit, you can check out the resulting system and see how hot the transformer actually becomes. See **Fig.6** for suggested derating of transformers in various power supply applications.

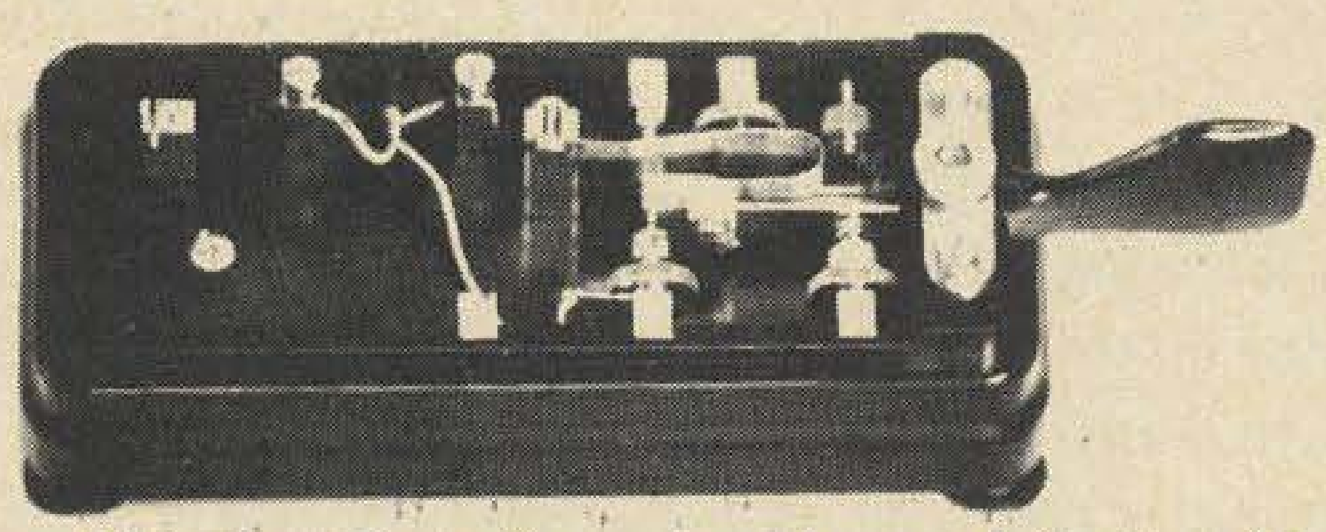
... K3DPJ ■ and WA3ACL ■

First Class Keyer Key

Having built several of the push-em and squeeze-em gadgets used to key todays automatic keyers, I was in doubt as to whether keys made with magnets, polar relays, brass stock and hinges were really worth all the effort. After all of my experimenting I came back to where I probably should have started in the first place. I modified my original bug.

My bug happened to be a Lafayette 99-2552, which sells for $10.95, but it is no different from any other bug. I like it because it has plenty of lead in its belly and rubber suction cups to grab the table.

Here is what I did. First I cut off the vibrating spring and weight end piece with electricians shears. This definitely commits you to the change. Tin snips won't fit down into the space to get at the spring. The two wire original cord was replaced by a three wire lead. The back original terminal is connected to the key lever arm underneath and this connects to the keyer ground. The dash terminal is the forward terminal. Run the third lead over to the left side of the key and fasten under the knurled nut used to adjust the stop. This is now the dot contact and the old dot contact is not used. Check out the key leads with an ohmmeter if there is any question.

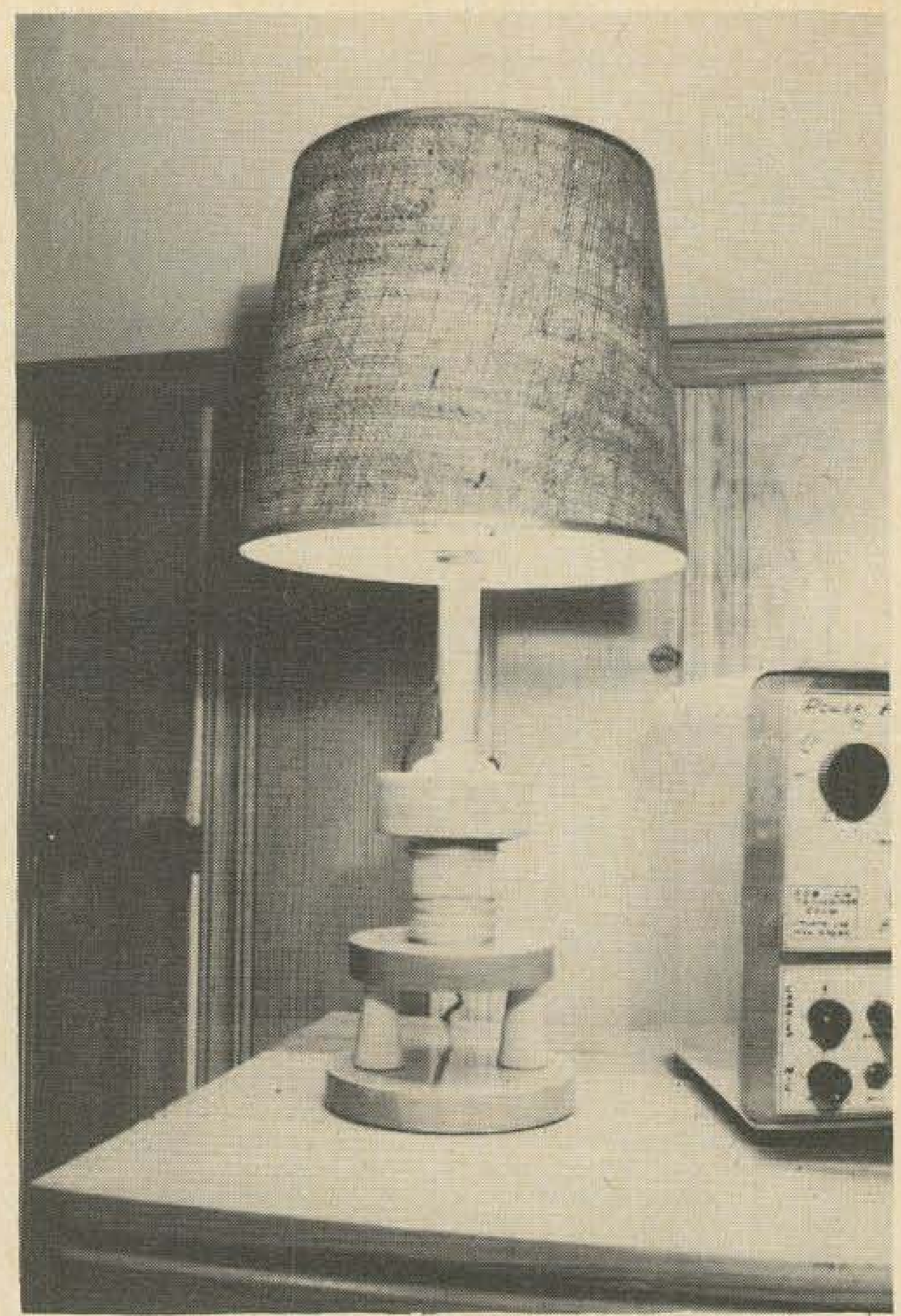


This key has the advantage of feeling like the old bug, but after a few weeks practice with the automatic key you'll never go back to the old bug again. It does take a while to break the old sending habits, but after you hear the dots coming out so much cleaner than those scratchy old bug dots you will never regret the effort spent in learning the new technique.

... Ed Marriner W6BLZ ■

W. F. Stortz K3QKO
5122 Alberta Ave.
Baltimore, MD 21236

Converting the 4CX1000A into Lamp

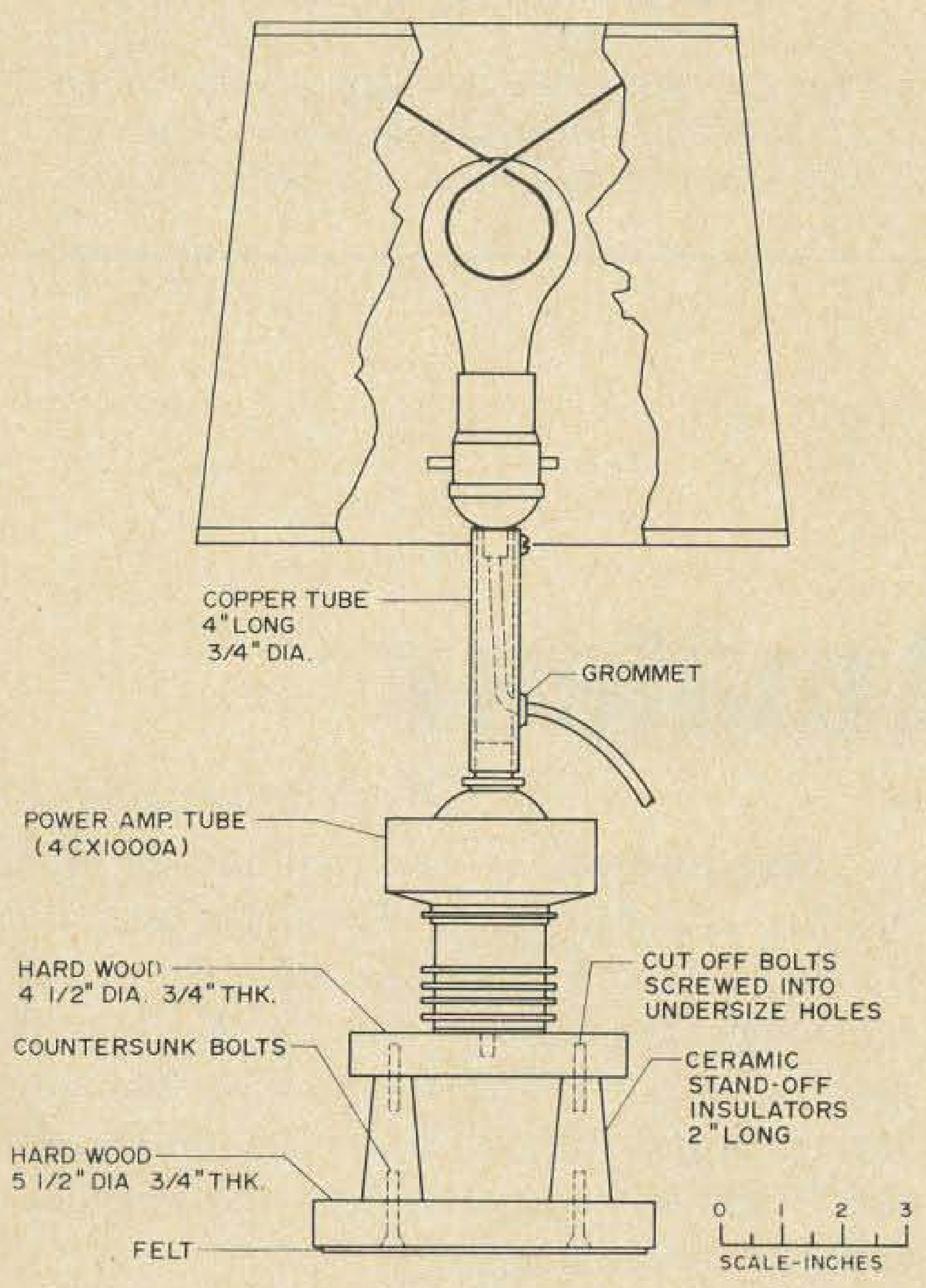

The finished lamp is a real conversation piece.

The average well-read ham knows exactly how to put to effective use his old TV set, burned out transistors, and half shot surplus diodes, but what to do with that $20 to $150 gassy final power amplifier tube presents a problem that almost defies even the most clever homebrewer. You can not just toss such an old friend into the trash can. Besides, who knows, wishful thinkers might expect it to start working again, after a well-deserved rest. Well, instead of storing it in some out of the way place until it's forgotten, here is a way to keep it intact and useful at the same time. Make a lamp out of it. Don't let out with the, "Oh boy, that caps everything" until you read a little farther. This project is very easy and I cannot think of another one more likely to go on without trouble. It will transform the XYL back into the loving wife when she finds that you must depend upon her shopping skill to select a lamp shade that matches the decor of the ham shack.

Construction

Glancing at the drawing (**Fig. 1**) you can see how a 4CX1000A was transformed into a really unusual conversation piece. This method can be used for any tube with a plate cap. The only changes that will have to be made are in the diameter of the copper tube post and the mounting holes in the base. All the connections to the power tube are press fit so as not to damage it. I could not get up courage enough to drill into such a magnificent dud; besides, the appearance of the lamp is enhanced with the tube showing signs of being in mint condition. The wood discs in this case were made of maple but only because there were two small pieces available. Any hard wood will do but it must be finished to as neat a polish as possible in order to provide the proper setting for the tube. After shaping and drilling, the bases should be sanded to remove all scratches with 200 grit garnet paper. Staining them to the color indicated by the wife is accomplished with ease using a Kleenex to wipe it on. The final finish is a coat of clear plastic spray that can be picked up at the variety store when you buy your socket and wire. The copper tube post likely will not fit the plate cap. In the case of the 4CX1000A the tube had to be expanded a little by driving a greased socket from a wrench set into it and then doing a bit of

Fig. 1. Diagram of lamp construction.



scraping with a penknife. In other cases it might require some type of filler, but select a tube of a diameter where the least amount of modification is required. A great deal of strength of connection will not be necessary. The socket can be mounted as shown in **Fig. 1** or a complete lamp socket kit can be obtained from the variety store that contains many cork bushings that can be used to adjust the diameter of the socket mount so it will fit almost any size tube. After completion, the copper post is polished with steel wool and along with the other metal parts is sprayed with clear plastic to prevent tarnish.

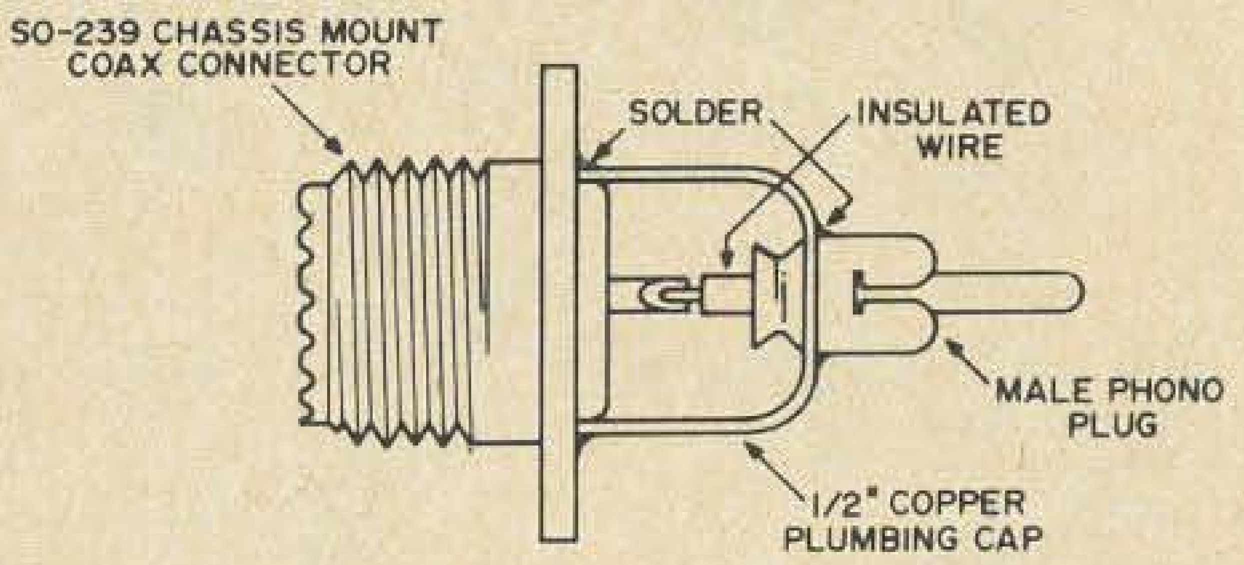
The effort of converting your defective power amplifier tube cannot in any way be in vain. If your wife returns to the XYL role and orders the thing out of the house because there is no place to plant Philodendron in it, pen your call in some prominent place and give it to a deserving chap to take to college with him. There certainly will not be a more "Now" lamp at the school and you will enjoy the bravos of the artistic world with Michaelangelo and Salvador Dali.

. . . K3QKO

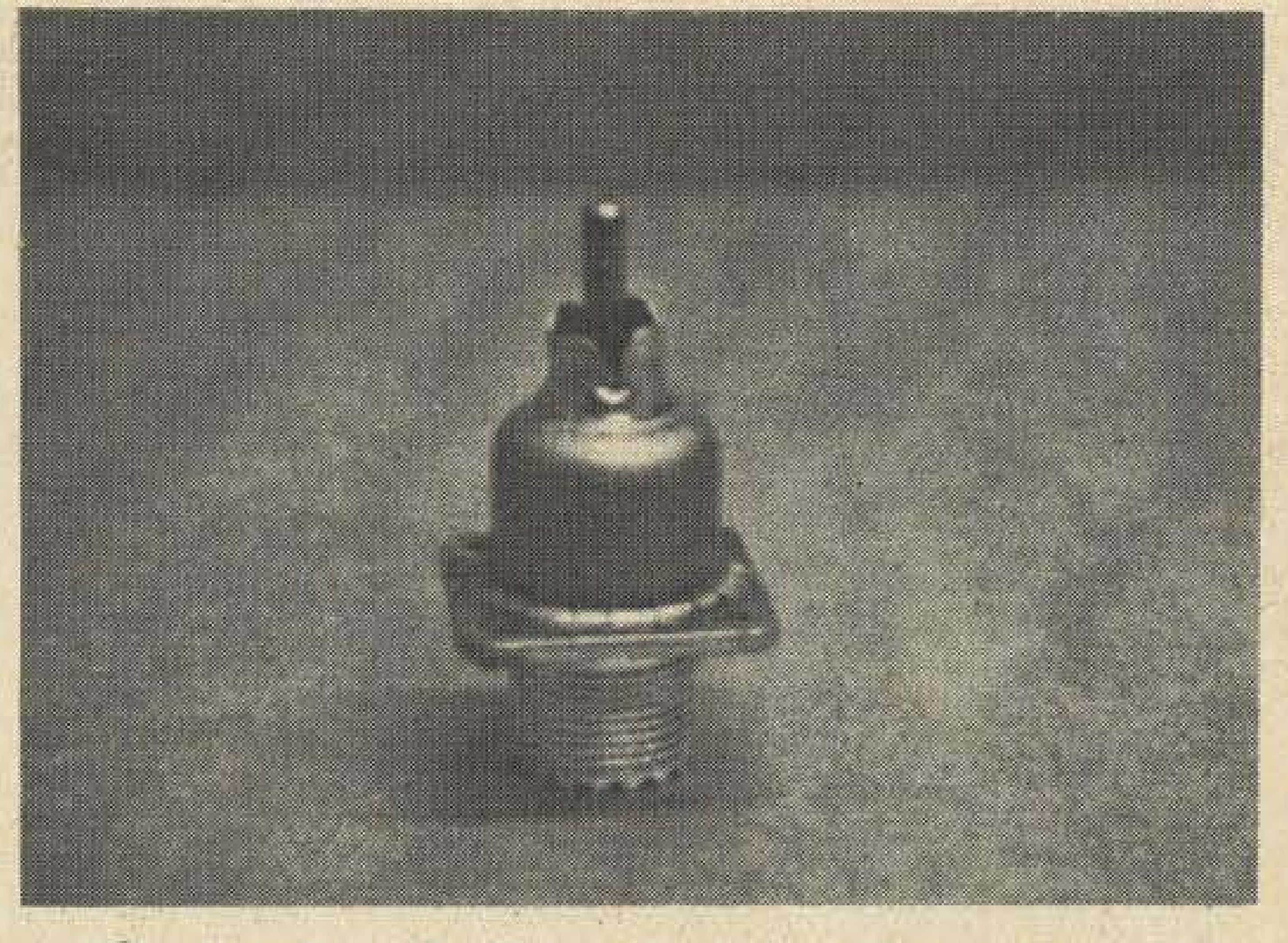
Coax to Phono Plug Adapter

Several pieces of ham gear, notably Heathkits, use a phono connector for the antenna terminal. While these work well, most ham stations are set up to use coaxial terminations, and adaptors for this type of plug are not readily available.

