nri journal

March / April 1964

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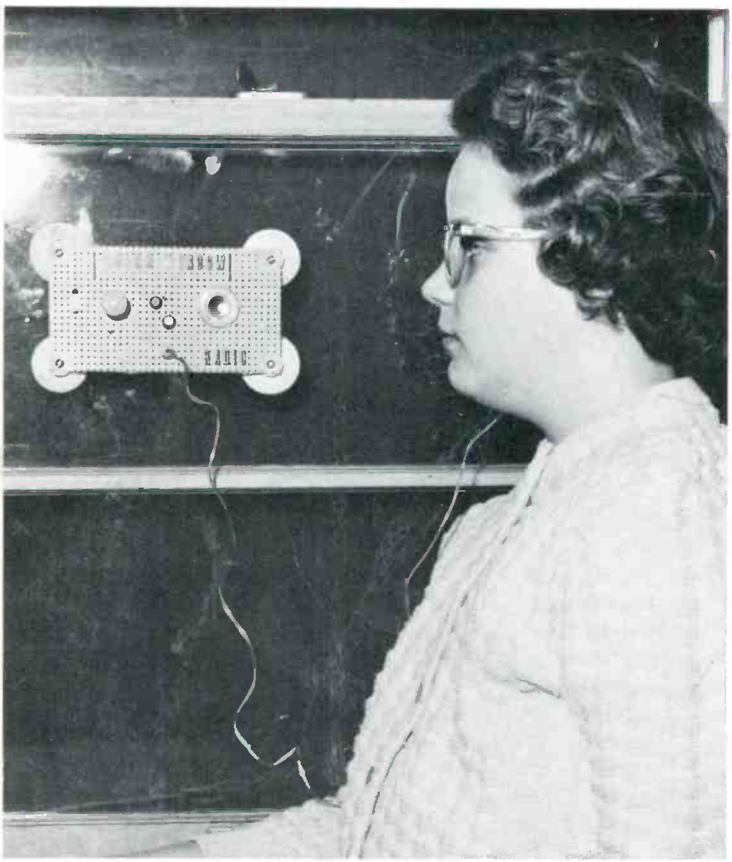

In this issue:

SOLAR WINDOW RADIO

AURAL RATE COUNT CIRCUIT

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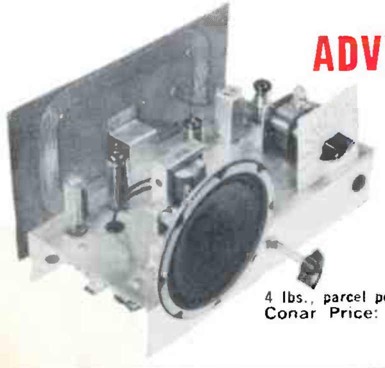

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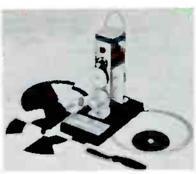

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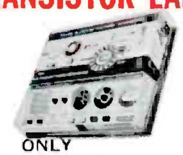

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ON OUR COVER

The cover photograph illustrates the use of the "Solar Window Radio" discussed in our lead article on page 5. Homer L. Davidson gives complete instructions on how to build it.

You won't need tubes, switches, or batteries. It gets its power from the sun - no house current is involved. It even works, with reduced volume, on cloudy days.

This radio is an ideal construction project both for the beginner and for the experienced serviceman. It is easy to build so the beginner should be able to build it without any trouble. It uses solar cells and transistors, two new devices which have created a great deal of interest.

If you like to build things you should enjoy this project and when you finish it you will have some fun showing it and explaining how it works to members of your family and your friends.

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6AB4, 6AC7, 6AF4, 6AG5, 6AG7, 6AH4GT, 6AH6, 6AK5, 6AL5, 6AL7, 6AM8, 6AN8, 6AQ5, 6AQ6, 6AQ7GT, 6AR5, 6AS5, 6AT6, 6AT8, 6AU4GT, 6AU5GT, 6AU6, 6AU8, 6AV5GT, 6AV6, 6AW8, 6AX4GT, 6AX5GT, 6B8, 6BA6, 6BC5, 6BC8, 6BD6, 6BE6, 6BF5, 6BF6, 6BG6G, 6BH6, 6BJ6, 6BK5, 6BK7, 6BL7GT, 6BN6, 6BQ6GT, 6BQ7, 5BY5G, 6BZ6

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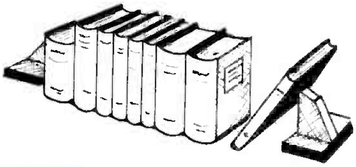

BOOKS

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Published by Howard W. Sams and Co., Inc., 4300 W. 62nd St., Indianapolis 6, Ind. 128 pages. Soft cover. $1.50

RADIO AND TELEVISION - HOW THEY WORK
By Mike Bienstock

This is a good book to have around when your son begins asking for explanations about electronics and what makes the TV go. In simple language it begins by explaining the principles of electronics and goes on to show how they work in radio and TV. There are plenty of illustrations to make the explanations clearer. Even the old pro might find that a quick reading will clear up a few points he's been having doubts about.

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____	6AH4	.81	____	6EW6	.57	____	12BF6	.60	____	35L6	.60
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____	6AU6	.52	____	6J6	.71	____	12CR6	.67	____	807	.75

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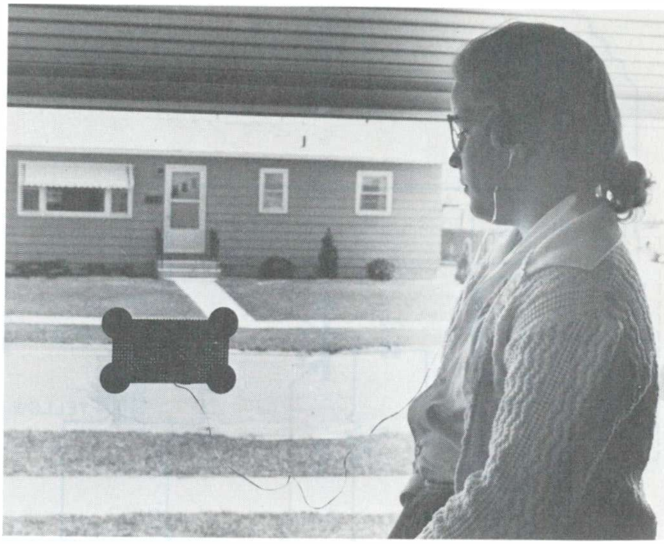


SOLAR WINDOW RADIO

BY HOMER L. DAVIDSON

Snap this little radio onto your window and listen to your local broadcast station. There are no batteries, switches, tubes, or anything to wear out. On strong local stations no outside antenna is needed.

The radio is built on a 6-1/2" × 3-1/2" perforated board. It uses two transistors in a regenerative circuit and is powered by solar cells. The cells generate about 1.25 volts under ordinary sunlight. The current drain will be only a few milliamperes. Even on cloudy days it will generate sufficient voltage to operate the radio at reduced volume. It will also work under a 6-watt lamp placed ten to twelve inches away.

A schematic diagram of the receiver along with a parts list is shown in Fig. 1. The parts can be obtained from your local radio wholesalers or from a mail order firm.

To build the receiver, first drill the perforated board as shown in Fig. 2. The holes in each corner fasten suction cups to the board.

After you have the holes drilled in the board, mount the variable capacitor in the 3/8" hole shown on the left in Fig. 2. Mount the regeneration control in the other 3/8" hole, positioning the terminals toward the tuning capacitor. Mount the earphone jack in the 1/4" hole. If you cannot get a miniature earphone jack, you can enlarge the 1/4" hole to take a standard jack.

Before mounting the loopstick, wind about 12 turns of No. 36 enameled wire on the one end, as shown in Fig. 3. You can hold this winding in place by covering it with two or three turns of cellophane tape. Now mount the loopstick on the board in the position shown in Fig. 4. Loosely mount the loopstick to the board by looping hookup wire around each end of the rod and through the board. Twist the ends of the wire on the back side of the board.

WIRING UP THE UNIT

A pictorial wiring diagram of the radio is shown in Fig. 5. By referring to it along with Fig. 4, you should have no trouble following the assembly instructions.

Start at terminal 1 on the antenna coil and solder this lead to the stator of the variable capacitor. Hook terminal 2 to the ground or rotor terminal of C1. Run a bare bus hookup wire from C1 to one side of J1. Now all of the

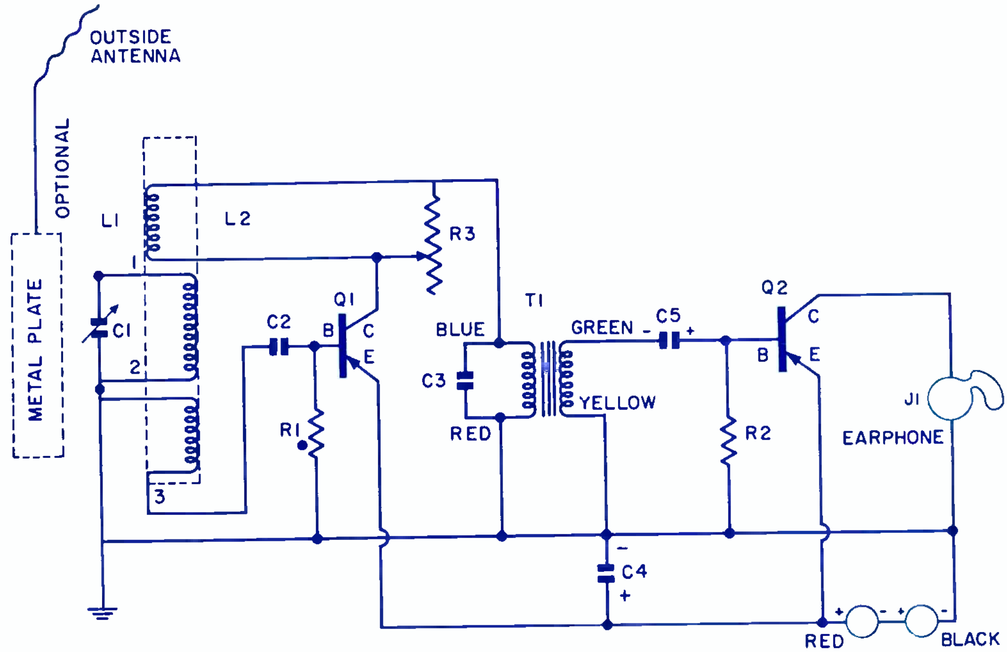


FIG. 1. Schematic diagram of the solar window radio.

PARTS LIST

- C1 - 365 mmf variable capacitor
- C2 - .01-mfd ceramic capacitor
- C3 - .0047-mfd ceramic capacitor
- C4 - 100-mfd 6 volts electrolytic miniature capacitor
- C5 - 2-mfd 6 volts electrolytic miniature capacitor
- R1 - 1.2-megohm, 1/2-watt resistor
- R2 - 100K, 1/2-watt resistor
- R3 - 50K-ohm variable linear taper control
- T1 - Argonne interstage transformer TR-97
- Earphone
- L1 - Antenna 5 inches long - Ferrite type MS-309
- L2 - 10 to 12 turns No. 36 enamel wound over secondary winding
- Q1 - transistor 2N410, or equivalent
- Q2 - transistor 2N408, or equivalent
- Solar cells - SD3 - International Rectifier - or B3M
- J1 - Miniature earphone jack
- Cups - Four 1-1/2" rubber suction cups - picked up at local hardware store
- Misc. - Knob, hookup wire, 6-1/2" × 3-1/2" perforated board, etc.

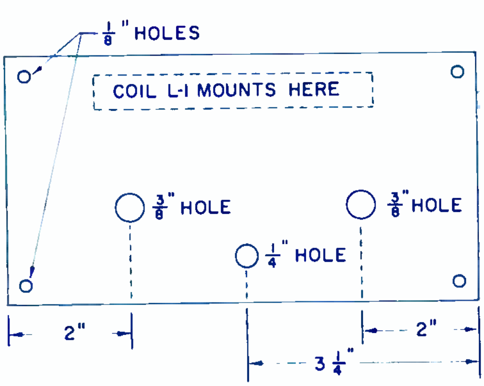


FIG. 2. Drilling of holes in perforated board.

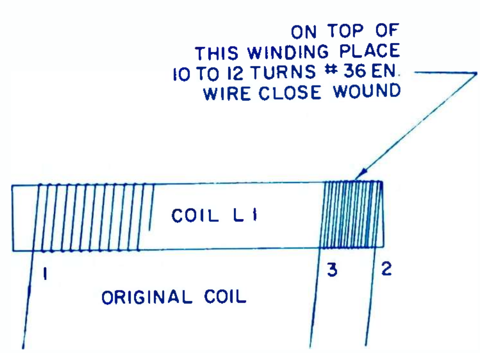


FIG. 3. Extra turns are placed in the position shown for feedback.

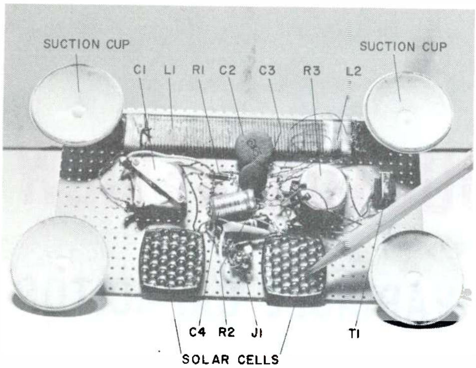


FIG. 4. Wiring of receiver with solar cells shown in lower center. The four suction cups to hold the radio against the window pane are seen at the corners.

