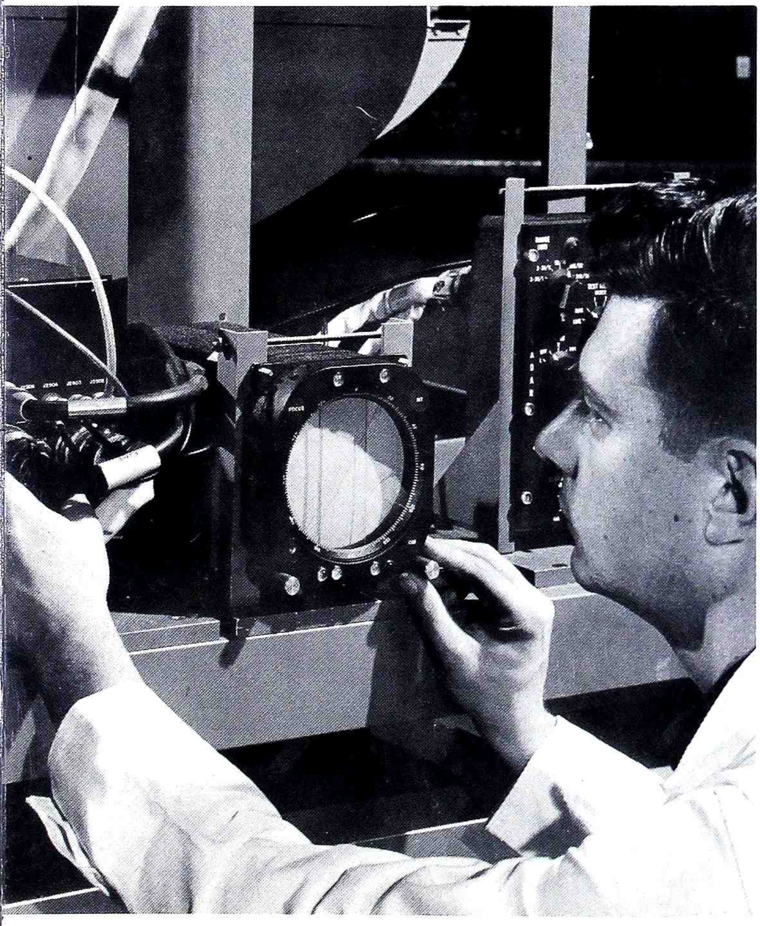
nri journal

JANUARY 1964



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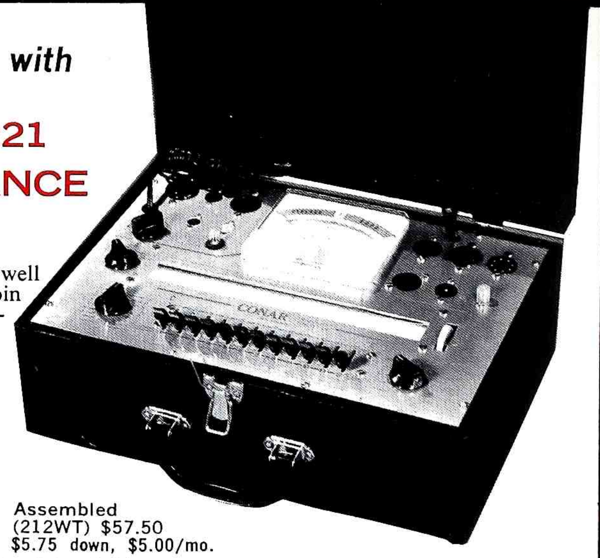

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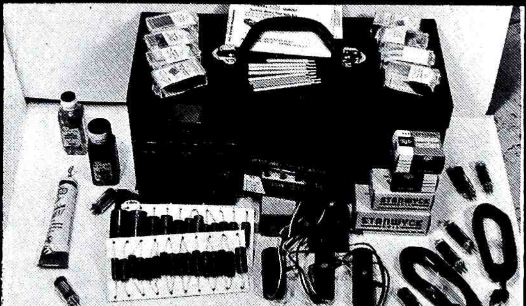

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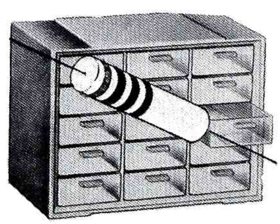

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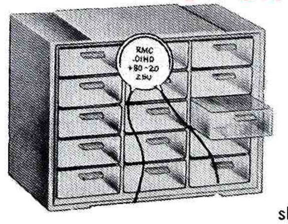

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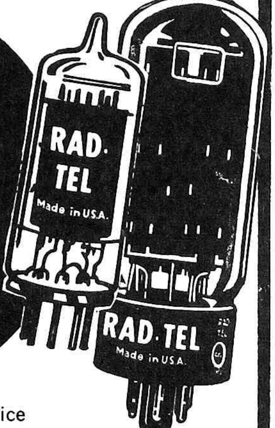

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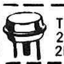

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MICROWAVE POWER MEASUREMENTS

A DISCUSSION OF SEVERAL MEASUREMENT TECHNIQUES

BY WALLACE B. CHANDLER

Power measurements at high frequencies are unique since the final reading, although in watts, is not derived by using current and voltage. At low frequencies, we generally have a device which is sensitive to current and voltage and actually multiplies I times E to give us watts. In the microwave region, we are measuring power that has been radiated (although it is confined within the walls of a waveguide). We cannot use a standard wattmeter to measure this energy, so we rely on the fact that a certain amount of power will do a given amount of work - then measure the work done. How do we do this? Let us use a simple analogy.

DISSIPATED POWER (HEAT)

If we had a known resistor and very sensitive fingers, we could connect this resistor in a circuit, and, after establishing the power required to heat the resistor to given temperature, use our fingers as a crude wattmeter. The heat will vary directly with power, since it is work being done within the resistor. The reading will be relative. This gives us a clue as to how power can be determined, if we know how many watts are required to give us a certain temperature.

Heat is the basis of microwave power measurements. A family of devices, resistive in nature, are used in many cases. These devices (bolometers) are the sensing elements used when the power is measured electronically. Different considerations must be made for pulsed power measurements than is made for cw operation. We will start with cw operation and discuss the sensing device used and the method of reading power, via heat, directly in watt units.

THE THERMISTOR AND THERMISTOR BRIDGE

The most common member of the bolometer group to be used in cw microwave power measurements is the thermistor. Fig. 1 shows one form of thermistor. Another type of thermistor is a bead suspended in a waveguide mount. The main thing to know about the device is that its resistance decreases with heat. As power increases, resistance of the thermistor decreases. The decrease in resistance is due to the use of a semiconductor material as the bead. The thermistor allows a high degree of accuracy to be obtained, and is in wide use today.

One of the limiting factors of thermistors is that they must be operated at a very low power level, in the order of milliwatts. This is true of the whole bolometer family and makes the use of calibrated attenuators a necessity whenever the bolometer is used. Even with the use of attenuators, the setup required is much easier to use than any other method of measurement.

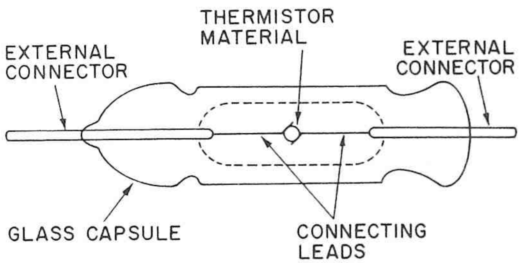


FIG. 1. The glass encapsulated thermistor showing how bead is suspended between leads.

The readout is simple. It is a bridge circuit shown in Fig. 2. The circuit in (A) illustrates a basic bridge circuit, while (B) shown a compensated bridge to give better accuracy.

The bridge, which has the thermistor in one of the resistor arms, actually measures the change in resistance of the thermistor when rf (heat) is applied. The meter may be calibrated to read the power in milliwatts directly. Thermistors are often used within the bridge to compensate for temperature changes while measurements are being made. These instruments, referred to as wattmeter bridges, are available and are factory calibrated and are direct reading. There are many variations of the circuitry, but the function is the same. Change in resistance is the determining factor that gives the power readout.

We mentioned attenuation. By knowing the attenuation (in db) from the transmitter to the thermistor, it is a simple matter to determine the full transmitter power. Although some error will be incurred due to tolerance build-up, the measurement is usuable for most purposes.

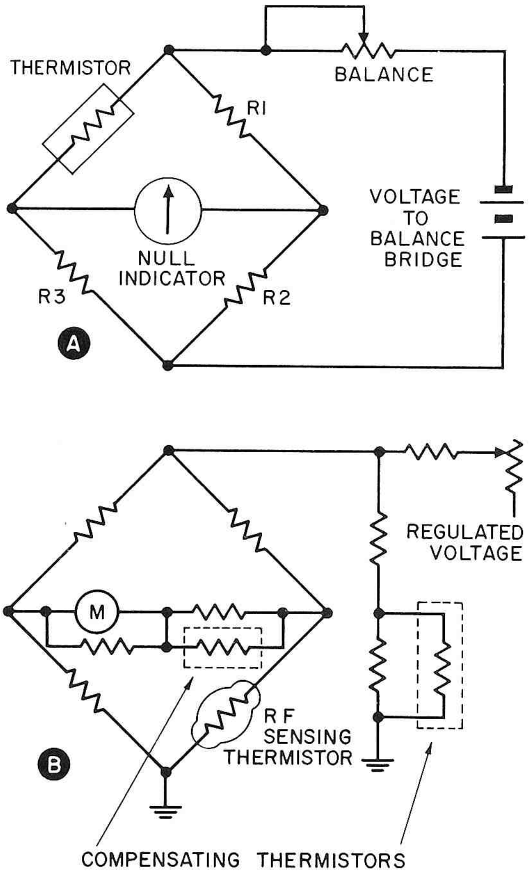


FIG. 2. The basic thermistor bridge, A; compensated thermistor bridge using disc thermistors for compensation, B.

PULSED POWER MEASUREMENTS

Now we come to the real problem area. Many methods are used to determine peak power in pulse applications, but it is hard to pin down actual peak power. We can see that since the pulse time is so short and there is a comparatively long off time between pulses, the average power is very low. We could not measure the power with a wattmeter bridge, because by the time the signal has been attenuated low enough to protect the thermistor from the tremendous peak power at pulse interval, there is not enough average power to measure (see Fig. 3).

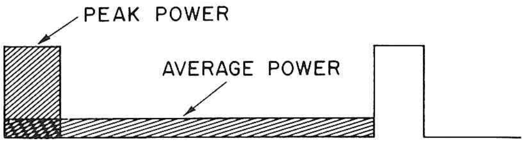


FIG. 3 Pulsed energy. The area under the pulse equals the peak power. The shaded area from one pulse to the other is average power. The ratio is exaggerated for illustrative purposes.

The measurements to be considered are very interesting. Three methods are not electronic, one is a bridge arrangement and the last is electronic and involves quite a bit of circuitry. Let's discuss each method briefly.

WATER LOAD (CALORIMETER) METHOD

The most accurate method, employed in laboratories for precision measurements, is by use of the water load. No attenuation is needed since the power is determined at the transmitter level. Fig. 4 shows a simple drawing of the water load. Note the temperature sensing elements on the input and output connections to the load. Water is pumped through the load at a controlled rate. The difference in temperature between the input sensing device and the output sensing device indicates to what degree the rf energy has heated the water passing through the load. The

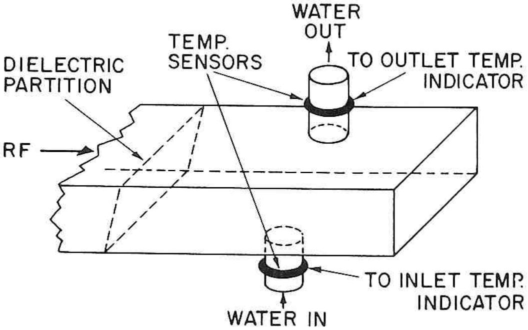


FIG. 4. Section of waveguide housing a water load. Water fills area between partition and end of guide.

power can be computed using the temperature and known factors about temperature versus volume. Since this method is complex, it is usually used only in laboratories and in calibration set-ups.

THE GAS LOAD

Fig. 5 shows the necessary plumbing and fixtures for a gas load measurement. A gas, usually ammonia, is located in the section designated on the drawing. As rf energy is applied, the gas is heated. Expansion takes place and pressure is applied to the column of colored kerosene. This kerosene is in a device called a manometer. The manometer scale is calibrated in pressure and the kerosene moves up the scale as pressure is applied due to higher power. Pressure can be related to power and the peak power is then calculated. This is a simpler method, but still rather clumsy.

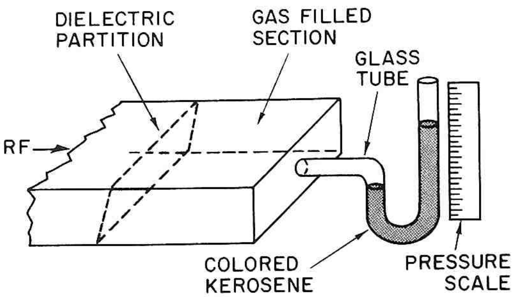


FIG. 5. Gas load showing manometer with scale. Expanding gas moves colored kerosene.

THE SAND LOAD

The sand load method involves measurement of heat transferred due to radiated power also. The sand is mixed with a proper amount of aquadag and packed into a termination. The surface of the composition is exposed to the radiated energy, and the heat is transferred via the sand mixture to a temperature sensitive element. The rise in temperature is then converted mathematically into power in watts.

THE JOHNSON METER

This device makes use of the fact that at high power, a certain metal (constantan) changes temperature greatly with changes in power. The constantan is placed in one wall of the waveguide after a section of the waveguide meterial is removed. Sensing elements in the form of platinum wire are placed on both the constantan and the regular wall of the waveguide. Since the waveguide metal is a better conductor of heat, there is a difference in temperature between the two surfaces. This gradient causes the two platinum sensing elements to have different resistance values, although they are identical when cold. The two sensing elements now make up two of the four arms of a Wheatstone bridge (Fig. 6). The power may be determined by calculation or by calibrating the meter for a direct readout.

The Johnson meter has two definite advantages over the other methods. It requires far less power from the line (water load must have 100%) so therefore it can be used as a monitoring device while the transmitter is on the air. The other advantage is that the Johnson meter is not restricted to the laboratory. It may be used in the field, making it a more versatile instrument.

Accuracy of 5 percent may be expected, which is very good for a peak power measurement.

ELECTRONIC PEAK POWER METER

Let's examine a method of measuring peak power that is almost as easy as using a VTVM to measure DC voltage. The ease of use is placing this instrument in service more and more every day. The only complication is in attenuation since a bolometer device, the barretter, is used. A known attenuation may be plumbed into the line permanently though, and terminated. Then, to make a measurement, the barretter mount replaces the termination, the meter is connected and we have peak power which can be read directly from the meter (at the attenuated point, as the wattmeter bridge measurement was).