An inexpensive adapter can be made using an SO-239 coax fitting, a phono plug and a ½" diameter copper plumbing cap. The results are a structurally rugged adapter with electrical properties considerably superior to the usual "plug dangling at the end of the connector" type that are so common!



Drill a 3/8" hole in the copper end cap and solder the phono plug in place. Snip off about 1/8" of the coax terminal, to prevent it from shorting to the phono plug when the unit is assembled. Solder a 3" length of insulated wire to the terminal, and pass it through the phono plug. Solder the copper cap to the coax fitting, then solder the wire to the phono plug. Check with an ohmmeter to make sure there are no shorts between the center conductor and the outside of either fitting.



Originally, I intended to file away the flange around the coax fitting, but later found it to be an advantage as it provides a firm finger gripping surface when attaching and detaching the adapter.

The total cost of the adapter, using all new components, came to sixty cents.

Bud Michaels, WB2WYO

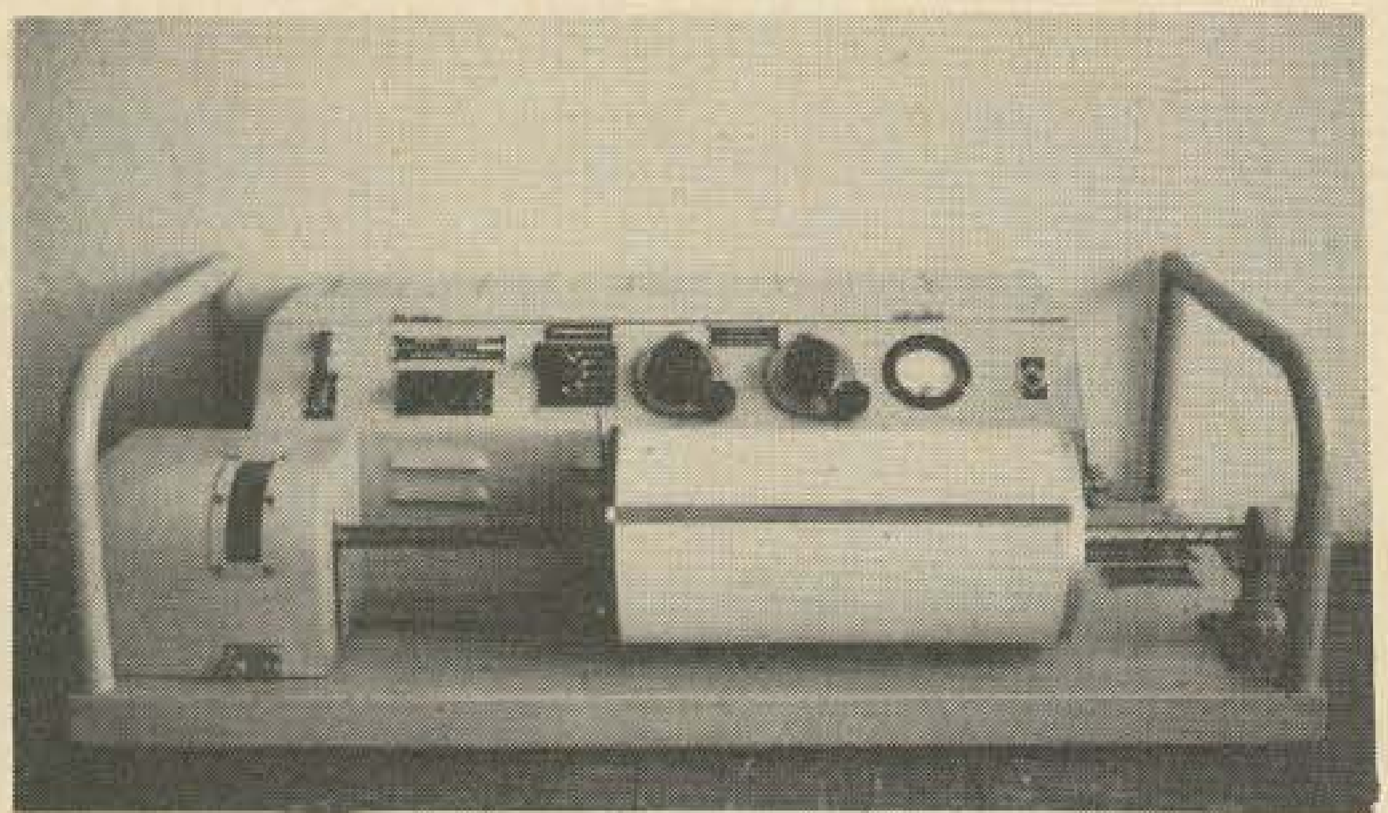
The death of Ralph L. Steinberg in September was a loss to 73 and its readers. His articles have always been of unusual interest, and all of us extend our sympathy to his wife, Lillian.

Facsimile and the Radio Amateur

Ralph Steinberg K6GKX

In the December 1968 issue of *73*, this author made mention of several pieces of facsimile equipment which were used in the summer of 1968 to transmit pictures to the Antarctic. Since then many requests have been received to give more details about the equipment and operations.

To get better acquainted with facsimile, this review will cover some of the mechanical and electronic operations of the TXC-1B facsimile transceiver, MD-168/UX modulator, RD-92/UX recorder and the CV-1066A (CV-172A/U) receiving converter. These are necessary for receiving and transmitting at any facsimile station.



TXC-1B Facsimile Transceiver

This transceiver is quite versatile and can receive photos, sketches, maps or any printed matter either by electro-mechanical optical or stylus needle operation and also record photographs in either negative or positive form. For transmitting, it will handle four 5 x 7 or two 8 x 10 inch photographs in one operation. Color pictures may be transmitted but all reproduction is in black, white or shades of gray.

Three operations are required in transmitting and recording. These are scanning, transmitting,and recording. (See **Fig. 1**) The scanning operation is that of dividing the picture into a large number of elemental segments and this process is accomplished in the facsimile transmitter by a scanning drum and photocell arrangement.

The picture to be transmitted is mounted on a cylindrical drum, which revolves at a revolution speed of once per second and travels along a lead screw (96 threads per inch) at the rate of 12.5 inches in 20 minutes. Light from the exciter lamp illuminates a small segment of the moving picture and is reflected by the picture through an aperture to a photocell. The amount of light reflected back to the photocell is a measure of the light and dark segments of the picture being scanned. During the transmission of a

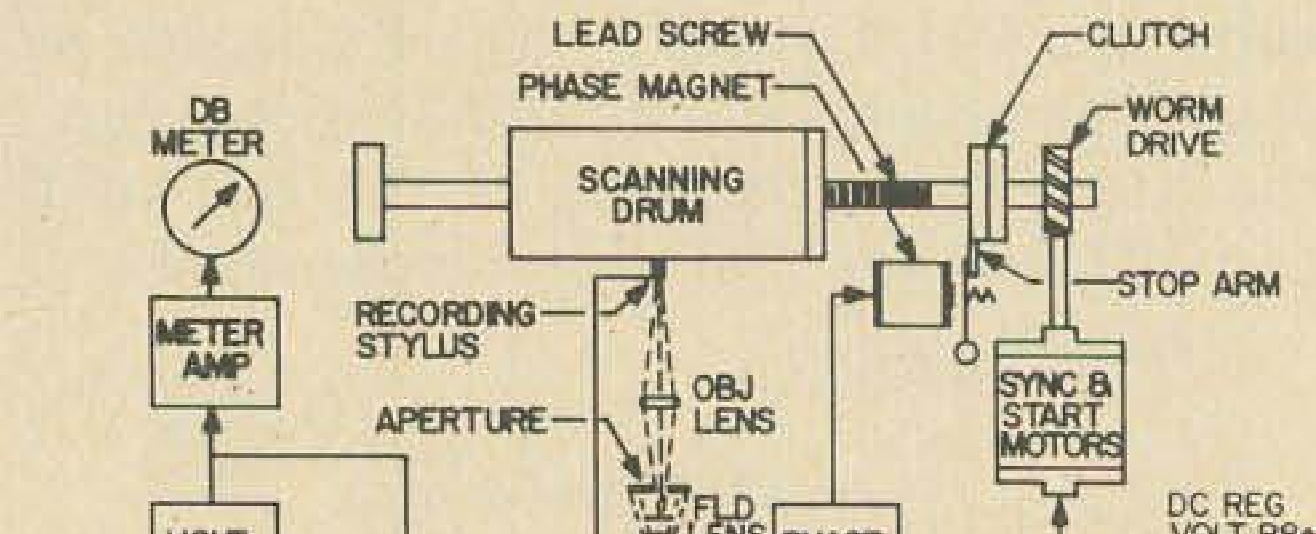


Fig. 1. Receiving block diagram, facsimile transceiver TT-1/TXC-1.

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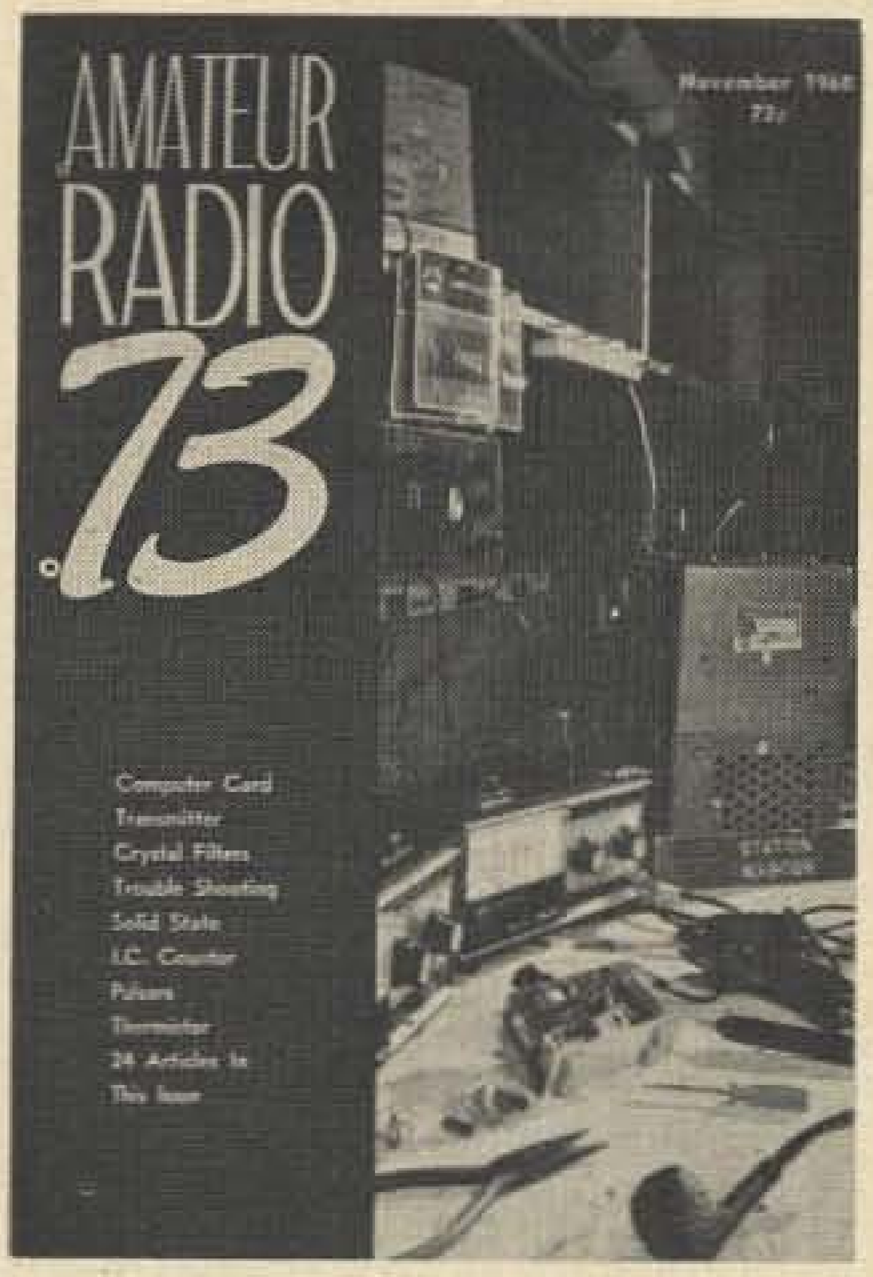

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complete picture, this light traverses every portion of the picture as the drum slowly winds around past the fixed lighted area. The reflected beam of light into the photocell, creates voltage variations into the output circuit and establishes the picture signal.

Signals being received by the facsimile transceiver are amplified and serve to activate a recording mechanism that makes a permanent record on the sensitive recording paper and at the same time synchronizes the transceiver drum until the complete picture is reproduced. Synchronization is obtained by driving both the receiving and the transmitting drums with synchronous motors operating at exactly the same speed. The drums can be operated at 30,60,or 120 rpm. The older type models are usually operated at 60 rpm but the newer models operate mostly at 120 rpm.

Framing (positioning) the receiving drum with respect to the transmitter drum, at a distant station, is done by transmitting a series of phasing pulses just before a picture transmission is to begin. The pulses operate a clutch mechanism that starts the scanning drum in the transceiver so that it is properly phased with respect to the starting position of the scanning drum in the transmitter.

A start motor mechanically coupled to the synchronous motor serves to increase the synchronous motor speed above synchronism during the starting period after which it coasts down to synchronous speed when operating on 1800 hz power.

The facsimile signal from the radio receiver is attenuated at the gain control of the facsimile transceiver and then amplified in the voltage and power amplifiers. The power amplifier output drives either the photographic recording or the recording stylus for direct recording. Another circuit from the power amplifier transmits phasing pulses to the phase amplifier, which operates the phase magnet and clutch during the phasing process just before each picture transmission.

The fork oscillator unit develops an output voltage that is applied across the bridge modulator. The frequency of this voltage is 1800 hz. When the bridge is balanced (photocell dark), the output voltage is zero. When the amount of light falling on the photocell varies, the resistance of the cell varies. This action unbalances the bridge and produces an output voltage that varies in amplitude with the variations in light. Thus, the 1800 hz voltage is amplitude modulated in the bridge modulator.

MD-168/UX Modulator

This modulator is designed to convert amplitude modulated facsimile signals from the TXC-1B transceiver to frequency modulated signals.

The input signal to the modulator has a frequency of 1800 hz and an amplitude that varies with the light and dark segments being scanned at the facsimile transmitter. The output signal from the modulator is an audio signal in which 1500 hz represents the maximum signal (in amplitude) and 2300 hz represents the minimum signal input to the modulator from the facsimile transmitter. Amplitudes between maximum and minimum signals are changed to corresponding frequencies between 1500 and 2300 hz. Since the audio frequency shift signal from the modulator is of constant amplitude, the emitted radio frequency carrier is modulated at a constant percentage of modulation.

