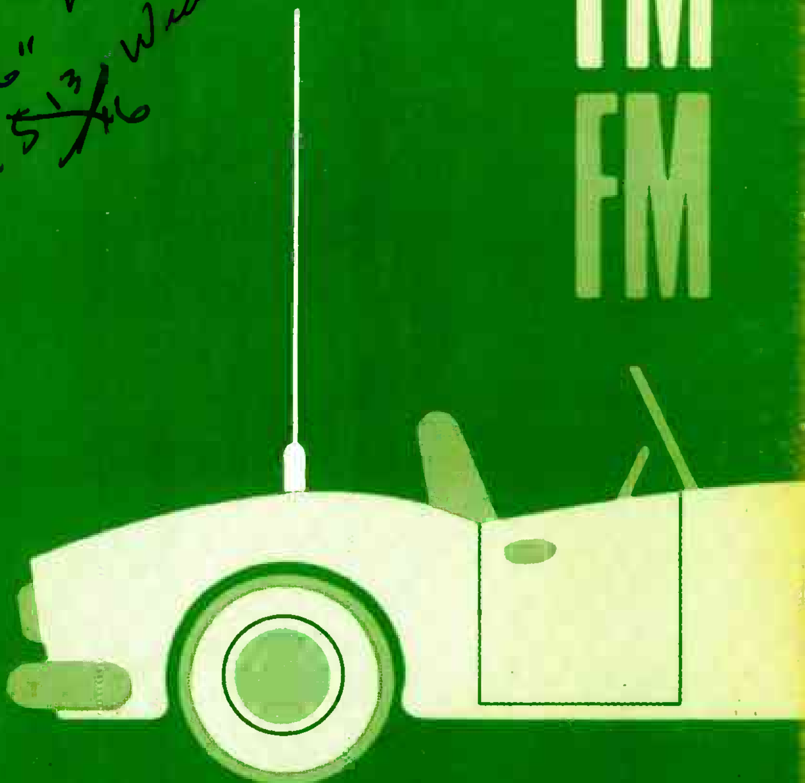
8 13/16" H 6" W

8 13/16 H x 5 13/16 Wide x 10/16" thick

FM
FM



- The growing ranks of mobile hams
- SCRs and triacs: What they are, how they work

nri journal

July/August 1974

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journal

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In this issue, Phil Deem presents a comprehensive survey of the rapidly growing mobile amateur radio field. In addition, Joe Turner examines the theory and applications of the newest in SCR's and triacs.

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the GROWING RANKS of MOBILE HAMS

Phillip D. Deem

What's a mobile ham? Well, its not a Swift's Premium riding on the back seat of your car enroute home from the grocery store! It's an amateur radio operator who has transmitting and receiving equipment installed in his car. The photo in Figure 1 shows me operating my mobile station, WB4EGA. Notice the "call letter" license plates.

FIGURE 1. A MOBILE HAM.

Any ham may have a mobile station; however, this type of operation has become popular only during the last few years. Previously, it was quite a task to set up a mobile station. Most of the equipment used tubes and required a special external power supply to develop the necessary high voltages from the car's 12-volt electrical system. The equipment took up quite a bit of space and since it usually operated on one of the hf amateur bands (20, 40 or 80 meters), a fairly large antenna was required. Mobile operation on the vhf (very-high frequency) amateur bands was not very popular due to the very limited communicating range of about five miles.

Today all that has changed. Nearly all mobile operation takes place in the vhf bands. Hams who had never even dreamed of having a mobile station wouldn't be without one now. How has this come about? The availability of relatively low cost vhf transistors certainly must be given some of the credit. They have allowed the mobile equipment to be reduced in size considerably and are operated directly from the car's electrical system. The antenna required is about the same size as the regular broadcast band antenna. Look again at Figure 1. You will see the antenna for my mobile station installed on the right rear deck of the car, just behind the passenger's seat.

Transistorized equipment and small antennas have not been the major reason for the increasing popularity of vhf mobile operation. The problem of limited communicating range still had to be overcome. Currently, the most popular amateur radio vhf band is 2 meters (144-148 MHz). Operation in this band has become so popular, in fact, that hams are rapidly moving on up to the next band, 1-1/4 meters (220-225 MHz). Communicating range at these frequencies is limited by the terrain over which the signal must travel from the transmitter of one station to the receiver of another. Anything blocking this signal path, such as trees or buildings, soaks up much of the signal rather than reflecting it. Ideally, you would like to have a clear path between you and the station you wish to communicate with. In mobile operation this is nearly impossible to achieve. The signal attenuation can be overcome only by increasing transmitter power, increasing antenna height, or increasing antenna gain. None of these things can be accomplished in any practical manner from a mobile station. The secret to overcoming this problem is through the use of a repeater.

A diagram of repeater operation is shown in Figure 2. As you might suspect from its name, the repeater is a fixed station which receives the relatively weak mobile station's signal on a particular frequency and rebroadcasts or repeats the signal on another frequency. When a ham wishes to communicate through a repeater to another station, he transmits on the repeater input frequency and monitors the repeater output frequency. Other mobile or fixed stations do likewise.

Since the repeater is a fixed station, it is practical to run fairly high power, use a high-gain antenna, and position the antenna at a good distance from the ground. All of these things serve to improve the communicating range of the mobile stations considerably. Depending upon the terrain surrounding the repeater station and the height of its antenna, coverage may be extended to a radius of 25 miles or more. Mobile stations at the edges of the area covered by a repeater such as this can communicate with each other even though they may be 50 or more miles apart!

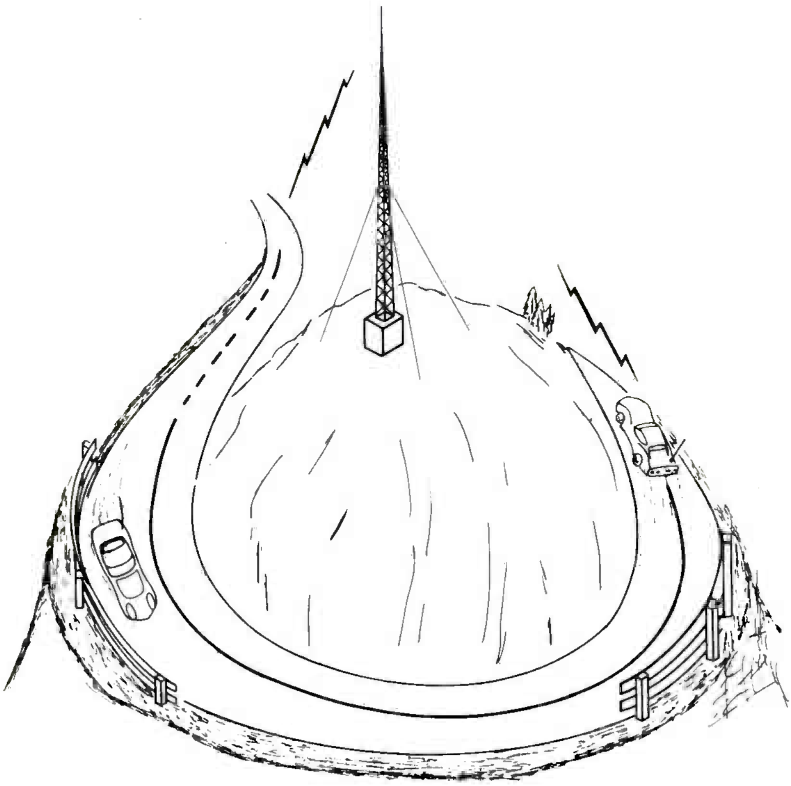

FIGURE 2. A DIAGRAM OF REPEATER OPERATION.

