73

MAY 1968
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73 MAGAZINE

May 1968
Vol. XLVII No. 5

Departments

Wayne Green W2NSD/1
Publisher

Kayla Bloom W1EMV
Editor

73 Magazine is published monthly by 73, Inc., Peterborough, N.H. 03458. The phone is 603-924-3873. Subscription rate: $5.00 per year, $9.00 for two years, $12.00 for three years. Second class postage is paid at Peterborough, New Hampshire, and at additional mailing offices. Printed in Pontiac, Illinois, U.S.A.

Postmasters, please send form 3579 to 73 Magazine, Peterborough, New Hampshire 03458. Say, don't read all this fine print. Get on to the articles, or better yet, send for our new DX Handbook.

This is one of three photos taken by Rex Heflin, an Orange County highway inspector, in August 1965. The UFO approached from the left, hovered over the road, moved right, hovered over the field, moved off and accelerated out of sight. The sighting lasted approximately 20 seconds. Helfin took this photo through the front windshield of his truck. This photograph is by courtesy of the National Investigations Committee on Aerial Phenomena, 1536 Connecticut Avenue, N.W., Washington, D.C. 20036.

THE UFO NET

Wayne Green W2NSD/1

Last month, in my editorial, I suggested the organization of an amateur radio network for reporting UFO contacts. This idea has met with widespread enthusiasm, I am happy to report.

There has to be a good reason for a network to exist if it is going to be successful. In this case amateur radio is probably the only medium that can help speed the solution of the UFO mystery. The basic problem is simple: Though there have been hundreds of thousands of sightings of UFO's, these contacts are usually of such a short duration that it is difficult or impossible to take adequate pictures or make any scientific investigations of the phenomena.

Amateur radio, by virtue of its ubiquity, can make it possible for advanced warning to be forwarded of approaching UFO's. This in turn can make it possible for pictures and scientific tests to be prepared, once the probable path of the UFO has been determined.

Amateurs who are interested in participating in this net should have an effective station set up on 80, 40 or 20 meters. I suggest the frequencies of 3900, 7250 and 14,250 kHz. The next step is to alert the local police that you are participating in the UFO network so that they will know to call you if anything is reported to their department. Then you should get in touch with every user of mobile radio in your vicinity and give them your phone number so they can notify you in case of a sighting. This can cover your local CB group, any amateur radio mobiles, taxis, doctors, vets, sheriff's departments, road crews, trucks, public service, forestry, etc. Give your card to the local newspapers and radio stations. They frequently are informed of UFO contacts first.

Once you have your community as informed as possible about calling you in case of a UFO report it is time to write a release to the paper and radio station telling them all about it so they can give you further publicity. This will be helpful to amateur radio too. We need all of the publicity we can get, as you know.

The UFO network will be rather informal at first. There are at present no fixed net control stations. We are interested in hearing from operators situated around the middle of the country who have very good signals and who have the interest and time available to help establish nets on the three major bands. In time I believe we will have a net that can be alerted anytime of the day or night, possibly with an alerting tone system. During the early phase of the net I suggest that we get together at 0000 GMT and discuss organization and plans.

The plans for the net have been discussed with the University of Colorado UFO inves-

(Continued on page 28)

Editorial Liberties

In 1939, the first foreign broadcast intruders invaded our 40 meter band. At that time ARRL assured us that their influence with the State Department would soon have our band clear again. The League gave it a good try, but unfortunately amateur radio was not strong enough to buck the invaders and today we have a multitude of foreign broadcast stations, not only on the 7 MHz band, but on other bands as well.

The international agreement on sharing the bands with broadcast stations is that they are welcome to use the amateur bands provided they do not cause undue interference. They *do* cause undue interference and still nothing can be done about it from the standpoint of ITU.

We ask how they can get away with this outrage. It is easy. Every time the question comes up as to their interference, they protest that they are *not* beaming their signals to the U.S. If you look at a schedule of Radio Moscow's broadcasts, they all say they are beaming toward the Scandinavian countries, or to Asia, or Africa. Never to the U.S. If this is true, why, pray tell me, are the broadcasts in English? And, why are they broadcast at the optimum hours for reception in the U.S.?

Their broadcasts scheduled for the Scandinavian countries are not only delivered in the English language, but, in most cases, at hours when they would be least likely to have a Scandinavian audience . . . like 0300 in Sweden. When it is 3 AM in Sweden, it is evening here in our hemisphere and the optimum hour for reception in the U.S. It becomes obvious to all but the ITU that they are covering their tracks by rather weak lies.

Our allies, the British, are little better, I'm sorry to say. Looking at their schedule one finds that the BBC broadcasts we hear in the evening hours here are intended for Australia. On *forty* Meters? C'mon, whom are they trying to kid? It's mid-day in Australia.

In case you haven't received the point so far, this editor is becoming annoyed by all this. Nearly thirty years of protesting has gained us nothing except more and more interference. And, in a way, we are to blame.

The amateurs of this country give the foreign broadcast stations a wide berth on all bands where they appear. We have, so far, made no effort to fight. We are much too willing to move to avoid the QRM, leaving the spectrum open to the invaders to use at will. Official protests obviously do no good, so we become resigned to our fate and allow the intruders to take over our bands. We give them an open invitation to take over more space by yielding our rights.

At some point or other there will be another frequency allocations conference and we will face the loss of frequencies. If we choose to ignore the foreign broadcast intruders, we could lose 40 meters. Once they can show that we are not using our allocated frequencies on that band, they will have a good case to take over from us. If you are willing to have them do that, fine, but don't scream when it happens. The time to begin fighting has long since passed, but perhaps we can put up a battle even now.

These broadcasts are all on AM. Ask any AM station what happens when a solid SSB signal comes close to the frequency. Copy is difficult at best. This works both ways, I grant you, but AM suffers more from SSB interference than SSB does from AM interference. A few strong SSB signals using a frequency which is just off zero beat from the foreign broadcast station's signal could create sufficient QRM that the listeners, with rather unsophistocated receivers, would cease their listening and thereby defeat the purpose of the broadcasts.

Don't think for one moment that this would be illegal. They, not we, are the intruders. By international agreement, we have the right to use 40 meters exclusively for amateur radio.

If some night you found yourself awakened by the sound of someone invading your property, would you wait until he had gained entrance to the house? Or, would you meet him at the gate and try to prevent him from invading the house where you keep your valuable possessions? Let's meet them at the gate and stop them before they gain entrance to our valuable frequencies. Fight the QRM with the knowledge that you are giving them just as much trouble as they are giving you.

. . . W1EMV


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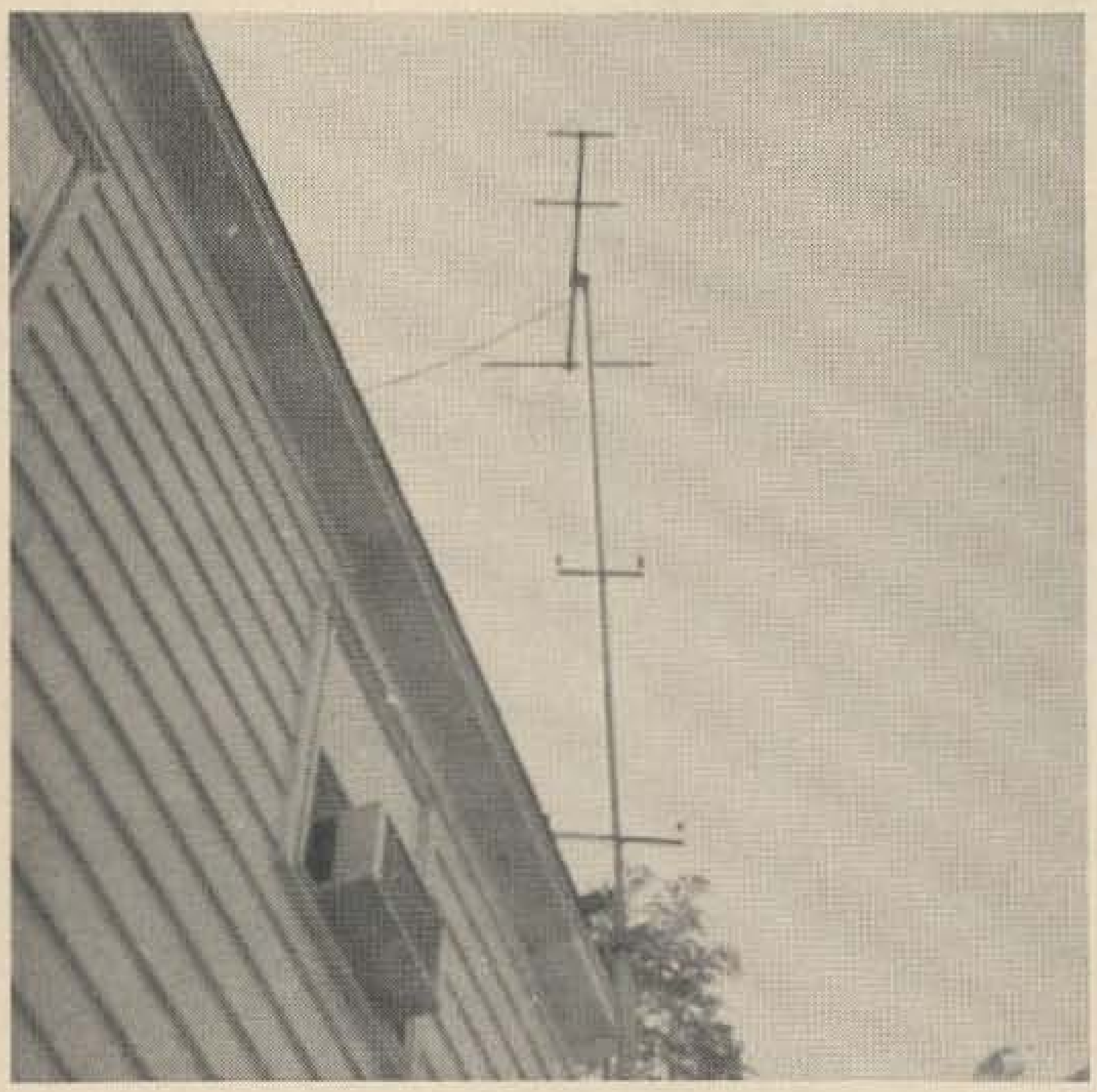
Practical Miniature Antennas For 80 Through 10 Meters

Robert L. Gilmer W8VVT
2743 Blue Rock Drive
Portsmouth, Ohio



Equipment miniaturization has become common-place in Amateur Radio with the advent of modern transceivers and kilowatt linears that can fit in a shoe box. This article carries the miniaturization idea one step further, however, and describes *antennas* that are only 1/20th conventional size and, amazingly enough, have almost imperceptable losses, − 1 1/2 dB, compared with full size half waves.

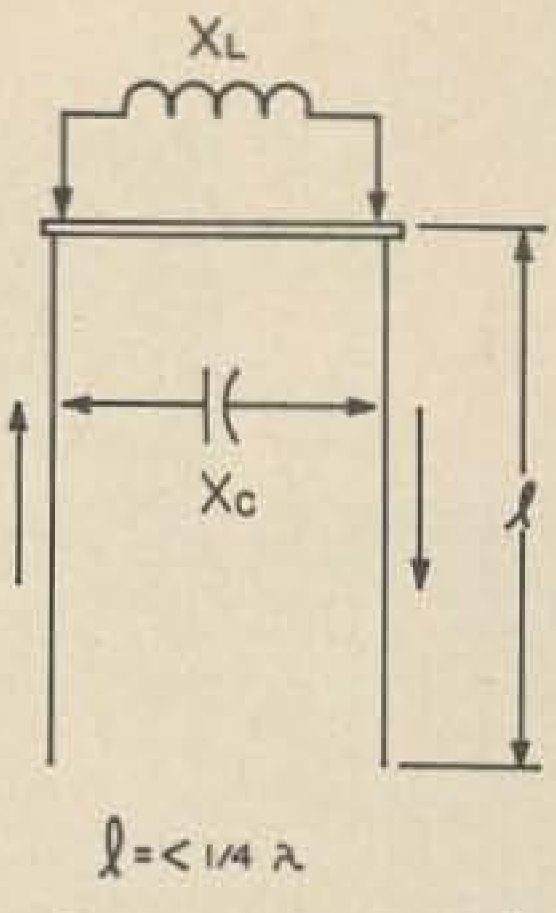


Fig. 1. The inductive reactance of a short copper element and the capacitive reactance of a ¼λ section of open-wire line are combined to form a resonant antenna system.

Theory

The theory involved is quite simple: The *inductive* reactance of a short copper element and the capacitive reactance of a 1/4 λ section of open wire line are combined to form a resonant antenna system. See **Fig. 1.**

Since the open-wire line carries currents 180° out of phase and the wires are separated by only .024λ, there is very little radiation from this section. All radiation, therefore, takes place from the short copper element.

Losses

Reducing the size of an element lowers the radiation resistance considerably. An element only .024λ long, the length used here, shows a radiation resistance of only 0.5 Ω. However, the efficiency of the radiator remains better than 98% since the ohmic resistance of the short 3/4 inch copper elements average less than 0.008 Ω. I^2R losses in the open-wire line section are shown graphically in **Fig. 2.** If the line is made of at least #16 wire, the losses are small averaging slightly over −1 db.

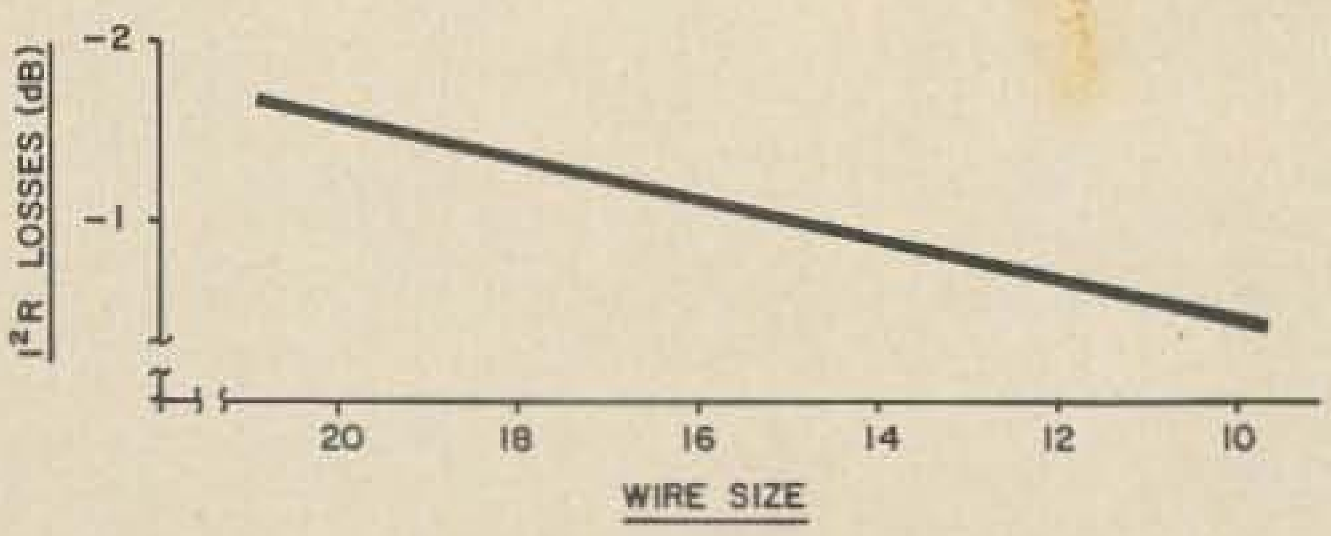


Fig. 2. Short antenna average I^2R losses vs. line wire size.

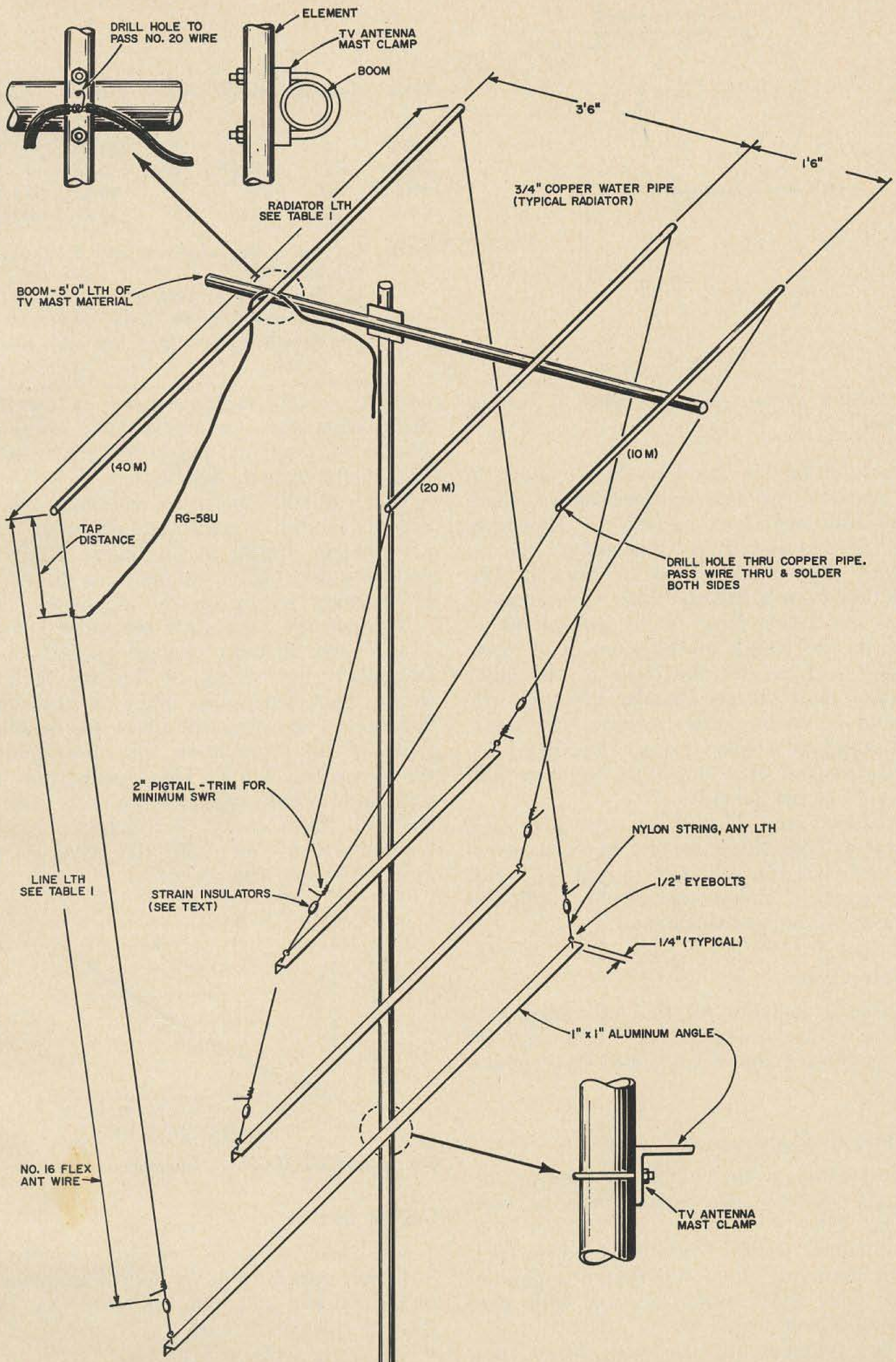


Fig. 4. Construction Details

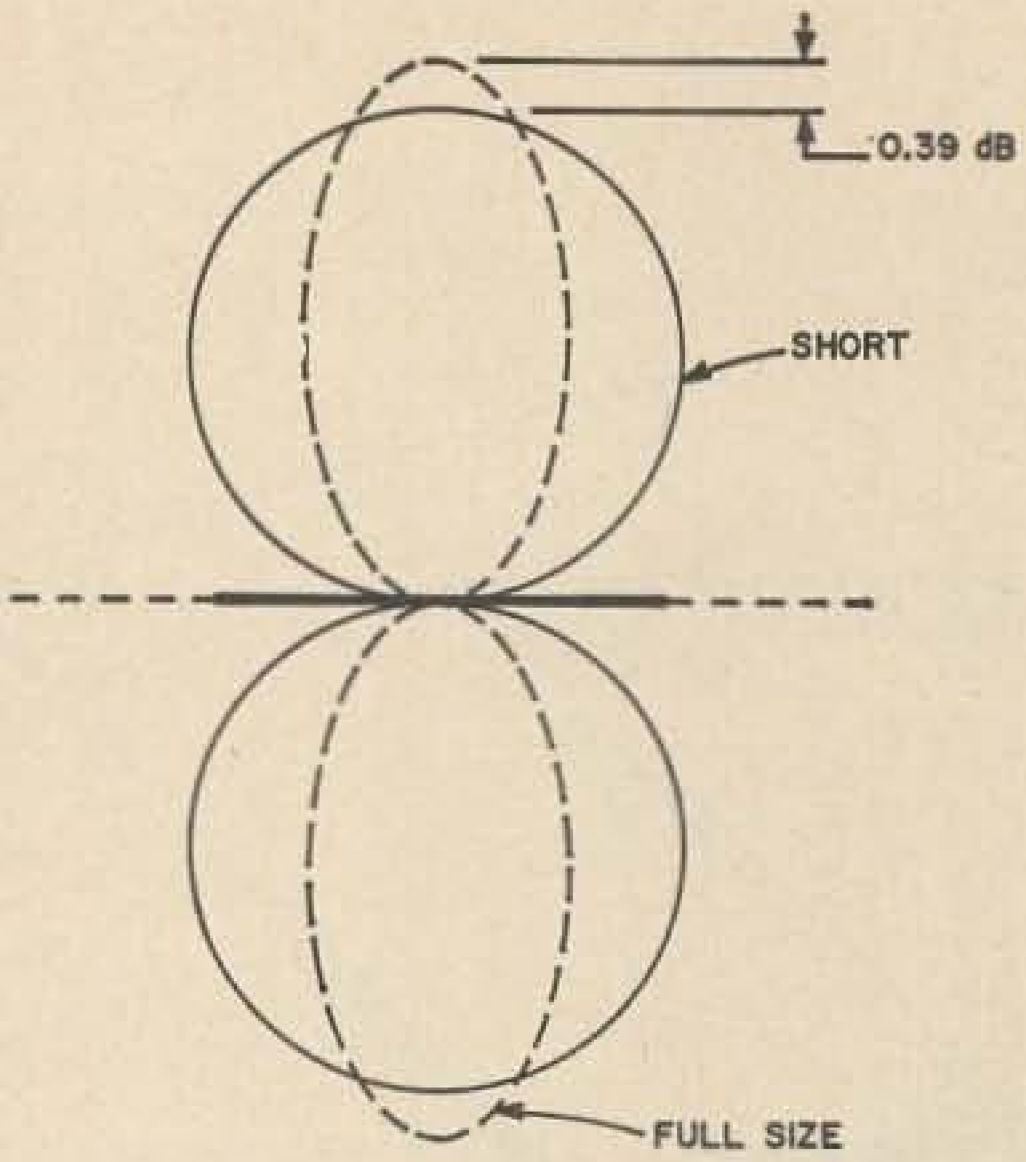


Fig. 3. Field pattern comparison short vs. full size element.

In addition to the I^2R (heat) losses in the element and line outlined above, there is an additional loss, termed the directivity loss, that results from shortening the radiator. This is illustrated in **Fig. 3.** The radiation from a full size half-wave element forms the classic figure eight pattern. However, as the length of the element is made smaller and smaller the ovals of the eight become more nearly circular although the general radiation pattern remains the same. The result is a loss in the immediate forward direction of −0.39 dB, and some "filling out" along the sides.

Summarizing: The directivity plus I^2R losses in these short element antennas average −1 1/2 db when compared with full size elements, a loss that could hardly be detected in the received signal!

Construction

Table 1 includes all the information required to size antennas for 10 through 80 meters. **Fig. 4** shows suggested construction details.

Additional Construction Notes

Horizontal arrangements are shown, although, vertical polarization could be used just as well.

Individual coaxial feeds are used on each band; however, one could design a parallel single feed that would function with very little additional loss.

Tap distances for use with 52 Ω coax are shown; however, feed lines of any impedance, balanced or unbalanced, can be

Table I

Band	Length Radiator	Line(1)	Tap(2)	B.W.(3)	Loss(4)
10M	10"	8'3½"	3"	245 Kc.	−1.3 db
15M	15"	11'1½"	4"	215 Kc.	−1.4 db
20M	20"	16'8½"	4½"	140 Kc.	−1.5 db
40M	40"	33'1"	7"	80 Kc.	−1.7 db
80M	80"	62'10"	12"	50 Kc.	−2.0 db

Notes: (1) Adjust line length for SWR 1:1 (see text)
(2) 52 Ω tap
(3) Bandwidth at SWR 2:1
(4) Includes line I^2R losses and 0.39 db directivity loss. #16 line wire size assumed.

used by merely tapping down on the line. Series capacitors are not required since the system is resonant and a purely resistive load is offered to the feed line.

Good quality moisture resistant end insulators should be used since extremely high r.f. voltages appear at this point. High impedances and higher voltages are the effects of standing waves on the open-wire line.

Because the capacitive reactance (of the 1/4 λ line section) changes rapidly with frequency, the tuning of the line is quite sharp. The dimensions given in the table, if followed closely, will place the resonant point of the antenna at the *lower* end of the respective band. The construction details show short pig-tails on each side of the line. These should be trimmed one-quarter inch at a time until the SWR is 1:1 at the operating frequency.

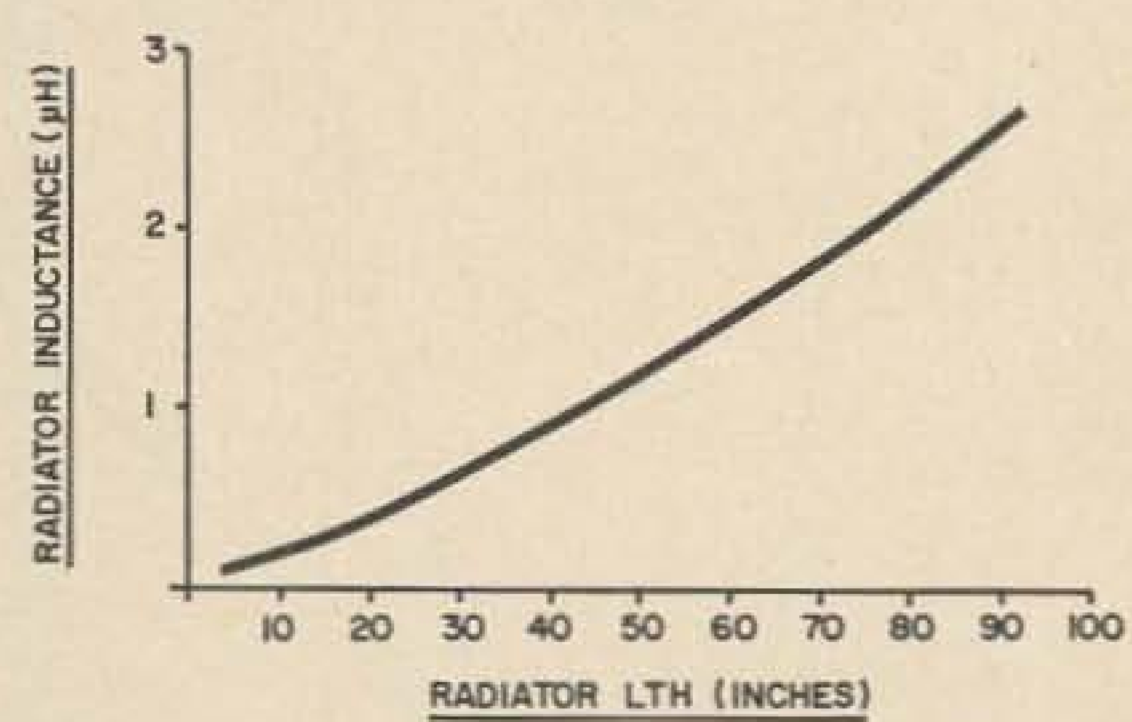


Fig. 5. Radiator length vs. inductance.

Design Details

The inductance, L_R, of short lengths of 3/4 inch copper pipe is shown graphically in **Fig. 5.** The inductive reactance, X_R, may then be calculated from:

$$X_R = 2\pi f_{mc} L_R$$

The length of open-wire line, l° (degrees), required to furnish the necessary resonant capacitive reactance can be determined from:

$$C_{OT}\,1^\circ = \frac{X_R}{Z_o}$$

The line impedance, Z_O, for various spacings is shown in **Fig. 6.**

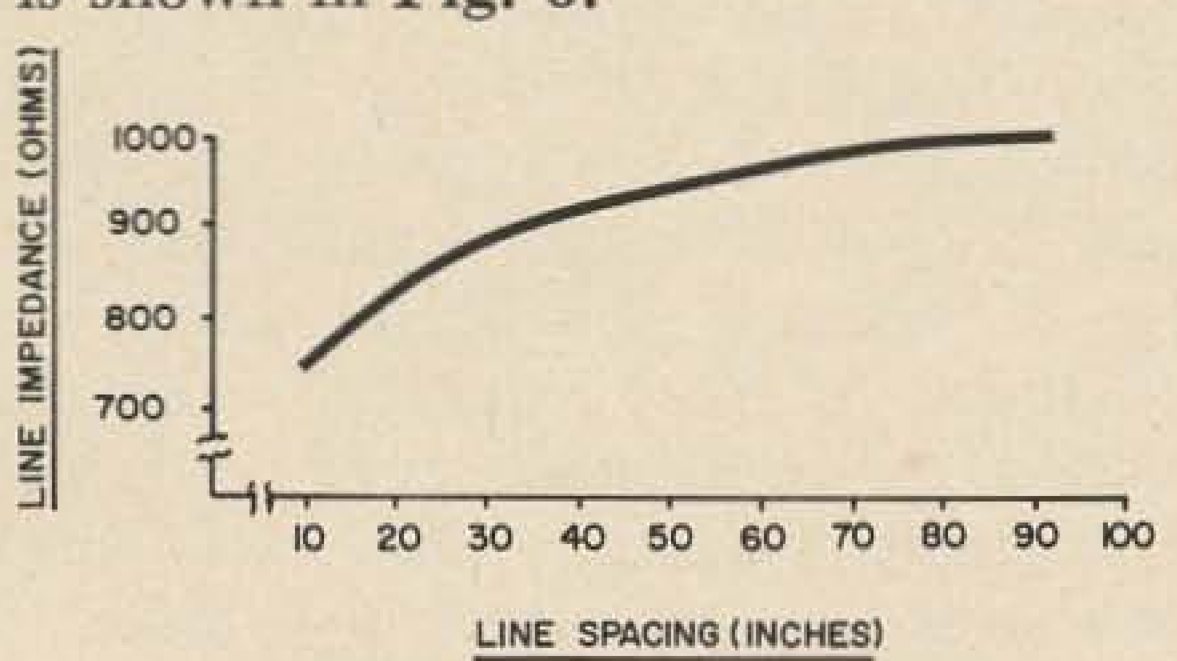


Fig. 6. Line spacing vs. impedance, Z_o, wire size #16.

Results

Tap distances, antenna "Q", and bandwidths were first calculated and then substantiated by testing. Unfortunately efficiencies were calculated but, lacking facilities to do so, were not checked under operating conditions.

Antennas for each of the bands have been constructed and used with results comparable to any of the full half waves used here at various times. Comparisons were run against a long wire (275 feet) antenna by switching between the two. In the direction of the maximum lobe of the long wire, the long wire outperformed the miniatures by 1/2 to 2 S units. In all other directions the miniatures were equal to or better than the longer wire. Both coasts are worked regularly on 40, 20 and 15 with reports ranging from S5 to S9.

Conclusions

Where space is available to mount them, full half waves have the edge, but if not, substitution of the minatures probably will not affect the results one way or the other, and then, you just might be able to raise the minature higher and that's a lot more effective than increasing it's length.

References

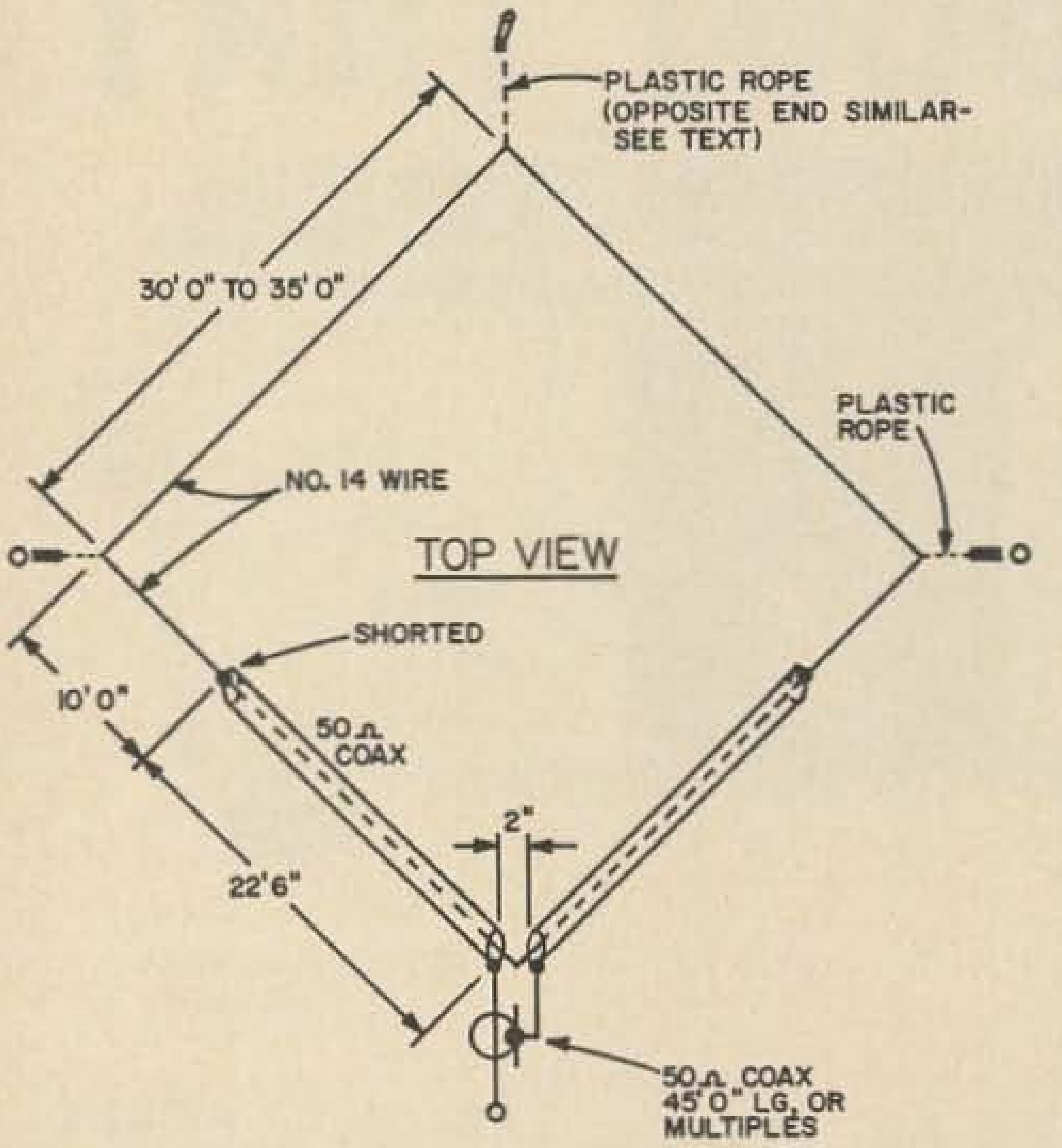
Radio Engineering Handbook—Terman, McGraw-Hill Publisher.

Electromagnetic Waves and Radiating Systems—E. C. Jordan, Prentice-Hall Publisher.

"Miniaturized Antennas"—J. J. Schultz, W2EEY/1, CQ November 1967.

The Diamond Array

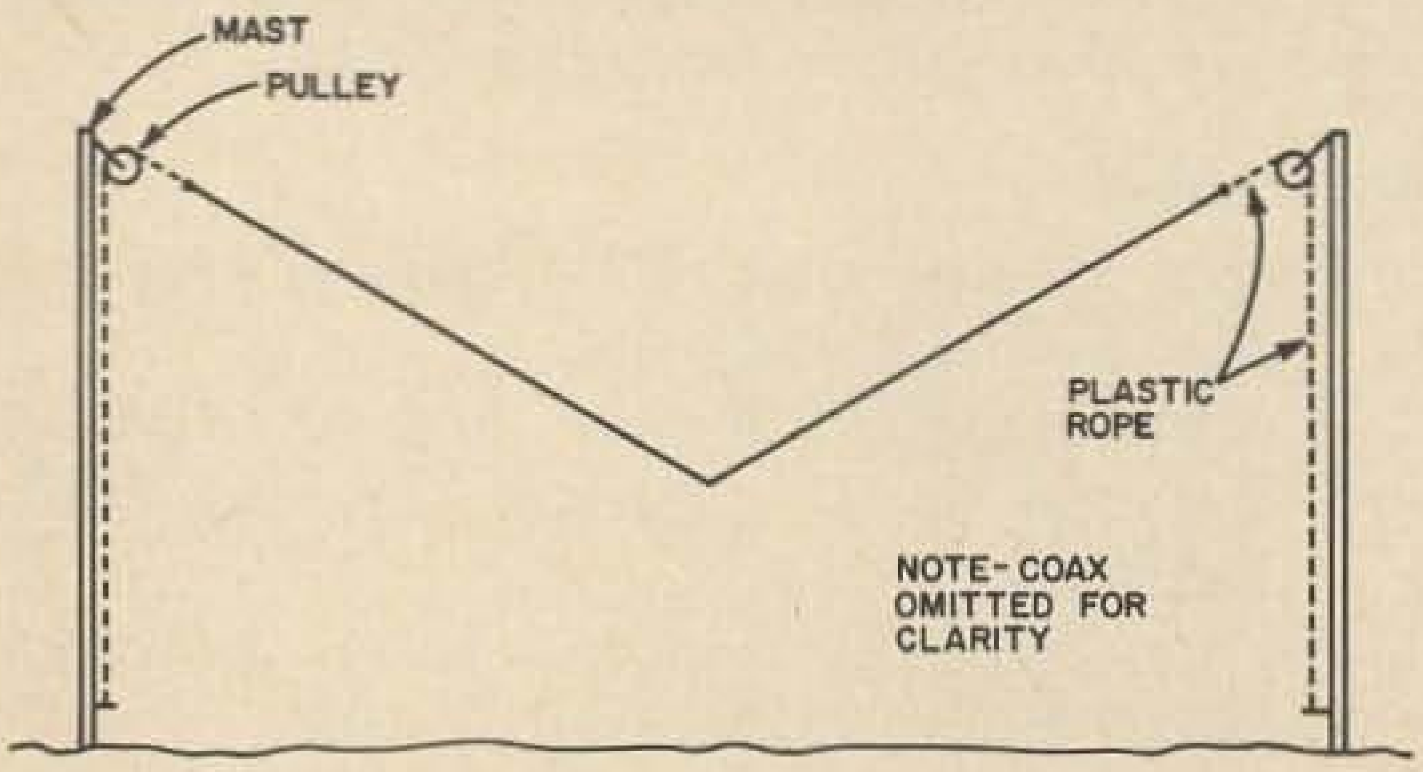
Ira F. Gardner, W6LNN
2613 Crosby Way
Sacramento, Calif. 95815



This efficient little antenna features several popular designs all in one. It is one element of a 40 meter quad-one full wave length in a diamond or square, two upright Vee antennas fed in phase, an upright Vee derived from the design of the familiar co-ax dipole, and it has a gain of 3½ or 4 dB over a standard dipole. It is rather broad in frequency response, and non-directional.

The antenna can be oriented 90 degrees, that is, fed from one of the high angles, with no noticeable change in performance. However, by using one of the low angles for the feed-point, it may be possible to keep the feedline away from the field of the antenna, and also even use a more direct feed to the rig.

Plastic or glass lines are used for support and are run thru pulleys for ease of erection and tuning. The lengths of the single wire on the opposite Vee from the co-ax fed half of the array is not critical, but the actual tuning for best SWR and frequency of the antenna is done with the 10 foot ends of this first co-ax half.



The two low opposite angles are pulled down and out to supports at each side of the lot, resulting in approximately 20 feet above ground for these angles. The opposite high angles of the diamond are around 45 to 50 feet high.

The far end of each half of the dipole co-ax section is shorted, with the single wire extending around the diamond from these points. The 50 ohm co-ax shielding only is opened up for 2 to 3 inches and the feedline connected at each section of shielding. This folded dipole effect gives the design a good flat SWR throughout the band. To reduce the strain at the feedpoint, a short bridle or yoke of plastic or glass line is wrapped around each side of the co-ax and tightly taped with the tie-line brought out from this spot.

In tuning for the best SWR or for the best center frequency, always use an SWR meter with an exciter for low power—100 watts is ample.

If the low frequency end of the band shows the best SWR, or it results in an increasingly better reading although still far from 2 to 1 or better, the single wire section is too long, and a foot should be cut off from each end of the 10 ft. extensions. The SWR reading then should be checked and if improvement is noted—continue cutting and testing until satisfaction is reached or the tuning is correct.

Now, should the SWR show improvement by tuning towards the high end of the frequency of the 40 meter band, and still in excess of what it should be, the antenna is too short. At least a foot or more should be added to each single wire end for the next check point on the SWR.

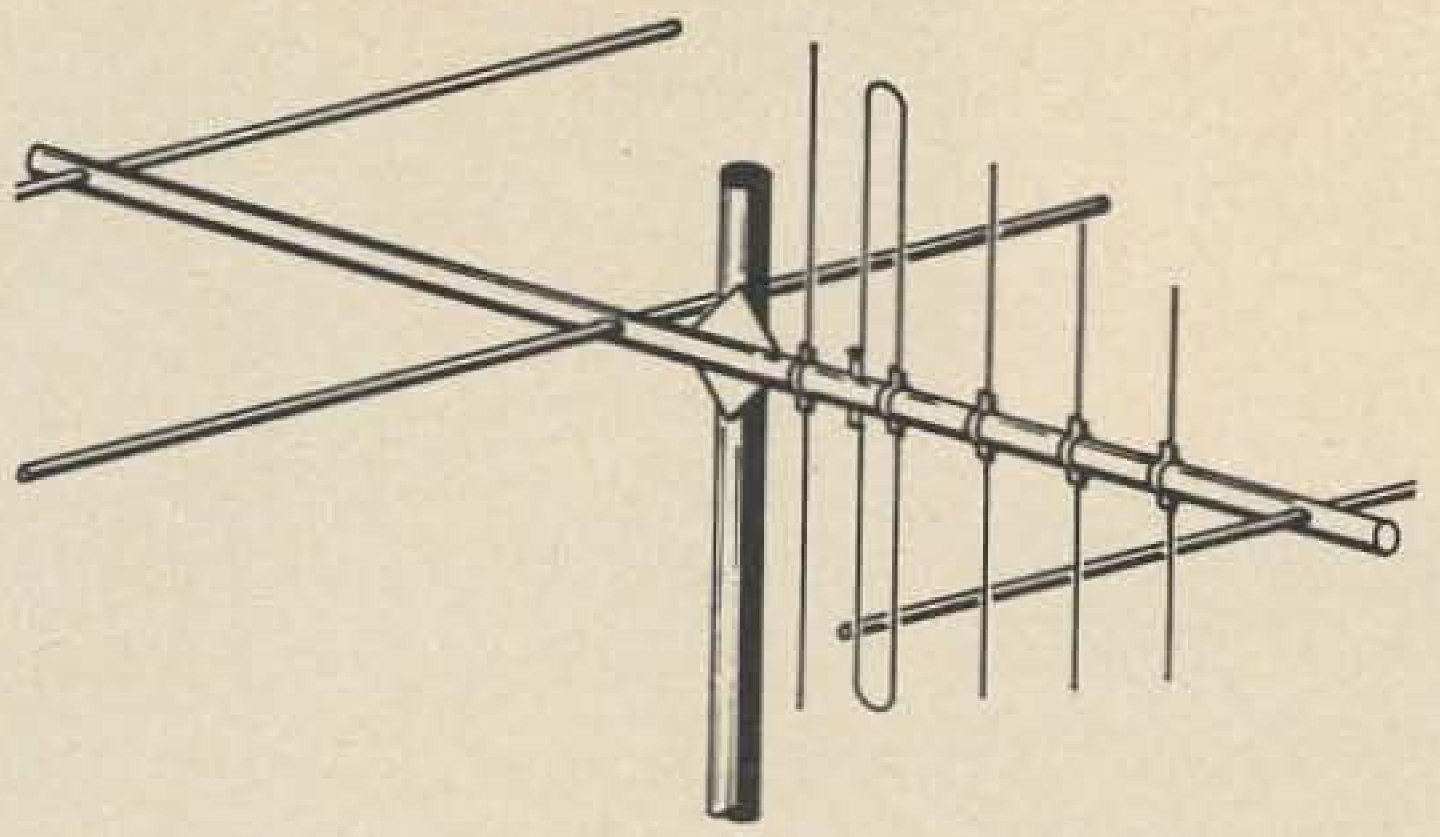
No balun is necessary, just keep your co-ax feed in the clear and away from grounds.

The writer's SWR figures were as follows:

7.3 mc—2 to 1
7.2 mc—1.25 to 1
7.1 mc—1.05 to 1
7. mc—1.22 to 1

In closing, much to the amazement of this amateur, very good SWR is obtained both on 20 and 10 meters. So, if you like to try out antennas, here is one that may surprise you.

. . . W6LNN



Why Not?

W. R. Lingenbrink W6HGX
1809 Hill Ave.
Hayward, California 94541

In the course of human events, one sometimes finds necessity the mother of invention. Since my low frequency beam had to come down for some adjustments, I begun wondering why one piece of equipment couldn't serve two functions. Since the beam usually occupies the tallest tower and located in the most favorable position, why not use it for a VHF platform, so to speak. The idea is simple, have the boom for the HF beam also serve as the boom for a VHF antenna. This works out well, especially where VHF is vertically polarized as it is here in California. There is virtually no interaction between the two beams.

To avoid drilling the boom, and thus weakening it, I used clamps to mount the VHF elements. The most convenient and readily available clamps are the strap type which are used to hold electrical conduit in place. However, you could use any similar arrangement; i.e. plumbers tape, U bolts, etc.

Construction is simple. The elements can be lightweight aluminum tubing with the ends flattened, or aluminum clothesline bent to fit the clamp on one end.

A supply of clamps, slightly smaller than the diameter of the boom are produced or fashioned. The elements are then cut to half their length (this being determined by any good antenna handbook) minus the diameter of the boom clamp. The elements are then drilled to take the clamp screw or bent to take the clamp screw if aluminum wire is used.

A top and bottom element are then fastened together, using two boom clamps for clamping the element to the boom. This leaves half the element above, and half the element below the boom.

The driven element is fastened much the same way, but at this location a folded dipole element is used. The feed point being brought to stand-off insulators on the boom and fed at this point either through a balun or using twin lead.

After proper spacing of the elements for best front-to-back, or forward gain, it was found that there is very little interaction between the two beams. There was less than ½ volt measured across the VHF lead when transmitting on the HF beam. This can be bled off with the use of a grounding switch or a simple diode placed across the feed line.

. . . W6HGX

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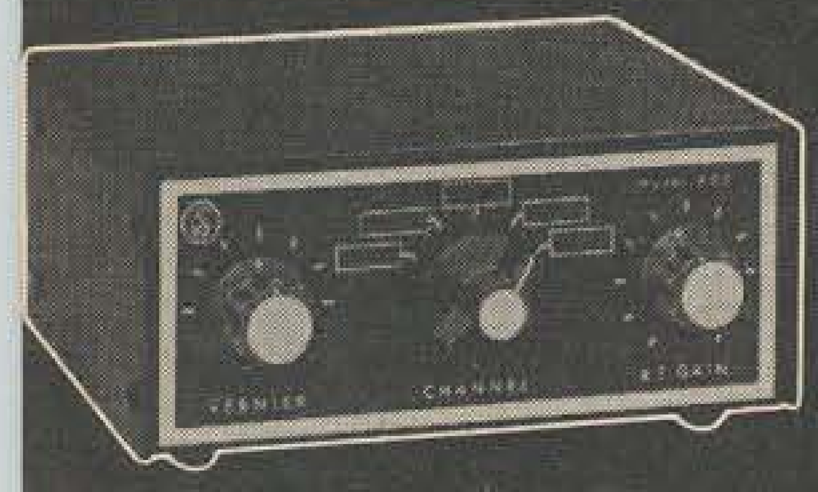

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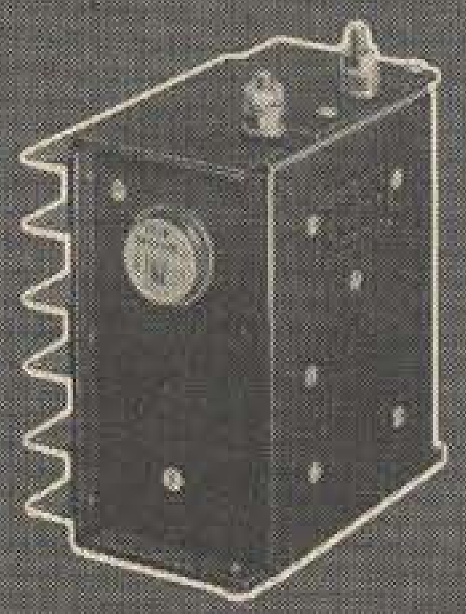

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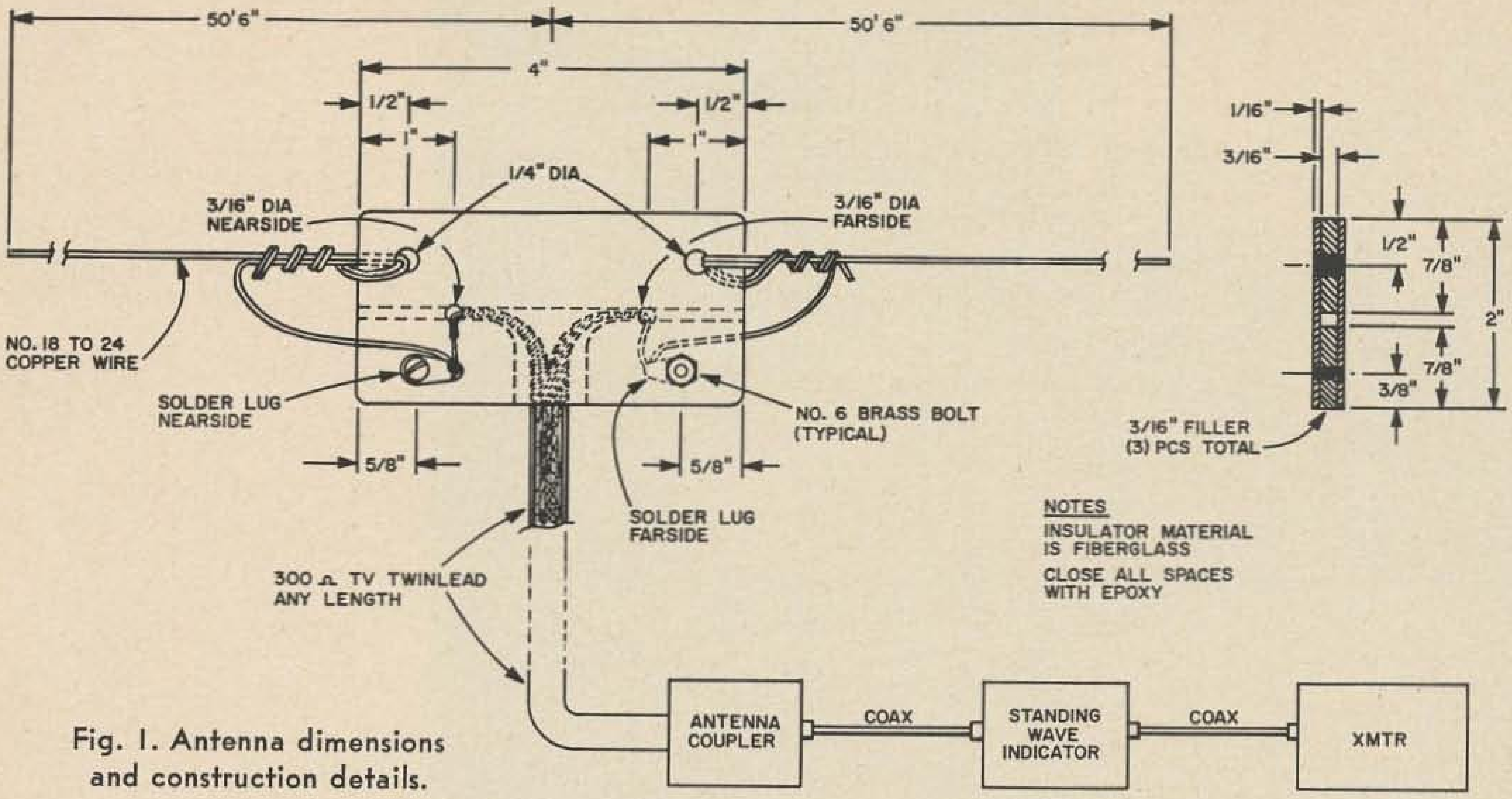

Fig. 1. Antenna dimensions and construction details.

Do It With a Wire

Warner Stortz K3QKO
5122 Alberta
Baltimore, Maryland 21236

It seems to be the proper thing these days for every ham to get with it and build something. Few people get any pleasure out of spending long, lonesome hours in the basement following someone's dull instructions on how to assemble a piece of equipment which could be bought outright for the same price. Then too, lots of people do not have the tools or test equipment to pull the job off effectively. However, there is one thing that just about every ham can homebrew and have a fine time doing it. That thing is an antenna. There is no more pleasant way to become a member of the elite homebrew set, than spending a sunny afternoon tramping around the back yard doing antenna work. It is even better if you are lucky enough to have a couple of trees to climb. You will be surprised at the fine view about fifteen feet up, and you have a ready adult answer for the neighbor's kid when he comes out, "Hey, mister, what are you doing up there?"

So, let us get started stringing one up which is a little different, and a bit better, than one you can buy. I have found that two very important things about antennas must be kept in mind if you want to have a pleasant experience when experimenting with them. First, contrary to popular opinion, they work according to the book. Second, any length of wire that is no shorter than a quarter wave length, can be center fed with 300 ohm TV twin lead, and be matched to a coaxial cable with an ordinary antenna coupler. Not only will it load, but it will operate with good efficiency and can handle powers up to 600 watts. The antenna I am about to describe, makes use of these important facts.

The radiation pattern of a simple single wire antenna will generally be as described in all antenna books. So, if it is a half wave long the maximum radiation will be at right angles to the wire. If it is a full wave in length, and center fed, it becomes a double Zepp and the maximum radiation is still at right angles to the wire. The antenna problem we are striving to solve is how, by using one wire, can we radiate East and West to cover the United States, and Northeast and Southeast to cover Europe and South America, with good efficiency. By carefully studying the radiation patterns of many lengths of antennas we find that a long wire antenna for twenty meter operation would be just the thing to cover Europe and South America. If it was made a wave and a half long it could

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be fed at the center current loop; be run North and South and have a fine East-West pattern when used for the forty and eighty meter bands. When excited with a twenty meter signal, here on the East Coast, one of its main lobes will cover Europe, and another South America. We do not have to be concerned about its impedance because we are going to use a tuned transmission line (TV twin lead) and an antenna coupler. Feeding it in the center will make adjustment of the coupler simple and broad enough to cover a large segment of each band without retuning. When it is used on twenty meters, a gain of .8 dB over a dipole and 3.8 dB over a vertical is realized. Also, its cone shaped pattern off the ends makes it less sensitive to height for low vertical radiation angles. This antenna was cut and strung North and South at a height of about 22 feet. Tests proved that it operated just as planned and out performed my vertical on every occasion. It also made a surprisingly neat appearance.