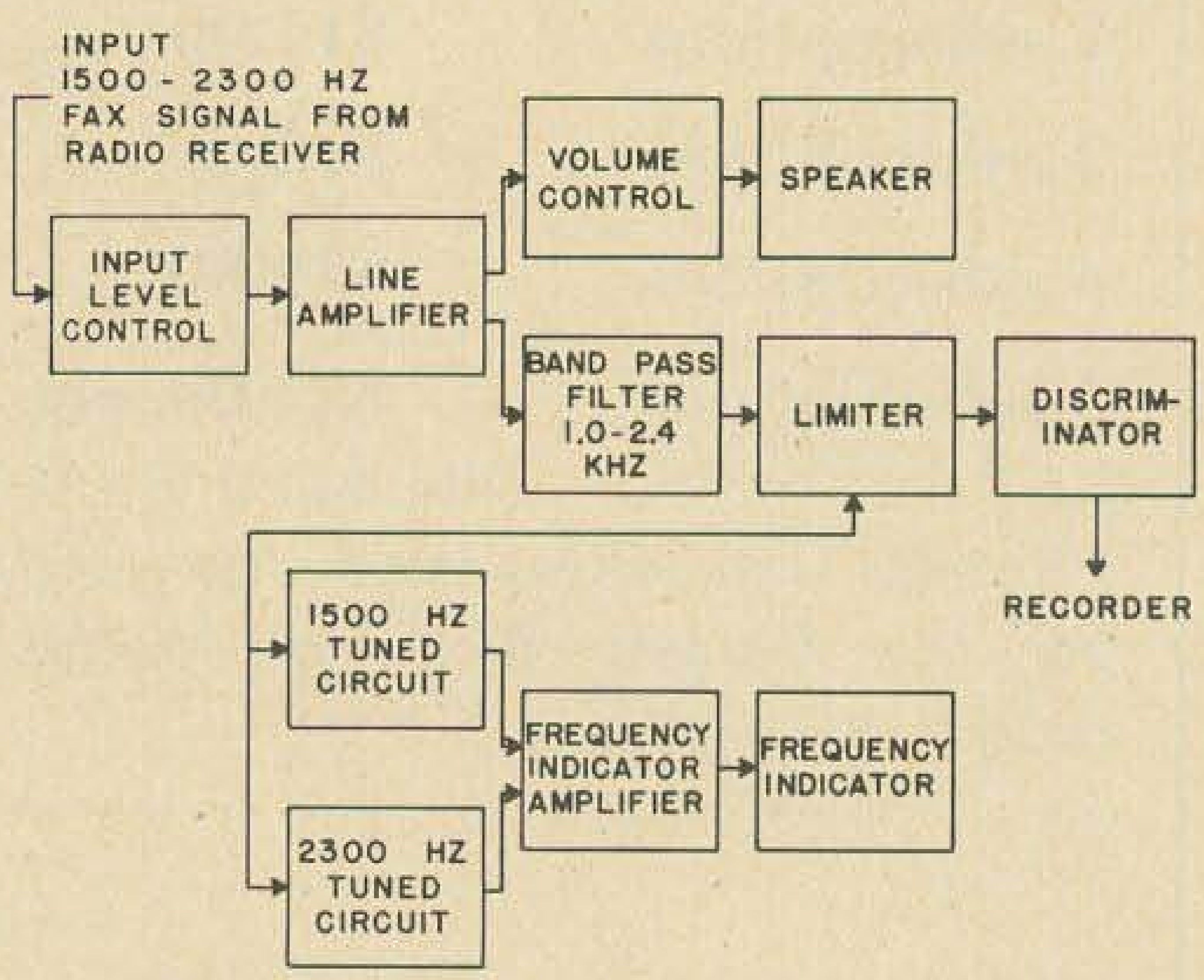
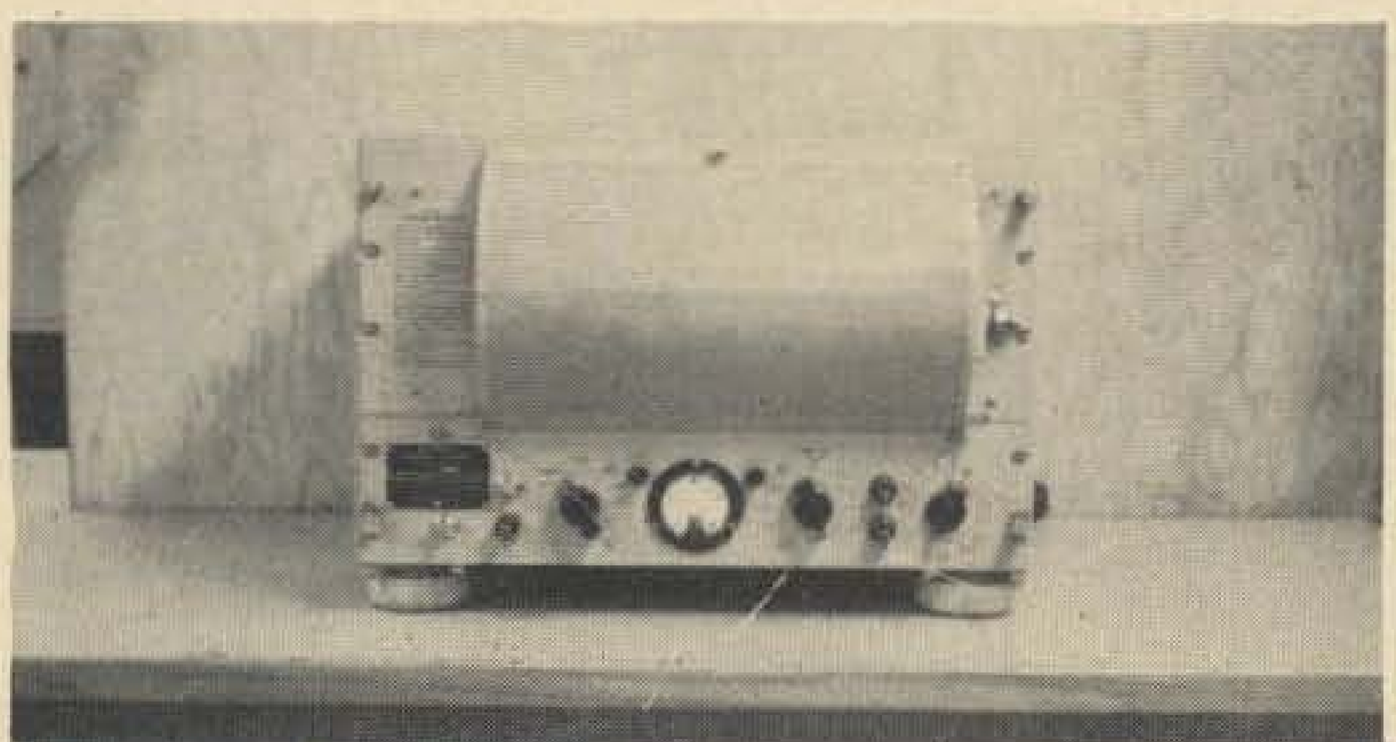


Fig. 2. Block diagram of CU-172A Converter.

CV-1066A (CV-172A/U Converter)

This converter is used to convert the 1500 to 2300 hz facsimile signals received from a radio receiver to AM signals suitable for operating the facsimile recorders like the RD-92A/UX or the TXC-1B facsimile transceiver.

The facsimile signal from the radio receiver is fed through an amplifier and filter to a limiter and then through a frequency discriminator. The discriminator is a low-pass filter having a cutoff frequency of 1500 hz. The output of the filter at 2300 hz can be adjusted to be from 10 to 20 db lower than the output at 1500 hz. The input signal is then changed from audio frequency shift signal of substantially constant amplitude to an output signal of varing amplitude in which the maximum amplitude is 10 to 100 times the minimum amplitude. See **Fig. 2.**



RD-92A/UX Facsimile Recorder

The RD-92A/UX recorder will make copies of recordings transmitted by the TXC-1B facsimile transceiver or equipment having the same transmission facilities. See photo. It has some similarity to the TXC-1B transceiver in that both are able to use the stylus needle for recording. Recording by the RD-92A/UX is done by rotating a drum at constant speed, while feeding a stylus needle along the drum, one scanning line for each revolution until the complete drum has been covered.

An amplifier-detector unit receives the input facsimile signal. This signal, consisting of phasing pulses and facsimile information (messages, drawings, maps, etc.) between the frequency limits of 900 and 2700 hz, is amplified by a class A amplifier and demodulated through the action of a full wave rectifier and low-pass filter to form a varying dc facsimile signal. The varying dc facsimile signal output of the amplifier-detector is coupled to the amplifier modulator where it combines with a 15 hz oscillator in the modulator stage.

The signal from the amplifier modulator is amplified by the print driver and amplifier to sufficient intensity, so that, when connected to the stylus needle in the recording mechanism assembly, it will record on the

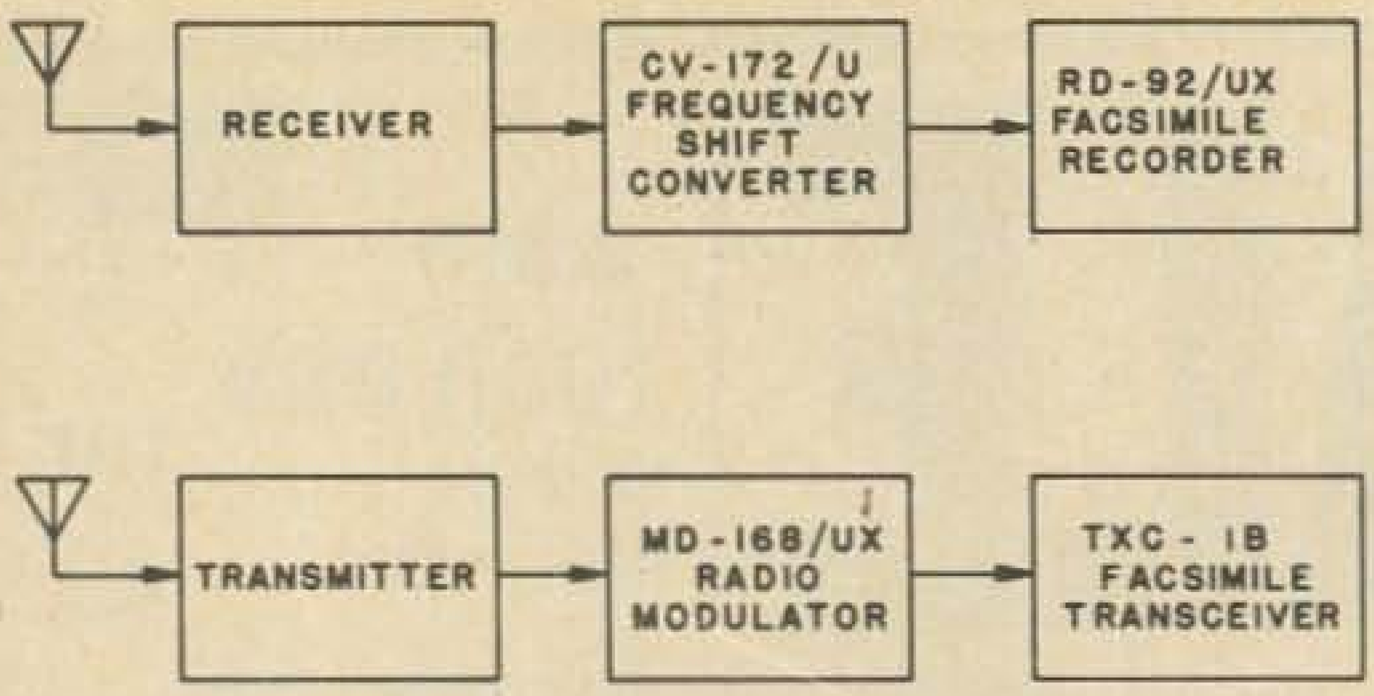


Fig. 3. Block diagram of the transmitting and receiving facsimile equipment.

recording paper points representing varying shades of dark elements of the transmitted copy.

The RD-92A/UX recorder is used aboard ships to receive weather maps and information. It can copy recordings 12 x 18 x 3/4 inches. The input impedance is 1600 ohms and the drum speed is at 60 rpm.

Applications

For amateur radio facsimile operations, the TXC-1B facsimile transceiver can be used on any of the vhf, uhf or microwave bands using either AM or FM modulation. If AM modulation is used, all that is necessary is to plug the facsimile transceiver into the input of the modulator of your transmitter. If FM is to be used, it will be necessary to have the MD-168/UX modulator in the place of your present modulator.

To receive facsimile, either the TXC-1B facsimile transceiver or the RD-92A/UX recorder can be used but it is necessary to use the CV-1066A (CV-172A) receiving converter. See **Fig. 3** if you wish to copy the weather stations in all parts of the world. All of them use frequency modulation. Copying weather maps (see **Fig. 4**) is good experience to become proficient in facsimile operations. Once you get the knack of it, you can be your own weather man.

Weather stations are located in San Francisco, Washington, D.C., Pearl Harbor, Guam, Tokyo, Kodiak, Alaska, Edmonton, Canada, New Delhi, India, Canberra, Australia, Khabarovsk (USSR), and Cambridge Bay, N.W.T. For time of transmission and frequencies of these weather stations (**Fig.5**). There are others in England, Germany, Turkey, Sweden, Spain, Norway, Morocco,

Call	Location	Frequency	Time of Transmission (GMT)
NHB	Kodiak, Alaska	2356 khz	0600-1800
		4825 khz	0600-1800
		8622 khz	Continuous
		12817.5 khz	1800-0600
		17045.6 khz	1800-0600
VFE	Edmonton, Canada	5360 khz	0000-2400
		8184 khz	0000-2400
		11615 khz	0000-2400
		15770.5 khz	0000-2400
NPG	San Francisco, Calif.	3268 khz	Continuous
		5345 khz	Continuous
		9455 khz	Continuous
		14927.5 khz	1500-1000
		18080 khz	1800-0600
		21785 khz	1800-0600
NSS	Washington, D.C.	3357 khz	Continuous
		4975 khz	0000-1030
		8080 khz	Continuous
		10865 khz	2300-1900
		16410 khz	0515-0000
		20015 khz	Continuous
RXB	Khabarovsk, U.S.S.R.	3980 khz	0000-2400
		4516.7 khz	0000-2400
		6870 khz	0000-2400
		7475 khz	0000-2400
		9230 khz	0000-2400
		14737 khz	0000-2400
JMH	Tokyo, Japan	3622.5 khz	0000-2400
		7305 khz	0000-2400
		9970 khz	0000-2400
		13597 khz	0000-2400
		18220 khz	0000-2400
		22770 khz	0000-2400

Call	Location	Frequency	Time of Transmission (GMT)
RJTZ	Tokyo, Japan	3205 khz	Continuous
		5960 khz	Continuous
		6940 khz	Continuous
		7938 khz	Continuous
NPM	Hawaii, Pearl Harbor	2122 khz	Continuous
		4802.5 khz	0600-1800
		9440 khz	Continuous
		13862.5 khz	Continuous
		16400 khz	1800-0600
AXM	Canberra, Australia	2628 khz	1000-2200
		5100 khz	1000-2200
		11030 khz	1000-2200
		13920 khz	1000-2200
		19690 khz	2200-1000
VFC 3	Cambridge Bay, N.W.T.	3253 khz	0215-0415
		7710 khz	1515-1715
NPN	Guam, M.I.	2554 khz	0900-2200
		3377.5 khz	All Schedules
		4975 khz	All Schedules
		6460 khz	All Schedules
		7645 khz	All Schedules
		9960 khz	All Schedules
		10255 khz	All Schedules
		10966 khz	All Schedules
		13807.5 khz	All Schedules
		15930 khz	All Schedules
		18620 khz	1900-1200
		20925 khz	All Schedules
		22865 khz	All Schedules
		23880 khz	All Schedules
WMH	San Francisco, Calif.	13642.5 khz	1800-2400
		15982.5 khz	2000-0400
WMI		10190 khz	0400-1800

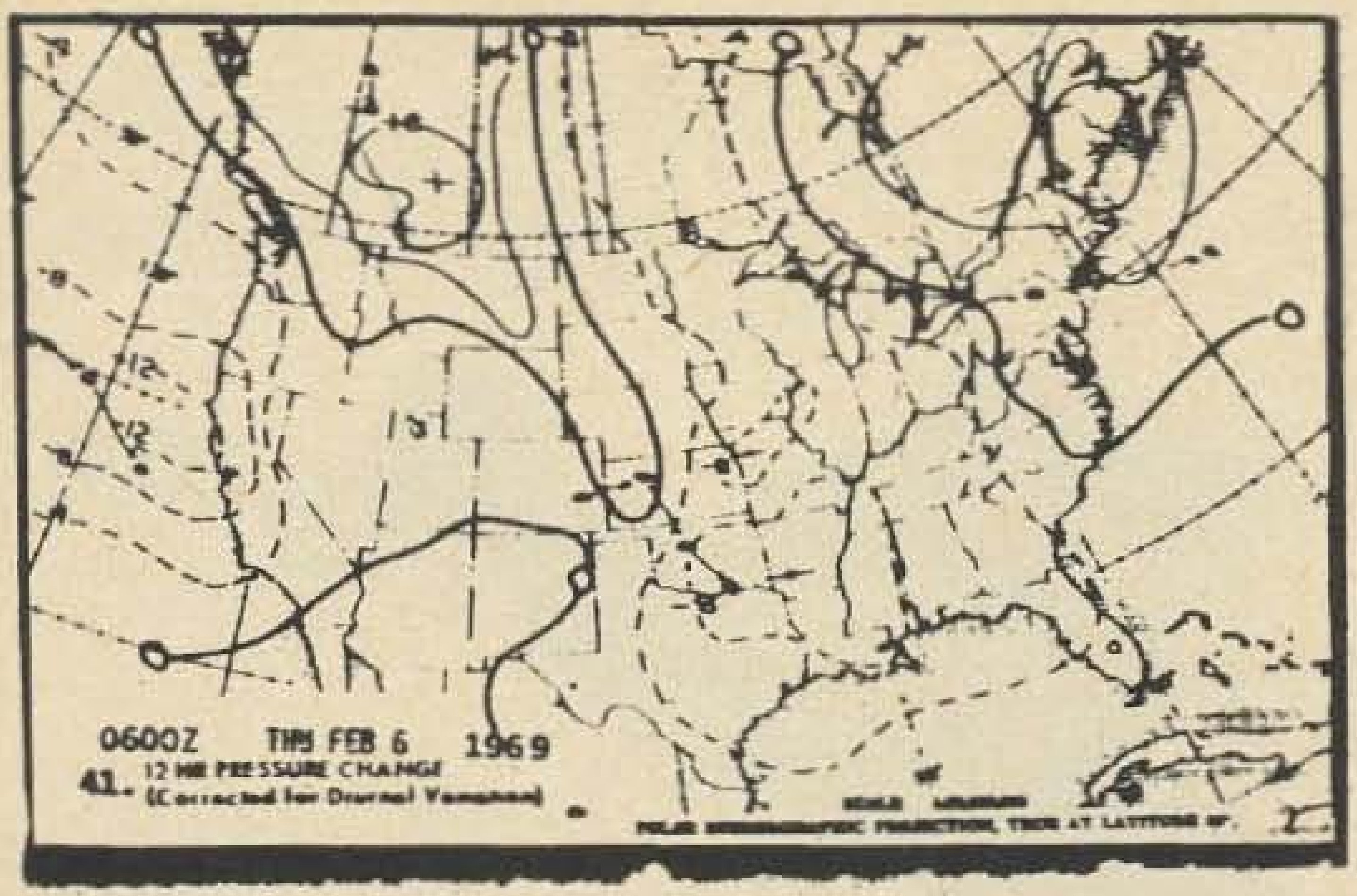


Fig. 4. A typical weather map.

Cypress and Argentina but frequencies, call letters and time of transmissions were not available at this time.

Facsimile is growing more popular each day. Here in the Southern California area there are twelve stations operating and several more have equipment and will be operating soon.

. . . K6GKX ■

Mr. Steinberg's articles have been popular with 73 readers—so much so, in fact, that the author frequently found himself engaged in correspondence with his fans long AFTER publication. His untimely death, of course, cut off this correspondence flow. Mrs. Steinberg has, therefore, submitted a few of Ralph's recently received letters to 73, with the thought that perhaps they might be answered by another amateur knowledgeable in the field:

Dear Ralph,

Recently read your article in June issue of 73. I agree with you on FAX. It was a short article and very practical. I enjoyed it and must compliment you on it. I'm with the SSTV gang that meets on Saturdays at 2 p.m. (New York time) at 14.230 MHz. Please send me as much information as you can on FAX (self-addressed stamped envelope enclosed).

