NRI news

August/September 1961

NRI TECHNICAL CLERK, MRS. ANNE GORMAN, PULLS A RADIO DIAGRAM TO BE REPRODUCED. IN THIS ISSUE WE TELL YOU ABOUT THE NRI DIAGRAM SERVICE. SEE PAGE ONE.

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NRI NEWS

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T. E. Rose
Editor
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J. A. Jordan
Publication Editors
L. L. Menne
Editor Emeritus

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Editorial: COMMON SENSE

We have all heard the remark that "so and so is a very capable guy" and seems to be able to solve problems with ease and without tearing his hair, or making things more complicated by failing to use common sense.

The electronics technician, in particular, needs to use a great deal of common sense as well as technical skill when troubleshooting a circuit. The design engineer, too, must consider what is expected of his product, what its worth and its practical value. Many of these individuals are perfectionists and consider what they themselves want rather than what is wanted by the consumer. So they "set their sights" to the development of a product that becomes very costly and complex.

We have known TV service technicians that failed to recognize the need for common sense by going overboard in substituting tubes as a cure-all for circuit malfunctions. In many cases, this technique actually compounds the difficulty in making a correct analysis.

Set performance goes from bad to worse. This is a common occurrence when the technician pulls all the tubes at once and substitutes a new set. The ailing stage can easily be lost in the shuffle and the trouble can be made even more difficult to locate.

Common sense tells us to substitute one tube at a time and to check the effect on performance after each substitution is made.

Webster defines common sense as "sound, ordinary sense; good judgment." We can't take an educational course in common sense. We either have it, or we don't. If we think before we leap -- we are practicing common sense.

I like to remember the words of a little old gentleman who once said:

"Finding a solution to a problem is not difficult, but finding a solution to a problem that does not create other problems is difficult."

J. E. Smith
Founder

IT IS A FUNNY THING about life: If you refuse to accept anything but the best, you very often get it.

W. Somerset Maugham

Dale Stafford

The NRI Diagram Service

By

Dale Stafford

NRI Consultant

Our "Cover Girl" this issue is Mrs. Anne Gorman, our Technical Clerk and "Keeper of the Files." What's she looking for? A diagram. If we have it, you can bet Anne will find it. And if it is a diagram of a radio or TV set, we probably have it.

Our collection goes back almost to the first days of radio. If you, gentle reader, are as young as I'd like to be again, we have diagrams of sets you have probably never seen and may never see. They were made and used before you were born. Most of them are worn out and gone. One of them still shows up occasionally, though, so we hang onto the diagrams.

One of these old timers is shown in the schematic diagram in Fig. 1. This is not the "grandfather" of this group - we have some diagrams older than this one.

Our file of diagrams marches right down through the years to include those that went on sale a few months ago. We have tried to make it as complete as possible.

There are two purposes of our diagram collection. First, it serves as a source of information for us and, second, it makes it possible for us to supply diagrams to our students and graduates.

Many of the letters we receive concern a particular radio or TV receiver. A student may write that a tube is missing from his set, a resistor has charred beyond recognition, or a capacitor has lost its markings. He wants to know the tube type or the value of the part, or perhaps the set operates poorly or not at all and he wants help in finding the trouble. We usually give him the help or information he needs without a diagram. In some cases, we might have to give him some general information and let him try to apply it to his particular difficulty. This is fine for the man who has had enough experience to know his way around in a radio or television receiver. He needs only a push in the right direction. However, this might not be of much help if the student is pretty short on practical experience. In fact, he is apt to feel that we are trying to brush him off if we don't give him an exact answer.

For this reason, we like to have a diagram for every set we are asked about. When we have one, we can do a better job of answering the letters we receive. In many cases, we may be able to point out the exact cause for the trouble or narrow the possibilities down to two or three components.

Quite often one of our students or graduates would like to obtain a diagram for a radio or TV receiver. We are glad to supply these whenever we can -- and that is most of the time.

So that we can do this, we have obtained permission to duplicate almost all the diagrams we have. Copies are made in a well-equipped darkroom where we have duplicating machines to copy almost any kind of diagram, drawing, or other printed or written material.

When we get an order for a diagram, our copy is taken from the files, a copy is made and mailed out to the student, and the original is returned to our files.

Fig. 2 shows Miss Elizabeth Mast seated at

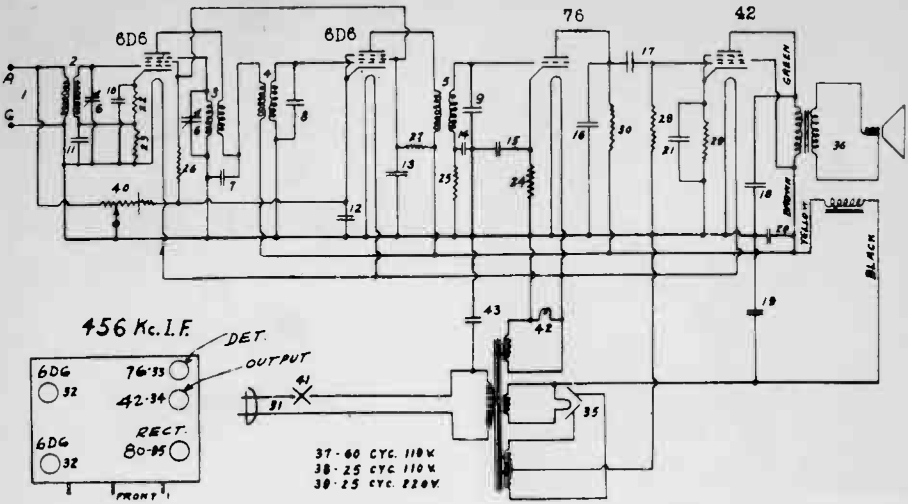

FIG. 1. Schematic diagram of Model 5M3. (Courtesy Crosley Radio Corp.)

one of the duplicating machines called the "Rocket". Along with the many other tasks they perform to keep The School running smoothly, she and Mrs. Gorman handle the diagram requests we receive. To them belongs the major portion of the credit for the success of our Diagram Service.

There is one thing that I would like to emphasize -- we are not in the diagram publishing business. Our Diagram Service is just that -- a service for our students and graduates.

We are equipped to make single copies of a great many diagrams. Diagram publishing houses, on the other hand, are equipped to make thousands of copies of one particular diagram. Thus, we couldn't hope to compete with these companies, even if we wanted to which we don't. Our primary interest is teaching.

We charge fifty cents for a radio diagram and $1 for a TV diagram. This is just about the least we can charge and hope to break even. Should you want one diagram, or a dozen, or more, we are happy to furnish them. If, however, you want to build up a complete file of all available radio and TV diagrams, it would be cheaper for you to buy diagrams put out by companies in that business.

These are available at your local radio wholesaler or from big mail order houses dealing in electronic equipment, such as Allied Radio or Lafayette Radio. They are published in sets and bound volumes by Howard W. Sams Co. and in bound volumes by Supreme Publications. The Rider Co. used to publish both radio and TV diagrams in bound volumes. Their TV Manuals are still available and a lot of the radio manuals can be found second-hand in good condition.

When you order a diagram, be sure to give us the make and model number of the receiver. By doing so, you can make sure your order is filled promptly and properly.

In some cases, you may find a chassis number instead of, or in addition to, the model number. This is especially true with TV receivers. Some manufacturers use the same chassis with only minor changes for several models. Give the chassis number if you find one, but look for a model number too and include it also if one is located.

FIG. 2. Duplicating a radio diagram on the "Rocket".

It sometimes helps to include the serial number, if known. Sometimes there is a production change that applies to all sets of one model above a certain serial number. Thus, we may be able to send you this change if it applies to your set.

However, the serial number alone -- without the model number -- is not much help in locating the proper diagram. Try to find a model number -- that is what we need.

If you can't find the model number, tell us the manufacturer's name and list the tubes used in the set. It is often helpful to make a rough sketch showing the tube locations. With this information, we can locate the diagram for your receiver if we have it. It takes a lot more time than when we have the model number, though, so look hard for that number, won't you?

In an attempt to be helpful, students often list various part numbers from the set, such as those on i-f transformers, output transformers, speakers, etc. We appreciate their efforts but this doesn't do much good. Manufacturers buy these parts by the carload and may use the same type of part in a dozen different receivers.

Having ducked the subject as long as possible, we will now take up something that sometimes presents quite a problem. We get many requests for diagrams besides those for radio and TV receivers.

Some are for standard circuits we know or can find in any good reference book. Others are for commercial equipment for which we can obtain diagrams. Others, however, involve working out new circuits or modifying existing equipment. In some cases, the student is not quite sure just what kind of a circuit he wants. He has an idea he would like to see carried out, he feels that a circuit could be designed for this purpose, and he wants us to design the circuit.

Sometimes, a request of this sort "puts us in a bit of a hole". We don't ever want to refuse a man any help we can give him. At the same time, we certainly don't want to see him stuck with a circuit that won't work properly. If we send him a diagram for a circuit and it works perfectly when he wires it up, everything is rosy. He'll be pleased and happy and he'll think we are about the greatest guys on earth. If, however, he spends several dollars for parts and a lot of weary hours putting them together and the circuit doesn't work just right, he is going to be pretty unhappy with it -- and with us.

On the other hand, if we don't send him a diagram, he is quite likely to get the idea we just don't want to take the time and trouble to help him.

Things would be easy if a circuit always worked the same on a chassis as it does on paper. Unfortunately, life is not that simple. Even a design engineer who devotes his life to this work doesn't expect, or hope, to design equipment on paper that doesn't have a few "bugs" to be worked out when it is wired up. Sometimes a part has to be added or omitted or voltages have to be changed. This happens with practically every piece of electronic equipment that is designed and is due to manufacturing variations in the parts used.

For this reason, we don't like to furnish a new circuit or a circuit modification unless we know that someone has wired it up and tried it out to be sure it works. In this connection, our file of technical magazines is invaluable. Often we can find an article on the exact circuit the student wants. In this case, the circuit will have been tried out by the author, and possibly by one of the editors, to be sure it is practical. More important, the magazine will usually have a record of any trouble that any of its readers ran into in building the circuit and a letter to the magazine will get this information if the student gets into trouble. When we can find information like this, we are glad to pass it along to the student.

Sometimes, though, our best efforts are unrewarded and we have to disappoint the student. When this happens, we just have to hope he understands that we would help him if we could.

Well, that's the NRI Diagram Service. It is yours to use if you need it. If you have a complete file of radio and TV diagrams, we're happy that you are so fortunate. If you need help in locating some particular diagram, drop us a letter. We'll certainly help you if we can.

NEW TELEMETRY SYSTEM

PHILADELPHIA, Pa. -- An experimental version of a new telemetry system has been completed here that is expected to be able to beam signals through space about three times as far as any telemetry system yet flown. This comparison includes Pioneer V, the U.S. solar satellite that last year exceeded all records by sending signals to Earth from millions of miles out.

The telemetry system is one of a family of communication systems called "Synchrolink" that will transmit data the same distance as systems now in use with about one-tenth the power requirements.

Scope Waveshapes in Servicing the 8W Receiver

By

Joseph Schek

NRI Consultant

The acknowledged key to rapid TV service trouble analysis is the oscilloscope. A scope is an unusually effective TV service instrument for isolating the faulty stage by rapidly analyzing its operating waveforms.

To show how this is done, we are going to use the popular NRI Model 250 TV Oscilloscope in conjunction with the NRI Model 8W TV training receiver. The scope and receiver are shown in Figs. 1 and 2, respectively.

The oscilloscope is always used as a signal tracer to visually display the shape, frequency, and amplitude of the video, sync, and sweep signals. By knowing beforehand what a normal scope pattern looks like, a stage with a circuit fault can be readily isolated by its distorted or off-frequency waveshapes.

The basis of this TV service technique is sound because those stages having no fault will show normal waveshapes, but the stage that is defective will be quickly detected by its distorted signal output. Another reason why this TV servicing procedure is very important is that all TV receivers, regardless of make or model, have virtually identical waveforms at corresponding circuit points.

For our scope tests, we will take each major section of the 8W separately and trace its normal waveforms. Then we will see how faulty stages are isolated by analyzing the trouble symptoms and using the oscilloscope to find the defective stage or circuit.

Fig. 3 is a schematic diagram showing the stages in the 8W video chain from the tuner to the picture tube. The relationship of the stages in the video chain to each other and to the remaining sections can be seen in the 8W block diagram of Fig. 4.
The basic procedure in using the scope to trace the signal in the video chain is to feed a signal into the antenna terminals of the TV receiver and check its waveform at each circuit point - usually the control grid and plate of each stage.

The starting point is the output of the tuner. This is located at the control grid of the first video i-f amplifier. The best signal to use is the signal from the local TV station but in weak signal areas you can feed a modulated rf signal from a signal generator into the antenna terminals and follow it through the receiver.