As shown in **Fig. 1**, the antenna is 50 feet 6 inches long on each side of the feed line. The twin lead can be any length, and seems to be lossless for all practical purposes. For parallel tuning on all three bands, it should be 73 feet long. **Fig. 1** also shows the construction details of the center insulator and feed line connector. It is made of circuit board material, preferably fiber glass, because of its strength. The three fillers and two outer plates are cemented together with epoxy to make sure it is sealed against the weather. The one hole in each outer plate is drilled before assembly. The holes for the antenna wire and solder lugs are drilled after the epoxy cement has hardened. Before passing the antenna wire through the insulator, bend it double about ten inches from the end. After it is through, wrap the doubled portion neatly around itself for about a inch. This will leave enough of the single conductor end to loosely bend back and solder to the lug along with the twin lead wire. The insulators at the extremes should be at least four inches long.

Details of the antenna coupler adjustments can not be given, because each type will have to be used according to its own operating instructions. There is one help that I always use. That is to connect one terminal of a NE51 neon bulb to one side of the twin lead at the couplet output. The bulb

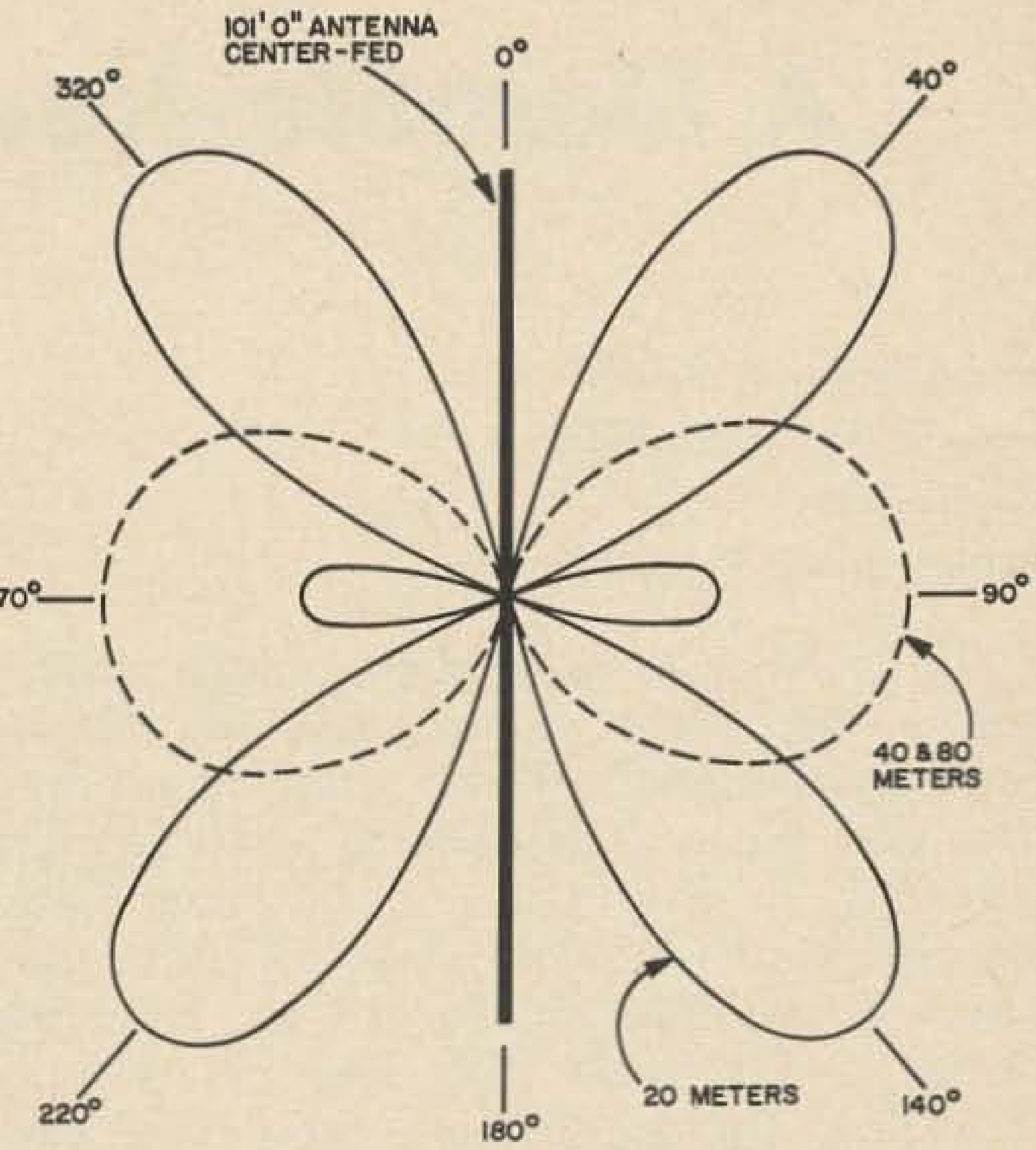

Fig. 2. Free Space horizontal pattern.

will glow if the glass part is near the case of the coupler and give a good indication of the amount of rf at its output. Keeping one eye on the standing wave indicator and the other on the bulb will prevent you from adjusting to a false standing wave indicator null.

Now a word to the ham who has an inquisitive nature and would like to do a little experimenting. There is no reason why this antenna can not be used for the ten and fifteen meter bands, in fact, its gain will be improved as the frequency gets higher. If the twenty meter band is your only interest, it can be fed with 75 ohm coaxial cable instead of TV twin lead eliminating the need for the coupler. You will have to carefully cut the antenna for the lowest VSWR in order to compensate for its surroundings, but after completed, its pattern will be the same as with the twin lead. **Fig. 2** shows the free space antenna pattern when excited with a twenty meter signal. All kinds of interesting results can be obtained by tilting the wire. This will tend to move the top part of the main lobe parallel to the ground, giving a very low angle of radiation. The lower angle will bounce your signal a little further.

The materials used for constructing this antenna are very strong, but light weight. This permits the assembly to be held in temporary positions with heavy fishing line for experimenting or permanently fastened strongly to withstand the heaviest weather.

. . . K3QKO

A Durable New Gamma-Match

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P.O. Box 205
Winter Haven, Fla. 33881

The subject is a **sturdy** gámma match with a one piece gamma rod. It can be made inexpensively from scrap metal and discarded parts. The gamma rod, labelled **A** in **Fig. 1**, is a piece of 50 ohm foamflex aluminum shielded coax. No more than 3 feet is required for 20, 15, or 10 meter beams, and a piece this size can usually be picked up gratis from most any two-way radio store. The SO 239 coax connector, **B**, is joined to the center of the driven element by an alunimum strap, **C**. At this QTH the aluminum was obtained from the scrap barrel at a local machine shop, gratis of course. At an arbitrary length from **B** a second aluminum strap **D** was placed which acts as the shorting bar. The distance, **d**, between the driven element of the beam and the gamma rod should be at least 3 inches or else the gamma rod will be inconvienently long.

The following steps were necessary in adjusting the gamma match:

1. First, the ends of the aluminum shielding next to the coax connector end of the gamma rod were bent outward slightly, and a coat of good sealer was applied for weather protection. The inner conductor of the coax was not connected to the SO-239 but was left floating, and a 100 $\mu\mu$F variable capacitor wired between the aluminum shielding and the coax connector as shown in the inset of **Fig. 1.**

2. The beam was taken up the tower to a height near that to be used in the final installation, as settings made near the ground will not be valid at normal operating heights. A signal was then fed to the beam from the transmitter, and the shorting bar and variable capacitor varied simultaneously until the setting with minimum SWR was determined. A Heathkit Reflected Power Meter and SWR Bridge was used for this operation. The shorting bar was fixed at this point.

3. The variable capacitor was brought down very carefully without disturbing the setting so that the capacitance could be measured with a capacity meter.

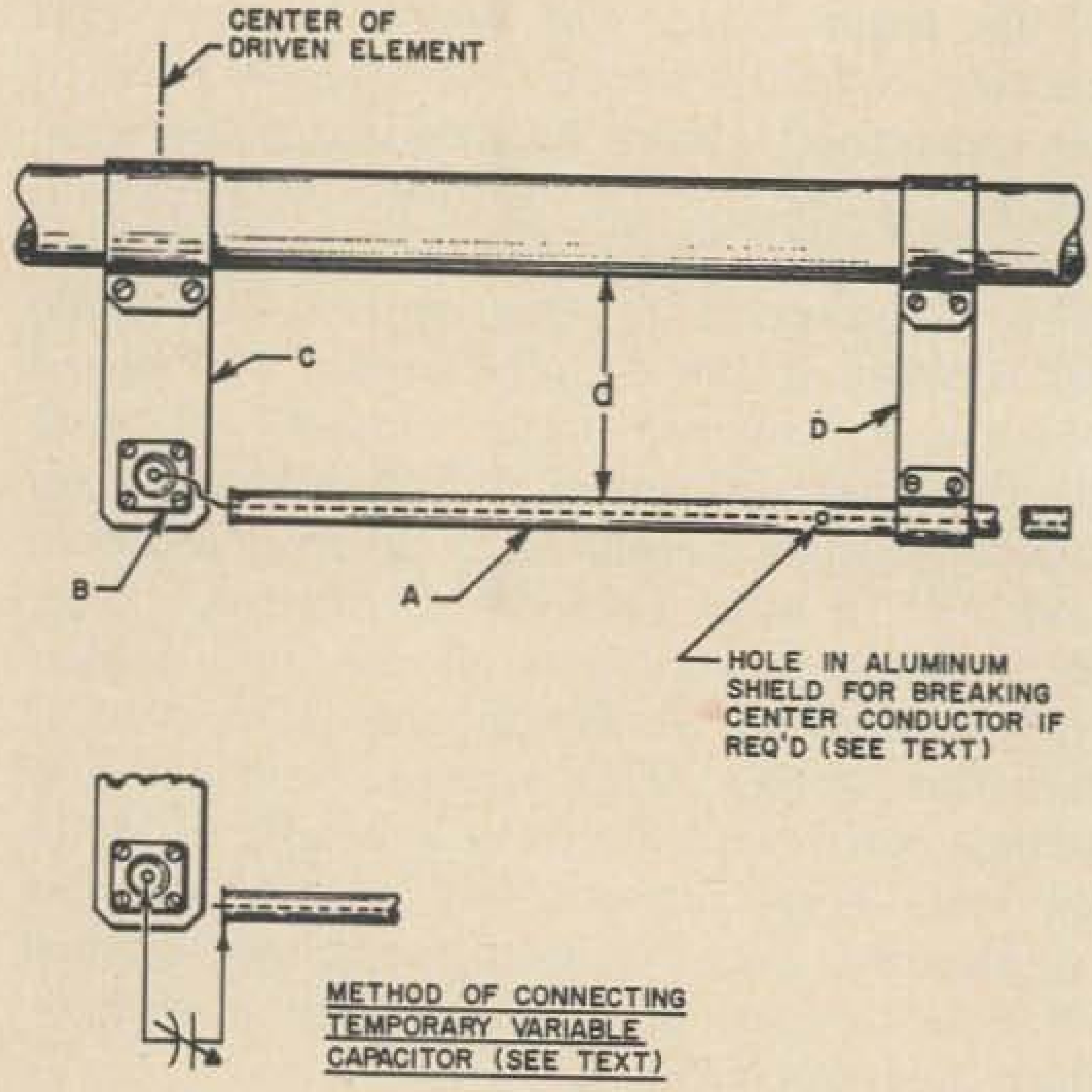

Fig. 1. The essential features of the gamma-match.

4. At this juncture knowledge of the capacitance per foot of the foamflex was necessary in order to use the proper length to equal the capacitance from the variable capacitor. Our material was known to have a capacitance of 29 $\mu\mu$F/foot, and an appropriate distance was measured. If the distance falls beyond the shorting bar the coax can be cut at this point as shown by the diagonal line in **Fig. 1.** If it falls inside the shorting bar, as was the case for our installation, a hole must be drilled into the foamflex breaking the inner conductor as shown by the circle-dot on **Fig. 1.** The hole was subsequently filled with sealing compound to insulate and weatherproof.

A gamma match constructed in this manner was used on the 15 meter beam made by converting a TA-33Jr. as described in an earlier issue of this magazine. In the past 20 months it has been fixed at a height of 73 feet and has endured sustained winds of over 60 MPH in brushes with 3 hurricanes.

No damage or malfunction has resulted and consequently we recommend it to you.

. . . K4IIF & K4ELB

How to Hang a Dipole

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Freeville, N.Y. 13068

If you're a beginning ham operator or SWL, why don't you try a twinlead dipole? It offers good performance from a design practically as simple as a random long-wire antenna, but without the longwire's grounding problems. Its relatively narrow-band performance is usually no inconvenience. And it can be tuned up without a transmitter or SWR bridge. TVI problems become less severe because the transmitter rf, provided with a good place to go, loses interest in house wiring and TV sets.

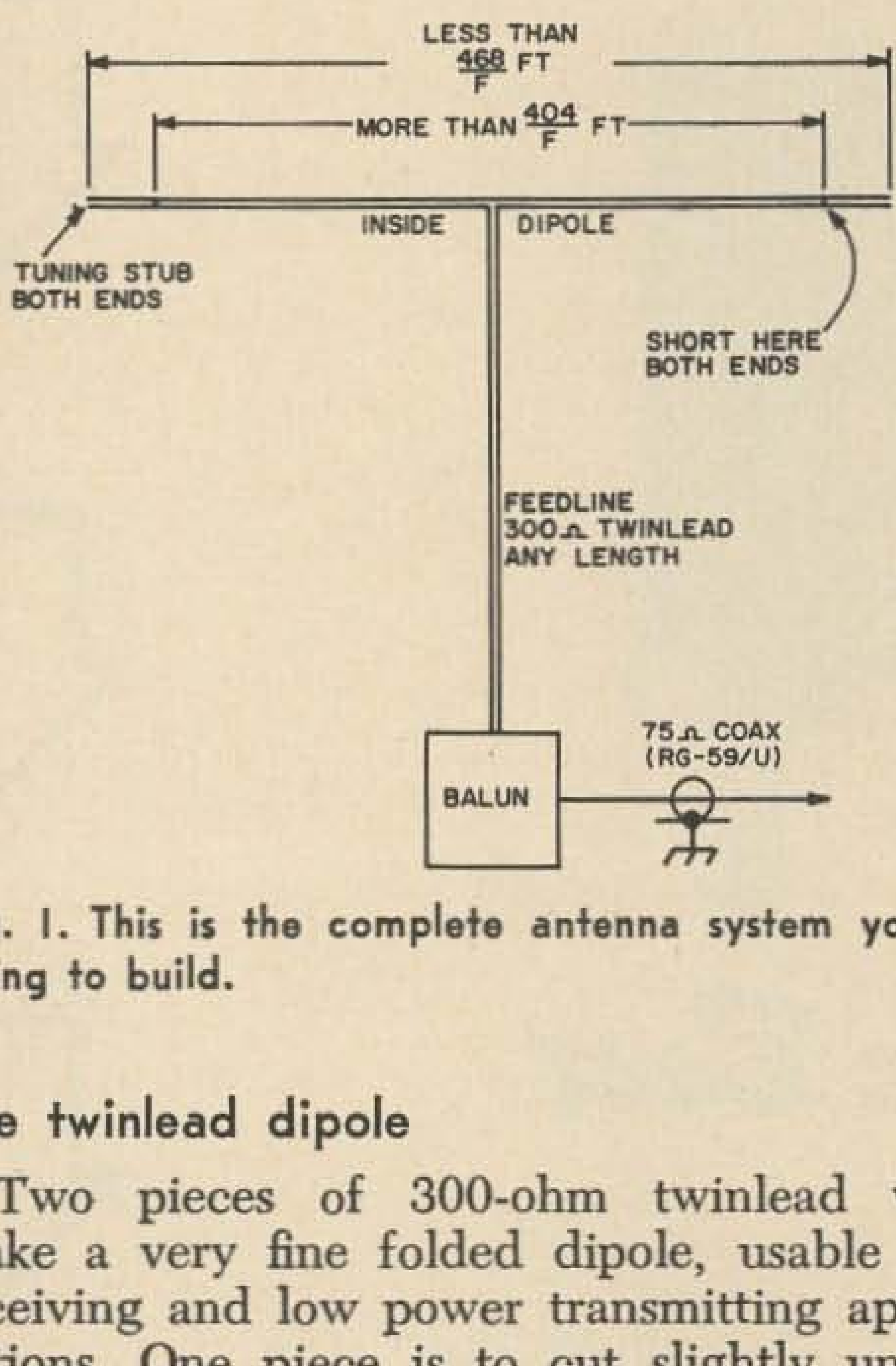


Fig. 1. This is the complete antenna system you're going to build.

The twinlead dipole

Two pieces of 300-ohm twinlead will make a very fine folded dipole, usable for receiving and low power transmitting applications. One piece is to cut slightly under a half-wave length at the operating frequency and hung parallel to the ground. The other piece is attached to its center to serve as feedline, as shown in **Fig. 1.** The feedline may be any convenient length.

The 300-ohm antenna and feedline inpedances are properties of the folded dipole kind of antenna. The 300-ohm twinlead was designed to meet this special requirement. "300 ohms" means that, as with dc, if you apply 300 volts you will find 1 amp flowing. But unlike dc, this applies only at the antenna's resonant frequency. If you replaced the 300-ohm feedline with 75 or 450 ohm twinlead, you'd end up with a mismatch, not a new antenna system.

Many radio receivers will take 300 ohm balanced or 75 ohm unbalanced input, but most amateur transmitters are designed to feed a 75 ohm load. These two load systems cannot be connected directly one to the other, but a transformer or an electrical circuit which seems to act like a transformer may be used as an almost perfectly efficient adapter. From the unwieldy term "balanced-to-unbalanced" we have the modern word "balun."

Three types of balun are used in most amateur work. All are equally appropriate for transmitting and receiving, if they are heavy enough to handle the transmitter's powerful rf. They are the toroidal transformer, the interwound coil, and the coaxial cable varieties. Only the coaxial cable balun, shown in **Fig. 2,** requires tuning.

If you don't already have a balun, the easiest and least expensive way to get one is to make it from coax cable. The exact length of cable required depends upon how fast the rf travels through it, so, if the balun is made up from a piece of coax perhaps 5% too long, you can use the haywire bridge described later to zero in on the proper dimensions. This eliminates difficulties with a piece of cable whose specs may not be quite right.

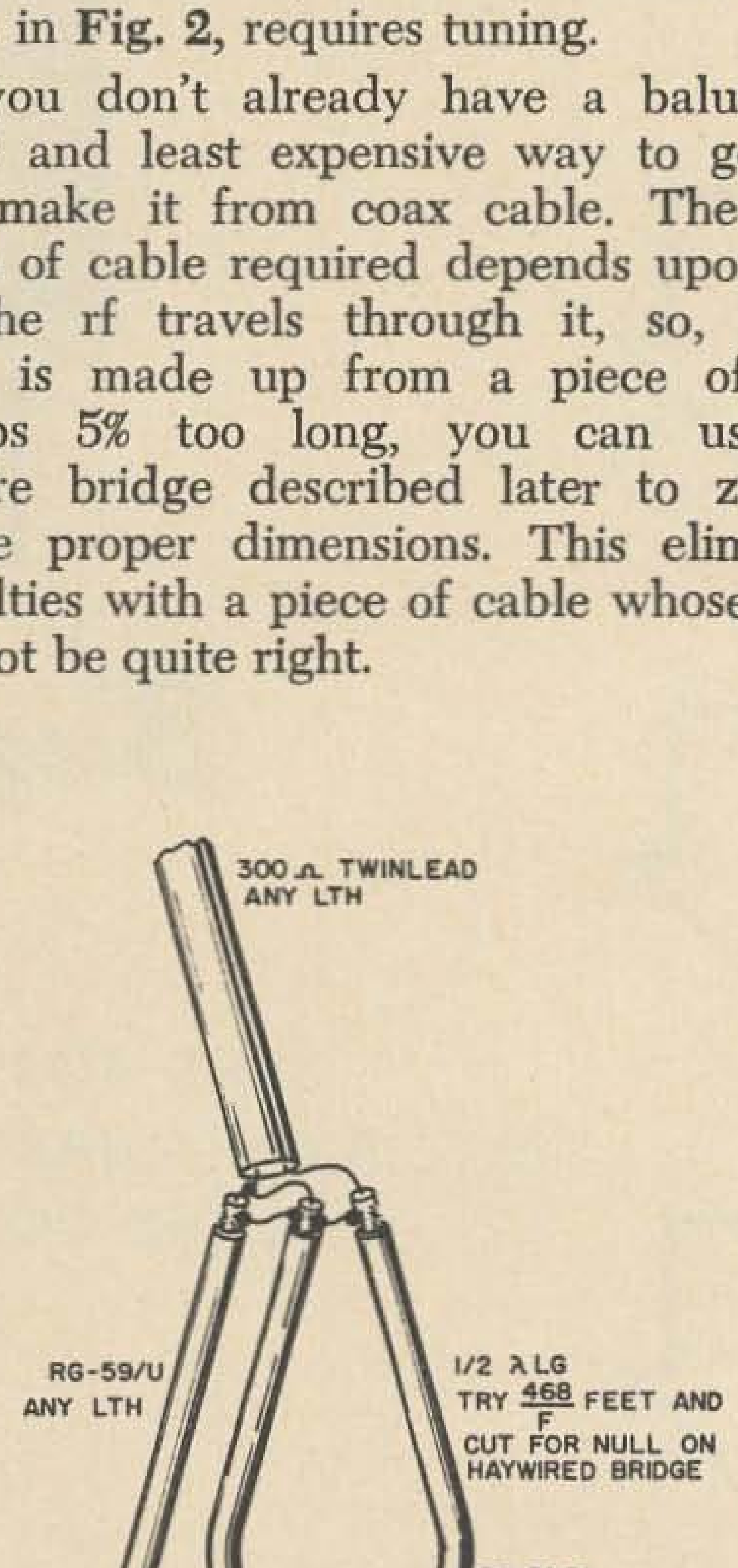


Fig. 2. This coax balun is about as simple as you can get. Avoid shorting between center and outer conductors!

The dipole's "radiation pattern" is which way the rf goes once it leaves the dipole. For receiving purposes, efficiency is best in the directions that get the most rf when transmitting. The dipole's radiation pattern varies sharply with height above ground, and the highest possible installation is not necessarily the best. **Fig. 3** shows the striking variations in radiation pattern as the dipole's height is increased from 0.2 wavelengths above ground to 0.5 wavelengths. If you cannot achieve either of these altitudes, simply try for the clearest possible location.

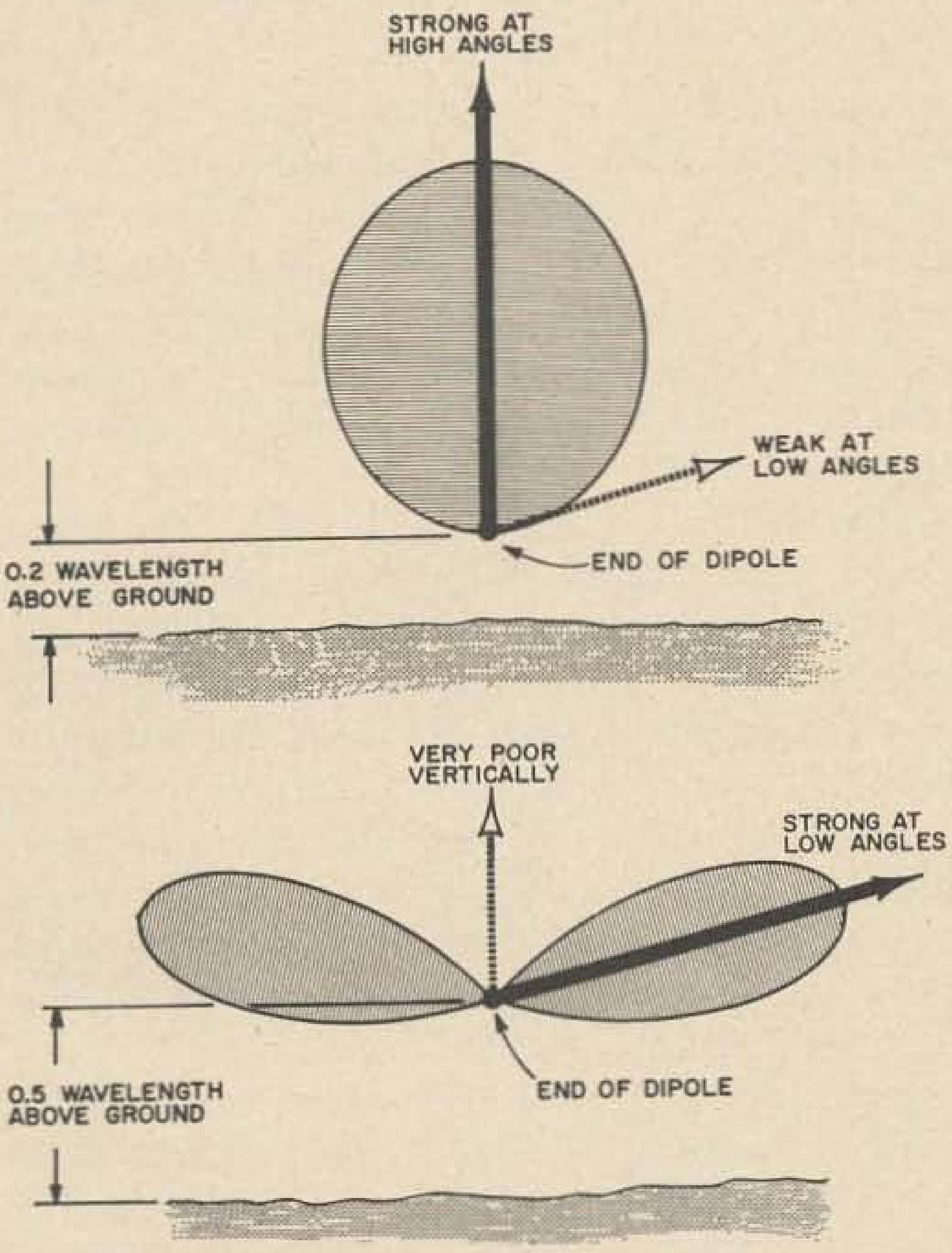


Fig. 3. The dipole has two basic radiation patterns. Here they are, as seen from the dipole's end.

The dipole's electrical properties also depend upon distance from ground. **Fig. 4** shows how the input resistance varies with height. For best results try for some height near one giving a 300-ohm input resistance.

Although the dipole is said to show zero response or radiation off it's ends, quite good signal reports may be obtained in these directions. This is because the dipole really does radiate off its ends, but only steeply up into the sky. Signals in these directions would be improved with a second better-oriented dipole. Well, why not?

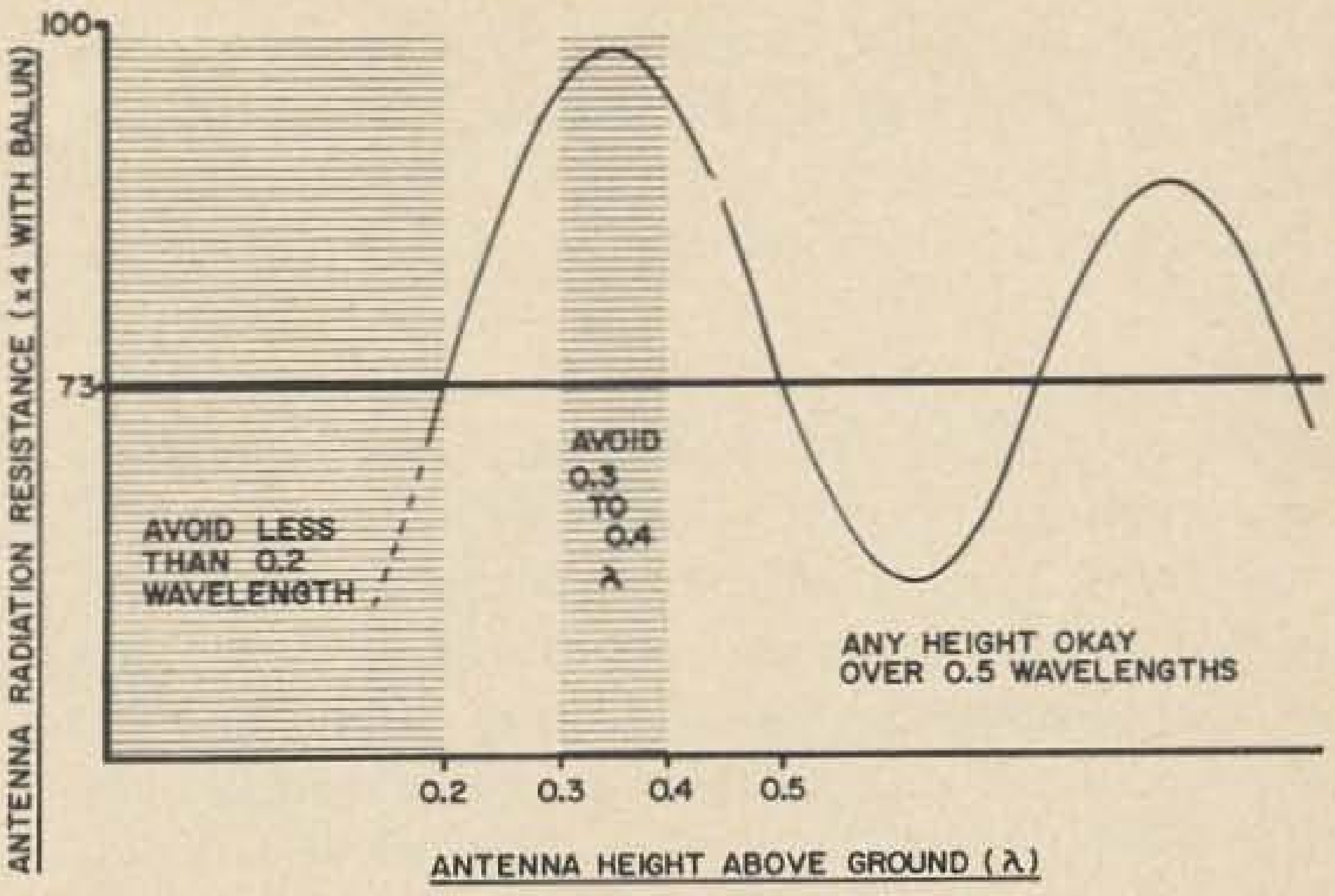


Fig. 4. The dipole's input characteristics depend upon height. Here are the two important numbers again: 0.2 and 0.5 wavelengths.

Putting up the dipole

Read everything you can find on dipoles of any variety. Then work out a way to get the twin-lead version into the air, and if you cannot meet all the specs put it up anyway. A cut-and-try test session will probably zero things in quite well.

Trees, drain pipes, lightning rod systems, towers, and what have you will all affect the folded dipole. The usual result is a measured resonant frequency lower than calculated. The dipole seems a little too long. And various nearby structures may also electrically unbalance the dipole.

Suppose L is in feet and F is the operating frequency in MHz. Cut a strip of twin-lead at least 404/F feet long, short both ends and attach the feedline to its center. Add tuning stubs to each end, both stubs equally long, for a total length of 462/F to 468/F feet. The twinlead makes good stubs. The dipole minus stubs is too short,

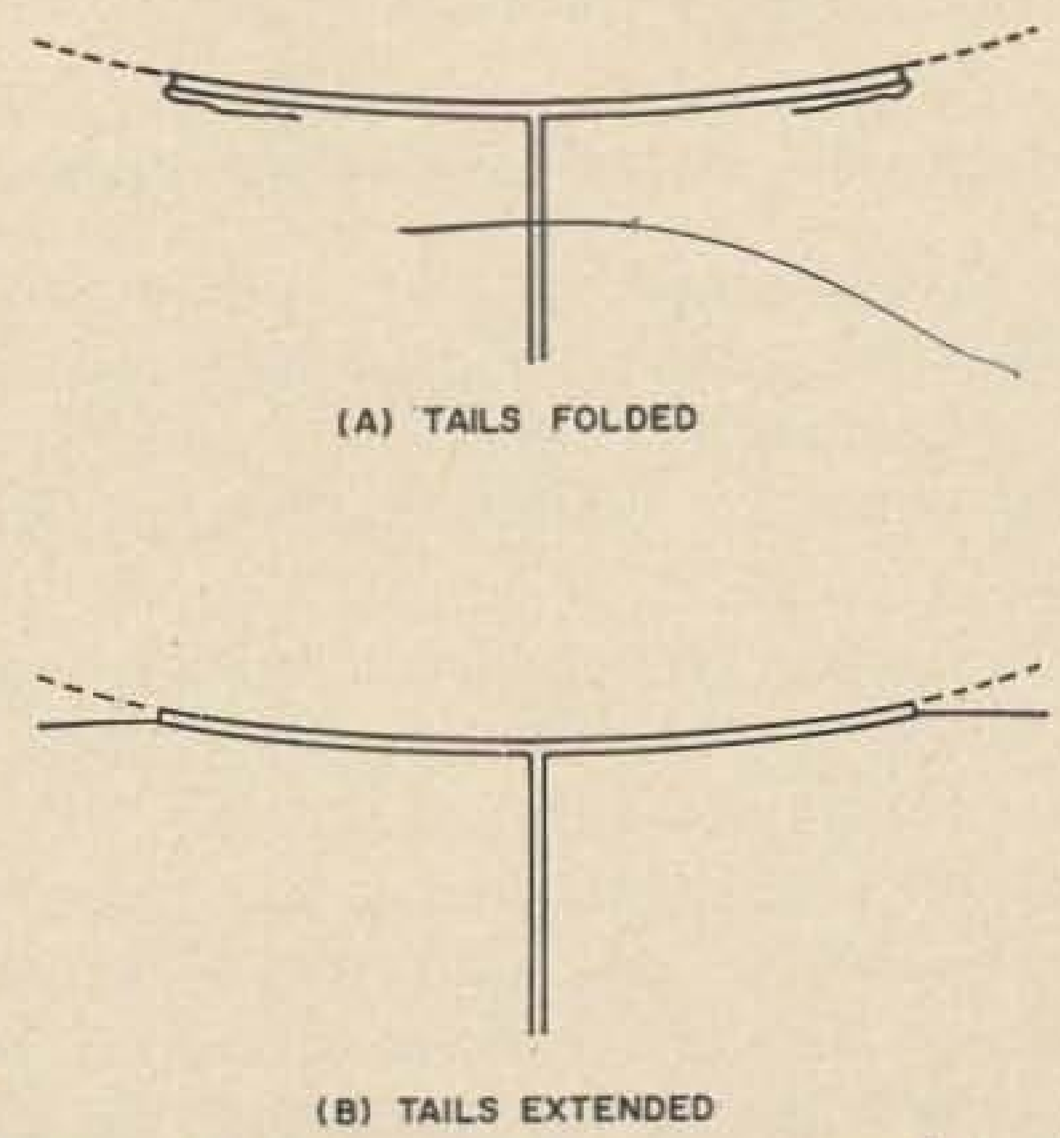


Fig. 5. How the tuning stubs are placed for highest (A) and lowest (B) resonant freqency.

with stubs fully extended is too long. See **Fig. 5.** By folding the stubs back, you can tune or retune the dipole to frequency, and balance out uneven effects of nearby structures.

Assemble the antenna in any convenient way similar to the handbook and magazine descriptions. Nylon line will do a fine job and you can omit the insulators for low power. Seal twinlead openings and splices, since moisture leakage may change the twinlead characteristics or corrode the wire. Tie the tuning stubs back against the dipole as shown in **Fig. 5A** and pull it up into the air.

Testing and tuning the dipole

With the twinlead dipole in place and the transmission line strung to the vicinity of the receiver or rig, everything that could affect its tuning or input characteristics has come into the picture. We know it will resonate near but above the correct frequency, and we know that we've done all we can to get the best input impedance. Now we do some testing.

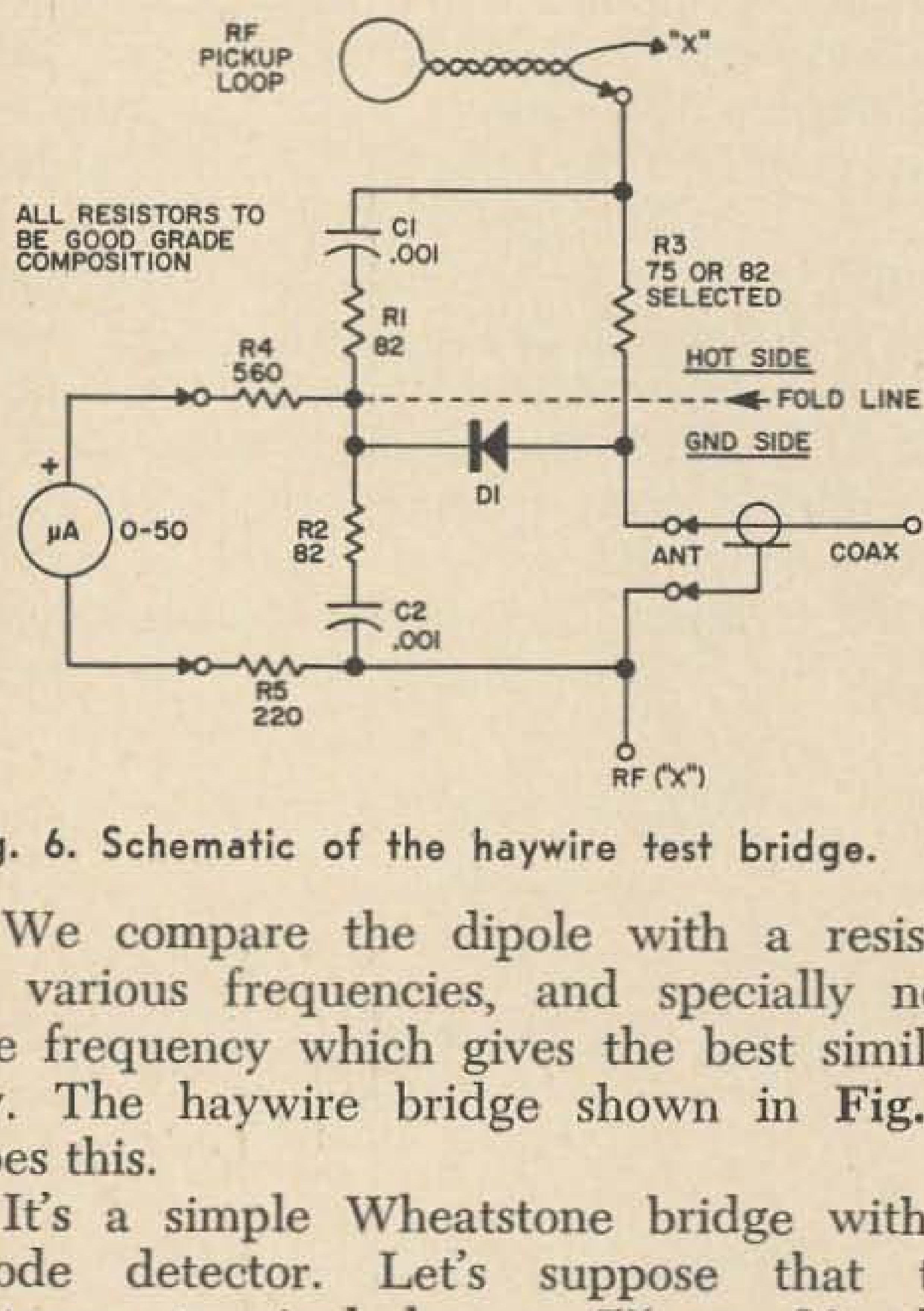


Fig. 6. Schematic of the haywire test bridge.

We compare the dipole with a resistor at various frequencies, and specially note the frequency which gives the best similarity. The haywire bridge shown in **Fig. 6** does this.

It's a simple Wheatstone bridge with a diode detector. Let's suppose that the antenna terminal has a 75 or 82 ohm composition resistor across it, the same value as R3. Then the LH and the RH component strings are 2:1 voltage dividers, points A and B see the same rf voltage, in phase, and there is no dc fed to the meter.

If the antenna resistance is replaced by

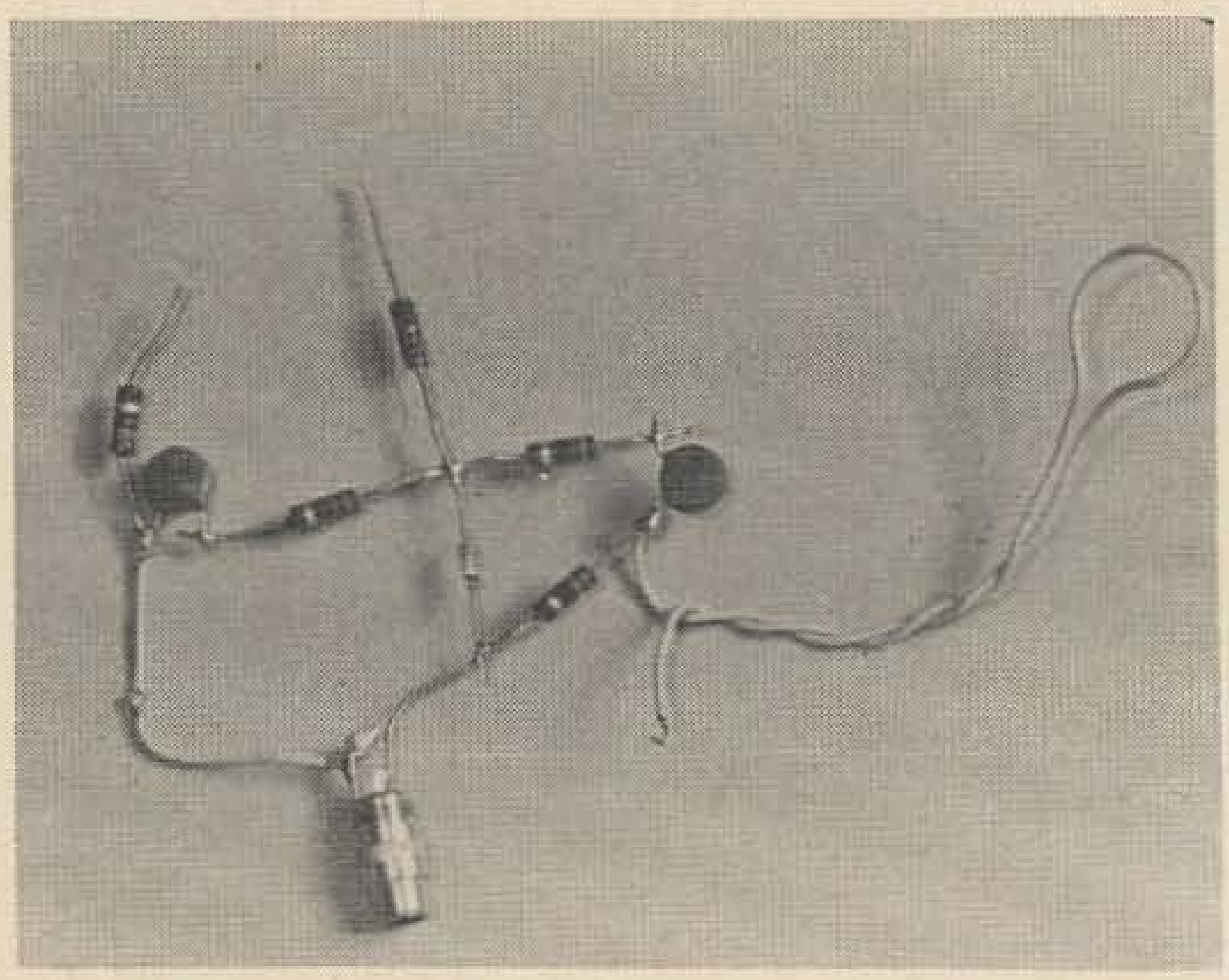


Fig. 7. This is what the haywire bridge looks like just before folding over.

any other value, or if inductive or capacitive reactance is added, the balance is disturbed and we see a meter reading. This circuit tells us when the antenna terminals look most like a resistor, which is enough to get by. There is more to this, which you should look up later, but for now: simple problem, simple answer.

The bridge circuit will give the best results if it is built of properly chosen components. Capacitors C1 and C2 are not critical, but should measure the same value on a capacitor tester. R1 and R2 are also ballpark accuracy if they measure the same on an ohmmeter. R4 and R5 are uncritical isolating resistors. Choose a good new resistor for R3. All resistors should be composition variety. D1 is any known good germanium rf diode.

Assemble the parts with short leads in the relative positions of **Fig. 6.** This should come out resembling **Fig. 7.** Then fold the entire assembly, like a book, around the diode, bring the two outside rf points together, and solder them to the rf input line. If you're using a signal generator, the ground site of the bridge goes to the generator's ground. Clip in the meter, and you're nearly ready to test your antenna. But first, test the bridge!

Feed enough rf into the bridge to bring

Fig. 8. Block diagram of the antenna test setup. A signal generator could replace the GDO. See how this fits into Fig. 1.

the meter to full-scale with an open circuit across the antenna terminals. That's what is happening in **Fig. 9.** Without changing anything, place a resistor equal to R3 across the antenna terminals, and the meter reading should go very close to zero. It should stay there independently of large changes of rf frequency.

Once you know the haywire bridge works properly you may want to attach it to the complete antenna system. Don't do that! Is your balun in good order? Connect a 300 or 330 ohm composition resistor across the balun's twinlead side, set up the bridge, and check for drop from full meter deflection to near zero. If you are using a coax balun, the null will be frequency dependent and belongs on your chosen operating frequency. Double check by finding the signal on your receiver.

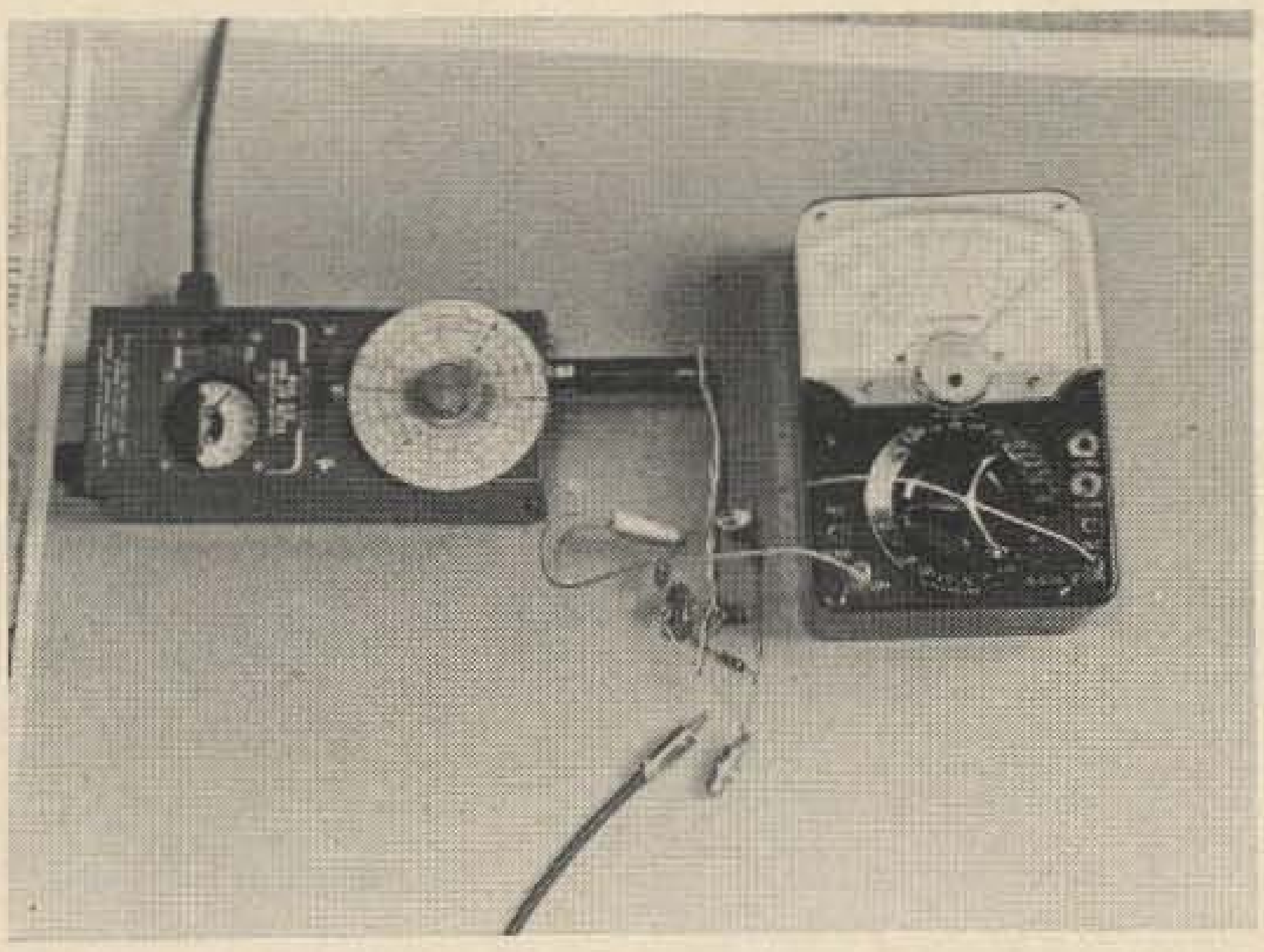


Fig. 9. Here's the haywire bridge, just before connecting the antenna. RCA connectors are handy, or use anything on hand.

Now you can test your antenna. As before, adjust rf source and bridge for full scale deflection, attach balun and antenna, and find the best null frequency. Repeat the test with the stubs fully extended, to find the lowest operating frequency. Your target frequency should be between these extremes.

By shortening the stubs and checking null or resonant frequency, you can quickly zero in on the antenna tuning you want. If you cut the stubs they're hard to lengthen, but folding and taping has the same effect. If the null is not sharp and deep, try raising, lowering, and unbalancing the antenna. Make one change at a time and keep a record of results.

When your new dipole is in the air it's likely to look different from the handbook

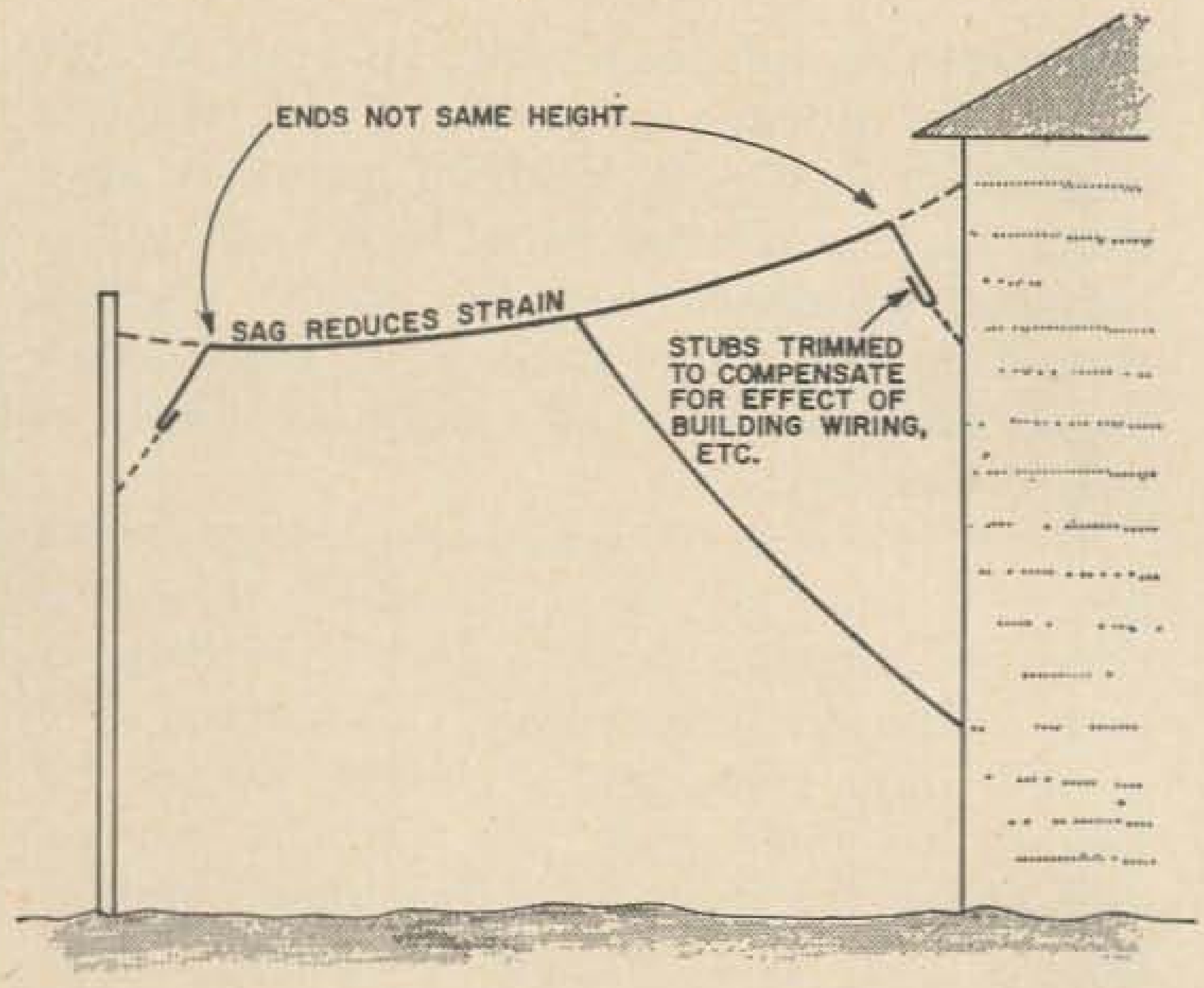
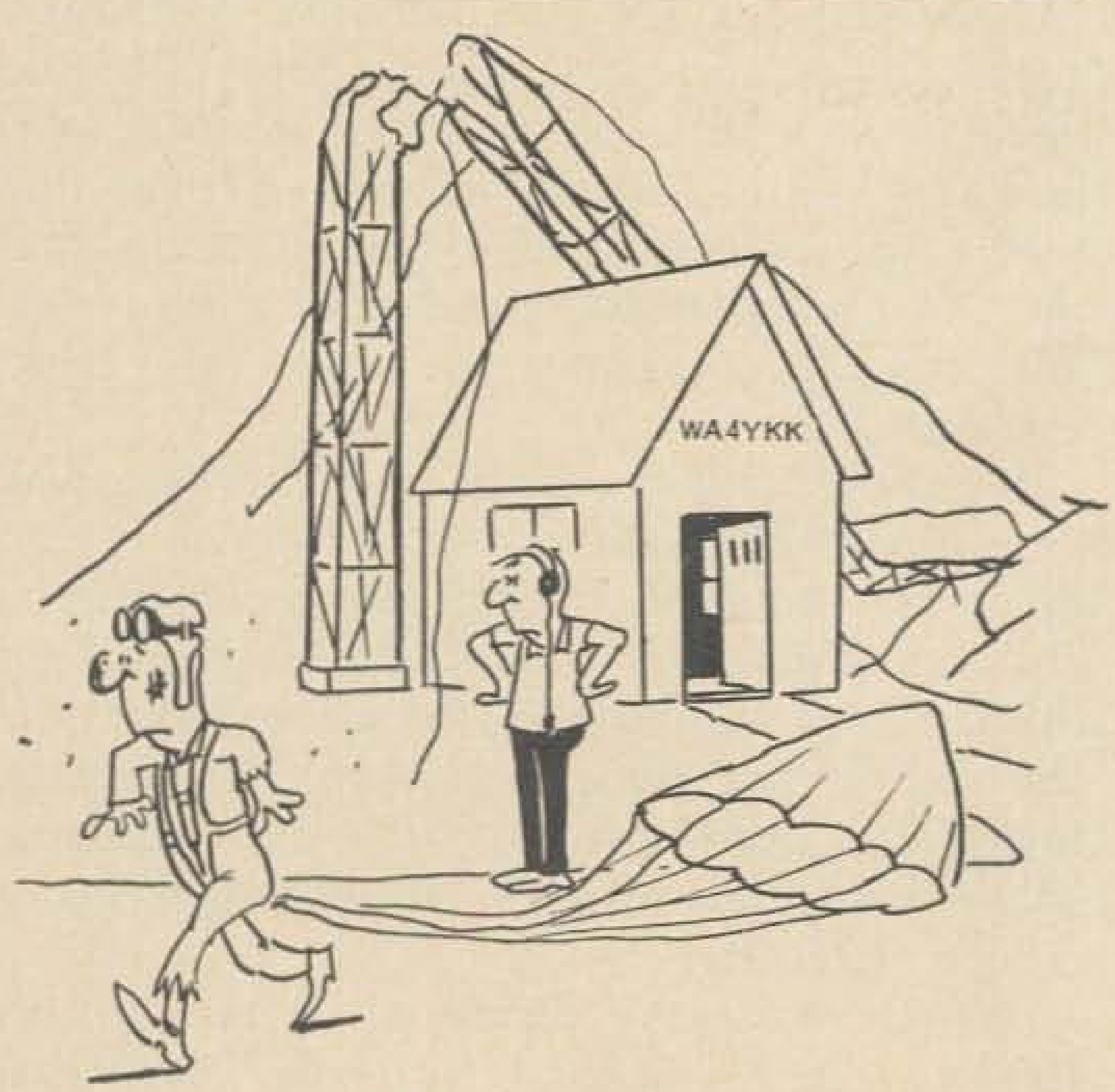


Fig. 10. Your finished antenna might look something like this. A little uneven, but tested right.

sketches. See **Fig. 10.** The sag reduces load on supports. The trim stubs are pulled off to the sides to guarantee their location and to improve their influence upon tuning. The floppy cords that are probably hanging around should be secured in place so you can find them next time they're needed.