Philip J. Lupi WA2NHH
1225 Hillside Place
North Bergen, J. J.

Dear Mr. Steinberg:

I just found your article in the June '67 issue of 73 Magazine about the TS34AP. I have just acquired a good TS34 without the lens or hood (not modified as in your article). Do you know anyone who has made the conversion recommended by you—who still has the lens and hood and would sell them? I used one of these scopes once and would rather have the original configuration.

David Potter
2844 San Gabriel
Austin, Texas 78705

Dear OM:

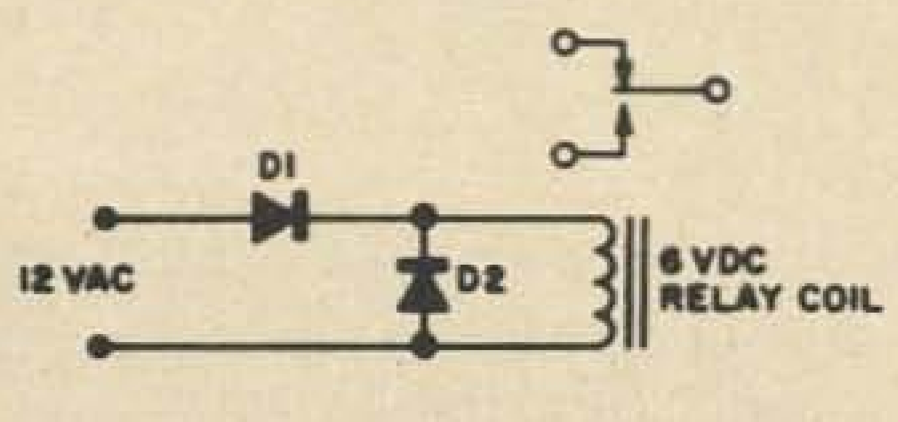
My friend Ted Cohen, W4UMF, told me about your activities in FAX. Because I am working FAX some years now and have been unable to contact some boy in the States, I ask for your help.

In past time, I contacted W2BK (Ray P. Clurmann), but recently I have been unable to establish contact with Stateside amateurs. I would like to know the systems and schedules of operation so that I may attempt a FAX QSO with you. I particularly need to know if you Americans can use the HF bands to work FAX. I regularly work 14087 kHz in FM mode (FSK), with Cooperation Index 576 or 288, positive or negative transmission, 30, 60, or 120 rpm. Some time back, I copied transmissions from States to Antartica with medium success. Is there a possibility that I might join you in FAX activity?

Ing. Hernando Vargas Martinex HK7XI
Ingenieria Electronica y Communications
Carrera 35 No. 52-75
Bucaramanga, Colombia, S. A.

USE DC RELAY ON AC WITH DIODES

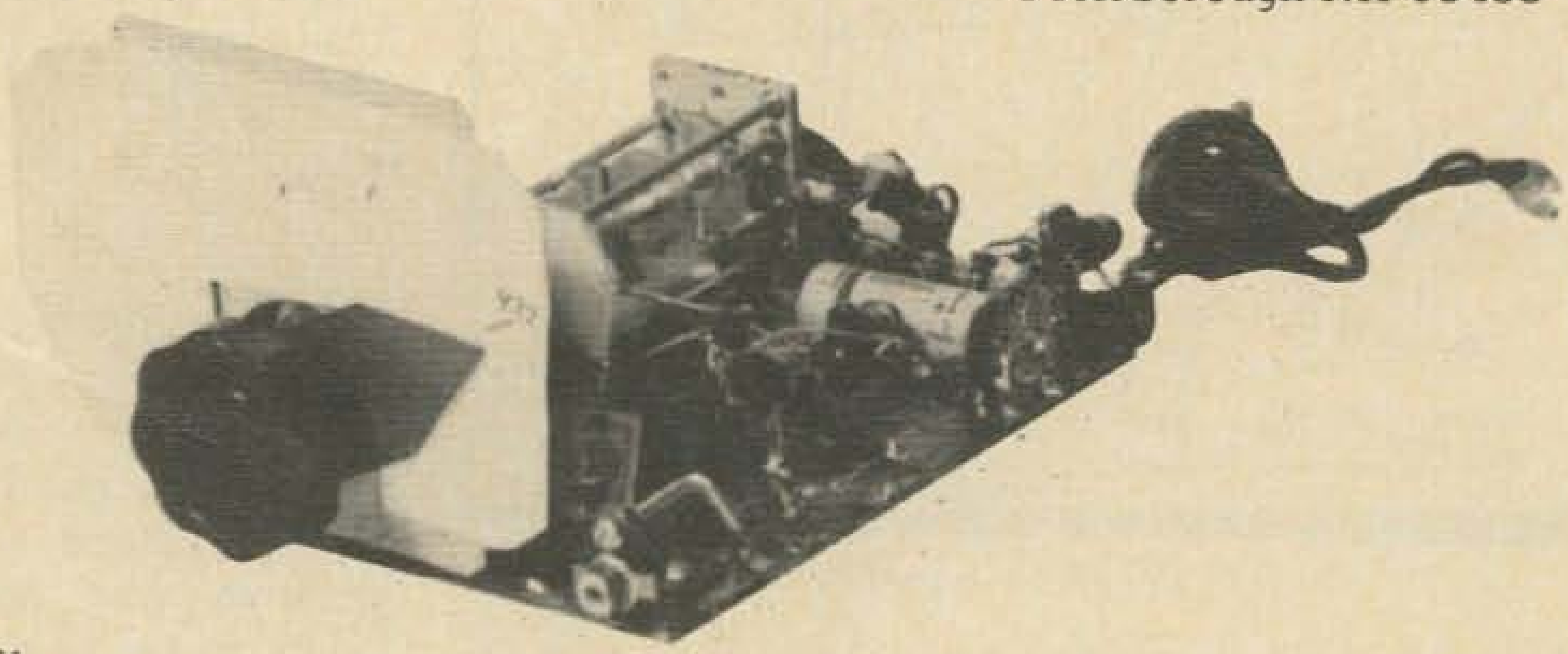
Another good way to use diodes is shown below. I needed to run a 6 vdc antenna changeover relay on ac. This is how I did it.



On the positive half cycle, diode D1 conducts, passing current through the relay coil, which builds a magnetic field. On the negative half cycle, this field collapses, and the resulting current is passed through D2, which shorts the ends of the coil together for the negative half cycle. You will note the current always flows through the coil in the same direction. Thus the relay operates as if it were on pulsating dc. In operation, there is almost no audible noise from the relay coil.

Edward Lawrence WA5SWD/6 ■

William Hoisington K1CLL
Far Over Farm
Peterborough NH 03458



Solid State Double Bandwidth Tunable IF Solid State Converters

This may sound like a lot of "solid state" but it does help get the idea over that there are plenty of battery-operated vhf and uhf converters on the market, but what are you going to hand-carry for a tunable i-f on that mountaintop or while camping?

Of course you can put your communication set in your car, haul an ac putt-putt along, drag it 100 feet away from the car, and *go*. It is peculiar though, the dim view Forest Wardens take of this racket going on all day Sunday with all those visitors around each paying 25¢. I did this for years and often had to lug the generator 100 feet *down* the mountain top on the side to keep it quiet.

So, our tunable i-f will help this situation, working on your favorite band, six, two, 432, or 1296 mhz, and even 2400 a little later.

Ten meters is used because that gives you a nice ten meter receiver for portable use, and when you're on 432, or 1296 you need at least 30 mhz to keep the image down.

Design Philosophy

This is a straightforward job with one rf stage, a mixer, and an oscillator, all tracking on a three gang capacitor from 28 to 30 mhz. See **Fig. 1**.

"Bipolar" (which means just the old-fashioned, regular triode type with three leads) transistors are used to keep down the cost and time of construction.

An S meter connection is shown because when you're using that high gain sharp beam up there, it's nice to know just where it does peak! And by how much, even if it's only relative.

General Notes

At this frequency, 28 to 30 mhz, almost any good vhf transistor does a good job. There is gain in the converter ahead, and gain in the i-f following, so you don't need much here. Once again, though, you do need tracking. There is a whole section on a painless method for doing this in this article.

The main tuning (or ganged) coils are all wound identically, to help in tracking, and with the exception of the oscillator collector, all other circuits are lightly coupled to them.

L1 brings in the first i-f from the 6, 2, 432, or 1296 converter, at 28 to 30 mhz on J1. If you just happen to put almost any kind of antenna into J1 you may be surprised at the ten meter signals you hear. Just incidental.

Note that for the sake of uniformity and ease of wiring all eleven coils are returned to ground on one side. This accomplished by dc blocking capacitors from the bases, which are dc fed by resistors, and by the use of the

L1	3 turns, no. 28 DCC, close wound on ground end of L2.
L2	17 turns, no. 26 DSC, on 6/32 tapped form, 5/32 O.D., with 6/32 threaded, powdered iron core.
L3	2 turns, no. 28 DCC, as L1.
L4	2 turns, wound close on L5.
L5	As L2.
L6	3 turns close wound on L5.
L7	4 turns on L8.
L8	As L2.
L9	2 turns on L8.
L10	1 inch long iron core, 5/32 OD wound for 2 mhz, two pi.
L11	4 turns on middle of L10.

Table 1. Coil turns.

collector dc voltage being at the baseboard level. Note that by this method most bypass capacitors are eliminated.

The copper-clad baseboard also makes it easy to ground all coils on one end. The capacitors are all the 1000 pf little ceramic jobs from Lafayette, 3/16ths of an inch square. C1-A, B, and C was a Bud three gang with 11 pf per section. For this unit, I removed one rotor plate from each of the three sections, and also spread the 28 to 30 mhz tuning range over 80 percent of the dial.

If you have a converter or converters having other than 10 meter outputs, you can change the coils to suit. The main reason here for choice of 10 meters was the large number of "amateur band receivers" with 10 being the only band with nearly 2 mhz tuning range. This should cause converters with 10 meter outputs to be in the majority, although I have not checked with converter manufacturers on this.

All transistors just happen to be Sprague 2N1726 (four years old right now) but you can use almost any good vhf ones, as the noise figure and gain are set elsewhere. The main deal here is to *tune* something so you can use crystal control for the uhf local oscillator where it is needed.

No critical points were found in the tune-up of this unit. For permanent use, installation in a Minibox should be used, matched to your favorite dial.

Summing up, this article is to show you how easy it is to make a good, low cost solid state, tunable i-f section as a necessary part of battery operated rigs for 6, 2, 432, and 1296 mhz. After all, isn't it better to be up on a mountain in the summer, and on the air, than to sit in the shack all the year round?

Details—RF Stage

The rf stage (refer to **Fig. 1**) has a tuned circuit in the base, with an untuned collector brought over to the mixer on L7. As detailed in the tracking section, the iron core is used to set the low frequency end of the tuning and the trimmer C2 sets the high frequency end. Trimmers C2, C6, and C11 also serve to spread the 2 mhz range over the dial. Battery voltage is high on the collector end of these stages which makes things a lot easier, especially for bypassing, as you will see.

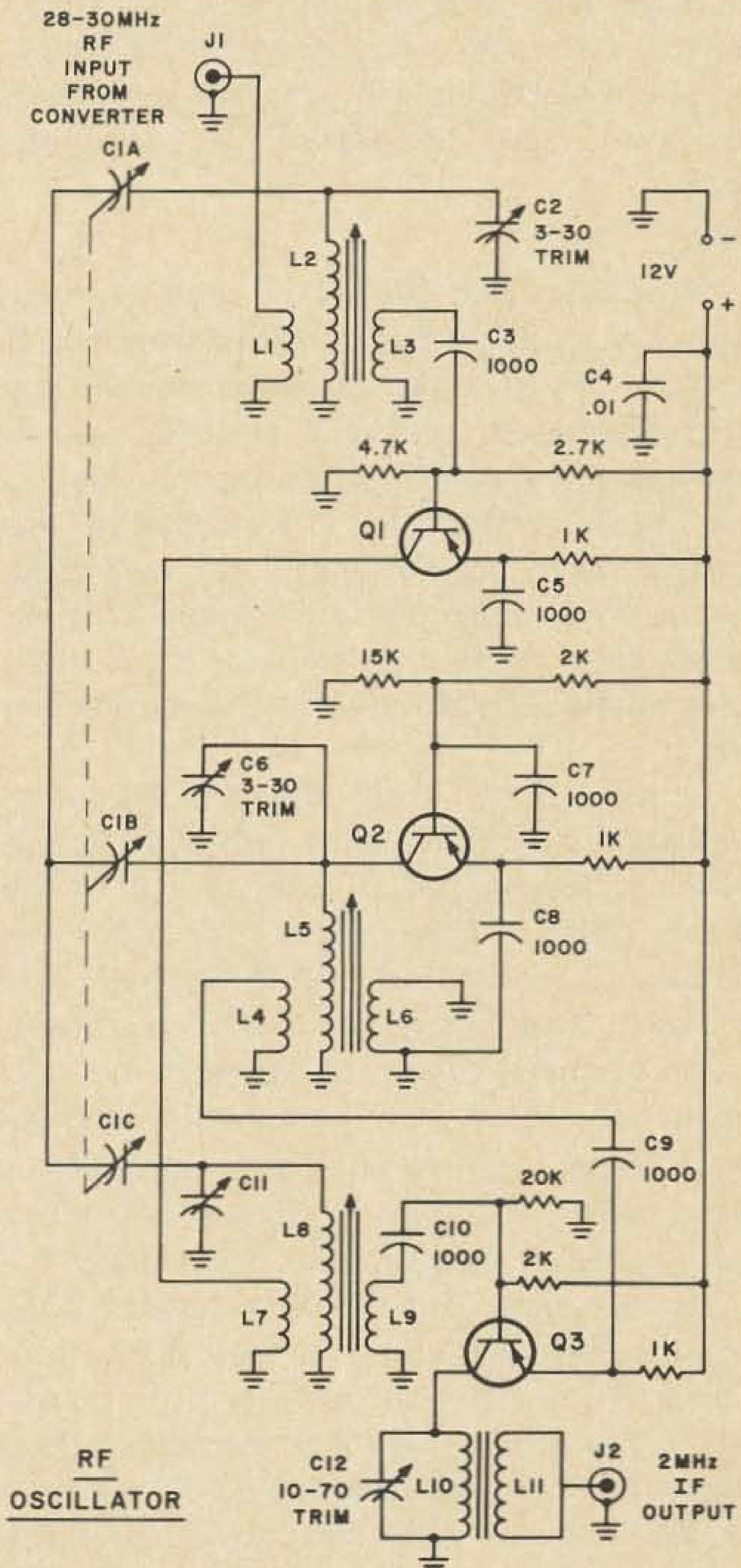


Fig. 1. 28 to 30 mhz tuneable i-f.

Oscillator

The oscillator is a sure-fire emitter coupled job, with the collector on the high end of L5. This is done to "set" L5 as the "slowest" tuning coil of the three. The other tuning coils, L2 and L8, are then made to track with a little more trimmer capacity, matching the collector capacity of the oscillator on L5.

Oscillator output is obtained from L4 and capacity coupled to the mixer emitter. Starting from ground, wind L4 on L5 in the same direction as L5's winding, and put the emitter of Q2 on the other end. It *has* to oscillate! There is a simple law of nature that says; "If a good transistor has good coupling back from a *good* collector coil so that the base goes negative when the collector goes positive, it will generate the signals you want, upon application of good voltage."

Mixer

Note first that the mixer uses the gang capacitor section furthest away from the rf section. The rf stage has never shown any sign of nuisance feedback in this tuner so far, but it's a good precaution anyway, to keep those sections apart. No shielding was needed either, but you might just need some if you try to make the unit smaller. It's six inches deep, by five inches wide by one and three quarters high now, not including the dial.

Tuned energy from the rf collector is brought to the mixer on 4 turn coil L7, and local oscillator input is capacity fed to the mixer emitter. The output coil L10 was tuned to 2.5 mhz in this unit, although you can use a little higher or lower if you want.

As a general rule a ten to one conversion frequency is good, but you are on a trade-off here: a high ratio will make your next i-f more selective but your image possibility will increase. A low ratio will make the image disappear but then you haven't done much conversion and you may need *more* converters to get you down to the final i-f you're counting on. More on this in Part Two where the "double-bandwidth i-f" is detailed. This is where you build a diode into each i-f section with separate volume controls for instant mixing into one af amplifier. This will give you broadband for quick and easy search, and narrowband for demodulating that weak signal from two states over!

Special Separate Section on Tracking

There is a very straightforward positive method for lining up coils for ganged capacitors, which will be detailed here, using the 28 to 30 mhz tunable i-f of this article as an example.

We start here with the circuit already designed and working correctly with three separate capacitors, one of which may be the oscillator section of the gang used.

The ganging together of the frequency versus rotation of the three section variable capacitor is not a matter to be taken lightly, however. Due to slight differences in the circuitry of the rf, mixer, and oscillator stages and their coupling, it is not enough to buy three movable iron core coil forms, wind six (example) turns on each coil, and expect them to track. The grid-dipper will not do the whole job either, although it may help some to get you started.

The first thing is to cover the range needed with the variable capacity of one of the sections of the gang, and still leave some capacity at the high end for the best Q. This residual capacity is furnished here by the parallel trimmers, which are of considerably greater capacity than the ganged sections, so that the L/C ratio actually changes very little over the range tuned.

Assuming you already have chosen the ganged capacitor suitable for the frequencies involved, which appears to be less than 10 pf per section (as I had to remove one rotor plate out of three from an 11 pf unit), check out which of the three stages takes the most variable capacity to tune the range. This will generally be the oscillator stage in this circuit. This is the one you will line up first because it is easier to stretch the frequency over the dial than it is to compress it.

Referring to **Fig. 2**, we will be concerned with connecting and disconnecting the three points shown, which will be designated hereafter by rf, mixer, and oscillator.