FIG. 1. The NRI Model 250 oscilloscope.

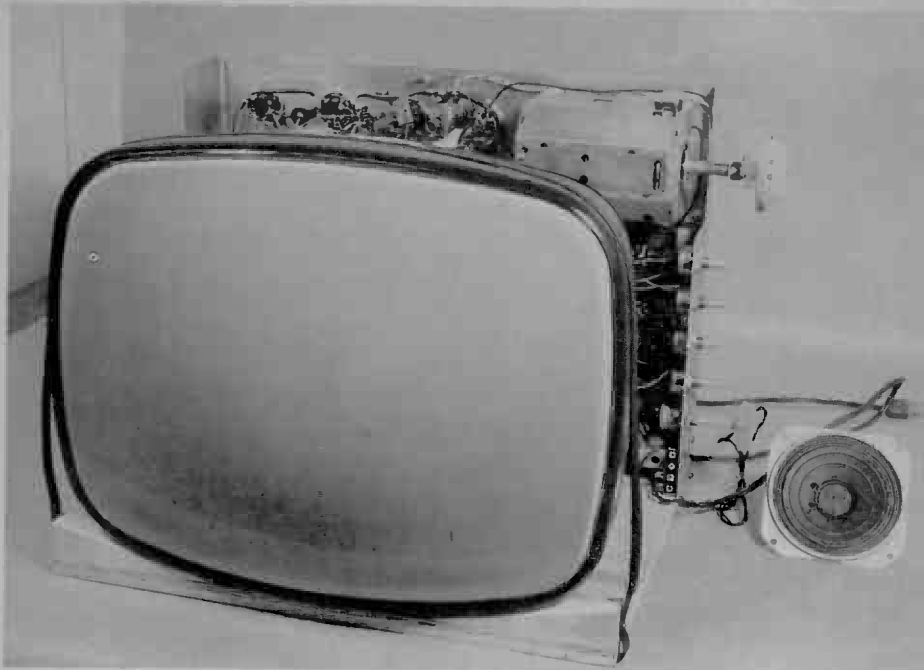

FIG. 2. The NRI 8W Receiver.

However, if a signal from a signal generator instead of from a station is used, a stage defect that is distorting the signal may not be so readily apparent.

Regardless of whether you use the signal from a TV station or a signal from a signal generator, the procedure is the same. Simply start following the signal through the receiver, tracing it from the tuner, through the video i-f stages, the video detector, and video amplifier to the picture tube cathode or control grid - whichever element is coupled to the video amplifier output.

SCOPING THE 8W VIDEO I-F STAGES

When an oscilloscope is used as a signal tracer in the video i-f stages, a detector (demodulator) probe must be used with it. Since the signal in the video i-f stages is an rf signal, it must be detected (demodulated) so that its modulation components (video and sync information) can be applied to the scope input and observed on the CRT.

A demodulator probe called the Signal Tracing Probe is included in the complete probe kit of the Model 250 Oscilloscope. This probe kit is shown in Fig. 5.

Once you have connected the detector probe output to the 250 scope input terminals - using the special cable supplied with the probe kit - turn the Vertical Gain Controls to the maximum sensitivity position; VERTICAL ATTENUATOR to 1X and VERTICAL GAIN to about .12.

At the 8W, hook the cable ground clip to a convenient B- point. The tuner chassis ground lug or anywhere on the lead of R55 connecting to this lug is satisfactory. You will leave the clip attached here for all of the tests. Switch on your 8W, which should be working normally, and adjust it to the strongest local channel. Turn on your Model 250 and set the SWEEP SELECTOR to its 15-100 position.

Bring the probe tip firmly in contact with hole 12 of the printed circuit board. Now carefully adjust the FINE FREQUENCY and SYNC controls until you see one or two 60-cycle field patterns. These will be similar to Fig. 6.

In most strong signal areas you will be able to pick up this signal at the input of the first video i-f in practically all receivers. However, in a very weak signal area, you may be unable to pick up a usable scope signal until you reach the output (plate) of the last video i-f stage.

After getting the signal at the input (hole 12)

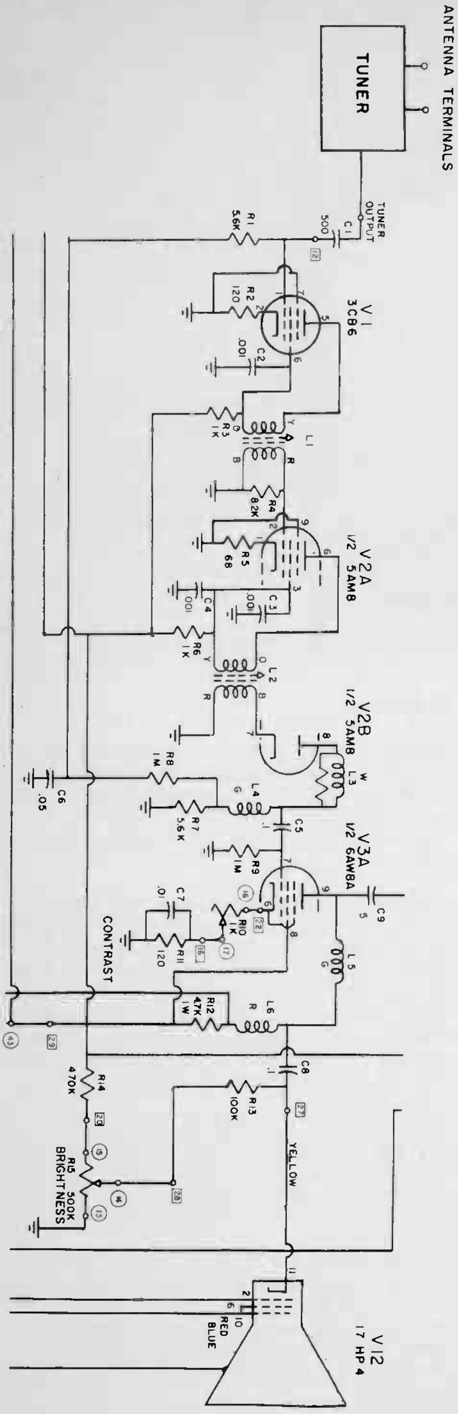

FIG. 3. 8W video chain.

of V1, move the detector probe tip to the terminal (Y) of the primary of L1 which connects to plate pin 5. This is the output of the first video i-f.

You will see the same waveform as at the input (control grid) but with considerably greater amplitude - about seven times greater. The video, blanking, and sync signals of the composite waveform will also have sharper detail. We next move the probe to the i-f transformer secondary terminal (R) which connects to the grid at pin 2 of V2A. The waveform here will be practically identical to that of the primary, indicating normal transformer coupling to the input of the second video i-f stage.

The signal at the output of this stage is next checked. Bring the probe tip to the primary terminal (O) that connects to the plate at pin 6. If you see the picture on the screen "wash out" and only "grass" on the CRT screen with the probe tip at terminal O, use a 3000-ohm, 1/2-watt resistor in series with the probe tip between it and terminal O. This will serve to minimize loading of this circuit by the probe. Just tightly wrap one lead of the resistor around the probe tip and touch the end of the other lead to terminal O.

The scope will show a clear field pattern indicating a normal signal gain of about 7 times. By checking the signal in the secondary of L2 at terminal B, you will have "scoped" all video i-f waveforms up to the input of the video detector.

THE VIDEO DETECTOR

The video detector demodulates the video i-f signal. In other words, the signal fed into pin 7 of detector stage V2B is an rf signal (carrier) with the video-sync information superimposed on it. This process called modulation takes place at the TV station.

The detector output signal at pin 8 is a video-sync signal less the rf carrier. This demodulated video-sync signal can be applied directly to the scope input, while an undetected signal cannot.

Incidentally, the scope rf Signal Tracing Probe employs a video diode detector circuit to strip the i-f carrier, leaving only the video-sync modulation for the scope input.

To check the receiver video detector and amplifier stages, remove the SIGNAL TRACING PROBE and attach the DIRECT TESTING PROBE. You should see the same composite signal with no increase in amplitude at pin 8 as is present at the detector input -- pin 7 of V2B.

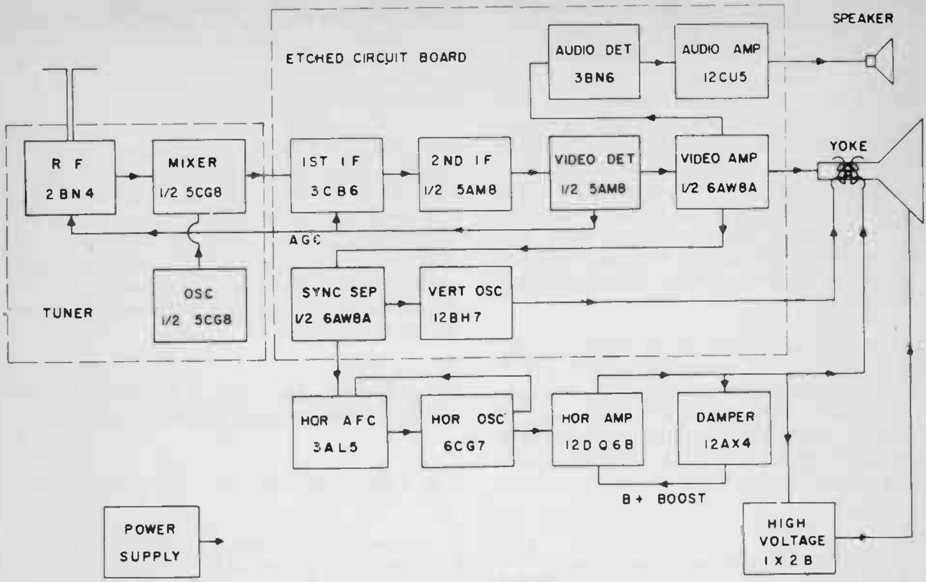

FIG. 4. Receiver block diagram (8W).

Failure to obtain this demodulated signal indicates that the video detector is not working. This might be due to a defective tube (or a defective crystal) if one is used in the detector circuit or one of the components used in the detector stage may be defective.

THE VIDEO AMPLIFIER

In the video amplifier, V3A, the 250 scope is used for signal tracing with the DIRECT TESTING PROBE since the signal has already been demodulated by the video detector. In addition, since the signal amplitude should be reasonably high at the output of the video detector, you should be able to use this signal from the TV station even in a weak signal area. If the signal is so weak at the video amplifier (pin 7) that you are unable to pick up any signal with the scope, the chances are you will be unable to obtain a satisfactory picture on the receiver.

FIG. 5. Complete probe kit for use with NRI 250 Scope.

To trace the signal through the 8W video amplifier stage, bring the probe tip to any part of the printed board circuit going to pin 7 (control grid) of V3A. Do not use the 3000-ohm resistor for video amplifier tests. The pattern will be identical to that present at the output of the video detector, having passed through coupling condenser C5.

With a normal signal at the grid, move the probe tip to the plate (pin 9) and observe this signal greatly amplified. You will probably need to reduce the scope input to keep a 1" to 2" pattern by adjusting the vertical attenuator to its 100 × position. The gain of a normally operating video amplifier will be from 20 to 30 times.

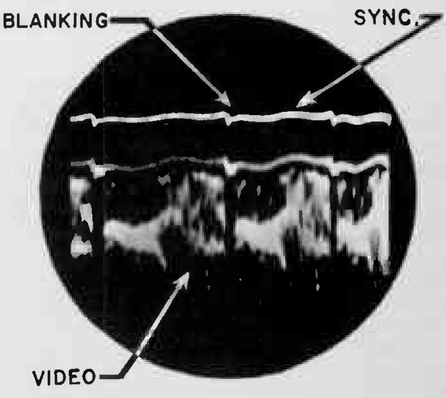

FIG. 6. Field pattern.

In addition, the signal on the scope should be inverted as compared with the video amplifier signal at pin 7. Remember that there is a 180-degree phase shift in a conventional amplifier stage. If the video amplifier section uses two stages as shown in Fig. 7, you should check the grid of the first tube, and check the plate of that tube, and then check the grid of the second tube and finally the plate of the second video amplifier. In this way you can quickly trace the signal through the entire video amplifier section and locate the stage in which the signal is being lost, weakened, or distorted.

After observing a normal waveform at the plate circuit of V3A, we would move the probe to the video amplifier circuit which connects to the picture tube. In the 8W, this would be at circuit board hole 27. The signal will be identical to that at the video amplifier plate, having passed through coupling condenser C8.

The same technique is followed in checking for signal at the input first, then scoping the output at the plate. Any distortion, lack of normal gain or absence of signal is immediately seen and the faulty stage pinpointed.

