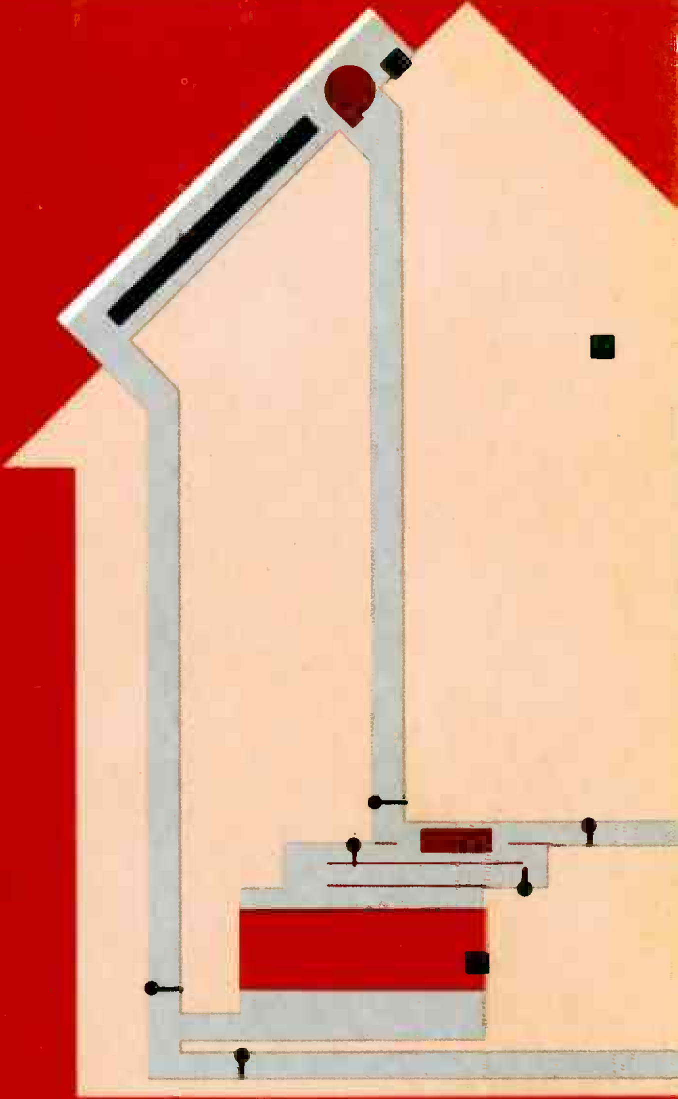
# HEAT PUMP/SOLAR HEATING



- Heat-Pump-Assisted Solar Heating
- Grounds and Grounding
- Update: Automotive Mechanic Certification
- Diagnosing Sealed Refrigeration Systems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In this issue, we kick off the new year with articles on the principles of grounds and grounding, the applications of heat pumps in the booming field of solar heating, the status of the automotive mechanic certification program, and ways of diagnosing ills in a sealed refrigeration system.

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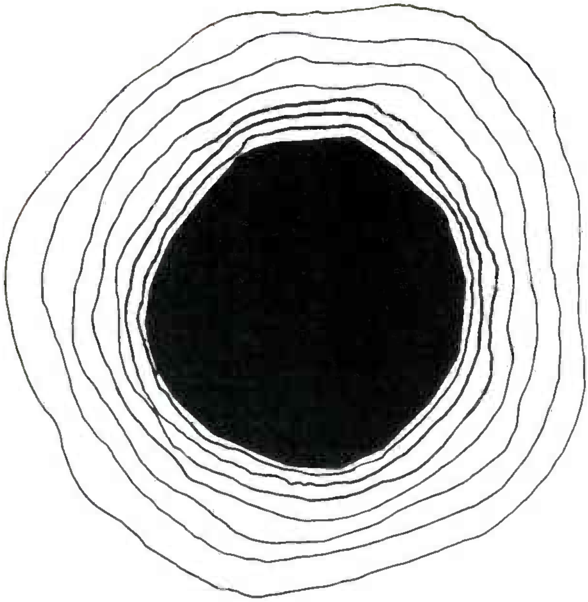

# Heat-Pump-Assisted Solar Heating

Dave Dasenbrock

The age of solar heating is here. Although still in its infancy, enough is already known about solar heating that it can effectively and efficiently be put to use.

When huge companies like Alcoa, General Electric, Exxon, Lennox, and General Motors begin investing in solar research and technology, you know that they see an opportunity for growth in that field. The opportunities are also there for those who install and service solar systems.

The United States currently uses approximately 35 percent of the world's energy. Over the next quarter century, this energy use will decline by about 10 percent. The decline will not occur because we are using less energy, but because the other nations of the world are using more. The United States is still not energy self-sufficient.

The oil embargo in 1973 brought home the fact that the United States already relies heavily on imported oil. Our use of imported oil since 1973 has risen, not declined, and any future embargo would have even more severe effects on our life-style.

Due to the limited supply of natural gas, gas furnaces cannot be installed in new homes in many areas of the country. The alternative heating system has been the electric heat pump. However, in most areas the cost per Btu of heat for operating a central heat-pump system still exceeds the cost for operating an equivalent natural gas furnace. Both systems still rely on our nation's dwindling supply of natural resources.

Solar heating can be used effectively in many areas of the United States. It has a marked advantage over fossil fuel systems. No foreign nation can come and shut off the rays of sunlight as they can turn off the valve in an oil pipeline. The sun will not run out of energy for at least another billion years.

Of course, solar heating also has disadvantages. Only in rare cases is it economical to construct a solar heating system capable of carrying the entire heating load because of the heat-storage capacity needed for periods of sunless weather. However, 50 to 90 percent of the heating needs of a dwelling can be supplied by the sun, depending upon environmental conditions. Thus, to be cost-effective, solar heating systems almost always require assistance in meeting the heating load. Heat pumps have become very popular for this purpose.

A typical solar heating system which uses air as the heat transfer medium is shown in Fig.1. The basic solar heating system consists of three main parts: the collector, the heat storage area, and the distribution system. Two fans are shown in Fig.1 (primarily for ease of explanation), although often only one fan is used. You will see how the single-fan system works later.

The purpose of the collector is to convert the sun's rays (radiant energy) into heat (thermal energy). The principal parts of the collector are the cover sheet, the absorber, and the insulating material.

The cover sheet is made of a clear or sometimes translucent material, usually glass or plastic, which allows the sun's rays to pass through. The cover sheet creates a "greenhouse effect" beneath it, and reduces the heat loss from the absorber due to wind cooling. The sun's rays fall on the absorber, which is usually made of a sheet metal such as copper, aluminum, or steel, and is painted black. The back of the collector is insulated to prevent heat loss. The collector can be mounted directly on a gabled roof, and should be directed toward the south for maximum efficiency.