All this does sound like a lot of hauling, but it's productive work because you know how to end up with a workable result. You'd have to do it anyway if you found that your antenna was mistuned. If you've never tested your dipole and it flunks this simple test, you may be quite surprised at how much livelier the band becomes. I know I was!

. . . W2DXH



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Matching Stubs

Blackwell B. Evans, Jr. WA5STM
5514 Sutton Place
New Orleans, Louisiana 70114

This article will show you how to match any feedline to an antenna and get an SWR of less than 2 to 1. There is no restriction on antenna type or feeder length. All that is required is an SWR meter; however, knowing the approximate antenna impedance will do.

First, I'll tell you how I came across this idea. I had just moved and no longer had any good trees for stringing up antennas. I looked through some old *73's* and came up with a bi-square antenna. It looks like a single element from a Quad, except that it is a half-wavelength long on each side. The article (*73*, August 1961) was by David Bell W8GUE/6. Many thanks to David for an excellent antenna.

There was only one small problem. My version was for 15 meters with each side about 22-feet long. This made it more than 30-feet tall when suspended from the peak. In the article it was matched through a quarter-wave stub of open wire line hanging from the end. This was another 11 feet added to the end. My only tree was not tall enough to accomodate this too. The bottom three feet of the stub were left on the ground. In addition, I was going to have to tune the thing by the trial and error method after I got it up. I figured there had to be an easier way to match all this junk up so it would radiate properly.

A few hours spent flipping through the pages of the ARRL *Antenna Handbook* and other books were very profitable.

When a line is hooked up to an antenna and the impedance of the line is different from that of the antenna, then there is a reactive component present on the line. The SWR is high and losses increase. A great deal of power may be lost without putting much of a signal on the air. To rectify this you need only put in an equal amount of reactance, but of the opposite kind. This will reduce the SWR and power losses.

A length of transmission line which is a quarter-wavelength long behaves like a resonant circuit. If it is shorted at one end, it appears as a parallel resonant circuit with high resistance; if open-ended, a series resonant circuit with low resistance. Lines shorter than a quarter-wavelength will exhibit reactance as well as resistance. An open end line will have capacitive reactance. A closed end line will have inductive reactance. A line less than a quarter-wavelength long may therefore be used to match antenna and line impedances for low SWR.

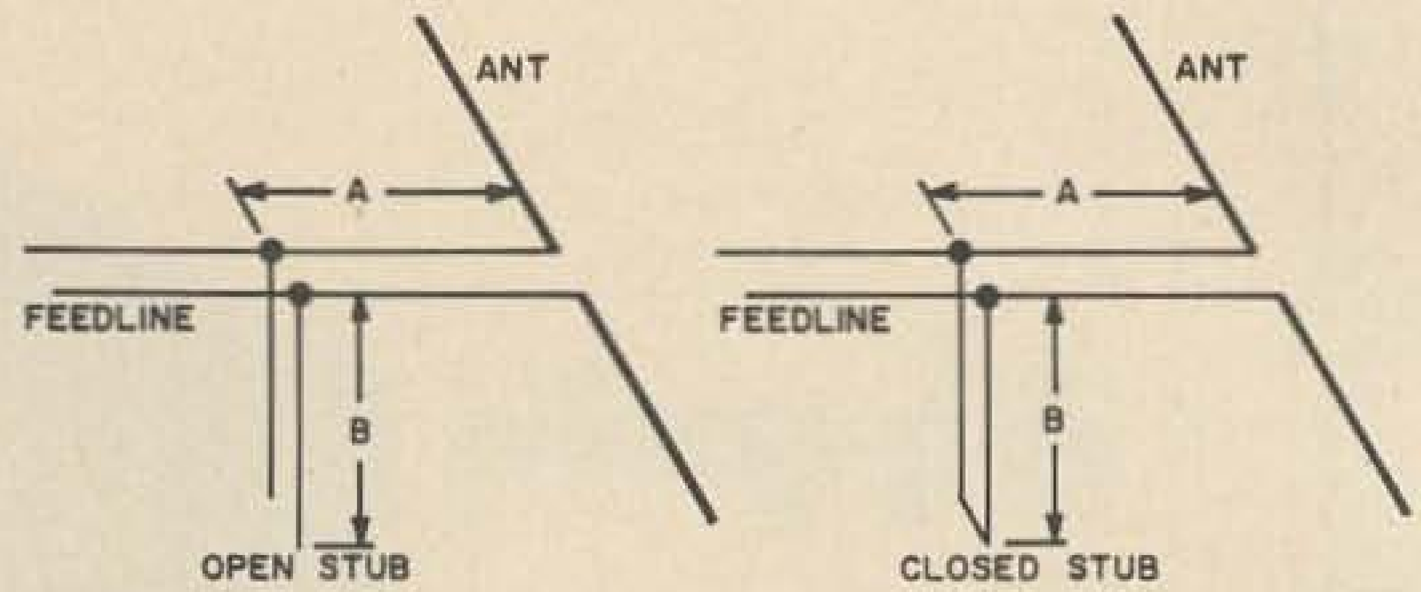

Fig. 1. How reactance is inserted. A shows the distance from the antenna for inserting the stub and B is the length of the stub.

Fig. 1 shows how the reactance is inserted. *A* is the distance from the antenna at which the stub is inserted. *B* is the length of the stub itself. **Fig. 2** shows another arrangement which performs the same way, but looks a little different.

If either the standing wave ratio or the impedance of the antenna is known, then lengths *A* and *B* can be computed easily. There are only two requirements. One, the stub and the feedline must have the same impedance, and two, the antenna must be resonant at the intended frequency of operation. These are easy requirements to fulfill.

The first decision to make is whether to use an open-end stub or a closed stub. This will depend on the ratio of antenna to line impedance. When the antenna impedance is

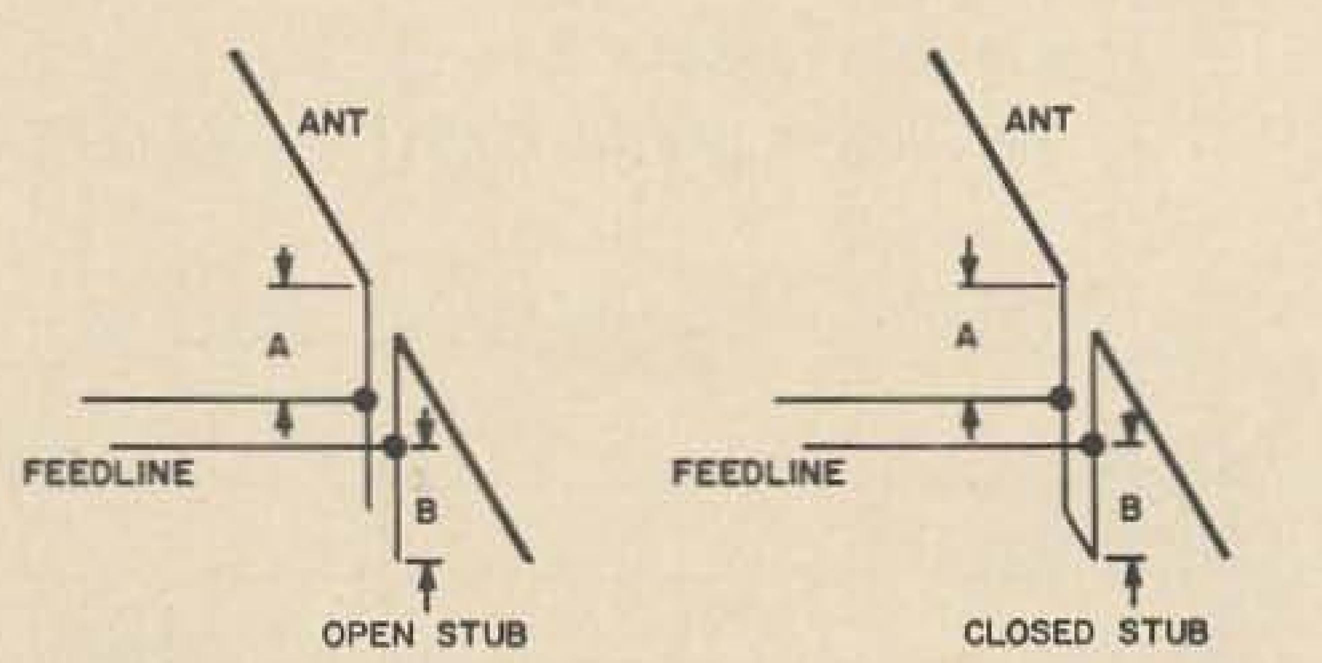

Fig. 2. This arrangement gives the same performance as Fig. 1 but is different in appearance.

less than the line impedance, a capacitive or open end stub is used. If the antenna impedance is greater than the characteristic line impedance, an inductive or closed end stub is needed. If you are using 150, 300, 450, or 600 ohm twinlead or ladderline and the antenna is current-fed, then you will probably need an open stub. If the antenna is voltage-fed, then a closed stub will probably be needed. There are exceptions.

Fig. 3 shows the current and voltage distribution along a half-wavelength of antenna. If the feedline intersects the antenna at a current loop (maximum) and a voltage node (minimum) then the antenna is current-fed. The old standby, the half-wave dipole, is current-fed. If the antenna is fed at a voltage loop and current node, then it is voltage-fed. Note that these terms do not correspond to the terms end feed or center feed.

Having decided what type of stub to use, the next step is to measure the standing wave ratio. Hook the feedline directly to the antenna and tune up. CAUTION: do not load to maximum. When these manufacturers say that their super-duper trans-

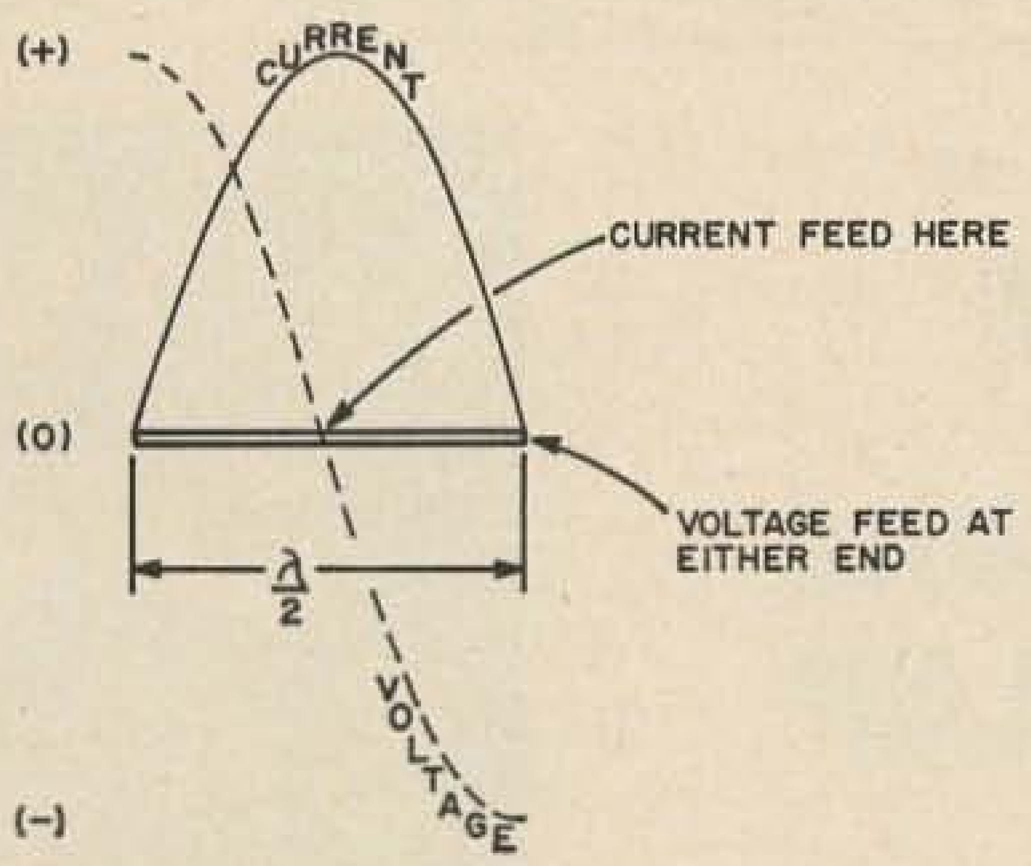

Fig. 3. Current and voltage distribution.

ceiver will deliver 400 watts to a load with an SWR of 2 to 1 or less, they mean it. These finals will not dissipate the reflected power. The feedline may not take the extremes caused by mismatch either. And while measuring, remember that you are radiating some power despite a monstrous SWR. I worked Europe 559 with 60 watts and SWR of 4 to 1, so your signal does cause QRM. If you know the impedance of the antenna, then forget about measuring SWR unless the antenna is not very high or is very near anything that might affect its impedance value. Divide the antenna impedance by the line impedance, or vice versa if the line has the larger value. Using this or the SWR reading (they should be about the same).

Chart 4. For Open-End Stubs

SWR	Wavelengths A	Wavelengths B
1.5	.109	.062
2	.096	.099
3	.083	.138
4	.074	.156
5	.067	.167
6	.062	.178
7	.058	.184
8	.054	.189
9	.051	.193
10	.049	.196
12.5	.044	.202
15	.040	.207
17.5	.038	.210
20	.035	.213

Chart 5. For Closed-End Stubs

SWR	Wavelengths A	Wavelengths B
1.5	.141	.188
2	.152	.151
3	.167	.113
4	.177	.093
5	.184	.081
6	.188	.072
7	.192	.066
8	.196	.061
9	.199	.057
10	.202	.054
12.5	.206	.047
15	.210	.043
17.5	.213	.039
20	.215	.037

Chart 6

Feedline Type	Velocity Factor
Coax (solid dielectric)	.66
Twinlead 75 ohm	.70
Twinlead 150 ohm	.77
Twinlead 300 ohm	.82
Open-wire line	.98

Due to the different dielectrics used, radio waves travel along transmission lines at different speeds, always less than the speed of radio waves in free space. Assuming you now have the wavelength required and the frequency and the velocity factor, you are now ready to compute the exact lengths needed. Use the following equation:

$$\text{length in feet} = \frac{985}{\text{frequency}} \text{ X velocity}$$

factor X length in wavelengths. You will need to use it twice; once for A, and again for B.

Now that you have the lengths required, merely break into the line at the appropriate point and connect the stub. If you use the arrangement in **Fig. 2,** just connect a stub equal in length to A plus B and hook the feedline onto it at a distance from the antenna equal to A.

Just to make sure you've got the idea, I'll work out an example. Let's assume that I have just put up a two half-waves-in-phase collinear for ten meters. This looks like a dipole except each side is a half-wave-length long. This makes it voltage-fed. Therefore I will use a closed stub. I hook up the 300 ohm twinlead and measure the SWR. I get a reading of about 15 to 1. Next I take a look at chart 5. From this I get a value of .21 wavelengths for A and .04 for B. Using the velocity factor of .82 for twinlead and an operating frequency of 28.1, I get the following equations:

for A

$$\frac{985}{28.1} \text{ x } .82 \text{ x } .21 = \text{approximately } 6.05 \text{ feet}$$

for B

$$\frac{985}{28.1} \text{ x } .82 \text{ x } .04 = \text{approximately } 1.15 \text{ feet}$$

Which means that a distance of six feet and one-half inch from the antenna I should insert a stub one foot two inches long, shorted at the end.

It's hard to say just how broadband this type of thing will be. On fifteen meters, by designing around a frequency of 21.050 MHz, I get a standing wave ratio of 1.1 to 1 at 21.0 MHz, and 1.5 to 1 at 21.350 MHz on my bisquare. Being a CW man, I have never been higher than this.

There is no reason why you cannot make the stubs out of coax if you want to. You can use a T-connector or splice it and seal the joint with tape.

This method should eliminate a lot of unnecessary work in tuning the feed system of any antenna that uses stub matching. No

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← 21" →

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more will you have to make an endless string of hit-or-miss adjustments and oftentimes end up settling for less than the best match. For those who want a more theoretical and detailed explanation, I recommend the ARRL Antenna Handbook. Also, strangely enough, many of the older radio handbooks (pre 1950) give excellent information on this aspect of antennas. I have always found that when it comes to putting up a new antenna, it is always the cost of the feedline that stops me. From now on though, I can feed a new antenna with whatever I can get my hands on. . . . WA5STM

UFO NET

(*Continued from page 2*)

tigation project of the Air Force and mutual cooperation has been assured. Nicap (National Investigations Committee on Aerial Phenomenon) is also interested in our project and has promised cooperation. The cover photograph on the April issue and the photograph at the head of this article were both provided by NICAP. Both photographs are considered authentic and have been exhaustively investigated. The net is also tied in with the 24-hour a day reporting system set up by Franklin Pierce College in Rindge, New Hampshire.

Are UFO's Space Ships?

In spite of the thousands upon thousands of eyeball reports on UFO's by dependable observers, there is still a serious question in many minds about their actual existance. Their existence has yet to be fully proven . . . and so has their lack of existence. The mere possibility that the UFO's do really exist and are space ships is, I am sure, motive enough to warrant the use of every means at our command to investigate the question.

The reports in newspapers of UFO sightings frequently follow very definite patterns across the country. It does appear that if communications were established throughout the country, communities along the projected path of these UFO's might be able to spot them and even get set up to take pictures. If this works out it would not be long before teams could start getting ready for more sophisticated examinations of the UFO's as they pass by.

If we set up our network so that we get immediate reports from every possible source in our communities, we will have made a major contribution to our country. And this sensitive detection system would work two ways. It would report anything spotted to the amateur radio network . . . and the network would report to the "eyes" of the community when anything was heading in that direction, alerting hundreds or even thousands of people to be on the watch.

On the UFO Net

During the establishment of the net it might be of interest to those gathered to review some of the books and magazine articles on UFOs. While some of them are rather obviously far out, others make every attempt to report only carefully checked facts.

It is interesting that many of the governments of the world take the UFO problem quite seriously. I believe that our own government is almost alone today in poopoohing UFO reports. Those of you who subscribe to Soviet Life or read it in your local library were undoubtedly fascinated by the article in the February issue on UFO reports in Russia and the establishment of a serious program to investigate them. They have mobilized their observatories, weather stations, and all other functions which could help in the quest for answers to the UFO's. Their pilots are taken seriously when they give detailed reports of sightings, unlike the ridicule that American pilots get when they try to give UFO contact reports. Is it likely that the thousands of UFO reports in Russia are just imaginary?

I would like to hear from operators interested in acting as net control for the UFO Net. I will call in whenever I can, but I pretty much work the clock around here at 73 and my air time is sadly scanty. With the backing of 73 I hope that we can get enough operators interested so that we will have a good solid network going. I will be glad to publish reports in 73 of the progress of the net and its accomplishments.

Remember, if the UFO's are not real our network will certainly make this obvious. If they *are real*, then amateur radio may be on the verge of doing the most important piece of PICON in its history. How about you? Are you going to be a part of this? We need every community in the country in this net.

. . . W2NSD

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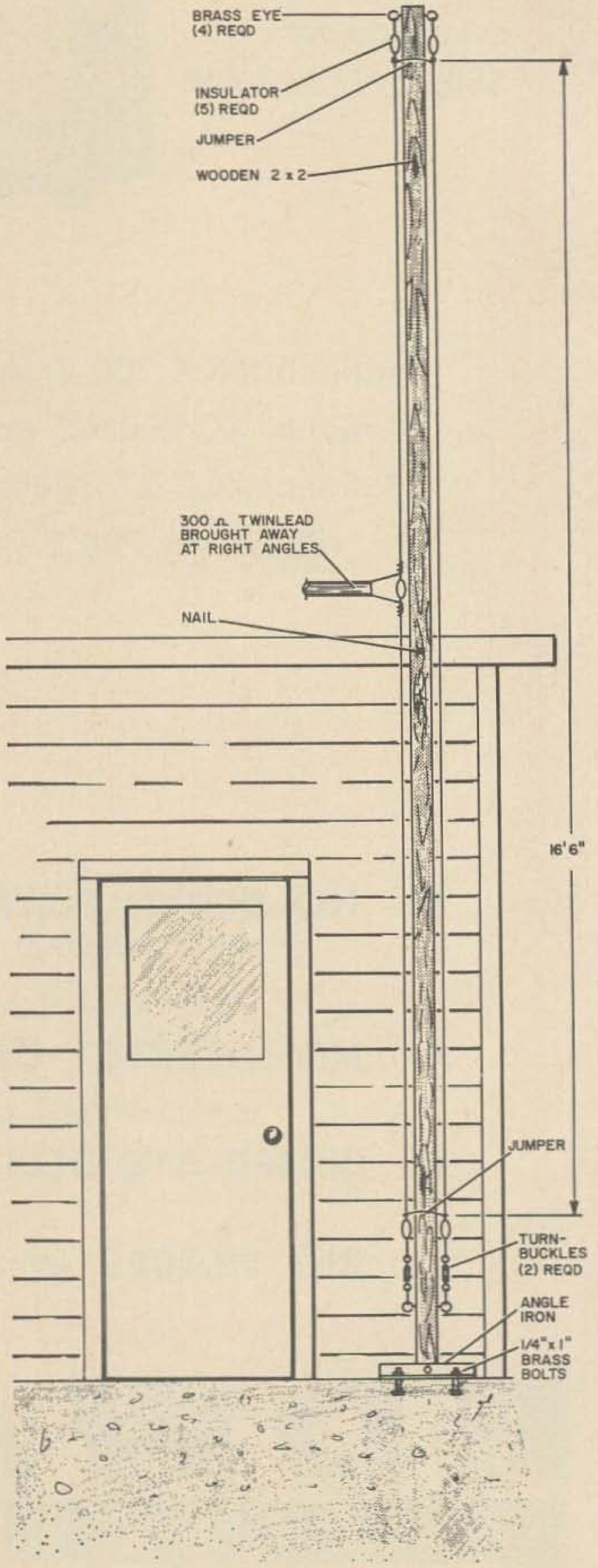
A Ten Meter Folded Dipole Antenna

Ed. Marriner W6BLZ
528 Colima Street
La Jolla, California

Ten meters is open! Along with the opening comes TVI on channel two. The TVI is especially bad on the new broad band TV color sets now coming on the market. To prevent interference the only solution is to use a one band antenna or one that does not radiate the second harmonic. Generally channel two interference cannot be cured with a low pass filter and a high pass on the TV set because the transmitter is sending out on channel two.

The best antenna is a ten meter beam, however, investing in a beam, rotor and tower for the short period that ten is open may be out of the question. The beam after a few years use is left swinging in the breeze during the dry spell. My experience has been to get a beam up just before the band goes dead. Not wanting to go through the cycle again a search was made for a substitute antenna. The selection narrowed down to a vertical folded dipole.



Theory

The length of a folded dipole can be found using the formula $468/f_q$ will give the length of the dipole in feet. The length of 16 ft 6 in is a good compromise for the whole of ten meters. The advantage of using a folded dipole are several: It is a broad band device. This is good for ten meters where the operating range is from 28.0 MHz to 29 MHz. The next advantage and most desirable characteristic is that it does not accept power at twice the fundamental frequency. This means that it should attenuate the channel two harmonic providing there is no capacitive coupling at the tuning end. Cutting the feeders 22-32 feet long or the length 52-64 feet long will also help.

The folded dipole does not accept power at even multiples of the fundamental because the folded section acts as a continuation of a transmission line. The folded dipole is better than a single dipole because the current in the two conductors flows in the same direction and acts as two conductors in parallel and the current therefor in each conductor is divided. Thus the feed line sees a higher impedance because it is delivering the same power at half the current and the impedance is about four times greater at the feed point than a regular dipole. This enables us to use 300 ohm twin lead to feed the antenna.

The folded dipole antenna mounted in a vertical position with the bottom 12 to 24 inches off the ground offers a low angle of radiation and probably a lower angle than most beams, although, without the gain. The lower angle is really an advantage when reaching out for the extreme DX. The all around pattern is also an advantage for SSB round table discussions.

For the investment the vertical folded dipole is a good solution for those who do not want to put up a beam for the short period of years ten is open.

Construction

Make a trip to the lumber yard and buy a 20 foot 2 x 2 and give it a undercoat and three coats of Z-Spar boat paint. Put two brass screw eyes at the top of the pole and two at the bottom a sufficient distance away to accommodate the length of wire and insulators plus turnbuckles. String the wire on each side of the 2 x 2 between the insulators and tighten the turn buckles. Solder jumpers on each end. The center insulators where the feedline is attached should be a short one. Wires can be soldered from it to several 6-32 machine screws on a piece of lucite which has been screwed to the 2 x 2 to help take the strain when the 300 ohm line is pulling. The 300 ohm twin lead should come away from the antenna about ten feet. It can be held by end slotting some sticks which are then nailed to the house or garage to support the line.

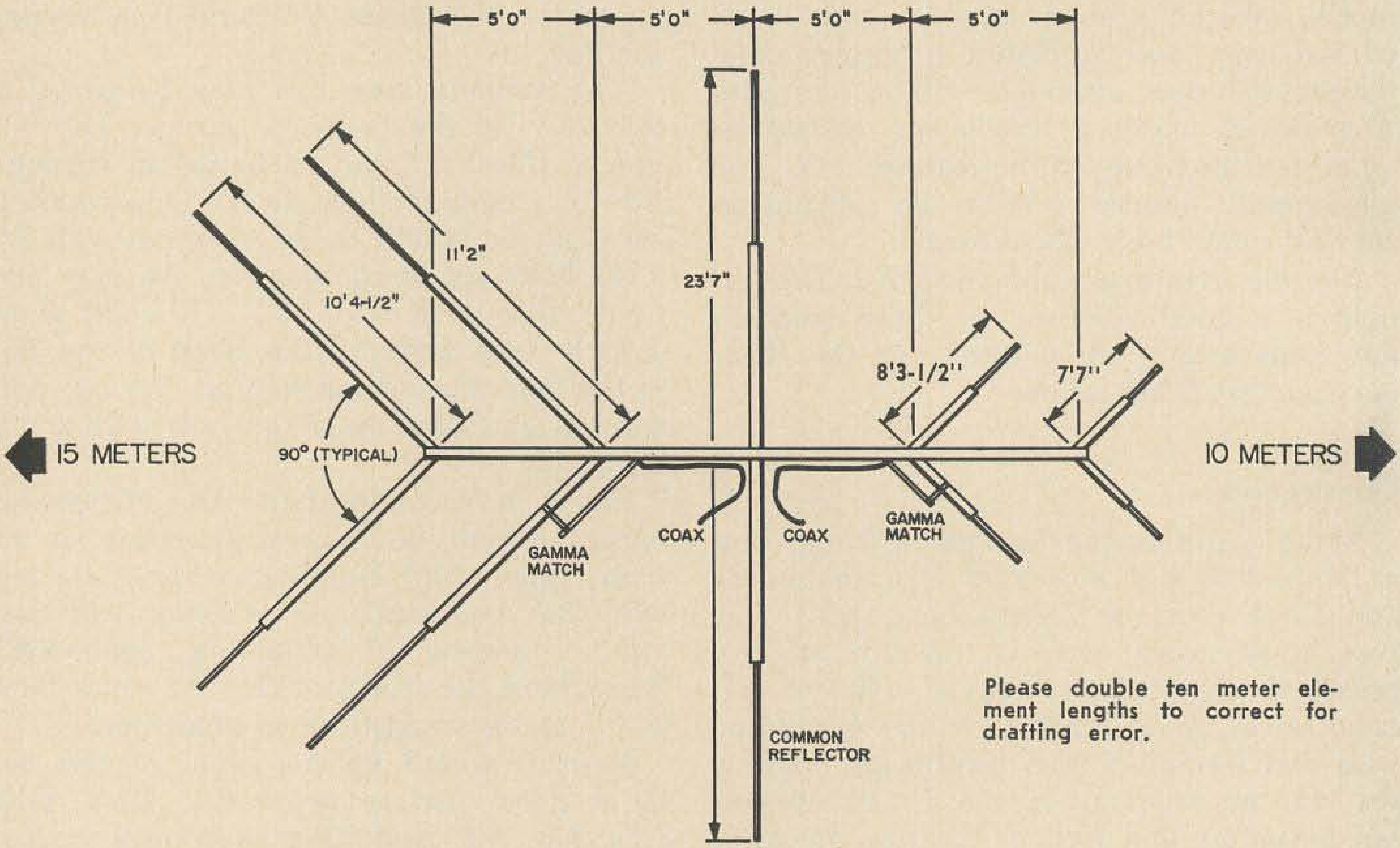
The antenna mast can now be nailed to the eaves of the house or garage. The bottom of the 2 x 2 can be bolted to an angle iron or aluminum four inches long which in turn can be bolted to the concrete with 1/4 x 20 bolts set in the cement. An easy way to do this is to star drill 3/8 holes about 1 inch deep and put the head of the bolt in the hole. Heat some sulphur in a can with a torch and pour it in the hole and it will be secure.

Since most transmitters are PI-Network output it will be necessary to use an antenna tuner. Link coupling to the tuner and with the condenser adjustments will provide a means of obtaining zero SWR throughout the whole of the ten meter band as far as the transmitter is concerned.

Does it work? By the order of the turtle it does. Just as many G's, DL's, DJ's, JA's, LU, VK, and ZL's have been worked with as much ease as with the old four element beam. For the few dollars investment for wood, paint and wire compared with the beam, tower and rotor you can say that I am sold on it!

. . . W6BLZ

The Duo Vee Beam Antenna



M. Eugene Spiess K1UFQ
6 Eastland Drive
Manchester, Conn.

The antenna can truly be called the front end of your rig. Regardless of the quality of the receiver or the transmitter the results that will be achieved will be dependent on the antenna.

To achieve the maximum transfer of energy to or from the antenna there are some items which are necessary to any antenna installation.

1. The elements should be full resonant lengths, no traps or loading coils.
2. The driven element should be resonant at the design frequency.
3. The reflector should not be resonant above the lowest design frequency.
4. Directors should not be resonant below the highest design frequency.
5. The antenna should be mounted as high as possible and in the clear.
6. Some type of matching device must be used at the antenna to match the antenna to the feed line to obtain an SWR of 1:1,

If the above requirements are met a good performing antenna will result. Notice that the matching device must be at the antenna. So many times I have had QSO's and the statement was made, "I have an SWR of 1:1 because I always use an antenna tuner." To be sure this station has a 1:1 SWR but it is between the tuner and the transmitter and what the SWR is between the tuner and the antenna is anyone's guess. There is only one place where a match can be correctly made, and that is at the antenna. Just so no one will get the wrong impression, I have nothing against antenna tuners or couplers. I always use one, not for SWR adjustments but for harmonic suppression and I firmly believe all transmitters should have one in the line with an SWR bridge permanently built in. While we are on the subject of antenna couplers let's discuss the correct place where they should be connected in the line. Here I go sticking my neck out by not going along with technical and hand books, but let's analyze the situation. Let us say we have a perfectly matched beam antenna to a 52 ohm line. We have an antenna coupler between the line and the TR relay. We turn on the transmitter and adjust the coupler for a 1:1 SWR. Let us say the transmitter has a 52 ohm output impedence. Right now we could not have a better situation. The 52 ohm output of the transmitter looks into the coupler, sees 52 ohms, the coupler looks into the transmission line and sees 52 ohms, the transmission line is terminated at the antenna matching device and sees 52 ohms. All the little electrons are as happy as larks. We now get an answer to our CQ and throw the TR switch to receive. The antenna now is the source of rf instead of our transmitter. The antenna looks into the transmission line and sees 52 ohms, the transmission line looks into the coupler and sees 52 ohms, the coupler looks into the receiver and doesn't know what it is liable to see. Perhaps on some band and some frequency on that band it might see 52 ohms. There is only one place the coupler should be and that is between the transmitter and the TR relay. If you don't believe this, build yourself a receiver antenna coupler and take some S readings.

The reader may well ask at this point what the above has to do with building a Duo Vee Beam Antenna. The answer is nothing regarding the building of the beam, but if the design is not made according to the basic rules as stated this antenna or any other antenna will not give optimum results.

Let's get on with the Duo Vee Beam construction and the reason for its creation. The author has tried all types of antennas except a rhombic, and the reason for not trying a rhombic is because of the terrain at this location. The most outstanding antenna on one band was the four element circular beam that was the brain child of K8CFU.*

The author could find no antenna that could equal this circular quad on one band. But two band operation was desired and as soon as the other elements were added, the original one lost its punch. The handbooks may again say there is no interaction but when "S" units go down, something is causing it. The desire for a two band beam with no interaction was the reason for experimenting and the result was the Duo Vee Beam. The accompaning sketch is self explanatory for building the beam. All the tubing can be obtained in a hardware store along with the aluminum flat stock. The two inch twenty foot aluminum boom is a piece of irrigation tubing. The clamps are TV type clamps.

No value of gain can be given as none was made for the simple reason that without laboratory equipment the readings would have no meaning. Even with laboratory equipment gain readings must be taken with a grain of salt. Suffice it to say that with the Duo Vee Beam fifteen over nine reports from Europe on fifteen meters was obtained and twenty over nine in South America on ten meters, all with an Apache running ninety watts input.

*Archibald Doty, Jr., Box 573, Franklin, Michigan.

With a ground wave signal a F/B ratio shows 24 dB. Note that this F/B was ground wave as a skip signal will cause the F/B ratio to vary depending on the angle of the arriving wave. The sketch shows the dimension for a design for 10 and 15 meters. This antenna can be designed for other bands by the use of the formula ¼ wave length equals $\frac{246}{FMHz}$ and the tuned by adjusting the telescoping tubing in the elements.

Of course your rotor indicator will read the opposite direction on fifteen if the ten meter side is set to compass directions but this poses no problem, so study the sketch, build yourself a Duo Vee Beam and I'll be looking for you with the strongest signal on the band, Hi. . . . K1UFQ

Computer Design of Beam Antennas

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Amherst, Va.

The purpose of this article is to acquaint the reader with the technique of using a machine to help make a decision, or even to make the decision for him. Computers are used in the business world to make marketing decisions, and in the Pentagon, cost analysis is employed to justify major decisions on the defense of the country.

Many articles have presented to the readers the problems arising in the computer age, with forecasts of dire results to the average man. This article hopes to persuade readers who have doubts about the value of computers, how such machines can be used for helping us reach decisions, even on the merits of antenna systems, a favorite for discussion at the amateur radio club.

The capability of the computer to do arithmetic at fantastic speeds is used in various "languages" where the user commands the machine to do his bidding. One common language is called "Fortran", and a set of instructions makes a program. We can instruct the computer with a Fortran program to do fast calculations on the merits of various systems, provided we realize that initially it knows nothing about the subject and we must prime it with knowledge. If the final result is wrong, it is not the fault of the machine, but of the programmer.

A relatively new development in the use of computers is in the principle of sharing an expensive machine among many customers. The new techniques in computer design have allowed the calculations to be made in less time than a teleprinter will type out the answer. So it is possible for a large computer at a central location to be asked questions by a person many miles away, using ordinary telephone lines to carry the conversation between the computer and an inexpensive teletype terminal. This can be located in an office or even in a home a considerable distance away. This leads us to your home in the not-so-distant future, where your wife will use a distant computer to help her do her shopping! Your children will have been taught how to carry on a conversation with a machine. In fact, programmers today are working towards the ultimate language, which will approximate normal conversation. The future computer will be instructed and will answer in speech, but today we type our instructions.

Most of us who like to dream of antennas on high towers have limited funds, so there is a height of the tower, in conjunction with the number of elements in the beam, which will give best results for our money. The question we want answered is, for a variable height and variable beam size (number of elements), what is the best value in terms of gain per dollar, and is there an optimum height and number of elements we could use for each band. For this article, we shall consider 7 MHz, 14 MHz, 21 MHz, and 28 MHz amateur bands, heights from 20 feet to 100 feet, and beams of the close-spaced Yagi type from one (a rotary dipole) to six elements. Individuals have different ideas on construction techniques, but for amateur home-built antennas we have an idea of the approximate cost of an antenna with a tower. Based on our knowledge, we then derive a formula which seems to be reasonable. Undoubtedly, the formula used will not agree with the experience of many amateurs. However, the principles used can be exploited to suit individual ideas, so your own formulae for gains and costs can be substituted. The cost formula is a little complex, as the tower cost increases with height and also with beam size, requiring greater strength for a heavier load.

First consider power gain relative to a 20 M dipole at 33 feet, or a half wavelength high. As the number of elements increases, the gain increases. As the height increases, the gain increases. As the frequency increases at that height, the gain increases. To simplify the formula for gain we shall assume a linear relationship. So we have Gain = Height x Elements x Frequency divided by a factor A. A 20 M dipole at 33 feet is our reference. Therefore, $1 = 33 \times 1 \times 14 \div A$, $A = 470$. To check A, assume 11 dB gain for a 5 element beam at 66 feet high on 14 MHz.

11 dB is a power gain of 12. Therefore, $12 = 66 \times 5 \times 14 \div A$, $A = 390$. Select a value of 400 as reasonable. Now we have $G = (F \times H \times N)/400$ as one formula for our program. The equation for the cost of the tower plus the beam comes from personal experience and can be varied to suit the individual. In this example, the final result was derived, Cost = 60 x Height x Square root of elements plus 600 x Elements all divided by frequency.

We shall break down the system cost into beam, tower and rotator. A reasonable formula for the beam cost is $\frac{500\ N}{F}$. For example, a 3 element beam at 14 Mc comes to $108, and at 28 Mc would be $54. Some ingenuity will give a 7 Mc 3 element beam for $216. The tower must be stronger as the beam size increases at a given height, so a factor involving N is used in the tower formula, with an estimated cost of $\frac{50 \times H \times \sqrt{N}}{F}$. For example, a 50 foot tower to hold a 14 Mc 3 element beam would cost $310. Adding 20% to the total estimated cost for a rotator gives the final formula.

$$\text{Cost} = \frac{(500\ N + 50\ H \times \sqrt{N}) \times 1.2}{F}$$

Therefore, for the computor,

$$C = \frac{60 \times H \times \sqrt{N} + 600N}{F}$$

Value can be defined as performance versus cost, or in this case, decibels of gain for our dollars. Transfer the gain into decibels by a logarithmic function to suit our formula, and we get, $V = \text{Log}\ G./C.$

We are interested in the *maximum* value obtained from 7 MHz to 28 MHz for all combinations of heights from 20 feet to 100 feet in steps of 2 feet, with antennas from one to six elements.

Each new calculation of V is compared with the previous, and the larger of the two selected. First, at F=7 MHz for a range of heights from 20 feet to 100 feet, the best value in dB per dollar is found for a dipole (one element). Then the computer goes through the next loop calculating the best value for a two element beam at all heights, comparing with the previous best for a dipole, and storing the maximum in its memory. The process is repeated up to six elements. The best value for the first frequency of interest, 7 MHz, is then printed. Similarly, the maximum dB per dollar is printed for 14 MHz, 21 MHz and 28 MHz. We shall see lines of print informing us of frequency, number of elements, height, gain in dB, and cost for the best value at that frequency.

Note that the figures shown apply to single beams on towers, so it should be obvious that we shall get better value for our money by using a tri-band beam on one tower.

Don Gordon, W4VTT, pointed out that an extension of the program would be to simulate the conditions when we have limited funds available, a common occurrence! He rewrote the program to find out the best beam size versus height for fixed costs, selecting $300, $400, $500 and $600. The comparison in value now is limited at a fixed cost in each case, and the print has an additional column, allowable cost. The print-out is now frequency, number of elements, height, gain, true cost, and maximum allowable cost. The performance in gain is compared to a half-wave rotary dipole at a half wavelength high, so the dipole on 7 MHz at 24 feet has a loss of 3 dB with reference to a height of 66 feet. If you have $600 available for a 28 MHz beam, using amateur construction techniques, the computer shows a 6 element beam almost 3 wavelengths high with a gain of 15 dB over a dipole at 16 feet.

We have seen how the computer can give answers rapidly when primed with knowledge. Knowledge is gained by learning, and in the average human being is a long, slow and sometimes painful process. But the computer can be rapidly educated, or re-educated. Suppose in our case we do not agree with our educated machine. We can erase the knowledge we primed it with, in other words, alter the formulas we had.

Among DX antenna enthusiasts there is always the old argument of height against beam size. Some believe in height, others believe in large beams. Our program so far can be seen to favor large beams at medium heights for best value for the dollar. For those who disagree, we can re-educate the computer by emphasizing the value of height. Instead of a 3 dB increase on doubling the height, we can assume a 6 dB increase. We now incorporate a new formula for gain. A 6 dB increase is 4 times the power, so power increases as the square of height. The gain formula is now re-written, $G = (F \times H)^2 \times N/A$. Again we know $G = 1$ for a dipole at a half wavelength high. Recalculating for A gives the value of 220,000. We prime the computer with this new formula and run the program again. The results are shown to suit the height-oriented DX chaser.

Note that a new formula for gain does not allow us to compare the actual dB shown in the gain column from one program to another. Gain comparisons should be made only within the formula used. For example, in the list of 28 MHz antennas at $300, $400, $500 and $600, we see that the increase in gain is 6 dB from $300 outlay to $600, while at 7 MHz the increase is from −8 dB to 0 or plus 8 dB for a 7 MHz rotary dipole increasing in height from 24 feet to 60 feet.

We can now draw some conclusions from the four programs. The first gain formula, which emphasizes the large beams, shows that at 7 MHz we must be prepared to invest a large sum to get the best value from the antenna system, $1386 for a large 5 element beam at 50 feet high. The second formula for gain, which is oriented to suit the height-conscious amateur asks for even more money for a 3 element beam on 7 MHz at 100 feet high, quite an antenna!

The favorite DX band is 20 Meters, so our two best values there are of interest. The first formula gives a 3 element beam at 40 feet for a cost of $425. The second formula, which emphasizes height, shows almost the same cost for a rotary dipole 100 feet high. It is a debatable point which of the two would give the strongest signal at a remote location.

Now let us examine the systems available for the fixed costs of $300 to $600. Our new gain formula should not make any difference in the inexpensive 7 MHz antenna, but the higher frequencies will be height oriented again. The 14 MHz antenna for $600 in the first instance is a 4 element beam at 50 feet, and in the second case is a 2 element beam at 84 feet. For $300, the choice is between 2 elements at 34 feet and a rotary dipole at 60 feet. At the highest frequency we have considered, 28 MHz, at the maximum allowable cost of $600, we can choose between a six element beam at 88 feet, or five elements at 100 feet.

Consider the time required to calculate all the values by conventional means, then compare our first print-out of maximum values taking 11½ seconds and the second print-out taking less than half a minute of computer time!

The whole conversation with the computer for the two programs is shown, but no attempt is made to explain details. For those interested, books on Fortran are easily obtainable. You can substitute your own formulae to determine values for quad antennas, and the computer can then answer the old question, yagi versus quad! The result will vary, of course, depending on the individual amateur's formulae, and the total result of this article will probably be to have more heated discussions in the club room.

```
System—Fortran
New or Old—New
New Problem Name—Antval
Ready.

Tape
Ready.

100 Print "Fortran for antenna cost vs. performance"
110 Print 10
120 10 Format (1H14X4HFREQ4X4HELEM4X4
    HHGHT4X4HGAIN4X4HCOST)
130 DO 4 F = 7, 28, 7
140 Z = O
150 DO 1 N = 1, 6, 1
160 DO 2 H = 20, 100, 2
170 G = F*H*N/400
180 C = (60*H*SQRT(N) + 600*N)/F
190 V = (LOGF(G))/C
200 IF (Z — V)3, 3, 2
210 3 Z = V
220 P = N
230 Q = H
240 R = 4.3*(LOGF(G))
250 S = C
260 2 Continue
270 1 Continue
280 Print! 5, F, P, Q, R, S
290 5 Format (5I8)
300 4 Continue
310 End

Key
Ready.

Run
Wait

ANTVAL     13:32     W1 MON 12/11/67
```

Fortran for Antenna Cost vs. Performance

I	Freq	Elem	Hght	Gain	Cost
	7	5	50	6	1386
	14	3	40	6	425
	21	3	30	6	234
	28	2	30	6	133

At line No. 310: Stop End, Ran 69/6 Sec.

System—Fortran
New or Old—Old
Old Problem Name—ANTCST
Wait.

Ready.

List

```
ANTCST      13:22     WI MON 12/11/67
100 Print "Best Antenna Gain for Fixed Cost"
110 Print 10
120 10 Format (1H14X4HFREQ4X4HELEM
    4X4HHGHT4X4HGAIN4X4HCOST4X4HMAX$)
130 DO 8 F = 7, 28, 7
140 R = Q
150 DO 7 M = 300, 600, 100
160 DO 3 N = 1, 6, 1
170 DO 1 H = 20, 100, 2
180 G = F*H*N/400
190 IF (G-R)1, 1, 2
200 2 C = (60*H*SQRT(N) + 600*N)/F
210 IF (M-C)1, 4, 4
220 4 R = G;  P = N;  Q = H;  S = C
230 1 Continue
240 3 Continue
260 D = 4.3*LOG(R)
270 Print 6, F, P, Q, D, S, M
280 6 Format (6I8)
290 7 Continue
300 8 Continue
310 End
```

Run

ANTCST 13:25 WI MON 12/11/67
Best Antenna Gain for Fixed Cost.

I	Freq	Elem	Hght	Gain	Cost	Max$
	7	1	24	−3	291	300
	7	1	36	−1	394	400
	7	2	26	0	486	500
	7	2	34	0	583	600
	14	2	34	3	291	300
	14	3	36	5	395	400
	14	4	38	7	497	500
	14	4	50	8	600	600
	21	4	32	8	297	300
	21	4	50	10	400	400
	21	6	46	11	493	500
	21	6	60	12	591	600
	28	4	50	11	300	300
	28	5	60	13	394	400
	28	6	70	14	495	500
	28	6	88	15	590	600

At Line No. 310: Stop End, Ran 169/6 Sec.

```
170 G = (F*H) ↑ 2*N/220000
Run
```

Anyval 13:47 W1 Wed 12/27/67

Fortran for Antenna Cost vs. Performance

I	Freq	Elem	Hght	Gain	Cost
	7	3	100	8	1741
	14	1	100	9	471
	21	1	70	9	228
	28	1	54	10	137

At line No. 310: Stop End, Ran 72/6 Sec.

```
180 G = (F*H) ↑ 2*N/220000
Run
```

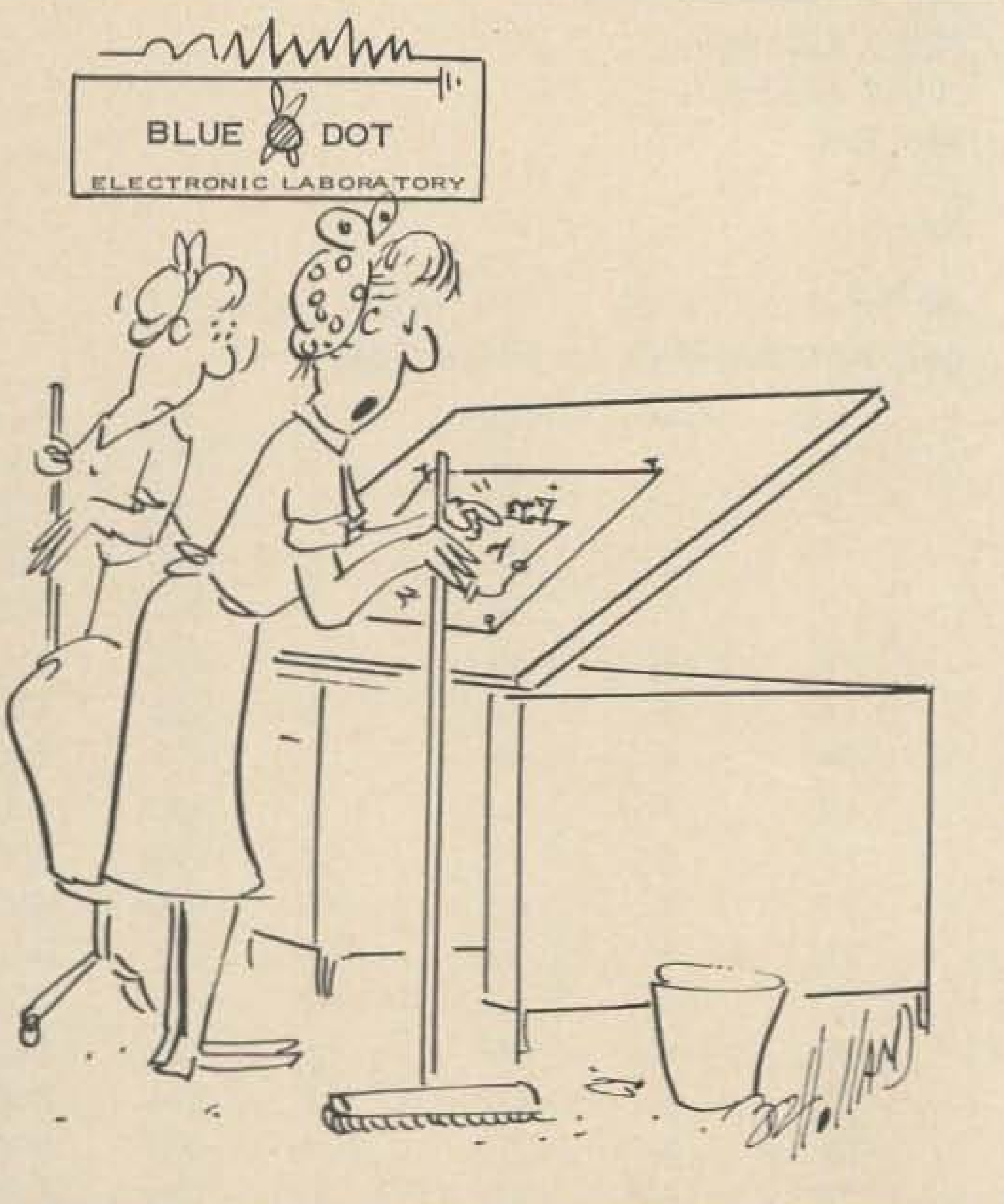
ANTCST 13:41 W1 WED 12/27/67

Best Antenna Gain for Fixed Cost

I	Freq	Elem	Hght	Gain	Cost	Max$
	7	1	24	−8	291	300
	7	1	36	−5	394	400
	7	1	48	−2	497	500
	7	1	60	0	600	600
	14	1	60	5	300	300
	14	1	82	7	394	400
	14	1	100	9	471	500
	14	2	84	10	594	600
	21	1	94	12	297	300
	21	2	84	14	396	400
	21	3	82	15	491	500
	21	3	100	17	580	600
	28	2	84	16	297	300
	28	3	90	19	398	400
	28	4	96	20	497	500
	28	5	100	22	586	600

At Line No. 310: Stop End, Ran 182/6 Sec.

. . . WA4WWM



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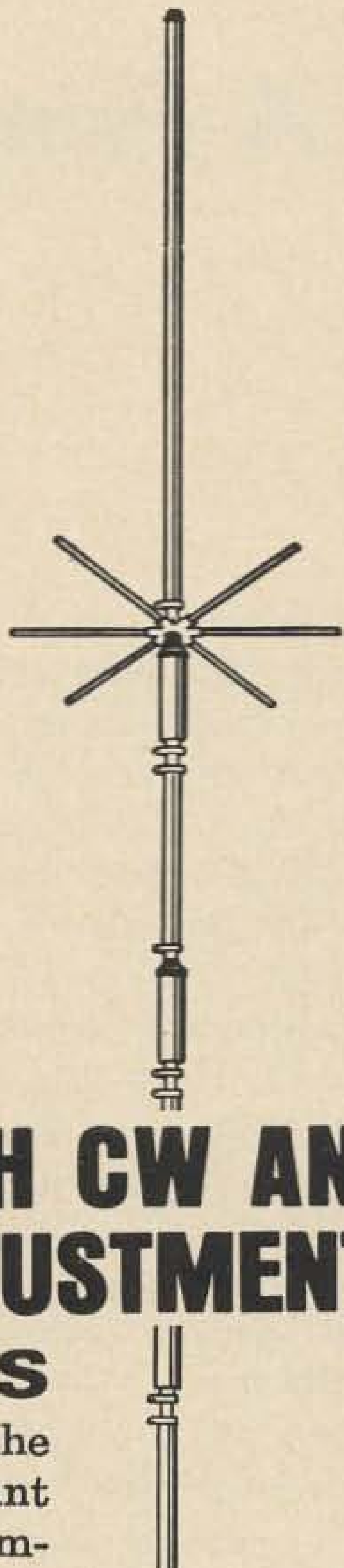

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A Primer of Basic Antenna Theory

Robert L. Nelson K6ZGQ/5
100 Morning Valley Dr.
San Antonio, Texas 78227

Antennas are a very popular subject among radio amateurs today, as they have been almost from the beginning of radio science. In fact, of all the pieces of equipment an amateur owns the one he probably spends the most time talking about, both on and off the air, is his antenna. There are at least two good reasons for this. First, the antennas themselves are pretty simple, at least from the standpoint of circuitry. They contain no transistors or vacuum tubes or other amplifying, oscillating, modulating or detecting devices, the exact operations of which are difficult to comprehend. Antennas are usually simply pieces of wire or tubing with perhaps a transformer thrown in for impedance matching. Thus, they are at least easy to visualize.