Now, using the completed unit, with two external capacitors temporarily tuning the rf and mixer stages, and operating into the i-f

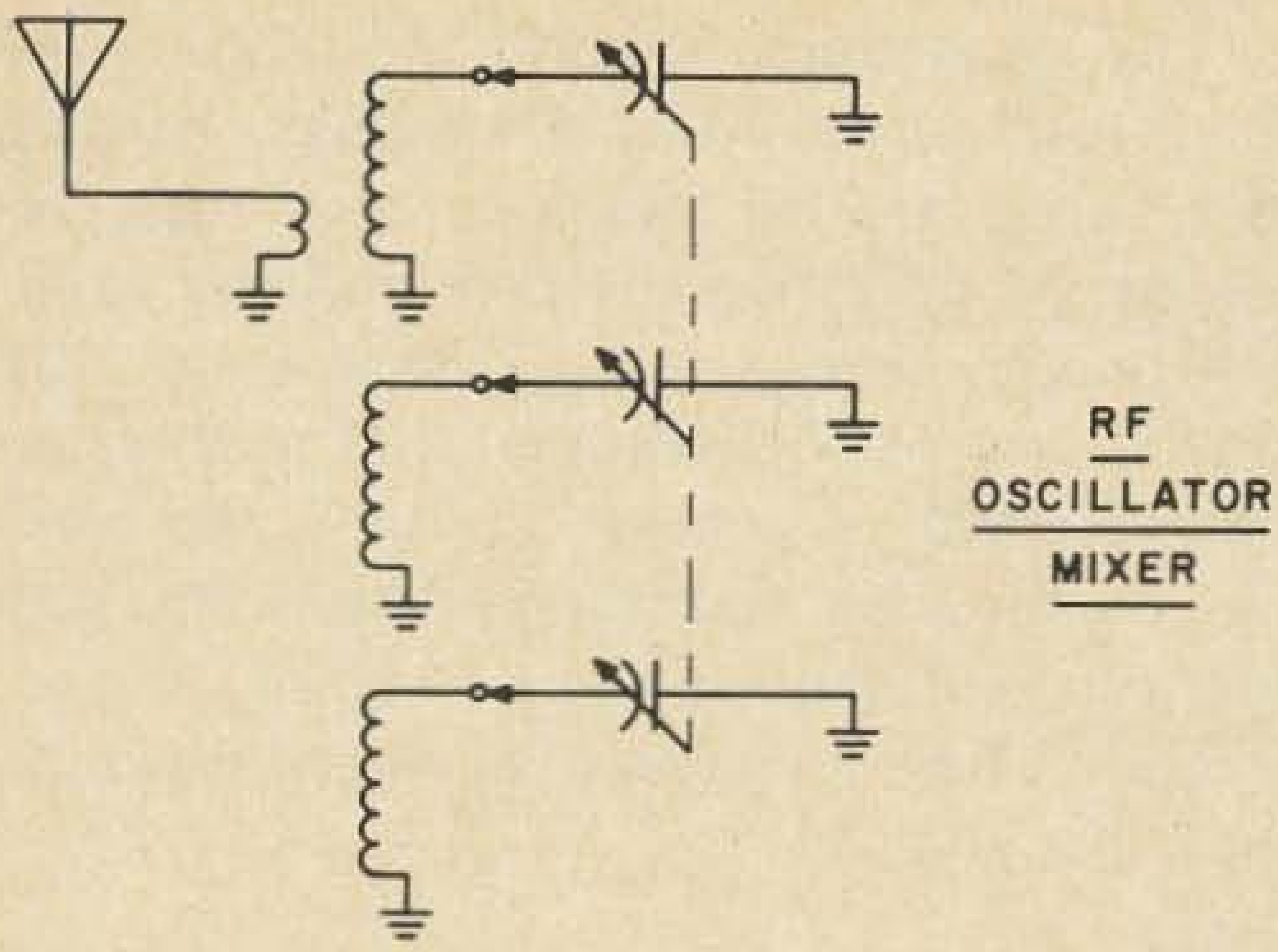


Fig. 2. Major connections for tracking.

you are going to use, such as 2 mhz, be sure everything works correctly, such as sensitivity, tuning range, absence of feedback in the rf stage, etc. Use an "S" meter or avc meter for this work. Tune the oscillator with one of the three ganged sections, and log three or five frequencies on **Table 2**. The dial must be in its permanent form. I used 28, 28.5, 29, 29.5, and 30 mhz for this purpose. The dial may also have any other scale as well on it that you may wish to set up, such as 431.9 to 434.1 for example. To make this unit you do need a signal generator, at least one of the $30 to $40 kind.

Some "quickie" manufacturers use only three points on the dial such as max., middle, and min., but that results in a $9.95 "radio." If you want to do a real job use five spot frequencies (as suggested above) for the 10 meter band as i-f for this tuner.

You can use 30 to 32 if you are afraid of rf leakage input from the 10 meter band. This whole unit should be ready to install in a Minibox with a good cover, so you should not have any trouble with i-f leakage on any frequency.

MHZ	RF	MIX	OSC
28			95
28.5			74
29			53
29.5			28
30			10

Table 2. Dial logging scales.

Now log on paper, the five frequencies chosen on a simple chart as in **Table 2**. You can see now the basic idea of this system. You have a positive, visible, and exact recording of the tracking of one of the gang

PROPAGATION CHART

J. H. Nelson

JANUARY 1970

SUN	MON	TUES	WED	THUR	FRI	SAT
				1	2	3
4	5	[6]	(7)	(8)	(9)	(10)
(11)	12	[13]	14	(15)	(16)	(17)
(18)	(19)	(20)	(21)	(22)	(23)	24
25	(26)	(27)	(28)	(29)	(30)	(31)

Good O Fair (open) Poor □

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

CENTRAL UNITED STATES TO:

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

WESTERN UNITED STATES TO:

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

A = Next higher frequency may be useful also.
B = Difficult circuit this period.

sections set up. Leave the oscillator core and trimmer set from now on so that these settings do not change unless a new start is to be made. This sometimes happens!

Now take the oscillator off the gang and solder the rf on. All you should have to do now for the rf is to set the iron core to trim the low end of the range, and the parallel pad trimmer to set the high frequency end. It's not always that easy though.

Right here you may have to do some readjustment of circuit values, and possibly some hard work! The rf may not track in the middle after lining up both ends! Or vice versa.

This is the reason for those funny-looking saw cuts you may have seen in the two outside plates of millions of ganged capacitors for over forty years! However, with the components and circuit shown in the overall schematic you will probably make out all right, although this section is intended to help you use other components, as well as helping on other frequencies.

The procedure is fairly straightforward now. Just make the rf readings coincide with those of the oscillator previously recorded by adjusting the core and the parallel trimmer. Using less core (that is, the core further out of the winding) and more trimmer you will of course "stretch" the readings on the dial. Make several runs this way and you will soon get the hang of it. And, you don't have to guess, it is logged down on paper for you.

Mixer

Now disconnect the rf, connect the mixer, and proceed as above. You should now be able to fill in the third column and be ready for the big deal.

Oscillator and Three-Gang Tracking

If the oscillator has been previously logged correctly, and the other sections fitted to those readings, on soldering all three together you should have no trouble. Don't fiddle too much with the adjustments after soldering all three connections back onto the gang, because you have no means of knowing what the curve of any one section, except the oscillator, will be.

The reason for some gang capacitors having different oscillator and rf sections, is mainly because the broadcast band has a three-to-one tuning range in frequency, whereas the oscillator for a BC band radio needs about a two-to-one tuning range.

When you are running at 28 mhz however, and the mixer is at 28 to 30 mhz, the oscillator is only some two mhz away. The tracking ranges are so close to being identical that no effect can be noticed. So in this case use a ganged capacitor in which all the sections are alike.

That's about it for this positive method of tracking procedure. It has always worked for me since 1928!

Conclusion

All you need now is your favorite band converter in front, one or two fixed tuned i-f strips following, two lantern batteries for a 12 volt supply, an af amplifier, a crystal controlled transmitter, another af for modulator, a good portable beam, a carrying rack of plywood with shelves, a walk-up mountain, and the right companion!

. . . K1CLL ■

(continued from page 9)

to find more bores per square inch than at any other time in our cycle. We are fed a diet of indigestible pap, the asininity of which is so transparently designed - solely to get our votes - as to be intolerable!

But don't imagine for a single moment that only American politicians conform to this sorry pattern. Other lands, far-flung and remote, suffer greatly from this same lamentable pathological disorder. They too are faced with the same loudmouthed, self-proclaimed geniuses, spouting the same claims of omniscience, with the same panaceas and nostrums for curing all the world's ills. (I do believe that when certain foreign politicians threatened that they would one day bury us, they really meant that they would bore us to death!)

The main trouble with politicians in general is that they have absolutely no sense of humor. They refuse to regard themselves with anything less than utmost seriousness. They are sublimely pompous because they claim to have absolute solutions for evils which have existed without any solution since the earliest beginnings of mankind. I sometimes think that they create some of these problems deliberately, so as to use them as fulcrums upon which to poise their perpetual quest for public office.

Years ago, and for what seemed an interminable period, a pig farmer in Secaucus, New Jersey, persisted vainly in running for the Presidency. Now, in retrospect, and speaking with serious objectivity, do you suppose, really, that he would have done terribly worse than some of our recent Presidents, governors, or mayors? Truly, I am inclined to doubt it.

* * * *

I've always found it fascinating to speculate upon the odd and wholly illogically logical sight of a clergyman blessing an artillery piece, a torpedo, or a rocket launcher on the eve of battle. Undoubtedly this monstrous distortion takes place on both sides, so that Providence must eventually either choose a preference through favoritism, or throw up the hands and ordain a pox on both houses.

Enlightened societies long ago dispensed with that old anachronism, the divine right of kings. But they have never quite overcome the perverted morality of religious righteousness of military adventure. Somehow there has developed a duality between armed conflict and religion. Saint Joan was above all a soldier. The Crusades were holy wars. Kings were called "Defenders of the Faith." And the most heinous cruelties ever known were committed in the fifteenth century by the Inquisition, a quasi-military arm of the church, whose entire thrust was based upon punishment for the crime of heresy.

I do not know, nor can anyone calculate the numberless masses slain in holocausts which were countenanced and blessed by religious authorities. From the time of the Israelites and Phillistines upon the plain before Shochoh and Azekah, and even before that, when Joshua chose out men in Rephidim and fought Amalek, people have perished in agony, fighting in wars sanctioned by Divine Authority. The entire lexicon of mankind is filled with examples of this carnage, running through the tapestry of our history like a scarlet thread.

Is it not a strange and inexplicable wonder, that all the combined prayers of wives, sisters, fathers, mothers, and brothers have not had the potency of a single incantation, mumbled over an artillery shell or a fragmentation bomb by a military chaplain?

It is possible, of course, that our world has periodically been weighed in the balance, as in ancient times, and has been found wanting. It is likely that Armageddon will continue to recur over and over again, until we humans finally decide to beat our swords into ploughshares.

(continued on page 96)

Modulated Vibrator Hash

VHF-FM: A New Involvement

The call "K6MVH" on the masthead of 73 will doubtless cause the eyebrows of about 4,000 subscribers to raise an inch or so. That's how many 73 readers there are who also receive monthly FM Magazine, a "splinter-group" publication that I have co-owned and edited for the past several years.

What Ever Happened to FM?

FM Magazine almost went the way of all prior splinter mags. Like VHF Horizons and the VHF'er, FM Magazine was well received by the amateur radio operators but virtually ignored by the advertisers. The journal was costing more than it was making. Mike Van Den Branden, its originator, paid for the enormously expensive printing, binding, and distribution costs; I paid for the typesetting cost and author remunerations. But there came a time when the costs were simply too much for me to bear. I accepted employment with an out-of-state firm, and was forced to abandon my expensive but pleasurable hobby of supporting the financially ailing FM journal. My partner elected to stay with it. He cut costs by thinning down the magazine and changing the page size, and is determined to make it go. He deserves success.

The fact that so many amateurs were active in FM (with repeaters, mobile telephones, and remote base stations) was sufficient justification for me to want to stay in the field. So, after turning over my share of FM Magazine to Mike Van Den Branden, I got in touch with Wayne Green.

To my mind, Wayne is a smart cookie; he is ever watchful for trends and new things. He was publishing articles about the real FM while the other journals were ignoring the fact that FM existed except as a switch position on a piece of AM gear. And lately, he has been emphasizing the repeater element even to the extent of personally communicating with as many repeater owners as he could to get information about frequencies, operating practices, ideas, and such.

73's Role

So it was that I proposed to Wayne the initiation of an FM/repeater segment of 73 Magazine. Categorically, 73 is opposed to departmentalized publications. Wayne's experience began in an amateur publication that was so departmented structurally that little room remained for general technical articles. His feelings along the lines of columns, multipart articles, and departments have not changed to this day. But Wayne shares with me the thought that FM operation is a cow in another stable. What was once a splinter group has become a chunk group. And it promises to engulf an even larger share of VHF operation in the immediate future.

Thus Wayne was not particularly keen on the idea of a column, but he could see the need for intensified coverage of the fast-moving field of repeaters, remote operation, and amateur FM. As a counterproposal, he suggested that I move to New Hampshire and serve as editor of 73, where I could work in FM articles regularly as a balance to the already abundant fare being served up monthly for all phases of amateur radio. It meant broadening my interests, of course, but a quick self-appraisal revealed the desirability of this–so, I packed my bags.

Now that I've been sold on the other interests amateur radio has to offer, I feel obligated to tell others about the advantages of FM. (Let's ALL be well balanced.)

The reasons for the popularity of FM are as varied as the interests of the operators, as any seasoned FM'er will attest. But FM's strongest points are these: Getting started is easy, and the results are more than proportionate to expenditures–particularly where repeaters are involved; there is an acknowledged superiority of equipment performance and operation over AM equivalents; and finally, FM is still an area where innovative thinking, pioneering, and experimentation are possible, in such branches as control design, link interconnection and deployment, telemetry, and even public relations.

That's the background. Now, 73 Magazine will carry FM articles with regularity. They may be technical, construction, instructive, generally informative, or conversion types, and they will be geared to the needs of the new discoverer of FM as well as the long-time operator. 73 will attempt to carry the same overall philosophy as it has carried with the entire magazine in the past: plenty of meat for every reader of every level, every month.

Spread the Word

There is lots of room in 73 pages for articles, and the pay has never been better. So those of you who have come up with a better carrier-operated relay for a repeater, or who have developed an antenna that gives better vertical separation, or who have found new ways to get higher repeater sites, start writing. Show the rest of the world photos of what you have done, schematics of what you built, or system diagrams of what you have designed. And watch these pages to see what the others are doing.

. . . Ken Sessions ■

Ed. Note.
For those new to FM, Ken Sessions' recently published, hardbound "Radio Amateur's FM Repeater Handbook" starts at the technological rockbottom and goes right through all the simplified details of building a repeater and keeping it on the air. His book is currently available at all major electronic distributors or from the publisher, Editors & Engineers, Ltd., New Augusta, Indiana.

BCI in Stereo

Some transistorized stereo systems are susceptible to BCI from *rf* energy in the 3.5 to 30 mhz range. What happens is that the long lengths of the speaker leads and power cord act as antennas, feeding *rf* energy to the first audio stage where it is rectified and amplified in succeeding stages. The solution is to add ferrite chokes in each lead.

The ferrite chokes consist of a 3" piece of ferrite rod about ¼" in diameter or larger, wound with at least 25 turns of each speaker lead and power lead. Begin winding as close to the chassis as possible. Some units are equipped with plugs for each speaker lead, which is a good place to begin. The speaker leads are usually zip cord as is the power cord, so that when you have at least 25 turns of wire wound on each rod there will be about three layers of wire on each which can be held in place with any ordinary tape you have available.

The ferrite rods can be obtained at most radio supply houses as ferrite antenna coils or loop sticks. They come with a coil of wire on them which is removed and discarded. Some rods are 6" in length. To make two 3" pieces, score the rod with a file at the 3" length and tap it on a hard surface and the rod will break cleanly.

After installing the chokes in each speaker lead, try out the system, both radio and record player; you may be lucky and not have to choke the power cord. But if there is a trace of BCI in either the radio or the record player add the power line choke, again beginning the winding as close to the set as possible, although it will probably work if you begin winding at the plug end of the cord.

...K1ZYG

(continued from page 93)

There has to be an answer to all this somewhere. I find it hard to understand how anyone can place other considerations higher than this one on his list of priorities. Everyone in this world should be hoping, praying and working for peace. And, for a change, we ought to be blessing not cannons, but school books . . . not machine guns, but construction tools and agricultural implements.

If we do not accomplish this change now, we may not get another chance to do it. As the highway signs says . . . "Last stop before exit!!!"

* * * *

There has been a ridiculous emphasis on bust fetishism over the past twenty years or so, which has proliferated into gigantic proportions, no pun intended. We seem to have carried this mammary-mania so far that it appears unlikely for it to develop further (again no pun intended) short of making the topless fad universal.

Now, for myself, I object strenuously. When there is nothing for the imagination to conjure, what is left?

There were times in the past when the same shamelessness became an accepted way of life. The ancient Etruscan ladies adorned their bodies with jewels, metals, cosmetics and heavy drapery, but allowed their bosoms to remain bare, a display which was thought to be esthetically attractive. But it did not help the Etruscans to avoid falling into ruin. The Roman legions, unhampered by the distractions of abundant feminine pulchritude, were able to beat the Etruscans into submission, without any difficulty whatever. Thus perished one of the earlier powers of Europe, a victim of its own unhealthy preoccupation with prurience.

From what I have seen of the open display of the female thorax in the more primitive areas of the world, it seems clear that these manifestations occur in direct inverse proportion to the degree of civilization. Most of these savage societies are throwbacks to the prehistoric eras, with scant development of agriculture, communications, or transportation. They consist principally of tribal groups, limited in area, governed by taboo and ju-ju, unaware of the slightest advance in the human state of being.

It would probably be quite pleasant to spend lazy days and soft nights lolling on the tropical South Sea sands, or listening to the plashing of river wavelets lapping at the banks of an African savannah, while tall, statuesque, ebony- or cinnamon-hued Venuses slink seductively by. I can even dream of being handed a tall, icy drink of what-you-may-please by an amply endowed vixen with soft-as-velvet epidermis whose sole function in life is to make me realize my masculine irresistibility. But when I think of riding in the New York subway on a chilly February morning gazing at huge expanses of pale, flabby, goose-pimpled, naked flesh, somehow the picture of the tropical idyll fades into the background of forgetfulness.

A friend of mine, hungry as a ravenous bear, unsuspectingly stopped in at a place in Greenwood Lake, where they employ topless waitresses. He had in mind a juicy sirloin, french fries . . the whole bit. When the waitress came over to take his order, he arose, stumbled spastically to the bar, ordered a bourbon boilermaker, and went his way . . . a chastened and a shaken man, mumbling to himself.

So, if you don't mind, I take my stand against all this open display of superdeveloped thoracic anatomy. Down with the Playboy centerfold. Down with cleavages, uplifts, and bikinis. A fellow has to be able to reserve something for quiet contemplation and solitary appreciation. If all our secret little fetishes are permitted to flourish out in the open, we might start to cultivate vices that are truly harmful and destructive. Three cheers for purity, modesty, chastity.

* * * *

Well, there you are . . . and as the dentist said, "Now that wasn't so bad, was it?" We've covered the three taboos, and I doubt whether I've trod on anyone's toes, or hurt anyone, or violated many sensibilities.