Heat obtained by the collector is either used to heat the dwelling or is stored for future use. The most commonly used storage materials are water and rock. The storage area is usually an insulated area in a basement or under ground. If rocks are used as the storage medium, they are from 1 to 5 inches in diameter. The smaller the rocks, the more fan power is needed to force the air through them. If water is used in a forced-air system, it is usually stored in plastic or metal cans on shelves in the storage area. Canned water is commercially available for this purpose. For the "do-it-yourselfer," empty plastic milk bottles make ideal storage containers, especially the one-gallon size. The space between the containers allows free air circulation around them.

The heat is distributed through ducts in the same manner as in a central-heating or air-conditioning system. There are three modes of operation for this type of system. In Fig.1, heat from the solar collector is being used to heat the dwelling. When fan 1 is on, damper 1 is in position A. Damper 2 is in position B. Heat from the solar collector is blown directly into the dwelling. The

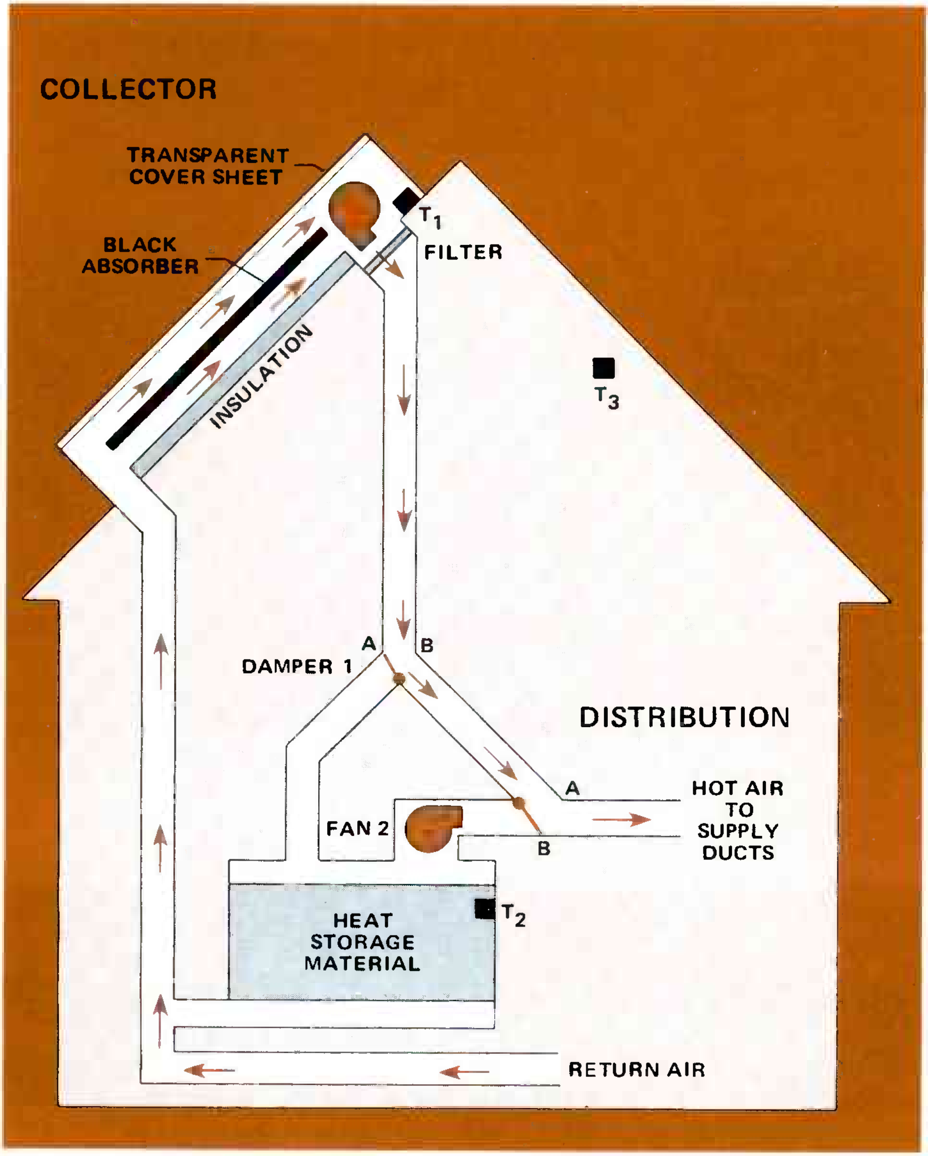


FIGURE 1. HEATING DIRECTLY FROM THE COLLECTOR.

return air flows directly back to the bottom of the collector. The system operates in this mode when the temperature of the collector is higher than the temperature in the dwelling and the dwelling temperature is below the thermostat setting.

Figure 2 shows what happens when the temperature within the dwelling reaches the thermostat setting. As with conventional central heat, no heat flows into the dwelling. In a solar system, however, if the temperature of the collector is higher than the heat storage