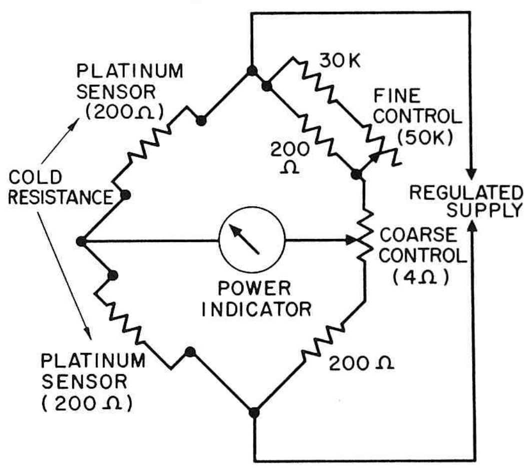


FIG. 6. Johnson meter bridge network. One sensor is on waveguide wall; the other is on constantan section.

The barretter has a positive temperature coefficient and, when biased with a constant direct current, causes a voltage to be generated producing a ramp function (see Fig. 7). This ramp is at a very low level, so amplification is needed. Also, we know that if we differentiate a sawtooth, we generate a pulse. By using a linear amplifier and differentiator

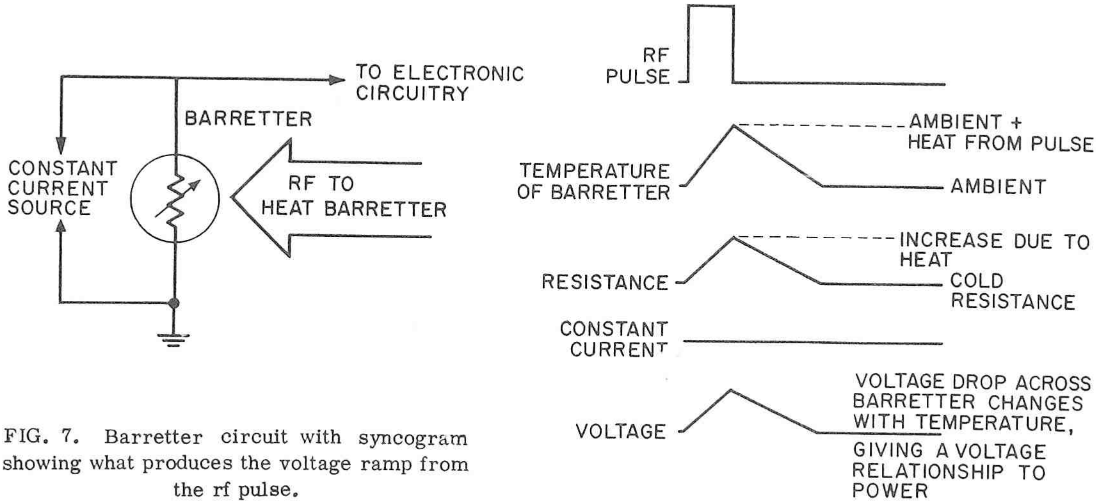


FIG. 7. Barretter circuit with syncogram showing what produces the voltage ramp from the rf pulse.

circuit, we can reconstruct the transmitter pulse faithfully.

For a given pulse width the slope of the ramp changes with peak power. This slope change causes, in turn, a peak voltage change on the reconstructed pulse. We now have a pulse whose amplitude is proportional to peak power.

You could have saved a lot of this trouble by using a crystal detector, you are thinking? True, except for the fact that the crystal could be operating as either a linear device or a square law device depending upon the power applied. This could really throw you for a loop. The barretter ramp is a good representation of power regardless of how much is applied, unless you exceed it's capabilities. If you do, it will remind you by burning out!

Now that we have a voltage pulse whose amplitude varies with peak power, what will we do with it? A peak detector is the answer. This circuit gives a DC voltage which corresponds to the peak of the pulse and, in turn, drives a meter. The meter is calibrated in peak power in milliwatts at the factory. The attenuated peak power can be read directly from the meter to an accuracy of 10 percent. For most purposes in the field, this is accuracy aplenty!

Fig. 8 shows a block diagram with waveforms depicting the reconstruction of a pulse and the DC readout.

SUMMING UP

As was pointed out in the beginning, power measurements at microwave frequencies are a very difficult task to perform accurately. We have discussed methods being used to familiarize you with terms and some of the problems encountered. To make these measurements, care must be taken to insure that standing waves are not created, and that attenuation values are what you think they are. If you still have your first power measurement to make, here's hoping you get within 3 db!

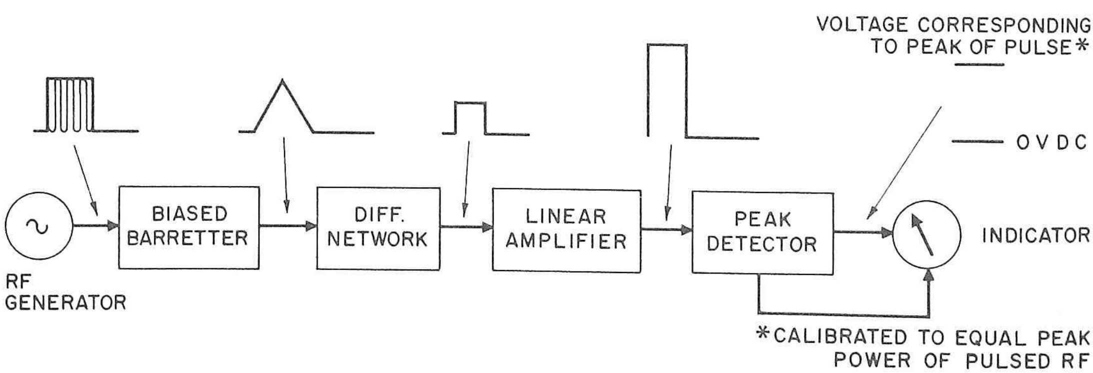
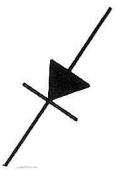


FIG. 8. Block diagram of peak power meter with waveforms. As the peak power varies, the voltage pulse varies proportionally.

THE DIODE ---- ELECTRONIC WORKHORSE



BY WILLIAM T. GOODWIN

There are few circuits in electronics that don't depend on the diode in one way or the other. It might be for power, since the diode is used to rectify, or it may be the source of signal for a stage, as is the case with a detector which takes the modulation from the carrier frequency and applies it to the audio amplifier. Diodes are used as mixers, since they have a nonlinear characteristic needed for this purpose. Also, the diode can be found performing as clippers and clamps, as well as reference devices (zener diode). Recently, another function has been added - amplification. This is achieved with another member of the family, the tunnel diode.

Since the diode comes in so many various shapes and sizes and can be made in so many different ways, and since the jobs performed are many in number, one should be well acquainted with this group of devices. There are thermionic diodes and those made of selenium, copper oxide, germanium and silicon (Fig. 1). Each material is best suited for some particular function. Let's examine a few of the uses.

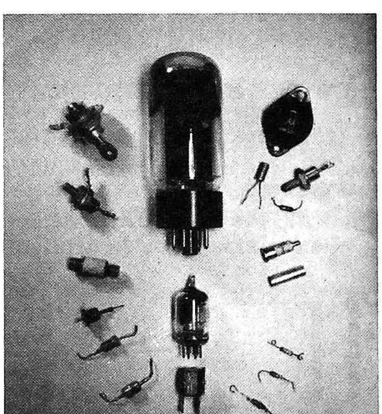


FIG. 1. Types of diodes. Thermionic (center), selenium (bottom). Left side shows display of silicon power rectifiers; at right (top to bottom) are zener, microwave, germanium and silicon signal diodes.

THE TYPES AND HOW THEY ARE USED

First, let's discuss the thermionic diode, which came into being with the discovery of the Edison effect - the flow of electrons through a vacuum from a negatively charged element to a positive element. The tube diode can be found as the rectifier in many power supplies, furnishing the plate voltage to tube amplifiers. Other functions, being replaced now by solid state devices, are detection, clipping and clamping. Since a cathode heater is required in the thermionic diode, the solid state semiconductor is replacing it in many applications.

Before silicon diodes came into being, the selenium and copper oxide rectifiers (diodes) found use as plate supply and instrument rectifiers. They needed no filament power but had a higher reverse current than the thermionic type. It was natural that, when a diode that had both good features appeared, the others would have to take a back seat.

The silicon diode, such as the top hat, cartridge type (M150 or M500), or any of the new solder-in rectifiers, has solved a space and power problem as old as electronics. With the use of these devices, large currents can be handled. The peak inverse voltage ratings are very good and no heating power is required except that used to solder the device into the circuit. Silicon diodes are also found in many other applications, such as switching, clipping and anywhere a fast response time is required.

Germanium diodes are good detectors, clippers and clamps. They are also used to shunt out relay coil transients and to isolate one circuit from another.

The crystal diode goes back to the old cat whisker used as a detector in the crystal receiver. They are widely used as detectors since they can handle very little power. The crystal is either silicon or germanium and is constructed as shown in Fig. 2.

CHARACTERISTICS OF A GOOD DIODE

A perfect diode would be a device which allowed maximum current to flow in one direction and none to flow in the other. The device would have no voltage dropped across it when it was "on" and would be able to stand an infinite voltage without breaking down when it was "off".

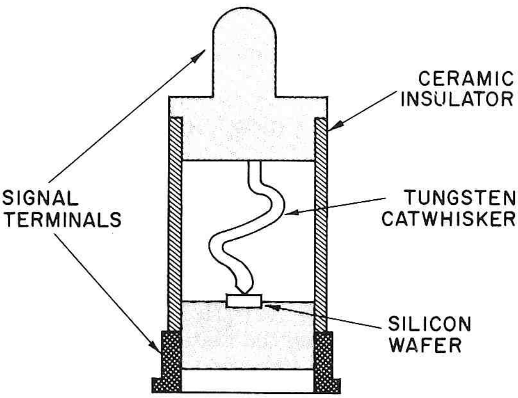


FIG. 2. Cross section of a microwave mixer crystal diode. Note cat whisker similar to old cat whisker receiver crystal.

Since the above conditions are not possible, a good diode comes as close as possible to satisfying these conditions. It should have a good front-to-back ratio of resistance, low in the forward and high in the backward (anode to cathode) direction. It should be able to withstand a reasonable amount of voltage without breaking down when a voltage is placed on it in a reverse manner. It should respond quickly. That is, when the voltage is reversed, it should be able to turn on or off at the rate at which the polarity is changed. If this is not a feature of a particular diode, high frequency operation is limited.

Since all the features of a perfect diode could not be met by one device, diodes have become specialists, so to speak. Some can carry large currents, some are fast, some have very good peak inverse voltage ratings for high voltage power supply work, and some have extremely good front-to-back ratios. The task in circuit design is to pick the proper diode to do a specific job best.

CATHODE - ANODE IDENTIFICATION

We all know that electrons flow from cathode to anode and that the cathode should be negative with respect to the anode. The problem sometimes is in physically identifying the anode and cathode leads. Fig. 3 shows a group of diodes and their identifying markings. The solid state diode elements can be identified with an ohmmeter, if the polarity of the ohmmeter leads is known. With the positive lead on the anode and the negative lead on the cathode, a much lower resistance will be measured than when the leads are reversed. Usually, there is a band or symbol, but frequently this becomes blurred or is rubbed off, so an ohmmeter check is the only answer on an older diode.

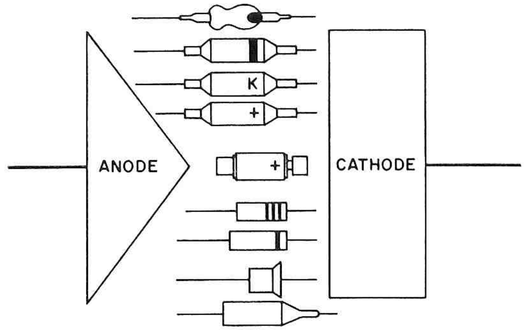


FIG. 3. Diodes showing different construction methods and method of identifying the cathode by various marking methods. The cathode is usually marked. The (+) means the side that a positive voltage would measured.

The thermionic diode can be identified with the use of a tube manual and pin numbers. It is simple to do with a manual, but next to impossible without one!

Schematically, the diode has two representations. The thermionic diode is shown in Fig. 4A, while the solid state device is pictured in Fig. 4B. The arrow is the anode of the solid state diode; the electrons flow toward the arrow. This is a point of slight confusion, so it is a point worth remembering.

HOW THE DIODE PERFORMS ITS FUNCTIONS

Rectification is probably the major role played by the diode. Fig. 5 shows a half-wave rectifier with the waveforms depicting its action. When a sine wave is applied across

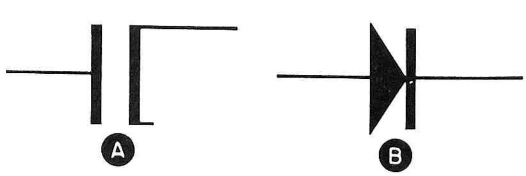


FIG. 4. The thermionic diode, A; the solid state diode schematic symbol. Special-purpose diodes are variations of the solid state symbol.

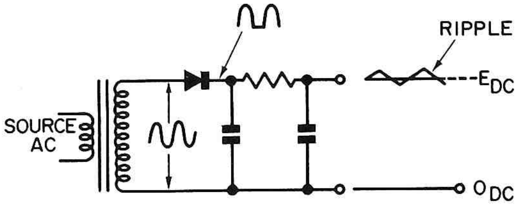


FIG. 5. A familiar half-wave rectifier with waveforms depicting the pulsating voltage and the DC rendered by filtering (plus ripple.)

the diode, current flows for one-half cycle and does not flow for the other half cycle. This gives us pulsating current, but all the electrons are moving in one direction within the load. The pulses are smoothed out by filtering and we have fairly constant DC. It's all possible because the diode conducts in only one direction.

Rectification is also applied in demodulation or detection. Fig. 6 shows a diode detector. The rf energy is rectified and we have pulsating DC whose amplitude is varying at an audio rate. After filtering, we have a DC component which varies at the modulation rate, so we have removed the intelligence from the carrier in the same manner that we got DC from the power supply.

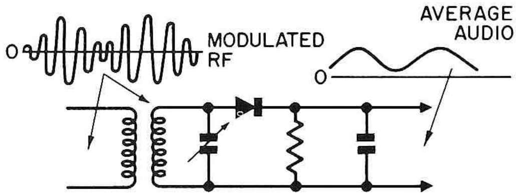


FIG. 6. Diode detector removes carrier and leaves modulation rate.

The diode clips by conducting after a voltage has reached a certain level. We can accomplish this by biasing if necessary. Fig. 7 shows a diode removing the negative half of a differentiated waveform. By turning the diode around, the positive half could have been removed.

When two signals are applied across a nonlinear impedance simultaneously, the resultant waveform is comprised of the sum, difference and two frequencies. This is mixing and the diode is used quite frequently (in the microwave region especially) as a mixer. It has a nonlinear resistance characteristic as can be seen in Fig. 8, so it is ideal for mixing.

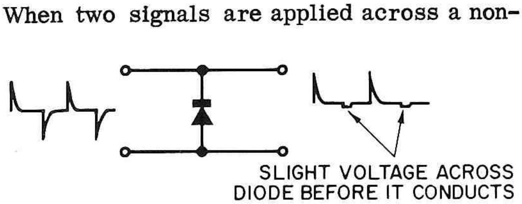


FIG. 7. The diode conducts when the voltage goes negative, removing this half of waveform.

