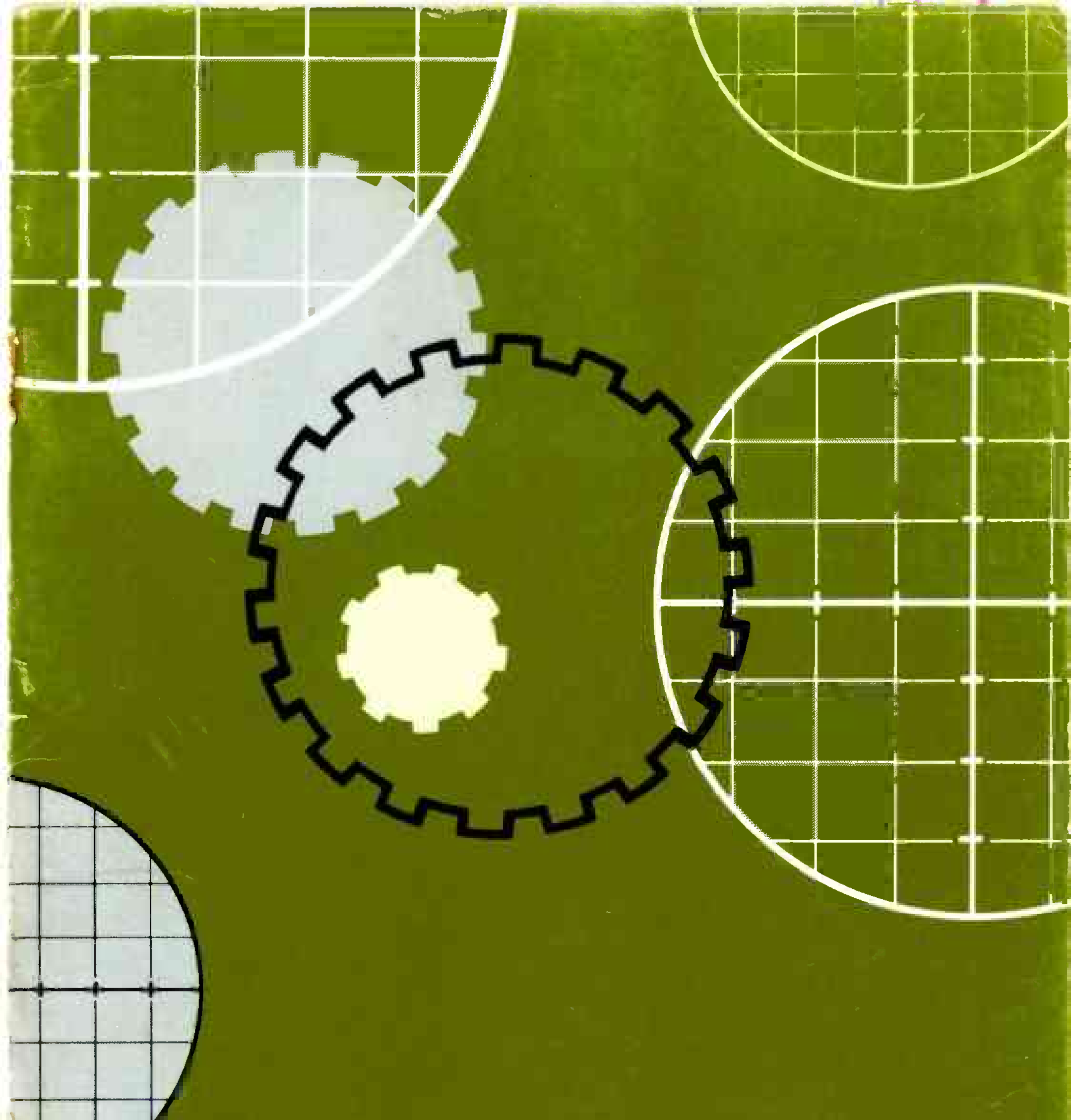

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November/December 1977

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November/December 1977
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In this issue, we bid welcome to about fifty thousand new readers with a larger Journal, a slightly more contemporary format, and some up-to-date articles by our contributors geared (we sincerely hope) to your NRI hands-on technological training in *all* fields.

The NRI Journal is published bimonthly by the National Radio Institute, a division of the McGraw-Hill Center for Continuing Education, 3939 Wisconsin Avenue, Washington, D.C. 20016. The subscription price is two dollars yearly or 35 cents per single copy. Second-class postage is paid at Washington, D.C.

A Message from the President

Important changes in this issue of the NRI Journal

With this issue of the NRI Journal, I am pleased to announce two important changes which are in keeping with our continued efforts to provide all students and graduates with timely news articles, stories on current technological developments, and helpful servicing features.

First, you will notice the number of pages in this issue has been expanded from 32 to 48 pages. This 50 percent increase in page space is an added bonus at no expense to you even though it appreciably increases our paper, printing, and postage costs.

Secondly, over the years the editorial content of the Journal has been directed primarily to students enrolled in television, communications, and other electronic programs. However, with the growing number of students enrolled in courses such as Automotive Servicing, Air Conditioning, Refrigeration and Heating, Servicing Electrical Appliances, and Small-Engine Repair, we are changing our editorial policy to provide a better balance of articles to improve the interests of all students and graduates. Hereafter, the Journal might be called an electronic-mechanical publication, better designed to enhance the interests of all readers.

Finally, as a reminder, NRI encourages all students and graduates to submit short articles for possible publication in the Journal which they feel would be of interest to other readers. If you have a story related to your training, servicing short-cuts, your job, etc., please feel free to submit it (preferably typewritten) to William F. Dunn, Editor and Publisher, NRI Journal, 3939 Wisconsin Avenue, Washington, D.C. 20016.

We hope you will find the changes beneficial to you in your studies and work.

John F. Thompson
President

Microwave Ovens

An Introduction

Harry Taylor

Microwave cooking is fast becoming popular among homeowners because of its speed and convenience. No longer does a person have to spend hours over a hot stove. Instead, it is possible to cook a complete meal in a fraction of the time needed with a conventional oven. Cookbooks and manuals are even available to teach you how to prepare nearly any food – from one item to a complete full-course dinner.

At first, microwave ovens were slow to catch on because they were expensive, had small oven cavities, did not brown food, and there was fear of hazardous radiation.

Since then, microwave oven manufacturers have incorporated many improvements in their products. They have enlarged oven capacities and now offer browning heating elements inside their ovens to give food cooked in them a more appealing and natural look. At the same time, the public has overcome its earlier fear of exposure to hazardous radiation.

It has been estimated that more than 1.5 million microwave ovens will be sold this year. This represents about a 50 percent increase in sales from last year, and points to increasing consumer interest in this type of product. Therefore, it is likely that you may have one in your home, now or in the future. If you are an appliance technician, microwave oven servicing can be a lucrative opportunity for you.

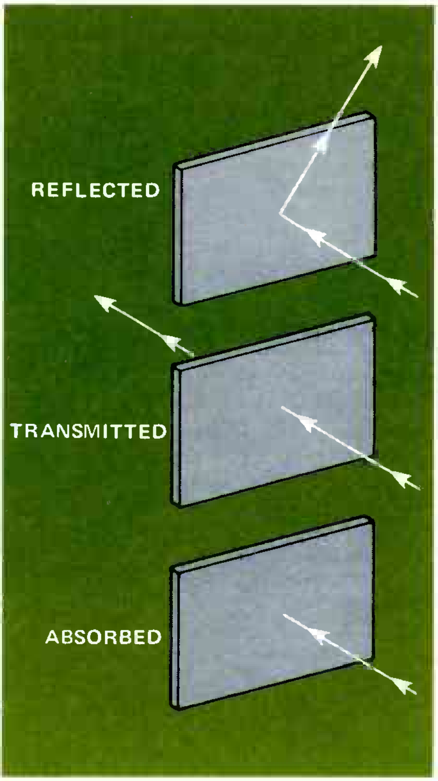
PRINCIPLES OF OPERATION

Microwaves are not heat waves. They are simply electromagnetic waves, similar to radio and television waves. They have a frequency and a wavelength that can be measured.

The higher the frequency of any wave, the shorter its wavelength and vice versa. As a comparison, the FM radio band extends from 88 to 108 MHz (a MHz is 1 million cycles per second). Microwave ovens generally operate at a frequency of 2450 MHz. Frequencies above 900 MHz are called microwaves, hence the name of the oven.

Like light waves, microwaves can be reflected, transmitted, and absorbed, as shown in Fig.1. Also, they travel in straight lines. Food and water absorb microwave energy, paper and glass and some china transmit or pass it, and aluminum and stainless steel reflect it. Stainless steel is used extensively in microwave oven walls to confine the microwave energy.

Microwave Cooking. It may be easier to understand how microwaves cook food by comparing a microwave oven with a conventional oven. In a conventional oven, the gas flame or electric heating element heats the air inside the oven. The heated air begins to heat the surface of the food and this heat is conducted toward the center of the food, thus cooking it.



Courtesy Westinghouse Electric Corporation

FIGURE 1. MICROWAVE ENERGY CAN BE REFLECTED, TRANSMITTED, OR ABSORBED BY VARIOUS MATERIALS.

With microwaves, the heat is produced in the food itself. The energy waves penetrate the foods and stimulate or agitate the molecules of the food. These molecules begin to move and try to align themselves with the energy waves. However, the waves are reversing themselves at a rate of 2450 million times per second – once during each cycle of the microwave frequency. This motion of the molecules produces friction heat in the food. The heat of friction produces enough heat to cook the food. The microwave energy penetrates up to three inches and cooks the outer portion of the food directly through this friction heat. The interior of the food is heated and cooked by conduction of this heat inward from the surface.

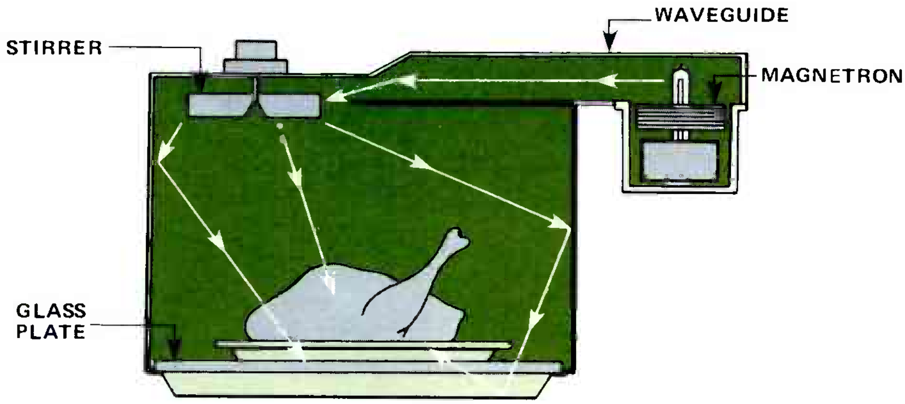
Since microwaves are energy waves and not heat waves, they do not brown food. If any browning does occur, it is a result of the tremendous amount of friction heat cooking the food. Larger cuts of meat such as roasts require a longer cooking time and, as a result, are browner at the surface than foods which require less cooking time. Many ovens have electric heating elements included to give the food a finished appearance.

Oven interiors do not get hot from microwaves. Any heat or warmth felt in the oven is a direct result of heat that is produced in the food being cooked. For example, a hot roast will cause the plate supporting it to get hot. The time required for cooking any food in a microwave oven depends upon how high a temperature is required throughout the food, how much heat is required by the food, and the weight and shape of the food.

Microwave Reflection. Microwave energy travels in straight lines, as mentioned earlier. This energy can be reflected by stainless steel and most other metals. The energy is channeled into the oven and allowed to bounce from one wall to the other so that it ultimately penetrates and cooks the food.

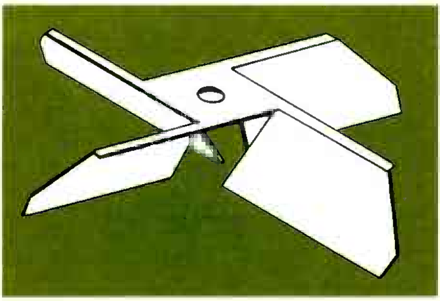
Microwave reflection is illustrated in Fig.2. The microwaves are generated by the *magnetron*, which is an electronic device external to the oven. The microwaves travel in a straight line through a waveguide from the magnetron into the top of the oven. The microwaves strike a slowly rotating fan called a *stirrer*. The stirrer blades (Fig.3) deflect the microwaves so that they enter the oven cavity at all angles.

The stainless steel walls of the oven cavity reflect the waves, causing them to bounce off the bottom, walls, and ceiling of the oven. The result is that the microwaves enter the food from all directions, cooking it evenly. The plate which supports the food is raised off the bottom of the oven, allowing the microwaves to bounce underneath and enter



Courtesy Westinghouse Electric Corporation

FIGURE 2. THE MICROWAVE ENERGY ENTERING THE OVEN CAVITY BOUNCES OFF THE INSIDE WALLS AND CEILING AND PENETRATES THE FOOD.



Courtesy Amana Refrigeration, Inc.

FIGURE 3. THE BLADES OF A STIRRER USED ON A MICROWAVE OVEN.

the food from the bottom. The glass in the oven door is covered by a perforated stainless steel sheet which reflects the microwaves, preventing any of the microwave energy from passing through the glass and escaping into the room.

The Magnetron. The microwave energy is generated by a special type of vacuum tube called a magnetron. The magnetron, shown in Fig.4, was developed for use in radar equipment during World War II. The tube operates in an intense magnetic field. Most microwave ovens use a permanent magnet for this field, but some use a field coil made of up of thousands of turns of wire.