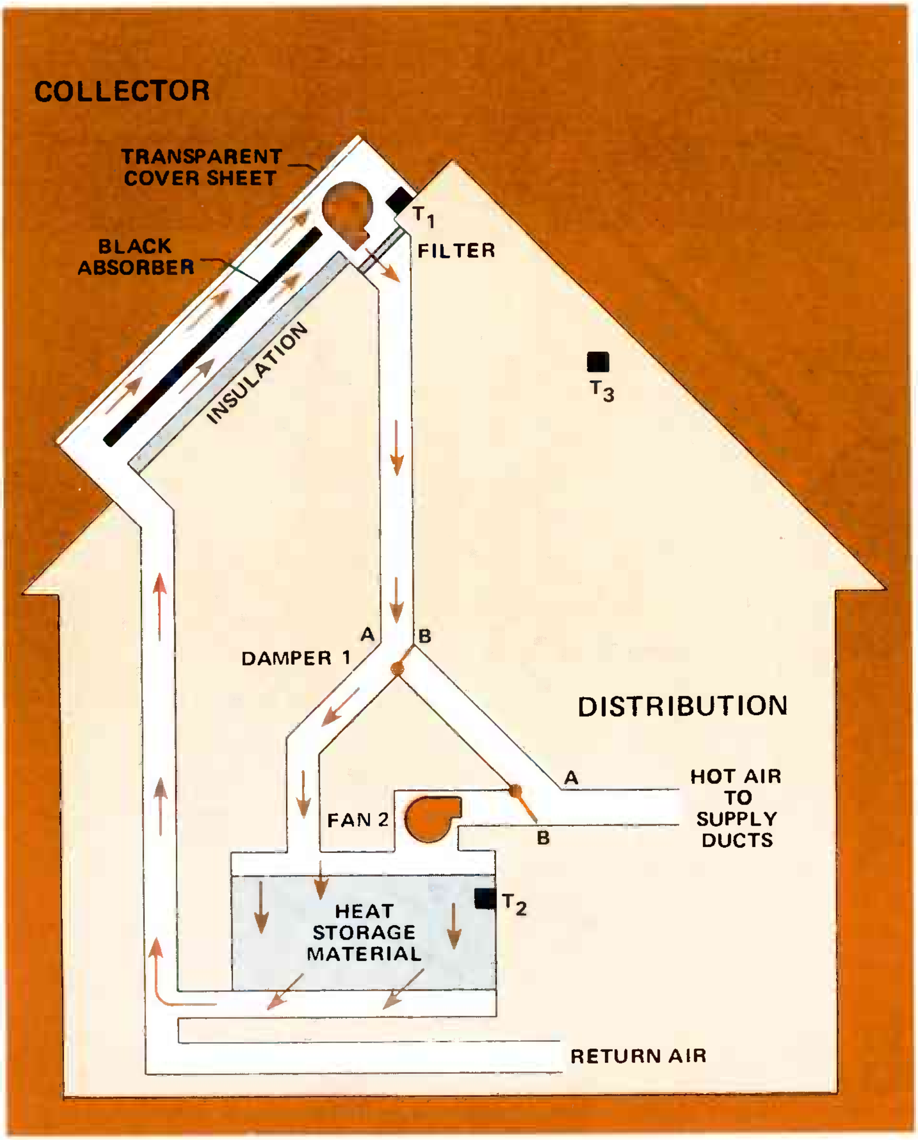


FIGURE 2. STORING HEAT FROM THE COLLECTOR.

material, fan 1 continues to operate. Damper 1 moves to position B, and the hot air from the collector is blown down through the storage material and then back up to the collector. Fan 1 will continue to run until the temperature of the collector is no longer higher than the temperature of the storage material.

Of course, at night or during periods of cloudiness, the temperature of the collector will be below the temperature of the storage material and the dwelling.

Under such conditions, providing that the temperature of the storage material is higher than the dwelling, heat will be taken from the storage material to heat the dwelling, as shown in Fig.3. When heat is taken from storage, damper 1 and damper 2 are in position A, and fan 2 operates.

On extremely cold days, a solar heating system may not be able to keep pace with the heating demands of the dwelling. This may also be true during

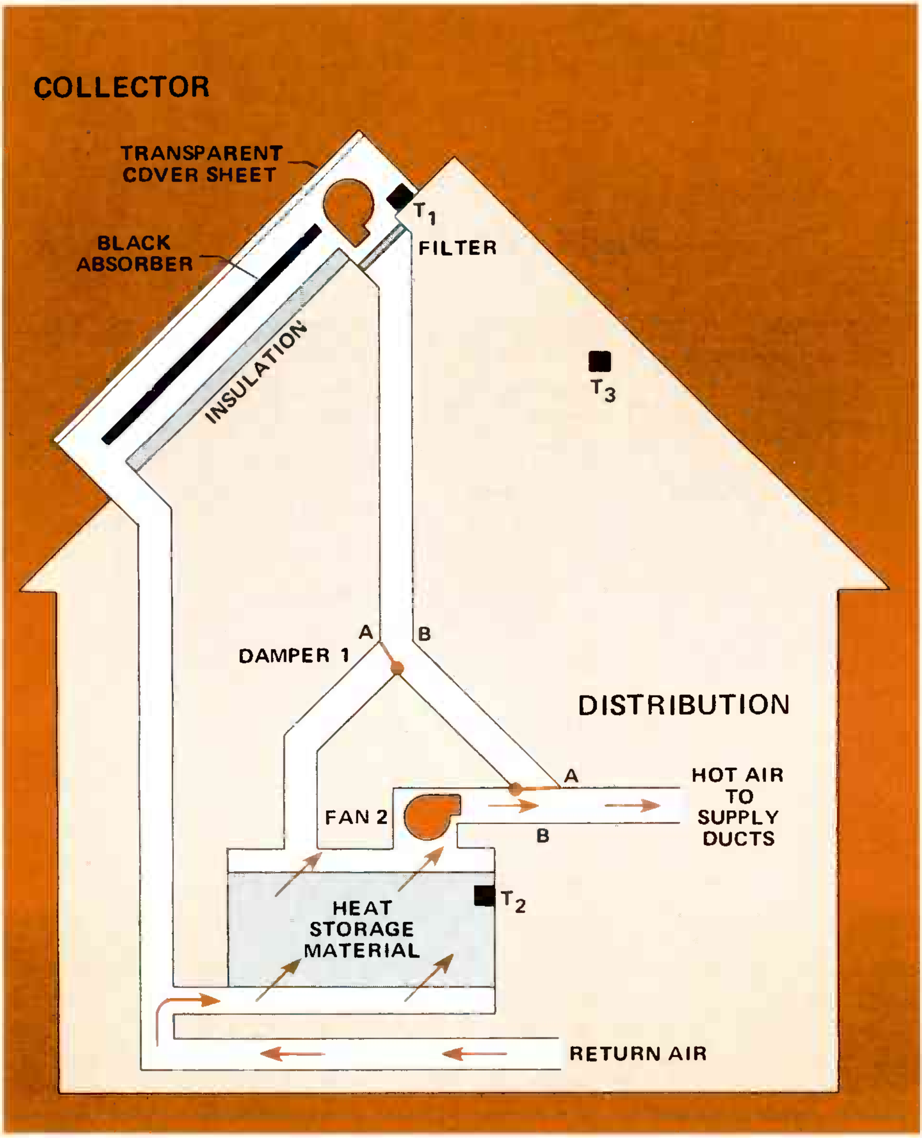


FIGURE 3. HEATING FROM THE STORAGE.

