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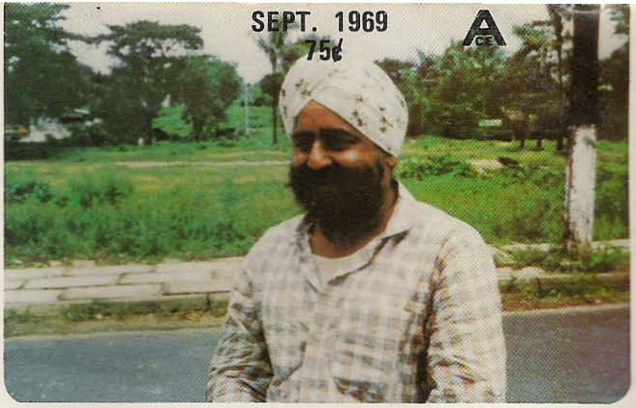

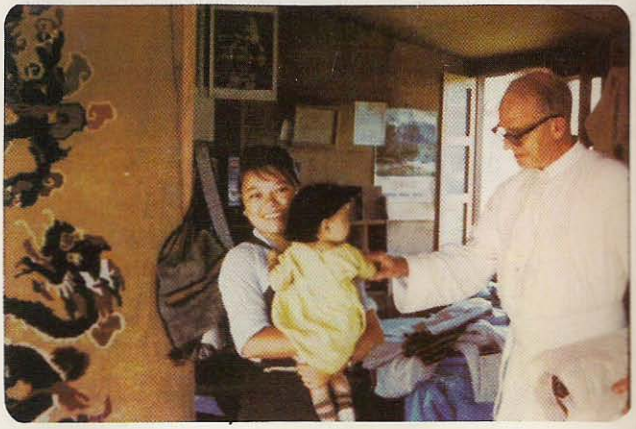

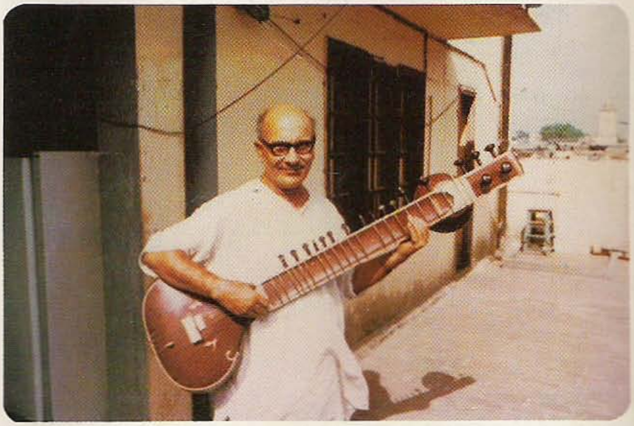

WORLD'S LARGEST INDEPENDENT HAM MAGAZINE

160 pages 160

40 FEATURE ARTICLES 40

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STERBA CURTAIN
TUNNEL DIODES
AFSK Generator
VHF-FM

73 MAGAZINE
PETERBOROUGH, NEW HAMPSHIRE 03458

73 Magazine #108, September 1969

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...de W2NSD/1

Wayne Green

Our New Magazine

Last month I mentioned briefly that we are planning to start a new magazine for debut this fall. Since we are depending very heavily on you, the readers of 73, for articles for the new publication, perhaps I should tell you a little more about it.

The idea is to put out a magazine which can be read by the general public and which will carry them on up through the Novice License. 73 is far too technical for the beginner and we are hoping that a magazine can be put out which will fill in this gap.

Remember back to when you got started in radio as a hobby. The chances are pretty good that you started out either in CB or as an SWL, depending mostly on when you got into the game. I went the SWL route myself, but I am quite sure that if I had come along during the CB era that I would have entered through that door. Both CB and SWL can be fun . . . a lot of fun. Both could, I believe, use an adult magazine to help people get more fun and education out of these aspects of radio.

For instance, have you seen any articles about listening on much more than the broadcast band or the short wave broadcast stations? What about VLF? I'd like to have readers send in articles on listening to some of the more offbeat bands . . . ship-to-shore, police, fire, CAP, doctor calling, telephone, aircraft, etc. And how about some articles on using RTTY gear for tuning in the ham bands, news broadcasts, stock market, weather, foreign languages, and other interesting services. Used FAX machines are available inexpensively now and can be used for copying Tiros directly . . . or FAX broadcasts of weather maps and other items. I think there is enough going on to provide interesting articles for a long time to come.

The beginner won't be able to build very much, so I think we should try and concentrate on telling him how to buy commercially available equipment and accessories . . . how to use it . . . what you can do with it . . . how to hook it up . . . and anything else they should know about it. This goes for all of the CB transceivers, antennas, test accessories, tuners, and gadgets, as well as converters, tuners, receivers, etc., for SWL. CB'ers want to know how to install equipment in their car and how to make it work the best possible way. They want to get every milliwatt out of their system at home or mobile. They want to know all the things they can do with their CB gear that are legal and how to avoid being illegal with it. They should be encouraged to work their way up to amateur radio if they find the need to get on the radio and talk for the fun of talking. That's what ham radio is for and CB isn't for.

Since we will be covering radio up through amateur Novice, we will be looking for articles on Novice gear and on Novice operating. I'd like to see a lot more straight from the shoulder articles which will help Novices enter our hobby with a better understanding of amateur radio. Too many of them get hung up with poor equipment which spoils their fun, just because they don't know any better than to scrimp on the receiver.

The time is already growing short and we are getting the first few issues of the new magazine ready for publication, so get busy writing and let's see if we can turn the tide and not only provide a lot more fun for those coming into radio as a hobby, but encourage them to go on to amateur radio.

If you don't feel that you have an article to write, perhaps you would like to volunteer yourself to answer questions from readers? Send me your name and address and let me know what particular type of questions you can handle in particular, and I'll list you as one of the Technical Advisory Group. Readers will be requested to send their questions to

(continued on page 66)

George Cousins, VE1TG
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Lower Sackville, Nova Scotia

A DX Curtain For 15 Meters

If you can afford a nice beam, complete with tower, rotator, coax, and all that sort of stuff, then no doubt you can get on 15 meters and enjoy all the DX you want. This article is probably not for you. But if you happen to be a Novice with limited funds or a family man who can't afford a major installation, then maybe you should read on a few minutes and see if you have found a solution to your problem with a very simple antenna that will take a back seat to no-one.

I've picked out 15 meters to talk about because it's the band a lot of beginners depend upon for their first taste of DX, but the antenna I'm going to describe could just as easily be built for any other band. As a matter of fact, I even built one for 40 meters a few years ago – now, *there* was a monster! (*CQ*, Nov., 1962).

The antenna I'm talking about is called a Sterba Curtain, named after a gentleman called Mr. Sterba who obviously liked building antennas very much. Although you may have heard of these marvelous arrays being used in great stacks by such people as international short-wave broadcasters, point-to-point stations, etc., don't be alarmed. Like many such arrays, they all start out very simply, and we'll keep them simple for our purpose.

The Sterba Curtain which I use right here on 15 meters was built from start to finish in a period of about three hours. It cost about \$5. I put it up alone, and it works like a charm on QSOs from here to Australia and most places in between. All you have to do is measure out some wire reasonably carefully and put it together in the pattern shown in **Fig. 1**. This is a simple, single-section Sterba, which is all you need to get started. Observe the dimensions: it's small enough to hang on a normal lot and needs only a couple of supports which can be very light – trees or poles because there is practically no weight involved. If you have a little extra room and would like some more gain, then you can extend the antenna by inserting more sections in between the small end sections, as shown in **Fig. 2**.

Now that you're convinced and ready to get going, let's take a look at materials. The wire is easy; just ordinary copper, about No. 10, 12 or 14, as long as it can support its own weight. These sizes should be easily obtained from any motor repair shop or electrical store. The insulators can be pieces of hardwood dowel if you haven't the proper porcelain ones, and the phasing lines can be pieces of 300 ohm twin lead or TV ladder line. The latter is best because it's wider spaced and will stand up to higher power and the rough treatment of the

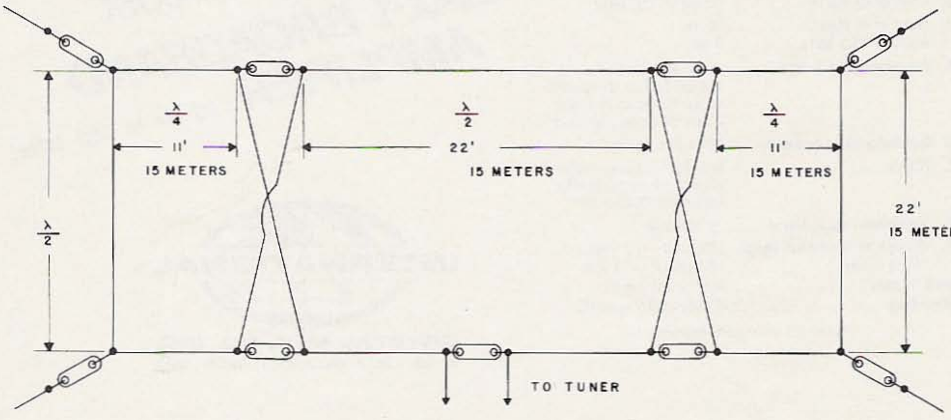


Fig. 1. Basic single section Sterba Curtain.

weather much better than the ordinary twin lead. If you have neither, then use some of the leftover wire and make your own line, using small hardwood dowel for spacers and keeping the wires from 2 to 4 inches apart. Don't forget to *transpose* the phasing lines!

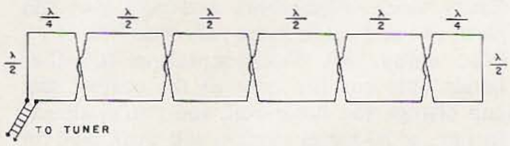


Fig. 2. Multi-section Sterba Curtain.

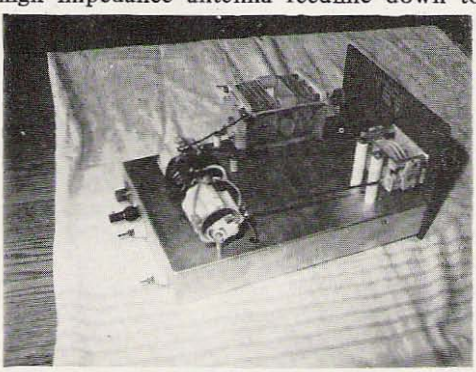
Dimensions are not critical; just be sure that all the half-wave sections are the same length, and likewise the quarter-wave ones. The feedline can be attached to either point shown in **Fig. 1** or 2, whichever is most convenient physically.

Once the thing is built and pulled up in the air, you may find you haven't much height between the bottom elements and ground. Will it comfort you to know that mine is only 5 feet off the ground? No? Well then, how about tilting the whole antenna by pulling back on the bottom element until it hangs at a 45° angle? This will work fine, will raise the bottom a few feet higher, and may even give you a little lower angle of radiation for long-haul DX.

Now attach the feedline (some more of that ladder-line stuff already mentioned), and connect it to the output of the tuner.

"*Tuner!!* Aha, Martha, I *knew* there was a catch to this yarn!"

Well, after all, you have to change that high impedance antenna feedline down to



Antenna tuner used with the 15 meter Sterba Curtain. The large split stator capacitor is connected in parallel to form C1, while the small capacitor is C2. The ceramic form is mounted firmly to the chassis, with input and output connectors on the rear apron. The weatherproof plexiglass covers have been removed for the photo.

that low impedance coaxial output from your rig, so let's not make a big fuss about it. The tuner is a pretty small item, and it tunes so broadly you can just leave it out in the yard under the antenna, and run a small coax cable from it to the rig. **Fig. 3** shows the tuner diagram, and the photo shows its construction. Just a tuned circuit for the band you're using, and a high-capacity variable to tune out the reactance of the coax line. Wind the coil on a ceramic or plastic form, and be sure to insulate C1 from the chassis and panel. The size of the

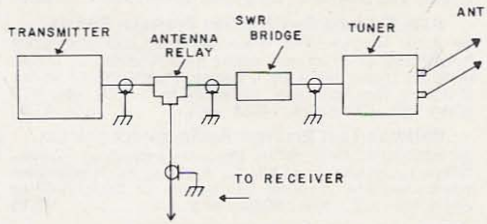


Fig. 3A. Complete set-up of tuner and SWR bridge.

capacitors shown in this tuner will handle the maximum legal power on any mode, but for lower powered rigs they can be much smaller, as long as the actual capacitance is the required value.

Tune-up is very simple. Connect the rig as shown in **Fig. 3** and feed a little power into the coax line. Resonate the rig's plate circuit, set the SWR bridge to Forward, and adjust it to a maximum reading on the meter. Then switch the meter to Reflected and adjust both capacitors in the tuner until the meter indicates a minimum SWR (lowest reading). There will be some interaction between the tuner controls and the rig's plate tuning, so be sure the plate circuit

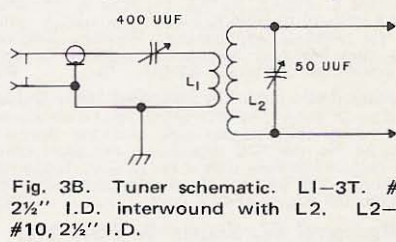


Fig. 3B. Tuner schematic. L1—3T. #10, 2½" I.D. interwound with L2. L2—6T, #10, 2½" I.D.

remains in resonance, and readjust the tuner several times to make sure the SWR is as low as possible. It should come down to almost 1:1 and will not shift higher than about 1:1.5 at any point in the band.

As a precaution against weather, I had to enclose my tuner, so I made a case out of a couple of pieces of plexiglass sheet. This can be cut and formed easily and fastened together with small bolts or glue. Even a little careful work with a propane torch will do the job, as the plexiglass will melt and the edges will weld themselves together. And it will *never* rust!

So there you are with a fine antenna which cost you almost nothing except a few hours' work (enjoyable), and now you can go ahead and catch some very fine DX on 15 (also enjoyable). For adaptation to other bands, just cut the wire to the correct size and change the tuner coil, and you're all set. In fact, a 20-meter version will work well on 20, 10 and 40, if you make an all-band tuner to go with it. Gain will be about 3 to 4 db from a single-section affair, but it'll be almost all low angle radiation, and that's the real secret of DXing. Have fun!

. . . VE1TG

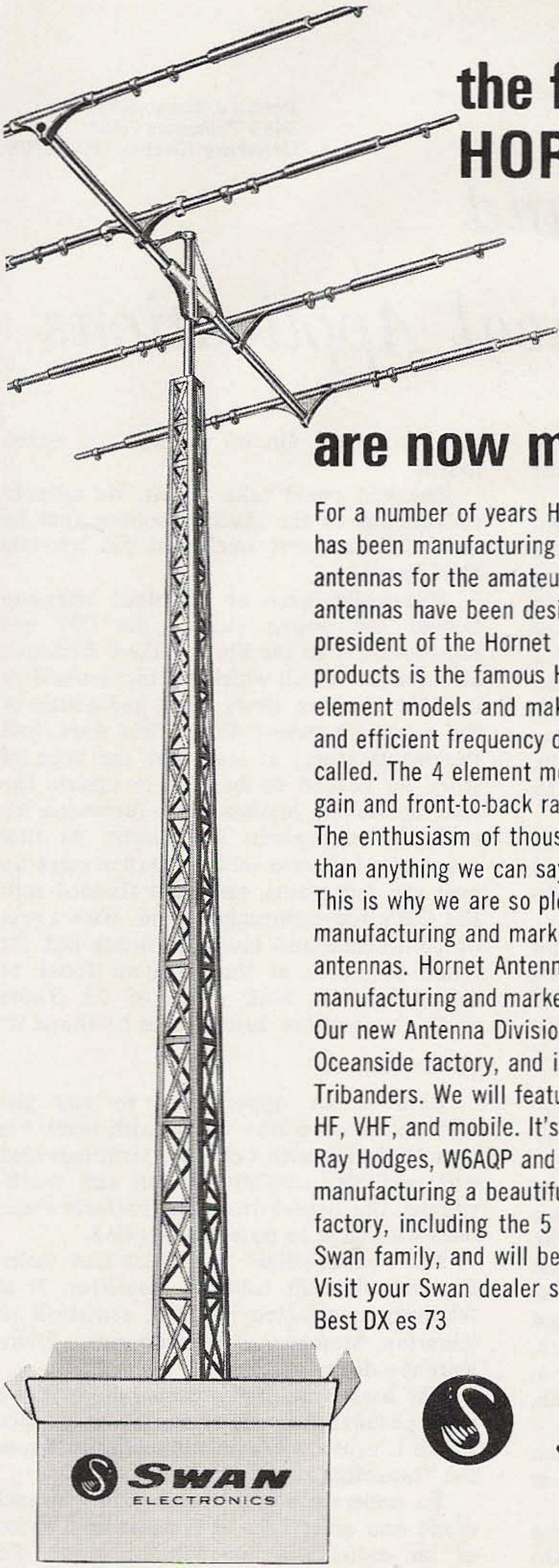
Stabilizing 40 Meters in the NCX–3

The 40 meter section of the VFO in my NCX-3 had been drifting downward and it had been difficult to have a good QSO. Sometimes it travelled as much as 10 khz. New components (capacitors and a coil), sent from National without charge, failed to correct the situation while checking the voltage regulation on the bench and in the car showed that the fault was not in that area. With the help of some new "freeze" spray material I located the trouble in the slug of the coil.

To compensate for that change in inductance as warm-up occurred I first substituted new temperature compensating capacitors of the original values. This failed to help. I next substituted various values of capacitors, each with different temperature coefficients. Soon the oscillator drifted upward which indicated that I was on the right track. After hours of trial and error I reduced the drift to about 1 to 2 kHz upward on warm-up. The final capacitance across the coil, not including the trimmer and tuning capacitors, was 150 pF NPO and 25 pF N470. I do not believe that I can stabilize the oscillator much more and I have had no more complaints of offensive drift. I pass this along with the hopes that others having the same difficulty may profit by my hours of work.

Gay E. Milius, W4NJF

the famous HORNET ANTENNAS



are now made by SWAN

For a number of years Hornet Antenna Products of Duncan, Oklahoma has been manufacturing a line of high quality, high performance antennas for the amateur bands as well as for other services. These antennas have been designed and manufactured by Jack Guest, W5AJZ, president of the Hornet company. Probably the best known of his products is the famous Hornet Tribander, made in both 3 and 4 element models and making use of Jack's patented, extremely rugged and efficient frequency dividers, or "traps" as they are commonly called. The 4 element model TB-1000-4 will equal or exceed the power gain and front-to-back ratio of any other beam built on a 24 foot boom. The enthusiasm of thousands of Hornet owners proves this better than anything we can say.

This is why we are so pleased to announce that Swan is now manufacturing and marketing the Hornet line of amateur band antennas. Hornet Antenna Products in Duncan, Oklahoma will continue manufacturing and marketing their line of Citizen's Band Antennas.

Our new Antenna Division is a 10,000 square foot addition to our Oceanside factory, and is now in production on the Swan-Hornet Tribanders. We will feature a complete line of antenna products for HF, VHF, and mobile. It's a double pleasure to also announce that Ray Hodges, W6AQP and Fred Schnell, W6OZF, who have been manufacturing a beautiful line of mobile antennas at their Los Angeles factory, including the 5 band Swantennas, have recently joined the Swan family, and will be in charge of antenna production.

Visit your Swan dealer soon, or write for further details.

Best DX es 73

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Tunnel Diodes -- Theory and Practical Applications

Dennis J. Lazar, K8TSQ
3494 Tullamore Road
University Heights, Ohio 44118

"Say, OM," said the Kid, dashing into the shack one day, "I've got a real puzzler for ya."

The OM put aside his worn soldering gun. He carefully brushed a bit of dust from the framed Amateur Extra Class ticket hanging above his bench and swiveled on his stool to face the young novice. He regarded the boy with cold, steel grey eyes while he lit his rough briar pipe. The fingers of one hand drummed an unconscious CQ upon the bench top. "Ok," he growled at last, his lips taking up the hint of a wise smile, "What's the problem? *Rf* amps? Receiver dead? Want to put up a quad?"

"It's those new solid state gadgets called tunnel diodes." The young ham leaned forward, breathlessly expectant. "What do they do?"

The OM snorted and sucked hard upon the battered pipe he held clenched between his teeth. "Why son," he exclaimed, "those varmints oscillate, switch, amplify, rectify and emulsify. and they'll do it all at once if you give them half a chance."

"Yeah, that's what I've heard," said the Kid, quivering with enthusiasm. "But how? Why? What kind of circuit? Huh?"

"Well, ah," the OM puffed sharply a few times, fell into a fit of coughing and sent a box of nuts and bolts spraying across the shack. "Dang it!" he exclaimed. He watched the Kid from the corners of his shifty eyes as he eased his bulk to the floor, calloused hands searching after the wayward hardware. "Look Kid, come back next week. As you can see, I just don't have the time. Yeah, next week I'll give ya the whole story."

"Here, let me help you." the Kid began to retrieve bolts from under the KW rig in the corner.

"No, no," the OM wheezed. "I'll take care of this. You take off. Go work DX. Go play in traffic. On 80 meters," he added hastily.

The Kid could take a hint. He sullenly stalked out of the shack, resolving that he would return next week and pin the Old Man down.

Meanwhile, even as the door slammed behind the young visitor, the OM was hot-footing it to the library where he began an intensive search which left him grumbling into his whiskers. Every book had a little of the scoop on tunnel diodes, but none told the whole story, at least not the type of story he needed to be able to update the Kid. Scratching his head and furrowing his brow, he cast about for insight. At that moment a bell rang within, the sun came up over the mountains, and light flooded into the OM's fog-enshrouded mind. With a grin of confidence and faith, he struck out for home in search of that amateur fount of knowledge, his back issues of *73*. There nestled among the dusty tomes he found it:

Tunnel Diodes

Here is an opportunity to end the mystery about a tiny device with many big uses. A device with only two terminals that will oscillate, amplify, switch and multivibrate, the tunnel diode can perform these feats with close to no power applied.

The tunnel diode is smaller and faster than an electron tube or transistor. It is relatively unaffected by heat, radiation or vibration. Moreover it is inexpensive. Prices start at a dollar.

The usefulness of the tunnel diode is due to its peculiar property of negative resistance which is caused by a phenomenon known as the "tunneling effect."

To understand the workings of a tunnel diode one must first be familiar with those of an ordinary semiconductor diode. To comprehend the latter, one must understand the atomic structure of semiconductors in general.

Atomic Theory Of Semiconductors

An atom, the basic unit of matter, consists primarily of a nucleus having a positive charge and one or more electrons, each having a negative charge circling about the nucleus. These electrons occupy orbits at differing distances from the nucleus **(Fig. 1)**.

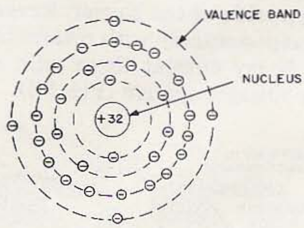


Fig. 1. Germanium atom.

Each orbit represents an energy level of the electrons within it. In other words, an electron in the orbit nearest the nucleus has an energy level or charge of -X. An electron in the second nearest orbit would hold a charge of -2X, and so on. The number of electrons and energy levels depends upon the particular element. The electrons of the inner three levels, or orbits, in **Fig. 1** are of relatively low energy and are tightly bound to the nucleus. Electrons in the outermost orbit or "valence" orbit are of high energy and are some what shielded from the nucleus by the inner electrons.

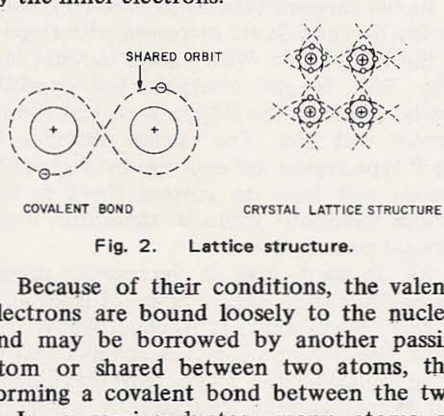


Fig. 2. Lattice structure.

Because of their conditions, the valence electrons are bound loosely to the nucleus and may be borrowed by another passing atom or shared between two atoms, thus forming a covalent bond between the two.

In a semiconductor, many atoms are bonded together to form a crystal structure **(Fig. 2)**. These atoms are so tightly packed that their individual energy levels merge to form "bands" of energy between which lie "forbidden regions" in which electrons cannot exist.

One of these energy bands is the valence band made up of the valence electrons previously mentioned. Electrons in this and higher bands are free to move about in the crystal lattice.

When an electron moves, it vacates the space that it had occupied and a "hole" remains in its place. This hole represents a positive charge equal in magnitude to the electron's negative charge. We regard it as an entity in itself however, since as electrons jump from one empty spot to another, the space, or hole, seems to be moving in the opposite direction. Thus we say that holes are positive charge carriers and flow in a direction opposite that of electrons. **Fig. 3** illustrates this effect.

In a crystal, with no external power applied, all possible vacancies in the valence band are filled with electrons and the crystal looks like an insulator. However, as energy is applied, electrons in the valence band gain enough energy to pass to the next higher energy state, or the "conduction band." To do this enough energy must be supplied to the electrons so that they can overcome the forbidden region or energy gap between the bands.

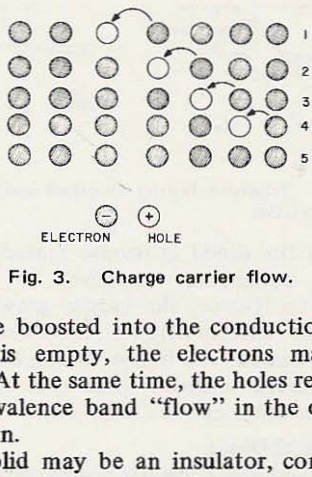


Fig. 3. Charge carrier flow.

Once boosted into the conduction band, which is empty, the electrons may flow freely. At the same time, the holes remaining in the valence band "flow" in the opposite direction.

A solid may be an insulator, conductor, or semiconductor depending on the width of its energy gap. In a conductor, there is no gap. The conduction and valence bands overlap.

The semiconductor's energy gap is small enough so that, given a boost, electrons can enter the conduction band. (0.7 electron volts for germanium; 1.1 electron volts for sillicon).

An insulator has a gap so wide that electrons cannot enter the conduction band without an extremely large applied voltage.

In semiconductor devices, crystals are "doped" to obtain specific properties. In doping, atoms of an impurity are substituted for atoms of the crystal substance. The impurity is chosen to have one more or one less electron in its outer (valence) band than the atoms of the crystal. If it has one extra, it can bond with the crystal atoms and have one free electron which can be easily excited into the conduction band. This material is known as N-type.

If the impurity has one less electron than the crystal atom, it takes one from the crystal atom to complete the covalent bond. This leaves a hole. The material thus has an abundance of holes and is known as P-type.

The Semiconductor Diode

To fabricate a semiconductor diode, a germanium or silicon crystal is doped with N and P type impurities to form a PN junction. The energy gaps on both sides of the junction are equal but the potential energy of electrons on the P-type side is higher than that of electrons on the N-type side. Thus there is a "potential barrier" between the two **(Fig. 4)**.

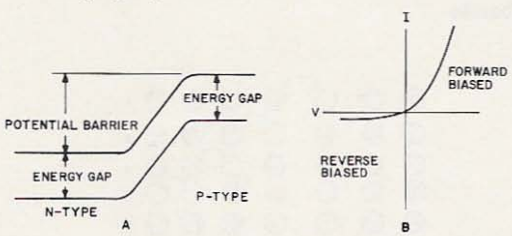


Fig. 4. Potential barrier of diode and I-V characteristics.

When the diode is reverse biased, with a battery connected negative to P-type, positive to N-type, the barrier grows larger and little current flows. However, when forward biased, the barrier becomes smaller and forward current increases with increasing voltage applied **(Fig. 4B)**.

The Tunnel Diode

A tunnel diode, unlike normal diodes, has a much narrower barrier region due to higher doping levels. This difference accounts for the tunneling effect which takes place in this device.

An electron, to climb over the potential barrier must have energy greater than that of the barrier. However, there is a possibility that if the barrier is narrow enough, some electrons will pass or tunnel through it. This tunneling effect gives the tunnel diode its name and its unique properties.

With no external potential applied to the tunnel diode, electrons from the conduction band on the N-type side can tunnel through the barrier to the P-type valence band and vice-versa. At zero bias these two currents are equal and thus balance each other such that there is zero net current flow **(Fig. 5A)**.

When the diode is reverse biased, the energy levels on the P-type side are increased in relation to those of the N-type side. Since there are many vacant energy states on the N-type side exposed to P-type electrons, a heavy tunnel current flow results from the P to N-type side of the barrier. Reverse current varies exponentially with reverse bias voltage and a heavy current flows with very small reverse voltages applied **(Fig. 5B)**.

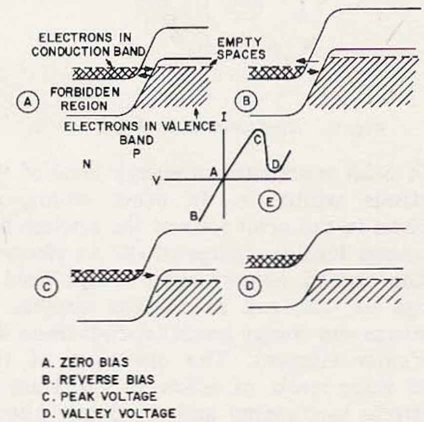


Fig. 5. Energy band diagram of tunnel diode junction.

In the forward-biased mode, energy levels on the N-type side are increased with respect to the P-type side. With a small forward bias **(Fig. 5C)**, N-type electrons are opposite empty states in the P-type area, and tunnel current will flow. The valence electrons in the P-type region are opposite the forbidden region, and thus no current flows in the reverse direction. There is, therefore, a net forward current flow.

As forward bias is increased, tunnel current increases until a point of maximum current (peak point) is reached. Above this point, the N-type valence electrons begin to move opposite the P-type forbidden zone and tunnel current decreases. A minimum value is reached (valley point) at which time tunnel current ceases and increasing forward bias decreases the height of the barrier, allowing conventional forward diode current to flow.

Fig. 5E illustrates the current VS bias voltage relationship in the tunnel diode. Point C is the peak point where maximum tunneling occurs. As voltage is increased past this point, net current drops until the valley point is reached (D). This decrease in forward current with increasing forward bias voltage is the negative resistance characteristic which enables the tunnel diode to function in so many ways.

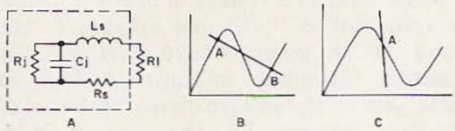


Fig. 6. Equivalent circuit.

Tunnel Diode Circuit Applications

A tunnel diode may be used as an oscillator, switch or amplifier depending upon circuit values and applied voltage. The parameters which determine the mode of operation are **(Fig. 6A)**: series resistance, load resistance, junction capacitance, series inductance, and negative resistance of the tunnel diode. These may be combined into two parameters:

$$\alpha \text{ or Alpha} = (R_s + R_L)/R$$

and

$$\beta \text{ or Beta} = (R_s + R_L)RC_j/L_s$$

The value of Alpha determines whether the diode will operate as a switch. With Alpha greater than one, the diode acts as a bistable switch since the load line intersects the I-V characteristic at two stable points **(Fig. 6B)**.

With Alpha less than one, the diode can be used as an oscillator or amplifier depending upon the values of both Alpha and Beta.

In **Fig. 6B,** it can be seen that the load line intersects the I-V characteristic at two stable points. If the circuit is biased to operate at point A and a positive current pulse is applied, the operating point shifts to point B. A negative pulse switches the circuit back to point A. Thus the diode functions as a switch. This ability is often utilized in computer logic circuits.

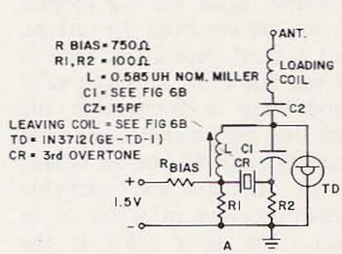
Fig. 6C shows the load line intersecting the characteristic at only one point, this being in the negative resistance region. This load line will provide the conditions necessary for the tunnel diode to operate as an oscillator. The location of the point of intersection or operating point is determined by signal swing, signal-to-noise ratio, and operating temperature range desired.

The greatest signal swing may be realized by biasing at the center of the linear portion of the negative resistance slope on the curve.

A higher current point should be chosen for high temperature operation or a low current point for best signal to noise ratio. It is thus obvious that to meet one requirement, another must be compromised. In designing a working circuit, values must be chosen which will best satisfy all operating conditions.

Tunnel diodes can operate at frequencies in excess of 5000 mhz at low cost and high efficiency. These devices are valuable as low-powered oscillators at microwave frequencies. Of course they will perform very well on any amateur radio band. For ham uses, the oscillators should be crystal controlled to prevent oscillation on spurious frequencies.

The basic crystal controlled oscillator utilzes a standard quartz crystal operating in its resonant mode across an L C tank circuit. To enable the circuit to oscillate, proper bias must be supplied such that the tunnel diode operates near the center of the linear portion of its negative resistance slope.



	C_1 =	LOADING COIL UH
144MHZ	20PF	0.1
50MHZ	2.2	0.65
28MHZ	58	2
14 MHZ	240	9
7 MHZ	900	32

B

Fig. 7. Basic crystal controlled oscillator.

In **Fig. 7,** R bias and R1 form a voltage divider which supplies bias to the circuit. With the crystal removed or the circuit out of resonance, R1 does not allow enough current to flow through R bias for a proper voltage drop to take place. Thus the diode is not biased in its negative resistance region and oscillation will not occur. At resonance, the crystal appears as a short circuit and thus R2 is shunted across R1, the total value of resistance than becoming half that of R1 alone. The voltage divider, R bias, R1 and R2 now provides proper biasing and the tunnel diode begins to oscillate. This circuit insures that the diode will not oscillate at any frequency other than the crystal frequency. If allowed, the diode is perfectly capable of oscillation at a number of different frequencies at once. Obviously this is not a desirable situation.

Fig. 7 provides circuit values for a crystal controlled oscillator making use of a GE TD-1 tunnel diode. This device operates at ± 180 millivolts (.18 volt) and draws approximately 1 milliamp of current. The oscillator as a whole operates from 1.5 volts at a current of 2.5 milliamps. This takes into account the power dissipated in the voltage divider. This circuit alone, if connected to a good antenna and keyed, will surprise you. As many QRP operators will testify, a very little power can and often does go a very long way.

A Solar Powered Transmitter

The tunnel diode transmitter is an ideal device to power with solar cells. Usually a single photovoltaic cell or perhaps two will suffice. The above oscillator can operate with the power derived from a common two cell flashlight beam focused upon a single solar cell.

Many types of solar cells are available to fit this application. Lafayette electronics lists two in their latest catalog. The S1M silicon solar cell has an output rating of 0.3 to 0.4 volts at 10 to 16 milliamps in sunlight while the B2M sun battery generates 0.5 volts at 2 milliamps. Both sell for around two dollars. As one can see from the ratings, the first cell has a great deal more current capability than the latter. In selecting solar cells, one should keep in mind that the ratings given are for full sunlight and that they may be greatly reduced should clouds appear. Arrays of cells are also available having cells wired together in series or in parallel or both. One such array is the Hoffman HSSP-2-40 Silicon Solar Module. This device consists of a number of cells, interconnected and packaged. The output of this module under full sunlight is 2 volts at a current of 42 milliamperes. The Hoffman module is available from Newark Electronics Corp. at the nominal price of $5.50.

One problem encountered in solar cell operation is that of maintaining stable output voltage. The tunnel diode, being very sensitive to bias level, will not operate above or below its proper biasing point. The light input to a solar cell normally varies over a wide range of intensities and therefore output voltage would likewise vary. To compensate for this, some means must be incorporated to clamp the output at the proper level. This is accomplished through use of a transistor as a shunt regulator.

A germanium transistor, the GE 2N404, was selected due to its sensitivity to low voltage and its low cost (58 cents).

The circuit in **Fig. 8** utilizes a solar cell supplying voltage in the range of zero to 500 millivolts. The tunnel diode transmitter must have an input of 150 mv for proper operation. The regulator circuit must therefore be capable of holding the voltage from the solar cell constant at this value.

When solar cell voltage is below 150 mv, the transistor is "off" and appears to the circuit as an open. Above 150 mv, the transistor becomes increasingly forward biased due to the voltage divider made up of the two resistors in the circuit. With increasing forward bias, the device conducts more heavily and thus appears to the circuit as a shunt resistor whose resistance decreases with increasing applied voltage above 150 mv. In this way, voltage above the bias point of the tunnel diode is dropped across the transistor and bias is held constant for all values above 150 mv.

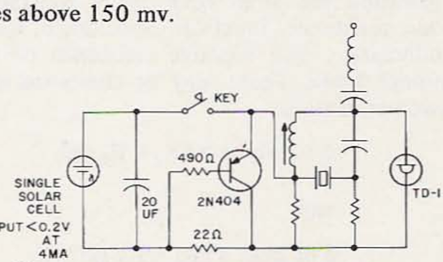


Fig. 8. Solar powered CW transmitter.

The 20 microfarad capacitor in parallel with the solar cell filters out any noise which may be picked up by the light striking the cell's surface. Fluorescent lighting will modulate a flashlight beam causing a 60 hz hum to be impressed upon the transmitted carrier.

Many interesting experiments may be undertaken which make use of modulation of a beam of light. The transmitter may be modulated in this way or keyed by interruption of the light source.

A crystal controlled tunnel diode transmitter, modulated by a transistor is shown in **Fig. 9**. Here a TD-3 diode has been used to take advantage of its higher output capability. This circuit is shown operating from a battery but it may be adapted to solar power if desired through use of a voltage clamping circuit such as that previously discussed.

The TD-3 tunnel diode draws 4.7 ma with a bias of 125 mv. Thus the input power to the stage actually used by the diode would be .58 milliwatts.

All capacitors should be chosen to be as physically small as possible. Voltage rating is not important as long as it exceeds two

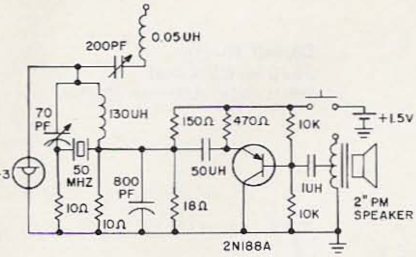


Fig. 9. 50 mhz phone transmitter.

volts. This device makes use of a bias network similar to that used in the transmitter in **Fig. 8**. Therefore it will not operate on frequencies other than that of the crystal.

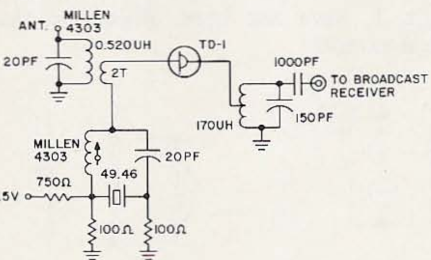


Fig. 10. 50 mhz converter for auto radio.

Tunnel Diode Converter

The converter in **Fig. 10** is of the "self oscillating" type. Using a single tunnel diode as both oscillator and mixer, this circuit will hetrodyne a 50 mhz input signal down to the broadcast band. System sensitivity is ± 4 microvolts at 1 mhz. The circuit may be operated from single solar cell power supplies and would make a fine companion for the CW transmitter in **Fig. 8**.

Needless to say, there are many devices that would benefit from the use of tunnel diodes in their design. Their low cost, low power requirements, and many functions make them a natural for the experimenters bench.

Well now OM, why not get out and buy yourself a few TDs and show the Kid that hams are not just switch throwers and knob twisters. Heat up the old iron and find out what its all about. You'll have a ball.

. . . K8TSQ

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The Magic T

If you have been disappointed with paralleling *rf* power transistors in an attempt to get more power output the magic T could be the answer to some of your problems. Paralleling transistors in *rf* power amplifiers quite often does not yield the expected result; that is, double the power output. Unless the transistors are closely matched, one transistor will usually hog the drive power while the other(s) loaf along at best. You may even experience a loss of power unless you are very careful. Moreover, if one transistor fails there is a total loss of power output. The solution: Use Magic T at both the input and output to isolate the transistors.

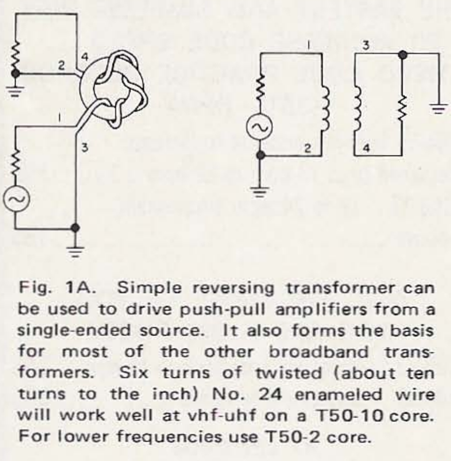

Fig. 1A. Simple reversing transformer can be used to drive push-pull amplifiers from a single-ended source. It also forms the basis for most of the other broadband transformers. Six turns of twisted (about ten turns to the inch) No. 24 enameled wire will work well at vhf-uhf on a T50-10 core. For lower frequencies use T50-2 core.

Broadband Transformers

Back in 1959, Ruthoff[1] described a series of broadband transformers wound on ferrite cores. Ruthoff achieved some rather fantastic bandwidths with most of his suggested transformer configurations. He achieved bandwidths from a few thousand khz to 800 mhz. He described several balun configurations which have been used quite extensively by amateurs and others. But, some of the other transformers including the hybrid or Magic T, have not been utilized to their fullest extent.

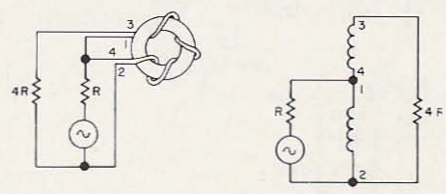

Fig. 1B. This 4:1 impedance transformer is very useful in transmitters to transform impedances. Five or six turns of No. 24 wire twisted together. See Fig. 1A for cores. As will be shown later, this transformer is great for boosting transistor impedances to a more useable level for matching.

Since copies of the above-mentioned article are not readily available to the average amateur, some of the popular configurations are reviewed in **Fig. 1** including the popular baluns to provide a ready reference.

The ferrite hybrid shown in **Fig. 1E** is a

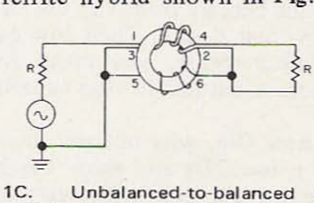

Fig. 1C. Unbalanced-to-balanced transformer (Balun) with a 1:1 impedance. The winding is the same as Fig. 1A with an extra winding to complete the magnetizing current path. For a KW balun in the 3 to 30 mhz range, wind a set of three biflar turns of No. 14 wire on a T200-2 core. For lower power requirements at vhf, use the lower-cost T50-10.

carryover from the familiar microwave waveguide Magic T. See **Fig. 2**.

Before discussing the waveguide hybrid Magic T, let's look at the general form of a hybrid as shown in the black box of **Fig. 3.** A signal applied to terminals A and C is delivered to B and D with no direct transmission from A to C or C to A. Likewise, signals applied at terminals B and D are delivered to A and C with B and D being isolated from each other.

In the waveguide hybrid, the above discussion holds; that is, a signal at 1 and 2 is divided equally between P and S with 1 and 2 isolated from each other. Also, if ports 1 and 2 are terminated, power applied at P or S is divided equally between ports 1 and 2.

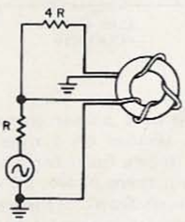

Fig. 1D. 4:1 balun. This is basically the reversing transformer described earlier. Five or six turns of No. 24 twisted wire on a T50-10 core will do at vhf/uhf. For a full gallon 3 to 30 mhz balun, bifilar wind ten turns (do not twist) of No. 14 wire on a T200-2 core.

Now, let's look at the Magic T as a power splitter. If power is supplied to port 3, it is divided equally between ports 1 and 2. The output signals at 1 and 2 have the same amplitude and phase. Assuming that ports 1 and 2 are terminated equally, there will be no signal or power output from port 4. If there is some mismatch at 1 and 2, some power will be delivered to port 4, which can be dissipated in a terminating load at port 4.

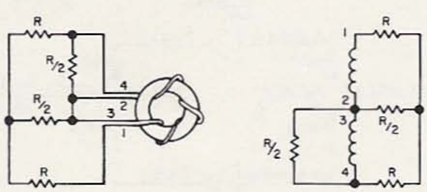

Fig. 1E. Basic hybrid or toroid Magic T. This transformer is similar to the 4:1 impedance transformer, but note that the leads are connected differently. Also, there is only 2:1 impedance ratio between 1 and 3 and 4 and 3. This is the basic device from which the power summer/divider is derived.

Signals can also be applied to port 4, in which case they again split equally between ports 1 and 2, but they are 180 degrees out

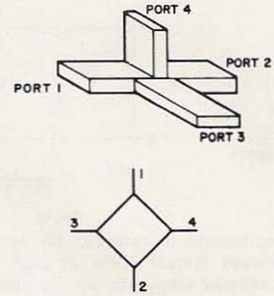

Fig. 2. Waveguide Magic T with a diagram representation.

of phase. This connection could be used for push-pull operation. The operation is just the opposite when the Magic T is used as a power combiner. If a signal is applied to port 1 and another signal at port 2, the output at port 3 will be the sum of signals at 1 and 2, and the output at port 4 will be the difference or zero. For push-pull operation, the output would be taken from port 4 where the out of phase signals would again combine in phase.

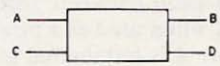

Fig. 3. General form of a hybrid.

While on the general subject of hybrids, another interesting configuration that has been used quite extensively at microwave frequencies will be covered. It's called a ring hybrid or ratrace. See **Fig. 4A.** Basically the ratrace consists of 1½ wavelengths of transmission line with taps as shown. The port numbers correspond to the waveguide Magic T, and it functions the same way as a power splitter and power combiner. At 450 mhz and above, it would be convenient to make the ratrace in printed circuit form; however at lower frequencies the size of the circle will become too big to handle conveniently. But, the ratrace can be made in lumped constant form, as described by R. M. Kurzrick, S. J. Mehlman, and A. Newton,[2] as shown in **Fig. 4B** with equations. This is a relatively narrow band device and should be designed for the center of a band. Using slug tuned forms, these devices can be made to function in the hf bands or at vhf with air core coils.

Toroid Core Magic T

The toroid core Magic T is essentially a

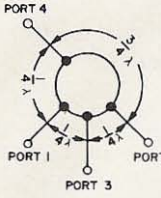

FIG. 4A

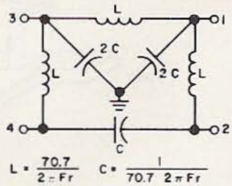

FIG. 4B

Fig. 4. Ring hybrid or ratrace. 4A can be made in printed circuit form at high frequencies. Lumped elements can be used at lower frequencies as shown in 4B which is the Pi equivalent of the ring.

ferrite loaded transmission line and is illustrated as such in **Fig. 5A**. The line lengths between points 1 and 2 and 3 and 4 represent the bifilar wound coils wound on the core as shown in the basic hybrid of **Fig. 1**. However, the practical toroid Magic T for transmitter coupling use is the one described here, because it shows the proper termination for port 4. The winding is the same as shown earlier. **Fig. 5B** shows how these windings are cross-coupled to make a four port Magic T. Bear in mind that there is a 2:1 impedance ratio between ports 1 and 2 and 3, and that when used as a power divider or summer, port 4 is terminated in a resistor of twice the resistance at ports 1 and 2.

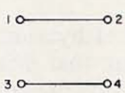

FIG. 5A

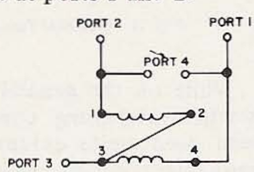

FIG. 5B

Fig. 5. Toroid core Magic T. This is the configuration that is used at the input of a parallel transistor power amplifier to divide the power and isolate the transistors, and at the output to sum the power. For broad band vhf uses, five or six turns of twisted No. 24 wire on a T50-10 core is a good start. Twist the wire about ten turns per inch.

Here's hoping that you've found your way out of the ratrace because there is one more useful power summer/divider. It's shown in **Fig. 6** and it is useful because it has a 1:1 impedance ratio which may be needed when you have the desired impedances and don't want to do any additional transforming. This device can be economical because it can be wound on high value resistor coil forms. However, it would be preferable to use toroid forms to keep losses to a minimum and to minimize the number of turns of wire.

Using the Magic T

The Magic T has been suggested by several authors as a means of connecting *rf* power transistors to get more power output to defeat the problems encountered when transistors are paralleled. The most recent article by James A. Benjamin[3] describes the

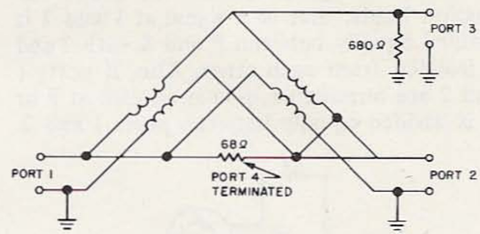

Fig. 6. Low-cost power summer/divider. Coils can be wound on 1 meg ¼ watt resistors. One device built for a special application had four turns of No. 26 wire twisted togethed on each form. This device had excellent characteristics over a frequency range that covered 350 to 550 mhz. To lower the frequency, simply add a few more turns. Also, better results (lower losses) can be had by using two toroid forms such as the T50-10.

technique very well. In fact, he describes a broadband *rf* power amplifier that covers a band from 200 to 400 mhz and it does not use any tuned circuits. Some of the material from this article is presented here in hopes of spurring interest in using these same techniques to develop amplifiers that can cover the range from 50 through 150 mhz. A general picture of how the Magic T is used is shown in **Fig. 7**. The method shown provides

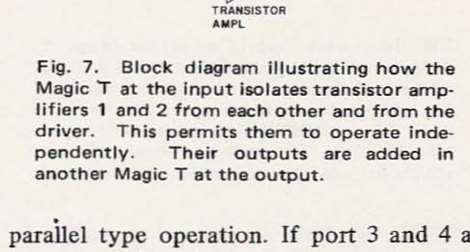

Fig. 7. Block diagram illustrating how the Magic T at the input isolates transistor amplifiers 1 and 2 from each other and from the driver. This permits them to operate independently. Their outputs are added in another Magic T at the output.

parallel type operation. If port 3 and 4 are interchanged at both the input and output, push-pull operation is achieved. This method of connection might be preferable since even harmonics will appear in phase at the terminated port and be dissipated in the resistor.

This technique is not limited to driving just two amplifiers but can be expanded by powers of 2 to the limit to your dollars. What I'm saying is that you are not stuck with rebuilding from the ground up if you want to go to more power. But, keep in mind that the driver must be able to supply enough power to drive the whole mess. See **Fig. 8.**

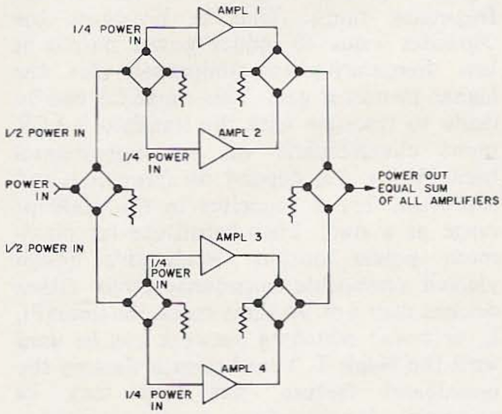

Fig. 8. Diagram representation of how four amplifiers can be combined to get more power output. The next step is eight amplifiers, then sixteen, etc.

The 200 to 400 mhz amplifier described by Benjamin is shown in **Fig. 9A.** Magic T (on toroid cores) is used at the input to divide the input power and isolate the transistors, and at the output to combine the power from the two transistors. Note that there are several other transformers in both the base and collector circuits. These are the 4:1 impedance transformers of **Fig. 1B.** Also note that there are no resonant circuits, hence with broadband transformers and the proper transistors a similar amplifier could be used to cover a wide range of frequencies: for example, 50 to 144 mhz or even 3 to 30 mhz. Bear in mind, that transistor gain decreases at higher frequencies so you are going to get a decreasing power output as frequency goes up. But this is a fact of life and you would get less power with an amplifier designed specifically for that higher frequency.

In the output, the load that the transistor must work into to develop the required power output is given by $R = \frac{V_{cc}^2}{2\ P}$

For the amplifier in **Fig. 9**, Vcc is in the range of 12 volts and the expected power output is 2.5 watts per transistor. Therefore, R is in the range of 25 ohms.

The 4:1 transformers T6 and T7 in the collector circuit step this 25 ohms up to 100 ohms which, in turn, is stepped down by the Magic T to 50 ohms. So, no other impedance matching is needed to feed a 50-ohm transmission line and antenna.

The 200-ohm resistor terminates port 4, and its value is twice the impedance at the two input ports. Actually, this resistor should be capable of dissipating the total power in case of problems. However, in practical operation, this resistor is dissipating very little power. So, you could get by with a ½ or 1 watt resistor. After all, if it does go, it's easy to replace. The devices used in the circuit are ITT Semiconductor 3TE467s which are experimental devices, however other high frequency transistors like the 2N3866, 2N3553, or 2N3924 could be used. The input impedance of the 3TE467 is 2 ohms which accounts for the double transformers T2, T3, and T4, T5 in the base circuits of the transistors. These 4:1 transformers step up the 2-ohm transistor input impedance to 32 ohms which is then stepped down by T1 to 16 ohms. The driver impedance will be higher than this, so you could probably use link coupling to step this up to the driver impedance. Most of the devices mentioned above require drive powers in the 100 to 200 mW range. So a 5

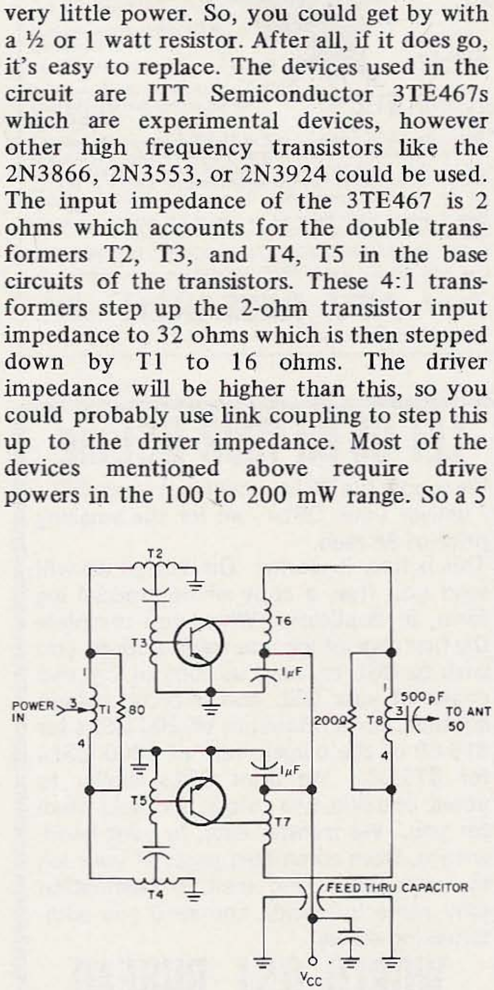

Fig. 9. Broadband vhf amplifier uses no tank circuits. T1 and T8 are the Magic T described in Fig. 5B. T2, 3, 4, 5, 6, and 7 are the 4:1 impedance transformers of Fig. 1B.

to 600 mw driver will do. The extra power is to take care of transformer losses.