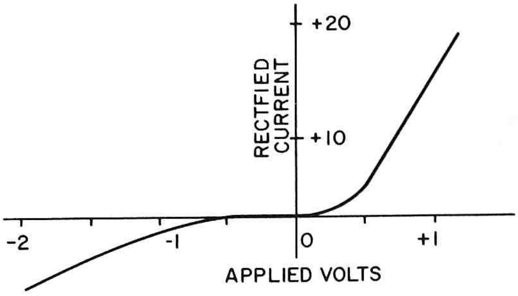


FIG. 8. Curve showing nonlinear characteristic which permits the diode to mix frequencies.

The next group of diodes are of a special nature, so we will discuss them as special-purpose devices.

SPECIAL-PURPOSE DIODES

The main diodes in this group are the zener and tunnel diodes. They are very important devices and are being put to very good use in many applications. The zener is shown schematically in Fig. 9A, while the tunnel diode is presented in Fig. 9B.

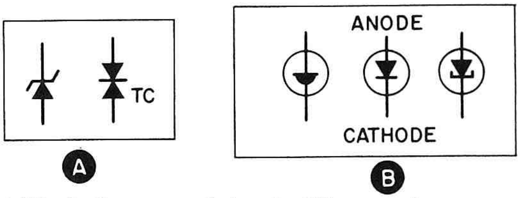


FIG. 9. Zener symbols, A. TC means temperature-compensated zener; most commonly used tunnel diode symbols, B.

The zener diode is used most frequently as a voltage reference and is similar to a voltage regulator tube in action. The voltage across the diode must reach a certain value (depending on the diode) before it will conduct; then it holds the voltage constant over a range by letting more or less current flow as the voltage tries to fluctuate. The zener is available in many voltage ratings and is a very handy device, used extensively in transistor circuitry.

The tunnel diode is a two-element germanium device which actually has the capability to oscillate or amplify. This diode has an extremely high-frequency response and stable

(Continued on page 17)

HOW TO SUBSTITUTE PARTS

CAPACITORS USED FOR COUPLING, BYPASS AND FILTERING

BY THOMAS R. HASKETT

Design engineers spend many hours juggling components until they get the results they want from a piece of radio or TV equipment. They put a 20 μfd, 450-volt capacitor in a power supply to do a specific job. Can you substitute another value if you don't have the proper one? Sometimes -- the secret is that both you and the design engineer work with relatively standardized component values and tolerances. There aren't really very many critical values in a piece of electronic gear. The only trick is knowing which part is critical, and which is not. In other words, what are the tolerances?

CAPACITOR SIZES AND MATERIALS

The size of a capacitor, the material it's made of, its voltage rating, operating frequency and temperature, are all interrelated. The smallest fixed capacitors are in the range from about 5 to 10,000 picofarad (μμf); these are used for UHF and VHF bypass and coupling work and come in several sizes and materials, some of which are illustrated in Fig. 1. The most common type has mica dielectric in a molded plastic case, and is fairly cheap and effective below 50 mc. Another feature of this type is the axial leads, useful in point-to-point wiring, but not necessarily in close bypassing. Quite similar to the above, the silver mica capacitor has slightly lower loss. Both kinds are also available dipped; a liquid epoxy resin solution is used, which solidifies into a hard case. A dipped capacitor is extremely resistant to heat and humidity, and it comes with

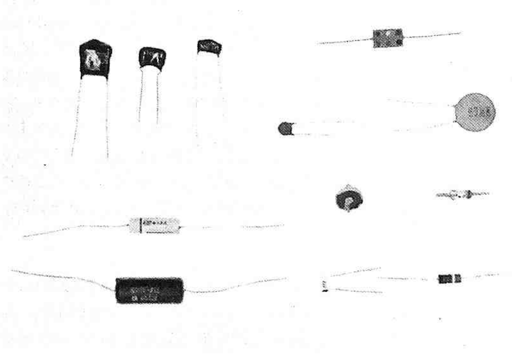


FIG. 1. Capacitor types.

radial leads -- quite useful when bypassing a tube socket to chassis or installing one on a printed board. For the latter job, crimped leads simplify proper installation -- the leads are inserted up to the crimp point, which provides a positive stop and prevents cracking the epoxy coat.

Above 50 mc mica capacitors have appreciable inductance, due to their construction and size. It is preferred to use a disc ceramic. These are quite small and are resistant to heat and humidity. Tubular ceramics are sometimes used and are often as small as their disc counterparts. Tubulars come with both axial and radial leads; discs have only radial leads. Since the capacitance of an ordinary capacitor increases with temperature (and this is undesirable in certain applications such as HF oscillators) special stabilized and negative-temperature types are available in the range of about 1 to 1000 pf. They are usually disc or tubular ceramics and require exact replacement. For example, type NPO (negative-positive-zero) have no change in capacitance for any change in temperature between -20 and +85 degrees centigrade. Type N750 are negative-temperature types -- they show 750 parts per million change in capacitance for each degree increase in temperature centigrade. When a negative temperature type is coupled with an ordinary positive type, the combination will be stable.

Disc capacitors, as well as molded micas, are made with flat plates, hence have less inductance than the tubular variety, in which the plates are rolled. Therefore, even though a disc and a tubular may have the same capacitance and voltage ratings, the tubular will ordinarily be unsuitable for VHF work, due to its inductance. The same is true of micas-- they are best restricted to lower VHF ranges. Disc ceramics can be used at almost any frequency, and they are the most useful stock items.

There are two more very small capacitors used at VHF and UHF in the range from 5 to 10,000 pf. Button micas make good bypasses to chassis and have compact size, low leakage, and low inductance. Ceramic feed-throughs are often supplied tapped and witn mating nuts for chassis-hole mounting. They are coupling capacitors and are made specifically for routing a lead through a chassis. Both button and feed-through types are slightly more expensive than molded mica or disc ceramics. Disc ceramics can often be substituted for either with no impairment of performance.

In the lower rf and audio frequencies, the range of approximately .001 to 0.5 microfarad is generally covered by tubular capacitors with rolled plates made of metal foil. Years ago waxed paper was used as a dielectric and the whole capacitor was dipped in a wax coating. Today better materials are used. The most common uses a polyester (Mylar) dielectric in either a molded plastic or a dipped epoxy case, with the same advantages as mentioned earlier. The dipped types usually have crimped leads. Another variety uses a film casing. Various materials are employed, but all provide resistance to moisture and temperature change. Metallized paper types are similar to film types, but an impregnated paper dielectric is used, in a molded plastic case. They are more expensive than the poly types. Other high-reliability types, found in military, communications, and industrial equipment, have metal cases and glass end seals, for near-absolute protection from moisture and temperature changes.

For almost all replacements, the epoxy-dipped tubular with a polyester dielectric and radial leads will do nicely, and it's probably the most common type available in stock. It costs no more than the molded-plastic type.

BYPASS CAPACITORS

One of the things a capacitor does is pass audio or rf while stopping DC. In amplifiers it's often necessary to shunt signal currents around parts of the circuit, which is the task of a bypass. For example, one is usually connected on the power-supply side of a plate or screen resistor, to prevent the signal from flowing back into the plate supply. Note C2 and C3 in Fig. 2. In a TV i-f amplifier, the value of a bypass is not too critical -- the range is about .01 to .001, and the range of replacement tolerance is 100% or 200%. When the value becomes too large, however, bypass action may be impaired, due to appreciable inductance. And the larger values are also larger in size, producing space problems. As outlined above, disc capacitors are preferred for high-frequency work, or where space is limited.

A capacitor's working-voltage rating is the highest DC voltage you should place across it. If exceeded, the dielectric breaks down and the capacitor shorts. Although there are many working-voltage ratings of capacitors available, the favorite replacement value (except those used in transistor circuitry) seems to be 500 or 600 volts, and these will do for most jobs. Always use capacitors with a voltage rating at least as high as the original component. It is, of course, quite all right to use one with a higher rating. You are simply paying a little more for increased reliability.

The cathode bypass circuit is well-known; DC travels through the cathode resistor, causing a voltage drop which grid-biases the stage, while AC goes around the resistor -- through C1 in Fig. 2. In audio power-output stages the cathode bypass is often 10 or 20 µfd. You can replace with less capacitance, if you're willing to sacrifice some low-frequency response. This is not a very critical point except in the highest quality audio amplifiers.

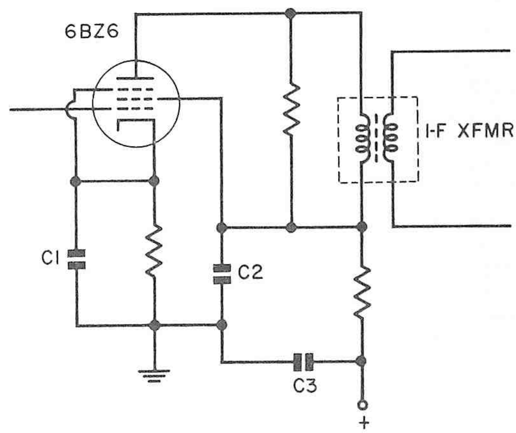


FIG. 2. Bypassing a TV I-F amplifier.

By the way, if a circuit being bypassed carries audio as well as rf, the capacitor should usually not be higher than .002, so it won't affect the higher audio frequencies. This applies, of course, to a first-audio grid bypass to keep rf hash from the sweep circuits out of the sound. This does not apply to a B plus bypass, since you want to get rid of both rf and audio. And in UHF bypassing the replacement should be as nearly identical to the defective unit as possible. Especially important is lead length and dress. Keep them as short as possible and route the same way as the original.

BLOCKING AND COUPLING CAPACITORS

Blocking and coupling aren't the same thing, but the capacitor assigned one job almost always does the other as well. However, the blocking capacitor is a special case of coupling capacitor: In a few circuits capacitive coupling is desired, even though no DC is present -- see Fig. 3(A). Usually, though, DC is present, as in Fig. 3(B), and this means blocking the DC to prevent it from getting into a following grid or base. In audio the coupling capacitor's value has been calculated by the designer in conjunction with the grid resistor of the following stage to provide the desired frequency response. You don't want to deviate much from this value, unless you don't mind altering bass response -- affected most. A similar point can be made in video and rf circuits, where appreciable phase shift (picture smearing, etc.) can be the result of too drastic a change in the coupling capacitor's value. You can generally substitute within a 100% range.

POWER-SUPPLY FILTER CAPACITORS

It is well-known that the purpose of the filter capacitor is to get rid of AC ripple from the rectifier. In fact, the ripple content of the B plus is directly related to the value of the filters; the more capacitance, the less ripple. Of course, the more capacitance, the more money, so there's a limit to the size of the filters put in various equipment. The point to remember is that you should always use at least as much capacitance, or more, but never less. That is, you can replace a 10 µfd filter with one rated at 15, but not the other way around, unless you want more hum in the amplifier. This rule applies to voltage rating, where it's more important -- always replace with a higher, never with a lesser voltage rating than the original.

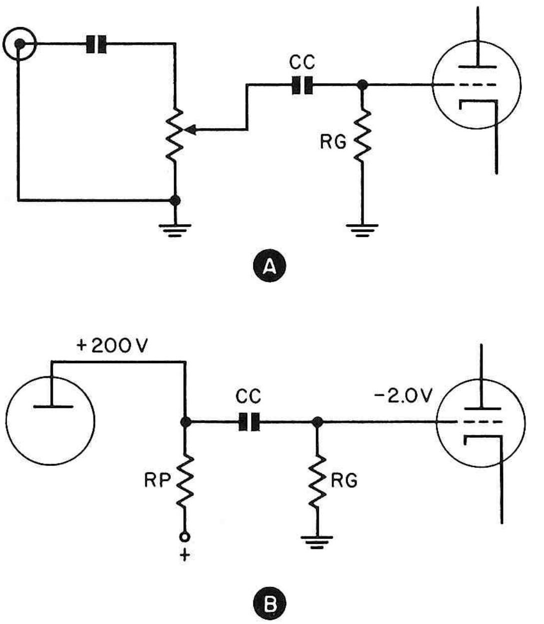


FIG. 3. The coupling capacitor. A, coupling only; B, coupling and blocking.

Fig. 4 shows some of the common filter capacitor types. The can electrolytic is the most common. The can is usually grounded to chassis, but for non-grounded applications a bakelite plate is supplied which can be inserted between the base and chassis. Some can types are made with octal bases, for convenient plugging into octal tube sockets. This facilitates replacement, but it's used chiefly in military and communications equipment. The tubular electrolytic, encased in a cardboard sleeve, is a favorite for replacement where space is limited. It has axial leads and a metal strap (not connected internally) for mounting.

Bathtub capacitors are high-reliability types, used principally in industrial and communications work. They contain paper, impregnated with mineral oil, have a metal case and side terminals, and are more expensive but more reliable than electrolytics. Both plates are often insulated from the metal case. The larger sizes are simply called oil-filled capacitors. On these the terminals are often insulated from the case by porcelain or rubber, especially where the working voltage is higher than 600 volts. Oil-filled capacitors are usually larger and carry higher voltage ratings than electrolytics. However, as the oils are more expensive and less likely to be carried in a service shop's stock, you can replace with electrolytics, observing capacitance and voltage rules.

If you haven't a capacitor with a voltage rating high enough for replacement, you can series two lower-rated units, as illustrated in Fig. 5, to be within safe limits. But they must be equal in both voltage rating and capacitance, and remember that the total capacitance is now one-half the value of each. To equalize

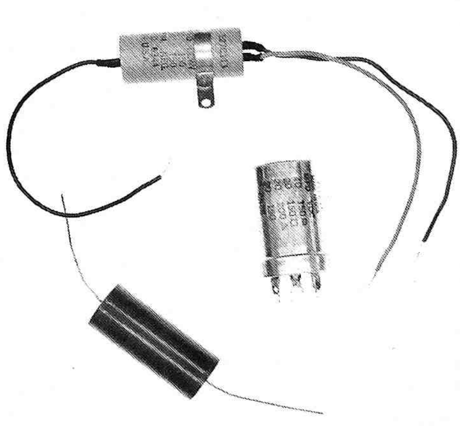


FIG. 4. Power-supply filter capacitors.

voltage drop across each filter (so the rating isn't exceeded) you should shunt each with a divider resistor, as shown. The approximate value should be 1000 ohms for each volt of B plus across the resistor. Then figure the power through each resistor, double it, and use the next higher size available. The divider can serve as all or part of the bleeder for the supply.

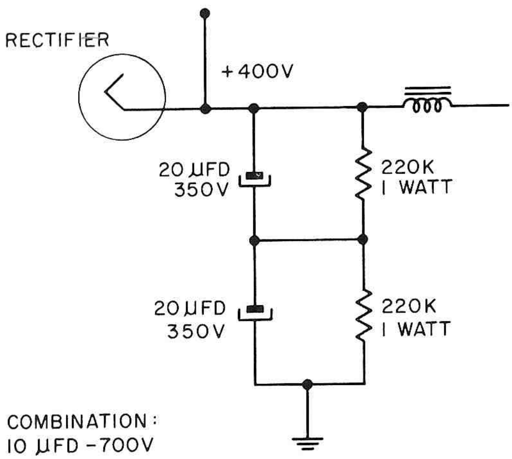


FIG. 5. Series capacitors for higher voltage rating.

In the smaller voltage ranges -- from 5 to 50 volts, used chiefly in transistor applications -- electrolytics often look like paper tubulars, with a metal case and axial leads. Some have a clear plastic sleeve to prevent undesired case grounding. For high reliability sintered Tantalum types are used, mainly in military and communications work. They are more expensive, but there's no danger of leakage or temperature effects, and they last longer.