Repeater stations are made up of some fairly expensive items of equipment, normally beyond the financial range of the average ham's pocketbook. Most repeaters are owned and maintained by groups of hams who pool their money and knowledge to get a repeater on the air. I belong to such a group here in the Washington, D.C. metropolitan area. The group is called the Northern Virginia FM Association. It was formed by five hams in March of 1971. Today we have 550 members! How's that for solid evidence of the popularity of mobile vhf FM?

The NVFMA owns and operates three repeaters. Two of them are in the 2-meter band and one is in the 1-1/4-meter band. Our first repeater is a split-site operation. This means that the repeater receiver and transmitter are at two separate locations. The received signal is demodulated and the recovered audio is sent by telephone line to the transmitter. A block diagram of a split-site repeater is shown in Figure 3. The receiver and transmitter have separate antennas. When a signal is received, the carrier-operated relay (COR) closes and applies a dc keying voltage through a coupler to the telephone line. At the transmitter end, this keying voltage causes the push-to-talk (PTT) circuits to turn on the transmitter. The received signal's audio is sent down the same telephone line and modulates the transmitter's rf carrier.

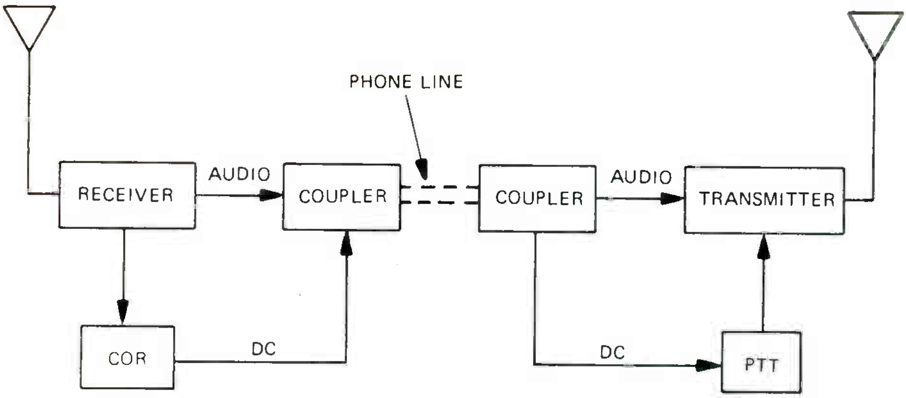

FIGURE 3. A SPLIT-SITE REPEATER SYSTEM.

When a repeater is operated split-site, the two antennas used must be quite far apart in order to eliminate desensitization of the receiver. This problem is common to any receiver. When a strong signal is being transmitted on a nearby frequency and originates from a place not far from the receiver, the receiver will no longer respond to weak signals on the frequency it is tuned to. There is another way to eliminate this problem, as you will see later. Now, let's take a look at the equipment.

Figure 4 is a photo of the receiver antenna and the tower upon which it is installed. The tower is owned by the government. We obtained permission to use it by demonstrating our public service ability. Our antenna is the top one on the left leg. It looks just about like the others, but each is designed for a specific frequency. This tower is 300 feet from its base to the top! The receiver is in a building at the base of the tower and is not visible in this view.

The repeater transmitter is in the basement of a building located about a mile from the receive tower. The NVFMA also operates another repeater from this building.

A closeup of the 2-meter transmitting antenna is shown in Figure 5. It is a collinear antenna and has 5.25 db omnidirectional gain. The actual elements of the antenna are not visible, since they are covered with fiberglass to protect them from the weather. The

FIGURE 4. THE RECEIVER AND ANTENNA TOWER.

FIGURE 5. THE TWO-METER TRANSMITTER ANTENNA.

antenna is about 20 feet long, but weighs only 23 pounds.

Figure 6 is a view of the tower at the receive site from the roof of the building where the transmitter antenna is installed. As you can see, the two sites are quite a distance apart. The antennas are also separated vertically about 200 feet. This prevents the transmitter signal from interfering with the receiver when the repeater is on the air.

The transmitter is contained in the equipment cabinet at the left of the photo in Figure 7. It is a solid-state 375-watt Motorola base station. The empty space in the rack originally held the receiver. The transmitter is transistorized with the exception of four tubes. Two tubes are used in the exciter section and two more are used in the final power amplifier. The exciter is behind the panel just above the empty space. The final power amplifier is in the upper portion of the cabinet.

FIGURE 6. LOOKING BACK AT THE WR4ABR RECEIVER SITE FROM THE TRANSMITTER SITE.

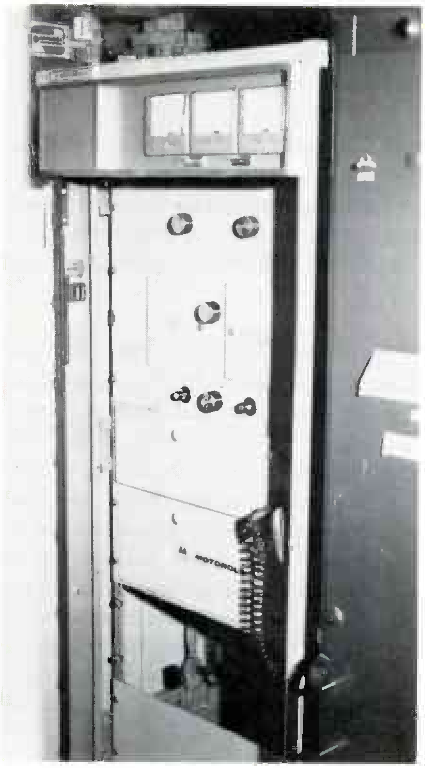

FIGURE 7. THE TRANSMITTER.

The left meter of the group of three at the top of the cabinet is switched into various circuits to monitor voltages and currents in the transmitter stages. It is used during the tuning procedure or to check on the operation of the transmitter. The other two meters monitor the final amplifier plate current and plate voltage continuously, as required by the Federal Communications Commission.

The equipment cabinet just visible at the right in Figure 7 was the first repeater the NVFMA put on the air. We replaced it with the solid-state equipment and it now serves as a backup. A view of the upper portion of this cabinet is shown in Figure 8. The transmitter section (or "strip" as it is commonly referred to) is at the top of the rack. The receiver strip is immediately below it. Both sections are tube-type equipment and require considerably more maintenance than the equipment we operate now. The section just below the receiver contains the transmitter keying relay and a transformer to match the audio circuits to the telephone line coupler.

The lower half of the cabinet houses the power supply for the tube-type repeater as well as the repeater control circuits, audio mixers, automatic identification circuit, and an autopatch. It is beyond the scope of this article to describe and explain all of these circuits. Some of them are required by the FCC. The control circuits allow us to turn the repeater off via telephone in case something goes wrong with the repeater. The automatic identification circuit sends the repeater station's call letters WR4ABR by impressing a tone

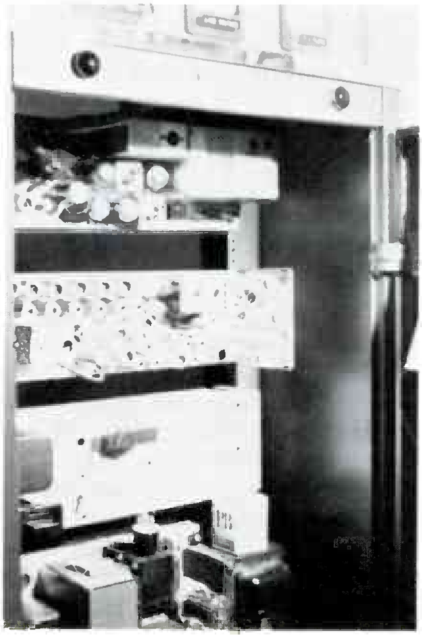

FIGURE 8. NVFMA'S FIRST REPEATER.

on top of the modulation coming from the receiver. The call letters are sent in Morse code once every time the repeater is brought into operation by the reception of a signal or once every two and a half minutes when it is in continuous operation.