Bear in mind that the input impedances of devices vary. These are specified on the data sheet. For example the parallel input resistance for the 2N3924 is about 11 ohms at 50 mhz. So, if you experiment with this device, you may only want to use one step up transformer in the base.

Benjamin used the blocking capacitor between the two base transformers to equalize power output over the desired frequency range. That is, he chose the capacitor value to reduce power output at low frequencies to compensate for the higher transistor gain. This capacitor can be made to resonate with the transistor's LCR input characteristic on an experimental basis. Value will depend on frequency and transistor. Try a capacitor in the 1000 pf range as a start. Then substitute for maximum power output. Benjamin's design yielded reasonable impedance levels. Other designs may not. In these cases, the usual Pi, L, or tuned matching network can be used with the Magic T. Tuned circuits destroy the broadband feature, but they may be necessary for matching or for harmonic attenuation. Lots of luck with your experimenting.

. . . Darrell Thorpe

The toroid cores mentioned are available from: Circuit Specialists Co., P. O. Box 3047, Scottsdale, Arizona 85257. The T50-10 or T50-2 cores are (2) for 1.00 with No. 24 wire. The T-200 core, for Kw blauns, is $2.00 each with No. 14 wire.

Please include 25 cents for shipping with each order.

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Uncle Will and News from the Poudre Valley

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Dere Mister Editer:

Our Radio Club president reported he had been hamming amongst his ham friends ever night for a week and had a sore throat from hollering loud enugh to get heerd above his friends' TV sets. The friends' TV sets kept trippin the VOX makin matters even wurse as then they doubled bout ever other transmission. Our presedent said he wasn't even shore if some of the members would recollect he was even on the air without rechecking their log, if they kept one they could read! But the good presedent admitted TV was here to stay, said he even was larning to live with it if Ben's TV could just keep it running.

We had some bad news lately with our presedent's doctor telling him he might be gettin ulcers. The doctor order him to take it easy and let the other "ham" members do more work. Our presedent sid all his members was working now, 4 was working *for* him and 30 was workin *again* him, but then they was ALL workin!

He also said him and a couple other members got out the records fer the last year to see how the work load was runnin and the record wasn't good. They showed that 15% was pushin the wagon and 85% was just ridin. It was that 85% he allowed, that mite be givin him ulcers. One of the other workin members looked at the things he had done and said he didin have no ulcers hisself but he was gettin tired blood and, after all that, he figgered he was just POOPED from PUSHIN!

Our presedent said him and the secretary decided to make another little survey to find out what that 90% of the inactive Radio Club "hams" was doing. They found 40% was pouting over somethin that had took place at an old meetin. These members couldn't recollect just what it was but they claimed they was so upset they couldn't get over it!

Another 8% was settin at their receiver keepin score on how many times some AM station would qrm them with carrier. One fellow, they reported, was keepin score by cutting notches in his mike. Twice his knife slipped and he cut through his mike cord which only made him madder. Once he waited an hour for a station to identify but then he found out the carrier was from his 100 hz calibraytor which he had left on by mistake.

About 22% was figgerin out how to get rid of ARRL. They didn't have nothin special again ARRL but getting rid of anything like that was jist one of there aims in life. Now ever club has some of them kind! It sure takes a wise ham to know when he is fightin for a principle or merely defending his prejedice.

The other 20% of the inactive Radio Club group was just being gud listeners. They wood never think of hookin up there transmitter and participating. They just sat and listened to the others.

Our Radio Club bunch sure haven't done too well lately on new gear. Out of the duzens I talked too there warn't one that has recently got some new TVI gear. I always say,

The ham who has everything
Must need ONE MORE, no doubt,
A gadget that will explain to his wife
The "junk" he cannot live without!

After comin thru anouther holiday season it seems as if we measure the *joy* of our holidays by the number that gits killed on the highways and ever year it gets more *joyful.* So please try to *drive careful* with your *car full!* I'll promise to be especial careful while driving and hammin. These summer holidays can be *murder.*

Lookin back at what I rote, I can tell you I ain't got the litterary talent nor them easy flowin werds of them writers who usually have articles in your magazine. I shore hope that you git the main message of this here letter though. So, anytime, Mr. Editer, you want to know the state of the werld and how things is goin in the ham werld, just git me the werd and I'll poll the Radio Club delegation. I shore don't rite nice, nor good, nor purty. I'm certingly not the best in the West but I am the cheapest you got.

"73" from the foot of the Rockies,
Old Uncle Will
KØDVI

Jim Ashe

Basic Soldering Outfit

Confused by all those ads and catalog entries offering soldering gear, guns, and irons? I've been soldering in electronics for the past twenty years, yet when I was researching this article I found a slightly disconcerting variety of choices. So if you think it's hard to choose the best tools for your work you must have lots of company.

The Basic Outfit

Over those twenty years I've tried a variety of gear, looking for some optimum collection. I have even experimented with soldering guns, which I do not recommend to anybody. Too clumsy and uncontrollable. By degrees I finally evolved what seems to be the best all-round soldering outfit, and the gear I'm describing here has all been busy in my private lab for something over the past five years. It's not the cheapest you could buy, but I believe it's the best investment.

Here's what it should cost you to duplicate this set, if you purchase all new materials.

Variac box, home made	$12.00
Ungar type 776 handle	1.43
Ungar type 4033 48 watt plated chisel tip	2.83
Ungar type 1237 38 watt thread-on tip	1.86
Ungar type PL-111 plated tip slightly modified	.70
Some good solder (1 pound)	3.00

Total investment in the order of $22.00. Not bad, considering everything except the solder will last many years, and the Variac box will have other uses.

The Variac Box

As the most expensive item in the system, perhaps the Variac box deserves attention first. And it is the part that makes the rest of the system thoroughly practical. The Ungar irons tend to run too hot if they are used while connected directly to the power lines, but with the added Variac box they can be toned down to just the right temperature for delicate work, or overvolted for heavy-duty cable or chassis soldering.

A 4 x 5 x 6 inch Minibox contains the circuit shown in **Fig. 1**. The Variac is the most expensive component, and I discovered Allied is selling some tiny 1-ampere Ohmite variable transformers for $8.00. And Lafayette's catalog lists a comparable transformer priced at $9.00, rated at 1.25 amps. Both prices are below the cost of my 1.75 ampere Superior transformer, and either will do a fine job of putting out the 0.5 amps or so required by Ungar's huskiest tip.

A neon pilot lamp in the input circuit avoids difficulties with indicating the variable output voltage, and the double-pole power switch is standard practice in all the gear I build. It disconnects *both* sides of the power line, an elementary safety precaution. I placed the fuse in the *output* side of the circuit because this is where the current may be greatest. I could be drawing one-quarter ampere input current to develop four amperes output current at seven volts or so, which could spoil a few turns of Variac winding at the low-voltage end. Of course that ruins the rest of the Variac, an undesirable accident completely preventable by a properly placed fuse.

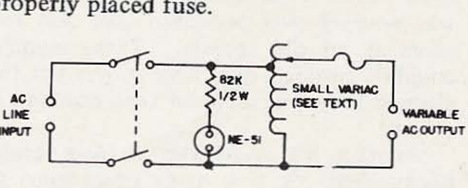


Fig. 1. Schematic of the Variac box. This circuit is a handy one to have on the bench. Be careful to respect the Variac's current as well as power limitations.

If you are using the Variac box for some test rather than soldering work, remember there's a straight-through connection at one side of the power line, and an almost-direct connection to the other. A slightly better but more expensive arrangement would have included an isolation transformer.

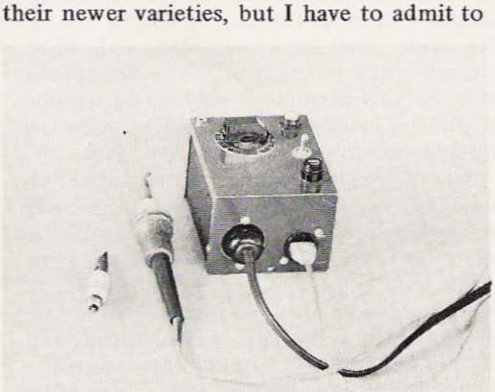
The husky ac chassis-mounted male plug appearing in the photo is going to come out one of these days. I'll replace it with a standard cheater-cord type tv connector. Everything else in my lab except a couple of instruments that require about 800 watts apiece (old vacuum-tube gear) now has these convenient cheater-cord connectors. It's nice to avoid carrying around all those cables when moving a piece of gear.

The interior layout is simple and straightforward. There's just enough room in the box for an uncluttered layout. The white wires go straight through from the input to output, and the black ones carry the circuit through the variable transformer.

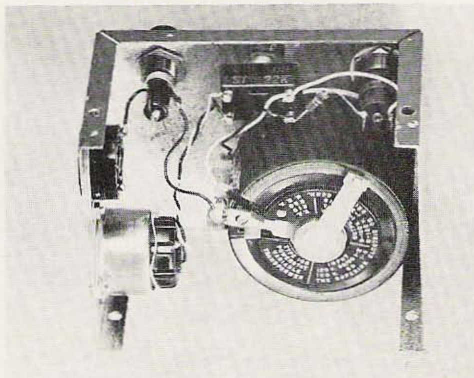
Before assembly, I cleaned the box and sprayed the upper part with dark green enamel, and the lower part with flat black. I used an inexpensive, fast-drying enamel that has proven remarkably long-lived.

The Ungar Hardware

Ungar's No. 776 handle is an evolved version of a simpler iron they started producing some time after WW2. I had one of those and liked it, although it tended to become quite hot, and the plastic gradually scorched black. Since then Ungar has licked those problems completely. The modern metal-shielded, cork-insulated handle is comfortable to use, cool, light, well-behaved and long-lived. Someday I'll have to try one of their newer varieties, but I have to admit to



The complete basic soldering outfit. Pretty simple, isn't it? Under $22 in all new parts should set you up with this, and it will last many years.



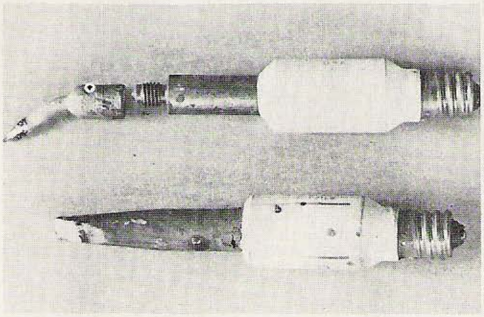
Parts layout inside the Variac box. Use plastic insulated solid wire.

a tendency to get by with the thoroughly satisfactory and less expensive old-standby No. 776 handle.

Depending upon whatever job you have in mind, you simply screw the appropriate tip into the handle, like an electric lamp bulb. If you have a heavy job of soldering or are working on large vacuum-tube gear, the type 4033 48-watt tip is very appropriate. When connected directly to the power line this tip runs hot enough to burn the solder, but at a lower-voltage setting it is extremely well-behaved. Since it is silver and iron-plated it does not have to be filed down and tinned frequently, as I used to do with the old copper irons. In fact, you *never* go at this tip with a file. It will wear out in a few years if you can use it enough, and then you spend less than $3.00 for a replacement.

When you have a heavy chassis-soldering job to do, you use this tip. Let the iron warm normally to soldering temperature, and then turn the Variac to maximum voltage. In a minute or so the iron will start to give the impression of being very hot. Shortly after this you can start soldering, and there will be enough heat to do much heavier copper cables than you would expect, or good chassis work. I have even used this setting for aluminum soldering, with messy but usable results.

As soon as you are finished, let the iron cool down to normal temperature and finally turn it off. *Don't* leave it at the high-voltage setting any longer than necessary. Some of this sounds like rough treatment, but since the iron spends most of its working hours at relatively low temperatures it seems not to have life problems. The gradual warmup and cooloff I've recommended for overvolting may have something



The two basic tip assemblies. Both have been in business for a few years in my lab.

to do with it too. I've never had an Ungar tip fail, although a couple or three have come apart after accidental very rough treatment. These tips are rugged, but are not up to being dropped onto hard concrete floors.

For light-duty work, small vacuum-tube gear, and printed-circuit wiring, use the No. 1237 heating element with a PL-111 tip. This tip comes as a straight-line piece, and after you assemble it to the element bend it to an angle of 30 degrees or so to the long axis of the iron. Take the strain on the metal part of the heating element, and bend with a heavy pair of pliers. The angled arrangement is far more convenient for soldering. This tip, too, does not need to be filed down and retinned. And as with the No. 4033 chisel tip use the Variac box to control the operating temperature.

If you don't dismantle the tip from the heating element once or twice a week you may find it has bonded itself permanently in place. Since I might want to use another tip sometime, I store the heating element with its soldering tip removed.

Soldering Hints, and Applications

I won't repeat all the stuff you find in the books (which you ought to read) and I'd specially recommend *How to Build Electronic Equipment* by Johnson, Rider Publisher No. 286. But here are a few suggestions.

Don't have any acid core solder in your lab. Use good rosin core solder, but watch out for what you find in the shops and stores open to the public. For instance, a certain very large retailer sells rosin-core solder at a very economical price. Turns out it is 40/60 solder: 60% lead. You don't want that because its melting point is about 100 degrees F. higher than the melting point of good solder.

Looking at any reel or package of solder, you should find an entry typically 50/50, maybe 60/40 or even 63/37. These are percentages of tin and lead, the tin percentage given first. Solder with more tin melts at a lower temperature, which is preferable. It costs more because tin is more expensive than lead. I use 60/40 solder for most work, which melts at about 370 degrees F., and always purchase the finer-gauge Kester or Ersin electronic solders.

When soldering, according to the books, you let the iron heat the work and then melt the solder directly on to the work. I think this advice is a bit misleading. Typically, the work is warmed with heat carried over by the *rosin flux*. Since the work is not yet warm and heats very slowly by conducted heat from the iron, there must be some flux free on the iron tip to carry the heat to the work. Next time you're soldering watch closely and you will see this. When I am soldering I place the iron against the work, and if the work does not heat very rapidly I touch the rosin-core solder to the *iron*. The fluxing causes the work to heat rapidly and as soon as I see the joint becoming hot enough to accept solder from the iron I then add a bit of solder to the work.

The iron should be warm enough that soldering proceeds quite rapidly, but not so hot the solder burns and free flux on the tip develops rapidly into crisp black flakes. Try experimental soldering at various settings and you'll soon discover which ones are best.

I haven't found anything better than heavy brown paper towels for cleaning my iron. It smells odd, but works great, and although the iron is quite hot there is no fire hazard. I start at the handle end of the tip and wipe right down to the end when necessary. Ungar and others offer special pads for this cleaning. I'm going to try one of these someday, but I've got by with the brown paper towels for some time now.

When you have some plastics or brown polyethylene work to do, use the heavier No. 4033 tip. It should not be so warm the solder softens. Once you're done with the plastics work (sealing a twin-lead dipole to its transmission line, for instance), turn up the Variac to a normal soldering setting and as soon as the solder softens start wiping the tip with the brown paper towel. You'll get strong sharp plastic odors, but the tip will clean up nicely. Apply fresh solder and you're ready for normal work again.

. . . Jim Ashe

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Light Naturally Runs Down

It is time, not Doppler recession, that causes the famous red shift of the spectrum of all the distant stellar and galactic objects.

The application of this principle to electronic communication may have a great effect on the high-speed digital transmission of computer data through space, here and elsewhere.

Even today 600,000,000 bits per second can be achieved, which could take care of several computers "talking" to each other at once.

The sentence in the Scientific American that triggered the writing of this article.

On page 58, third column, February, 1969, we find the following, written by V. L. Ginsberg, of the U. S. S. R., speaking of quasars. ". . . not one of the approximately 1000 Quasars so far observed shows a shift to the ultra-violet that would indicate motion towards us."

Many times I have read about the red shift of light from distant sources, from which the "Big Bang" theory was evolved. According to this one, every island universe, galaxy, star, quasar, pulsar, what-have-you, is receding, each from the other, including us. It is a possibility, perhaps, but one which never appealed to me at all. Now of course Doppler shift does most certainly exist, but there is another possible explanation of this red shift that is found to increase in direct proportion to the distance of the source from us.

This is the theme and purpose of this article, a possible explanation of how light can slow down (not in velocity, although it might do that too, over a long period of time) and increase its wavelength. This slowing down, once again, concerns its rotation as a three dimensional blip of energy, whose shape is yet to be determined. Maybe a flat spiral?

Introduction and philosophy of this article

There is a possible explanation of how light can "run down", which is detailed below. It also shows why these same light waves act like particles. They have to; they're shaped like particles! As the title suggests, light naturally runs down, not in velocity, not in frequency (it hasn't got any!) but in rotation, which causes the size, and therefore the wavelength, to increase.

I can imagine, so far, no mechanism whereby it should speed up, but have for years been working on one whereby it may slow down. Not in its travel through space, but in its "rotation," which is accompanied by an increase in wavelength. I am repeating here for emphasis. It just takes a little more *time*, measured in light years, and does not require any Doppler caused by motion. Doppler shift can occur also, of course, but the large red shift found on all distant objects had nothing to do with Doppler, which is another subject entirely.

In this article we will bring to bear on the subject many ideas and facts which, after study, will be seen to be very pertinent. The application to "radio" transmission will also become apparent.

Waveshape

Anyone having experience with fast timing in electronics during the past thirty


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or so years knows the importance of the shape of waves, even if only in two dimensions. Pursuing this a little further we come to, or rather approach, the "infinitely short pulse". This, as the old German professor used to say, "Ve don't got", but we can get pretty close, as will be seen.

Plunging right into the intriguing world of electromagnetic pulses which are extremely short in time, **Fig. 1** shows a "multi-barrelled" graph of certain parameters which will help you break away from the much too narrow concept of only sine waves and frequency, useful as they have been and may still be, for certain special cases, and lead you into another more generalized world where the three-dimensional shape of a wave is very important.

After all, how can a single event have a "frequency"? Fourier said that any pulse can be resolved into its component frequencies. In the sense that "it is possible to divide time into smaller lots of time" this is true, but blind following of his work, great as it was, with "sine waves only" has unfortunately served to obscure equally important possibilities of work with "non-sine-waves," as will be shown. This work covers the entire left side of **Fig. 1**.

A single event, by definition, cannot have a "frequency". If you attempt to chop it up into "component frequencies," you are not dealing with the original event, and you are certainly practising obscurantism, even if unwittingly. If you grind a stone into molecules it no longer falls, but drifts away on the breeze. It is, of course, no longer a stone and doesn't act like one. It cannot truly be said to be "Just a matter of size or degree."

Single electromagnetic waves are present all over the world as lightning, etc. Such single waves can bounce back and forth in space or on conductors or filters and *acquire* a frequency by so doing, but that is not necessarily *its* frequency!

The action of filters has been dealt with at great length through the years, but please do not neglect the preceding sentence.

Features Shown On Graph No. 1

1. The entire left side of this graph is still mainly unused by engineers today. It has however had immense usage by "Nature" for millions of years. This is the region of heat and light waves. The time duration of the photon has not yet been directly measured, other than to say that it can be obtained using the velocity C and the wavelength of light.
2. It is interesting to note that the work with Lasers moves to the right on the graph, increasing the "time on the air", and the frequency precision. Naturally, hasn't everybody been brought up on sine waves?
3. Even with today's crude methods, information can be transmitted through space at a rate of about 600,000,000 bits per second, by operating on the left side of this graph.
4. The need for "frequency bandwidth" of course disappears on the left side of this graph as we enter the domain where time reigns supreme. Each event, photon, single electromagnetic pulse, digital bit, or what have you, is a single event. There is no need, nor any utility, in considering frequency while on the far left of this region.

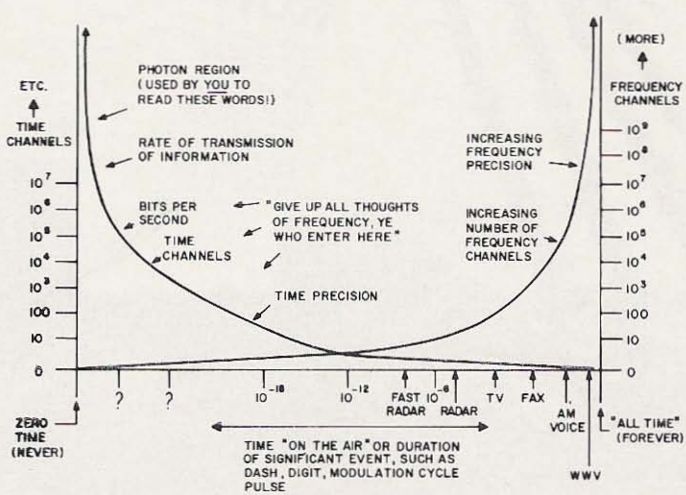


Fig. 1. Graph No. 1.

5. By the following means "noise" can be reduced in time channels in the same fashion as is done with frequency channels. Any one time channel is "open" for a very small amount of time. In a way this can be considered the "reciprocal of integration," and just as useful.

6. One example of the use of this graph; Use two transmitters, one operating on the far right of the graph as an excellent clock and only as a clock, the other on the left side as the "bit sender". Transmitter A sends precision timing using a highly stable crystal controlled microwave signal on, for example, 1,000 megacycles. Transmitter B sends one bit every nanosecond, timed by A's clock. At the distant station, Receiver A sets up the clock based on transmitter A. Receiver B is turned on by clock A, and receives the digital information through the nanosecond gates.

You can't say much that is meaningful in terms of frequency about a single wave of this nature, except that it "spreads from here to there" in frequency. Belaboring the point because of most reader's training in Fourier's analysis, with, I believe, no corresponding studies of really short pulses, like 10 to the minus 18th, getting into the photon region, to say it has a "bandwidth", which to most people means frequency bandwidth, doesn't really say very much about the wave as yet.

However, if you speak in terms of time bandwidth and time filters (narrow time gates), and use something handier than the second which is very "gross" for this work you can begin to define these waves, (photons, small, large, and giant) with great precision. You can see here, of course, the action of Heisenberg's famous uncertainty principle working right in front of your eyes. The closer you measure a wave in frequency, the more time it takes. The closer you measure it in time, the more frequency it takes. Real simple, right?

It doesn't matter very much in time whether you listen to WWV for two hours or for three, and it doesn't matter very much in frequency bandwidth whether you say 20 GHz or 30 GHz.

This relation is trying to tell you something, if you will open your mind a little. As a clue the photon is caused by an electron changing its energy level. Well, didn't we agree above that for a conductor (obviously full of electrons) to radiate you touch it with a battery?

This whole subject region is of course way out on the left side of graph no. 1, and as such is strictly in the time domain. Just forget about frequency while you're over there.

It just happened that someone (I think perhaps Fessenden, but Lodge had some claims way back nearly one hundred years ago), first put an inductance in the line, or across it, thus setting up resonance. This allowed the use of two stations at the same time in the same town, which was most ususual for those days. And so we inherited frequency separation for our multitude of broadcasters. Time division could have given us an equal number of stations but no doubt an equal number of problems; all different!

All of this is leading up to the third dimensions of the photon, the one which causes it to "look" and "act" like a particle. At times, that is!

Oscillators are not needed for the generation of electromagnetic waves

Light and radio waves (that is once again electromagnetic waves), are fundamentally generated by a change in voltage, or current, or both. Because, although a battery may just sit there with positive voltage on one end and negative voltage on the other, no event really occurs until at least one electron is moved; then you have a current. If a conducting sphere, in space, is touched by one side of a battery and then by the other side, radiation will take place and travel outward at the velocity "C". It will do the same if touched by an electron and then by a "hole".

A copper sphere radiates some eighty percent of an electrical energy distribution on its surface in the first half wavelength. It is the world's fastest radiator, has the worst

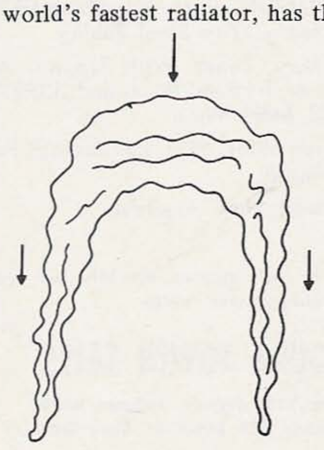


Fig. 2. Vortex wave grazing on water.

"Q" known, and if properly treated, can serve to radiate and transmit right now, even with crude methods, some 600,000,000 bits per second of information through large amounts of space every second. Takes care of any information several big computers can handle simultaneously, too!

We are getting warm now, on the basic subject matter. We just need to find a small enough sphere to radiate those small light wave pulses. What's that you say? The molecule or the atom, or the nucleus? Sounds possible. We will need a real wave, but one that has a *3D shape* like a particle.

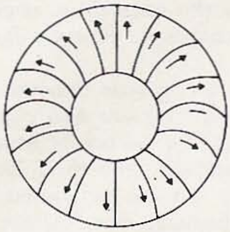
A wave already exists which is constricted in three dimensions, even four if you count time also.

But, you say, "all waves spread out as they travel". That's what you've been taught, so that's what you believe. Who are you to question your "betters", the Great Savants who proved that light consisted of waves, and the other greats, like Einstein, Planck, and Bohr, to name a few, who proceeded to prove light was composed of particles? Now just a minute, aren't the above contradictory? Yes, of course, and then they were also combined (partially) by the Nobel prize winner Prince De Broglie.

And so it has gone on, perhaps needlessly, for there has been in existence for untold decades, a type of wave that *has* the *shape* of a *particle*. It even has a name! The vortex wave. True, it is a sound, or shock, wave, and sound waves require a "substance" in which to propagate, such as air, water, or a solid. But supposing and here comes a great big supposition, we simply investigate this sound wave as a starting model only, for an electromagnetic wave to work on later? Don't forget sound waves are also taught as "radiating in all directions".

My first meeting with the vortex wave

In my youth we lived on an island in Maine every summer and I used to go a mile and a half over to the mainland every day to get the mail. On clear calm days with a slight swell running our one-lung Captains boat pow-powing away, the fourteen minute trip was a great pleasure, with time to relax and watch things that were happening. One of these was the exhaust from the old five horsepower make-and-break engine. It fired several times a second and the blast was released through the exhaust vent, on out through the muffler (which I believe had no "insides" left), and on out through the two inch pipe, positioned horizontally out over



DIRECTION OF TRAVEL OF WAVE IS OUT OF THE PAPER.

Fig. 3. Doughnut wave phase diagram.

the water. When the 22 foot dory rolled slightly at an angle just under the horizontal, a peculiar phenomenon occurred. An impression was created on the still surface of the water anywhere from 25 to 100 feet out, with every exhaust blast.

This impression, shown in **Fig.** 2, occurred with a slight delay which I associated with a sound wave. I found out later it was the mark a vortex wave makes on hitting the water at a slight grazing angle, the doughnut shaped wave standing up vertically as it hit the water.

Later vortex waves

Working as a member of the Technical Staff, Bell Telephone Laboratories in New York in the late forties, was a considerable inspiration. One which encouraged me to pursue my studies of fundamentals, and helped to make me think deeply about electromagnetic waves in particular, even though H. S. Black, inventor of the feedback amplifier, said to me, "You must think, write, and talk rigorously here at Bell".

These studies led me to wonder more and more about the famous controversy over the particle-wave question, and to investigate the generation and propagation of the vortex sound wave as a class of non-spreading waves that perhaps could be used to imagine an electromagnetic wave of similar character and action.

Generation and mechanism of the vortex sound wave

Boxes with small round holes in front were pounded on the back with a hammer and these indeed generated nice vortex waves. Satellites, space ships, and other things entering our atmosphere also make nice ones. They have a name too; *"sonic boom"*.

These boxes were filled at times with smoke, and very fast-travelling rings were blown, as well as quite slow ones. Note that shock waves can travel at all kinds of speeds, such as the Bikini shock wave was that travelled at *many* Mach numbers. With these smoke rings, the mechanism of the ring, its slowing down in frequency (rotation) as it travelled, the rotation of the smoke particles following the wave motion around the doughnut shaped ring, their rotational phase-change of 360 degrees around the ring, and their generation by the round exit hole of the box could be seen by the eye. Each particle rotated, travelled around the cross-section, and the ring as a whole travelled forward. Perhaps, if you are old enough, you remember the Flettner Rotor-Sail Ship? A cylinder, or sphere in a slipstream (gas or water) which, perhaps due to its own motion, or that of the medium, or both, is subject to a force at a large angle to the direction of travel. This causes each particle to move sideways, as it travels ahead, making a spiral relative to the previously undisturbed medium; air in this case.

The doughnut shaped ring of smoke has a fascinating stationary metallic toy equivalent known as a "Slinky", which is a flat spring that can be curled around and have its ends joined. Then if you rotate the metal around the cross-section you will see the "phase" go 180 degrees out opposite your fingers and magically come back in phase again. See **Fig. 3**, which illustrates both the Slinky and the smoke ring.

Slowing down in rotation

Naturally, the smoke ring particles slow down as they travel through the molecules of air, as does the force-wave associated with these particles. Also, the cross-section gets bigger, the doughnut gets bigger and its forward travel slows down. Now, of course, the force-wave itself is the generator, and the particles were only put there to render the wave visible, which they do nicely.

The electromagnetic vortex wave

The great Maxwell said that there was a "medium" for electromagnetic waves. He confidently assumed other physicists ("Natural Philosophers") would discover this. But, as you know, they did not do so, and, one hundred years being quite a time to wait, it became unfashionable to talk about this "aether." After all, if you were unable to find it, even though you know a wave has to have a medium, and being a professor you *had* to teach something, the only thing you could do was to make it an "out" thing and stop talking about it. Maybe then people would stop trying to make you admit you didn't know. You can also fall back on the excuse that the only thing needed is to be able to measure it. Pretty slim pickin's, I think.

Now let us suppose that the light waves, or quanta, as they are also called on alternate days of the Advanced Studies Group's week, are actually something like the vortex wave. They can be generated by a phase delay mechanism, but, before that, they cannot be other than a single event. This fits fine. The non-phase-coherence of *unfiltered natural* light waves (sunlight for example), is a fact.

The single wave (the shock wave as generated in the box), allows the wave to fold on itself, as can be seen best in a glass smoke ring box, so that the doughnut shape is formed, travelling forward, with everything nicely in phase in that *single* little energy-packet-wave itself. If you try to make the vortex wave out of a continuous wave motion you will fail.

Still, supposing that we succeed in making, by means which I propose to use later, a somewhat similar type of electromagnetic wave. What will we have? It probably will travel at the velocity C, at least at first, unlike the vortex wave which can go at Mach N when first generated by a hydrogen bomb.

Due to an entirely *different* medium being used, not only in our atmosphere and in Space, but pervading even the atom itself and probably the nucleus too, our electromagnetic vortex wave will rotate (spin?) (1/2 spin?) at a rate which will be very fast, dependent on its size, like gamma rays, X-rays, blue light, red light, etc., as this size increases.

This length may be seen to be the size of the "doughnut" or whatever shape it may turn out to have, (perhaps a varying one?) as it goes by or impinges on something, such as a photo-electric surface, for example, at the velocity C. Although it may not be shaped like a doughnut at all, it *will* be confined in three dimensions.

A wave of this type also needs quite a special type of detector, and would quite naturally need to be small in order to knock one photo-electron out of an atom. I have imagined a detector for this type of wave (the giant photon one) but it doesn't look like an atom. Or does it? What does an atom look like anyway? It was Lord Rutherford I think who said, "You will never see an atom". Maybe so. And then again, maybe not so!

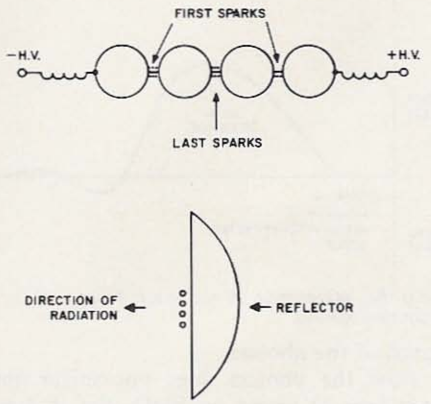


Fig. 4. One of Marconi's first radio transmitters.

The light wave gets *bigger* as *time* goes by

As the photon-lightwave-particle doughnut wave travels through space and through the medium which after all *must* be there in some form or other, even though the mind of man has not yet actually "put his hand on it", it may well act like the vortex wave model in several respects and slow down its rotation (or whatever it is doing to keep itself together) over a large number of years at least, getting bigger as a result of that medium having *some* friction, however small this may be.

This will of course increase its wavelength, making a "red shift." Don't forget that it is a unique, single wave, or event, and therefore not having any frequency, as far as a continuous collection of waves following each other is concerned.

As we go by here in sort of a rush (after all this is an article, not a book) the particle-wave controversy may be cleared up once and for all.

Time division versus frequency division and the uncertainty principle, as they apply to the photon and radio waves.

In our present era, frequency division reigns almost supreme but it was not always so! Marconi's first transmitter was the "four-ball" type, which was that of his teacher, Professor Rhigi, who followed Hertz' model, as shown in **Fig. 4.**

In this system the two outer balls charged up, then discharged by spark, over to the two inner balls which then proceeded to generate a spark between themselves, and the two outer balls then disconnected themselves automatically by quenching their sparks as the voltage dropped.

Note the absence of inductance, other than the copper surface of the spheres themselves, and remember that a copper sphere radiates some 80% of its energy in the first half wavelength. There is not much point in calling it half a cycle as the event is almost over by then. **Fig. 5** shows an approximation of the waveshape, as drawn by some of those lads in the last century, one of them being Sir Oliver Lodge, who was quite aware of the time duration involved which was a few picoseconds (10 to the minus 12th sec.) even in the absence of such things as Tektronix or H. P. scopes!

Being considerably versed in optics, they measured it by the use of interferometers and, of course, in a wave as shown, there is little to interfere with! But the interferometer will, and did, draw the waveshape nicely for them, even if only in two dimensions.

Into the realm of pure conjecture
The Electron.

Let's really delve into things a little. I have never read anything about the shape of an electron, other than it is not known. Even though some learned types of people say that, "it is useless to inquire into such a thing," this still doesn't satisfy me. It has mass, probably of electronium, and can thus stand still, which is impossible for a photon. It is the basic unit of electricity, at least so far as is known today. It still suffers tremendous confusion with something called "current" because our learning and teaching suffer even more from tradition and authority. The chief engineer of a large and prosperous, tube plant, which shall be nameless, was, due to this "training", unable to think of the difference between the electron flow and wave flow in and around the very good (but limited) tubes made by his technicians.

Both Faraday and Maxwell studied and wrote, in quite a different style of course, about something they called "displacement current", which left the conducting metal and jumped across the intervening space. This "thing" is of course electromagnetic energy and travels at the speed of light. I expect it would, being emitted in quantum style and thus made up of photons!

But the slow-poke electrons, according to Einstein, and everybody else too, never reach the speed of light. Indeed, in these tubes they suffer badly from transit time. Not any more so of course, than those of any other good manufacturer.

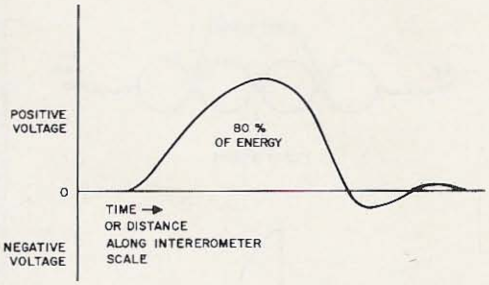


Fig. 5. Waveshape of radiation from a conducting sphere.

Speed of the photon

Now the photon does not suffer much from lack of speed on Earth but it does a little when you talk to someone on the Moon, and a great deal when the day comes you would like to talk to someone many light years away. The photon travels at a velocity known as a "Universal Constant" which has been given the name "C"

As emitted from its source, such as molecules, atoms, nuclei, moving electrons, etc., and measured *nearby,* this velocity appears to be quite uniform. But, has anyone measured the velocity of a photon arriving on Earth from, for example, a quasar after travelling through the quite far reaches of space? Just a question for the astronomers, really.

The shape of the photon.

What shape does the photon really have? Well, I think this is a good question, and one which I will keep asking for a while anyway. The wave people saw a plane wave spreading out in all directions transverse to the line of travel from the origin. Of course they couldn't account for the photoelectric effect this way. The particle people (sometimes the same people but on a different day of the week) saw a little blob of "energy" but could not account at the same time for the positive wave-like actions of the photon under other test conditions. De Broglie became famous for his predictions of the waves associated with particles having mass, such as the electron. He still did not solve the whole problem by a long shot. There remained the "model", or "shape" of a wave that is restricted in three dimensions and does not spread out much, but does a little as time, quite a good deal of it (like lots of light years), goes by.

I am so sure of this that I am writing an article about it. *This* article! I also think (although of this I am less sure), that I may know how to make a "giant photon."

Probably other people do also, which may well account for the pulsars. Maybe I'll get time to do it later, with help.

Requirements for a wave that does not spread out

Several requirements for a wave that does not spread out are listed below, starting from the consideration of the wave we already have, the vortex sound wave that is restricted in three dimensions.

1. It must be a single wave. A single event. Generated, radiated, and done with. You can send another one pretty close after it maybe in the next ,nanosecond but they must *not* be connected, and it is immaterial whether the second one is there or not. This makes it pretty nice for digital transmission of course! To be sure of this check up on the vortex wave you can make in a glass smoke ring box and radiate from it.
2. It must then, as a single wave be subjected to further treatment which will cause it to rotate on itself. Watch that smoke ring closely! It does this as it goes forward. In the electromagnetic model this rotation may be some form of repeated action (frequency?) which may be a type of action completely unknown as yet . . . Perhaps a rotation or alternation of its *internal fields,* possibly a spiral effect.
3. It must do this at the speed of light, which should be easy. It *is* light, and in a medium of which we know *naught*! We have drawn a blank there; Maxwell described some of its properties but no one has been able to "find" it so far. Maybe we amateurs

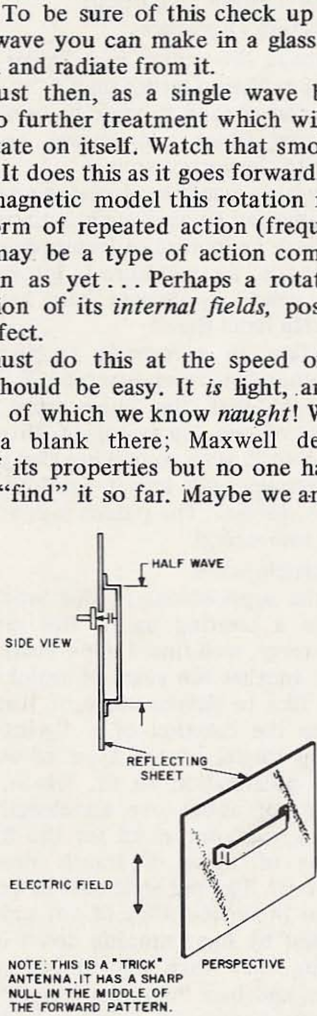


Fig. 6. Horizontal dipole which is vertically polarized.

can find it while the main crowd of physicists rush madly on with their thirty to forty "new particles" found in the supposedly tiny nucleus.

4. It must, when generated and travelling outward at the speed of light (which it is!), at the same time, be subject to polarization.

End of list of requirements, so far. There may well be more. Number 4 does not mean the type of polarization accomplished by optical workers, who pick out those photons polarized, for example, vertically, and then throw away those which are polarized horizontally.

This polarization describes the "electric field" as opposed to the "magnetic field". We are getting pretty close to real fundamentals now, so we have to watch words closely. After all, new theory many times requires new words, which goes "against the grain" (of thought) with some people, who credit themselves with a sufficient vocabulary to describe anything they can think about. Don't worry about this matter though. We are all groping in the dark here, I believe.

Polarization of the photon

This has always been a real tough subject. Not so bad in radio, where you can put a dipole sideways and be sure you are horizontally polarized. Even here you have to watch your step though. The dipole shown in **Fig. 6**, whose length is in the horizontal plane is nevertheless polarized vertically! Try it sometime!

But this photon now, how can it have a polarization? A little slug of energy moving out at the speed of light. How can it be polarized? Well, we know it does have such a property so we have to live with it. As far as I know, no one knows how to *emit* light which is polarized in one plane only, as is done in radio. This probably stems from, at least so far, an inability to "arrange" an atom so that it does emit polarized light. Quite a job I would guess! Still, some people are achieving remarkable minute maneuvers today like showing pictures of bacteriophages which are only a few atoms long.

Of course it would help a lot to know the shape of such things as atoms and photons. Maybe someday. Maybe the "giant photon" I'm proposing to build could help.

This question of polarization, to me, is the hardest part of the whole deal. At least I'm in there trying!

The medium

This "ghost," this "spectre," is always in the background, making physicists unsure of their work at times when dealing with light, remaining a bad question when leading electronic engineers are asked about it by juniors.

Personally I'm not afraid of it, but so far I haven't made much progress in dealing with it. I believe there is a "medium" but, in common with everybody else, I have no concrete ideas about it. I can only hope at present, that my ideas on the 3D wave as proposed in this article may suggest *something* (anything!) useful about it, and make it a little less an "out" subject and one which becomes a little more an "in" one.

There must be *something* there! So the photon is a "travelling, alternating, field". See you later on this, I hope.

Speculation on pulsars

Perhaps the pulsar is a "giant photon" type of radiation rather than a "plane wave" affair, and as such it could be using extreme directivity (does not spread out much) similar to the vortex wave.

In which case the calculated power of the pulsar needed to send such radiation to our earth may be in need of tremendous revision downwards. As mentioned, I think astronomers would appreciate help here. I sure need help from them!

In fact, in a recently received private communication from Arrecibo, P. R., I have been told that the pulse from a pulsar consists of one fell swoop of "frequencies" from A to Z with something that just might be a message built into it. Look at graph no. 1 again, please. The pulsars may soon really tell us *something!*

The particle-wave.

If the suppositions in this article finally lead to a clearing up of this century-old controversy, well fine. I'm 64 years old now, expect another ten years of useful work and would like to devote some of that time at least to the creation of a "giant photon" working model of the type of wave, with proper polarization to fit, which, from an aperture of about one wavelength, should hardly spread out at all for the first many millions of miles of travel. Beats radar doesn't it? The red shift gets to be about 3 db near the visible edge of our universe, so, if caused by light running down instead of Doppler, may turn out to be our oldest, biggest, and best "universal clock," and one which is known as such throughout said universe.

. . . K1CLL

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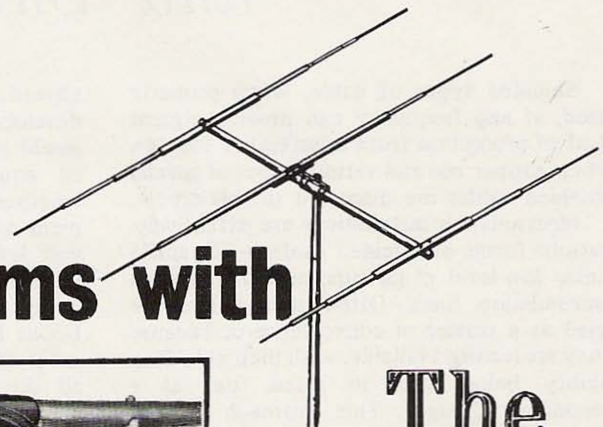

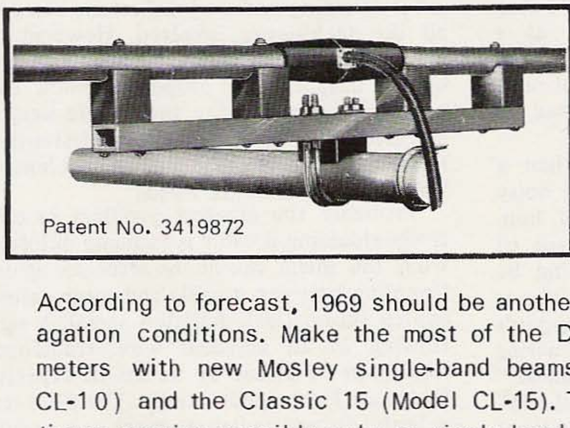

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Cable Pickup and Shielding

John J. Schultz, W2EEY/1
40 Rossie Street
Mystic, Connecticut 06355

Shielded types of cable, when properly used, at any frequency can provide a great deal of protection from interference sources. Their proper use and various types of special shielded cables are discussed in this article.

Most amateur installations use extensively various forms of shielded cables – for audio lines, low-level *rf* circuits, and for antenna transmission lines. Often such cables are used as a matter of convenience or because they are readily available, with their shielding ability being kept in mind, but as a secondary thought. This approach suffices for many installations because no real need exists for great care to be exercised as regards cable shielding.

However, there are instances when a station is located in an electrically noisy environment or internal problems of hum and feedback develop within a piece of equipment which require that cabling be properly shielded. Too many amateurs believe that the best they can do as regards cable shielding is to use some form of wiring with a woven wire covering or "shield." However, what really constitutes a "shield" depends upon a number of factors and what appears to be a physical shield may not, in fact, be a good electrical shield. To obtain an effective shield, one has both to understand what one desires shielding against and what the shielding capabilities of various cables are.

This article discusses some of the general considerations that are applicable to cable shielding effectiveness. The principles developed apply whether one is trying to shield against a hum problem inside a piece of equipment due to cable pickup or whether one lives in a noisy city environment and is concerned with bringing microvolt level signals from an antenna along a transmission line without having external noise sources mask or distort the signal. Books have been written on the subject of cable shielding and no brief article can cover all the techniques involved. However, the material presented should at least give some better insight into proper shielded cable usage and explain why the simple usage of shielded cable does not always instantly or immediately solve cable pickup problems.

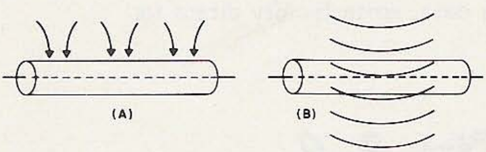


Fig. 1. Interference can couple to cable by capacity (electrical) or magnetic fields or a combination of the two.

Noise and Interference Fields

Probably the greatest problem in effectively shielding a cable is to really determine what the shield should be effective against. Coupling between a cable and some external source (noise field, radiated signal, a signal flowing in an adjacent wire, transformer field) can be either by means of capacitive (electrical) or magnetic fields. The field from a fairly distant radiated signal can produce the former type of coupling while a wire run close to a transformer will be coupled by the latter means. In a complex situation where a number of interfering sources must be shielded against, coupling can be achieved by a combination of both means.

Fig. 1 shows how both fields can effect a single-shielded coaxial type cable. The capacity coupled field is theoretically stopped by the outer conductive shield of the cable. Actually, this is not completely true, since most shields are only 80-90% effective. Still, such a degree of shielding suffices for many applications. The magnetic field passes through the woven copper-wire shield of the cable. Actually, nothing happens because the fields couple to the cable where somehow only a current can flow.

This takes place when the shield of the cable is grounded in some manner, as shown in **Fig. 2.**

Ground Connections

When a ground connection is placed at both ends of a coaxial cable **(Fig. 2A)**a loop (closed circuit) is formed consisting of the shield and the ground circuit. Thus, if the cable is subject to either of the fields shown in **Fig. 1**, they can cause a current to flow in the shield. Naturally, since the shield must also carry the desired signal current in one direction, the signal will be degraded by the amount of the coupled interference.

It is assumed, by the way, that the fields are coupled to the cable with such an orientation that they can induce currents. Normally, this will be the case since most interference has a random orientation. However, there may be special cases (inside a chassis, for instance) where the interfering field is fixed and one can achieve a considerable reduction in the couple interference by reorienting the signal cable.

Again, however, on the subject of shield grounding, one common idea is that the shielding effectiveness of coaxial cable is enhanced by grounding as often as possible along the length of its run. Actually, it is possible that such ground can have just the opposite effect, as shown in **Fig. 2B.** The smaller closed loops formed can increase the induced current flow. Also, the ground path may have other currents from external noise sources flowing in it which will be coupled onto the shield of the coaxial cable.

Therefore, the best approach usually is to have as few ground connections as possible. In fact, the best situation, as shown in **Fig. 2C**, would be to have a single ground connection at the signal source. Thus, no

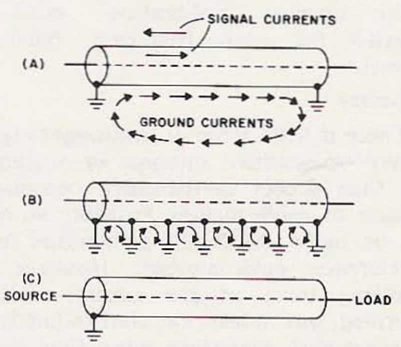


Fig. 2. Methods of grounding simple coaxial cable or shielded wire.

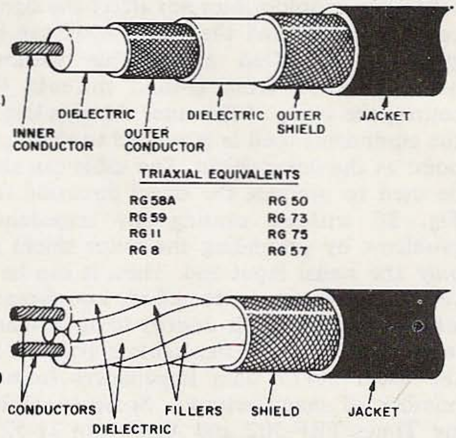


Fig. 3. Triaxial and Twinax cable construction.

closed loop would be present to allow induced current flow. In practice, such a method is not always possible, especially with low impedance cables, because of the impedance mismatch that occurs at the load end of the cable. However, the method can often be used with very good results with very high impedance cables. A variation on the method is to ground the shield of the cable at the load end through some sort of selective device – an *rf* choke, for instance – if a dc path through the cable is desired, but *rf* pickup induced currents are to be surpressed.

Special Shielded Cables

Single conductor shielded cable or coaxial cable is certainly not the only type of shielded cable available, although its common usage overshadows the availability of other types. It was mentioned before that the shield of a coaxial cable is not 100% effective. To retain flexibility while improving the shield effectiveness, double shielded coaxial cable is available (RG5A/V and other types). The cable has two woven shields directly placed on top of each other. At frequencies in the mf through vhf range, the shielding effectiveness is about 97%. The cable is used in the same manner as single-shield cable and all the considerations mentioned regarding grounding of the shields still apply.

If one takes a double shielded cable but insulates the two shields from each other, the result is Triax **(Fig. 3A).** This cable can be used as shown in **Fig. 4A.** The outer shield is connected to ground and the inner shield and conductor are used for the signal circuit. Because of the separate outer shield, capacitive coupling does not affect the signal carrying circuit and the outer shield can be grounded as often as possible without harmful effects from ground currents. Of course, the value of the outer shield is lost if the equipment used is grounded to the same point as the outer shield. The cable can also be used to produce the effect discussed for **Fig. 2C** without causing any impedance problems by grounding the outer shield at *only* the signal input end. Thus, it can be a very effective means to reduce interference when a coaxial line is desired to an antenna in a noisy location. Triax cable is available in the usual 50/75 ohm impedances from a number of manufacturers. Some examples are Times TRF-502 and Amphenol 21-527. Such cable is not inexpensive but can be very effective. For short runs, tinned braid can be purchased separately and slipped over regular single shield coaxial cable to form inexpensive home-brew Triax.

Still another special cable is shown in **Fig. 3B**. Twinax, as this cable is called, has a twisted 2-conductor pair inside a single-shield. As shown in **Fig. 4B**, the shield is grounded to isolate the conductors from capacity coupled fields. The twisting design of the inner two conductors provides a great reduction from the effects of magnetic field induction since the currents induced cancel in alternate twisted sections. The cable is meant for use in a balanced transmission line system and is generally available in 90-150 ohm impedances (RG22/U, Belden 8227, etc.). A form of Twinax with a double insulated shield is even available, but only useful for specialized applications.

Checking Shield Effectiveness

The effectiveness of a shield is a complex thing to evaluate by test instruments because of the variety of fields over a wide frequency range to which a cable might be subject in usage. However, checking shield effectiveness in an actual installation is not complex, and a simple method is usable no matter what type of cable is being used.

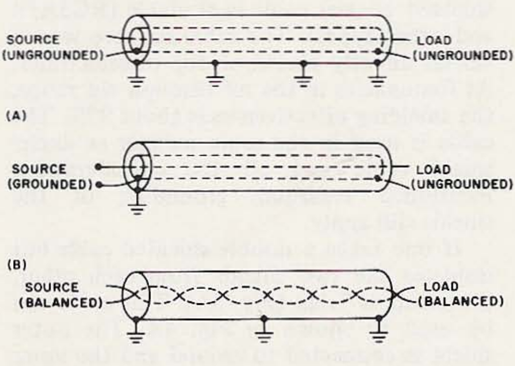


Fig. 4. Triaxial and Twinax cable shield connections.

The method requires only a receiver tuned to the frequency at which the cable to be tested will be used and a *shielded* dummy load (a ½ watt resistor, for instance, placed *inside* a coax connector). The dummy load is placed on the receiver antenna terminal and a multimeter is attached across the receiver's audio output to measure output voltage (the headphone jack is usually the most convenient location using a 600 to 1,000-ohm resistor in place of the headphone load). The *rf* gain control is set at maximum and the *af* gain control used to set some convenient "noise" voltage level on the multimeter scale (usually 1-4 volts).

Without changing any receiver control settings, the dummy load is removed and placed at the far end of the cable run under test. The near end of the cable is connected to the receiver (or transceiver) antenna terminals.

The increased noise reading on the multimeter is now due to cable pickup. Even in the best of installations, there will be some increase in the meter reading because the dummy load and connector shielding are not perfect. However, in a good installation, the increase will be minor and certainly not more than 1.5 times the original meter reading.

This method can be used to check the pickup of a cable already installed or to check the improvement in an installation as different cables, grounding methods, etc. are tried. The important measure is only the *increase* in noise reading as the dummy load is moved from the receiver to the far end of the cable, not any absolute readings. The entire receiver "calibration" must be repeated for each frequency band of interest.

Summary

There is little sense or economy to spend money on sensitive antennas or equipment and then accept performance degradation because of cable pickup. Probably no cable can be made absolutely pickup-free in all interference environments. However, by following some of the general methods described, one at least can start to tackle the situation with something more than simple coaxial cable as the only possibility.

. . . W2EEY

Arthur Levy, WA1AAU
47 Dayton Street
Springfield, Massachusetts 01118

WWV — Pioneer in Standards Broadcasting

"National Bureau of Standards, WWV, Fort Collins, Colorado. Next tone begins at twenty-one hours Mountain Standard Time."

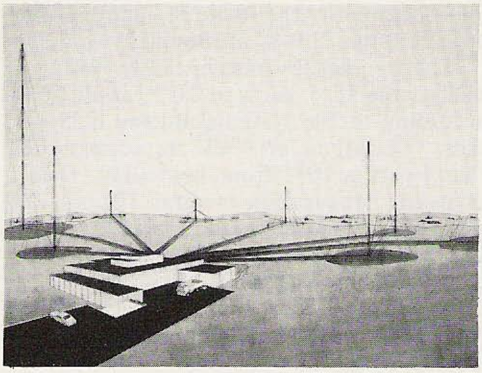
The National Bureau of Standards radio station, WWV, began operating from its new home in Fort Collins, Colorado, early in December 1966. The station was moved from Greenbelt, Maryland, to the present site, 60 miles north of Denver, at a cost to the government of $970,000. The move was prompted by rapidly obsolescing equipment, the need for a more central location, the high ground conductivity of the new site, and the proximity to the N.B.S. frequency standard at Boulder, Colorado.