VARIABLE CAPACITORS

It isn't often that you'll need to substitute variable capacitors. When you do, the only rule you need remember is that you can always substitute greater range, if the increase isn't more than about 20% or 30%; you can seldom substitute lesser ranges. This assumes, of course, that size is not a factor or that the two are identical. For example, you can substitute a capacitor with a range of 10 to 150 pf for one with a range of 15 to 150. The only difference is that the tuning will cover a slightly larger range, and in some spots it can be crowded. If you try to use a slightly smaller range you can still get by sometimes, as designers often include a safety margin in tuning which you can do away with. Of course, this applies only to relatively non-critical applications, such as the tuning capacitor in a small AM receiver.

BOOKS

ELEMENTS OF TRANSISTOR TECHNOLOGY
by Robert G. Middleton

An informative reference source covering the intricacies of the various semiconductor devices used in today's electronic circuitry. Although a basic knowledge of electronics by the reader is assumed by the author, the book is "easily" written in an interesting style.

Published by Howard W. Sams and Co., Inc. Indianapolis 6, Ind. $6.95.

AUDIO MEASUREMENTS
by Norman H. Crowhurst

Not a late release - but one of specific value to technicians engaged in the installation and repair of hi-fi and stereo equipment. The author is well known in the audio field and gives a very comprehensive coverage of measurement techniques, test equipment, basic measurements, amplifiers, transformers, preamplifiers, pickups and arms, turntables and changers, tape recorders and microphones. A well written handy reference of material for the service technician and to the audiophile.

Published by Gernsback Library, Inc. 154 West 14th St., New York. 224 pages. Soft cover. $2.90.

HANDBOOK OF TRANSISTOR CIRCUITS
by Allan Lytel

A compilation of transistor and rectifier circuits used for a variety of applications. More than 200 practical transistorized circuits are included for use in counters, timers, indicators, power control, photoelectric devices, regulations, amplifiers, power supplies, oscillators, converters and other applications. Technicians and students of semiconductor circuitry will find the circuits of interest and value in obtaining a better understanding of these devices.

Published by Howard W. Sams and Co., Inc. Indianapolis 6, Ind. 224 pages. Soft cover. $4.95

Low Cost Isolation Transformer

BY JOHN GARDNER

You can build a low-cost isolation transformer and safeguard yourself from accidental shock when working on AC-DC sets. All you need are two old TV power transformers and a few junk box parts.

First obtain the power transformers -- and the bigger the better. You don't have to know the exact voltages, but you should try to get identical units if possible. If they are exact twins, you won't have to worry about juggling secondaries to obtain proper output voltage. Before you go any further, use an ohmmeter to check for any possible open windings.

If no windings are open, lay one transformer on its back and separate all leads carefully. See Fig. 1 for the color code and wiring arrangement for the preliminary test. Connect a 3-amp fuse in series with the primary and connect to an AC plug. Be sure no leads are touching, but connect the ground side of the voltmeter to one side of a winding. Then plug in the primary of the transformer. If the fuse blows, you've either got two leads touching or a shorted winding. If a winding's shorted, discard the transformer and try another. If the fuse does not blow, touch the voltmeter's hot probe to the other end of the winding and make a note of the voltage. (Don't connect both voltmeter probes and then plug in the transformer -- transients could destroy the meter movement.) Repeat this measurement for each secondary, noting voltages. Don't worry about absolute accuracy here; what you want is a comparative reading.

After you've read all secondaries on the first transformer, repeat the process for the second. With twins, voltages will be almost identical. With dissimilar units, there may be slight discrepancies. However, the system will still work.

Now you must connect all secondaries (except HV) of the first transformer in series. The simplest way to do this is by connecting the voltmeter to one lead of the rectifier filament winding; then connect the other end of the rectifier winding to one end of the amplifier filament winding. See Fig. 2. Plug in the transformer, touch the other voltmeter probe to the open end of the amplifier winding, and note the voltage reading. Unplug the transformer and remove the VOM probe from the amplifier filament winding. Now break the common junction between the two filament windings and connect the other end of the amplifier winding to that common point. (In other words, reverse the leads on amplifier winding.) Plug in the transformer and place VOM probe on empty lead, again noting the reading. You'll find one connection gives a higher voltage reading than the other. For instance: 12 volts and 2 volts for typical 6-volt secondaries. The higher-voltage connection is the one to use -- it indicates the windings are then series-aiding. The lower reading indicates the windings are series-bucking, and should not be used.

If there is a third filament winding, connect it in series with what you already have, repeating the above process. But do not connect the high-voltage secondary -- since it was never made to carry much current. It would limit the entire isolation transformer current to a very small amount, thus partially defeating your purpose. Carefully tape each HV lead back on itself, being careful to avoid any shorts. When you've finished connecting the leads on the first transformer, do the same on the second.

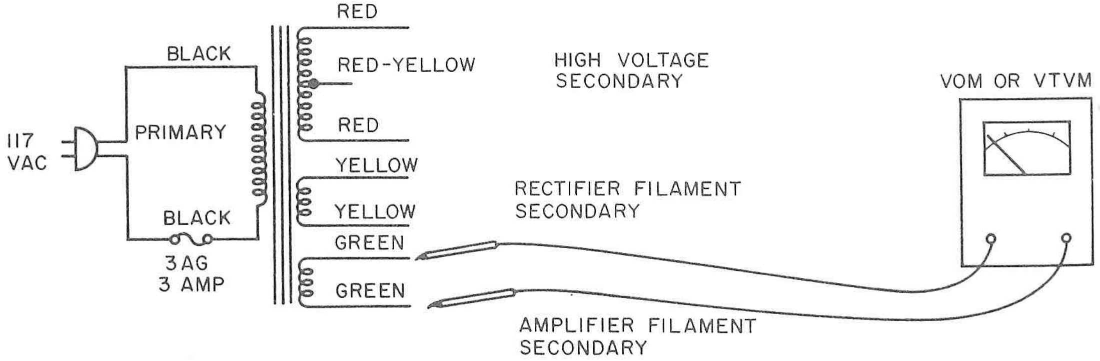


FIG. 1. Measure secondary voltages.

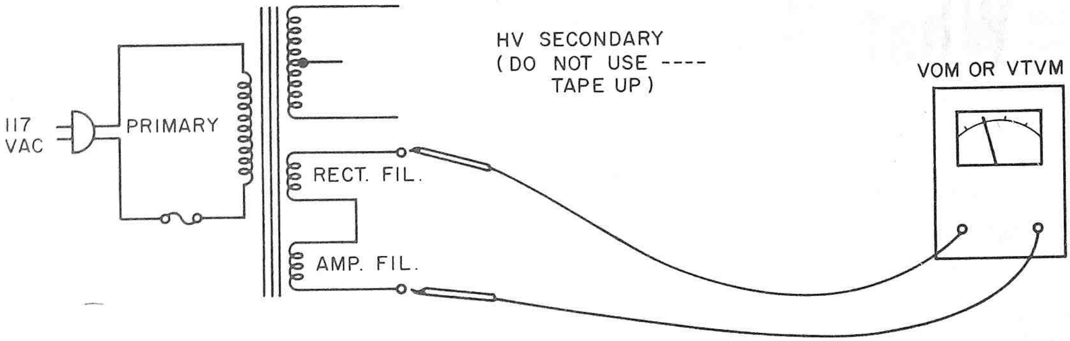


FIG. 2. Connect filament secondaries in series; meter shows if they add or buck.

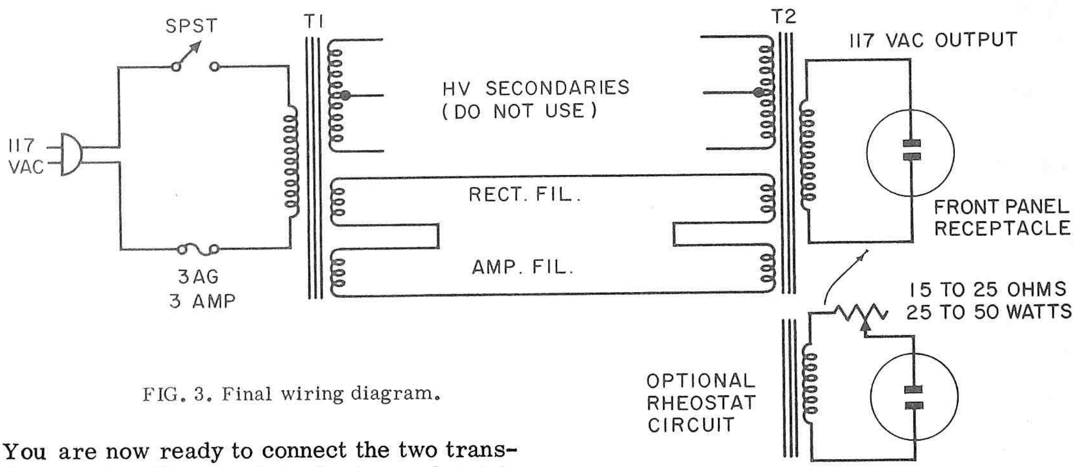


FIG. 3. Final wiring diagram.

You are now ready to connect the two transformers together, back-to-back, as shown in Fig. 3. See Fig. 4 also -- it shows you how to mount the transformer: at right angles and at opposite ends of the chassis. Any chassis will do -- even wood. Make all connections underneath, and use terminal strips, soldering all leads firmly in place so there's no shock hazard. If you like, you can mount the AC receptacle on the front of the chassis apron; or you may prefer to mount a panel on the front and put the receptacle there. You'll also want to put the SPST switch in front, as well as the fuse mount. Try a thumbscrew assembly (3AG size) as it's easiest to replace. Since both the fuse and the switch are in the AC line ahead of everything, they kill all voltage when either is open.

If you find, after hook-up, that you've got a great deal less than 117 volts, turn the entire electrical assembly around. Make the input transformer the output, and vice versa. This will give you more than 117 volts, and you can install a rheostat in the circuit feeding the front-panel receptacle, as in Fig. 3. The rheostat will let you drop the voltage back to 117 -- or even lower, for certain tests. Although the amount of voltage control will depend on how much current you pull through the rheostat, if you never use more than 1.5 amps and don't need to drop more than 20 volts you can get by with a 15 to 25 ohm rheostat rated at 25 to 50 watts.

If you want a further refinement, mount insulated pin jacks on the front panel and connect them across the output receptacle. This will let you use your voltmeter to monitor output voltage; it helps when you want to put low line voltage into a receiver to check for oscillator dropout.

Don't add a second receptacle, and don't use

(Continued on page 17)

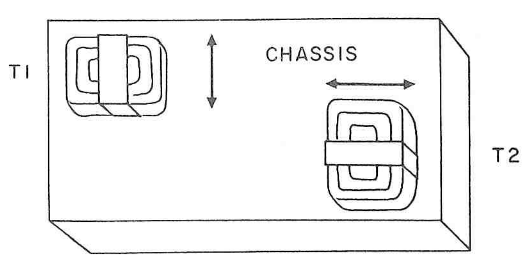


FIG. 4. Place transformer laminations at right angles to each other and as far apart as possible.

What Would You Have Done ?

TEST YOUR SERVICING KNOW-HOW BY MATCHING WITS WITH LUCKY LYTEL

BY GEORGE D. PHILPOTT

Inventory time served a dual purpose at Lucky's TV Shop in Suburbia U. S. A. An itemized accounting of tubes and parts not only furnished Lucky with a semi-annual check on items purchased and sold, but just as quickly informed him of any service techniques that might, unfortunately, be getting old.

Whistling softly to himself, the slender, greying, shop-owner added another set of figures to a column of figures on the pad in hand, slowly pushed shut a drawer which he had been searching, and turned and walked towards the rear of the shop. His normally quiet voice might have sounded slightly sympathetic to anyone but his helper, Super-Sonic Smith, actively occupied at a back bench.

Lucky dropped the pad in front of the younger technician and began - "Last year, Super, it was tubes. We managed to give away nearly three hundred tubes ... big tubes, little tubes, and middle-sized tubes. Recall? You'd try them ... uh, I mean, WE would try these tubes in TV sets -- and forget and leave them in. Presto! so-long tubes. Another hundred, maybe, we nearly lost because we didn't turn in our new-tube replacements before expiration dates ..."

Sensing the urgency in the boss's tone, Super-Sonic squelched again and immediately cast a quick eye at the incriminating Inventory sheet. "Yeah, Boss," he replied thoughtfully, "for several days there it looked bad ... as if we might have had a second-shelf man in the store. I mean, a gang of tubes just don't go f-s-s-t - like a bunch of blown fuses - and then disappear. Do they? ... more haven't, have they?"

Came the pause that might have refreshed Super-Sonic, had he caught the grin on Lucky's profile. But he missed. The shop-owner finally continued: "I am very happy to report that our tubes no longer are going, f-s-s-t, and mysteriously departing. Marking them down on the repair tag at installation, in red, licked this problem. Double-checking each set before it leaves the shop helped, too," he added.

"That's a relief!"

"Don't get too relieved, Speedy Gonzales," Lucky chided, on occasion trying out a new nickname on his helper, "something else has taken the place of the tubes. And I'm not kidding you when I say they probably went f-s-s-t in a hurry!"

Shifting uncomfortably on his metal stool, Super-Sonic changed color slightly, towards the red end of the spectrum, and appeared to be very deep in thought.Lots of new TV parts had disappeared up a verbal smokestack, charged to experience, so-to-speak, in the past eight or ten months. "Accidents will happen", he always told himself on these occasions. More than that, he knew Lucky expected a few such incidents. Super-Sonic was the first one to admit - to himself - that he didn't know everything. The only components he could recall actually having had trouble with - numerically - were the fusistors. He explained, "Truthfully, Boss, I can't think of anything we should be short of ... unless it's a few fuses and fusistors. I guess maybe I did get a little careless at times."

Lucky laughed, not unkindly, at the sheepish look in the young man's eye, and replied, "Lad, in some ways, you amaze me - not many technicians could get rid of two hundred and fifty fusistors in six months. We've charged for about fifty, have maybe ten or fifteen in stock ... Say, you haven't been eating them, have you?" he asked.

Super-Sonic swallowed pretty hard, hard enough to have swallowed a fusistor or two, saying, "Sometimes a fellow can't help blowing the darned things. The receiver needs a fusistor. You put it in. On comes picture and sound. It plays a few minutes - then pop - something's wrong! You need a new fusistor."

"A very interesting run-down on how to blow fuses," commented the boss, dryly. "I suppose that job in front of you is one of those fuse-blowers, too? I see a small handful of my fusistors in front of you?"

"As a matter-of-fact, yes, Boss, it is. This one came in with an open line. It played for an hour before the new fusistor kicked out. I think I know what did it, though."

Lucky closed his eyes and rubbed his forehead. After his urges had subsided again, he resumed his stature and pulled-up a stool. "Super," he began, "try to absorb what I am about to explain to you concerning fusistors. First, we are going to consider only those used to protect the low voltage section of a TV set. Glo-Bars and Thermistors are another subject.

"I'm locked-in, Boss."