As you can see, the control circuits are scattered all over the lower portion of the cabinet. We built them up as we needed them and added other functions later, which explains why there are so many separate boxes and wires all over. Since these circuits were designed, a completely new control system has been developed and is in operation at another repeater site. This new system will be duplicated and used to control each repeater the NVFMA operates.

I bet you've been wondering what an autopatch is! Well, let's stop right here and discuss it. Autopatch is probably one of the most desirable features of a repeater system. Through special circuitry at the repeater site, a mobile ham can place telephone calls from his car! He connects the output from a regular Touch Tone (Bell System registered trademark) pad to the microphone circuit of his mobile transmitter. The pad is just like the one used in your home telephone, although some hams use a different type which develops the same tone frequencies used by the telephone company. By punching an "access code" he causes the repeater to connect itself to the telephone line. When he releases his mike button, he hears the dial tone. He then presses his mike button and punches the telephone number—just like he would at home! From there on it is just like a regular telephone conversation with the exception that only one person can talk at a time. When he is finished with the call, he disconnects by punching another button on the pad and the repeater is returned to normal operation!

The FCC requires that we keep a record of this type of traffic and for this purpose we use a remote controlled tape recorder. The circuits which connect the telephone line to the repeater also turn on this recorder to make a record of the conversation. When the ham disconnects the telephone line from the repeater, the recorder continues to run for an additional 15 seconds. The ham uses this period to state the name of the party to whom he spoke and to identify his station. A box connected to the recorder contains a digital time-code generator. The audio output from the generator is fed to another track on the recorder to record the time of day the patch was made.

The autopatch is a valuable asset of any repeater. It is used several times daily by mobile hams to summon police and rescue vehicles to the scene of a traffic accident, fire, crime, etc. For example, one of our NVFMA members observed a possible auto theft in progress. He used the autopatch to summon the Montgomery County (Maryland) police. They arrived on the scene quickly, and caught a person in the act of forcing the vent window! On other occasions, sanding trucks have responded to a report of hazardous spots on the highway; traffic control people have been called to repair traffic lights at busy intersections; lives were saved following a head-on collision; tow trucks have come to the aid of stranded motorists; traffic tie-ups have been attended to; and, the mobile hams have served the public in many, many ways through the use of an autopatch.

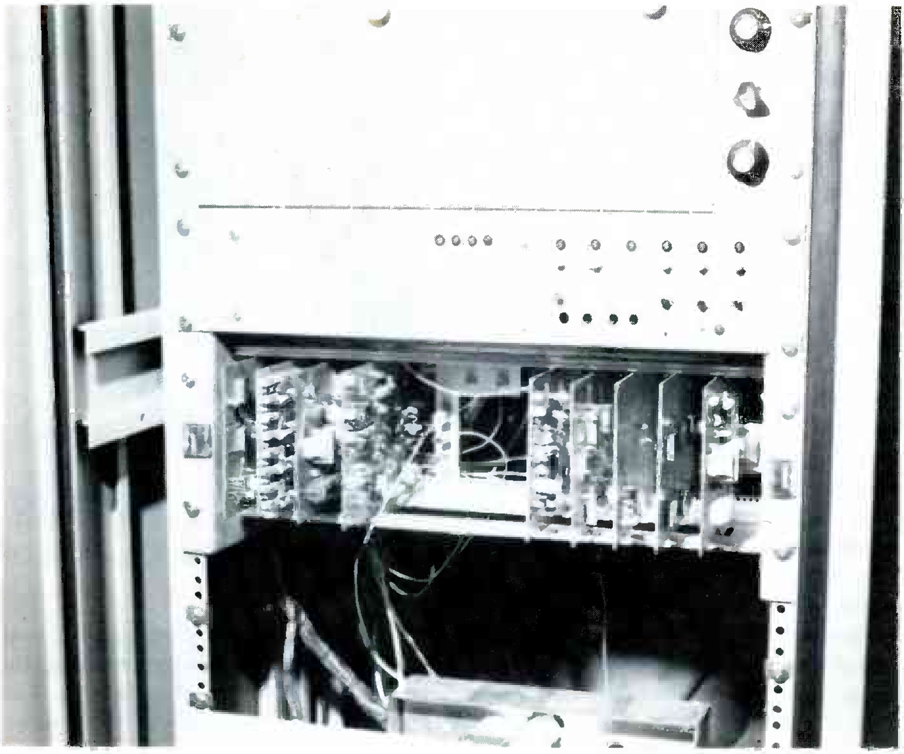

FIGURE 9. THE NEW CONTROL SYSTEM AT WR4AAD.

Of course, the hams get some pleasure from the autopatch, too! They call their wives or girl friends to say that they will be a little late in arriving or telephone someone at their destination for a "talk-in" when directions were not clear. Well enough of that! Let's get back to the repeater.

The photo in Figure 9 shows the new control system mentioned earlier. This is at the site of another repeater operated by the NVFMA. It also operates in the 2-meter band and has the call letters WR4AAD. The complete control system and an autopatch is contained on nine printed circuit cards.

The section immediately above the card rack contains the control circuits, power supply, pushbuttons for manually testing the system, and LED (light-emitting diode) status indicators. The panel allows the maintenance crew to tell at a glance the condition of the system. In addition to being much more compact, the system has a number of additional repeater control features and provisions for more to be added later. These allow the control station operator many more alternatives than just turning the repeater on or off, as was the case with the old control system.

You remember I said there was another way around the receiver desensitization problem? Well, this system is used at WR4AAD and uses a device called a duplexer. It allows the repeater transmitter and receiver to share the same antenna! It consists of four sharply tuned resonators (cavities), two between the receiver and the antenna and two more between the transmitter and the antenna. A sizeable number of coaxial transmission lines make up a phasing harness which also affects the tuning of the system.

Two of the cavities are tuned to accept signals arriving at the antenna on the receiver input frequency, in this case, 146.19 MHz. The other two are tuned to the transmitter frequency 600 kHz up the band at 146.79 MHz. The cavities provide over 100 db of isolation between the transmitter and receiver. As a result, they both behave as though they had their own separate antenna! Well, you may say, why bother with the trouble and expense of setting up a split-site repeater system when you can use just one antenna and have all the equipment at one location? Ah, now there's the rub. The duplexer, in addition to providing the necessary isolation between the transmitter and receiver, also introduces a 3-db loss. That means that only one-half the transmitter's power reaches the antenna and only one-half the power of the incoming signal reaches the receiver. Therefore, a single site repeater system involving a duplexer is used only when one antenna is allowed and the transmission-line length between the repeater and the antenna is relatively short.

FIGURE 10. PORTABLE HAND-HELD EQUIPMENT.

In addition to boosting the popularity of mobile operation, repeaters have enabled the use of portable, hand-held equipment for reliable communications, too. One such hand-held unit is shown in Figure 10. By the way, it's not the girl, it's what she is holding! It is a 6-channel, 2-meter FM transceiver. Its power output is 1-1/2 watts. This low power would be good only for about one mile if it were not for repeater operation. The transceiver is quite popular among the ham fraternity. It is manufactured by the R. L. Drake Company as their Model TR-22.

This story may have been enough to convince you to become a ham! If you're interested, you may wish to check into the NRI Amateur Radio courses. They teach you the necessary radio theory and FCC Rules and Regulations to prepare you for the license exams. You also receive instructions in Morse code. A Technician Class license or higher is required in order to participate in the operation I have described. The Northern Virginia FM Association and, I am sure, other similar groups throughout the country would welcome you!

WHAT THEY ARE

SCR's and TRIACS

HOW THEY WORK

Harold J. Turner, Jr.