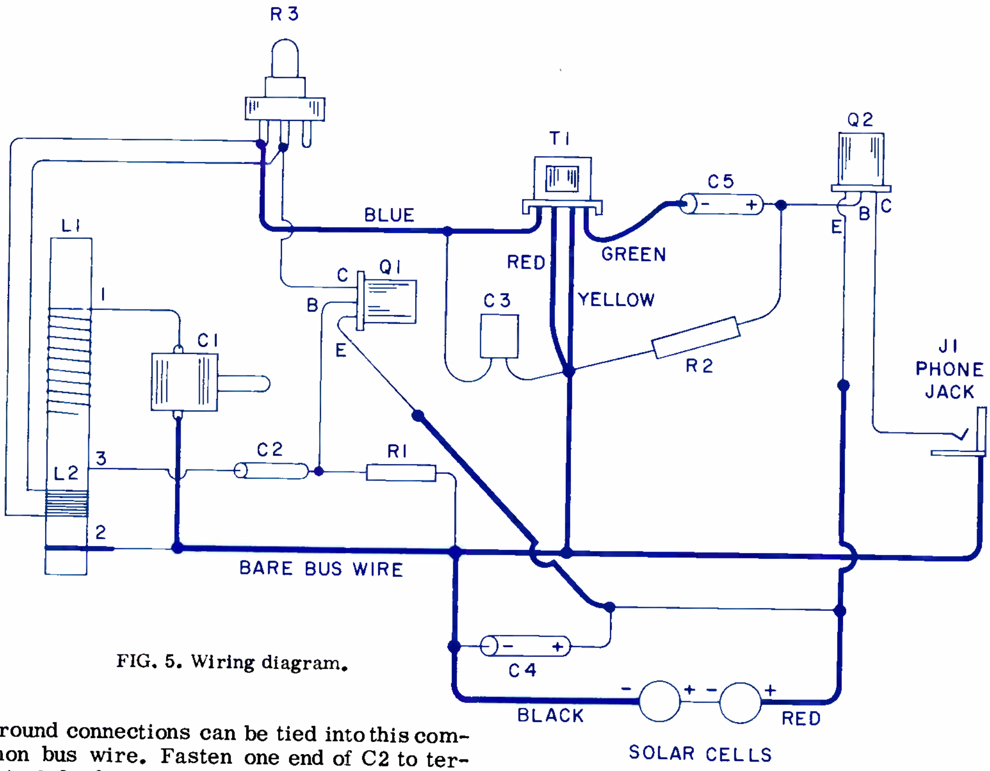


FIG. 5. Wiring diagram.

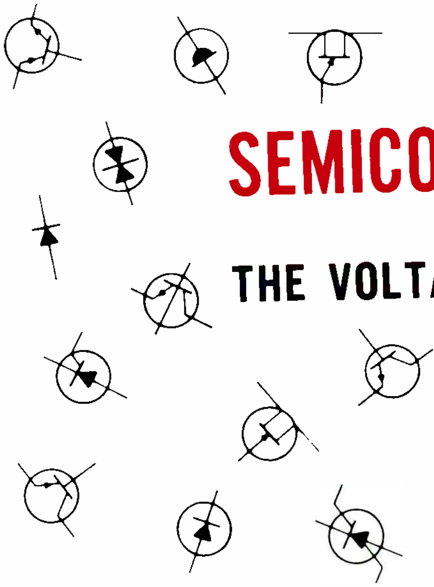
ground connections can be tied into this common bus wire. Fasten one end of C2 to terminal 3 of L1 and the other end to the base connection of Q1. You can identify the transistor connections from Fig. 6. A 1.2-megohm resistor (R1) ties also from this point to ground. Run the two enameled wires from the coil you wound on the loopstick to R3. Be sure to scrape the enamel from the wire and tin the ends with a soldering iron. Wire in the primary and secondary of T1 to their components. Blocking capacitor C5 couples the signal to the base of Q2. Tie the collector terminal to the other side of J1.

It is best to hook the two solar cells in series before they are glued to the perforated board. Take the red wire from one and the black wire from the other, cut, and solder together. The free red wire is the positive terminal and will go to both emitters on the transistors. There are no switches to turn the radio on and off as there are no batteries to wear out.

When all of the wiring has been completed you are ready to test it. Plug the earphone into J1 and rotate the regeneration control. About half way through rotation the radio should start to squeal. If not, reverse the connections on L2. Now adjust C1 until a local station is received. Then sit back and enjoy free radio reception while the sun shines.

-30-

FIG. 6. Transistor connections.



SEMICONDUCTOR REVIEW

THE VOLTAGE VARIABLE CAPACITOR

BY

JOHN POTTER SHIELDS

This month, we'll take a look at the Voltage Variable Capacitor; a special type of semiconductor diode which is finding extensive use in devices ranging from the family's FM receiver to large computers.

As its title implies, the voltage variable capacitor (VVC) exhibits a capacitance which is a function of the applied voltage, the capacitance decreasing as the voltage is increased.

In order to understand the operation of the voltage variable capacitor, we must take a look at some basic junction diode theory. Fig. 1A represents a P-N junction diode with a small reverse voltage applied across its terminals. The area where the diode's P and N sections meet is known as the "depletion region" due to the relative absence of charge carriers. This depletion region may be considered a dielectric separating the P and N sections. This combination fulfills all the requirements of a capacitor, and is known as the diode's "junction capacitance."

Fig. 1B shows the same diode with 6 volts of reverse bias applied across it. This reverse bias establishes a stronger electrostatic field which effectively widens the depletion region due to charge carriers being "swept" from it by the electrostatic field. This greater depletion region width increases the "dielectric" between the diode's P and N sections lowering the junction capacitance.

The diode of Fig. 1C has an even greater applied reverse bias and has a correspondingly smaller junction capacitance due to the increased width of its depletion region.

From all this, you can see that varying the reverse bias to a VVC will neatly change its effective capacitance. Now let's take a look at some practical applications of the VVC.

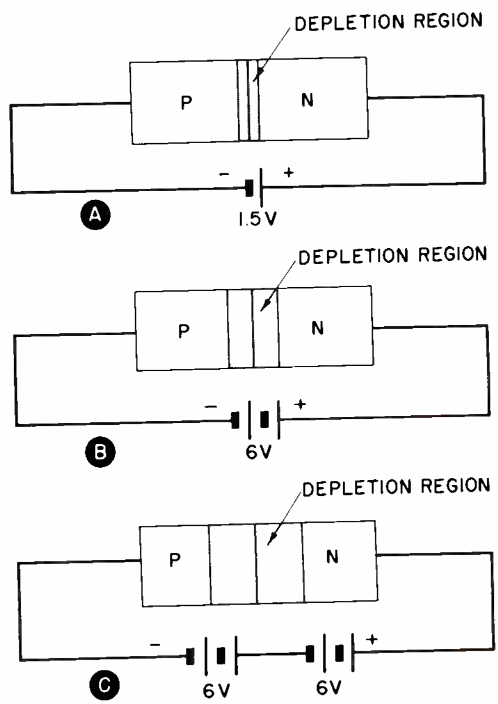


FIG. 1. The depletion region acts as a dielectric of a capacitor, A; widening the depletion region reduces the capacity, B; capacity further reduced by increased reverse bias, C.

Fig. 2 illustrates one application of the VVC ... the automatic frequency control element of FM receivers, particularly those of the transistorized variety. As you can see from Fig. 2, the VVC is connected across the local oscillator's tank circuit in that its effective capacitance will largely determine the oscillator frequency. The AFC DC control signal, obtained from the output of the receiver's discriminator (as ratio detector), is applied as a control bias to the VVC via the rf choke which isolates the local oscillator voltage from the AGC signal. The VVC diode is "biased" into a reasonably linear portion of its voltage/capacitance characteristics by a fixed DC voltage source... a battery is shown in Fig. 2 for purposes of illustration.

In operation, the DC AGC control signal will shift C3's capacitance either up or down, de-

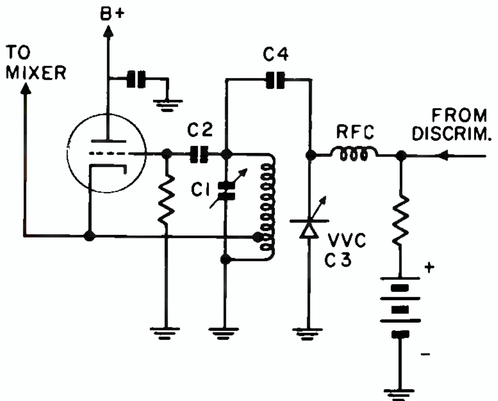


FIG. 2. Oscillator frequency controlled by DC voltage from the discriminator.

pending upon direction of oscillator drift.. this being sensed by the discriminator or ratio detector. This shift in C3's capacitance will be in such a direction as to bring the oscillator's frequency "back into line."

The use of the VVC diode in place of the more conventional reactance tube results in a much simpler, more efficient means of controlling oscillator frequency.

Voltage variable capacitor diodes may also be used for "DC" tuning of receivers, converters, etc. Fig. 3 shows in simplified form how two VVC diodes may be used "back to back" in a receiver tuning system. Placing the two diodes back to back results in both a greater effective capacitance change and more linear voltage/capacitance ratio. As in the case of the previously described AFC system, an rf choke is used to isolate the DC control signal from the rf circuitry. The major advantage of this "DC tuning" system

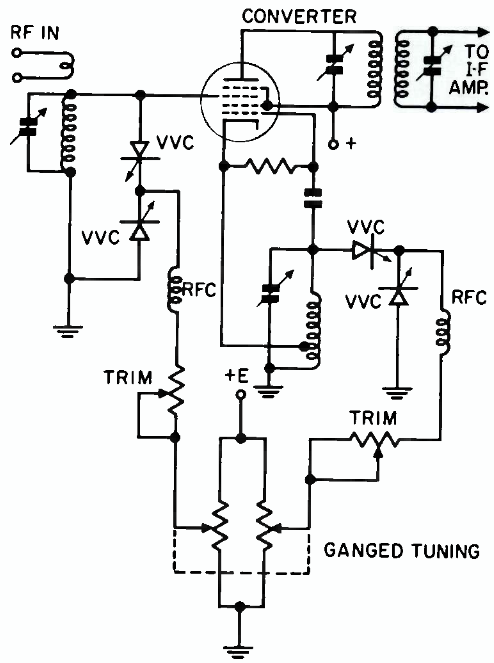


FIG. 3. Fine tuning accomplished by varying DC supply voltage.

is that it is admirably suited for remote tuning applications, as tuning can be achieved by a simple ganged carbon or wire wound pot with no rf appearing on the control leads. This, of course, eliminates extensive shielding and signal radiation problems.

Fig. 4 shows still another application of VVC diodes. Here, a VVC diode is used in place of a reactance tube to frequency modulate a small FM transmitter. This arrangement is particularly attractive in portable units where size and weight is a prime consideration. In operation, audio signals from the unit's

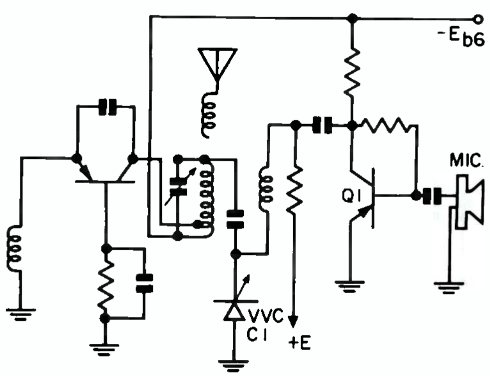
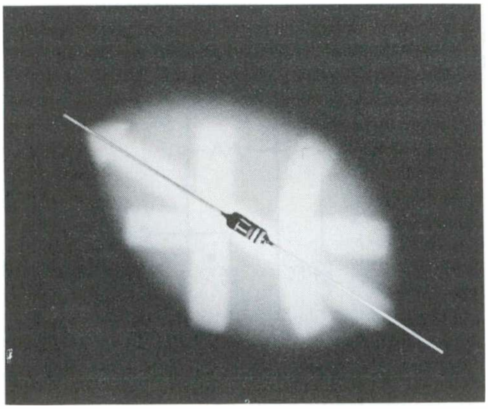


FIG. 4. The VVC used in a frequency modulation setup.



The Voltage Variable Capacitor.

microphones are amplified by transistor, Q1, and applied as a varying reverse bias to C1, the VVC diode. As in the previous circuits, a static DC reverse bias is applied to the VVC diode.

VVC diodes have other desirable features aside from their unique capacitance/voltage characteristics. As shown in the accompanying photo, VVC diodes are extremely small, thus lending themselves to miniaturization. Most VVC diodes exhibit exceptionally high

Q well up into the hundreds of megacycles. VVC's may be obtained with nominal capacitances ranging from 10 or so pf upwards to 500 pf or more. All in all, these little diodes do a remarkable job and you can expect to see them used more and more.