Bad coupling circuits can be quickly isolated by the scope. For example, if a good signal is seen at the video detector output (pin 8 of V2B) but none at the input (pin 7), L3 and C5 would be suspected. Move the scope probe to the other end of L3. Lack of signal shows this peaking coil to be open. Presence of a signal shows the peaking coil to be good and C5 to be faulty.

SIGNAL TRACING WITH THE 250 SCOPE IN THE 8W SYNC AND SWEEP SECTIONS

Fig. 8 shows the 8W sync, sweep and flyback

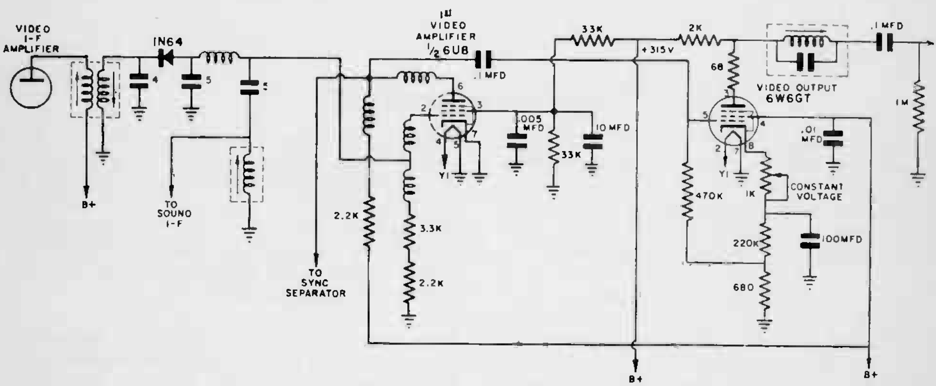

FIG. 7. Typical 2-stage video amplifier.

transformer circuit.

In troubleshooting or testing sync and sweep stages in TV receivers, the professional NRI service technician relies almost exclusively on his oscilloscope to reveal the operation of these circuits in these stages.

The 8W uses a section of the 6AW8 tube as the sync separator-amplifier stage. The scope will show the regular composite video-sync signal similar to Fig. 6 at the grid (pin 2) of V3B. Due to the desired clipping of the video signal, the remaining output signal of the separator will show only the sync signals.

This action is important because, should excessive video reach the sweep oscillators, they will not respond completely to the carefully timed sync signal pulses. Instead, the sweep oscillators will only intermittently sync in and the result can be erratic rolling and horizontal pulling.

EFFECT-TO-CAUSE REASONING

Very often scope signal tracing can be used in conjunction with effect-to-cause reasoning to isolate the defect quickly.

For example, suppose you have raster but no sound or video in the 8W. By effect-to-cause reasoning, you can immediately isolate the defect to a stage in the video chain. In a strong signal area, you may be able to pick up a local TV signal at the input of V1. If you cannot, the tuner is at fault. If you can, go on to the plate at pin 5.

Where the signal is present and stronger at the plate, this stage is operating normally. However, if the signal is weak or not present, the cathode (R2) or decoupling resistor (R3) is faulty or its connections poor. Whatever the cause, this procedure definitely nails down the trouble to the first video i-f.

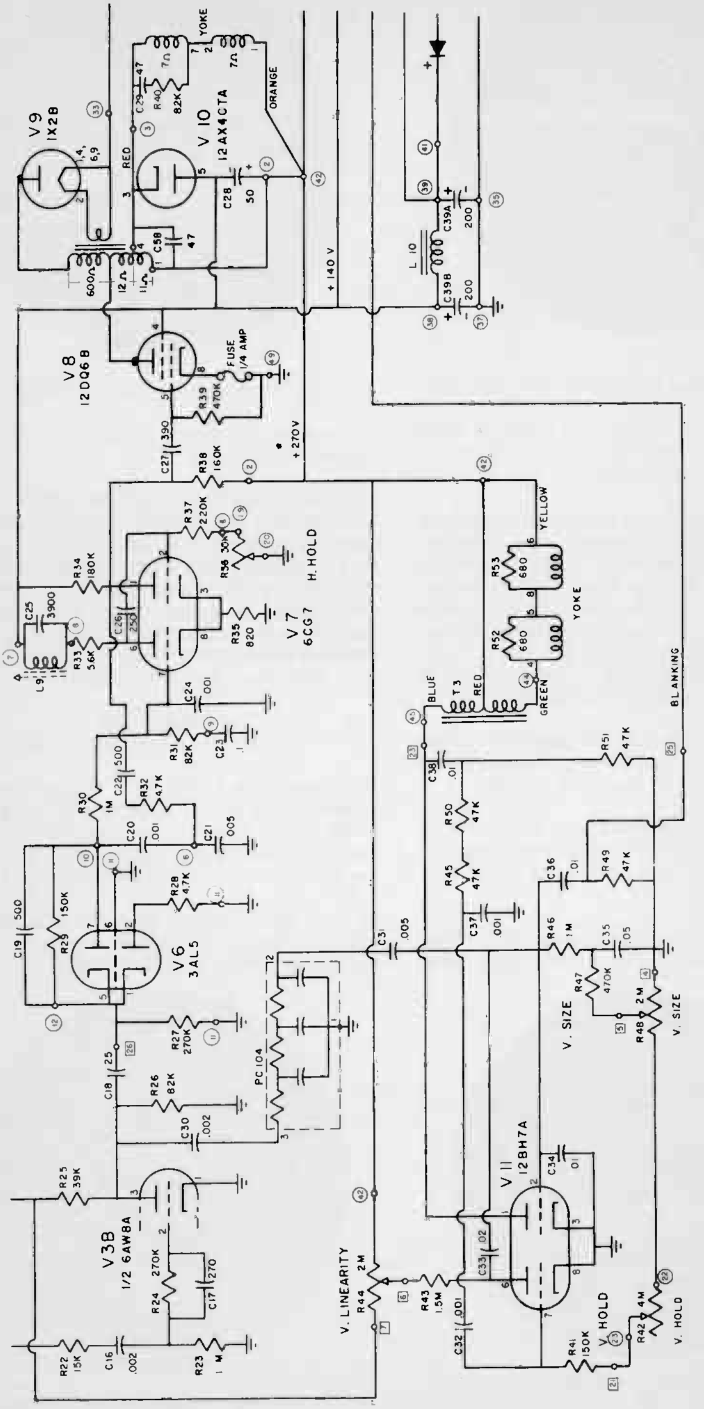

FIG. 8. Sync and sweep sections of 8W Receiver.

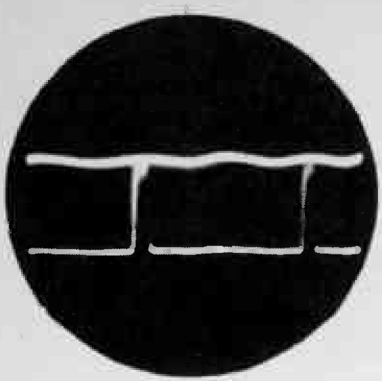

FIG. 9. Field pattern at output of sync separator.

Move the scope to the plate of V3B. With the scope set to view field waveforms, you should see a signal similar to Fig. 9.

At this time, you should check the waveshape of the horizontal sync signal alone. This requires readjustment of the scope controls in order to have it display these high frequency signals. First, bring the sweep selector knob to the 10-100kc position. Then, carefully adjust the FINE FREQUENCY and SYNC CONTROLS to get a stationary pattern similar to the line waveform shown in Fig. 10.

Try both MINUS and PLUS positions of the SYNC SELECTOR. Use the setting giving best waveform stability on the CRT screen.

To observe the waveforms with as little circuit loading as possible, remove the DIRECT TESTING PROBE and attach the LOW CAPACITY PROBE.

The circuit in this probe is designed to reduce the input scope capacitance to a very low value

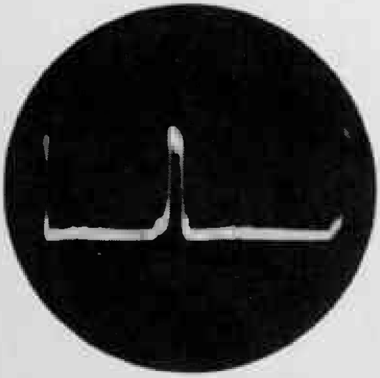

FIG. 10. Line waveform at output of sync separator.

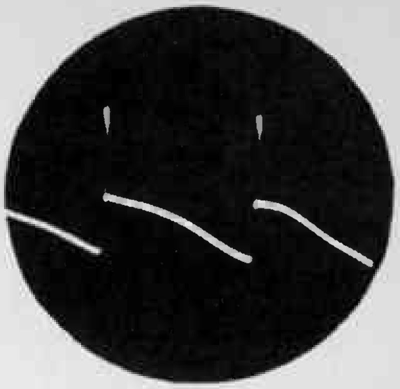

FIG. 11. Waveform at plate of vertical output.

and in this way permit viewing the sync pulses without distortion.

Control of the horizontal oscillator is more difficult than the control of the vertical oscillator. Therefore, a defect distorting the sync pulses slightly may cause the horizontal oscillator stability to be poor, causing tearing and pulling. However, the vertical oscillator may be quite stable. Because of this, always observe the horizontal, as well as the vertical, sync signals at the sync output.

SCOPING THE 8W VERTICAL SWEEP STAGES

With the LOW CAPACITY PROBE still attached, bring the tip to plate pin 1 of vertical sweep tube V11. Reset the scope controls to view field information waveforms. Normally, the pattern seen will be similar to Fig. 11.

At grid pin 2 and plate pin 6, the waveform will be similar to Fig. 12. Lack of vertical sweep waveforms would cause a receiver

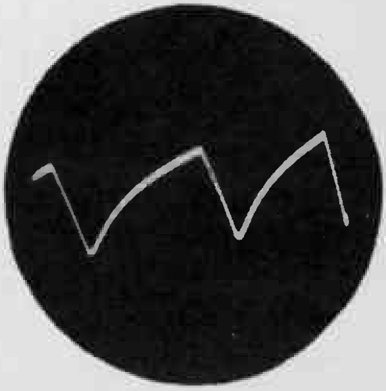

FIG. 12. Waveform at grid of vertical output stage.

screen to display only a horizontal line -- the typical visual symptom of vertical sweep failure.

The servicing procedure is to first check each condenser in the vertical sweep circuits with a reliable R-C Tester, such as the NRI Model 311. If this does not show up any faulty condensers, take ohmmeter readings across resistors, transformers, and yoke windings. This should uncover open circuits or parts that do not have the resistance values shown on the diagram.

THE HORIZONTAL SWEEP SYSTEM

The operation of the stages in this section provides high voltage as well as horizontal deflection. A defect in the circuits of these stages usually stops the high voltage from building up in the flyback transformer.

FIG. 13. Waveform on the grid of the horizontal amplifier.

Lack of high voltage will prevent a screen raster. The transformer steps up a signal that originally is generated by the horizontal oscillator; in the 8W this is V7. Then the oscillator output signal is coupled to and drives power amplifier V8.

To isolate the defect to either the oscillator or amplifier with the Model 250 Oscilloscope, set its SWEEP SELECTOR to 10-100kc and use the LOW CAPACITY PROBE.

With the cable black clip lead still hooked to the 8W B- point on the tuner chassis, bring the probe tip to control grid pin 5 of V8. (The horizontal amplifier tube in your 8W Receiver). If the horizontal oscillator is operating, you should be able to obtain a pattern similar to that shown in Fig. 13.

This characteristic sawtooth waveform signal on the grid of the horizontal amplifier tube indicates that the horizontal oscillator is operating and that the signal is reaching the grid of the horizontal amplifier. The defect may be in the horizontal amplifier, the damper, or in the high voltage (flyback) transformer.

Of course, if there is no signal on the grid of the horizontal amplifier stage, the horizontal oscillator is not operating or C27, used to couple the oscillator and the output stages, is open. No raster is a very common defect in TV receivers. You will probably find this defect more often than any other single complaint in your TV service work.