It occurs to me, now that I think of it, that all the objections to having discussions about these allegedly sensitive areas has, for years, been based upon a false footing, a subterfuge. While it was always stated that these topics should be avoided so that no one's feelings might be hurt, the true reasons for the proscription was something altogether different. Such discussions tend to examine the underpinnings of society, the basic structure and nature of the entire human community. A too close scrutiny of these elemental foundations is very apt to disclose some dry rot. And it is to the advantage of certain groups and individuals within society to preserve the status quo and resist change. People have been conditioned to avoid such analysis.

I have a suspicion that the strongest and most vocal opponents of free discussion on these points are not at all concerned with the delicacy or indelicacy of such dialog at all. Political discussions are not viewed with favor by political scoundrels and grafters. Religious discussions are not popular with bigots, zealots, and fanatics. And sexual discussion is unpalatable to evil-minded puritanical, inhibited, perverted, or otherwise abnormal misfits. Everywhere they see revolution, blasphemy, and carnal sin.

There once was a well known sect called the Shakers, who believed that man's physical nature must be contrary to the Almighty's design - the work of the devil, therefore a sinful thing. They did not even countenance procreation among their own community, with the inevitable consequence . . . the Shakers disappeared from the scene. As did the dodo bird, the wooly mammoth, and the pterodactyl before them, they were unable or unwilling to adapt, so they became extinct. In the struggle to overcome a hostile, changing environment and survive, all species must evolve, adapt, accommodate. For the environment invariably prevails . . no matter how strongly the changes may be resisted.

Inexorably, our world will become more and more aware of its true nature. The thought censors do not enjoy an optimistic prognosis. In time they will be forced to give way altogether, for truth is on the march. All revolutions need not be political. Revolutions of the spirit of man are ever so much more drastic. The spheres of materialistic concepts ... money, power, war, possessions, and others, may still be in the forefront of man's interest and desire. But there is an irresistible motion toward a great and mighty goal ... a fulfillment. Tiny quantitative changes, all but imperceptible, will result in a tremendous qualitative leap .. total intellectual emancipation.

There is nothing so powerful as an idea which comes into its proper time. There is nothing so futile as an outworn principle, fighting against time and progress. Change is inevitible, and we are going to see many changes. There is a new world a-coming, a brave, new world of tomorrow. Those who refuse to change along with it are going to become extinct. It's just that simple.

... **Dave Mann K2AGZ** ■

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de W2NSD/1 (continued from page 2)

Are Sub-bands Meaningful Today?

In the early days of amateur radio, when phone operation was first invented, it raised such hob with CW that it was split off into the higher parts of the bands, the frequencies that no one used much. This was just fine with the pioneer phone men because they didn't like those confounded CW signals in their phone band any more than the CW men wanted the mass of heterodynes that made up the phone bands.

By the 30's we had 100 khz on 20 and 75 meters for the Class A operators. Both bands generally were jammed up tight with about ten solid kilowatt signals. When one of these rock piles would go off you could hear ten weaker heterodynes coming through the gap from ten lower powered hopefuls. No wonder that about 90% of the activity was in the CW bands in those days.

Phone DX was worked outside of the American phone bands. Few DX stations had signals that could cut through the enormous heterodynes that filled our phone bands. In the good old AM days it took about two stations to have an unreadable pileup.

Then came sidebands and the layers of heterodynes gradually died away. We began to hear more and more DX operators working right in the American phone bands. Today most of the phone DX is worked in the American band, with the exception of an occasional backward DXpedition operator.

Now that AM is about gone from our DX bands, perhaps it is getting to be time to do away with the concept of separate American and foreign phone bands? For that matter, with the percentage of amateurs using CW growing smaller every year, perhaps the time is not far away when we will be able to do away with sub-bands entirely? I'd like to see it given a try for a while to see how it works out.

The present day CW op has filters available that can virtually remove sideband. The sideband op can virtually remove CW, if he uses a couple of notch filters. Our bands can hold many times the number of phone and CW signals that they could a few short years ago just because receivers have come such a long way.

I note that a group of amateurs is about to petition the FCC to open the phone bands for an extra 100 khz on 75-40-20 meters. Good plan, of course, but why not go all the way and open all frequencies to everyone? Instead of taking more and more frequencies away from the active operators, why not give them all more? Is there really that much harm to be done? We could try it for six months on one band and see what happens!

ARRL Board Meeting

The special November meeting was supposed to come up with recommendations for the FCC regarding incentive licensing frequency changes. Unfortunately the FCC didn't wait for the advice, so the Board found itself with a lot of little matters and no main topic. The 1970 national ARRL convention will be in Boston. Fine. I hope that 73 will be permitted to attend this one ... the last Boston National saw us excluded by personal directive of Huntoon.

The board agreed to petition the FCC to grant counterpart call letters to amateurs moving from one call area to another. I'm glad they did this. But I do wish that some interested ARRL member would buy a subscription to 73 for the directors so they would know that this petition has already been entered. I reported this in October on page 127 as RM-1455. If any one of the directors or the headquarters gang had read 73 they would have known that this had been done. A reading of the FCC actions would have also alerted them about this. I'll bet you'll never guess who sent in the petition to the FCC originally. Heh, heh!

... Wayne ■

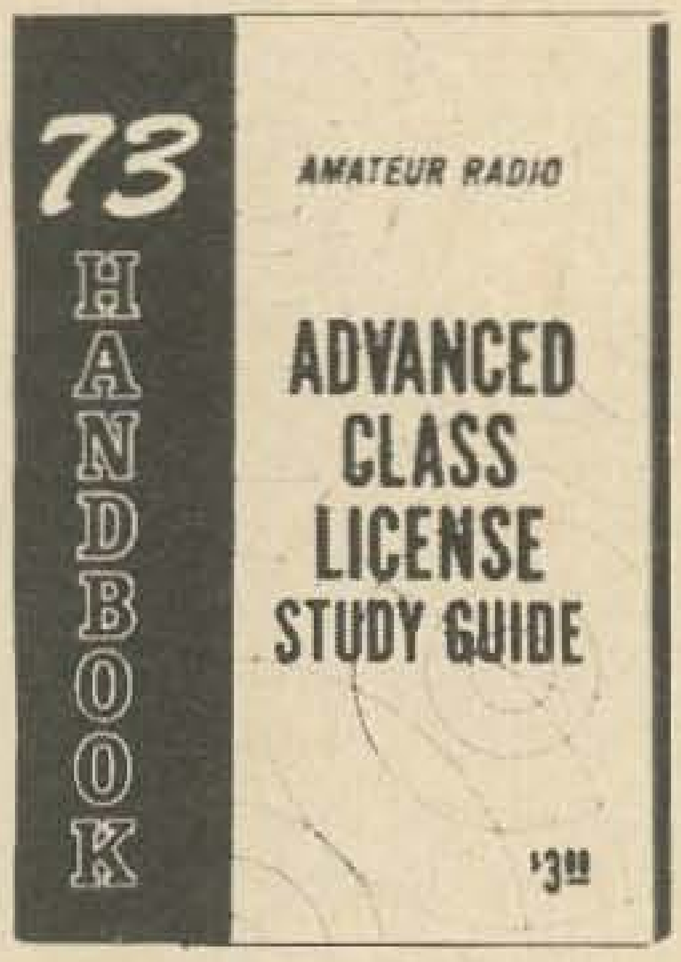
NASTAR/MOONRAY

RTTY/SSB Broadcast Schedule

Broadcast times are GMT on Tuesdays. This is Monday EST. There will be no broadcast on the first Tuesday of each month.

0001	14.090	RTTY to Europe
0015	14.090	RTTY to Africa
0030	14.235	SSB to Europe
0040	14.235	SSB to Africa
0200	14.090	RTTY to southern USA
0210	14.090	RTTY to western USA
0300	14.235	SSB to southern USA
0310	14.235	SSB to western USA

73 Books for Hams



ADVANCED CLASS STUDY GUIDE

128 pages of up-to-the-minute simplified theory, written with the beginning radio amateur in mind. This unique book covers all aspects of the theory exam for the Advanced Class license and has helped hundreds of hams to sail through the exam. . .nothing else like it in print. **$3**

DX HANDBOOK

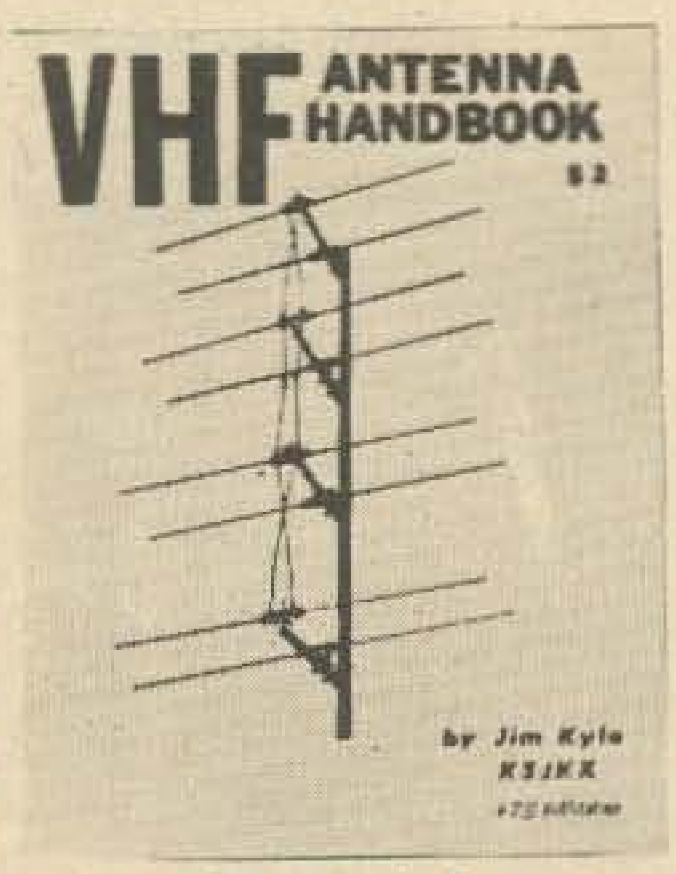
Includes giant world country-zone wall map. Articles on QSL design secrets, winning DX contests, DXCC rules, DXpeditions, reciprocal licensing and many more. World postage rates, WAZ record lists, time charts, propagation, etc. Special ham maps and bearing charts. A must for the DXer. **$3**

COAX HANDBOOK

Invaluable book for the ham or the lab and for everyone else who doesn't want to have to keep a whole library on hand for reference. . .or even worse, have to write to the manufacturer for coax spec. **$3**

PARAMETRIC AMPLIFIERS

For the ham who wants to work DX on the bands about 432 MHz, there is nothing that can beat the gain and noise figure of a paramp. This book shows you how they work and how to build and use them. Lavishly illustrated with photographs and drawings. **$3**



VHF ANTENNAS

This handbook is a complete collection of up-to-date information about VHF and UHF antennas, with design hints, construction and theory. If you've been wondering what array you need, this book will give you enough background to make the right decision. **$3**

INDEX TO SURPLUS

Do you have a piece of surplus equipment that you want to convert but can't find an article? If so, this is the book you need. It lists all of the surplus articles and conversions in popular electronic and amateur magazines from 1945 to 1966. **$1.50**

DIODE CIRCUITS HANDBOOK

An invaluable reference book. Covers rectifiers, mixers, detectors, modulators, FM detectors, noise limiters, AGC, BFO'/Q-multiplier, AFC, Varicap tuning audio clippers, balanced mods, field-strength meters, RF probes, zeners, control circuits, etc. 111 different circuits. **$1**

73 USEFUL TRANSISTOR CIRCUITS

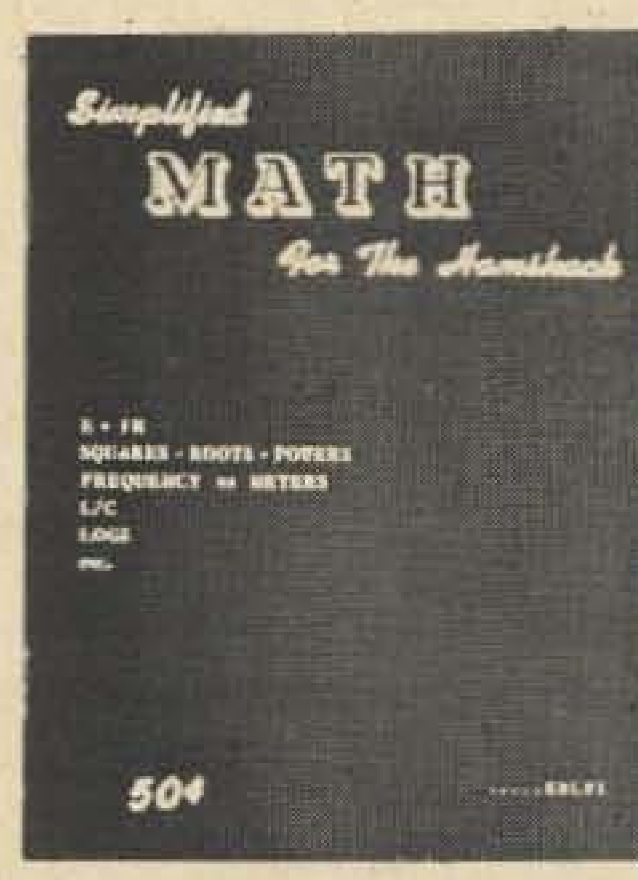
If you've been looking for a transistor circuit to do a special job, chances are there is a circuit in this book that will give you a head start. It covers circuits for audio, receivers, transmitters and test equipment. **$1**

HAM TELEVISION

The Amateur Television Anthology is a collection of the technical and construction articles from the **ATV Experimenter,** edited by WØKYQ. If you're interested in ATV, this is the book for you. It covers the gamut from the simple to the complex in amateur television equipment. **$3**

MILITARY SURPLUS TV EQUIPMENT by W4WKM is a necessity to the surplus-scrounging ATV addict. **$1**

SIMPLIFIED MATH



Does math scare you? – It shouldn't. This easy-to-understand book explains the simplified exponential system of arithmetic, simple formulas, logarithms, and their application to the ham shack. **50¢**

CW by W6SFM explains code and how to learn it. **50¢**

CUMULATIVE INDEX lists all the articles in 73 up through December 1966. **25¢**

_Coax Handbook. $3.00
_Transistor Circuits $1.00
_Index to Surplus $1.50
_Parametric Amplifiers . . .$3.00
_VHF Antennas. $3.00
_Simplified Math. . . . . $ .50
_ATV Anthology. $3.00
_CW. . . . . $ .50
_Military TV. $1.00
_Cumulative Index. . . . . . . $ .25
_DX Handbook. $3.00
_Advanced Class. $3.00

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73 Magazine

Peterborough, N. H. 03458

LETTERS

Dear Wayne,

Without question, your magazine is by far and away amateur radio's superior publication. In the September issue on P. 134 was a letter by Arthur Woods W4GJW in which he made many suggestions for new subject matter for your magazine. This I heartily endorse.

I would like to see owners reports of manufactured amateur gear such as those automobile owner reports in Popular Science, etc. Proper editing would bring out the strong and weak points or limitations of each piece under investigation. Simple modifications could be thrown in, if desired. The series would be self perpetuating by asking at the end of each article . . . Owners of the Super Whamee Mark IX (or whatever gear desired) please send your comments to 73 Magazine.

I am certain that a series of this kind would be successful as hams from around the world would feel that they are contributing in a small way to a fine publication as well as to amateur radio. I can't think of an easier way for amateurs to get involved.

Stan Pugh WA7KSC
2521 North Proctor
Tacoma WA 98406

Dear Wayne,

Been reading 73 now for several years–just like I read CQ when you were running the show there. Even met you once in San Antonio at the Gulf States Convention about fifteen years ago! So long?? Anyway, I have enjoyed the reading.

Like a lot of other hams I am also interested in making things that are not always for the hamshack. Right now it is metal detectors. I'm wondering if there aren't a bunch of other readers who have the same interest. I would like to swap circuits if anyone wants to and I would particularly like to have a good BFO circuit using a crystal controlled oscillator on 100kc–like the unit made by White's Electronics in Oregon.

So how about it? Can someone do an article on the subject? Or just print this letter–maybe someone will come up with a good one.

Les Spoonts W5WWX
1600 S. Jones Dr.
Arlington TX 76010

Dear Wayne:

In the ". . .de W2NSD/1" portion of your issue for November, at p. 126, I seem to read an echo of my letter of March 7, 1969 to you–under Public Relations. I do understand that QST has now retained a PR consultant, or some such. Hope the rumor is correct, or that it at least indicates a change of attitude.

Hopefully, this may all lead to some constructive effort to lobby *for* amateur radio in Washington. Too often I have found that PR work, per se, merely serves to lock the barn after the horse has been stolen. Your very pertinent remarks concerning the obvious results of the implementation of Docket 15928 seem to me to show pretty clearly that horse, barn, and most of the crops are long gone.

Of course all of this, involving frequencies, spectrum utilization and amateur population are matters that many of us brought to the attention of ARRL and FCC when 15928 was first weaned. That our protests were very generally ignored must by now be accepted and recognized as a great disservice to amateur radio by those whose declared reason for being was the orderly and constructive development of the hobby, art, service or whatever one likes to call it.

I can remember when very few amateurs had a good word for that hot-headed radical, W2NSD. I suspect that if a poll were taken today you would be considered something of a dedicated prophet! Some miles northwest of you there is, in Hanover, a college that has the motto–"Vox Clamantis In Deserto," or something like that. My recollection is that it means something along the lines of "A Voice Crying In The Wilderness."

It must be so with you. It can only be hoped that in some way the larger body of amateurs will really listen to what you have to say, and will give tangible support to a movement towards a sane and constructive program to give vitality and purpose to the amateur game.

Al Smith W2AFJ/K3ZMS
Penury Priory
Doylestown PA 18901

Dear Wayne,

I sure do like your magazine and its unbiased (?) opinions. What I really wrote about, however, was to enlist the services of anyone who knows the "magic trick': how to use the Central Electronics 10B as an SSB exciter with the Heath TX1 Apache transmitter. Also, any teens or Novices wish to start a net on 15m? Please contact me.

Gregg Marco WN6IZT
2880 Ridgeway
San Bruno CA 94066

Dear Wayne,

The reason everyone is so interested in "sex, religion and politics' may be that most amateurs are far behind the professional world in technical matters.

The biggest problem seems to be that manufacturers of components gear themselves for industry not the individual amateur. There are integrated circuits that contain an i-f amplifier, and detector including AGC. Another IC for the audio, a third for the rf, add a couple tuning coils and a speaker and you have built a high performance portable receiver. With the manufacturer's data sheets, you don't even have to know how a transistor works to have a good time building.