The second reason for the great deal of attention antennas get is their performance. Every ham who has been around very long knows that there is no easier way to improve his station's capabilities than to improve his antenna. When a significant change for the better is made in the antenna, the improvement in the station's ability to communicate is immediately apparent, on both transmission and reception. Seven hundred dollars (the usual price of a storebought kilowatt amplifier these days) spent on an antenna installation will do worlds more good for the amateur than will a similar amount spent on a big "pair of shoes" for the exciter.

Also, antennas are popular because they are easier to homebrew than most pieces of equipment, and easier to make operate properly after their construction.

Thus, the antenna deserves its popularity. And if this is so, then the simple theory behind the antenna deserves to be understood by us all. So, the reason for this article. These few pages will discuss the very simple theory of antenna gain, efficiency, capture area and effective height. These are subjects of which very few amateurs seem to have a good grasp today. Much is heard about antenna "gain" especially, but few seem to have an exact understanding of what they are speaking about. Perhaps this article will help to clear up a little of the confusion.

Antenna reciprocity

An antenna can basically be thought of as a device for converting energy from one form to another. When an electromagnetic (EM) wave strikes an antenna we find that electrical power is available at its terminals. On the other hand, when we apply electrical power to the terminals of the antenna, we find that an EM wave is radiated by the antenna. Thus, the antenna is capable of converting electrical energy to EM energy, and EM energy to electrical energy. This property of working both "backward and forward" is called "reciprocity" and is characteristic of antennas.

Now because the antenna is only a go-between for conversion of electrical to EM energy and vice-versa, a complete understanding of even basic antenna theory cannot be had without also obtaining some basic knowledge about EM fields, and electrical circuits as applied to antennas. Consequently, in this article we shall first discuss some things about EM fields before turning to antennas themselves. Later we will discuss basic antenna circuitry.

Electromagnetic fields

Most of us realize that it is EM fields or "waves" that provide the invisible link between transmitting and receiving stations in a radio communications system. But the fact is that no one, even the professionals, knows just what an EM field is.

For several thousand years men have

known that, after being rubbed, certain substances, amber for instance, would attract other bodies. This was a form of action at a distance, and came to be called "electric" attraction. Other substances, such as lodestone, could also attract matter at a distance, but did not require rubbing. This sort of attraction became known as "magnetic" to differentiate it from electric attraction from which it appeared to be different. These sorts of attraction remained a puzzle for thousands of years and to some degree are still puzzling. But thanks to the work of James Clerk Maxwell, engineers and physicists today have a mathematical grip, at least, on the elusive phenomenon of electromagnetism. Maxwell's theoretical work showed that there was a very definite relationship between electric and magnetic fields, and that they were really parts of the same natural phenomenon. Eventually he was able to express the relationship between the electric and magnetic fields as a set of two mathematical expressions which have come to be known as "Maxwell's Equations." These equations have been the foundation upon which most all mathematical EM theory has been built since.

The Traveling wave

As far as radio systems are concerned the most significant feature of EM fields is their ability to move, that is, to transport energy from one place to another. These fields are called "traveling waves" and are composed of two components, an electric field component and a magnetic field component. If a person were able to stand in one place and watch an EM wave pass by he would see the energy in the wave alternately in the electric and magnetic form. Actually, the transformation of the energy from one form to the other is gradual (sinusoidal) and is complete only at an instant each cycle.

The speed with which the transformation of the energy takes place is known as the frequency of the wave. For example, if the transformation from electric to magnetic and back to electric (one complete cycle) takes place once every millionth of a second, the frequency of the wave is 1,000,000 cycles per second, or one megahertz.

Electromagnetic energy in the form of a traveling wave moves at a tremendous rate of speed, about 300,000,000 meters per second. The wavelength of a particular moving EM field is the distance the wave moves during one cycle. For our one megahertz wave above it is 300,000,000 divided by 1,000,000 or 300 meters. This relationship between frequency and wavelength can be expressed algebraically:

$$(1) \quad C = f\lambda,$$

where: C = speed of light
= 300 million meters/second
f = frequency, Hertz
λ = wavelength, meters.

Power density

If you drop a stone in a quiet pond, small waves will radiate away from the point where the stone struck the water. Each wave will have a circular form around the starting point, and will move away from the source. Thus we can say that the waves have a circular wavefront.

Now if we visualize a "point source" of EM energy situated in space it is easy to imagine that EM waves will radiate away from the source, and form a spherical wavefront. The surface area of this spherical wavefront will of course depend on its distance from the point source. From high-school geometry we remember that:

$$S = 4\pi r^2,$$

where: S = surface area of sphere, meters (m^2)
π = 3.14
r = radius of sphere, meters.

Then if the point source were to radiate a certain amount of energy every second (i.e., power), the EM power would be distributed over an ever increasing surface area as a particular wave radiated away from the source. Notice that the total power is not diminished, it is just spread over a greater and greater area as we move further and further from the source.

The amount of electromagnetic power contained in a unit of surface area on the wave front is termed the "power density" of the EM wave, and depends on the distance from the source:

$$(2) \quad D = \frac{P}{4\pi r^2},$$

where: D = power density, watts/m^2
P = radiated power, watts.

Thus we see that as the wavefront moves away from the source, the power density decreases with the square of the distance from the source. This decrease of power density is termed "spherical divergence". It means that the EM wave is diverging or spreading out as it moves away from its origin.

As we can see from the above, a very convenient way of measuring the amplitude of an EM field is to measure its power density. Power density is today one of the most commonly used measures of EM field magnitude.

Field strength

We mentioned above that the EM field is made up of two components—the electric field and the magnetic field. Since the EM field is capable of transmitting power from one place to another it seems reasonable that the power must be embodied in the two field components, and indeed this is the case. Thus if we were to increase the power level (and consequently the power density), there would necessarily be a corresponding increase in the strength of the electric and magnetic field components.

The mathematics which governs the relation between the power density, electric field strength and magnetic field strength is quite simple:

$$(3) \quad D = EH,$$

where: E = electric field strength, volts/meter
H = magnetic field strength, amperes/meter.

This equation holds so long as the point of measurement is at least a few wavelengths from the transmitting source, which is a reasonable assumption in radio systems.

There is also a very simple relation between the electric and magnetic field strengths:

$$(4) \quad E = Z_s H,$$

where: Z_s = intrinsic impedance of space
= 377 ohms.

You have probably noticed the similarity between Ohm's Law and Equation (4) above. Now if we combine Equations (3) and (4), we obtain two other simple expressions for EM power density:

$$(5) \quad D = \frac{E^2}{377}, \text{ and}$$

$$(6) \quad D = 377H^2.$$

Summary

We have now discussed the very basic elements of EM theory necessary to an understanding of antennas. The concepts of point sources, electric and magnetic fields, frequency, wavelength, power density and field strength have been explained. Power density and electric and magnetic field strength are particularly important to understand, because they are what we measure in order to determine the amplitude of an EM field. Making a measurement of either D, E or H is equivalent to specifying all three, because they are all simply related by Equations (3) to (6). We are now ready to push on to antennas themselves.

We mentioned before that an antenna was a reciprocal device—that it worked both forward and backward. This means that the theory for both transmitting and receiving antennas must be identical. Thus it is only necessary to discuss one type, either transmitting or receiving, and the conclusions will be found to hold for both. For the purposes of this article we will discuss the antenna from the transmitting point of view, because it is easiest to visualze. Later we will have some comments about the receiving antenna.

Antenna equivalent circuit

When an antenna is attached to the output terminals of a transmitter, power flows from the transmitter output to the antenna and is radiated electromagnetically. The antenna loads the transmitter, the same as an impedance would. Thus the antenna could be represented, as far as the transmitter is concerned, by an impedance. Almost always the antenna is tuned to resonance (or nearly so) at the operating frequency, so that the impedance it presents to the transmitter is purely resistive. Then the input impedance of the antenna is purely resistive, and the antenna could be represented by the simple equivalent circuit of **Fig. 1.**

In **Fig. 1**, R is a resistance equal in value to the antenna input impedance. The transmitter knows not whether an antenna of input impedance R, or a simple resistor of

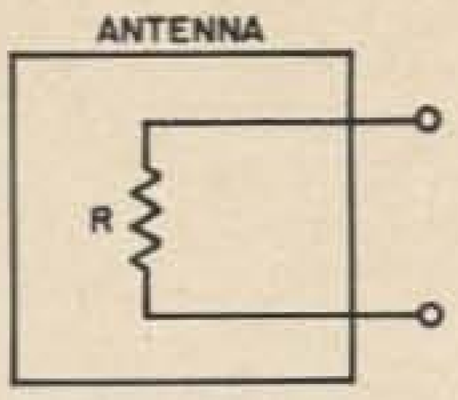

Fig. 1. Simplest antenna equivalent circuit.

R ohms is connected to its output terminals.

Radiation efficiency

Actually in a practical antenna not all of its input power is radiated as EM signal energy. Some is also radiated as heat, due to losses in the antenna structure. (Heat is just another form of EM energy. It is "incoherent" and at an extremely high frequency.) Losses in an antenna structure stem from several sources: dielectric losses in supporting insulators, resistive losses in the antenna system conductors, losses due to leakage currents over insulators, losses due to currents induced in nearby conductors and the ground, and corona loss. These losses can be minimized by proper design and location of the antenna.

In order to represent the splitting of the antenna input power into two parts, we split R into two parts and represent the antenna as in **Fig. 2.** Here R_r represents the portion of the input power that is radiated as useful signal power, and is called the "radiation resistance". R_l represents that portion of input power which is lost as heat, and is called the "loss resistance".

In order for an antenna to be a good radiator, it should have very low R_l in relation to R_r, or in other words, by far the greatest portion of antenna input power should be radiated as useful signal. The "radiation efficiency" of an antenna is expressed mathematically like this:

$$(7) \quad \eta = \frac{R_r + R_l}{R_r},$$

where: η = radiation efficiency
R_r = radiation resistance, ohms
R_l = loss resistance, ohms

If we desire to maximize this radiation efficiency, we want R_l to be small in comparison to R_r. In the extreme case of a perfect radiator, R_l would be zero and then η would be equal to 1, or 100%. When R_l increases from zero the efficiency drops, and if R_l should equal R_r, for example, then η would be only ½, or 50%.

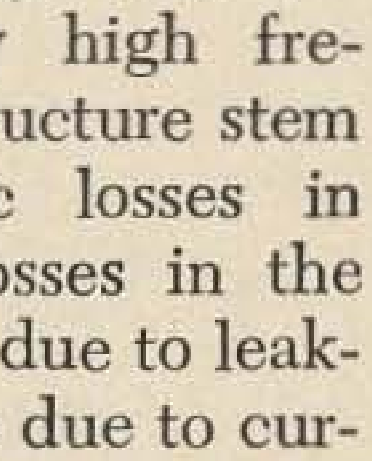

Fig. 2. Antenna equivalent circuit, includng effect of losses. R_r is the radiation resistance, R_l the loss resistance.

The Isotropic antenna

An isotropic antenna is one which radiates equally well in all directions. It is similar to the point source which we discussed before. Such an antenna is a convenient reference to use for measuring the "gain" of another antenna, although in reality there is no antenna which is truly isotropic.

Antenna gain

When discussing the "gain" of an antenna, it should be emphasized that there are two kinds of gain—power gain and directive gain (sometimes called directivity). The two are related by a simple expression which includes radiation efficiency:

$$(8) \quad G_p = \eta \, G_d,$$

where: G_p = antenna power gain
G_d = antenna directive gain.

Suppose, for example, that an antenna with a radiation efficiency of 50% had a directive gain of 4 (6 db). Using Equation (8) then, power gain would be ½ times 4, or 2 (3 db). But what do these terms power gain and directive gain mean?

Any antenna which is not isotropic has some directive gain. The directive gain is only a measure of the ability of the antenna to radiate in one direction to the exclusion of others. In other words, directive gain is a measure of the *shape* of the "radiation pattern" of an antenna, as compared with the circular shape of the radiation pattern of an isotropic antenna.

Power gain, on the other hand, includes not only the shape of the radiation pattern, but also the size of the pattern, or, in other words, it measures how effectively the antenna radiates in a particular direction.

An example should serve to make the above concepts clear. In **Fig. 3** we have the radiation patterns (in two dimensions) of three antennas—a 100% efficient isotropic antenna (antenna A), and two directive arrays, each with a directive gain of 4. One of the directive arrays, antenna

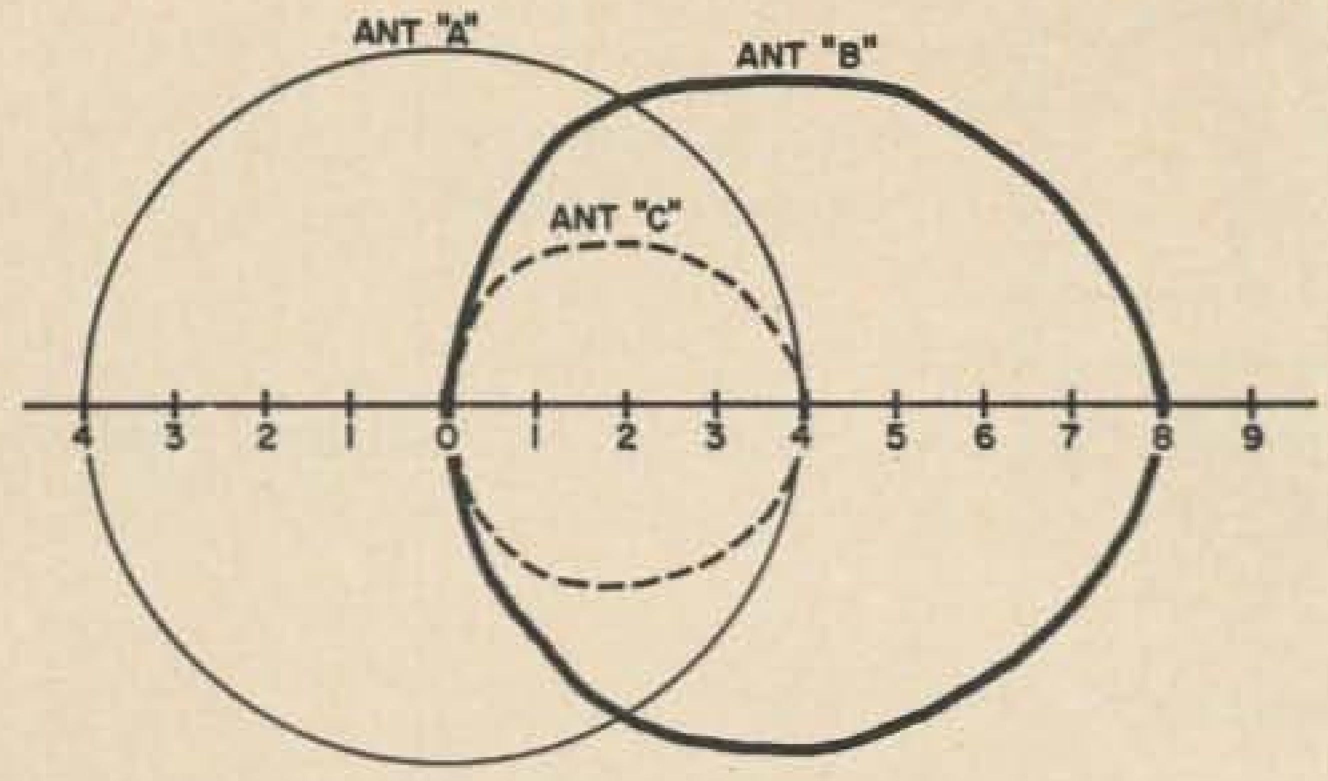

Fig. 3. Radiation patterns of three antennas, one isotropic.

B, has a radiation efficiency of 100%, and the other, antenna C, an η of only 25%. Notice that the *shape* of the patterns of antennas B and C is the same, only the size is different. Also note that in the favored direction, antenna C is no more effective a radiator than the isotropic. Nonetheless it has directive gain, due to its ability to radiate better in the favored direction than in others.

Antenna B, on the other hand, has the same directive gain as antenna C, since the shape of its radiation pattern is the same. But its efficiency is four times greater, and thus, as shown in the diagram, is a much more effective radiator in the favored direction.

The power gain of antenna B is, from Equation (8):

$$G_p \text{ (antenna B)} = \eta G_d = 1 \times 4 = 4 \text{ (6 db)}.$$

For antenna C, the power gain is:

$$G_p \text{ (antenna C)} = \tfrac{1}{4} \times 4 = 1 \text{ (0 db)}.$$

The G_p, G_d and η for the three antennas is summarized in **Fig. 4.**

ANTENNA	A	B	C
POWER GAIN, G_p	1	4	1
DIRECTIVE GAIN, G_d	1	4	4
RADIATION EFFICIENCY, η	1	1	1/4

Fig. 4. A summarization of the power gain, directive gain and radiation efficiency for the antennas of Fig. 3.

Power gain can also be thought of as the power density of the EM wave radiated by a directive antenna in its favored direction, divided by the power density radiated by a 100% efficient isotropic antenna in the same direction. In **Fig. 3** antenna B gives twice as much field strength in the desired direction than does the isotropic antenna. And since power density, from

Equation (5), is proportional to field strength squared, it gives four times as much power density. Thus its power gain is 4. Antenna C, on the other hand, gives identically the same field strength, and therefore power density, as the isotropic, and thus its power gain is 1. From this it can be seen that power gain can be determined from an antenna's radiation pattern.

At this point let's look at a practical example of power gain versus directive gain. A three-element yagi, optimally designed and adjusted, has a maximum directive gain of about 11.7 (10.7 db). However, if loading coils or traps are added to the elements to decrease their size, or provide for automatic bandswitching, the efficiency is decreased due to losses in the wire from which the coils are wound. If the efficiency is decreased to as little as 80% (not an unrealistic figure in the case of tri-band beams), the power gain will suffer by about 1 db. Of course this small price has been paid for added flexibility in the antenna system.

Normally power gain and directive gain are measured with respect to an isotropic antenna, as we have done in the examples above. Historically this has not always been the case, however. In the earlier days of radio, gain was most often measured with respect to a half-wave dipole antenna, and this is still done today in the amateur radio community. The gain (either power or directive) is less when measured with respect to a dipole than with respect to an isotropic, because a dipole itself has gain with respect to an isotropic antenna. A 100% efficient dipole antenna has a power gain of 1.64 (2.15 db) with respect to an isotropic. Thus to convert a gain figure measured with respect to a dipole to that with respect to an isotropic, the figure should be multiplied by 1.64.

Which gain is important?

The question now arises, Which gain, directive or power, is important in a radio system? In the transmitting system, power gain is the most meaningful criterion of antenna effectiveness, since the ultimate aim is to radiate in the direction of the receiving station an EM field with the greatest power density. Power gain gives a good measure here because it includes both directivity and radiation efficiency.

In a receiving system, the important type of antenna gain depends on noise, and its origin. If the largest portion of the receiver output noise originates in the receiver itself, power gain is necessary in the antenna. This is normally the case in the frequency range above about 30 MHz. But if the output noise originates external to the receiving system, such as is the case with atmospheric noise below 30 MHz, then only directive gain is necessary in the antenna.

Normally below 30 MHz we amateurs use an antenna with high power gain for both receiving and transmitting, since it allows us to get by with only one antenna. When transmitting the power gain is necessary to system effectiveness, but for receiving it is not, although it certainly does no harm. By sacrificing efficiency (which we don't need anyway) we could use a physically much smaller receiving antenna, though, and get equal results. At least one manufacturer is taking advantage of this principle in small receiving antennas being built for the commercial services.

Summary

Some important conclusions can now be stated from our study of antenna gain. First, when speaking of antenna "gain" two things must be stated for clarity—the type of gain referred to, power or directive, and the reference, isotropic or dipole. Second, high radiation efficiency, while always desirable in a transmitting antenna is not necessary for receiving antennas below 30 MHz where the large majority of the receiver output noise originates outside the antenna. With low efficiency both the signal and noise are reduced proportionately in the antenna, and therefore the signal-to-noise ratio is largely unaffected.

Receiving Antennas

So far as transmitting antennas are concerned, we have now covered the basics, but for receiving antennas we have more work to do. While the antenna parameters we have specified and described above for transmitting antennas are also adequate for receiving antennas, two other unique terms have come into great usage to describe receiving antennas, capture area and effective height.

Capture Area

When using an antenna for receiving purposes, it is usually desirable to know the amount of signal power available from the antenna output, to be supplied to the receiver input. From the power density of the EM field of the signal we know the amount of power per unit area in the field. If we knew the effective capture area of the receiving antenna, then, we could find the power available from the antenna simply by multiplying the power density and capture area together. Thus, the capture area is the ratio of the power available at the antenna terminals to the power density of the intercepted EM field. Capture area is related to the power gain of the antenna, and the wavelength of the field by:

$$(9) \quad A = G_p \times \frac{\lambda^2}{4\pi},$$

where: A = antenna capture area.

Let's take a simple example. Say the wavelength is 7.1 meters and G_p of the antenna is 8 (9 db). The capture area then is $8 \times \frac{7.1 \times 7.1}{4 \times 3.14} = 32$ square meters. Then if the power density of the EM field striking the antenna were 2 nanowatts per square meter, the power available at the antenna terminals would be 2 x 32 = 64 nanowatts.

Large capture area is essential if a VHF antenna is to be highly effective for receiving purposes. But Equation (9) shows that capture area decreases with the square of wavelength. Therefore, as we go to higher frequencies, and consequent shorter wavelengths, power gain must be rapidly increased if we are to maintain a respectable capture area. The result of all this is that highly effective VHF antennas are just as physically large as those for the lower frequencies, despite the shorter wavelengths. They must be in order to develop the proportionately higher power gains necessary to maintain a high capture area.

Capture area is coming to be used more and more today as a measure of VHF and UHF receiving antenna effectiveness. Historically, however, antenna "effective height" came first, and we will explain that next.

Effective height

Back in the days when regular AM broadcasting was getting its start, the amplitude of an EM field was most often specified by its electric field strength, E. Power density was very seldom used. Consequently, an antenna "transfer function" was needed which was based on field strength rather than power density. The term settled on was "effective height", and it was defined in terms of the voltage measured at the antenna terminals with no load connected across those terminals (the open-circuit voltage):

(10)

$$L = \frac{\text{antenna open-circuit terminal voltage}}{\text{electric field strength, E}}$$

$= \text{antenna effective height.}$

This choice has turned out to be a bit ambiguous for two reasons. First, for a given field amplitude, it gives only the voltage available from the antenna. Ths is ambiguous for a given antenna because it depends on where the antenna is fed. If the feed terminals of a dipole antenna, for example, are located at its center the open-circuit voltage is much lower than when the terminals are located a good deal off center. And besides, it takes power to drive a receiver anyway.

Second, the term "height" has proved to be unfortunate because it implies how high the antenna is above ground, which connotation is purely incidental. A much better word here would have been "length", and indeed it is now coming into wide usage.

An amateur frequencies and higher, antenna capture area is gradually replacing the usage of effective height, especially among professionals. Its usage among amateurs should also be encouraged, but the old term is still hanging on with real tenacity.

Conclusion

This article should have given you a basic insight into antenna theory. The knowledge you have gained will enable you to interpret antenna literature more wisely, and this in turn will mean better antennas at your station for the dollars you have to spend.

. . . K6ZGQ/5

CLUB SECRETARIES NOTE

Club members would do well to get their club secretaries to drop a line to 73 and ask for the special club subscription scheme that we have evolved. This plan not only saves each club member money, it also brings badly needed loot into the club treasury, if desired. Write: Club Finagle, 73 Magazine, Peter Boro Ugh, New Ham Shire 03458.

1968 HAMFEST AT 73

Come on up July 6th and visit New Hampshire

Ever since our last hamfest, in 1965, everyone has been after us to have a repeat performance. The editorial in February explained some of the reasons for the delay.

This year we are going to do it again. July 4th comes on Thursday this year, so we will schedule our Hamfest for Saturday, July 6th. We'll try to have lots of entertainment for you on Saturday. We'll have more details on this later, but it looks as if the VHF gang will have a chance to bring their 144 and 432 MHz antennas for a measuring contest run by Leger Laboratories. I expect that André of Vanguard will be up here with all of his latest products; plus many other 73 advertisers.

We'll organize an auction of gear, so bring stuff you want to sell and lot's of money to grab the bargains. Last time thousands of dollars worth of gear changed hands and I'm afraid the buyers got some incredible bargains.

Saturday evening I will show some of the slides of my DXpedition to those interested in seeing some pictures of weird places.

Early Sunday morning we will form a caravan heading north into the White Mountains, about 100 miles away. There we will visit some of the tourist attractions that have made New Hampshire the most visited tourist state in the East. We will see the famous Old Stone Face, the great New Hampshire Man of the Mountains. We'll see and walk up through the Flume. We'll take the tramway to the top of Canon Mountain for one of the panoramas of a lifetime. We'll see the beautiful Old Man's Foot Basin. We'll stop off at Clark's Trading Post and see and hear some of the old time music boxes and see the trained bears. We'll visit the historic Morse Museum and, if we can work it in, climb through the caverns of Lost River.

New York is just a little over 300 miles of turnpike driving away, so those that have to get back can make it Sunday evening. For the rest we can drive or take the cog railway to the top of Mount Washington on Monday morning. The more athletic can start from the cog railway station at the base and climb the mountain.

This will be an outing that the whole family will enjoy. There are many beautiful picnic spots near Peterborough and we show them on a special map that we have printed of the Monadnock region of New Hampshire. You can get one of these maps when you arrive or send us a SASE and we will send you one right away. This map also shows points of interest in this area, restaurants, etc.

Mobileers will want to try their luck from the top of Pack Monadnock, just 3.5 miles east of the 73 headquarters. You can drive right to the top of this mountain and get a straight shot right into Boston and down to New York.

At any rate, if you can get away for a couple of days or so, why not join us up here at 73 for a couple of days of fun and sightseeing around New Hampshire?

. . . W2NSD/1

Norman B. Watson W6DL
5501 Via del Valle
Torrance, California

Triangular Loop Beam 7 thru 28 MHz

Introduction

The writer, returning to amateur communications after thirty years away from it, found antennas a source of interest. Accordingly, during two years while part of spare time available was being spent in obtaining an extra class license and building a tilting tower, a research program was carried out oriented to a few long-wire antennas, such as the rhombic, and to beam antennas. Calculations and literature research covering log-periodic dipoles and monopoles, helices and phased arrays together with experimentation led to design of the antenna described herein. This antenna incorporates on a 28 foot outrigger boom, four triangular loop elements comprising a two-element beam on 7 MHz and four-element beams on 14, 21 and 28 MHz. Apertures and gain of a number of element configurations are compared and experiments with square and triangular loops are covered.

Antenna design criteria

The following criteria for an amateur antenna were traded off in evolution of the triangular-loop-beam:

- Operation on 7 thru 28 MHz bands
- Rotary beam to maximize effectiveness
- 3 to 5 dB gain on 7 MHz and 8-9 dB gain on 14, 21 and 28 MHz as compared to a dipole
- KW power capability
- High radiation efficiency
- Withstand 85 mph winds coupled with ice loads
- Turning radius of 17 feet maximum
- Minimum weight and cost commensurate with design capable of amateur construction.

Loop Beam vs Helix

The multiple loop beam antenna is merely a special case of the axial mode helix an-

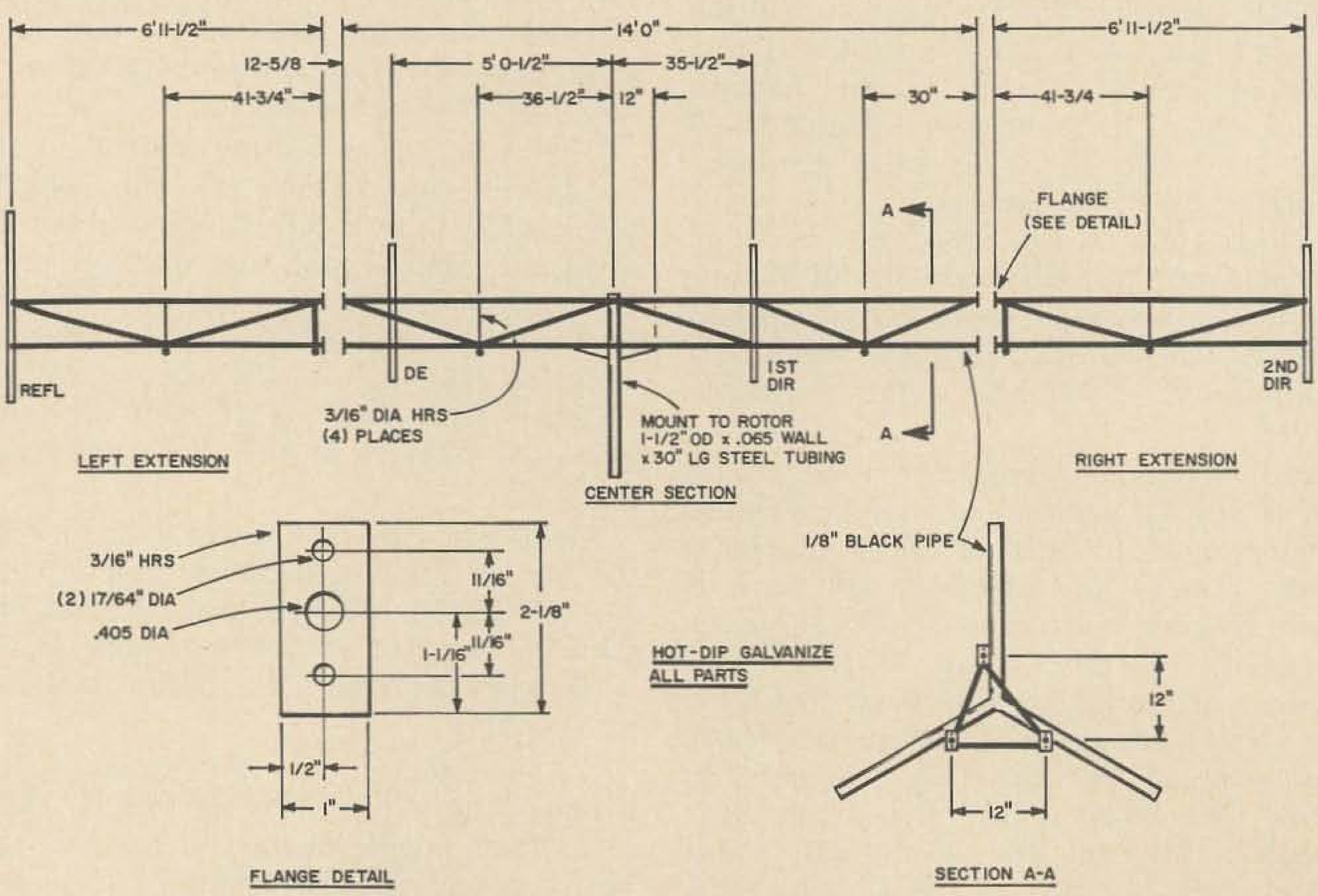

Fig. 1. Truss boom construction details

tenna in which the helix pitch is zero. The other extreme of the helix is a straight wire, when the helix is stretched out until its diameter becomes zero. The multiple loop parasitic antenna and the axial mode helix when both of one wavelength in circumference exhibit equivalent gain when the boom length is less than about ½ wavelength. For longer boom lengths the helix outperforms the parasitically driven antenna. For the less than $\frac{\lambda}{2}$ boom length, the greatest differences apparent between the two antennas are that the helix has a bandwidth of almost 1.7 to 1 of the design wavelength (much broader than the loop) and the loop has a better front to back ratio than the helix.

The helix requires a ground plane of 0.8 wavelength diameter behind it to be really effective. If one considers use of the helix for 14 MHz a ground plane 56 feet in diameter becomes a real structural problem for the amateur. The parasitic loop beam antenna uses a reflecting loop instead of the ground plane and is somewhat easier to build.

The writer, in extrapolating axial mode helix data for the one-wave-length pitch circumference helices and comparing it with various data for performance of parasitic beams, concluded that a four-element parasitic loop antenna using loops of one-wavelength in circumference and a boom length of 0.4 wavelength should turn out an honest 10.5 dB gain as compared to an isotropic radiator or about 8 dB more than a dipole. A boom length of 0.4 wavelength at 14 MHz was therefore adopted as meeting the design criteria. This boom length is 0.2 wavelength at 7 MHz and is satisfactory for a two-element folded dipole beam having a gain of about 3 dB over a dipole.

Element apertures, gain and radiation resistance

Many amateurs are aware that the gain of an antenna is proportional to its "capture area," (also called aperture, intercept area, or cross section). Apertures and gain of several element configurations are tabulated in Table 1 together with radiation resistance. In comparing antennas or antenna elements it is well to bear in mind that as the radiation resistance of the antenna increases, the power radiated to a distant point as opposed to the power stored as a space charge around the antenna increases. If one were to select a beam antenna element from only the data of Table 1, the 1½ wavelength loop would be the logical choice; however, the 1½ wavelength loop for 14 MHz on a 28 foot boom requires a clear turning area of 23 feet which is more space than many of us have available. The turning radius criteria of 17 feet incidentally resulted from consideration of space available on an average metropolitan area lot to swing a beam without invading neighboring air space or encountering obstructions when working with it on the tower.

Square vs triangular loop

The question arises: How do the triangular and square loops compare in performance? Table 1 shows that the triangular loop of one wavelength periphery has 96.5 per cent the gain of the square loop. Comparison of the patterns and gain of the two loops on near and DX signal reception over a six month period of time revealed the following information. The triangular loop when oriented with one triangle apex down and fed at the lower apex (horizontal polarization) has two major lobes concentric with the loop axis in the horizontal plane and broadside to the loop plane. Since it is a single loop, it radiated in two directions like a dipole and it has two main lobes in each of these directions about 20° off the loop axis. When oriented with one apex of the loop-up and fed either at the top apex or the center of the lower horizontal leg of the triangle (horizontal polarization) one broad lobe can be detected at right angles to the loop plane in two directions. This pattern is similar to a dipole.

The square loop (horizontally polarized) exhibited two lobes in the horizontal pattern about like the triangular loop oriented with one apex down. Los Angeles stations about 10 miles away could be completely nulled with either the single, square or triangular loop, although the triangular loop seems to be slightly better than the square loop in front to side ratio and also slightly broader in pattern than the square loop. One other point of interest was noticed and that is that the triangular loop is better than the square loop on QSB when oriented with one apex straight up.

The diamond configuration square loop and the triangular loop were also mounted

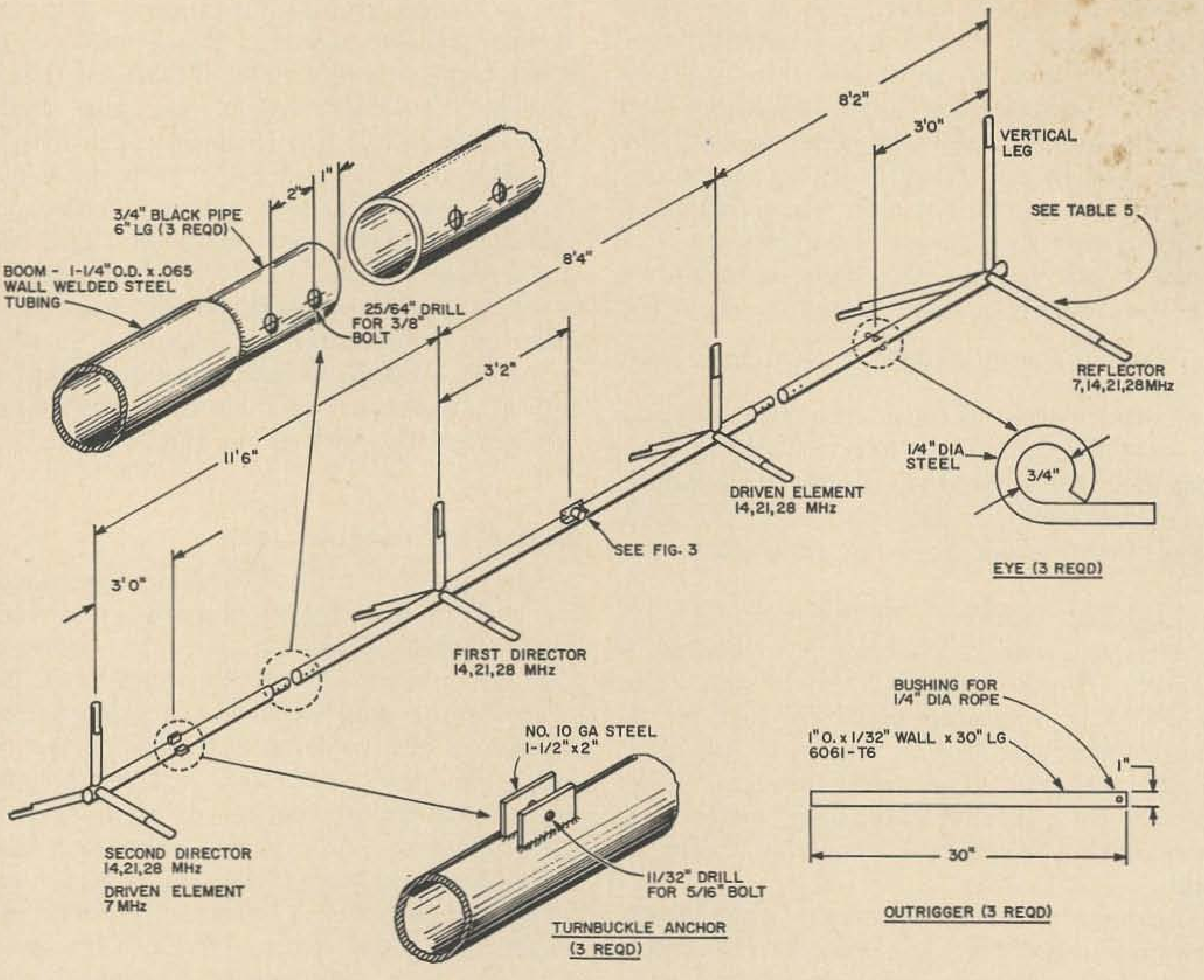

Fig. 2. Outrigger Boom Details

on a tilting fixture and gain was measured at various angles of inclination of the plane of the loop to the vertical. The tilting operation originated from a desire to see if the one wavelength diamond loop really acted like a rhombic as has been hypothesized in some diamond quad articles. It does not from the author's measurements. The effect of tilting up or down from an initial position with the loop vertical is to decrease the low angle radiation of the antenna because the horizontally radiating aperture is decreased. Also, the one wavelength diamond loop is not a uniform traveling wave antenna like the rhombic or the helix; it is simply a resonant, standing wave radiator and its gain over a dipole results from the larger aperture of the one-wavelength of wire (see Table 1).

Wind loads

The primary structural load on the multiloop beam is wind force. For practical design purposes the wind force on an antenna or tower is given by:

$$F = (\nu)^2 C_d\, A/391$$

Where: F = wind force on structure in lbs

ν = wind speed in mph

C_d = drag coefficient which should be taken as 1.7 for amateur antennas or towers

A = Area in square feet of antenna in a vertical plane (that is at right angles to a horizontal wind force)

Using an 85 mph wind criteria for the antenna yields a force per square foot of vertically disposed antenna area of:

$$F = (85)^2\,(1.7)\,(1)\,/\,391 = 31.5\ \#/\text{sq. ft.}$$

Wind loads for various wind velocities are tabulated on Table 6.

Antenna boom design

Three commonly used designs for beam antenna booms are (in their order of increasing complexity of construction): (1) the self supporting type fabricated from

TABLE I
ANTENNA PARAMETERS

Antenna Element	Effective Aperture (Square Wavelengths)	Directivity *	Gain Over Isotropic Source (DB.)	Radiation Resistance (ohms)
Isotropic Source	0.08	1.0	0	
½ Wavelength Linear	0.13	1.64	2.15	73
1 Wavelength Linear	0.142	1.8	2.55	93
1½ Wavelength Linear	0.158	2.0	3.0	106
½ Wavelength (Open End) Folded Triangularly	0.126	1.59	2.0	75
1 Wavelength Triangular Loop	0.145	1.83	2.63	140
1½ Wavelength (Open End) Folded Triangularly	0.2	2.51	4.0	110
1 Wavelength Square Loop	0.147	1.86	2.7	140

* Directivity = Maximum effective aperture divided by maximum effective aperture of isotropic source. An isotropic source is one which radiates power equally in all directions.

6061-T6 aluminum or mild steel tubing; (2) tubing strengthened with outrigger tension members consisting of solid rod, steel cable or nylon rope and (3) the truss. As an example of strength of the tubing boom and of the wind forces which are exerted on the loop antenna, a two-element quad on a 10 foot boom of 1.5 diameter x 0.058 wall steel tubing is stressed to the bending point of the material (elastic limit) in a steady state wind of 60 mph (calculated).

In section 3.0 it was stated that a 0.4 wavelength long boom is required for a four-element loop antenna to achieve the 8.0 dB gain stated in the design criteria of section 2.0. At 14 MHz the 0.4 wavelength is 28 feet. Applying the wind load of 31.5 lbs/sq ft for an 85 mph wind to design of a 28 foot long steel tubing boom to support four square loops reveals that a 4 inch O.D. x 0.134 wall is required and that the antenna will weigh 190 lbs. While the tubing boom is simple to construct, 190 lbs weight is excessive for many towers, including the author's home brew tilting tower. Truss construction is attractive as a means of reducing weight because the truss places direct axial tension and compression loads on the framework members (elimination of bending loads) and thereby achieves a maximum strength to weight ratio. If one uses the triangular loop to decrease loop weight by 25 per cent over a square loop and loop wind forces by 30 per cent over a square loop, a structure such as shown in **Fig. 1** is required for a 28 foot boom. The complete antenna weighs 65 lbs. using this truss. The **Fig. 1** structure was built by the author for this antenna as a first approach. It required 70 hours to build the boom which was forthwith completely ruined by the galvanizer when handled with a bundle of heavy tower sections. Time was not immediately available to make a second truss, therefore, the outrigger construction was utilized at a sacrifice in boom weight. The design shown in **Fig. 2** uses three outriggers attached to the boom three feet from the end so that the boom carries a combined bending and column (compression) load. This boom required 30 hours to build and the resultant antenna weighs 77 lbs. It is designed for 85 mph wind loads and an 80 lb total ice load.

Element spacing trade-offs

Any multi-band beam represents a compromise between element spacings for the various bands in terms of antenna gain and bandwidth. The basic trade-off factors are as follows:

- An element spacing of 0.12 yields maximum gain for up to three elements on the beam.
- With a fourth element added a spac-

TABLE 2
ELEMENT SPACING

	Spacing for Maximum Gain (Wavelengths)	Actual Spacing in Wavelengths			
		7.15 MHZ $\lambda = 137.5'$	14.17 MHZ $\lambda = 69.4'$	21.25 MHZ $\lambda = 46.2'$	28.7 MHZ $\lambda = 34.2'$
Reflector to Driven Element	0.118	0.204	0.118	0.177	0.238
Driven to First Director	0.12		0.12	0.18	0.243
First Director to Second Director	0.3		0.167	0.25	0.338

ing of 0.3 wavelength between first and second directors seems to yield optimum gain.

- As the element spacing is increased gradually over a practical range from 0.12 to 0.2 wavelength the gain drops and the antenna bandwidth increases.
- Decreasing director spacing and increasing reflector spacing from the 0.12 wavelengths optimum will reduce gain and increase front to back ratio.

Table 2 shows the element spacing used by the author for a 7, 14, 21 and 28 MHz band *compromise;* two elements on 7 and four elements on the other bands.

Element wire lengths

Wire lengths of one wavelength driven elements can be calculated from $1 = 11800/f$ where 1 = length of wire in inches and f = resonant frequency in MHz.

Sufficient bandwidth for the amateur bands covered by the antenna is obtained when the reflector wire length is made 5 per cent longer than the driven element; the first director is made 2.5 per cent shorter than the driven element and the second director is made 2.5 per cent shorter than the first director.

Table 3 shows wire lengths and frequencies used by the author. Wire lengths were calculated and strung on the frames with no attempt made to tune them since the loop at its resonant frequency has very little inductance and any extraneous capacitance, introduced from measuring equipment or the human body, is sufficient to throw it off frequency. The accuracy of the wire length formula had been checked previously in building the single loops and the wire length variations for reflector and directors resulted from tabulation of much

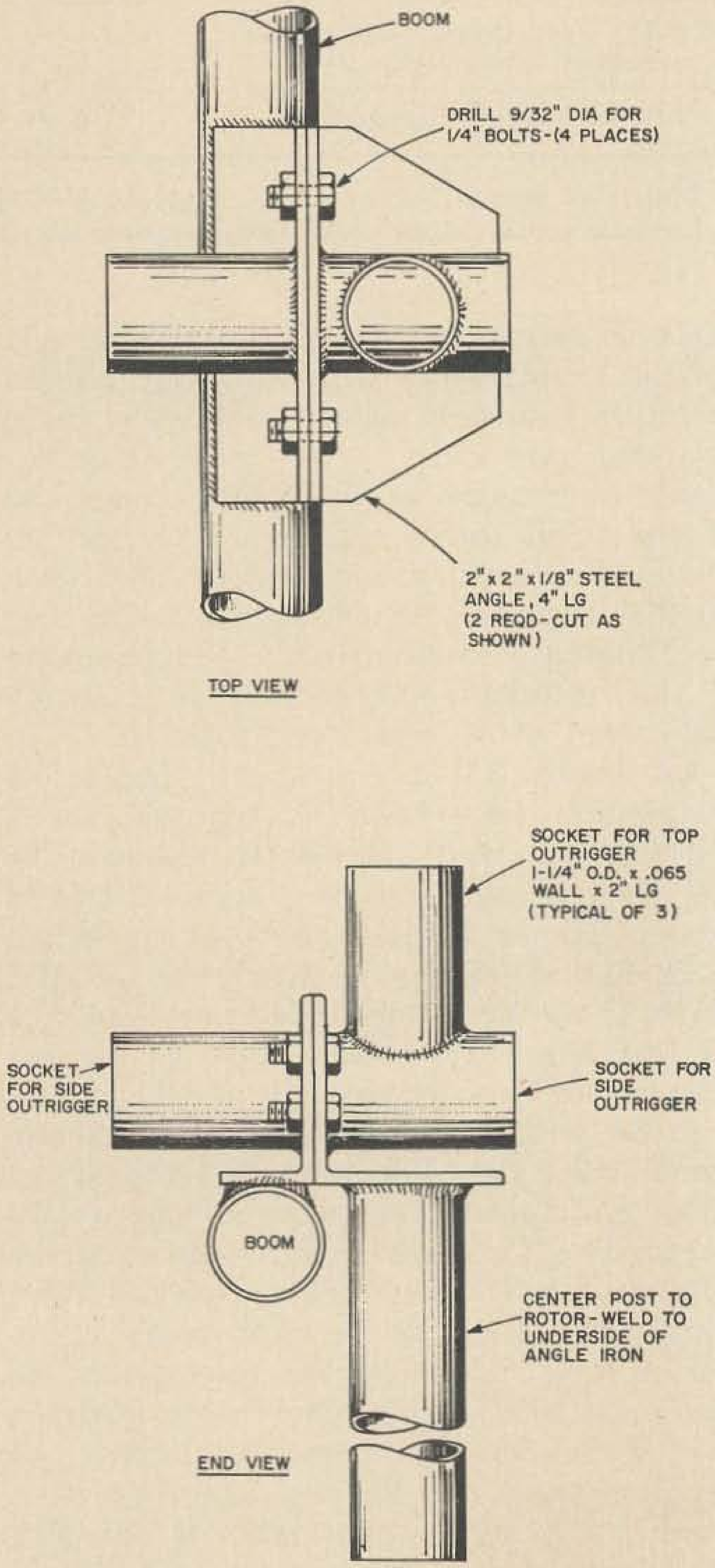

Fig. 3. Center Post To Boom Construction

TABLE 3
WIRE LENGTHS IN INCHES

	Frequency-Band			
Element	7.15 MHZ Dipole	14.17 MHZ Loop	21.25 MHZ Loop	28.7 MHZ $\frac{3\lambda}{2}$ Folded
Reflector	846	883	582	635
Driven	806	833	555	602
Ist Dir		812	541	586
2nd Dir		792	528	572

data by others. The two 7 MHz elements are not loops; they are ½ wavelength wires folded into an equilateral triangular shape. The 7 MHz antenna uses the two end spiders on the boom. The 14 and 21 MHz antennas use one-wavelength loops and the 28 MHz antenna uses 1½ wavelength wires folded into an equilateral triangular shape with the upper ends separated. A 6 inch spreader is needed between legs of the 7 and 14 MHz wires on the two end elements to keep them separated; ¼ inch diameter lucite works well.

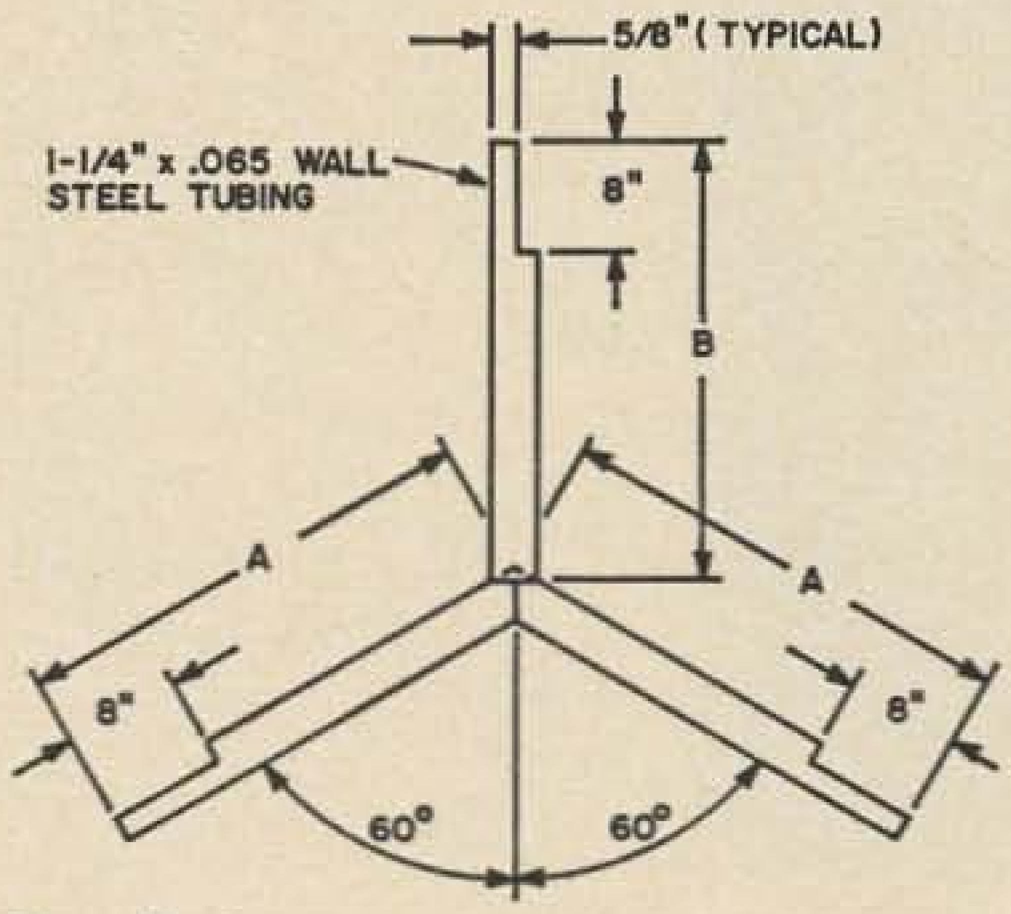

Fig. 4. See Text.

Feed point impedances

All driven loops of the antenna are fed at the center of the bottom, horizontal wire. Dependent upon height of the antenna and proximity to surrounding objects, impedances of the antenna will be found to be close to the following: 7 MHz-45 ohms; 14 MHz-50 ohms; 21 MHz-80 ohms and 28 MHz-55 ohms. Many methods of feed have been published and will not be repeated here. One fact is very pertinent concerning feeding loop antennas; that is, in relation to nearby sources of RF interference the loop will respond only to the magnetic component of the interfering field *if it is balanced.* (That is, it will not respond to the electrostatic field and will therefore pick up less interference with balanced feed.) The feed system used by the author uses double shielded 125 ohm twin lead coax from the transmitter to an antenna switch at the top of the mast. The switch completely isolates those antennas not in use. The 75 ohm, twin lead ¼ wavelength lines (not shielded) run from the antenna selector switch to the 7, 14 and 28 MHz antennas. A ¼ wavelength line from the switch to the 21 MHz driven loop is formed from three pieces of 300 ohm TV lead in parallel which yields a 100 ohm section. Lengths of the ¼ wavelength matching sections from the antennas to the switch are: 7 MHz–24.75 ft; 14 MHz–12.32 ft; 21 MHz–8.21 ft; 28 MHz–6.08 ft.

The above method of antenna feed results in close matching across the bands, a low SWR and the feed to the antenna is balanced for low noise reception of DX signals. If an antenna switch is used, it is important that it switch both sides of the transmission line completely isolating the driven elements not in use. Switching of one wire, such as the center conductor of unbalanced coax with all of the shields of the coax antenna feed lines remaining connected, results in degraded performance over complete isolation.

Construction notes

Both the truss boom of **Fig. 1** and the outrigger boom of **Fig. 2** are constructed

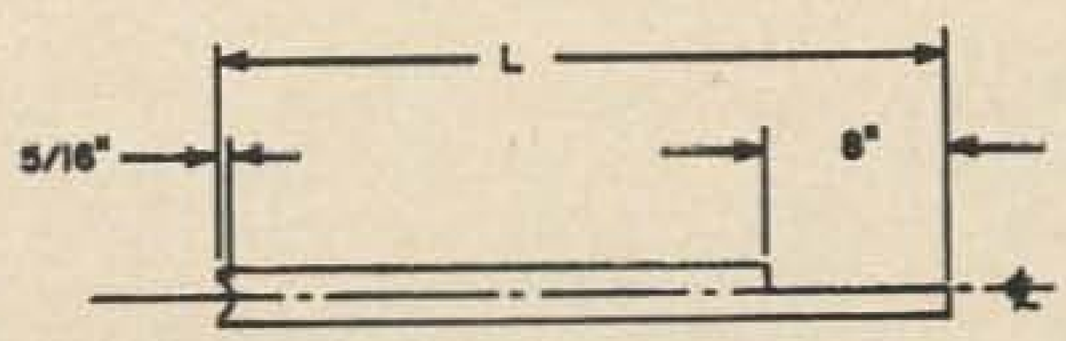

Fig. 5. See Text.

in three pieces for ease of handling, galvanizing and assembly of the wire on the frames. The center post used can be any size suitable to match your rotor or extension mast. The 1½ O.D. x 0.065 wall low carbon tubing shown in **Fig. 1** is only strong enough to extend six inches from the rotor and still meet the 85 mph wind load design criteria. The spider construction for both types of boom is shown in **Tables 4 and 5.** The 1¼ O.D. x 0.065 wall tubing used for the spider is cut back for 8 inches along the tubing center line to receive the fiber glass arms which are fastened in place with two hose clamps per arm.