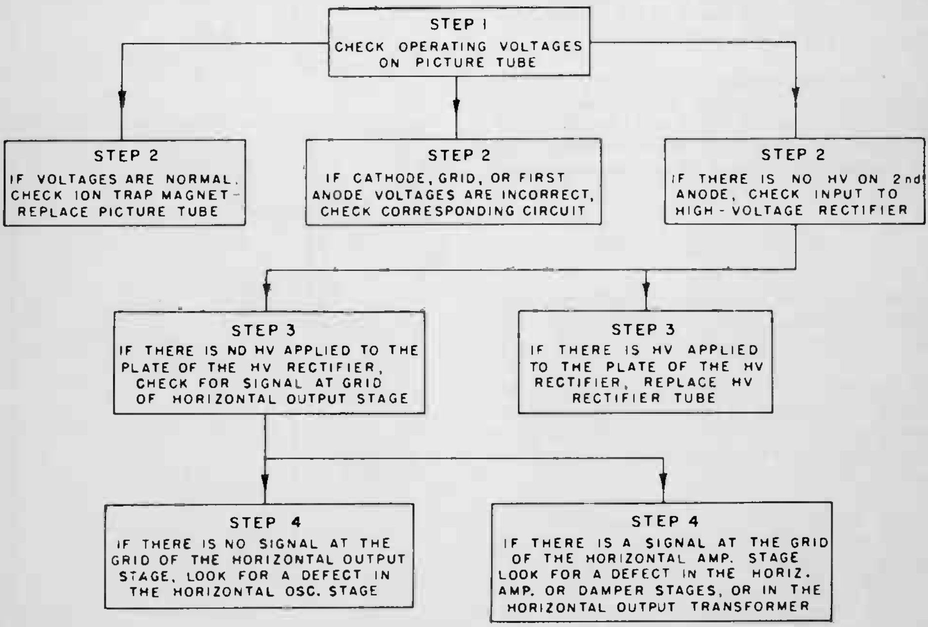

FIG. 14. A servicing procedure for use in sets where there is no raster.

Therefore, it is important that you know exactly how to go about servicing for this type of defect. The chart in Fig. 14 lists tests in the order in which they should be made to locate quickly the actual circuit defect.

SOUND SYSTEMS

The scope is a valuable tool to isolate the faulty sound stage between the detector output and last af amplifier.

For example, in the sound circuits shown in Fig. 15, a symptom of normal video but no sound can be quickly localized. Use the DIRECT TESTING PROBE to check the output of the detector at plate pin 7 of V4. Set the SWEEP SELECTOR to 15-100 cps.

On the Model 250 screen, you should see a constantly fluctuating pattern, basically similar to Fig. 16. You then move the probe tip to control grid pin 5 of V5. Normally, the pattern is the same as at the sound detector output.

If there is little or no audio signal and the volume control is turned up all the way, either coupling condenser C13 is open or there is an open between the control grid and C13.

With normal signal at the control grid but very little at the plate of V5, either the tube is faulty or the cathode, plate, or screen grid circuit is open. No sound at the af amplifier plate can also mean a short in C15.

A good scope signal at the plate but no audio output clearly pinpoints the trouble to a defect in the speaker voice coil circuit. Check the speaker voice coil, its connections, and the output transformer (T1) secondary winding.

SCOPING THE B+ LINE

A loss of capacity in one or more electrolytics may cause hum bars in the video, rolling, or horizontal tearing.

To determine the amount of ac ripple at B+, which is terminal 38 of filter C39B in the 8W, bring the tip of the DIRECT TEST PROBE to this terminal. The scope sweep controls are set for 60 cycles pick-up.

Adjust the VERTICAL ATTENUATOR to 1X since the ripple will probably be less than 1-volt. A 1-volt peak-to-peak signal is indicated when the height of the waveform is 1" and the VERTICAL GAIN control is at 1.0. A typical ac ripple pattern is shown in Fig. 17.

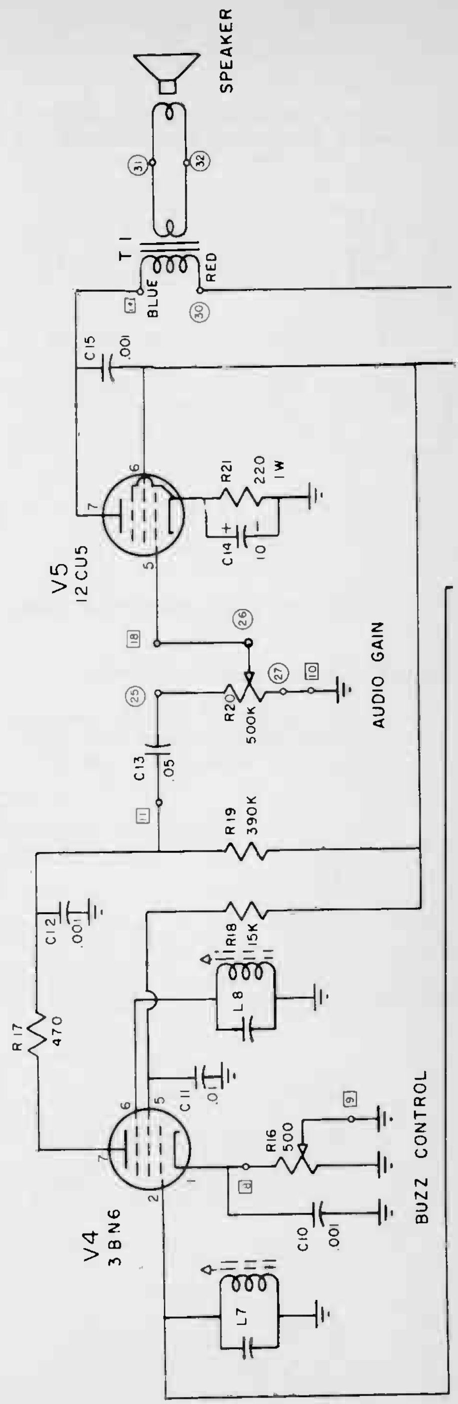

FIG. 15. 8W sound section.

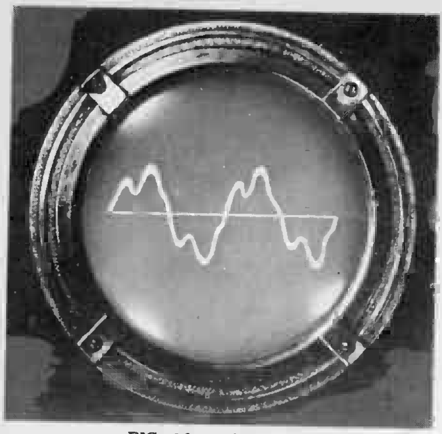

FIG. 16. Audio signals.

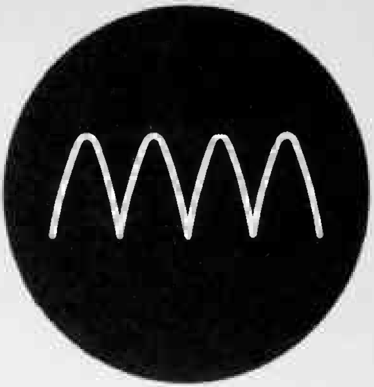

FIG. 17. Waveform of ac ripple in B+ line.

When this ac ripple exceeds about 2 or 3 volts at the output B+ terminal, your set will probably have one or more of the trouble symptoms I have previously indicated.

These procedures, if conducted carefully and thoroughly with your Model 250 Oscilloscope and 8W Receiver, will develop your ability to gain maximum use of your scope in TV servicing. At the same time you get additional TV servicing training from your 8W receiver.

STORIES WE LIKE

The factory manager was getting married and his assistant was selected by the gang to arrange for a wedding gift. The assistant visited the 2000 employees and collected a quarter from each.

With the $500 he collected, he went to the nearest supermarket and bought 2000 packs of cigarettes. He then removed the gift coupons given with this particular brand, and redeemed them for a silver coffee service as a wedding gift.

He then gave each employee a pack of cigarettes!

When the president of the factory heard of this, his eyes lit up. "That man doesn't belong down in the factory -- he should be a member of top management! Send him up to me at once!"

After searching for the assistant, the president's secretary reported back. "I'm sorry sir, but Joe's not here. He also got 5000 green stamps from the supermarket when he bought the cigarettes. With these, he picked up a complete fishing outfit and has taken off on vacation!"

REACTO-TESTER

Model T-401

TESTS FOR

All open connections • All shorted elements • All open elements • Useful life • Cathode emission • Gaseous tubes

REPAIRS

Open elements • Inter-element shorts

NRI PRICE

$44.95

RESTORES

Emission and brightness

Using a picture tube adapter with a tube tester, you can usually check the cathode emission of a picture tube and also test for inter-element shorts. But an adapter will not rejuvenate a tube with low emission or clear up shorts and opens. The usual answer is to install a new or rebuilt picture tube even though the original tube may have considerable useful life remaining.

With the REACTO-TESTER, you can in-circuit check the condition of a picture tube, see if it is gassy, reactivate a worn out cathode, clear up most shorts and opens. Often, it will extend the life of a tube for a year or more.

Here's how the REACTO-TESTER can put dollars in your pocket . . . win customer confidence. When you discover a TV receiver is inoperative due to a weak or worn out picture tube, inform the customer you will attempt to rejuvenate his old tube. If it works, brightness and emission will be restored. Charge the customer $5.00 for this service and give a 90-day guarantee on the job. Also tell the customer, should the tube fail within 90 days, you will credit his $5.00 toward the cost and service charge for installing a new or rebuilt tube. Result . . . a satisfied customer and sure sale of a picture tube should the original tube fail within the warranty period.

If the original tube cannot be rejuvenated with satisfactory results, you've lost nothing and gained the sale of a new tube.

NRI engineers and technicians have tested -- approved the REACTO-TESTER as a practical and profitable addition to any service shop.

FEATURES

Ease of operation; complete portability; attractive styling; detailed instructions; full-view 4-1/2" D'Arsonval meter; selenium rectifier power supply; 90-day warranty. The T-401 REACTO-TESTER can pay for itself after only a few service calls. Saves time . . . takes just minutes to locate faults and make repairs. No need to remove tube from set. No guessing about picture tube defects or need for replacement.

SPECIFICATIONS

Maroon leatherette case. Size: 6-1/4" × 9-1/2" × 4-1/4". Full-view 4-1/2" rectangular D'Arsonval meter. Selenium rectifier power supply. Neon bulb shows shorts and opens. Actual weight 4-1/2 lbs. Shipping weight 6 lbs. Shipped complete with detailed instructions and two adapters for 110° picture tubes. 90-day warranty against defective parts and workmanship.

MODEL 2 BATTERY ELIMINATOR

A compact power supply designed to take the place of the battery used to operate transistor portable radios and other transistorized equipment.

No need to buy, stock, or "run down" batteries on transistor radio service jobs. Fully variable DC output from 0 to 15 volts — will operate transistor receivers up to 22½ volts.

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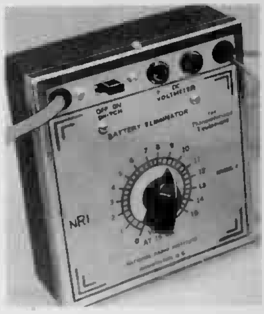

The NRI MODEL 2 BATTERY ELIMINATOR is a "must" for shops doing transistor service work. This compact, low-cost unit will pay for itself many times -- saving you time and batteries. Take a common case -- one in which a receiver's trouble is due to a shorted or leaky transistor. This condition will completely run down a new battery in just a fraction of its normal life span. In fact, a new battery may be "dead" before you've even had time to trouble shoot the receiver. And -- replacement transistor batteries retail for up to $2.65!

The MODEL 2 will eliminate this problem -- makes it unnecessary to stock a large, expensive selection of seldom used batteries with limited shelf life. Substitution of the MODEL 2 in the circuit quickly spots faulty batteries. As output is continuously variable from 0 to 15 volts, you can make measurements at exact manufacturer's recommended voltages shown on schematic diagram. Also, current can be measured by inserting milliameter in series with the MODEL 2 -- sometimes difficult to do this using regular snap-on connector batteries.

If you own a transistor receiver yourself, use the MODEL 2 as a power supply for home listening. (Note: The MODEL 2 is not designed for tube or hybrid transistor automobile radios.)

SPECIFICATIONS

Supplies 0 to 15 volts of continuously variable, well filtered DC.

Line by-pass eliminates hum modulation.

Internal impedance less than 2 ohms.

Average internal DC resistance less than 100 ohms.

Voltage scale calibrated at 15 ma, maximum output is 100 ma.

Output transformer isolates output from power line.

Dimensions: 4-1/2" wide × 5" long × 1-1/2" high.

Panel: Gold finish with deep etched black lettering.

Case: Green wrinkle-finish.

For 105-115V AC, 60 cycle operation only.

Shipping weight: 1-1/2 pounds.

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Zener Diodes

By

Art Widmann

Technical Editor

The Zener diode is becoming an increasingly important solid state electronic device. If you haven't already run into Zeners in repair work, you probably will soon. At present Zeners are used mostly in military and industrial electronic equipment. However, they are beginning to show up in commercial entertainment equipment. Like other new devices, the Zener operation remains a mystery until you have studied what makes it "tick". A background of understanding is necessary so the technician can intelligently troubleshoot circuitry containing Zener diodes.

In this article we will begin by examining the semiconductor material used in Zener diodes. Since the same material is used in transistors, this will be in the nature of a review for many. Next, we will study the Zener and avalanche breakdown action. We will see how the action of a Zener diode differs from ordinary rectifier type junction diodes. Finally, we will examine some of the applications of Zener diodes so you can see how they operate in practical circuitry.