"Okay," Lucky grinned, "you should be, you've been out of sync long enough. Now, as every experienced technician knows, a condition known as cycling is always present across a fuse, or fusistor, in an AC line. This condition amounts to a 60-cycle thermal wear on the fuse element, per second. After a certain time, this microscopic action, plus the numerous current surges from turning on the receiver, may eventually deteriorate the fuse element and the unit will open. However, it doesn't happen too often, and you should never count on it as a reason for the fuse, or fusistor, being blown. The fuse is a safety device and should be thought of in this light. Do I make my point?"

Super, scratched his blond noggin: "Caughtcha, Boss. Something wrong usually pops the fuse. Right?"

"That's the general idea, all right. A flaking or arcing damper tube is usually the number one suspect. Sometimes, these babies are tough to detect, I'll admit. Next, horizontal amplifier tubes can short, turn gassy, or overload the B plus circuitry because of insufficient grid-drive from the horizontal oscillator. Any of these conditions can be evasively intermittent. Shorted silicon rectifiers and filter capacitors blow fusistors without delay. Once-in-awhile, other circuit components turn out to be the bad actors, but usually any overload originates somewhere in the circuits I've mentioned - the fuse-blowing type of overload, I mean."

"Makes sense," Super-Sonic agreed, "but, Boss, to check-out a set I've got to have it cooking. If I short the fuse-clip and run it without a dropping resistor in series with the rectifiers and the filters ain't I taking a chance on ruining them?"

"You are. But there's an answer to that problem, too. Due to the fact that fusistors are by-far the most popular protection device in late model sets, averaging 5.6 ohms, or slightly higher, in resistance, it is possible to know and measure the load across them. When you are checking a receiver for a possible overload, this is the procedure ..."

(Answer on page 26)

The Diode (Cont. from P. 9)

characteristics. These are not effected for the operation of this low noise, light weight device. The diode is small and the circuitry required is relatively simple.

Tunnel diodes will not replace active components (transistors and vacuum tubes) but will enhance the functional value of these components by aiding them in their tasks.

These special-purpose diodes are adding to the usefulness of the diode in circuitry more than ever. At one time the diode was a simple device that was thought of as a rectifier or detector and that was it. No more. Now diodes do jobs that are as sophisticated as any of the other electronic devices, in addition to their old chores.

Remember that this two-element device was the basis for Deforest's triode. He placed a third element in the diode and spurred this world of electronics onward to a brilliant career. The next time you have a schematic in front of you, check the number of functions performed by the versatile diode - you'll be surprised. Heretofore, you have probably taken it for granted, but when you have a job to do electronically, we doubt if you get by without at least one diode! -30-

Low Cost Isolation Transformer

(Cont. from P. 15)

a cube tap to plug in more than one unit. If you have two or more units plugged in on an isolation transformer you defeat the purpose. If one or both receivers are AC-DC you'll have a shock hazard on the bench. Also, don't wire any part of the circuit to the chassis on which it's mounted -- let it float and you won't have a shock hazard.

The power rating of this home-made unit will depend on the size of the transformers. Generally, you can expect to drive radios and amplifiers up to an hour or so before you'll have to shut down for a cool-off. A TV set will safely run for at least 15 minutes. To be safe, use the transformer on intermittent duty only -- 15 minutes on, 15 minutes off. -30-

COMING NEXT MONTH

TV Distribution Systems

DEVICE OF THE MONTH

Quartz Crystals

BY R. C. APPERSON, JR.

Can you imagine, while trying to enjoy radio or TV, having to get up constantly to retune - or maybe just sitting and listening as one station drifts out and another drifts in? This would have one novel effect: an audio parade for your listening enjoyment! Not a very pleasant thought, eh? This could be the case if it weren't for a crystalline growth called quartz. This rocklike substance controls the entire radio spectrum, wherever stability is necessary. Since it plays such a great role in our lives as members of the electronics clan and also as entertainment loving human beings, we should know more about the physical and electrical characteristics of quartz.

The crystal is usable because of the piezoelectric effect. This is displayed when a voltage is applied to opposite sides of a slab of crystal which has been cut to a given dimension. The crystal slab will start to vibrate. This in itself means nothing. The secret is that the vibration occurs at a precise frequency which is determined by the slab size. We call this mechanical resonance. In passing, it should be pointed out that the piezoelectric effect can be reversed. By twisting the slab mechanically, a voltage is generated between opposite faces of the crystal. In our discussion, this phenomenon will have no bearing, but is a nice bit of information to store for later use.

The quartz resonator is used in frequency stabilization applications such as broadcast transmitters, precision oscillators used in laboratory testing, calibrators for determining unknown frequencies and producing markers at accurately spaced intervals and in filter applications. The quartz lends itself well to filter arrangements, since it has a very high Q, meaning narrow bandpass.

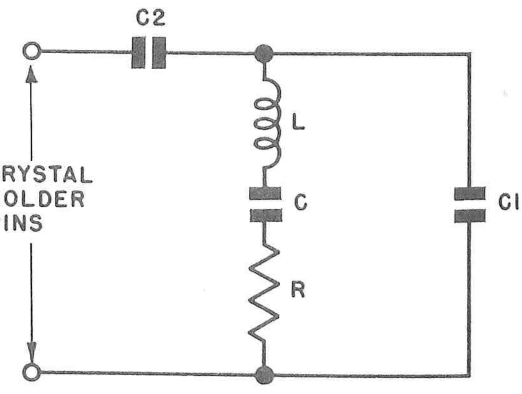
We mentioned that crystals are cut to various frequencies and that size is a determining factor in the frequency of operation. This is true, but another factor is the plane in which the cut is made.

Since the cutting of crystals is a task which most of us will never encounter (and is covered thoroughly in textbooks), we will not delve into the many aspects of this art. We will want to know how to use the crystal and how to care for it to preserve its life.

Schematically, we recognize the crystal by this symbol

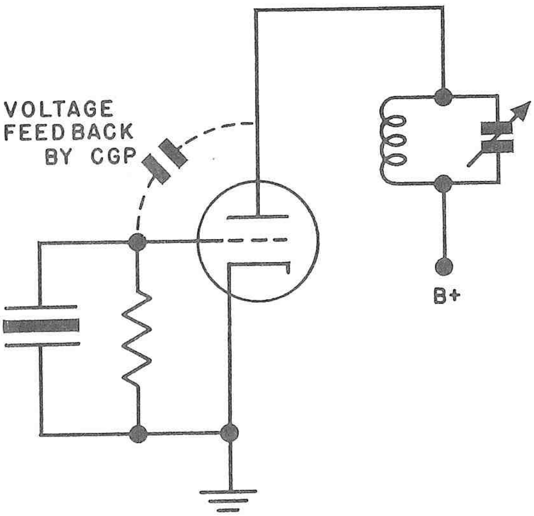
which represents the slab and the two metal holding plates. We will find this symbol in most transmitter oscillators, usually in the grid (or base) circuits.

Knowing that metal plates hold the slab by being applied to parallel surfaces, it is reasonable to assume that capacity is present. It is. The equivalent circuit will show us that not only capacity, but inductance and resistance are present. Here is the equivalent circuit.



L, C, and R are the mechanical characteristics of the crystal. They are the mass (L) which is the mechanical equivalent of inductance, resilience (C) or mechanical capacity, and friction, electrical resistance. C2 is a series holder capacity (present only in air gap holders) and C1 is the crystal slab acting as a dielectric between the plates. These characteristics should be noted, since they demonstrate how the mechanical quartz structure resembles the resonant tank circuit which it replaces in stabilized circuitry.

This leads us to the actual circuitry. The Miller crystal oscillator is used extensively in transmitter applications.



Examining the circuit, we see that it is essentially a tuned plate-tuned grid oscillator. The grid tank circuit is a mechanical tank, our crystal.

Feedback is applied as it is in the TPTG oscillator. This feedback voltage must be at the crystal frequency (within a very narrow band) or the circuit will not oscillate. It is possible to adjust the frequency of the feedback voltage to the proper point by tuning the plate tank circuit. A point in passing: this adjustment should be made by a qualified technician (holder of at least a second class FCC licence) in most cases. Make sure that it is permissible for you to adjust before undertaking the job. The second class license does not apply to the amateur bands, but here again, a ham license holder is a qualified technician.

The crystal needs special consideration in handling. It is a very thin wafer of brittle material and will break or chip if not handled with care. The slightest chip will affect the operating point - this cannot be tolerated in a controlling device with a close margin of allowable error.

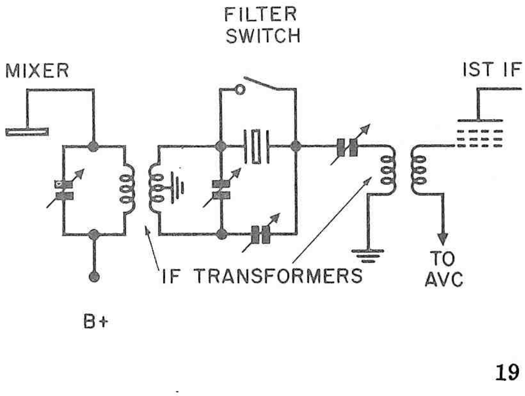
Some crystal holders permit access to the wafer. If it is ever necessary to handle the crystal wafer, it should be cleaned with care after handling. Pure grain alcohol or carbon tetrachloride are two recommended cleaning agents. The rule to follow is HANDS OFF!

Crystals are, by nature, not very temperature sensitive. They do shift slightly, though. In areas where the climate changes abruptly, a problem might arise. This problem becomes more severe when a crystal is within the allowable tolerance, but closer to the outer limit than to the center frequency. One day the transmitter may be very close to nominal operating frequency. The next day the weather might change. The temperature change will cause the transmitter to be out of tolerance, since the crystal shifted in the opposite direction and went out of its specifications.

This problem we can beat. A crystal oven is employed which holds the crystal's environment constant. These ovens are also used in precise devices, such as calibrators, counters and marker generators. They operate from either AC or DC, depending upon their design, and are thermostatically controlled. The temperature on some expensive ovens is adjustable, but most are fixed.

Crystals are found in many filter applications. If we consider the crystal as being a tank circuit, it is easy to imagine places that it would appear as a filter.

What is a filter? A filter is a device tuned to trap out (or let pass) some frequency. It is usually made up of inductance or resistance and capacitance. This combination will resonate at the frequency at which it is tuned. This is why the crystal works so well. It more nearly filters the one frequency, since it has a high Q. We see an application here in a broadcast receiver.



where selectivity is necessary in communications in which many pieces of intelligence are riding carriers close together in the frequency spectrum. Since the intermediate frequency is fixed, a crystal may be used satisfactorily. It is evident that the crystal could not be used in, say, the rf stage, since this is tuned to many frequencies manually, and would require a crystal for each setting of the tuning capacitor.

Another place the communications technician may expect to find crystals is in the local oscillator of a receiver. Since the channel allotment is very narrow on many bands, the receiver must be almost as stable as the transmitter. The crystal controlled receiver not only gives stability, but allows for switch-tuning to various channels. You are sure that your receiver is tuned to the same channel that you are transmitting on if this arrangement is used in a transceiver.

The crystal (although its holder is stamped with a certain frequency) is not always used at its fundamental frequency. By treating the quartz, it is made to resonate at an overtone, which is close to a multiple of the fundamental. The reason this is done is because of the size limitation as frequency increases. The information furnished by the manufacturer will usually specify on which overtone the crystal is operating. The case will be stamped with the overtone frequency, but the specifications will say "27.225 mc, 3rd overtone", as an example.

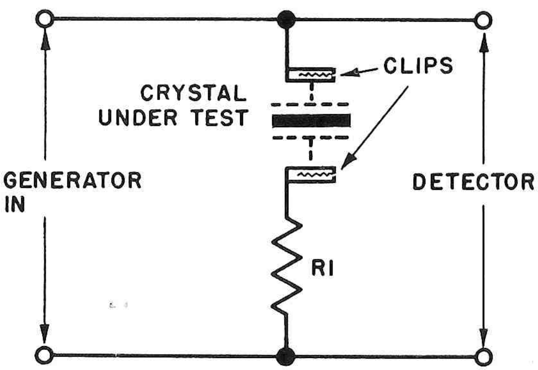
The circuit of the month is intended to demonstrate the operation of the device of the month and also be useful to the builder. This circuit is simple, but fits the description of the letter. It is a crystal checker, which allows you to find the approximate frequency of operation and the activity of the crystal. To make it universal, clips are provided to attach to the crystal. Sockets may be wired in parallel, if you care to purchase a selection of common crystal connectors. Also, since the frequency range is so great, an rf generator is necessary. A built-in oscillator would be too great an undertaking. The detector is either an oscilloscope with a good frequency response, or a VTVM using an rf probe.

The circuit is very simple. The crystal is placed in the circuit as a filter. When the resonant frequency (watch it, or you'll miss it!) is tuned to on the generator, current is allowed to flow through the resistor and a voltage is dropped across the resistor. This is what we detect. The sharpness of the resonant peak denotes the Q and the voltage across the resistor as compared to the output of the generator tells us whether the crystal is active or not. The voltage should compare well to the generator output.

The frequency may be read from the generator. It is hard to determine the frequency of an unstamped crystal, since it will respond to the fundamental as well as harmonics and overtones. The circuit is intended to verify marked crystals, not identify unknown ones.

In closing, we would like to quote a scientist of a bygone era, Lord Kelvin. "I often say that when you can measure what you are speaking about and express it in numbers, you know something about it, but when you cannot measure it, when you cannot express it in numbers, your knowledge is of meager and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of science, whatever the matter may be". The quartz crystal has allowed us to control, measure, and therefore know our science.

THE CIRCUIT OF THE MONTH



THE CRYSTAL CHECKER

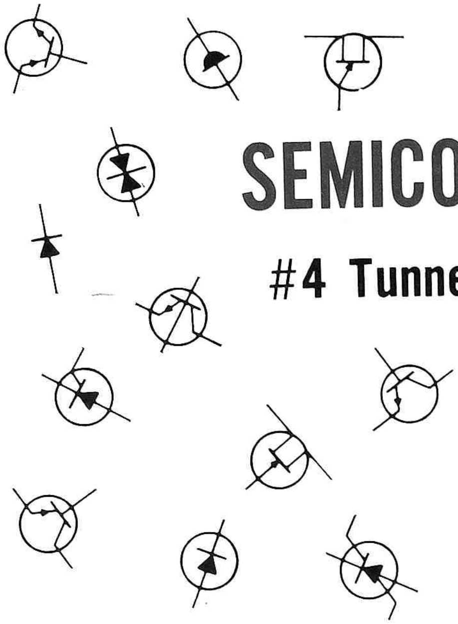
PARTS LIST

R1 - 10K 1/2W.
Misc. Items:

Alligator clips
4 pin-jacks or 4 binding posts

COMING NEXT MONTH

Build Your Own Electronic Flashing Signal



SEMICONDUCTOR REVIEW

#4 Tunnel Diodes

BY

JOHN POTTER SHIELDS

The tunnel diode represents one of the most important semiconductor developments since the transistor. The device so named because of the "tunneling effect" occuring at the junction of a heavily doped P-N diode, was first observed by Dr. Lee Esaki.

The tunnel diode makes an ideal circuit element for a number of reasons. Its ability to operate at extremely high frequencies (up into the microwave region) makes it an ideal supplement to the transistor at these high frequencies. The "two terminal" nature of the tunnel diode greatly simplifies its use in circuitry, and its small size and relative freedom from radiation effects make it an ideal unit for outer space applications.