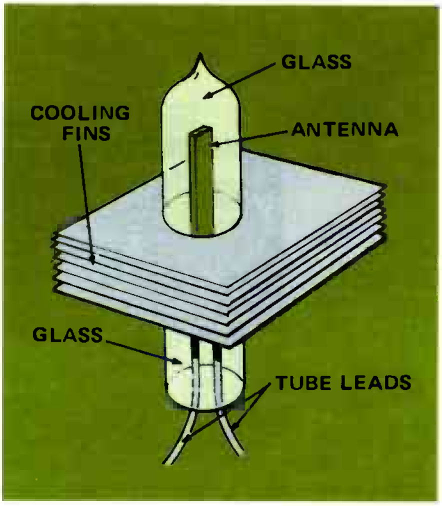
The magnetrons used in microwave ovens are air-cooled. A small fan blows air over the cooling fins attached to the magnetron assembly. The blower may be next to the magnetron so that it blows air directly on the cooling fins, or it may be below the magnetron so that the air flows through a duct and the blower housing to the magnetron.

The microwave energy that the magnetron produces is radiated through a waveguide to the top of the oven cavity. The waves may be reflected from side to side as they pass through the guide. The guide is carefully designed to pass the microwave signal with a minimum of loss of power.

The Transformer. A physically large transformer supplies the voltages required by the magnetron – approximately 3.5 volts ac and 4000 volts dc. The transformer has three windings: a 115-volt primary winding, a low-voltage (3.5 volts ac) secondary winding, and a high-voltage (2500 volts ac) secondary winding.

The low-voltage winding supplies the ac filament voltage that heats the internal elements of the magnetron. The high-voltage winding supplies voltage to a rectifier-voltage doubler that converts the ac into approximately 4000 volts dc. These voltages furnished to the magnetron are necessary for the magnetron to operate and produce microwaves. Figure 5 shows a typical power transformer, rectifier, and magnetron assembly.

Controls. The timer is the principal control in a microwave oven. This is a clock-operated switch that keeps the oven operating for the period of time selected by the user. Some ovens use



Courtesy Westinghouse Electric Corporation

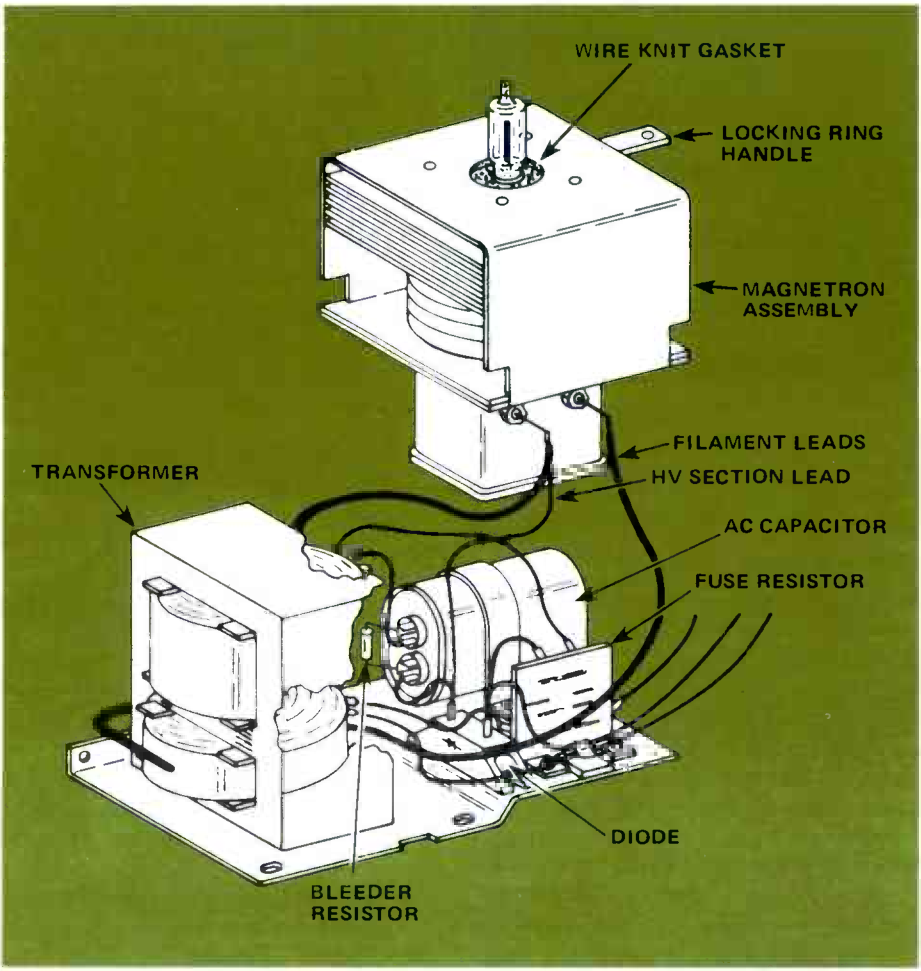
FIGURE 4. A MAGNETRON TUBE.

motor-driven clock-type timers while others use electronic timers similar to a digital clock.

In addition to the timer, there are several safety controls. Typical of these are safety and interlock switches, circuit breakers, thermal switches, and fuses. These devices shut off the power to the magnetron whenever there is a malfunction that could cause a hazard.

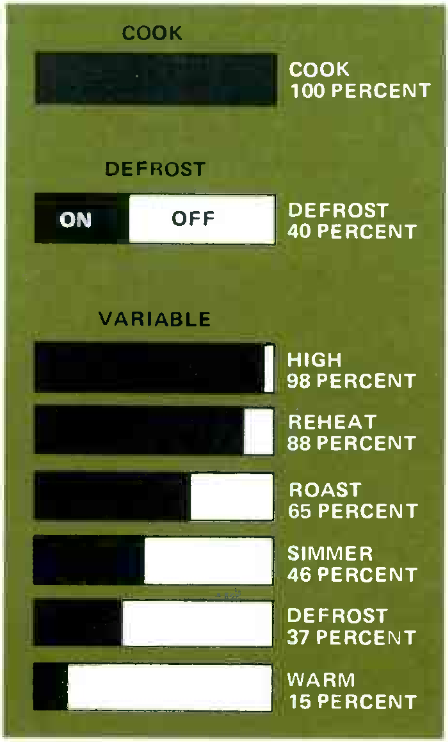
Special Features. There are numerous variations in the microwave ovens currently on the market. The cheaper models use a simple timer for control and operate at full power only. The more expensive models are likely to have variable power and programmable timers.

As in a conventional oven, you do not always need maximum heat or



Courtesy Amana Refrigeration, Inc.

FIGURE 5. A TYPICAL MAGNETRON AND TRANSFORMER-RECTIFIER ASSEMBLY.



Courtesy Litton Industries

FIGURE 6. CHART SHOWING THE PERCENTAGE OF MAGNETRON ON-TIME FOR VARIOUS OVEN FUNCTIONS.

power. For defrosting frozen food or keeping food warm, low power can be used. However, a magnetron can only operate at full power. Therefore, for reduced power operation the magnetron is cycled on and off several times each minute. The average power fed to the oven, then, is determined by the percentage of time during each cycle that the magnetron is turned on.

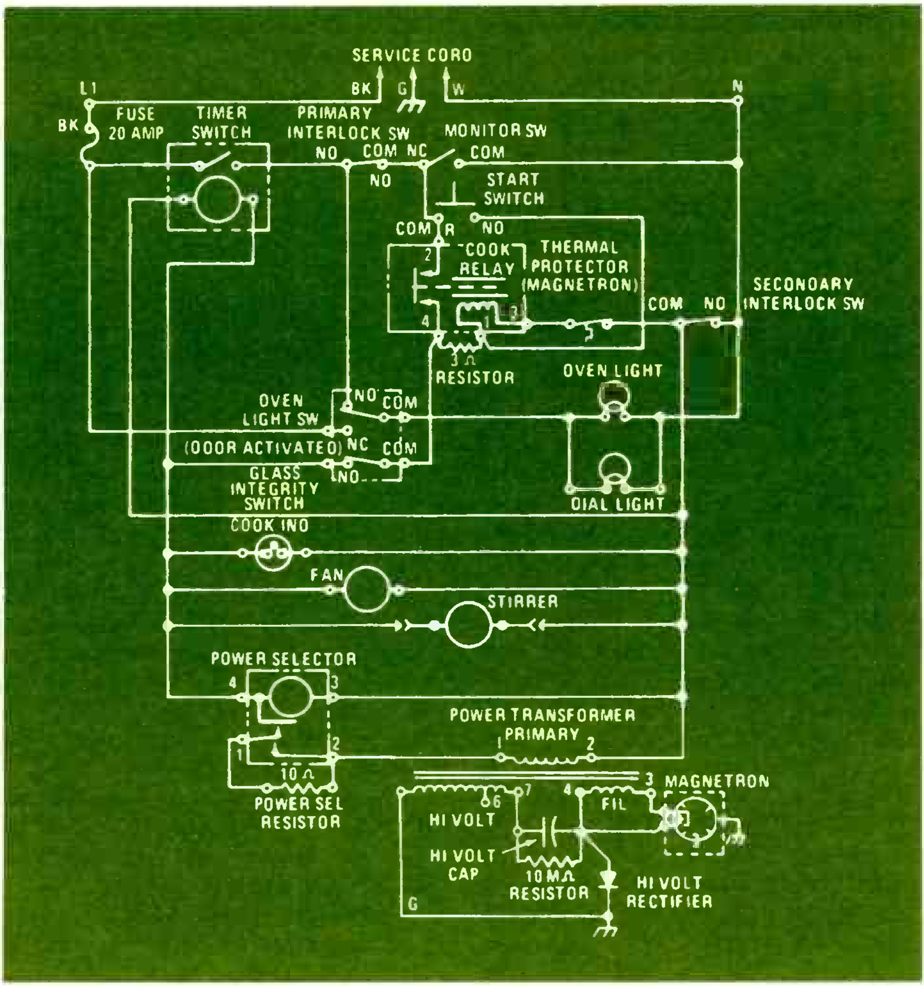
The diagram in Fig.6 shows the relative on and off times of the magnetron during various microwave oven functions. As you can see, the average on-time (and average power) varies from 100 percent for "cook" down to 15 percent for "warm."

Some microwave ovens have programmable timers. These are electronic devices wired into the microwave oven circuit. By punching in the desired duration of each function, you can program the oven to defrost, cook, and keep warm a meal taken directly from the freezer.

ELECTRICAL CIRCUIT

The electrical circuit of a typical microwave oven is shown in Fig.7. Actually, the circuit is not as complex as it may appear at first glance. Note the presence of both electrical and electronic symbols. The main parts in the circuit are as follows:

1. **Timer.** A clock-operated on/off switch.
2. **Safety Switches and Interlocks.** On/off switches controlled by the oven door.
3. **Fan.** For air-cooling the magnetron.
4. **Stirrer.** A slowly rotating fan for distributing the microwaves inside the oven cavity.
5. **Oven Lamp.** A lamp for illuminating the interior of the oven.
6. **Power Supply.** The transformer and rectifier that produce the operating voltages for the magnetron.
7. **Magnetron.** The special vacuum tube for generating the microwaves.
8. **Thermal Protector and Fuses.** For protecting the magnetron from overheating or drawing excessive current.
9. **Cook Relay.** A single-pole relay in the power circuit.
10. **Power Selector.** A timer for switching the magnetron on and off several times each minute for reducing the average magnetron output power.



Courtesy Whirlpool Corporation

FIGURE 7. THE CIRCUIT DIAGRAM OF A TYPICAL MICROWAVE OVEN.

The cook relay, when energized, completes the power circuit to the cook indicator lamp, fan and stirrer motors, and the primary winding of the power transformer. The power transformer, high-voltage capacitor, and rectifier supply the operating power for the magnetron.

The cook relay is controlled by the timer switch, primary interlock switch, secondary interlock switch, and start switch. The relay is closed by pushing the pushbutton start switch when these other switches are already closed. The relay is self-latching. That is, the relay contacts complete the circuit through the relay coil. Opening of the timer contacts or any of the safety switches will cause the relay to deenergize and open, thus shutting off the power to the magnetron and other devices. In order to turn the magnetron back on, you would have to close all safety switches and the timer contacts, and push the start switch.

The oven light and dial light are controlled by the oven light switch. The switch is mounted to the door frame and operated by the oven door.

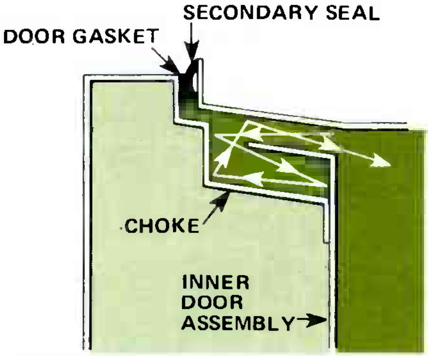
You will note that the circuit in the upper left corner of the diagram in Fig.7 is protected by a 20-ampere fuse. In the event that the safety switch does not operate, closing the timer switch can complete a short circuit directly across the 115-volt power line. This will cause the fuse to blow and protect the circuit.

The power selector (shown at the lower left) is a motor-driven timer. A cam, operated at a speed of 3 rpm, opens and closes a set of contacts. The on-time is determined by the manual power-selector setting.