The detail of the center post to boom construction of the outrigger boom is shown in **Fig. 3.** The outriggers are 30 inches lg. 6061-T6 aluminum as shown in **Fig. 2.** The outriggers fit loosely in the sockets of **Fig. 3** so that the outriggers will not be loaded eccentrically. A ¼ inch diameter nylon rope is used for tension members and it slides through the bushings in the outriggers. The author made the bushings of nylon, but they can be any non-rusting material. One 5/16 inch turnbuckle is used in each tension member, positioned at one end of the boom for a tilting tower or the center of the boom for non-tilting towers. All stainless steel hardware was used by the author except for the aluminum turnbuckles.

TABLE 6

Wind Velocity (MPH)	Horizontal Force on Antenna or Tower (Pounds psf)*
30	3.9
35	5.3
40	7.0
45	8.7
50	10.9
55	13.3
60	15.7
65	18.4
70	21.3
75	24.3
80	27.8
85	31.5

*Take area as largest cross section of member. For example, tubing cross section equals diameter x length.

Advantages if this antenna can be summarized as follows:

- It provides a four-band rotary beam capability.
- Directivity and discrimination against rear and side signals is excellent on all bands. Front-to-side ratio better than the quad and gain is equivalent.
- It is less susceptible to QSB than the square loop.
- Cost of arms is reduced along with antenna weight and wind load area over the square loop.
- Appearance is good.
- It will stay up.
- If fed with a balanced line, it is very quiet on reception.

Disadvantages are:

- It requires 1.3 feet more turning space (radius) than the square loop (with 28 foot boom).
- It is more sensitive to interference between ground and sky waves than a plain wire. (Also true of the square loop.)
- Hams will knock on your door and tell you that part of your quad has fallen off.

. . . W6DL.

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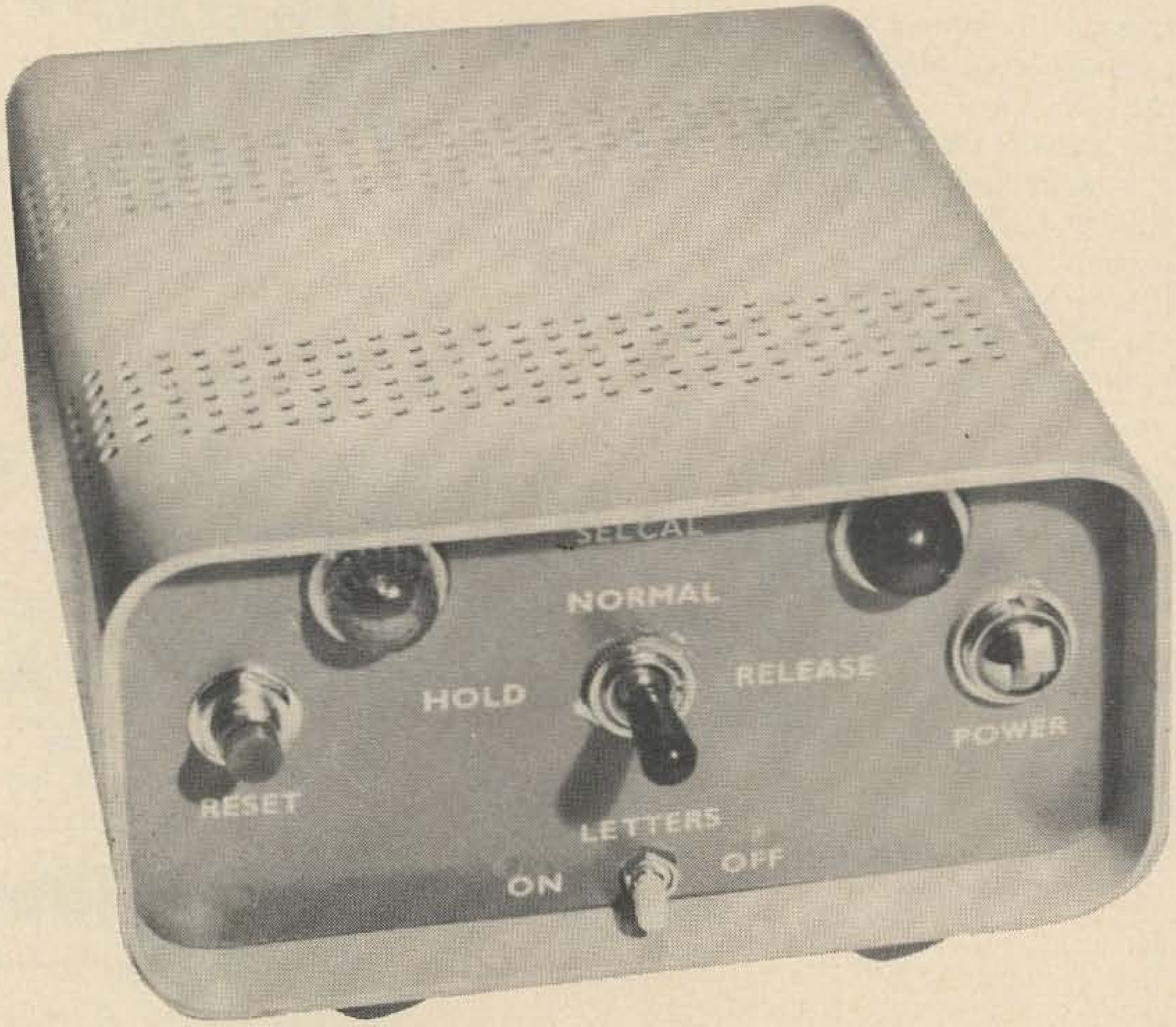
Terman, Electronic and Radio Engineering
Langford Smith, Radiotron Designers Handbook
Jasik, Antenna Engineering Handbook
Henney, Radio Engineering Handbook
Editors and Engineers Ltd, The Radio Handbook
I.T. and T. Corporation Reference Data for Radio Engineers
Numerous foreign and domestic papers

The Selcal

An RTTY character recognizer

Bill Malloch WA8PCK
1179 Temple Drive
Yardley, Pa. 19067

Tom Lamb K8ERV
1066 Larchwood Road
Mansfield, Ohio 44907



The Selcal is sort of an electronic stunt box. It receives RTTY characters directly from the loop, with no machinery running. It recognizes four (or more) characters, in the proper sequence. An output relay closes to turn on your printer or other device. It then recognizes receipt of four letters "N", sent at the message end, to turn off your printer. While the characters must be received in the proper sequence, the Selcal does not distinguish between upper and lower case. Fig. 1 shows how the Selcal is hooked up.

The basic system is very versatile, and will be the basis of further RTTY logic systems such as regeneration, series-to-parallel conversion, and speed conversion.

The system is digital, using inexpensive Motorola integrated circuit (IC) logic blocks. This logic is designed to operate in practically any combination, with voltages, switching times, etc., figured out for you, eliminating much circuitry detail. Best of all, they work! Their cost is far below even junk box prices.

Logic

The Selcal is built entirely of three types of logic. Each will be described to allow the reader to follow the Selcal operation. See the reference list at the end of the article for more information on logic. This logic series operates on two voltage states: high (H) voltages—over 0.8—will turn on any gate; low (L) voltages—under .43—insure all gates are off. Levels between .43 and 0.8 would give erratic operation and are not used. The logic symbols do not show the B+ (3.6v) or ground connections.

Inverters

The simplest type of logic is the inverter, shown in **Fig. 2.** This is just a resistance-coupled amplifier designed so that in the "on" state the output is less than 0.43 volts.

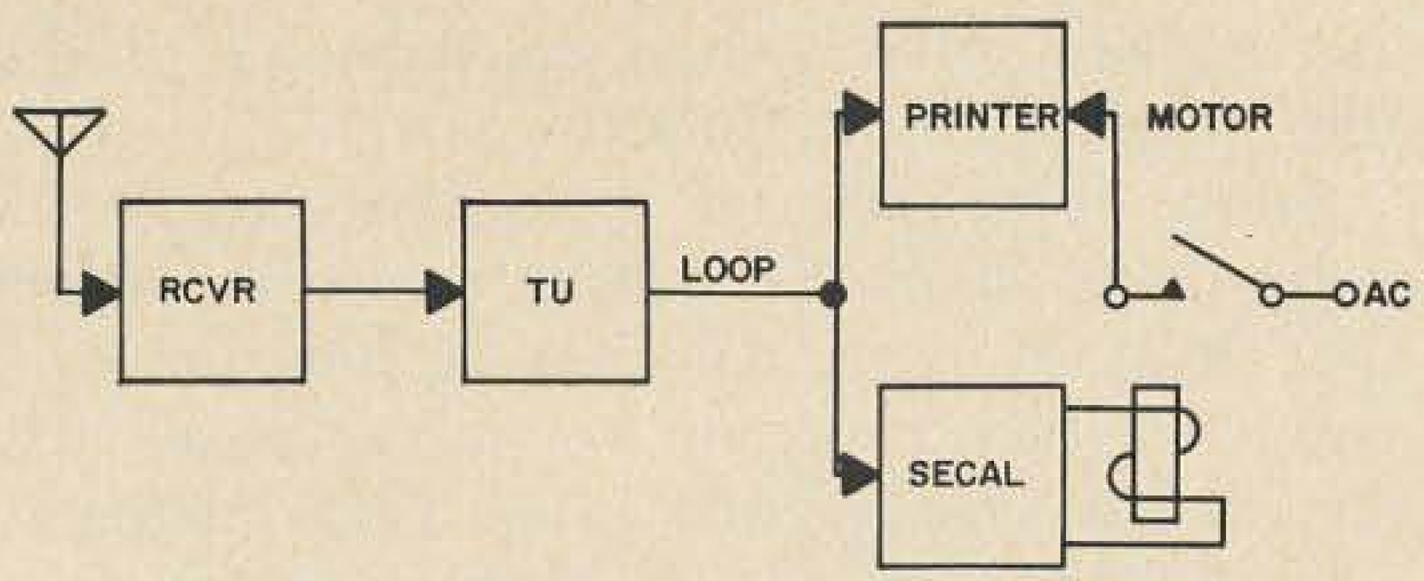
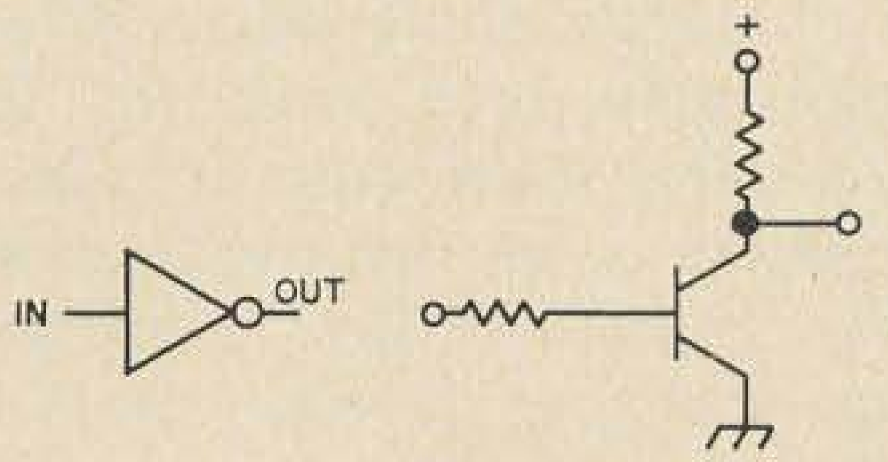


Fig. 1. Connecting the SELCAL into your RTTY system to turn on your printer when your call letters are received.

The inverter has a small "logic gain," or fanout, meaning one stage will drive several succeeding stages. A buffer is similar to an inverter but has a greater fanout capacity, and is available in both inverting and noninverting circuits. The MC789P Hex Inverter contains six independent inverter stages for only $1.08!



IN	OUT
H	L
L	H

Fig. 2. Inverter logic.

Nor Gate

The next logic type used is the nor gate, shown in **Fig. 3.** It is obvious that if any input is high, a transistor will be saturated and the common output will be low. Only if *all* inputs are low can the output be high. The nor gate is a most universal function, and nearly all digital computer circuits and systems can be built from combinations of this logic type. In the Selcal we will use the nor gate as a coincidence recognizer. With varying high and low signals on all inputs, there will be an output only at the instant all are low.

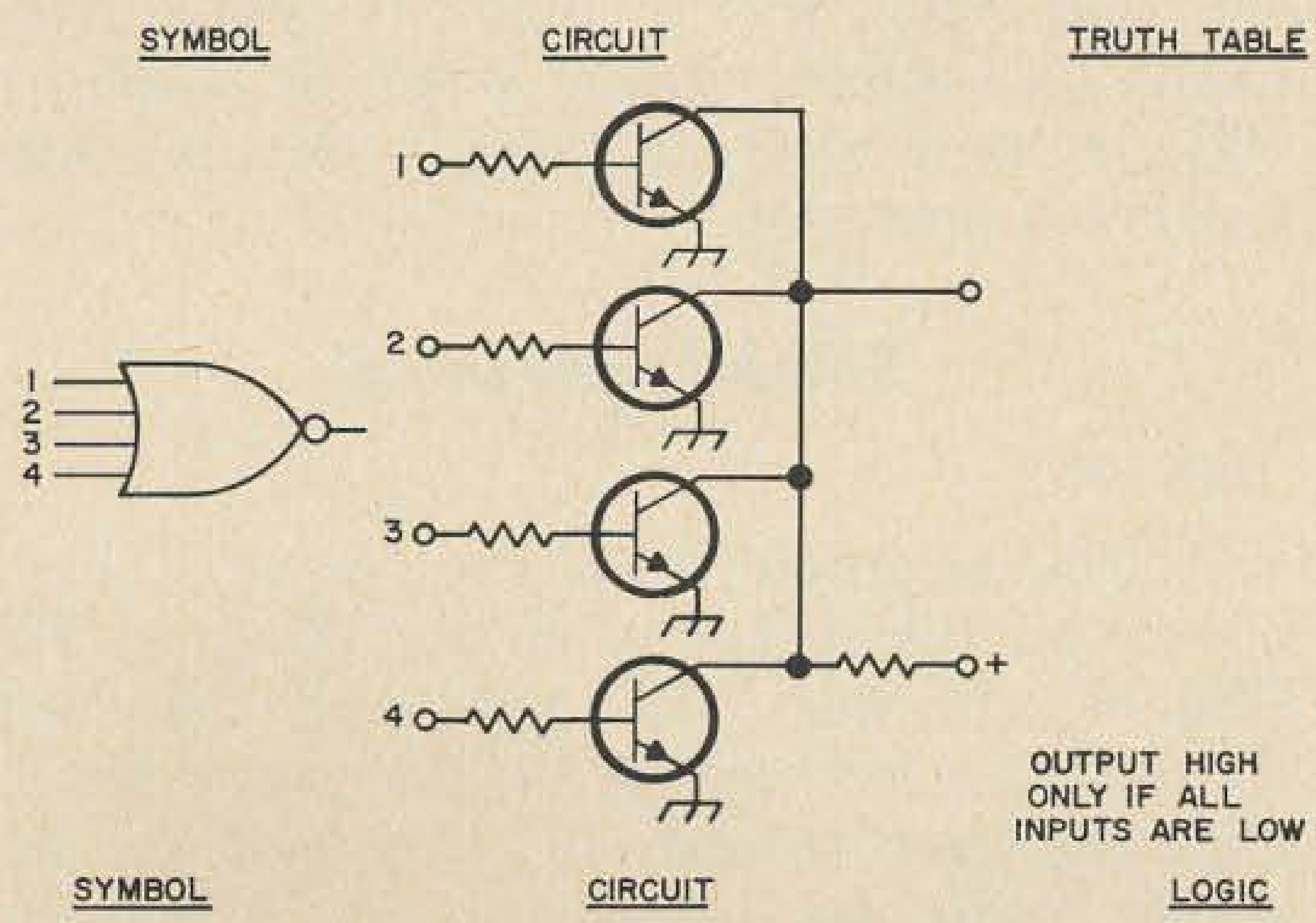


Fig. 3. Nor gate.

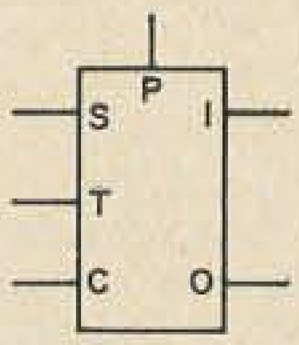
Flip-flops

The J-K is an unusual but most versatile type of FF used in modern digital systems. It is also called a "master-slave", or "clocked" flip-flop. Its symbol and operation table are shown in **Fig. 4.** The inputs are: Set (S) and Clear (C) (sometimes called the J and K inputs), toggle or trigger (T) and preset (P). The outputs are (1) and (0), sometimes designated as $(\overline{Q})$ and (Q). These outputs are *always* in opposite logic states; that is, when one is high the other is low. The preset function is not shown in the truth table. When the (P) lead is high, the (1) output is forced low, regardless of the states of the other inputs. While the integrated-circuit J-K contains the equivalent of 15 transistors, two independent circuits are contained in the Motorola MC790P for only $2.00.

The J-K can be connected for several different logic functions. **Fig. 5A** shows the J-K used as a common binary counter, or divide-by-two circuit. This divider will be used to count down the oscillator frequency in the Selcal.

Fig. 5C shows the clocked flip-flop operation. For this use the (S) and (C) inputs must be in opposite states, so an inverter is used as shown. The output logic

*STATE AFTER TRIGGER PULSE



S	C	(1) *
H	L	H
L	H	L
L	L	REVERSES
H	H	NO CHANGE

SYMBOL TRUTH TABLE

Fig. 4. J-K flip-flop

states duplicate the input states *after the clock pulse.* This FF is seen to be timed, or "clocked." It will be used in this mode in the Selcal Shift Register. The truth table in **Fig. 4** shows all modes of operation.

Basic operation

The Selcal is basically a series-to-parallel converter. The five character-information pulses, mark or space, are briefly stored in a five-stage shift register. The desired character is recognized by a coincidence circuit. The state of recognition is stored in a flip-flop. When all four characters have been received, the output relay is closed.

Lets see how the register stores the letter J, which is Start-M-M-S-M-S-Stop. The first logic level seen by the register is the start pulse, a space. This (L) input is inverted to a (H) and applied to SR 5 lead (S). After the clock pulse, the (1) output also becomes (H), which we will define as the space condition of the flip-flop. The next signal pulse (one), is a mark, which makes

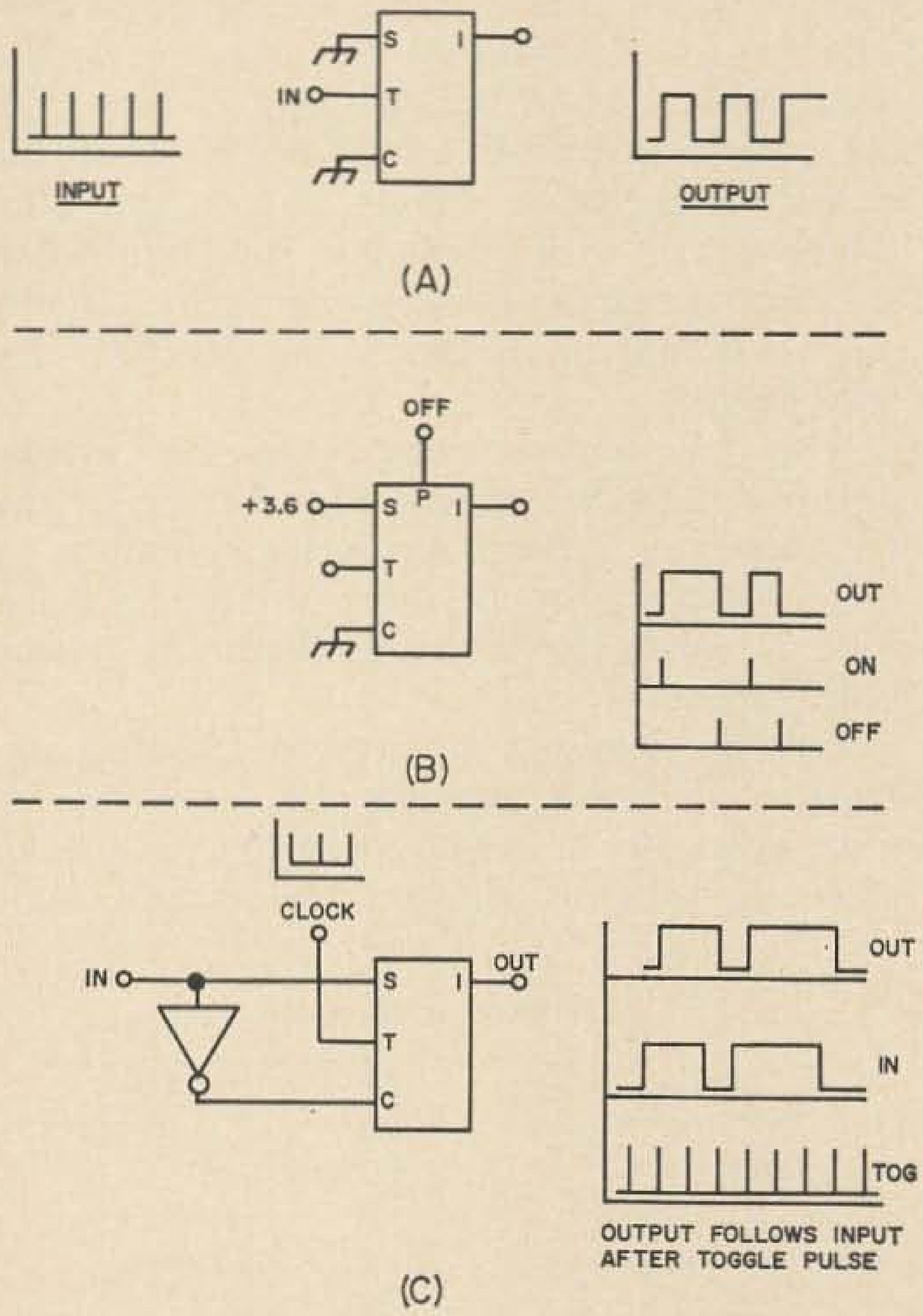


Fig. 5. Applications for the J-K flip-flop. A J-K divider is shown in A; a set-reset flip-flop in B; and a master-slave or clocked flip-flop in C.

SR 5 lead (S) low. The next clock pulse now does two things. At this point SR 4 sees the space condition of SR 5 and duplicates its output, making SR 4 (1) low. The start pulse has been passed from SR 5 to SR 4. Also the output (1) of SR 5 is changed to high, following the input signal. At the next clock pulse, the input is a mark (pulse 2). After this clock, SR 5 and SR 4 are in a mark condition, SR 3 in a space. The shift register now contains the start and first two information pulses of the letter J. These pulses continue to enter the register from the left. Finally the start pulse is pushed out the right end of the register, which then contains all of the five J information pulses.

Since both (H) and (L) outputs are available from each SR stage, we can select that lead of each SR that is low for a J. Only for this J (upper or lower case) will the all-low coincidence exist. These selected low outputs are now fed into a nor gate. Recall that the output of a nor gate goes high only when all inputs are low. It is the nor gate that actually recognizes the J. The high pulse output is fed into a character-1 FF, that flips and thus remembers that the J has been received. See **Fig. 7.**

To detect the next call letter, say K, another nor gate is independently connected to the SR outputs that will give all lows with a K. The output of the character-1 FF feeds a low to the character-2 nor gate so that the first character must be received before the second gate may look for its letter. This prevents the Selcal from responding to your call letters in an incorrect order.

When both the J and K have been received, the third nor gate is free to look for the third letter, say L. When received, the third gate gives a high output which turns on the print FF and the print relay. The printer is now on and receives your message.

To turn your machine off, the sender ends the message with "NNNN". The letter N is recognized just like the J, with a properly connected nor gate. The gate feeds a two-stage binary counter which turns off the print FF when four N's are received.

The Selcal circuit is complicated by the lack of the exact logic needed. Several nor gates are paralleled to get enough inputs, and buffers and inverters are used to increase fan-out or driving power. Note that the A-B signal lines carry the same pulses, the split being just to prevent device overload. The abbreviations listed in Table 1 will be used in the following detailed discussion of operation.

Selcal operation

Turn on

At the beginning of a start pulse, a high occurs on the m-s line, setting the start FF (**Fig. 8**). In this "set" condition, the start FF places a low on the divider preset leads, allowing them to operate. The oscillator inverter raises the voltage on the 6.8 k resistor to high, starting the clock oscillator.

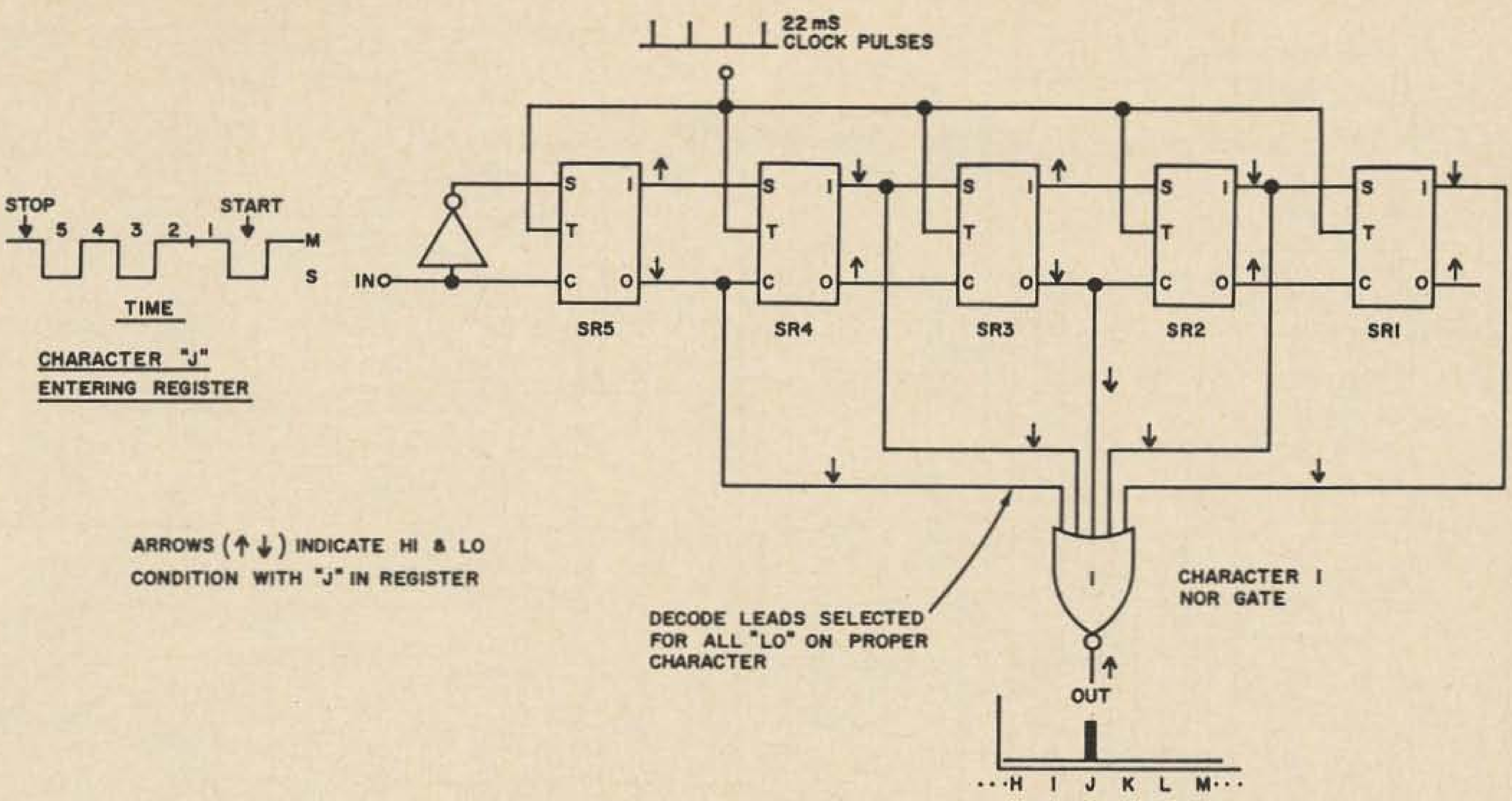


Fig. 6. A shift register connected to provide an outputwhen an RTTY letter "J" is applied to the input.

The clock is a multivibrator that generates 5.5 ms (181-Hz) square waves as shown on line 2, **Fig. 9.** These pulses are divided by two, five times, by the dividers D1-D5. These waveforms are shown on lines 3-7 of **Fig. 9.**

Recall that a nor gate has a high output only if all the inputs are low. By properly selecting the clock and divider outputs, a set of low leads can be found for each single clock pulse. As an example, lets see how the single decode pulse is obtained. At the decode time, (line 11), D2 and D3 leads (1) are low, but D4 and D5 leads (1) are high. By selecting the (0) leads of D4 and D5, we obtain all low inputs for the decode gate. D3 is not needed. Only at one particular time will the above conditions exist, so the decode nor gate gives an output pulse only at the proper decode time.

In this way, nor gates connected to the divider outputs produce properly timed set, shift, and end pulses. The end pulse resets the start FF, ending the Selcal sequence for one character. The "reset" start FF stops the clock oscillator and presets the dividers, making them ready for the next operation. The *hit* gate looks for a spacing signal partway into the start pulse. If a mark exists at this time (non-RTTY signal), the hit gate resets the start FF, terminating the operation. This resets the circuit after a false start from noise. The set-shift-not gate suppresses unwanted set and shift pulses.

Now back to **Fig. 8.** Assume the call K8ERV is being received. To prevent casual copy reference to "ERV" from operating the printer, the code will be "ltrsERV", which already exists in the callsign. The first character "letters" (ltrs) enters the shift reigster as described earlier. At the time of the decode pulse, the ltrs marks and spaces are contained in the register. The C1 nor gates are connected to the five SR output leads that will give all lows. The C1 gates will now recognize the ltrs character and give a high output to the CH1 FF. This high, with the decode pulse, causes the CH1 FF to set, remembering that character one was properly received.

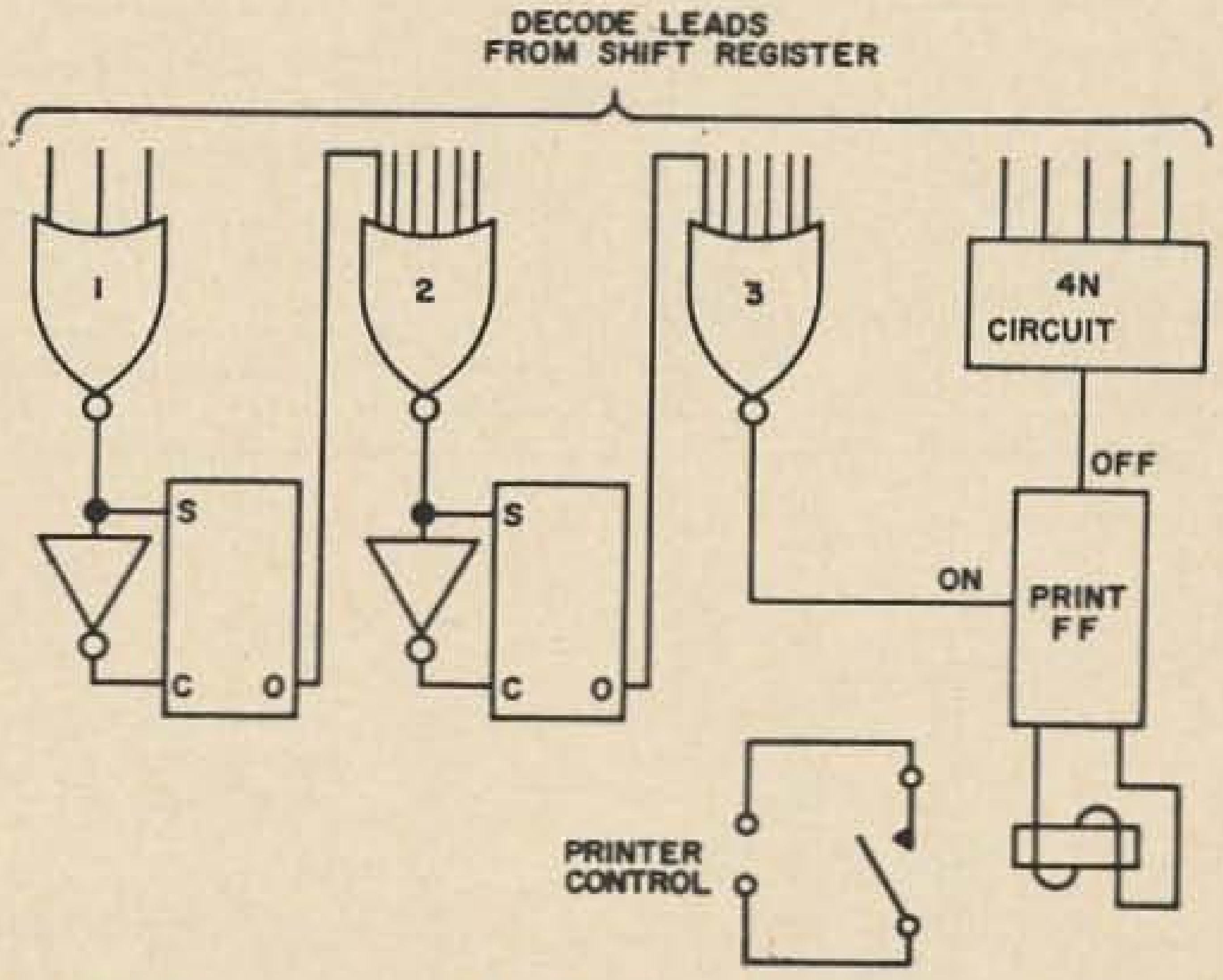
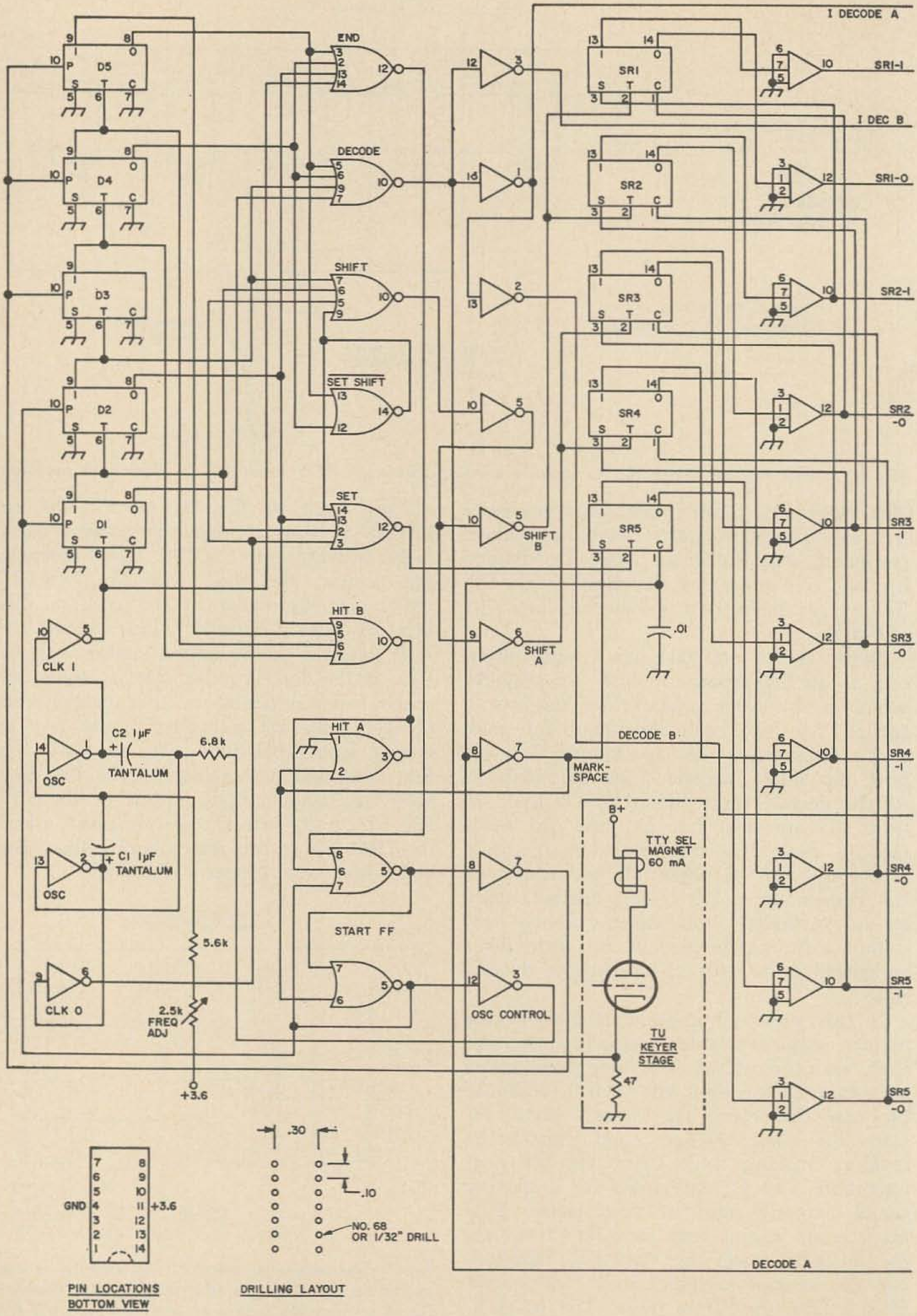


Fig. 7. The sequential selector. This circuitry is connected to the output of the shift register shown in Fig. 6 so that the letters of your call sign will turn the printer on only if they are in the correct sequence.


I DECODE A
D5
D4
D3
D2
DI
END
DECODE
SHIFT
SET SHIFT
SET
HIT B
HIT A
START FF
CLK I
OSC
CLK O
C2 1µF
TANTALUM
6.8k
C1 1µF
TANTALUM
5.6k
2.5k
FREQ
ADJ
+3.6
OSC CONTROL
SHIFT
B
SHIFT
A
MARK-
SPACE
DECODE B
SR1
SR2
SR3
SR4
SR5
SR1-1
I DEC B
SR1-O
SR2-1
SR2
-O
SR3
-1
SR3
-O
SR4
-1
SR4
-O
SR5
-1
SR5
-O
.01
B+
TTY SEL
MAGNET
60 mA
TU
KEYER
STAGE
47
DECODE A
GND
+3.6
PIN LOCATIONS
BOTTOM VIEW
.30
.10
NO. 68
OR 1/32" DRILL
DRILLING LAYOUT

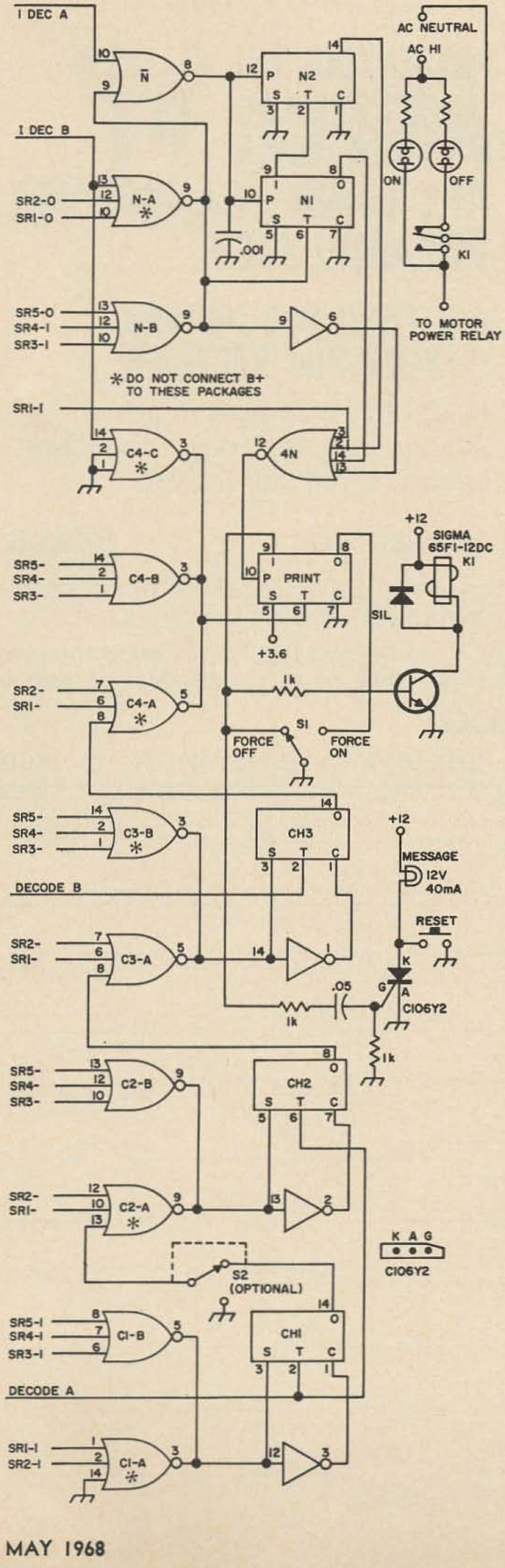


Fig. 8. Schematic diagram of the selcal. Relay K1 is a 12V Sigma 65F1-12DC. Transistor Q1 may be any high-gain silicon transistor such as the Motorola MPS3393. The message light is a Sylvania 12ES. Switch S2 is an optional "omit first character switch".

The CH1 FF low output (lead (0)) is fed to the character-2 nor gate, permitting it to look for, and recognize the next character, "E". As the decode pulse transfers the "E" recognition into the CH2 FF, it also resets the CH1 FF, which insures that characters will be recognized only in the proper sequence. The "E" makes the CH2 FF output (0) low, and the following "R" makes the CH3 FF output low. This low, plus the SR lows from the "V", and the inverted decode pulse (a low pulse) place all low inputs on the C4 gates. The high output from C4 sets the print FF, turning on the output relay and your printer. The Selcal has recognized the last four characters of the call K8ERV! Any wrong character will interrupt the sequence and reset the logic, preventing turn-on.

Turn off

The print FF will now remain on until reset by a switch or by the reception of NNNN, a commercially used disconnect sequence. This section operates by recognizing and counting consecutive "N"s. The fourth N received gives an output through the 4N gate which resets the print FF. Any character other than N operates the N-not gate which resets the FF's, destroying the count. The Selcal must see four consecutive N characters (or upper case equivalent) somewhere in a sequence, to turn off.

All-call

An important addition by KØOJV permits all Selcals to turn on with one particular calling code besides your selected call letters. Since recognition circuits exist for both "ltrs" and "N", an all-call code requiring a minimum of additional logic is "LtrsNLtrsNLtrsN". This code, besides being the easiest, will not occur in normal text. The use of six characters decreases the chance of false turn-on from noise.

Fig. 10 shows the all-call addition. This is a counting arrangement similar to the 4N turn-off, except that the sequence "LtrsN" is counted until all three pairs are received, turning off the print FF. The counter is

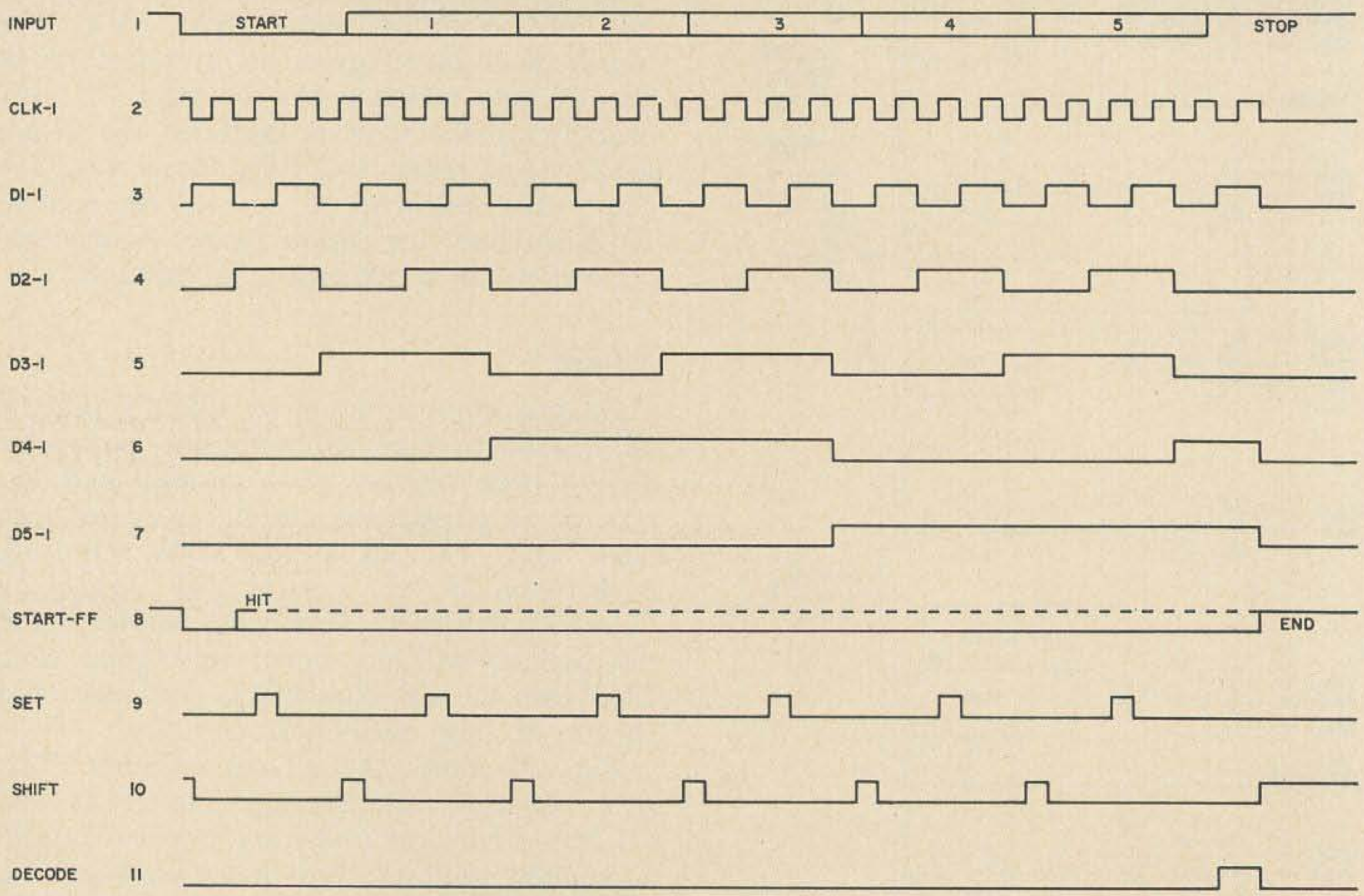


Fig. 9. Timing chart for the Selcal.

reset by any character other than "Ltrs" or "N".

Message light

This circuit can be included to lock on a pilot light when a message is received. This alerts the operator to look at the copy. The print FF output pulse is used to trigger a small SCR that locks on a low current lamp. The lamp is manually reset by a momentary, normally open push switch.

Construction

The integrated circuits used in the Selcal are the Motorola RTL (Resistor-Transistor-Logic) 700 or 800 series, in a plastic dual in-line package. These differ only in price and temperature range, the 700 types covering 15-55°C and the 800 types covering 0-75°C. Data sheets are available from Motorola.*

These logic blocks may be laid out in any order. While IC sockets are available, they are expensive and unnecessary. One way to mount the IC's is to drill holes in a plastic sheet, insert the IC leads in the holes, and wire to the pins. Another way is to mount the blocks on their backs, using an adhesive, or double faced tape, and again wire to the pins. Leave plenty of room for the wires, there are several hundred of them! The easy way is to use the pair of circuit boards from KØOJV*, at $10.00 a set, undrilled. We strongly recommend small (#26) colored Teflon wire to prevent soldering iron damage in the rather cramped wiring space. The cheapest Teflon seems

Table I

I	Inverter, or inverted.
SR	Shift register or stage.
N	Used in the 4N disconnect circuits.
C	Character; letter being recognized.
CH	Channel; memory for a character.
FF	Flip-flop.
Not	Circuit operating on all characters except ( ).
M-S	Mark-space.
Set	Pulses toggling SR5.
Shift	Pulses toggling SR4-SR1.
Hit	Non-RTTY pulses.
D	Divider stage (by two).
High	Voltage over 0.8.
Low	Voltage under 0.43.

to be the Knight brand available from Allied radio, at about 5c a foot.

The power supply must provide 3.6V ±10% at about 600 mA. The design shown in **Fig. 11** has excellent regulation and negligible ripple to about 90 line volts. Its performance is better than needed but not expensive. Z_1 is a group of forward biased diodes of any silicon type, used as a low-voltage Zener. Z_2 is optional, being a group of one-amp diodes used to limit the voltage in case of any type of supply failure. The Selcal can be operated from two flashlight batteries for testing, using a voltmeter in place of the output relay.

The power supply and front panel layouts are not critical The only controls really needed are the on and off switches, but all sorts of pilot lamps and other goodies can be added as described.

Decoding

Setting up the letters you wish to receive is done by hooking the particular character nor gates to the proper SR outputs. Character 1 is shown set up for "Ltrs". The N gates are, of course, wired for N's, although any repeated character could be used. To construct the decode chart (**Fig. 12**) for any character, replace the character marks with (1), and spaces with (0), omitting the stop and start pulses. The first information pulse (after the start pulse) will eventually be in SR1, so the chart is actually reversed from the normal character construction. Since N is S-S-M-M-S, it becomes SR1-(0), SR2-(0), SR3-(1), SR4-(1), SR5-(0). Enter your letters in rows C2, C3, C4. Now transfer this decode to the C2, C3, C4 nor gates in **Fig. 8**. C1 is done for you for "Ltrs". Connect each nor gate lead to the indicated SR output lead. The SR outputs may feed more than one nor input. This is the reason the non-inverting buffers are used.

The simplest method of decode wiring is to permanently connect the decode leads. But two other methods are more versatile.

Fig. 13 shows how twenty inexpensive slide switches can be used to set in the four characters at will. This scheme permits fairly rapid changes in the decode set. A piece of cardboard with holes that accept the slide levers in a particular decode setup can be used to check the settings.

A still faster decode change can be obtained by using a multi-pin connector as a patch board. Each decode group is wired to a separate plug and inserted into the

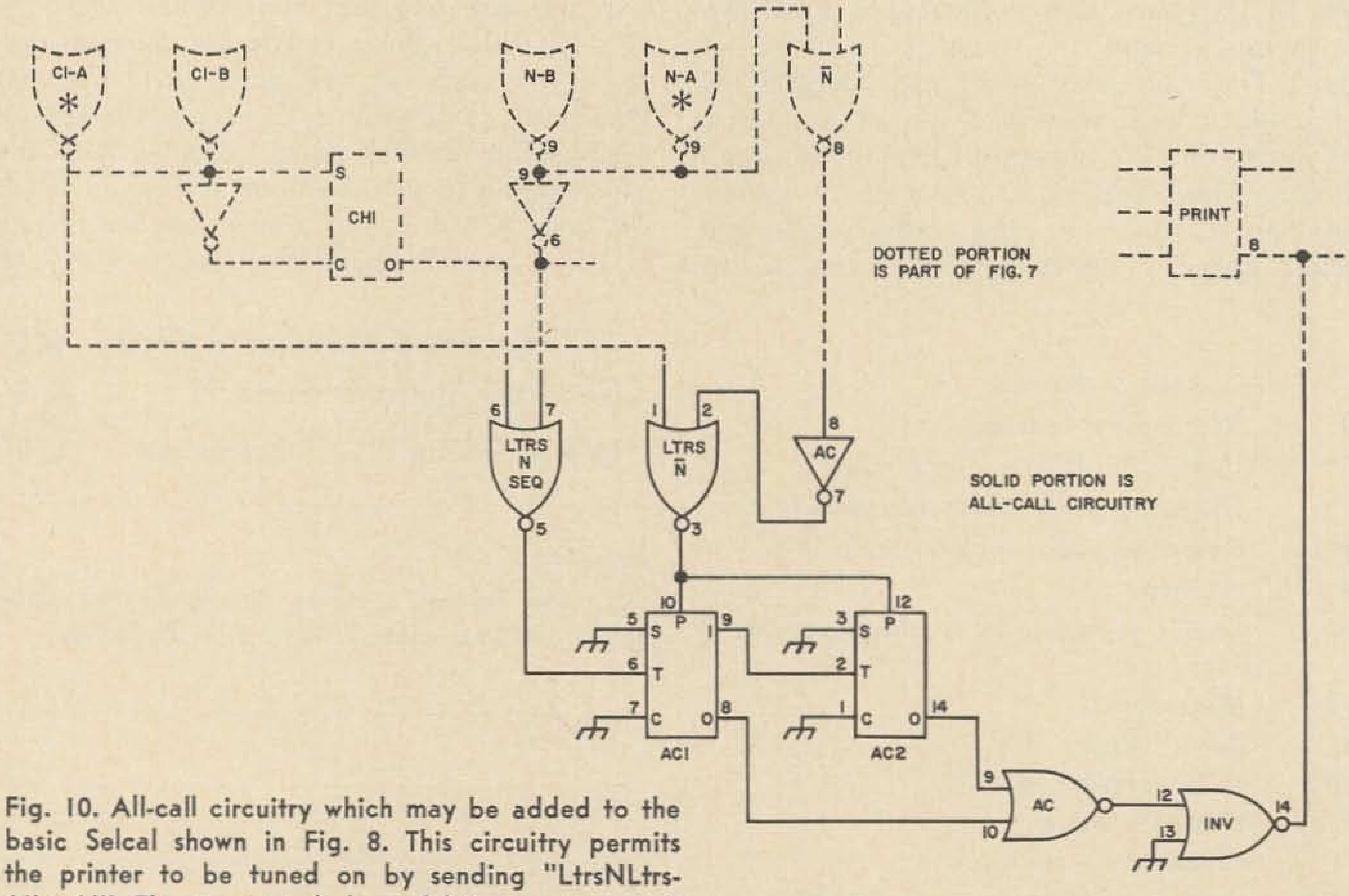


Fig. 10. All-call circuitry which may be added to the basic Selcal shown in Fig. 8. This circuitry permits the printer to be tuned on by sending "LtrsNLtrsNLtrsN". This is particularly useful for turning on all the machines of an RTTY net.