NOVEL TRANSISTOR CIRCUITS

Here's a novel gadget that should appeal to the younger set. As you can see from Fig. 5, it is a simple audio oscillator using an inexpensive transistor audio output transformer, power transistor and a few capacitors, resistors and switches. The circuit is pretty much self-explanatory; closing any of the switches places a given value of capacitance in Q1's base circuit... a different tone being generated for each different value of capacitance. The pot, R1, can be adjusted to set the overall tonal range. This little unit can be assembled with a small speaker and battery and placed in a Bud minibox or similar enclosure. This gadget can also be used as a code practice oscillator by inserting a key in series with one of the battery leads.

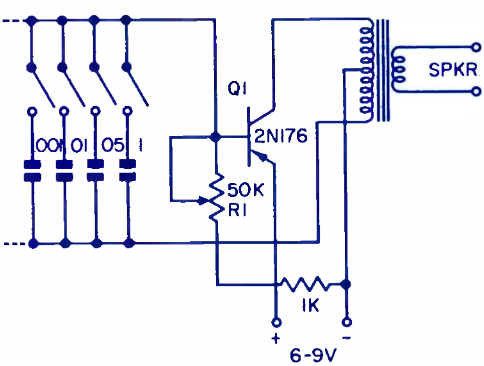


FIG. 5. A simple audio oscillator.

Here's a circuit that should appeal to those of you who do any amount of audio or Hi-Fi

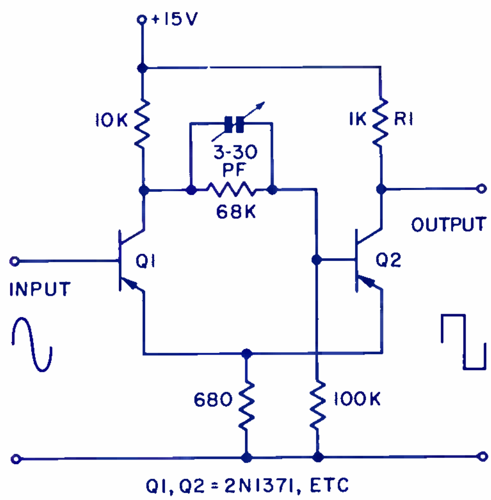


FIG. 6. Transistorized clipper producing square waves from sine wave input.

servicing. The circuit, a Schmitt trigger, will generate extremely fast rise-time, well defined square waves when fed from an audio generator.

As illustrated in Fig. 6, the circuit requires only two transistors and a handful of components. In operation, when the sine wave applied to the base of Q1 from the audio generator, reaches the circuit's "trigger devil" Q1 and Q2 abruptly switch conduction states causing a sharp voltage change across R1. When the applied sine wave drops below a certain level, the circuit again abruptly changes state, causing an opposite voltage change across R1. The circuit's switching rate from one conducting state to another and hence square wave frequency output is determined by the sine wave input frequency. For proper operation, the audio generator must be capable of providing an output voltage of at least 5 volts peak to peak.

Still on the subject of multivibrators, here's a circuit that is handy for general receiver and audio amplifier troubleshooting. As you can see from Fig. 7, the circuit is a simple free-running multivibrator. With its fundamental frequency lying in the audio range, its greatly distorted waveform produces harmonics well up into the broadcast band.

To use this little gadget, simply touch its "hot" output lead to various points in the receiver or amplifier under test, starting at the output stage and working back towards the input. Since it develops harmonics in the BC band, it may be used to check out the receiver's rf and i-f stages as well as the audio stages.

Well, that's about it for now. See you all next month. -30-

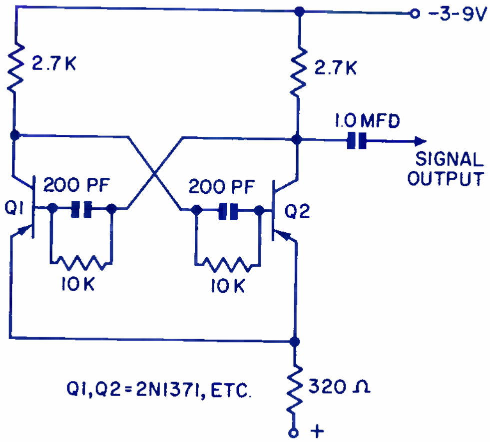


FIG. 7. Simple multivibrator.

Local Chapters of NRI Alumni Association Seek New Members

There are local chapters of the NRIAA in fifteen cities in the U. S. These chapters were founded and are maintained by NRI graduates. Their purpose is to provide facilities for NRI men to hold meetings for the benefit of the members. The meetings are devoted primarily to talks, demonstrations, and discussions on the practical side of Radio-TV servicing. These programs are generally conducted by the senior members of the Chapter, who lead, guide, and otherwise help the more inexperienced members.

The members also enjoy the opportunity to associate with other fellows who have the same interests as they in Radio-TV-Electronics. They like to get together, swap experiences, hold "bull" sessions. Many Chapters serve refreshments such as cold drinks, coffee and doughnuts or snacks. This helps the members to relax and enjoy the good fellowship.

Membership in a local Chapter is NOT limited to graduates. Students are just as eligible as graduates. All local Chapters constantly strive to get as many new members as they can and extend a warm welcome to any NRI student or graduate who wants to join or visit the Chapter.

If there is a local Chapter in your area (see "Directory of Local Chapters" on page 32) we strongly suggest you drop in on some meeting night and get acquainted, or get in touch with the Chairman and talk with him about the Chapter. You'll be missing a good bet if you don't.

Repairing Tube Sockets Having Broken-Off Lugs

Sometimes when you are doing repair work or making wiring changes in an old receiver, or other piece of gear, a tube socket lug breaks off so close to the socket that you cannot solder onto it. This can be an exasperating experience, but hold on, you don't always have to replace the entire socket with a new one.

If the socket is one of the types shown in the photo, it is only necessary to poke out the remains of the lug, remove a like lug from a new socket, and then push the new lug into the slot in the socket in the receiver. This cannot be done however, with wafer type sockets. These lugs also come in handy for making connections to power transistor pins, crystal phono cartridges, etc.

The photo shows a miniature tube socket (left); a lock-in tube socket (center); and octal tube socket (right), with a lug removed from each.

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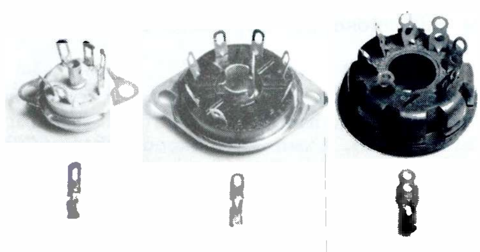


HOW TO SUBSTITUTE PARTS

- RESISTORS AND INDUCTORS

BY THOMAS R. HASKETT

In January we devoted our discussion to capacitors. Now, we describe the many types of resistors and inductors, how they are substituted and their limitations.

FIXED RESISTORS

Fig. 1 gives the standard values for fixed composition resistors of 10% and 5% tolerance. Only the significant figures are shown; you must add zeros to get the specific values desired. For instance, a grid resistor often has a value of about 500,000 ohms. If the circuit tolerance is not given it is assumed to be 10% and according to the table the designer would use 470K. Note that the 5% figures have closer specifications, as they include all the 10% figures, plus the half-interval points. If you don't have a 10%, 470K resistor on hand, you can safely substitute either a 5% 430K or 510K, since these are within the range of the 10% tolerance. Of course, precision resistors are also available with 2%, 1%, and even lower tolerances which come in almost any value. However, they are seldom used in home-entertainment equipment.

Actually, grid, screen, and plate resistors are not so critical for most amplifier circuits. You can safely substitute such components 20% or 30% away from the specified values without impairing performance in many applications. This does not apply to cathode resistors that furnish grid bias, especially in power-output tubes, oscillators, and TV sweep-drive tubes. Replacements here should be quite close, since operation is usually very critical.

Sometimes you can substitute two resistors for one. If you have a defective 560K resistor, for example, it can be replaced with two 270K units in series. Or, you can parallel two 560K's to get 270K total. If the original was a 1-watt size the replacements can be 1/2 watt, since in either case the total power will divide equally between the two. Remember that

Tolerance	± 10%	± 5%
Value in ohms (significant figures)	1.0	1.0
	--	1.1
	1.2	1.2
	--	1.3
	1.5	1.5
	--	1.6
	1.8	1.8
	--	2.0
	2.2	2.2
	--	2.4
	2.7	2.7
	--	3.0
	3.3	3.3
	--	3.6
	3.9	3.9
	--	4.3
	4.7	4.7
	--	5.1
	5.6	5.6
	--	6.2
	6.8	6.8
	--	7.5
	8.2	8.2
	--	9.1

FIG. 1. Standard resistor values.

the effective power rating must be the same or larger in the final hookup. Never substitute a resistor with a lower power rating, except as outlined above. If you're in doubt about the power dissipated in the circuit and the schematic doesn't help, hook up a resistor near the expected value and measure the drop across it with a VOM. Multiply the drop in volts by the current in amps to get the power in watts. Double this value and choose the next higher resistor size. For example, if 0.3 watts are dissipated in a resistor, doubling this would give 0.6 watts. You should use a 1-watt size.

When using resistors from a junkbox or existing equipment, it's a good idea to measure them on a good ohmmeter. If you doubt the ohmmeter's accuracy, calibrate it with a known-to-be-good new resistor near the value of the unknown. If the doubtful resistor is about half a megohm, get a new 470K and set the ohmmeter to read that value. Then you can read the doubtful resistor by comparison. This method is especially important where small resistors, like the 1/4 watt variety, have been soldered, since this heating can cause appreciable resistance change.

Don't substitute a wirewound resistor for a composition type unless it's used for DC only. The wirewound is commonly used in power-supply service, where high power rating with small size is desirable; composition types, to have a comparable power rating, would be quite large. However, wirewounds possess inductance, making them unsuitable for any circuits carrying signal rf, video, or audio. Power-output stage cathode resistors may be wirewound, as they carry only the DC plate current (if bypassed). If unbypassed, for current feedback purposes, you may have to stick to the composition types.

VARIABLE RESISTORS

There are three general types -- composition potentiometers, wire-wound rheostats, and adjustable slider-tap wire-wound resistors. When replacing pots the resistance value must usually be duplicated exactly. So must the taper, which is the way the resistance varies with shaft rotation. Fig. 2 illustrates four common tapers. Linear taper is used for things like TV size and AGC controls; audio log taper parallels the sensitivity curve of the human ear and is used in volume controls; a semi-log taper is used for tone control; and a reversed semi-log is used for TV contrast control. Since proper circuit operation depends on the correct taper, you must obtain an exact replacement, although in emergencies you can substitute a non-standard taper. Don't forget also that many tone controls use only two connections -- one end and the arm. If an open spot develops at one end you can

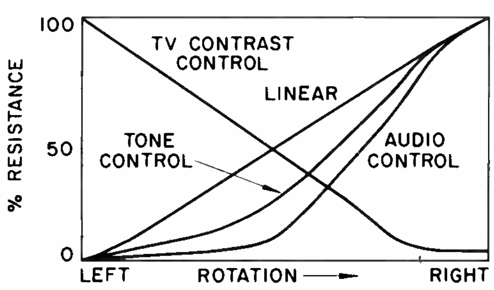


FIG. 2. Potentiometer tapers.

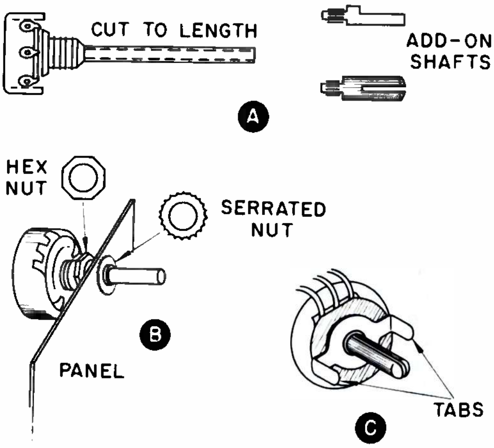


FIG. 3. Potentiometer mounting: (A) Hollow extension shaft; (B) double-nut mounting; (C) twist-tab mounting.

reverse connections and get by using the control in reverse. This also applies to adjustable-tap wirewound resistors where only two connections are used.

The half-watt carbon pot is standard in many circuits, although in industrial and communications work you'll find what is called an A-B type, which is sealed and has a 2-watt rating. It's more costly but practically immune to dirt, hence more reliable. Except for the extra reliability, it's interchangeable with ordinary carbon pots. Transistor circuits often use a smaller pot rated at 0.02 watt, since it's compact and the circuit dissipates only a small amount of power. When replacing pots, by the way, you need consider only the DC power in most cases, which will usually be quite low. If in doubt, measure the current and calculate. Since most grid-circuit controls operate on voltage rather than power, you can use the smallest rating on hand.

Depending on the particular mounting and knob, there are several shafts commonly furnished with pots: slotted, fluted, round, half-round, screwdriver adjust, and the hollow shaft, which will accept almost any of the previous as an extension. Fig. 3(A) shows how it works -- you cut the shaft to the desired length and insert the small end of one of the extensions. Three types of switch are often used with pots, the turn, the push-pull, and the push-push. These are clamped to the back of the pot, unlike older types, which were integrated assemblies. Although some technicians replace both switch and control when either goes bad, the snap-on switch enables you to salvage one or the other if you're short on stock. Some pots are tapped -- e.g., audio tone or loudness controls. These must be exact replacements. Remember there are kits available at distributors which contain a variety of controls, shafts, and switches; you can make up almost any kind of control -- single, ganged, tapped, with switch, etc. -- from the kit, to suit each particular job.