The thermal protector is a bimetal switch mounted to the magnetron assembly. If the magnetron overheats, this bimetal switch will open and deenergize the cook relay. This will shut off power to the magnetron. Overheating of the magnetron can be caused by a defective blower motor or blocked air passages. The switch ususally opens at around 300°F and closes or resets at around 260°F.

The three colors of the power cord wires are indicated at the top of Fig.7. BK, G, and W represent black, green, and white, respectively. The green wire is grounded to the oven chassis. The white wire is the common side of the circuit. The black wire is the "hot" side of the microwave oven circuit.

Door Seal and Leakage. When the microwave oven is in operation, the door opening must be sealed to prevent leakage of the energy. The typical microwave oven has a primary seal and a secondary seal around the door. Both are shown in the sectional view in Fig.8.



Courtesy Westinghouse Electric Corporation

FIGURE 8. A SECTIONAL VIEW OF THE PRIMARY AND SECONDARY DOOR SEALS ON A MICROWAVE OVEN.

The primary seal is called a *choke*. This choke is a carefully designed slot along the edge of the door. Most of the microwave energy that does get through the narrow gap between the door and the frame finds its way into this slot and is reflected back into the oven cavity.

The secondary seal is a gasket that absorbs microwave power. This gasket is made of a special grade of vinyl that is impregnated with carbon-black.

Microwave Leakage Test. Sensitive instruments are available for detecting microwave leakage around the oven door gaskets and in other places where leakage could possibly occur. The instruments are calibrated in milliwatts per square centimeter (mw/cm^2). To perform this test, place a load in the oven and sweep the sensing probe of the instrument around the points where leakage is more likely to occur. A container of water is usually used as the load when making this test. The test should be completed before the water boils away.

In most cases, excess leakage can be corrected by adjusting the door or by replacing the door gasket, which is the secondary door seal.

Performance Test. A microwave oven should never be operated without a load, or something to be heated or cooked. The most simple test of an oven is to put a glass of water in it and see how long it takes for the water to boil. The typical oven should cause the water to boil in about three minutes. You will find specific instructions in the operator's manual that is packed with the appliance.

Relatively few appliance technicians are qualified to service microwave ovens. Some are fearful of the electronics in them. Others are just unwilling to put in the effort needed to learn about something new. This leaves the field wide open for those technicians who qualify. If you really want to increase your earning potential as an appliance technician, this is one appliance you should learn how to service.

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What's New?

Some time back, we began offering a synthesized 2-meter transceiver as part of our complete communications course. Your response to this new offering was so enthusiastic that we were unable to ship transceiver kits to some of you when you were ready for them.

We're in full production now, however, and we think that the Model 452 is just about the neatest piece of equipment that has ever come out of the NRI

The 452.

Development Laboratory. For the many of you who are still working toward the point in the course where you receive the transceiver kits, and maybe to tempt some others of you into considering Complete Communications as your next course, we'll look at some of the features of our new Model 452 right now.

WHAT DOES IT DO?

The Model 452 is a fully synthesized personal communications transceiver designed to operate on frequencies between 144 and 148 MHz. Since this band of frequencies belongs to the amateur radio service, an amateur radio operator license is required to operate there. (Obtaining such a license should pose no particular problem for an advanced student or graduate of the Communications course, however.)

Though we hesitate to make the comparison, the Model 452 is used in much the same manner as an ordinary CB radio. Both are used to provide personal communication between individuals while either on the move or at some fixed location. One important difference is the use of frequency modulation on the 2-meter amateur band as opposed to amplitude modulation on the citizens band. FM ensures practically interference-free communications even in crowded metropolitan areas.

Another important advantage the amateur operator has over the CBer is a greatly increased operating range through the use of repeaters. A repeater station (see Fig.1) receives the transmissions from an individual unit, such as the Model 452, and simultaneously retransmits the signal on a different frequency at a much higher power level.

The repeater station operates automatically, usually from atop a high building or tower where its signals can be received over thousands of square miles. Solid communications between units 100 miles or more apart is not uncommon through a repeater.

Many repeaters offer an added bonus. On command from a properly equipped transceiver, the repeater has the capability of connecting itself to an ordinary telephone line. This permits the amateur operator to make telephone calls from

Jim Lytle

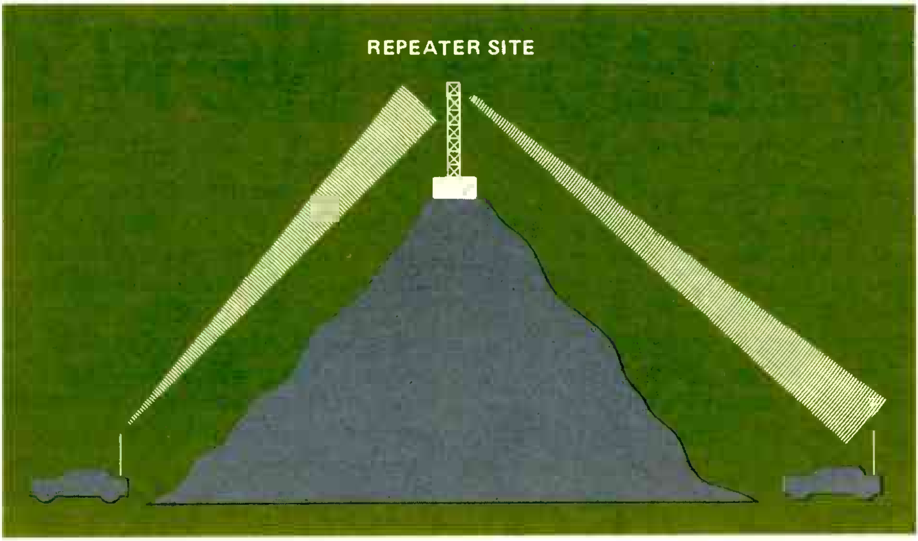

FIGURE 1. A REPEATER GREATLY INCREASES COMMUNICATING RANGE.

the car, the campsite, or wherever the transceiver has been set up. There are hundreds of repeaters located all over the country (and the world) with more coming on the air every day.

As many of you know, early this year the FCC increased the number of CB channels from 23 to 40. Despite this increase, it's difficult to get a word in edgewise on any of them if you live in a community of any size. With 800 channels to choose from on the 2-meter band, there's always a place for the amateur to go to have an uninterrupted conversation with a friend, to pass the time of day with a fellow amateur, or to obtain information or directions in an unfamiliar area.

HOW DOES IT WORK?

Figure 2 shows a block diagram of a basic transceiver. It could be designed to operate on the amateur band, the citizens band or any of the many public service bands merely by selecting the proper crystals and tuned circuits in the receiver and transmitter sections. In the transmit mode, the antenna is connected to the transmitter and the selected transmit crystal determines the frequency transmitted.

In the receive mode, the antenna is connected to the receiver. The required local oscillator signal is then determined by the selected receive crystal. One pair of crystals is required for each operating channel. With crystals costing about $5 each, this scheme is practical only for transceivers which operate on just a few channels.

With the hundreds of channels available on the 2-meter amateur band, a system such as shown in Fig.2 is obviously not practical. In our Model 452, we avoid this problem by using a digital frequency synthesizer. With such a circuit, it's possible to generate virtually any number of separate frequencies with only one crystal. Furthermore, each and every frequency generated by the synthesizer will have the same accuracy and stability as the crystal.

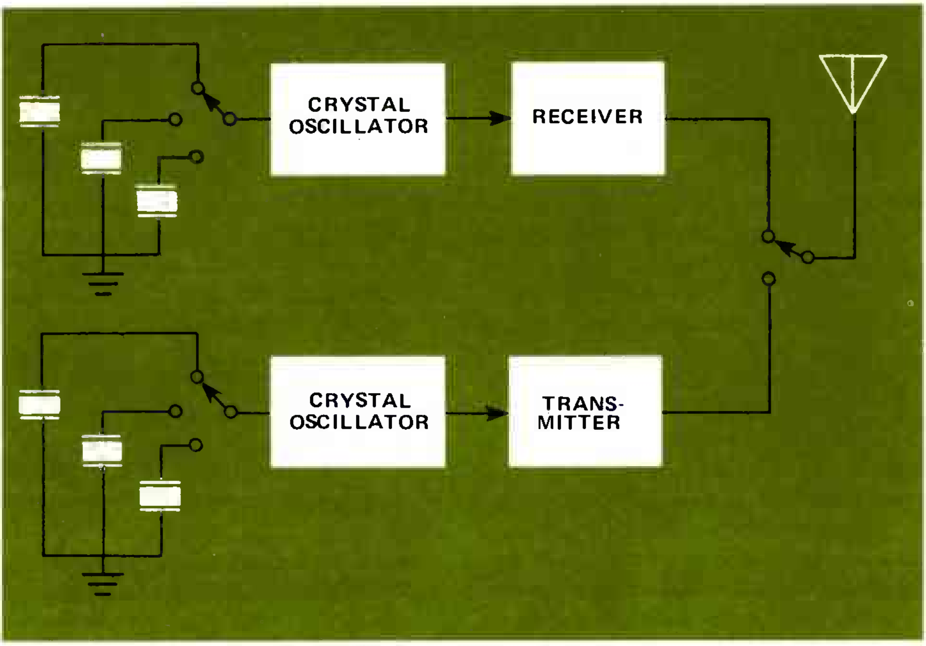

FIGURE 2. A BASIC TRANSCEIVER.

In Fig.3 we've replaced the two crystal oscillators of Fig.2 with a single voltage-controlled oscillator (VCO). As its name implies, the frequency of this oscillator can be varied by changing the dc voltage on the control voltage line. In the transmit mode, the control voltage is adjusted so that the VCO operates at the desired transmit frequency. In the receive mode, the control voltage is changed to operate the VCO at the required local-oscillator frequency. But where does the control voltage come from?

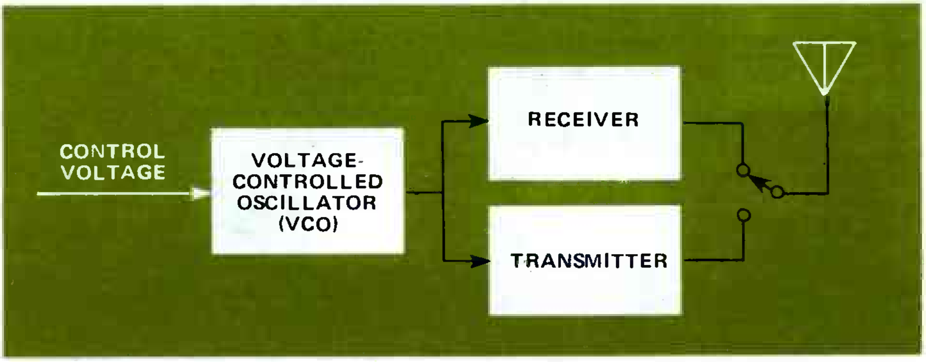

FIGURE 3. BASIC TRANSCEIVER WITH VOLTAGE-CONTROLLED OSCILLATOR.

In Fig.4 we've added a phase detector and a crystal-controlled reference oscillator to the circuit of Fig.3. The phase detector compares the phase of the two input signals and generates a dc output voltage proportional to the phase difference between the two input signals.

For example, we can say that the control voltage output of the phase detector will be zero when the two input signals are in-phase and will go either positive or negative depending on the relative phase difference between the two inputs. Let's further assume that the output frequency of the VCO will be exactly 145 MHz when the control voltage is zero, will increase in frequency when the control voltage goes positive, and will decrease in frequency when the control voltage goes negative.

Now, then, with the reference oscillator operating at exactly 145 MHz and the VCO operating at exactly 145 MHz, the two inputs to the phase detector are equal in frequency. If a phase difference exists between them, the control voltage output of the phase detector will tend to either increase or decrease the frequency of the VCO, as necessary, until it either "catches up" or "slows down" to come into phase with the reference input.

Once the two are in-phase, the control output becomes zero once again and the VCO is again operating at exactly 145 MHz. At this time, the VCO is said to be "phase-locked" to the reference oscillator. The circuit of Fig.4 is called a phase-locked loop.

So far, so good. The output frequency of the VCO in Fig.4 will have the same accuracy and stability as the crystal reference oscillator. Any tendency of the VCO to drift will be sensed at the phase detector and instantly counteracted by an appropriate adjustment of the control voltage to the VCO.

The circuit of Fig.4 has one serious limitation which you've probably noticed – the VCO will operate only at the frequency of the reference oscillator. The circuit, as it now stands, has no advantage whatsoever over a simple crystal oscillator. We can remedy this situation with the addition shown in Fig.5.

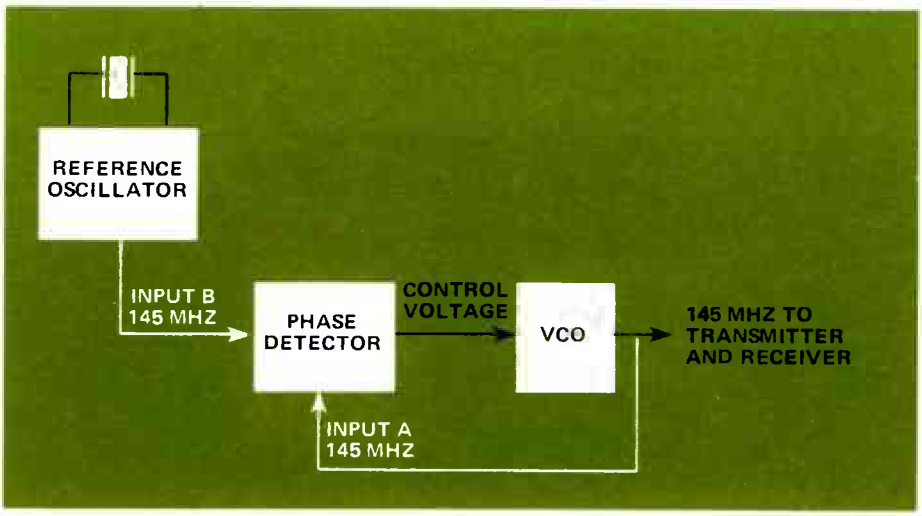

FIGURE 4. A PHASE-LOCKED LOOP.