But there is the problem: How does the average ham find out about the latest circuits? The only way seems to be to read trade magazines and write for data sheets. Either that, or wait until some other ham does so and writes an article for 73.

What we need is more information on these new devices so hams need only read amateur magazines to keep up to date. Maybe the ultimate would be a special ' newsletter" for amateurs only.

What say?

Paul Zander WA8JCM/9
25-5 Ross Ade Dr.
W. Lafayette IN

Dear Mr. Green;

It is seen that the growth of 73 Magazine is like that of the field in which you are dedicated. This may seem to you as a way of saying congratulations to you and your staff for this is true.

It is with great sadness that it is easy to see that there are those who cannot see that the use of that which is called, telegraphy, is that which cannot serve the growth of the nation. There was a time when the state of the art was such that telegraphy was all there was. When we see the advancements which are known to us today, we see that telegraphy is not responsible for these advancements. We see that these advancements would not have been possible had it not been for those who saw that telegraphy can never serve in the successes of the electronic control systems of all kinds which were used for positive control in the automatic control of the space program and in industry as well. High speed Teletype has replaced telegraphy. All of this gives more work for many more people in a growing country in the sense that electronic technicians far outnumber the few remaining telegraph operators.

In the public view, the repair of an electronic device or a television set requires a technician. In the public view, the public does not look for a telegraph operator to repair a television set or any of the electronic devices which the public uses and/or enjoys. This is to say, telegraphy is not important to the public.

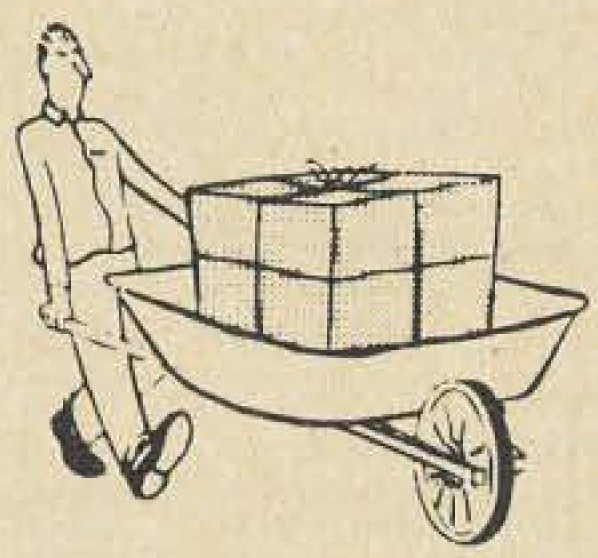
When we see this, we see that the public will never be convinced that telegraphy can serve them in their needs. Their needs are not that which telegraphy represents. In the public interest, telegraphy is not known nor is it needed.

Telegraphy is like a man who lost one leg. He cannot walk as can a man who has both of his legs. The previous paragraphs explain this in other words.

It is seen that there are those who seem to believe that telegraphy is needed in order to prove that a technician is not a technician unless the technician knows telegraphy. We all know that this is not true for we see that a knowledge of telegraphy can never repair a television set or any electronic device used in the public interest. This clearly tells one, there is no need for telegraphy in industry and commerce of a nation. It is seen that this is true.

When we see that the military services have been abandoning telegraphy for more exotic means of communication, it is seen that the military services recognize the fact that their only use of telegraphy is in battle. Even here we find that the military frequently uses equipment which is not designed for telegraphy in the sense that voice commands are more quickly understood. We refer here to armies committed in battle and each knows the others position. We find that there is no time to be lost in these conditions. This is to say, not even telegraphy serves here.

It is seen that there are those who believe or who seem to believe that it is necessary to provide a limit or to limit the number of radio amateurs in the belief that telegraphy is the means which they see as being effective. The manner in which this has been done in the division of the bands is seen as that which the Government of the United States cannot do in the sense that the Government cannot discriminate. It is seen clearly that this division discriminates against some and in favor of others.



This is to say that the Government is not an individual who can select his or her own friends.

The selection of one's own friends results from common interests or common desires. Electronic theory is not easy to learn and is never fully learned. Those who know electronics are those who know this to be true. Those who do not know electronics find that for them it is not that which interests them. This can be said of any profession. The practice of medicine is an example of this.

It can be seen that the interest in electronics is that which has given and will continue to give more technological advancements which are in the public interest. It can be seen that the amateur bands have provided the radio amateur with the means by which he does develop a technical skill which industry needs and which industry does not provide. Industry wants a man already trained. It can be seen that were there to be no amateur bands there would be no developments in industry. It is the radio amateur who has been responsible for the technological advancements.

Industry requires men who are trained in all of those fields which are available to the radio amateur who is a technician. The only reward for a radio amateur is a greater knowledge which he has gained.

Mr. Lin Carol
Avenida Cometas 180-B
Colonia Contry
Monterrey N.L. Mexico

Dear Mr. Green,

I have been subscribing to "73" for several years, and I think it is getting better with each issue. I wish to add my thanks for the Advanced and Extra Study articles. They are much clearer than many other study guides, and contributed greatly to my getting the Advanced ticket. My code speed is improving gradually, and I will have the Extra one of these days.

I hope you will allow me to comment on some of the issues which you and others have raised in letters and articles which you print. First, I disagree with W1DIS's opinions (page 40, Nov. issue) on what can be discussed on the air. There is nothing in FCC regulations which says we cannot use the ham bands for an open forum. For those who have not read it or cannot find their copy, subpart E of FCC amateur regulations says ONLY that, "NO LICENSED RADIO OPERATOR OR OTHER PERSON SHALL TRANSMIT COMMUNICATIONS CONTAINING OBSCENE, INDECENT, OR PROFANE WORDS, LANGUAGE, OR MEANING." (Par. 97.119 FCC regulations). I have gone over these regulations time after time and nowhere can I find any other mention of what we can or cannot talk about. In other words, I believe the FCC gives us the benefit of the doubt that we will conduct ourselves on the air with common, ordinary decency, and if we do otherwise as stated in Par. 97.119, we can expect our tickets to be suspended. I will, therefore, discuss any subject with anyone in as gentlemenly a manner as I know how, but will break off or refrain from such a discussion if it becomes ungentlemenly!

I do not agree with those who are fussing about the difficulty of the license exams. The FCC uses only 98 words to describe the basis and purpose of Amateur Radio, (Part 97.1), and these words include the following; ". . .provide emergency communications; . . .advancement of the radio art;

. . .rules which provide for advancing skills, . . .trained operators, technicians, . . .". An old timer told me many times that anyone can learn the code and can increase his speed if he is willing to practice, so those who gripe about it are just plain lazy. The FCC provides the Citizens Band Radio Service for those who do not care about advancing their skills or improving themselves as a trained operator.

For those who do not like the present incentive licensing program, I suggest they write the ARRL and also write the FCC even if it takes 14 copies. Here are my suggestions for a better incentive licensing program, and I have written my ARRL director, and intend to write FCC also:

1. Drop Advanced Class license.
2. Restore to Generals the frequencies allowed prior to Nov 22, 1968, in the interest of public service.
3. Allow Extras to use phone in what is now known as the "Foreign" phone segments.
4. All licenses except EXTRA class, should be non-renewable. Conditional should be for only one 5 year period except for disabled with doctor's certificate stating inability to travel. Anyone else should be able to find his way to an FCC office or field examiner sometime in 5 years.

I can hear the moans and groans about having to take a new exam every 5 years, but how else can we fulfill the basis and purpose of Amateur Radio if we don't upgrade ourselves? I hope you will print this letter to get some reactions, and also maybe it will stimulate some more thinking on how to improve the situation.

J. W. Harrison, Jr. WB4TBX
1234 Little Bay Avenue
Norfolk VA 23503

Dear Editor:

I am writing to commend author R.J. Zach and the editors of 73 Magazine for the series of articles on FM. We are in favor of any means of furthering the cause and have noted that several articles on the subject have been recently published.

I have noticed, however, that only one of the many articles published (Bill Orr's in Ham Radio) even mentioned the existence and availability of any new equipment made for the amateur market. I think it only fair that some mention of this new equipment should be made–not only of the Varitronics-Inoue line, but also of several other manufacturer's equipment–so that your readers will know that used gear is not the only thing available.

I am enclosing specification sheets on our current models for your information. Again, thanks to you and the editors for furthering the FM cause.

Sharon LaTraille
Vice President
Varitronics, Inc.

See editorial "VHF FM: A New Involvement" and "Low-Cost Electronics: Japan's FM Invasion," this issue. . .ed.

Wayne Green:

I have subscribed to 73 for four years, now, and it IS the best that I have read. I also subscribe to Ham Radio, QST and CQ, so I think that I have all the numbers covered. 73 Magazine, in my opinion, gives me the greatest pleasure of them all and I shall stay a very satisfied one–till death due us part, or something. I passed the Advanced without your help—no sarcasm intended, and would pass the Extra—if you could get the FCC to lower the CW to 15 wpm. What is this—proficiency in CW or theory? Of course, as you have surmised, I am excellent on theory and lousy on CW, but I am honest. I am writing like mad to QST and directors, to forget the second half of this incentive thing, which, I am Afraid, will kill or set back Am. Rad. Anyway, good luck to you.

Jack Golden WA2YPW
Portville NY 14770

Dear Wayne:

There are occasions upon which I wish you would base your writings upon fact.

On page 127, November 73, you state that I publish two magazines on a commercial basis complete with ads and subscriptions. I do not *publish* any magazines whatever. I do *print* three. The Auto-Call is published by the Foundation for Amateur Radio, of Washington, D.C., a fact which can be determined from the address side of any issue. The DARA Bulletin is published by the Detroit Amateur Radio Association. The ARNS Bulletin (surely you're not accusing this one of being commercial?) is published by the Amateur Radio News Service. Each of these is printed in my basement on the basis of materials cost only without any charge or retainer whatsoever for labor or machine depreciation. Each publisher receives, directly, all money for subscriptions, advertisements or dues and any profit (or loss) accrues directly to them, not me.

I am gratified that you are concerned about the time I spend in printing these publications, but I can assure you that only a small portion of my time is involved in the printing.

Since you are now set up for printing (page 129) I would be most happy to turn the entire affair over to you, providing you will do the work at the same price.

For your information complete financial details of my entire operation were furnished the members of the Executive Committee of the ARRL who passed on my eligibility for Vice-Director, and who adhered strictly to the provisions of Article 12.

I insist that you print this letter in its entirety as a correction to your statements.

Ralph V. Anderson KØNL
Vice-Director
Mid-West Division, ARRL

My Oxford Universal Dictionary defines a publisher as, "One whose business is the issuing of books, periodicals, music, etc., as the agent of the author or owner; one who produces copies of such works, and distributes them to the booksellers and other dealers, or to the public." The dictionary says nothing about profit. You admit in your letter that you are issuing periodicals and distributing them to the public and this makes you a publisher, whether you or the Executive Committee like to call it that or not. Article 12 has been violated, obviously. . .Wayne.

Dear Mr. Green,

Mr. Hartley's recent article ' Religion, Politics or Sex' has raised two basic ideas:

1. Why can't amateur radio be a forum for exchange of ideas? There is nothing wrong with calmly discussing politics, where a real dialogue exists and ideas and ideals are exchanged and expressed. People who object to one's ideas must

either learn to accept other's ideas or change frequency.

2. To preserve our society, we all must learn to accept each other's ideas, and accept his right to say his ideas any time and anywhere he wishes. (If he breaks the rules, he must be punished, however.)

It is ironic that we have the fantastic communication capability, but we have nothing of any value to say to each other.

James Altman WA0UWL
1921 Pinehurst
St. Paul MN 55116

ADDENDA & ERRATA

APOLLO TV & RADIO (Nov. 73) Addenda: An adjustment should be made for Westinghouse Electric Corporation and Radio Corporation of America as follows. The monochrome TV camera used on the Apollo 7 and 8 space missions was made by RCA, as stated. However, the monochrome TV camera used on Apollo 11, which was left on the lunar surface, and the monochrome TV camera used on Apollo 9 was made by Westinghouse as well as the color TV cameras for Apollo 10 and 11. The statement to the effect that the RCA camera was utilized in Apollo 11 and 9 was based on incorrect information. I am thankful for being corrected.

Thomas Laffin W1FJE
Hillsboro NH 03244

Dear Wayne:

The error on page 76 of the November issue of 73 should read: "This is possible if we assume that the dc current gain h_{FE} is much greater than one, and that the collector current is very nearly equal to the emitter current." This is because the high h_{FE} makes the base current much much smaller than the collector current. Recall that the emitter current precisely equals the collector current plus the base current.

I have received letters, but I was surprised to receive a couple of long distance phone calls. Letters are fine because it gives me time to sit down with the magazine and work out an intelligent answer, but a phone call catches me suddenly without a chance to think, and I usually can't give an answer right off.

Cliff Klinert WB6BIH
520 Division St.
National City CA 92050

Ham Tips: More Uses for Bx Armor

When running antenna leads from the roof to the house, it is almost impossible to avoid subjecting the cable to abrasion from either the building or the roof edge. In time, this abrasive action will cause the wire to fray, and then break.

A section of Bx armor, placed at the point of stress, and securely taped in place will guard against the effects of abrasion and insure that the antenna cables you put up in June will still work well in December.

Elliott S. Kanter, W9KXJ

Caveat Emptor?

- ★ Price—$2 per 25 words for non-commercial ads; $10 per 25 words for business ventures. No display ads or agency discount. Include your check with order.
- ★ Deadline for ads is the 1st of the month two months prior to publication. For example: January 1st is the deadline for the March issue which will be mailed on the 10th of February.
- ★ Type copy. Phrase and punctuate exactly as you wish it to appear. No all-capital ads.
- ★ We will be the judge of suitability of ads. Our responsibility for errors extends only to printing a correct ad in a later issue.
- ★ For $1 extra we can maintain a reply box for you.
- ★ We cannot check into each advertiser, so Caveat Emptor . . .

50 TELETYPE PICTURES for sale for $1.00. Perforated and audio tapes available. Volume two pictures needed. W9DGV, 2210 30 St., Rock Island IL 61201.

GOING MOBILE –SELL–HQ170C–$170; Heath TX-1 & SB10–$165; Dow-Key T-R relay–$14; or all together for $335 pre-paid. Plus NOVICE station Eico 720 & 4 xtals & Ntl. NC121 for $85 packed FOB Durango. Clean excellent gear in daily operation with all manuals. Bill Watts WAØSQL, Box 774, Durango CO 81301.

ELECTROLYTIC CAPACITORS 1240 µfd 360VDC. Unbelievable 3 inch x 1¾ inch diameter, $3.50–formed and tested. Peterson K6ZSJ/2, Box 20, Roselle Park NJ 07204.

HAM-AUCTION February 1, 15th Annual by Toledo Mobile Radio Ass'n, at the Lucas County Recreation Center, 2901 Key St., Maumee, Ohio. $1.00 Registration, open table sales, map and further information–write Ron W8STA, 4654 Monac Dr., Toledo OH 43623.

NOVICE CRYSTALS: 40-15M $1.33, 80M $1.83. Free flyer. Nat Stinnette Electronics, Umatilla FL 32784.

SUPER GAIN (R) ANTENNA much gain, makes exciter sound like linear. See pgs 8 & 144, Oct. 73. GUERILLA (R) high efficiency ant. See pgs 57 & 113, June 73.

CHRISTIAN Ham Fellowship now organized for Christian fellowship and gospel tract efforts among Christian licensed amateurs. Christian Ham Callbook, $1.00 donation. For details and sample copy of ham gospel tract, write to Christian Ham Fellowship, P. O. Box 218, Holland, Michigan 49423.

"TOWER HEADQUARTERS!" 11 brands! Heights aluminum 35% off! Strato crank-ups, low cost! Rotors, antennas and gear discounts. Phone patch $11.95. Catalog–$.20 postage. Brownville Sales Co., Stanley, WI 54768.

HOT CARRIER DIODES: New HP 2800, 90¢, 12/$10 pp. HAL Devices, Box 365L, Urbana IL 61801.

73 IS AVAILABLE to the blind and physically handicapped on magnetic tape from: SCIENCE FOR THE BLIND, 221 Rock Hill Road, Bala Cynwyd, PA 19004.

3 PLASTIC HOLDERS will frame and protect 60 cards, $1.00–or 10 holders $3.00. Prepaid & guaranteed. Patent 3309805. Tepabco, Box 198N, Gallatin, TN 37066.

NOVICE THREE-BAND DOUBLE INVERTED-VEE: Tuned assembled SWR. Under 1.5-1 15-40-80 Novice bands. W3FQJ Design, $15.75. Antenna Products, Box 276, Warrington, PA 18976.

WIRELESS SHOP–new and reconditioned equipment. Write, call or stop for free estimate. 1305 Tennessee St., Vallejo, CA 94590 (707-643-2797).

DAYTON HAMVENTION April 25, 1970: Sponsored by Dayton Amateur Radio Association for the 19th year. Technical sessions, exhibits and hidden transmitter hunt. An interesting program for XYL. For information, watch ads or write Dayton Hamvention, Dept S, Box 44, Dayton OH 45401.

GREENE. . .center dipole insulator with. . .or without balun. . .see 73, November '69, page 107.

DIAL PLATES: all types. Give your home brew and other gear an attractive appearance. Send for catalogue. Radio Dials, 1397 Washington Circle, Forestville OH 45230.

WANTED: Turret Tuner with coils or all chassis with tuner for Hammarlund SP400X receiver. Later model with 13 plate stator & 14 plate rotor. Ralph M. Williams, Box 372, Dixfield ME 04224.

2 METER FM–30D for 12 volts, not converted, complete, $35. Commercial 5 watt portable 6/110 battery, $30. Globe CB-100, $30. K9KIC/7, 804 48 St. S., Great Falls MT 59401.

TECH MANUALS–R390, R390A, USM-26, OS-8C/U, $6.50 each; TS-323/UR, TS-186D/UP, R-274/FRR, $5.50 each. Many others. List 20¢. S. Consalvo, 4905 Roanne Drive, Washington DC 20021.

HALLICRAFTERS SR-150 xcvr with matching pwr supply and manual. In mint condition. Price, $325.00. R. A. Faraone, 7727B Nelson Loop, Ft. Meade MD 20755.

GET YOUR "FIRST!" Memorize, study–"1970 Tests-Answers" for FCC First Class License. plus-"Self-Study Ability Test." Proven. $5.00. Command, Box 26348-S, San Francisco CA 94126.