Two general types of shaft mountings are available -- the concentric nut and the twist tab. The former usually comes with a single nut, but some have two. As Fig. 3(B) shows, the hex nut should mount behind the panel, and the serrated nut in front. The serrated nut is round and has a dressy appearance. The two are tightened against each other to grip the frame of the pot securely on the front panel. The twist-tab mounting, shown in Fig. 3(C), is usually found in transistor or printed-circuit applications. Two metal tabs protrude from the sides of the control; these are inserted in the chassis and twisted like the ears on a filter capacitor. This type is often furnished with a non-conducting phenolic shaft, serrated and split, for back-panel TV size control use, where a metal shaft would present a shock hazard.

Wirewound rheostats are found in older TV's as size controls, and in some high-fidelity amplifiers as cathode balance controls for push-pull output stages. Usually rated at 3 or 4 watts and up, the resistance value is not too critical if only two connections are made to the control. At least in this case you can replace with a slightly larger control and still get by. If all three tabs are wired in, you must replace with the same resistance value, for changing the total value would upset the circuit.

Where audio is distributed to many speakers and it's desired that each speaker have an independent volume control, pads are used. As Fig. 4(A) illustrates, an L pad maintains constant impedance at the input (line side) while varying the impedance, and the signal, to the speaker. This permits the speaker to take various amounts of signal from the line without changing signal level to the other speakers. For exact matching and best frequency response, however, a T pad is used, as in Fig. 4(B). The T maintains constant impedance at input and output. It's a little more expensive than the L, and both cost more than carbon pots. They come in the usual audio impedances: 4, 8, 16, 100, 250, and 500 ohms are the most common. All become dirty (noisy) after a while and are difficult to clean. The worst offenders in this respect are the lower values, and for this reason many PA technicians like to install 500-ohm pads on the line side of speaker-matching transformers, which minimizes noise. Nearly all pads will handle 10 watts of audio, some more.

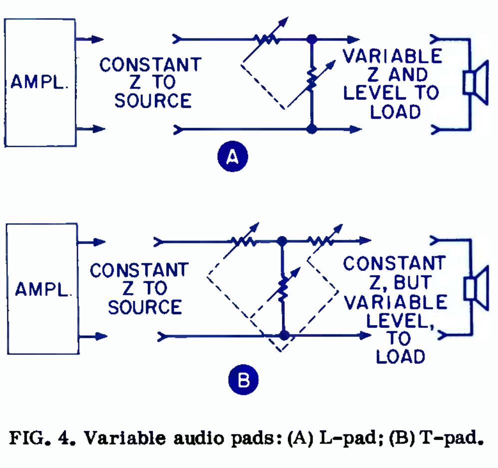


FIG. 4. Variable audio pads: (A) L-pad; (B) T-pad.

One point often overlooked when handling wirewound rheostats is that they are usually across quite a bit of voltage, and will present a shock hazard unless the shaft is grounded (or unless a nonconducting shaft is used). This is usually taken care of by chassis mounting with a concentric nut, but in case a home-made wooden or fiber panel is used, a jumper should go to ground. In the rare event that the control must work more than about 600 volts above ground (as, for instance, in some scopes and older TV's) you'll have to mount it on a plastic insulator behind the panel to prevent arcing. This, in turn, calls for an insulated shaft at least an inch long.

RF CHOKES

The common rf choke has a relatively large inductance, compared to a coil or transformer used for rf signal transfer. The large inductance causes it to present a high impedance to signals, thus blocking them. Fig. 5 illustrates choke function in the rf section of a transmitter, where RFC1 and RFC2 are connected in the DC leads to the plates. They prevent rf from flowing back into the power supply. If bypass capacitors C1 and C2 alone were used, the plate tank circuit would be bypassed, and the amplifier wouldn't work. By using RFC's, rf is prevented from getting into the power supply but not from getting into the plate tank and on to the next stage. Likewise, RFC2 blocks rf from the bias supply but not from the grid.

Values for RFC's aren't critical; they usually work by brute force, and 750 microhenry to 2.5 millihenry is a common range for amateur and CB transmitters and TV receivers, unless otherwise specified. The ultimate test of

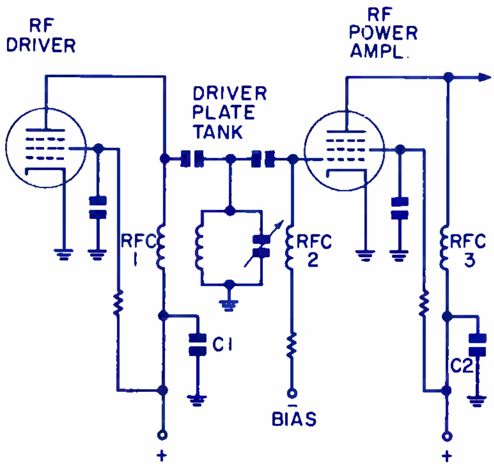


FIG. 5. Use of rf chokes in transmitter.

an RFC is to hook it up and see if the signal is blocked; if not, try another. Various current ratings are available, and 300 ma is a safe minimum for most commonly-encountered circuits. If in doubt, calculate current in the circuit and use a higher-rated choke.

POWER-SUPPLY CHOKES

The important thing to remember here is that the current rating of the original must be duplicated or exceeded, but never lowered. For example, a 2-henry choke shorts, and you have only a 4-henry unit on hand. The catalog shows that the original was made to carry 100 ma, while the replacement will safely handle 150 ma. You can replace. It's even possible to use a replacement choke with less inductance (provided you don't exceed the current rating) if you can stand the increased ripple or hum in the DC. If the filters are to be replaced at the same time, you can simply kill the extra ripple with heavier capacitors. Test the replaced unit by feel -- it should run no hotter than the original, and preferably cooler, if possible.

POWER TRANSFORMERS

If you cannot obtain an exact replacement, there are two critical points to watch when substituting: filament current and plate voltage. Add the heater currents of the tubes in the amplifier or receiver to find what the total current rating of the heater string must be. (These values are listed in any tube manual.) Watch out for separate strings; TV's sometimes use a separate 6-volt winding for the damper tube and the substitute transformer must have such a separate winding. For the damper tube's cathode operates at such a high potential it cannot be grounded.

Pick a transformer which can supply the required filament current (and voltage), and try to get as near the same plate voltage on the B plus or high-voltage winding. It's not necessary, however, for this value to be exactly the same. For instance, if the original transformer was rated at 400-0-400 and you have only a 350-0-350 on hand, you can probably use it. The voltage output won't be quite as high, but in many cases it will work.

A better solution is to use a transformer with a higher plate voltage rating. Don't go too far on this, though (50-100 volts), or you may exceed the ratings of the filter capacitors. You can drop the rectifier output by using a resistor (500-1000 ohms, depending on current) between the rectifier cathode and the input capacitor.

If you choose a transformer which can supply as much or more heater current than the tubes will draw when hot, you can usually assume that the high-voltage winding will be able to supply the required B plus current, as transformer designers usually allow a safety margin here. If in doubt, you can add up the various plate and screen currents, or measure the drop across a series power-supply resistor or choke.

AUDIO TRANSFORMERS

In many cases output transformers must be exact replacements, especially in high-fidelity amplifiers. But in non-critical applications, such as ordinary radio or TV receivers, it's useful to remember that the output transformer does not have fixed impedances, but only changes one impedance to another. This is determined solely by the ratio between primary and secondary turns. You can sometimes juggle transformers until you find one which will work, depending on the circuit. There are many similar output tubes which use the same transformers, as far as impedance is concerned: 6AQ5, 6V6, and 6L6, for example. However, the amount of DC which must pass through the windings is the limiting factor. High-power tubes cannot use a transformer built for lower-power tubes, although the reverse is true. And don't overlook the possibility of using one of the so-called universal output transformers, which comes with 6 or 8 output taps. You can thereby match several output tubes.

WIRE AND SPAGHETTI

Solid wire is easier to handle for hookup work than the stranded type, because it will go through holes in lugs easily. As long as it's not subject to bending it works fine. Where

CONTINUED ON PAGE 29

DEVICE OF THE MONTH

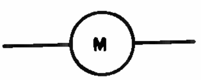
BASIC METER MOVMENTS

BY R. C. APPERSON, JR.

How much do you know about the most valuable instrument on your bench? You use a VOM or a VTVM every day but do you know how the movement functions and how to handle meters properly to avoid damage and give them extended life? These two questions lead us into a discussion that I hope will be helpful to each technician who reads it, either old pro or beginner, because we do tend to forget. Every rule or good habit we can acquire in the use and handling of meters is money in the pocket - they are delicate and demand care.

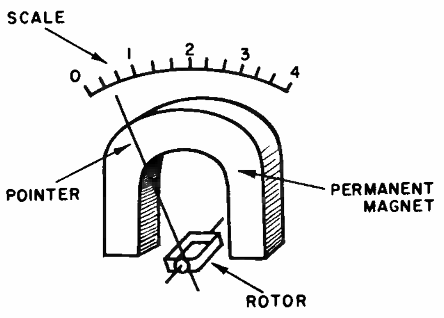
I'd like to point out the many uses of meters in electronics, discuss how the most common movement works and then talk about some do's and don'ts that I've dug up or have had burned into my brain by doing the don'ts! The most sickening feeling in the world is to see the pointer move swiftly in either direction and go CLACK as it wraps around the stop. Anyone who denies ever pegging a meter never used a meter, that's why the old pros can benefit as well as the rest of us!

The meter movement, when shown schematically, appears as a circle with the letter M inside it or an arrow to represent the needle.



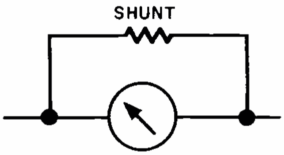
It will be found on schematics of power supplies, transmitters, communications receivers, and Hi-Fi equipment as well as many types of test equipment. The movement is used in the VTVM, VOM, audio voltmeter, frequency meter, wattmeter, tube tester, capacitance and inductance meter and ammeter, only to name a few. It would be safe to say that we cannot do without the basic meter movement.

The most used movement today, after exploiting many methods of obtaining a needle deflection proportional to a given current, is the D'Arsonval meter. It is really a little motor, having a field piece of permanent magnet and a rotor through which the current to be measured passes.



We know that when current flows through a wire, a magnetic field is set up around the wire which is proportional to the current. We also know that like magnetic poles repel each other. Here we have the basis for deflection proportional to current. The rotor is on pivots, the permanent magnet flux opposes the flux set up in the rotor by the current and the rotor has no choice but to move. The needle pointer is attached to the rotor so it moves upscale as the rotor turns. The only trick now is to find out how much the needle moves for a known current and we're in business. This is exactly how the scale is calibrated. We'll discuss calibration later.

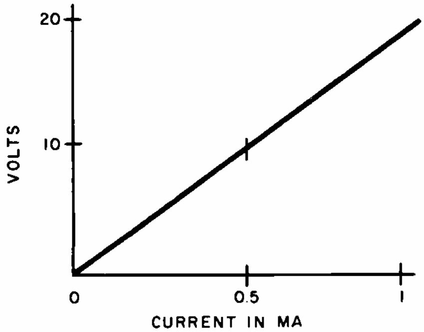
What determines the full scale current of the meter? The number of turns of wire used on the rotor and the strength of the permanent magnet are the main considerations. Usually the basic movement is capable of carrying small current and for larger currents the meter is shunted to change its sensitivity.



You will note that a meter can be made less sensitive by shunting, but the only way to get a more sensitive meter is to buy one! The basic meter movement's full scale current cannot be changed, all the shunt does is bypass the current not needed to deflect the meter. This gives a combination which appears to make the meter's full scale current greater.

The meter movement is very delicate because the rotor is pivoted on jeweled bushings. These are damaged easily. Advances by meter manufacturers have made the movement more rugged, but not to the point where they don't have to be treated carefully. One of the advances is a new type of suspension for the rotor called taut suspension. This does away with the jeweled bushings and allows the rotor to "float" slightly, adding a shock absorber action which may save some movements from damage when not handled properly.

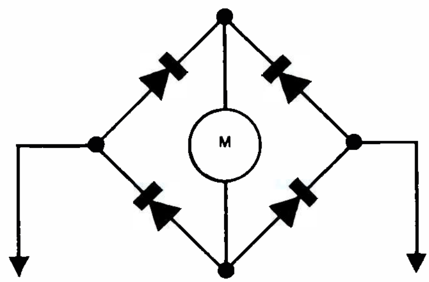
We know that the basic meter movement is a current device. If this is true, how can we use it as a voltmeter, "S" meter, rf wattmeter or capacity meter? Simple. We calibrate the scale in the desired values of voltage or "S" units or whatever the units desired are. Knowing how much current through the meter is proportional to units being measured, we can mark the scale accordingly. If we know that the meter has a full scale current of 1MA and that 20 volts causes 1MA to flow through the meter, the scale will have a full deflection of 20 volts. A graph shows that the relationship is linear, so that at 0.5 MA we have 10 volts.