WWV's services are among the most widely used and vital services provided by the National Bureau of Standards. Its time and frequency signals are used by ships, aircraft, electronic laboratories, radio and television stations, electrical power companies, and the makers of musical instruments (who depend on WWV's tone for standard pitch).

Amateur radio operators around the world account for 35% of WWV and WWVH (Maui, Hawaii) listeners. Hams use the signal to calibrate their equipment.

WWV joins two other N.B.S. standard frequency radio stations at the Fort Collins site. The stations, WWVB and WWVL, were established in 1963. They operate on low frequencies making possible world-wide coverage.

Station WWV broadcasts on frequencies 2.5, 5, 10, 15, 20, and 25 MHz. The broadcast are continuous, night and day, except for a four minute period each hour. The silent period commences at 45 minutes (plus 15 seconds) after each hour.



Artist's drawing of WWV and its antennas.

The 5, 10, and 15 MHz transmitters deliver 10 kw to the antennas, while the 2.5, 5, 20, and 25 MHz transmitters deliver 2.5 kw. The linear amplifier, which has a 40 kw input, is driven by a one watt driver. All of the antennas at WWV are vertical, half-wave dipoles, and are omnidirectional. They are fed with 50 ohm 3 5/8" coax cable. Antenna height varies from 20 to 120 feet.

At WWV, all modulation is double sideband amplitude* with 75% modulation on the steady tones and 100% on the second pulses and voice.

In case of a power failure the station is tied into two power grids in addition to having an emergency power generator.

Since December 1, 1957, the standard radio transmissions from WWV and WWVH have been held as nearly constant as possible with respect to the atomic frequency stand-

New antenna designs are tested out on 1/40th of the wavelength before the final installations are made. Here is a model of the 10 khz antenna to be built for WWVH. The model is on 400 mhz.

ards which constitute the United States Frequency Standard. The U.S.F.S. is maintained and operated by the Radio Standards Laboratory of the N.B.S. at Boulder, Colorado.

The frequencies transmitted by WWV are held stable to 5 parts in 10^{11} at all times, according to the National Bureau of Standards. Deviations at WWV are normally less than 1 part in 10^{11} from day to day. Changes in the propagation medium (Doppler effect, etc.) result, at times, in fluctuations in the carrier frequencies received, and may cause greater error than noted above.

Standard audio frequencies of 440 Hz and 660 Hz are broadcast on each carrier frequency at WWV and WWVH. The audio frequencies are transmitted alternately at five-minute intervals starting with 600 Hz on the hour.

The 440 Hz tone is the note A above middle C, which is the standard in the music industry throughout the world.

Universal Time (referenced to the zero meridian at Greenwich, England) is announced in International Morse Code each five minutes from WWV and WWVH. The time announcement refers to the time when the audio frequencies are resumed. The station also broadcasts a voice announcement every five minutes in Mountain Standard Time. It is given during the first half of the fifth minute and is in English.

In addition to the time signals, WWV also broadcasts radio propagation forecasts in International Morse Code during the last half of every fifth minute of each hour. The forecast tells users the condition of the ionosphere at the time of broadcast and for the following six hours. A world-wide network of geophysical and solar observatories feed information, which includes radio soundings of the upper atmosphere and short wave reception data, to the Telecommunications Space Disturbance Center at Fort Belvoir, Virginia. The forecasts are sent at 0500, 1200, 1700, and 2300 UT. They are broadcast in Morse Code as a letter and number. The letter identifies the radio quality at the time the forecast is made. The letters denoting quality are "N," "U," and "W." They signify that the radio propagation conditions are either normal, unsettled, or disturbed. The number portion is the forecast of radio propagation quality on a typical North Atlantic path during the six hours following the forecast.

The forecasts are made for the North Atlantic area using a path from Washington, D.C. to Frankfort, Germany as a standard. They are used, for the most part, for direct point-to-point radio telephone transmissions. The scale used for radio quality is based on a one to nine scale which follows:

Disturbed grades (W):

1. Useless
2. Very poor
3. Poor
4. Poor-to-fair

Unsettled grade (U):

5. Fair

Normal grades (N):

6. Fair-to-good
7. Good
8. Very good
9. Excellent

Another service of WWV and WWVH is the broadcast of current geophysical alerts. The alert tells what days there will be outstanding solar or geophysical events and when these events have occured in the past 24 hours. The broadcast is made during the first half of the 19th minute of each hour. The letters GEO are sent in CW followed by a letter repeated five times. The letters are:

M–Magnetic storm
N–Magnetic quiet
C–Cosmic ray event
E–No geoalert
S–Solar activity
Q–Solar quiet
W–Stratospheric warning

A time code is also broadcast by WWV for one minute out of each five, ten times an hour. The code provides a standard base for scientific observations. The code is transmitted at a 100 pps rate and is carried on a 1,000 Hz modulated signal. The code con-

WWV transmitter building.

tains the Universal Time in seconds, minutes, hours, and day of the year. The code is synchronized with the frequency and time signals.

The time standard uses a Cesium Atomic Beam to calibrate the oscillators, dividers, and clocks, which generate the controlled frequency and N.B.S. time scales. Information from this reference is fed to receivers which monitor the transmissions from Fort Collins. The signal is compared to the reference phase. If an error exists, a signal is transmitted from Boulder to Fort Collins by a 50 MHz transmitter. Automatic correction equipment at Fort Collins corrects any error.

The oscillator controlling the transmitted frequencies and time signals is continuously compared with the LF and VLF signals. Adjustments are then made to the controlling oscillators. To assure that systematic errors do not enter into the system, the N.B.S. time scale is compared with the transmitting station clocks by the use of a very precise portable clock. By this method time synchronization to a few millionths of a second can be attained.

...WA1AAU

(Ed. note. SSB operation is planned for the near future.)

Big Do in Bombay in December

The First All India Amateur Radio Convention will be held in Bombay on December 27-30 this year. If you have a chance, by all means plan to visit. Write to VU2TP for further particulars.

Mark A. Fritz, WA1FHJ
775 Broadway,
Somerville, Mass.

Basic Theory and Application of Transistors

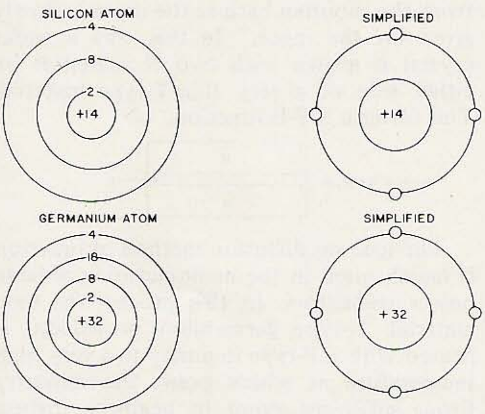
A transistor, like a triode vacuum tube, is basically an amplifier of electric voltages and currents. However, unlike the electron tube, it is in a solid state, therefore the electrons are passing through a solid material rather than through a gaseous medium.

The transistor was invented forty-two years after the electron tube by W. Shockly, W. H. Brattain, and J. Bardeen of Bell Telephone Laboratories. These men demonstrated that a solid state device could replace the vacuum tube in performing all of its functions more efficiently.

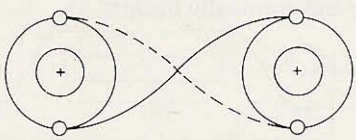
There are four main advantages of transistors over vacuum tubes. These are size, shock resistance, operating temperatures, and slowness of their aging. Because a large gaseous space is not needed in a transistor, their physical size is many times smaller. A transistor does not require filament power for its operation; no heat is generated internally (this is the major cause of failure in a tube) under normal operating conditions. Also because of this fact, transistors have an almost indefinite life because there is no filament to burn out. Transistors, for the most part, are shock resistant with the exception of fracturing of the internal structure from a severe shock on one of its leads. Transistors are built inside of a small metal case rather than in a glass envelope as is the electron tube; therefore, they are not susceptable to breakage.

If a particle of a substance is cut in half, what do you have? Two halves, both identically the same if care is taken. What would happen if it was cut in half again and again until it could no longer be seen? Does it disappear? No, it is only divided up into the smallest particles of the substance (which retains all of its chemical properties) called atoms. An atom consists of three main subparticles. These are the proton, the electron, and the neutron. These three particles are situated in two main areas of the atom. The protons (positively charged) and the neutrons (neutrally charged) are in the heavy center of the atom, the nucleus. The electrons orbit around the nucleus in eliptical orbits. Each atom contains an equal number of protons and electrons; thus, the sum charge is 0. They are electrically stable but chemically unstable.

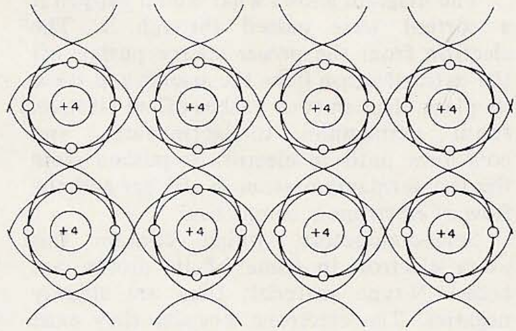
The electrons are in different orbits or levels around the nucleus according to the amount of energy that they have. These orbits are labeled; K, L, M, N, etc. The K orbit can hold two electrons, L-8, M-18, N-32. In the study of the flow of electricity we are concerned only with the outermost or valence electrons. The charge of the atom is determined by whether the atom wants to give off or take on electrons to reach a chemically stable state. For example, if the K shell had two electrons in it, it would be stable both chemically and electrically because the plus and minus charges would balance out, and since the shell is full, it neither wants to give off or take on electrons. If the atom contained three electrons, two would go into the K shell and since this is full, the third would go into the L shell. The atom wants to have a full outermost shell, so it can either take on seven more or give off the extra electron. This process gives the atom a charge of plus 1 from the addition of the two charges: +2 -1. It gives off the one instead of taking on seven because there is less energy required. Atoms which have a positive valence are classified as metals. Those which have a minus charge (atoms in which it is easier to take on electrons) are called non-metals. Those which can give or accept electrons with equal energy are called transition elements (Ex. element with 4 electrons in L shell). Metals are called conductors, non-metals, non-conductors, and transition elements, semi-conductors. A semi-conductor is neither a metal nor a non-metal but is in between the two in its properties. The most common semiconductors are silicon (At. No. 14) and germanium (At. No. 32).



As shown in the diagram, both silicon and germanium have similar outermost shells, therefore they have almost identical properties. Silicon and germanium are in a crystal lattice which accounts for most of their conducting properties.

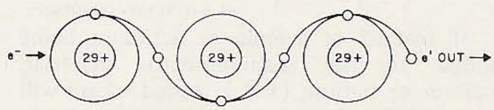


Breaking the crystal down into only two atoms, it is shown in the diagram how an electron is shared in a covelant bond. Since all electrons are almost exactly alike, an electron of one atom can take the place of an electron in another atom. In this diagram the atoms are spaced so close together, that the electrons of one atom go into the orbit of the other atom. If the atoms of the crystal lattice were drawn out excluding imperfections it would be diagramed as below:



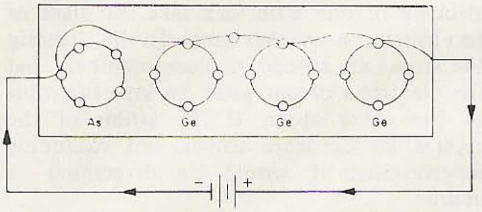
In the diagram all of the electrons go into the orbits of the other atom; however, there are never more than four electrons around an atom at one time.

This diagram may also show how electricity is conducted. Copper, which can be basically diagramed in the same manner only with one electron in the outside shell, is one of the most common conductors in wires. If an electron is pushed into the end of a wire, the electron forces another one out the other end. In this way, a steady voltage produces a steady flow of electrons out of the end of the wire.



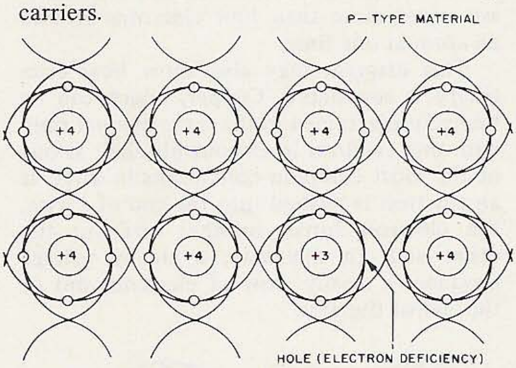
Since silicon and germanium are only semi-conductors, a slight impurity must be added for them to be able to conduct enough for the purposes of a transistor. If the resistance of a pure block one centimeter long is measured, its resistance would be in the order of hundreds of thousands of ohms. If a small piece of arsenic or antimony is added and the mixture recrystalized, the resistance would be less than one hundred ohms.

In the diagram below, the arsenic atom contains five electrons. This means there is one extra electron (the fifth) which will not combine covalently.



The diagram shows what would happen if a current were passed through it. The electron from the power source pushes off the extra electron from the arsenic and takes its place. This in turn pushes off an electron from germanium to germanium, and continues until an electron is pushed from the last germanium atom in the bar and the flow of electrons is completed.

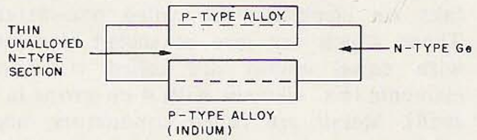
Semi-conductors, which contain this extra electron in some of its atoms, are called N-type material; they are slightly negative. The electrons, because they exist for the most part in excess, are called majority carriers; the holes which exist from the loss of an electron are called minority carriers.



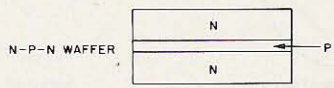
If instead of arsenic or actinium being added to the semiconductor material, gallium or indium (+3) is added, there will be a need for electrons in some of the atoms. The same process will occur as in the N material conductor, only in this way the current will flow in the opposite way. In this case the holes are the majority carriers and the electrons, the minority carriers. This material is called P-type material. The impurities which are added to the semiconductor are called "dope" and the process is called "doping."

There are two main types of transistors. These are P-N-P and N-P-N. These are named by the material out of which they are made and the order in which they are connected. The connection point is called a junction.

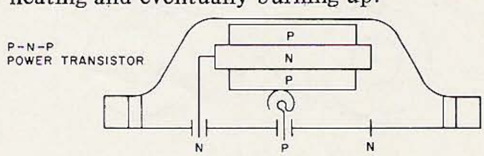
There are three ways of forming a junction. These are the diffused-alloy process, the rate growth process, and the gaseous diffusion method. In the diffused-alloy process, tiny dots of indium are pressed into each side of a slice of germanium. This is placed in a temperature controlled furnace where the indium melts and gradually diffuses below the surface of the N-type germanium. A P-type alloy is thus formed in the surface of the indium. An extremely small unaffected N-type germanium separates the alloys. This process is used to produce P-N-P transistors.



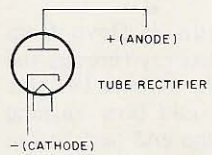
"In the rate growth process, molten germanium is doped with impurities so proportioned that, although the original molten mass is in P-type germanium, it changes to N-type germanium when the temperature of the mass is carefully controlled. This change is dependent upon the rate at which the forming ingot is withdrawn from the moulten bath as the crystals slowly grow on the ingot." In this way a wafer crystal is grown with two N materials on either side of a very thin P-type material. This forms a N-P-N junction.

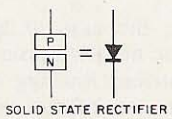


The gaseous diffusion method of junction is mainly used in the manufacturing of large power transistors. In this process the base material, N-type germanium or silicon, is heated with a P-type impurity to a very high temperature at which point the impurity forms sufficient vapor to begin to diffuse slowly into the surface of the base material, forming a P-N-junction on each side. The N-type base material is slowly converted into P-type material as the process continues. These large junctions are necessary in power transistors where heat must be dissipated quickly to prevent the transistor from overheating and eventually burning up.

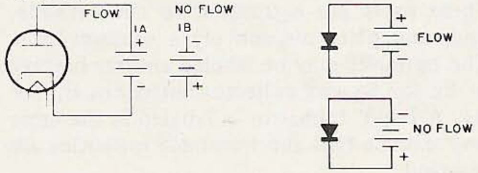


If a P-N junction is made, the P material is positive or the anode, and the N material is the negative or cathode. In this way a diode can be formed out of solid state material rather than a vacuum tube.



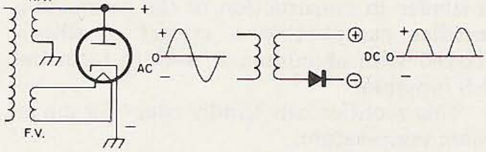


If a battery is connected across a diode, the current (which flows from - to +) will only flow in one direction. In **Fig. 1A** the negative of the battery is connected to the cathode and the positive to the anode or plate (see appendix). Electrons are given off from the filament and collected by the plate. However, when the battery is reversed, **(Fig. 1B)**, the + to the cathode and the - to the anode, no current flows for the cathode does not have a surplus of electrons which it can "boil off."

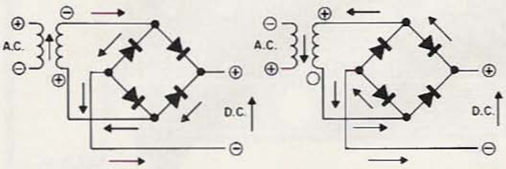


This same theory applies to the semiconductor diode. When the batteries' - pole is connected to the N part of the diode and the + pole to the P side, current flows. When the battery is reversed, no current flows because of the lack of electrons carriers in the P region. When the battery is connected forward again, both holes and electrons cross the junction, join with each other and cancel charges. This allows the electrons to enter the N side and leave the P side.

A single semiconductor diode may be used as a rectifier. (change alternating current to direct current).

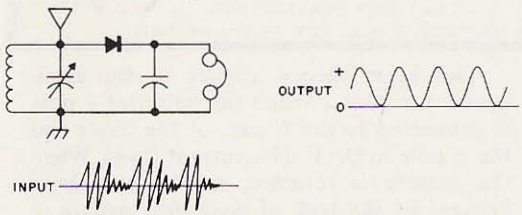


In the first circuit, a vacuum tube is used. Because of this, a filament voltage supply is needed which uses a great amount of current and also generates a great amount of heat. In the semiconductor circuit, no filament power is needed, thus no large power supply and no heat is generated. Also, semiconductor diodes are about 99% efficient. In a single diode circuit, the negative peaks (of the sine wave) are cut off during one half of the cycle because the diode is only conducting for half of the time. This stoppage of current flow may be prevented by using four diodes in a square circuit called a bridge circuit. In this circuit, current flows continuously therefore eliminating the nulls.



This current is much easier to filter (smooth out peaks) and gives a much stabiler dc voltage.

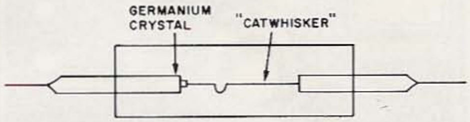
A semiconductor diode may also be used as a detector in a crystal diode radio. In the diagram, the high frequency ac wave from the transmitting station is picked up by the antenna and the exact frequency is tuned by the L. C. (coil-capacitor) network. This signal is rectified into dc current which powers the headphones.



There are two main types of rectifiers in use today. These are germanium and silicon. These two are very similar in outside structure, however, their electrical characteristics vary greatly. A germanium rectifier can handle up to about 250 ma of current at 85° C. Above these specifications the crystal lattice burns out. For higher power and temperature, a silicon rectifier is used. This is similar in construction to the germanium rectifier except that a crystal of silicon alloyed with aluminum is used to form the P-N junction.

This rectifier can handle over 750 ma at room temperature.

Both types of rectifiers have what is called the reverse current. This rating is given for all rectifiers in their specification sheets and tells the amount of current which the rectifier allows to flow back during the + half of the cycle. A typical reverse current rating, as in a 1N91 diode, is two 125 ua which is relatively small when compared to the forward current rating, which is about 150 ma. A third type of diode, which is used for low power applications, is the point contact diode. Point contact diodes are usually made out of glass and thus are much more fragile. In this diode a small piece of germanium is used as the N-type material with a dot of P-type diffused into it.

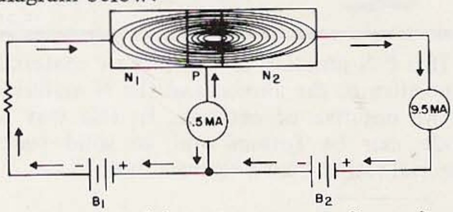


POINT CONTACT DIODE

One side of the germanium is placed against one of the conductors, while the other side is attached by a fine phosphor-bronze or beryllium-copper wire nicknamed "cat whisker."

If two P-N junctions are placed back to back having a common thin N junction, a P-N-P junction is formed. This type of junction (also reversed called a N-P-N junction) is called a transistor.

There are two possible ways to bias (supply voltage) a transistor: positive and negative bias. These are shown in the diagram below:



In the case of B_1, the current flows from the negative pole of the battery through the current limiting resistor (if it were left out almost infinite current would flow burning out the transistor) from the end part to the P- material and through the meter which shows a small flow of current. This type biasing is called forward bias. As shown in the case of B_2, a great amount of current flows as in the meter reading; this section is reversed bias.

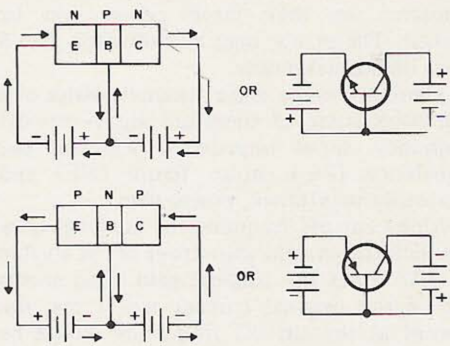
In an N-P-N transistor as in the diagram N_1 is labeled the emitter (for it emits the electrons), P the base (because it formed the base support of early transistors), and N_2 named the collector, C, for it gathers the electrons which flow from the P section. These parts are equivalent to the cathode, grid, and plate respectively a vacuum tube. The batteries may be labeled emitter battery or Ee for B_1 and collector battery or E_c for B_2. A P-N-P transistor is labeled in the same way except that the transistor polarities are reversed.

As mentioned previously, the emitter current is very slight with only E_e supplied. This is because of the shortage of the majority carries and the base. However, if both E_e and E_c are connected, the emitter supplies electrons which are forced through the base and pulled through the collector to the positive battery terminal. Only about 5% of the total current flows out through the base while 95% flows through the collector.

"Through this we conclude that the emitter battery controls the potential between emitter and base, that this potential controls the current that flows from emitter to collector but that the base itself takes very little of this current."

A P-N-P transistor acts in a similar way except that the majority carriers are holes rather than electors. Because of this the battery polarity must be reversed or the transistor will be destroyed.

The ratio between the elector current and the emitter current is called Alpha ($a = \Delta I_c / \Delta I_e$) because of resistor differences between the emitter-base and the base-collector parts of the transistor, different voltages must be used in the two parts; Example of a typical transistor would be E-B of 250 Ω and B-C of 300,000 Ω. E_e would only have to be around 1.5 volts.



E_c would only have to be up to 45 volts to get a good output power.

Resistance gain in a transistor is a ratio of output resistance, R_L, to the input resistance, R_i, provided that alpha is 1.0 (alpha is usually .95 to .99). If the two formuli are combined with the formula for voltage gain in an amplifier $VG = \Delta E_L / \Delta E_i$, we get the formula for the voltage gain as $VG = aR_L/R_i$ Example of a voltage gain would be 100 R_i and 100,000 R_L with alpha equal to .95. The voltage gain would be (.95) x (100,000/100) or 950. Substituting in the formula for power gain as in Ohms Law into the previous equation we get: $PG = \Delta I_c{}^2 x R_L / \Delta I_e{}^2 x R_i$. Since $\Delta I_c / \Delta I_e$ is a, we get simply

$PG = \alpha^2 x R_L / R_i$. If the original set of values are used, we would get: $PG = (.95)^2 x 100{,}000 / 100 = 903$. This number should show that, contrary to belief, relatively large power gains are possible in transistors.

There are many factors which must not be exceeded in the transistor. Some of these are current, voltage, temperature and heat dissipation. The current to all transistors must be limited, thus a limiting resistor is used in series with a power supply. If this current rating, which is always given in a specification sheet, is exceeded, the transistor will heat up and burn out. This factor is generally the same for voltage. This rating is also given in a specification sheet.

Most germanium rectifiers and transistors break down or burn out when the temperature approaches 100°C so silicon is used for many transistors in its place. In this way a transistor can operate under much more severe conditions. The transistor also creates a small amount of heat under normal conditions. If these conditions are exceeded, the transistor may build up enough heat so that it will burn out. However these conditions may be exceeded by using heat sinks. These are ribbed metal devices which help to quickly dissipate the heat away from the transistor so that more power can be applied. The power may be increased 4 to 5 times its normal power.

There are many signal characteristics of a transistor; some of these are alpha- cut off frequency, input impedence (Z_i), out put impedence (Z_O), noise figure (NF) and previously mentioned, power gain.

Alpha cut off frequency is the frequency at which the current gain drops off at a value of .707 times the original gain. This means that if the original current was 1 ma, the current at the cut off frequency would be .707. The transistor does not stop functioning at this frequency, but only loses a large percentage of its efficiency.

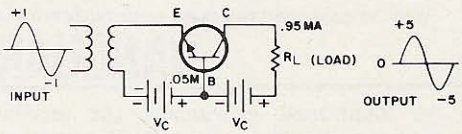
The input impedence is the measurement of resistance between the emitter and the base. This impedence is relatively low (around 250 ohms). Output impedence is the resistance measured between the base and the collector and is relatively high (around 5 meg. ohms) Both the input and output impedences must be matched to the circuit component's impedences. This is done by the use of input and output impedence transformers.

A certain amount of noise is generated in the transistor. This is serious for the noise is amplified along with the signal. The noise is measured in decebel (db), and in transistors, and is about 10 db. This figure increases inversely with the frequency, that is, the noise increases while the frequency decreases. Power gain may be restated as taking the log. of the power gain in db from the ratio of power gain:

$$\log\left(\alpha^2 \frac{R_i}{R_L}\right) = \frac{db}{10}$$

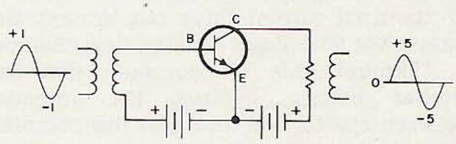
The most common use of transistors today are in amplifiers and oscillators. There are three basic types of transistor amplifiers, but, because of its simplicity, only the common base circuit will be fully explained.

In the common base amplifier, the base is connected with both the emitter and collector battery. As shown in the diagram, a signal is completed through the input of the emitter of the transistor. About 5% of this amount returns through the base because of the resistance previously mentioned. The rest of the power would go out through the collector circuit.

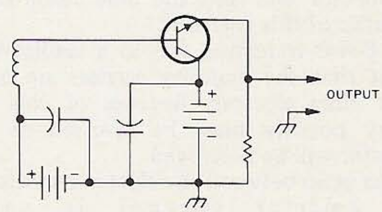


COMMON BASE AMP.

Since much more voltage may be placed on the collector of the transistor than on the emitter, more voltage and thus more amplitude is added to the input signal.

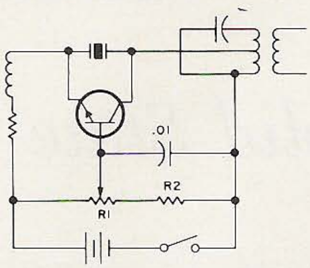


COMMON EMITTER AMP.



COMMON COLLECTOR

If the output of the amplifier is recoupled to the input, it is called an oscillator. This oscillator has a specific frequency which is determined by a LC network. Taking the simple practical oscillator below:



This circuit will oscillate at higher frequencies, depending upon the transistor that is used. The crystal (a quartz crystal in a case) which is connected across the collector and the emitter, keeps the oscillator resonating at a specific frequency. The crystal acts like a high Q (quality factor) series as a resonant circuit. The coil is a tuned tank circuit which also determines the resonant frequency; however, not as exactly as does the crystal.

When Edison first discovered the Edison affect in the light bulb, people were amazed. When the electron tube was invented, people thought it was a miracle that voices could be transmitted and received through the air. Some went further on this idea and invented the transistor. Up to a few years ago, the miniature transistor was thought to be the ultimate in perfection of quality and size. However, more research was done and integrated circuits have been invented. These are small blocks about the size of transistor which may contain as many as 14 transistors, and their associated parts such as, resistors, capacitor, etc. This miniaturization was made possible by the discovery of film resistors and capacitors visible only under a microscope and which have transistors that function even better than those circuits built on a conventional circuit board.

Through the use of transistors, it is now possible to shrink the size of electronic equipment many times so that it is both lighter and smaller in size. This is of great importance for its use in space capsules where space and weight are very valuable. These electronic marvels also affect the homeowner, for now small transistor and integrated circuit radios are being made. Also possible through the use of integrated circuits and transistors are miniature television sets and television cameras which may easily be carried around with the power running off a battery pack. In this way transistors have shown their immediate success to both the scientist and the common man alike.

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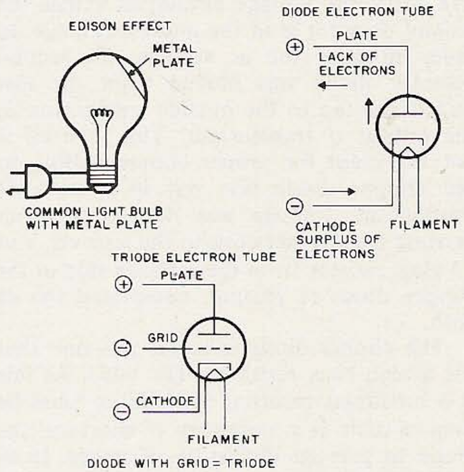
APPENDIX

Basic Theory of Current Flow in an Electron Tube

A filament in a common light bulb is made out of a type of metal which when an electric current is passed through it, heats up and glows. This happens because there are more electrons put into the wire than it can carry easily; thus, the wire heats up from the energy that it can not carry. If a metal plate were placed inside of the bulb, a cloud of electrons would surround it because it would have fewer electrons than the filament, thus being relatively positive. This effect is called the Edison effect, named after its discoverer, Thomas Edison. The electron tube was invented upon the principle that the cathode "boils" off electrons and the plate gathers them and returns them to the power source. Since the cathode has a very great negative charge and the plate has a positive charge, the tube can conduct only in one direction, negative to positive.



If a screen-like element is placed between the cathode and the plate with a slightly negative charge, it will be slightly positive compared to the cathode and negative compared to the plate (not as negative as the cathode). In this way the grid, as it is called, is used to control the flow of current. By varying the grid current slightly, the plate voltage and current vary greatly. Just as in the transistor, the relatively small voltage and current from the cathode (or the emitter in the transistor) is "amplified" to a higher power level.

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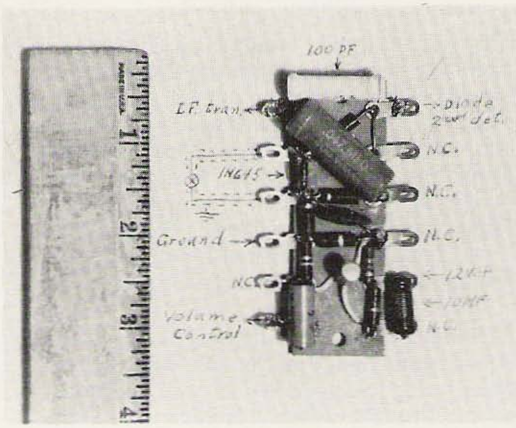
Oakland, California 94602

Series Gate, Solid State

When I recently decided to go fully transistorized, receiver-wise, on two meters, I decided to use a transistorized converter working into a transistorized broadcast receiver. The only problem that arose was that of the noise clipper. Having had very good results in the past with tube-type diodes in a series gate configuration, I decided to follow the same circuitry.

As in all series gate clippers, it is necessary to have sufficient voltage developed at the second detector for proper operation; however, with transistorized circuits and solid state diodes, instead of the preferred five volts, the voltage developed across the second detector is in the microvolt range. In order to raise the ac voltage, the second detector diode was moved from the low impedance tap to the outside connection of the output *if* transformer. This in itself is not sufficient for proper clipper action, so the clipper diode was put in a state of conduction. Voltage was derived from an existing resistor network in the receiver, and a 1 meg. resistor from the cathode side of the clipper diode to ground, completed the dc path.

The clipper diode selected was one that has a high back resistance (IN 645). As this is a broadcast receiver, and will at times be used as such, it is necessary to short out the diode to prevent distortion of music. In so doing, be sure to use individually shielded wires so there is as little capacitance across



Series gate limiter.

the diode as possible. Keep these shielded wires as short as possible.

Bench test, using a diode noise generator to the converter and an oscilloscope across the volume control. It was noted the clipping action started at approximately 60%, with the circuit components shown. This, of course, is on the positive half of the cycle, as this is a half-wave clipper. No clipping action takes place on the negative side. However, as the signal cannot go below zero, the extra components necessary for full wave clipping are not worth using for the results achieved.

Field tests of the clipper were conducted as follows: With an automobile having no suppression, and using a 5/8 wave whip

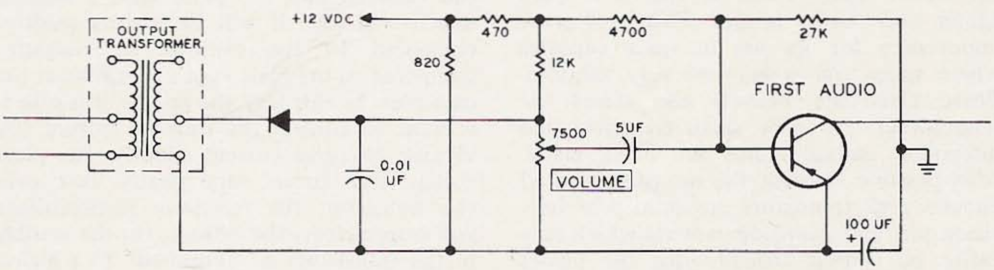


Fig. 1. Original 2nd detector and 1st audio.

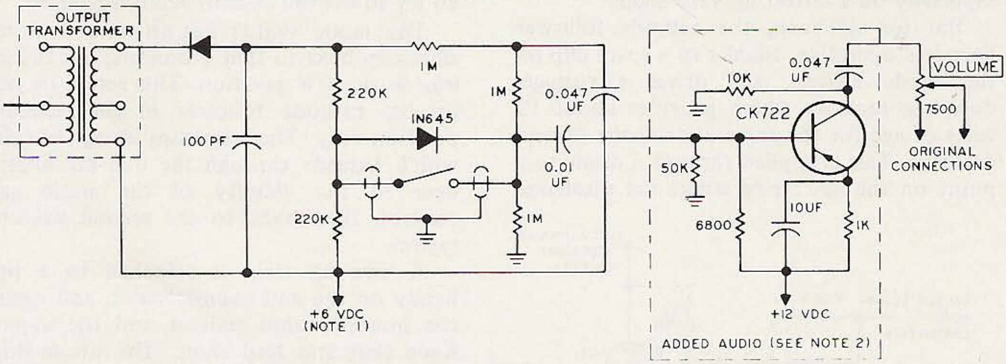


Fig. 2. Modified 2nd detector, clipper and audio. If the added audio is not required the .01 may be connected directly to the volume control.

mounted on the roof, I drove to an isolated spot and listened to various signals on the air. Picking one that had a signal strength of S4, I started the engine. The radiated *rf* noise tore up the signal beyond the point of intelligibility. Snapping the clipper on restored the signal to readability. Now moving to a highly congested area and parking near an intersection and tuning across the two-meter band, the same signals heard in the isolated area were heard here. However, with the clipper off, copy was impossible.

The clipper shown here is as good as any I have ever used, either homebrew or commercial. As in any series gate clipper, some audio is lost; however, for my own use, it was still more than sufficient. For those who play their radios loud, however, an extra state of audio has been added. Be careful, though. You may lose your speaker cone!

For those who will use this circuit, first study the second detector circuit of your broadcast receiver. There will be variations among manufacturers; however, in most cases the circuit will be adaptable.

. . . K6ZFV

Improving NC-300 SSB Reception

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Now that NC-300's are on the used market at attractive prices there are many people interested in modifying them. The NC-300 was designed in 1954, and is rather inconvenient for SSB operation, but not very much work is required to improve it considerably. The agc system gets the most effort, since stronger control and a more appropriate attack/decay performance are required.

The first thing you need is a good schematic. I'll suppose you have that, and let's go to **Fig. 1.** A five volt signal at the second detector gives about six volts at pin 2, and this feeds the S meter and the agc bus.

In the original circuit the charge time constant was something like 25 milliseconds and the discharge time constant only slightly longer. These values seem good for AM, especially on a fluttering VHF signal.

But for sideband, the cathode follower becomes operative, thanks to a spare clip on the mode switch, and drives a voltage-doubling rectifier which provides about 12 volts of agc for the same drive at the second detector. This is applied through a diode to a point on the agc string where the discharge resistance is over a megohm, in order that a long time constant can be obtained more easily.

The actual charge time depends on the value of the 470 pF capacitor and the cathode resistor, but the 1 mF capacitor can be charged in less than 30 milliseconds without loading that last tuned circuit any more than it is already. The one-second discharge time constant seems about right, in listening tests.

The net effect is to hold down the level in the *if* amplifier, but there still seems to be adequate audio in the "SSB" position of the mode switch.

The cathode follower socket can be mounted in one of the ventilation holes next to the 6AL5, or the whole thing can be hung in midair, so to speak, in the considerable space beneath the chassis and under the accessory socket. The tube type is not critical, but do try to use the resistor values specified.

The mode switch has an unused, accessible clip next to that grounding out the agc bus in the CW position. This serves to turn on the cathode follower in the sideband position only. The wire runs along the cable which threads through the dial mechanism over to the vicinity of the audio gain control, then back to the second detector region.

A two-lug strip is attached to a bolt handy on the coil compartment, and carries the hundred ohm resistor and the bypass. Keep that grid lead short. The whole thing looks sort of temporary the way I did it, but seems to work okay.

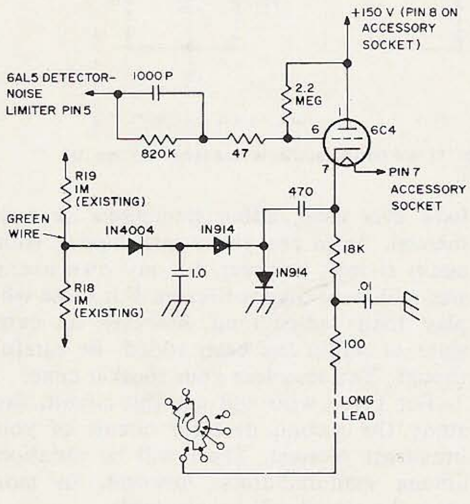

Fig. 1. Schematic diagram for modifying the NC-300 for improved SSB reception.

Other Suggestions

The selectable-sideband feature used in some Hallicrafter receivers is easily added. See the second half of W6HOG's article in the April 1966 issue of 73, page 95. Ignore the first part of this, and item 2 is in error.

A 2135 kHz oscillator will have a harmonic in the 15 meter band. It is desirable to crystal-control the second oscillator on 2295 kHz because the second oscillator is responsible for most of the receiver's drift, especially drift due to varying humidity.

. . . W1OOP

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AFSK Generator

Here is a versatile crystal-controlled AFSK generator using digital ICs. In addition to providing an accurate source of mark and space tones (accurate to less than 1 hz with tone amplitudes within 1 db of each other) it also contains a microphone preamp. The generator displays no keying transients, and three methods of keying are provided.

Evolution

I had long contemplated using a stable 425 hz source and then selecting the 5th and 7th harmonics to produce the mark and space tones of 2125 and 2975 hz in an AFSK generator. However, no practical means of executing this idea was apparent until Motorola RTL digital ICs came on the market at a reasonable price. Although the IC can not be used to multiply, they can divide. So, we design backwards:

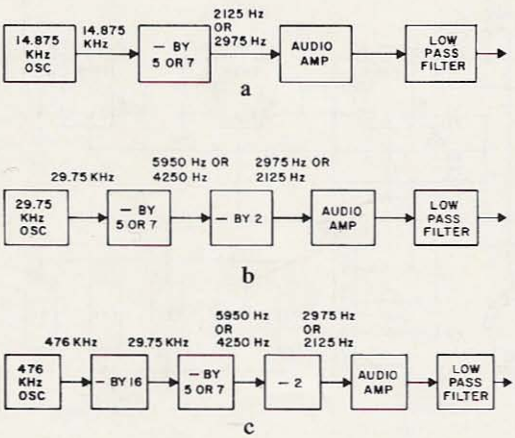


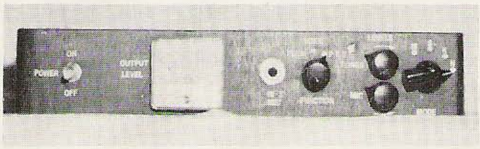
Fig. 1. Three stage evolution block diagrams.

Overall angle shot of unit. The unit is housed in a cast-aluminum box which was covered with wood-grained contact paper.

If two frequencies are each harmonics of another frequency, it follows that they are also sub-harmonics of still another frequency. In this case 2975 and 2125 hz are the 5th and 7th sub-harmonics of 14,875 hz. Now, we have arrived at a single signal source to provide both mark and space signals.

Since this device was to be used on 2 meters FM, sufficient audio was required to drive the primary of the usual carbon microphone transformer. An RCA CA3020 IC audio amplifier is adequate for this purpose. And it doubles nicely as a microphone preamp as well. However, there was the problem of transforming the IC divider's square wave output into sine wave tones. This was accomplished with a low pass filter following the audio amplifier, suppressing the square wave's higher harmonics, and producing sine waves.

This was the original idea as shown in Fig. 1a. But the new approach presented the



Head-on front shot. The narrow front panel made control location a bit of a problem.

problem of passing 2975 hz through the low pass filter with less than 1 db attenuation, and, at the same time, suppressing 4250 hz (the second harmonic of 2125 hz) to at least 40 db down. However, this turned out not to be a problem since, according to Fourier, there are no even harmonics generated by a symmetrical square wave – just odd ones. So, if the input frequency of 14,875 hz is doubled to 29.75 khz, we can then add a divide-by-two stage after the divide-by-five or -seven stage. Now, the lowest frequency to be concerned about is the third harmonic of 2125 hz, or 6375 hz. It is taken care of by the simple 5th order Chebyshev filter. **(Fig. 1b)**

Now, about that basic 29.75 khz signal source – how do we obtain it? One solution would be to use two cross-coupled NOR gates in an astable multivibrator. But these could be trouble-makers, since the oscillation frequency can be affected by supply voltage and temperature variations. Another possibility considered was a uni-junction transistor relaxation oscillator. It is relatively immune to voltage changes and can be temperature compensated. Then an even better approach became apparent. How about a crystal oscillator?

Crystals at 29.75 chz are expensive. But a surplus FT241 crystal that is the 16th harmonic of 29.75 khz is easily and cheaply obtained. The crystal used in this generator turned out to be one marked "Channel 57, 25.7 Mcs", cut for 475.925925 khz. So, the final configuration of **Fig. 1c** evolved.

The 476 khz oscillator precedes a divide-by-sixteen stage. Then comes a divide-by-five or -seven stage, followed by a divide-by-two stage. The latter feeds the audio amplifier, followed by a low pass filter. The result: pure, stable, crystal-controlled mark and space tones.

Circuit Details

1. 476 chz square wave generator

NOR gates Gla and Gld **(Fig. 2)** form an astable multivibrator with a free running frequency slightly below 476 khz. Potentiometer R1 controls that frequency. When

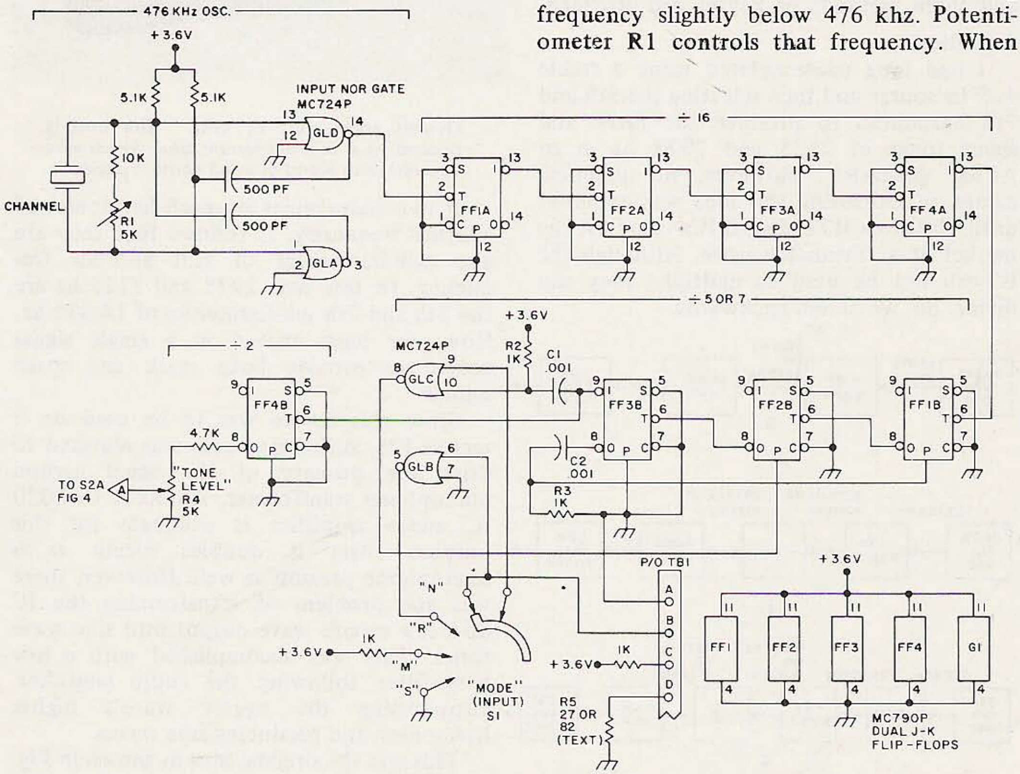


Fig. 2. Digital mark space tone generator schematic.

crystal Y1 is hung across the two inputs to the gates, it tries to synchronize the frequency to its own resonant frequency. Synchronization, of course, depends upon the free-running frequency, therefore, as R1 is varied, so is the frequency, by a slight amount. Of three crystals used, two allowed the multivibrator to synchronize at 476 khz with some adjustment range on both sides.

2. *Divide-by-sixteen stage*

A simple binary counter is assembled by the J-K flip-flops, FF1a, FF2a, FF3a and FF4a. It divides the input frequency by 16. Therefore, if the input is 476 chz, the output will be 29.75 chz. Although the more observant may note the counter actually functions backwards, this configuration was used for wiring convenience. Either way, forward or backwards, it takes 16 cycles of input frequency to get one cycle of output frequency.

3. *Divide-by-five-or-seven stage*

The heart of the AFSK generator is the divide-by-five-or-seven stage. The basis for this circuit was published originally by Donald E. Lancaster in the January 1968 issue of *The Electronic Engineer.* Lancaster demonstrates how to design counters to divide by any number. (Reprints of this article are available free from the magazine at P. O. Box 11081, Philadelphia, Pennsylvania, 19141.) Before detailing how this circuit is used, we should first review the Motorola RTL logic circuits. First the simple NOR gate: if any input is high, the output is low. If we use positive logic, (i. e. high voltage is 1, low voltage is Ø), a truth table for a 2 input NOR gate would look like this:

Inputs A	Inputs B	Output
0	0	1
1	0	0
0	1	0
1	1	0

The J-K flip-flop is more complex. Basically, it has three inputs and two outputs. Set, Clear and Trigger are the terms for inputs; outputs are Ø and 1. In the Ø state, the flip-flops Ø output is high and the 1 output low; in the 1 state, the Ø output is low and the 1 output high. To place the flip-flop in either of these states, various combinations of the inputs are used.

If both the Set and Clear inputs are at a logic 1 level, and a 1 level pulse is applied to the Trigger input, the flip-flop changes state,

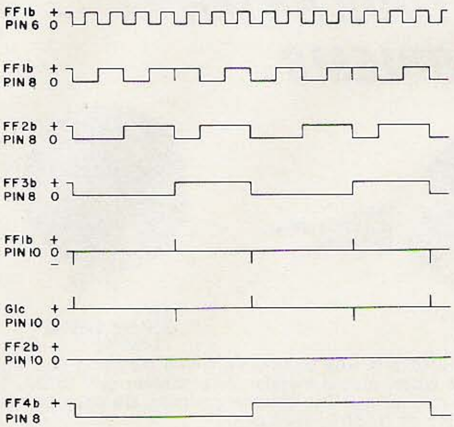


Fig. 3a. Mark condition waveforms.

or reverses itself. If the Set input is at a logic 1 level,and the Clear input at a logic Ø level, and a logic 1 pulse is applied to the Trigger input, the flip-flop goes into the 1 state. If the Set input is at a logic Ø level and the Clear input at a logic 1 level, a logic 1 level pulse applied to the Trigger input will induce the flip-flop into the Ø state.

Referring to **Fig. 2**, note that the Motorola RTL J-K flip-flops operate slightly differently. The S, T and C inputs as well as the Ø and 1 outputs have little circles after them, denoting inverters. They invert the logic into and out of the flip-flop, thus converting a Ø to a 1 and a 1 to a Ø. So, the truth table for the Motorola J-K flip-flop would look like this:

Inputs*		**Outputs****		
S	C	1	Ø	State
Ø	Ø	Changes State		
1	Ø	1	Ø	Ø
Ø	1	Ø	1	1
1	1	No State Change		

**Before Negative Pulse to T.*
***After Negative Pulse to T.*

So, if the flip-flop is in the 1 state, the output from the 1 output (after it goes through the inverter) is low, or a Ø logic level.

The Motorola RTL J-K flip-flop has an extra input it calls "Direct Clear." This may be confusing since, if a positive pulse is applied to it, the flip-flop goes to the 1 state, regardless of the inputs to the other three input terminals. The Fairchild RTL series also uses this extra input, but terms it "Preset," which more accurately describes its function.

The divide-by-five-or-seven stage is formed by flip-flops FF1b, FF2b, FF3b and NOR gate G1c. Referring to the waveform diagram, **Fig. 3a**, observe how the divide-by-seven state operates. Basically, these flip-flops form a divide-by-eight counter. However, when the fourth input cycle is received, FF1b and FF2b go into the Ø state, with FF3b going to 1 state. The positive going output from pin 8 of FF3b goes into the RC network R3C2, which is a differentiator. It takes in a square wave and produces a spike out, maintaining polarity. The positive spike out of the network feeds the Preset input of FF1b, placing it in the 1 state. Thus we have deceived the counter into believing it has received an extra pulse. From this point on, the counter again counts normally. This is the counting sequency:

000
001
010
011
101
110
111

Note we have skipped the 100 state and it takes only seven input cycles to get one output cycle.

Pin 9 of FF3b also has a differentiator following it, R2C1. When FF3b goes into the 1 state, it produces a negative spike out. This is fed to NOR gate G1c. However, since the other input to G1c is high during the divide-by-seven sequence, the output is always low. During the divide-by-five sequence, pin 9 of G1c is at a low level. Pin 10 as returned to +3.6 volts through R2, thus the output is still low.

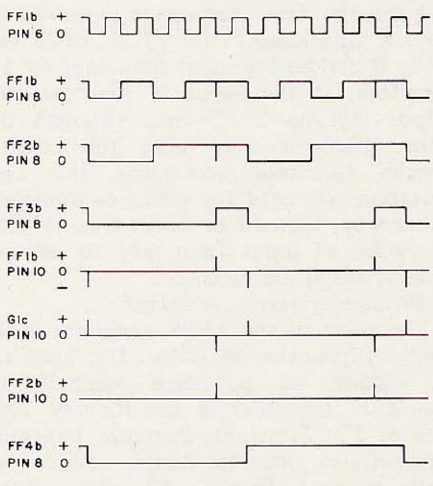


Fig. 3b. Space condition waveforms.

Examining waveform drawing **Fig. 3b,** we note that when FF3b goes into the 1 state, the negative pulse from R2C1 is fed into Glc. Since pin 9 of Glc is already low, when pin 10 goes low, a positive voltage appears at the output. Therefore in this divide-by-five state, Glc inverts the input to pin 10. The output from Glc is fed to the Preset input of FF2b. Now both FF1b and FF2b are placed in the 1 state, and the counter believes it has received 3 extra pulses. The counting sequence appears like this:

000
001
010
011
111

This time we have skipped the 100, 101 and 110 states and it requires only five cycles at the input to get one cycle at the output. It is the level at pin 9 of Glc which determines whether the counter divides by five or seven. Glb simply inverts the input level for reversed keying.

4. *Divide-by-two stage*

FF4b forms a simple divide-by-two stage. It takes the non-symmetrical square wave output from the divide-by-five-or-seven stage at 4250 hz, or 5950 hz, and produces a symmetrical square wave output of either 2125 hz or 2975 hz. This is then fed to the audio amplifier.

5. *Audio Amplifier*

IC1, an RCA CA3020 integrated circuit audio amplifier (see Fig. 4), accepts the square wave from the divide-by-two stage and amplifies it when the "Function" switch S2 is in the "AFSK" position. "Tone Level" potentiometer R4 varies the level of the square wave into the amplifier. When switch S2 is in either the "PTT" or the "voice" position, IC1 functions as a microphone preamplifier. The microphone is fed to pin 10 of IC1 which is the base of an emitter-follower. This follower's emitter is pin 1 of IC1 and connects to R6, the "Mic Level" potentiometer. The audio is then fed back into IC1 for further amplification.

The output impedance of IC1 is about 130 ohms. Matching was achieved by using two transformers, T1 and T2, with their voice-coil windings connected back-to-back. T1 is an Argonne AR-176 with a 125 ohm centertapped primary. T2 is an Argonne AR-164 with a 500 ohm primary. Both are available from LaFayette.

6. *Output Network*

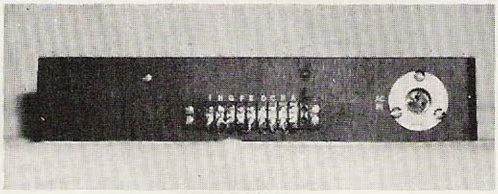
There are three separate stages in the

output network. R8 and R9 form a 500 to 430 ohm minimum loss pad. C3, L1, C4, L2 and C5 form a five-section Chebyshev lowpass filter. R10, R11 and R12 form a 430 to 600 ohm 16 db pad. The requirements for the lowpass filter led to this unique arrangement.