SELL: SX-100 receiver, $100.00; Triple H meter 631, $40.00 or make offer. Local deal preferred. Jim—WB6MQE, 517 E. Emerson Ave.. Monterey Park CA 91754.

WORLD RADIO used gear has trial-guarantee-terms! KWM2—$695.00; G50—$159.95; SR150—$299.95; HW32—$89.95; Swan 250—$229.95; DuoBander 84—$119.95; EICO 753—$129.95; TR3—$369.95; NCX3—$169.95; NC200—$249.95; SB33—$199.95; SB34—$299.95. FREE "blue-book" list for more. Write WORLD RADIO, Box 919, Council Bluffs IA 51501.

INTEGRATED CIRCUITS 20 page article. Anyone can design successful projects. Educational and informative. Send $1.00. Solid State Tekneex, Rt 1, Doniphan MO 63935.

WANTED TEST EQUIPMENT HP608 generator, RX meter, 704 Jerrold FSM, 601, 900 Jerrold sweep generator, HP130 oscilloscope or equivalent. VE3BVX, 11 Sussex North, Lindsay, Ontario, Canada.

ROCHESTER, N. Y. is again Hamfest, VHF meet and flea market headquarters for largest event in northeast, May 16, 1970. Write WNY Hamfest, Box 1388, Rochester, NY 14603.

FOR SALE: HEATH Apache transmitter and SB-10 sideband adapter. Factory assembled, excellent working condition. $128. A. Peterman, 455 Territorial Hall, Minneapolis MN 55455. 612-373-6618.

BUY TRANSISTOR RADIOS direct from import-export dealers overseas. Also many other items. Info $3.00. H & L Associates, PO Box 474, Port Hueneme CA 93041.

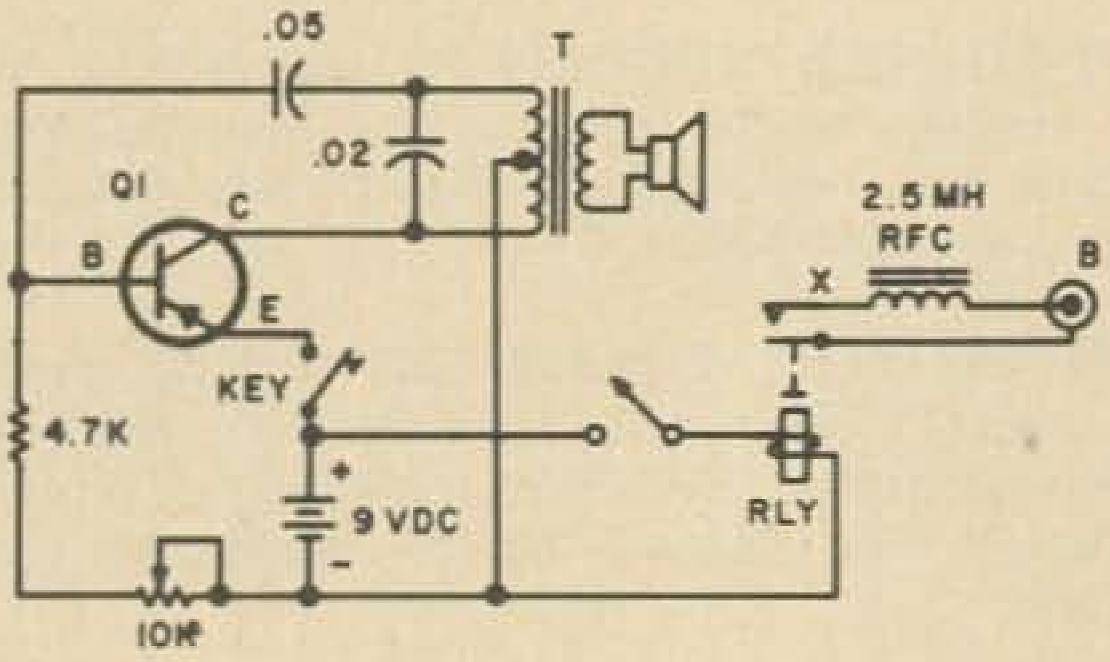
SB-101 & SB-200 with matching power supply, speaker and 400 cycle filter. Also HD-15 and HM-15. All for $600 or best offer. Roger Melen WB6JXU, Rm 340, Crothers Memorial Hall, Stanford CA 94305.

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.

The Combo

Most amateurs cannot send good CW unless they monitor what they send, and few have come up with a monitor which satisfies them. Here is one that won't win any ribbons, but it will do a good job and with perfect reproduction. It doesn't think for itself, so you must control it as it will key the transmitter exactly as you send.



The circuit is very simple; a single PNP audio transistor in a common base configuration. All parts except the relay and choke came from a discarded transistor radio. It will work well with any general purpose audio transistor and an NPN may be used by reversing the battery polarity. The key acts as the oscillator switch, and switch SW controls the keyer.

Be sure that the choke is placed directly at the relay points and short the contacts with a small by-pass condenser at the point marked X, keeping the leads as short as possible. This will eliminate chirp and key clicks.

The relay can be any very small make and break type that will operate at the battery voltages and must draw very little current or the battery will not last long. Make sure the relay will work at the speeds you operate, and that it does not chatter.

The entire unit can be housed in a small black plastic meter case (3½x6x2 inches) available from Lafayette for about 75 cents. It has enough spare room to house a small power supply should you desire to include one.

The keyer will key any type transmitter as long as the relay contacts will stand the current and it will need no reverse blocking diodes.

The ten K pot is a tone control and resistance is not critical and may be changed to suit taste.

The keyer requires no practice to learn to use and can be built for a few dollars at most. It is just the thing to tuck in your pocket for Code Practice at Scout or club meetings.

Earl Spencer K4FQU

Ham Hospitality

Dear Wayne, OM

We have just received our June issue of 73 Magazine. Big deal, but this was relatively fast, as many issues arrive 3 to 4 months late, due to the mail service here.

I note that on page 119 your article about hospitality for hams. Since we have been here in Brazil for over five years, and speak the language fluently, perhaps we can assist any hams who may wish to visit Brazil. We would be delighted to have a "casal," couple stay with us in our home, and I (the XYL) would be glad to take any XYL shopping, while the OM made visits to other localities, such as our kinescope factory, record factory and if they wish to buy precious stones in the state of Minas Gerais (where we have our receiving tube factory), I can assist them there also. We lived in that state for over three years, and I have learned quite a lot about stones.

Just remember that this country is large, and Recife (where some people visit) is about 1000 miles away, HI! Any one coming to Sao Paulo is more than welcomed. Our home phone number is 62-4530.

Continue to work hard, but at the same time enjoy your work! As yet Brazil does not have reciprocal licensing so we are not on the air, but we know many hams here who are always anxious to meet American hams.

Let us hear from you!

Frances L. Gunther-Mohr
(Mrs. J. P. Gunther-Mohr K2UMD)
Rua Cardoso de Almeida 2041
Pacaembu, Sao Paulo, Brazil

5 LEVEL TAPE READER

Made for teletype use but we have been advised they are just as useful for other methods of data transmission when tied in with computors. Removed from used equipment. Last time offered, they sold out in one advertising.
TAPE READER . . $15.00

16 BIT SCRATCH PAD MEMORY

4 x 4 matrix, 4 inputs "X", 4 inputs "Y", Dual inline package . . . . #AACVI $2.75

FOUR 2-INPUT "AND" GATES "OR'D" TOGETHER, BUFFERED & INVERTED

Dual inline package . . . . #AAAB3 $1.75

SYNCHRONOUS RICELESS FLIP-FLOP

May be converted to most any flip-flop mode (R-S, D, J-K, etc.) 4 separate 2-input AND gates, "OR'd" together & fed to universal flip-flop.
Dual inline package . . . . #AAFLI $3.00

DUAL 4-INPUT GATE W/EMITTER FOLLOWER RESISTORS

Dual inline package . . . . #F1116 $1.00
12 for $10.00

DECODER LAMP DRIVER HIGH CURRENT

Similar to Fairchild SH2001. Dual 2-input gate w/amp. 14 pin dual inline ceramic package.
. . . . #SHO-579 $2.25

TUBES TUBES TUBES TUBES

Used, guaranteed OK condition.

4X150	$4.00
813	5.00
6164	2.00

2N706A HI-FREQ. TRANSISTORS

First line factory marked. 400 mc, 15 volt, NPN
#2N706A 3 for $1.00

FIBRE OPTICS KITS WITH IMAGE TRANSMITTER

An experimenters delight, fantastic display of the unique properties of clad-fibre-optics to pipe light as well as images. Kit #1 includes PVC sheathed bundle of glass fibres with polished ends (light pipe), bundle of plastic fibre optics, bundle of glass fibres, coherent light pipe (transmits images), instructions & experiments.
. . . . BLISS-FULL PAK #1 $5.00

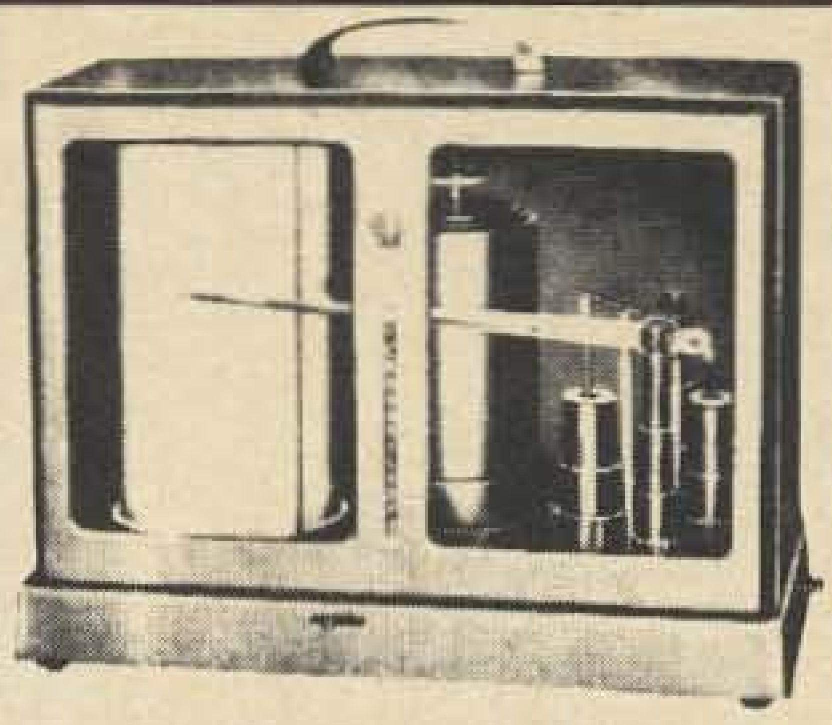
Kit #2 includes all of the above but more fibres, longer lengths, fatter bundles and also includes light source, heat shrink tubing, a 5 ft. light pipe, a longer coherent bundle (image transmitter) & more experiments.
. . . . BLISS-FULL PAK #2 $10.00

FIBRE OPTIC LIGHT PIPE

1 ft. length jacketed glass fibres (200 fibres) each end sealed and optically polished for maximum light conduction. Pipe light around corners, into difficult locations, etc.
#LP-1 $1.00

BULK LIGHT PIPE

3 feet of fibre glass (200 fibres) with jacketing. Make your own light pipes, Christmas tree displays, psychedelic lighting, etc. Any length you wish at 3 feet for $1.00



RECORDING MICRO BAROGRAPH

Surplus U. S. Air Force Bendix-Friez recording barograph. The standard instrument for U. S. Weather Bureau, armed forces, airlines. Records a full week, powered by a jeweled spring-driven clock mechanism. A valuable instrument for the yachtsman or anyone interested in weather variations. An unusual gift for "the man who has everything." These are checked out, with a year's supply of ink and charts. Should last a lifetime. Gov't. cost $367.00.
Our price $125.00 plus shipping.

FIBRE OPTIC OPTICAL SCANNER

Photo optics scanner, as used in IBM punch card scanner system. We offer the 12 position optical scanner consisting of 2 ft assembly light pipe fanning out into a 12 channel scanner. All terminations optically polished. Make your own card scanner, light chopper, etc. A value for the 22 inch light pipe alone. With 4 page evaluation & application data. #LP-3 $5.00

SAPPHIRE ROD

Pure sapphire rod, 1 inch long x 1/16 diameter polished each end and sides. Cuts glass, used for bearings, end-window for UV or IR, etc.
$1.25 each

IBM WIRED MEMORY FRAMES

Removed from high priced computors. Exlnt condition.

640 Wired Core Plane	$ 5.00
4,000 Wired Core Plane	$ 9.00
4,096 Wired Core Plane	$12.50
8,000 Wired Core Plane	$13.50
8,192 Wired Core Plane	$15.00
16,384 Wired Core Plane	$19.00

INTEGRATED CIRCUITS

926	Hi-Speed flip-flop (TO-5)	$1.50
900	Buffer	1.00
910	Dual 2-input NOR	1.00
2-903	Dual input gate	1.00
914	Dual 2-input gate	1.00
914-925	Dual 2-input gate dual expander	1.00
923	JK flip flop	1.00
925	Dual 2-input gate exp	1.00
946	DTL 4 2-input NAND/NOR gate	2/1.00
	DTL Clocked flip flop	2/1.00
1M5	Dual 4-input logic gate	2/1.00
7M6	6 NPN transistors in one package, gen use	3/1.00
12M2	Diff Amp	1.00
711	Dual Comp Amp	2.00

Above equipment on hand, ready to ship. Terms net cash, f.o.b. Lynn, Mass. Many other unusual pieces of military surplus electronic equipment are described in our catalog.

Send 25¢ for Catalog #70

JOHN MESHNA JR.

19 ALLERTON ST., LYNN, MASS. 01904
P. O. BOX 62, E. LYNN, MASS. 01904

73 Readers' DOUBLE BONUS

Want info quick? Just check the box next to the name of the advertiser of your choice in the index below. We'll rush your name to the firm so you can get all the dope direct from the source. (Don't forget to include your name and address at the bottom.)

ADVERTISER INDEX

What's the matter, Bunky? Don't want to go through all the ads? Here's a way to get around it and still get the information you need.

SUBJECT INDEX

□ Antennas
□ Baluns
□ Calibration/Repair Svc.
□ Callbook
□ Camera Switching units
□ Capacitors
□ Clocks
□ Coaxial Relays
□ Code tapes
□ Components
□ Converters
□ Crystals
□ Diodes
□ DX
□ Equipment dist.
□ Filters
□ Integrated circuits
□ Keyers
□ Linears
□ Nameplates
□ Oscillators (code)
□ Oscillators (rf)
□ PC negatives
□ Preamps
□ Receivers (FM)
□ Surplus Elec.
□ Test Equipment
□ Towers
□ Transceivers (AM)
□ Transceivers (FM)
□ Transceivers (SSB)
□ Transformers
□ Transistors
□ TV/Fax
□ Vacuum tubes

MAIL TO **73 Inc., Peterborough NH 03458**

Name ______________________________

______________________ Call

Address ____________________________

______________________ Zip __________

DOUBLE BONUS!

Check the top index for specific firms of interest—or check the lower index for the items that turn you on. Either way, you get the dope—and you get it fast.

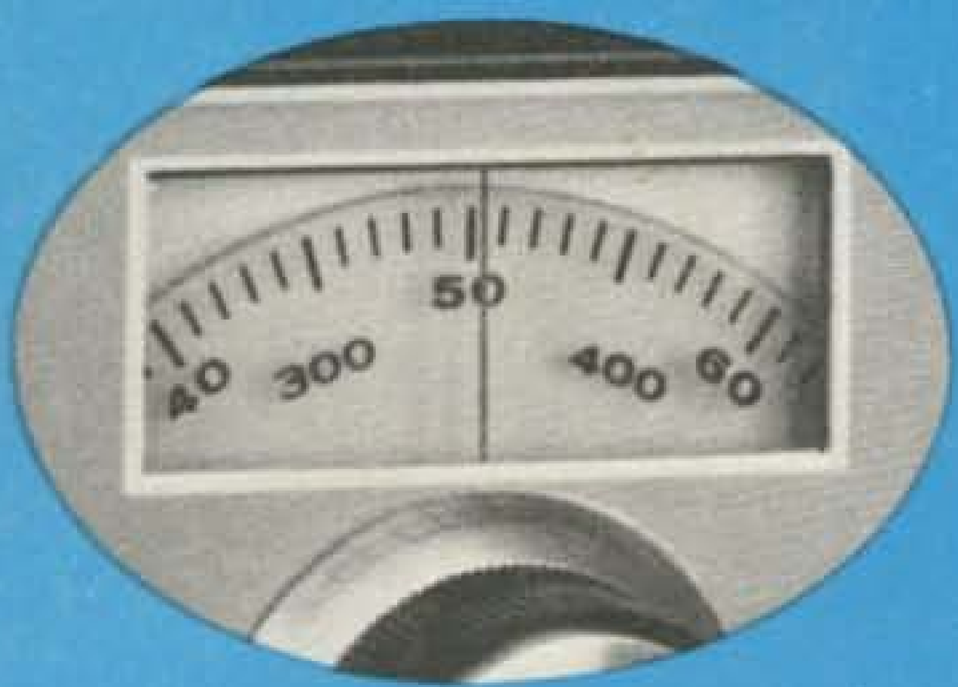
DRAKE

- *Direct Frequency Dialing*
- *Programmable Coverage*

COMMUNICATIONS RECEIVER

- *All Solid State*
- *FET Circuitry*

MODEL SPR-4...379^{00} NET



Precision tuning dial . . . tune station frequency directly . . . no searching.

Programmable frequency coverage . . . change crystal and label on dial.

The SPR-4 is a general purpose receiver which may be programmed to suit any interest: SWL, Amateur, Laboratory, Broadcast, Marine Radio, etc. Frequency Coverage: 150-500 KHz plus any (23) 500 KHz ranges between .500 and 30 MHz.

FEATURES: • **Linear dial** with 1 KHz readout • **4-pole crystal** filter in first IF • **4-pole LC filter** in second IF • **Three bandwidths:** 0.4 KHz, 2.4 KHz, and 4.8 KHz for: CW, SSB, AM • **AVC time constants** opimized for each mode • **Superior** cross-modulation and overload performance • **Power:** 120 VAC, 220 VAC, and 12 VDC • **Crystals supplied** for LW, standard broadcast and seven shortwave broadcast bands • **Built-in speaker** • **Notch Filter.**

ACCESSORIES: 100 Khz calibrator, noise blanker, transceive adapter (T-4XB), DC power cord, loop antenna, crystals for other ranges.

For more information write

R. L. DRAKE COMPANY

Dept. 310, 540 Richard St., Miamisburg, Ohio 45342