This can be done with any value, but the graph should be plotted when calibration is made to determine if the function is linear, current squared or logarithmic, the three most used functions.

All that is needed to calibrate a meter in the desired units is a known reference, such as an accurate voltmeter (if the meter is being calibrated in volts). If, for instance, an rf wattmeter is being calibrated, the source should be in the frequency range in which the device is to be used. This is not because of the meter movement, but due to the tuned circuits and components in the rest of the circuitry. The meter is not subjected to rf; the rf is rectified and filtered, leaving DC to drive the meter. The calibration may be done using an rf probe with a VTVM and a known load. The wattage is then calculated, knowing the voltage across the resistance of the load. This is not extremely accurate, but is close enough for most uses, such as on the citizen's band.

Using the D'Arsonval movement for AC, as we do in the VTVM and VOM, makes it necessary to "operate" on the AC before the meter will respond. Here again, we rectify. Usually a full wave bridge rectifier is built into the measuring instrument for smoother DC to be applied to the meter.



One very important thing to remember when using a rectifier type AC meter, is that the instrument was calibrated on a sine wave and any harmonic distortion will cause inaccurate readings. Another point in passing - always give a quick calibration check when turning on your meter before measuring AC. Measure the power line voltage. This varies a few volts, but will tell you in an instant that all of your rectifiers within the meter are still good.

Now for a look at some of the precautions that will help save the meter movement. Most of these are plain common sense - but so are most rules! The first and foremost rule is simply - don't drop a meter or set it down carelessly. Handle a movement as you would that nice watch you wear.

When making a measurement, start on a high scale first, unless you know approximately what voltage is present, like measuring a flashlight battery, for instance. Also make sure that the function switch is set properly on a multirange instrument before connecting it to a source.

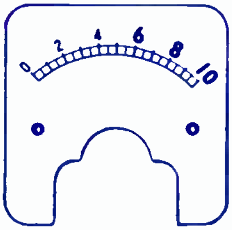
Don't tamper with a precision instrument. You wouldn't try to fix your watch - let this be a rule with the meter also. If you have reason to open a meter case, be sure that there are no iron filings present. The magnetic field piece will attract them and they will align within the gap, obstructing the rotor. One of the best precautions is to have two separate workbenches. One for circuit work, the other for metal work. In this way, you will never have to worry about pounding on a bench on which a delicate movement might be setting. This is a great cause of meter damage.

When transporting a meter, extreme care must be exercised. If it is a basic movement of low current capacity, one good trick is to allow the meter to damp itself. A motor is also a generator, so by connecting the two terminals together, movement will generate an opposing field that will keep the meter pointer from moving very much. Simply short the terminals. Cushion a meter well when transporting it in a vehicle, vibration is hard on the movement.

The best rule to follow when using a meter is THINK, THEN ACT - a few burned-out movements instills this in most!

The circuit of the month this time will be replaced with a procedure for making meter scale calibrations look like "store bought" jobs. I think that the use of the meter is so common that not much could be learned from a circuit.

The first thing needed for making a professional scale is a set of decals or, preferably, dry transfers. These are available from Allied Radio under the tradename of LETRASET. They are handy for many applications, try them.



The procedure is to find what new unit corresponds to the old unit on the scale (5 watts = 1 MA). With this information plotted on a graph, remove the scale plate from the meter. In most cases the stamped graduation may be used, only the numbers will change. A pencil eraser will remove the numbers from the scale nicely. Now, simply apply the decals or transfers in the proper place, mark the scale face with the function, such as volts or rf watts and replace the scale face. Try it, you'll be surprised at the professional results! -30-

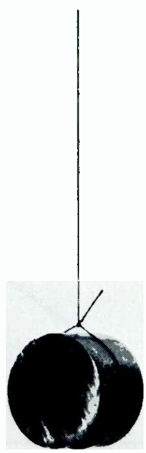
Finding Polarity of Speaker Magnet Slug

BY ART TRAUFFER

When students and experimenters remove a magnet slug from a junked PM speaker, the first thing they should do is to determine the polarity of the slug. This is easily done without the use of a compass, as shown in the photo.

Tie a length of sewing thread to the center of the slug, as shown, and let the slug hang by the thread. Be sure that there are no iron objects near the slug to disturb it. The slug will slowly spin in one direction and then the other, for a while, and then come to a halt with one flat side facing north. The flat side facing north is called the "north seeking pole", or "north pole", or "plus pole." The flat side facing south is called the "south pole", or "negative (-) pole."

Mark the north pole by nicking it with a file, or marking it with wax crayon.



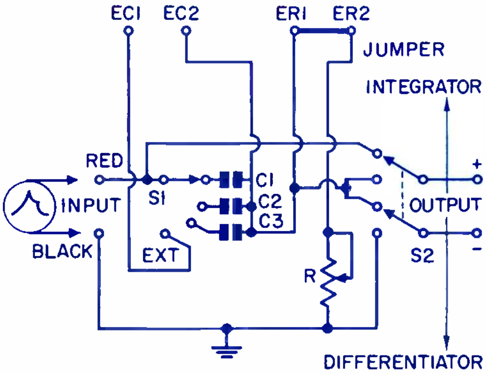
THE DIFFEGRATOR

A FLEXIBLE CIRCUIT WHICH PERMITS THE CONVENIENT ADJUSTMENT AND OBSERVATION OF THE CIRCUIT COMPONENTS

BY A. W. EDWARDS

In radio and electrical theory classes, as well as in some actual design situations, occasionally it is desired to learn the effect of a given RC network upon an applied signal. All television sets, for example, employ both a differentiating and an integrating circuit, in order to separate the elements from which the horizontal and vertical sweep sync rates are developed from the complex pulsed waveform. An understanding of how this is accomplished, and other interesting RC actions, may be gained from experimenting with the circuit of Fig. 1. By applying appropriate waveform inputs, and observing the output waveform on an oscilloscope, the varied effects of RC combinations are quickly made apparent.

The little circuit has been dubbed a "diffegrator" in recognition of its facility to provide either the output of a differentiator (i.e., output taken across the resistor) or of an integrating circuit (output taken across the capacitor) at the throw of a switch. While it is basically a very simple circuit, it is also a great convenience over other methods of connecting up circuit elements, which usually give poor connections and inconclusive results.



SUGGESTED VALUES:

CI .01 µf
C2 .10 µf
C3 .50 µf
R 50,000 Ω, 2W, LINEAR TAPER.
SI SP, 4-POS. ROTARY
S2 DPDT TOGGLE OR ROTARY
ECI, EC2, ERI, ER2, (+), (-), RED, BLACK = INSULATED BINDING POSTS

FIG. 1. Circuit of the diffegrator.

Once the circuit is built, waveshape observations are easily made. When a desired effect has been obtained, by adjustment of the circuit elements, the values for R and C may be easily determined and similar components obtained for the tested circuit. The capacitance is merely read off the switch setting, or from the capacitor in use; the resistance is determined by making an ohmmeter reading between ER1 and OUTPUT (-).

If it is desired to use other values of capacitance or resistance than those indicated in the circuit of Fig. 1, the preferred values may be wired in, or may be connected into the circuit temporarily via the binding posts provided for that purpose. To add external capacitance, the capacity switch is placed in the EXT position, and the external unit is connected between EC1 and EC2. To add series resistance, the jumper between ER1 and ER2 is removed, and the desired resistance unit is connected between these terminals. Measurement of the total resistance is always taken between ER1 and OUTPUT (-), as was previously indicated.

It should be remembered that, in this circuit, the (-) post is connected to chassis ground only in the "Differentiator" position of the switch. Thus it is possible to short circuit the resistance, when the switch is in the "Integrator" position, if the signal generator and oscilloscope have a common ground. This would be true of any such circuit. -30-

What Would You Have Done ?

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

BY GEORGE D. PHILPOTT

Tonight, it was Lucky's turn to answer questions at the monthly Radio-TV Association meeting and as he drove towards town and Chapter Headquarters, he thought about this. The technicians he knew could ask some good ones.

Later, as he stood before the group of local servicemen and their apprentices, he requested their attention and said, "Men, figuratively speaking, it's my turn in the barrel now. The Question and Answer Clinic is officially open for business. Last month we discussed Stereo problems and Multiplex adapters. This evening we have agreed to talk about Citizens Band equipment."

"Ten-seven!" came a voice from the rear.

Lucky smiled, shifted from one foot to the other, and continued, ". . . a natural reflex, perhaps? Well, anyhow fellows, I don't have to remind you that CB radio is fast becoming one of the most profitable branches of the electronic tree. We use it in our business - and nearly one-half million other licenses have been granted. For the first time since radio began, the citizens, in general, of this country and others are being allowed the privilege of owning and operating a radio transmitter. This is no small thing to the electronic industry - or to you and me, as service technicians called upon to maintain such equipment. I don't mean to go off on a tangent and sound as if I'm trying to sell you CB servicing - I realize I'm before you to try to answer questions - but think it over. In fact, I'll ask a question. From past experience, who is it - what member of the family - will spend the most, the quickest, to have a certain type of receiver repaired?"

Group faces lighted immediately and the replies were spontaneously the same. "Car radios!" barked Shorty Harris, nearly choking on his cigar.

"The TV can be rolling, the hi-fi growling, battery portables dead, and tape recorders jerking ... who cares? Let the Old Man's car radio go on the fritz, though, and he will be waiting when you open shop to dump it in your lap," Lucky went on. "Right?"

"The point I want to bring out, then, is rather obvious," Lucky continued, "We may assume that at least half of the CB units manufactured are in mobile use right now. Unlike most car radios, these transceivers must be installed by competent, local technicians. Special problems arise. If a customer buys a new car, he usually transfers CB equipment, instead of letting it go with the old vehicle. Here is the NEW field we can expect to explore."

"Most of the fellows I know with CB outfits installed them themselves," peeped Walt McGee.

Lucky lighted a cigarette and paused long enough to consider the statement. "So far you may be correct," he answered, thoughtfully, "but don't forget, Walt, like many other growing infants, CB radio gained most of its strength and popularity from a minority group, who, from the first, were not afraid to wade right into the electronic pool and wet their feet. Inquisitive and determined, they usually were required to install their CB outfits because our shops were too busy ... I maintain, as the Industry expands, service technicians will be called on frequently to repair and install transceivers. It will be profitable. First, though, we must be prepared; have the technical know-how, tools, parts, test equipment, and, as soon as possible, a First or Second Class Commercial License."

This last suggestion immediately brought one of the club members to his feet, roaring, " ... A question! I have a question!"

"Speak up," Lucky intoned.

"Why are we required to have a license to work on transceivers when a ten-year-old can assemble a kit and tune it up?"

The room became understandably silent as Lucky sifted a reply through his mind. "It's a fair question, John," he finally answered, "with an answer that might seem unfair to the electronics technician. Still, I believe such a regulation is necessary to avoid, or at least limit, future chaos on the Band. Unrestricted servicing methods would invite tinkering by the uninitiated and soon cause trouble. However, an unlicensed technician can repair any circuit or section of a CB transceiver - LEGALLY - when he is sure it will not affect the frequency of the transmitted signal. He may check operating frequencies and modulation percentages, using a dummy load. Concerning kit manufacturers, the responsibility for proper frequency operation is assumed by them when a kit is assembled according to their specific instructions. Oscillator coils are pre-aligned and sealed at the factory. I believe most technicians know how to read such instructions ..."

A sly smile or two from men before him, told Lucky they grasped the point. Then, Tom Brown, of Ace TV caught Lucky's eye. "Question, Tom?" he asked.

"In a way, yes I have. You see, this fellow, a friend of mine named Ange, is a real CB bug -- with a bite. He's nuts about radio and forever foolin' with his transceivers. Four of 'em. Well, yesterday he brought one to my shop and asked me to take it apart and add two crystal sockets to the front panel. Said it would make it easier to change frequencies. I can't decide if it's a good idea or not? The way I figure, he might get into trouble with the FCC and drag me into it some way?"

Tom's question raised several eyebrows in the room. Lucky shifted his position on top of the desk where he had been leaning back, relaxed, frowned, and said, "I am not qualified to say what the FCC would think of such an alteration - even by the holder of a Second Class License. But basically the idea seems unsound, because it would be very easy for Ange to mistakenly insert a receive-type crystal in the wrong holder and be off-frequency by hundreds of kc. I tried this with a popular model not long ago and it kicked plenty of rf into the wattmeter with a 28.750 mc rock. Outboarding the crystals is unwise for several other reasons, too. Constant handling might indirectly be the cause of damaging the crystals, by dropping them. Open-air temperature extremes might be more than enough to affect the crystal's tolerance rating of approximately 1350 cycles at 27.065 mc. Right?"

"I'll say you are," exclaimed the worried-looking technician, "but one more question. What's so special about oscillator plate coils ... the tuning. I mean?"

"I'm glad you brought it up," Lucky replied. "To give an intelligent answer, perhaps I should explain oscillator-amplifier theory, in short. Discussing the popular two-stage circuit only, we start off with the crystal-controlled oscillator, crystal excited with an overtone type unit. Physically, the crystal is carefully cut to its proper length, width and approximate thickness. Then it is precision ground and polished to its final operating thickness. The vibrating mode of the crystal is such that it oscillates strongly on the third harmonic - which is the desired operating frequency. This oscillation is amplified by the tuned plate circuit of the oscillator and coupled to the control-grid of the final amplifier tube.