The tunnel diode owes its usefulness to the fact that it is "a package of negative resistance" and as such, can deliver energy to a circuit. This, of course, is in contrast to a conventional resistance which absorbes energy from a circuit. While the tunnel diode is not the first practical form of negative resistance, point-contact transistors and pentode vacuum tubes when operated over a certain portion of their characteristics also exhibit negative resistance, the tunnel diode is the most stable negative resistance device to date.

A good understanding of the tunnel diode's basic operation can be gained by a look at Fig. 1, which shows the voltage-current characteristics of both a tunnel diode and conventional P-N silicon rectifier diode. As you can see, in the case of the conventional rectifier diode, forward current doesn't begin to flow until a forward bias of about .5 volts is applied. In practice, this so-called "offset" voltage will vary depending upon the particular type of semiconductor material involved.

In the reverse bias direction, the conventional diode presents a high resistance until reverse bias is increased to the point where it breaks down, with a resultant increase in current flow. This breakdown point is often referred to as the "zener point". The diode will return to its high resistance state when the reverse bias is reduced below the zener point ... if the reverse bias is limited to the rated value.

As shown in the comparison curves of Fig. 1, the tunnel diode will conduct in either the forward or the reverse direction with only a slight amount of bias. As the forward bias

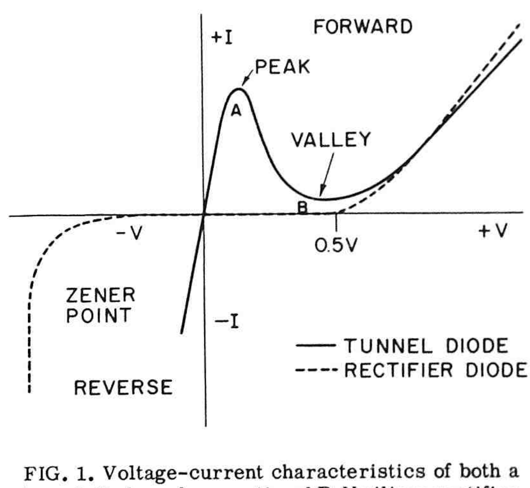


FIG. 1. Voltage-current characteristics of both a tunnel diode and conventional P-N silicon rectifier diode.

on the tunnel diode is increased, the forward current increases, reaching a maximum (peak), then drops to a much lesser value (valley), and then finally increasing as in the case of the conventional rectifier diode.

Notice that between points A and B in Fig. 1, the tunnel diode's forward current decreases with an increase in forward bias, indicating a condition of negative resistance. This property enables the tunnel diode to function as an amplifier or oscillator as it is capable of delivering energy to a circuit.

While the theory behind "just how" the tunnel diode operates is quite complex, involving the principles of quantum mechanics, basically what happens is that a change carrier injected into one side of the tunnel diode's P-N junction will almost instantaneously reappear in the other side of the junction. This tunneling action occurs at nearly the speed of light. The effect is as though the charge carrier had "tunneled" under the P-N junction.

The width of the junction is made extremely thin by very heavy doping of the semiconductor P-N section, thus further enhancing the charge carrier speed to travel across the junction.

Early tunnel diodes were fabricated from silicon or germanium. Subsequent investigation has shown that semiconductors such as gallium arsenide produce a greater peak to valley voltage swing.

To produce a gallium arsenide tunnel diode, gallium arsenide crystals are sliced into wafers and etched to provide a clean surface. The wafers are next doped with suitable impurities by diffusion; this is done by enclosing them in an evacuated container with the desired doping agent such as zinc or cadmium and free arsenic. This diffusion process results in the formation of the P type portion of the diode.

The diode's N type portion is formed by alloying a dot, consisting generally of lead or tin doped with sulphur, onto the previously prepared P type wafer. The P type wafer base is connected to a base-plate and a small wire is connected to the N type dot. This assembly is encapsulated in a suitable hermetically sealed package.

TUNNEL DIODE OSCILLATORS

Fig. 2 shows how a tunnel diode may be used in a simple sine wave oscillator circuit. Battery B1 provides operating power for the circuit, while resistors R1 and R2 form a

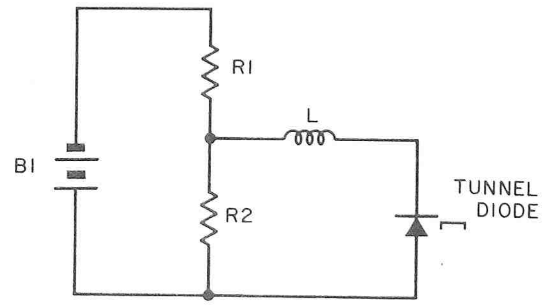


FIG. 2. Schematic showing how a tunnel diode may be used in a simple sine wave oscillator circuit.

base impedance voltage divider, the values of which are chosen to bias the tunnel diode in the negative resistance portion of its operating characteristics. Oscillator frequency is determined by the value of series inductance, L, and the shunt capacitance of the tunnel diode.

Fig. 3 illustrates the use of a tunnel diode as a 100 kc crystal oscillator. The circuit's frequency of oscillation is controlled by the crystal due to the fact that at off-resonance, its impedance is extremely high, and the resistances of R1 and R2 are too high to allow oscillation.

NOVEL CIRCUITS– AN FET IMPEDANCE MATCHER

The availability of inexpensive germanium Field Effect transistors (Texas Instruments type TIX-880) makes practical their use in a number of interesting experiments. A good example is its use as an impedance matching device which is handy in matching such high impedance devices as crystal or ceramic phono cartridges (or microphones) to low input impedance transistor amplifiers.

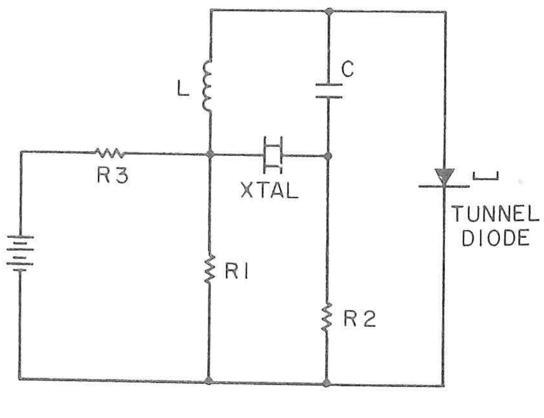


FIG. 3. Use of a tunnel diode as a 100 kc crystal oscillator.

As shown in Fig. 4, the unit is very similar to a transistor emitter follower, although in this case, the low impedance output is taken from the FET's "source" electrodes and the high impedance input signal applied to the "gate" electrode.

The circuit exhibits an effective input impedance of well over one megohm and will accept an input signal up to one volt before overload occurs due to the degenerative nature of the circuit.

The small size and low current consumption of this little circuit makes it ideal for inclusion in the housing of an inexpensive crystal microphone, thus making it compatible with any transistor amplifier.

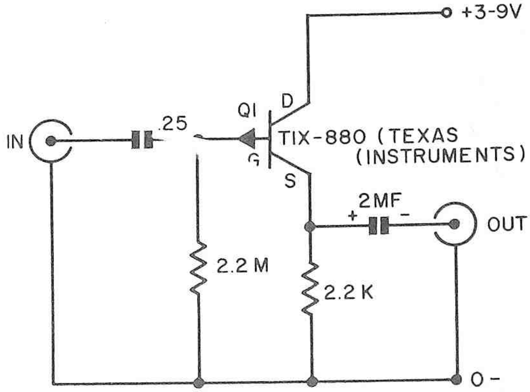


FIG. 4. Circuit showing FET transistor used as an impedance-matching device.

CB Transceiver "Ping"

Citizens Band transceivers sometimes develop an annoying, on-the-air, "ping", during the transmit-to-receive switching. Relatively minor, at first, this trouble may become progressively worse. At best, ping will usually make a set-owner wonder what is going to happen next.

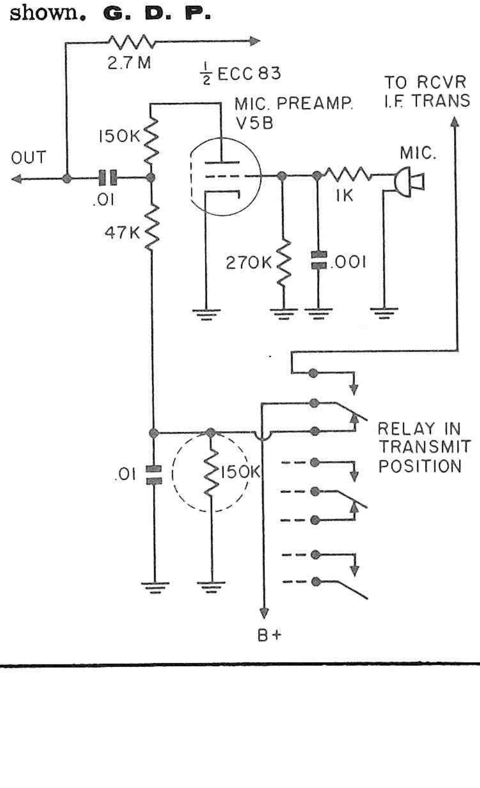
Such ringing sounds (often a squeal) originate, in most cases, as an audio feedback between the microphone and speaker, and happen at the precise instant when control relay contacts are tripping from the transmit-to-receive position. Oxidized relay contact surfaces, pitting, or reed spring-tension are generally the reasons why a relay becomes the offender. As you might expect, the remedy is cleaning with a good contact cleaner. A careful adjustment of the contact reeds may help. Occasionally, relay replacement is necessary.

The unusual circuit conditions responsible for the writing of this column, however, are entirely different from the above mentioned set of circumstances and appear to be a design problem, inherent in some model transceivers.

As shown by the partial schematic, microphone preamplifier stage of a Knight C-22 CB Transceiver, ping was finally isolated and traced to relay action—but not to actual contact failure or delay.

During transmit-to-receive switching of this unit, B+ voltage to the preamp section is cut off and fed to the receiver I-F strip. Thus, the preamplifier is made inoperative. A small fly-in-the-ointment appears at this instant, however, inasmuch as an active B+ charge is still left in the .01 bypass capacitor bridging this line and it is high enough to operate the stage for the brief part of a second that it takes for feedback to occur.

An effective cure for this condition is to install a 1/2 watt, 150K bleeder resistor across this capacitor, to ground, as shown. **G. D. P.**



AUTO RADIO SERVICING TECHNIQUES

PART II OF A TWO-PART ARTICLE **BY JOE GRIFFIN**

You can use either signal tracing or signal injection methods to isolate a defect in a weak receiver. Many servicemen prefer signal tracing because they can measure stage gain accurately. The procedure for using signal tracing is basically the same for servicing all types of radios. A tuned signal tracer should be used with transistor radios. You can begin at either end of the receiver and measure the signal level at the input and output of each stage. If you start at the loudspeaker and obtain a great increase in signal level at some point as you work toward the antenna, this indicates that you have just passed over the defective stage.

The procedure for using the signal injection method is basically the same for locating defects in tube-type, hybrid, or transistor radios. For transistor work, however, you should use a signal generator that has a low impedance output, such as a cathode follower, to match the low impedance of the transistor stages. The output of the generator should be adjustable to a very low level to prevent overloading the stages. Feed the signal first into the input, and then into the output of each stage, beginning at the antenna. Feed a modulated rf signal at the frequency of the receiver dial setting into the antenna, rf amplifier, and converter stages. Use a modulated rf signal at the receiver i-f frequency, to inject into the intermediate frequency stages. Be sure to switch the signal generator to audio output before applying the signal to the af stages. You can check the gain by listening to the audio output from the loudspeaker. The defective stage will immediately precede the point at which the gain suddenly increases to normal.

STAGE BLOCKING

You can use the stage blocking method to isolate noise, or a defect that causes a set to operate intermittently. The procedure is essentially the same for servicing tube-type, hybrid, and transistor radios. To block a stage in an automobile set that uses tubes, you can simply remove the tube from the socket. In a transistor set, you can short across the base-emitter junction, thereby removing the forward bias. To use the stage blocking method, start at the antenna and work toward the loudspeaker, blocking each stage until you reach a stage where you fail to hear the noise. This will be the stage where the noise is originating, or where the defect that causes the set to be intermittent is located.

Once the defective stage is isolated, you can usually make a few simple circuit continuity tests or DC electrode voltage measurements to localize the trouble to a particular tube or transistor circuit. This will eliminate quite a few parts from your list of suspects for the next step.

Use either an ohmmeter or a DC voltmeter to make tests in the suspected circuit (or the suspected defective stage if circuit isolating techniques cannot be applied) until you have tracked down the defective part. A logical procedure for locating the defective part in the circuit involves first checking the tube, in tube sets. Next, check the tube or transistor electrode supply circuits with a DC voltmeter.

In a tube set, check the voltages with respect to B- or chassis, after making sure that the main plate supply voltage to the stage is correct. If there is no voltage at a tube electrode, connect one probe to the chassis or B- and move the other probe along the supply circuit, part by part until you reach a point where you measure the normal voltage. By proper interpretation of the voltage readings, you can easily detect shorts or grounds.

Either NPN or PNP transistors may be used in transistor radio circuits. These two types of transistors require operating voltages of opposite polarity. Fig. 1 shows the proper relationship between the base, emitter, and collector voltages in both NPN and PNP type transistor circuits. Note that no matter which side of the supply voltage is grounded, the direction of current flow is the same at all times, (counterclockwise in the NPN circuit, and clockwise in the PNP).

In making resistance measurements in transistor circuits you will have to remove the transistors from the circuit in order to obtain correct indications of values of resistance. This is because the low internal resistance of the transistors would be in parallel with the part being measured which would give you an erroneous reading.

In servicing a defective transistor automobile receiver the following checks will aid you in making the repair. Use these checks in the same order as they are listed below.