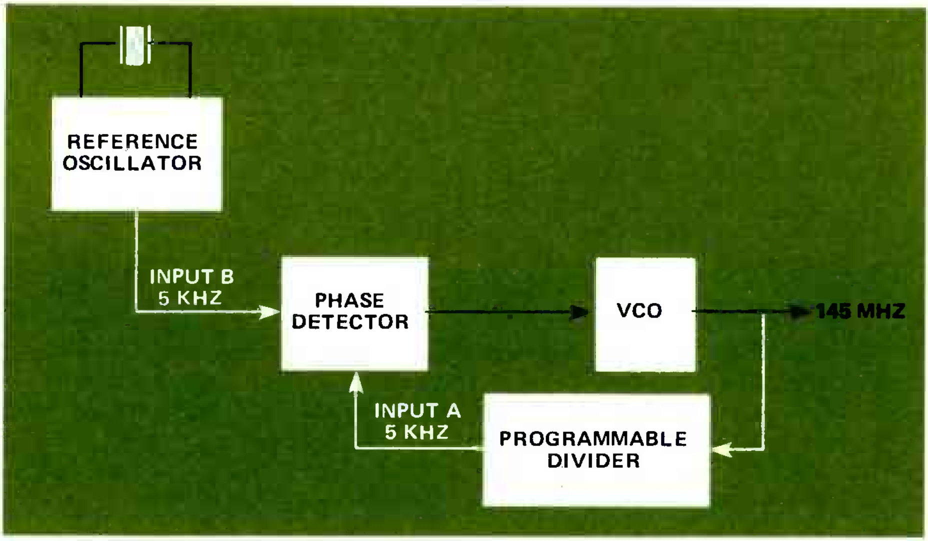

FIGURE 5. A DIGITAL FREQUENCY SYNTHESIZER.

As you can see, the new block in Fig.5 is called a programmable divider. It divides the frequency of the incoming signal by a number selected or "programmed" into it. This number, called the divisor, can be changed or "re-programmed" at will. Notice in Fig.5 that we've also changed the reference frequency to 5 kHz. An example will illustrate how these changes have increased the usefulness of the circuit.

Assume that the programmable divider has been set to divide by 29,000. With our VCO still operating at 145 MHz, the output of the divider will be $145 \times 10^6/29{,}000 = 5000$ Hz or 5 kHz. Since the reference oscillator also operates at 5 kHz, the two inputs to the phase detector are equal in frequency and will be quickly brought into phase lock by the action of the phase-locked loop. The result is the same as in the previous example – a 145-MHz VCO output signal phase-locked to the reference oscillator.

Now here's where the usefulness of the programmable divider comes into play. As already mentioned, the divisor of the programmable divider can be re-programmed at the will of the operator. What happens when the divisor is changed? Let's see.

Suppose we change the divisor to 29,500. With the divisor suddenly increased, the instantaneous frequency at the output of the programmable divider will be slightly less than 5 kHz. The phase detector instantly senses the change because the phase of the lower-frequency signal at input A will begin to lag the phase of the reference input at B.

The phase detector responds by changing the control voltage to the VCO by an amount just enough to bring the output of the programmable divider back up to 5 kHz and back into phase-lock with the reference. The new VCO frequency then becomes:

$$\frac{X}{29{,}500} = 5 \text{ kHz}$$

$$29{,}500 \times 5 \text{ kHz} = 147.5 \text{ MHz}$$

When the divisor is changed, the correction in the loop takes place very quickly.

One important point that you should understand in the previous example is the conditions that exist at the phase detector after the divisor is changed and the VCO has responded. Although the two inputs to the phase detector are phase-locked, a phase relationship other than zero exists between them. Also, the dc output from the phase detector is now some positive value as necessary to raise the frequency of the VCO to its new value of 147.5 MHz.

You can see also that the VCO frequency can be changed simply by re-programming the divider. The theoretical number of different frequencies that can be generated in this manner is limited only by the range of divisors that can be programmed into the divider. Each frequency is phase-locked to the reference oscillator signal and is therefore automatically maintained at the same accuracy and stability as the reference frequency.

The block diagram of Fig.5 illustrates all the important principles of a digital frequency synthesizer. As you might expect, practical synthesizers, such as the one used in the Model 452, incorporate a number of circuit refinements. The VCO in the Model 452, for example, does not operate directly in the 145-MHz range. Actually, the VCO operates at one-sixth the required transmit or receiver local-oscillator frequency. Its signal is then fed to a frequency tripler, then a doubler circuit for a total multiplication of 6. This brings it into the frequency range required by the transmitter or the receiver.

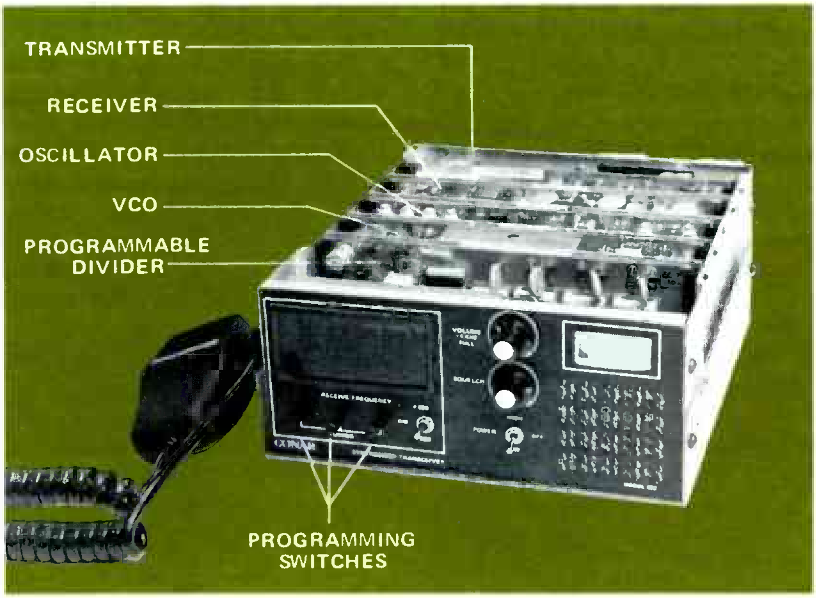

FIGURE 6. THE MODEL 452 WITH TOP COVER REMOVED SHOWING THE FIVE MAJOR CIRCUIT BOARDS.

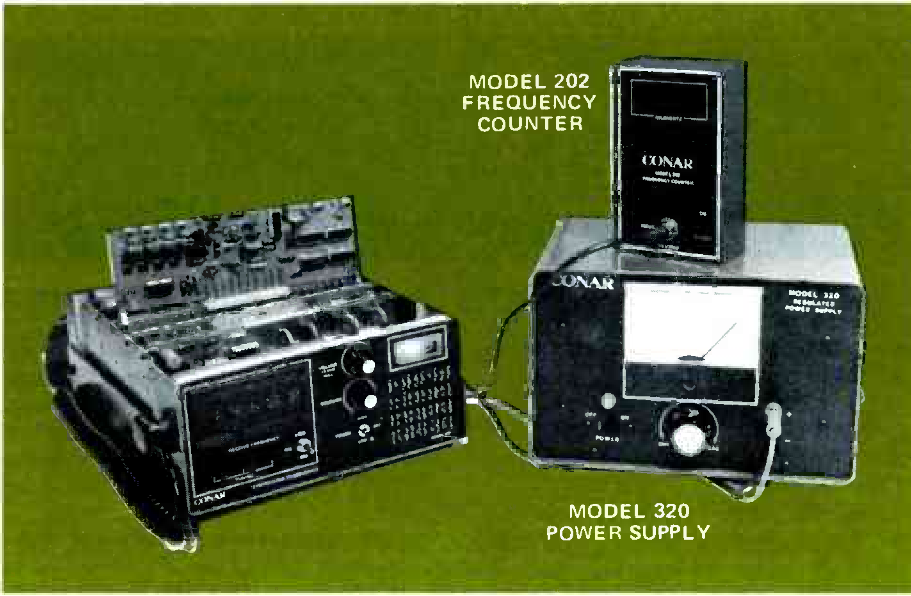

FIGURE 7. THE MODEL 452 WITH THE OSCILLATOR CIRCUIT BOARD IN THE EXTENDED POSITION.

WHAT DOES IT LOOK LIKE?

After the decision is made to develop a new NRI training kit, a project team is assigned to the task. One important area where much of their efforts are concentrated is the mechanical layout and construction of the kit. The most interesting and advanced circuit features are valueless to a student unless they are accessible and fully operational as they are constructed.

Soon after the circuitry of the Model 452 was finalized, it was broken down into five major circuit areas, each of which occupies one of the five plug-in circuit boards. Figure 6 shows the transceiver with the top cover removed and the five major boards identified. Also shown in Fig.6 are the front-panel-mounted programming switches. These switches are used to select the operating frequency which is then indicated on the large LED displays.

Figure 7 shows how complete training access is provided using the extender circuit board. Any of the five major boards may be extended in this manner while the transceiver is fully powered and operational. Many of the experiments and demonstrations of circuit operation are made possible with the extender circuit board. The Model 320 power supply and Model 202 frequency counter, both included with the transceiver, are also shown here.

As you can probably tell, we're very proud of this latest addition to our growing line of kits designed for training. Much as we'd like to praise its virtues further, space here does not permit it. Complete specifications for the Model 452 are listed in our latest catalog. If you don't have a copy, drop a line to Harry Taylor, our new director of Information and Graduate services. He'll be glad to furnish any information you need on NRI courses or training kits.

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Base diameter: 5"

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Base: 5" x 4¼"

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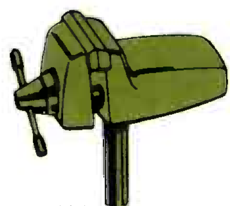

Model 303
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Wide 2½" jaws open to 2¼". Head is pressure-diecast aluminum alloy with steel and brass inserts. Hammertone graygreen finish. Replaceable nylon jaws.

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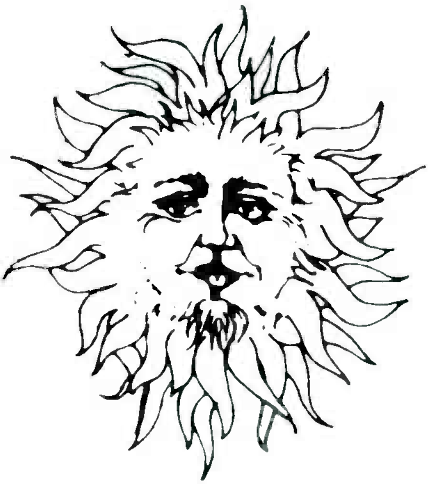
Model 315
Circuit Board Holder
Holds PC boards exactly where you want them. Spring-loaded arm for quick board changes. V-grooves for boards to 5/32" thick. Second set of lateral grooves near tip ends for exceptionally small PC boards and small electronic parts. Standard model holds PC boards up to 8". Cross bars up to 30" and extra arms are available for multiple board use.

Only $16.95

Shipping weight
1½ pounds

HEAT PUMPS



They're Here To Stay

Mike Taylor

With another hard winter predicted for this year, more and more emphasis will be placed on energy conservation. One energy-saving practice that is gaining popularity is the use of the electric heat pump for space heating. Despite the higher initial cost of the heat pump, almost one-half million heat pump units will be sold this year.

Although few people realize it, the heat pump has been around for more than 40 years. However, due to many design problems as well as the relatively high cost of electricity compared with oil or natural gas, heat pumps never seemed to catch on. After all, only ten years ago we were more concerned with convenience than with economy or efficiency.

Now, in some parts of the United States, natural gas and fuel oil costs are no longer lower than electricity costs. Also, it is likely that the cost of natural gas and oil will rise faster and higher than electricity rates. No longer can we enjoy the luxury of cheap and plentiful energy.

Many of the energy experts believe that the best way to deal with the energy shortage — at least for the immediate future — is to use more electricity, not less. This does not mean we should waste electricity, but shift to it from natural gas and oil. Natural gas and oil should be saved for purposes only they can serve.

Within the last few years, it has been found that the natural gas furnace is not as efficient as first thought. With all the factors determining the efficiency taken into consideration, the natural gas furnace efficiency was found to be in the 40 to 50 percent range, rather than in the 65 to 75 percent range as first believed.

For space heating purposes, efficiency is determined by the ratio of input energy to 1 unit of useful heat energy output. As shown in Table 1, the natural gas furnace requires 2.2 units of input energy to produce 1 unit of useful heat energy. The electric resistance furnace and electric baseboard heater, which work like giant electric toasters, require 3.2 units of input energy to produce 1 unit of useful heat energy output. On the other hand, the electric heat pump only requires 1.6 units of input energy to produce the same 1 unit of heat energy output.