Since standard available inductors were to be used, the choice was confined to 11, 22, 44 or 88 mh. The filter had to be 40 db down at 6375 hz. A large pad appeared to be necessary to isolate the lowpass filter from the load since the primary impedances of various carbon microphone transformers might differ considerably. Since it was desirable to lump most of the loss on the output side of the filter, it should have an impedance near 500 ohms to minimize the loss in the input matching pad. Using 22 mh in the design equations for the lowpass filter resulted in an impedance closest to 500 ohms. It varies directly with the 40 db down frequency. Since the minimum 40 db frequency is 6375 hz, that figure and 22 mh in the equations came out to 433.5 ohms.

R8 and R9 match the 500 ohm output of the audio amplifier to the 433.5 ohm input of the lowpass filter. Insertion loss is about 3.28 db for this minimum loss pad. The lowpass filter is a five-section Chebyshev which means its skirt is fairly sharp, but it does have some ripple in the pass band. It is about 1 db and its 3 db point is above 3500 hz. At 6375 hz, it is 40 db down, and much more so, of course, at 8925 hz, the third harmonic of 2975 hz.

In computing loss through the lowpass isolation pad, it was determined that 4 to 5 milliwatts should be sufficient to drive most carbon microphone inputs. This figures out to about 20 db loss between the audio



Head-on rear shot. Only an engineer could label the terminals backwards.

amplifier and output. The input of the lowpass filter already shows a 3.28 db loss through the minimum loss pad. Therefore, about 16 db would be needed for the output pad. R10, R11 and R12 form this pad which also matches the output impedance of the lowpass filter to 600 ohms. Using standard value resistors, the loss actually comes out to 15.53 db. This produces a total loss of 18.81 db in the pads and between Ø and 1 db in the lowpass filter. Shorting the output, the filter sees 407.8 ohms; with an open circuit, it sees 454.4 ohms. The maximum variation between open and short is less than 6%, an excellent isolation.

Meter M1 is an illuminated miniature "VU" LaFayette meter, part number 99 h 5024. This is a "B" scale VU where Ø VU is 1.228 volts RMS, when used with the precision resistor supplied with it. This corresponds to +4 dbm across a 600 ohm line, or about 2.5 mw. The external multiplier resistor can be changed to display a Ø VU reading for other levels if desired.

7. *Power Supply*

The power supply **(Fig. 5)** is fused on the input side. T3 is a 6.3 volt, 1 amp filament

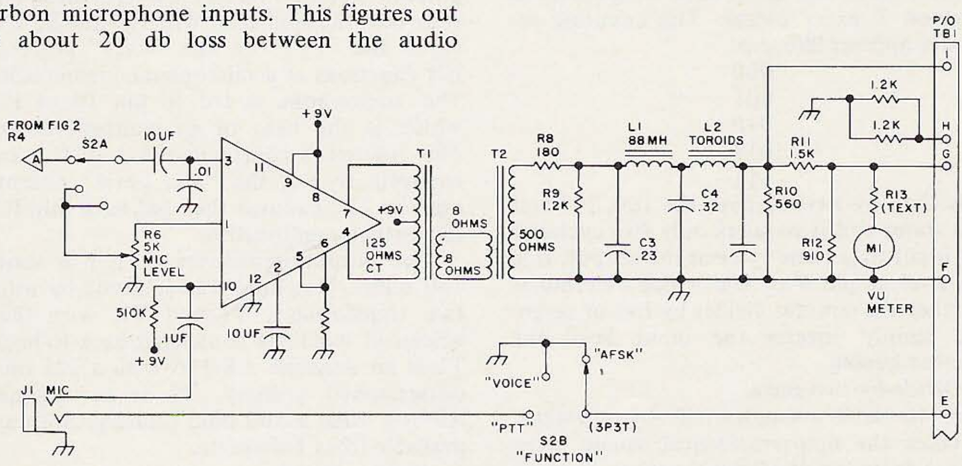


Fig. 4. Audio amplifier and output network schematic.

transformer. It is also fused on the secondary since a short probably would not

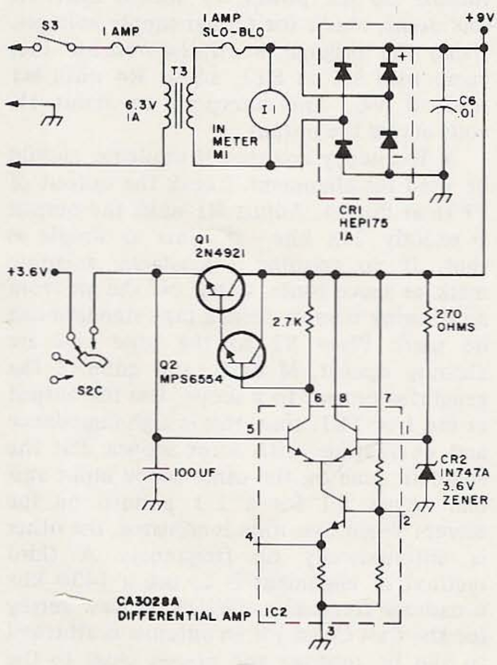


Fig. 5. Power supply schematic.

take out the primary fuse. A "slo-blo" is required because of the large peak currents drawn due to the large value of C6.

I1 is part of the VU meter, M1. CR1 is a full-wave bridge rectifier in a single neat package. C6 is a 10,000 mfd. (Correct: .01 farads!) 25 volt capacitor, available from Barry. Depending on load, the output is between 8 and 9 volts. Most of the voltage drop under load appears to occur in the transformer winding. Therefore, a huskier transformer should provide better regulation. Output powers the audio amplifier and the +3.6 regulator.

The regulator is required to supply +3.6 volts to the digital ICs. The voltage holds steady under varying loads and eliminates any residue ripples that might leak through C6. Diode CR2 is a 3.6 volt zener. This regulated voltage is fed to pin 1 of IC2, and RCA CA3028A. IC2 is a high gain differential amplifier. Its function is to compare the reference input on pin 1 to the regulator output on pin 5. The output is then fed to the base of Q2, connected to Q1 in a Darlington circuit. So, if the output is higher than the reference, the output on pin 6 of IC2 is lowered. This in turn reduces the base current to Q2 which lowers the base current to Q1. This drops the output voltage on the emitter of Q1. The reverse process occurs if the output is lower than the reference.

Although fair regulation might have been obtained with zener diodes, there was doubt about their performance at low voltages. This regulator maintains output voltage changes to less than .1 volt and there are no ripple or transient problems. Even this small voltage variation might be avoided by using a larger primary power transformer.

Construction

Although the prototype was developed on a Vector 3477 DIPlugboard, constructors are advised to use standard unclad perf-board both for ease of construction as well as to minimize coupling between the close-spaced etched leads on the DIPlug-board. This type of board also is susceptible to ground loops. It is advisable, even using standard perf-board, to use a common ground point for the bottom ends of R4, R6 and R7 and the ground ends of the bypass capacitors on pins 2 and 3 of IC1.

Particular care must be observed in shielding, since harmonic-rich *rf* square-waves are being generated. Use of an *rf* tight metal box is essential.

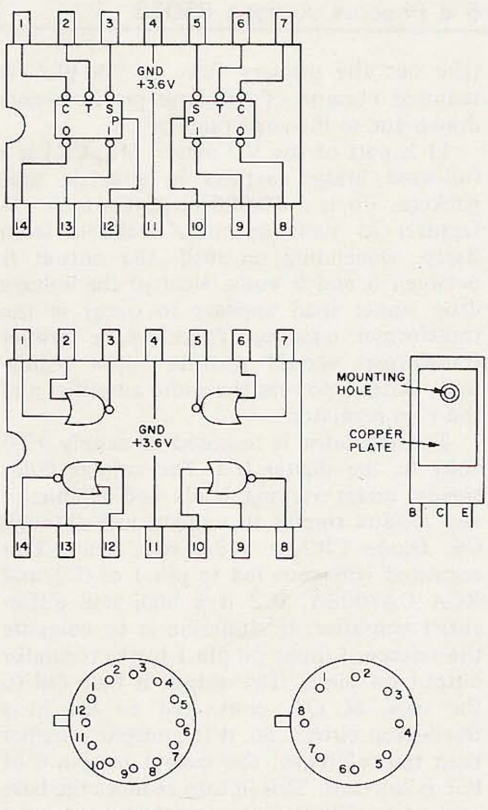


Fig. 6. Component basing diagrams.

Fig. 6 should simplify identification in IC and transistor lead basing. Looking at the MC700P ICs from the bottom with the notch on the left, Pin 1 is on the left end of the top row of pins. The remainder of the pins are numbered consecutively clockwise, Pin 14 being on the left end of the bottom row. Viewing the CA3000 ICs from the bottom, note the little tab on the case. It is adjacent to the highest numbered pin, Pin 12 of the CA3020 and Pin 8 of the CA3028A. These pins are also numbered clockwise. The 2N4921, Q1, may be confusing. The case is rectangular plastic with three leads on the bottom and a copper plate on one side. There is a hole through it. Viewing from the bottom, with the copper plate up, the base lead is to the left, the collector in the middle, the emitter on the right. The leads for Q2, MPS6554 are marked on the case. Note that a heat sink must be used on IC1.

Alignment

Alignment is simple. Without connecting to the rig, jumper pin G to Pin H on TB1. This places a 600 ohm load on the unit. Place the S2 "Function" switch to "AFSK." Pots R4 and R6 should be at minimum. "Mode" switch, S1, should be in either the "M" (mark) or "S" (space) position. When turning on the power, I1 should light. At this point, check for proper supply voltages. Using the original multiplier resistor that came with M1 as R13, adjust R4 until M1 reads Ø VU. This interprets to about 1¼ volts across the output.

A frequency counter, if available, should be used for alignment. Check the output of FF1a at Pin 14. Adjust R1 until the output is exactly 238 khz – it's just as simple as that. If no counter is available, accurate mark or space tones, either off the air from an obliging ham or from a tape standard can be used. Place S1 to the tone you are aligning against, M or S, and connect the generator output to a scope. Use the output at Pin I or TB1, since this is high impedance and compatible with most scopes. Put the standard tone on the other scope input axis and adjust R1 for a 1:1 pattern on the screen. When one tone is adjusted, the other is automatically on frequency. A third method of alignment is to use a 1430 khz broadcast frequency. (WNJR in New Jersey for the East Coast.) If an antenna is attached to the bc receiver and placed close to the 476 khz square-wave generator, you should

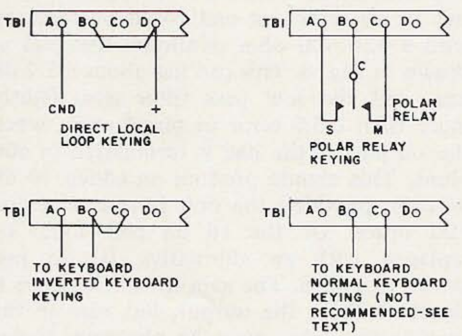


Fig. 7. Keying connection diagrams.

hear a beat note. This is the third harmonic of the generator and the 1430 khz signal. With the unit placed in the mark condition, connect the output to one axis of a scope. The audio of the bc receiver goes to the other axis. Adjust as described earlier for a 1:1 pattern between the beat note and the mark tone. This method may satisfy the purist since there will be a small amount of error. Actually the square-wave generator is producing 475.95840 khz and the Mark and Space tones are 2124.8143 hz and 2974.7400 hz, respectively. The maximum error is 0.26 hz!

Tuning of the low pass filter is a simple matter. No test equipment is required. The only value to be adjusted is that of C4. Start with a value of 0.22 uf. Then add capacity in steps of 0.001 uf until the Mark and Space tones are within 1 db of each other as indicated on M1. Now disconnect the jumper from terminals G and H of TB1 and you're ready to hook it up to your rig.

Operation

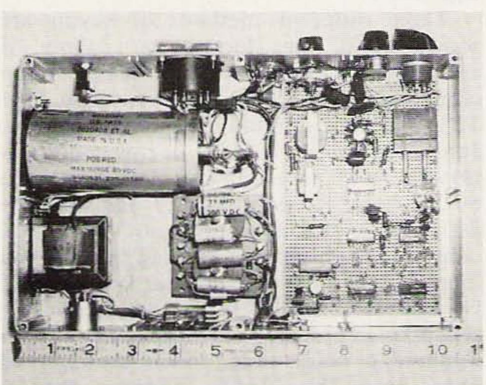
Three different methods of keying are provided. If the local loop supply is grounded and well-filtered, break it at the ground point and connect to terminal D of TB1. The loop ground goes to terminal A. Jumper terminals B to D. In this configuration the local loop runs through R5. For a 60 ma loop, R5 should be 27 ohms; with a 20 ma loop, R5 is 82 ohms. In the MARK condition with current flowing through the loop, about +1.6 volts appear on pin 9 of G1c with S1 in the N (normal) position. This serves to inhibit G1b and causes the unit to generate a mark tone. When the loop is open, or in the SPACE condition, Ø volts appear on pin 9 of G1c, enabling G1c, and the unit generates the SPACE tone.

Polar relay keying is also provided by connecting the common to terminal B, the mark contact to terminal C and the SPACE contact to terminal A. In this arrangement, Glc receives +3.6 volts through a 1 K resistor in the mark condition and a ground during SPACE.

Direct keyboard keying can be used by connecting terminal B to terminal C, and connecting the keyboard between terminals A and B. Although keying will be inverted, it can be corrected by placing S1 in the R (reverse) position. The keyboard could be connected between terminals B and C for normal keying, but this would result in the input line on terminal B left open during SPACE, but this could produce hum. The alternate connections are shown in **Fig. 7.**

It is assumed that S1 is in the N (normal) position in the preceding instructions. In the R (reverse) position, pin 9 of Glc is no longer fed from terminal B of TB1. It is now connected to the output of Glb, which takes the input from terminal B and inverts it. Therefore, the keying is inverted. In the M (mark) position, Sl connects the input of Glc to +3.6 volts through a 1 K resistor; in the S (space) position it grounds the input to Glc.

To apply the generator's audio output to the transmitter, any voltages connected to the primary of the carbon microphone transformer should be removed. Terminal G of TB1 should then be connected to the high side of the transformer and the low side to terminal F. Connect the PTT line to terminal E. With the transmitter in the stand-by condition, and the generator operating, placing S2 in the AFSK position should activate the transmitter. Advance the "tone level" pot to achieve approximate 100% modulation. Then select a value of R13 that



Interior bottom view. The diplugboard was wired by a dextrous midget. The bridge rectifier was mounted directly on the filter capicator to avoid ground loop problems. Note heat sink on IC1.

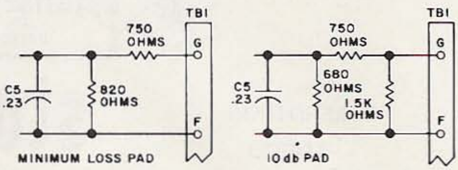


Fig. 8. Alternate output pad diagrams.

displays Ø on the VU meter. Then place S2 in the "voice" position and advance the "mic level" pot to produce about -3 VU while speaking normally into the microphone.

In the event the audio levels are low for your particular transmitter, it might be due to a mismatch between the 600 ohm output of the generator and the microphone transformer. This could be remedied by connecting a 600 ohm center-tapped transformer to the generator's output, and then hooking the microphone transformer between the low side and the center tap. We then have an autotransformer with a 600:150 ohm ratio. Or the carbon microphone transformer could be replaced with another unit with a 600 ohm primary.

If more output is desired and it is evident you have a 600 ohm load for the generator, the 16 db matching pad could be replaced with a 430:600 ohm minimum loss pad as shown in **Fig. 8.** This pad has about a 5.2 db loss, and the low pass filter sees slightly more than 0.5% error in termination when the output of the pad is terminated in 600 ohms. This should produce an added 10 db of gain, provided the unit is terminated at 600 ohms. Or the 16 db pad could be replaced with an alternative 10 db pad shown in **Fig. 8.** The gain in this instance is about 6 db in the output, but care in the termination value must be observed. Going from short to open circuit makes the low pass filter see a variation of about 20% from its design impedance. This is much greater than the 6% variation with the 16 db pad.

Still another method of obtaining more gain is to short out R7. This raises the current drawn by the amplifier and may increase distortion. Or Pin 11 or IC1 could be connected to the +9 volt line through a 1.5K resistor. However, these alternatives may lead to amplifier instability, since the 3 db point of this little IC is about 8 mhz with a resistive load. It is usable up into the vhf range with tuned loads.

Various modes of keying were tried in on-the-air testing of this unit. While all appeared to perform normally and, as anticipated, scope patterns and analyses at the receiving ends indicated that the polar relay method produced the most accurate keying characteristics. If a relay is used, be sure that it is a well adjusted polar relay. This unit will follow keying up to near a 4 khz rate. Any contact bounce will be faithfully reproduced by the unit. In all modes, there was favorable comment on the purity of the tones as well as their accuracy. Even the most exotic commercial counter was only able to detect a 1 hz variation on either Mark or Space.

Although there is an evident mismatch between the audio unit and the carbon mic input transformer of the transmitter, there was no evidence of insufficient drive to the rig's audio amplifier. No appreciable improvement was obtained using various external transformers, although any arrangement which can provide less than a 2 or 3 to 1 mismatch is desirable. Although the microphone is not used on the RTTY frequency, the same rig is switched to other 2 meter frequencies, so the unit can be left connected to the transmitter at all times, and the microphone is available for use whenever desired.

Since this unit was constructed, RCA has come out with the CA3020A and the CA3028B, newer editions of the linear ICs used in this unit. No circuit modification is required to use these later versions, and almost 3 db more gain is available in the CA3020A than in the CA3020.

Conclusion

As one operator observed after listening to this device on the air and learning of its design and construction: "That's a helluva complicated way to get a couple of simple tones." And so it is. However, for the experimenter who wishes to increase his familiarity with ICs and develop new techniques in obtaining standard results, working with these devices should be both challenging and rewarding. It is also a source of pride to this operator to assure others on the RTTY net that our tones are unchanging "on the nose" standards.

I would like to thank my father, KØREC, who put his not inconsiderable editorial talents to work, translating enginerese into English. He also performed the on-the-air tests, since I am not presently on the air, due to the fact that my father has my model 15 and won't relinquish it.

. . . W1ESH/3

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Transistor Transmitter Aspirin

or how to keep things from going pffft!

I am sure many have experienced the tragic "blowing" of a transistor (sometimes costly) and weren't sure what caused the darn thing to blow.

Some quotes from RCA's application sheet SMA-40 plus my own experiences may help many of you to save a few transistors.

How many of you have built a transmitter and, with dummy load connected, power on and even a current meter or two in the supply circuits, pull out the crystal and the darn thing still puts out *rf*? Or, sometimes when a stage 'is just on the verge,' it needs a little "tickling" or slight amount of drive to put stage into oscillation (usually the final, but not always). This latter type of trouble will disappear when the crystal is removed. This can cause thermal runaway and many times open or short the junction without you being aware by noting current meters.

As the RCA manual states: A transistor having a power gain of 5 at 174 mhz may have a power gain of 30 at 10 mhz. That doesn't seem like much, but wait, that's around 8 db stray inductance (even portions of the printed circuit board) plus stay capacitance, *rf* chokes and by-pass capacitors may make the 50 mhz (or any band) take off wildly at a lower frequency, and sometimes could be at a higher frequency if circuit components are just right.

Use of low Q ferrite chokes or even a wire wound resistor (that's right) in the base and collector load circuits with emitter (if not grounded) and supply leads by-passed with two capacitors, one for low frequency and one for frequency being used, plus very short leads and a design that will permit one ground per stage will help. Roughly, a .001 mF capacitor will have three ohms reactance at 50 MHz and 16 ohms at 10 Mhz, and 31 ohms at 5 MHz. With even one watt of power, a few tenths of a volt could develop across this reactance and, by a sneaky way known only to itself, could get into other circuits and make them go wild. Believe it or not, but with a homebrew peak *rf* voltmeter on my two transistor 125 mw rig, from the emitter connection on the socket back to the main ground run, about 3/8", I measured .15 volts. I laid a piece of #14 wire along this 3/8" stretch and soldered it, using as much solder as wire to make the lead very low resistance. So in printed circuits, lay wire or better, small strips of copper or brass and solder all along the way. It will lower the resistance path. After you get over a 100 or so milliwatts, I would strongly urge you to forget printed board and go to metal chassis.

On my printed boards, if at all possible, I try to leave a strip clear around ¼" wide of the copper plus strips from one side to the other where I plan to solder a shield, and if you don't use wire or strip brass, coat all printed board with solder to lower the R and Z.

Even using low Q chokes of bigger wire and adding a 33 to 47 ohm resistor as shown in **Fig. 1** will help to cure some of the ills. Don't forget the by-pass C.

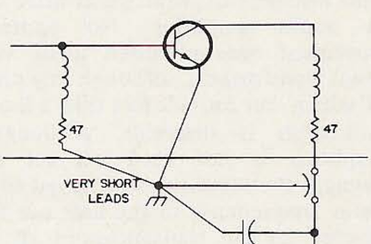

Fig. 1. Circuits can be tamed by proper VHF grounding.

I have had the experience in tuning up the driver and the final, of seeing the dummy load brighten up as expected and then suddenly drop down. I was at a loss to explain this till RCA cleared it up for me. It would also clear up the downward modulation when it shouldn't have been downward. The base/collector junction (especially of overlays) capacitance changes with applied voltage (or drive on the base). You have a varactor or varicap diode here that can detune your circuits! I bet this answers why to some of you! Using common emitter circuits and just enough drive to fulfill the job (like in the 2½ w transmitter, I state I can tune up to three watts but 2½ is stable and it rides there) and possibly a little higher L to C than before, in the tuned circuits.

I would strongly urge all you who are interested in solid state transmitters to buy RCA's "RCA Silicon Power Circuits" and write and request from RCA their Application sheets #SMA 36 (Design of Large Signal VHF Transistor Power Amplification) and #SMA40 (Frequency Multiplication Using Overlay Transistors). In fact, most of the others that make transistors will send you application sheets dealing with the subject you are interested in. They also have some good notes (and lots of math) on matching networks; matching from one stage to another and matching from final to antenna. Easy? Well, try matching a transistor collector of a few ohms impedance to several hundred ohms impedance to a circuit that will have some Q and will tune (without being shorted out or swamped by the transistor) and match this to a 50 ohm antenna.

A regulated power supply is a must (or batteries). You can imagine several hundred mills being pulled by the driver and final and several hundred in the modulator (assuming high power here, but it's the same with a 100 mw rig and a flea power supply) at voice peaks and how the voltage would swing madly everytime the thing was modulated. This will cause downward modulation, FM'ing, oscillator pulling, plus many other weird troubles.

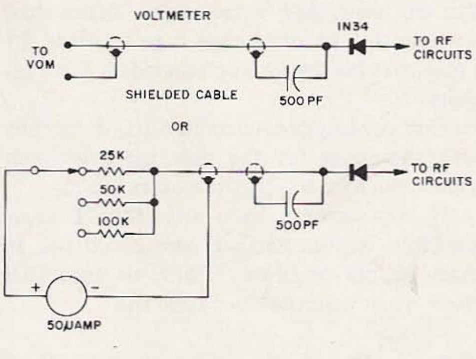

Fig. 2. Meter for finding ground loops.

Fusing the power supply or the supply leads to various stages can help. Mostly when a transistor goes bad, except in thermal runaway which may start slowly and end fast, fuses can't blow fast enough to offer too much protection, but now and then they may help!

If you have the habit of connecting the rig up backwards especially after playing around with both PNP's and NPN's transistors, connect a diode (50 mill to 1 or more amps depending on circuit) in series with supply leads in the right polarity that will give you the polarity wanted and by-pass it well. Now reverse the supply and you can do no damage, if done right.

In Fig. 2 is a meter that is very helpful. You can tell if the following stage is getting drive and if there are ground loops causing *rf* voltage drops. You can use your multimeter here with a probe. In this case you will be reading RMS values, but my meter has a scale of 0-1 so I use it as a relative meter just to tell me if I've got it, or if I haven't. If I can get a good indication on the lower scale from one point to another on chassis ground, I try to correct or lower it fast.

As stated in another article, I couldn't put the transmitter and modulator in the same case in spite of shielding. Always try it out breadboard, as it sure is work to tear it partly down and redesign and rebuild. I prefer separate modulators, then I can use it on other transmitters also.

Use heat sinks, preferably the finned types, and bigger types in larger powered rigs. Don't be greedy for power. In my 125 mw. rig, I went to 16 volts and under modulation the oscillator transistor "went west." If you design for 9, 12, 16, or 28 volts – stay with it. If you want more power – build for that power!

Last but not least, and very important, use a dummy load or antenna on your rigs as you test them. If not, where do you think the power (you hope to go into the antenna) is going? Mostly heat and ruined transistors!

...KØVQY

(. . . de W2NSD/1 continued from page 2)

TAG members, with a SASE for the answer. This is a wonderful opportunity to help some newcomers over the first hurdles.

If you are a member of a radio club that will welcome neophytes and help them on the road to becoming a Novice, then please send in the name of the club and the address so we can pass it along through the magazine and try and get you new members.

We are wide open for any suggestions for articles or services that would be of value. We need more amateurs and we need them desperately . . . I am hoping that the new magazine will help.

Articles We'd Like to See

International Crystal has a set of transistorized circuits on pc boards that have sparked a lot of building. Their crystal oscillator board sells for only $2.95 and is available in 3-20 mhz or 20-60 mhz models. I'll bet that you could put one of these down on 455 khz easily by changing the coil and use it for a bfo. The *rf* amplifier unit is $3.50 and is available in 3-20 or 20-170 mhz models. The mixer unit is available in the same two ranges at the same price. For $3.75 you can get a broadband amplifier unit that can be used for audio or, with *if* transformers, as an *if* amplifier. It will go from 20 hz right up through 150 mhz. There is also a power amplifier available at the same price for the 3-30 mhz range, designed to follow the crystal oscillator and give you up to 200 mw output.

More people will have fun with these units if you will send in articles showing them in application. They should make a 2M receiver rather simple to make. I'd like to see fifty articles on different uses for these interesting and inexpensive transistor units.

Another field that is interesting more and more amateurs is the burglar alarm problem. There are a number of commercial units appearing on the market as the crime rate skyrockets, but I'll bet that many of you look at them about the same way I do. I'd like to have a good alarm system, one that would warn of fire, smoke, or intruders, but I can't see buying one of those extremely expensive commercial units. It seems to me, that as the resident electronics expert, I should be able to come up with something more of a ham nature and with a ham price tag on it to do the job.

Have any readers worked out some alarm systems for their homes or cars which might be of value to the rest of us? Have you found any alarm components which are available at ham type prices which we should know about? Have any of you worked out any simple sensors for heat or smoke? Hundreds of mobile rigs are being swiped every year and we all should have an alarm system of some kind in our car. And, if your wife is like mine, a home alarm would help her sleep a lot easier.

Far too few FM articles are being submitted. This is one of the fastest growing areas of amateur radio at present and I would like to see a lot more articles on it. We need more information on setting up remote repeaters and operating them. We need articles telling us what areas of the country are covered by repeaters. We need articles on tests of some of the new FM transceivers that are being made for ham use. We need articles on antennas for FM. Anything that is of good general interest to all amateurs is worthy of being published . . . let's go.

New Typesetting System

IBM has just installed their new MT/ST taped typesetting equipment for us and we are having fun getting used to that kluge. With this arrangement we set the type by typing it up on a regular IBM Selectric typewriter. As this is typed it is recorded on a magnetic tape. Then we put the tape into the print-out unit, set the width of the margins we want, and watch it go. Other than stopping for us to change type faces or for a line that has to be hyphenated, it just zips along.

This contraption costs like the devil, but with the plans for the new magazine this winter, we'll be needing the extra speed.

If any readers have any MT/ST tapes available reasonably, we sure could use an extra supply of those. I hate to drive IBM stock up any more than I have to.

Cars

Whenever I meet readers at conventions or at ham clubs I am invariably asked about my Porsche. It has been some time since I have written much about my cars. Believe it or not, but I still have my old Porsche . . . the one I bought in 1957. This is the old Speedster model which they discontinued shortly after I bought mine. I've tried a couple of newer models since then, but I haven't found anything that I like nearly as well as the old Speedster. It is lower and more open than anything newer, and handles like a dream.

Last fall Lin and I made a short trip to Europe and picked up a Rover 2000 TC sedan. I'd been thinking about this for a couple of years . . . ever since Jean Shepherd K2ORS began talking it up on his radio program over WOR in New York. The review in *Car and Driver Magazine* finished me off and we got one.

What brought this all to mind was a little experience I had during my visit to Des Moines and the ARRL National Convention. I went out to dinner with a heck of a nice ham and his wife . . . Iowans. He said that he didn't enjoy driving. Well, I enjoy driving. I love it. But this didn't start until I discovered that there is one tremendous difference between cars. The Porsche woke me up to how much fun could be had with a really responsive car. Now, every time I take the Rover out, even to the store, I marvel at how it handles . . . how comfortable it is . . . how much fun to drive. It buzzes along at 80 and 90 with the same comfort that I find in the Sporty US cars at about 40. It holds the road through the sharpest of curves a lot like the Porsche. The leather seats are more like my living room chairs than a car.

Every time I go on a trip and have to rent an American car from one of the rental companies I get more and more depressed with the American product. I haven't found one yet (and I think I have tried almost everything now) that I would ever trade for my Rover . . . and it cost only a little over $3000.

Get mad at me if you will for telling you about my Rover, but whenever I find something that gives me as much pleasure as that car, I feel that I have a responsibility to tell you about it.

Microwave Oven

One of the big excitements of the 73 exhibit at the Boston ARRL Convention was a great big bowl of free hot dogs. "Food For Thought" was the heading. We set up one of the new International Crystal Microwave Ovens in our booth and turned out red hots for the crowd. The oven is a ball to use. It turns cold franks into juicy hot dogs in about 15 seconds.

Lin and I have been having a lot of fun with the oven at home too. What a difference it makes to be able to have baked potatoes with any dinner in a matter of about five minutes instead of running the hot stove oven for 45 minutes or so. Baked apple? About three minutes is all it takes, so I have them for lunch or even an afternoon snack now, freshly baked. Bacon comes out tender and juicy in 30 seconds. Frozen rolls take half a minute. Tender hot croissants take a few seconds for breakfast, ditto most any of the packaged rolls and cakes. Leftovers can be warmed in seconds right in the plastic refrigerator boxes. Hot coffee or chocolate takes seconds. Hot sandwiches, too.

Frozen vegetables can be defrosted and cooked in a couple of minutes. Frozen meats can be defrosted quickly too, though we prefer them cooked the regular way most of the time. Since it cooks from the inside it is great for sausages, but beef seems a bit different this way. It does warm up slices of roast beef deliciously in ten seconds though.

The oven costs a little under $600, which really isn't bad for someone who loves to cook. Once you have one, you will use it a dozen times a day. *(continued on page 136)*

Improvement of Phone Intelligibility by Base Clipping

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Shortly before the beginning of World War II, a number of operators and experimenters discovered, more or less independently, that phone signals, made unintelligible by noise, could be "cleaned up" and made more intelligible by base clipping. Theory of operation of the base clipper, as it was outlined at the time, is shown in **Fig. 1**. This theory was later proved to be somewhat incorrect, yet base clipping demonstrably improved the intelligibility of received phone signals. As originally outlined, if a signal (A) and a noise (B) were both present in an audio circuit, the resultant combined signal (C) could be "cleaned up" by eliminating all parts of it from +N to -N, giving the improved signal (D). The rounding off of the zero-crossing "step," caused by base clipping, occurred in later stages of amplification. A recent base-clipper circuit, using this principle, has been outlined by Shelby.[1]

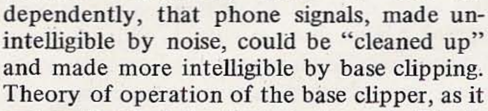


Fig. 1. Preliminary (and incorrect) theory of base clipping.

Although oscilloscopic studies of audio signals showed that the noise signal was added to the audio signal, so that this theory was definitely incorrect, I made and used several base clippers with gratifying results from 1946 to 1960. These consisted substantially of a phase inverter, followed by a push-pull amplifier, with a wide range of bias adjustments, so that it could be operated in any class from A to C. Using this device, there was a point of optimum intelligibility for any signal, this point being toward class A operation with clean signals, and toward class C operation with signals mushed by noise. A variety of biased series diode circuits were also used, in conjunction with pre- and post-amplifiers, to perform the same function, and they worked about as well as the variable class audio amplifier.[2]

Checking of the base clipper operation with a good oscilloscope corrected the original erroneous theory of operation, and finally showed just how the noted signal improvement came about. Referring to **Fig. 2**, if we feed an amplifier with a signal (E) and a noise (F), the resultant output will be the mushed sine wave (G). Clipping the base of this curve at levels +N and -N will produce the curve (H), and no detectable improvement in tone quality. With continuous sine waves, base clipping does not improve signal quality. However, with wave trains, such as a CW signal, base clipping at the level of the average noise (or slightly higher) does produce a definite improvement in readability, as in **Fig. 3**, and this is still further increased if base clipping is followed by peak clipping. Wave envelope of a noise-free CW signal is shown in **Fig. 3**, (I). To this is added noise (J), producing the output (K), a combination of signal and noise. The signal plus noise-to-noise ratio here is poor. By clipping the base at a level equal to or slightly exceeding the noise, envelope (L) is produced, with a greatly improved noise ratio. If this signal is now peak-clipped,

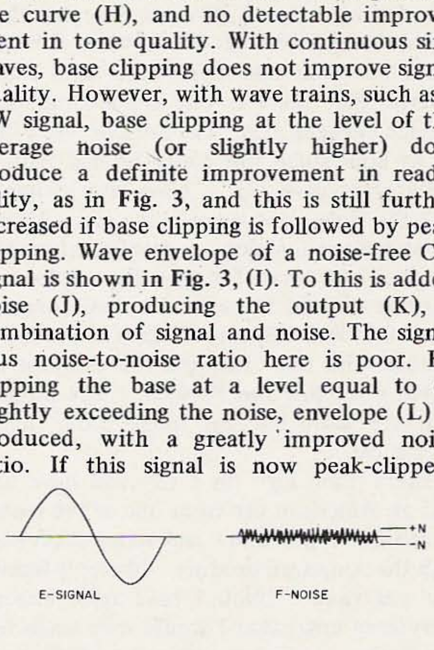


Fig. 2. Behavior of sine-wave signal in the presence of noise.

envelope (M) will be produced, which is almost "pure" signal.

If, now, this output is rectified and filtered, it can be used to key an audio oscillator, the combination being known as a "code regenerator."

This still does not tell how base clipping improves the quality of received speech, but *"Eppur si mueve."* Oscilloscopic studies with sine waves and CW signals, however, do disclose a key fact: with base clipping at the no-signal noise level, where there is no signal, there is also no noise.

Further oscilloscopic studies of actual speech signals, plus some excursions into physical linguistics, greatly assisted by published researches of the Bell Telephone Laboratories, finally gave a very satisfactory answer, which is outlined in **Fig. 4**.

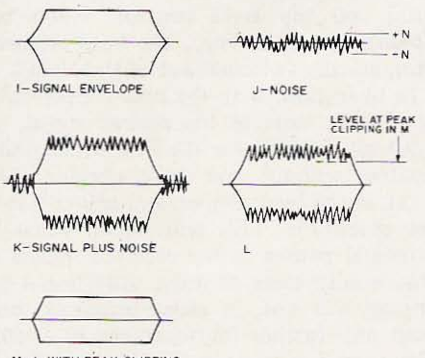


Fig. 3. Improvement of CW signals by base clipping.

Speech, basically, consists of an audio carrier, of varied frequency content, modulated in a rather specific fashion. The "carrier" frequency is not too important, as we can understand the spoken words of a "Russian" bass and of a "screeching" soprano with almost equal facility, all other factors remaining the same. The shape of the modulation envelope, however, is quite important, particularly the phonemal pauses, which are intervals of no signal occurring at the ends of syllables, and as a part of certain labial and lingual phonemes (the building blocks of speech). If the phonemal pauses are clearly defined, the diction is said to be good; if the phonemal pauses are not clearly defined, diction is called poor. Intelligibility of speech, in very general terms, is a function of the quality of the diction.

A speech envelope is shown diagrammatically in **Fig. 4** (N), with the phonemal pauses indicated by X. Noise is shown at (0),

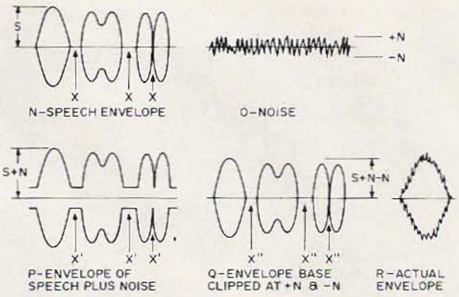


Fig. 4. Improvement of speech intelligibility by reduction of masking noise.

and signal plus noise, as received, at (P). Note here that the phonemal pauses, indicated by X, are plugged up, so that diction is degraded, as is intelligibility. This situation, which you can duplicate by connecting an oscilloscope across your receiver output while listening to a phone signal on "one of those nights," almost exactly parallels the "masking noise" situation so thoroughly studied by Harvey Fletcher.[3] If, by base clipping at the average level of the noise, we clear up the phonemal pauses, signal intelligibility is greatly improved, and the signal envelope now looks like (Q) in **Fig. 4**. The effect is quite similar to that produced by increasing the percentage of modulation. A still greater improvement is indirectly brought about, in the case of "white" noise, because a low frequency will tend to "override" a sound of higher frequency. Although noise above the clipping level is still superposed on the signal envelope, as in (R) of **Fig. 4**, the human ear will tend to disregard the higher frequency, and respond to the lower, through a wide range of signal and noise intensities. This also has been studied and reported in detail by Fletcher (op. cit., p. 153). This same line of reasoning points out the need for keeping hum at a minimum, and explains why a measured low level of hum has a high perceived level of annoyance.

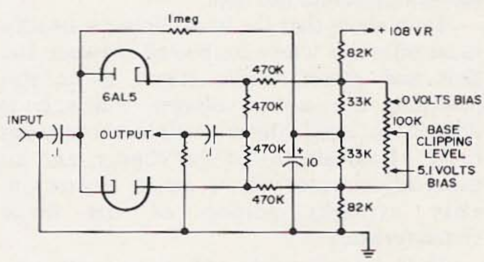
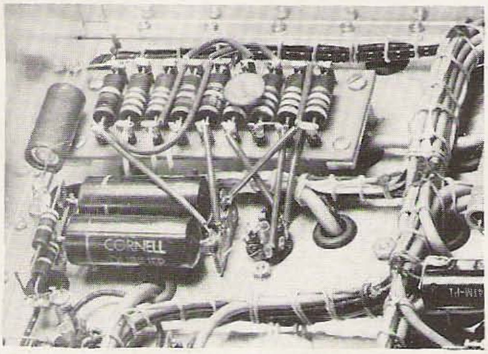


Fig. 5. Earle threshold modified for base clipping.



Under-chassis view of base clipper using modified Earle circuit.

Methods of base clipping have been greatly improved and simplified during the past few years. One of the best base clippers now known is derived from a circuit developed by W. A. Earle.[4] This, shown diagrammatically in Fig. 5, consists of a biased dual diode in series with the signal line, diodes being in opposed polarity. Since both diodes are cut off by a bias, which can be varied from zero to more than five volts, a signal applied at the input will not pass through the diodes until its peak amplitude exceeds the bias. When the signal peak amplitude does exceed the diode bias, all excess signal voltage reaches the output through a 470 k resistor. Thus, any signal may be base clipped at any desired value from zero to about five volts. Insertion loss of the base clipper, at zero bias setting, is about 6 db (measured).

Experiments with various semiconductor diodes in place of the 6AL5 dual diode indicates that a wide variety of high back resistance germanium diodes will work very well, the "toe" of their characteristic being unimportant under normal operating conditions.

Silicon diodes are slightly less applicable, as their toe is at approximately .6 volts. This can be offset by a complex biasing arrangement and becomes less important when signal amplitudes are high.

Tests show that the base clipper is usually most effective when connected between the first and second audio stages, as in this position, the noise voltages which it is desired to eliminate are within the normal range of adjustment of the clipper, and all usual adjustments will be within the reasonably straight portion of the diode characteristics.

Unlike many audio filters and clippers, this type of base clipper is easy to build, and requires no special adjustments or tricky "diddling" to make it work. All fixed components except the 6AL5 are mounted on a conventional terminal board, and all signal wiring is point-to-point. For reasons of stability, 2 watt 5 percent carbon resistors were used, although current in circuit would permit use of ½watt resistors. Leads to the 100k level control resistor, mounted in the panel, are shielded microphone cable, to prevent hum and unwanted coupling to other circuits, and a .02 μf ceramic capacitor is connected across the control to reduce contact noise. Filament of the 6AL5 is biased +40 volts with respect to ground, to prevent hum injection, and this is as effective in this application as pure dc on the filament.

For operating convenience, the base clipper was switched in and out of circuit by means of a relay, which is controlled by a switch on the level control. When base clipping bias is at zero, the base clipper is automatically switched out of the circuit.

In operation, with the base clipper out of the circuit, tune in the desired signal, and adjust all controls for the best intelligibility possible without the base clipper. Then switch in the base clipper, and adjust bias for best reception. This will occur when the phonemal pauses in the received speech are substantially clear of noise. Additional base clipping will not, in most instances, bring about any further improvement in intelligibility, and too much base clipping will turn most speech into gibberish.

Experimentation with base clippers also explains, in part, why some operators who have obvious hearing impairments ("tin ears") seem to copy about as well under almost hopeless conditions as they do when conditions are good. They have a built-in base clipper!

. . . Ronald L. Ives

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[4] Earle, W. A. "A-C Threshold Converts to Switch", *Electronics;* Vol. 31, No. L, Jan. 3, 1958, 98-100.

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Measurement of Meter Resistance

It is often necessary, when building any sort of equipment using a sensitive meter, to know the internal resistance of the meter. The obvious way of measurement – simply slapping an ohmmeter on it – is not safe, because most ohmmeters, when switched to a range which will read the comparatively low meter resistance, will pass a high enough current through the meter to damage it.

The following method, though old, is not widely known. It uses the meter itself as the indicator. The meter is connected to a constant-current source, that is, a voltage source in series with a suitably high resistance. A variable resistance is then connected right across the meter terminals and adjusted to take exactly half the total current. The variable resistance is now equal to the meter resistance and may be removed and measured by any of the usual methods.

For a practical circuit see **Fig. 1**. The voltage source may be anything handy, even a 1.5 volt dry cell, though a higher voltage will give more accuracy. The total resistance R1 plus R2 is calculated by Ohm's law to allow full scale current to flow through the meter. *Don't* make a mistake in this calculation and pass 10 or 100 times too much current! If in doubt, start with too high a resistance and work down. At least 2/3 of the resistance should be in the fixed resistance R1, so that accidentally cranking R2 to the wrong end will not injure the meter. Also, connect the battery up last, after everything else is ready.

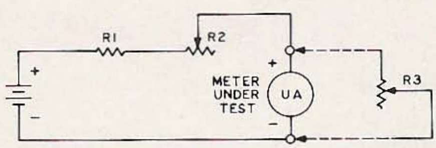

Fig. 1. Circuit for measurement of meter resistance (see text for values of R1, R2, R3 and V).

Having set R2 to make the meter indicate full scale, connect another variable resistor R3 across the meter terminals and adjust it to make the meter indicate exactly half as much current. Now, without disturbing the setting of R3, remove it and measure its resistance with an ohmmeter.

An example may make things clearer. A 0-100 microampere meter out of our junk box will be measured using a 1.5 volt dry cell as the voltage source. The total resistance will be 1.5 volt divided by 0.0001 ampere (watch the decimal point!) or 15,000 ohms. R1 can conveniently be 10,000 or 12,000 ohms, and R2 a 5,000 or 10,000 ohm potentiometer. Connect them up as shown in **Fig. 1**, and set R2 for full scale indication, 100 microamperes.

For a first try, a 1,000 ohm potentiometer can be used for R3. Connect it across the meter as shown by the dotted lines in **Fig. 1**, and adjust it to make the meter indicate 50 microamperes. Now remove R3 and measure it; let us suppose it turns out to be 500 ohms. We can then say that the meter is also (almost exactly) 500 ohms.

Note that connecting R3 reduces the total resistance in the circuit slightly, so that in our example the total current flowing would not stay exactly at 100 microamperes. If the meter resistance is 500 ohms, connecting R3 would reduce the resistance of the meter-and-R3 combination to 250 ohms. The resistance seen by the battery would drop from 15,000 to 14,750 ohms, so that the current is not 100 microamperes now, but 101.7. This means that R3 is carrying 51.7 microamperes and will turn out to be 484 ohms, which is low by about 3 percent. This amount of error is not objectionable in many cases, and can be reduced by using a higher voltage source with correspondingly larger R1 and R2. There is not much point in trying to reduce this kind of error below 1 percent, since the accuracy of the ohmmeter and the scale linearity of the meter being measured are not likely to be any better than this. Putting it another way, it will rarely be necessary to use a source over 4.5 volts to keep the current acceptably constant. On the other hand, the voltage source may be as high as desired, except for the shock hazard and the fact that R1 and R2 will get inconveniently large.

The value of R3 will depend on the meter range. Most 0-1 milliammeters will be between 25 and 100 ohms, and microammeters will be higher, up to perhaps 5000 ohms for the most sensitive ones.

Go to it, but be careful. Any time you mess around with a meter and a battery, one mistake is all it takes.

. . . WA6NIL

Diode-Stack Power Supplies – The Easy Way

E. H. Conklin, K6KA
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La Canada, Calif.

Many amateurs wish to have quick-start transmitters with reduced heat during standby periods. This leads to thought of the possibility of replacing rectifier tubes with diodes in high-voltage power supplies.

The first approach generally is to look for a hatful of 800-volt or 1,000-volt diodes with a current rating somewhere between 750 ma and 3 amperes, and to plan for an equal number of capacitors and resistors to go across them. The result is an impressive installation. Some, like Fred Mason, KH6OR, had a failure before the number of series elements was increased to provide an adequate safety factor.

There are some direct tube replacements, such as the Sarkes Tarzian S-5130 used by W4PR, and by W6RT in the Collins 30-S1, with a protective device added, but this unit is listed in the mail-order catalogs at $22.50 each. They are rated at 10,400 inverse peak (7400 rms) volts; and at 300 ma continuous, 3000 ma peak, current. For a capacitive load, the current should be derated by 20 percent and the rms input voltage by 50 percent. This cuts the rating very thin when one unit must stand the full voltage of a center-tapped transformer. The current rating is less of a problem due to the low duty cycle for single-sideband transmitters.

I wanted a simple solution for my Henry 2K amplifier, without any modification, if possible. The 3B28 tubes are in front where they get some air circulation from the blower intake. There is space above the sockets. The matter was discussed with Frank Clement, W6KPC, of Diodes, Inc., 9261 Independence Avenue, Chatsworth, California. This resulted in the purchase of four No. 5244 high-voltage diode stacks at about $8 each.

These can be used two-in-series on each leg of a center-tapped transformer, or singly in the conventional bridge circuit producing the same output. Each stack is rated at 6,000 volts peak and ½ ampere continuous duty when fastened to a heat sink. They have stood up when drawing 800 ma, key down, during tuning using a dummy load. They will tolerate a 50-ampere "in-rush surge" if it is not longer than half a cycle.

The heat sink should be the chassis, or a plate with about 25 square inches of surface for each of the rectifier stacks. This can be reduced to as little as ten square inches in SSB application where the duty cycle is short. Both sides of the surface can be counted. I use a plate 40 square inches on a side. With it, the diode stacks seem to remain close to room ambient temperature. A commercial heat-sink could provide this surface in a smaller volume.

The plate was mounted vertically on a horizontal sheet of insulation that rests on the rectifier sockets. A two-inch bolt with its end threads filed slightly passed from the insulation down into one socket clip to connect to the idle filament transformer and the filter. Two stand-off insulators, with a small stack of washers on the bolt, made fine

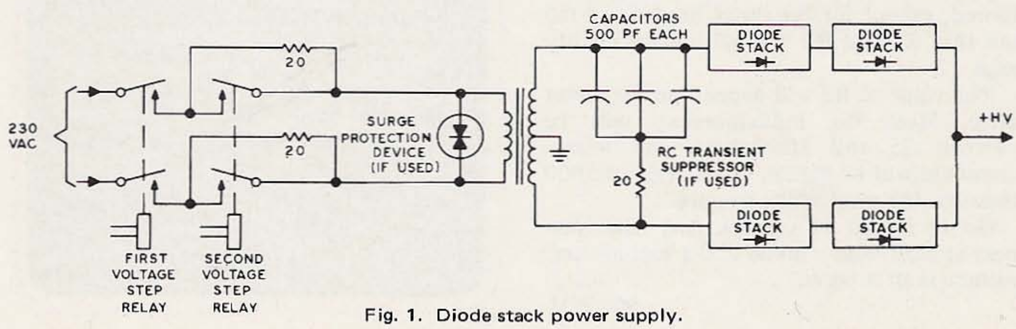

Fig. 1. Diode stack power supply.

places to attach the two plate clips from the ends of the transformer secondary. After carefully checking polarity, the four stacks of diodes, each the size of a package of chewing gum, were bolted to the aluminum plate.

In order to obtain quick start, the twenty-second amperite relay was removed from its socket, and a two-second one used in its place. No time delay at all is required, according to Bill Orr, W6SAI, at Eimac. However, I saw no reason to transmit before the filaments were fully on.

In a few minutes, the unit was plugged in and was on the air. The time from cold start to full power was four seconds, and much less after the thermal relays had warmed. It became possible to shut down the Henry 2K during round-table discussions and between calls, without waiting unduly to fire up the amplifier.

My Henry 2K was built in August, 1965, when Henry was using two-step power relays. In order to equalize the contact sparking, the series resistors had been doubled to 20 ohms each. This feature reduces substantially the tendency for a surge to damage the diode stacks. In the absence of the step-start feature, it would be desirable to use some surge protection, or to add one or two more diode stacks in each leg.

One protective measure was suggested by Frank Clement. This is to obtain three or four TV fly-back capacitors, which are 20,000 volt, 500 $\mu\mu$f, ceramic units. They cost about a dollar, but can be found in old RCA TV sets between the picture tube shield and ground, connected at the filament of the high-voltage rectifier tube. In series with these paralleled capacitors, place a 200-ohm resistor. This RC network is then connected across the entire power-transformer secondary – between the two standoff insulators on the heat-sink plate. It tends to absorb the voltage transient which is likely to occur about once each 150 times that the power relays open, and could exceed the diode stack voltage rating.

Alternatively, Jim Smith, W6RT, obtained a thyrector, General Electric No. 6rs21sa10d10, found in the Allied and Newark industrial catalogs at a few dollars. The thyrector is connected directly across the power transformer primary. It may have to depend upon the coupling of the transient from the secondary to the primary, but has proved useful.

. . . K6KA

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Transistor Testing Techniques

The ham is, perhaps, gifted with an overabundance of ideas, and at the same time cursed by a lack of funds. To compensate for this continuing deficiency of the wallet, he tends to buy the many assortments of untested transistors, and, taking his trusty VOM in hand, proceeds to destroy what few or many useable transistors he found in the poly-bag. Instead of having a collection of good useable transistors, he has on his hands a collection of shorted three-leaded metal cans.

To prevent this needless loss, let us first review some basic facts about transistors. For lack of a better description we can consider a transistor as being composed of two back-to-back diodes (see **Fig. 1**). The base connection will always appear at the common connection of the two diodes. The orientation of these two diodes as shown in **Fig. 1** will indicate whether the transistor is of the PNP or NPN variety.

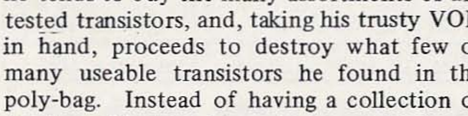

Fig. 2. Polarities for various tests.

As we can see from **Fig. 1**, there exists a difference of operating voltage polarity for each type.

In the case of the PNP transistor, the base is positive with respect to the collector, and negative with respect to the emitter. The NPN transistor is just the opposite, with the base negative with respect to the collector and positive with respect to the emitter. The collector-to-base diode junction is reversed biased and the emitter-to-base junction is forward biased in both the PNP and the NPN transistors. The collector and emitter are at opposite polarities in both cases.

The purpose of this brief review of what constitutes a transistor is necessary because in order to safely test a transistor, we must first understand the internal make-up and the differences which do exist in polarity. Many articles have described the use of a VOM for transistor tests. Unless care is taken and the polarity of each transistor element is carefully observed, the seemingly innocent testing procedure will result in the destruction of the transistor under test.

How, then, do you test a transistor safely but without buying a rather sophisticated and costly transistor checker? The answer lies in the *careful* use of your VOM. By making a few simple pre-tests and following the testing procedures outlines in this article, you will be able to test almost any transistor you might come across without damaging it.

The first step is to borrow an additional meter with a dc range of approximately 0-10 V. Switch your VOM to its resistance scale and measure both the voltage and polarity appearing at the test prods. Rotate the range switch until you find the least voltage (about 1.5 V) usually Rx10. Now comes the hard part; either misappropriate your mother's or wife's nail polish or be a coward and use paint. Mark this range with a small dot, and

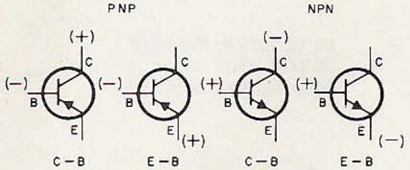

Fig. 1. We can consider a transistor as being composed of two back-to-back diodes.

also indicate which prod is positive and which is negative. This may vary from VOM to VOM; many types reverse the polarity when in the resistance measurement ranges.

Testing procedures

It is most important to determine that each diode junction of the transistor under test exhibits low resistance in one direction and a high resistance in the other. Emitter to collector resistance should be high in *either* direction. Polarity is important at the emitter-base junction of small signal transistors due to the low reverse voltage rating of this junction. Only the forward resistance of the base-emitter junction should be measured. Emitter junctions of power transistors may be checked in both directions without fear of damaging the transistor. **Fig. 2** shows the proper polarities for the various tests.

Reviewing what we have discovered and why we went to the trouble of measuring the voltage present at the test prods before we attempted to test a transistor, relates back to our earlier discussion of what a transistor is and how it is made. The value of approximately 1.5V is a safe range for making the forward reverse tests and will not damage a transistor. The exact meter reading is immaterial, what we are looking for is a definitive difference in the forward and reverse readings. In small signal (germanium) transistors forward resistance is in the neighborhood of 20 to 30 ohms. Small signal silicon transistors have diode junction resistances of from 40 to 60 ohms. In either case a reading of 15 ohms or less will indicate a short. Power transistors should exhibit a resistance (forward diode junction) of from 6 to 12 ohms.

To sum things up, we have discovered what a transistor is, how we can safely test it and what sort of readings we should expect. Please remember that small signal transistors should never be subjected to reverse resistance tests of the emitter-base junction. With proper techniques we now may safely test those bargain transistors; who knows, you might find the elusive 2N2219 you needed is really good.

...W9KXJ

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2 1/2 W Transmitter

As my hobby is transistors, I just had to keep building and of course – more power! This model checks out 2-1/2 w on Bird wattmeter. It has no dx record as yet except using a No. 47 bulb as a dummy load. Located on my work bench in the basement, making the transmitter about 2 to 2 1/2 feet below ground level, I worked a friend two miles away, getting an S6 report. Does anyone know how to make a good 5-element yagi using 47 dial lights?