1. Check batteries under load and use a battery eliminator when servicing.
2. Confirm the complaint and inspect for surface defects.
3. Localize the trouble to a stage.
4. Make voltage measurements and look for the proper relationship between the base, emitter, and collector voltages.
5. Check for shorted or open parts with your ohmmeter, and replace defective parts.
6. An abnormal base voltage usually indicates trouble in the base circuit.
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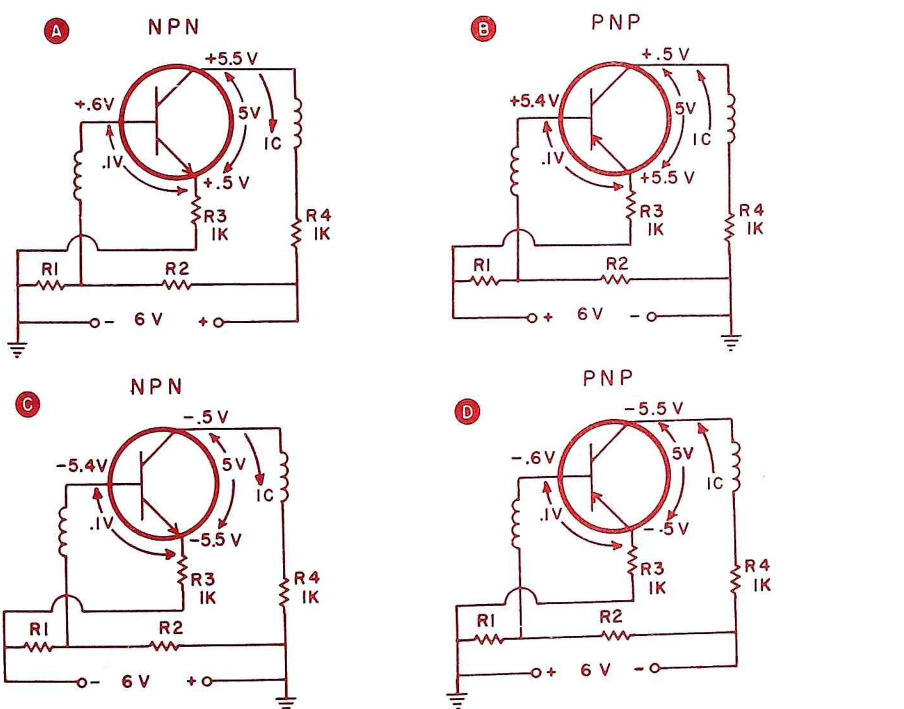

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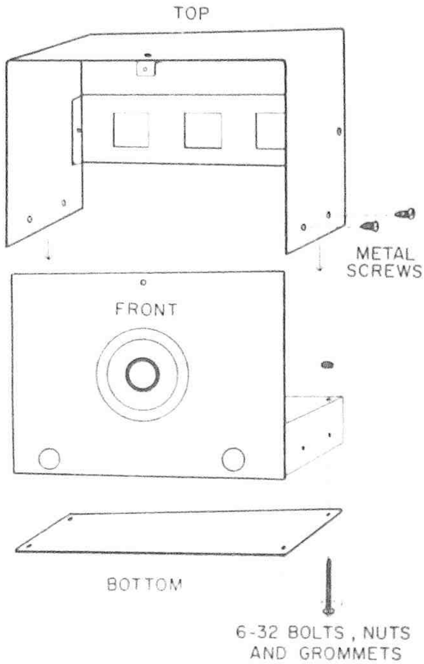

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AUTO RADIO SERVICING TECHNIQUES

PART II OF A TWO-PART ARTICLE **BY JOE GRIFFIN**

You can use either signal tracing or signal injection methods to isolate a defect in a weak receiver. Many servicemen prefer signal tracing because they can measure stage gain accurately. The procedure for using signal tracing is basically the same for servicing all types of radios. A tuned signal tracer should be used with transistor radios. You can begin at either end of the receiver and measure the signal level at the input and output of each stage. If you start at the loudspeaker and obtain a great increase in signal level at some point as you work toward the antenna, this indicates that you have just passed over the defective stage.

The procedure for using the signal injection method is basically the same for locating defects in tube-type, hybrid, or transistor radios. For transistor work, however, you should use a signal generator that has a low impedance output, such as a cathode follower, to match the low impedance of the transistor stages. The output of the generator should be adjustable to a very low level to prevent overloading the stages. Feed the signal first into the input, and then into the output of each stage, beginning at the antenna. Feed a modulated rf signal at the frequency of the receiver dial setting into the antenna, rf amplifier, and converter stages. Use a modulated rf signal at the receiver i-f frequency, to inject into the intermediate frequency stages. Be sure to switch the signal generator to audio output before applying the signal to the af stages. You can check the gain by listening to the audio output from the loudspeaker. The defective stage will immediately precede the point at which the gain suddenly increases to normal.

STAGE BLOCKING

You can use the stage blocking method to isolate noise, or a defect that causes a set to operate intermittently. The procedure is essentially the same for servicing tube-type, hybrid, and transistor radios. To block a stage in an automobile set that uses tubes, you can simply remove the tube from the socket. In a transistor set, you can short across the base-emitter junction, thereby removing the forward bias. To use the stage blocking method, start at the antenna and work toward the loudspeaker, blocking each stage until you reach a stage where you fail to hear the noise. This will be the stage where the noise is originating, or where the defect that causes the set to be intermittent is located.

Once the defective stage is isolated, you can usually make a few simple circuit continuity tests or DC electrode voltage measurements to localize the trouble to a particular tube or transistor circuit. This will eliminate quite a few parts from your list of suspects for the next step.

Use either an ohmmeter or a DC voltmeter to make tests in the suspected circuit (or the suspected defective stage if circuit isolating techniques cannot be applied) until you have tracked down the defective part. A logical procedure for locating the defective part in the circuit involves first checking the tube, in tube sets. Next, check the tube or transistor electrode supply circuits with a DC voltmeter.

In a tube set, check the voltages with respect to B- or chassis, after making sure that the main plate supply voltage to the stage is correct. If there is no voltage at a tube electrode, connect one probe to the chassis or B- and move the other probe along the supply circuit, part by part until you reach a point where you measure the normal voltage. By proper interpretation of the voltage readings, you can easily detect shorts or grounds.

Either NPN or PNP transistors may be used in transistor radio circuits. These two types of transistors require operating voltages of opposite polarity. Fig. 1 shows the proper relationship between the base, emitter, and collector voltages in both NPN and PNP type transistor circuits. Note that no matter which side of the supply voltage is grounded, the direction of current flow is the same at all times, (counterclockwise in the NPN circuit, and clockwise in the PNP).

In making resistance measurements in transistor circuits you will have to remove the transistors from the circuit in order to obtain correct indications of values of resistance. This is because the low internal resistance of the transistors would be in parallel with the part being measured which would give you an erroneous reading.

In servicing a defective transistor automobile receiver, the following checks will aid you in making the repair. Use these checks in the same order as they are listed below.

1. Check batteries under load and use a battery eliminator when servicing.
2. Confirm the complaint and inspect for surface defects.
3. Localize the trouble to a stage.
4. Make voltage measurements and look for the proper relationship between the base, emitter, and collector voltages.
5. Check for shorted or open parts with your ohmmeter, and replace defective parts.
6. An abnormal base voltage usually indicates trouble in the base circuit.
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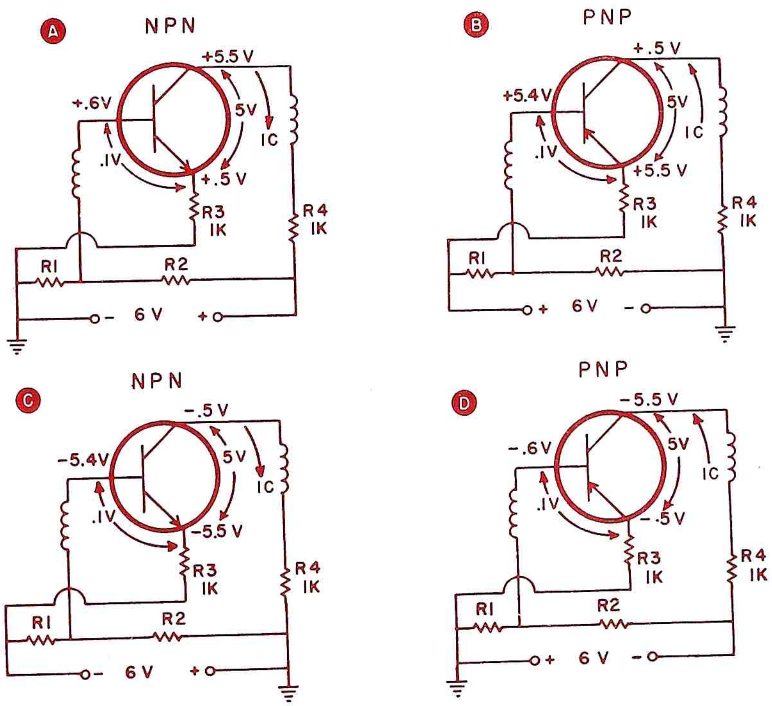

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Jiffy Cabinet

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Experimenter, technician, or set constructor, you undoubtedly will agree that no piece of electronic equipment - regardless of size - is complete without a cabinet. Yet, ready-built cabinets do not always suit the chassis, your imagination, or pocketbook. Custom-styling the unit is one answer. The following construction method features an easy-to-build, economical, and attractive way to house small receivers and testers.

Basically, any piece of electronic equipment consists of a chassis and front panel. (See drawing, center.) We therefore have part of our cabinet, to begin with. All we must do to have an easily accessible enclosure is to build around our basic unit.

First and last, we need a top, sides, cabinet back and bottom. The most practical metal to be used, of course, is ordinary No. 18 gauge sheet aluminum. Even No. 15 gauge is not too thick for bending-by-hand, should requirements demand it.

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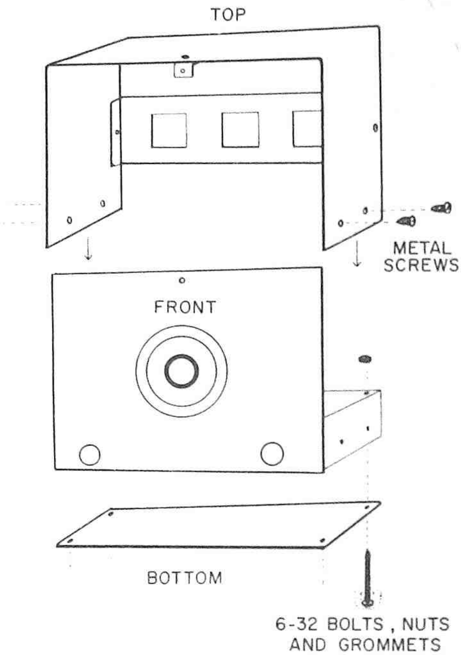
The front panel and chassis, usually held together by the various control shaft mountings,



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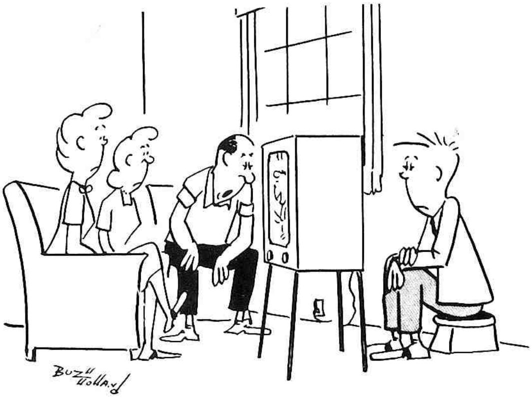
should be assembled so the front panel bottom edge extends slightly below the chassis. One eighth of an inch here is usually sufficient. This allows the bottom to fit flush against the inside edge of the panel. The bottom piece should be trimmed to the same size as the chassis and secured in place by 6-32 nuts and bolts extending upward, as shown. Rubber grommets on these bolts add a professional touch to the job.

The front panel edges are cut so they will be even with the ends of the chassis. The cabinet top requires a bit of careful measuring and bending. Aluminum, however, is very malleable and a slight error in bending the sides can easily be rectified by working the metal, using a small hammer, toward the fault in the original dimensions. To bend sheet aluminum, sandwich the stock between two pieces of 3/4" thick hard pine or maple boards. Be sure these pieces are square. Adjust the scribe line about 1/32nd above the boards. Clamp in a vise and bend. A perfectly square bend is possible by tapping the metal slightly, using another piece of wood, along the length of the bend.

As to styling, the leading front edge of the top and sides may be cut to extrude slightly, giving the popular 'canopy' effect. As shown, this cover is held in place by four bolts, or metal screws, secured into the sides of the chassis. An L bracket, front top center, adds rigidity to the case. The back piece is measured and cut to fit as shown. Adequate ventilation is acquired by cutting several holes in the back, using a 3/4" square Greenlee punch.

To snaz-up the job, try a two-tone crackle-finish of grey and black. G. C. Spra-Koat, available at any parts distributor, gives a beautiful finish. **G. D. P.** -30-



"Agnes tells me you're studying TV servicing".

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Enclosed is a down payment of $________ on the equipment I have listed on the reverse side. Beginning 30 days from the date of shipment I will pay you $________ each month until the total payment price is paid. You will retain title of this equipment until this amount is fully paid. If I do not make the payments as agreed, you may declare the entire unpaid balance immediately due and payable, or at your option, repossess the equipment. Your acceptance of this will be effected by your shipment to me of the equipment I have listed.

Date ________________ Your written signature ________________

CREDIT APPLICATION

Print Full Name ________________ Age ________

Home Address ________________

City & State ________________ How long at this address? ________

Previous Address ________________

City & State ________________ How long at this address? ________

Present Employer ________________ Position ________________ Monthly Income ________

Business Address ________________ How Long Employed? ________

If in business for self, what business? ________________ How Long? ________

Bank Account with ________________ Savings ☐ Checking ☐

CREDIT REFERENCE (Give 2 Merchants, Firms or Finance Companies with whom you have or have had accounts.

Credit Acct. with ________________ (Name) ________________ (Address) Highest Credit ________

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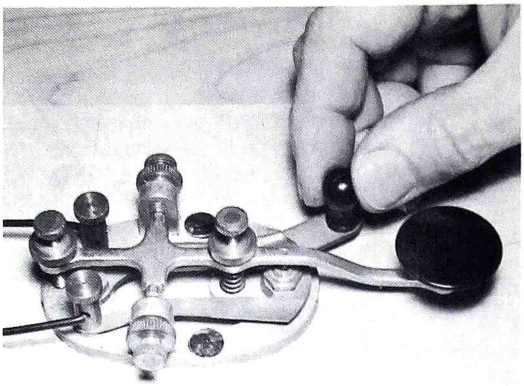
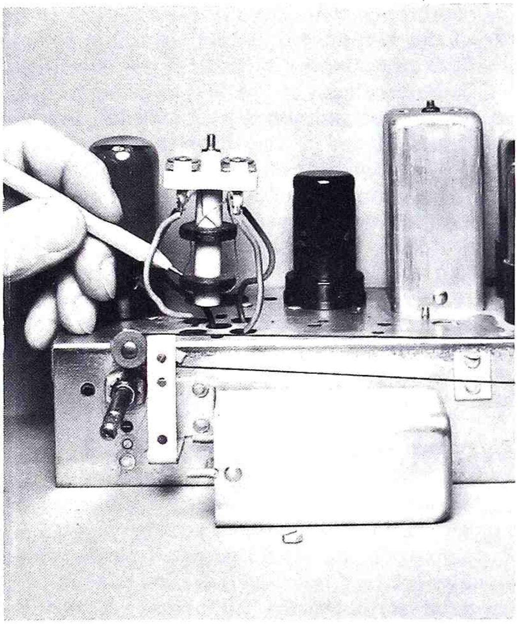
Transmitting Key Doubles as Two-Purpose Switch

In a pinch, that Government-surplus transmitting key comes in handy as a SPST throw-switch, or as a SPST momentary push-switch. As shown in the photo, simply connect your two leads to the key's binding posts in the usual way and you have a combination throw-switch and push-switch. The photo shows the key being used as an SPST throw-switch. This emergency switch is not recommended for use in high-voltage experiments because of danger of shock and possible damage to the key's contact points due to arcing. **A. T.**



Increasing Bandpass of AM Superhet Receivers



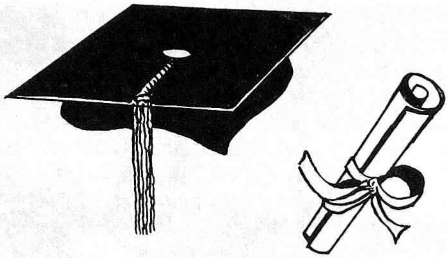
The pencil points to one of the coils in the i-f transformer. Carefully push the bottom coil a little closer to the top one to increase the bandpass of the receiver.