You would think from this information that the heat pump would be the overwhelming choice for a

Table I
Cost and Efficiency Comparison

Heating System	Energy Ratio	Overall Efficiency	Initial Cost
Natural Gas	2.2	45 percent	Medium
Electric Resistance	3.2	31 percent	Low
Heat Pump	1.6	62 percent	High

central heating and cooling system. However, the early heat pumps were plagued with many problems.

Early heat pumps, which were simple air-conditioning systems working in reverse, were unreliable and subject to frequent breakdowns. Past heat pump designs would not work well at low outside temperatures. The lubricant for the compressor would turn to syrup at the lower temperatures, which prevented adequate lubrication of the compressor.

Low temperatures caused other problems for the heat pump. The early heat pump operated efficiently from 0°F to about 115°F. As a result, heat pumps were mainly limited to the milder southern climates, where extremely low temperatures were never reached.

Now, with more emphasis on energy conservation, the heat pump producers are designing more reliable and efficient heat pump systems. With new and higher quality lubricants, modern heat pump compressors will work efficiently down to −20°F. No longer are heat pumps designed only from the standpoint of the cooling function. Now they are designed from the standpoint of the heating function as well.

The heat pump works on the principle of reverse refrigeration or reverse air conditioning. In general, the only difference between the heat pump and the air conditioner is that the heat pump is used for both heating and cooling, not just cooling. Both systems serve the same purpose – to extract heat from one place and deliver it to another.

To understand how the heat pump works, you should keep in mind a few simple facts:

- **Heat exists in all matter.**
- **Even in the coldest air, there is some heat.**
- **Temperature is the measurement of heat concentration.**
- **When a liquid changes to a vapor or gas, the energy to make this change is stored by the vapor. This energy is in the form of heat. When the vapor condenses back to a liquid, the heat stored within the vapor is then released.**

Keeping these facts in mind, let's discuss the cooling operation of the heat pump. During the cooling cycle, the inside coil acts as the evaporator. As shown in Fig.1, a low-pressure liquid (refrigerant) is fed to the evaporator (inside coil). The warm inside air comes into contact with the evaporator and causes the refrigerant to boil and vaporize. This boiling action takes heat from the inside air.

The refrigerant vapor is than drawn to the compressor where it is compressed into a high-pressure gas. The high-pressure gas is forced through the outside coil (condenser) where it condenses back to a liquid. This action transfers the heat picked up from the inside air to the outside.

During the heating cycle, just the opposite occurs. The evaporator and condenser "switch places." Since it's not practical to physically exchange the evaporator and condenser with every season change, reversing valves are used.

The reversing valves simply serve to control the direction of the refrigerant flow. For example, during the heating cycle the reversing valves control the refrigerant flow so that the outside coil acts as the evaporator and the inside coil acts as the condenser, as shown in Fig.2.

During the heating cycle, when the outside temperature falls below 40°F, frost will begin to form on the outside evaporator. The frost will act as an insulator and reduce the air flow through the outside coil. This will greatly reduce the amount of heat picked up by the outside coil and thus affect the efficiency of the heat pump.

One method to remove this frost is to use electric resistance coils. The coils preheat the outside air and defrost the outside coil. However, this defeats the purpose of the heat pump.

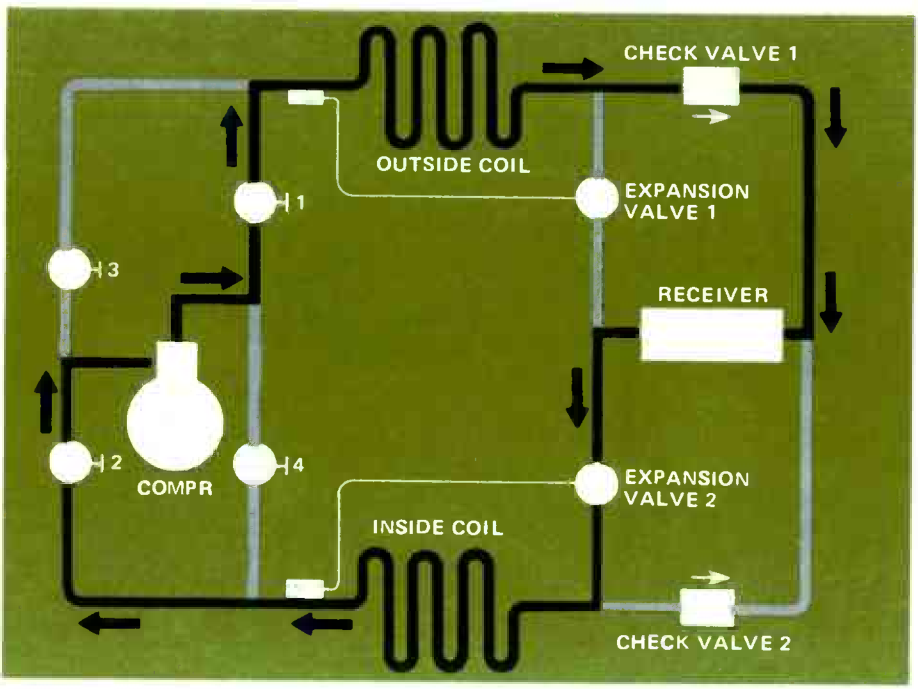


FIGURE 1. THE REFRIGERANT PATH DURING COOLING. THE ARROWS INDICATE THE DIRECTION OF FLOW. VALVES 1, 2, 3, AND 4 ARE REVERSING VALVES.

In most cases, a hot gas bypass (HGP) system is used. Here, a portion of the hot high-pressure gases from the inside coil are periodically bypassed to the outside coil. The hot gases warm the outside coil and melt whatever frost has developed.

This brings up the one drawback of the heat pump. Even though there is still a great deal of heat outside, the heat pump must work harder and harder to extract this heat as the outside temperature falls. It then becomes necessary to supplement the heat picked up by the heat pump. Supplementary heaters are usually of the electric resistance type, which are automatically switched on when the outside temperature falls below a preset point.

Why not install a larger heat pump system in the first place rather than use supplementary heaters? To answer this question, you will have to remember that the heat pump will also be used for cooling in the summer. If we size the heat pump for the winter load, the system will be too large for the summer load.

This will cause the system to *short-cycle* during the summer. This means that the system will only run for short periods of time, with frequent starting and stopping. This can be very hard on the compressor, and may not provide adequate humidity control.

Since the supplementary heaters will only be used on the coldest days, it is best that the heat pump be sized for the cooling load. This may seem like a compromise, but does provide the best overall economy for the heat pump system.

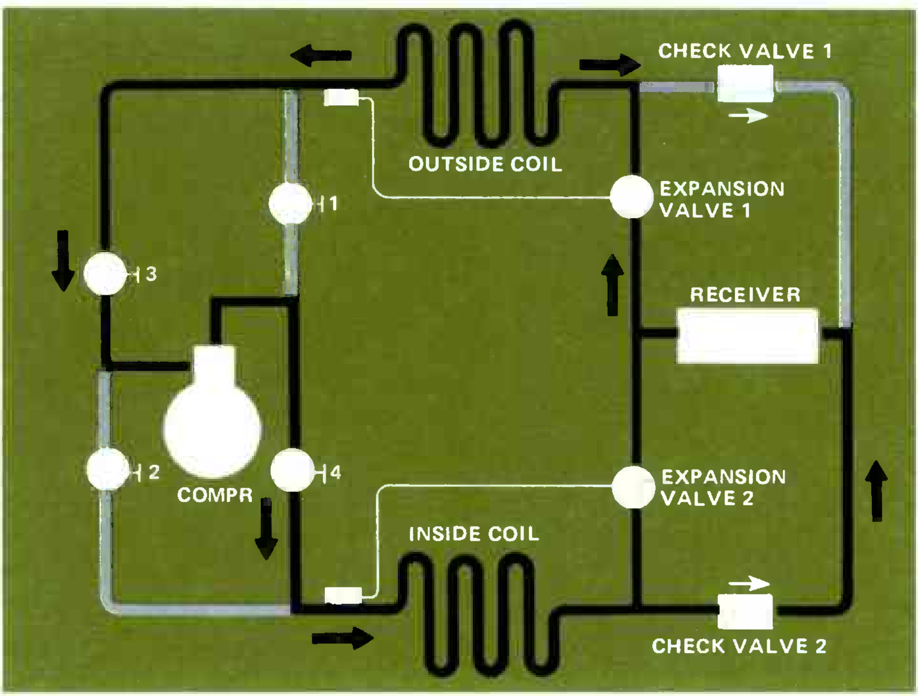


FIGURE 2. THE REFRIGERANT PATH DURING HEATING. THE ARROWS INDICATE THE DIRECTION OF FLOW. VALVES 1, 2, 3, AND 4 ARE REVERSING VALVES.

Servicing the heat pump should not be a problem for the experienced air-conditioning mechanic. As in troubleshooting and servicing any piece of equipment, you should have a thorough understanding of how the equipment operates, and the sequence of operation.

A frequent customer complaint is cool air coming from the duct system. This is an especially common complaint from customers who are used to gas or oil furnaces. The air supply from a heat pump has sufficient heat to satisfy the home thermostat. However, the supply air temperature is somewhat lower than the 130°F to 150°F air temperature of a gas or oil furnace. Therefore, the blower speed for the heat pump should be slower than the gas or oil furnace to prevent these cool air drafts.

Another frequent customer complaint is steam coming from the outside unit. After the defrost cycle, the heat pump will automatically return to the heating cycle. Then the melted water left from the defrost cycle blows off the outside coil and vaporizes, creating the steam effect.

A frequent problem encountered with heat pumps that the customer should be made aware of is a dirty air filter. A dirty air filter will restrict the amount of air flow through the inside coil, resulting in high system pressures. If the filter becomes clogged, it may cause the pressure cutoffs to operate. The pressure cutoffs are protective devices which shut down the system when the system pressures exceed a safe limit. Without such protective devices, you run the risk of damaging the compressor.

The pressure cutoffs may operate during the defrost cycle also. During the defrost cycle, the unit operates in the cooling function with the outside fan off. The system pressures will be abnormally high, and may trip the pressure cutoffs. This situation is usually caused by a defective or out-of-adjustment defrost thermostat or defrost switch. Any adjustment to the defrost controls should be done only according to the manufacturer's instructions.

The reversing valves mentioned earlier very rarely cause trouble. Most valves operate by an electromagnetic solenoid triggered by the heat/cool switch on the home thermostat. A defective reversing valve will cause difficulty switching from the heating cycle to the cooling cycle and vice versa. Most problems with reversing valves involve the solenoid coil. A simple ohmmeter check will determine if the coil is open or shorted.

An ohmmeter will not reveal a mechanical problem with a reversing valve. When the system switches from heating to cooling, you should hear a distinctive "click" from the reversing valve as it changes positions. If the valve appears to stick, or is sluggish, try reversing the valve with the outside coil air flow restricted to raise the system pressures. This will sometimes free the obstruction, and allow the reversing valve to operate.

Reversing valves may also develop internal leakage, which will reduce the system's capacity. Internal leakage can be checked by feeling for a temperature difference between the inlet pipes and the outlet pipes to the reversing valve.

Notice the check valves in the refrigerant lines in Figs. 1 and 2. They are used to prevent the refrigerant flow from going in the wrong direction. A defective check valve will show up on either, but not usually both, the heating or cooling cycles. A frozen check valve will restrict the refrigerant flow, and like the reversing valve, can sometimes be freed by reversing the system several times.

A final caution: Novice mechanics should not attempt to service heat pumps, which can be extremely dangerous electrically and mechanically.

A Simple & Accurate (!) Method of Calibrating Standard Frequency

Wendell P. Turner, Jr. W1NN

Today, nearly everyone who works in the field of electronics has need of an accurate standard frequency source to calibrate frequency counters and other equipment. In this article, Graduate Wendell Turner, Jr. shows you how a normal color television receiver can be used to set the time base of your frequency counter to a precise frequency that can be directly traceable to the National Bureau of Standards! The two NBS publications listed at the end of the article give you all the needed information. In addition, you can build the simple adapter yourself from directions in the NBS bulletin, or buy a commercially made adapter as indicated in the third reference at the conclusion of the article.

Every color TV set has a 3.58-MHz crystal oscillator which is phase-locked to the incoming color subcarrier frequency. If the color TV is receiving a program being sent out by one of the three major networks (CBS, ABC, or NBC), then the color subcarrier of each nerwork is controlled by an atomic oscillator to be exactly 3.5795454545. . . MHz with an accuracy continually monitored and published[1] by the National Bureau of Standards (NBS). Thus, *your* color TV can be used as a handy and highly accurate frequency standard. A free brochure[2] on how to use this frequency standard is available from NBS.

Briefly, you can quickly check the accuracy of your counter, or other standard crystal oscillator, as follows. You will need a color TV receiver, a stopwatch or other means of measuring seconds accurately, and a stable crystal oscillator (counter time-base, for example) at 10 MHz, 5 MHz, 2.5 MHz, 1 MHz, 0.5 MHz, or 0.25 MHz. The higher the frequency of the crystal oscillator, the more accurate your results will be. Finally, you will need a special color-bar comparator.

A schematic for home-brewing this special comparator is furnished in the NBS brochure[2], or one may be purchased ready made[3]. The comparator is essentially a frequency divider circuit which converts the local crystal oscillator signal to the color subcarrier frequency.