"Now, if exact resonance in this coil to the crystal operating frequency was our prime consideration, coil adjustment would be relatively simple. However, in order for the crystal to oscillate efficiently, there must be exactly the right amount of phase-shift and feedback in the plate circuit, and this criterion is met only when the plate LC network is slightly out of resonance with the crystal. Therefore, plate coil adjustment tends to be critical and frequency determining, in so far as erratic operation, oscillator pulling, and harmonic content of the transmitted signal goes. To make this adjustment, a technician should adjust the coil for specified negative grid-bias voltage at the control-grid of the final amp. Most manufacturers recommend using a 100K resistor soldered temporarily to this grid terminal, to the VTVM probe tip. Tom, is this clear, or do I have to call my protege, Super-Sonic Smith, on stage?"

"No. I get the drift," was the reply.

Marcus B. Gladistor shot both hands in the air as Lucky paused to take a breather. He couldn't wait to be heard. "Lucky, what in heaven's name do you do to test CB crystals? We all can't own Crystal Tester machines, you know?" he asked. "There must be some way?"

His demeanor rather than the question brought several chuckles from the men, but Lucky gave him a straightforward answer. "There is a way to bench test without a special tester. If you don't have one my method should help. I've had doubts many times about certain crystals. One job in particular was a transceiver with three dead transmit crystals. I didn't know it at first, but the final amplifier was doing the oscillating and pushing plenty of rf into the antenna. I had to prove to the customer that his crystals were shot.

"Other times, a CB'r will stop in, hand you two or three crystals and want them tested. I will say this, the way I test them takes a little practice with normal crystals and low activity types. Dead crystals show up immediately. But the method is fast and perfectly reliable. Before I go into the details, which do not include using a VTVM, as some of you might suspect, think a minute and perhaps we can close this session all on the same frequency." Lucky urged.

What alternative method did Lucky have in mind? ANSWER ON PAGE 29

AURAL RATE COUNT CIRCUIT

A DEVICE THAT ACCEPTS PULSES AND PRODUCES AN AUDIBLE TONE WHOSE FREQUENCY VARIES AS THE REPITITION RATE OF THE INPUT PULSES VARIES

BY RICHARD W. BAILEY

In nuclear radiation counting, an aural indication of the intensity of the radiation source is very often useful. Since the output of some nuclear radiation detectors is a pulse output, by using an amplification stage and a speaker, one can obtain an audible reproduction of the pulses. In this case, however, one needs necessarily to listen for the repetition rate of the output pulses all of which are of about the same intensity, to determine the relative strength of the source radiation. Several years ago some researchers[1] at ORNL (Oak Ridge National Laboratory) in Oak Ridge, Tennessee constructed a device which accepted a pulse input and produced a variable frequency tonal output. It was found that this tone modulation (corresponding to varying source intensity) was easily perceived and that smaller differences in input pulse repetition rates were detectable than with the single click per pulse method. ORNL's device ("Howler", as it was called by its creators) was a vacuum tube device. The circuit described in this article is a transistorized version with slightly different characteristics. This unit consists of two main sections: (1) a linear count rate circuit and, (2) a variable frequency oscillator.

GENERAL DESCRIPTION

The first section of the Aural Count Rate Circuit, i.e., the linear count rate circuit (LCRC), consists of a single shot multivibrator to provide a fixed width pulse of constant amplitude, a capacitor charging (integrator) circuit, and a meter amplifier. The second section, i. e., the variable frequency oscillator (Howler) circuit, consists of a free-running blocking oscillator, whose output frequency is a function of an applied voltage, and a power amplifier for driving a loudspeaker.

The operation of the entire system then is summarized as follows. A pulse source provides negative pulses to the input of the LCRC circuit. These pulses are converted into a DC voltage, the magnitude of which is a linear function of the meantime of arrival of the pulses. This output voltage is presented to the input of the Howler circuit where it is used to control the frequency of a free-running blocking oscillator. The output of the oscillator, in turn, is fed into a power amplifier which drives a loud speaker. The output frequency range is from about 20 cps to 3K cps as the input pulse repetition rate varies over one decade.

LINEAR COUNT RATE CIRCUIT (LCRC)

Transistors Q1 and Q2 (See Fig. 1) form a Schmidt trigger which is used as an amplitude discriminator. The principle reason for its use is that of eliminating small noise pulses that would be interpreted as "real" pulses. The operation of the trigger is as follows. In the quiescent state, transistor Q1 is cut off and Q2 is conducting owing to the fact that the base of Q2 is more negative than its emitter. To show this, notice that the base of Q2 is connected to the voltage divider formed by R2, R3 and R4. The current through this string is about -.28 ma. The voltage across R4 then is about -4.2 volts. The voltage across R6 is about -1/4 volts. With the 4.7K resistor R1 in series with the base of Q1, an input signal of about -4 volts is required to cause Q1 to conduct. When Q1 conducts, the collector potential approaches zero causing the potential at the base of Q2 to go towards zero. Q2 then cuts off very rapidly and remains off as long as the input signal is present.

The negative transition at the collector of Q2 is coupled to transistor Q3 which drives the single shot multivibrator consisting of Q4, Q5 and Q6. Q3 serves as an isolating amplifier used to prevent reflected pulses from entering Q2 through its collector when the single shot multivibrator fires.

This multivibrator is the pulse-width trigger used to supply a constant width pulse to the integrator circuit. The inclusion of Q5 in the conventional single shot is to prevent loading of the collector of Q4 while affording an amplified current charging path for the capacitors C3, C4, C5, C6 or C7. The diode shunting the base-emitter junction of Q5 provides a discharge path for the width determining capaci-

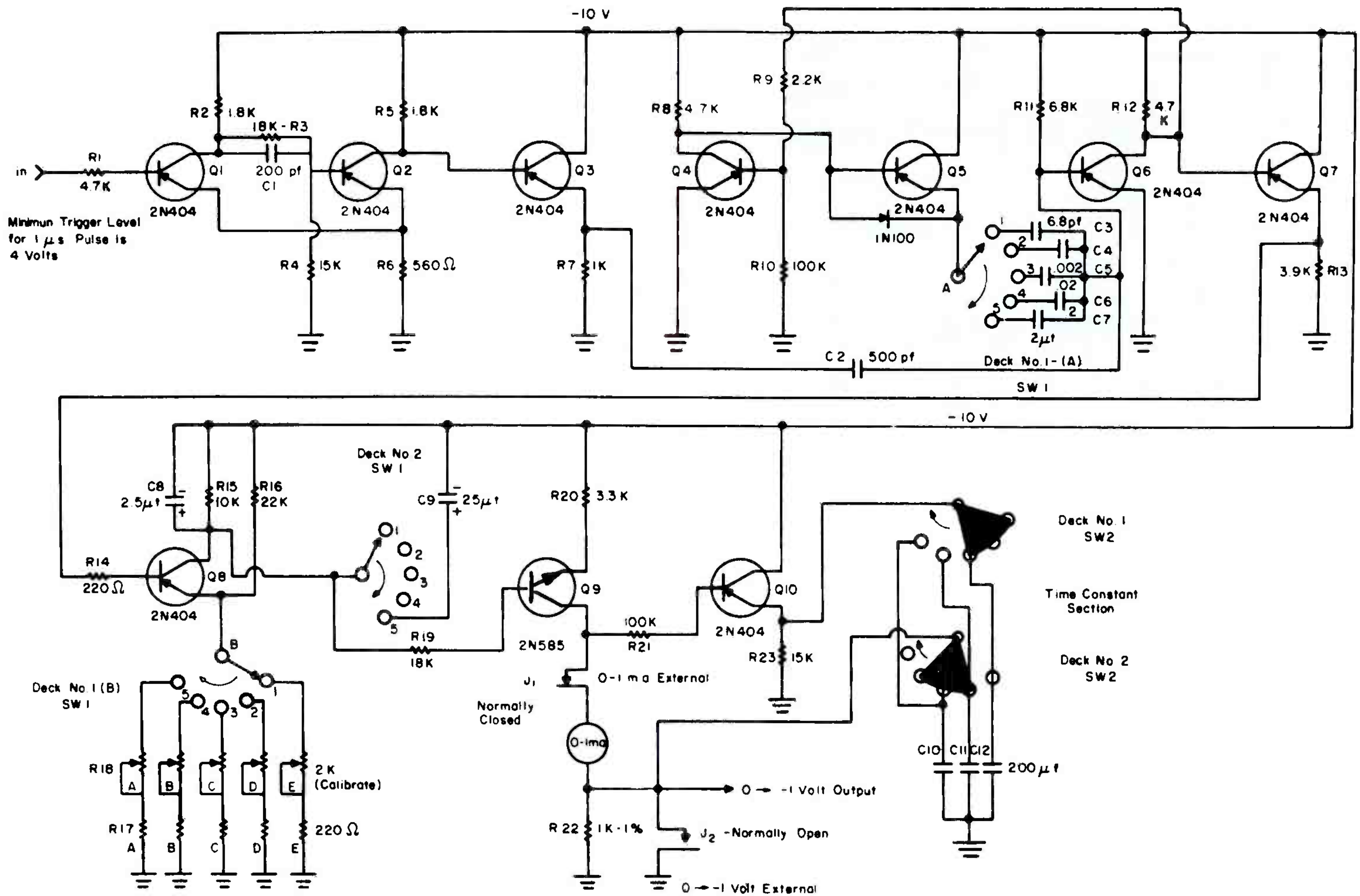


FIG. 1. Linear Count Rate Circuit (LCRC).

tor via R8, the 4.7K ohm collector resistor of Q4. Q7 is again an emitter follower amplifier designed to provide a low impedance driving source for the integrator. The operation of the integrator is as follows. R16 provides enough negative bias on the emitter of Q8 to prevent it from being in conduction. When a negative voltage pulse, of constant amplitude appears at the base of Q8, a current flows in the collector circuit, the magnitude of this current being determined by the emitter resistors R18 and R17. This in effect introduces a fixed amount of charge on capacitor C8. The voltage developed across R15 is determined by the integration of the current pulse over a time period equal to the mean-time of arrival of the input pulses.[2] The expression that describes the voltage developed across the load resistor R15 is as follows:

$$e = nEt(R15/Re),$$

where n is the pulse arrival rate in pulses per second, E is the pulse amplitude in volts, t is the pulse width in seconds and R15 and Re are the collector and total emitter resistances of Q8, respectively, in ohms.[3] The voltage E is assumed to remain constant, the resistors are fixed for a given range, thus the voltage E is proportional to n, the count rate and t, the pulse width. Five (5) basic pulse widths (t) are provided by the single shot multivibrator and each of 5 emitter resistors (R18 A through E plus R17 A through E, respectively) are associated with each pulse width allowing calibration within a decade. Extra integration is supplied by C9 on the low input repetition rate scale. The values of the emitter resistors and the pulse widths (t) are chosen so that a particular value of e (given by the above equation) occurs when-

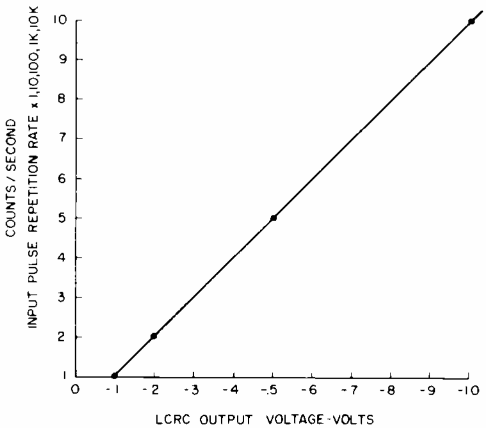


Fig. 2. Graph of input pulse rate vrs. output voltage.

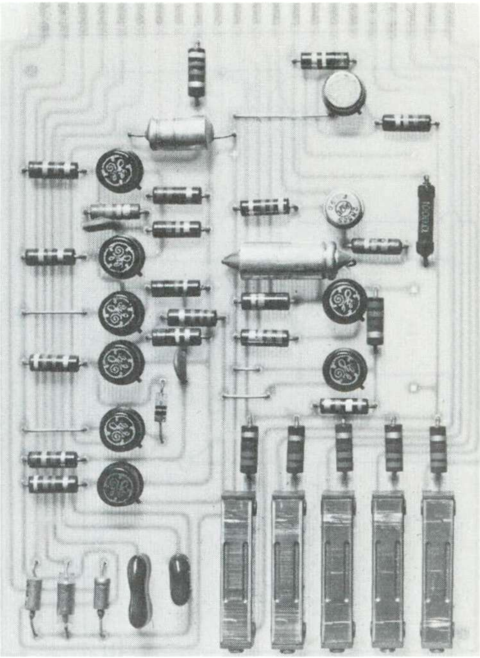


FIG. 3. Printed circuit board of LCRC.

ever a certain repetition rate is reached. Increasing the repetition rate by a factor of 10 means (t) must be reduced by about a factor of 10 and R18 A through E trimmed to make up the difference so that e remains constant.

The transistor Q9 is a meter amplifier which takes the voltage developed across R15 and converts it to a current, driving the 0-1 ma meter. The collector current of Q9 is 1 ma at full scale and is independent of the meter or external (Jack J1) load impedance. A 1K-1% resistor, R22, is used to provide 0 to -1 volt for operating the Howler portion of the circuit. A graph showing the output voltage across R22 as a function of input pulse repetition rate is shown in Fig. 2.