In today's electronics, not all semiconductor devices are used for the classical purposes of amplification, oscillation, modulation, and detection. Many circuits and components are today devoted to the switching and control of power—lots of power. Just look around you . . . right in your own home. There are light dimmers, photoelectric controls, and all kinds of applications for motor speed controls. Have you looked inside your blender lately? If you did, chances are you'd find its speed control uses an SCR or triac. With so many commonplace applications for these modern semiconductor devices, just imagine the thousands of uses to which they are put in industry.

THE SCR

The silicon controlled rectifier (SCR) and triac are both members of the family of semiconductors known as *thyristors*. The term thyristor is applied to any semiconductor device whose action resembles that of the thyratron, a special type of vacuum tube which was formerly used in applications where thyristors are now cheaper and more efficient. Let's look at the SCR first.

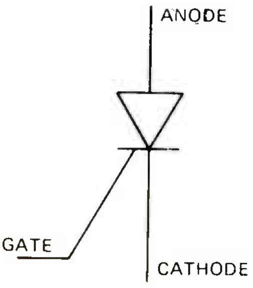

FIGURE 1. SCHEMATIC SYMBOL OF SCR.

Figure 1 is the schematic symbol of the silicon controlled rectifier. Note that the symbol is the same as that used for a standard pn junction diode, except that a third electrode, the *gate* terminal, has been added. As you might suspect from its name, the gate terminal is used to control the conduction of the diode formed between the anode and cathode connections. Figure 2 shows the relationship between gate current (I_G) and anode current. First of all, notice that the

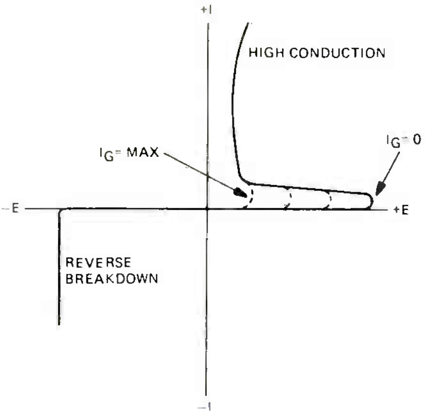

FIGURE 2. E-I CURVE SHOWING BASIC SCR OPERATION.

gate current has no effect on the reverse breakdown characteristics of the SCR. The diode operates in a reverse-blocking mode until its breakdown, or avalanche, voltage is reached. This voltage is typically in the range of 200 to 400 volts, and determines the maximum circuit voltage that may be applied to the SCR for normal operation. Voltages higher than the reverse breakdown voltage rating of the SCR generally cause permanent damage to the device.

In the forward direction, the SCR behaves as a conventional diode only when the value of I_G is at maximum; then the diode conducts heavily whenever forward voltage is applied. However, at progressively decreasing values of I_G, the breakover voltage of the device is increased until, at a point where I_G = zero, the anode voltage must be very high before any forward conduction occurs. In a typical circuit, the breakover point when $I_G = 0$ is at a voltage greater than that applied to the SCR, so conduction *never* occurs. Thus, in such a circuit, some gate current must be applied before the SCR will turn on. In this respect the device is somewhat similar to an ordinary transistor. However, this is where the similarity ends. In a transistor, once conduction has begun, it can just as easily be stopped by removal of base current. *However, in the SCR, once the device is triggered, the gate loses all control over the anode current.* Those old-timers among you will recognize this feature of operation as being a key feature of the operation of the classic thyratron tube. Of course, as soon as the anode voltage is removed, and anode current drops below some low value (known as I_H, or holding current), the device will revert to its original state, and another gate trigger will be required to turn it on again.

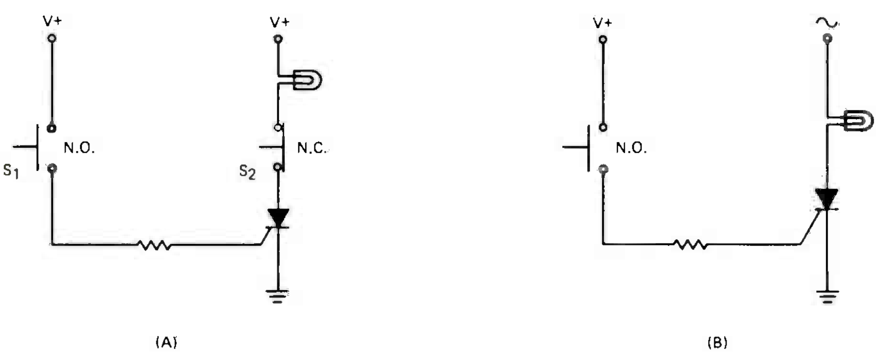

FIGURE 3. BASIC SCR CIRCUITS.

Figure 3(A) shows how this basic property of the SCR is used to form a simple latching circuit. In this circuit, switch S_1 is a normally open pushbutton, while S_2 is a normally closed pushbutton. Note that the voltages applied are dc, and positive with respect to the cathode. When power is first applied, nothing happens because there is no gate current, and thus the SCR will not turn on. The device is now said to be in its *forward blocking state.* The voltage between anode and cathode is of the correct polarity, but the device is blocking the flow of current because no gate current has been received.

Now, if S_1 is closed, gate current will flow, and the SCR will turn on, or "fire." *It will remain on even when S_1 is released,* thereby removing the gate current. As long as the SCR remains turned on, the lamp in series with its anode will remain lighted. The only way to turn the lamp off is to remove the supply voltage entirely or to press S_2 momentarily. By alternating between pushing S_1 and S_2, the lamp will be turned on and off repeatedly.

While this circuit looks very simple, and indeed it is in terms of the number of parts involved, it is a very important one as it clearly demonstrates the basic operation of the silicon controlled rectifier.

Figure 3(B) is a variation of the previous circuit. Note the differences: the normally closed pushbutton has been eliminated, and the supply voltage to the lamp (and thus to the anode of the SCR) is now ac. *It is precisely because the supply voltage is now ac* that the normally closed pushbutton is no longer required to turn off the SCR. In this case, the SCR will fire whenever the pushbutton is closed and the supply voltage is positive. But, as soon as the supply voltage goes to zero, or becomes negative, the SCR is automatically turned off because forward current through the anode-cathode curcuit has dropped below the holding current level. Since the ac frequency is relatively high, normally 60 Hz, the lamp will appear to turn on and off as the button is pushed and released. Of course, there is actually some slight delay, as the turning on and off is synchronized with the polarity of the applied ac voltage. Again, this circuit looks very simple, but it is a key to understanding how the SCR functions in ac circuits.

VARIABLE OUTPUT

The two circuits we have studied up to this point have been simple on-off switches, known as static switches, or contactors. They are used to allow a low-current switching circuit to control a high-power load. But the control has been limited to simple on-off switching. Now let's see how we can actually vary the power applied to a load.

Actually, it's not strictly correct to say that the control circuits we are about to investigate allow the thyristor to vary the power applied to a load. Really what happens is that the *timing* of the device's conduction will be varied so that the percentage of total time that power is applied to the load can be varied from zero to some maximum value. The thyristor itself *always behaves as a switch.* It is either on or off, and cannot assume any in-between states. Thus we must control the output power not be regulating the amount of conduction in the SCR, but rather *by regulating how long the device is allowed to conduct.*

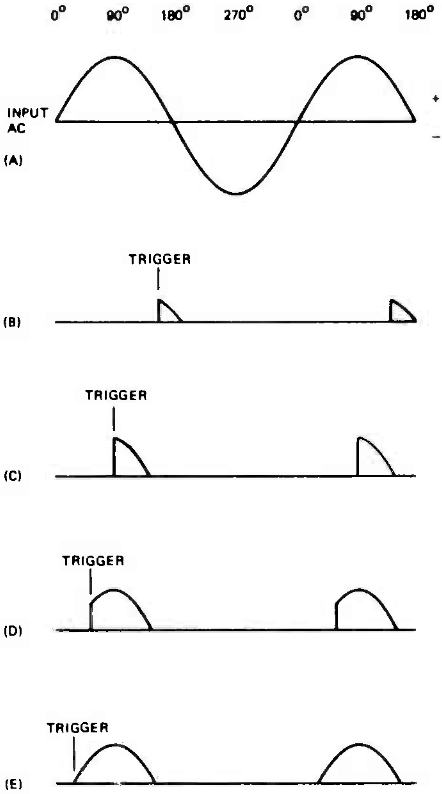

FIGURE 4. SHOWING HOW TIMING OF TRIGGER AFFECTS OUTPUT POWER.