The whole setup is shown in Fig.1. The incoming signal from the major network (you cannot use local TV programming or advertising periods on network shows if you want NBS accuracy) is "locked" onto by the color phase detector in the TV, and the local subcarrier oscillator is exactly in step with the network subcarrier signal. The signal from your crystal oscillator is converted by the comparator circuit to the 3.58-MHz range. This latter signal is then fed into the chroma circuit of the color TV to beat with the signal from the network. The result is a vertical color bar on the TV screen. If the displayed color bar remains stationary, your reference oscillator is exactly on frequency. Normally, however, you will see a slowly changing bar pattern, from red to green to

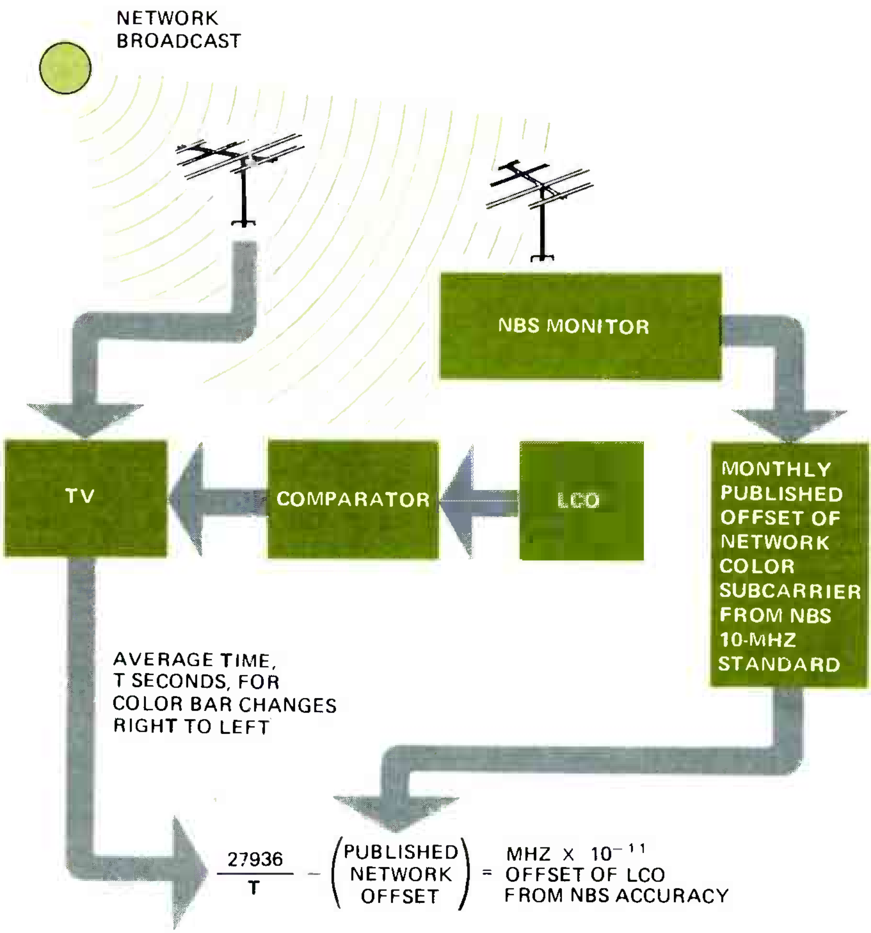


FIGURE 1. CONNECTIONS FOR PRECISE FREQUENCY CALIBRATION.

blue and back to red again. The speed with which this bar pattern changes is an indication of how far off your local oscillator is – rapid movement means way off frequency.

You should adjust the frequency of the local oscillator so that the colors appear to move as slowly as possible, *from right to left*. Then, using a stopwatch, measure the lowest convenient time of one complete change (red to green to blue to red, for example). Do this several times and take the average for the greatest accuracy. Now you can use the formula given in Fig.1, along with the published offset of the particular network being used to obtain the offset of your local oscillator with NBS accuracy.

As an example, I have a 10-MHz crystal oscillator standard which I hooked up as shown in Fig.1. I was able to adjust the frequency for an average time of 14 seconds for the color bar to change from green back to green (right to left!). I was tuned to an afternoon soap opera on CBS, for which the NBS published offset was -2999.2×10^{-11} MHz. Thus, the offset of my oscillator at that reading was:

$$\frac{27936}{14} - 2999.2 = -1003.8 \times 10^{-11} \text{ MHz}$$

In other words, my oscillator was actually operating at a frequency of:

$$10 - 0.000000010038 = 9.999999989962 \text{ MHz}$$

Editor's Note: For most of us, the accuracy represented by using a color TV receiver with the color-bar comparator as an indicator of zero beat for the time-base of our frequency counters would be more than sufficient! However, Wendell's method will surely give very accurate and precise calibration, if ever such a need might arise.

References:

1 NBS Time and Frequency Services Bulletin, published monthly, free. Available from NBS upon request to: Time and Frequency Services Section, National Bureau of Standards, Boulder, Colorado 80302.

2 "New Frequency Calibration Service," 32-page brochure on the color-bar method, free. Available from the same source as in Reference 1.

3 DYCO Model 176. Available from the Dynatron Company, Box 48822, Los Angeles, California 90048.

Job Ops

TECHNICIAN WANTED: Latour Radio and Television, located in Kapuskasing, Ontario, would like to hire a radio-TV technician. Good opportunity for overtime bonuses. Bilingual (English and French) desirable but not required. Must be a graduate of NRI or other accepted school. Send resume to J. P. Latour, Manager, 3 Queen Street, PO Box 356, Kapuskasing, Ontario, Canada P5N-1G5.

TECHNICIANS WANTED: Computer Service Representatives, experienced and trainees. Multiple openings in Washington, D.C. and a few in Europe. Current starting rate for trainees is $196 weekly. Trainee position qualifies for VA OJT benefits also. Apply: Staffing and Development, Box 500, Sperry Univac Federal Systems, 2121 Wisconsin Avenue, N.W., Washington, D.C. 20007. EEO-M/F/V/H.

Artificial Oil?

Ed Cochran

New synthetic engine oils are currently attracting attention. From recent advertisements, you can draw two conclusions. First, manufacturers claim the synthetic oils have miraculous properties. Second, synthetic oils are expensive. From my experience, most people are suspicious of the claims, and reluctant to pay the $3 to $4 a quart that the oil sells for.

One of the most authoritative articles that I have seen on synthetic oils appeared in the June 1977 issue of *Automotive Engineering*, a monthly publication of the Society of Automotive Engineers (SAE). The SAE is the engineering society for the transportation industry, and establishes most of the standards and recommended practices for materials and equipment for the automotive industry. The information presented here is based on the SAE article and an SAE paper presented by J.A.C. Krudish, H.V. Lowther, and B.J. Miller of the Mobile Oil Corporation.

The word "synthetic" comes from a Greek word that means "to put together." One of Webster's definitions of synthetic is "produced artificially or man-made." We shouldn't be too surprised to find synthetic engine oil because we are surrounded by synthetics. We have nylon and orlon to replace natural fibers such as cotton, silk, and wool. We even have synthetics to replace natural foods such as butter, lard, sugar, and orange juice. The list could go on and on. Synthetics are usually produced because they are better than the natural product, cheaper than the natural product, or both.

There are many synthesized materials that have properties that might make them usable as an engine lubricant. A partial list is shown in Table 1. This table shows that most materials have at least one negative characteristic. It would appear that the synthesized hydrocarbons have the best overall properties. Let's go over the listed properties one by one.

Viscosity-Temperature Properties. Viscosity is a measurement of the consistency of a liquid. Molasses has a high viscosity, particularly when cold. Water has a low viscosity. Most mineral engine oils (refined from petroleum) have a high viscosity when cold and a low viscosity when hot. The ideal engine oil would have the same viscosity at 0°F and 210°F. That is why we have grades such as SAE 10W-30 and SAE 10W-40. The oil has a viscosity of 10W at 0°F and 30 or 40 at 210°F, but is still thicker when it is cold than when it is hot.

Low-Temperature Fluidity, Low Pour Point. This is also a measurement of how well the oil will flow or pour when very cold. It is necessary that oil flow readily when starting a very cold engine.

High-Temperature Oxidation Resistance with Inhibitors Present. The engine oil in an operating engine can get very hot, as high as 325°F to 375°F. At these temperatures, engine oils oxidize or break down. Additives to inhibit oxidation are added to engine oils, but they are not completely effective with mineral oils.

Compatibility with Mineral Oils. Today, all new cars come from the factory with mineral engine oil in the crankcase. If the owner decides to switch to a synthetic oil, it is next to impossible to get all of the old mineral oil out of the engine. If the new synthetic oil will not mix with the mineral oil, or will react with it to form sludge or varnish, the new synthetic oil will do more harm than good. Also, there may come a time when the owner must add engine oil when a particular brand of synthetic oil is not available. For the time being, the synthetic oils must be compatible with mineral oils.

Low Volatility. Volatility is a measurement of how readily a liquid evaporates, especially when heated. When part of the engine oil evaporates during its service life, the remaining oil becomes thicker and loses some of its lubricating properties.

Effect on Most Paints and Finishes. It is obvious that any engine oil that would mar the car's finish, if the oil were accidently spilled on it, would be totally unacceptable to the motoring public.

Stability in Presence of Water. It is impossible to keep moisture out of the crankcase. The water can come from products of combustion, leakage from the cooling system, or condensation from atmospheric moisture. Any oil that will react with the moisture to form sludge or varnish is unacceptable.

Antirust Properties in Presence of Inhibitor. Rust inhibitors are added to engine oil to prevent or reduce the formation of rust from the moisture that gets in the crankcase. The engine oil must be compatible with the inhibitor.

Table I

Relative Performance of Synthetic Fluids and Mineral Oils

Courtesy Society of Automotive Engineers

Typical Properties	Typical Mineral Oil	Synthesized Hydrocarbons		Dibasic Acid Ester	Hindered Polyol Ester	Polyalkylene Glycol	Phosphate Esters	Silicone Fluid
		Olefin Oligomer	Alkylated Aromatic					
Viscosity-temperature properties	Fair	Good	Fair	Very Good	Good	Good	Poor	Excellent
Low-temperature fluidity, low pour point	Poor	Good	Good	Good	Good	Good	Fair	Good
High-temperature oxidation resistance with inhibitors present	Fair	Very Good	Fair	Very Good	Excellent	Poor	Fair	Good
Compatibility with mineral oils	–	Excellent	Excellent	Good	Fair	Poor	Fair	Poor
Low volatility	Fair	Excellent	Good	Excellent	Excellent	Good	Good	Good
Effect on most paints and finishes	None	None	None	Slight	Moderate	Moderate	Considerable	Slight
Stability in presence of water	Excellent	Excellent	Excellent	Fair	Fair	Good	Fair	Good
Antirust properties in presence of inhibitor	Excellent	Excellent	Excellent	Fair	Fair	Good	Fair	Good
Engine oil additive solubility	Excellent	Excellent	Excellent	Good	Fair	Fair	Good	Poor
Elastomer swelling tendency—buna rubber	Light	Nil	Light	Moderate	High	Light	High	Light

Engine Oil Additive Solubility. Engine oil must act as a solvent to dissolve the oxidation, corrosion, antirust, and other additives that are added to the oil to improve its operational characteristics.

Elastomer Swelling Tendency-Buna Rubber. Rubber in the presence of mineral oil deteriorates rapidly and cannot be used for seals and gaskets in an engine. In the place of rubber, a number of rubber-like synthetics, called elastomers, are used. One is neoprene. These elastomers are fairly stable in the presence of mineral oil, and a synthetic oil must be compatible with them also.

Looking at Table 1, you can see that the synthesized hydrocarbons have the widest range of performance features with the olefin oligomer having the slight edge. The olefin oligomer has better viscosity-temperature characteristics and is easier to inhibit against high-temperature oxidation than most of the other synthetics. It shows significantly better low-temperature viscosities than the alkylated aromatic, and also less increase in viscosity after oxidation at 325°F and 375°F with different inhibitors.

Commercial synthesized oils use an olefin oligomer/organic ester blend (Table 1, column 2 and column 4 or column 5) to take advantage of the best features of both types of material. The organic ester is added to the blend because it provides excellent engine cleanliness.

Table 2 shows the comparative performance of a number of viscosity grades of synthetic engine oils compared to a reference SE quality SAE 10W-40 mineral oil. You can see that the SAE 5W-20 synthetic oil has the greatest number of positive features. We will talk about these positive features using the SAE 5W-20 synthetic oil which we will call Syn. 1.

FUEL ECONOMY

You can look at Table 2 and see that the SAE 5W-20 synthetic oil has a considerable advantage in fuel economy over the higher numbered grades of mineral oils. Direct comparisons of over 600 test points shows an average 4.2 percent advantage in fuel economy for Syn. 1 over the reference mineral oils. These tests involved the same vehicles under the same conditions, with a variety of test cycles, speeds, and lubricants being studied.

Take, for example, a short trip of six miles, involving a cold (ambient) start, with 40 percent urban and 60 percent highway driving. *Syn. 1 would be expected to provide an average fuel economy improvement of over 5 percent.* What makes this important is that most passenger car trips are about this duration or less.

Of course, much of the fuel economy comes from the fact that Syn. 1 is a low viscosity product and thus has reduced friction losses. However, tests suggested that there were other considerations than just the lower viscosity that helped the improvement. The tests showed that even with mineral oils having the same viscosity, there was less viscous friction using Syn. 1, especially under high pressure. Syn. 1 has a lower coefficient of viscous friction than the equivalent mineral oil. This means the synthetic oil is slicker or more slippery than mineral oil of the same viscosity, and even more so when under high pressure.