SEMICONDUCTOR MATERIAL

The operation of the Zener diode depends on the properties that are used to form the diode junction. The material is usually either germanium or silicon such as used in transistors. The junction is formed by placing a P-type semiconductor material in contact with an N-type semiconductor material. The semiconductor material (germanium or silicon) is "doped" by adding a controlled amount of impurities. The type of impurity added determines whether the material will be a P-type or N-type. Before discussing the doped material, let's examine the electrical properties of pure germanium and silicon.

The manner in which an electrical current flows through a semiconductor material can best be understood by considering the structure of the material. Semiconductors are a crystalline structure. That is, the atoms that make up the material are arranged in a definite fixed pattern. We can think of this crystalline structure as resembling a lattice network with an atom placed at each lattice intersection. The atoms are held in this pattern by forces acting between the atoms. The atoms are free to vibrate about an average position within the crystalline structure but they cannot move past each other. Most of the electrons associated with each atom are tightly bound to the nucleus of the atom. In each atom the outer ring of electrons, called the valence ring, is shared by the adjacent atoms. That is, an outer ring electron acts to offset part of the positive charge in the nucleus of its own atom and also offset part of the positive charge in an adjacent atom. In this way, the electrons form covalent bonds between the atoms to maintain the crystalline structure.

This arrangement leaves very few "free" electrons to allow current to flow through the semiconductor material. As you know, a good conductor has many "free" or unattached electrons and the movement of these electrons along the conductor is an electric current. On the other hand, a good insulator has its electrons tightly bound to the atoms so no "free" electrons are available for an electric current. Thus, the semiconductor material lies more between a good conductor and a good insulator. However, in order to understand how electrons flow through semiconductor material, we must use a slightly different concept of electrical current. This concept states that an electric current can be the movement of electrons or the movement of holes. A positive hole or simply a hole is the space left in semiconductor material when an electron moves out of that space. This concept of holes is required when discussing semiconductor material because electrons move in discrete steps within the semiconductor material. An electron moves a small distance into a positive hole. The space it leaves is then available for another electron to move into.

The idea of the movement of holes can be gathered from Fig. 1. In Fig. 1A, ball 1 has been moved one space to the right. This leaves a hole between 1 and 2. In Fig. 1B, ball 2 has been moved to the right leaving a hole between 2 and 3. Likewise in Fig. 1C, ball 3 has been moved to the right one space leaving a hole between 3 and 4. Notice that as movement of balls proceeds to the right the space or hole has moved to the left. In the same way we can think of current in a semiconductor material. The electric current consists of the movement of electrons in one direction and the movement of holes in the opposite direction. These holes and electrons are called charge carriers. The movement of these charge carriers, whether they are negative electrons or positive holes, constitutes an electric current through the semiconductor material.

The orderly procession of holes and electrons shown in Fig. 1 is not duplicated in the actual semiconductor material. Instead, holes and electrons move about in random directions. You recall we said that the outer ring of electrons forms covalent bonds with adjacent electrons. At ordinary room temperature, enough thermal energy is present in semiconductor material to force some of these electrons out of their orbit. These electrons that have been freed from their orbits are now charge carriers. The space or hole they leave in the lattice structure of the crystal also becomes a charge carrier. Thus, when thermal agitation frees an electron, a pair of charge carriers is generated -- one positive hole and one negative electron.

If a voltage is applied to the material, the positive electrode will pull off some of the freed electrons. Also some electrons from the negative electrode will fill nearby holes. Electrons will proceed in a haphazard fashion from hole to hole, from the negative electrode, and head in a general direction toward the positive electrode. At the same time, holes

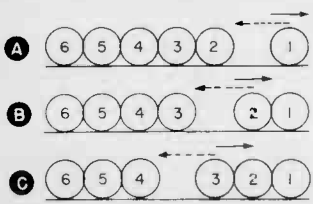


FIG. 1. The concept of hole movement can be compared to the position of the space between the balls.

will be moving from the positive electrode toward the negative electrode. When a hole reaches the negative electrode, the hole is filled by an electron and the hole disappears. Likewise, when an electron reaches the positive electrode, it is removed from the semiconductor material and becomes part of the electron flow in the external electric circuit. This net drift of charge carriers through the semiconductor material constitutes the electric current.

At this point you may wonder why we have gone into so much detail in tracing a current through a semiconductor material. The net result is no different from current through any other material. We have just complicated the discussion by bringing up the idea of charge carriers being either positive holes or negative electrons. But remember, we have been dealing only with pure crystalline semiconductor material such as pure germanium or pure silicon. The more we know about what goes on in the material, the easier it will be to understand the operation of semiconductor devices.

In the above discussion we obtained the charge carriers by thermal agitation. Let's examine the formation of charge carriers in accordance with the Band Theory of Solids. This theory holds, in part, that the energy levels in solids exist in discrete bands with regions between the bands where energy cannot exist. While the Band Theory is developed on the basis of complex mathematical studies, we don't need to go into the math for the theory to help us understand semiconductors.

The theory enables us to represent a charge carrier graphically and will help to explain many things about semiconductors. In Fig. 2 we again represent electrons as balls. In Fig. 2A we represent a group of valence electrons located at energy level 1. At this energy level, the electrons are in their covalent bonds and cannot act as charge carriers. In Fig. 2B we show one of the electrons at energy level 2. Thermal agitation has imparted enough energy to this one electron to raise it to the upper energy level. It is now free to act as a charge carrier. Also notice that the hole left in energy level 1 now allows lateral movement of the electrons at this energy level. In effect, thermal agitation has created a pair of charge carriers -- one free electron and one hole. According to the Band Theory, the electron must attain enough energy to reach level 2 or it cannot break away from level 1. In other words, it must have one energy level or the other. Since the electron cannot be at an energy level between 1 and 2, this region is called a forbidden region. The width of this forbidden region is called the energy gap. Thus, the energy level in a solid

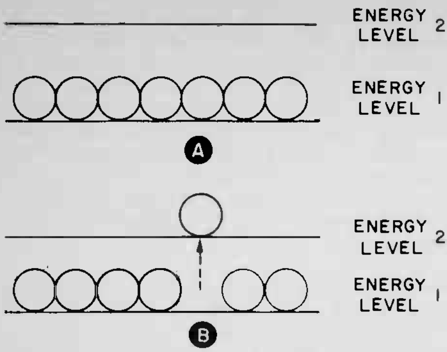


FIG. 2. Elevating an electron to higher energy level produces a pair of charge carriers.

exists in bands separated by gaps. Within each energy band numerous energy levels exist.

The bands, as they apply to semiconductor material, can be represented as shown in Fig. 3. Band 1, shown as the conduction band, is nearly empty. A few electrons reach an energy level in this band by thermal agitation. Band 2, shown as the valence band, is nearly full. At room temperature there will be some interchange of electrons between bands 1 and 2. When an electron gains enough energy to go from the valence band to the conduction band, a pair of charge carriers is generated. Later, the electron gives up its energy and returns to a hole in the valence band. This is called recombination of carriers. The generation of electron-hole pairs and the recombination process goes on continually in the semiconductor material.

With these few carriers present in a semiconductor material, only a small current will flow when a voltage is applied to the material. Therefore, it has a high electrical resistance. If the material is heated, the increased thermal agitation will generate a greater number of carriers and its resistance will decrease. An extreme increase in temperature can destroy the crystal. In semiconductor operation only valence and conduction bands are used. As shown in Fig. 3, band 3 and other energy bands in the solid are left undisturbed.

DOPED CRYSTALS

The current-carrying properties of a semiconductor material can be altered by adding a controlled number of impurity atoms to the crystal structure. This is called "doping" the crystal. For example, when pure silicon is doped with boron, the silicon becomes a P-type semiconductor material. Individual boron atoms replace silicon atoms in the crystal structure. A silicon atom has four electrons in its valence ring while the boron atom has only three electrons in its valence ring. When the boron atom replaces a silicon atom, the crystalline structure is lacking one electron. This means that a hole exists around each boron impurity atom in the crystal. This hole or absence of an electron is, therefore, a positive charge carrier. It will readily accept an electron to fill the hole. For this reason, boron is called an acceptor or P-type impurity.

In a P-type semiconductor material, current is carried by positive charge carriers. The excess holes, produced by the acceptor impurity, become the majority carriers in the P-type material. When a voltage is applied across the P-type material, current will be conducted by the action of these positive charge carriers. The presence of the holes in the lattice structure makes it easier for electrons to be forced through the material.

In terms of the energy bands, a hole can be represented as extending an energy level into the forbidden region. Fig. 4 shows the effect of the boron impurity in the silicon crystal. Notice that the energy level of the acceptor is just above the valence band. In effect, the holes created by the boron impurity have created an energy level only a little above the energy level of the valence band. Only a little energy is required to remove an electron from the valence band to the acceptor level. The hole left in the valence band can now conduct electrons through the semiconductor material. It is no longer necessary for electrons to gain enough energy to reach the conduction band. In P-type material the few free electrons that do reach the conduction band are the minority carriers.

N-type semiconductor material can be produced by doping silicon with antimony which has five valence electrons. An antimony atom is used to replace a silicon atom which, as mentioned before, has four valence electrons. Therefore, an extra electron is present at this point in the crystal. N-type material

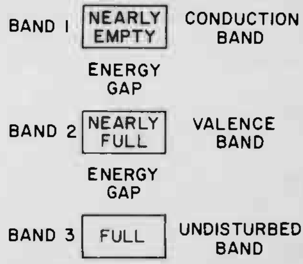


FIG. 3. Graphic representation of the energy bands in a semiconductor material.

will readily donate the extra electrons so the antimony is called a donor impurity. Since the electrons are in excess, electrons are the majority carriers in N-type material.

In terms of energy bands, the antimony impurity atoms produce a donor energy level just below the conduction band. As shown in Fig. 5, only a small amount of energy is needed to lift an electron from the donor level to the conduction band. When the electron reaches the conduction band, it is available for conducting current as the majority carrier in N-type material. Thermal agitation can still cause electrons to leave the valence band and reach the conduction band. The holes they leave in the valence band are the minority carriers in N-type semiconductor material.

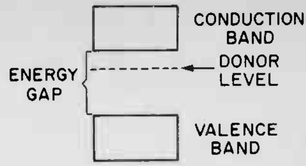


FIG. 5. The donor impurity atoms produce an energy level just below the conduction band.

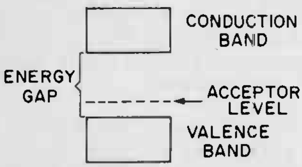


FIG. 4. The acceptor impurity atoms produce an energy level just above the valence band.

Semiconductor material, whether it is pure or doped, is electrically neutral. For each mobile carrier that exists there is a corresponding ionized atom. For example, in pure silicon, for each electron in the conduction band there is an atom in the crystal that is a positive ion because one of its valence electrons is missing. Thus, the net charge on the material is zero. Likewise, in doped material, each mobile carrier, whether it is a hole or an electron, is balanced by an immobile ionized atom.

THE P-N JUNCTION

When a P-type and an N-type material are brought into contact to form a junction, the carriers diffuse across the junction. Electrons which are the majority carriers in the N-type material cross the junction into the P-type material. Since the N-type material was electrically neutral before, it now becomes positively charged because it has lost electrons. Likewise, some of the holes in the P-type material are diffused across the junction. A loss of the holes from the P-type material causes it to become negatively charged.

This condition in a P-N junction is illustrated graphically in Fig. 6. The diffusion of carriers across the junction produces a potential hill at the junction. The loss of holes on the P-side puts it at a higher negative energy level. Likewise, the loss of electrons on the N-side places it at a lower energy level. The potential hill, also called a potential barrier, opposes the passage of majority carriers across the junction. Electrons on the N-side (majority carriers) have to surmount the potential hill before they can diffuse into the P-side. Likewise, the holes in the P-side (majority carriers) are opposed by the barrier. You can think of the holes as bubbles that try to rise. They must be forced down to get them over the potential barrier.

The built-in potential of the P-N junction diode can be readily measured with a vacuum tube voltmeter. The hook-up shown in Fig. 7A will produce one-half volt or more using a diode such as a 1N45. The presence of this voltage readily accounts for the front-to-back ratio of resistance readings on these diodes. The simplified ohmmeter circuit in Fig. 7B shows the positive terminal of the ohmmeter cell connected to the N-side of the diode. With this connection, the built-in voltage of the diode opposes the ohmmeter voltage and the reading on the meter is a high resistance value. Reversing the diode as shown in Fig. 7C produces a low resistance reading on the meter. You can think of the built-in diode potential as aiding the ohmmeter cell potential to cause increased deflection of the meter needle.