Figure 4 shows how this is accomplished. At the top, in Figure 4(A), the input ac waveform is shown. Figures 4(B) through 4(E) show the conduction of the SCR with gate trigger pulses arriving at various times. As you can see from this drawing, the earlier in each cycle the trigger is applied. the longer the SCR will conduct current to the load, and thus the greater the average power output will be. In Figure 4(B), for example, the trigger pulse is applied to the gate nearly at the end of the positive alternation, so the power output will be very low. Of course, the SCR does not conduct at all on the negative alternation. In Figures 4(C) through 4(E) the trigger is applied earlier and earlier until finally it coincides with the beginning of the positive alternation, in which case the SCR will conduct for a full 180°. Now, how can we provide a trigger pulse whose phase is variable, using only simple components? Remember, this circuit must be usable in very low-cost consumer devices, as well as in industrial power controllers.

Now you'd never expect to find mention of the ordinary neon lamp in an article about sophisticated semiconductor devices, would you? Well, that's exactly what can be used to furnish trigger pulses to the gate of the SCR. Figure 5 shows the E-I relationship in a typical neon lamp. Note that the device is symmetrical; that is, it pays no attention to polarity. It conducts not at all until a certain voltage, known as the breakdown, or firing, voltage is reached, then its voltage drops and it conducts very heavily. Now keep this E-I relationship in mind and look at the schematic diagram in Figure 6. Here the neon lamp is shown used as the triggering device in the basic SCR phase control dimmer circuit. By varying the value of the

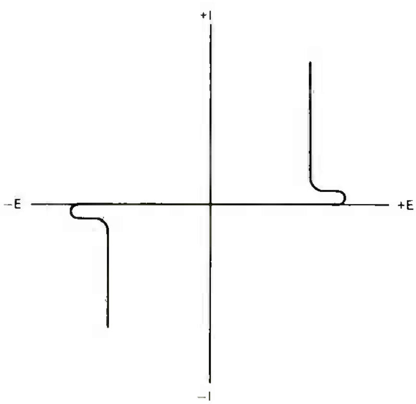

FIGURE 5. CURVE OF A TYPICAL NEON LAMP.

resistor, we vary the phase shift produced by the RC circuit. The phase relationship of the voltage across the capacitor to the applied voltage depends upon the setting of the control. The values of R and C are selected so that the phase of the capacitor voltage can be varied over a wide range. By changing the phase of this voltage with respect to the phase of the voltage applied to the anode circuit of the SCR, the average power output of the circuit can be varied. For widest range of control, the top end of the control is often connected to the bottom end of the load, as shown by the dotted line in Figure 6. Incidentally, the load, while shown here as a lamp, might be just about any type of electrical device, such as a heater, etc. Similar, although usually more complicated, circuits are used for controlling the speed of various types of electric motors.

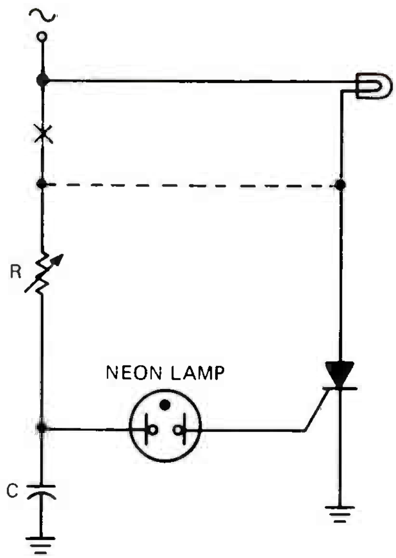

FIGURE 6. BASIC SCR PHASE CONTROL DIMMER.

FULL-WAVE CONTROL

The one thing that all the circuits that we have looked at so far have in common is that current can pass through the load on only one alternation of the input ac voltage. Now there are several ways of getting around this. Early lamp dimmers and motor controls used a standard junction diode which could be connected in parallel with the SCR by a switch. With the switch off, the SCR would function normally, allowing current to pass through the load during a selectable portion of the positive alternation. When the switch is closed, however, and the diode is put in parallel with the SCR, load current is always permitted on the negative alternation. By ganging the switch with a suitable control, smooth variation from zero to full-wave output is possible.

Another popular method of obtaining full-wave control from an SCR was to enclose the entire SCR circuit with a bridge rectifier, with the anode of the SCR connected to the positive output of the bridge, the cathode of the SCR connected to the negative output of the bridge, and the ac terminals of the bridge connected in series with the applied ac voltage and the load. The bridge rectifier automatically kept the correct polarity applied to the SCR phase control or switching circuit, while providing full-wave control of the load. Inverted parallel pairs of SCRs have also been used for this purpose, with various complicated triggering circuits, using sometimes even light-activated SCRs (Lascrs). Note that this discussion of how to obtain full-wave control has been in the past tense. This is because it is no longer necessary to resort to such tricks, now that *triacs* are available.

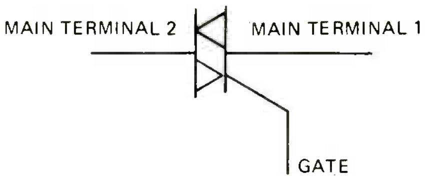

FIGURE 7. TRIAC SYMBOL.

ENTER THE TRIAC

Figure 7 shows the schematic symbol for the triac (incidentally, triac is an abbreviation of *tri*ode and *ac*). The operation of the triac is very similar to that of the SCR, except that the device is bilateral, or non-polarized. It operates equally well with positive or negative applied voltages. Note that the terminals formerly labeled anode and cathode are now simply labeled main terminals 1 and 2, since there is no polarity distinction. This is not to say, however, that the two terminals are interchangeable; they are not. The gate is always shown nearest main terminal 1, and this relationship must be observed when connecting a triac into a trigger circuit. However, this has to do with the operation of the gate rather than that of the current-handling portion of the device.

The triac could be installed in the circuit of Figure 6, and the neon lamp would trigger it at various points, just as it did the SCR. However, modern-day triac circuits make use of a two-terminal thyristor known as the diac, whose symbol and equivalent circuit are shown in Figure 8. The diac is a highly reliable solid-state device which is very similar to the neon lamp. Consider the diac as two Zener diodes connected back-to-back with blocking diodes added to prevent forward conduction through the Zeners. The E-I curve for such a combination would be as shown in Figure 9, which is quite like the curve shown in Figure 5. In

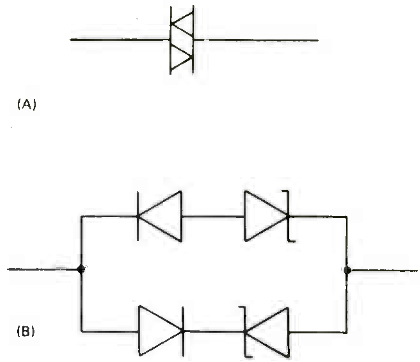

FIGURE 8. (A) DIAC SYMBOL. (B) EQUIVALENT CIRCUIT.

fact, the only real difference is in the breakdown voltage; on the order of 30 volts for the diac and about 90 volts for the neon lamp. Thus, in addition to its higher reliability, the diac finds near universal application in lower-voltage ac circuits. In fact, some manufacturers offer triacs with integral diacs as part of a combined device with only three terminals. This gives added reliability (fewer external connections) and reduces assembly costs.