OIL ECONOMY

A synthetic engine oil such as Syn. 1 must control oil economy as well if not better than the higher viscosity mineral oils if it is to be successful in the marketplace. Oil economy has long been recognized as a very difficult feature to

Table 2
Alternate Synthetic Engine Oil Viscosity Grades

Courtesy Society of Automotive Engineers

SAE Viscosity Grade	5W-20	5W-30	5W-50	10W-30	10W-40	10W-50	20W-50
Improved fuel economy	+++	++Est.	=	+	=	—Est.	—
Improved oil economy	+	++Est.	++	++	++Est.	++	+++
Easier cold starting	+++	++	++	+	+	+	—
Excellent hot performance	+++	+++	++	+++	++	++	+++
Cleaner engines	+	+	+	+	+	+	+
Cleaner intake valves	++	+	=	++	+	=	++
Reduced wear	+	+	+	+	+	+	+
Extended drain capability	+++	++	++	+++	++	++	++
Energy conservation	+++	++Est.	=	+	=	—Est.	—
Viscosity index improver	No	Yes	Yes	No	Yes	Yes	No

\+ Means synthesized oil gives better performance than **SE** quality **SAE 10W-40 mineral oil** (the greater the number of + signs, the greater the improvement in performance).

= Means synthesized oil gives equal performance to **SE** quality **SAE** 10W-40 mineral oil.

— Means synthesized oil is poorer than **SE** quality **SAE** 10W-40 mineral oil.

measure accurately because it varies widely with the type of operation and engine condition. Yet it is one of the few performance features of engine oil that is readily apparent to the motorist.

Low viscosity mineral oils such as an SAE 5W-20 have often given excessive oil consumption. For this reason, it was necessary to study the Syn. 1 product very carefully.

The oil economy data obtained was based on 130 American and European vehicles using Syn. 1 and 80 American and European vehicles using SE quality SAE 10W-40, 10W-50, and 15W-40 mineral oils. It was concluded that Syn. 1 would provide oil economy equal to a combination of the mineral oils.

It must be stressed that the engines using Syn. 1 must be in good mechanical condition. Those that are not, and particularly those having leaky seals or gaskets, will leak more Syn. 1 than oils with a higher viscosity.

ENERGY CONSERVATION

The characteristics of synthesized hydrocarbons make it possible to make low viscosity engine oils that provide better fuel mileage and equal oil consumption control as compared to the much higher viscosity mineral oils. The stability of the synthetic oils with the optimized additives make extended drain intervals possible.

It appears that widespread use of synthesized engine oils, taking full advantage of their capabilities, results in considerable national energy savings. This savings even takes the increased energy required to manufacture the synthesized materials into account.

It is calculated that the use of one barrel of a synthesized SAE 5W-20 engine lubricant, such as Syn. 1, would save about 6.6 equivalent barrels of crude oil. Of course, the saving due to the improvement in fuel mileage is the principal consideration, far overriding the small increase in process energy required to make the synthesized oils. The greater drain interval for Syn. 1 would result in even greater energy savings.

TEST PROCEDURES AND RESULTS

We don't have the space here to cover all of the tests and results that were used to compare Syn. 1 with SAE 10W-40 mineral oils. The tests are the result of the combined effort of SAE, American Petroleum Institute (API), and American Society for Testing and Materials (ASTM). The tests include laboratory tests and operating engine tests in the laboratory, on a dynamometer, and in the field.

One of the tests for SE quality oil is called the Oldsmobile Sequence IIIC test. In that test, the viscosity of the oil under test cannot increase over 400 percent at the end of 40 hours. The viscosity of Syn. 1 increased 33 percent after 40 hours and only 112 percent after 128 hours. This test uses a 425 CID engine operating under load with a coolant temperature of 245°F and an oil temperature of 300°F. With Syn. 1, it was difficult to reach 300°F, while with SAE 10W-40 oils, a heat exchanger had to be used to keep the temperature down to 300°F.

In another test, Syn. 1 was used in nine 455 CID Parkway Police fleet cars. These cars run at very high speeds and have been known to develop enough heat to melt battery cases. After 5000 miles, the Syn. 1 was drained from the cars and easily passed the IIIC requirements for *brand-new* SE quality oils. This showed excellent protection against oil viscosity thickening and engine cleanliness.

Syn. 1 was also evaluated in a one-year/100,000-mile test in Parkway Police cruisers. The cars started with 5000- or 10,000-mile oil-drain intervals. However, because of the excellent performance being obtained during the initial 40,000 miles, some units completed the final 60,000 miles without an oil change. Final inspection showed virtually equivalent cleanliness performance for Syn. 1 at 5000-, 10,000-, and 60,000-mile oil-drain intervals. It also demonstrated excellent rod bearing, cam lobe, and valve lifter wear reduction.

Some of the drivers who used Syn. 1 while it was being developed reported that they thought their cars ran better and had more snap. This was a "seat-of-the-pants" observation which was checked. A series of precisely timed part-throttle accelerations from 0 to 35 mph was conducted, with maximum speed after a specific time being recorded. Ten acceleration tests were run using both Syn. 1 and SAE 10W-40 SE mineral oil. Syn. 1 had a 3.6 percent advantage for cold starts and a 3.9 percent advantage under warmed-up conditions. The drivers impressions were real.

CONCLUSIONS

The conclusions drawn in the SAE article are that a synthetic SAE 5W-20 engine oil has shown the following advantages over the most popular types of mineral oil products:

- **Improved fuel economy.**
- **Normal or improved oil economy.**
- **Outstanding performance in extended drain laboratory testing.**
- **Outstanding performance in extended drain field testing.**
- **Improved energy conservation.**
- **Reduction in oil sump temperatures.**
- **Improved driving "peppiness."**
- **Excellent low-temperature starting capability.**
- **Excellent wear protection.**

SUMMARY

I think it has been documented that a synthetic SAE 5W-20 engine oil in a number of ways can be superior to higher viscosity SE quality mineral oils. But whether synthetic oil is superior for you depends in most part on your car, and the way you drive it. So before you run out and buy five quarts, let's do some figuring.

A 5 percent increase in fuel mileage is impressive. This is documented and not a gimmick or wild claim. Say you get 16 miles to the gallon and pay 65 cents for your unleaded gas. In 1000 miles you will use 62.5 gallons and pay $40.63 for it. A 5 percent savings would be $2.03. That's fine, and in 10,000 miles you will save $20.30.

Now, the true synthetic oils on the market cost about $3 a quart more than premium multi-grade mineral oils. If your car burns or leaks one quart every 1000 miles, you are going to pay $3 to save $2. If your oil consumption improves 50 percent to one quart every 1500 miles, you'll be breaking even and probably have a better-running car. Your car's engine has to be in *good* mechanical condition.

You won't have any trouble with a new-car warranty if the synthetic oil has an SE service classification and you change the oil at the interval recommended by the car manufacturer. Wait until the warranty runs out before you go on an extended drain interval.

One other thing – extended drain intervals can only be used with cars that are driven often and regularly, and on trips long enough to bring the engine up to full operating temperature. Contaminants such as unburned fuel and moisture will still collect in the crankcase and must be removed by heat or by changing the oil. Synthetic oil manufacturers are very careful about recommending extended oil change intervals.

Honors Program Awards

For outstanding grades throughout their NRI courses of study, these July and August graduates were given Certificates of Distinction with their NRI diplomas.

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Warner C. Williamson, Virginia Beach VA
David L. Willig, Goshen IN
John H. Wolf, Jr., Morgantown WV
Riley Wollen, Cedar Rapids NE

Ham News

Ted Beach K4MKX

As you can tell from the new look of the NRI Journal, there have been some changes made! We hope these changes will be for the better, and wish to extend a warm welcome to all our new readers.

I'll take just a few minutes this time to let our new readers know just what the "Ham News" column is and how they can join in the fun. Briefly, this column reports on items of interest to people who are radio amateurs (Hams) or who are interested in becoming a radio amateur. We started this column some years ago when NRI first offered the Amateur Radio Courses, to let our students and graduates know who and where the NRI amateurs are, and to pass on information of interest to amateurs.

We always welcome the opportunity of getting to know those of you who are Hams, and ask that you write to let us know who you are, what your call sign is, where you live, what class of amateur license you have, and what your interests are. If you're just interested in becoming a Ham, maybe you'll see the name of someone who lives near you here in these pages, and you can get together for an "eyeball" contact.

In addition, if you need help, we'll try to give it to you through this column. Please do not expect a personal reply, as there usually just isn't time enough to write each of you individually. However, we always like to hear from you and will do our best to help you out when we can.

One of the continuing items we have in this column is a running update of FCC Rules and Regulations as applied to Amateur Radio. This is the purpose of the boxed-in table which appears elsewhere in this column. For those of you who have received earlier *Journals* you will notice that there is a new addition this time. Once again, we do not yet have the latest printed copy of Part 97 from the Government Printing Office, so we have stayed with the paraphrased summaries of the changes.

	Rule Change	Date Effective
1	Conditional Class License eliminated. Novice power limit upped to 250 W.	June 25, 1976
2	Technicians given Novice privileges.	July 23, 1976
3	No new distinctive Novice call signs, although Novices may sign "/N."	October 1, 1976
4	No requirement to sign "portable" or "mobile" except foreign operators using reciprocal licenses.	November 26, 1976
5	First "comprehensive" cw exam given in Washington, D.C. office. No solid copy for one minute requirement.	January 1, 1977
6	Court case "temporarily" suspends all license fees.	January 1, 1977
7	New "interim" licenses issued upon upgrade of license class at an FCC office.	March 1, 1977
8	Secondary station licenses eliminated.	March 3, 1977
9	97.95(a)(2) deleted. No notification of new address required.	March 9, 1977
10	New emission purity standards. All spurious emissions down 40 db for transmitters operating below 30 MHz, down 60 db for transmitters of 25 watts or more operating between 30 MHz and 235 MHz (97.73).	April 15, 1977
11	Code sending test deleted from Commission-administered examinations.	August 26, 1977
12	97.95(b)(2) rescinded. Maritime Mobile in Region 2 may use all amateur frequencies. In foreign waters may use only frequencies authorized by regional government.	September 12, 1977

The newest item is that taking a Morse code sending test will no longer be required on all examinations taken at an FCC office. Now, only the Novice examination requires a sending test. This rule was put into effect so that the code test can now be administered by untrained personnel in the various Field Offices, making the administration of Amateur exams a strictly clerical job. This should save the Commission quite a bit of time and money in giving the exams, and for the applicant, it is one less thing to "sweat out" in the exam room. A change for the better as far as I'm concerned.

Two or three people wrote and called asking for more information on the improved antenna tuner developed by Joe, K5DQT, so thought I'd devote a little space to describing the tuner here since we do not have too many other respondents this time (summer is a slow time of year!).

For those of you who missed out on my original antenna tuner article, I will say that it was a simple, multi-band tuner that did not use switches or rotary inductors. It matches the output of most low-power CW and SSB rigs into just about any type of load – balanced or unbalanced. Its one slight shortcoming was that it would not handle more than about 200 watts, and the amount of coupling (loading range) was somewhat limited.

The unit designed by K5DQT is shown in Fig.1. This one has only unbalanced input and output, but is usable at full legal power, and offers an adequate loading range.

L1 and L2 are wound end-to-end on a

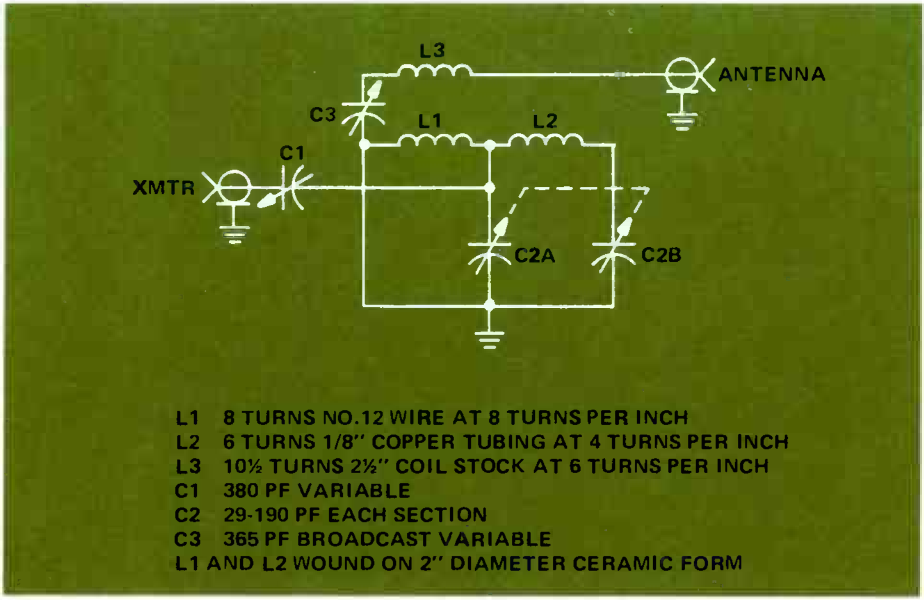

FIGURE 1. REVISED ANTENNA TUNER DIAGRAM.

2″ diameter ceramic form, and L3 is mostly over L1, so the left ends of L1 and L3 are even. C1 and C2 should have at least 0.050″ spacing (0.090″ is better). C3 is a low-voltage capacitor such as is used in a tube-type broadcast radio.

Joe says his linear operates a pair of 4-572B tubes running at 2500 volts on the plates. Under these conditions, he has been able to hold a perfect match from 3.5 MHz to 29.7 MHz without any sign of arcing in the tuner. Sounds real good. As soon as I can locate a suitable form, I'll have to build one up and give it a try (even though I'm still running the Hallicrafters barefoot).