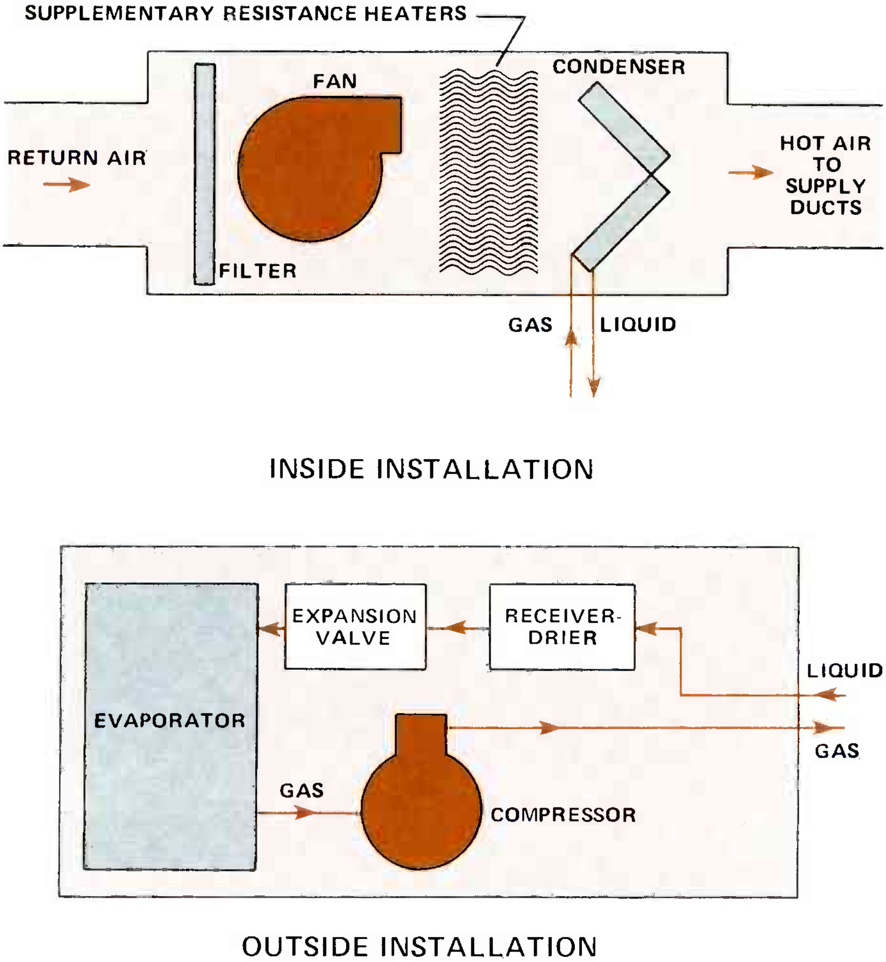


FIGURE 4. A DIAGRAM OF A CENTRAL HEAT PUMP.

periods of prolonged cloudiness, although heat can be drawn from the storage material until it reaches about 80°F. Most solar systems require some sort of assistance to carry the heating load under such conditions.

In the heat-pump-assisted system, the ductwork is modified so that the fan in the central unit can also be used for the solar system. A diagram of a typical heat pump is shown in Fig.4.

During the heating cycle, hot refrigerant gas is pumped to the condenser, where it changes from a gas to a liquid. In the change-of-state process, it gives up heat to the condenser. Air is warmed when it flows past the condenser coils. The liquid refrigerant then flows to the evaporator, which is located outside of the dwelling. The liquid sprays through the expansion valve, changing into a gas and absorbing heat from the outside air as it does so. The compressor pumps the gas back to the condenser. In the process, the compression action also adds heat to the gas. If the outside air is too cold for the heat pump to work efficiently, the supplementary resistance heaters are placed in service.

Figure 5 shows a single-fan hot-air solar system. A rather complex system of automatic-damper control is used.

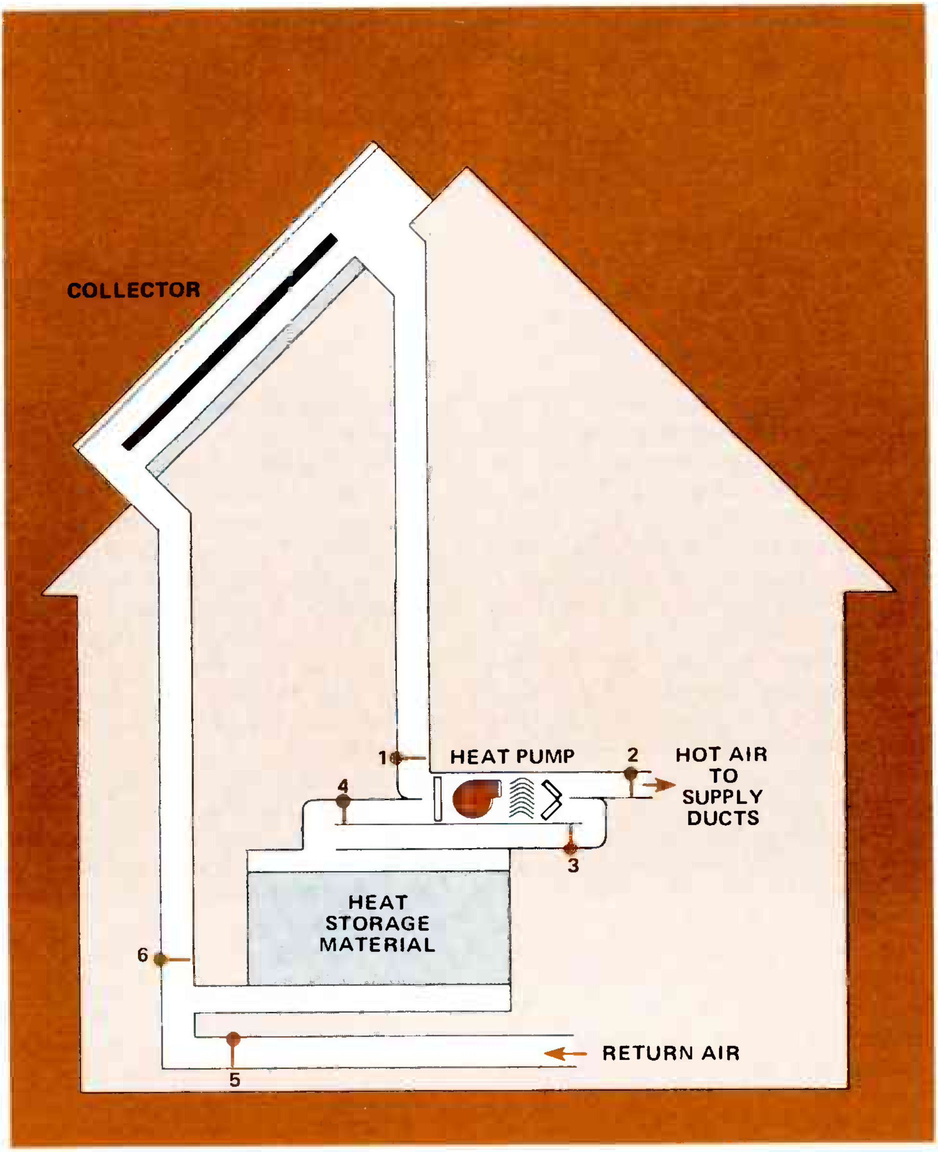


FIGURE 5. A HEAT-PUMP-ASSISTED SOLAR SYSTEM.