Applying an external voltage to the diode junc-

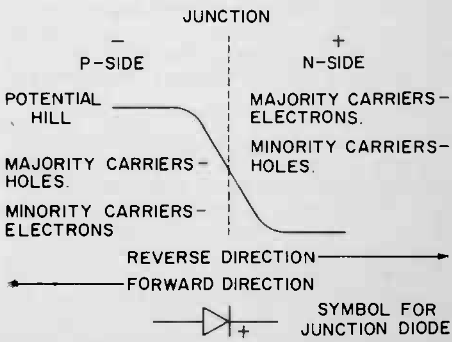


FIG. 6. A potential hill is formed at the P-N junction.

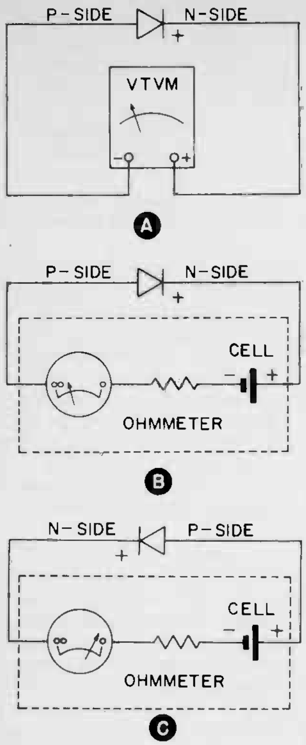


FIG. 7. The built-in diode potential (A) accounts for the high back resistance (B) and the low forward resistance (C).

tion changes the level of the potential hill. Applying a positive potential to the P-side lowers the potential barrier. This is called forward bias. The positive potential carries off the electrons from the P-type material leaving a large supply of majority carriers (holes) to diffuse across the junction. At the same time the negative potential applied to the N-side furnishes majority carriers (electrons) to the N-type material. The forward bias voltage enables the majority carriers to overcome the potential hill producing a large forward current.

The junction is reverse-biased by applying a negative potential to the P-side. The negative potential applied to the P-type material further decreases the majority carriers (holes) in the P-type material. At the same time the positive potential on the N-side decreases the majority carriers (electrons) in the N-type material. The potential barrier has been increased and the majority carriers will not conduct any current. A small leakage current can flow. This current is the result of the minority carriers that are generated by thermal agitation. The minority carriers are attracted across the junction by the electrostatic field of the applied reverse voltage. Up to a point, the amount of reverse current is nearly constant and is practically independent of the applied voltage. When the reverse voltage exceeds a certain value, the junction suddenly breaks down and passes a large reverse current.

REVERSE BREAKDOWN

In ordinary junction diodes, reverse breakdown occurs when we apply too much reverse bias to the junction. We associate the breakdown with a circuit condition in which we accidentally apply more than the rated voltage to the diode. Also, we expect the diode to be damaged when it breaks down. Zener diodes are different. They are designed to operate continuously at the breakdown point without damage, or they can be switched into and out of breakdown without damage. It is this characteristic that makes Zener so useful in its many applications.

Fig. 8 shows a plot of the current versus applied voltage for a typical P-N junction. For your convenience, we have shown a forward-biased diode circuit and a reverse-biased diode circuit beside the plot. As forward bias voltage is applied to the junction, current starts to flow when the applied voltage overcomes the potential barrier. The forward current increases slowly and then increases almost linearly as voltage is increased further. The amount of forward current is limited by the ability of the diode to dissipate the heat produced in the junction.

When a small reverse bias voltage is applied to the junction, only a small leakage current flows. Notice that the leakage current increases slightly as the reverse voltage increases. In a perfect diode the current would

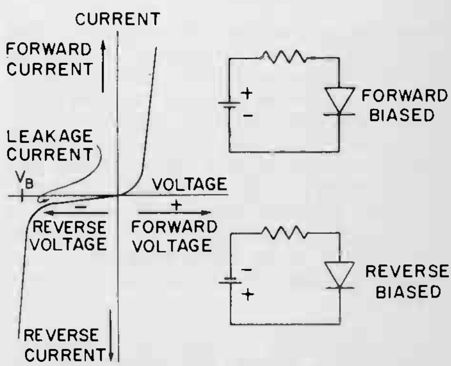


FIG. 8. The characteristics of a diode are shown by a plot of the current-voltage relationship.

remain constant. However, in practice it increases slightly due to surface leakage and other factors.

When the reverse voltage is increased to the breakdown voltage, V_B, the current increases tremendously. This large current breakdown is often referred to as the avalanche current. Notice that the voltage across the diode remains essentially constant at V_B for a large change in current through the diode. It is this constant voltage across the diode during breakdown that makes the Zener useful as a voltage regulating device.

The amount of avalanche current is limited by the ability of the diode to dissipate the internally produced heat. In a Zener diode, the internal resistance after breakdown is very low. Therefore, it can pass a large current without undue heating. Zeners designed to handle high wattage - above 3 watts - use special mountings so the heat can be dissipated into a heat sink or into the chassis.

The explanation of exactly what occurs to cause the breakdown in a junction diode has been the subject of a great deal of study. Much original work was done by Carl Zener in the study of the breakdown of dielectrics. It was assumed that the same theory accounted for the breakdown in diodes so Zener diodes were named in his honor. However, it now appears that two distinct types of breakdowns occur. At low breakdown voltages the Zener effect occurs. At voltages above about 6 volts, breakdown is caused by the avalanche process.

The Zener effect is a process of internal field emission. When electrons in the semiconductor material are subjected to an intense electrostatic field, the electron can be made to cross a forbidden energy gap without climbing over the potential hill barrier. To get on the other side of the potential hill, the electrons tunnel through the hill. The energy required to tunnel through the barrier is much less than would be required to climb over the hill. This tunneling process is based on quantum mechanics where the electron is considered to be a wave motion instead of a particle. Thus, in low breakdown voltage diodes, a small reverse voltage produces an electric field that is strong enough to cause tunneling. Electrons tunnel through the energy gap providing many free electrons in the conduction band to support a large reverse current.

The avalanche process can be compared to the ionization of gas in a gas-discharge tube. You recall that when the P-N junction is reverse-biased, a small leakage current flows. The few electrons that are raised to the conduction band by thermal agitation support only a small reverse current. As the reverse bias is increased, these electrons are accelerated to higher and higher velocities. At the breakdown voltage, these electrons reach sufficient velocity to dislodge electrons from the valence ring of silicon atoms. Each electron that is knocked out of a silicon atom produces one electron-hole pair of carriers. Also the freed electron is now capable of being accelerated to strike other atoms and produce more electron-hole pairs. The chain-like reaction results in an abundance of free electrons and ionized silicon atoms. These electron-hole pairs are able to support a large avalanche breakdown current.

ZENER DIODE VOLTAGE REGULATIONS

The breakdown characteristics of a Zener diode can be used to produce a very stable voltage regulator circuit. Fig. 9A shows a simple shunt Zener diode regulator circuit. Fig. 9B shows other commonly used symbols for representing Zener diodes. The purpose of the regulator is to maintain the output voltage, E_O, constant across the load, R_L. The output voltage should remain constant even though the load varies or the applied voltage, E_A, varies. This is accomplished by operating the Zener diode in the breakdown region. As you can see in Fig. 9, the diode is reverse-biased by the applied voltage, E_A. When the voltage across the Zener reaches the breakdown voltage, the diode conducts heavily. The current through the diode also flows through the series resistor, R. Enough voltage must be dropped across R so that the breakdown voltage plus the drop across R equals the applied voltage. This is illustrated in Fig. 10A by assigning values to the circuit with no load. Suppose the Zener has a breakdown voltage of 8.2 volts, the applied voltage is 12 volts and the value of the series resistor R is 100 ohms. Since the voltage across the diode remains essentially at 8.2 volts, the drop across R must be 12 minus 8.2 or 3.8 volts. The diode must pass 38 milliamps of current to produce the 3.8-volt drop across R.

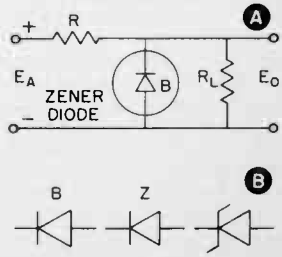


FIG. 9. Simple shunt diode voltage regulator circuit (A) and other commonly used symbols for Zener diodes (B).

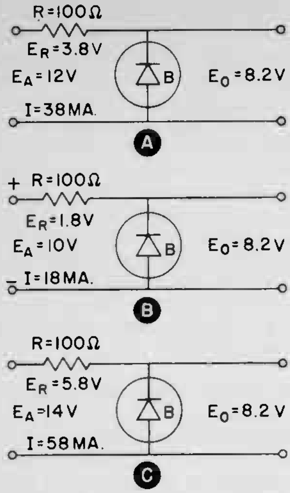


FIG. 10. The Zener diode keeps the output voltage nearly constant when the input voltage varies.

Now suppose the applied voltage drops to 10 volts as shown in Fig. 10B. The current through the diode will decrease so as to maintain the breakdown voltage across the junction. The current decreases to 18-ma so that the drop across R is only 1.8 volts. This condition still maintains the 8.2 volts at the output terminals.

Fig. 10C shows the regulating action when the applied voltage rises to 14 volts. To maintain the 8.2 volts at the output, the diode passes 58-ma of current to produce a 5.8-volt drop across the series resistor. In this way, the diode maintains a practically constant voltage at the output terminals of the regulator when the input voltage varies.

Let's see how the diode regulates the output voltage for variation of the load applied to the circuit. Fig. 11A illustrates the same regulator circuit with a load R_L applied to the circuit. With 8.2 volts applied to the 1000-ohm load, R_L, the load will draw 8.2 ma of current. The Zener draws 29.8 ma to make a total current, I_T, of 38 ma through the series resistor R. This drops 3.8 volts across R to drop the 12-volt applied voltage to 8.2 volts. Now suppose we double the load on the circuit by decreasing the load resistance R_L to 500 ohms. The circuit adjusts to the condition shown in Fig. 11B. The 8.2 volts across the 500-ohm load produces a current of 16.4 ma. The Zener diode adjusts to this condition by decreasing its current to 21.6 ma. This provides the same total current of 38 ma through the series dropping resistor R.

From this discussion you can see that the Zener diode will regulate the voltage across the load at a nearly constant value for changes in either the applied voltage or the load. In the examples, we showed the regulated voltage at exactly 8.2 volts for all conditions. Actually, the voltage across the Zener will increase slightly as more current is drawn through the diode.

The Zener diode regulator has many advantages over tube type regulators. It is small in size, light in weight, and not subject to breakage. Zener diodes are rugged both physically and electrically. The Zener is extremely stable and shows essentially no aging effects during its operating life. Unlike gas regulator tubes, the Zener does not require a high striking voltage. The applied voltage need not be much above the regulated value. At present these advantages are somewhat offset by the higher price of Zeners, but with increased use, the price difference is rapidly disappearing.

OTHER APPLICATIONS

The Zener diode is probably best known as a regulation device. However, it has a host of other applications. An important use is for the protection of circuit components. Transistors are particularly subject to destruction by transient overload voltages in a circuit. The transistors can be protected by including Zener diodes in the circuit. An application of this kind of protection is shown in Fig. 12. This is part of a typical output circuit used in high power Class B audio and servo amplifiers. The Zener is connected directly between the collector and the emitter. The PNP transistor requires a negative voltage at the collector. The Zeners are placed in the circuit so the collector voltage places a reverse bias on the Zener. The Zeners are selected with a breakdown voltage considerably greater than the collector operating voltage. Therefore, in normal operation, the Zeners pass only a very small reverse current. However, any circuit disturbance such

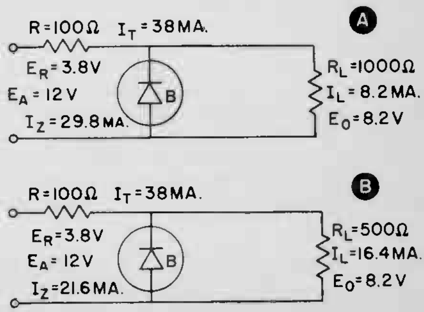


FIG. 11. The Zener diode keeps the output voltage nearly constant for load variations.

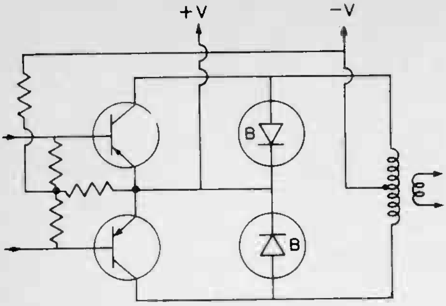


FIG. 12. A pair of Zener diodes protects the transistor in this typical output circuit.

as a transient that causes the collector voltage to exceed the breakdown potential of the Zener will result in heavy conduction and prevent further rise of the collector voltage. In this way, the transistors are protected from excess voltage that would destroy them.