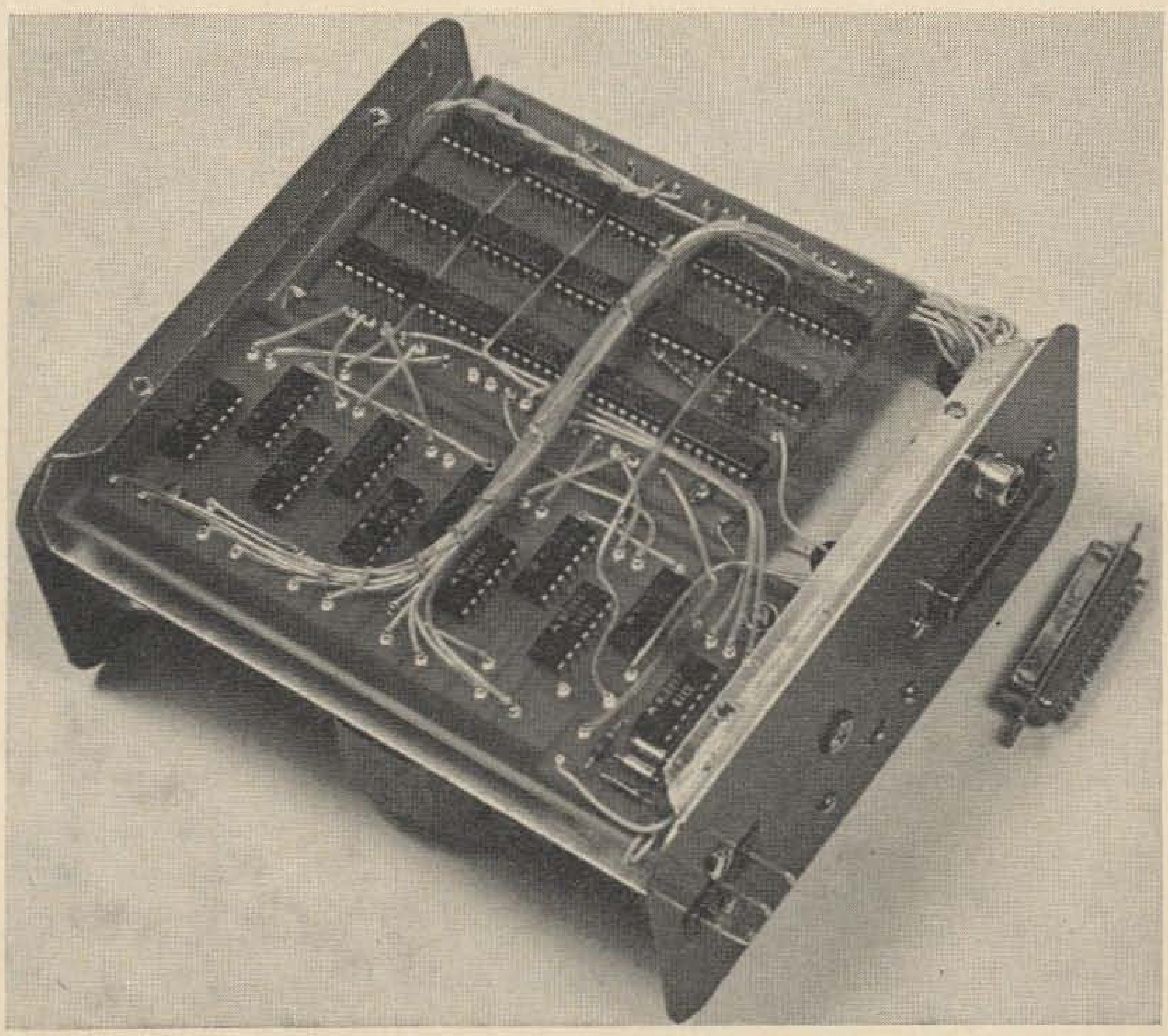
socket in the Selcal. Twenty-five pins are required for a three-letter decode, thirty pins for four letters.

The Selcal turns on the printer motor when its code set is received. If fed with continuous random noise, eventually the Selcal will receive its code and give an unwanted turn-on. A three letter decode for commercial or experimental copy can be obtained by grounding the C2 output lead, as shown in **Fig. 8.** This is not recommended for unattended copy due to the increased possibility of noise turn-on. We suggest the Selcal be teamed up with an auto-start system, such as in the TT/L to inhibit the noise fed to the input.

Adjustment

The only adjustment is the clock oscillator frequency. Temporarily turn on the clock by shorting the Selcal input. Connect a scope to either clock output. Using the line frequency for comparison, adjust the 2.5k pot for 180-Hz output. If a scope is not available, set the pot in the center of the range that gives proper Selcal operation.

The power supply output should be from 3.3 to 3.9 volts. It can be varied slightly by changing the 100-ohm resistor from 50-200 ohms. If greater shift is needed, change



Construction of the *Selcal* used by Bernie W7AHW/4. The connector and plug are used for decoding purposes as described in the text.

the number of diodes in Z_1. Caution, do not operate into the logic with Z_1 disconnected. A 6-ohm, 5-watt resistor can be used as a supply load to simulate the Selcal when "tuning up." If a Variac is available, run the line voltage down until the output starts to drop. This should be about 90 volts, but depends on the gain of the 40310. Lowering the value of the 270-ohm resistor will reduce the required input voltage, but too low a value will reduce regulation and may overload the 2N3904.

If wired correctly, the Selcal should take off when connected as in **Fig. 1.** Note that the Selcal relay will not handle a printer motor load, and must be used only to drive a suitable motor relay, such as the RBM 84-903 ($3.05).

Connect your printer into the local loop and send your call letters. The Selcal relay should turn on. If it by any chance does, you have made about 350 proper connections! Now send any letter except N, to reset the all-call, and then send "NNNN", and hope it turns off. If not, don't despair, a troubleshooting guide follows.

Troubleshooting

First check to see if the start FF and clock oscillator are being keyed. Hook a scope or headphones through a 1000-ohm isolating resistor to the Clk-1 output. Sending any letter should produce a burst from the oscillator. Ground the Selcal input and check for proper outputs from each divider and from the set, shift and decode gates,

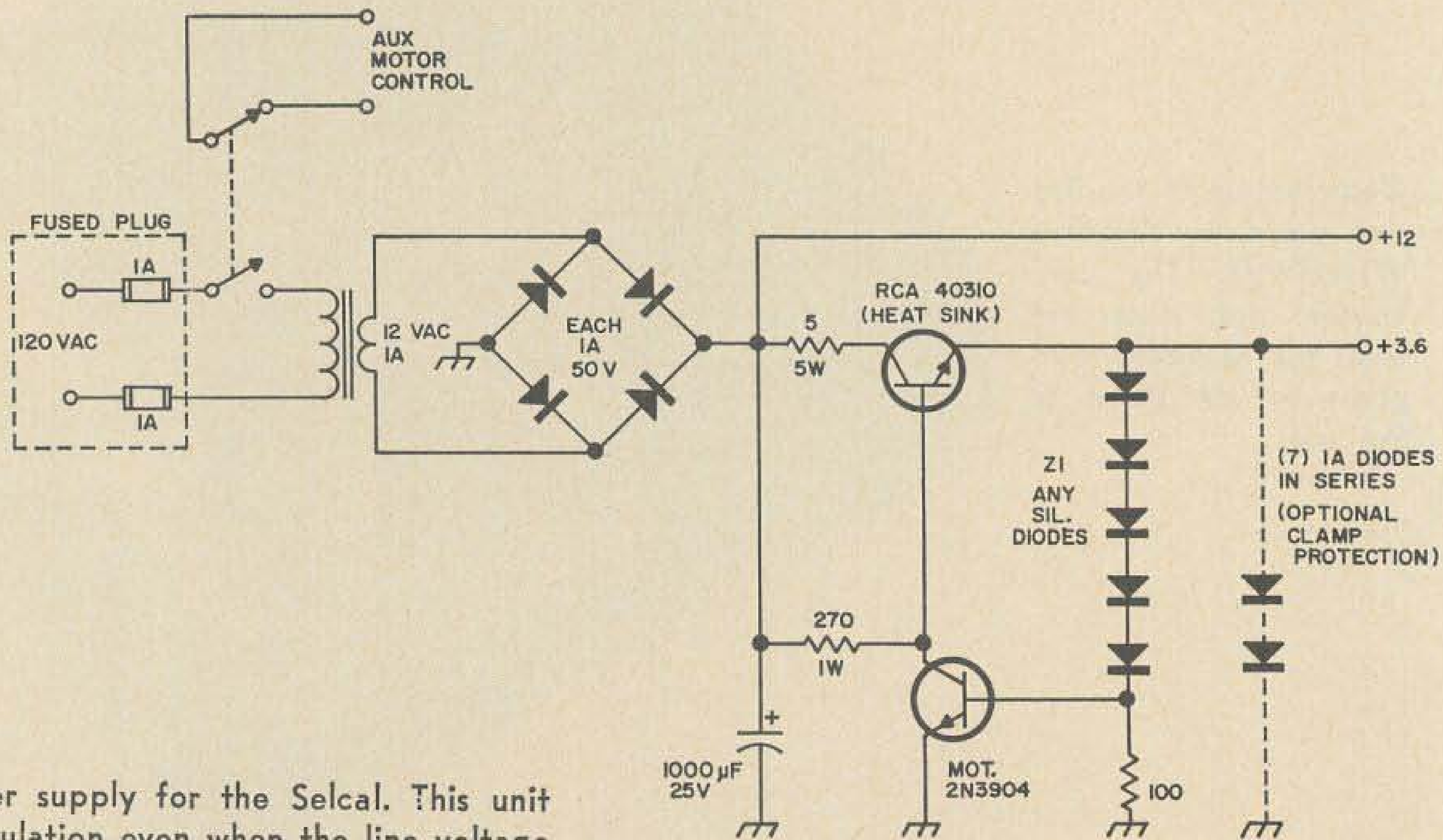


Fig. 11. The power supply for the Selcal. This unit provides good regulation even when the line voltage dips down to 90 volts.

as shown in the timing chart. Any logic block pin, except B+, may be connected to B+, or grounded, to force a circuit on or off, without harm to the logic.

Now check the shift register by sending a "letters" character. With a voltmeter see that all the SR-1 leads are low (less than 0.43 V), and that all the SR-0 leads are high (over 0.8V). Send an N and check for lows on SR3, 4-1, and on SR1,2,5-0. Any letter should leave its proper pattern in the shift register. If the higher number SR stages work, but the lower ones don't, check the wiring and logic at the point of signal loss.

Now send any letter not in your code set. A meter should show highs on all of the character FF (0) leads. Your first code character (Ltrs) should make CH1-0 go low. The second code character will reset CH1-(0) to high and make CH2-(0) low, etc.

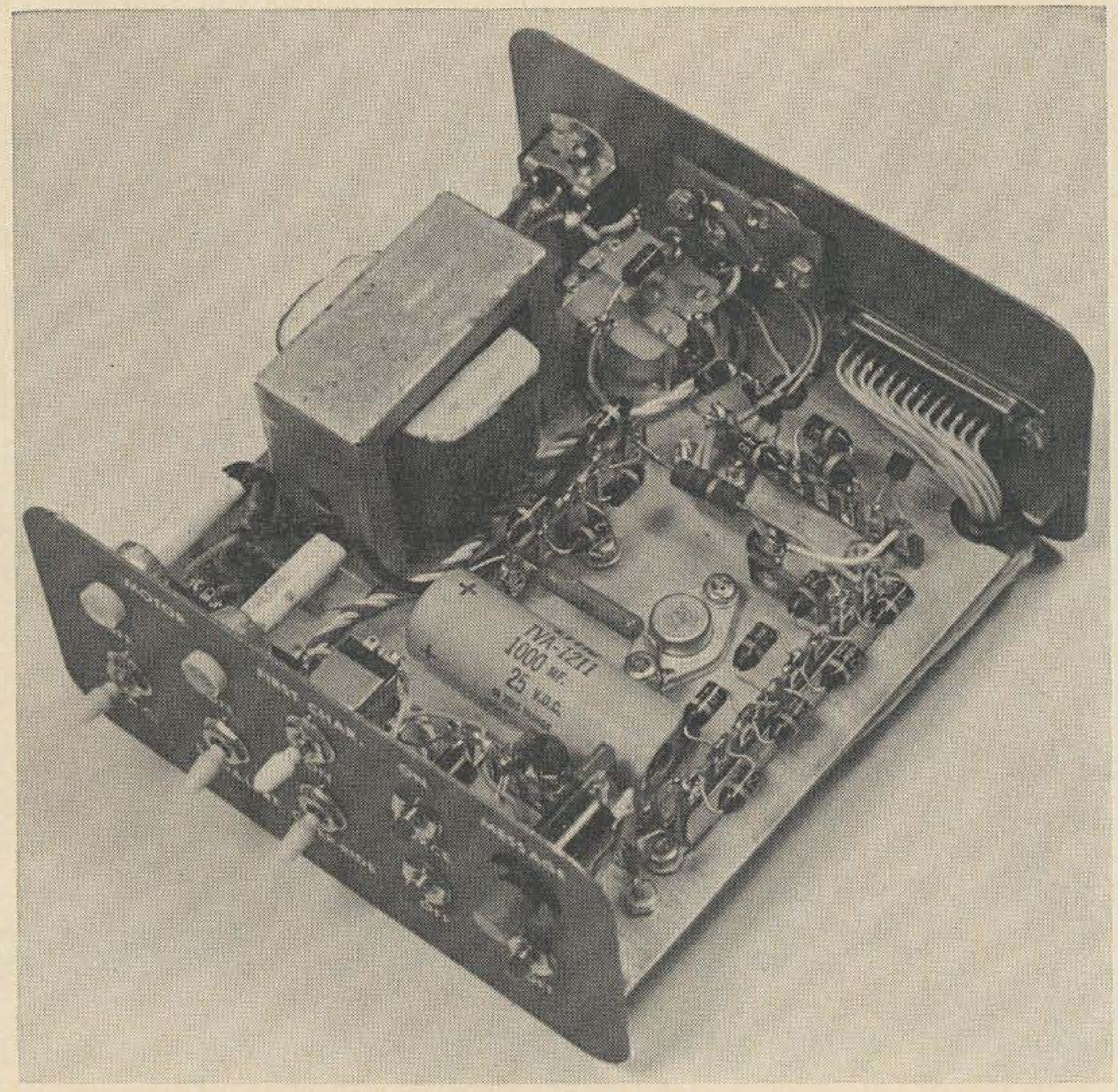
Check the 4N gate as follows. Send any letter other than "N". All four inputs to the 4N gate should be high. The first N will place a low only on 4N pin 14. The second N should make only 4N pin 2 low. The third N will make both pins 2-14 low. During the fourth N, only at the decode time, do pins 3-13 go low, but a scope is needed to see this. The 4N gate output briefly goes high, resetting the print FF and turning the relay off. With the exception of the 4N system, most of the Selcal functions hold their states after decode, so that a voltmeter is all that is needed for testing.

DECODE CHART					
SR	5	4	3	2	1
LTRS	1	1	1	1	1
C2					
C3					
C4					
N	0	1	1	0	0

Fig. 12. The decode chart which is used in setting up the Selcal for receiving your call letters. Its use is fully discussed in the text.

Use

In operation, the receiver, tuning unit, and Selcal are left running continuously, or connected to a time clock. The sender should transmit your call several times to insure reception and turn-on. After his call, it is helpful to include the time in GMT,



Top view of the *Selcal* built by W7AHW.

followed by an extra line feed to separate the messages. After sending the message, he should return the carriage to the left, and send 8-10 N's. If conditions are poor, send extra N's to insure turn-off, any not needed will not be copied. Automatic CR-LF systems are very convenient for any unattended autostart or Selcal operation.

While autostart is not useful for monitoring continuous commercial stations, the Selcal is, and can be used to select only those parts of interest to you. However, for 75 or 100 WPM monitoring, the Selcal clock must be changed.

The **RTTY Journal** of January 1967 has information on the Miami Weather Station, WBR-70, on 14.395 MHz. A few hours of copy may show some particular parts of interest. Set up the Selcal to decode the appropriate heading and you are in business. For example, the Weather Satellite predictions are preceeded by "TBUS". The 4N turn-off is sent regularly.

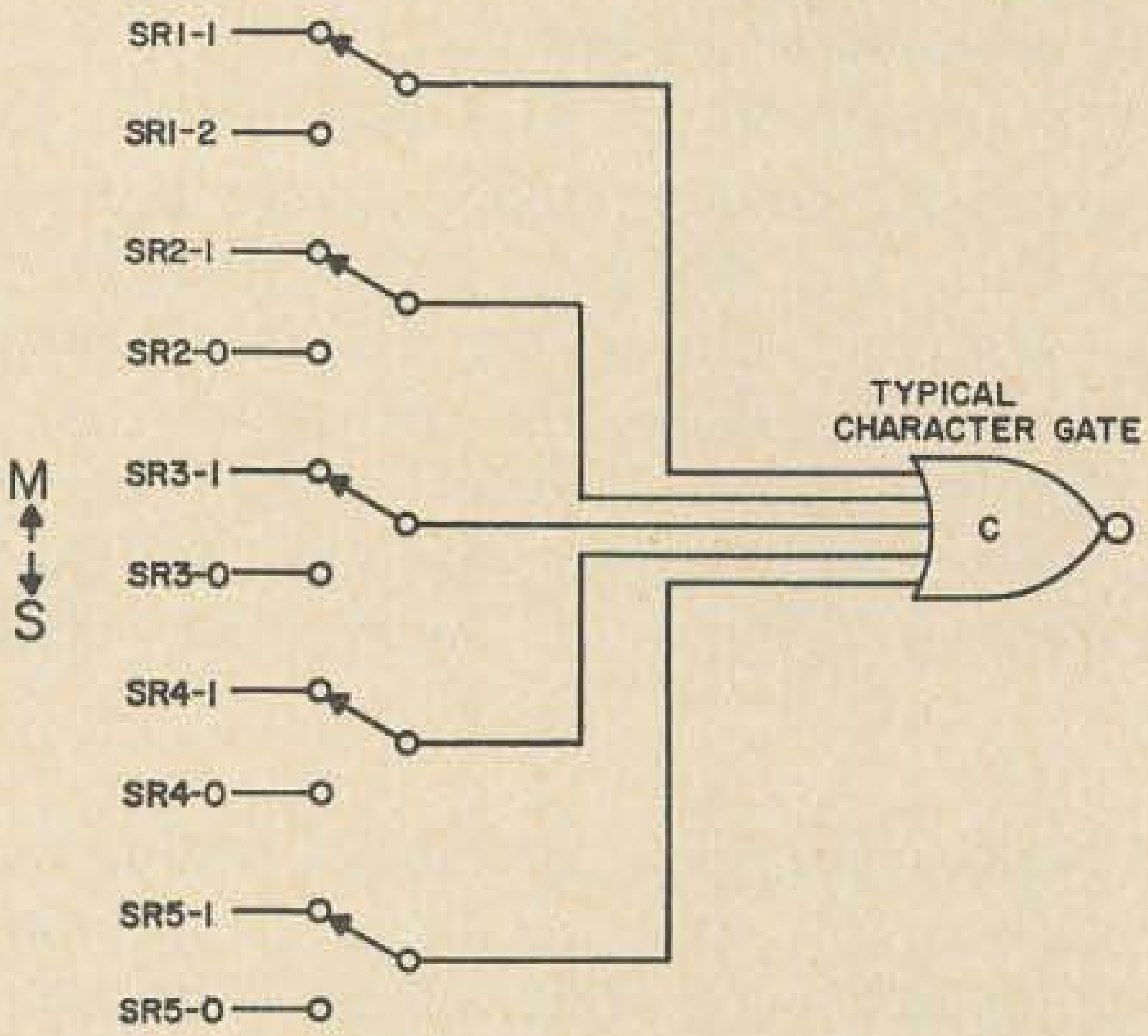


Fig. 13. By using slide switches in the input to the character gates, various turn-on codes may be used with the Selcal.

We would like to acknowledge the help of these RTTY'ers Harold Quinn, KØOJV for his circuit suggestions, his All-Call development and his circuit boards; Tru Boerkoel, K8JUG for parts list and kit he makes available on request;* and the many on the autostart net who patiently listened to the groaning birthpains of the Selcal.

. . . K8ERV, WA8PCK

*Technical Information Center, Motorola Semi-conductor Products, Inc., Box 955, Phoenix, Arizona 85001.

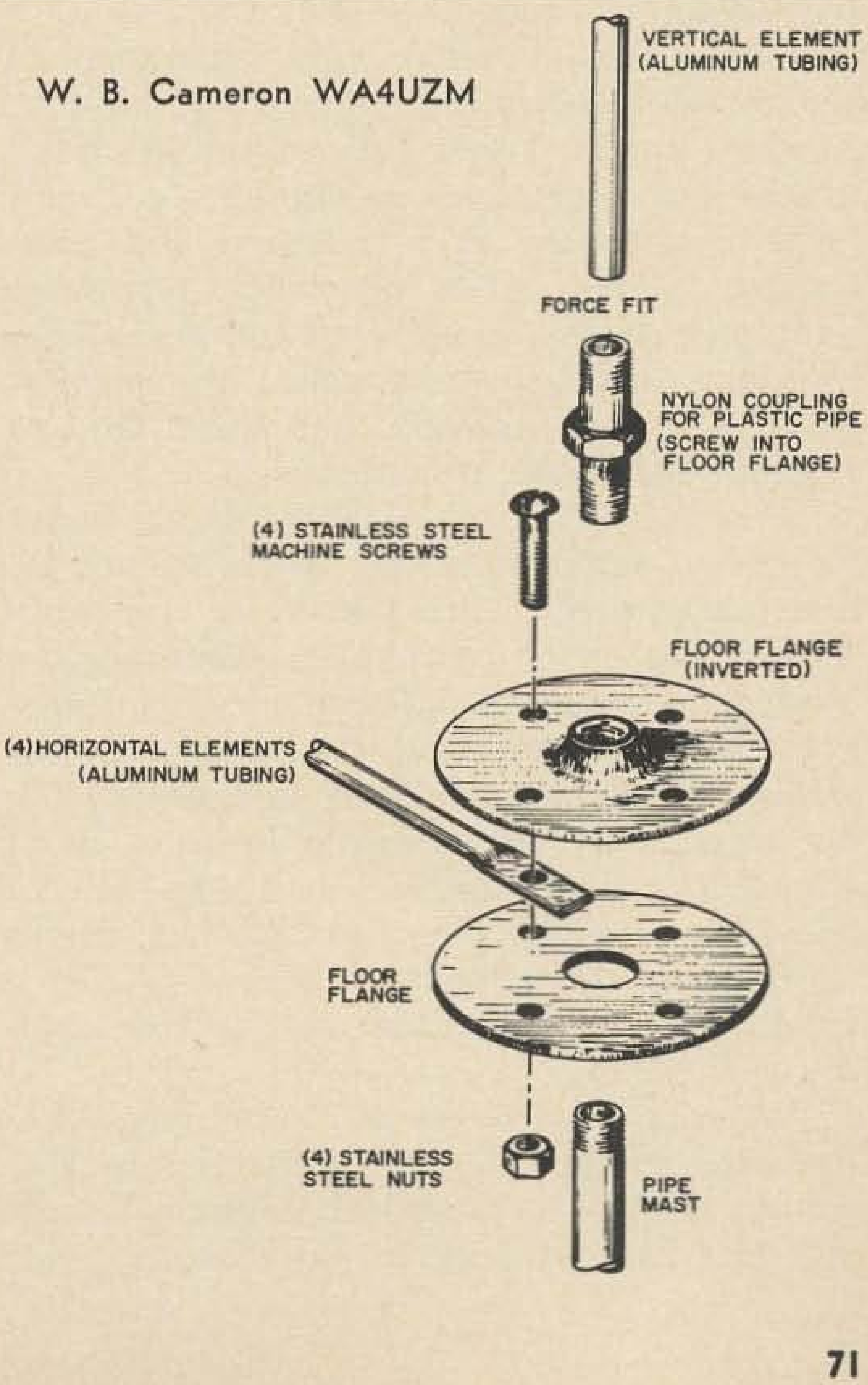
*Harold Quinn, 6605 Mardel Avenue, St. Louis, Missouri 63109.

*Tru Boerkoel, K8JUG, 195 Brandywyne Drive, Comstock Park, Michigan 49321.

Hardware Store Ground Plane Antenna

W. B. Cameron WA4UZM

One of the classic vertical antennas for VHF work is the ground plane, and one of the classic problems is how to assemble it mechanically. Lacking machine tools to make special parts, this can seem formidable, but the attached exploded drawing shows how to assemble a sturdy ground plane quickly from parts available in any well stocked hardware store. The size of pipe and fittings to be used is not critical, and can be determined by what is available. For a 50 MHz antenna a reasonable size is 3/4 inch pipe and the aluminum tubing of such diameter to make a firm drive fit into the nylon coupling. For a high wind area the pipe might be a 1 inch or one could use ½ inch to make a light portable job. In addition to quick assembly this construction permits quick disassembly merely by unscrewing the pipe mast and loosening the four bolts that hold the horizontal elements in place. For optimum match to a 52 ohm line the horizontal elements may be bent down about 30 degrees. This is best checked with a standard SWR bridge.



Ken Sessions K6MVH
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Ontario, California
91762

ARE PHONE PATCHES LEGAL?

Probably every amateur that has connected a phone patch to his radio system has experienced the fleeting and cursory twinges of guilt that accompany each soldered connection. Or the flash of anxiety each time he sees a telephone company truck parked near the QTH.

Are phone patches legal?

Many self-respecting commercial producers of amateur radio gear include complete packaged hybrid telephone patching units in their basic equipment lines. Following a logical line of reasoning, then, an amateur might well assume that phone patches are indeed legal. None can say that phone patches are unlawful, but they're not exactly legal, either. Not quite yet.

Indications are that they will be, however—and very soon.

Not too many amateur radio operators are familiar with the little-publicized prohibitory mandate called Tariff 132, and FCC edict which gives telephone companies a broad range of freedom in rate-setting and rule-making. Among other privileges, telephone companies have the right to establish price schedules and ban "telephone attachments" and "foreign equipment" that might tend to degrade telephone performance.

The truth is, there's nothing illegal about the phone patch, itself; it's the amateur's interconnection of it that causes all the problems. If the phone company would make the connection or give a blessing to the installation *before* it is done, all would be well. The manner in which the official government ruling is written and interpreted makes it an offense to attach *anything* to a telephone or telephone circuit. Thus, as the law stands today, a busy telephone user can't even legally connect a shoulder rest to the handset.

Just what constitutes an "attachment" has been the subject of many litigations in U.S. courts. Surprising though it might be, a device may be considered an "attachment" even when there is no direct connection to the telephone or line! A case in point is the Carterfone, manufactured by Carter Electronics Corporation in Dallas, Texas. The Carterfone, a cradle arrangement onto which an ordinary handset may be placed, couples the handset audio to a mobile radio system. The device makes no electrical connection to the phone and requires no handset modifications. Yet, in 1965, the FCC advised Carter that the Carterfone device violated the provisions of Tariff 132. An FCC examiner confirmed this finding later, and held that the device was an "attachment" within the meaning and intent of the original ruling.[1]

An interesting outcropping from the Carter Electronics case was a recommendation by the FCC examiner that the Carterfone be allowed *despite the ruling*. He said the tariff was an unwarranted restriction of a telephone user's right to use his phone "in a way that is privately beneficial without being publicly detrimental." This official assertion is extremely significant to amateurs with phone patches. Many of us have been thinking that the phone patches were frowned upon because of rate-jumping, a fallout of a telephone/radio marriage.

The Carter case served to bring general reappraisal of the tariff regulations by the FCC and the Justice Department. As a result, the Common Carrier Buerau of the FCC has recently recommended that Tariff 132 be rewritten to permit wider use of telephone attachments. The recommendation was seconded by the Justice Department. The consensus was that the tariff's restrictions tended to place the telephone companies in monopolistic positions with respect to the supply and installation of peripheral telephone-dependent equipment.

The telephone companies have been plagued with their share of "monopolistic practices" problems, anyway, and probably will not be able to prepare any overwhelming stumbling blocks to a new FCC ruling on attachements. Two large telephone companies were recently under heavy fire from the Private Communication Association for unfair restraint of trade. The PCA went so far as to accuse the two giants of acting in contempt of court by "flagrantly violating" provisions of an antitrust injunction filed by the U.S. Government in the U.S. District Court of New Jersey (Civil Action 17-29, 24 January 1956).[2] The PCA complained that the telephone companies were not restricting their business to "common carrier communications service" and were engaged in leasing of intercoms, alarms, public address equipment, and similar not-too-closely-related systems.

All these events weigh heavily in favor of the FCC reversing the "no attachments" mandate, because a more liberal ruling would invite open competition from manufacturers of terminal phone devices. The way things are now, not even the phone companies can legally connect most equipment, since this takes them out of the realm of direct "common carrier communications."

So how does all this affect the amateur with his harmless little phone patch? Very profoundly! Already the restrictions on phone patches are relaxing. Telephone companies acknowledge the fact that amateurs are attaching audio patching circuits, and they are beginning to realize that these devices pose no major threat to their overall income.

One Southern California amateur (Donald Milbury, W6YAN) has been operating a fully automatic phone patch from his mobile station in conjunction with a radio repeater for years in the Los Angeles area under the cognizance of Pacific Telephone Company. He received "implied" permission, he says, when he was requested by that company to use a particular tone frequency for telephone control to avoid the possibility of interference with other telephone circuits.

An automatic phone patch is a standard telephone system (consisting of dialing and answering capability) operated from a remote location, such as in a car or from a portable transceiver. It should be noted that automatic phone patches are compatible only with FM. Levels for automatic patching must be set for 0 dB (1 mW into a 600 ohm line), and maintained within 1.0 dB of this value regardless of transmitting and receiving conditions. A standard as rigid as this is a little too much for AM. Telephone companies *do* get upset when audio is patched into a line at a high enough level to intermodulate with adjacent wire-pair signals. Use of FM assures a relatively constant audio level at the receiver almost without regard to the strength of the received signal.

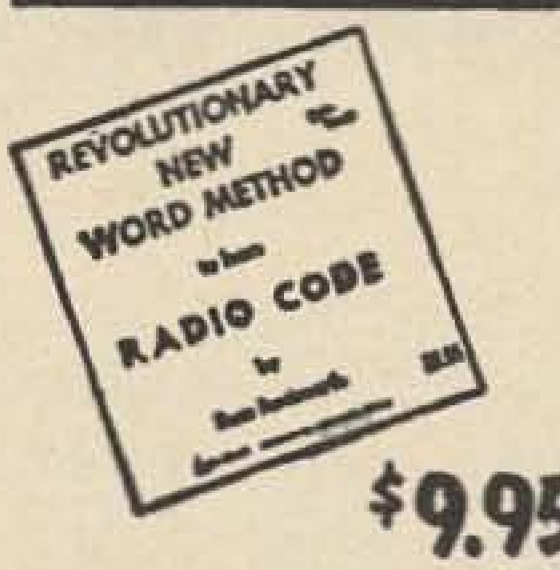
My own remotely controlled telephone system was given FCC sanction—also by implication—when it was licensed after a detailed description of the automatic phone patch was submitted with the official application.

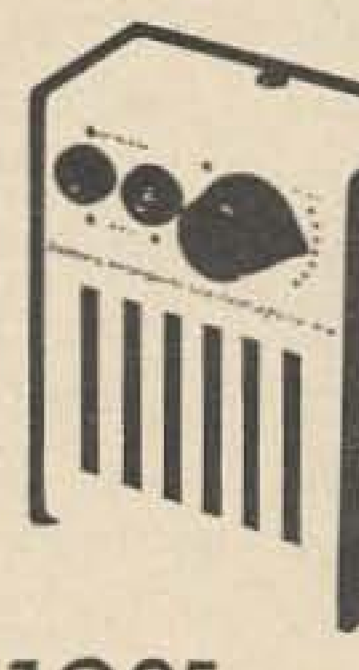
Today, the amateur who connects his phone patch runs the risk of a hand-slapping from his local phone company. It's highly unlikely he'll get its blessing tomorrow. But if the FCC recommendations are followed, the amateur would have the right to connect a phone patch or any other similar device as long as it proved nondetrimental to the phone's principal function; and the phone companies would be saddled with the task of "showing cause" for denial of this right.

. . . K6MVH

1. Staff Article, "FCC Weighs Wider Use of Telephone Attachments," Electronic Design, 8 November 1967.

2. Staff Column, "Hot Line," Communications News, December 1967.





Amateur Radio and Public Service

During my recent visit to the Sahara Amateur Radio Operators Convention in Las Vegas two aspects of amateur radio public service were brought to mind. One of the exhibitors was a local ham club who had as a part of their display a sign obviously intended to be displayed along the highway approaching the area in which the club operates. This sign listed frequencies that are monitored by members of the group which travelling hams may use to contact someone for assistance. This is not a new idea by any means, but it is one which I feel deserves more wide-spread usage and publicity. I know there are many areas of the country in which local hams do monitor one or more frequencies for just such a purpose. It seems to me that wherever this is done it would be to the benefit of all hams to have these signs conspicuously posted on the main highways. As a further aid, I can visualize a national directory, arranged geographically, listing frequencies monitored; the purpose for this monitoring; and by whom the monitoring is done. As I visualize it, this directory would be similar in format to the ARRL Net Directory, but I think, at least in the beginning, there would not be a need for cross referencing, but merely the geographical listing. As an attempt to get this program going, I am offering through this editorial and similar information to be sent to the editors of the various amateur radio magazines to compile this information as my time and the facilities available to me permit. When the directory is ready, it will then be made available to anyone interested. I would hope that in time the preparation of this directory could be done under the auspices of an amateur radio club. I would expect that there will be a small charge for those who desire a copy, but this charge in turn should not be higher than necessary to cover the costs of publication. In any event, I will be appealing in the near future through various publications and perhaps by direct letter to some clubs, for information to be included in this directory. My only hope is that others will find this information to be of value and will see fit to co-operate with me in this venture.

A similar situation, in that it also involves public service, was also brought to mind at SAROC. No doubt those of you who read the ham magazines regularly are familiar with WCARS or the West Coast Amateur Radio Service. This is a group of several hundred amateurs, as I understand it, in the western states who monitor the frequency 7255 kHz, essentially during the daylight hours every day. They have a roll call at noon, so that the members have a chance to get together. However, the important part of their work is that by monitoring this frequency continually, they have been able to assist in any number of emergency situations which have come up. It seems to me that a similar arrangement could be extremely beneficial in other parts of the country and, again, I am going to put myself on the line as a guinea pig to see what can be developed. I feel that an East Coast Amateur Radio Service such as I have described could probably operate on the same frequency as this frequency should give reasonably good coverage up and down the eastern part of the nation while at the same time be far enough removed to avoid mutual interference with the West Coast Amateur Radio Service. If one or more services such as this were to be set up in the central part of the country, it is my feeling that perhaps a different frequency should be chosen. However, I can not do all things in all places and would hope that someone else will pick up the ball in other areas of the country. For my part, however, starting on or about February 1st, I will try to monitor the frequency of 7255 kHz at least during normal working hours and will try to institute a roll call at least once during that time.

As I was told at SAROC, one man started the West Coast version just by getting on the air everyday and having a call-up. If it can be done in the West, why not in the East as well? Those of you who are interested in this project, look for WB2QGK on 7255 at noon everyday. If I am not at work, look for me under my home call, W2CFP, at the same time. I expect to talk personally to other amateurs in this area in the hope that they will be able to assist me in this project and I hope further that by spreading the word on the air and through publications that in the not too distant future an East Coast Amateur Radio Service will be developed that will be able to do the same good and public service that is now being done in the western part of our country.

If you are interested in working with me on either or both of the above projects, please don't hesitate to contact me either on the air, by mail, or by phone. If you know of anyone currently undertaking either of these projects, please let me know, as I have no desire to step on anyone's toes. I just want to get the job done. It is important to remember that public service is one of the basic principles of ham radio and in this day of diminishing ham population and increasing danger of losing some of our frequencies, it certainly behooves all of us who are hams to participate in whatever we can.

. . . David G. Flinn W2CFP

Excerpted from Comtact
Volume III Number 4

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Microfilm Your Magazine

There have been a couple of good articles in 73 about what to do to reduce the huge pile of magazines you have on hand and to increase your chances of finding a particular article you want.[1]

But even with these fine ideas I still find myself having to look through most of the magazines to find the article I want. The annual indexes help, but even with those I still have to search a lot.

Another problem I have encountered is magazine portability. I am in the Army and move around quite a bit, four times in a year and a half. I use my magazines and other books a lot and I need them with me. I needed a way to have the information without the pounds.

I have reduced my electronics library from many pounds to a few ounces by using microfilm techniques from the TV spy shows. I get two pages of information per frame of 35mm film. Thus, a total of 72 pages of information on a 36 exposure roll of film is possible. The weight is about an ounce including the film storage can.

There are many approaches to filming your articles. The first approach is to film the individual 73's or other electronics magazines. This gets you away from the poundage but you still have the "Article, article, where's the article?" question.

I have been categorizing my articles. This method is time consuming but very rewarding in the end. It's nice to pick up a small can labled "Microfilm Vol. 1, *Coaxial Cable Handbook*, Parts 1, 2, and 3,"[2] and not have to go to three different issues to get the information. I have given a partial list of my favorite categories in Table 1.

The third idea is the least expensive and the least time consuming. You can film only the annual indexes and the indexes of the magazines of the current year. This may, as all the other methods, be kept up to date from time to time by splicing your new filmstrips to the one already started. You then have the "Where to find it" information at your fingertips. It will save you time and frustration. It is much easier to look at a short filmstrip than to go through several back issues.

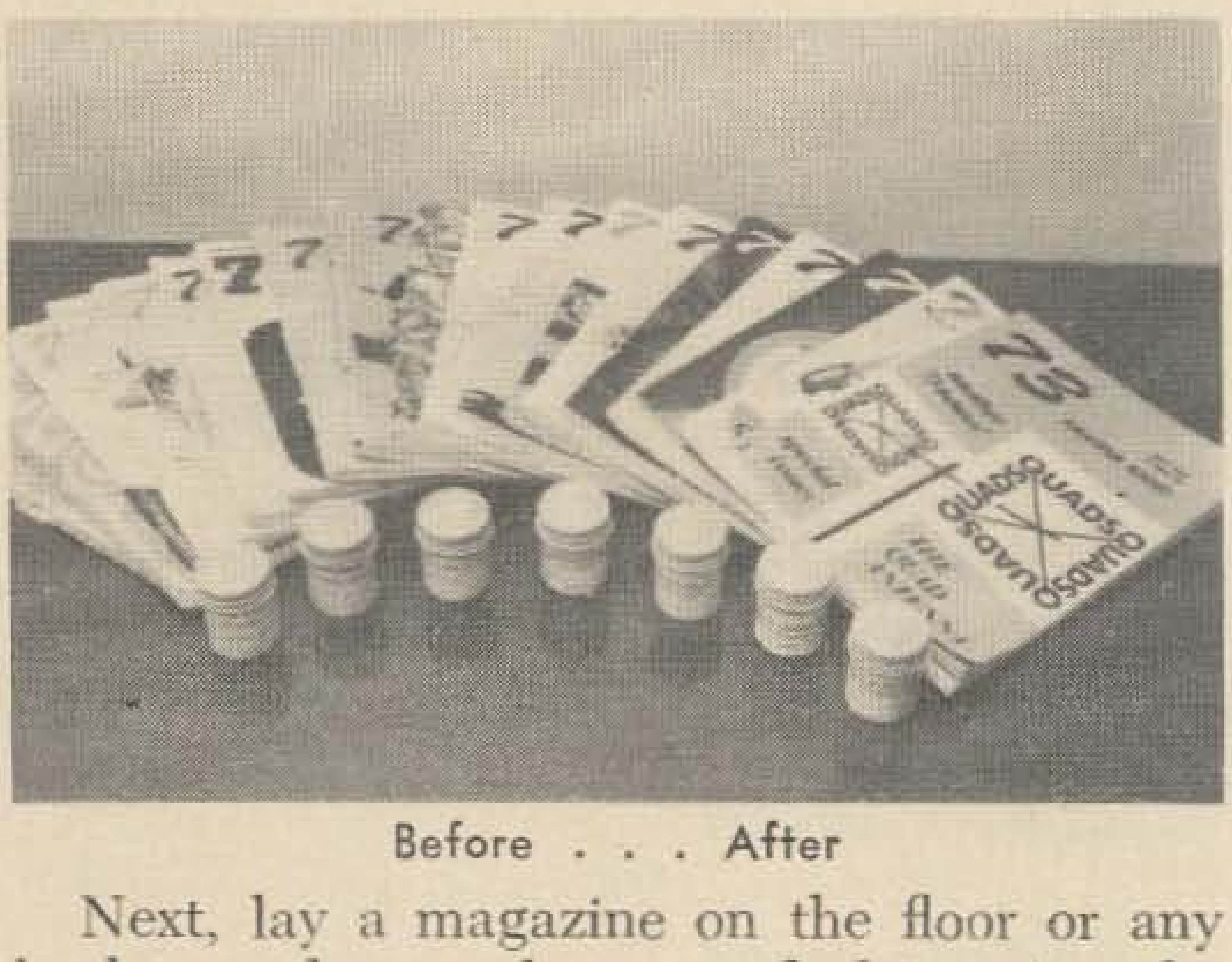
Techniques

If you have chosen any of my ideas or have thought of one better, let's begin.

The first thing you need of course is a camera. Both 35mm and 16mm cameras are classed as microfilm cameras. I use a 35mm camera and get very good results.

You will need a place to work which is well lighted such as a room with a high wattage ceiling light. I use no direct light or flash on the material because the glare from the glossy pages will over expose the film. Believe me, a light meter is of no use.

I use a camera setting of 1/8 second and f stop (lens opening) 8. You will probably have to use about a half roll of film and experiment to find the correct settings for your particular camera and favorite type of film. Use only black and white film and be sure to keep a log of your shots for comparison with the negatives after developing.



Before . . . After

Next, lay a magazine on the floor or any background you choose and determine the closest distance you can get and still be in perfect focus. I can get only about 2.75 feet without a close-up lens. This is adequate for most of your work, but a close-up lens will give you more detail with less magnification of the finished shot. If you don't have one I suggest the method used by K6UGT,[3] or if you prefer, you may order a 13 inch close-up lens from Edmund Scientific Co. for $1.10.

You will need a way to keep your material flat while photographing it or part of it may be blurred.

A tripod is very helpful in keeping a fixed focus and holding the camera steady. But it is not really necessary unless you have several articles to do at one time.

If you have a pile of magazines to photograph at one time, you will save yourself a lot of time by having all the magazines open to the articles you want to photograph before you begin.

After you have taken a roll of film you may do one of two things. You may take it to the local drug store to have it developed or you may do it yourself with a Kodak home developing kit. I prefer the do-it-yourself way. In either case you only want the negatives, no prints, and you want them in a strip, uncut. If you have microfilmed only the indexes as in the third method I described, you may want to mount the negatives in slide mounts to view with a slide projector. You can buy the mounts in a camera shop and mount them yourself. If you have several articles on film, as I do, it is best to keep them in filmstrip form for convenient filing and ease on viewing. You can get a film-strip projector fairly cheap if you shop around. As for the screen it can be anything from a white bedsheet (beware of your XYL) to a home brew microfilm reader.

Don't limit yourself to magazines. After you finish a logbook you can film it for future reference and not have to worry about sorting it. You could also microfilm your "Idea File" ("Card-boarding," Edward Burke, W6FTA, 73, April, 1967). The possibilities are only limited by your imagination.

Besides the advantages described earlier, you will find that the film will last much longer than the paper magazines. The fire hazards in your shack will be greatly reduced by using film stored in metal cans instead of bookcases full of inflammable magazines.

After you microfilm your magazines don't go in a mad rush to a trash can with them.

Table I

Volume I
Coaxial Cable Handbook, Parts I, 2, and 3

Volume II
Integrated Circuits

Volume III
432 Mhz Equipment

Volume IV
144 Mhz Equipment

Volume V
50 Mhz Equipment

Volume VI
VHF Test Equipment

Volume VII
UHF Equipment

Volume VIII
Test Equipment (General)

Volume IX
Transistor Equipment Design

Volume X
Antennas and Antenna Design

Bind them in the binders available from 73 and store them in a safe, dry place. If you travel around as I do, store them in your in-law's garage until you settle down again. If you are real good hearted, you can donate them to your local ham club so that the newer hams can benefit from them.

I am very much pleased with my microfilm library and I'm sure you will be just as pleased with yours.

. . . WA4HRX

Footnotes

1. "Make The Most Of Magazines," Jim Kirk, W6DEG, *73*, Dec., '66. "Dealing With The Information Explosion," James Ashe, W2DXH, *73*, May, '66

2. "Scope Pix Trix," Fred Blechman, K6UGT, *73*, March, '65

3. "Coaxial Cable Handbook," Jim Fisk, WA6BSO, *73*, July, Aug., Sept., '66

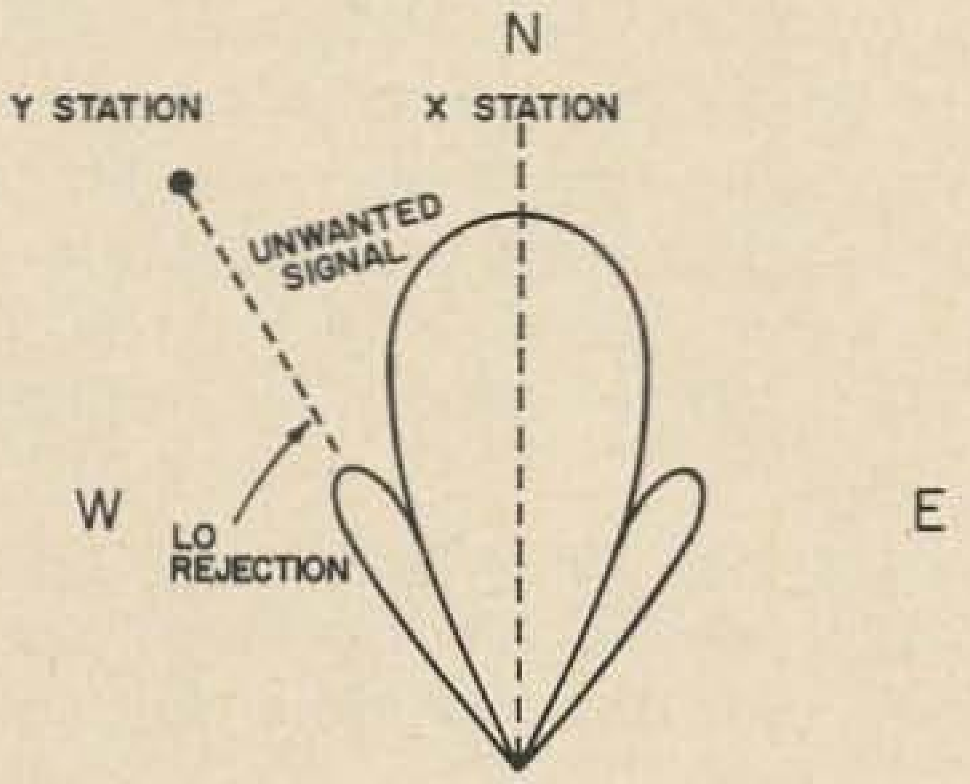
Breaking the 100,000 MHz Record

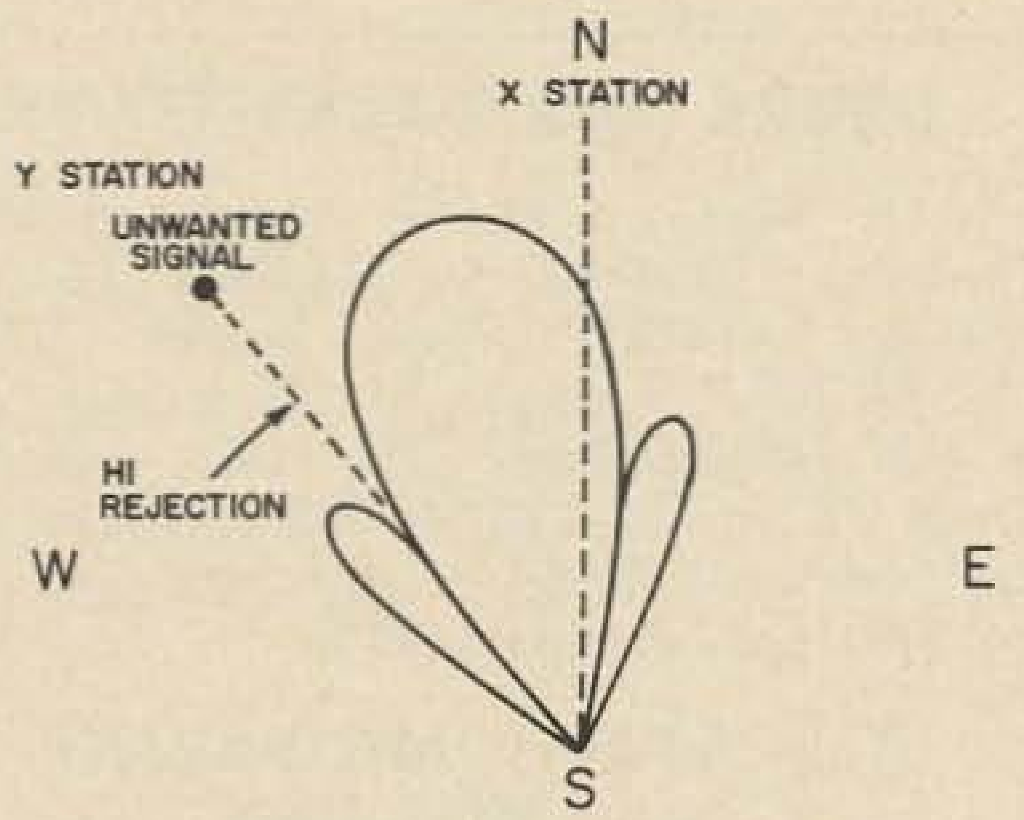
Detriments Can Be Beneficial

I think it was Will Rogers who said, "I can see some good in everybody."

If you will study the two figures in this article, you will see that deep lobes which generally appear on beams with high gain, can be used to an advantage. In **Fig. 1**, we are beaming a powerful signal at station X, but when we change to receive, we are getting a large amount of signal from station Y which makes receiving a bit difficult.

All we do to virtually eliminate signal Y is to turn the beam a bit to the west until that signal is in direct line with the null formed by the side lobe that is not being used. It will be noted that the signal to station X may be *slightly* attenuated, but the fact that we have, to all intents and purposes, eliminated signal Y by placing it in the null, we have actually gained more than we have lost.





This will be of the maximum good if station Y is near and very strong, and station X is weaker and further away. You are actually making the null in the beam act much like a notch filter in a communications receiver. The null is very pronounced and you can get an immense amount of rejection through this method. More important, is the fact that it doesn't cost a dime. That's pretty nice in this day and age—something for almost nothing.

. . . Bill Roberts W9HOV

Full Break-in for the Galaxy III or V

C. A. Bierbaum, WØJHD
2728 Avenue G
Council Bluffs, Iowa 51501

Since I like CW and also like to operate without having to move anything but the key; I was forced to find some way to use my Galaxy III on CW break-in.

This system has been in use for one and one-half years now and is working for me and several other people who have tried it with the Galaxy III and Galaxy V. No VOX is required as the VOX is inoperative in the CW position of the Galaxy.

No damage is done to the transceiver and the modification could be accomplished is as little as ten minutes.

On the front wafer (panel wafer) of the function switch near the top, you will find the lead coming from the push-to-talk line. Two contacts are jumpered here with the lead coming from the push-to-talk line being hooked to the contact used in the tune position. The function switch is used to ground one side of the relay in the Tune and CW positions via these contacts. If you will simply cut this jumper; the jumper can be re-soldered if original operation is desired.

When this jumper is cut; the unit will function normally except in the CW position. In the CW position all of the normal changes (including carrier shift) will be made; except that the transceiver is receiving not transmitting.

Make a jumper so that the external relay contacts can be used to complete the keying circuit.

Now with the function switch in CW; key the push-to-talk line for full break-in operation. If operation is desired or necessary where you will be zero beat with your contact, an external or Remote VFO will be necessary. The carrier is no longer shifted in relation to the receiver when you transmit. Normally this is no handicap as the difference is the audio pitch or frequency of the received CW note, which is a kHz or less.

This system is simple and works well without disturbing other functions of this fine transceiver. No abnormal wear of the relay or associated parts have been noticed after one and one half years of operation. Keying is good with no noticeable ill effects on the note. Speed is going on the relay with about fifty words per minute being about tops.

One clip (of the dikes), one jumper (via connectors on the back panel), no holes or damage, and a good time is had by all;

. . . WØJHD

RENEWAL CODE

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

Getting Your Higher Class License

Part II — SSB

Last time around, this study corner for the new Advanced Class examinations went into radio waves and propagation. The subject this month appears to be far different—single sideband—but the two are more closely allied than you might think.

The study-list questions dealing with SSB which we're going to examine in this installment are:

3. What methods are most commonly used to generate single sideband signals? Draw a block diagram of the filter method showing all essential stages. How can a low frequency SSB signal be converted to the desired transmitting frequency?
7. What types of emissions can be received with selectable sideband receivers?
8. The ratio of the peak envelope power to the average power in a SSB signal is primarily dependent on what?
25. How can SSB signals be amplified with little or no distortion?
44. How does the peak envelope power input of an amplifier used for CW compare to the PEP of an SSB amplifier when using the maximum legal dc power?

Just as we did before, let's re-phrase those five specific questions into five more general questions which will include the original ones as well as most of the possible variations.

Perhaps a bit obvious, but still the best starting place, is the question "What are sidebands?" Next in line comes the more specific one which will fence in our subject matter: "What is meant by 'single sideband' signals?"

Once we are reasonably sure we understand what a SSB signal is, we're ready to ask "How are SSB signals generated?" By this time we will have definite answers for questions 3, 8, and 44. Two more questions —"How is SSB transmitted?" and "How is SSB received?"—will wrap the subject up neatly.

At the beginning it must be emphasized that the discussion here is not intended to be exhaustive in detail; many times the available space would be required for that. It will, however, more than suffice for the examinations—and, if you're interested, will set you off on the track of those not-yet-fully-answered exhaustive questions.

What Are Sidebands? Before we can begin to answer this question, we must define several other terms—such as "audio". Anything our ears can perceive comes to us as sound waves in air at audio frequency. These sound (pressure) waves correspond to electrical waveforms of the same relative intensities and absolute frequencies. An electrical sine-wave applied to a loudspeaker produces a "pure" audio tone.

Most sounds are not sine waves of air pressure, and so their corresponding electrical waveforms are not sine waves either. A somewhat advanced mathematical theory says, however, that any waveform which is *not* a sine wave can be proved to be identical with one composed of many different sine waves. Because of this, and the fact that it's not hard to deal with sine waves mathematically but next to impossible to deal with any other representation of the waveforms of sound, communications engineers for several generations have spoken of sound in terms of the *band* of sine waves represented in the Fourier equivalent of the actual sound waveform.

The audio-frequency band, for most adults, ranges from a low end between 15 and 50 Hz to a high end between 10 and 20 kHz. Most of the actual sound energy is concentrated in the frequencies below 1 kHz. More than 20 years ago, researchers in acoustics discovered that speech could be transmitted accurately within a band ranging from 300 to 3000 Hz; this is now considered the "normal" speech bandwidth.