This transmitter is held in reserve and will be my six-meter solid state job after the 1/4 w has done its job. I have the reputation of building up a job, using it for awhile and then tearing it down to use the parts in something else. Building is my hobby. If it works and the novelty has worn off, I'm ready to scrap it.

The coil forms for this unit were scrapped from some war surplus. They are ceramic 3/8" with iron slug and wound with 6 turns of about No. 20 silver plated copper wire. I used the coils as is and applied the necessary capacity to bring them to frequency, with the exception of adding links and tapping the final tank.

The 2-1/2 rig was built on a metal chassis as ground loops of current on a printed board could not be tamed.

The driver transistor was heat sinked with a slip over fin-type heat sink. The oscillator needed none. The final was a Bendix B3466 (looks like a TO-5 transistor pressed into a stud mounting case, with threaded stud at one end and wire leads from transistor at the other end). I used a 1/4" thick piece of brass, 1" by 1-1/2" on the stud as a heat sink.

I use transistor sockets on all my jobs so I can try out various transistors and change them easily when I blow them. (I cry a little too.)

With no shorts and power applied, the oscillator transistor is the one to worry about getting to work. The others are class C and will take "drive" to turn them on. All the oscillators mentioned are capable of lighting a No. 49 bulb, some brighter than others, depending on transistor and circuit.

The modulator used was an exact copy built up from the 5 w CB rig. described in RCA's transistor Handbook.

2N3553's or 40341 (both RCA) will work in the final. I intend to try a grounded collector and take the output from the emitter in another rig, so I can mount the stud (which is also connected to the collector) for better heat sinking. Maybe some of you have tried it.

The final may present a problem, due to the varactor action of overlay transistors. After tuning the final for maximum into a

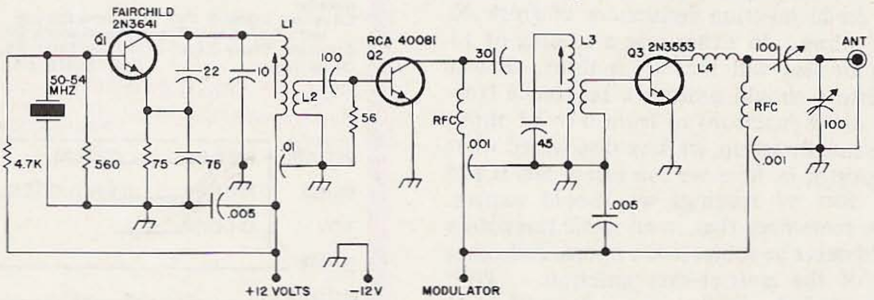

Fig. 1. Schematic of 2½ watt transmitter. L1 and L2 = 6 turns # 20 On iron core 3/8" ceramic form. Links are 2 turns # 20 insulated at bottom of L1 and L2. L3 is center tapped. These coils are 'war surplus' used 'as is'. Both windings are ½" long. L4 = 6 turns Airdux 516 or BW 3007. Q1 = Fairchild 2N3641; Q2 = RCA 40081; Q3 = Bendix B3466 or RCA 2N3553 or 40341 (all heat-sinked).

No. 47 dial bulb, and peaking the driver again, you may find a point where the power goes way down, and turning the slug in the driver stage will bring it back. I can get a little over three watts out on this rig, but it gets unstable to tune. Don't try for the utmost power output, but about 80 to 90%, which I have found to be where the driver and final are stable and will stay that way under modulation.

Ground the final emitter right at the socket by bending the emitter socket pin to the chassis and solder. Mount the driver coil on the opposite side of the between stage shield so the ground side of the final base link can come through the shield and ground at the same emitter ground, making this lead as short as possible.

You can try all sorts of transistors in these circuits. Even the 2N706's will work as an oscillator and driver (reduced power), but may "pop" under modulation in the 2½ W rig. Beware of some of the bargain transistor ads. A 2N697 may work at 50 mhz, but I haven't been able to get one to do so and if I did, it would be with reduced power and wouldn't be worth the effort.

...KØVQY

Soldering to Desolder

Of course, we all know how to make good soldered joints. First, one makes a tight mechanical joint by wrapping the wire around the terminal, firmly. Then one applies the solder, by first heating both the wire and the terminal hot enough to melt the solder and then applying the rosin-core solder to the parts to be joined.

However, in experimental work, it frequently becomes necessary to unsolder the joints thus made. This entails removing the solder and unwrapping the wire. Not only is this a difficult job–it is often destructive to the components. A simple expedient in such work is to avoid making a tight mechanical joint by bending a short loop on the end of the wire and hooking this to the terminal to which it is to be connected. Applying a drop of hot solder completes the job. Later, in changing the circuit, one needs only apply the hot soldering gun and the hook will slip off very easily.

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Neutralizing the HX-10

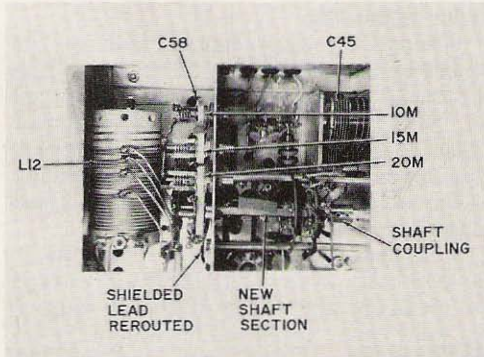
A few HX-10 owners have experienced a neutralization problem with this sturdy SSB transmitter on 10 and 15 meters. Per the instruction manual, neutralization is accomplished at a frequency of 14250 khz and generally holds well enough for satisfactory all-band operation. However, due to the nature of the neutralization circuit employed in the HX-10, some degradation in neutralization occurs at frequencies removed from 14250 khz with resultant occasional instability on 15 or 10 meters. Neutralizing the rig on 15 or 10 meters produces little improvement as instability can then occur on the lower bands. The 20 meter "compromise" neutralization, while effective on 80, 40, & 20 meters, leaves something to be desired on 10 and 15 meters.

As a result of this problem, the following symptoms have been experienced in tuning some HX-10 transmitters on 15 and 10 meters. Plate and grid control adjustments are very touchy and interact with each other. At times the 6146's take off on their own. This is evidenced by a full power forward indication on the SWR bridge with no audio input. Slight movement of either the grid or plate control usually stops this oscillation. On the air reports on 15 and 10 are not always satisfactory; the signal is often broad with fuzzy audio quality, sometimes accompanied by spurious radiation on either side of the fundamental signal.

In solving this problem with my own HX-10, and after much consideration, it was decided to install two additional neutralizing capacitors; one for 15 meters and one for 10 meters. These would function independently of the original one, which would be retained for the 20, 40 and 80 meter bands.

The following step-by-step procedure is provided for those who wish to perform the same modification:

1. Remove tank coil L12 from present location by carefully unsoldering all leads, and removing screws in stand-off insulators.



Modified HX-10.

2. Place band-switch in 3.5 mhz position.

3. Unsolder all remaining leads on band-switch wafer BS7 and remove it from the end of the switch shaft.

4. At the open space adjacent to capacitor C45 (in the 6146 compartment), carefully cut the shaft of the band-switch approximately 3/8" from the dividing partition (refer to picture) with a hacksaw. This is in preparation for adding a longer shaft section with a coupling. Place a rag under the shaft to catch metal chips.

5. Slide the cut shaft section toward the rear chassis apron until it touches the apron. Locate this position on the other side and drill a 5/16" hole through the apron. This hole will permit installation of the new, longer shaft section. Remove the short section of shaft and discard. Be careful not to move the position of the wafer switch rotors.

6. Obtain a new shaft section 3-3/4" long with the same diameter and flats as the original. Also procure a single pole 11 position wafer switch section which is required for switching the three neutralizing capacitors. Only seven positions of the switch will be used. (See **Fig. 1.**)

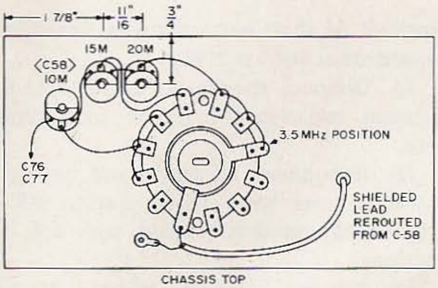


Fig. 1. Rear view of neutralizing switch.

7. Slide the new switch shaft through the hole in the rear apron and through the centers of the switch sections in the adjacent 6146 compartment. Be careful not to disturb their position. Connect the new shaft section to the old one using a conventional ¼" coupling. (Refer to photo.)

8. Wire the new 11 position wafer switch section with jumpers and 3 inch lead extensions as shown in **Fig. 1**. Position the rotor or armature of this switch in the 3.5 mhz position as shown in the figure.

9. Using 1/8" and 3/8" spacers, and longer screws, mount the two switch sections on the end of the new shaft. Be sure the tank switch section is in the 3.5 mhz position and installed as removed. (Refer to Fig. 2.)

10. Locate C58, the original neutralizing capacitor, and the shielded lead connected to the lug under the knob. Unsolder this shielded lead from C58 and the ground lug and reroute it through the hole vacated by the tank coil stand off insulator screw. Keep this lead close to the chassis and connect it to the armature lug of the new wafer switch section. Refer to the photo and **Fig. 1**. Connect shield to nearest ground lug.

11. In accordance with dimensions in **Fig. 1**, locate and drill holes for mounting the two new neutralizing capacitors. Holes must be of correct size to allow proper seating of shoulders on insulating washers used to isolate each capacitor shaft from ground. The location of original neutralizing capacitor remains unchanged.

12. Mount new 0-9 pf capacitors (Hammarlund MAC-10 or the equivalent) in these two holes as shown in the photo. Be sure to use insulating washers on threaded bushings.

13. Connect the three wires extending from the new switch section to the *rotor*

terminal of their corresponding neutralizing capacitors as shown in **Fig. 1**.

14. Connect the stators of all three neutralizing capacitors together with jumper wire.

15. Reconnect all leads and capacitors removed from band-switch section BS7 to original connections (except tank coil connections).

16. Remove chassis ground terminal from rear apron to make clearance for new tank coil location. Drill hole and relocate ground screw approximately one inch toward accessory socket.

17. Refer to **Fig. 2** and drill the two holes required to relocate the tank coil in its new position.

18. Carefully remove the two stand-off insulators from the tank coil and remount them on the opposite side of the coil. This permits the coil to be mounted as shown in the picture with the tap loops toward you.

19. Mount the tank coil as pictured.

20. Using new wire, reconnect the tank coil to the band-switch section BS7, and to other connection points. Keep all leads as short as possible to minimize the effect of additional inductance on the high frequency bands. Check solder connections to taps on tank coil to insure that solder is not touching adjacent windings.

21. Check all connections to BS7 and L12 to make sure they are connected to the original tie points. Remove all drill chips.

22. Install knobs on shafts of new neutralizing capacitors.

23. Following Heath manual instructions, neutralize the HX-10 on 14250 khz using the original C58 capacitor.

24. Next neutralize on 21250 khz using the new 15 meter neutralizing capacitor.

25. Then neutralize on 28500 khz using

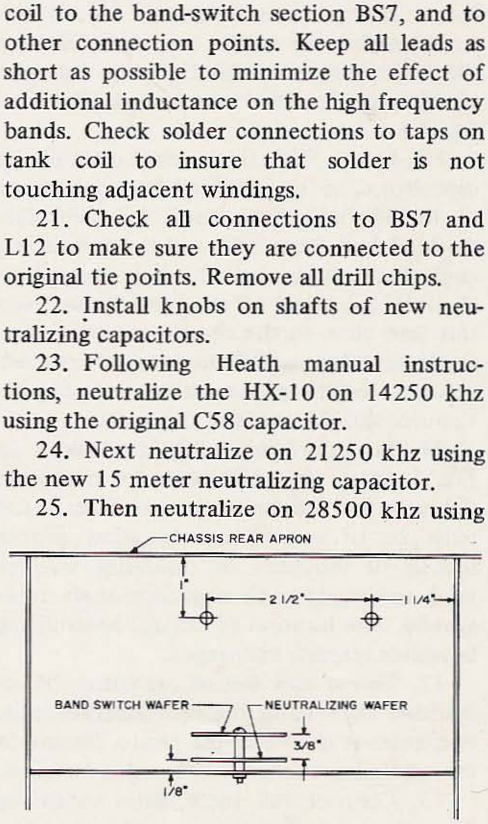


Fig. 2. Position of switch decks.

the new 10 meter neutralizing capacitor.

26. After completing neutralization for all three bands, repeat the process, as there may be some interaction between these adjustments due to the close proximity of the 3 capacitors.

If it is found that the tank tuning capacitor C77 is at minimum capacitance when resonating on 10 or 15 meters, it may be necessary to remove one or more plates from this capacitor to further reduce the effective capacity. This may be required due to the relocation of the tank coil and the slight increase in lead lengths involved. I removed three plates in order to bring the front panel markings back to the original band locations. Plates are removed by using needle nose pliers and carefully bending the plate loose at its soldered connection points.

This modification has worked well for me and has eliminated the neutralizing trouble which prevented satisfactory operation of my Marauder on 10 and 15 meters.

. . . W2PQG

Low Cost Capacitor Covers

More often than not the high voltage supply for a modern transceiver or linear uses several capacitors in series, all capacitor cans, except the one at the cold end, above ground. This is an inexpensive way of eliminating bulky high voltage capacitors. Homebrew design has followed suit to a large extent.

There is a distinct disadvantage to having the capacitor cans above ground. The cans are hot electrically and present a serious safety hazard if not covered in some manner. Having built a 3000 volt power supply and not desiring to build a metal cage, catalogs were consulted in hopes of finding an inexpensive Kraftpaper tube of the type so often seen in TVs. No luck, not only were they expensive, but they didn't come in the required length.

Why not cut lengths of cardboard tube from that most noble of paper products? Because it's too large, that's why. But there are ways around that, and besides we need protection on the top of the can anyway. How about painting the tube flat black to obscure its ancestry, slipping it over the capacitor and sealing it in place and covering the top with silicone rubber (black if possible). It works fine and costs almost nothing.

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More Taylor Modulation

In the past few years there has been a large interest in the Taylor modulation system, as well as other high efficiency types of modulation. When the first article was written, I became interested in this system. As a result of this interest I did some research and letter writing and would like to pass on the information I have gained.

To begin with, R. E. Taylor made a fascinating discovery and introduced his form of Super-modulation in 1942, when he was issued U. S. Patent number 2,282,347. According to Taylor, up to 87 percent efficiency is possible through this form of operation.

The system consists of two tubes, one tube operating as a power or *rf* amplifier and the other tube operating as an audio amplifier. The principle of the system is to connect the two tubes together in such a way that one tube may be adjusted to handle the *rf* carrier and the negative modulation peaks with maximum efficiency, and to adjust the other tube to carry the positive modulation peaks. Two examples of this system are the Doherty linear amplifier and the Terman-Woodyard high-efficiency grid-plate modulation system. However, both of these systems employ quarter-wave impedance-inverting lines, which are very

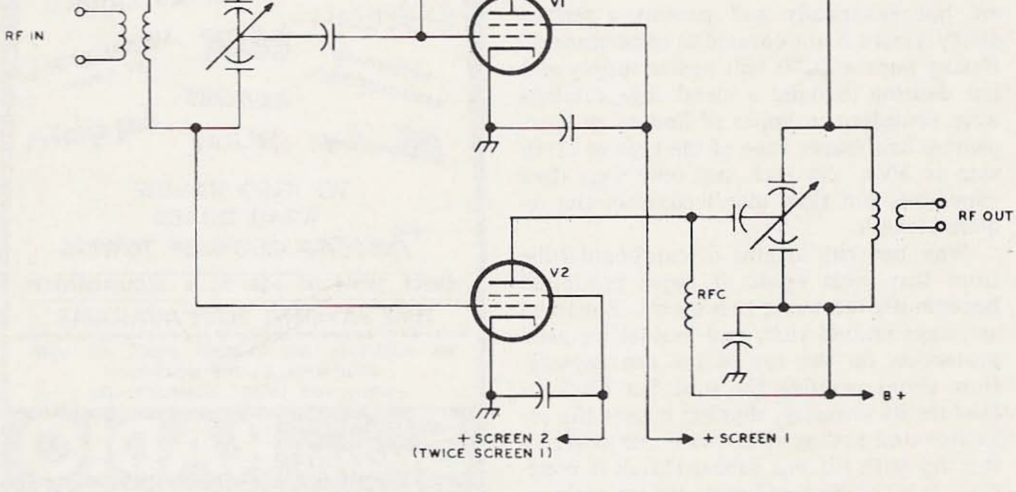

Fig. 1. A basic super-modulation circuit with two grid modulated amplifiers connected to a common tank circuit.

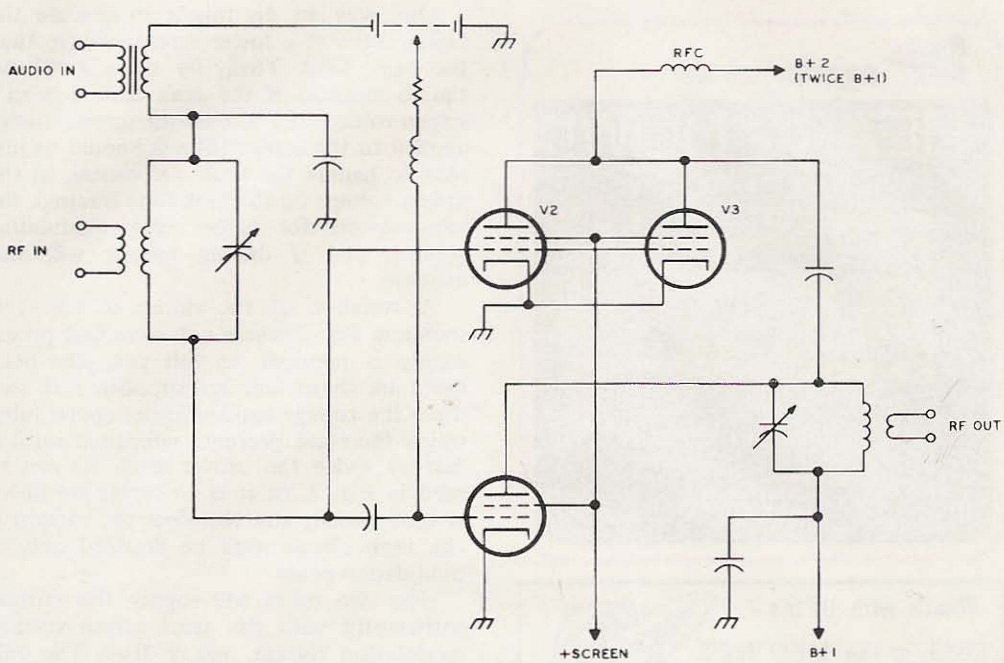

Fig. 2. A variation of the circuit in Fig. 1 in which a dual voltage power supply is used.

difficult to adjust and almost impossible for the average amateur.

Taylor, however, has shown that the quarter-wave lines may be avoided, and still maintain an efficiency nearly equal to the previous two examples. In his system, the dc input to the peak tube (audio amplifier) increases while the input to the carrier tube (*rf* amplifier) decreases.

Basically then, the super-modulation circuit is composed of two grid-modulated amplifiers which are connected to a common tank circuit. In **Fig. 1**, a basic system is illustrated. As shown, the peak tube (V2) is biased beyond cut-off, and therefore contributes no output. The carrier tube (V1) is operated in a nearly saturated condition, and therefore, delivers its maximum output. Due to the low plate dissipation in this system, the efficiency will be good. As can be noticed in **Fig. 1**, the peak tube (V2) is delivering it's *rf* output to a tap at the center of the tank circuit, and must therefore deliver four times the carrier tube's carrier level in order to effect full upward modulation. This is because, first, the carrier tube (V1) delivers no output; and second, the peak tube (V2) is connected to a load impedance of only one-fourth the impedance presented to the carrier tube.

One way to do this is to operate the carrier tube at a lower screen voltage than the peak tube. Then, by using a rule-of-thumb measure, if the peak tube is given a screen voltage of 2.5 times the screen voltage applied to the carrier tube, it should be just able to handle the peak. Of course, as the screen voltage on the peak tube is raised, the requirements for higher bias, modulating voltage, and *rf* driving voltage will also increase.

A variation of the circuit of **Fig. 1** is shown in **Fig. 2** where a dual voltage power supply is required. In this case, the peak tubes are shunt fed, and supplied with two times the voltage applied to the carrier tube, which therefore prevents saturation until it reaches twice the carrier level. As can be seen in **Fig. 2**, there is no center-tap in the output circuit, and therefore the current in the tank circuit need be doubled only at modulation peaks.

The two tubes will supply this current sufficiently with the same screen voltage, modulation voltage, and *rf* drive. The only difference is in the dc bias levels.

There are many variations of this type of modulation, most of which have appeared in print in earlier publications. Therefore, I will not go into the many variations on Taylor Modulation. I am listing my references, for anyone interested in additional information. I would highly recommend the article written up in *73 Magazine* by Fred Dougherty, W3PHL, for additonal basic information.

To those not interested in this form of modulation I wish to say, if you haven't tried it, don't knock it.

. . . DL5KS

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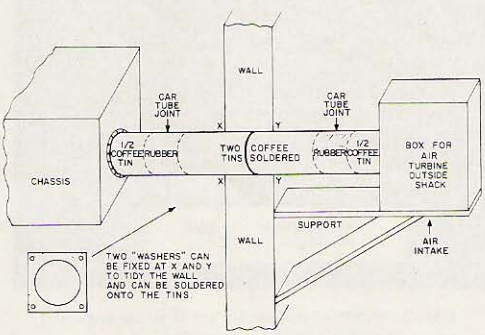
A Large Volume of Silent Air for a Large Tube

Here in East Africa it is quite impossible to buy ham shack requirements.

I have no doubt that it is possible to buy quiet blowers to fit into a chassis, but it is two months to wait over here. In any case, the average ham loves making gadgets and is always trying to improve apparatus and gild the lily.

I like a quiet shack, and a noisy blower is a pest. I found a real large size blower which cost two dollars, complete with its squirrel cage; nobody wanted it as it was 110 volts and we use 240 volts. As simple as that. But what a noise and volume, ¼ HP motor and all. After promising to make good if necessary, I chipped out a 3½" hole through the shack wall near my P.A. (use a small pilot hole to check your measurements) and collected some 3½" diameter coffee tins, cut the bottoms out, soldered two together and stuck them in the hole. With rubber inner tube you can make fine couplings at any angle by trial and error using the curve of the tube. The chassis has half a tin soldered on the side for the intake. With such a powerful blast of air (noiseless) you can afford to ignore sealing the chassis and don't even need a bottom plate if your bench is flat.



You have guessed it - it's a 3-1000Z Eimac tube which is loaned by a friend, and I dare not risk overheating it. It's a tube worth taking trouble over and a good supply of air is the least you can do for it. The air blower was mounted on brackets on the wall outside and coupled up with more inner tubing and a weather-proof roof tied on.

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Edit. Note

Many of these new tubes require a blower, a good one; even if only the filaments are on.

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An Audio Sinusoid Generator

Do you need an audio generator which delivers a sine wave over the frequency range of 500 hz to 5 khz? The oscillator described here will do the job while maintaining a nearly constant output voltage over the range of 1 khz to 5 khz.

An audio oscillator which generates a low-harmonic-content sinusoid has many uses. Examples include two-tone generators for use in amplifier linearity tests and AFSK oscillators for encoding Teletype signals for radio transmission. The oscillator described here is well suited for the latter application because switching different capacitors into the circuit allows generating two equal-amplitude non-simultaneous tones using the same oscillator.

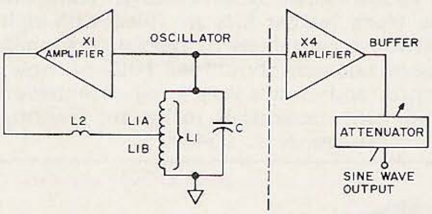

Fig. 1. Sine wave oscillator and buffer.

Fig. 1 illustrates the complementary audio oscillator circuit. The npn-pnp amplifier has a unity voltage gain and is active over a 10 volt dynamic range. The complementary amplifier provides drive through L2 to the tuned circuit composed of L1 and C. The single-ended buffer amplifier prevents heavily loading the tuned circuit. The circuit uses two 88 mh telephone loading coils. These toroid inductors have two windings which can be connected in series for L1 = 88 mh or only one of the windings can be used for L2 = 22 mh.

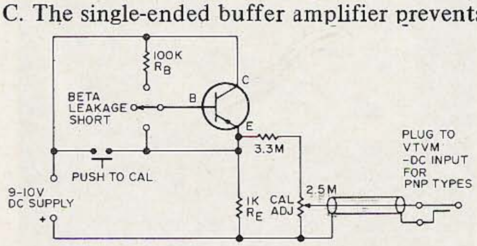

Fig. 2. Functional diagram of oscillator and buffer.

The operation of the oscillator is better understood by considering the functional diagram illustrated by **Fig. 2**. The current which flows through L2 is in phase with the voltage developed across the tuned circuit. The output voltage from the X1 complementary amplifier is divided between L2 and L1B. The drive voltage to L1B does not vary with frequency between 1 khz and 5 khz.

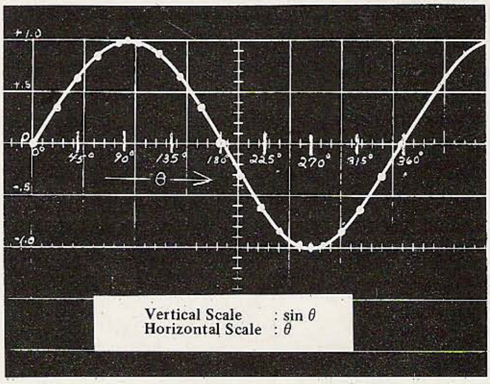

Fig. 3. Plotted points of sin θ superimposed upon measured output waveform.

Consequently, the output voltage is constant over this frequency range. The buffer amplifier has a voltage gain of 0.4 and drives a potentiometer which can be adjusted to provide a sine wave output of zero to 9 volts peak-to-peak.

Fig. 3 shows an oscilloscope photograph recorded to show the quality of the sine wave as measured at the output of the buffer amplifier. Points are plotted on the oscillograph to show the theoretical waveform of a pure sinusoid. The oscillograph in **Fig. 4**

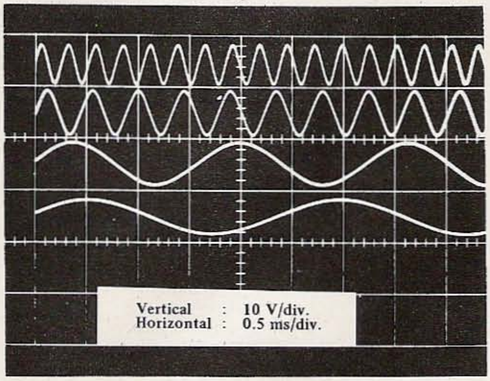

Fig. 4. Measured output waveforms.

shows the waveform quality at four operating frequencies in the range of 400 hz to 4 khz. The waveform distortion decreases with frequency. The results of distortion analyzer measurements made on the signal output from the buffer show a waveform distortion of 4% at 3.5 khz and a 1.4% waveform distortion at 500 hz. Filters can be used to decrease the waveform distortion to less than 0.1% if required.

The output voltage is plotted as a function of frequency in **Fig. 5**. The decrease in output voltage at lower frequencies is caused by: (a) The Q of the resonant circuit decreases at lower frequencies; (b) the inductive reactances of L2 and L1B decrease at lower frequencies, and the voltage drops across the 100 emitter resistors become appreciable. The oscillator can be made to operate at lower frequencies by increasing the values of L1 and L2.

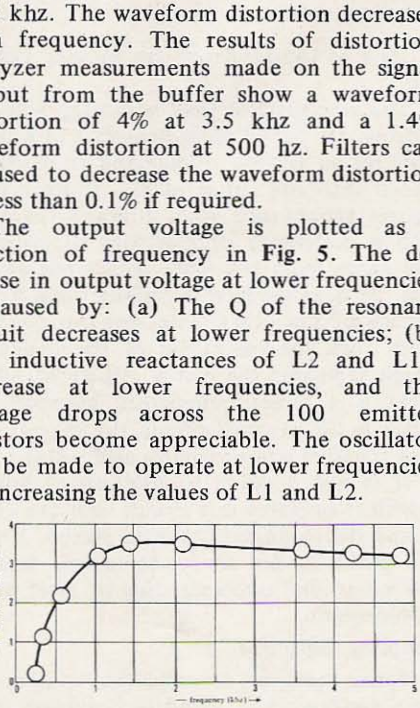

Fig. 5. Measured output voltage from buffer.

Fig. 6 shows a graph which can be used to select a value of C for any desired oscillator frequency. The error bars above and below the plotted data points reflect the ± 20% tolerance of the capacitors used to obtain the data.

The choice of semiconductors is not critical except that silicon transistors and silicon diodes should be used. The bias conditions are designed to make use of the forward voltage drop (0.7 volt) across a silicon diode. The power supply voltage values are not critical. If the semiconductor breakdown voltage specifications are not exceeded, higher output voltage can be obtained by using higher power supply voltages. The physical layout of the components is not critical, and special construction techniques are not required.

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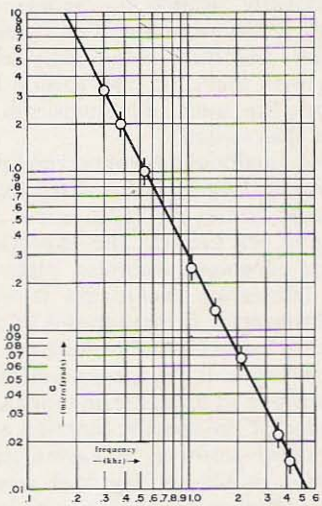

Fig. 6. Capacitance vs oscillator frequency.

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Capacitor Usage and Electron Flow

How long has it been since you looked at a schematic in one of *73*'s construction articles and said to yourself, "Hmmm... wonder what *that* capacitor is there for?" Chances are that unless you are an engineer, there will be at least one capacitor in this very issue that will mystify you. This article is designed to dispel the mystery by describing the electron flow and pointing out examples of common capacitor usage.

Note that the word "capacitor" has been used consistently in lieu of "condenser". "Capacitor" is the word specified by someone at IEEE, and there seems little reason to quibble with them. It does seem a little more logical, tho some old timers still had rather fight than switch.

Texts and handbooks devote several pages to the theoretical aspects of isolated capacitors, but most do not say much about their functioning in practical circuits. Knowledge of dielectric constants, formulas, plate spacing, and fabrication techniques is worth having. However, it is more useful to a design engineer than a ham or technician. The reader interested in the more theoretical approach is referred to suitable handbooks.

Knowledge of the specific function a particular capacitor performs in a given circuit is a valuable troubleshooting tool when it comes to locating a malfunction in either homebrew or commercial gear.

What a Capacitor Is

A capacitor is an electrostatic device. Its purpose is to store electrical energy in the form of a static electric field. Remember that "static" means "standing still" or "unmoving". This is in contrast to an inductor which stores energy in a magnetic field only so long as the electrons are moving thru a coil.

The electrostatic field is created when electrons are pulled from one plate of a capacitor by an applied voltage and an excess is forced into the other plate. Since unlike charges attract each other, it is as if the plate with a deficiency of electrons is trying to pull some from the plate which has an excess. It does succeed in pulling them to the surface of the other plate, but can not pull them thru the insulation of the dielectric which separates the plates. However, when there is a direct connection between the plates in the external circuit, the charges will flow together and neutralize each other.

It is not possible to understand how a capacitor operates in a circuit until the charge and discharge paths can be traced. These two paths are not always the same. It is at this point that understanding of most hams is inadequate.

Coupling Capacitor

Terms used to describe this component have done more to confuse beginners than to enlighten them. At least one writer of elementary texts has been observed to call it a "coupling condenser" and a "blocking capacitor" all in the same paragraph. For those interested in the whole boring story, the correct designation would be: an ac coupling-dc blocking capacitor. Obviously this is an inconveniently long name, so it may get shortened to coupling or blocking capacitor. Which it is called depends mostly on the writer's whim.

The coupling capacitor is always in a signal path, for the signal is what it was put there to couple from one circuit to the other. It is most frequently used in resistance-capacitance coupled amplifiers similar to those in Fig. 1. The purpose of the capacitor C, is to transfer the signal from the plate circuit of V1 to the grid circuit of V2 while preventing the high level dc voltage from following the same path. It has a continuous dc voltage across it during the time power is applied to the circuit. The signal voltage causes momentary increases and decreases in the average charge as it swings more or less positive at the plate of V1.

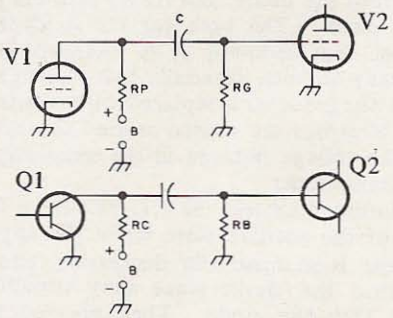

Fig. 1. Resistance Coupled amplifiers; (A) Tube type, (B) Transistor type

The charge path for C in **Fig. 1A** during a more positive signal voltage swing at the plate of V1 is such that electrons will move up from ground, thru the tube cathod to the plate and into the left plate of the capacitor. They will flow out of the right plate, thru Rg and on to ground. The negative voltage at the top of Rg will therefore increase in step with the signal at the plate.

Discharge occurs when the voltage at the plate of V1 swings less positive. Electrons will flow out of the left plate of the capacitor, down thru Rp, thru the B supply to ground and up thru Rg into the right plate. This makes the right plate of the capacitor, and hence the grid of V2, less negative with respect to ground. The grid may still be negative with respect to the cathod if suitable biasing is provided. Thus the signal applied to the grid is developed across Rg.

Electron flow in the transistor circuit of **Fig. 1B** is essentially the same as in the tube circuit.

It can be noted from the foregoing explanation that there is a phase shift as the signal "passes thru the capacitor." This is not as great as would at first appear because the time constant of the capacitor and resistors in the charge and discharge paths limit the shift. It is this phase shifting which makes possible operation of the phase shift oscillator illustrated in Fig. 2. In practice, it works out that there is usually somewhat less than ninety degrees of shift. That is the reason three capacitors are required to sustain oscillation in the circuit of Fig. 2.

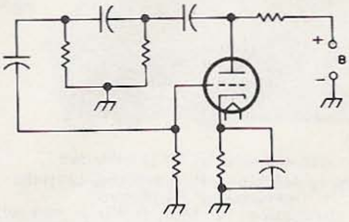

Fig. 2. Phase-shift oscillator.

The coupling capacitor becomes a "grid leak" when *rf* is supplied from V1 and no bias is placed on V2. If the value of C and Rg are properly chosen, C will have time to discharge only slightly between *rf* peaks. Then the voltage at the grid of V2 will have the general waveform of the AM modulation on the *rf* input voltage.

Capacitors function in a similar manner in many tone control and pulse shaping circuits. Such circuits are becoming more important to hams with the increasing use of integrated circuits and digital techniques. As stated earlier, a capacitor with the purpose of coupling a signal must be in a signal path.

All types of capacitors are used for coupling with the possible exception of high voltage and variable types. Small film types are used in *rf* circuits. The range runs all the way to large electrolytics in low impedance audio frequency circuits. The type chosen for use depends on applications and mechanical considerations.

Bypass Capacitor

The bypass capacitor is known by even more names than is the coupling capacitor. Depending on just where it is located in the circuit, it is variously called a smoothing capacitor, filter capacitor, feed-thru capacitor, integrating capacitor, decoupling capacitor, or of course, a bypass capacitor. Attempt will be made to show that these functions are all essentially the same.

Let's start with the common filter capacitor, sometimes called a smoothing capacitor. Fig. 3 shows the common configuration of a power supply filter. The purpose of both the capacitors is to bypass the ac ripple remaining in the rectifier output before it reaches the load. Electrolytics or oil filled capacitors are most frequently used in this application.

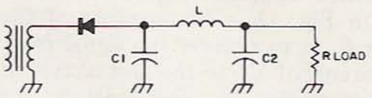

Fig. 3. Power supply with filter.

The charging path for C1 starts at the negative plate from which electrons are pulled when voltage is applied. They continue to ground, up thru the transformer secondary, thru the diode, and finally into the positive plate. The path for C2 is identical except that inductor L is included in it. In many circuits, especially low current supplies, the inductor is replaced with a resistor. The electrons are moved around the circuit by the voltage induced in the secondary of the transformer.

During discharge of C1, electrons flow out of the positive plate when the applied voltage is momentarily decreasing, and go on thru the choke since they cannot go back thru the diode. They proceed thru the load represented by R, on to ground and into the negative plate. In this case the path for C2 does not include the inductor, tho it is otherwise the same as for C1.

The electrons flow during discharge because the voltage being applied to the capacitor is insufficient to maintain the electrostatic field which holds the electrons in the capacitor positive plate. The capacitors of the filter thus supply current to the load during the intervals when the rectifier is not doing so. The energy stored in them during the charging part of the cycle is returned to the circuit during discharge.

It should not be inferred that discharge is complete while the filter is operating. The very purpose of the arrangement is to prevent variations, so far as possible, in the current. Large values of capacitance are chosen to accomplish this.

Decoupling capacitors operate in the same way as the filter capacitors just described. The only reason for the difference in name is the part of the circuit in which they are used.

Fig. 4 shows an AVC decoupling network. Its purpose is to shunt to ground any audio or *rf* that might get into the AVC line whether it comes from the rectifier or one of the branch lines. No appreciable current flows in the line for tube circuits, since the tube grids in which it is terminated are negative with respect to ground. Current does flow in transistor AVC lines in most cases since they are current controlled devices. This will somewhat modify the discharge path for the capacitors. The current consuming transistor can be thought of as equalivent to the load in Fig. 3.

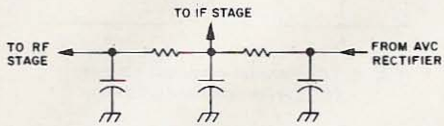

Fig. 4. Decoupling filter, AVC type.

Since the electron flow paths are so similar to those of the previous figure, it will be left as an exercise for the reader to trace them.

Decoupling capacitors are also used in dc supply lines to keep signals which are generated in the stage which the line supplies from getting into other stages by way of the line. The circuit looks almost exactly like that of Fig. 4 when the labels are changed.

Feedthru capacitors are used to bypass to ground *rf* which may have been picked up by supply voltage lines as they enter or leave a compartment where stray signals may be present and induced into the supply lead. These are seldom larger than a few tens of picofarads. They may be small ceramic types or a cylinder of metal with an insulated lead for the supply voltage running thru its center. Heater bypass capacitors are very similar.

Feedthru and heater bypass capacitors are simply special cases of decoupling capacitors. Tracing their charge and discharge paths is not difficult if it is kept in mind that the source of supply is voltage induced into the leads which they bypass. Once this is borne in mind, the paths are found to be very similar to those of Fig. 3.

Fig. 5 shows a circuit containing both a cathod bypass, Cc, and a screen bypass, Cs. The purpose of both is to keep the signal

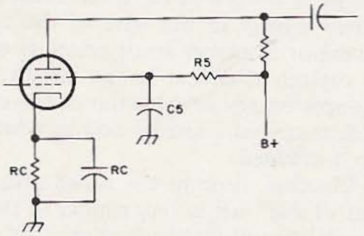

Fig. 5. Tetrode amplifier showing bypass capacitors.

voltage off the respective elements. They operate in slightly different manners.

When V1 conducts, the top of the cathod resistor, Rc, becomes more positive with respect to ground. Some of the electrons coming up thru the resistor leave the stream and flow into the positive plate of the capacitor. At the same time some flow out of the negative plate and up thru the resistor.

When there is a decrease in the positive voltage on the top of Rc, some electrons flow out of the positive plate and join those coming up thru the resistor and go on thru the tube, the load, power supply, on to ground and back into the negative plate of Cc. In this way voltage variations tend to be leveled out.

Value and types for Cc depend on the operating frequency. Electrolytics of several mfd are used in audio circuits. Tubular and disc types are used in *rf* circuits. Values for *rf* work are usually from .001 to .01 mfd in both transistor and tube circuits.

Charge of the screen bypass, Cs, begins when power is applied to the circuit and the top of the screen resistor becomes positive with respect to ground. Electrons flow from the grounded negative plate, thru ground, Rc, the tube as far as the screen and into the positive side of the capacitor.

During a momentary decrease in the positive voltage at the screen caused by signal voltage getting into the screen circuit, electrons flow out of the positive plate, thru Rs to the power supply, on to ground and into the negative plate of Cs. Ac voltages of almost any frequency appearing at the screen are neutralized by the charging and discharging of Cs which tends to maintain a constant voltage at its junction with the screen and Rs.

Values for Cs are usually less than .01 mfd for audio and are only a few hundred pf for *rf*. Ceramic and paper types are widely used.

Resonant Circuit Capacitors

Resonant circuit capacitors are the easiest of all to recognize on a schematic because they are always associated with an inductor. In addition, they are variable types in a high percentage of cases. An understanding of electron flow in them aids in understanding other facets of operation of the resonant circuit.

Referring to **Fig. 6**, the symbol for the ac generator can be replaced by tubes, transistors, or antenna-ground systems responding to electromagnetic radiation, etc. In the explanation it is assumed that the circuit is being excited at its resonant frequency.

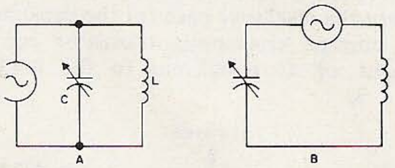

Fig. 6. (A) Parallel resonant circuit; (B) Series resonant circuit.

When the upper terminal of the generator in **Fig. 6A** becomes negative with respect to the lower one, electrons will flow from the negative terminal into the upper end of the coil. The upper plate of the capacitor will also contribute some electrons to the stream. After going thru the coil, some electrons will continue back to the generator and some will go into the lower positive plate of the capacitor. It is now plain that more current is flowing in the coil than in the wiring outside the resonant circuit.

At the instant when the applied voltage reaches its peak, the maximum amount of energy is stored in the circuit. Electrostatic energy is in the capacitor and electromagnetic energy is stored in the field surrounding the coil.

As the applied voltage decreases the stored energy is returned to the circuit. The magnetic field around the coil collapses. This induces a counter voltage in the coil that tends to keep the current flowing in the same direction with as little change in rate of flow as the component values will permit. The capacitor supplies the current for this process, since by this time the generator voltage is dropping to a low level. In doing so, its charge at the peak has become completely reversed. Continuing the cycle, the voltage across the generator becomes reversed. Current in the external circuit is also flowing in the opposite direction that it was during initial charge. Some of the stored energy is dissipated in circuit resistance contained mostly in the wire of the coil. The generator furnishes small amounts of energy to replace that lost in the circuit. It also replaces energy coupled out of the circuit by such means as a nearby coil in which a voltage is induced.

Electron flow in the series resonant circuit of **Fig. 6B** is very similar to that of the parallel circuit discussed above. As shown in the figure, it can be visualized as a parallel circuit with the generator inserted in series with the components. Therefore the high current circulating in the resonant circuit will also flow thru the generator.

Parallel resonant circuits are used to present a high impedance to *rf* currents. The higher the impedance, the higher will be the voltage developed at the frequency to which it is tuned. This is desirable whenever it is necessary to pick out a small group of frequencies from among many possibilities. A few typical uses are in antenna circuits, tuned amplifiers, and oscillator frequency control circuits.

Series tuned circuits offer a low impedance path for a particular small group of frequencies to which it is resonant. The best known use of this function is for bypassing a specific unwanted frequency to ground from the antenna input. It is sometimes used in selective coupling circuits and as a feedback path for oscillators.

Combinations of the two types of circuits are used to produce many characteristics in band pass, band rejection, high pass, and low pass filters.

Timing Capacitors

The fourth use is as timing capacitor. It is not often used in ham gear, but does appear in oscilliscope sweep generators and pulse generators. Such circuits are becoming more common as digital techniques are applied to communications.

Fig. 7 shows the basic circuit. It is frequently called a relaxation oscillator. The voltage waveform across the capacitor will have a slow rise-fast fall sawtooth shape. The charge path for the electrons is out of the lower plate of the capacitor, thru the B power supply, down thru the resistor and into the positive plate.

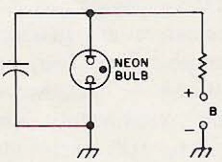

Fig. 7. Neon bulb relaxation oscillator.

Partial discharge occurs when the voltage across the capacitor reaches the firing potential of the neon bulb. This voltage varies from 60 volts up. At firing, electrons flow out of the positive plate, thru the neon bulb, and into the negative plate. When the capacitor discharges to the point that the applied voltage will no longer keep the gas ionized, the bulb is extinguished and conduction stops, and charging begins again. The extinguishing voltage is only a few volts below that for firing, so only a small part of the charge on the capacitor is bled off.

The neon bulb in **Fig.** 7 can be replaced with many types of rapid-turn-on devices such as the unijunction transistor or silicon controlled rectifier.

Cross coupling capacitors in multivibrators are not exactly timing capacitors. They do have a similarity however. The function of these is adequately covered in most of the texts on the subject. Suffice it to say that they serve both a timing and a coupling function. It is this combination of function that makes multivibrators possible.

Conclusion

This discussion makes no pretense of being all encompassing in the description of capacitor uses and associated current flow. The four uses mentioned do cover the great majority of cases in which this component is likely to be used in amateur equipment.

...WØHMK

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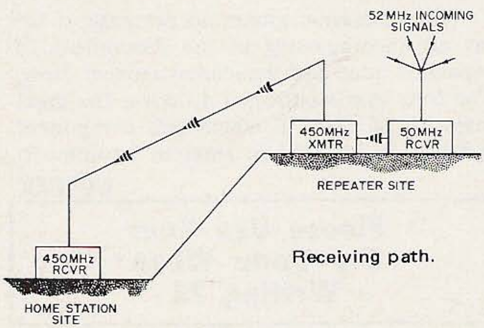
What About FM?

As I read through the many ham periodicals of the day, I am surprised at the absence of concern given to a field of amateur radio that seems to be growing by leaps and bounds, vhf FM. I have noticed a few editorials which share my concern.

Not many years ago, in the 1950's, amateur radio experienced what has been called by some, "the FM Fad." Whatever it was, it did bring to light some of the definite advantages of FM. These advantages include: it could be slope detected with an AM receiver, it often helped in the solution of TVI problems, large expensive modulators were eliminated, and a ham could run high power phone with an efficient class C amplifier. Not a bad list of advantages for any system.

Well, that was in the '50's, before SSB, selective receivers, inexpensive transceivers and linear amplifiers. Does this mean that FM is dead? Absolutely not! Now there is a new area open to FM. I probably should not say new, because it has been used commercially for years. This is vhf FM.



Receiving path.

Low and high band FM equipment has been available in varying amounts for many years as surplus. Three or four years ago when the FCC changed its specifications for frequency deviation there was a great deal of obsolete wide band gear available. Even today, with the big change over to transistors there seems to be a fair number of units on the market. This can be affirmed by the many amateurs who have this equipment on the air. I wish I could find some accurate figures concerning the number of amateurs using vhf FM, but I have not been able to do so.

I am not going to argue the merits of AM vs SSB vs FM, because I feel each system has its merits in the vhf spectrum. If the FM units have proven successful for commercial service, I am sure that the amateur can also use them successfully.

This equipment has been built by such manufacturers as Motorola, General Electric, Link, Raytheon, Comco, RCA, etc. These transmitter-receivers are generally well designed and trouble free. They contain sensitive many tubed or transistored receivers with efficient transmitters whose output ranges from 5 to 100 watts. Most of them are complete with power supply, either vibrator or dynamotor type depending on the transmitter power rating. Some of the newer units employ transistorized power supplies.

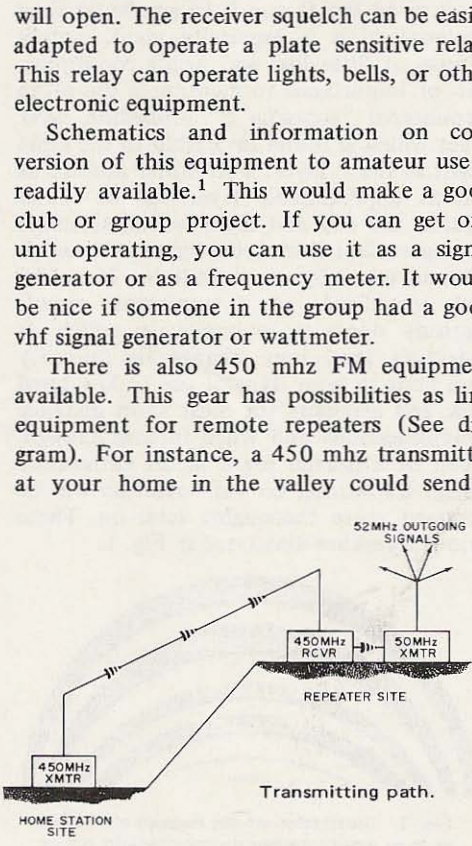
They are terrific for mobile installations. Since they are crystal controlled, all that is needed under the dash is a small control head and a mike. The XYL might appreciate that feature. The fact that the receivers are squelch controlled makes it easy on the nerves; when there is no signal, there is no audio or noise. Because of the natural characteristics of an FM receiver, it limits AM, there is little ignition or pulse noise. If you have been a mobiler, you are aware of what a problem noise can be. VHF antennas for mobile use are simpler to install, smaller and more efficient than their big hf brothers. You can obtain a fine non-directional radiation pattern by placing a quarter-wave vertical whip in the roof of your car, a very difficult feat to accomplish in the hf spectrum.

There are presently two national calling frequencies, 146.94 mhz and 52.525 mhz. Depending on your local customs, there are several other channels being used, such as 52.640 mhz, 52.720 mhz, 146.670 mhz and 146.790 mhz.

Obviously, the fact that this equipment is crystal controlled makes it a natural for net operation. The receiver squelch system makes 24 hour a day monitoring practical. You can never tell when the six meter band will open. The receiver squelch can be easily adapted to operate a plate sensitive relay. This relay can operate lights, bells, or other electronic equipment.

Schematics and information on conversion of this equipment to amateur use is readily available.[1] This would make a good club or group project. If you can get one unit operating, you can use it as a signal generator or as a frequency meter. It would be nice if someone in the group had a good vhf signal generator or wattmeter.

There is also 450 mhz FM equipment available. This gear has possibilities as link equipment for remote repeaters (See diagram). For instance, a 450 mhz transmitter at your home in the valley could send a signal to a 450 mhz receiver on a hilltop many miles away. The squelch operated receiver could then turn on a six meter transmitter and retransmit the incoming signal. If you reverse the process, a six meter receiver on the hill can operate a 450 mhz transmitter and your 450 mhz home receiver will hear everything that can be heard at the hill on six meters. Other combinations are possible, six meters to two meters, 450 mhz to two meters, etc. The characteristics of FM, the squelch operated receivers, and the bandwidth of the vhf spectrum all combine to make repeater operation feasible. There are many of these systems in use today.



Transmitting path.

The repeater operation greatly increases the range of mobile units. Its uses for emergency and public service duty are almost endless. Think of the challenge of trying to get a rack full of this equipment working smoothly and then sitting back and watching all those pilot lights blink merrily and hearing all of those relays chattering noisily – beautiful – beautiful.

. . . W9VZR

[1] Sherman M. Wolf, *FM Schematic Digest* (Boston: Two-Way Radio Engineers, Inc.)

Ralph J. Irace, Jr., WA1GEK

A Primer on Radio Propagation

It has never been a secret that long-range communication in the amateur bands is primarily dependant upon the ionosphere, however it is essential to visualize the structure of the ionosphere and to understand more thoroughly the basic theory behind the usage of sky-wave methods of transmission if effective use of the ionosphere is to be made.

The Ionosphere's Structure

The ionosphere's overall structure consists primarily of three ionized layers ranging from 35 to 215 miles or so above the earth. The region lowest in height found at about 35 miles extending to 70 miles, is called the *"D" layer* and for all practical purposes, is useless to the amateur. Instead of reflecting radio waves, the D layer acts as an impediment and attenuates the signals strength to some degree, sometimes completely absorbing 160 and 80 meter signals while passing through its region either upward or downward after being reflected back to earth by another ionized layer. However, after darkness, the D layer is virtually a nonentity. The next ionospheric layer is known as the *"E" layer* and is found from about 70 to 175 miles above the earth. This particular region will reflect signals back to earth for a good part of the daylight hours however after darkness, it similarly vanishes like the D layer. Next in line upward is the *"F" layer* which during the daylight hours divides into two separate layers called the *F1* and *F2 layers,* and during night hours forms one single layer (F layer). The F1 layer is generally found at about 140 miles in height and extends to 200 miles where the F2 layer then makes its appearance. The F1, F2 and the F layer are able to reflect signals back to earth in the order of a thousand up to several thousand miles depending upon the angle of radiation. These particular layers are useful for both day and night, although daytime usage of these layers is relatively "lossy" due to the presence of the D and E layers. Night time communication is especially good, mainly because of little loss and prime conditions. Also of importance to mention is the often encountered "sporadic E" ionization layer effect which is found invariably in the same height as the E layer. This rather unusual as well as unpredictable layer can be found both in the day and night hours, although more prevalent during daylight time, and it is found generally at all latitudes. It can be best visualized as intermittent clouds relatively dense in ionization in which its ionization level may change its intensity from hour to hour. It is of use to low band work and accounts for most short distance communications and when intense enough, it can be a heaven for 6 meter enthusiasts though its bearing on vhf operation will be discussed more thoroughly later on. These various layers are illustrated in **Fig. 1**.

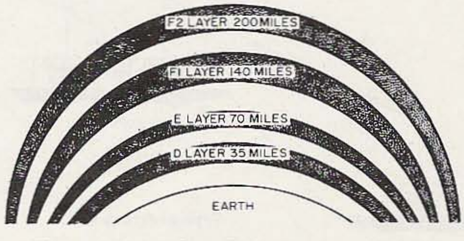


Fig. 1. Illustration of the ionospheric layers as they would appear during daylight hours.