Table 1

| Operation | Damper Number 1 | 2 | 3 | 4 | 5 | 6 | Heat Pump |
|---|---|---|---|---|---|---|---|
| Solar heating from collector | Open | Open | Closed | Closed | Open | Open | Off |
| Solar storage | Open | Closed | Open | Closed | Closed | Open | Off |
| Heating from storage | Closed | Open | Closed | Open | Open | Closed | Off |
| Heat-pump assistance | Closed | Open | Closed | Open | Open | Closed | On |

□ Open ■ Closed

Table 1 shows the position of the dampers during operation. When the dwelling is heated directly from the solar collector, dampers 1, 2, 5, and 6 are open. Dampers 3 and 4 are closed. The fan circulates the air directly from the solar collector through the ductwork. The air is returned to the bottom of the solar collector.

When heat from the collector is put in heat storage, dampers 1, 3, and 6 are open, while the others are closed. Hot air is drawn down from the collector and forced through the heat storage medium. Since damper 5 is closed, air is prevented from flowing into the return air duct and flows back up to the collector.

Heat is taken from storage when the collector temperature is not sufficient to heat the dwelling. In this case, dampers 2, 4, and 5 are open. The others are closed. Air is drawn up through the rock or water containers, absorbing heat as it moves past them. The heated air is forced into the supply ducts. The return air enters the bottom of the heat storage area.

The dampers are automatically controlled from a master panel. The control system includes a differential thermostat which determines the temperature differences between the collector, the storage area, and the dwelling. The control system determines which mode of operation to use. It also determines when the heat storage is insufficient to heat the dwelling, and switches on the heat pump. Under such conditions, the system operates as a normal heat-pump central system.

Depending upon the climate, a solar system of this type may be able to carry half of the heating load, thus reducing the energy consumption of the heat pump by 50 percent. In any solar air system, keeping the air filter clean is a must, especially if rock is used as the storage area. If dust and dirt settle on the rocks, the passages between them would soon clog and no air could flow through the storage medium. The system would then become useless.

**Note:** The method explained here is only one way in which the solar system and heat pump are used together.

STATEMENT OF OWNERSHIP, MANAGEMENT AND CIRCULATION
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# Grounds & Grounding

Bill Dunn

In any unit of electronic equipment, ground is simply the point of zero potential. Potential is just another word for voltage – they both mean the same thing.

The term "ground" derives from the early days of radio. In the early radio receivers, it was customary to connect zero voltage points in the receiver circuits to the chassis. The tubes used in the earlier radios did not provide nearly as much gain as our modern tubes or transistors. Therefore, to improve reception and make sure that the chassis did not change in potential, a wire was run from the chassis to a metal rod driven into the earth. Thus, the name "ground" originated from earth ground.

Later, as better tubes with a higher gain were developed, the ground was no longer needed for reception. It was also found that the precautionary step of connecting the chassis to earth ground was seldom necessary. The metal chassis showed no tendency of changing in potential when the receiver circuits were connected to it. For these reasons, the connection to earth ground was omitted. However, the name "ground" was still used whether the chassis was actually connected to the earth or not.

When transformerless sets came along, the practice of making connections to the chassis was no longer advisable. In fact, it was downright dangerous. Before we discuss why it is dangerous to connect a ground to a transformerless receiver, let's stop for a moment to look at a phrase you will frequently encounter in any discussion of electronic circuits. The phrase is "with respect to." What we mean by this term is that we are making a comparison.

When we say that "the grid is negative with respect to the cathode," we mean that the voltage at the grid of the tube is negative in polarity when we compare it with the voltage at the cathode. Similarly, when we say that "the base of an npn transistor is positive with respect to the emitter," we mean that the voltage at the base is positive in polarity when we compare it with the voltage at the emitter.

If we say that "terminal A is positive with respect to terminal B," we mean that the voltage at terminal A is positive in polarity when we compare it with the voltage at terminal B. The phrase "with respect to" points out the particular point in the circuit that we are using as a reference point for our comparison.

Now let's look at some typical power supplies using a power transformer. Figure 1 is a schematic diagram of a typical full-wave rectifier power supply that was used for many years in radio and television until the advent of solid-state rectifiers.

The first thing to notice in this power supply is that the power transformer completely isolates the primary and secondary circuits. In other words, there is no direct connection between the secondary winding on a power transformer and the primary winding.

Notice the ground symbols in the schematic diagram. These represent connections to the chassis. During operation, when the end of the power transformer winding that connects to plate 1 of V1 is positive, electrons will

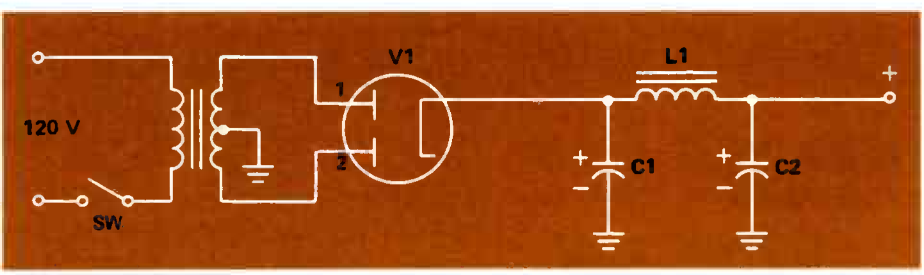



FIGURE 1. FULL-WAVE RECTIFIER.

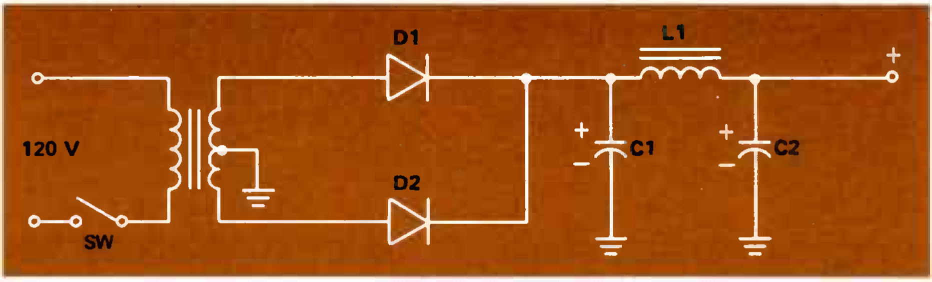



FIGURE 2. DIODE FULL-WAVE RECTIFIER.

flow from the center tap of the transformer to ground through the load (which would be the other tubes in the receiver), to the positive terminal of the power supply, through L1 to the cathode of the tube, through the tube to plate 1, then through the transformer winding, and back to the grounded center tap.