You will need an SWR bridge in the line between the tuner and the transmitter. Always start with C2 fully meshed, C1 about half meshed, and C3 fully unmeshed. Tune the final so that you have the amplifier tank at resonance but do not try to fully load it yet. Adjust C1 and C2 for minimum reflected power onn the SWR bridge. Then you can use C3 to match to the load (antenna) as you increase the loading on the amplifier to its rated output.

You will probably have to "retweak" C1 and C2 in the process as all capacitors interact to a certain extent. The "best" settings for C1 and C2 are such that you have the most possible capacitance in the circuit for a given output. This will assure least harmonic radiation, and will help to keep you from tuning the unit up on a harmonic rather than the fundamental – a real bad scene, sure to get a QSL card from the FCC!

Anyway, the tuner looks like it will do the job, so now you guys and gals can start rummaging through the old junk box for some of those old capacitors you stashed away last year! We would like to hear from any of you who do build the tuner, and we'll pass along your comments here in these pages.

Jim	WD4EFS	–	Athens AL
Mike	WA7ZPQ	–	Miles City MT
Arnold	WD8AKU/DT	G	Newberry MI
Scottie	WD9GGR	–	Williamsville IL
Aaro	K1JPA	N	Wallingford CT
Harry	WA3VRF	–	Bradford PA
Ed	WD4GOY	G*	Norfolk VA
Dorsey	WD4ONR/WN	T*	Alexandria VA
Larry	K7VAS	–	Yakima WA

*Just upgraded—Congratulations!

Now, let's take a look at the rather meager list of people we have heard from since last time. As usual, those listed first are students and graduates of our Amateur courses, and those listed last are students and graduates of other NRI courses.

Jim, WD4EFS, sent us some swell color snapshots of his shack and a real fine-looking beam and vertical antenna system atop a huge tower. Unfortunately, by the time the pictures and Jim's envelope reached my desk, the letter or note that must have accompanied them had disappeared! Anyway, from the pictures, Jim is using the Conar twins, a Lafayette receiver, and a Johnson Challenger in the shack. He also has an electronic keyer, a wall covered with Callbook World Maps, and a nice 24-hour clock. Looks like an ideal setup, Jim. I sure would be interested in getting a rundown on that stack of antennas you have.

Mike, WA7ZPQ, sent a simple post-card (all we really need!) to let us know his call. He says that a lot of people don't believe that there are any amateurs in Montana, but he is living proof. Fine, Mike. Next time, give us a little more about your rigs and antenna setup.

WD8AKU finished up his course in June and went down to take his General test early in July. The FCC gave him a nice graduation present – his new call as a General. Arnold is retired at the tender age of 62, and says that Ham radio is a very worthwhile and rewarding pastime for him. Arnold uses a Swan 350 with a dipole, so listen around for him, gang.

K1JPA got his Novice ticket back in August, after having held the same call some years earlier (Technician). Aaro says he is working like mad on the code so that he can get back real soon to take the General test.

Harry, WA3VRF, says he has been reading the "Ham News" column for some time now, and has just gotten around to writing in. He is a retired policeman, and took up amateur radio as a hobby. This created an interest in electronics in general and encouraged him to enroll in our Color TV course. He is now about two-thirds through. Fine business, Harry. Do let us know when you take the step up to Advanced.

WD4GOY started out the other way. Ed enrolled first in the Color TV course, then after seeing the goings on in the "Ham News" column decided he would try it. Ed passed the Novice test with no sweat, and then in May participated in a group testing at the Roanoke ARRL Hamfest and got his General ticket. Ed says "The technical aspects came easy and I attribute NRI to a lot of that! Thank you." And we thank *you*, Ed.

We had a nice eyeball QSO with Dorsey, WA4ONR, the other day. He had called from Alexandria and talked with me about some antenna problems he was having. When he dropped in to the office, he indicated that he had cured his problems. Seems like the air pollution in the D.C. area was lousing up the loading coil of his vertical! Ever hear of anything like that?

K7VAS wrote us a nice long letter about his entry into amateur radio and just how much he enjoys it. Larry was first interested way back in 1934, but it wasn't until around 1962 that he "knuckled down" to learn the Morse code and get his ticket. Now he is retired, but is keeping busy as SEC for the Washington Section of the ARRL, and studying the new advances that have been taking place in the field of electronics in recent years.

Finally, we received a brief note from WB3HDJ, Brother Nicholas, enclosing a clipping from a newspaper. The article told of the extraordinary involvement of the amateurs in the Johnstown area during and after the flood they experienced this summer. Brother Nicholas was proud to have been one of those participating, and says he only wished he had his General ticket so he could have helped out with some of the long-distance communications on the lower bands.

During the flood, all usual communications were out, and the amateurs provided the only outside link to Johnstown. In addition, since there was no electric power, the 2-meter mobile rigs provided much needed communications for the police and rescue squads in the city. There were even several amateurs from the D.C. area who went up to help out. A job well done by all involved.

And there we have it for this time. Do write and let us know what you're doing, who you are, and what sort of rig you are using. Don't forget to send us the class of your amateur license as well. My Callbook is too old to be of much use looking up these new WD-type calls!

See you next year – until then, very 73 from TED – K4MKX

•••• • •—•• •——• *(Help!)*

Roland LaCroix, one of our graduates, is looking for a good, used Ham Receiver. Roland is disabled and housebound, and would appreciate corresponding with NRI Amateurs. If you can help him out, please drop a note to: Box 342

Lakeville, Connecticut 06039

Alumni News

Harry Taylor

The smiling face in the box at the right is that of Harry Taylor, new Executive Secretary of the NRI Alumni Association. Harry is a longtime NRI all-around (air conditioning, electrical appliances, electronics, automotive) writer, editor, and project leader. He has been chosen to replace Tom Nolan, who will be retiring this autumn after nearly ten years as Executive Secretary.

SPRINGFIELD CHAPTER STARTS FALL SESSIONS

After a summer recess, the regular monthly meeting of the Springfield Chapter of the NRI Alumni Association was held at the shop of Chairman Norman Charest September 10. Preston Atwood substituted as secretary for John Park who is touring in Japan. John is expected to entertain the Chapter with stories and pictures of his trip at a future meeting.

Chairman Charest commented on the wonderful time that the members and their wives had at the annual picnic. He also said that he was looking forward to another good time next year.

Plans for the coming year include a detailed study of color television, according to Chairman Charest. They will use the Chapter's Zenith color TV for demonstration/work sessions.

Robert Wiley of Belchertown, Massachusetts and Paul Christian of Amherst, Massachusetts were both welcomed as visitors. The Chapter hopes to enroll them as members soon. Both are students of the NRI Color TV Repair Course.

There was a short discussion of power cord troubles and the dangers involved in homes with older types of electrical wiring.

For the work session, Jack Vaida brought in an inoperative Silvertone black-and-white television set. The set had a raster, but no sound or picture. The Chapter found two defective tubes in the video i-f section. After replacing these tubes, the set worked fine.

Next, Norman demonstrated the proper method of adjusting the vertical linearity and height using a B&K analyst with a standard test pattern.

The meeting adjourned with the usual coffee and donuts and a social hour.

SAN ANTONIO CHAPTER WELCOMES NEW MEMBER

At the August 25 meeting, the Chapter welcomed a new member, Ben Starnes. Ben is very interested in the field of television servicing and took an active role in the meeting.

The highlight of the program was troubleshooting a couple of television "tough dogs." The first one turned out to be a bad vertical output tube socket. The other appeared to be a classical open vertical output tube cathode circuit, but wasn't. It was not readily discernable what it really was. As usual, Sam Dentler offered some good theories to follow up.

Mr. Hughes brought in some pictures of the party given for outgoing NRIAA Executive Secretary Tom Nolan and his wife Janet during their recent visit.

The meeting closed, as usual, with refreshments.

PITTSBURGH CHAPTER REPAIRS TAPE UNITS

At the September 1 meeting, a Craig tape recorder was brought in for repair. The unit would not change from one track to another. The service literature available on the unit was not the best.

DIRECTORY OF ALUMNI CHAPTERS

DETROIT CHAPTER meets at 8 p.m. on the second Friday of each month at St. Andrews Hall, 431 E. Congress Street, Detroit. Chairman: James Kelley, 1140 Livernois, Detroit, Michigan. 841-4972.

FLINT (SAGINAW VALLEY) CHAPTER meets 7:30 p.m., the second Wednesday of each month at Andy's Radio and TV Shop, G-5507 S. Saginaw Road, Flint, Michigan. Chairman: Roger D. Donaven.

NEW YORK CITY CHAPTER meets at 8:30 p.m., first Thursday of each month, at 1669 45th Street, Brooklyn, N.Y. Chairman: Sam Antman, 1669 45th Street, Brooklyn, New York.

NORTH JERSEY CHAPTER meets at 8 p.m. on the second Friday of each month at the Players Club, located on Washington Square in Kearny, New Jersey. Chairman: Al Mould. Telephone 991-9299 or 384-8112.

PHILADELPHIA-CAMDEN CHAPTER meets on the fourth Monday of each month at 8 p.m. at the home of Chairman Boyd A. Bingaman, 426 Crotzer Avenue, Folcroft, Pa. Telephone LU 3-7165.

PITTSBURGH CHAPTER meets at 8 p.m. on the first Thursday of each month in the basement of the U.P. Church of Verona, Pa., corner of South Avenue and Second Street. Chairman: James Wheeler.

SAN ANTONIO (ALAMO) CHAPTER meets at 7 p.m., fourth Thursday of each month, at the Alamo Heights Christian Church Scout House, 350 Primose St., 6500 block of N. New Braunfels St. (three blocks north of Austin Hwy.), San Antonio. Chairman: Robert Bonge, 222 Amador Lane, San Antonio. 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 at 8 p.m. on the last Wednesday of each month at the home of Chairman Daniel DeJesus, 12 Brookview Street, Fairhaven, Mass. 02719.

SPRINGFIELD (MASS.) CHAPTER meets at 7:30 p.m. on the second Saturday of each month at the shop of Norman Charest, 74 Redfern Drive, Springfield, Mass. 01109. Telephone (413) 734-2609. Chairman: Preston Atwood.

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

However, the Chapter solved the problem by obtaining and installing a new solenoid in the unit.

July and August meetings were held. These were basically social gatherings, as no technical programs were given. The Chapter is planning technical training sessions during the next couple of months to instruct and help the younger Chapter members.

FLINT/SAGINAW VALLEY CHAPTER CONTINUES SUMMER PROGRAM

Andy Jobbagy demonstrated an old Bell telephone lightning arrester at the July 6 meeting. This is a very simple device, consisting of a carbon block sandwiched between a porcelain plate and a copper plate. The copper plate is in turn connected to a good ground.

After the meeting, the CB store next door to the meeting place opened to enable everyone to look over the stock of CB equipment.

At the July 20 meeting, Dale Keys went through the procedure for troubleshooting a deflection yoke. As part of the summer training, a quick but effective checking method was explained.

Next, the Chapter used a Zenith black-and-white television set for a servicing demonstration. This receiver had no horizontal sync. Dale Keys and Jerry Lev located and corrected the problem. Andy hinted where to look and how to remedy the problem. Replacing the afc diodes and a 470-pf capacitor and two 0.001-μf capacitors in the afc circuit corrected the trouble.

Andy demonstrated how to repair the ferrite core of a horizontal output/high-voltage transformer. By using a magnetic cement made by General Cement Company, it was possible to repair the core. It works as well as a new core. The members were cautioned to replace the tape spacer between the two sections of the core. This tape spacer actually tunes the resonant frequency of the transformer.

At the August 31 meeting, two subjects were covered: checking transistors and analyzing various television antenna splitters. This ended the summer meetings. All newcomers to the Chapter enjoyed the programs very much.

ANDY JOBBAGY AND DALE KEYS WORK ON A HIGH-VOLTAGE TRANSFORMER AT THE AUGUST MEETING.

NRI Journal
November/December

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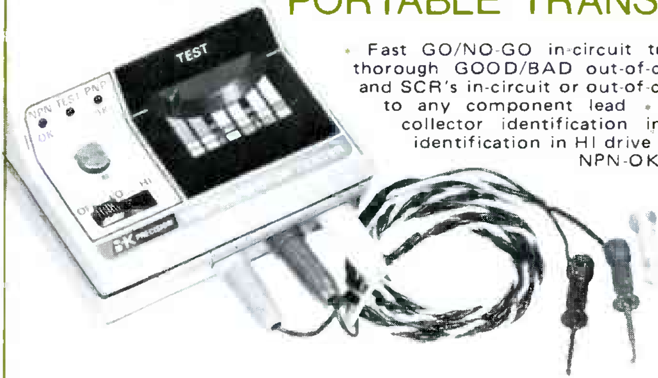

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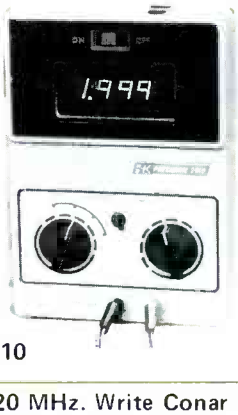

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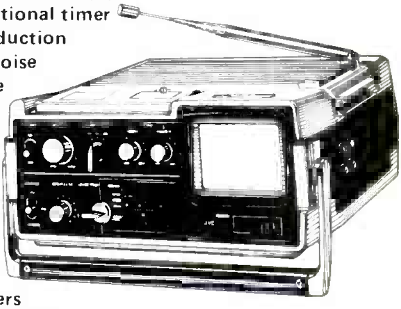

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