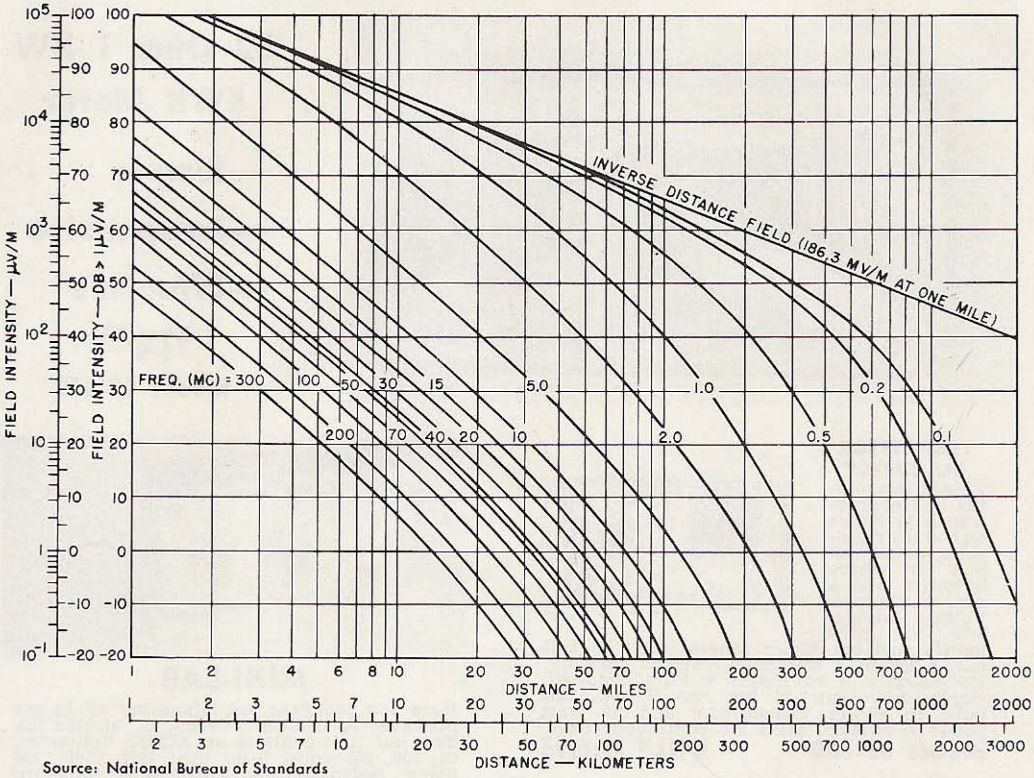


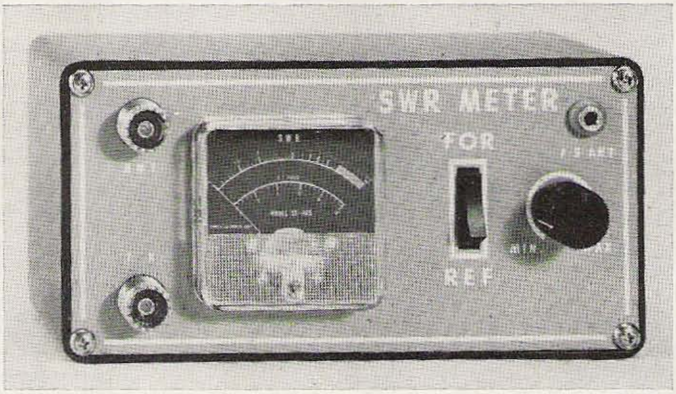
Fig. 2. Graphic chart illustrating the typical groundwave field-intensity curves for 1 kilowatt of rf power radiated from a short vertical antenna at ground level assuming a "good earth" path.

Different Modes of Radio Propagation

When electromagnetic waves are emitted from an antenna, they can take either one of two possible types of communication processes: groundwave or skywave. The former method of transmission is used for relatively short distances and is heavily dependant upon the path it takes wherein the signal travels. Groundwave transmissions are subject to what can become a severe signal attenuation by a phenomenon known as "shadow loss".[1] This occurs when signals are unable to bend around natural or manmade obstacles or structures. Increasing your antenna height as well as the power can at times overcome some of these barriers, although a portion of the signal will nonetheless most always be attenuated to some extent. See **Fig. 2** for a graphic chart illustrating typical groundwave field-intensity curves for radiation over a good-earth path. Skywave transmission is simply explained as having a large (or moderate, small) portion of your total radiation from the antenna directed up toward the ionosphere. For reasons already obvious, skywaves may be (1) completely absorbed in one of the ionized layers, (2) reflected back to earth, or may (3) go through all the ionospheric regions and on into space. See **Fig. 3** for a typical field-intensity graph relating skywaves.

Other Factors

High-angle signals are those in which the actual angle of direction upward is so high that the layers sometimes don't have the ability to reflect them back to earth. The highest angle of radiation in which a signal is returned downward toward earth is called the critical angle. Similarly, if we transmit a signal on 40 meters and it is reflected back to earth, we could then switch to a higher band, say on 20 meters, and so forth up the frequency ladder until we reach a certain frequency in which the signal isn't reflected back by the ionosphere and instead is permitted to continue into space. This particular frequency is known as the critical-frequency and it varies with each



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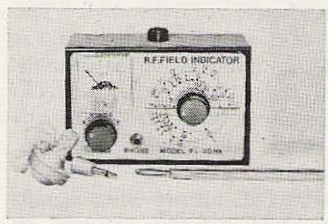

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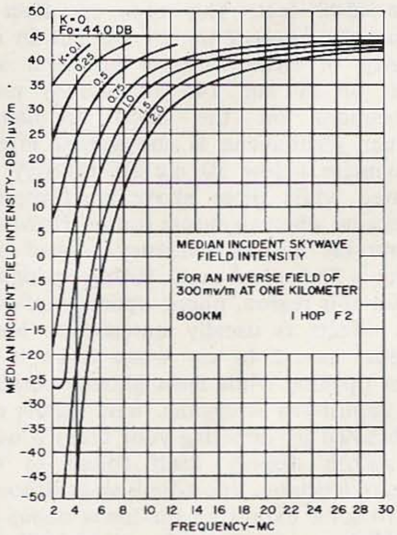

Fig. 3. A typical field-intensity graph for incident skywaves. The appropriate adsorption-factor K is used to predict the received field strength in μv/meter (microvolts excited per meter of antenna length). The curves show the variations in received field strength for a kilowatt of rf power radiated from a dipole antenna. Corrections are required for different power outputs and antenna gains.

different inonspheric layer and usually increases with the height of a layer. With reference to the critical angle again, as the angle of radiation is diminished, the radio waves return to earth at increasingly greater distances as illustrated in **Fig. 4**.

Suppose we then lower the angle of radiation and repeat a gradual increase in frequency. As we continue to lower the angle and simultaneously increase the frequency, we'll find that we can transcend the critical frequency while still retaining a back-to-earth reflection. However, we eventually come to a frequency where despite the lowest possible angle of radiation, our signal is not returned to earth. This is known as the maximum usable frequency (muf).

Next, we come across what is termed path absorption (or just absorption). While a radio wave is traveling through an ionized layer, some of its energy will be dissipated into that particular layer. Path absorption is directly proportional to an absorption factor K, used in the following equation: $K=T \times M \times S^2$ where T stands for the time-of-day correction factor, M corrects the seasonal variations in the ionization level or the layer, and S signifies the solar activity

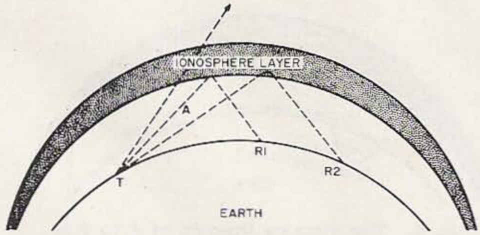

Fig. 4. Illustration of the critical angle. Any wave angle above wave A is beyond the critical angle and will not be returned to earth. As the wave angle is lowered, greater distances are possible.

correction factor based on the current sunspot cycle. The National Bureau of Standards regularly issues charts and tables to which this formula can be applied to; however, we will discuss this later.

Of equal importance are conditions in which signal reflection back to earth is at its maximum and minimum. As a rule, the larger the wavelength, the lower the radiation angle and the better the reflection (also called refraction). Also, the greater the intensity of an ionospheric layer, the lower the angle a signal is bent back. When the ionization intensity is at a relatively low level, the higher frequencies may not be reflected back to earth at all whereas the lower frequencies (3.5, 7 mc) could still be used for effective communicating purposes. For this reason, the lower frequencies are generally more dependable than higher frequencies.

Skip

When a signal is emitted from point A and is returned via the ionosphere to point B, the distance between those two points is called the skip distance. There will almost always be some amount of useful groundwave distance on a skywave signal, though usually only a fraction of the skywave skip distance. From the point where useful groundwave transmission begins to terminate to point B where the signal was reflected back to earth, we have what is known as the skip zone. Signals occasionally upon returning back to earth are reflected by the earth itself up to the ionosphere and subsequently bent back to earth again. This type of process is called multihop transmission, and it may repeat itself several times. However with each encounter of the ionosphere and earth, energy from the signal is absorbed and consequently the signal's strength diminishes with each "hop." See **Fig. 5** for an illustration.

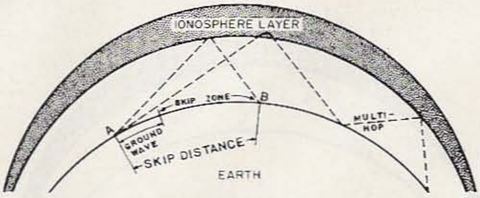

Fig. 5. The distance from Point A to B is the skip distance and from the ending point of groundwave transmission to point B we have the skip zone. Multihop transmissions are frequently occuring at all seasons of the year.

Sunspot Cycles and Ionospheric Variations

Ultraviolet radiation from the sun is believed to be the source of energy which ionizes the ionospheres numerous layers. This belief is constituted on the basis of what is known as the 11-year sunspot-cycle. Over a period of a few years, the number of sunspots increases to a peak and then gradually declines. The duration from one sunspot peak to another usually covers about 11 years. During its peak, communicating conditions are excellent especially for 20, 15 and are even better on 10 meters. We are approaching a sunspot peak now and therefore world-wide contacts should be at their best before very long. At a sunspot minimum or "sunspot dip," communicating ranges are poor with very few band openings. There also exist what is known as ionospheric storms, and when they occur, the critical frequencies drop considerably and absorption of radio signals in the ionosphere is substantially increased. These ionospheric storms are resultant of certain sunspot activity. They usually last from a few hours to several days.

The critical frequencies vary with the seasons as with the days. During the summer, the E layer maintains a higher critical frequency as does the F1 layer. Conversely, the F2 layer's critical frequency peaks occur during the winter months and are at a minimum during the summer.

vhf Propagation Characteristics

Many amateurs are inclined to believe that the several types of low-band propagation effects are equally present on the vhf frequencies. This is not so. The vhf bands have rather unusual propagation phenomena which is most certainly very effective at times. The first of these is known as tropospheric bending and it's brought about by changes in the humidity and temperature in the lower atmosphere at altitudes of about 4500 feet. This type of effect is occasionally present on 28 mc but in the majority of cases is more prevalent and potent on 50 and 144 mc, usually more pronounced on the latter frequency. Another phenomena is the aurora effect. Frequencies below 30 mc are severely attenuated while those above are favorably propagated when an aurora occurs. However, the auroras have a tendency toward sustaining a flutter or rapid fading on signals and for this reason, phone operation during these effects is usually unreadable. Many amateurs resort to cw when there is an aurora opening while most phone operators find themselves struggling. Best results can be obtained by directing your beam toward the aurora display itself found in the northern latitudes. Sporadic-E skip, although used to some extent on the lower bands for short distances, is most often responsible for ranges in some instances up to 1,400 miles on either 50 or 144 mc, although the effect is much more pronounced on the former frequency. F2 layer skip is best at the peak of the 11-year sunspot cycle and can easily propagate a 50mc signal to distances exceeding 2,000 miles. Thus, worldwide communications are possible. F2 layer skip was responsible for the first transatlantic QSO on 50 mc on November 24, 1946.

Both forward and back scatter are also effective means of propagation. The former type is more widely found in the vhf and uhf regions, and back scatter usually only on 50 mc (and the lower-bands). These two types of scatter are present in both the troposphere and ionosphere. Tropospheric forward scatter usually produces distances up to 400 or so miles on 50 mc; ionospheric forward scatter has ranges of 500 to 1300 miles attributed to it. Back scatter most often occurs when either sporadic-E or F2 layer skip is taking place. At the bottom of the totem pole we have the most intriguing and challenging of all vhf propagation methods, known as moonbounce, irregularly referred to as "lunar communication." In order to have a successful QSO via moonbounce, one must possess the absolute ultimate in receiver performance, mass arrays of high gain beams or a large parabolic reflector of helical type antenna in addition to a large amount of transmitter power usually on the order of one kilowatt or just a little less, not to mention the technically correct type of antenna-rotation polarization, tremendous receiver and transmitter stability amongst other factors. Some amateurs who have these prerequisites for effective moonbouncing have had their signals reflected back to earth at frequencies exceeding 1,200 mc! However, only the amateur who can afford such immense requirements and who is technically competent of undertaking such an effort should try any moonbounce work.

Propagation Data

If the amateur has in his shack a wealth of propagation charts or just one or two of them, he will be much better off than the other amateur who doesn't have any. By subscribing to the Institute for Telecommunication Sciences and Astronomy, you can be put on the mailing list to regularly receive their monthly prediction charts if you are interested in predicting muf's for the upcoming months. The subscription rate is $2.75 annually or you can purchase these charts separately for 25 cents apiece.

. . . WA1GEK

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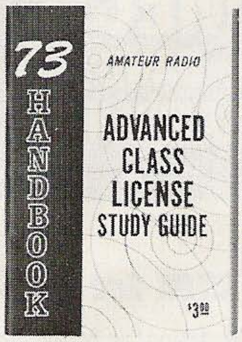
1, 2 "Radio Propagation and the Amateur Radio Operator," H. Jones, *Ham Tips*, Winter, 1964-65.
3. "ARRL VHF Manual," E. P. Tilton, 1st edition, p. 11, Charts from the National Bureau of Standards.

73 Books for Hams



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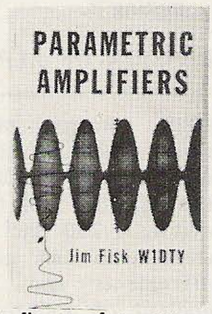

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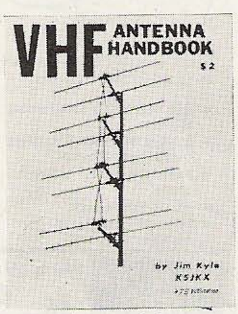

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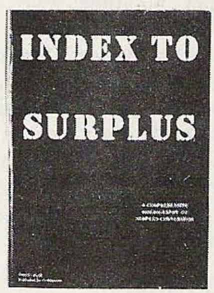

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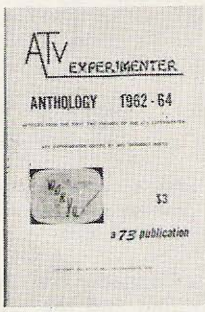

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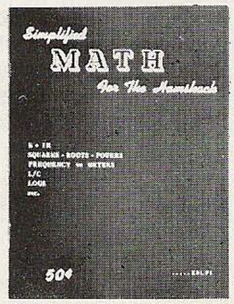

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Measurement of Percentage of Modulation of an AM Transmitter

Willard S. Granger
1212 Valle Vista
Vallejo, California 94590

Did you ever need to know how well a plate-modulated AM transmitter was being modulated and could not make this measurement for lack of an oscilloscope or a modulation percentage meter? Well, here's a way to make this check which works surprisingly well, considering its simplicity. All you need is a VOMA and a 0.1 ufd capacitor which has voltage ratings greater than twice the plate supply voltage to the final *rf* amplifier. Some VOMAs are equipped with an output range, which simply inserts a capacitor in series with the ac scales. This range may be used in lieu of the series 0.1 uf capacitor if the voltage range is sufficiently high.

The percentage of modulation of an AM signal is:

$$\%\ \text{Modulation} = \frac{100\ E_{\text{max rf}} - E_{\text{min rf}}}{E_{\text{max rf}} + E_{\text{min rf}}}$$

$$\text{or approximately} = \frac{\text{ac Modulation Voltage}}{0.007 \times \text{dc Plate Voltage}}$$

It will be convenient, but not necessary, to have a milliameter in the final amplifier plate circuit. To make the simple hook-up, proceed as follows: With the transmitter de-energized locate the junction point "X" in **Fig. 1**, between the modulator output and the dc input to the modulator amplifier. The voltage at this point is dc plate voltage with ac modulation voltage superimposed on it. To measure percentage of modulation, these voltages will be separated and used in the simplified equation.

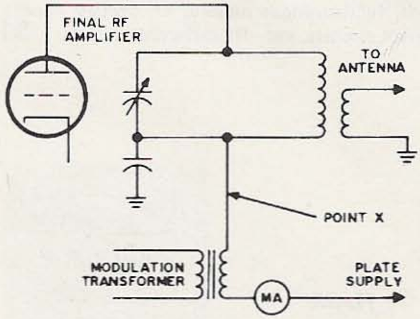

Fig. 1. At point "X" the voltage is dc plate voltage with ac modulation voltage superimposed on it.

Connect the VOMA between chassis ground and the junction located above and set the meter to dc volts. Energize the transmitter and load it into an operational antenna or into a dummy load for bench testing. See **Fig. 2.**

Now, modulate the transmitter by talking or whistling into the microphone. The plate current to the modulated amplifier should not change appreciably under modulation. If no plate current meter is available, the VOMA, which is now connected into the circuit, may be used as a rough check on plate current stability. An increase in plate current will cause an increase in the voltage drop across the power supply impedance, and a corresponding drop in the voltage read on the VOMA. A decrease in plate current will cause an increase in the voltage read on the VOMA. These changes will not be large and you will have to use care in making this reading.

Any change in plate current to the *rf* amplifier indicates trouble and must be corrected before proceeding. Changes in plate current may be caused by any one or more of the following troubles: Insufficient

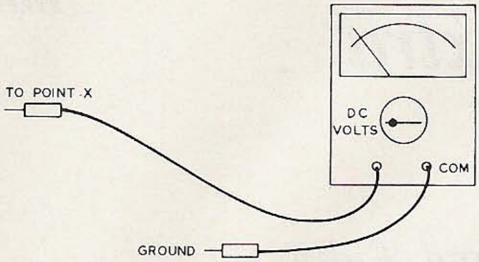

Fig. 2. Meter at dc volts.

rf drive to the final amplifier; a flat final amplifier tube; a flat rectifier in the power supply to the final amplifier; improper tuning and/or loading of the final amplifier; improper neutralization of the final amplifier (many pentodes require neutralization when operated in the vhf range); parasitic oscillations; modulation exceeding 100%.

A word of caution: transmitters employing exalted carrier or so-called range gain operation will normally show an increase in plate current during modulation. This simplified method cannot be used with such transmitters.

When necessary corrections are completed and no significant changes in plate current are evident, you are ready to measure percentage of modulation. Note the dc voltage reading and jot it down. De-energize the transmitter. Connect the 0.1 uf capacitor in series with the VOMA lead and reconnect to the test point. Set VOMA to ac volts. See **Fig. 3.**

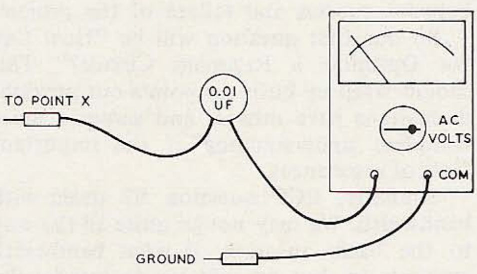

Fig. 3. Meter at ac volts.

Re-energize the transmitter and, using the microphone, modulate the transmitter with a slow steady count or a long sustained whistle. Note the peak values of the ac modulation voltage indicated by the VOMA.

The percentage of modulation of the transmitter is equal to:

$$\frac{\text{ac modulation voltage}}{0.007 \times \text{dc plate voltage}}$$

Typical values of modulation as measured on a Heath Two-er are:

Normal voice with microphone 3" to 6" from mouth.	Fluctuating 30% to 70% with peaks to 100%
Long sustained whistle into microphone	Steady 50% to over 100% depending on loudness of the whistle.

Modulation appreciably less than these values can indicate trouble and should be located using standard trouble shooting techniques.

Should you need measurements more definitive than can be obtained by whistling into the microphone, substitute an audio signal generator for the microphone. Using a shielded cable, connect the output of the generator to the microphone input of the transmitter through a resistor equal in value to the microphone impedance, and set the signal generator output level to the sensitivity rating of the microphone. Typically, a series resistance of 50,000 ohms and a signal level of -55 to -45 db one volt at a frequency of 1,000 cycles per second should be used.

Although a parallel tuned *rf* tank circuit and a transformer type modulator is shown in the sketch, the same measurements can be made on amplifiers using Pi-networks or series tuned tank circuits and Heising or choke type modulators. Simply locate the junction point between the modulator output and the dc input to the modulated amplifier and proceed as above.

A final work of caution: The voltage at this junction can be lethal and since you are using a new technique, be extra careful to de-energize the transmitter and to short out the power supply before you make or break the connections to the junction point.

. . . Willard S. Granger

Getting Your Extra Class License

Part VIII – Band Widths

In the preceding installments of this Extra Class study course we have attempted to concentrate upon a single primary subject each month, covering as many questions from the FCC study list as possible within the confines of that subject.

We'll do so in the future, too – but this month as a change of pace we're doing things a little differently. The reason is partly due to comments we've received from you, partly due to some relatively recent additions to the original study list which add questions not completely covered in prior chapters, and partly because this month's subjects are themselves a little different from the normal course of events.

In electronics, as in all study of physics and similar things, we take certain "facts" for granted. Once we've all agreed to do this, nobody bothers to examine those facts any more – but many of them can stand some examination. And that's what we're up to this time around.

In the process of examining some of these "obvious" matters, we'll hopefully reach a position to know the answers to the following questions from the Commission's list of study questions for the Amateur Extra Class Examination (the numbers are those appearing on the official list):

80. What must the value of an inductor be to cancel a capacitive reactance of 12.6 kilohms at an operating frequency of 2 Mc/s?
82. What are the bandwidths normally used for A1, A3 (single and double sideband), and F3 (narrowband) type emissions?
88. How does a frequency converter operate?

You may feel that we are short-changing you this time by dealing with only three of the FCC questions – but read on. These three are all based on some of those taken-for-granted facts which turn out, upon close examination, to be far from obvious.

As always, we won't attempt to obtain direct answers to the FCC questions. Instead, we'll pose some new questions which cover the basic principles involved, but which include some implications of the basics which are omitted from the specific study questions.

For instance, FCC question 80 deals with most specific values of inductance in a single case – but to answer it we must be familiar with most of the basic principles of ac theory. We've already gone into this quite a way (in the first installment of this series and the final installment of our previous study course on the Advanced ticket) but one area of it we have omitted in the past: that is the question of obtaining proper Q in the resulting resonant circuit, and the allied question of picking the proper LC ratio for the circuit. In the FCC question neither of these questions is pertinent – but in any practical application of the theory involved, either of them may mean the difference between success and failure of the project.

So our first question will be "How Can We Optimize a Resonant Circuit?" This should wrap up both the points our previous discussions have missed, and assure a more complete understanding of the important facts of resonances.

Similarly, FCC question 82 deals with bandwidth. We may not go quite all the way to the basic question of what bandwidth amounts to, but we will try to resolve the paradox that a carrier with no bandwidth at all can be used to transmit a signal which occupies quite a considerable chunk of the band, yet is itself composed simply of many single frequencies, none of which have any bandwidth of their own. See what we mean about things getting sticky when we question the "obvious"?

But we'll try anything once, so we'll ask – and attempt to answer – "How Can a Signal Exist Without Taking Any Space?"

Assuming that we'll come out of that one satisfactorily, we'll move right on to the second basic principle involved in question 82: "Why Do Signals Require Bandwidth?"

Question 83 deals with the operation of "frequency converters" but most of us think of these devices under the name "mixers" instead. We've all been told by Authorities that any non-linear device can act as a mixer, and that any mixer must be non-linear. Few of us have had the gall to ask publicly "Why is it mandatory that a Mixer be Non-Linear?" For our final question this time out, we propose to remedy that situation – and ask why.

All set to dive into this potential mess of confusion? Leave your prejudices behind, get all set to adopt some unusual viewpoints, and we'll jump right in.

How Can We Optimize a Resonant Circuit? Virtually all radio communication involves the use of resonant circuits in one way or another. Any tuning element involves resonance; without it we could neither transmit a stable signal, nor could we select the desired signal with our receivers. In the earliest days, when big spark gaps furnished the transmitted *rf* and mechanically-shaken coherers were the receivers, resonant circuits as such were unknown – and radio's usefulness was sorely limited.

We don't have the space to repeat our two earlier discussions of impedance, reactance, and their effects upon resonance; we'll have to assume that you've already gone through them and are willing to agree that the condition of resonance exists whenever a capacitive reactance and an inductive reactance are canceling each other out in a circuit.

However, if you're designing the circuit in the first place, and your major requirement is to obtain resonance at some single desired frequency, you have an infinite number of values of reactance to choose from! No matter what size of capacitor you may choose to use, it will have a definite capacitive reactance at your desired frequency, and all you need to achieve resonance is to provide an inductive reactance of exactly the same value at the same frequency.

There are, of course, some practical limits. You wouldn't normally want to try to resonate a 100-mfd capacitor at 432 mhz, because its capacitive reactance would be so small that any physically achievable inductor would probably be too large to resonate. Similarly, you wouldn't try to tune a 10-pf capacitor to resonate at an audio frequency, because the required coil would have to be far too huge and cumbersome.

But even within the practical limits you still have an infinitely variable range of choices. To tune a circuit to 4 mhz, for instance, you might use a capacitor as large as 5000 pf, or you might choose one as small as 10 pf for the job.

Once you do choose a capacitor, your inductor's value is immediately set by the frequency at which resonance is required. This is a natural consequence of the definition of resonance; whatever the reactance of the chosen capacitor at the desired resonant frequency, the coil must be of the precise value to provide the same amount of inductive reactance at that same frequency.

A little playing around with the reactance equations turns them into an interesting statement which involves only L, C, and f; the square roots and 2-Pi terms of the reactance equations vanish to leave only: $LC = 25{,}330/f^2$, where f is frequency in mhz, L is inductance in microhenries, and C is capacitance in picofarads.

The value you get when you plug a frequency into this equation is known as the "LC product"; for the example we used above of 4 mhz, the LC product is 25330/16, or 1583.125. This means that if we choose a 5000-pf capacitor, our coil must be 1583/5000 microhenry; if we choose a 10-pf capacitor, our coil must be 1583/10 microhenry.

The LC product is constant for any one frequency – but the LC *ratio* is not. The LC ratio is not completely defined, but in general it's the ratio of inductance to reactance within the circuit. If we used a 5000-pf capacitor with an inductor of approximately 0.317 microhenries (1583/5000), the LC ratio would be 0.317/5000 or 0.0000634. If we used a 10-pf capacitor with a 158.3-microhenry inductor, the LC ration would be 158.3/10 or 15.83. You can see that even though we stay within practical limits with our choice of C, the LC ratio varies over a four-million-to-one range.

And what we're setting out to determine here are the factors involved in your making that choice from the wide range of possible LC ratios.

You probably will never be able to make the exact choice; such things as stray capacitance get into the act, so that the final circuit is only an approximation to the values you worked out on paper in advance. This is the reasoning behind the popular technique of simply choosing a value at random, and tuning the coil by use of a grid dipper so that it resonates at the desired frequency.

And while such a rough-and-ready approach can always get you a resonant circuit, the results may not be nearly what you expected; even though the final version must always be trimmed in to the proper value, it's best to at least be in the right county before you start the cut-and-fit process.

The main factor involved in choice of an LC ratio is the desired impedance of the resulting resonant circuit. All other factors remaining equal, a tuned circuit with a low LC ration (little L, high C) has relatively low impedance while one with a high LC ratio has high impedance. Thus for use with a transistorized amplifier you would want tuned circuits with low LC ratio, while for use in a Class A amplifier with vacuum tubes a high LC ratio might be preferable.

However, this is very much an oversimplification, because of those "weasel words" "all other factors remaining equal." The fact is that all other factors *cannot* remain equal. In any tuned circuit with moderate to high Q – that is, with a Q of 10 or higher – the impedance of the circuit at resonance will be Q times the reactance of either the coil or capacitor alone. The kicker is that the Q of the circuit is defined as the ratio of inductive reactance to series resistance; if we keep the series resistance constant, then as we reduce the L and increase C to work toward a lower LC ratio we will at the same time be reducing the Q, and so reducing circuit impedance more rapidly than we would desire.

Similarly, with constant series resistance, increasing L and reducing C to get a higher LC ratio will at the same time increase the Q, and multiply circuit impedance more rapidly than we would expect.

But we can't hold series resistance constant either, because it's really just a tidy mathematical way of accounting for the circuit's losses – and most of the losses are in the coil. This leads to a rule of thumb that the lower inductance coil has lower losses; Q may then remain constant, or may even increase as we lower the LC ratio. If we move toward a higher LC ratio, we may actually reduce Q so that the expected increase in impedance is somewhat cancelled out by a reduction in circuit Q.

Because there *are* so many variable factors involved – not the least of which is

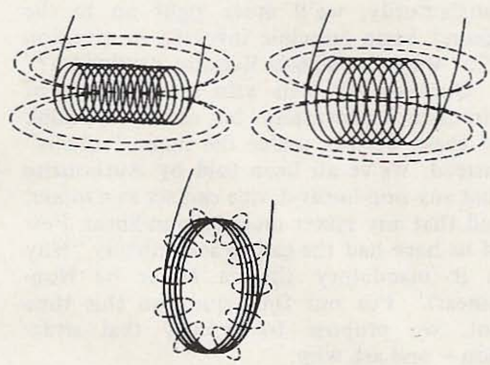

Fig. 1. Q of coil is ratio of energy stored in coil's magnetic field to energy dissipated in coil's resistance and radiation losses. Long thin coil, at left, requires more wire and so has higher resistance while at the same time producing smaller magnetic field. Large short coil, right, also has smaller magnetic field and because of its size is more subject to radiation losses. "Square" coil, center, strikes balance between large magnetic field for energy storage and small enough size to minimize radiation, and so has optimum Q.

the problem of winding a coil to a specified Q value – we don't have any precise rules for choosing the optimum LC ratio. All we can go on are some rules of thumb: the lower the LC ratio, the higher the Q is likely to be. This increase in Q usually does not prevent the low-LC-ratio circuit from having lower impedance, but it may turn out to be sharper in its tuning than expected. A high LC ratio, on the other hand, tends to produce less selectivity but a higher impedance. If a coil of known Q is available, the coil rather than the capacitor can be used to set the LC ratio with considerably more accuracy than if the capacitor is chosen first.

We've talked quite a bit about this factor "Q," and even defined it as "the ratio of inductive reactance to series resistance." Actually, it has quite a bit more meaning than that:

The symbol "Q" comes from the phrase "quality factor," and originally the only use of "Q" was as a figure of merit for different coils. Under those conditions, the reactance-to-resistance ratio definition was more than adequate; the more resistance in a coil of given inductance, the lower its Q and presumably the lower the quality as well.

But when a coil is combined with a capacitor to form a tuned circuit, then the entire circuit has its own Q factor, which is not always the same as that of the coil although the coil Q is the largest single influence on the circuit Q in the absence of any loading or deliberately introduced resistance.

And since the Q of the circuit is not necessarily totally set by the Q of the coil, the simple reactance-to-resistance definition may not always apply; it will never apply unless we also assume that all of the losses in the circuit are concentrated in the coil as a part of its "resistance."

This extended meaning of "Q" can be covered by redefining Q as the ratio of peak energy storage in the circuit to average power loss; an alternate wording of this definition is the ratio of peak energy stored to energy dissipated per cycle. The "energy stored" referred to in these definitions is that which alternates between magnetic and electric fields to provide the "flywheel" effect of the resonant circuit, and the "energy dissipated" or "power loss" is that energy which is lost by being converted to heat energy.

While this definition of Q is considerably more abstract than is the simple "X/R" ratio with which we started, it not only includes the simpler version as a special case but covers many of the effects usually associated with high-Q or low-Q circuits.

For instance, it's a generally accepted idea that a physically large coil will have higher Q than will a smaller coil of the same inductance. This happens because the larger coil has two things going for it: its larger size permits it to create a larger magnetic field for energy storage, and also reduces built-in resistance so that less energy is lost.

It's also generally accepted that a "square" coil – that is, one whose diameter is the same as its length – has higher Q than does a coil of any other proportions. The reasons for this are a little harder to see, though, because many things are working at the same time and the final result is a balancing of all of them. The inductance of a coil depends, among other things, upon the magnetic linkages between turns; this means that the more turns, the greater the inductance because there are more linkages. Q, on the other hand, is influenced by physical size. To carry these two ideas to extremes, a coil could have very small diameter and many turns, or very large diameter and only a few turns. Between these two extremes, the huge coil with few turns would have higher Q – but when the coil gets sufficently large, it begins to lose energy by radiation, and this is "energy lost" just as much as if it were converted to heat. The result is a decrease in Q.

As the diameter of a coil is increased, for any specific value of inductance, the length must decrease to keep the inductance value constant. This raised Q by increasing physical size. By the time the coil reaches the "square" proportion, though, the increase in Q gained by any additional diameter increase is very small, and the accompanying decrease in length actually reduces the amount of energy storage space available. Any increase in diameter beyond the "square" proportion then begins to reduce the Q – and that's why square coils normally have higher Q than those of any other proportion. Of course, anything which tends to add losses, such as shielding or lossy coil forms, will reduce Q, so the comparison doesn't mean that a poor square coil is of higher quality than a good non-square one.

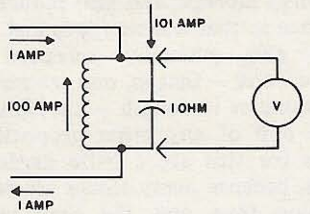

Fig. 2. Voltage drop across any single impedance in a resonant circuit is affected by Q as shown here. This circuit has Q of 100 since 1 amp of current overcomes losses to maintain 100 amps of circulating energy. If impedance of capacitor is 1 ohm, voltmeter will measure 101 volts across the capacitor, although only 1 amp is flowing in external portions of circuit. Meter impedance must, of course, be taken into account since it will load circuit and effectively reduce Q.

What about some of the other implications of Q? For one thing, as the ratio of energy stored to energy lost per cycle, it defines the ratio of *circulating energy* to *driving* energy in a resonant circuit. To keep energy circulating, the external energy source must supply enough driving energy to exactly overcome the losses. When this much energy is supplied, then Q *times* this much energy will be circulating. If we look at this energy, as for instance by measuring the voltage drop across either the coil or capacitor, we can see it as a "multiplication factor." If we feed such a circuit with 1/2 volt, and circuit Q is 100, we will measure 50 volts across the circuit as a whole.

Of course, our measuring device must take out some energy in order to make the measurement, and this energy is lost to the circuit. This means that the circuit Q is lower when we're measuring than when our voltmeter is disconnected, and the figures in the previous paragraph are correct only if Q is 50 with the meter connected.

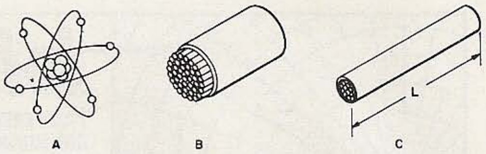

Fig. 3. Physicists tell us that atoms consist of nucleus surrounded by orbital electrons (A), and all materials are made up of atoms (B). If this is the case, absolutely precise measurement of the length of a piece of wire is impossible (C) because the length varies plus of minus the diameter of an atom as the electrons orbit the nucleus. This doesn't keep us from making useful and "accurate" measurements, but it does point up the sharp dividing line between the absolute precision of any theory and the slight uncertainties we face when we apply that theory to the actual world around us. "Measurement" is a part of the real world; and the idea of "length" belongs to the world of theories. In most cases they are close enough to each other to permit us to consider them as identical—unless we insist on "measuring" something with no error at all!

This point is important, because it involves the practical applications of most tank circuits. A vacuum-tube grid, operating Class A, is next to nothing in its loading effects, and so a Class A amplifier has little effect upon the Q of its tuned grid circuits. A plate circuit, on the other hand, is a relatively low resistance and will load a tank circuit heavily. This is why final amplifiers, for example, are designed to operate at Q values between 5 and 20.

We could continue examining Q and its implications for many times the length of this article without exhausting the subject. It's a key factor determining the selectivity of a tuned circuit; it determines, almost by itself, the stability of an oscillator; it is related very simply to the power factor of a circuit (which is approximately 1/Q); to mention only a few of its other meanings. But we have other subjects to explore.

How Can A Signal Exist Without Taking Any Space? Open any text you like which discusses the bandwidth requirements for radio transmission, and sooner or later you'll come across the statement that "a carrier has no bandwidth."

How can you have nothing from something? Pick any carrier at random; you can see it on a spectrum analyzer, get an FCC citation for off-frequency operation, convert it to an audio frequency which you can hear, see it hold up an S-meter needle. How can this have no bandwidth? Obviously it must exist, and if it exists then it must be somewhere. And if it *is* somewhere, then that somewhere must take up at least a little spectrum space no matter how small. But if it takes up any space then that space is its bandwidth, and the authorities say the bandwidth is zero. Therefore it occupies no space, and since only the non-existent can fit into "no space," the carrier must not exist!

Most of us who first get tangled up in that self-contradicting line of reasoning cited in the previous paragraph conclude that the authorities who say bandwidth is zero are wrong. If the statement "a carrier has no bandwidth" is changed to read "a carrier occupies so little bandwidth that it cannot be measured," then the contradictions vanish. For all practical purposes, the two statements are equivalent – but the minute difference between them permits the carrier to exist.

Unfortunately, this simple answer to the paradox is wrong. A perfect, ideal carrier actually does occupy *zero* bandwidth, and this statement does not rule out the possibility of such a carrier's existence. No one has yet created one, and the chances of it happening at any time in the future are incredibly small (it's much more likely, for instance, that all the water molecules in the Pacific Ocean will move in the same direction in the same instant, thereby putting the entire ocean into orbit and exposing its muddy bottom), but that's not because of the zero-bandwidth requirement. Quite a few practical carrier signals have unmeasurably small bandwidths.

The paradox involved in the zero-bandwidth question is that involved in all measurements. *No* measurement can ever be accurate, to zero tolerance. No matter how much we refine our equipment, for instance, can we be sure that a piece of wire is precisely one inch long – because it may be the width of an electron less than one inch, or greater, depending upon precisely what instant we measure it! And if it's either, then it's *not* precisely one inch.

This may sound like splitting hairs. Actually, splitting hairs is a rather imprecise operation compared to the idea we're attempting to explore. What we're really looking at is the difference between absolute precision, and possible achievement.

Absolute precision may exist somewhere in the Universe, but we could never recognize it even if we stumbled across it. The only place it has any use for us is in the theories which we evolve in our attempts to explain why things happen as they do.

But the theories *must* be framed in terms of absolute precision. When we look at Ohm's law, for instance, we find that $E = I \times R$; this is precision. It does *not* say that E is approximately (almost I) times (somewhere very near to R) – but any attempt to put the law to use will have to make use of *approximate* quantities for I and R, because we cannot measure any other kind.

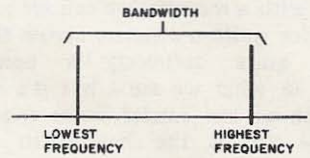

Fig. 4. If we assume that any single frequency is just that—a single frequency—then it cannot be any other frequency. Any practical signal contains several different frequencies, and a group of frequencies all taken together is called a "band." The bandwidth of this band is simply a measure of the difference between the lowest frequency in the band and the highest. In the case of a single-frequency carrier, only one frequency is present and it is both the lowest and the highest, so that the "bandwidth" of that single frequency must be zero. Note that this doesn't say that the single frequency doesn't exist; it merely says that no other frequency is associated with it.

And that's why a carrier has zero bandwidth. The carrier exists; we can observe its effects. Bandwidth, on the other hand, is an idea straight out of the world of theory. It is defined only in theoretical terms; it's the amount of spectrum space between the lowest (not the approximately-lowest) frequency in the signal and the highest (again, not the approximately-highest). A carrier is a single frequency, and so it is at the same time both the lowest and the highest frequency in its signal. The result – theoretical, of course – is that carrier minus itself equals zero, and the carrier has zero bandwidth.

Any practical carrier we put on the air is likely to have at least a little modulation upon it, though. It's most difficult to get all the hum out when we use ac upon the filaments of the transmitter. This hum may be so far below the carrier in amplitude that we cannot tell it's there – but if the carrier's frequency ever varies by so much as one ten-millionth of a ten-millionth of a cycle per century, then there's a "lowest" frequency and a "highest" frequency which are *not* equal, and that carrier will have a non-zero bandwidth. In the rather extreme case just cited, the bandwidth would be somewhere in the neighborhood of 0.00000000000000001 cycle per year, or 0.00000000000000000000076 hz (give or take a few). This is an extremely small number – 0.76×10^{-21} – but it's still infinitely greater than absolute zero!

Now when we look at a carrier on a spectrum analyzer, it appears to occupy a definite bandwidth. Similarly when we tune across it with a receiver, we can see it on the S-meter for quite a distance across the dial. There's quite definitely a bandwidth involved in what we see – but it's not the bandwidth of the carrier we're examining. What we see is the bandwidth of the spectrum analyzer or the receiver, as traced out for us by the almost-zero-bandwidth carrier.

When we looked a some of the implications of Q in our preceding section, we noted in passing that Q determines selectivity of a tuned circuit – and selectivity is just another term for bandwidth. The higher the Q of a circuit, the narrower its bandwidth. Also, the higher the Q, the less the loss in the circuit.

When we trace out the bandwidth of any measuring device by sweeping it across a carrier, we can tell nothing about the bandwidth of the carrier from that. The only way we could hope to actually measure the bandwidth of any carrier would be to have a test instrument with *less* bandwidth than the carrier.

We can attempt to get this, by increasing the Q and therefore the selectivity of the tuned circuits in our receiver or spectrum analyzer. As we do so, we increase the ratio of energy stored to that lost. Less and less driving energy is needed to produce the same amount of circulating energy within the circuit.

As Q climbs, somewhere along the line we'll reach the point at which the circuit "rings" so badly that we can't tell whether there's a signal coming through or not. This is because the Q is so high that any injection of energy takes a very long time to fade back down.

If we increase Q just a little more, we'll find that our selective amplifier is behaving more and more like an oscillator – so we increase our shielding and take all possible steps to prevent feedback.

But as we keep it up, we will eventually come to a point at which the Q is essentially infinite; any energy getting into the circuit just stays there circulating forever.

As we kept increasing the Q, the bandwidth got ever narrower. When we reached the point of practically infinite Q, our bandwidth was essentially as wide as a mathematical line; that is, zero. Now we have the device which has sufficiently narrow bandwidth to attempt to examine a carrier.

Unfortunately, we can't use it to examine anything. It has turned itself into an oscillator and is generating a carrier of its own!

Why Do Signals Require Bandwidth? Now that we've taken a look at the reasons why a carrier – or any single-frequency signal that is always on and never changes frequency – has no bandwidth, let's turn to the other extreme and try to find out why practical signals require *more* than zero bandwidth. It's just as confusing a question as was that of the carrier's lack of bandwidth.

In fact, many areas of communications (and not just communications by radio) involve a confusion between ideal theory and best achievable practice. So long as we keep firmly in our minds the notion that a theory is just that, and practice is something else again, we may be able to avoid some of the confusion. Most "authorities" lose sight of the separation between theory and practice, and then attempt to "simplify" the resulting confusion by putting in all kinds of assumptions. The inevitable result of this approach is increased confusion. We're often guilty of oversimplifying things – but we try to warn you when we do so.

About 21 years ago, a graduate student published a paper entitled "A Mathematical Theory of Information." In it, he drew a number of rather amazing comparisons between identifiable relationships in the practice of communications, and other relationships in the field of physics. Because of these comparisons, he showed how it was possible to fit the mathematical models developed by and for physicists onto the problems faced by communications engineers, and the result was the foundation of what we now call Information Theory.

Claude Shannon's original work has had astonishing consequences in the two decades

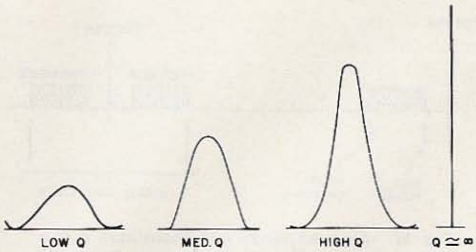

Fig. 5. Relationship between tuned-circuit Q, bandwidth, and impedance is shown in this sequence. Low-Q circuit has wider bandwidth and lower impedance than does medium-Q circuit. As Q is increased, impedance rises and bandwidth decreases. If means can be found to decrease circuit's losses, Q can be increased indefinitely—but at some point in this process the Q will be so close to infinite that no one can tell the difference. When this occurs, the bandwidth is unmeasurably close to zero and the impedance is also near-infinite. Any circuit we can build to do this will keep going indefinitely when a single noise pulse happens to ring the tuned circuit—and so we call it an oscillator.

since his original paper. Information Theory is now a recognized specialty of science, and has a jargon and a mathematics all its own. While almost all of it is applicable to our problems in radio communications, we won't try to go very deeply into it here at this time.

But we must examine the most basic part of it. The keystone to Shannon's whole theory was his establishment of a unit for measuring "information." He concluded that the least possible amount of information which could be sent anywhere about anything would be a single true-or-false statement, on the order of "does the object exist, yes or no?" Such a statement can be represented electrically by the presence or absence of a voltage on a wire, or by the presence or absence of an *rf* carrier.

Mathematically, a number system which has only two possible conditions is a "binary" or two-valued system, and each of the combinations is one binary digit. Shannon contracted the name "binary digit" into the abbreviation "bit" – and it's now the standard unit for measuring information.

In the International Morse Code, for instance, each character contains a specific number of bits – although in this code, the number of bits varies from character to character. The teletype code offers a much better example; it's standardized at seven elements per character. Of these seven, one is a start pulse and one is a stop pulse, leaving the other five free to vary from character to character. The code is thus a 7-bit code, but contains only 5 bits of information per character while the other 2 bits are used to identify the start and stop of the character.

Shannon extended the bit concept to cover *all* transmissions of information. Even a SSB round table can be described in terms of the number of bits involved, using the mathematics of Information Theory. We don't need to go quite this far, any more than we need to know how many electrons must pass a point in one second to produce a current of one ampere in order to use an ammeter.

Because Shannon went on, having defined the bit as the basic unit of information, to formulate a law which relates bandwidth of an information transmission and bits transmitted per unit of time just as the ammeter relates current flow to electrons passing per unit of time. You might say he gave us an "informationmeter."

The law is simple enough. To transmit information at the rate of "n" bits per second requires a bandwidth of two times "n" cycles per second. To mark the start and finish of each bit requires that the signal be first turned on, then turned off; a cycle is defined as one full swing between on and off. Within a single cycle, it's not possible to tell whether the bit is on or off; within two cycles, though, you can determine whether both cycles are the same (bit on) or whether one differs from the other (bit off).

Once the relationship "frequency = twice bits" is set up, it's an easy mathematical operation to move it around and find out that "bits = half frequency." This is our "informationmeter." If we're using a bandwidth of 3000 hz for our voice transmissions, we're able to send no more than 1500 bits of information per second. Note that this rule doesn't say we're actually sending that many – it just says that we can't send information any faster than that within the 3 khz bandwidth. If we want to send information more rapidly, we must use wider bands; if we must conserve bandwidth, we'll have to slow down the information rate.

This also implies that *any* transfer of information requires at least some bandwidth. Our zero-bandwidth carrier conveys no information (except possibly the fact of its own existence, and that's nothing new after it has once been established). If we turn it on or off we can use it to send

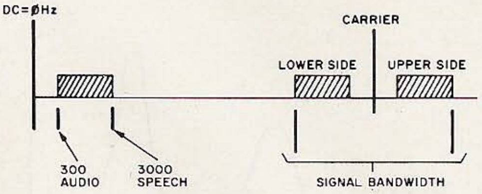

Fig. 6. Conventional AM translates audio signal such as 300-3000 hz speech shown here, up into rf spectrum as a pair of sidebands surrounding the rf carrier. Bandwidth of the composite signal then is equal to two times the highest frequency of the original audio signal because the lowest frequency in the composite is equal to carrier frequency minus the highest audio; and the highest frequency of the composite is equal to the carrier plus the highest audio. SSB signals eliminate the carrier and one of the sidebands, to provide a composite rf signal of only half as great bandwidth. DSB signals take as much bandwidth as conventional AM, but have no carrier.

information, but the mere act of turning it on or off introduces bandwidth.

About this point is where the confusion between theory and practice begins to become acute. It's not too hard to see how theory and practice fit together when we're talking about am voice signals, since it's obvious to our ears that voices have a mixture of frequencies and it makes fair sense to assume that the whole mixture is somehow made a part of the signal, in which case it's only natural to assume that the mixture must occupy more space than would a carrier alone.

But when we come to examine the bandwidth implications of merely turning a carrier on or off, or extend them into a study of the bandwidth required for a slow CW signal as compared to a fast one, it's a little harder to see.

Let's first see just how the voice signal comes to have a bandwidth, then work from there to see if we can find some similarities between voice and CW (no matter how ridiculous that may sound at this stage).

The human voice may contain frequency components as low as 50 hz and as high as 10,000 hz, but communications engineers determined by experiment about 1940 that recognizable and identifiable speech could be heard if the frequency range were limited to those components between 300 hz at the low end and 3000 hz at the high end. This, it must be emphasized, is *not* theory. It was the result of tests upon literally thousands of tourists during the 1940 New York World's Fair. Later tests have shown that an even smaller frequency range can be used at some sacrifice in the identifiability of the speaker. Common practice today, however, uses the 300-3000 hz limits as the accepted range required for "communications quality" speech.

This pair of frequency limits, one upper and one lower, define a bandwidth of 3000 – 300 or 2700 hz as that accepted for communications quality speech transmission.

Any form of voice transmission, whether by telephone or radio, must transmit the whole bandwidth in order to meet the requirements of "communications quality transmission." If we're transmitting by wire, we simply convert the sound to its ac electrical equivalent, transmit the resulting electrical signal over the wire, and reconvert it to sound at the other end.

If we're using radio, we must be a little different. Audio-frequency energy isn't convenient for direct transmission, so we convert the *af* signal up to the *rf* region, radiate it to the receiver, and there convert it back to an *af* electrical signal.

With conventional AM, our conversion from *af* to *rf* is rather direct; we simply offset the frequency by the desired amount. Since the "center frequency" of speech is zero rather than anywhere within the bandwidth of the signal, when we offset it up to the *rf* region we get not just one but two signals known as sidebands, either of which is a complete conversion of the original *af* signal. The carrier, between the two sidebands, corresponds to the zero center frequency of the original signal, and in the receiver it serves to allow the two sidebands to fold back into a single replica of the original signal, reproducing each of the original frequencies perfectly.

We can get SSB by eliminating the carrier and either of the sidebands, but at least one sideband must be transmitted.

If we choose to use FM, we use the original *af* signal to vary the frequency of the radiated *rf;* while it would appear that no exact replica of the original signal is transmitted in such a case, it can be shown mathematically (and demonstrated physically as well) that the original signal is present in the sidebands of the FM signal in such a way that it can be recovered from them without making use of the frequency variations. Normally, of course, our FM receivers do make use of the frequency variations.

When we use FM, we "encode" the original *af* in the frequency variations of the transmitted signal. This means, in practice, that we must occupy more bandwidth with the FM signal than is necessary to transmit the signal by AM; in Shannon's terms, we must transmit more information when we use FM.

But no matter which of these techniques we use, we must transmit the full original bandwidth of the signal – and that's our major point now.

While we're looking at modulation is a good time to dispose of one of the more confusing practical points introduced by authority's attempts to "simplify" – that's the notion that "carrier shift" in a modulated signal indicates some malfunction.

"Carrier shift" is a change in the strength of the carrier when modulation is applied, and the general belief is that the carrier's strength always remains constant during amplitude modulation, with only the sidebands changing in amplitude.

This general belief is true – if you're transmitting only a pure sine wave as

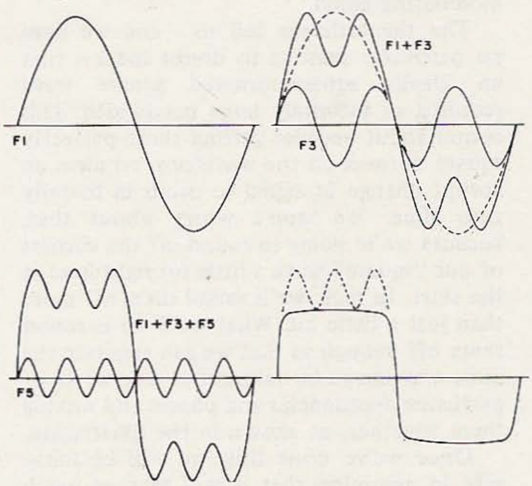

Fig. 7. Square wave signal (lower right) can be built up from sine waves when they have the proper frequency and phase relationships to each other. Start with a sine wave of the same frequency as the final square wave (upper left). Add to it another of three times the frequency but "in phase" with it; this sharpens the sides and flattens the top (upper right). Add to the resulting signal another sine wave of five times the original frequency still in phase, which flattens out the top of the waveform still more (lower left). Clipping off the top and bottom of this waveform produces a "square" wave with some slope on the sides.

modulation. If you're transmitting speech, though, or any other signal which has more of its energy on one side of the zero line than the other, then carrier shift *must* occur in a properly operating modulator! The reason for the confusion is that almost all explanations of modulation action are based on the "simplification" that only sine waves are to be used as modulating signals; in practice, of course, sine-wave modulation is hardly ever encountered.

In TV transmission, carrier shift is necessary in order to convey the average brightness level of the scene being transmitted. This offers an excellent example of the discrepancies between most theoretical explanations based on simplifications, and the conditions actually met in practice.

But it doesn't tell us much about the reasons why CW signals require bandwidth, when all they amount to is the turning on or off of a zero-bandwidth carrier.

To tackle this particular bag of worms, let's begin by forgetting all about CW signals, and both voice and sine-wave modulation too for a little while. Let's look instead at the interesting case of a square-wave modulating signal.

The theoreticians tell us – and we have no particular reasons to doubt them – that an ideally square-cornered square wave requires an infinitely large bandwidth. This comes about because getting those perfectly square corners on the waveform requires an abrupt change in signal to occur in literally zero time. We won't worry about that, because we're going to round off the corners of our "square" wave a little bit right here at the start. In fact, we'll round them off more than just a little bit. What we'll do is round them off enough so that we can generate the same waveshape by taking five sine waves of particular frequencies and phases and mixing them together, as shown in the illustration.

Once we've done this, we will be fairly safe in assuming that it will take as much bandwidth to transmit either the rounded-off "square" wave itself, or the combination of the five sine-waves. We can easily calculate the bandwidth requirement of the five sine-waves by simply subtracting the lowest frequency from the highest. The square wave, then, must require at least as much.

Since we want a squared-off flat top on our wave, and the mixture of sine waves has some ripple along its upper edge, we must also permit the square wave to contain a dc component. This means that its required bandwidth must extend from zero to dc at the lower limit, up to that of the highest-frequency sine wave at the upper limit. In other words, if the repetition rate of the square wave we have shown is "n" cycles per second, then it will require a bandwidth of "5n" hz for transmission.

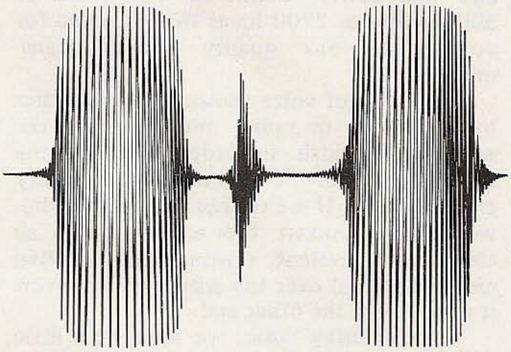

Fig. 8. If we modualte an AM transmitter 100% with the signal we developed in Fig. 7, the output waveform will look like that at the above left. If, on the other hand, we key a CW signal and have the proper shaping circuits to prevent key clicks, we'll get an rf output from the transmitter as shown at right. Essential identity of these two waveforms shows that CW may be considered as a special case of AM, using a "square" wave modulating signal instead of speech or tones.