The transistor Q10 is an emitter follower that keeps the capacitors C10, C11 and C12 charged. These capacitors may be switched in for additional time constant while operating a recorder via J1 when the count rate is low. The only change produced by switching C10, C11 and C12 into the circuit is that of providing a smoother recorded trace. Fig. 3 is the Printed Circuit Board of the LCRC.

VARIABLE FREQUENCY OSCILLATOR (HOWLER)

Referring to Fig. 4, C13, C14 and R24 form a Pi R-C filter network designed to further

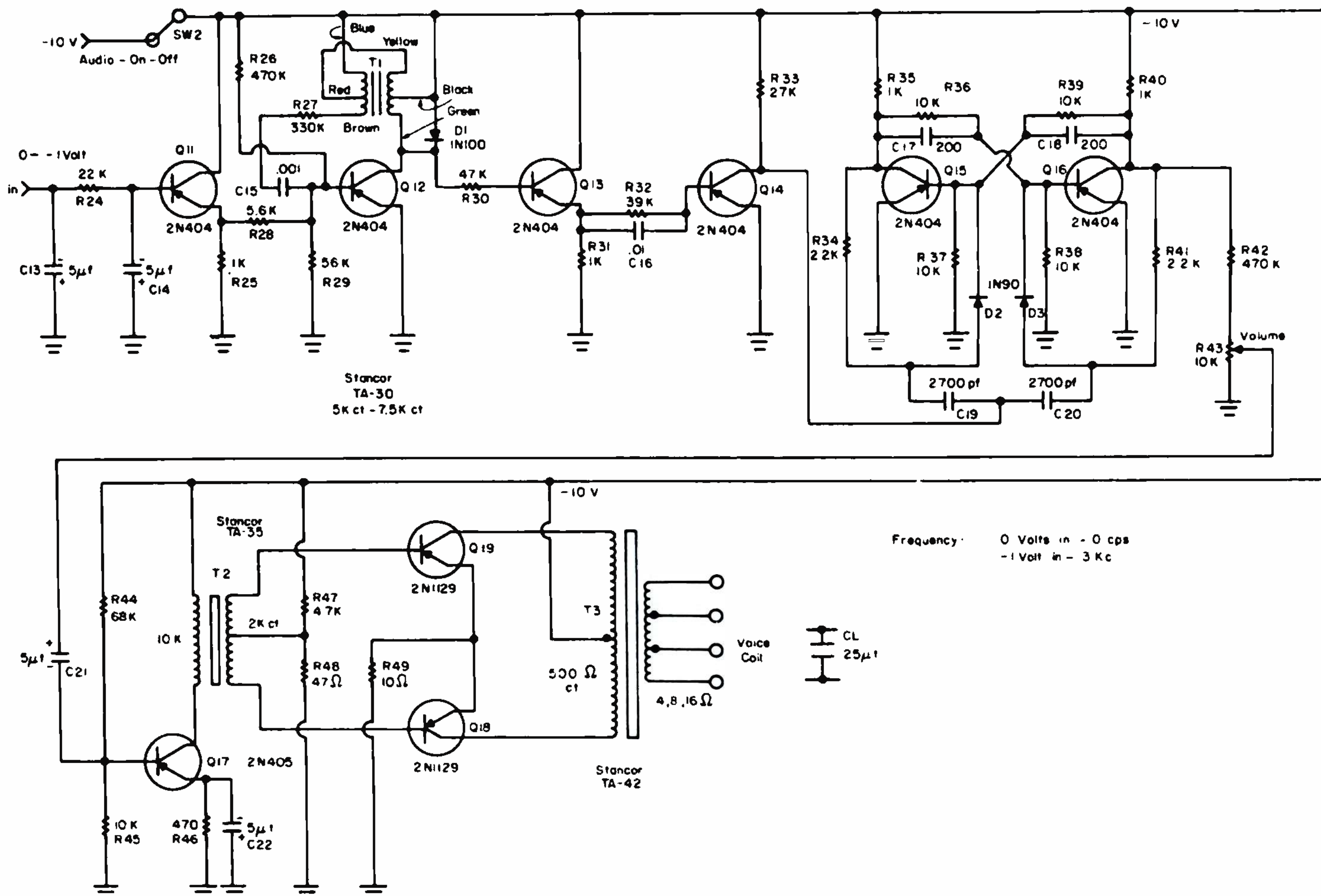


FIG. 4. Voltage to Frequency Converter Circuit (Howler).

smooth the output voltage from the LCRC. Q11 is used to provide a low impedance voltage source to the base of Q12. Q12. T1 and their associated components form a free-running blocking oscillator whose frequency is controlled by the input voltage to Q12's base. To understand the operation of Q12, assume the steady-state case when the collector current is zero. Now apply a negative voltage from Q11 to the base of Q12. The current increases in the collector circuit of Q12. A voltage is induced in the secondary of T1 phased 180° with respect to the collector voltage. This voltage is coupled back to the base of Q12 appearing as more forward bias causing Q12 to conduct even more. This regeneration continues until T1 saturates.

When T1 saturates, the secondary voltage falls to zero cutting Q12 off. The output pulse width is essentially a function of the transformer core material and construction. The frequency of operation depends on how fast C15 discharges. Without the voltage from Q11 this would be controlled principally by R26, R29 and C15. However, upon introducing a voltage from Q11 to the base of Q12, the discharge time is shortened depending upon how negative the base is made. Thus, by varying the DC bias on Q12, the frequency of oscillation is varied. The more negative voltage applied, the quicker C15 discharges and the faster the oscillations. The diode D1 clamps the collector to a maximum negative value of -10 volts preventing voltage puncture of Q12. The next transistor, Q13, is an emitter follower used solely to prevent loading of the oscillator.

Following the emitter follower is Q14, a voltage amplifier using speed-up capacitor C16 to provide a fast voltage spike to trigger the bistable multivibrator formed by Q15 and Q16. The bistable is used in this application to normalize the pulses to a regular square wave. The frequency out of the binary, however, is still a function of the input voltage, and is 1/2 of the frequency fed into it. Following the bistable is the power output stage. The power stage is a conventional class B power amplifier providing about 1/3 of a watt of audio power to the loudspeaker. At the speaker. a capacitor CL shunts the voice coil. This is to eliminate the high frequency components of the square wave, providing a more pleasant sound. Fig. 5 is the printed circuit board of the Howler circuit.

REGULATED -10 VOLT POWER SUPPLY

Fig. 6 is the schematic diagram for the -10 volt regulated power supply used to provide DC voltage for the LCRC and the Howler circuits. The circuit operation is as follows. Following the full-wave rectifier, formed by D4 and D5, is the resistor R51. This resistor limits the initial charging current of the filter capacitor C23 to a value safe for the rectifiers. In addition, note the fuse F1 is a slow-blow type. After the filter capacitor comes the series regulator transistor Q20. This transistor acts as a variable resistor controlled by the amplifier Q21 and maintains a constant voltage at the output. The overall regulating operation can be described starting with zener diode D6. The emitter of Q21 is anchored to the voltage dropped across D6. The current flowing in D6 is established by R53 and is of such a magnitude as to insure that the operation of D6 is well maintained within the zener region even if the line voltage varies by as much as 10 volts. The entire regulating operation is then built around the fact that the voltage drop across D6 is constant. Slight variation in the voltage drop across D6, caused by slight variations in the current through it, is a limiting factor in the overall regulating ability of the circuit. To proceed, assume that R55 is adjusted to pick off a voltage equal to that of the voltage across D6. For a 1N710 diode this voltage is about 6.8 volts. If the output voltage is -10 volts, the current through R54, R55 and R56 is about 5.5 ma. Thus the setting of R55 should be such that about 1,240 ohms appear between the base of Q21 and ground, while about 590 ohms should appear between the base of Q21 and the output.

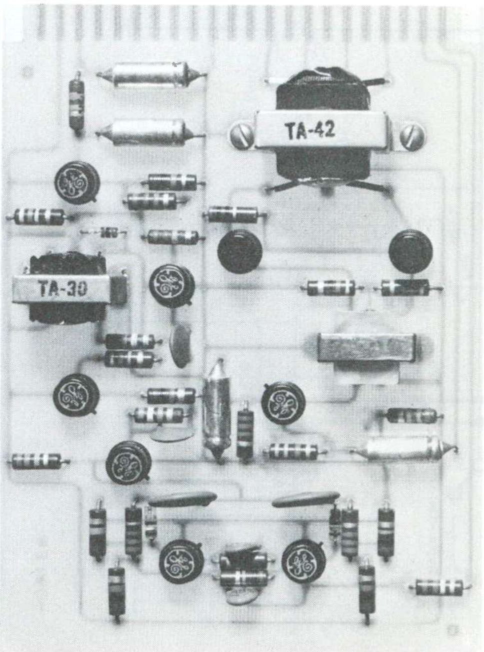


FIG. 5. Printed circuit board of Howler.

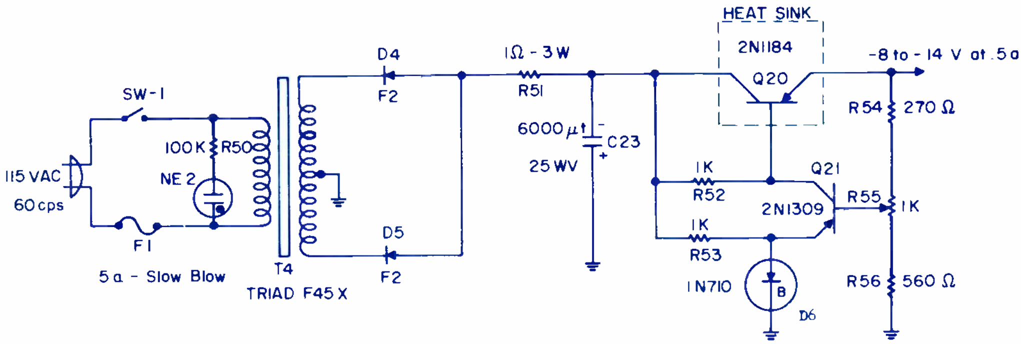


FIG. 6. -10 volt power supply.

Now qualitatively consider the case when the output load increases for some reason (still remaining within the capability of the regulator). As more current is drawn from the output, the output voltage tends to decrease. As this happens the voltage at the base of Q21 tends to decrease. This causes the base-emitter junction of Q21 to become reversed biased tending to cut Q21 off. The collector voltage of Q21 then increases becoming more negative causing Q20 to conduct more, which supplies the demanded output current increase and causes the output voltage to increase until the voltage at the base of Q21 becomes again equal to the zener voltage. This description, of course, neglects the consideration of events caused by V_{BE} variations in Q21.

If, for some reason, the output current decreases tending to allow the output voltage to increase, the reverse of the above operation occurs. Namely, the voltage at the base of Q21 tends to increase, forward biasing the base-emitter junction of Q21, driving it towards saturation. The collector potential of Q21 then decreases tending to shut off Q20 by decreasing the forward bias of the base-emitter junction of Q20. This action causes the output voltage to decrease until the potential at the base of Q21 returns to normal. The other two conditions the regulator must

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contend with are those of increasing and decreasing line voltage. But, as was stated earlier, R53 is chosen so that the current through D6 does not vary enough to permit operation outside of the zener region. This means the voltage across D6 remains constant for line voltage variations (within limits determined by R53 and D6) and the regulator operates as follows. Assume an increase in voltage at the collector of Q20. The voltage increase is also seen at the collector of Q21 and thus at the base of Q20, tending to forward bias Q20 and thereby raise the output voltage.

However, this output voltage increase is regulated against exactly in the same manner as the output voltage increase caused by decreasing the load current. A decreasing voltage at the collector of Q20, by the same reasoning, causes a decreasing output voltage which is regulated against by the same action that occurs when the output voltage decreases due to an increase in output current.

This regulator also acts as a ripple filter because its response time is short enough to follow ripple variations (which are input voltage variations) and, in effect, cancel them.

LIST OF REFERENCES

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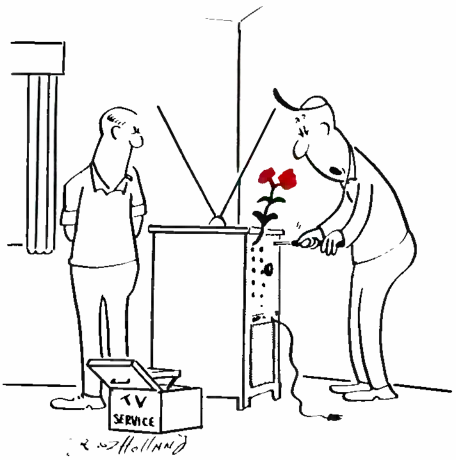
2. Electronics; Elmore and Sands, McGraw Hill Textbook, published in 1949.
3. A Transistorized Pulse Height Analyzer For Gamma Spectroscopy; Robert T. Graveson, USAEC Report No. HASL-59, March 23, 1959.

-30-



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HOW TO SUBSTITUTE PARTS

Continued from page 15

a wire is bent or flexed it should be stranded, because it won't fatigue and break so fast. While stranded is a bit more expensive, the extra reliability is worth it. Most non-chassis work calls for stranded wire.