Zener diodes are used to produce a reference element that is the solid state equivalent of a standard cell. Selected Zeners are combined in a circuit in such a way that the terminal characteristic of one Zener is compensated by opposite terminal characteristics of another Zener. In this way an ultra-stable reference voltage is maintained. It provides the same accuracy as a standard cell.

The fast switching time of Zener diodes makes them very useful in high speed computers. The Zener can be switched into or out of breakdown in a small fraction of a microsecond.

In the short time that Zener diodes have been in use, the number of applications has grown rapidly. In the future, we can expect them to be used more and more in new equipment.

G. E. TRANSISTORS ON MINUTEMAN MISSILE

SYRACUSE, N.Y. -- Ultra-reliable transistors produced by the General Electric Company at Electronics Park here played an important role in the recent successful firing of the Minuteman missile at Cape Canaveral, Florida.

G-E transistors are vital components of the Minuteman's delicate guidance system which directs the flight of this Intercontinental Ballistic Missile to its target.

The first firing saw the three-stage, solid fuel Minuteman roar down the Atlantic test range approximately 4000 miles, and drop perfectly on target.

Nomination Ballot

T. E. Rose, *Executive Secretary*
NRI Alumni Association,
3939 Wisconsin Ave.,
Washington 16, D. C.

I am submitting this Nomination Ballot for my choice of candidates for the coming election. The men below are those whom I would like to see elected officers for the year 1962.

(Polls close August 25, 1961)

MY CHOICE FOR PRESIDENT IS

....

City ....State ......

MY CHOICE FOR FOUR VICE-PRESIDENTS IS

1. ....

City ....State ......

2. ....

City ....State ......

3. ....

City ....State ......

4. ....

City ....State ......

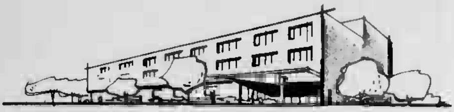
Your Signature ....

Address ....

City ....State ......

Student Number ....

NRI ALUMNI NEWS



NOMINATIONS FOR 1962

This year's election of officers to serve the Alumni Association for 1962 will be unusual in one respect: F. Earl Oliver of Detroit will not be a candidate for the vice president.

Oliver has been elected as a national officer, first as president then vice president, more than any other member in the history of the Association. And with good reason. For many years Oliver has served the Association and his chapter, the Detroit Chapter, well and faithfully. His repeated re-election to national office has been a well deserved honor. This is true, but over a much shorter period, of current Vice Presidents Howard Smith of Springfield, Mass., and John Babcock of the Minneapolis-St. Paul Chapter. All three of these members are ruled out as candidates because of the restrictions placed on the re-election of vice presidents by the amendment of Article VI, Section 2, of our Constitution and By-Laws. This amendment was adopted September 1, 1960.

Our first task, of course, will be to nominate our candidates. They will be, for President, the two members receiving the largest number of votes for the Presidency. The candidates for Vice Presidents will be the eight members who receive the largest number of votes for a Vice Presidency.

The deadline for nominations is August 25, 1961. Mail your ballot in time to reach NRI by that date. National Headquarters will tally the votes delivered on or before that date, and publish the names of the candidates in the October-November issue of the NRI News. Then, using the ballots included in the October-November issue, members will cast their votes for their choice of a President and four Vice Presidents.

The election is being conducted as provided in Article VI, Section 2, of our Constitution and By-Laws.

Go-getter Jules Cohen of the Philadelphia-Camden Chapter will bring his term of office as President to a close on December 31. The President-Elect, whoever he may be, will then become President for 1962 on January 1.

In last year's election, Frank Skolnik of Pittsburgh was nominated to run against Jules Cohen. Although Cohen won handily, Skolnik received a sizable vote, which makes him first in the running among the candidates for President this year.

Skolnik took the lead in establishing the Pittsburgh Chapter in 1953, served as its Chairman for the first five years, and continues to take a leading part in its activities. Before that, he participated in the formation of the Radio and Television Serviceman's Association of Pittsburgh, has served as a member of the Association's Board of Directors, and has been its First Vice President. Skolnik should, therefore, make an able President of the NRIAA. Another member who deserves serious consideration for President is John Berka of the Minneapolis-St. Paul Chapter.

As mentioned above, neither F. Earl Oliver of Detroit, Howard Smith of Springfield, Ill., nor John Babcock of the Minneapolis-St. Paul Chapter can be candidates for re-election as Vice Presidents this year. President Jules Cohen of the Philadelphia-Camden Chapter likewise cannot be a candidate for national office in this election. But the other Vice President, J. Arthur Ragsdale of the San Francisco Chapter, is eligible as a candidate for either the Presidency or a Vice Presidency.

The names of other members that may be considered as candidates, selected geographically, are given under "Nomination Suggestions." But in making your choice of candidates you are not restricted to the names mentioned above or listed under "Nomination Suggestions." Vote for whomever you wish, provided only that they are members of the Alumni Association.

Fill in your ballot and mail it in time to reach Washington on or before August 25.

NOMINATIONS FOR 1962 (Use Ballot on Page 23)

Richard L. Norton, Birmingham, Ala.
J. M. Warren, Jr., Montgomery, Ala.
Elton W. Robbins, Glendale, Ariz.
Loral L. Yarbrough, Mesa, Ariz.
Luther B. Fishback, N. Little Rock, Ark.
Riley F. Brisco, Peel, Ark.
Edward Persau, San Francisco, Calif.
Anderson Royal, San Francisco, Calif.
Reginald Selby, San Francisco, Calif.
Eugene DeCaussin, Hollywood, Calif.
William Edwards, Norwalk, Calif.
Charles J. Esposito, Denver, Colo.
Russell D. Palmer, Cunnison, Colo.
Albert J. Mead, Danbury, Conn.
Roger E. Vallerand, Hartford, Conn.
Joseph A. O'Kavage, Dover, Del.
Russell S. Dennis, Wilmington, Del.
Benjamin L. Harrison, Washington, D. C.
Henry C. McKinney, Washington, D. C.
Jack J. Bassatt, Jacksonville, Fla.
Edgar Bloodworth, Pensacola, Fla.
John W. Welch, Atlanta, Ga.
Dave R. Nelson, Jr., Marietta, Ga.
Dallas McCausey, Ashton, Idaho
Joseph H. Bingham, Twin Falls, Idaho
Caleb Davis, Chicago, Ill.
Leroy Marks, East St. Louis, Ill.
H. W. Johnson, Galesburg, Ill.
Walter M. Hinz, Moline, Ill.
Anthony F. Coppoletti, Rockford, Ill.
Warde M. Wagner, Springfield, Ill.
Jerry Sadler, Evansville, Ind.
George E. Britton, Indianapolis, Ind.
Marvin H. Rostenbach, Davenport, Iowa
Ross E. Mason, Mason City, Iowa
Rhan D. Moats, Sr., Kansas City, Kans.
James W. Liotta, Topeka, Kans.
Harry W. Pace, Calvert City, Ky.
James E. Wingfield, Louisville, Ky.
John Conrad, New Orleans, La.
Patrick Boudreaux, New Orleans, La.
Robert Beaule, Lewiston, Maine
Milton H. Huey, Portland, Maine
John E. Robinette, Cumberland, Md.
Lance M. Hopkins, Salisbury, Md.
Arnold Wilder, Springfield, Mass.
Orin Hayden, Longmeadow, Mass.
Michael Lesiak, Taunton, Mass.
William Wade, Jr., New Bedford, Mass.
Walter Berbee, St. Paul, Minn.
Kermit Olson, Minneapolis, Minn.
Elsworth Umbreit, Detroit, Mich.
James J. Kelley, Detroit, Mich.
Clyde Morrisett, Flint, Mich.
Andrew Jabbagy, Flint, Mich.
Hubert E. Bailey, Jackson, Miss.
Emmett T. Davis, Natchez, Miss.
Carl Roshay, Jr., Kansas City, Mo.
Warren J. Feldworth, St. Louis, Mo.
Joseph T. Lane, Billings, Mont.
Milburn H. Parker, Missoula, Mont.
Garth Wiltshire, Lincoln, Nebr.
Charles R. Boyce, Omaha, Nebr.
Donald V. Harper, Carlin, Nev.
Michael Kuchman, Las Vegas, Nev.
M. V. Guillaume, Jeffrey, N. H.
George Stylianos, Nashua, N. H.
Maryan H. Bouchard, Egg Harbor City, N. J.
Warren A. Horn, Palmyra, N. J.
Ray R. McCarty, Albuquerque, N. Mex.
Harold G. Hopper, Las Cruces, N. Mex.
David Spitzer, Brooklyn, N. Y.
James Eaddy, Brooklyn, N. Y.
S. N. Carter, Brooklyn, N. Y.
Frank Zimmer, Long Island City, N. Y.
Frank Catalano, New York, N. Y.
Hasea M. Wyrick, Elon College, N. C.
Jasper F. Waters, Sr., New Bern, N. C.
Clyde C. Nyreen, Burlington, N. Dak.
Marvin B. Olson, Forbes, N. Dak.
Gordon E. Lind, Columbus, Ohio
Donald Moser, Orrville, Ohio
Clyde A. Rowley, Enid, Okla.
Melvin H. Betzer, Sand Spring, Okla.
Amiel D. Meihoff, Ocean Lake, Oreg.
Mike Rice, Portland, Oreg.
Herbert Emrich, Cornell Hgts., Penna.
Harvey Morris, Philadelphia, Penna.
John Pirrung, Philadelphia, Penna.
Joe Burke, Philadelphia, Penna.
William Lundy, Pittsburgh, Penna.
Howard Tate, Pittsburgh, Penna.
Harold J. Rosenberger, Waynesboro, Penna.
Charles Miller, Carlisle, Penna.
Raymond O. Blachette, Pawtucket, R. I.
Charles King, Warwick, R. I.
Herbert E. Warren, Jr., Charleston 43, S.C.
Vendel Tierney, McColl, S. C.
Dallas Martin, Sioux Falls, S. Dak.
John F. Drake, Watertown, S. Dak.
Basil McKeehan, Elizabethton, Tenn.
Robert L. Whitaker, Memphis, Tenn.
Frank C. Gonzalaz, El Paso, Texas
M. C. Morales, San Antonio, Texas
Jay T. Lyon, Heber, Utah
Ivan L. Nichols, Salt Lake City, Utah
Raymond H. Whisenant, Sr., Danville, Va.
Thomas L. Johnson, Richmond, Va.
Edward A. Reilly, Bennington, Vt.
Delmer C. Austin, St. Johnsbury, Vt.
Benjamin Allen, Pasco, Wash.
Everette M. Wood, Seattle, Wash.
Wm. J. Hancock, Elkview, W. Va.
Robert E. Nichols, Nitro, W. Va.
Robert D. Wiegner, Eau Claire, Wis.
Milton E. Ver Doot, Green Bay, Wis.
Mack W. Whitaker, Cheyenne, Wyo.
Hal R. Tormey, Moorcroft, Wyo.
James Loughlin, Gander, Nfld, Canada
Geo. Lee Cameron, Dorchester, NB, Can.
K. W. Hemeon, Dartmouth, N. S., Canada
D. F. Hayes, London, Ont., Canada
R. M. Willows, Gagnon, P. Q., Canada
Leo Stern, Hague, Sask., Canada
William Newransky, Flin Flon, Man., Canada
Peter Mayert, Revelstoke, B. C., Canada
John Threewit, Anchorage, Alaska
Joseph K. Maunupau, Honolulu, Hawaii

Chapter Chatter

NRIAA WELCOMES NEW LOCAL CHAPTER

Last March Graduate Thomas Dubose of San Antonio, Texas, wrote National Headquarters suggesting the possibility of forming a new local chapter in San Antonio. After the necessary research, National Headquarters found there were enough graduates in the vicinity to justify the attempt. Accordingly, Graduate Dubose was appointed as Temporary Chairman of the proposed Chapter to get the ball rolling. With the able assistance of Graduates E. V. Garcia, Tom Love and Sam Dentler, Tom Dubose secured the necessary number of signatures to an application for a Chapter, which he forwarded to National Headquarters.

Tom Dubose is an employee of the National Cash Register Company. The Company graciously gave its permission for the organizational meeting to be held in the Company's building in downtown San Antonio. NRIAA Executive Secretary Ted Rose flew to San Antonio to attend the organizational meeting.

The first item on the program of the organizational meeting was the election of officers. The successful candidates were: Tom Dubose, Chairman; Joe Garcia, Vice Chairman; Bill Jones, Secretary; and Tom Love, Treasurer. Ted Rose administered the oath of office and installed the officers. He then expressed the appreciation of the members and of the NRIAA to Chairman Dubose and his assistants for their successful efforts in establishing the new Chapter. He also explained briefly what other Chapters are doing and offered a few suggestions and advice about the Chapter's activities and programs, then turned the meeting over to Chairman Dubose.