Now let's take our modified square wave and feed it into a modulator connected to an ordinary AM transmitter. At low modulation levels we get something not too different from speech; but if we keep cranking up the gain until we reach the point of 100% modulation, so that the signal is completely cut off during the "down" portion of the square wave and is at full amplitude during the "on" portion, the transmitter's output is difficult to distinguish from CW.

Yet we have determined that the square wave shown requires a bandwidth of five times its repetition rate for transmission, and we know that any conventional AM transmitter must produce a signal with a bandwidth at least equal to that of its modulating signal. This means that our transmitter's output must occupy a bandwidth at least five times the repetition rate of our "square" wave.

We can show that the output of a CW transmitter being keyed at the same speed, with the keying waveform shaped to exhibit the same "make" and "break" rounding, must occupy the same bandwidth in the same way that we built up the "square" wave from five separate sine waves; things which are indistinguishable from each other are equivalent to each other, and in order to be indistinguishable each must have *all* the characteristics of the other.

Since the bandwidth is related to the repetition rate of the modulating or keying signal, it follows naturally that the greater the keying speed, the more bandwidth is required. The conversion factors to get from keying speed for repeated "dits" over to a transmission speed in words per minute are numerous – and many of them involve statistical averages and approximations, such as the average number of bits in any random code character. The working factor most usually used is that the bandwidth required (in cycles per second) is equal to four times the keying speed in words per minute. A 10 WPM transmission, then, would require only a 40-hz bandwidth, while to transmit CW at 100 WPM the signal must occupy 400 hz.

When the FCC – or any other governmental agency – talks about signal characteristics, they usually use the CCIR emission-type code to designate the type of signal they mean. This is a combination which always includes a capital letter, followed by a single numeric digit, and may be preceded by another number. The letter designates the general class of modulation applied to the signal; A stands for "amplitude," F for "frequency", and P for "pulse." The digit following the letter indicates just what type of modulation ia applied; Ø indicates the absence of any modulation intended to carry information, 1 indicates telegraphy with no superimposed audio, 2 indicates telegraphy making use of audio modulation accompanying the carrier, 3 indicates telephony, 4 indicates facsimile, 5 indicates television, and 9 indicates composites of the above and miscellaneous types.

If a number precedes the letter, that number indicates the signal's bandwidth in khz.

For example, A1 indicates that amplitude modulation of telegraphy without accompanying audio is involved. This is the classic CW case. If raw ac were applied to the transmitter plates so that the signal were audio-modulated by the 60-hz hum, it would be A2. A3 is any type of amplitude-modulated telephony, including SSB and DSB. A5 is amplitude-modulated television. AØ would be a steady carrier, so would FØ or PØ, for that matter.

The FSK signal used in most RTTY work is type F1; AFSK used at vhf, is F2. FM voice communications are F3.

Indication of bandwidth produces such codes as "6A3", which is 6-khz bandwidth AM telephony; "6000A5,F3", which is commercial TV including its FM audio channel, and "0.1A1", which is 25-WPM CW (which takes 100-hz bandwidth).

In addition to the three elements of this code we've discussed, lower-case letter suffixes may be used in some cases. SSB is indicated as "3A3a," in which the "a" indicates single-sideband reduced carrier transmission. If two independent sidebands are transmitted, the code would be "6A3b"; this type of transmission is used only in military and commercial work, and is known as "independent sideband" modulation. The different types of pulse modulation, similarly, are denoted by "d" for PAM, "e" for PWM, and "f" for PPM.

By decoding the capital letter and following numeral to determine what type of signal is being discussed, you can then supply the appropriate bandwidth. Bandwidth for an A1 signal depends upon the keying speed, but will be approximately 4 times the WPM of the keying. Normal AM voice requires 6 khz (6A3), as does DSB, but SSB takes only half as much space since only one sideband is used. With FM, the adjective "narrowband" is often used but it has very little meaning. In commercial FM broadcasting, any bandwidth less than 150 khz is "narrow", and in commercial two-way work "narrowband" means anything under 25 khz. In ham use, though, it usually means a bandwidth not greater than that required to transmit the same signal be conventional AM; for voice, this would be 6 khz. F3 transmission on the 3-through-30 mhz bands is illegal unless its bandwidth is restricted to this figure or less.

Why Is It Mandatory That A Mixer Be Non-Linear? One of the master keys to modern radio is the principle of "mixing" or frequency conversion, which permits us to change a signal from one frequency to another without changing the modulation it carries – and, for that matter, permits us to modulate it in the first place!

All authorities agree that a mixing device must be non-linear, and that any non-linear device can be used to mix signals – but the reasons why non-linearity and mixing go hand in hand are seldom examined with any degree of clarity.

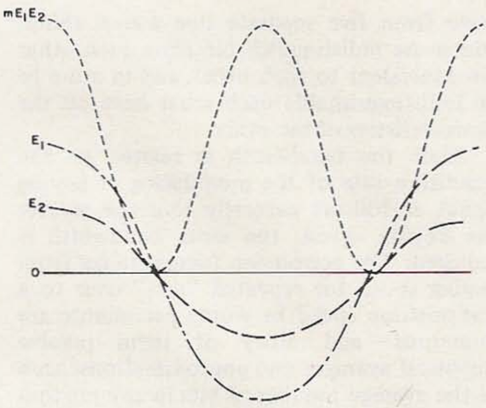

Fig. 9. Mixer action is shown here. Dotted waveform is the output signal of sample circuit, produced by multiplying two input signals E1 and E2. This plot, traced from one produced by a digital computer, extends over only one cycle and so does not show envelope variations described in text. It does, however, show how multiplication of two sine-wave signals produces a third signal which is the sum of the two original signals.

About the only studies of it to be found in print look at the whole question mathematically – and require some knowledge of the integral calculus! Let's see if we can make this a little easier to get a handle on, with an absolute minimum of mathematics.

The one bit of math which we can't escape is the idea that an amplifier has the effect of "multiplying" the amplitude of its input signal.

That is, for an input of "x" volts the output will be "gain times x" volts, if the amplifier is operating in a completely linear manner.

This assumes, of course, that the gain is constant – and that defines for us any "linear device." A linear device is any device in which the output signal is equal to the input signal multiplied by some constant factor.

A resistive voltage divider composed of two 1000-ohm resistors in series is a linear device, for instance, because its output is always equal to half the input signal. The "half" is the constant.

But if the constant in a linear device is truly constant (which it must be, by definition), then every output signal from the device must have come into it as an input signal identical to the output in every characteristic except amplitude, and with amplitude equal to output amplitude divided by the constant.

This means that if we apply a 1-volt 60-hz signal to a linear device with a gain constant of 10, and at the same time apply a 10-volt 6-khz signal, out output can consist only of a 10-volt 60-hz signal and a 100-volt 6-khz signal. No interaction between input signals can possibly occur in a linear device, because if it does then the device *by definition* is not linear!

Now let's assume we have an amplifier with two sets of input terminals on it. For one set of input terminals, the amplifier is linear; any signal fed in here appears as an exact duplicate (only larger) at the output. The other set of terminals, however, provides gain control for the amplifier. Any signal applied to this set doesn't show up in the output; instead, it causes the gain of the linear part to change.

This is an approximate description of the action of an AVC-controlled receiver *if* amplifier stage; it acts as a more-or-less linear amplifier for the signal path, but its gain is controlled by a dc signal applied to the AVC input terminal.

Just to try to keep things simple, since we're talking about a theoretical amplifier anyway rather than any actual circuit, let's assume that the gain-control terminals are "linear" too. That is, if the voltage at the gain terminals is 2 volts, gain is 10 (let's say), and if we raise the voltage to 4 volts the gain through the linear section rises to 20. Cutting gain voltage back to 1 volt, though, reduces gain to 5. The "constant" for this action is simply that the gain of the linear section is five times the voltage applied to the gain-control section.

If we apply steady dc to the gain-control section of this circuit, we will have a linear amplifier from signal input to output. A 1-volt 60-hz signal going in will produce only a 60-hz signal out, at a voltage level five times that of the dc applied to the gain-control section.

But what happens if we apply ac on top of the dc at the gain control terminals? Let's assume that we're putting 4 volts of dc in, with 1 volt of 10-hz square-wave ac superimposed on it. That means that for 1/10 second, the dc level at the gain control terminal is only 3 volts, and for the next 1/10 second the dc level will be 5 volts.

With our 1-volt 60-hz signal going into the signal input, our output now consists of 1/10 second of 3-volt 60-hz followed by 1/10 second of 5-volt 60-hz. The ac signal fed into the gain control terminal has varied the gain through the signal channel, and has introduced itself into the output signal by so doing.

Notice especially that the output consists of the original 60-hz input signal, *controlled by* the 10-hz control signal. Had we simply applied the 60-hz and the 10-hz signals to the same input of a completely linear device, they would have both appeared in the output but each would have been completely independent of the other. Had we used a linear amplifier with a gain of 10, for instance, the 60-hz signal would have had a peak-to-peak value of 10 volts at all times regardless of the level of the 10-hz signal. In our special circuit, the amplitude of the 60-hz signal is determined directly by the amplitude of the 10-hz signal.

We can make it a little clearer by using just a trace of math at this stage. We defined a linear amplifier as one which produced an output exactly equal to gain times input. If we represent the "gain" constant by the symbol "k," the equation defining linear amplification is: $E_o = k \times E_i$.

The equation defining action of our special circuit is very similar, but instead of "k" we must put in a term which relates gain to control-input voltage. Let's call the "signal" voltage E_1 and the gain control-input voltage E_2, and use the symbol "m" for the constant which relates circuit gain to control input voltage. Circuit gain then can be expressed as "$m \times E_2$", and the defining equation for output voltage becomes: $E_o = (m \times E_2) \times E_1$, which we can simplify to $E_0 = mE_1E_2$.

The big difference, since both "m" and "k" are constants, is that in a linear circuit the output depends *only* upon the input, while in our special circuit the output is the product of two input signals multiplied together.

The special circuit, incidentally, cannot be linear except under the special circumstances we picked to introduce it. If varying signals are applied to both inputs, the gain is not constant and therefore the circuit cannot meet the requirements of the definition of a linear device.

At this point we have determined that we have at least one non-linear circuit, and we have found that its output signal is the product of its two different input signals. We have not yet, however, proved that the circuit satisfies the definition of a "mixer" by producing in its output both the sum and difference frequencies as well as the original frequencies of both signals – although we have seen how both original frequencies are present, and we have also seen that they are inextricably mixed together.

It's fairly easy to see how a difference frequency is developed if we stick with the same circuit but try some new signals. Let's put a 1000-hz sine-wave signal in at the input E_1, and a 1010-hz sine-wave in at E_2. We'll begin our examination of the action at some point when both input signals are at their peak value at the same time. This means that the output signal will also be at its highest possible value for these input signals since it is thy product of the two multiplied together.

Now let's let one full cycle of E_1 go by so that it is again at its peak value; this will take 1/1000 second. In that same 1/1000 second, E_2 will go through a little more than on full cycle (1.01 cycle, to be exact) and will be at a voltage a little lower than its peak value. This will cause the level of the output signal to be a little lower than it was at the previous E_1 peak.

Another cycle of E1 later, E2 will have gone even farther and the output will be lower still. Every cycle of E_1, E_2 will have gained 1/100 cycle and so the output will always be changing at a rate 100 times slower than E_1. When 50 cycles of E_1 have elapsed, though, E_2 will have gained exactly half a cycle and will be at its *negative* peak; for the next 50 cycles of E_1, the value of E_2 will be climbing back, and exactly 100 cycles of E_1 after our initial point, both signals will be at their peak value simultaneously again.

The envelope of the output signal, therefore, must be varying periodically at a rate 100 times slower than E_1, or 10 hz. This variation of the output signal envelope *is* the difference-frequency component; if we feed the output through a resonant circuit tuned to this frequency, the higher-frequency components will all be shunted out but the variation at this frequency will drive the resonant circuit.

Generation of the sum frequency is similar, but does not involve the output-signal envelope as such. Instead, the sum frequency component comes from considering the positive half-cycles of the output signal as being driving pulses in themselves. During any one-second period, E_1 will contribute 1000 positive half-cycles, and E_2 will contribute 1010 of them. The output circuit, then, contains potential driving pulses for a resonant circuit which occur at the rate of 2010 per second. Even through the few times when the peaks of both input signals coincide (and therefore contribute only one driving pulse instead of two), the statistical average frequency is still the sum of the two input frequencies because it's picked up by a tuned circuit and the flywheel effect of the resonant circuit smooths out any occasional miss in the driving source.

Since we've scored the "authorities" so heavily for their attempts at oversimplification, it's only fair to point out that this description of mixer action is in itself highly oversimplified in order to escape the cumbersome mathematics usually employed. Among our simplifications were the assumption that a perfectly linear circuit might possibly exist, the statement that it was possible in our sample circuit to vary gain in a linear manner so that the output was exactly equal to the product of the two input signals (this is ideal mixer action, not practical action), and the use of signals of approximately the same strength for mixing together.

The statement that mixing occurs by gain variation was only a partially correct one; most practical mixers operate by gain variation but it's not completely necessary, since a few work by switching action.

In most practical mixing circuits, the non-linearities involved are considerably more complex than those we have examined here. The gain of any actual amplifier must have some curvature in it over any wide range of input voltages. This curvature provides the "non-linearity" usually used for mixing. In most mixers, the mixing action is achieved by selecting the operating conditions so that the curvature effectively squares the input signal; this is called "square-law" action.

The signals we're dealing with are most usually sine waves, and when several sine waves are all squared at the same time, the production of sum and difference components follows automatically in any mathematical description of the circuit. The actual process, though, may be more like the picture we've presented here than it is like mathematics; no one knows for sure, but math is a tool for describing things – not a necessary reason for their existence! No mathematical equation ever forced a physical event to happen, although it may have permitted us to forecast the event's occurrence.

Staff

Switch Controlled VOX Delay

The SB-400, and many other rigs, have semi break-in CW which is just fine when calling DX stations and then listening for your call to come back—or when passing traffic and listening for a break from the receiving station. It is, however, a distinct disadvantage when you wish to chat with a fellow on CW. The make and break of the exciter and antenna change-over relays between each letter and sometimes between characters of a letter can drive you to AM, not to mention the wear and tear on your nerves and the relays themselves. I am now on my third Dow-Key relay, and they aren't cheap.

The solution: Add extra capacitance in parallel with the .05 μf capacitor C123 at V12B—the relay amplifier. I found that .2 μf of capacitance between pin 7 of V12B and ground—controlled by a foot switch (Linemaster 491-S or similar), gave me a two second delay before the relays dropped out. This gives me plenty of time to collect my thoughts and still continue sending in peace and quiet. A .3 μf capacitor will give 2½-3 seconds of delay, if needed.

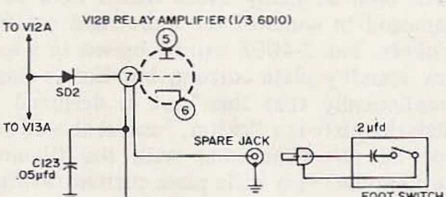

Fig. 1. Foot switch control for VOX delay.

The particular foot switch used here allowed plenty of room inside to mount the capacitor, and a zip cord was run from the switch to one of the spare jacks on the rear of the 400.

When you want the extra delay, just press down on the foot switch. Releasing it will instantly bring back the original vox delay time as set by the internal control.

Gerry Offenberg, WB2HXD

Don't put old wine in sheep's clothing.

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Big Signal – Good Looks

You can build a good performing, professional appearing linear amplifier. You don't have to be an electronics engineer either. Building and operating your own equipment is a highly enjoyable part of ham radio, and careful workmanship will produce a unit you can operate and show with great pride.

Having compromised my antenna for the sake of neighborhood relations, my T-4X wouldn't reach out as I wanted. More power seemed to be the only answer: A linear amplifier.

Here is how I reached my goal, not a step-by-step construction article, but a description of what I did and at least some of the "whys." One of the first decisions I made was to select a tube. The 3-400Z offered a lot of advantages, and I had a power transformer to suit it.

The power supply is on a separate chassis with the space shared about equally by the transformer and the series bank of filter capacitors. Other essentials are tucked in corners here and there. A perforated aluminum cover was made for the top, and there is a heavy plate on the bottom. Interlocks were included to help reduce the likelihood of electrical shock. The meter on the panel also helps, because it indicates how much charge is still on the capacitors. Regulation is fair. The voltage is 3,000 at 100 ma; SSB peaks cause it to drop to about 2,800 volts. At 400 ma the voltage is 2,500. The high voltage is supplied to the amplifier through a piece of RG-8/U. All other leads to the amplifier are in a common shielded cable terminated in an octal plug.

The amplifier circuit is quite straight forward. A few changes were made to fit the components on hand, of course, just as you will want to do. Also, some extra pains were taken to bypass power and control circuits leaving the amplifier so as to concentrate the *rf* in the antenna circuit.

Local Eimac engineers talked me into buying their air system socket, because they have seen so many tubes which have been damaged in some of the more rigid ceramic sockets. The 3-400Z can be biased to a very low standby plate current, but Eimac states emphatically that this tube is designed so that the plate is a "getter," and it should run hot. If the tube idles with the filament burning and very little plate current flowing, there is a strong possibility that the tube will be "poisoned." Of course it does take a little while to get used to seeing a tube on "standby" with a red-hot plate!

The power switches on the amplifier are wired uniquely. Only SPST switches are needed, but I had DPST types on hand and I couldn't let those extra contacts go to waste. No matter which switch is operated first, the filament, only, is turned on. The second switch to be operated turns on the high voltage. If the second switch on the amplifier is not turned on, keying the exciter will not operate the antenna change-over relay,

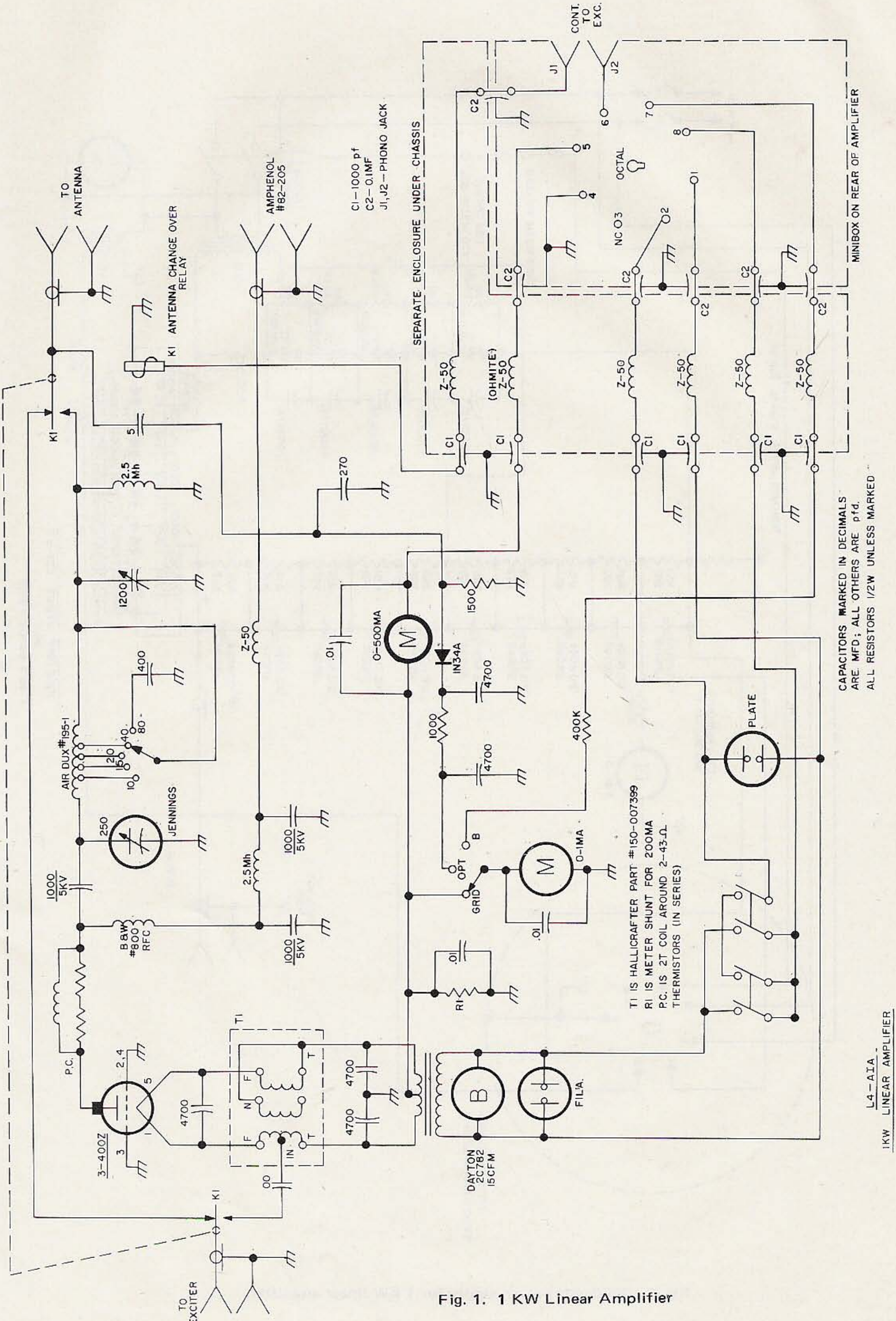


Fig. 1. 1 KW Linear Amplifier

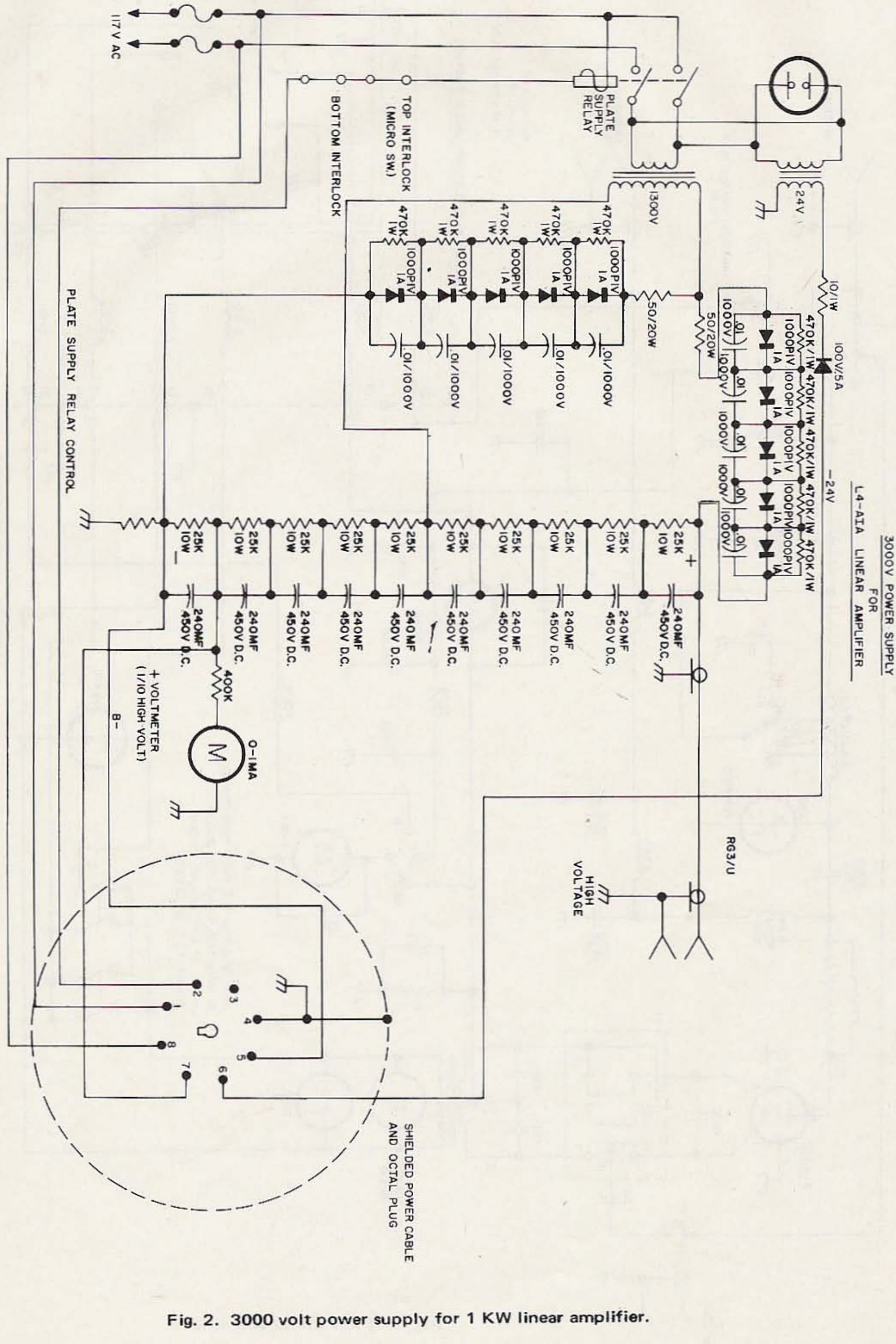
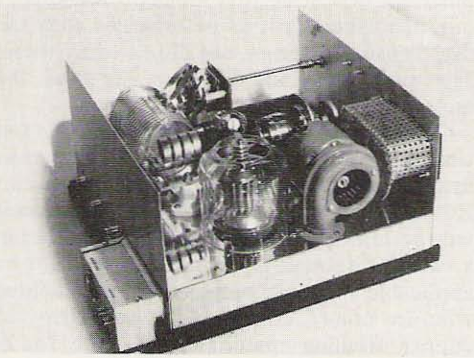


Fig. 2. 3000 volt power supply for 1 KW linear amplifier.

and the exciter will be connected to the antenna. If the high voltage supply is turned on, power will be supplied to the antenna change-over relay whenever the exciter is keyed, and the relay will connect the exciter to the amplifier input and the antenna to the amplifier output.

The pilot lamps (Olson Electronics) have large red lenses on which the lettering was applied. NE-51H are used in them with a 33k series resistor. This is a lower value than is specified for the lamps, but it doesn't seem to affect their life very much.

Several commercial amplifiers use only one meter on the panel, but I wanted to be able to monitor the grid and plate current simultaneously. The grid current meter (1 ma movement) can be switched to monitor relative power output or B+. In fact, it is connected so that it can also be used to monitor the exciter output.



No space wasted here! Notice filterbox on rear panel.

The Z-50 *rf* chokes shown inside the dotted lines on the amplifier schematic are enclosed in a separate shielded compartment beneath the chassis. The feed-through capacitors, C1 and C2, extend from this enclosure into, and out of the chassis, respectively. The screw terminals of the 0.1 feed-through capacitors (Sprague Hy-pass) are enclosed in a 2¼ x 2¼ x 5 inch Minibox on which the octal socket for the power plug is mounted. The phono jacks for the control leads to the exciter are also mounted on the Minibox. The control leads are also shielded as an additional precaution to avoid stray *rf*.

Most of the parts are rather common and few were purchased of a special nature. Due regard was paid to circuit requirements, but available components with suitable characteristics were used freely. The antenna change-over relay (in the corner beneath the tank coil) is a surplus unit with large

contacts. I can note no significant increase in SWR because of it.

So much for components and circuitry; now for some comments about obtaining a commercial appearance. Before you drill a hole, make several trial layouts of your components. It is best to make your sketches to approximate scale. Crossruled paper (I use 4 squares to the inch) is very handy for this preliminary layout work. Measure everything very carefully; check clearances, and try different layouts before "freezing the design."

Commercial enclosures are available from several sources; I purchased one from the R. L. Drake Co. to match my exciter. The chassis and the front and rear panels were carefully designed to fit the enclosure. A local sheet metal shop helped me with some of the bending and shearing. Panels are aluminum; the chassis is sheet iron (ungalvanized). After all the holes were drilled in the chassis, and parts checked for fit, the chassis was copper plated. Some component mounting brackets were made of aluminum, and I finished them nicely and polished them before mounting the components. A few pieces of scrap lucite were used in both the power supply and the amplifier for supports or spacers.

The rear panel is not painted, but it is clean and smooth and all connectors have been labeled. After the front panel was completely drilled, and after all parts had been mounted a time or two to make sure everything would fit, it was ready to be finished before "final assembly."

First I polished it, and then I cleaned it with benzine to remove all traces of oil and grease. Then I carefully masked the lower part with masking tape and newspaper and sprayed the light color on the top part of the panel. The rule here is to spray *lightly:* thin coats dry quickly and aren't so likely to sag. Spray paint cans work better when held nearly vertical, but panels are most apt to have runs if they are vertical. My solution is to spray quickly and lightly with the panel (and spray can) vertical, and then quickly lay the panel horizontal until it is ready for the next coat. Incidentally, I find that a "tack rag" is indispensable at this point. I carefully wipe the panel with it before each spray coat. (You can buy a "tack rag" at your paint store – or work varnish into a cloth and make your own. The commercial ones are not expensive and are much better than the ones I've made.) When you have enough coats on the top section, put it aside to dry well. It is best to remove the masking tape as soon as the last coat begins to dry; don't wait too long. After the top part was thoroughly dry I masked the painted part and proceeded to put the darker color on the bottom section of the panel.

After the paint is dry (wait 48 hours) the control markings and labels can be put on. *This is the time to take great care.* Sloppy panel markings will spoil the appearance of a good project every time. There are two easy ways to mark your panels: decals or "rub off" (dry transfer) lettering. I prefer the latter, but you can get either kind from your local supplier in black, white, or gold (Datak or Walsco). Use a color which will contrast well with the panel finish; do not mix colors. If I use decals, I always trim the background material right down to the letters. It isn't so conspicuous that way. After the decal is dry, I spray it with clear "Acry Spray" (Walsco). Be careful though! Use the spray very lightly or you may find you have sprayed your beautiful panel with a very effective paint remover! I found some automobile paint in touch-up spray cans that is acrylic so is not affected by the Acry Spray if you use it

Homemade . . . but it looks pro, doesn't it?

lightly. Be very careful with enamel though; it is touchy.

The dry transfer labels and markings look a little more professional, I think. Read the instructions carefully. I found that by rubbing very lightly you can get the results you want. After rubbing the letters, peel the plastic backing away slowly; if a part of a letter sticks to the plastic you can rub a little more. But if you rub too hard the plastic base will stretch, and you will have to start over. If that does happen, you can easily remove the unwanted letters. After burnishing according to the instructions I use the clear spray to seal them to the panel. Remember, spray lightly. My meter dials were originally marked "dc volts" and "dc milliamperes." I carefully removed those markings with a soft rubber eraser. I didn't touch the scales; I found meters with the graduations that I wanted. It is very hard to put on a new scale that looks professional. I put new labels on the meter scales with the dry transfer lettering, but didn't spray them. The new markings look as good as the factory job.

When assembling your project for the last time be very careful. A slip of the screwdriver can make a mighty big, unsightly scar. Route your wiring as neatly as the circuit will permit. Tie noncritical leads together in a cable. Although my technique will not be applicable to some projects, I used shielded wire in non-*rf* circuits and used strips of copper flashing material 3/8" wide for *rf* circuits.

Frequently it is convenient to make compression connections where some plastic material is included in the "sandwich." *Don't do it!* Sooner or later the plastic will change its dimensions enough to permit the connections to loosen. This will cause an intermittent or poor connection. If the connection carries much current it will start to heat up and things will rapidly get worse as the plastic "cold-flow" phenomenon accelerates as the temperature increases. I followed the tune-up procedure contained in the *Radio Amateur's Handbook*. I was very careful to give the high voltage all the respect that it deserves. How does my homebrew linear perform? I am pleased to report that during a recent contest I was able to work several new countries. How does it look? The illustrations speak for themselves. Why don't you plan now to have a top-performing, good-looking entry in that next homebrew contest? Now is the time to start!

. . . WA7A1A

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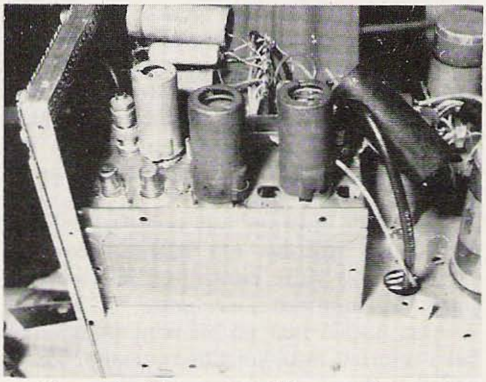
A New Vidicon Camera for ATV

In the last several years many articles have been published on vidicon cameras. Two of these articles are outstanding, number one appeared in the November, 1959, issue of *Radio Electronics.* This was entitled "T. V. Camera" by Derek Swaine of Sylvania Electric. The article discussed a closed circuit TV system. The second article appeared in the Denson Corporation's ATV booklet.

That now brings us to this article on a vidicon camera system. This system will be directly applicable to transmitting video on the air. The type of vidicon used in this camera is the 6326A.

By studying the block diagram you can see that there are quite a few modifications and additions to the existing closed-circuit TV systems.



View of video preamplifiers as they are located on the camera chassis.

Video Preamplifier

Referring to **Fig. 1.** it is noted that V1 and V2 (6CW4 nuvisters) are used as a

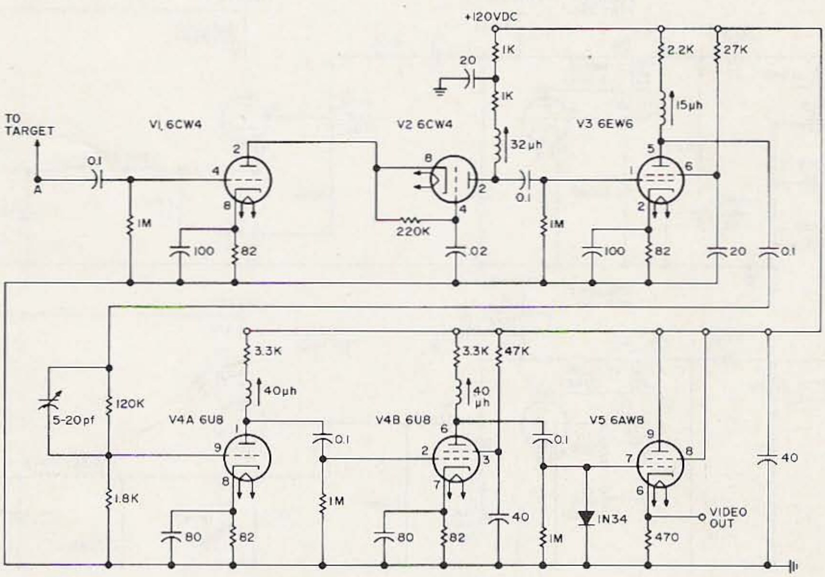
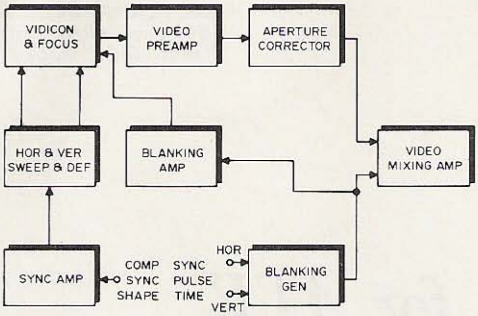


Fig. 1. Video preamplifier.



Block diagram.

cascode low noise input stage. V3 (6EW6) amplifies the video from the cascode stages. Stage V4A is the high peaker stage. V4B amplifies the peaked video to a usable level. V5 is the cathode follower output stage. The preamplifier is rather sensitive to closely located broadcast stations. Complete shielding and decoupling is a must in this case, particularly the B plus and filament leads to the video preamp.

The video preamp was redesigned for at least three reasons: (1) Higher frequency response; (2) More control on high peaking stage; (3) Improved noise figure.

Also notice that no blanking pulses have been inserted into the video preamp. This is added in the video mixing amplifiers.

Sweep and Deflection Amplifiers

Our next task was the redesign of the horizontal and vertical sweep oscillators, which is shown in **Fig. 2**. The purpose being for the sections to accept the standard RETMA sync pulses. Both of the horizontal and vertical oscillators are of the blocking oscillator types. The composite sync is fed to an integration and differential networks respectively. Locking action is very good.

No problems were experienced at this point. The pulse amplitudes and shapes are identical at the inputs to the deflection stages, as in the original camera units. The deflection amplifier's design was altered very little. A little difficulty was experienced with the centering controls, so that voltage dividing networks were altered. This modification is noted in the schematic.

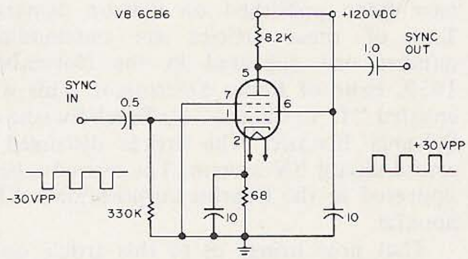


Fig. 3. Sync amplifier.

Composite Sync Amplifier

This amplifier is located on the sync shaping generator chassis and is not located on the camera unit. Although there is no reason why this could not be performed.

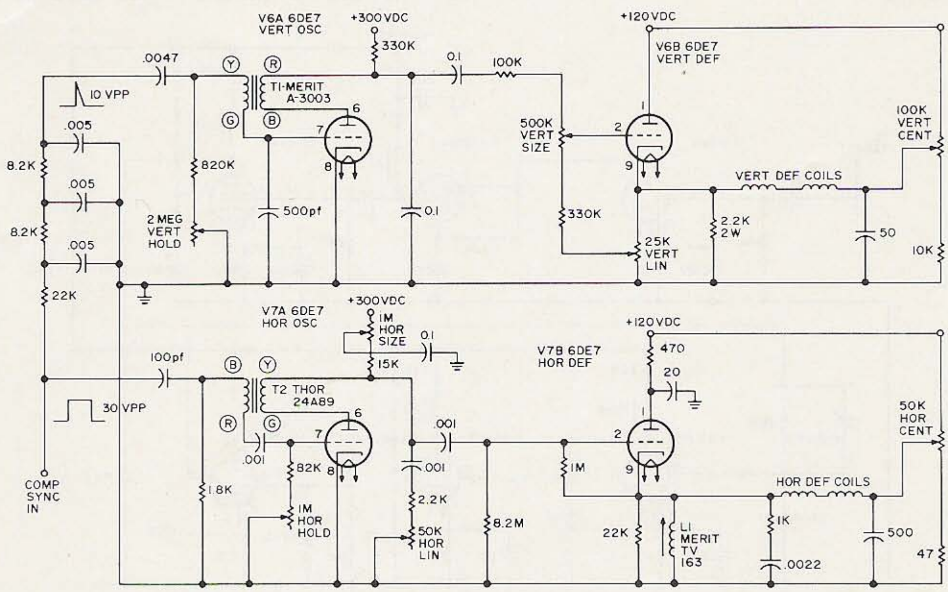
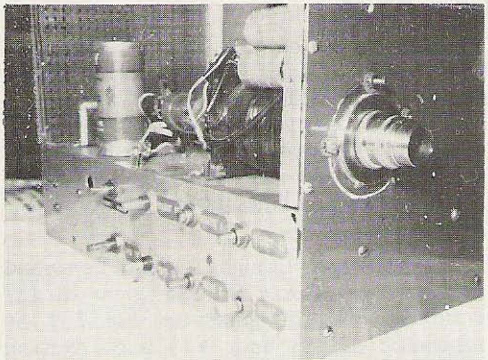


Fig. 2. Sweep and deflection circuits.



The other side of the camera with the vidicon and focus coil mounting, along with the adjustment pots for the vidicon.

The main purpose of this unit is two fold: To change polarity of the composite sync from negative to positive, and to amplify the sync to a usable level. This being in the neighborhood of a gain of 10. The circuit of this amplifier is shown in **Fig. 3**. The composite sync is derived from the sync shaping generators (this is with the sync delayed 1.25 us). There is no delay in the vertical sync.

Composite Blanking Amplifier

Fig. 4. is the schematic of the composite blanking amplifier for the vidicon camera tube. The sole purpose of this amplifier is to increase the amplitude of the blanking pulses

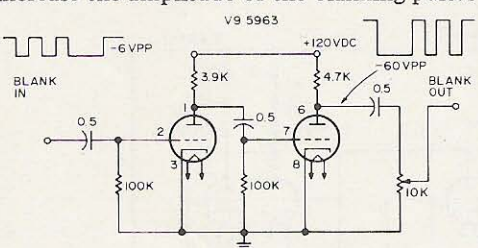


Fig. 4. Blanking amplifier.

to a level which the camera tube will cut off. For the 6326A vidicon, the level is a minimum of -30 volts. Again this amplifier is remotely located on the video mixing amplifier chassis, which, by the way, could be mounted on the camera chassis proper. A means of adjusting the blanking level is provided. This value being dependent upon the particular vidicon used.

Vidicon and Focus Coil

Fig. 5A is the schematic of the vidicon socket connections with the various voltages which are required. Deviations from the original circuits will be noted. The cathode of the vidicon is (pin 7) grounded. The target current and its associated circuitry is still located in the video preamplifier. All voltages are virtually the same as in the original article

Another change that was made was the isolation of the focus coil from the horizontal output stage. This circuit is noted in **Fig. 5B.** The best focus condition was found when a current of 37 ma was flowing through the focus coil. This coil is identical to the original.

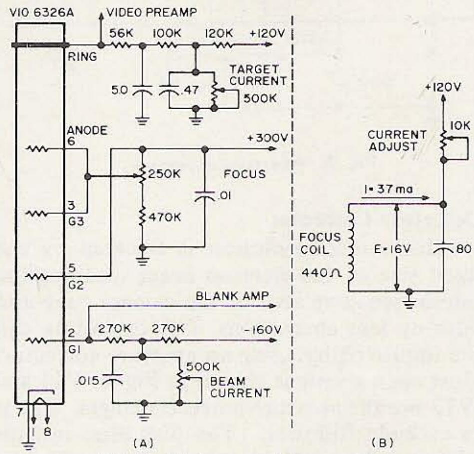


Fig. 5. Vidicon and focus coil.

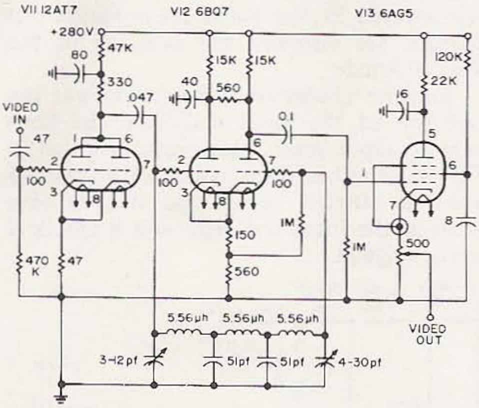


Fig. 6. Aperture corrector.

Aperture Corrector

Horizontal resolution is affected by the spot size of the electron beam scanning the photo sensitive area of the camera tube and also by lens aberrations. This resolution can be improved by using an aperture corrector. Just such a unit is shown in **Fig. 6. V11** and V12 are the aperture corrector stages. V13 is a cathode follower. The 500 ohm resistor shown in the cathode circuit is in reality the gain control in the video mixing amplifiers. This is indicated to simplify the schematic. The time delay line provides high frequency boost with a linear phase characteristic throughout the whole video range.

The time delay line is a half wave at 9 mhz. Low frequency response and gain is not affected, and maximum high frequency boost is obtained with the circuit as shown.

Blanking Generator

At this stage I thought it would be a good idea to also throw in a diagram of the composite blanking generator. Fig. 7 is the schematic of this unit. V14 is the vertical multivibrator. Two controls adjust both the repetition rate and the pulse width. The same applies for V17 which is the horizontal multivibrator. V15 is the mixer, where both the vertical and the horizontal pulses are combined to form the composite blanking pulses. The clipper stage and the cathode follower being V16. Sync pulses are derived from the sync timers, which are a series of dividers.

The system which I have been using is now a few years old, and has been relatively maintenance free. Interconnections of signals are with coaxial cable, where it is required. Shielding and good grounding of all units is very desirous.

. . . W8VCO

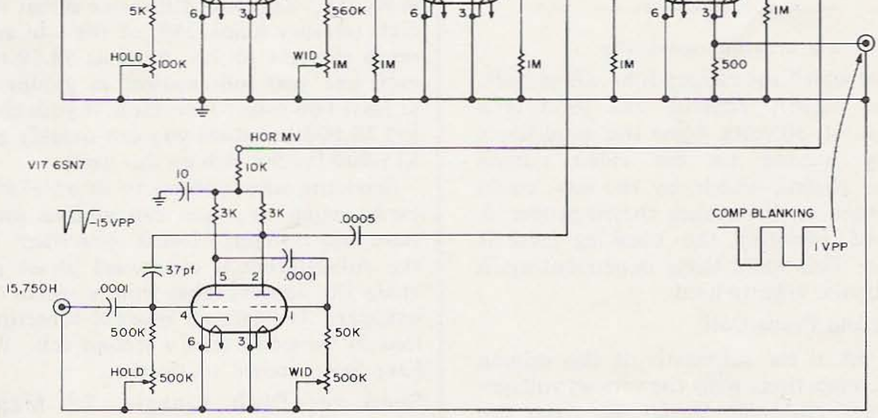


Fig. 7. Blanking generator.

Two More Transistor Testers

(Haven't you built one yet?)

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Downers Grove, Ill.

If you have built one or more of the many simple transistor testers which have been described over the years, here is a modification that will give you a direct reading beta scale. And, if you haven't built one yet, one of the two adapters to be described here should be right up your alley. But, if you are not quite ready to build one, read the article anyway and you just may change your mind. These adapters are really simple and come as close to being one-evening projects as you are likely to find. Before I get to the construction part, let me tell you how I stumbled onto this direct reading feature.

Many years ago while working on a transistorized electronic organ project in my basement, I built a test adapter for use with my VOM using circuit of **Fig. 1**. This is a little gem which served me well. Much as I would like to give proper credits, the publication where this appeared is no longer in my library. And you may see a similarity to circuits appearing in trade journals [1,2] as well as Darrell Thorpe's circuit in the January, 1967, issue of *73*. There are two equally effective ways of using this type of tester for measuring dc gain, or dc beta (also known as hFE), and most testers of this type use one of the two.

Method one: To make the beta measurement, simply adjust RB starting with maximum resistance, until the voltmeter reads one half of the battery voltage. Neglecting the slight voltage drop from emitter to base, half the battery voltage appears across RE as read on the meter, and the voltage across RB will be nearly the

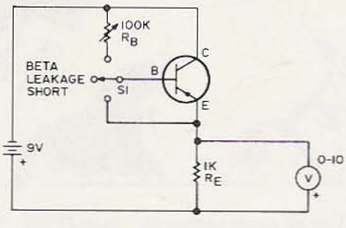


Fig. 1. Basic circuit of a popular and simple adapter for testing common "milliwatt" size transistors.

same. Under these conditions: IC=E/2RE; IB=E/2RB; beta (hFE)=IC/IB; then beta=RB/RE.

By marking the dial of RB in even thousands of ohms, beta readings are obtained from this dial. I built my tester with an RB pot of 50 k originally, because in those days transistors seldom had betas over

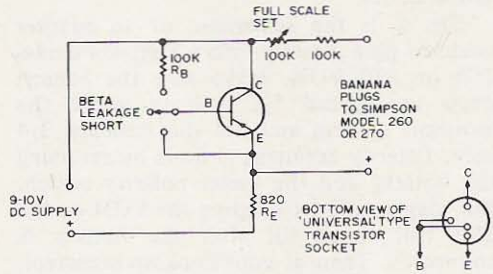


Fig. 2. This circuit will provide direct reading of transistor beta right on your VOM ohm scale. Polarities are shown for PNP type.

20. As the state of the art progressed, even 30-cent transistors started showing betas close to 100, so I changed RB to a 100 k pot. What if betas go over 100? Well, I didn't change the pot again; I just went to method two.

Method two: set RB to 100 k or replace with fixed resistor of this value. Next make up a table of values from the formula:

$$\text{beta}=\frac{\text{meter reading in volts}}{\text{battery voltage} - \text{meter reading}} \times 100.$$

By using a 10-volt supply and a 10-volt meter scale, the table comes out like this:

Meter Reading in Volts	Beta
2	25
3	43
4	67
5	100
6	150
7	230
8	400

At this point I could have made up a special scale but still did not have a spare meter to commit to this service. So I was quite satisfied using the table. For years I went on in this primitive way in an age of digital instrumentation till a thought tremor went through my noggin. One end of the meter scale represents a beta of zero and the other end of the scale represents infinity. But wait! My ohmmeter scale is already marked this way. Only in reverse . . . and besides, the middles of the scales would never match. Or would they? A check of the formula for calibrating a series circuit ohmmeter and the formula for calibrating my transistor tester meter showed them to be similar. But by connecting the meter across the transistor instead of across RE, the formula reduced to the same form. Check this for yourself if you like algebra problems.

Construction

Fig. 2 is the schematic of an adapter made to plug directly into a Simpson model 260 or 270 VOM. Make sure the banana plugs are spaced 5/8 inch to match the Simpson spacing and not the standard 3/4 inch. Polarity reversing is done by reversing the battery and the meter polarity switch. But play it safe by keeping the VOM on the 250 volt range till after the battery is connected. Then, if your hook up is correct, the needle will deflect upscale slightly. Now switch to the 2.5 volt range and set the 100 k pot for full scale volts (zero ohms). Next insert transistor to be tested in test socket. Check as follows:

Switch Position	Reading	Result
Short	2.5 v	OK
	near zero	Collector shorted or wrong type Xstr.
Leakage	2.5 v	very low leakage (normal for silicon)
	2.2 v	some leakage (normal for germanium)
	2.0 v or less	excessive leakage
Beta	Read ohm scale & multiply by 10	

Note that a transistor which shows "shorted" in the Short position may be the opposite type (NPN or PNP) than you have set up for so don't discard it yet.

If you are adapting this circuit for another model VOM, you may have to use different values for RE and/or RB. Keep RE somewhere near 1,000 ohms. Note what your particular ohm scale is marked at exactly center, referring to the dc voltage scale. If this center scale ohm reading is 10, for instance, call this 100 for your transistor beta scale. Then RB/RE must be made to equal 100. If the center scale ohm reading is 30, you could make this come out to either 30 or 300 for your beta scale. Just make RB/RE equal 30 or 300 to correspond. On the Simpson 270, the center of the ohm scale is 12, so I wanted this to be 120 for beta: Therefore I made RB/RE equal 120. (100 k/820 is approximately 120 and plenty close for this purpose.) In case your VOM does not have 20,000 ohm per volt sensitivity, you will also have to reduce the values of the *full scale set* resistors to give smooth control at full scale.

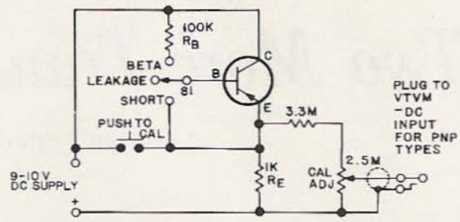
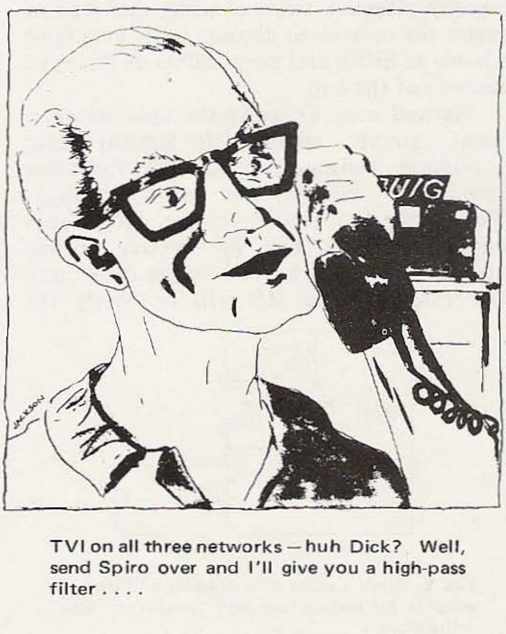


Fig. 3. Here is the direct reading version for use with V.T.V.M.'s. Notice the similarity to **Fig. 1.** Again, polarities are shown for PNP type.

VTVM Version

Fig. 3 shows the circuit for use with VTVM's. It's almost the same as the one I started with but it also will give direct beta readings on the ohm scale. Notice that the meter is back across resistor RE where it was in **Fig. 1.** This works for VTVM's which have an ohm scale reading in the same direction as the volt scale. That is, zero ohms is at the left end of scale and infinity at the right end. Construction details are up to you for this adapter and for the previously described



TVI on all three networks — huh Dick? Well, send Spiro over and I'll give you a high-pass filter . . . .

one; open breadboard or enclosed, temporary or permanent, doesn't matter. Follow the schematic and they'll work. You can make this one plug into your VTVM if you wish, but on mine I used a short connecting cable to reach my VTVM on its shelf. Operation procedure is also similar to the VOM adapter; however, full scale is adjusted by holding pushbutton and adjusting the 2.5 M pot. Set the VTVM to dc volt range, about 3 to 5 volts full scale. Resistor values shown in Fig. 3 are for VTVM's having 10 (or 100 or 1,000) at center of ohm scale. For other center scale values proceed as before; keep RE near 1,000, but make RB/RE equal desired center scale beta value to match your VTVM. Having set full scale using the pushbutton, plug in or connect the transistor to be tested. Check as follows:

Switch Position	Reading	Result
Short	0	OK
	near full scale	Collector shorted or wrong type Xstr.
Leakage	0	very low leakage (normal for silicon)
	0-10%	some leakage (normal for germanium)
	10% or more	excessive leakage
Beta	Read ohm scale & multiply by 10	

Conclusion

Watch out for some of the new epoxy or economy packaged transistors, as several manufacturers are using unconventional basing and the base connection is not always in the middle. Maybe future transistor testers will get to look like tube testers with fifty or so sockets! So better consider providing some extra sockets or at least three binding posts for clip leads. It should be understood that several assumptions have been made in designing these simple testers, and the effects of leakage, or ICO, on the beta reading have been ignored. But nevertheless they are very useful gadgets. So pick the circuit that matches one of your VOM's, scrounge up the parts, and build. If you already have a simple test adapter, just a few changes will give you the "direct reading" feature. Then go through your junkbox and check about fifty of the little unmarked devils. You'll be surprised how fast you can read those betas.

. . . W9DJZ

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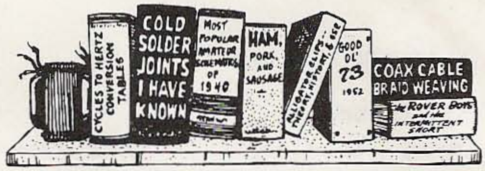
1. *Small, Simplified PNP Beta Tester* by Benjamin H. Rose, Eatontown, N.J., **Electronic Design**, July 22, 1959
2. *A Do-It-Yourself Transistor Tester* by E.J. Crossen, Blue Bell, Pa., EDN May 1966



NEW BOOKS

Ham Radio Incentive Licensing Guide

This hard cover book, written by Bert Simon, W2UUN, has been prepared with the aid of FCC. It covers every question which may be encountered on every amateur test from Novice to Extra. The questions are presented in the form you find on the actual exam.