Figure 10 is a schematic of a practical lamp dimmer that you could build

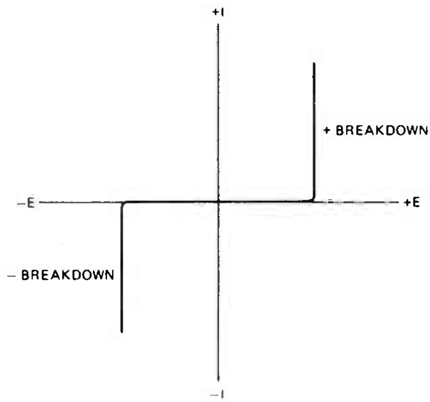

FIGURE 9. CURVE OF TYPICAL DIAC.

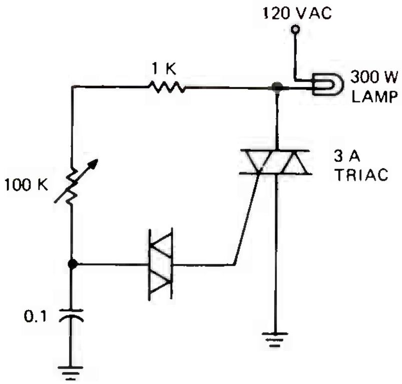

FIGURE 10. PRACTICAL TRIAC FULL-WAVE DIMMER CIRCUIT.

from readily available components. With a 3-ampere triac, lamp loads of up to 300 watts can be safely controlled. There's not much to the selection of a diac; simply pick one which is rated to perform with your triac.

While this article has been aimed at the most popular thyristors, it has by no means covered all available types. You have but to flip through any electronics magazine to see mention of Puts, Ujts, and so on. Perhaps in a later article we'll bring you up to date on some of these other devices. In closing, let me recommend an excellent reference on thyristors in general. It's the fifth edition of the General Electric SCR manual, available for only $3 from your local distributor. This nearly 700-page book explains (at both the student's and the engineer's level) the operation of just about every thyristor imaginable. Anyone seriously interested in this fascinating area of electronics should definitely have one.

Reader Exchange

FOR SALE: 157 Sams Photofact sets for $99 starting at No.500 and up. Contact Radio Appliance TV Service, 600 E. Park Avenue, Fairmont, West Virginia 26554.

Job Ops

POSITIONS AVAILABLE: The Watkins-Johnson Company has positions available for qualified electronic and test technicians, especially in the fields of communications and industrial and business electronics. Contact John F. Bean, Personnel Administrator, the Watkins-Johnson Company, 700 Quince Orchard Road, Gaithersburg, Maryland 20760. An Equal Opportunity Employer.

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HAM NEWS

By Ted Beach K4MKX

There's something that has been kicking around in my mind for some time that I thought I'd mention here as a sort of for-what-its-worth item . . . metrication. I'm sure that you've all heard the term, but just what is being done and how will it affect all of us?

That's the big question, and I'm sure the answer is that metrication will affect all of our lives to some degree. It is a tremendous undertaking, and there are presently about four or five plans before Congress that are being considered as to HOW to introduce the metric system to the people of the United States. However it is done, it will be a very long and costly process.

But you can be assured that most of us will probably see full use of the metric system in the United States in our lifetimes, so I feel the sooner we can get to it and start to use it the better off we will all be.

Already my daughter is doing some serious study in the fourth grade on this subject. Several food manufacturers and packagers have their products labeled in grams as well as ounces. Many large manufacturers of machine tools are presently specifying parts using a double measuring system (also very costly) because they do business in Europe as well as the U.S. It sort of looks like we (the U.S.) are playing "catchup" in this area instead of being the technical leader as we have in so many instances.

At any rate, I feel that this is something that we should all be aware of and should take steps to prepare ourselves for the inevitable. After so many years of training and indoctrination in the "unreasonable" English (American) measuring system it will not be easy. At the present time, I'm going through the exercise of trying to think in terms of centimeters and millimeters instead of inches and surprisingly enough it is getting to be fairly easy to judge "directly" in metric rather than saying mentally, "Hmm, that pencil looks to be about three inches long which is, let's see, three times 2.54 is 7.62 cm or 76.2 mm."

Instead, I say, "That looks like a pencil that's 76 mm long!" It isn't easy, but it's just like learning the code or how to play the piano or anything like that—it takes practice!

Most of you guys already have a sort of head start since we always talk about the "20 meter band" or "75 meters," "2 meters" or whatever. All we really have to do is carry that one step further and say that we need a half-wave dipole on a certain frequency, figure it out in meters and measure the wire with a meter stick instead of a yardstick. This saves one (usually inaccurate) conversion and you can use decimal numbers instead of feet, inches and fractions of an inch. Try it, you'll like it!

Just to make it all a bit more palatable, Edmund Scientific in Barrington NJ has a really neat kit which includes a booklet on the metric system and a whole bunch of gadgets and calculators for a measly five bucks that I'm sure anyone would find extremely useful. Their stock number on the deal (which is called a Metric Conversion Kit) is 71,844 and the $5 includes postage. Their address is:

Edmund Scientific Co.
300 Edscorp Building
Barrington, NJ 08007

I have gotten several letters from students and graduates requesting design help and other technical assistance which I truly wish that I could respond to properly. However, my main job at NRI is to assure the technical accuracy of our materials and my amateur radio work (particularly in this column) is strictly an "at home" chore which, unfortunately, gets second billing to my other home chores. In addition, many of the letters require a "timely" reply to be of value to the person writing the letter and I cannot, alas, set aside everything to answer letters. If you have any technical questions (no design problems, please), please direct them to the NRI technical consultants and they will be more than happy to help you. Indeed, usually when there is a Ham-type question that comes up the consultants come to the amateurs on our staff for advice if they do not have the answer readily at hand, so that's the way to go to get quick replies to technical questions.

The way the mail delivery has been lately, I think perhaps I should not have said "quick replies" above; at any rate you will be assured of a "quicker" reply if you write to our consultants! Questions that I feel are of general interest will be aired here in your column, but once again this is a fairly slow process as the column, as well as the rest of the Journal, is written about two months before you get your copy.

At any rate, my apologies to any of you who have not gotten a prompt written answer from me directly. I have a couple of letters in my file right now that should have been answered a week ago but there just has not been enough time to research the problems and come up with possible solutions. I will try, however, to get to these right away.

Now, let's see who we've heard from since last time. Looks like the ranks are getting thinner every time! There *must* be more Hams out there that we haven't heard from yet.

As usual, those listed first are students and graduates of the NRI Amateur Courses, while those listed last are other students and graduates. In addition to those listed, we have heard from some others who are "awaiting" a call and some who are aspiring amateurs. One such aspirant is Norm Tackett whose "work area" is shown in the photograph.

Martin	W2FEI	–	Cedarhurst NY
Harry	WB2MDX*	A	Woodstock NY
Dorwin	WN2SQG	N	Corinth NY
Gerald	WN2UIF	N	New York NY
Mike	WN4IMT	N	Milton FL
Bob	WB4IHK	T	Chattanooga TN
Wayne	WA5YHM*	A	Palestine TX
Emma	WN6DQD	N	Oceanside CA
Edward	WN9MMA	N	Hoffman Estates IL
Walter	WN9NDC	N	Brazil IN
Robert	WN1SUZ	N	Malden MA
Don	W3GOM/9G1HP	E	Ghana
Mark	WA3OLV	E	New Oxford PA
Mike	W6DYC/7	–	La Grande OR
Jack	W8LDY	A	Lakewood OH

* Just upgraded - congratulations!