When the polarity of the power line reverses so that the end of the transformer winding connected to plate 2 becomes positive, electrons will flow from the center tap to ground, through the various tubes in the receiver, and back to the positive terminal of the power supply. The electrons will then flow through L1 to the cathode, and through the tube to plate 2, and then through the lower half of the transformer secondary winding to ground.

The rectifier circuit is called a full-wave rectifier because current flows on each half of the ac cycle, flowing to plate 1 during one half-cycle and plate 2 during the other. Capacitors C1 and C2 are the filter capacitors, and are used along with L1 to filter or smooth the pulsating current flowing through V1, so that we have pure dc to operate the tubes.

When solid-state rectifiers were first introduced, diodes D1 and D2 simply replaced the vacuum tube, as shown in Fig.2. Other than this change, the two circuits are identical. The first solid-state diodes widely used in radio and TV receivers were selenium rectifiers. Unfortunately, these rectifiers were rather large, somewhat expensive to manufacture, and also somewhat unreliable. In addition to these undesirable characteristics, they had an even greater fault. When a selenium rectifier shorted, it would almost invariably give off a foul-smelling aroma similar to rotten eggs.

Selenium rectifiers were soon replaced by silicon rectifiers. Silicon rectifiers are smaller than selenium rectifiers, and are relatively inexpensive to manufacture. They also have extremely good reliability, and have a very low forward resistance so that there is a very low voltage drop across them.

Transformers are quite expensive to manufacture. The cost of manufacturing a transformer is directly influenced by the number of turns on each winding. In the circuit shown in Figs.1 and 2, we are only using one-half of the secondary winding during each cycle. The number of turns on the secondary winding, for a given output voltage, is double what we need if we can use the entire secondary winding during both halves of the cycle. The circuit shown in Fig.3 does exactly that. During one half-cycle when the upper end of the secondary winding is negative with respect to the lower end, current flows through D1 to ground. It won't flow through D4 because the anode of this diode is negative. Current flows from ground through the various

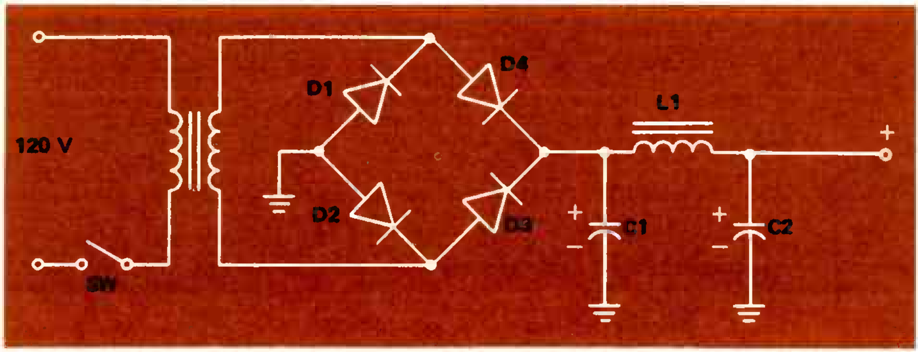



FIGURE 3. DIODE BRIDGE RECTIFIER.

loads in the receiver, which could be either transistors or tubes, to the positive terminal of the supply, through L1, and then through D3 to the lower end of the transformer winding. The load current flows through D3 because its anode is positive since the lower end of the transformer winding is positive.

During the next half-cycle, current flows from the lower end of the transformer winding through D2 to ground, through the various loads back to D4, and through D4 to the upper end of the transformer winding. Although this circuit requires four diodes instead of two, it should be no hardship since diodes are relatively inexpensive. It costs less to use two extra diodes than it does to put twice as many turns on the secondary of the power transformer. The circuit shown in Fig.3 is the most widely used rectifier circuit used in modern radio and TV receivers that uses a power transformer.

We mentioned earlier that it was dangerous to ground a transformerless receiver. Let's see why. Figure 4(A) is a schematic diagram of the power supply widely used in table-model tube-type radios. When the end of the power line connected to the switch is negative, current will flow through the switch to ground, from ground through the various tubes which represent the power supply load, to the positive terminal of the power supply, and through L1 and V1 to the other side of the power line.

During the other half-cycle when the plate of the tube is negative, there will be no current flow. The output voltage from the power supply is kept reasonably constant by using large-value capacitors for C1 and C2. The tubes used in the receiver have relatively high-voltage heaters that are connected in series, so that the total voltage requirement of the series-connected tubes will be equal to the ac line voltage. Thus the receiver can be operated without a power transformer.

The solid-state equivalent of this power supply is shown in Fig.4(B). The only difference is that the tube has been replaced with a solid-state rectifier and resistor R1 has been added. The resistor is needed in power supplies using a silicon rectifier since the rectifier has such a low resistance that when the receiver is first turned on, the current flow through the rectifier would be so high while C1 is charging that D1 could be overloaded and burn out. The resistor limits the maximum current through D1 while C1 is charging. Otherwise, the operation of the two power supplies is identical.

For safety reasons, the power company connects one side of the ac power line to ground. If you plug a transformerless receiver into a power receptacle so that the power plug connecting to the grounded side of the power line connects to the switch in either of the circuits like those shown in Fig.4, the grounded side of the power line will be connected to the ground of the receiver. Under these circumstances, everything will be fine. However, if you remove the power plug and rotate it so that the ungrounded side of the power line connects to the switch, you will now have the "hot" side of the power line connected to the receiver ground.

If the receiver ground is connected to the chassis and you connect an external ground to the chassis, you will now have a short circuit directly across the power line. Even worse, if the chassis is used as a ground, with the ungrounded side connected to the chassis, and you touch the chassis and a grounded object at the same time, you would be connected directly across the power line. This could result in a fatal shock.