Some of the fellows buy old AM superhet receiver chassis, for a dollar or two, and use them as AM tuners for their hi-fi amplifiers and speakers. In this case, it's a good idea to try to increase the bandpass of the receivers, even if you have to sacrifice some selectivity for better quality. And selectivity becomes less important if you live in the smaller cities, or only listen to local stations.

Some of these old receivers have capacitor-tuned i-f transformers and cans that are easily removed by removing two nuts on the underside of the chassis, as shown in the photo. In this case, you simply remove the cans and push the two coils a little closer together to increase the bandpass of the receiver. You will have to experiment a little for best results; if you move the i-f coils too close together, selectivity may not be adequate for your area. The i-f stages should be realigned after you have put the cans back on the coils. You will be pleased with the boost in fidelity. **A. T.**

ON OUR COVER

Sperry Gyroscope Company technician performs final tests on one of a number of airborne radar sets being produced for the Air Force. Called the APN-59, the radars can handle search, surveillance, storm detection and other all-weather navigation work. The new sets will be added to 2,500 APN-59 radars already in Air Force service on such planes as the C-130B and the KC-135A. Technician is Conrad Hansen of Mineola.



ALUMNI NEWS

J. Arthur Ragsdale	President
Howard Tate	Vice President
Frank Zimmer	Vice President
Eugene DeCaussin	Vice President
Jules Cohen	Vice President
Theodore E. Rose	Executive Sect.

CHAPTER CHATTER

DETROIT CHAPTER, at the last meeting on which we have a report, devoted most of its time considering the many projects to be presented at future meetings. This was a thorough discussion and much consideration was given to selection of projects. From all appearances this is a busy season for the Chapter.

FLINT (SAGINAW VALLEY) CHAPTER members were guests at a special meeting put on for them by the Taylor Electronics Company, local distributors for the Channel Master Antenna, in the WJRT Studio. Guest speaker John Eicholt's main topic was TV Antennas. A color film on the manufacture of picture tubes was exhibited. Guest speaker Frank Moch gave a talk on the future of the TV serviceman and touched on the serviceman's competition with TV rentals and closed circuit TV.

A round table conference (with refreshments) in progress at a meeting of the Saginaw Valley Chapter.

Another meeting was held at the Orem Distributing Company, Saginaw, which rebuilds picture tubes. This was a family outing. The members brought their wives, family and friends. It was an interesting and educational experience for all those attending.

HACKENSACK CHAPTER opened one meeting with a question-and-answer period presided over by Cres Gomez. These discussions meet a definite need and Cres seems only too glad to meet the challenge. He ably answers all questions put to him and the members are grateful for the valuable help he gives them.

Any members who cared to were invited to attend the recent Philadelphia-Camden Chapter at which Executive Secretary Ted Rose and J. B. Straughn of the NRI Staff were also guests. Three members accepted the invitation and attended the meeting: Chairman George Schalk, Secretary George Schopmeier and Treasurer Ole Svane. Secretary Schopmeier said this about the meeting: "We found it very encouraging to see and realize what an active Chapter can amount to and what it means to its members and to the community. We are particularly grateful to Chairman John Pirrung and Secretary Jules Cohen for their willingness to receive and entertain us on a particularly busy night."

HAGERSTOWN (CUMBERLAND VALLEY) CHAPTER was pleased at the considerable increase in attendance at its November meeting at which the guest speaker was J. B. Straughn, Chief, NRI Consultation Service. Throughout this talk and demonstrations Mr. Straughn stressed the importance of understanding basic circuitry from a servicing viewpoint.

LOS ANGELES CHAPTER members were much saddened by the loss of one of their staunchest and best-liked members, Earl Dycus, who died of a heart attack. Six of the members served as pallbearers at his funeral: Gene DeCaussin, Joe Stocker, Fred Tevis, Bob Belew, Lee Chavez, and Jim Law. Our sympathy to Mrs. Dycus.

When the next meeting night rolled around, none of the members had any heart for it, so the usual program and activities were dispensed with.

At the next meeting a sharp increase in attendance was noted. This was believed to be the result of the Chapter's new meeting place.

At the adjournment of each meeting the members' wives usually serve refreshments. These are very tasty and are always enjoyed by both the members and the ladies themselves, also the good-fellowship that goes along with victuals. Because of this, Chairman Gene DeCaussin favors encouraging the wives to start an auxiliary chapter of their own. Excellent idea, Gene.

MINNEAPOLIS-ST. PAUL (TWIN CITY) CHAPTER held its annual banquet at Jen's Embassy, Minneapolis. The food was very good, the company the very best. The members and their wives always enjoy this annual event.

The Chapter's Technical Adviser, John Berka, demonstrated the Weller Endico Model 100A Soldering Iron. There was a consensus of opinion among the members that this iron seems to be the answer to soldering printed circuits. At another meeting John demonstrated the alignment of the Zenith Space Command with the aid of a signal generator.

The latest members to be admitted to membership are: Edwin Rolf, Grasston, and Floyd Hansen, Minneapolis. Our congratulations to you, gentlemen!

NEW YORK CITY CHAPTER was gratified to have one of its newest members, Robinson Vargas, address the members for the first time on the many uses of the neon bulb as a test instrument. It was a fine talk.

James Eaddy has continued his talks on the servicing of transistor clock radios, and Chairman Dave Spitzer enlarged upon his exposition of the electrical side of an oil-burner, illustrating his talk with actual relay mechanisms as well as schematic drawings.

A general discussion of Chapter affairs with suggestions from the floor about running the Chapter was a prelude to the annual nomination of officers, which was lively. It was proposed to make Tom Hull an honorary member, since he is unable to continue as Executive Vice-Chairman. It was with regret that the members found Frank Catalano wished to retire as Treasurer.

PHILADELPHIA-CAMDEN CHAPTER went all out for its annual Fall party. It was well attended. The guests included three officers of the Hackensack Chapter as well as Executive Secretary Ted Rose and J. B. Straughn of the NRI Staff. The Chapter has held this party every Fall for years. But Secretary Jules Cohen said this was the first time he ever had to go out for more food.

The main speaker at the next meeting was Stan Sherr of Jerrold Electronics, from whom the members learned all about the decibel and wave length sizes of antennas. Mr. Sherr made it so clear that the members came away with a pretty good understanding of the subject. Mr. Sherr also distributed literature and promotional material of Jerrold Products.

The Chapter has many more interesting meetings lined up with representatives of Radio-TV Manufacturers as guest speakers.

The meeting hall has recently been renovated: New wall paneling, new ceiling, and an all-over paint job. As some of the members say, the hall now "looks like a million dollars" and makes the meetings even more enjoyable.

The Chapter continues to report more and more new members, this time five: Allen Schiavoni, Harry Siegel, Charles Johnson, Jr., Charles Kanem and Louis Smial. Our congratulations to these gentlemen.

PITTSBURGH CHAPTER'S Jim Wheeler and George McElwain conducted a service clinic with a new 1964 portable TV set. They demonstrated the ease of servicing modern receivers and discussed some of the problems of servicing a good, well-laid-out chassis as compared with other hard-to-get-at chassis encountered in service work. The troubles introduced into the set were found and corrected, the new circuitry discussed and compared with that of early TV receivers. This was a well-conducted and profitable session for all the members present.

SAN ANTONIO (ALAMO) CHAPTER has also been pleased to welcome a new member, Harold Wolff of San Antonio. Glad to number you among the membership, Harold.

The Chapter a short time ago inaugurated what its members call "controlled bull sessions" in which discussions on particular subjects are led by one of the members. The members themselves submit their own ideas of the subjects to be discussed. The Chapter is so well pleased with the results of these sessions that it is continuing them.

SAN FRANCISCO CHAPTER members are understandably quite proud of Art Ragsdale's election to the Presidency of the Alumni Association for 1964. Art labored long and hard to organize the San Francisco Chapter and he has devoted much time and effort to it ever since.

Art collaborated with Ed Persau on a program in which they discussed sync circuits. In this demonstration they introduced defects in a TV receiver and used a scope to show the resultant changes in wave shapes.

SOUTHEAST MASSACHUSETTS CHAPTER must have hit the jackpot in admitting three new members at one meeting. That's a sizable increase in membership for this Chapter. The new members are Oscar April, Quincy, Antone Paiva, Fall River, and Edwin Ferguson, Pawtucket. Congratulations to the new members!

Oscar April, who is a professional technical writer, celebrated his joining of the Chapter with a talk right off the bat. He lectured on the use of the slide rule and the members were facinated by his talk.

SPRINGFIELD CHAPTER, in accordance with plans made some time before, held a dinner at Oaks Inn, Springfield, on the occasion of Executive Secretary Ted Rose's annual visit to the Chapter together with J. B. Straughn, Chief of the NRI Consultation Service. Following a delicious dinner, Mr. Straughn conducted a rather extensive lecture and demonstration. The interest of the members was evident from the rapt attention of his listeners and the fact that it was rather late when the evening finally came to an end.

Directory of Local Chapters

Local chapters of the NRI Alumni Association cordially welcome visits from all NRI students and graduates as guests or prospective members. For more information contact the Chairman of the chapter you would like to visit or consider joining.

CHICAGO CHAPTER meets 8:00 P. M., 2nd and 4th Wednesday of each month, 666 Lake Shore Dr., West Entrance, 33rd Floor, Chicago. Chairman: Frank Dominski, 2646 W. Potomac, Chicago, Ill.

DETROIT CHAPTER meets 8:00 P. M., 2nd and 4th Friday of each month. St. Andrews Hall, 431 E. Congress St., Detroit. Chairman: James Kelley, 1140 Livernois, Detroit, Mich., VI-1-4972.

FLINT (SAGINAW VALLEY) CHAPTER meets 8:00 P. M., 2nd Wednesday of each month at Chairman Andrew Jobbagy's Shop G-5507 S. Saginaw Rd., Flint Mich. OW 46773.

HACKENSACK CHAPTER meets 8:00 P. M., last Friday of each month, Hackensack YMCA, 360 Main St., Hackensack, N. J. Chairman: George Schalk, 471 Saddle River Rd., Ridgewood, N. J.

HAGERSTOWN (CUMBERLAND VALLEY) CHAPTER meets 7:30 P. M., 2nd Thursday of each month at the YMCA in Hagerstown, Md. Chairman: Francis Lyons, 2239 Beverly Dr., Hagerstown, Md. Reg 9-8280.

LOS ANGELES CHAPTER meets 8:00 P. M., 2nd and last Saturday of each month, 4912 Fountain Ave., L.A. Chairman: Eugene DeCaussin, 5870 Franklin Ave., Apt. 203, Hollywood, Calif., HO 5-2356.

MINNEAPOLIS-ST. PAUL (TWIN CITIES) CHAPTER meets 8:00 P. M., 2nd Thursday of each month, Walt Berbee's Radio-TV Shop 915 St. Clair St., St. Paul. Chairman: Paul Donatell, 1645 Sherwood Ave., St. Paul, Minn., PR 4-6495.

NEW ORLEANS CHAPTER meets 8:00 P. M., 2nd Tuesday of each month at Galjour's TV, 809 N. Broad St., New Orleans, La. Chairman: Herman Blackford, 5301 Tchoupitoulas St., New Orleans, La.

NEW YORK CITY CHAPTER meets 8:30 P. M., 1st and 3rd Thursday of each month, St. Marks Community Center, 12 St. Marks Pl., New York City. Chairman: David Spitzer, 2052 81st St., Brooklyn, N. Y., CL 6-6564.

PHILADELPHIA-CAMDEN CHAPTER meets 8:00 P. M., 2nd and 4th Monday of each month, K of C Hall, Tulip and Tyson Sts., Philadelphia. Chairman: John Pirrung, 2923 Longshore Ave., Philadelphia, Pa.

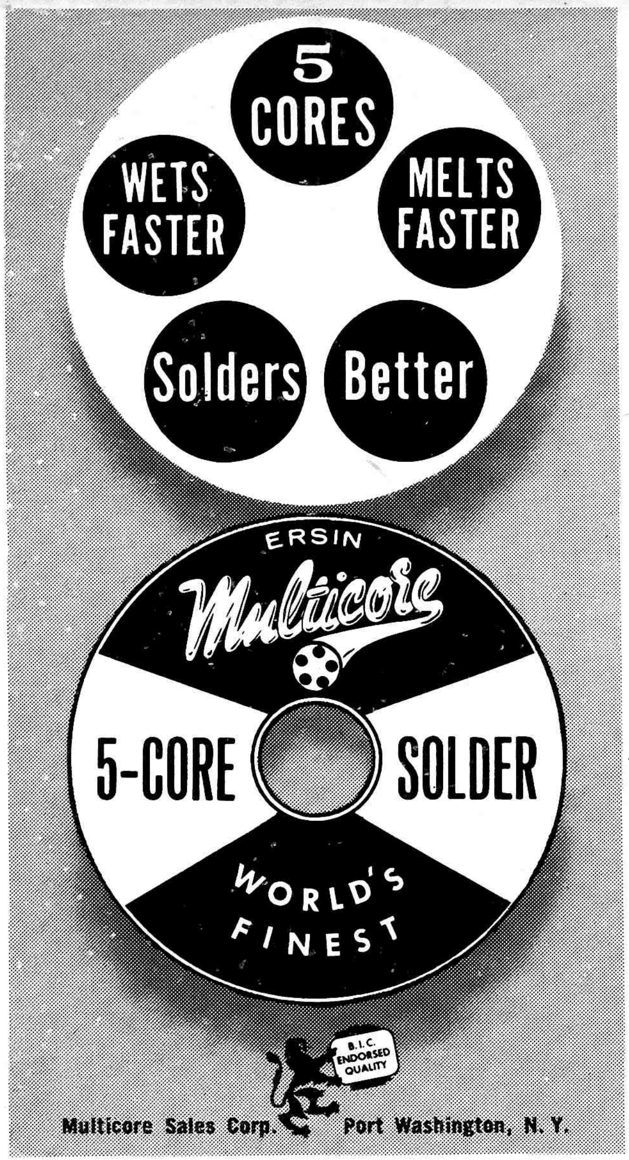
PITTSBURGH CHAPTER meets 8:00 P. M., 1st Thursday of each month, 436 Forbes Ave., Pittsburgh. Chairman: Thomas Schnader, RD 3, Irwin, Pa., 731-8327.

SAN ANTONIO ALAMO CHAPTER meets 7:30 P. M., 3rd Wednesday of each month, Beethoven Hall, 422 Pereida, San Antonio. Chairman: Jesse De Lao, 606 Knotty Knott, San Antonio, Texas.

SAN FRANCISCO CHAPTER meets 8:00 P.M., 1st Wednesday of each month, 147 Albion St., San Francisco. Chairman: Peter Salvotti, 2543 Great Hwy., San Francisco, Calif.

SOUTHEASTERN MASSACHUSETTS CHAPTER meets 8:00 P. M., last Wednesday of each month, home of John Alves, 57 Allen Blvd., Swansea, Mass. Chairman: James Donnelly, 30 Lyon St., Fall River, Mass. OS 2-5371.

SPRINGFIELD (MASS.) CHAPTER meets 7:00 P. M., last Saturday of each month at shop of Norman Charest, 74 Redfern St., Springfield, Mass. Chairman Steven Chomyn, Powder Mill Rd., Southwich, Mass.



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