Norm has taken his Conditional test and soon hopes to be on the air. In the meantime he has a CB license and keeps busy repairing electronic equipment in West Germany.

Ken Harden also hopes to join the Ham fraternity soon and sent in a "technical" letter asking how to convert a 21 MHz solid-state rig described in the 1971 Handbook to 40 meters. The answer is—don't. It is not a simple matter of scaling down capacitors and inductors when working with transistors, Ken. Better you should look for a rig designed—and tried—for the band you're interested in. The 1973 or 1974 Handbook has a two-band (80 and 40) rig that might just be your cup of tea. If I recall correctly the 1973 edition was the one that had it, but you can check your local library for back editions if you can't find one.

Sister Mary Benita Carey wrote that she had her Novice license, but neglected to tell us the call. She says that she is not yet using the license as she has not finished the receiver and transmitter.

W2FEI sent a letter to the address I have listed in the Call Book and the letter was returned to him. Sorry about that Martin. I moved. At any rate, he wanted to know how to send a CQ to let a person know (via cw) that you are using low power. Well, my experience has been that one doesn't send CQ using low power. It's just about a waste of time as you will receive very few replies. Better you should *answer* CQs and in the course of the QSO let the other fellow know you are running low power. QRP really means: "Shall I reduce power?" or "Reduce power" and has been used, probably incorrectly, to indicate power less than 100 watts. The term QRPp was generated by goodness knows who to indicate *very* low power operation, say less than 10 watts on the hf bands (10 watts in moderate power at vhf). Okay, Martin?

WB2MDX feels that the Advanced Class license he got from the FCC was of much more importance than the Certificate of Distinction he received when he graduated from his NRI course. I'm inclined to agree, Harry. And that was quite a feat to pass both the General and Advanced tests at a single sitting. Thanks too for mentioning NRI Training in your QSOs.

WN2UIF received his call in March of this year and is not yet satisfied. Gerald says his primary goal right now is the General or Advanced as soon as he can "put it all together." Good luck Gerald, I'm sure you'll make it.

WB4IHK is quite pleased with his new call (issued in March) and has gotten very active in 2-meter FM work in Chattanooga. Bob reports that they have a very fine machine on 19/79 atop Signal Mountain and are soon to open a second repeater on 01/61 which will be located on Lookout Mountain. Very fine, Bob, and congratulations. Those names—Chattanooga, Lookout Mountain, etc.—really bring back the memories for me. I went to prep school "way up north in Tennessee" (from Florida, that is) in Sewanee and we had to pass right through Chattanooga on the way. My, but that was a few years ago! Maybe someday I'll get down that way again, and I'll sure have my 2-meter rig in the car!

Wayne, WA5YHM, started his course soon after we brought it out, and after four years has gotten to Advanced. Very good, Wayne, it only took me fifteen years! And, when it came time to renew my Advanced Class license I did just that as I have not had enough practice to feel really comfortable at 20 wpm yet. Now I have another five years to work on it. Being as lazy as I am, I'll probably "renew" next time also. However, if they up the filing fee again, as they are bound to do, I may try and get my money's worth and go for Extra before the five years are up. Who knows? Anyway, a Ham ticket is still a bargain compared to a CB license.

WA3OLV writes that he is wild about antennas and currently has a phased four-element inverted vee array in his yard. Fantastic! Mark can vary the phasing from the shack and reports a 40-db front-to-back ratio is possible on 40 meters. The system only took him three years to design. Mark also says that he is working for an Electronic Engineering degree (as he studies our Color TV course) leading to—guess what—a specialty in antenna engineering. More power to you, Mark.

W8LDY is a real ex . . . ex-W2CRS, ex-KR6HD and ex-DL4ZZ. Jack likes hf cw operation and has a DX100 and HQ215 which are idle at the present due to having an apartment QTH (no antenna). Jack also has a First Phone and Second Radiotelegraph with ship radar endorsement. He hopes to sit in the very near future for the Extra. With qualifications like those, Jack, you shouldn't have too much trouble.

Well, that about wipes us out for this time. Let us hear from you and do make use of the free Ham Ads—we don't have any this time!

Very 73 - Ted - K4MKX

NRI HONORS PROGRAM AWARDS

In the tradition of NRI's pursuit of excellence in training, the following graduates who earned NRI electronics diplomas in March and April also earned unusual recognition under the NRI Honors Program. On the basis of their grades, these graduates distinguished themselves by earning the right to honors listed below and to the appropriate Certificate of Distinction in addition to their regular NRI Diploma. This distinction is made part of their permanent NRI records.

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Joe T. Dickey, Huntsville, AL
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*Name was omitted from previous list.

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Edward A. White, Plattsburgh AFB, NY
Thomas N. Whiteside, Taylors, SC
Samuel C. Wilmouth, Jr., Lynchburg, VA
Edward E. Wilson, Sr., Fairborn, OH
Joseph J. Woodring, Audubon, PA
Ted Wychopen, Ft. McMurray, AB, Canada
Dale R. Young, APO New York
Paul J. Zeik, Hutchinson, MN

A Note of Thanks...

The staff of the NRI Journal wish to thank the many readers who responded to our questionnaire in the last issue, and particularly for the many helpful suggestions, new ideas, and words of encouragement we received. While we cannot, of course, implement all of them immediately, we feel we have been given a fresh insight into our readers' interests and preferences.

DIRECTORY OF ALUMNI CHAPTERS

CHAMBERSBURG (CUMBERLAND VALLEY) CHAPTER meets at 8 p.m., 2nd Tuesday of each month at Bob Erford's Radio-TV Service Shop, Chambersburg, Pa. Chairman: Gerald Strite, RR1, Chambersburg, Pa.

DETROIT CHAPTER meets 8 p.m., 2nd Friday of each month at St. Andrews Hall, 431 E. Congress St., Detroit. Chairman: James Kelley, 1140 Livernois, Detroit, Mich. 841-4972.

FLINT (SAGINAW VALLEY) CHAPTER meets 7:30 p.m. twice a month every other Wednesday at Andy's Radio and TV Shop, G-5507 S. Saginaw Rd., Flint, Mich. Chairman: Larry McMaster, (517) 463-5059.

NEW YORK CITY CHAPTER meets 8:30 p.m., 1st and 3rd Thursday of each month at 199 Lefferts Ave., Brooklyn, N.Y. Chairman: Steve Kross, 381 Prospect Ave., Brooklyn, N.Y.

NORTH JERSEY CHAPTER meets 8 p.m., 2nd Friday of each month at The Players Club, Washington Square. Chairman: George Stoll, 10 Jefferson Ave., Kearney, N.J.

PHILADELPHIA-CAMDEN CHAPTER meets 8 p.m., 4th Monday of each month in RCA Building, 204-I, Route 38 in Haddonfield Rd., Cherry Hill, New Jersey 08034. Chairman: Joe Szumowski.

PITTSBURGH CHAPTER meets 8 p.m., 1st Thursday of each month in the basement of the U.P. Church of Verona, Pa., corner of South Ave. and 2nd St. Chairman: George McElwain.

SAN ANTONIO (ALAMO) CHAPTER meets 7 p.m., 4th Thursday of each month at Alamo Heights Christian Church Scout House, 350 Primrose St., 6500 block of N. New Braunfels Street (three blocks north of Austin Highway), San Antonio, Texas. Chairman: Norman Bird. All San Antonio area NRI students are always welcome. A free annual chapter membership will be given to all NRI graduates attending within three months of their graduation.

SOUTHEASTERN MASSACHUSETTS CHAPTER meets 8 p.m., last Wednesday of each month at the home of Chairman Daniel DeJesus, 12 Brookview St., Fairhaven, Mass. 02719.

SPRINGFIELD (MASS.) CHAPTER meets 7 p.m., 2nd Saturday of each month at the shop of Chairman Norman Charest, 74 Redfern Dr., Springfield, Mass. 734-2609.