Radiotelephone transmissions of any type, however, do not try to transmit these audio-frequency waveforms directly. While such waves *can* be propagated with huge antennas

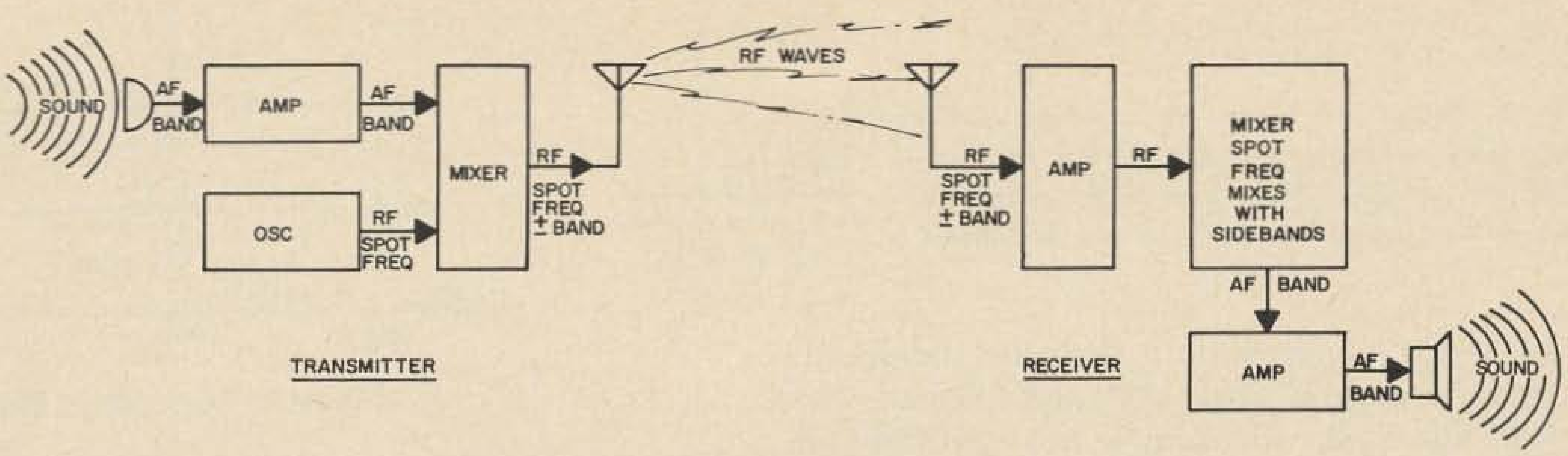


Fig. 1. This simplified diagram shows how sound waves at the transmitter are converted to an audio-frequency band, then mixed with an rf spot frequency for transmission and radiated. At the receiver, the process is reversed, resulting in new sound waves which are essentially duplicates of the originals. Same process applies to all radiotelephone transmission; details of the mixing vary from technique to technique. SSB, for instance, eliminates 75% of the transmitted material but holds all information content.

and megawatts of power, the process is neither efficient nor practical. All phone operation is accomplished by translating the audio band up to the desired spot in the rf spectrum for transmission, and bringing it back down to audio frequencies for the benefit of the receiving operator. This is accomplished by the "mixing" process which is also the heart of a superhet receiver.

What is "mixing"? When two electrical waveforms of different frequency are applied to any circuit which is not completely free of distortion, more than two waveforms come out. Among the "new" waveforms which emerge is one which represents the *sum* of the original frequencies, and another which represents their *difference*. A good mixer will have no other outputs, a poor one, or a circuit in which mixing is only incidental, will have many others, including harmonics of each of the original signals and of each of the outputs, as well as the sum and difference products between each pair of outputs taken separately. If you imagine this as being quite a mess, you are absolutely correct.

If one of the original waveforms was in the rf region and the other was a pure sine wave of audio, the "sum" will be a new radio frequency above the original rf by the frequency of the original audio, and the "difference" will be a second new radio frequency which is below the original rf by the same amount. These are known as "side frequencies" since they are alongside the original rf in the spectrum.

If the audio input to the mixer, however, was a "band" type of signal rather than a sine wave, then the "sum" and "difference" frequencies will also occupy bands alongside the original rf, rather than spot frequency positions. These are "sidebands", and every radiotelephone signal must be involved with them, since they and they alone carry the audio information to the receiver. Even FM has its sidebands, surprising as that may sound.

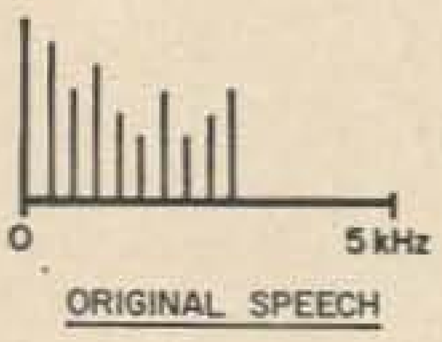
At the receiver, the two sidebands and the original rf "carrier" are applied to a detector circuit, which is simply another type of mixer. The rf sidebands and the rf carrier again undergo a mixing process; the "difference" in this case is a reproduction of the original audio waveform.

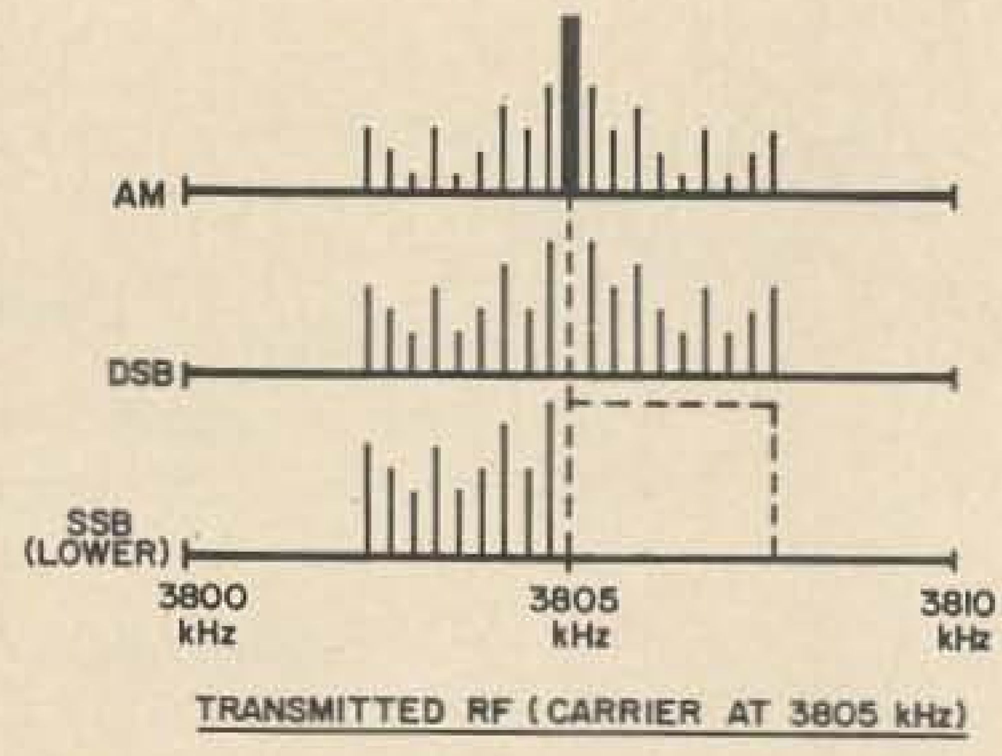
Fig. 1 shows the process; it is the same for BCB disc jockeys, military communications, FM, AM, DX, or local work. In every case, the audio put into the transmitter is converted into rf sideband energy, the rf sideband transmitted to the receiver, the received sideband converted back to an audio-frequency waveform, and the waveform finally converted back into sound.

What Is Meant By "Single Sideband" Signals? More than 40 years ago, an ingenious engineer with A.T.&T. noticed that the mathematical expressions which indicated that sidebands existed also showed that the *two* sidebands which accompany every "normal" phone signal were identical in every respect but one—their frequency and phase relationship to the original "carrier" signal—and that this one was a simple mirror-image relationship.

From this, he reasoned that it was a sheer waste of power to generate and transmit both the carrier and one of the sidebands. A single sideband, alone, would convey all the audio. It was an ambitious theory—but when it worked as expected, in 1927, it

Fig. 2. Spectrum views of original audio band and resulting transmitted RF for normal AM (top), DSB, and SSB, assuming carrier frequency of 3805 kc for all three.





proved for the first time that the sidebands actually existed, and also established the single-sideband technique for radiophone communications.

For the first 20 years or so, single sideband was exclusively a commercial technique. Getting rid of the carrier and especially of the unwanted sideband was a tricky operation; more equipment was necessary than most hams could afford in those days. The only reason the original experiment could succeed was the very low transmitting frequency used (below 50 kHz), at which antenna resonance alone provided a sufficiently sharp filter to reject the unwanted sideband and prevent its radiation.

However by 1948 the time was ripe, and O. G. Villard (with others) put W6YT, the Stamford University club station, on the air with SSB. Within a few weeks, the new technique had caught on nationwide. The '50s saw the battle of the sidebands spread across the HF bands, and by the early years of this decade SSB was even a standard operating procedure on VHF and UHF bands.

The characteristic of an SSB signal, tuned in on an ordinary receiver, is a "Donald Duck" or monkey-chatter sound. This results from the total lack of a "carrier" signal against which to mix the sideband. Instead, the sideband mixes with its own strongest components, or with any nearby carrier that happens to lie in the AF region around the sideband itself.

When a locally-supplied "carrier" from the receiver's BFO is provided, however, and the receiver is carefully tuned, there is the original audio. If you don't like the tone of the other guy's voice, you can move the tuning just a trifle and shift his voice an octave or more.

Figs. 2 & 3 shows the spectrum representation of the original audio signal (speech), this same audio translated to rf by normal AM, as a SSB signal (with the missing carrier and sideband dotted), and as recovered in the receiver. Both perfect tuning and mistuning of the receiver are shown in **Fig. 3**, to illustrate how receiver tuning affects the pitch of the received signal.

The important thing to remember about a SSB signal is that it *is* the audio signal itself, translated directly into the rf spectrum. Conventional AM phone, on the other hand, is a "coding" of the audio into rf. The SSB signal cannot be permitted to suffer distor-

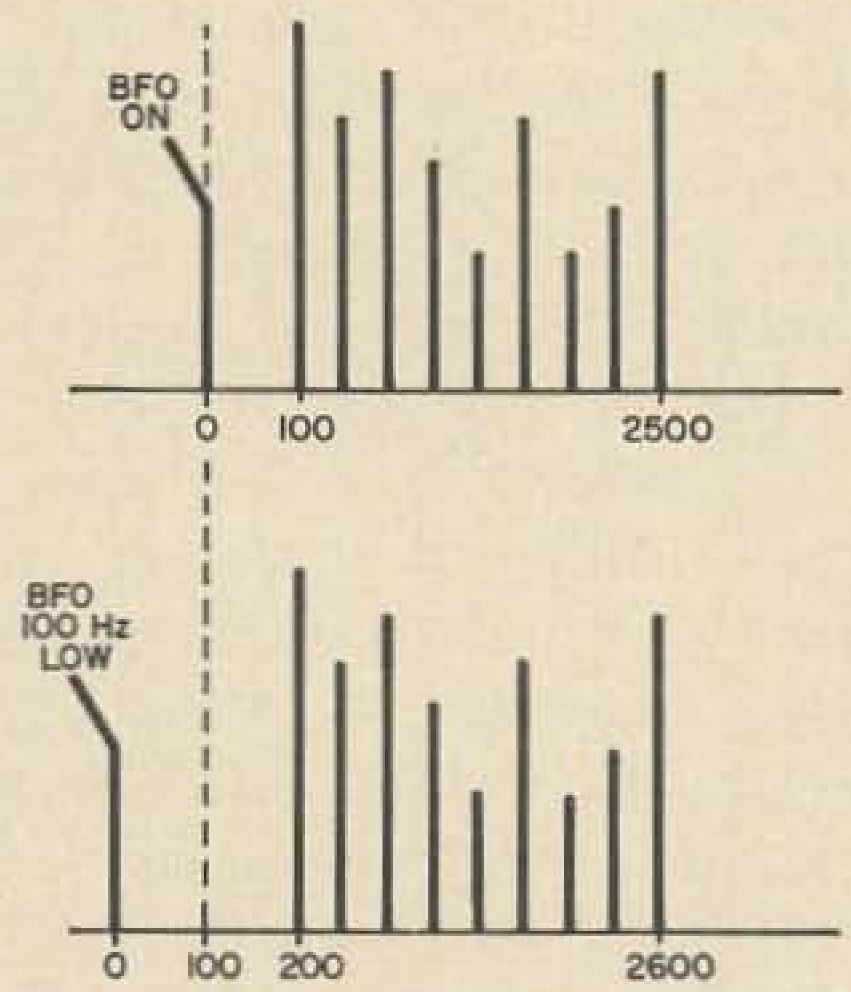


Fig. 3. Effect of receiver mistuning on SSB signal is to shift pitch of all parts of signal. 100-cycle tuning error, bottom, makes all parts of signal 100 cps too high. This is small error for high-frequency portions, but is 100-percent error for lows. Result is almost unintelligible signal. With DSB, result is worse—some of wrong sideband gets into output.

tion at any stage after it is generated, or the individual frequencies within the band will mix with each other to create sum and difference products which were not originally present. These sum and difference products not only cause annoying and illegal interference to other operators (who know it as "buckshot") but can themselves mix with each other to introduce additional distortion back into the original signal.

The single sideband signal must be protected against distortion from the time it is originally generated until it is once again returned to the audio range; this requires not only carefully operated linear amplifiers in the transmitter, but specially designed detector circuits—product detectors—in the receivers. Development of such circuits is one factor in the rapid rise to prominence of SSB.

In all of this discussion, the emphasis has been on the direct electrical differences which mark a SSB signal. Were these the only differences, hardly anyone would be willing to use SSB. These direct electrical differences, however, produce some startling operational differences which make SSB appear almost 10 times more powerful under difficult operating conditions than ordinary phone at its best.

One of the differences is the fact that since only one sideband is transmitted, only half the spectrum is necessary. This tends to reduce interference between competing signals, and permits use of extremely selective receiving techniques which also combat interference. A second difference also due to the presence of only one sideband is the fact that *all* the legal power is carrying voice; in conventional AM, only half the legal power is carrying voice—and that half is split between two essentially identical signals. In other words, a SSB transmitter can put out around 700 watts of talkpower on the average. While an AM rig can produce only an effective 175 watts or so. All the rest of the power in the AM signal is either furnishing carrier or duplicating this 175 watts of effective voice power.

Probably the greatest advantages offered by SSB, though, is its elimination of the steady carrier signal. This signal, in AM operation, is essentially the same strength as would be produced by the same transmitter operating CW with the key held down. It has approximately 4 times the power of the accompanying voice sidebands. Two AM stations of approximately equal strength, operating 2 to 3 kHz apart, will drown each other out with a beat note equal in frequency to their frequency separation. Two SSB signals of equal strength at the same spacing cause little interference to each other; an operator listening to one will hear the other only as superimposed "monkey chatter" on top of an intelligible signal.

Elimination of the carrier and concentration of all the power into the single sideband offers a few more bonuses, and these are important from a legal (licensing) standpoint as well as for general operation. The exact power of a SSB signal at any instant is determined by the voice waveform which it is carrying, since the signal *is* the voice waveform translated up into rf. Our voices range from no sound at all, during pauses between words, up to rather explosively intense sounds as those which form the words "boy" or "plow". The power level of the SSB signal at its most intense or "peak" value is known as the "peak envelope power".

You cannot read the peak envelope power of an SSB signal from any meter, since the meters respond far too slowly. If you monitor power output of a transmitter with an oscilloscope, you *can* measure peak envelope voltage and from this reading calculate the power.

FCC regulations, however, require that power input to an amateur transmitter be determined by metering the voltage and current applied to all stages which deliver power to the antenna. They recognize that dc meters cannot respond to the variations in level of a SSB signal, which are due to the variations in sound intensity of your voice.

For this reason, the regulations state that the maximum power input as read by meters having a "¼-second time constant" shall never exceed 1000 watts. The key phrase is "¼-second time constant", and that includes almost all high-quality meters. It means that when voltage or current changes, the meter reading will follow it within ¼ second Thus the meter needle never keeps up with the voice peaks, but does record *average* rather than *peak* power.

The ratio of peak envelope power to average power in a SSB signal depends primarily on the characteristics of the operator's own voice, and may range from about 1.2-to 1 up to more than 2-to-1. If your voice is such that the ratio is 2 to 1, then you will be able to produce a legal 2000 watts of peak *input* power while the *average* upon which the regulations are based remains within the limits. If your voice produces a 1.2 to 1 ratio, you can get only 1200 watts peak input while remaining in the legal kilowatt limit.

This is a notable bonus for SSB operation when compared to either CW or AM operation. A CW transmitter is not permitted to run more than 1000 watts input under key-down conditions. This limits its peak input power to 1000 watts regardless of the average; when sending a string of mostly dits, the average power would be about 500 watts. An AM transmitter is limited to 1000 watts input in the absence of modulation. Addition of 100% modulation brings the peak input up to 1500 watts (1000 watts carrier and 500 watts in the sidebands, contributed by the modulator) but this is still less than the possible 2000 watts with SSB. Especially when you consider that only 250 of the AM rig's 1500 watts are useful and the rest are merely tagging along for the ride.

Despite the possible 4-to-1 advantage in peak power enjoyed by SSB in comparison with CW, the dits and dahs retain the advantage of maximum transmission range. This comes about because CW may be received with only 50 Hz bandwidth in the receiver, while SSB requires a minimum of 2.7 kHz, some 540 times as great. The 4-to-1 power advantage is cancelled out exactly when CW is received with a 675-cps bandwidth. Cutting that bandwidth in half gives CW a 2-to-1 advantage in effective received signal strength, and each additional halving of bandwidth doubles CW's power advantage.

For voice operation, though, no other technique can approach SSB's effectiveness. The nearest competitor is wide-band FM, which requires receivers even more specialized than those for SSB and is also illegal on the HF bands.

How Are SSB Signals Generated? Single sideband signals may be generated in any of three ways. The two most common methods are by filtering out the unwanted sideband, and by phasing out of unwanted components. The other method, known only as "the third method", combines parts of both the filter and phasing techniques, and is so critical in operation that it is almost never used.

Regardless of the method used, the starting point is always an rf signal which is modulated by the audio which is to be transmitted. Normally, the carrier is eliminated during the modulation process by use of a "balanced modulator". This is a circuit which accepts as its inputs an rf signal and an audio signal, one of which is applied in push-pull and the other of which is applied in parallel, and from which output is taken in push-pull. The resulting phase reversals of the rf signal as it mixes with the audio signal cancel out the constant-phase carrier component and leave only the two sidebands

In the "phasing" method, not one but two balanced modulators are employed. The rf signal is phase-shifted by 90 degrees between the oscillator and one of the balanced modulators, and is applied to the other modulator without any phase shifting. Similarly, the audio signal is shifted in phase by 90 degrees before its application to one of the modulators, and is applied to the other with no phase modification. Phase relationships in the modulator circuits make one pair of sidebands (either both lowers or both uppers) identical in phase at the outputs, while the other (unwanted) pair is 180 degrees out from each other. The unwanted signals then beat each other's energy out, while the desired sideband components assist each other on through the transmitter. Either pair can be selected by reversing connection of the two audio paths to the two balanced modulators. **Fig. 4** shows a block diagram of this "phasing" technique.

In the "filter" method, the rf signal is applied to only one balanced modulator. The resulting double-sideband-less-carrier signal is passed through an extremely sharp filter which passes only one of the two sidebands.

In the "phasing" technique, the original rf signal can be at any frequency from the low *if* region up to VHF, and the only part of the generator which requires adjustment (besides, of course, the various tuned circuits) is the rf phase-shift network. In the "filter" technique, though, the original rf signal must

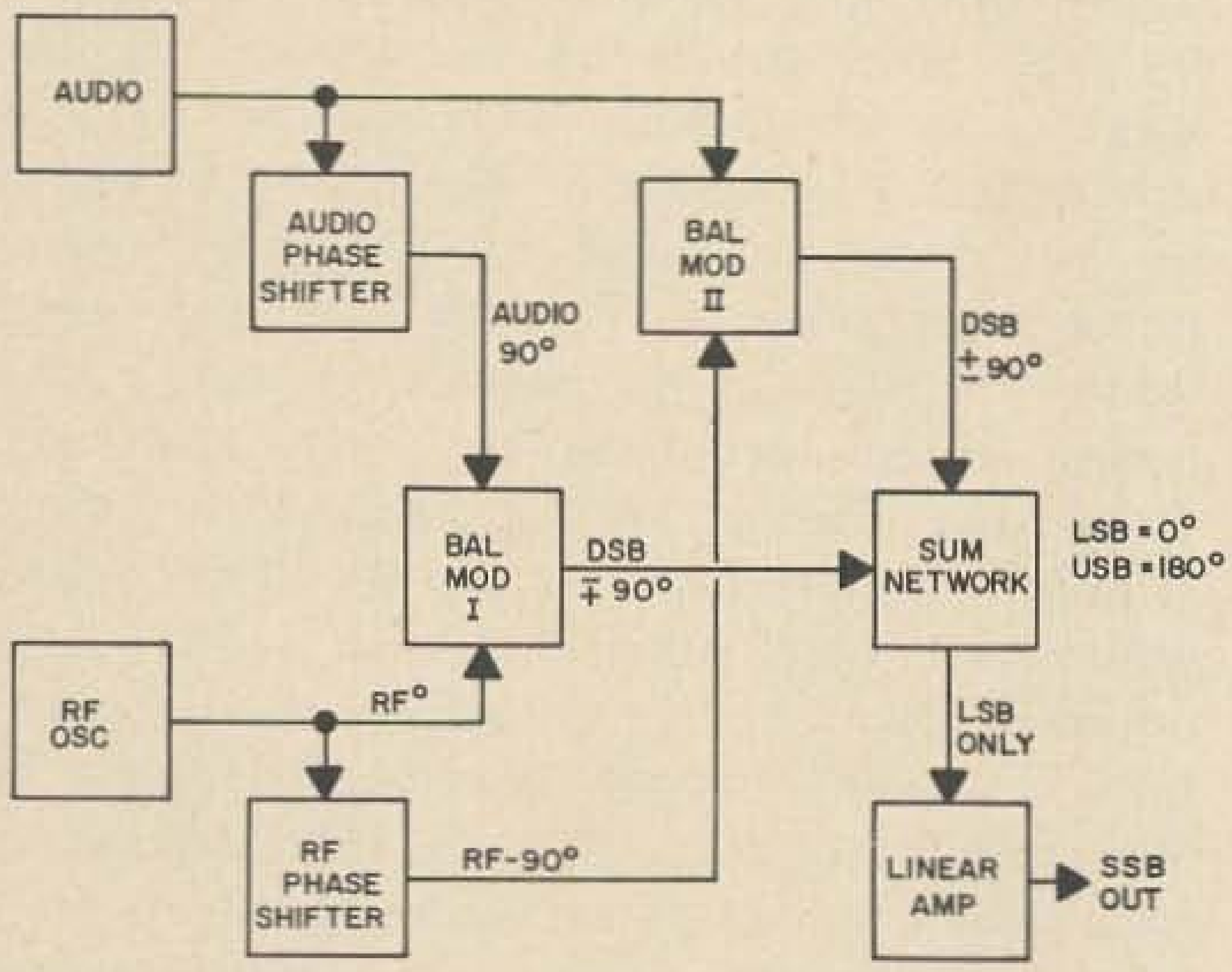


Fig. 4. Block diagram of phasing method of generating SSB signal. With phase relationships as shown, lower sideband signal is generated; to get upper sideband, move either (but not both) phase-shift network to feed opposite modulator. Success depends upon careful adjustment of all controls; up to 40 db suppression can be obtained but 30 db is more usual figure in practice.

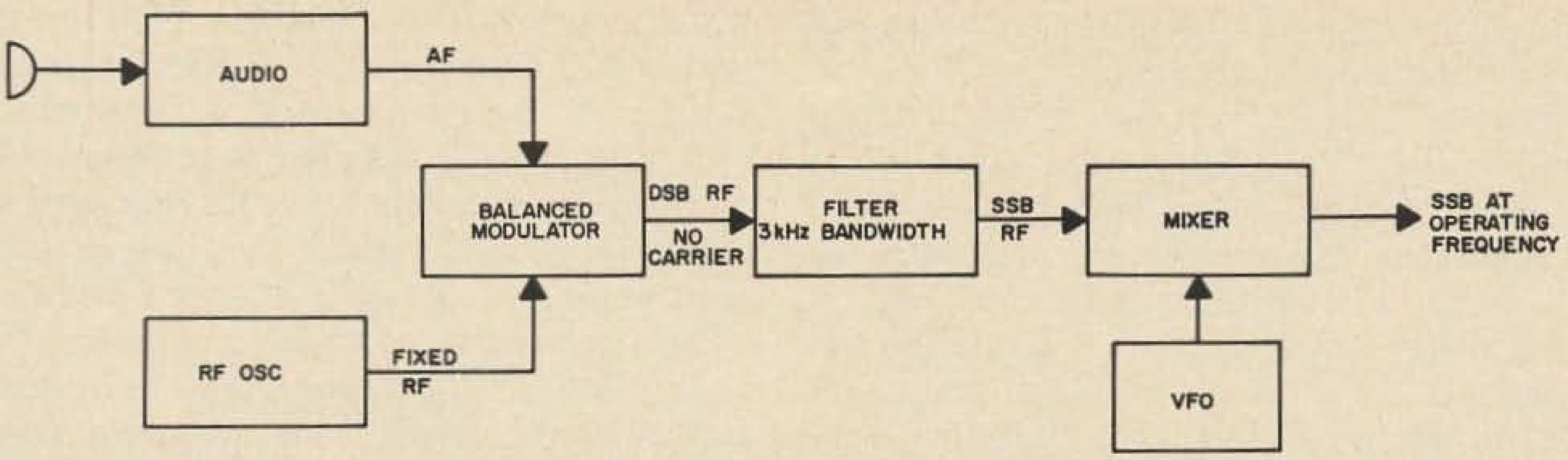


Fig. 5. Block diagram of filter method of generating SSB signal. Either upper or lower sideband can be generated by modifying frequency of RF oscillator to properly position DSB signal at filter input, with regard to filter's passband. Filter's rejection helps eliminate carrier and makes adjustment simplier than with phasing method, but careful operation is still necessary.

be at such a frequency that the desired sideband matches the passband of the filter rather precisely. Early filter techniques could not achieve the required selectivity at frequencies very much above the audio range—one of the first popular SSB filters operated at 17 kHz! Mechanical filters raised the frequency up to the normal *if* region around 455 kHz, and development of crystal lattice networks has since raised the filter frequency as high as 9 MHz. Regardless of the frequency, it is fixed for any one generator by the filter frequency. In practice, phasing units are usually also adjusted at fixed frequency.

Since the signal is at a fixed frequency when the carrier and unwanted sideband are shaved off, some means of moving it to the desired operating spot must be provided in any practical generator. This normally consists of a stable VFO and a mixer which is very like a receiver's product detector. Output of the mixer is then amplified as much as desired (or to the legal limit) by linear amplifiers. **Fig. 5** shows a block diagram of a typical filter-method SSB generator including the VFO and mixer stages.

The VFO and mixer operate to transform the SSB signal to some other part of the rf spectrum in just the same way as a normal modulator or a receiver's mixer move audio up to rf or vice versa. The mixer in a SSB generator is operated with particular care so that no distortion products are introduced, but the output always contains both original input frequencies, their sum, and their difference. The "sum" frequency has the same characteristics as the original SSB signal, but the "difference" frequency is inverted and becomes the "opposite" sideband. One of the favorite frequencies for generation of a SSB signal in the early days, and one which is still widely used, is 9.0 MHz. This permits a sum output in the 20-meter band, and a difference output on 75 meters, from the same 5-Mc VFO. The inversion caused by using the difference frequency is the reason old-timers on SSB considered LSB standard on 75, and USB standard on 20. Anything lower than 9 MHz required LSB, and anything above USB. With improvements in operating and construction techniques in the past few years, you can now find either sideband in use on either band.

How Is SSB Transmitted? Transmission of a SSB signal neither begins nor ends with generation of the signal itself. Before being applied to the SSB generator, the audio is normally shaped for maximum effectiveness. Broadcast quality is *not* the objective; communications punch *is*. To meet this end, the bandwidth of the signal is usually limited to the effective 300-3000 Hz range. Often, some measure of volume compression is applied—although this will change the peak-to-average power ratio, by trimming the peaks back and boosting the normally weak parts of the syllables.

For the phasing method, frequency limiting is necessary; the phase-shift networks operate well only within this range. In the filter technique, the limiting will be done by the filter anyway. Despite this, the audio is normally shaped at an earlier stage in order to concentrate power where it will be used. Many operators begin the frequency-shaping at the microphone by using a mike which responds primarily to the speech range and tends to reject other frequencies.

The processed audio signal goes into the SSB generator, regardless of the sideband-generation scheme employed, and a SSB signal at final operating frequency comes out. This signal is, however, rather puny; about the most produced by typical SSB generators is around one watt. To compete with the big boys, amplification is necessary.

And since distortion of any type is taboo with SSB, the rf amplifier used must be of the "linear" variety. Now "linear" is a word with almost as many different meanings as it has users. The most general meaning is "distortion-free". Any type of rf amplifier *can* be operated in a manner which makes it "linear" in this sense, but some types are easier to linearize than others.

For instance, to make a class C amplifier—typical of AM and CW final stages—operate as a linear, considerable special circuitry and careful adjustment is necessary. The net effect is a sort of cross between an amplifier and a modulator, but it can be made to do a good job if you have enough patience. The technique has been described in detail elsewhere; the idea here is to look at all the linear amplifier techniques but none in extreme detail.

A properly adjusted class B amplifier—an amplifier which is operated exactly at the cutoff voltage—will reproduce the envelope and frequency content of a SSB signal without distortion, and so it too is linear.

The class A amplifier—one in which plate current is never cut off during the operating cycle—is easiest of all to make linear. If grid bias is adjusted so that plate current remains constant through the syllable cycle, and if drive to it is kept within bounds, it's difficult to make one of these distort. Unfortunately, only about 20 to 25 percent of the dc power comes out as rf, so they're not the most efficient approach to the problem.

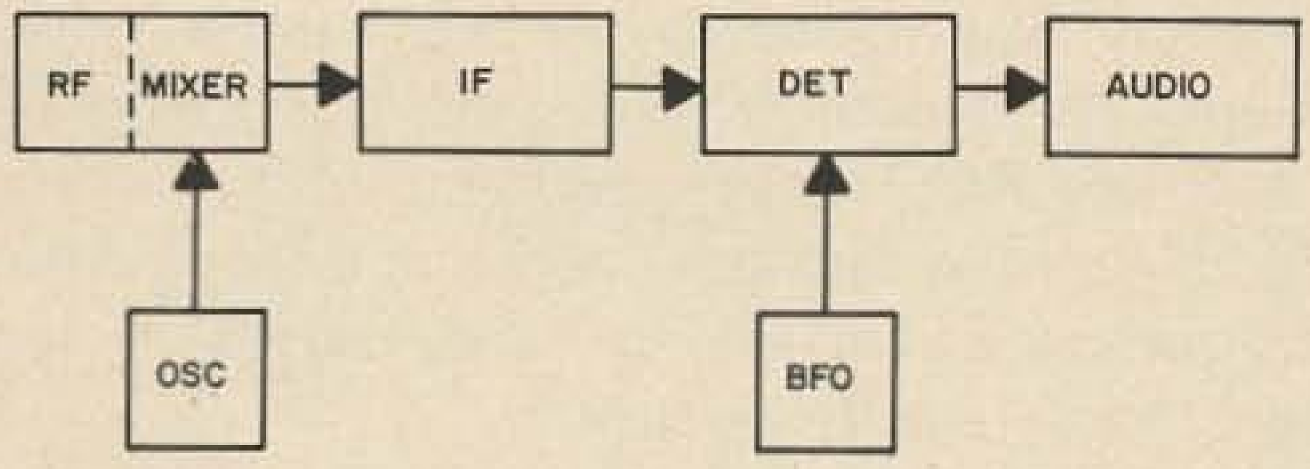
Most transmitter designers settle for the class AB_1 approach. This is an amplifier adjusted to operate midway between class A conditions and those for class B; no grid current flows, and plate current rarely is reduced to cutoff (never in a properly operating design), but plate current *does* vary through the cycle. With no signal input, most amplifiers of this type are adjusted to dissipate the maximum power possible within the tube ratings. As signal is applied, plate current rises—but dissipation decreases. Eventually, with continually increased input, the point is reached at which additional input results only in distortion rather than in increased output. Normally, though, grid current is drawn just before this point is reached.

The fact that most class AB_1 amplifiers are still distortion-free when grid current sets in can be used to advantage in the "automatic load control" circuit which has gained wide popularity. In the speech-processing portion of the transmitter, a compressor circuit is included. The control signal for this compressor is taken by rectifying and amplifying the "hash" which appears in the final grid circuit as the grid draws current. Thus when grid current appears, a control signal is applied to the compressor to reduce the input signal level. This negative feedback prevents distortion by automatically reducing drive whenever the input signal level is excessive. Of course, like all "automatic" devices, it can be overloaded—but used with some intelligence, it is a powerful aid.

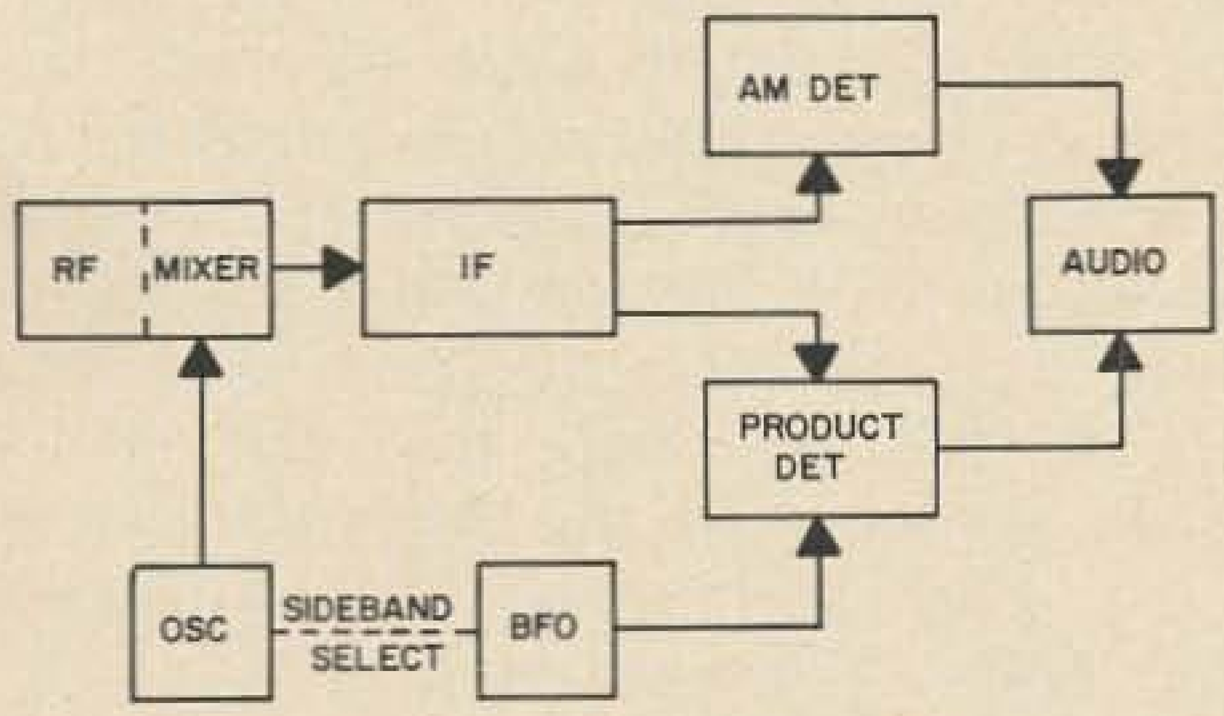
The main factor which prevents distortion when the SSB signal is amplified in the transmitter, however, is the proper tuning and adjustment of the amplifier stage. All adjustments must be on the nose for proper performance; sloppiness which would never be noticed with most AM or CW rigs results in a SSB signal which fills the band with "buckshot" and can rapidly earn you a pink ticket for spurious radiation.

Grid bias must be at the proper level. Too much will result in intermodulation (third-order) distortion, and too little will restrict the amplifier's ability to handle high-level signals. Drive must also be proper. Too little hurts only your output power; too much results in flat-topping and consequent splattering over the spectrum. Coupling to the load (either next stage or antenna) must be correct, so that the load reflects the proper impedance back to the amplifier plate. *All* of these adjustments interact strongly with each other. As a result, the only way to be sure of proper operation is to tune up with an oscilloscope.

To tune up with a scope, connect the scope to the transmitter output (through a coupling link, not direct) and apply a two-tone test signal to the input. With a phasing rig, all you need do is insert carrier. With a filter rig it is often easier to apply two sine waves of different frequency to the mike jack. The scope should display a perfect bow-tie pattern if operation is correct. Too much bias makes the diagonals of the bow-tie concave. Too little bias, or too much drive, flattens the peaks. Too little loading makes the diagonals concave. For additional details on interpreting the pattern, refer to any of the SSB handbooks. The important point to remember at this stage is that SSB signals may be ampli-



(A)



(B)

Fig. 6. Block diagrams of (A) a communications receiver for AM/CW use only and (B) a selectable-sideband receiver for AM/SSB/CW use.

fied without distortion only by a properly designed *and* properly operated "linear" amplifier. Either poor design or poor operation will introduce distortion, and consequent illegal operation.

How Is SSB Received? Once transmitted, the SSB signal must be received. While almost any receiver can be used (it's a matter of record that one-tube regenerative "bloopers" have successfully copied SSB), most operators consider a reasonably good superhet with sharp selectivity, a slow tuning rate, and exceptionally stable oscillators the minimum for serious SSB use.

Importance of stability is directly due to the small margin of error for reinsertion of the suppressed carrier; a mistake of as little as 20 Hz—that's the same tolerance broadcast-band commercial stations must keep—is clearly audible. Much more scrambles the voice beyond recognition. The slow tuning rate is important for the same reason; a jeweler's delicate touch can substitute for this, though.

The selectivity is necessary in order to take advantage of the capability present in the SSB signal. If the receiver's acceptance band can be trimmed down to just the width of the one sideband in which you're interested, then all possibly interfering signals near the sideband but not actually in it will be reduced or eliminated. Such a receiver is known as a "selectable sideband" receiver since it can select either sideband of a normal AM signal.

A selectable sideband receiver can receive any type of signal which can fit within its 3-kHz passband; it is not limited to just single sideband signals. The selectable sideband receiver can receive CW, SSB, DSB (double sideband suppressed carrier), or AM signals interchangeably. It *may* be able to receive narrow-band FM or PM signals as well, although as a rule special detector circuits are necessary for these "angle-modulated" (FM or PM) signals.

Whether SSB, DSM, or AM signals are being received on such a receiver, the technique is similar. The receiver's BFO is adjusted to a point just outside one edge of the passband, and the receiver is then carefully tuned until the signal becomes intelligible. If an AM signal is being received, the receiver is tuned for zero-beat (or the BFO may be turned off). This effectively shaves the unwanted sideband from a DSB signal, turning it into an SSB signal at the receiver instead of at the transmitter.

CW signals are tuned in by the same method except that the BFO may be adjusted to some other point on the passband, depending upon your own personal preference in beatnote pitch. Some operators like relatively high notes, around 1 kHz, while others prefer low pitches, from 50 to 200 Hz.

A good AGC system is also essential in a receiver for SSB use, since the signal varies at such a rapid rate. Normal AVC won't work right; it cuts in and out far too rapidly, producing a "thump" each time it cuts in and permitting noise to roar up between syllables of a word. For sideband use, a "fast-attack" "slow-release" system is necessary; this one acts rapidly when signal strength increases, but holds gain down for some time after the signal goes down (as long as 1 second in many cases). This permits the receiver gain to match the *average* rather than the *peak* levels of the SSB signal.

Selectivity, stability, slow tuning, and good AGC are all essential to SSB reception. Yet all of these are wasted for long-session use unless the actual detector circuit of the receiver is properly designed. Today's receivers almost invariably include "product detectors" for SSB use; the older breed, which is still with us in large numbers, did not.

The product detector is simply a name for a type of low-distortion mixing circuit which accepts two radio frequencies (normally the *if* and the BFO) and produces only the sum and difference outputs, without adding intermodulation distortion or other forms of garbage to the audio output.

By contrast, the older diode or peak envelope detectors produced distortion levels as high as 15% of the audio signal itself. This difference didn't have much effect during short listening sessions—but during contest operation, for instance, it made the difference between keeping the top of your head in place and blowing it clean off your scalp!

To sum up reception requirements for SSB, Figure 6 shows block diagrams of (A) a communications receiver for AM/CW use only and (B) a selectable-sideband receiver for AM/SSB/CW use· Note that the sideband receiver contains all the required functions for the other two types of reception, and merely adds a few new ones.

Next: One of the most important areas of any license exam deals with transmitter design and adjustment techniques. Next time we'll get into the first of three looks at this key subject. Don't go away . . . ■

Technical Aid Group

If you have a question which can be answered adequately through the mail, look through the following list of TAG members and write to one whose specialty covers your problem area. Be sure to explain your problem clearly and write legibly. Enclose a Self Addressed Stamped Envelope for a reply. Do not ask a member to design a piece of equipment for you. The purpose of this group is to assist the ham with problems he encounters in the course of building or trouble shooting.

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

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

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

Jim Ashe W2DXH, R.D. 1, Freeville, New York. Test equipment, general.

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

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

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

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

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

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

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

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

Theodore Cohen W9VZL/3, BS, MS, PhD, 261 Congressional Lane, Apartment 407, Rockville, Maryland 20852. Amateur TV, both conventional and slow-scan.

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

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

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

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

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

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

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

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

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

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

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

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

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

Howard Krawetz WA6WUI, BS, 654 Barnsley Way, Sunnyvale, California 94087. HF antennas, AM general.

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

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

Ronald King K8OEY, Box 227, APO New York, New York 09240. AM, SSB, novice transmitters and receivers, HF receivers, RTTY, TV, test equipment, general.

Charlie Marnin W8WEM, 3112 Latimer Road, RFD 1, Rock Creek, Ohio 44084. General technical questions.

Michael Wintzer DJ4GA/W8, MSEE, 718 Plum Street, Miamisburg, Ohio 45342. HF antennas, AM, SSB, novice gear, semiconductors.

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

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

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

John Perhay WAØDGW/WAØRVE, RR #4, Owatonna, Minnesota 55060. AM, SSB, novice transmitters and receivers, HF receivers, VHF converters, semiconductors, mobile, product data, general. Has access to full specifications on almost all standard components presently catalogued by American manufacturers.

David D. Felt WAØEYE, television engineer, 4406 Center Street, Omaha, Nebraska 68105. Integrated clrcuits, transistors, SCR's, audio and rf amplifiers, test equipment, television, AM, SSB, digital techniques, product data, surplus, general.

Tom Goez KØGFM, Hq Co USAMAC, Avionics Division, APO New York, New York 09028. HF antennas, mobile, airborne communications equipment, particularly Collins and Bendix gear, AM, FM, or SSB–HF, VHF, UHF, general.

Robert Scott, 3147 East Road, Grand Junction, Colorado 81501. Basic electronics, measurements.

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

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

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

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CORRECTION

In the VHF Remote Control article (April, page 32) please change the 35 second timer in Figure 7 to a 3.5 second timer. Also, on the voltage control relay, connect points two and three with a jumper. This is fairly, but not completely obvious from the diagram.

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

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

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

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

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

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

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

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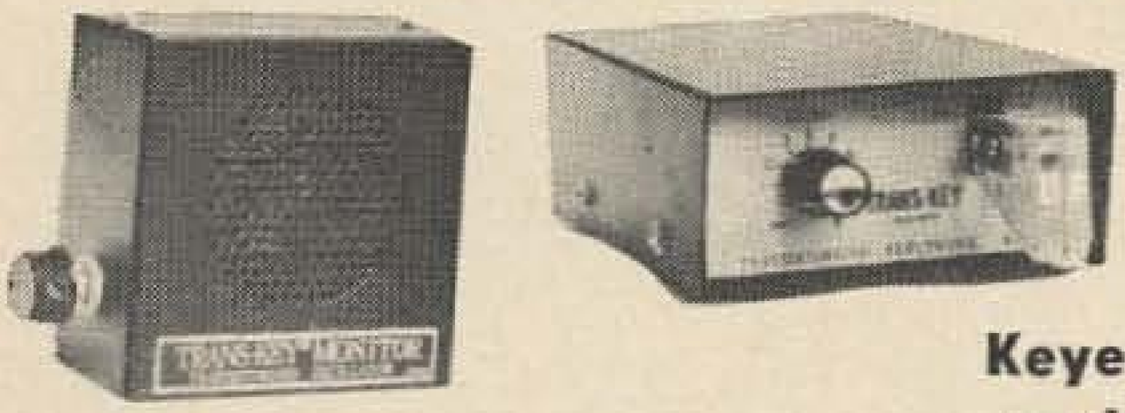

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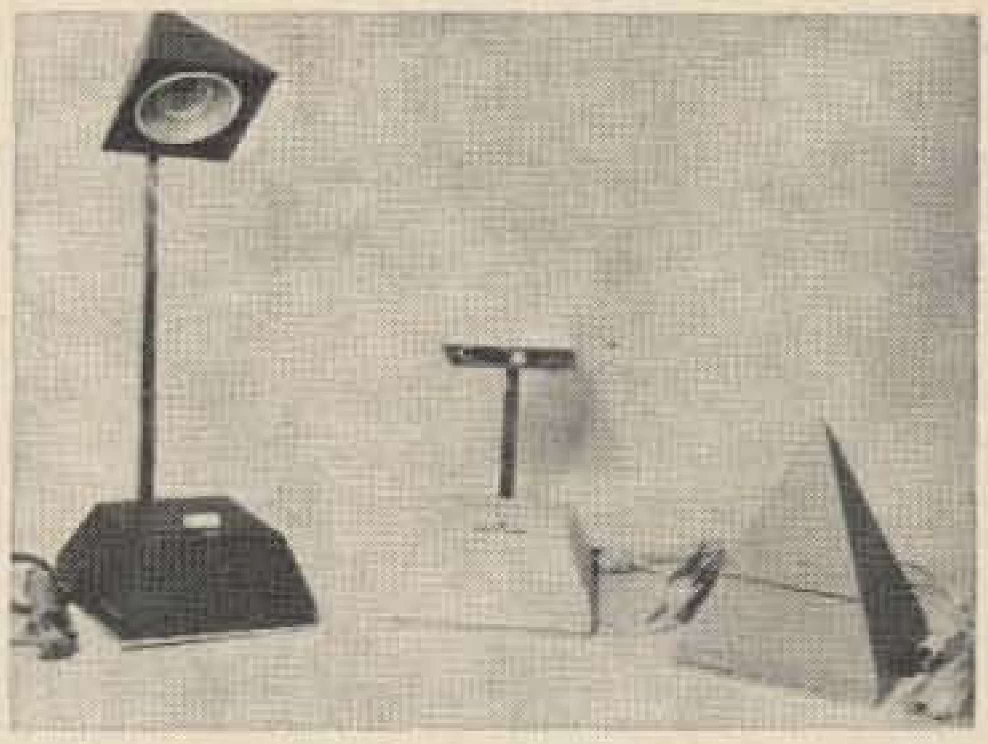

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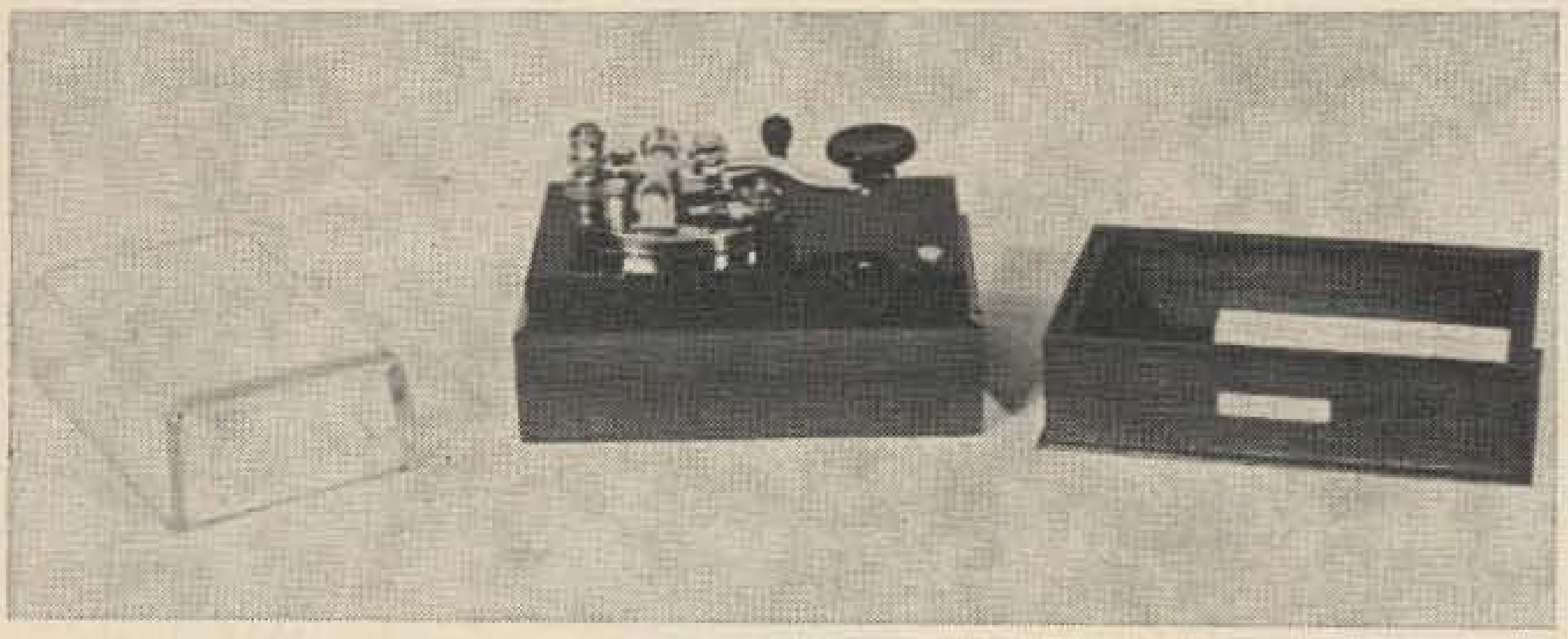

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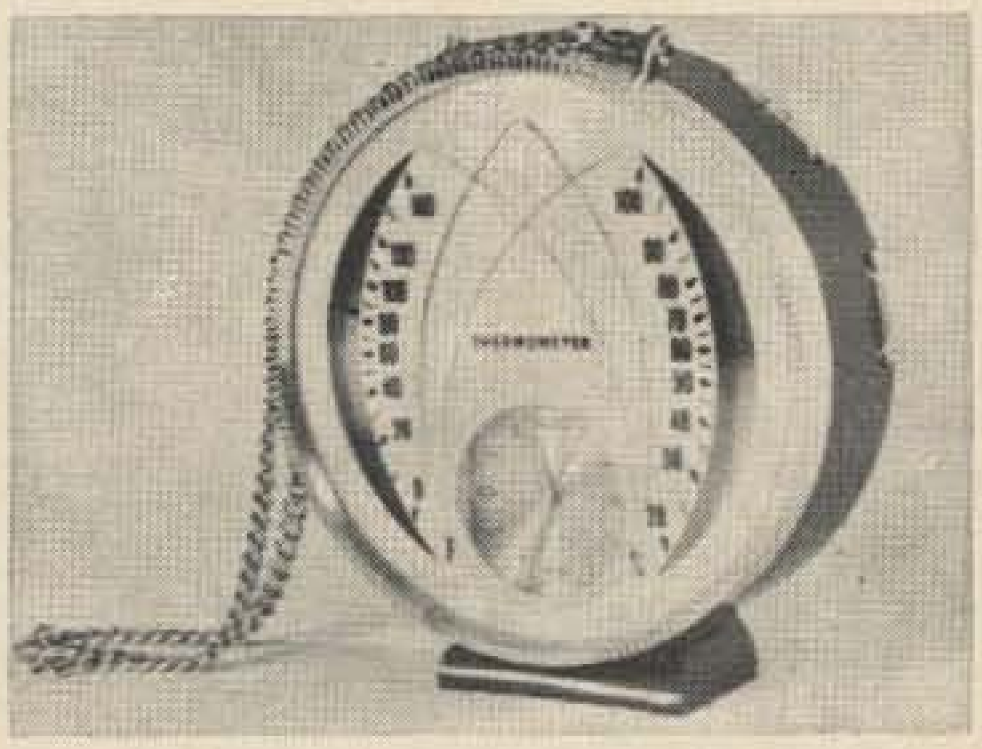

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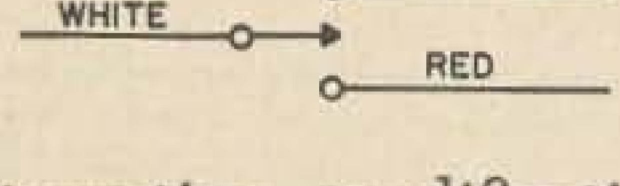
4. Connect a third wire (green) to lug 3 of TR switch.

5. Mount S1 (SPDT) on front panel directly below the words "The Sixer."

6. Feed all three wires through grommet U.

7. Connect wires to switch (S1) as shown in **Fig. 1.**



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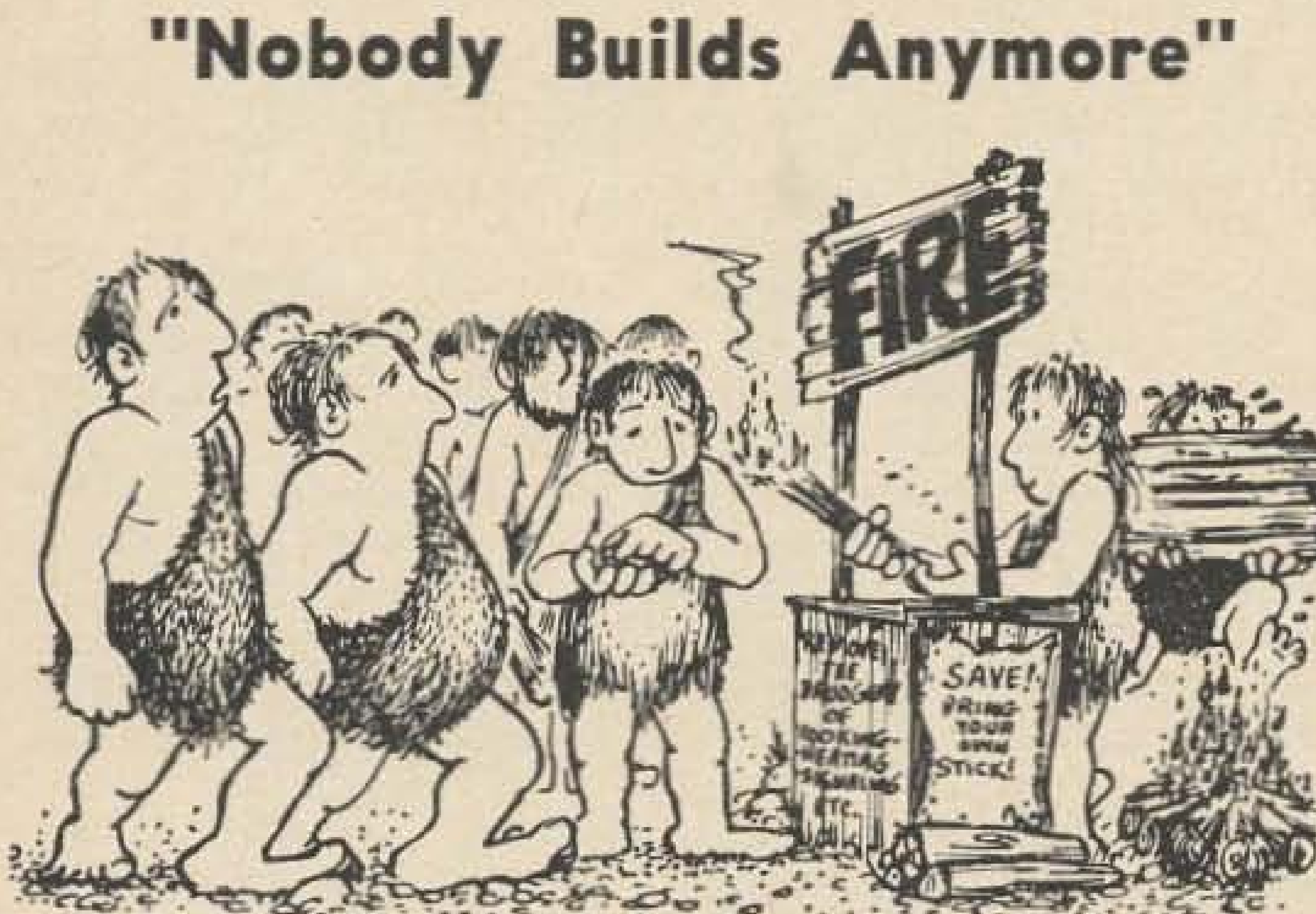

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SOME NOTES ON OUR

REGINAIR 321 QUAD

Perhaps you too looked at the familiar "H" pattern of the conventional 3 band quad and wondered how acceptable performance could be had from such a configuration. To Larry Johnson, WA1BUN, this concept was all wrong for the electrical spacing between elements varied widely and obviously the resulting terminal impedance of the driven elements varied equally. Trying to connect one feed line to three different impedances is touchy and mechanically difficult. The outcome, it was reasoned, was a constant electrical spacing for all three bands. This was achieved in the Reginair Quad by means of a spider type design, the hub for which is illustrated here. Eight inches long, 3½ inches in diameter, and a thick ¼ inch wall give ample mechanical support to the four aluminum tubes, which in turn support the insulating dowels. This aluminum hub is drilled to accommodate up to 1¾ inch diameter masting, to which the hub is fastened with a ½ inch plated steel bolt.