In receivers using a rectifier circuit of this type, the chassis is not used as as ground to avoid this dangerous situation. The problem is solved by the use of a common negative circuit called B−, which is isolated from the chassis. This common circuit is also frequently referred to as a "floating ground." One wire of the line cord is connected to one of the terminals of the on-off switch. The other terminal of the line cord leads to a series of insulated terminals throughout the receiver. Connections, which in a receiver using a power

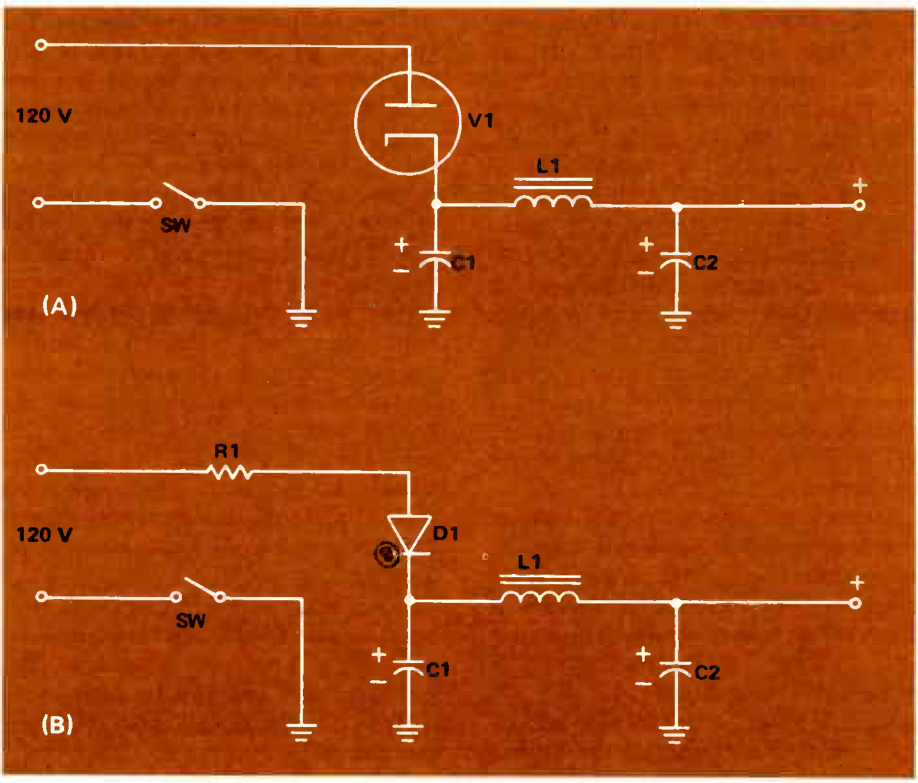



FIGURE 4. TYPICAL HALF-WAVE RECTIFIER CIRCUIT.


FIGURE 5. GROUND CONNECTION SYMBOLS.

transformer would go to the chassis, go to these insulated terminals instead.

This common circuit is called B– because in the early days of radio, a battery called the B battery was used to supply voltage to the plates of the various tubes. The two terminals were referred to as B+ and B–. When batteries were replaced by ac-operated power supplies, the names stuck. Even today, you'll hear old-timers refer to B+ and B– in transistorized equipment, although manufacturers are getting away from this by using the terms V+ and V–.

Ground connection symbols used in modern radio and TV diagrams are shown in Fig.5. If the receiver uses a power transformer and the ground connections are made to the chassis, the symbol shown in Fig.5(A) will be used. If the receiver is of the transformerless type, the symbol shown in Fig.5(A) will be used to indicate B– or the floating ground. The symbol shown in Fig.5(B) will be used to indicate an actual chassis connection.

Modern receivers use printed circuit boards to simplify wiring and assembly. Large amounts of copper are left on the board to form a ground connection. If the receiver uses a power transformer and a chassis, the copper ground is usually connected directly to the chassis, in which case ground connections will be indicated by the symbol shown in Fig.5(A). If the copper ground is not connected to the chassis, the symbol shown in Fig.5(A) will indicate the copper ground or floating ground and the symbol shown in Fig.5(B) will indicate an actual chassis connection.

If you are working on a receiver, you can check to see how the connections are made. However, if you are just looking over a diagram and do not have the receiver, the easiest method of finding out what each symbol means is to look for notes on the diagram. The common ground and chassis ground symbols may be indicated on the schematic. In some cases you may find a note on the diagram indicating whether the voltages are measured with respect to the chassis or with respect to B–. The note may not actually say B–, it might say common negative or common ground.

The dc voltages in a receiver may either be positive or negative with respect to ground. It all depends upon the direction of current flow and the ground connection. In tube-type receiving equipment, the voltages will usually be positive with respect to ground, although not always. In transistorized receiving equipment using npn transistors, the voltages will usually be positive with respect to ground, but again, not always. In transistorized equipment using pnp transistors, the voltages would usually be negative with respect to ground, but again there are exceptions.

Let's look at Fig.6, which shows a tube rectifier and the push-pull output stage of a tube-type amplifier. This

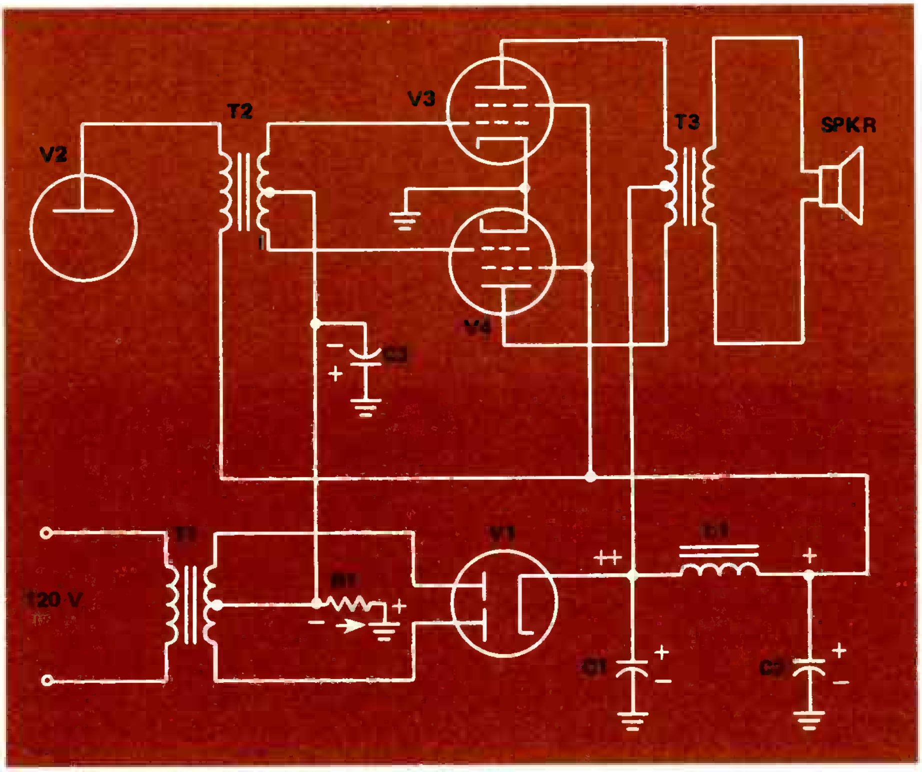



FIGURE 6. POWER SUPPLY AND PUSH-PULL OUTPUT STAGE OF TUBE-TYPE AMPLIFIER.

amplifier might be used in a hi-fi system, a radio, or even in a television receiver. Notice that instead of a direct connection from the center tap of the secondary of the power transformer to ground, we have inserted a resistor, R1.