The usual insulation found on hookup wire is cellulose acetate or polyvinyl chloride, both fairly cheap plastics which are moderately heat- and chemical-resistant. They do for most general jobs. Better sheaths are made of Teflon or Neoprene. These are more costly but have further advantages: they are even less affected by heat and moisture, have greater insulating properties, and handle easier.

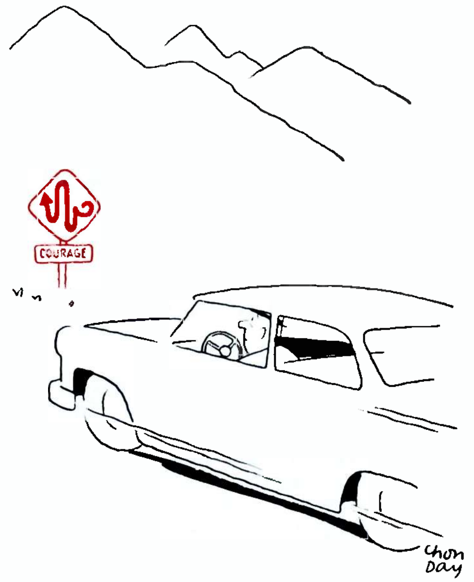
Outside the chassis, for AC power cords, multi-conductor cables, mike and remote-control lines, three general types of insulation are available. Vinyl or polyethylene plastic types are cheapest, and have low capacitance, low loss, good oil resistance, light weight, and small diameter. However, plastic-covered wire is best used for fixed applications, where the cable won't be moved much. Rubber-covered cables have greater abrasion and impact resistance, and they will lie flat and limp, both features being handy for portable equipment, such as power tools. Rubber-covered cables are best used where punishing work is involved. Neoprene is recommended for outside use. Although it's not as limp nor as resistant to abrasion as rubber, it will withstand sun and oil. It's more expensive than the other two.

Special test-lead wire, for scopes, voltmeters, etc., is made of many strands covered with a highly-supple rubber sheath. It's extremely rugged and flexible, and will withstand much abuse.

Spaghetti -- insulated tubing used on component leads and bare wire -- also comes in a variety of materials. Vinyl and poly plastics are the commonly-available types, and will do for nearly all applications. Where extremely low loss and high reliability are important, Teflon tubing should be used. It's expensive, but worth it. You should not overlook a fairly recent development -- shrinkable tubing. Often made of irradiated polyolefin, it shrinks tight when heated. This is most useful for cabling several wires together, for covering splices and joinings, and for marking cables.

- 30 -

> Our worst misfortunes never happen, and most miseries lie in anticipation.
> Balzac.



ANSWER TO LUCKY'S PROBLEM

No one in the group was sure of the answer: "There is really nothing to it. Connect the prongs of the unmounted crystal to the output of your rf Signal Generator. Set the Signal Generator frequency at about 27 mc modulated at 400 cycles. Connect one lead of a diode detector, such as a 1N64, to the vertical input of your oscilloscope. Now connect the other lead of the diode and the scope ground lead to the crystal prongs. Set the scope for maximum <u>Vertical Gain</u>, and <u>Internal Sweep</u> with a <u>Coarse Sweep Frequency</u> of approximately 200 cycles. The screen pattern should now show the detected modulation - a 400-cycle sine wave. Carefully tune the Signal Generator through the crystal frequency. An active crystal will show very prominent ringing. The ringing of the crystal is indicated on the scope as an 800-cycle sine wave. The 800 cycles is a beat note produced by the crystal frequency and the sidebands of the signal generator. For example, when the upper sideband frequency of the signal generator equals the crystal frequency, these two signals combine to produce a large amplitude upper sideband signal. This large amplitude upper sideband signal beats with the lower sideband signal producing an 800-cycle difference signal. The 800-cycle sine wave is superimposed on the 400-cycle sine wave in the scope presentation. It appears as a 400-cycle signal with pronounced second harmonic distortion. Defective or dead crystals show absolutely no response."

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.

Visits To Local Chapters

Last year J. B. Straughn, Chief of NRI Consultation Service, accompanied Executive Secretary Ted Rose on his annual visit to the various local chapters. Mr. Straughn's lectures and demonstrations on Radio-TV-Electronics were so enthusiastically received that he is repeating them this season. Below is a schedule of the visits yet to be made.

CHAPTER	DATE
Minneapolis-St. Paul	April 9
Pittsburgh	May 7
Hackensack	May 29

All NRI students and graduates are welcome at the meetings whether they are members or not. Take advantage of this chance to meet Mr. Straughn and to hear him lecture on Electronics. See "Directory of Local Chapters" on page 32 for information on time and place of meetings.

CHAPTER CHATTER

DETROIT CHAPTER's Chairman Jim Kelley provided the members with an excellent lesson on using the oscilloscope to service television receivers. In addition to pointing out how to troubleshoot with the scope, he explained the kinds of probes used in the various sections of a TV receiver, their voltage, ratings, capacities, etc. The members are indebted to Jim for his painstaking effort in preparing this fine demonstration.

John Nagy, whom the Chapter regards as its audio expert, gave an equally interesting lecture. His was about the different kinds of wires used in the various kinds of sound equipment in Detroit theaters. Many members expressed their surprise at how interesting wire can be when used in these applications.

At the next meeting Secretary George Povlich delivered an hour-long talk on how and where to buy tubes and electronic parts at the lowest prices, gave confidential tube price lists and other buying information. John Nagy suggested the possibility of the Chapter having its own building, which would include an electronic museum. There will probably be more talk about this at future meetings.

FLINT (SAGINAW VALLEY) CHAPTER members had a real treat. Last summer former Chairman Andrew Jobbagy made a trip to Europe. He traveled extensively, visited seven countries. On Sunday afternoon, January 26, at the Southland Lane Bowling Alley, where the chapter occasionally holds its meetings, Andy showed a movie that he made of his travels. This was a very entertaining film.

The Chapter reports its officers for 1964 as follows: Henry Hubbard, Chairman; Donald Darbee, Vice Chairman; Andrew Jobbagy, Secretary; Clyde Morrissette, Treasurer; James Windom, Jr., Sergeant at Arms; Charles Wotring, Entertainment Committee; Robert Poli, Educational Director; Leroy Cockrell, Photography; Richard Jobbagy, Movie Operator; Art Clapp, Civilian Communications Radio; Raymond Kitt, Paul Crippen, Leslie Carley, William Duncan, Kenneth Melborne, Robert Newell, Membership Drive Committee.

Our congratulations to the latest member admitted to membership, Raymond Elliot.

HACKENSACK CHAPTER members thought very highly of a color program put on by the chapter. At the next meeting the feature was three films secured from Bell Telephone by Chairman George Schalk. The first was a color film on Telstar. The other two were "The Dew Line Story" and "The Transistor." These films were thoroughly enjoyed by the members, who found them not only instructive but entertaining.

Chairman Schalk brought a large supply of tubes and other radio components to this meeting, which he offered for sale to the members, the proceeds to go to the chapter treasury. A sizeable amount resulted from this sale.

As we go to press the chapter plans called for a visit to both a radio and television station. This visit may have been made by the time this issue of the Journal is published.

LOS ANGELES CHAPTER reports that its entire slate of 1963 officers has been re-elected to serve during 1964, the only difference being that Jim Law has been elected as Secretary instead of having been appointed as he was for 1963. The other officers are Eugene DeCaussin, Chairman; Bill Edwards, Vice Chairman; Fred Tevis, Treasurer. Congratulations, gentlemen!

The members were sorry to learn that former Secretary Earle Allen's wife had passed away.

MINNEAPOLIS-ST. PAUL (TWIN CITY) CHAPTER had one of its shortest business meetings on record. The meeting was set up as a dog night and the response was overwhelming. So many TV sets were brought in by the members that the business part of the meeting was as short as possible, so as to devote maximum time to discussion and repair of the receivers. The members enjoyed the evening, felt that this was a very successful meeting.

NEW ORLEANS CHAPTER in January held one of its best meetings in recent years. This was partly because of the excellent program conducted by J. B. Straughn, Chief of NRI Consultation Service, who accompanied Executive Secretary of the NRIAA, Ted Rose, on his annual visit to the Chapter.

In the course of his program Mr. Straughn propounded two tricky problems in radio servicing. Two members succeeded in solving them. Frank Ryder hit on the solution to one and James Bolden the other. This was an enlightening session and gave the members much food for thought.

The photograph reproduced here was snapped just after Chairman Blackford had presented the guests with a very attractive pearl stickpin as a token of appreciation for their efforts on behalf of the Chapter.

NEW YORK CITY CHAPTER chose the following members to serve as its officers for the current year: David Spitzer, Chairman; Frank Zimmer, Executive Chairman; James Eaddy, First Vice-Chairman; Al Bimstein, Second Vice-Chairman; Joseph Bradley, Secretary; and Samuel Antman, Treasurer. Our congratulations to these officers.

After the elections, Jim Eaddy talked on using a transistor portable as a means of tracing electrical noise and using the rf section on one set to supply signal to an inoperative set.

PHILADELPHIA - CAMDEN CHAPTER scheduled another one of its most outstanding meetings. It was to be conducted by the General Electric Company at the General Electric Auditorium in Philadelphia on January 13. It was what GE calls a "Service Training Meeting." The subject for this one was Basic Theory and Application of Transistors.

But the meeting had to be postponed on account of the weather. That was the weekend that we had such a severe and heavy snowstorm in the Eastern half of the country. As in so many places, travel was practically at a standstill in Philadelphia. So this meeting was postponed until March 9.

Executive Secretary Ted Rose and J. B. Straughn of the NRI Staff attended one of these GE programs a few years ago. They can vouch for the excellence of the programs and their value to the Radio-TV serviceman. All NRI students and graduates in the Philadelphia area should take advantage of this opportunity to attend this meeting. They will be most welcome by both GE and the Philadelphia-Camden Chapter.

PITTSBURGH CHAPTER welcomed Mr. Thomas Dapra as a guest. He is the sales manager of the Radio Parts Company of Pittsburg. He made a valuable contribution to the meeting: The showing of a movie on the rebuilding of picture tubes by Channel Master. The members found this film so interesting that the suggestion was made that other chapters might like to see it. Any

Herman Blackford, Chairman of the New Orleans Chapter, flanked by NRI's J. B. Straughn (left) and Ted Rose, at the Chapter's January meeting.

interested chapters should drop a line to the chairman.

SAN FRANCISCO CHAPTER employed its first meeting of the year as the occasion for an anniversary celebration. The Chapter was chartered on January 7, 1959.

Art Ragsdale, President of the NRI Alumni Association this year, first proposed the establishment of the San Francisco Chapter, was its chief organizer and first Chairman, and later Secretary. He has been very active in and a leader of the Chapter ever since. Art gave a history of the Chapter at this anniversary celebration.

He then cut a cake which was especially prepared and decorated for the occasion by Mrs. Ragsdale. The members of the Chapter expressed their appreciation to the wives and friends for helping make the celebration a success and particularly for the refreshments and entertainment.

SPRINGFIELD (MASS.) CHAPTER's first meeting of the year was devoted largely to discussion of preparations for its annual banquet which was to be held at Betty's Town House, Agawam, Mass., on January 25. This is always an enjoyable occasion; we trust the one held this year was as much so as those of former years.

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 Andrew Jobbagy's Shop, G-5507 S. Saginaw Rd., Flint. Chairman: Henry Hubbard, 5497 E. Hill Rd., Grand Blanc, Mich., 694-4535.

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: James L. Wheeler, 1436 Riverview Dr., Verona, Pa. 793-1298.

SAN ANTONIO ALAMO CHAPTER meets 7:30 P. M., 3rd Wednesday of each month, Beethoven Hall, 422 Pereida, San Antonio, Chairman: Sam O. Dentler, 329 Southcross, San Antonio, Texas. WA 2-8682.

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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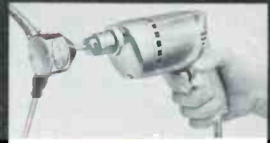

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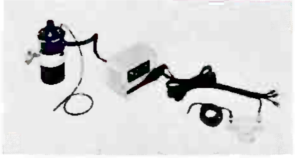

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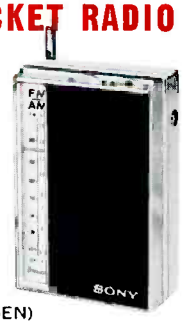

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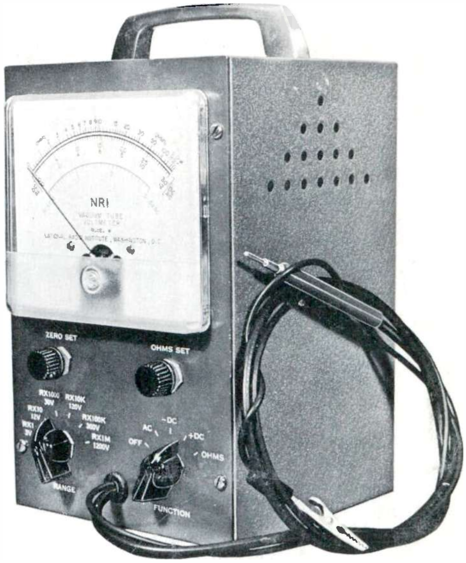

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