TORONTO CHAPTER meets at McGraw-Hill Bldg., 330 Progress Ave., Scarborough, Ontario, Canada. Chairman Branko Lebar. For information contact Stewart J. Kenmuir (416) 293-1911.

FLINT-SAGINAW VALLEY CHAPTER HAS MOCK GUN BATTLE

At the April 10 meeting, everyone brought in a different type of soldering gun. These included a Blixt one-hand-operated gun, a Weller soldering and desoldering one-hand gun, and the deluxe and standard Soldapullt guns. There were also a variety of other soldering guns present. Each unit was demonstrated on printed circuit boards to show how the solder could be eliminated so that the parts could be removed.

Andy Jobbagy gave a talk on the resistor color code and a discussion was held on one of the articles from *Tom's Technical Flyer* entitled "Troubleshooting Microwave Ovens."

At the April 26 meeting a discussion of electronic mathematics including Ohm's law was held. A digital multimeter built by Andy Jobbagy was put to a test by the membership, including matching its results to a normal type of meter.

Fred Malick brought in an English-made radio to be repaired, which was something different. Dennis Besser showed us the Heathkit Dual-Range Fish Spotter with an audible alarm which he had constructed.

NRI AA OFFICERS	
James Kelley	President
William W. David	Vice President
Albert H. Sharp	Vice President
W. L. Simmons	Vice President
Arnold E. Verdow	Vice President
Tom Nolan	Exec. Secretary

Alumni News

SAN ANTONIO CHAPTER ENTERTAINS EXECUTIVE SECRETARY

At the March meeting of the San Antonio Chapter, the new CET study program was started, and there will be about six members getting together to make a common effort to achieve eligibility for the test.

At the April meeting, Tom Nolan presented a talk on interpreting oscilloscope waveforms which was very interesting and informative. He demonstrated the new NRI Model 255 cathode-ray oscilloscope. This is a triggered scope, which few of us have; thus, its capabilities gave us all something to look forward to when we are able to own one. Also, the varied uses of the scope probes was a subject everyone listened closely to since it was also applicable to their present equipment.

Two new members have been admitted, William Witte and Eugene Hughes.

Ed. Note: The Executive Secretary and his wife Janet wish to thank the San Antonio Chapter for their most gracious reception as always and for the fine entertainment at Mr. and Mrs. Bob Bonge's home on the following evening.

C.W.A. Hoffman

With deep regret we announce the loss of a long-time member of the Alamo Chapter in San Antonio, Texas, Mr. C.W.A. Hoffman. Mr. Hoffman was born in View, Texas, in 1906. His family moved to San Antonio when he was three, where he attended school. At the age of 18 he went to work for the Southern Pacific Railroad where he worked as a carman and inspector.

Mr. Hoffman spent three years in the service and was honorably discharged in 1945, when he returned to the railroad. After a long career with the Southern Pacific, he retired in 1967 because of ill health, but even so he remained active in railroad retirement activities. His wife Anita and son Lawrence remember him as a loving and good husband and father.

Mr. Hoffman's NRI diploma is dated February 28, 1950. His field was television repair. He has been a long-time member of the San Antonio Chapter and was an ex-Chairman. "Hoffie" was a good chapter booster, and he will be very much missed.

SPRINGFIELD CHAPTER HELPS NRI STUDENT

The speakers at the April meeting were Arthur Byron and John Park, who spoke on problems in the color section and AGC and vertical problems.

This meeting demonstrated the fact that NRI never loses interest in their students or graduates, as here was a group of graduates and one student. Our speakers were members of our own group who had solved problems and were willing to share their experience to help others.

Max Behard brought in a CONAR 600 color set and explained his troubles. He received what could be called classroom assistance from the membership of the Chapter.

DETROIT CHAPTER HAS BUSY SPRING

At the March meeting, a number of projects were worked on. These included a metal locater, a small TV which was overheating and had a short, and a CONAR color-bar generator. With a cooperative effort most of the equipment was put back in working order.

At this meeting we had two visitors, Wilson Crane and Carl Ceruti. Mr. Ceruti was admitted as an associate member of the Chapter.

At the April meeting, Jim Kelly brought in his Model 600 color receiver, and with the assistance of Ray Berus and Bruce Rittenhouse a demonstration of the color section of the CONAR TV was completed. Ray handled the scope and Bruce the bar generator. Jim asked everybody in the Chapter if they knew what a GIC was. Of course, the response was "No, what is it?" Well, that's what you get when the color oscillator stops oscillating (a Good Irish Color—green).

He also showed how the fine tuning affects the video color signal when it is improperly tuned, and demonstrated the proper use of probes in checking for the color signal.

NORTH JERSEY CHAPTER ENTERTAINS EXECUTIVE SECRETARY

At the April meeting Mr. Crusco, a part-time repairman, gave a talk on the "Sencore touch-tone cricket" which is the in and out of circuit transistor checkers. Mr. A. Mould, a local repairman, discussed the Zenith modules.

At the May meeting, the Chapter entertained Tom Nolan, the Executive Secretary. Tom presented an interesting lecture and a demonstration of the new NRI CONAR Model 255 solid-state triggered oscilloscope. The lecture included the proper uses of probes and methods of using the oscilloscope in troubleshooting. Refreshments were served after the lecture.

PITTSBURGH CHAPTER HAS GOOD ATTENDANCE

At the March meeting, the Pittsburgh Chapter presented the Sams Color TV Review Series numbers 3 and 4, consisting of a series of slides and tape recordings. After the slide show there was a question and answer session.

Also at this meeting, George C. Morris, one of the charter members, was readmitted to the Chapter. A total of 17 members attended the meeting.

At the April meeting, Thomas Schnader and George McElwain presented the program for the evening using the Chapter's bugged TV set. A question and answer session followed.

At the May meeting, Thomas Brutscher, a Zenith field service supervisor, will present a program entitled "What Does Zenith Do for the Independent Servicer?" He will also discuss horizontal sweep troubleshooting of the new 17/EC45 color chassis.

At the June meeting, Executive Secretary Tom Nolan will be our dinner guest and evening speaker with his annual visit.

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30.01- 35.00	2.05	4.50		
35.01- 40.00	2.65	4.75		
40.01- 50.00	3.00	5.00		
50.01- 60.00	4.15	5.50		
60.01- 70.00	5.50	6.00	6.40	4.50
70.01- 80.00	7.00	6.50	8.00	5.00
80.01- 90.00	8.00	7.75	10.10	5.00
90.01-100.00	9.00	8.75	12.60	5.25
100.01-110.00	10.00	9.75	14.80	5.50
110.01-120.00	11.00	10.75	16.20	6.00
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300.01-320.00	32.00	25.50	44.20	17.00
320.01-340.00	35.00	27.00	47.80	18.00
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( ) OWN HOME ( ) RENT .... RENT OR MORTGAGE PAYMENTS $ .... PER. MO.

WIFE'S NAME .... MARITAL STATUS ( ) MARRIED ( ) SINGLE

NUMBER OF DEPENDENT CHILDREN ....

PREVIOUS ADDRESS .... HOW LONG? ....

B → WHERE DO YOU WORK?

YOUR EMPLOYER .... POSITION .... MONTHLY INCOME $ ....

EMPLOYER'S ADDRESS .... Street .... City .... State .... HOW MANY YEARS ON PRESENT JOB? ....

PREVIOUS EMPLOYER .... Name .... Address .... HOW LONG? ....

WIFE'S EMPLOYER .... Name .... Address .... MONTHLY INCOME $ ....

C → WHERE DO YOU TRADE?

BANK ACCOUNT WITH .... Street .... City .... State .... ( ) CHECKING ( ) SAVINGS ( ) LOAN

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