In addition to the question/answer sections, the book goes into detail on learning code, the requirements for each class of license, details on how to fill out the form 610, and the examination schedule for the various FCC offices. There is also a chapter devoted to the schematic diagrams needed for the exams.

This book does not profess to teach theory and is simply a question and answer book. Theoretically, someone with a good memory could squeeze by the exam using this guide. I suggest that this guide be used in conjunction with a sound theory course such as the one which has been running in 73 since March 1968. Available from TAB Books, Blue Ridge Summit, Pa. 17214. Price: $6.95 hardbound; $3.95 paperbound. TAB Book #469.

Trouble Shooting the Solid State Chassis

A brand new handbook detailing specific procedures for servicing all types of transistorized devices. It contains case histories, and troubleshooting charts. The opening chapter details how to isolate a defective transistor, how to remove and replace it, and general test information. The book then goes on to more specific pieces of equipment: TV, small portable transistor radios, ac-dc, AM-FM and multiband receivers of all types, auto radio repair, removal and installation, tape recorder repair (including mechanical details) and ends up with repair of printed circuit boards.

The author, Homer L. Davidson, has presented the most complete and up-to-date information in an easy to understand manner. This book is 256 pages of valuable material for anyone dealing with solid state devices. Available from TAB Books, Blue Ridge Summit, Pa. 17214. Price: $7.95 hardbound; $4.95 paperbound. (TAB Book #495.)

(. . . de W2NSD/1 continued from page 67)

ARRL Elections

Every year one half of the ARRL Directors come up for re-election. Many amateurs feel that one of the very best things that could happen to the ARRL would be to get some new blood into it . . . some new Directors, fellows who would take an active interest in the League and in bettering amateur radio.

Please notice that the subject of opening an office in Washington, even a small one, as a lobby for amateur radio, wasn't even *discussed* by the Directors at this May's meeting. Nor were any plans brought up even for consideration with regard to setting up a public relations effort to increase interest in amateur radio among the teenagers and the general public. Amateur radio is withering away and a crash program is badly needed. Nothing has even been discussed despite considerable pressure from the members.

Perhaps you have a friend or a club member who is interested enough in amateur radio to volunteer to run for Director? You haven't much time to get organized on this, you know. The most difficult part of the whole deal is overcoming the unbelievable inertia of the other ARRL members and getting them to do anything but either not vote at all or else rubber stamp the same old face back into office for two more years of tedium and inaction.

The requirements to run for Director are that you be a licensed amateur (they have interpreted this as meaning a General Class license or better), with four years (continuously) as an ARRL member. If you know of anyone who meets these stringent requirements and who has a genuine interest in helping amateur radio, get him to agree to run. You must send a petition to the ARRL Secretary before September twentieth signed by at least ten full members of the ARRL to put your man into nomination.

The by-laws state that no one shall be eligible for the office of Director who is commercially engaged in the sale, rental, or manufacture of radio equipment which can be used for communications. They have waived this rule in some cases where a nominee was particularly favored by HQ, but used it to reject others. Radio magazine publishers are also exempted in the by-laws.

The whole thing is really up to *you*. Amateur radio is staggering along these days because virtually no one has taken the interest to try and put it right. For one reason or another everyone has pretty much decided that they want one and only one organization in the country. This is no problem if you follow through and make sure that the basket you have all your eggs in doesn't come unstuck. You've left those eggs alone in the basket for so long that vapors are beginning to arise.

This year new directors can be elected in the Atlantic, Dakota, Delta, Great Lakes, Midwest, Pacific, Southeastern, and Canadian Divisions. If you get busy and get eight new directors this year and then eight next year, we could have amateur radio back on the tracks again by next winter! If you shrug and let someone else run a director, then you will have personally done your bit to help our wonderful hobby die a little more. To ignore evil is to become its pawn . . . as millions of Germans learned all too well when they ignored the rise of Hitler. If you find that you personally don't have the will to try and do something to help amateur radio, at least don't make it difficult for those that are trying. Even a loud huzzah from the sidelines is better than a kick in the groin.

If you do run a director, you will need to know how to get him elected . . . and this is another kettle. If you don't get to most of the ARRL members before the election, they will go right ahead and return the same director, year after year, no matter whether he is good or incredibly bad. The ARRL must furnish addressed envelopes for all of the members in the division on your request, so work up a piece of campaign literature that explains why a new man is running and what he intends to do for the members. The incumbent will usually run on his "record." Fortunately for him, few members are aware of how sad that record is . . . in all too many cases.

The ARRL has been losing members for many years now, so no matter how much you think of those in charge, you must recognize on some level that they are not

"Now I'm running the Swan barefoot . . . . "

doing their job satisfactorily. The League, our only national amateur radio club, should be growing every year, not shrinking. This, certainly, is the final measure of the effectiveness of management. The only real means that amateurs have of protesting the actions of the ARRL HQ management is to drop out of the organization. Much has been written, even in the pages of 73, about joining the League and fighting from within for an improvement . . . but the only means that the average amateur has of expressing his will to the League is in his election of his director . . . and seldom is there any real choice when the election actually comes along. Year after year the same old men run, unopposed, and win automatically. No wonder there is apathy and more drop-outs than new blood.

Honestly, if it was really important, couldn't you find someone to run for director from your division? Well it *is* important, so let's see what you can do.

. . . Wayne

PROPAGATION CHART

J. H. Nelson

September 1969

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

Legend: Good O Fair (open) Poor □

EASTERN UNITED STATES TO:

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

CENTRAL UNITED STATES TO:

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

WESTERN UNITED STATES TO:

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

A—Next higher frequency may be useful this period
B—Difficult current this period

Ted Williams, WAØIOC
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Clinton, Iowa 52732

The FET Compressor

The addition of a speech compressor to your rig is a worthwhile project. A speech compressor will not only increase your talk power but also reduce flat topping. The simple circuit described here uses two Motorola HEP 801 Field Effect Transistors. The entire unit can be built for approximately $15 or less, depending on the size of your junk box.

Features

The compressor has an overall gain of unity. Therefore, the output of the circuit is comparable to the output of the microphone connected to it. This is accomplished by the voltage divider R3 and R4 in the output. If for some reason more output is required, the value of R4 may be increased provided the value of R3 is decreased by an equal amount. In other words, the sum of R3 and R4 must remain approximately 70.2 ohms.

Because of the inherent high impedance of the HEP 801's, the input impedance of the compressor is determined almost entirely by R5. The value of R5, 470K ohms, is not critical and may be changed to match the output impedance of any high Z microphone. However, the 470K ohm will provide a good match for most crystal, ceramic or dynamic microphones. At high signal levels, a 6 db change in the point will result in only 1 db change in output. The circuit also has an inherent threshold voltage of approximately 10 mv. due to the characteristics and operating point of the FETs.

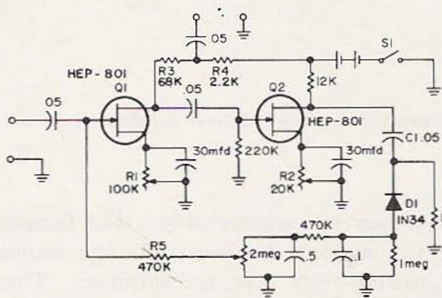

Fig. 1. Audio Compressor using two HEP-801 FETs. All resistors ½ watt, all capacitors are in μf.

Circuit Operation

The compressor is composed of two audio amplifiers, an AGC rectifier and an AGC circuit. The output from the microphone is amplified by Q1 and then capacitively coupled to Q2 where the signal is amplified further. The output from Q2 is coupled through C1 to the AGC rectifier, D1, and is rectified. The rectified audio is then filtered and fed through the AGC circuit and applied to the gate of Q1 as negative bias.

A small input signal will develop very little AGC voltage and have little or no influence on the circuit gain. A large input signal will develop much more AGC voltage. This large AGC voltage will reduce the transconductance of Q1, Thus lowering the circuit gain considerably and resulting in an output that is only a few db greater than that of a small input signal.

Construction

The compressor was built on a 2½ by 4¼ piece of perforated bakelite which was then mounted in a minibox. The size of the unit can be reduced through the use of miniature components.

The FET used as Q1 must have a low pinch off voltage. To determine which transistor has the lowest pinch off voltage, the source and gate leads should be temporarily connected together. The resistance from the drain to the source is then measured with a VOM or VTVM. Whichever FET shows the highest resistance reading should then be used as Q1.

The parts layout of the circuit is not critical if proper construction methods are followed. In the original unit three pieces of buss bar were run across the board and used as tie points for the B+, ground and AGC line.

Adjustments

The resistors R1 and R2 should be adjusted to give maximum output. This is done by placing the compression level at minimum and then measuring the voltage across R6. The value of these resistors is critical and pots had to be used. Fixed resistors were used at first but failed because the nominal values were not accurate enough.

When these adjustments are complete, the compressor may be inserted in the microphone line. With the compression level at minimum, adjust the audio gain on the transmitter as normally. The compression level can then be raised to the desired level. The audio gain can now be raised again until the output meter peaks at the same reading as it normally did.

Operation

Two 9-volt transistor radio batteries were used to supply the B+ to the circuit. The compressor draws only one mill so battery life should be very reasonable.

Besides increasing the talk power of your rig and reducing flat topping, the circuit has many other advantages, depending on the operating practices of the builder. For example, the man who runs phone patches will no longer have to continually reach for the audio gain when the caller changes the level of his speech.

I would like to extend my sincere thanks to Lee Michaud, K8OOV, for his assistance in designing and testing of this compressor.

. . . WAØIOC

Roger D. Farley, WA2YRF
Box 104
East Schodack, New York 12063

The Mike Mixmaster

This little device is so simple that most hams just never think of it. If you're operating push-to-talk, however, it will transform every microphone in your shack into a push-to-talk mike. The switch in this piece of gear will also trigger your transmitter, leaving hands free for logkeeping, minor adjustments and the like.

I'm control station for a civil defense net, and one day I began wondering what I'd do if my microphone conked out unexpectedly. I have a number of other mikes in the shack, but none of them are the required push-to-talk type necessary to key my transmitter. In an emergency, rigging up a substitute would take precious minutes – finding a switch and the proper plug and making the right connections to operate the rig. I reasoned that if I had a microphone mixing box with some kind of a switch which could fire-up the transmitter, I could use any mike in the shack in an emergency. I could also compare their modulation capabilities, using the same box.

By pouring the contents of my junk-box on the floor, (which I find is the easiest way to locate anything) I came up with the necessary jacks to match my assortment of mike plugs. In my case, these were a standard phono connector, an RCA-type phono connector, a quarter-inch two-circuit, and a quarter-inch three-circuit phone plug. In the same mess was a switch that I had picked up for 25 cents at a fire sale when one of the local radio stores burned down. Pushing this switch in one direction makes a momentary contact, and in the other direction, it latches. The switching operation is similar to that of the Heath Twoer and Sixer.

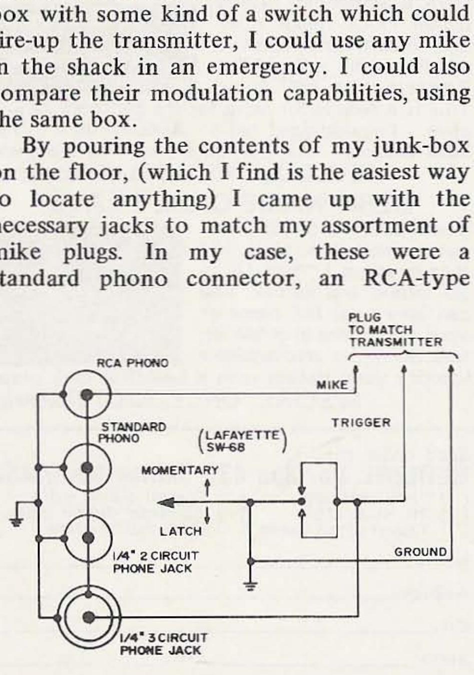

Fig. 1. The WA2YRF Mike-Mix-Master.

Wiring is simple, as you can see from the schematic. The various jacks are in parallel and the one matching the push-to-talk microphone is wired straight through. The switch is wired so it will key the transmitter when it's pushed in either direction.

Layout of the jacks and the switch is not critical, nor is the size of the chassis used for the project. I used a mini-box which was larger than necessary (3 x 4 x 6), looking forward to the day when I might dream up a transistorized VOX circuit to make the unit even more versatile. It's wise to leave room for more jacks in case you obtain more microphones in the future. To minimize the possibility of hum pickup, I kept all my wiring close to the chassis, but I don't believe this would be a problem. I have had no bad modulation reports.

One improvement which might be made is to make the output lead to the transmitter "plug-inable," and make up a variety of leads for each of the different types of transmitters you have in the shack. With this feature, you can use it as an all-purpose microphone adaptor. I've even had three mikes (a ceramic, a crystal, and a dynamic), located at strategic points about the room, plugged in at once. This works just fine if you have plenty of audio and want to move around the room while transmitting.

Build it. It's handy, compact, and even if you don't use it, it doubles as a dandy paperweight and conversation piece.

. . . WA2YRF

Ralph J. Irace, Jr., WA1GEK

The T-60 Works Just Fine

As I neared Mac's QTH, quite exhausted after pedaling uphill several hundred feet, the tall seventy-foot towers glistening in the sun with all the grandeur of tri-band beams, quads, stacked yagis, amongst other mouth drooling additions, came into rapid sight. "Gee," I thought, "those dipoles of mine sure are crummy." Gazing at the antenna complex admiringly, I reached the gravel driveway, parked my bike and walked toward the back door. I rapped on the door a few times. I heard approaching footsteps. "Hi Scott. How's the ole T-60 coming along?"

"Oh pretty good I suppose," came my pretty-well-standard reply. Mac motioned for me to enter and follow. Within a duration of seconds, I was in his enormous shack. He sat himself in a comfortably cushioned swivel chair while I took refuge on a three legged stool. For once I decided to start the rag session.

"How's the new quad working on 40, Mac? Looks like a real swell skywire, hi" my voice crackling.

"Ahh, it's not too hot a performer actually. I'm having a chore trying to load it for some odd reason. Thought the problem might be in the 32S-3 but I gave it a looking over yesterday and couldn't find the problem. I bought the best coax in the store too."

"Perhaps I can help," I said, walking toward the console. Mac appeared slightly annoyed. "Say, Mac," I said after a minute or less, "this connection you have on the coax plug looks pretty poor. In fact the center conductor of your coax is wiggling around."

"What?"

"Yeah. Right here. See?"

Mac was clearly upset but tried to pretend as if nothing was at fault. "Can't be such a small thing like that–maybe the balun or my antenna is kaput or something. I'll find the trouble for sure later on."

"All right Mac," my voice quivered slightly after seeing Mac in such a state of aggravation. I had idolized Mac for many months because of the fine DX record he had and most of all because of his fabulous station.

He dismissed me promptly . . . "Let me know how you make out on the contest this weekend, Scott. I've got to mail out a batch of QSL's now."

"Okay Mac, I know you'll take first place in the contest. Don't forget to work me. Bye."

After getting back to my own shack, I surveyed the scene and decided that some final preparations for the weekend contest had yet to be made, so I set about doing them. As I was touching up a few things around the station, I wished that I was the owner of a station like Mac's. If only I had the money! This T-60 is like an insect compared to his transmitter. Golly, his antenna farm rivals those of broadcasting outfits. I'll be lucky if I get even twenty percent of Mac's contacts during the contest, I thought to myself. While outside checking and rechecking the antenna supports and connections, I saw Mac's towers off in the near distance up on the hill. "Shucks – just maybe someday I'll be able to have one small tower, then Mac won't kid me anymore about my small station."

Well, the contest came and went. I worked as long as my parents permitted and tallied up a final score of 2,785 points, probably nothing compared to what Mac had racked up.

After I completed copying the scores onto the final sheets, I mailed them off for placement in the score list; I was probably at the bottom and Mac at the top. I then went over Mac's house and was greeted by one of his family and shown into Mac's shack. It was in complete disarray. Transmitters, receivers, power supplies, swr meters, etc, were scattered all about the shack, obviously after being worked upon. Mac and I exchanged mutually surprised greetings. Mac slumped heavily into his chair and looked exasperated. I asked what the trouble was, and for once he conceded defeatingly that he didn't know. "Maybe I can be of some help," I said with Mac even looking more annoyed than he had on my previous visit. I hesitated at seeing Mac disturbed but then thought that perhaps I really could help. Then I turned up the culprit. "Say Mac, I don't even think your getting a connection here between the antenna plug and SO-239. Look, there's hardly a bit of solder on the plug tip and the center conductor has slipped down . . . I doubt if you're even getting twenty percent efficiency from your transmitter output to the antenna. I'll bet this is the reason why. . . . "

"Would you like to be my official station maintenance man, Scott? I could provide you with a lot of opportunities to work with my antennas, climb my towers and even use the S-line here, if you like. You'll find it quite a thrill over that little T-60 you use . . . how about it?"

I thought for a few seconds and then realized that even hams with big stations can make blunders over little errors when they let themselves become possessed with inflated egos and visions of grandeur because of the extra-large stations they have. I was sorry Mac didn't work the contest for apparent reasons. "No thanks, Mac. The T-60 is just fine, just fine." And this time I went home without even glancing at his antennas.

. . . WA1GEK

Dave Mann, K2AGZ
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Kinnelon, New Jersey 07405

Leaky Lines

I'd like to share a little vignette with you . . . hardly worth mentioning but for its utter incongruity. It fails to make any sense whatever to me.

I think, somehow, there's nothing more ridiculous than a man with delusions of grandeur, pushing his heft around, trying to prove himself a big shot. And whom does he select for his target? Generally someone with more importance and status than his own. It's a truism. Some little squirt with a chip on his shoulder and a snoutful of booze invariably picks the biggest, burliest fellow in the saloon and provokes a fist fight with him. Well . . . just get a load of this type and his antics.

In connection with the Apollo 10 mission, WB4ICJ, club station of Space Center Amateur Radio Society (SCARS) at Cape Kennedy, operated for about ten hours last May. The club offered a handsome special event certificate to all stations contacted. Over 900 QSO's were logged, including 80 odd from 23 foreign lands. The frequency was 14.340 mhz., and operations commenced on the morning of the liftoff.

Sometime during the evening hours a station came on, and the operator *commanded* WB4ICJ to relinquish the channel because, in his words ". . . it is used daily by ICHC, IFHC and ISWL-CHC." Is this combination of initials intriguing? Well, they were intriguing to me, so I looked them up. They stand for (1) International Certificate Hunters Club, (2) International Flying Hams Club, and (3) International Short Wave Listeners Certificate Hunters Club, respectively. Now, don't get me wrong. I'm not trying to imply that the SCARS operation was of first-magnitude importance. But you'll have to admit that these certificate hunter groups were certainly not engaged in high priority matters either.

I am reminded of an incident which occurred while I was on jury duty some years ago. I had been chosen, along with eleven other people, to sit on a case. The lawyers were asking us various questions to determine our qualifications as jurors. One of us was an insignificant looking mouse of a guy but pompous as a rooster, and who had a constant sneer on his face as if he were smelling something unpleasant. All during the preliminary stages, before we had even been selected for the panel, this weasel had been asserting the obvious guilt of the defendant, even though not one single fact had been presented in evidence.

"And what is your line of work," he was asked.

He answered the attorney imperiously, with exaggerated hauteur: "I am the president of the American Cigar Band Institute." Everyone looked at him with new-kindled respect.

"You manufacture cigar bands, do you?"

"No," he answered, somewhat chastened, as his bubble burst. "We collect them!"

The entire courtroom, including His Honor, rocked the building with a peal of spontaneous laughter, and the little peacock slumped down in his chair, deflated.

Well, anyway, to get back to the story, the interloper stated that this group of his was about to start its net, which had been using this frequency for years, and that the NASA group had certainly known of this from the beginning, hence was guilty of stealing the frequency, Ugly Americanism, poor sportsmanship, etc., etc. . . . ad nauseum.

He stated further that if they did not vacate the frequency he would use his influence as an editor and publisher to make sure they were penalized for their ". . . obnoxious, ungentlemanly conduct." He accused them, among other things of ". . . deliberate interference," notwithstanding the fact that his certificate hunters were nowhere in evidence during the period when the Apollo 10 activity had commenced operations. In other words, these certificate hunters clubs were nationally famous, and every ham was aware of their existence and of their net activity. Well, I must confess that I had heard of certificate hunters. But I had no idea that they operated a net on 20 meters. This man conveyed a distinct impression that his group had a lock on this particular frequency, and that no one had better use it, because it belongs to CHC and the others – lock, stock and barrel, now and forever, world without end, in perpetuity, case closed, period!

The operator of SCARS, who hadn't heard of CHC either, obviously not wishing to engage in a time-consuming dialogue, particularly since the complaining part was becoming more and more abusive, suggested that he send a copy of his promised editorial to the radio club. Then he proceeded with the space shot contacts.

In due course a letter was received by the Public Relations Director of National Aeronautics and Space Agency at Houston, and a copy at Cape Kennedy. The "letter" is lengthy, verbose, lugubrious, vehement, fractious, rude, egocentric, supercilious, obnoxious, nauseating, rambling, irrational, and has neither validity nor merit. It is of no consequence whatever. It is like the proverbial burst of afflatus in a gale of wind.

If that were all it meant, I wouldn't have mentioned the incident at all. But, unimportant though it is, there is one thing about it which is very important indeed. The letter contains a series of threats, both direct and implied. And this merits not only attention, but strong condemnation. It reflects a most intemperate attitude all too prevalent nowadays. This man's use of the term, blacklist, in the context of today's world is an abomination; a stench in the nostrils. The blacklist is an undemocratic, totalitarian disease, which can infect society like a plague, destroying the very fabric of our democratic institutions.

He also writes, instructing NASA, – "You would do well to insure that this could never happen again."

The unutterable cheek of the man! He knows, as you and I know, no one has a priori rights to a frequency. I knew that we had some peculiar people in our midst. But I did not suspect that we harbored out and out lunatics. With two letter calls, yet!

* * *

During the Swampscott convention, I found another piece of literary garbage, also deserving of attention because of its complete lack of awareness of the outside world. It's sad to hear the ravings of a poor, deluded soul, totally out of touch with reality.

This misbegotten piece of drivel was issued by a group called – are you ready? – the National Association for the Advancement of Amplitude Modulation. Can you believe it?

Please understand this: I am not opposed to the use of AM at all. In fact, I rather enjoy listening to it. There is much to be said for the nice audio quality with the soothing low frequencies a la broadcast stations. What I find objectionable is the constant proselytizing, either for or against one mode or another. I don't find it any more palatable in ham radio than in religion. I feel that it's my own affair, and nobody else's damned business.

According to this leaflet, anyone who operates single sideband, using a rig not designed and built by himself, is some sort of microbe. He is called a variety of names, any of which would buy him a punch in the nose if uttered face to face. Here are a few quotes:

" . . . a more glorified form of Citizens' Band."

"After all, any idiot can buy an appliance . . . plug it into a wall outlet, and make noises."

" . . . plugging in an appliance and creating meaningless chatter on the ham bands."

"Amplitude modulation isn't a dirty word." (This is funny, for obviously, single sideband *is* a dirty word.)

"There is great potential in AM. Why not look into it someday?"

Somehow this tawdry little scrawling graffiti gives me a feeling of melancholy. To think there are such benighted little guys, running around unrestrained, hopefully trying to start ground swells of opinion which will inundate the collective intellect like a mighty tidal wave of reformation, and turn back the clock. Like the song laments, Ah, for the dear dead days beyond recall.

These people remind me of the homely little shop girls and tired drudges, hoping to find romance, who queue up at the five and dime, buying cheap perfume and loud, tasteless jewelry; answering the pulp magazine ads that shriek, "Win your man and hold him forever by using our miracle product to increase the size of your bust!"

What a waste of time and energy! And how cruel!

* * *

Those of you who have read some of my meanderings and ruminations are aware that a follower of precedent or convention I'm not. I believe that traditions are made to be broken. Indeed, were it not for this, hardly any progress would have been made since we emerged, dripping, from the primordial ooze. Somebody has always had the guts to say, "enough already." And this tendency will ultimately result in the conquest of humankind's oldest enemies; famine, war, ignorance and pestilence.

Nonetheless, there is much to be said for traditionalism, with its time tested values and verities. It is pointless to turn over the applecart unless there is a more efficient conveyance to take its place. I think there are far too many who scream for change merely for its own sake. There is no percentage in change without progress. When change means chaos, it is folly not to sit tight. Yet, over-cautiousness pays a poor dividend.

Most of us deplore the violence taking place on the campuses. It is too bad that the meaningful aspects of the student movement are being ignored because of the ugliness and anger of the confrontation itself. We are apt to disregard legitimate gripes and grievances because of the utter stupidity and over-zealousness of the militant extremists on both sides of the controversy.

Kids today are not placid, me-too-ers. They are not Pollyannas, nor do they hold with Voltaire's Doctor Pangloss that this is the best of all possible worlds. We elders display unbelievable naivete if we fail to perceive that the world is in pretty sad shape.

I believe, actually, that this is the best crop of youngsters we've ever had. They are not satisfied with the things that motivated prior generations. They are not willing to barter their integrity for automobiles or their concern for truth and justice for membership in the Country Club. They are far more interested in doing away with injustice than in acquiring material wealth or social position. And they mean to make the Constitution more than just a collection of flowery words and phrases.

What has this to do with Amateur Radio, you ask? Only this: On the air, there has been a lot of talk about what should be done about this group and that. Among others, our youth have been singled out and attacked viciously. I am appalled at some of the proposals I've heard on the bands. I cannot imagine any rational person saying this, but someone was heard to advocate "standing them up against the wall and shooting them." Another proposed that they be "strung up." I was under the impression that this type of philosophy died in a bunker at the Berlin Chancellory with its chief protagonist, back in 1945.

This younger generation of ours, splendid in its energy and vitality, more mature in its goals, earnest in its desire to implement the very best American ideals and the basic tenets of the Judeo-Christian ethic, is being shamefully and slanderously vilified. All are being blamed for the sins of a negligible few. How dare we fasten collective guilt on an entire group, after living under the blessings of a form of government whose very basic premise is exactly the opposite? How can anyone who loves America take a position which does her so much harm?

And who does all this talking on the air? Who are those, without sin, who are so ready to cast the first stone? Who are these sanctimonious ones who criticize our youth, our poor, our minorities, our political leaders, our clergy; in short, anyone and everyone?

They need not be pointed out. They know who they are. There is no point in disclosing their identity. If I could speak to them, I would say this: Listen, all you self-appointed super-patriots. Who do you think is doing all the dying in Viet Nam? Who did all the dying in Korea, and in your war and mine, back in the 40's? The kids; that's who! And among them, don't ever forget, there are black and white, rich and poor, educated and unlettered. They're out there, laying it on the line, while you and I are sitting in the ham shack, leisurely enjoying the comforts of home, making pronouncements and judgments. Maybe we ought to take a breather and just listen to what they have to say once in a while. How about it?

Well, there it is, and, like the old bromide says, let the chips fall where they may. My father used to say, "Maybe the truth will hurt, but sooner or later it's going to be said. So why not get it over with?"

* * *

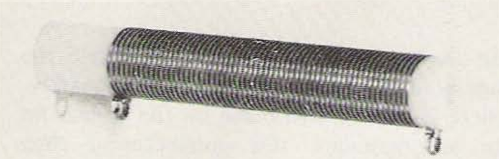
Don't forget. ECARS on 7255, MWARS on 7258 and WCARS on 7255. These are exciting, stimulating and they are of great help to all of hamdom. Give a listen and join in on the fun.

Till next time,

. . . K2AGZ

A Unique RF Plate Choke

Bill Deane, W6RET
8831 Sovereign Rd.
San Diego, California 92123



A unique rf choke.

At times it is difficult to obtain the exact *rf* plate choke that one may desire for a new final amplifer. In looking for a material to make a 2 ampere 5000 volt dc *rf* plate choke for non-ham use, I came across a material made by DuPont called Delrin. Delrin has high strength but can easily be cut and drilled. It has excellent electrical properties as an insulator with a high heat distortion temperature. These features make it an excellent form for *rf* plate chokes and other coils. Delrin is available in rods of 1/4 inch to 1 1/2 inch diameter and can be purchased in 12 inch lengths. The 3/4 inch diameter was selected for the choke and is available from Allied radio for $1.42 per foot (Allied part 60D9565CF).

The choke shown in the photograph is 5 1/4 inches long. The terminals of the coil are No. 8 brass cotter keys 5/8 inch long. The form is prepared by drilling the two terminal holes on a 4-inch spacing 5/8 inch deep, using a drill slightly smaller than the cotter key size. A 11/32 or 3/8 inch hole is drilled down the center of the rod to a depth of 3 3/4 inches. A 1/2 inch deep hole is drilled in the opposite end of the rod with a 29 drill. This hole is tapped for a 8/32 mounting screw. A 3-inch piece of .33 inch diameter ferrite rod (Lafayette 32C6102) is inserted into the hole and held in place with a few drops of epoxy. Next force the cotter keys into the form holes using a vise or by tapping lightly with a hammer. Sixty turns of No. 20 formvar wire is space wound (15 turns per inch) on the form with the coil ends soldered to the cotter key terminals. The space winding can be accomplished by a dual winding of No. 20 wire and then removing one winding. A light coating of coil dope will hold the turns in place.

The completed choke has an inductance of 90 uh, loafs along at 2 amps, has a Q of 225 at 3.6 mhz and has a series resonance well above the ham bands at 43 mhz.

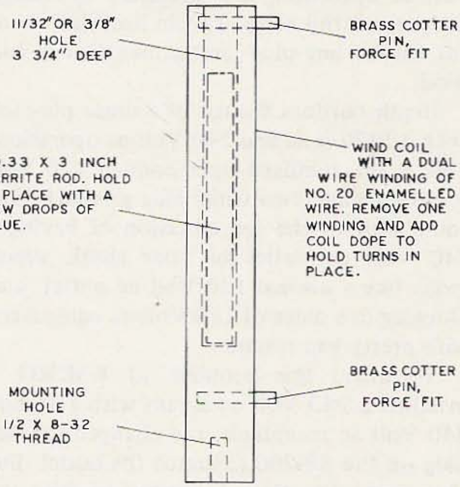


Fig. 1. Diagram of completed 2 amp 5000 volt rf choke using DuPont "Delrin."

If you do not wish to build a choke with the ferrite rod and will be limiting your plate requirements to 800 ma at 2500 vdc, a choke can be wound on a 3/4 X 4 3/4 inch rod with No. 24 formvar wire closewound to occupy 3 1/2 inches. This choke has an inductance of 90 mh, a Q of 160 and a series resonance of 25 mhz. My thanks to Don Bidwell for his photograph of the choke.

. . . W6RET

Modification of the ac Input on the SB-200

Al Brogdon, K3KMO
RD 1 Box 390A
State College, PA 16801

The Heath SB-200 is a real gem, giving top performance per dollar in a linear amplifier. There are few ways it could be improved, but one feature which falls into the "needs improvement" category is the ac input arrangement.

In the original amplifier, terminal strip "S" has the wires from the power transformer's two primary windings connected to it. To change between 120 Volt ac and 240 Volt ac operation, it is necessary to change jumpers on this strip. This in itself isn't bad, but the ac line plug arrangement is not too good.

Heath outlines the use of a single plug for both 120 Volt ac and 240 Volt ac operation. This is the standard three-contact 120 Volt ac safety plug (two wires plus ground). This could lead to the sad situation of having a 240 Volt ac outlet in your shack which looks like a normal 120 Volt ac outlet, and plugging in a piece of 120 Volt ac equipment with pretty bad results.

To avoid this problem at K3KMO, I installed a 240 Volt ac circuit with a normal 240 Volt ac receptacle, and changed the line plug on the SB-200 to match the outlet. But then came the time I wanted to take the SB-200 to a friend's shack where only 120 Volt ac was available, and I was faced with the prospect of having to change line plugs, re-wire the jumpers on terminal strip "s" to make the change, and then do the same thing again when I brought the SB-200 home.

Rather than do this and be faced with the prospect of doing it other times, I decided to change the SB-200 to come up with an arrangement for simpler change-over. I placed an Amphenol 86PM8 male octal plug on the rear deck of the chassis, where the line cord had previously exited. Fortunately, there is just enough room on the chassis lip to accommodate this connector. I then wired the four leads from terminal strip "S" plus a ground wire to this plug as shown in **Fig. 1.**

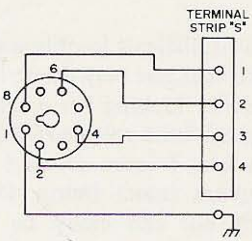


Fig. 1. Wiring changes in the SB-200, from terminal strip "S" to the new power connector (Amphenol 86PM8).

Then two line cords were prepared for the linear, one for 120 Volt ac operation, and the other for 240 Volt ac. The 120 Volt ac cord is the original SB-200 power cord with the plug supplied by the manufacturer. The other end of the cable is terminated in an Amphenol 78PF8 female octal cable connector, wired as shown in **Fig. 2a.** A second power cable was prepared using the 240 Volt ac plug on one end, and another octal connector on the other end, this time

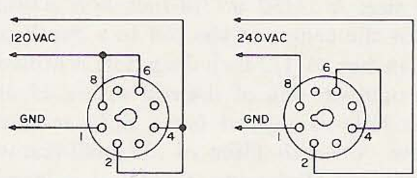


Fig. 2. Connections for the two line cables to mate with the new power connector.

wired as shown in Fig. 2b. Notice that with both power cables, the ac input is connected to the proper transformer leads, and the appropriate jumper connections are also made in the octal connector.

Therefore, the change from one input voltage to the other requires only that the appropriate ac input cable be connected. **Caution**: Be sure all jumpers are removed from terminal strip "S" when this modification is made.

If you are building an SB-200 from the kit, this change can be incorporated as the amplifier is being built, eliminating terminal strip "S" completely. The transformer primary leads and capacitors C1 and C2 can be wired directly to the octal plug. Be careful not to cut the transformer primary leads off too short by following the instructions for normal wiring. Just wait and cut them to length when you're ready to connect them.

This same approach can be used with any piece of equipment which has provisions for either 120 Volt ac or 240 Volt ac line input. And other types of connectors can be used according to your personal preference.

. . . K3KMO

LETTERS

Dear Wayne,

There were several omissions in the schematics of the "Six Meter KW Linear" in the July issue. The most important are as follows:

Page 21. 1. Coil data not given–should be 3 or 4 turns of 1/8" copper tubing, 1" diameter, spaced to resonate with the chosen capacitor.

2. There should be a connector in series with one lead of K1–this goes to the N. O. contacts of the exciter PTT relay.

3. R2 is 100K, ½watt.

4. Cathode pins 2 and 4 should be grounded in addition to pins 6 and 8.

Page 23. 1. Note 4 should read transient rather than equalizing.

Many thanks for the new tower and antennas, the cassette tape recorder, the trip through the Heath factory, and the other things 73 has bought for me in the year I have been sending in fillers. They are very much appreciated. I hope I will be able to supply similar material for "73 Junior."

Would 73 be interested in a short article on the subject of how semiconductor grade silicon is produced?

Bill Turner
Five Chestnut Court
Saint Peters, Missouri 63376

No . . .ed.

Dear Sir:

We thought it may be of interest that there is a new net on the air for emergencies and DX contacts. The world DX Round Table operating on 14270 KC Wednesday and Saturday from 0500-0800 GMT.

All QSL's for net contacts may be forwarded to (WA5UHR) net QSL manager.

Scott Freile
1510 Lynnview
Houston, Texas 77055

Dear OM Wayne,

I was given "DX-Handbook" first-edition from my good friend WA9NKG, "Paul" & find it a very nice book, especially I enjoyed the article about 80 meters DX. Here in JA, there are not so many DX's on 80 meters, only JA6AK is active. Hi. By the way I found some misunderstanding on page 90, "Call Areas." Please correct as follows:

JAPAN	Wrong		Right
JA1	Kanto, Shinetsu	JA1	Kanto
JA2	Tokai, Hokuriku	JA2	Tokai
JA9	Fukui, Toyama, Kanazawa, Ishikawa	JA9	Hokuriku
JAØ	Nagano, Suwa, Niigata	JAØ	Shinetsu

JA9 includes three prefectures; Fukui, Toyama, & Ishikawa, and Kanazawa is capital city of Ishikawa, like Phoenix in Ariz! JAØ has two prefectures; Nagano & Niigata, and Suwa is the name of one city in Nagano!

About 7 or 9 years ago in JA, there were only 8 areas from JA1 to JA8, and then JA1 & JA2 were divided into two till then JA1 had Kanto & Shinetsu, JA2 had Tokai & Hokuriku, but since then Shinetsu changed to JAØ & Hokuriku got JA9 calls, so you might use the old date! Hi! Anyway now you are all right!

Another info here, you wrote "for DX Watch for gigantic do-it-yourself coloring map," on 22 page. We can buy do-it-yourself map for DX from our JARL. About 55x80 cm ¥ 200 (about 60¢) with great circle map. This map is very nice for DX hound! You may get the map if you send about $1 to JARL, P. O. Box 377, Tokyo.

Oh, one more info, JA1 area got too many hams and they needed another call so they used JH1. It was two or three years ago. And now JH1 also going away the newest call right now (29 June '69) is JH1VZZ and JH1Y . . . JH1Z . . . is used for club stations so the rest is JH1WAA to JH1XZZ, when all of these calls used, they use JR1. First JR1 will go on the air in '69!

Narumi Kawai, JA9APS
1-10 Suwanokawara
Toyama-City 183, Japan

Dear Wayne,

I read with interest the article on facsimile and the radio amateur by Ralph Steinburg K6GKX in June, 1969. (I also had an article starting on page 130.)

You should know that facsimile and slow scan TV are exactly the same thing electrically if you add a horizontal sync pulse to the facsimile signal.

I have been running slow scan TV for the past 2½ years (one and a half years under the special slow scan TV license), using facsimile equipment. As far as I know, this is completely legal since I am conforming in every way to the various television kinds of signals that are being sent. Those who are receiving the slow scan TV signal using facsimile equipment can use the horizontal sync pulse if they wish. Those receiving the slow scan TV signals on a CRT presentation, generally require the sync pulse. Those that are receiving them on facsimile machines, do not need it.

Mr. Steinburg's statement, "with slow scan television legal on the low bands, facsimile may be the next mode of communications to follow in the near future. All it needs at the present time is enough interest by the radio amateurs to show the Federal Communications Commission, by petition, that facsimile will contribute to the state-of-the-art," really impedes matters by continuing the fiction that there is a difference between facsimile and slow scan TV.

J. R. Popkin-Clurman, W2BK
1623 Straight Path
Wyandanch, New York 11798

Dear Wayne,

Up until the past few months, very little effort had been made to attract youngsters into our ranks and it is indeed regretful that we have been so tardy in promoting amateur radio to this particular age group. Editorials in some of the amateur magazines have at last recognized the severe lack of youth-intake in amateur radio and soberly suggest that we make strong efforts to try and introduce these young people to ham radio.

Some may ask, "Why is youth so important to amateur radio?"

There are a multitude of good reasons why amateur radio needs new blood and certainly each reason has its own merits. To mention but two, we might start with what amateur radio as a hobby can provide for a youngster just getting started in ham radio. It offers a youngster the chance to convert his spare time from roaming the streets, lying idle on the couch, etc., to something constructive, educating, challenging and rewarding. For some, amateur radio can lead to a very successful career in electronics later in life. Amateur radio in the years to come, will need new amateurs to improve the state of the art and in general to man the helm. Todays youthful prospective amateurs will be the people to assume this task. This is why it is of cardinal importance that all amateurs do their utmost to familiarize the youth of today with ham radio.

Today's youth are basically a good group of people and they have a tremendous amount of potential and energy which if could be directed to the area of amateur radio, would lead to an eventual license and a genuine feeling of accomplishment and satisfaction.

Boy Scout Explorer posts, high school radio clubs, camps and other outlets have time after time graduated the prospective young amateur from training in code and theory, to an amateur license. However, these organizations lack the ability to make the initial contact with a youngster and this is where the individual amateur must help out.

One may ask at this point, "Well, what can I do?"

Get in touch with the youngster down the street and invite him or her over to the shack. Fire up the rig and explain how it works. Show them your collection of qsl's–let them have a try at the mike–show them what an amateur license looks like–be patient and encourage them, and most of all, let them know that you sincerely want to help them. You might then direct them to a local radio club or some other group that teaches code and theory classes for future hams. If there isn't any such group in the area, then you, yourself, could certainly help these young people. Five wpm and elementary theory and regulatory material certainly isn't difficult to teach to eager students, is it? They will always admire you for your guidance and assistance, believe me.

While amateur equipment becomes more and more sophisticated, and with DXpeditions and contests taking up a substantial amount of our hamming time amongst other facets of amateur radio, let us not neglect the youth around us for they certainly hold a share in ham radio's future.

The initiative is up to you. Ham radio is a very fascinating and rewarding hobby and has so very much to offer. Why not get in touch with the youngster down the road and lend the helping hand they need and at the same time, strike a blow for amateur radio.

Ralph J. Irace, Jr., WA1GEK

Dear Wayne,

Thanks for the articles by K1YSD. Many moons have passed since I laughed so hard. As a result of your fine articles on the Advanced Class License I passed my test.

Tom Shirley, K4HVV
410 Patton Road
Hinesville, GA 31313

Dear Editor,

Would any members of the American Cryptogram Association who are readers of "73" drop a line to the writer? The intent is to form a net to discuss crypto systems and solutions.

Thank you.

Herbert S. Dunkerley, WA3JIX
RFD 2
Jeannette, PA 15644

Dear Wayne,

I have finally rounded up a bunch of information on the recent beginners course in ham radio and a photograph of some of the instructors and graduates. Only 17 of the 28 who received a novice ticket are on the picture, but that was the best that I could do.

As for the course, here are the bare facts: Enrolled–109, Attended 6 or more lessons–48, Attended less than 6 lessons–61, Quit after attending 6 or more lessons–15, Earned Novice ticket–28, Attended whole course but not passing exam–5, Oldest earning ticket–69 years, Youngest earning ticket–13 years.

The course ran for 16 weeks. There was one hour of lecture on theory and one hour of code instruction each week. The first eight or nine lectures were on basic radio theory and regulations, and the last seven or eight were on specific topics: antennas, transmitters, power supplys, etc. Most of the basic theory was taught by Charlie DePoe, WA5VQR, a professor at the local college, who also kept the vital statistics throughout the course. The specific topics were taught by various members of The Twin City Hams radio club, some of whom are in the enclosed photo.

I taught the code portion of the course. It was designed for the beginner and started at zero wpm. At the end of the course the average speed of those finishing was about 7½ wpm, with a couple of the fast learners copying around 15. The code practice was recorded on magnetic tape prior to each

Recent FCC News

RM-886. The ARRL has requested that the CW-only band on two meters be moved from the high end of the band to the low end, 144.0 – 144.1 mhz. It has been the custom to use only CW in this lower 100 khz of the band, however, it may be worthwhile to make this into law if there are too many operators that refuse to honor the convention. It seems a shame that we have to make federal laws just to force a few inconsiderate operators to conform to custom.

RM-950. The ARRL has requested the opening of 28.0 – 28.5 mhz for F1 emission. This is RTTY which is now restricted to the CW portions of 80-40-20-15 meters. It should have been allocated that way in the first place. It is nice to see the ARRL behind this request . . . they were the principle opposers to the original requests for F1 on the low bands and managed to delay the FCC ruling on this for several years.

RM-981. A petition has been filed with the FCC to open all bands from two through 80 meters to maritime mobile while in Region 2 and to open 3.5 – 3.8 and 7.0 – 7.1 mhz for maritime outside of Region 2. At present maritime ops are permitted to use 40 thru 2 meters in Region 2 and 20-15-10 meters outside Region 2. Seems reasonable enough.

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.

session to keep sending errors and resulting confusion to a minimum.

Everyone in the club agrees that the course was an unqualified success and that we all learned a great deal from it. It is still hard to believe that so many people are interested in amateur radio and are just looking for a chance to get into it. Any club can do itself a lot of good by encouraging people with a genuine interest.

Now, can anyone tell me how to keep 28 brand new Novices on the air?

Bill Gulledge, K5UAR
700A Plum Street
Monroe, LA 71201

Dear Wayne,

Since working as Chief Engineer of KALX (FM), my perspective on the Amateur license technical examination has changed. Many people will agree that it is a simple and uncomplicated task to pass the technical section. But in comparison with the First Phone exam, it is hardly a test at all.

You might note that the Amateur license is just that: for amateurs. But what has this done to the quality of the average ham? One can simply listen to the low bands any evening to provide the answer.

The degradation in quality has been brought about through the lack of respect in the ham license. Years ago it took real perseverance and intelligence to be a ham operator. There were no readily available stations, as today. Kits, if any, were almost the same as building from scratch. And when the ham was finished with a piece of gear, a receiver perhaps, he had a sense of pride, a sense of accomplishment. Today, the closest thing to that most hams experience is the sense of relief one feels when the last payment is made on a complete transceiver. Too, there was a feeling of fraternity. There was belonging, brought about because there was a great hurdle that everyonr had to pass to become a ham: the building of a transmitter and receiver, and the exam.

Today the exam is not difficult. And today the only comradeship most hams feel is in their mutual animosity towards CB'ers. Little wonder that the bands should be in such poor shape. When one loses respect in something, one is not apt to take good care of it.

One good way to make an Amateur license more valued is to require a stiff technical exam, one that would require actual studying, not memorization sessions with the License Manual. But the more difficult technical skills it engenders would prove greatly beneficial to the ham, and the country. It might even save the Amateur Radio Service.

I'd like to hear your comments on my letter.

Stephen L. Diamond, Radio KALX
500 Eshleman Hall
Berkeley, California 94720

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

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

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

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

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

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

SPECIAL CLOSE-OUT SALE. Rectifiers, Transistors, and many other Electronic Parts. Lowest prices. Send 15¢ for Catalog. Electronic Components Company, P.O.Box 2902 S., Baton Rouge, La.

3 PLASTIC HOLDERS will frame and protect 60 cards, $1—or 10 holders $3. Prepaid & guaranteed. Patent 3309805. Tepabco, Box 198N, Gallatin, Tennessee 37066.

WANTED ANTIQUE RADIO and wireless equipment. Also radio magazines of teens and twenties. Also buying supply catalogs, Duck, Manhattan! etc. Farrell, 2252 Dixie Pontiac, Mich. 48055.

THE ANNUAL HAMFEST for the Washington DC metropolitan area, sponsored by the Foundation For Amateur Radio, will be held at the Gaithersburg Fairgrounds in nearby Gaithersburg, Maryland on Sunday September 21st, from 1000 until 1700.

RTTY GEAR FOR SALE. List issued monthly, 88 or 44 mhy torroids 5 for $2.50 postpaid. Elliott Buchanan & Associates, Inc., 1067 Mandana Blvd., Oakland, California 94610.

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

TECH MANUALS, and service data for Surplus Electronics. Thousands of publications on hand, covering communication and test equipment. Sorry—no catalogs, but will rush price and availability quotes for specific literature that you may need. Propagation Products Co., Box 242, Monroe Street Post Office, Jacksonville 1, Florida.

OHIO VALLEY 6 meter phone net 50.350 every Sunday. 2000 EDT, WA8WIW, NCS Sciotoville, Ohio. Traffic and Rag Chewers Welcome.

FIND OUT about the New Greene Balun. Read all the details on page 59 of this issue. Greene Balun, Warfield, R.I. o2880

WANTED: TECHNICAL material. Corp model XFK freq. shift exciter for Tmc model GPT 750—also TMC single sideband exciter, model SBE for GPT 750 & manuals—plus 18 to 30 foot parabolic dish. What will you take for it in place of money—will swap brand new towers or test equipment. Write, wire or call: Eugene Leger, Hollis St., East Pepperell, Mass. 01437.

SELL: COLLINS KWS-1, Ser. 896, $640; 75A4, Ser. 5763, $420—or both for $1025. I will ship. Lew Hindert, Rt. 4, Box 290, New Braunfels, Texas 78130.

WANTED: CR tube for Tektronix 561 or 561A oscilloscope. Sell: Collins CC-2 Carrying Case, $50.00; TMC Commercial TTG-1 two-tone oscillator, $95.00; Kepco SC-18-4M transistorized power supply, 0-18 VDC, 0-4 amps, 0.1% regulation, metered, $110.00; Bird 6254 R-F watt meter, 0-2 watts, 30-500 mc, 50 ohms, $50.00; Bird 67 R-F watt meter, 0-25/100/500 watts, 30-500 mc, 50 ohms, $125.00. FOB, H. T. Cervantes, 34 Johnson Rd., Binghamton, N. Y. 13905 (607-724-5785).

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

WANTED TEST EQUIPMENT: Bird watt meter, measurements of G. R. sig. gen. up to 450 mc; Tektronix scope. State price. W2EDN, 93 Gilmore Ave., Binghamton, N. Y. 13901.

WRL'S USED gear has trial-terms-guarantee! KWM1-$249.95; HW32-$89.95; Swan 250-$249.95; TR3-$369.95; NCX3-$169.95;SB34-$299.95; Galaxy V-$229.95; Galaxy Vmk2-$279.95; Ranger-$99.95; HT32A-$259.95; 100V-$259.95; Galaxy 2000 linear-$329.95. Many more. Free "blue-book" list. WRL, Box 919, Council Bluffs, Iowa 51501.

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

SELL HALLICRAFTERS HT-32 Transmitter, excellent condition inside & out, $210. Will deliver within 50 miles. Want Collins 32S1 or 32S3. Robert Kujawski, WA2VDX, 30 Rose St., Florida, N. Y. 914-651-7212.

GREENE . . center dipole insulator with . . or . . without balun . . see September 73 issue.

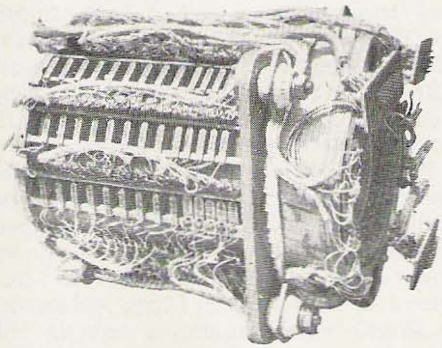
HAMS WHO LIKE audio, too, try new quarterly: Amplifiers by Williamson and Bailey, speaker by Baxandall. Details, Audion 307 Dickinson Ave., Swarthmore, PA 19081.

WIRELESS ELECTRONIC TACH

Portable transistorized, wireless (no connections required). May be used on 2 or 4 cycle engines, 1-2-4-6 or 8 cylinder, outboards, marine, autos, trucks. 2 scales 6,000 & 12,000 rpm.

$20.

$6,400.00 MEMORY DRUM



Military surplus made by HUGHES for the AF. Condition appears excellent due to being enclosed in air tight case with terminations on plug connections. 134 read/write heads, 12 heads phase adjustable timing. Integral drive motor 115 volts 400 cycle.

Shipping wt. 39 lbs. . . . . #DRUM $100.00

INTEGRATED CIRCUITS

900	Buffer	$1.00
910	Dual 2-input NOR	1.00
2-903	Dual input gate	1.00
914	Dual 2-input gate	1.00
914-925	Dual 2-input gate dual expander	1.00
923	JK flip flop	1.00
925	Dual 2-input gate exp	1.00
946	DTL 4 2-input NAND/NOR gate	2/1.00
	DTL Clocked flip flop	2/1.00
1M5	Dual 4-input logic gate	2/1.00
7M6	6 NPN transistors in one package, gen use	3/1.00
12M2	Diff Amp	1.00
711	Dual Comp Amp	2.00

JOHN MESHNA JR.

19 ALLERTON ST., LYNN, MASS. 01904
P. O. BOX 62, E. LYNN, MASS. 01904

COMPUTOR GRADE CAPACITORS

15 volt 110,000 mfd	$2.00 ea.	12/$20
18 volt 6,500 mfd	1.00	12/$10
50 volt 4,000 mfd	1.00	12/$10
450 volt 600 mfd	2.00	12/$20

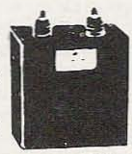
VARIABLE DISC TRIMMER

Miniature ceramic variable trimmer capacitor. Piston type tuning, size .375 diam, .275 deep. Printed circuit mount. Amateur net on this is $1.68 each. Our price only 25¢ each or 24 for $5.00. All are brand new. State size, may be assorted if you wish.

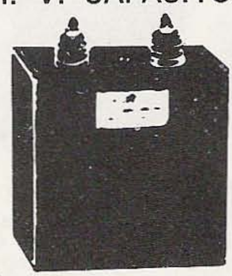
#N300 2.5-11 pf
#NPO 5.5-18 pf
#N650 9-35 pf

0.5 mfd 7,500 Volt

Brand new Military surplus oil filled transmitting cap. Ceramic standoffs.
5 lbs. . . . . #69-210 $5.00



H. V. CAPACITOR



GE oil filled capacitor, A real brute, rated 1 mfd at 15,000 volts. Terrific savings due to being Govt. surplus.
30 lbs. . . . . #69-63 $10.00

"IF" TRANSFORMERS

262.5 khz tube, Miller type 6572
262.5 khz transistor, Miller type 8008
10.7 mhz tube, Miller type 1463
10.7 mhz transistor, Miller type FM-IF

The above 6/$1.00 36/$5.00

CINCY STAG HAMFEST: The 32nd Annual Stag Hamfest will be held September 28, 1969 at Stricker's Grove, Compton Road, Mt. Healthy, Cincinnati, Ohio. Door prizes each hour, raffle, lots of food, flea market, model aircraft flying, and contests. Identify Mr. Hamfest and win prize. $5.00 cost covers everything. For further info., contact John Bruning, W8DSR, 6307 Fairhurst Ave., Cincinnati, Ohio 45213.

INTEGRATED CIRCUITS: new Fairchild Micrologic; epoxy TO-5 package. 900 buffer, 914 gates, 60¢ each; 923 J-K flip flop, 90¢ each. Guaranteed. Add 15¢ postage. HAL Devices, Box 365W, Urbana, Illinois 61801.

Increase Your Grid Dipper Range

There is general agreement that a grid dip meter is an invaluable piece of amateur test equipment. Why then confine its use to the usual frequency range of 2 or 3 mhz to perhaps 250 mhz when it is some easy to make additional coils to cover the lower ranges?

Browsing through the catalogs will quickly convince you that hardly anyone sees fit to supply low frequency coils and when they do it is at additional cost. Why not make your own? All that is necessary is a base which will fit the coil socket of your dipper, a coil form or two, and a little patience. My current dipper is a Heath GD-1 (which I find superior to several others I have had around the shack) which requires a two-pin coil base. In my case I had only to bend two lengths of copper tubing to the proper spacing for the coil terminals at one end and the socket spacing at the other. After the proper frequency range was established, the entire coil and about a half inch of the leads were potted in casting plastic, making a very sturdy assembly.

The low cost coils I used (5 cents each at a local hamfest) came equipped with a ferrite slug. I left the slug in for the lowest range – 250 khz to 1 mhz and took it out of the higher range – 1 mhz to 2 mhz. No exact data can be given due to the variation in dipper circuitry. This will be a case of pure "cut and try." The range of the new coils must be plotted on a graph against the original dial markings.

A general coverage receiver will allow calibration down to 550 khz and by feeding the signal into its *if* strip, an additional point at approximately 450 khz is obtained. Below that frequency things get a little tougher. If you happen to have a low frequency receiver, fine, if not, use harmonics in the BC band.

William P. Turner, WAØABI

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