The Chairman lead a discussion on dues and scheduling meetings. The membership decided on dues of $5 a year for the present and voted in favor of holding meetings at 7:30 P. M. on the second and fourth Thursday of each month at the National Cash Register Building, 436 S. Main Avenue, San Antonio. This meeting place is not only excellent in itself but is also conveniently located in the center of the business district.

The membership chose "San Antonio Alamo Chapter" for its name -- and it is an excellent choice. Here is an opportunity for NRI men in the vicinity to take advantage of the many benefits of membership in a local Chapter. Graduates are eligible for full membership; students may join as associate members. Those interested in joining the Chapter or attending a meeting as a guest should contact Chairman Tom Dubose, 127 Harcourt St., San Antonio.

CUMBERLAND VALLEY CHAPTER program Chairman, George Fulks, gave a fine demonstration on servicing AC-DC radio receivers. He gave another such demonstration on servicing transistor radios at the next meeting.

It was decided to have a family-style picnic instead of the regular monthly meeting in August.

New members recently admitted to the Chapter are Claude Poole and Norman Frantz. A warm welcome to these new members!

FLINT (SAGINAW VALLEY) CHAPTER, after solving the trouble with a few "dog" TV receivers brought in by members, devoted the entire remainder of a meeting to transistors under the direction of Professor De Jenko. Professor De Jenko explained the basic elements of transistors and the basic rules to follow as well as the safety precautions to take in working on transistor sets. Some of the members present attached such importance to this meeting that they took time off from work in order to attend it.

At the next meeting hi-fi was the main subject, with particular interest being given to adjustable speaker baffles. This was followed

Vice-Chairman of the Saginaw Valley Chapter Andy Jobaggy (right) explaining to Bill Duncan and Clyde Morrisett how adjustable baffles work, at a meeting of the Chapter.

by a discussion on how to identify a gassy tube in a TV receiver by the gas burn on the side of the tube.

LOS ANGELES CHAPTER, not to be outdone by the San Francisco Chapter members who toured a TV station, visited Radio Station KMPC in Hollywood, This tour was conducted by Mr. Paul Pierce of the station, who gave a lecture on the early beginnings of the station and explained how it has expanded. The group saw the newsroom where six Western Union Teletype machines were operating and also watched the men at the controls. The members were so enthusiastic about this tour that they considered plans to visit a TV studio.

At another meeting the members explored and discussed a portable 7-inch TV receiver in the shape of a suitcase, and decided to repair it, also a Magnavox TV receiver which Treasurer Fred Tevis brought in.

Secretary Earl Dycus donated a Hoffman TV set to the Chapter to be repaired by the members and then sold, the proceeds to go to the Chapter's Treasury.

At an earlier meeting the resignation of the former Secretary, Earl Allen, was regretfully accepted. Earl was forced to resign the office because of ill health. He served the Chapter faithfully and well for several years. Our very best wishes to you, Earl.

MINNEAPOLIS-ST. PAUL (TWIN CITY) Chapter voted to purchase a Project-A-Scope (a device that will project printed mater and pictures on a screen) as an aid to lectures on circuitry. (Editor's Note: See the report from the New Orleans Chapter on such equipment in this issue.)

This decision was a result of the Chapter's plans to go very deeply into circuits. This program was inaugurated at the following meeting when John Berka led a discussion on rectifier circuits. But John's discussion precipitated a real hassle as to electron flow and current flow. The members agreed that they will spend more time on the subject.

Because July is such a popular vacation month, the members voted to forego a meeting for that month. The next meeting was scheduled to be held on August 10.

NEW ORLEANS CHAPTER is enthusiastic about its new equipment which was purchased to make its meetings even more interesting and helpful to the members. See the accompanying photo.

New Orleans Chapter's new equipment in use at a meeting.

In the photo Pat Boudreaux is standing back of and operating the Chapter's new opaque projector. He is throwing on the screen the schematic of a set brought in by Frederick Dobard, seated at the extreme right. He was unable to repair the set so he brought it to the Chapter's Radio-TV Clinic, which is a feature of the Chapter's monthly meetings. Chairman Herman Blackford is lecturing to the members through a Public Address system (also owned by the Chapter) showing the proper manner in which to repair the set. He is being followed by Pat Boudreaux with the projector.

Secretary Grossman rightfully felt that this equipment and demonstration would be of interest to other Chapters. He states that experience has shown that with the schematic blown up before them and using the public address system so that everyone can hear the lecture clearly and easily, crowding around the set is avoided, everyone is relaxed and comfortable, everybody is more interested and gets more out of the lectures and demonstrations. Louis says that before obtaining this equipment their trouble was that members would form separate groups of their own in order to discuss problems but that the new equipment has eliminated this.

Our thanks to the New Orleans Chapter and to Louis Grossman. Other Chapters please take notice. You may want to get similar equipment in order to make the same improvement in your meetings.

NEW YORK CITY CHAPTER'S Chairman Dave Spitzer and Julius Greico traced a defect in the agc circuit of the Chapter's TV set, using an oscilloscope, and Jim Eaddy told how to troubleshoot a transistor radio receiver using the oscilloscope.

There was more on the oscilloscope at the next meeting. Julius Greico demonstrated how to calibrate one and explained the basic operation of a scope. Dave Spitzer then introduced a defect in the Chapter's TV set and Julius used the scope to trace the defect. The members felt that they got a great deal of good out of these demonstrations.

As customary, the Chapter has suspended meetings during July and August. The members feel that the past year was a pretty good one for the Chapter but they are looking forward to making the coming year an even better one.

PHILADELPHIA-CAMDEN CHAPTER is busy with final plans for its banquet in October. This promises to be quite a social affair.

The Chapter is particularly pleased with the ability of one of its newer members, Bill Davis, as a speaker on servicing techniques. He delivered a talk and demonstration on the scope which the members felt was exceptionally practical and helpful.

Another meeting featured Al Kushner, Field Engineer for Jerrold Electronics, as guest speaker, who gave a talk on antenna distribution systems and amplifiers. Mr. Kushner was very thorough in his treatment of the subject. The members were so pleased with him that they invited him to return for another talk in the Fall. Obtaining Mr. Kushner as a guest speaker was arranged with Morris Green, President of the Almo Radio Company of Philadelphia. Mr. Green is very cooperative with the Chapter and the members are properly appreciative.

Four new members have been admitted to membership in the Chapter since those reported in the last issue of the NRI News. They are James Repose, Dan Ferris, James Mintzer and Carl Bach. Our congratulations to these new members!

The Chapter suspended its regular meeting for July and August but will hold the Service Night meetings for the benefit of those members who wish to make use of the Chapter's equipment. A surprising number of members take advantage of this opportunity.

PITTSBURGH CHAPTER held a meeting with the RTSA of Pittsburgh, at which Mr. Powell of Delco Radio, Kokomo, Ind., gave a very interesting talk on the use of transistor receivers as automobile radios.

Chairman Howard Tate displayed TV waveshapes on the scope and he and William Lundy and Charles Kelly discussed horizontal sweep troubles, their causes and remedy.

At another meeting Mr. Clement McKelvey, a teacher of Electronics in a local school and an honorary member of the Chapter, gave a talk on power supply and its defects. Mr. McKelvey's lectures are always very clear and to the point, so that all members find them easy to understand and follow. Mr. McKelvey was also scheduled to deliver a talk and demonstration on gated AGC with a blackboard and a Westinghouse receiver at the next meeting.

Three new members have been admitted to the Chapter: Burnard Clark, Bill Zeis, and Alexander Bizakis. Glad to number you among the membership, gentlemen!

SAN FRANCISCO CHAPTER members enjoyed a 2-1/2 hour tour of TV station KQED conducted by Chief Engineer Robert J. Nissen. He explained the technical details of the control panels, the operation of the image-orthicon TV cameras in the studios, the microwave transmission of the programs from the studios to the broadcasting tower 7 miles away on San Bruno Mountain. The station is owned and operated by a non-profit community corporation. The programs consist of adult educational courses. The members voted in favor of appropriating $10 for a membership in the station.

At a subsequent meeting Anderson Royal, Chairman of the Program Committee, discussed i-f, converter, and rf stages of the Chapter's Radio "mock-up" construction and at the Chapter's "shop night" Chairman Ed Persau worked with other members on the power supply and audio section of this experimental radio. Phil Stearns helped members with their "tough dog" problems.

David J. Webster has become a member of the Chapter. Congratulations, Dave!

SPRINGFIELD (MASS.) CHAPTER held its last shop meeting of the summer at Arnold Wilder's Shop in Springfield. Members brought in three TV sets and two radio receivers. All were put in working order with the exception of one old "dog" which looked as if "it had had it."

Elections for officers for the next season beginning in the Fall were then held. Last season's officers were unanimously re-elected for another term by voice vote. They are: Norman Charest, Chairman: Ray Sauer, Vice-Chairman; John Park, Secretary; and Sam Infantino, Treasurer.

Also unanimously elected, to the Executive Committee, were Howard Smith, Rupert McLellan, and Joseph Gaze. Joe Gaze was also appointed to the Refreshment Committee by the Chairman, with the consent of the members, Arnold Wilder as his alternate. The election or appointment to the various other committees was postponed until the first meeting in the Fall, which will be held on September 8 at the regular meeting place, the Army Reserve Center.

In a talk which he made at the end of the meeting, Chairman Norman Charest included a discussion on the purchase of equipment for future meetings. The members then expressed their appreciation to Mr. and Mrs Arnold Wilder for the use of their shop for the Chapter's Shop Meetings.

SOUTHEASTERN MASSACHUSETTS CHAPTER was pleased to welcome its newest member, Alfred C. Fleck, to membership in the Chapter.

Manuel Souza, a full-time Radio-TV serviceman, delivered a practical and informative talk on AGC troubles.

Chapter members held their customary annual banquet meeting at the Hangar's Night Club, Acushnet, Mass. The feature of the evening was a steak dinner followed by a very entertaining floor show.

Jim Donnelly agreed to bring in a TV set to be analyzed stage by stage at the meetings. This program should provide valuable practical suggestions to the members.

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: Edwin Wick, 4928 W. Drummond Pl., 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.

FLINT (SAGINAW VALLEY) CHAPTER meets 8:00 P. M., 2nd Wednesday of each month, Andrew Jobbagy's Shop, G-5507 S. Saginaw Rd., Flint. Chairman: William R. Jones, 610 Thomson St., Flint, Michigan.

HAGERSTOWN (CUMBERLAND VALLEY) CHAPTER meets 7:30 P.M., 2nd Thursday of each month, at homes or shops of its members. Chairman: Harold J. Rosenberger, R.D. 1, Waynesboro, Pa., 1650R11.

LOS ANGELES CHAPTER meets 8:00 P.M., 2nd and last Saturday of each month, 5938 Sunset Blvd., L.A. Chairman: Eugene DeCaussin, 5870 Franklin Ave., Apt. 203, Hollywood, Calif.

MILWAUKEE CHAPTER meets 8:00 P.M., 3rd Tuesday of each month, Radio-TV Store and Shop of S. J. Petrich, 5901 W. Vliet St., Milwaukee. Chairman: Philip Rinke, RFD 3, Box 356, Pewaukee, Wis.

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: Kermit Olson, 5705 36th Ave., S., Minneapolis, Minn.

NEW ORLEANS CHAPTER meets 8:00 P.M., 2nd Tuesday of each month, home of Louis Grossman, 2229 Napoleon Ave., New Orleans. 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.

PHILADELPHIA-CAMDEN CAHPTER meets 8:00 P. M., 2nd and 4th Monday of each month, K of C Hall, Tulip and Tyson Sts., Philadelphia. Chairman: Herbert Emrich, 2826 Garden Lane, Cornwell Heights, Pa.

PITTSBURGH CHAPTER meets 8:00 P.M., 1st Thursday of each month, 436 Forbes St., Pittsburgh. Chairman: Howard Tate, 615 Caryl Dr., Pittsburgh, Pennsylvania.

SAN ANTONIO ALAMO CHAPTER meets 7:30 P. M., 2nd and 4th Thursday of each month, National Cash Register Co., 436 S. Main Ave., San Antonio. Chairman: Thomas DuBose, 127 Harcourt, San Antonio.

SAN FRANCISCO CHAPTER meets 8:00 P.M., 1st Wednesday of each month, 147 Albion St., San Francisco. Chairman: E. J. Persau, 1224 Wayland St., 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: Edward Bednarz, 184 Grinnel St., Fall River, Mass.

SPRINGFIELD (MASS.) CHAPTER meets 7:00 P.M., 1st Friday of each month, U.S. Army Hdqts. Building, 50 East St., Springfield, and on Saturday following 3rd Friday of each month at a member's shop. Chairman: Norman Charest, 43 Granville St., Springfield, Mass.

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