Constant electrical spacing resulted in a terminal impedance on each band of 100 ohms. This is transformed down to 52 ohms by a Q section of RG11/U cut for 21 megacycles (when matching 2 to 1, a Q section works very well over the octave from 14 to 28).

The bugaboo of suck-out, caused by 10 meter radiation from the 20 meter element, has consistently plagued Quad builders, for VSWR invariably jumped on 20 meters—the very band where we wanted the flattest response. After many trials, Mr. Johnson resolved this problem by inserting a quarter wave 10 meter shorted decoupling stub made of RG8/U, within the 20 meter driven loop.

No baluns need be used with the Reginair 321 Quad. The Quad is a full wave device, not a half wave. As a result, the RF currents from both the sheath and the center conductor of the feed balance out and no balun or balancing device is needed. You can prove this with 2 RF ammeters. In other words, the Reginair Quad is self-balancing; it is, in effect, its own balun.

Previous quad design used stubs or other devices to achieve low VSWR. Our Quad needs no adjustments of any kind—no loading coils—and yet reflects less than 1.5 to 1 VSWR over the entire 10, 15, and 20 meter bands. This most important feature is obtained by making the reflector loops very slightly larger, tuned to a slightly lower frequency.

The measured gain of this Quad is 5.9 db, compared to a conventional dipole; 8.5 db as compared to an isotropic dipole. The front to back will be 25 db equivalent to an average of 4 S units on a typical receiver.

This Quad is quickly assembled from a complete package with pre-assembled driven and reflector elements. All you need do is furnish the 52 ohm feed and raise it into position. A light TV rotator, such as the AR22R ($33.95) will swing it easily. The completed Quad weighs but 35 pounds and requires 19 feet of area, or 9½ feet of radius.

The most salient feature of our Quad is its flat response. This is particularly important because most hams today use transceivers or transmitters that can accommodate only VSWR of up to 2.5 to 1 at the most. Consider your finals and the longevity of their life, and you can see why. In a typical illustration, a pair of 6HF5's are employed as finals in a transceiver with a 400 to 500 watt PEP rating. The tubes themselves are TV horizontal oscillator types, with a dissipation rating of 30 watts each. Sixty watts then is the most you can tolerate. The idling current of the finals is 50 mills times 800 volts or 40 watts. At 2.5 to 1 ten per cent of the forward power is coming back to roost. With 250 forward watts from our transceiver, 25 watts are returned. Twenty-five and forty equal 65 watts—5 more than should be considered safe. As you slide up and down in frequency, think of what is happening in your rig—unless you had the good judgment to operate at your antenna's resonant frequency, or better yet, the wisdom to use our Reginair Quad where the VSWR is guaranteed to be less than 1.5 to 1.

Remember too, a quad has more than twice the capture area of a similar rated beam. In the case of the 321, more than 350 feet of wire are used.

To you doubting Thomases, read what WØKHI had to say. "I want to add my name to the many satisfied users of your new Quad. This is the first Quad kit that I have purchased that was a 'true' kit and not simply a do it yourself bunch of quad parts to homebrew. All the parts used in your kit are of good quality and well put together; the wire used is especially appreciated for ease in Quad assembly. It does give me for the first time an SWR that pleases me; it is between 1.2/1 and 1.0/1 on all bands."

The Reginair 321 Quad is available at $89.95 in one improved model using poly vinyl chloride tubing of two dimensions and an indestructable ABS spider hub. The shipping weight is 37 lbs. packed in a cylindrical tube 6' long by 6" in diameter and therefore suitable for inexpensive Parcel Post APO mailing. Delivery from stock.

HERBERT W. GORDON COMPANY

Woodchuck Hill Road • Harvard, Massachusetts 01451

"Helping Hams to Help Themselves"

The 321

George Johnson WA1BUN
43 Raymond Street
Nashua, N.H.

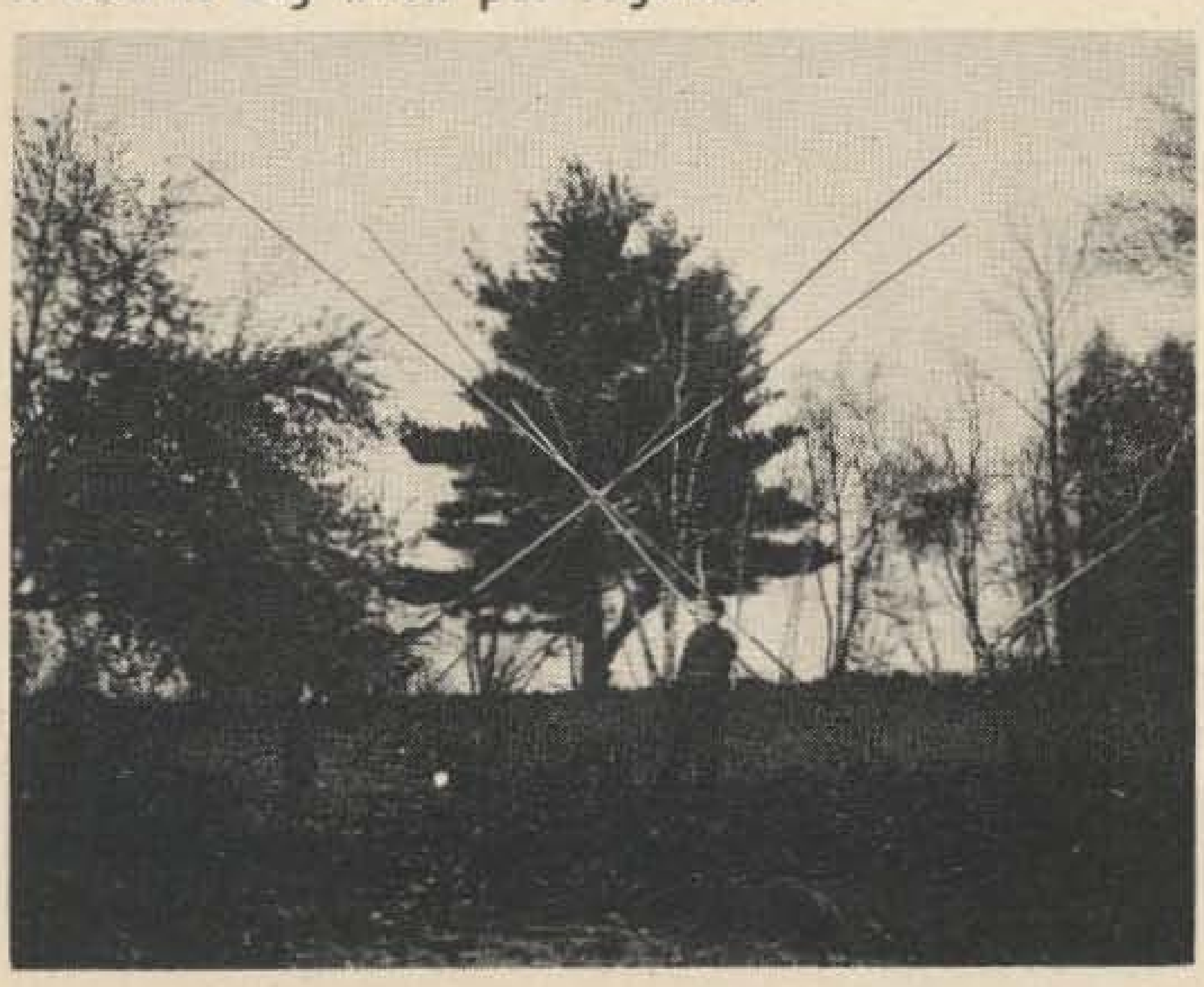
A New Quad Design

3 bands, 2 elements, 1 feed line

In 1965 I moved to the city of Nashua, New Hampshire, into a house which had no antenna facilities whatsoever. Having had considerable experience with beams in the past, and knowing their limitations, I decided this time that I would put up a Quad. The quad had a reputation as being a fine antenna, and yet there was a considerable amount of discussion on the air with respect to the relative merits of a quad versus a beam. I decided that I would find out, even if it meant doing it the hard way and experimenting all the way through. First, I found out that there weren't any finely drawn lines on quad design. When I talked to most fellows about quads, everyone seemed to agree that although the quad was a fine antenna, they would invariably end up by describing theirs from a mechanical point of view. For example, "I got it up, and boy, I had a hard time tuning that thing up; but once I managed to tune it, why, it seemed to work fine." Then other fellows would tell me about what happened to their quad when the first storm came and took it away.

After some study of the construction methods employed by conventional quad design I began to understand why so many people had trouble with their quads. In a conventional quad design, which essentially was shaped like the letter H, having a boom of 8 to 10 feet and cross spreaders on each end, the quad loops themselves are strung across the spreaders, with the whole structure being supported by a slim mast and a light rotator. I began to understand why such a quad would wave with the breeze, slop up and down and not maintain any fixed electrical configuration.

It sure is big when put together

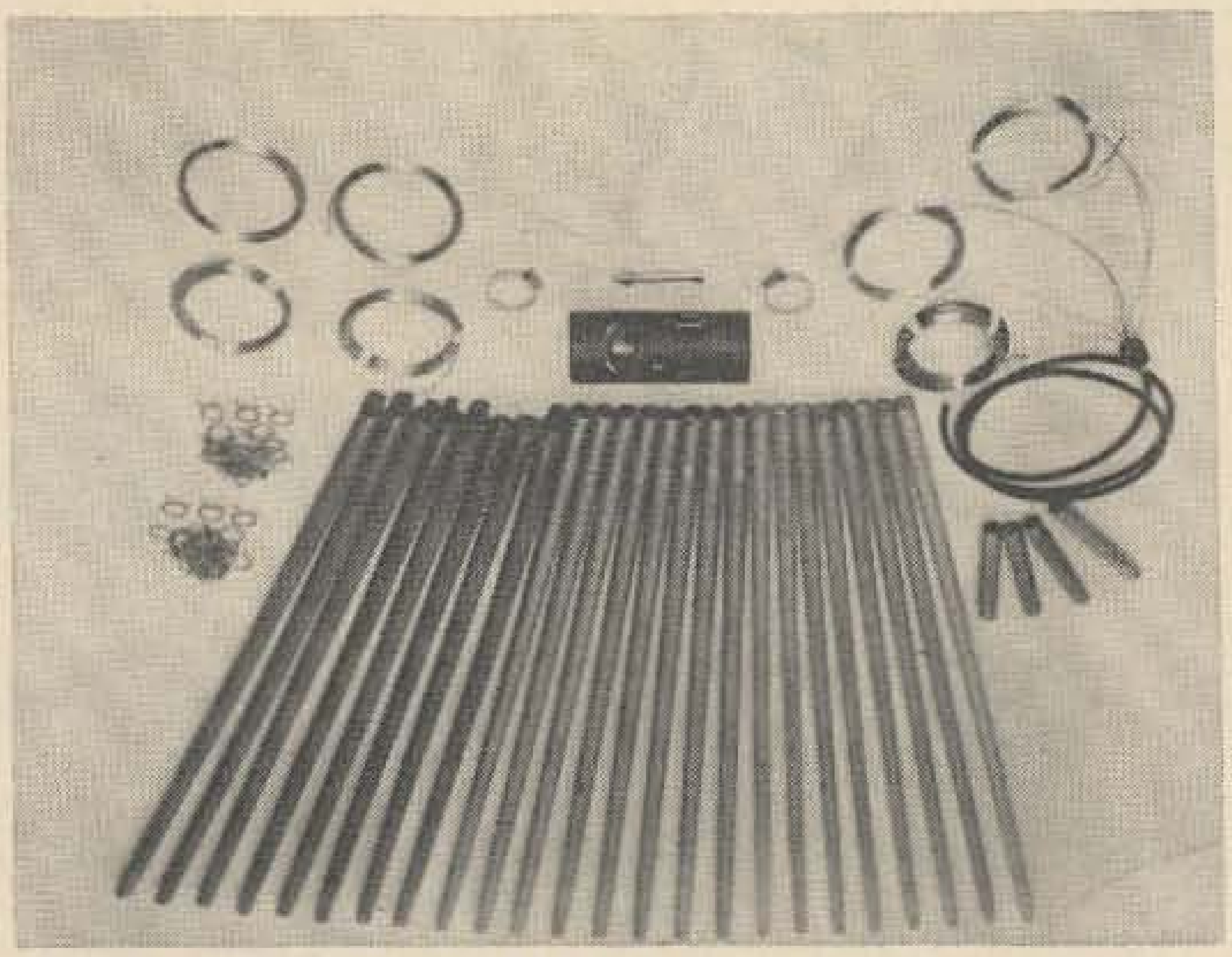


I wanted my quad to stay up, and I wanted to have a different design. And still in all, I wanted my quad to operate on each of the 3 high frequency bands most popularly used in amateur radio, the 10, 15, and 20 meter bands. I recognized that the physical distance between the 10 meter sections, 15 meter sections, and 20 meter sections were one and the same. But since the electrical distances were different, this would have to result in an odd ball combination of impedances, which would be difficult to match. This became more and more apparent as I went to look at the problem of feeding. The 3 different electrical spacings in a conventional system yield 3 different feed impedances. The prospect of matching elements to a single feed line, which was my goal, seemed very remote. So, looking around, it became evident that some drastic revision in my overall concept of a quad had to be realized. At about this time, in various publications, I found evidence of a boomless type of quad, or spider design, which had spreaders radiating from the center in a V type of configuration. Obviously, the different driven elements and reflectors would provide a different set of spacings on a frame of this type, and evidently the boomless hub would be a good starting point for me. I also realized that if someone were to put 4 cross-brace wires between the corners of the loops, it would pull this type of quad into a more rigid, boxlike structure, which could put real tension on the loops and prevent any spreaders from bending individually.

Before I started construction of my first quad, I decided that I had to build a crank-up tower. This was constructed out of 2" x 4" and 1" x 6" lumber, actuated by a hand crank winch. It consisted of a cross-braced A frame with a T section upper member, pivoted in the middle. The whole thing was mounted on my back porch, in such a position that it could be cranked up or down with the aid of the winch, thus lowering the top of the antenna down into a double turn-around in my back yard, for easy work. This seemed to be necessary if I was going to develop any kind of an antenna, for I realized that I would have to crank the tower up and down innumerable times. This proved to be a modest prophecy, for ultimately I had to crank the tower up and down at least many hundreds of times before I was satisfied with the resulting quad.

My first attempt at building a quad was to use all aluminum construction. I found that using aluminum resulted in serious capacitive loading effects on the elements in the quad, to such an extent that their resonant frequencies were considerably lower, and that unless the aluminum spreaders were severely broken up with insulating material, the radiation pattern was adversely affected. What I'm trying to say is that the spreaders themselves, made of aluminum, would absorb rf energy from the resonant elements, and distort the radiation pattern of the quad severely. I didn't get anywhere with it, so I turned instead to insulating materials for the spreaders.

My first attempt, for insulation, was to use wood for the spreaders. Many quads use bamboo. Fiber glass was, of course, available, but it seemed to me that a good solid piece of wood, particularly hard wood, if it were treated properly to prevent weathering, would last a long time and could be used. Then, too, I decided to make the center portion of my quad out of aluminum tubing, heavy thick wall tubing. After all, why not take advantage of the strength of aluminum tubing at the base of the quad, where it does not have to carry any electrical ele-


This is the complete 321 kit

ments and where all of the mechanical stresses stem, or come from. An aluminum spider hub, illustrated here, was my first attempt to work out this thing mechanically. Even this was a long time in evolving. I had to plan just how the shape of the holes could be drilled so as to fit the design of the spider quad and still at the same time preserve mechanical strength sufficient to take care of the job. I made the spreaders, or dowels, out of a combination of aluminum and wood. They were, overall, 13½ feet. This type of structure seemed reasonably good mechanically, and I therefore started experimenting with various configurations of wires, attempting almost any length to try to make a quad for 10, 15, and 20 meters, on the one frame. The first attempts used conventional stub tuning. I just tied all of the elements together at the feed point, figuring that problems would develop, and I surely wasn't wrong. The 20 meter section would radiate when I fed 10 meter energy into the 10 meter section. The VSWR's were humped, and very, very poor. More experimentation showed that we were getting pretty close to a consistent 2 to 1 mismatch on each of the 3 bands. That is to say, the best match available was about 2 to 1. I analyzed the resulting feed impedance from such a configuration, and I found that the quad was consistently higher than the 50 ohms which I had planned to use. Since the mismatch was the same on all bands, it would seem to prove that at least I had the right idea in choosing the spider type of design. I needed to find some corrective device to broadband the resulting quad. The study of the various publications revealed that a Q-match is a good means for attempting such a transformation of impedances. And, of course, a Q-match is a relatively

The junior op figured out the more complicated assembly

broad band device. So this was tried, and we found that by cutting the Q match section for any one of the 3 different bands, we would obtain a perfect match for that band. We also found that if the Q match section were made out of RG11 cable, which has a 72 ohm impedance, and we designed this for 15 meters, that the match was very good for both 10 and 20 as well as 15 meters.

My next specific goal was to try to obtain the best front to back ratio, or forward gain, for my quad. I realized that this meant that I had to tune it up very accurately. I found to my surprise that tuning the quad was indeed very difficult. My first attempt at tuning the quad was made with a grid dip meter in the regular, accustomed fashion. I found that the reflector elements had to be approximately 200 kilocycles lower than the low limit of the amateur band involved, in order to have a reasonably decent VSWR. Stub tuning was trickier than I had assumed. Furthermore, the tuning would move, and sometimes rather unpredictably, when I raised and lowered the antenna. So, it was not always easy to tune the antenna in a down position and have the same results when it was put up in an operating position. I did, however, make the quad this way, and was able to get reasonably good results with it, using just plain conventional stub tuning. The results of this type of tuning meant, however, upon close examination, that the front to back ratio varied across the band. It didn't seem to matter how closely the reflector was tuned to the low end of the band, the front to back ratio would seem to deteriorate at the high end of that band. I reasoned that the stub was an inductive loading center for the reflector. It was probably raising its Q and lowering its band width and thereby narrowing the range of frequencies over which it could operate effectively. Accordingly, I determined that I would try to design the reflector without any stubs at all. The reflectors were altered and I found that we actually had to make the poles or spreaders longer, to accommodate a full-sized 20 meter loop, instead of that which he had been using before. Now the 20 meter loop was a full 72 feet around. I wanted, in effect, to have a long enough reflector and full size dimension so that it would resonate at approximately 13.8 megacycles on 20 meters. In this concept, which was subsequently proven correct, the results were outstandingly different in our favor. In the first place, all we did was to make a calculated length cut, and put the loop on what was supposed to be a theoretically correct length. We ran the quad up into operating position, and somehow it worked. Furthermore, the front to back ratios across the band were now consistent. That is to say, they were generally between 20 to 25 dB, whereas in the tuned stub version, we had as much as 7 dB of deterioration at the high frequency end.

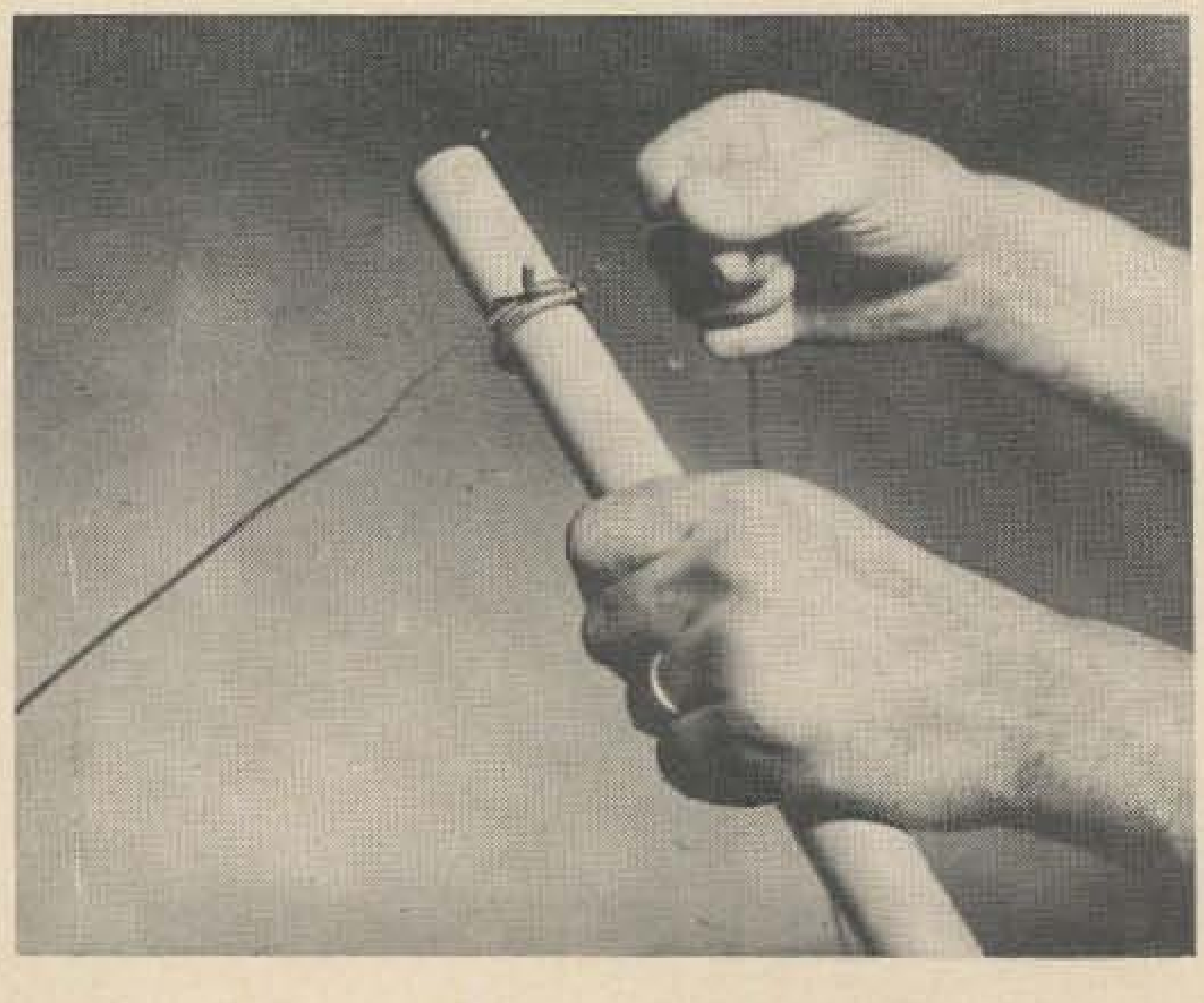
The next problem to be encountered was that of suck-out energy on the 20 meter loop, when the system was fed with 10 meter energy. The 20 meter element represents 4 half-waves on 10 meters, and it will absorb energy in the feed line on 10 meters, unless something is done to kill the resonance, or somehow make it a poor impedance match on the 10 meters.

My first thought was to try a parallel tuned trap tuned to 10 meters and inserted in the 20 meter driven element. Sure, this worked after a fashion, but to make an impervious seal against the weather, and still have it remain tuned to its original frequency was most difficult. This trap had to have appreciable inductance in order to reach the Q necessary to effectively trap out 10 meters. This meant in turn that a considerable portion of the remaining 20 meter driven loop was being wasted and not being used to radiate properly and further reduced the desired band width. Not only that, but the idea of losing energy in such a trap was against my better judgment. There had to be a better way, and there was. I finally employed a piece of 50 ohm coax, 5½ feet long, connected with its open end at a point half wave up from the feed point in the 20 meter loop. This move was the proper one, as proven from a simple test of feeding 10 meter energy to the 20 meter loop and then going around with a neon bulb to detect voltage points on this loop. Better instrumentation revealed that the 20 meter loop no longer served as a 10 meter antenna.

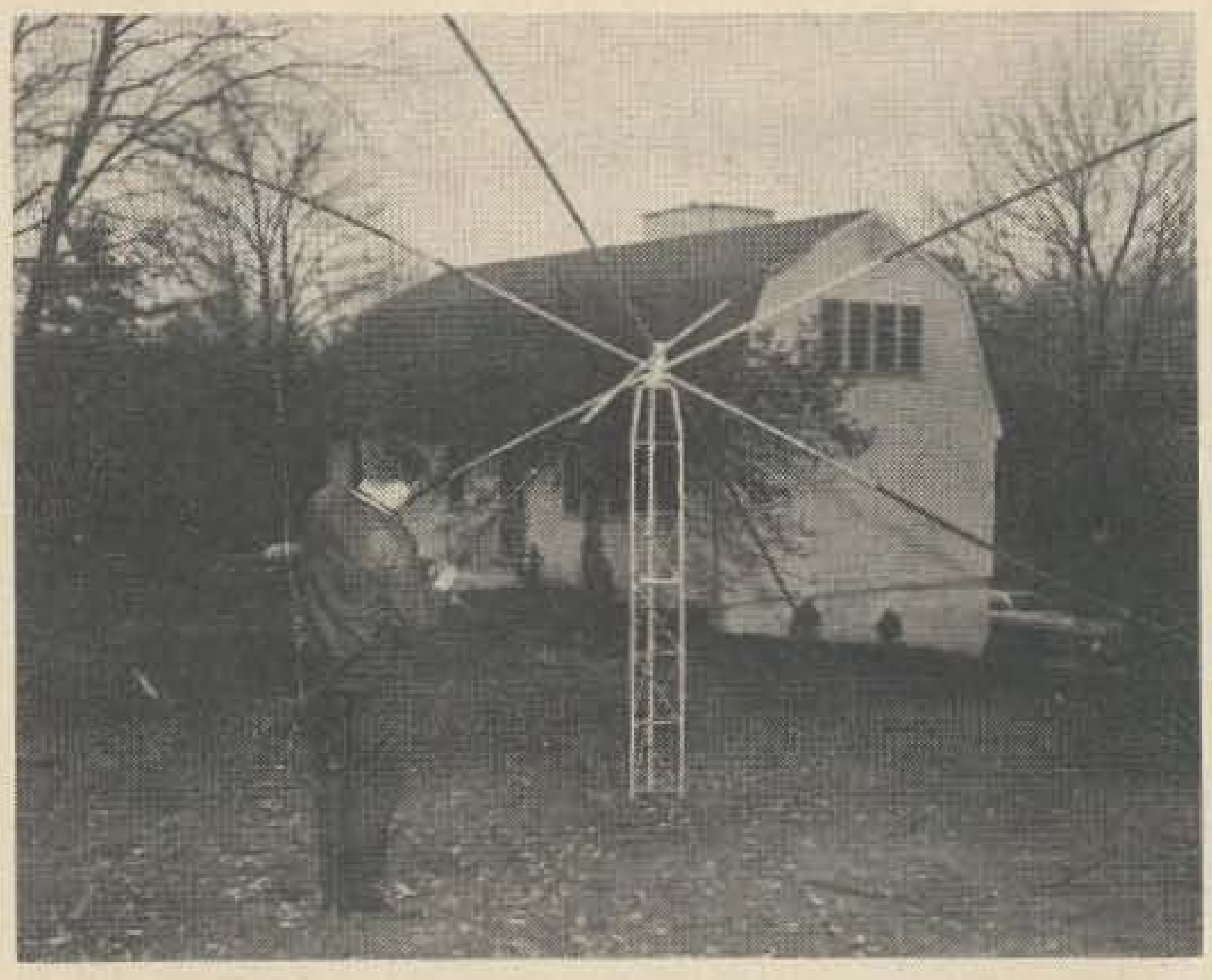
At this point in terms of time and progress I had a fine performing antenna—but in line with trying to improve still more, felt a need for installing a coaxial balun as a series element from my main feed line, a broad band device with lumped constants. First, I knew that it would be necessary to establish existing standards on the performance of the quad as it now was. Accordingly I plotted frontal lobes and observed that the radiation was beautifully symmetrical. Reports confirmed this study. Perhaps I didn't need a balun. So I measured the rf with a small ionized gas stick around the square of the driven loop. Deionization occurred at the same equidistant points from center feed. Two rf current meters inserted at the junction or feed point both read the same current, proving again the fact that the full wave loop was in itself a balun, and therefore needed no external device to effect radiation balance!

What pleases me the most after a year and a half of experimentation is the unmistakable fact that the resulting quad has singular merit in that it affords me the lowest and flattest VSWR over the entire 3 bands (10, 15, and 20) of any antenna I have ever used, including most commercial beams and dipoles. The freedom from worry concerning high VSWR means that I can operate CW at the bottom of 20, then merely swish up to the top of the sidebanders without disturbing the load on the rig. My finals are really protected with this antenna! The front to back is a consistent 25 dB; the greater capture

Attaching the wire to the spider ends



area of the full wave antenna plus its unusual vertical and horizontal configuration enables me to hear stations earlier in any day and then again later in the day at the closing of the MUF which are not otherwise identifiable on a competitive 3 element beam pointed similarly and used concurrently. Even though this Quad design is inherently limited to a gain over a dipole of about 5.9 dB, some other parameters must be working for me, for the reports indicate marked superiority whenever a test is suggested. Again, my belief that the quad could be mechanically improved has been borne out in practice. Evidently other hams feel this way too, for I



Almost finished and ready to raise

have been kept busy making reproductions of this original "Queen of the Air" ever since. Moreover, there are no traps, baluns, stubs, or adjustments of any kind necessary to the final Quad. It's simply a case of assembling precut wire loops and precut aluminum and wood spreaders before you, too, have a similar Quad.

The 321 quad is being distributed by the Herbert W. Gordon Co., Harvard, MA 01451.

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.

"Yipes! I thought this was my soldering gun!"

Letters

Dear 73,

Anent your comments in current 73 (Feb), I can but whole heartedly agree: there is absolutely no respect for any sort of law and order on the ham bands, and it is getting worse. Our major problem, right now, is one of *enforcement*. Same problem on the 11 meter band. I too have heard the mish-mash on W1AW's signal, the horror that 75 has become, and the awful messes on 15 and 20. There are "broadcasters" and clowns with motor-driven "aroooga" horns, belches, and assorted obscenities. These are pale when compared to the drunks on the air.

I feel strongly that we have come too far along the road we have taken to ever clean house—not without a greatly strengthened enforcement division in the FCC and a quadrupled budget for them. The State of the Art has indeed advanced, but our society seemingly has regressed. The common attitude seems to be "the hell with it", and that's it.

F. C. Hervey W9IIU
Chilton, Wisconsin

Dear 73,

How clever of you to put your "April Fool" article in your February issue!! I'm referring to the hillarious article by W4PJG, "How to Get Better Returns from your QSL". I worked W4PJG on Grand Cayman Island as ZF1EP and sent three QSLs with SASE each time but received nothing in return. I suppose the answer is in the advertisement contained in his article, "A small contribution anywhere from a dime to a dollar is appropriate"—he already has 16c of my postage.

I can suggest another DXpedition he might undertake!

Luther D. Miller, Jr. WA3FMO
Washington, D.C.

Dear 73,

Banzai and tally ho to your Feb. Editorial Liberties. Amen to the fact that amateur radio is in a sorry mess by and large. Agreed that a general house cleaning is in order and long overdue. Like you, I find myself restricting encouragement to prospective amateurs and the number of tests given. We should consider the overall value to the Service in dealing with those who aspire to join us.

It appears the only way to clean up the bands is for each of us to do some serious soul searching, abandon our inconsiderate and hoggish attitudes, have more regard for the other fellow and if necessary, place some restrictions on our band habits and attitudes. If each of us individually attends to this problem of bettering amateur radio as a whole—then we got it made, friend. Bless that small percentage who are a credit to the Amateur Radio Service.

G. L. Baker W8GIU/5
Dalhart, Texas

I like to think it is the SMALL percentage who are NOT a credit to the ARS.

Dear 73,

The article on Operations Deep Freeze by Ralph Steinberg moved me to the point of writing this letter to you. I did thrill to the article very much as I felt to be a small part of it.

I might say that I enjoy 73 very much and part 1 of Getting Your Higher Class License was very interesting. I know of no better ham magazine at the present time.

Edward Kovalan K8AVO
Clarksburg, West Virginia

Dear 73,

So at long last the great secret is out—we now know the dead truth—the Editor of our favorite magazine really *is* a woman! Here in Europe the argument has raged fast and furious over the local natter bands as to the sex of *73's* new Editor. It was generally agreed that Kayla sounded as if it should be a woman's name, but then most *73* readers were equally sure that absolutely no feminine hand could possibly write technical articles! So, the consensus of opinion was that W1EMV must definitely be a man. And now we know . . . what a letdown for so many radio amateurs who are sure the XYL could not even be trusted to dust the shack.

Douglas Byrne G3KPO
Peterborough, England

Gulp! I'm glad you can't see the dust in my shack. . . along with bits of wire, globs of solder, and parts scattered all over the place.

Dear 73,

In the February 1968 73, W4YM asks why he gets greater difference in comparing a 2 element vs a 4 element quad on transmit than on receive. The answer probably lies in the fact that his SWR on receive is significantly higher than on transmit. I would guess the quads were tuned up using his transmitter so that the antennas were matched to his transmitter feed line. However, the SWR is determined by the impedance of the *load* and when receiving this is the impedance of the receiver input.

Line losses will also affect SWR and if there are additional transmission line losses (such as for a T/R switch) for the receiver as compared to the transmitter this will also increase the receiver SWR and impair its performance capability.

Forrest Wilcox W2CT
Yorktown Heights, N.Y.

Dear 73,

Through the medium of your magazine I would like to thank all those amateurs who handled our radio telephone patch traffic from Korea over the Christmas Holidays. There were several and one in particular I would like to thank is W7CHZ, who was so faithful in coming up on frequency daily and handled 90% of our traffic. There were many tears of joy on this side of the ocean when these patches were completed. The Commanding General 2nd Inf. Div. sent out certificates of appreciation to those who handled all patches and believe me, fellows, our hats are off to you.

Indianhead Amateur Radio Club HL9TF
APO San Francisco 96224

Dear 73,

On incentive licensing: I am buckling down, studying for that Extra and find the work and discovery is recapturing some of the thrill and fun of amateur radio. I was quite skeptical, but I think it will be a feather in amateur radio's cap for the future.

On bad operating practices: I am staggered, apalled, and aghast at things I have recently heard on 40 SSB. The saddest was malicious CW QRM of a SSB QSO consisting of pure anglo Saxon 4 letter words. I'm no prude, but conduct of this sort can be the downfall of amateur radio. Why can't these guys realize that?

The "Getting Your Higher Class License" series is a superb idea and will be a positive contribution to amateur's self improvement. Bravo for publishing an excellent magazine that is not afraid to face problems extant in ham radio today.

Doug Hutchinson KØDTK
Lompoc, California

Dear 73,

The new license program may turn out to be our salvation. Already, one can sense a lessening of the immediate feeling of resentment which followed it's inception. The human race thrives on competition and that is really all that incentive licensing means.

Robin Gaardsmoe K3UUL

Dear 73:

It is with great interest that I read your editorial in the April issue of 73 on the subject of UFO's.

Having been for several years an active investigator on behalf of NICAP in this area as well as being an active ham, you can see why your article would be interesting to me. I have kept up with this subject for about ten years and have read about everything available, both pro and con, on these objects.

I could relate many interesting experiences I have had investigating these reports, however, since that would take too much space, I can only state that having made these investigations and studying the story in depth, I have become thoroughly convinced on the reality of the objects.

A good friend, Jim Rogers, WA4UHK and myself have discussed a possible UFO net on several occasions. We came to the conclusion that it would work only if we had the backing of one of the Amateur Radio publications to get it started. You have of course taken care of that problem.

Both Jim and myself would like to throw our names in the pot to help if the net becomes a reality. Neither of us have KW rigs which would probably be needed for net control stations but will assist in any other way we can.

D. H. Robertson WA4KLT
Greenville, S. C.

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.**

★ **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 . . .**

THE KNIGHT RAIDERS VHF Club will hold its Second Annual Hamfest on Saturday, July 20, 1968 at Weasel Drift Picnic Grove, Garret Mt. Reservation, West Patterson, N.J. from 10 am until dark. The location is the same as last year. Manufacturers displays, swap shop, junque tables, contests, door prizes, and a good time for all will be the order of the day. Picnic tables and barbeque pits available. No tickets, no fee, it's free. Refreshments will be available. Talk in station K2DEL/2 will operate on 50.4 MC and 146.898 MC. Special certificate for contacting the talk in station available. For more details write K2DEL.

THE AMATEUR RADIO ASSOCIATION of Bremerton, Inc., Bremerton, Washington, will hold its annual Hamfest on May 18, 1968 at the Westside Improvement Club. Tickets are $4 per reservation or $4.50 at the door and $2.00 for each child. Registration begins at 1 pm with various activities during the afternoon and dinner at 6 pm, following by drawing of door prizes. Dancing will conclude the day's festivities. Reservations and further information may be obtained by contacting either the ticket chairman, Doug White, WN7GXL, Box 12, Belfair, Wash. or Harry Hill, W7CQI, ARAB President, 3230 Harren, Bremerton.

HEATH HA-20 Linear $79.00. Surplus BC-611 Handi-Talki $25.00. SX-42 Receiver, needs work, $45.00. New 813 Tubes $10.00@. Ampex one inch video tape, 5,000 foot reel $10.00. You pay postage. Bruce Hilderbrand, 6090 Upland Terrace South, Seattle, Washington, 98118.

ST. PETERSBURG AMATEUR RADIO CLUB, INC. will hold their annual Hamfest at Lake Maggiore Park, entrance gate at 9th Street and 38th Avenue South, St. Petersburg, Sunday, May 19. Plenty of parking space. No charge for entering Park. All Hams and guests cordially invited. This is an old fashioned Hamfest, picnic lunch, swap table, and prizes.

TEST EQUIPMENT, etc. Large variety, including H.P. 400B; Simpson 260 $30, 269 $45, 38 $30; Beckman counter #7370 10cps-10mc $650; Tetronix scope plug-ins $30 to $125; BC 659 Transc. $10. Send 25¢ for large list of test equipment, etc. Palen Electronics, P.O. Box 1536, San Mateo, Calif. 94401. Phone 341-9747.

IMMACULATE SR 160 w/dc supply and cables. $175.00. Will ship. K7HVE, 103A University Village, Salt Lake City, Utah, 84108.

HX-20 XMTR. 80-10M SSB and CW. Professionally wired by Collins Radio Engineer. Excellent condx. $110. James Demler, WØDSU, 1100 W. Godfrey Ave., Apt. 407, Philadelphia, Pa. 19141.

GALAXY V MODIFICATION KITS: Foot-Switch CW Operation, external receiver antenna jack, three extra relay connacts, and more. $15.00 pp. Write WB6NWW, 5349 Abbeyfield St., Long Beach, Calif. 90815.

DAH-DITTER ELECTRONIC KEYER . . . New integrated circuit automatic keyer. Fully self competing on both dit and dah. Built in AC supply and keying monitor. Isolated reed relay output. Completely assembled and ready for operation. Price $34.95. Order now direct from: M&M Electronics, Keyer Dept., 6835 Sunnybrook, NE, Atlanta, Ga. 30328.

WRL's USED GEAR HAS trial—terms—guarantee! 75A1—$169.95; G66B—$39.95; 913A VHF Amp.—$179.95; Apache—$99.95; HA10 Amp—$189.95; HW30/2'er—$44.50; AF67—$49.95; Ranger 2—$149.95; 2B receiver—$179.95; Valiant—$149.95; HQ100—$99.95. Low price on hundreds more. Free "bluebook" list. WRL, Box 919, Council Bluffs, Iowa 51501.

516E—1 D.C. POWER SUPPLY 351D2 Mount for Collins KWM-2 both $135.00. Excellent condition. M. Halle, 1520 Turcot Dorval, P. Que., Canada. 514-631-6676.

SPRING AUCTION of the Rockaway Amateur Radio Club will be held Friday evening, April 26, 1968 at the American Irish Hall, Beach Channel Drive at Beach 81st St., Rockaway Beach, N.Y. Come to the best Auction in the New York area. For detailed directions write to the Rockaway ARC, PO Box 205, Rockaway Park, N.Y. 11694.

FOR SALE: Lampkin 105 Frequency Meter $140, 205 Modulation Meter $140, Model 15 Teletype 60 words excellent $40, W8CJP, 11446 Lakeshore, Grand Haven, Michigan, 49417.

FOR SALE: Heath Apache TX-1 very clean, $90; also like new Hammarlund HQ170C $165. K1MWF L. J. Burns, RFD, Plainville, Conn. 06062.

ATV OR CLOSED CIRCUIT CAMERA, new, self contained power supply, video output, & 3-6 transmitter $265.00. W2MCA Rivoli TV, 287 W. Merrick Rd., Valley Stream, N.Y. 11580. 516 LO 1-8090.

LOS ANGELES AREA—Complete station—Heath SB-301 with all filters and Johnson Ranger with PTT, mike, key, manuals—like new, $350. Phone 213-323-3823.

CERTIFICATE will be issued by Henry Ford Museum to any station that works the Motor City Radio Club station, W8MRM, during the 24 hours prior to the Old Timers Night banquet. Work W8MRM on May 4 (GMT) on or near 3.663, 3.900, 7.070, 14.300, 50.178, 145.350, or 146.94 Mc. QSL for certificate. Peter Tippett, WA8VIF, Sec'y., Motor City Radio Club, Greenfield Village, Dearborn, Mich. (novice contacts by schedule.)

FOR SALE: Steward Warner 390A/VRR Recv. $850.00; RBA 15kc to 600kc recv. $45.00; National HFS rcvr. 27mc to 230mc $60.00; Heath Imp Bridge IB-1 $40.00; 50 watt 6 meter AM XTMR H.B. $35.00; model 15 teletype complete $70.00. W2ØAP J. Murray, 40-33 61 St., Woodside, N.Y. 11377.

HEATH APACHE transmitter for sale for $130. In excellent condition. Will ship. WA4ZGQ Rodney Bland, 512 Roberts St., Ahoskie, N.C. 27910.

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THE ASTRO Amateur Radio Club Swapfest Sunday May 19, Humphreys Park, Linton, Indiana. Free Lunch. No Charge. Information: Jr. Barnard WA9RUU, Route 2, Linton, Indiana 47441.

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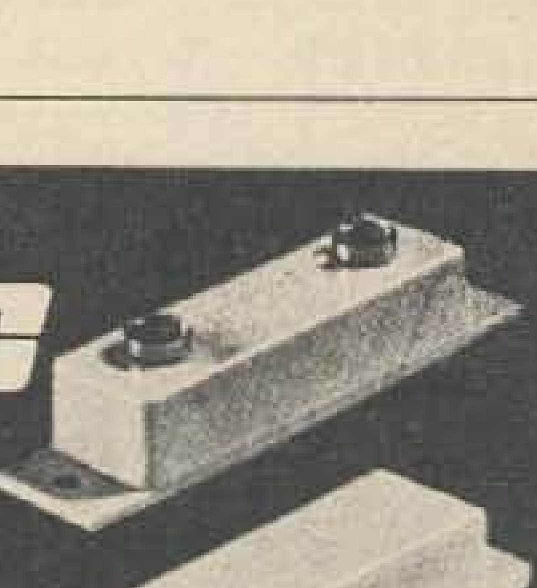

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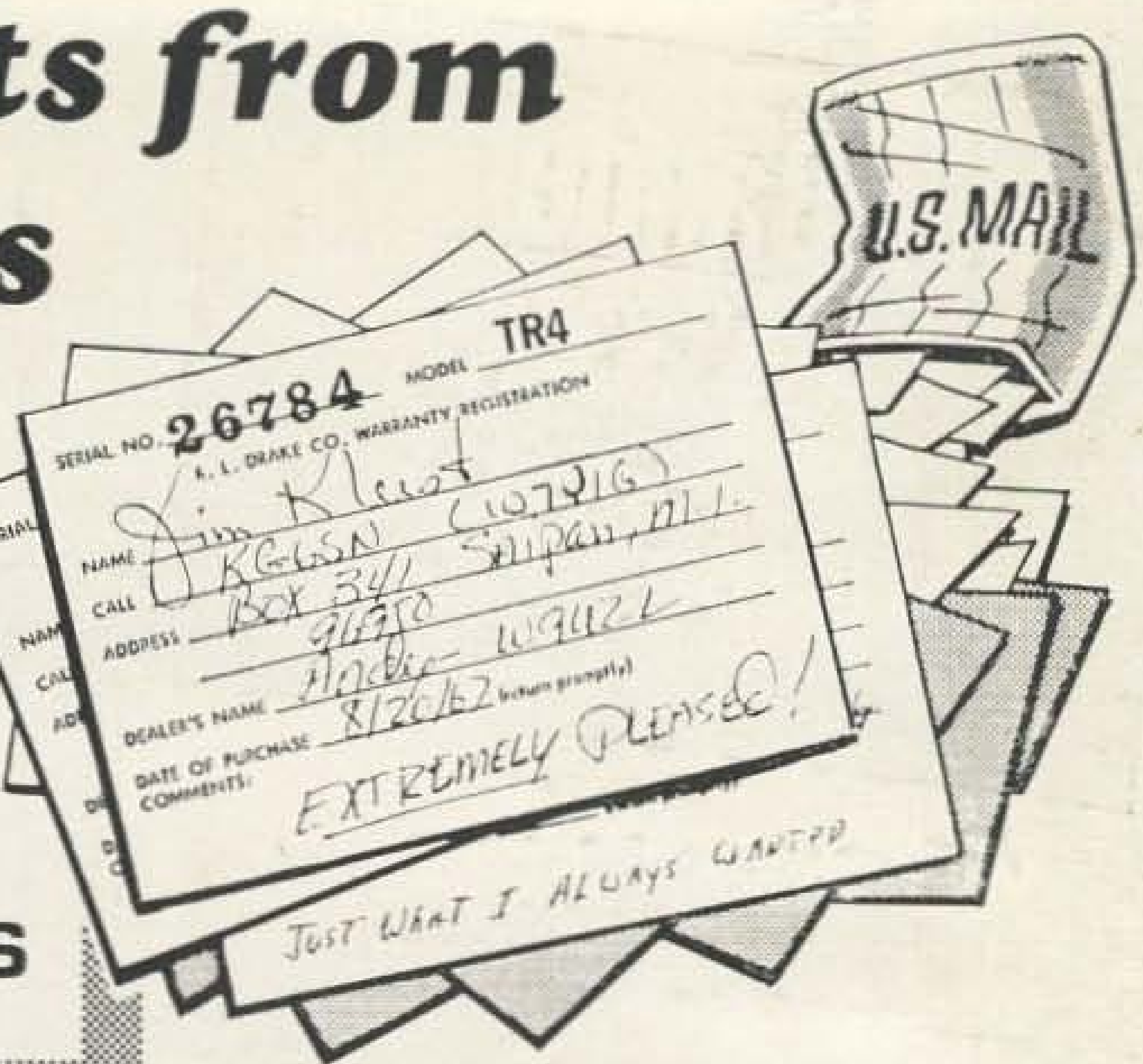
18 Pressfit Diodes to 100 Piv .....5/$1
MICRO-MUSWITCH 35A AC/DC, 10/$1
2N408 RCA SHORT LEADS, 5 for $1

Rheostat & Knob 100 ohm/50 watt 10/$5
Instant Magnetic Circuit Breaker. One Amp Xtra P.L. Contacts Protect Rig $2@ ....4/$5
Oil Cndsr 12MFD/2000WVDC $5@, 3/$10
Oil Cndsr Strobe, Photoflash 25MFD 2000V G.E./Pyranol, $7@ ....2/$10
Micro Switch Assortment ....8/$1
USN Sound Pwr. Headset & Mike, 2/$12
Bar Knobs 12/$1; RD Knobs ½"..15/$1
Neons ¼ Watt ....5/$1
Neon NE51 Type ....10/$1
VARIAC/GR 750 watt/115V@400 cys useable up to 300 watt/60 cys or lower VAC ....$3@, 2/$5
.0025 MICA/CM30/500WV ....25/$1
Daven H/Pad 600/600 ohm #950 ..10/$5
Ceramicon 30MMF/NO80 ....25/$1
Mica .033/600WV/ 1KV Test ......6/$1
Mica .0035/5KV/2.5KV wkg ......4/$1
Mica .01/500V Postaage Stamp ..25/$1
Mica .01/5KV wkg 13A/1MC ....5/$5
Alnico Magnet 1500 Gauss/25 lb. ..2/$2
Oil Cndsr 1MFD/6KV ....3/$10
Choke 150MA/10Hy ....2/$1
Oil Cndsr 2 x .72MKD/600VAC ..10/$1
Relay 115VAC RBM 3A/ND ......2/$2
Interlock SD 12VDC/1.24A & 115VAC $1
Galvonomtr 250-0-250 micro/A $2
Fast Chgr 100A/6 & 12V Rectifier $9
Batty Chgr 6 & 12V up to 6 Amp $7

INDEX TO ADVERTISERS

Some comments from warranty cards by owners of



DRAKE TR-4
SIDEBAND TRANSCEIVERS

"The TR-4 is the best rig I have ever known to be made. Glad to own one."

Dan Tangorra, WA7FWH
Tacoma, Wash.

"Finally got what I wanted!"

Ronald E. Lyons, WB2BQX
Oakhurst, N. J.

"A superb piece of equipment, no comments necessary.

C. G. Noakes, G3UHR/VO2
Labrador City, Newfoundland

"Great rig—First contact was an ON5 in Belgium."

Bill Busse, WA9TUM
Mt. Prospect, Ill.

"Best gear I have had the pleasure of working with. Receiver is exceptionally sharp and stable."

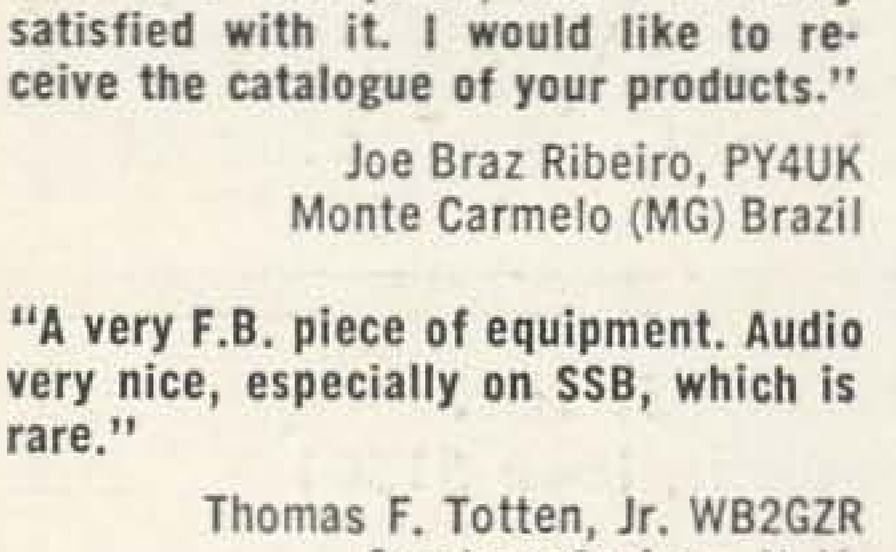
Albert V. Mitchell, WA9BUP
Jeffersonville, Ind.

"Nothing to comment, except that my TR-4 is a real jewel, and I am very satisfied with it. I would like to receive the catalogue of your products."

Joe Braz Ribeiro, PY4UK
Monte Carmelo (MG) Brazil

"A very F.B. piece of equipment. Audio very nice, especially on SSB, which is rare."

Thomas F. Totten, Jr. WB2GZR
Saratoga Springs, N. Y.



"Running it with a Mosley "Classic" beam and proves a most fine and nice transceiver. Really proud of it."

Orlando Escudero O., CE-3-OE
Santiago, Chile

"Looks good—sounds good—very well pleased with performance."

Wayne M. Sorenson, WAØETL
St. Paul, Minn.

"Have had Drake 2-B for three years. Knew that TR-4 was same Good Stuff."

Charles E. Bishop, WA8FTT
Columbus, Ohio

"Just what I always wanted."

Daniel N. Hamilton, WA4WXQ
Ashland, Va.

"Why not build a good 6 Meter SSB & AM Transceiver . . . hurry up, I'm waiting."

Harold A. Zick, WA9IPZ
Creve Coeur, Ill.

"Excellent equipment."

W. T. Newell, WB6UZU
Palm Springs, Calif.

"O.K. 100 x 100. RV-4: O.K./W-4: O.K./ L-4: O.K. Very Good!"

Franscisco Fau Campmany, TI-2-FAU
San Jose de Costa Rica

"A beautiful piece of equipment. My second piece of Drake. The first was a 2-B and this sold one friend an R-4 receiver and another a TR-4. We are Drake-minded here in town. Many thanks."

Charles E. Boschen Jr., WA4WXR
Ashland, Va.

"I'm sure this, like the other Drake equipment I have, is the finest money can buy. YOU MAY QUOTE ME ON THAT."

C. E. (Ed) Duncan, WA4BRU
Greenville, S. C.

"I'm a real happy man with it. Does a real good job of getting thru."

Jerome D. Lasher, W2RHL
Hamburg, N. Y.

"Replaces my TR-3."

D. G. Reekie, VE 6 AFS
Calgary Alberta Canada

"Finest performing gear I have ever had the pleasure of operating."

Milton C. Carter, W2TRF
Lakewood, N. J.

"PS Several months have passed . . . I now employ TR-4 as mobile unit and base station. I have logged more than 1000 contacts, many being rare DX. I am looking forward to owning a second unit to be used strictly for mobile. To date TR-4 has been trouble-free."

Milton C. Carter, W2TRF
Lakewood, N. J.

"Well pleased."

Rev. James Mohn, W3CKD
Lititz, Pa.

"I am delighted with Drake gear. This is the second of your transceivers for me. I have used a TR-3 in my car for about 2½ years—only trouble: replacing a fuse!"

Guy N. Woods, WA4KCN
Memphis, Tenn.

"Ask the ham who owns a Drake TR-4"

. . . or write for details . . .

Dept. 358 **R. L. DRAKE COMPANY** 540 Richard St., Miamisburg, Ohio 45342