When current flows from the center tap of the transformer to ground, it will develop a voltage drop across R1 having the polarity shown. This voltage is used to bias the push-pull output tubes, V3 and V4. Since current flows through R1 in the direction shown, the negative voltage across R1 will make the grids of the tubes negative with respect to the chassis. The cathodes are connected directly to the chassis so they are at ground potential.

Notice capacitor C3 in Fig.6. This is an electrolytic capacitor used to keep the dc voltage applied to the grids of the tubes constant. Since this is a negative voltage, the capacitor is connected with the polarity shown.

Notice that we've taken the plate voltage for the output tubes from across C1. The voltage across C1 will be higher than the voltage across C2, due to the voltage drop in the choke, L1. As a matter of fact, L1 is frequently replaced by a resistor which produces an even lower voltage across C2 than across C1. A resistor is frequently used in place of a choke because it is less expensive. Frequently, the voltage across C1 is marked B++ or simply ++ to indicate

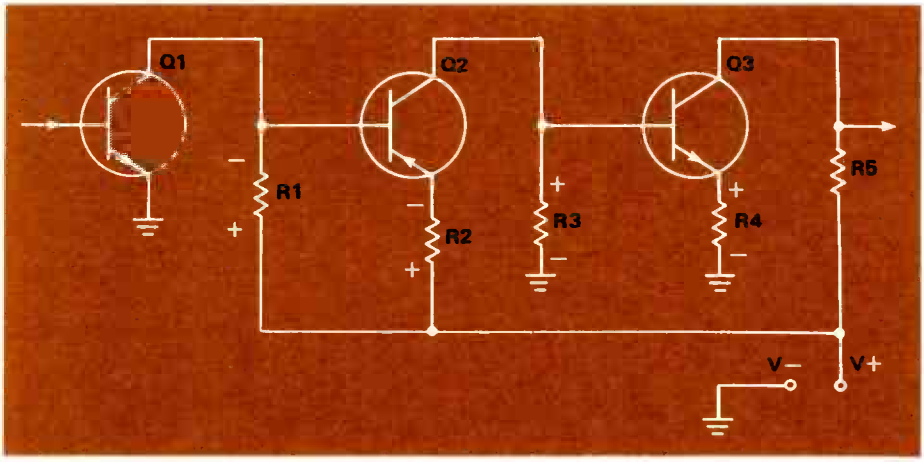



FIGURE 7. THREE-STAGE TRANSISTOR AMPLIFIER.

that this voltage is positive and higher than the voltage across C2 which may be marked B+ or simply +.

The voltage across C1 will have considerably more ripple or hum voltage mixed with it than the voltage across C2, but remember that the current through a tetrode tube is determined primarily by the grid and screen voltages rather than the plate voltage. Thus, the varying hum voltage applied to the plates of the tubes does not cause the current flow through the tubes or the current flow through the primary of T3 to vary.

Thus, no hum current will be produced in the secondary and fed to the speaker. The voltage applied to the screens of the tubes is taken from across C2. This voltage is well filtered and essentially pure dc to reduce the hum voltage applied to the screens of the tubes which would cause the plate current to vary and produce an audible hum in the speaker.

Therefore, in the circuit shown in Fig.6, when measuring voltages, you'll find that the plate voltage on V2 and the plate and screen voltages on V3 and V4 are all positive with respect to ground. The cathode voltages of V3 and V4 are zero and the grid voltages of V3 and V4 are negative.

We mentioned earlier that in transistor equipment using pnp transistors, the dc operating voltages were usually negative with respect to ground. Figure 7 is a schematic diagram of a three-stage amplifier using both npn and pnp transistors; Q1 and Q3 are npn transistors, whereas Q2 is a pnp transistor. All voltages in this amplifier will be positive with respect to ground.

You will recall that the emitter-base junction of a transistor must be forward-biased. To forward-bias a pnp transistor, the base must be negative with respect to the emitter. In the amplifier shown in Fig.7, current flow through R1 will set up a voltage drop across the resistor having the polarity shown. The collector of Q1 will be positive with respect to ground, but the end of R1 connected to the collector will be less positive than the other end. Current flow through Q1 will be from the emitter through the transistor to the collector, through R1, and back to V+.

Since Q2 is a pnp transistor, conduction through the transistor is by means of holes. In this circuit, electrons will flow from ground through R3, developing a voltage across it to have a polarity as shown. Electrons will leave the emitter of Q2 and flow through R2 to V+, developing a voltage of the polarity shown. R2 is selected because the voltage drop across it is smaller than the voltage drop across R1. This means that the base of Q2 will be less positive than the emitter. In other words, the base of Q2 will be negative with respect to the emitter. This forward-biases the transistor.

Meanwhile, the voltage drop across R3 has placed the base of Q3 at a positive potential with respect to ground. Electrons flowing from ground through R4 will develop a voltage drop across it having the polarity shown. R4 is selected so that the voltage drop across it is less than the voltage drop across R3. This will make the base of Q3 positive with respect to the emitter and thus forward-bias the npn transistor, Q3.

We've had examples of all voltages measured with respect to ground being positive, except in the case of Q2. In Q2, the base is less positive than the emitter so that in effect, the base is negative with respect to the emitter. In the case of Q3, the base is more positive than the emitter so that the base is positive with respect to the emitter.

In a receiver using a half-wave rectifier to provide an output voltage that is negative with respect to ground, the negative voltage is obtained using a rectifier circuit like that shown in Fig.4, simply by reversing the diode and the filter capacitors, as shown in Fig.8. In this circuit, when the end of the power line connected to R1 is negative and the end connected to the switch is positive, current will flow through R1, through D1, through R2, and through the load. It will then flow back through the switch to the positive side of the power line.

During the other half-cycle, there will be no current flow through the rectifier. Notice that in this circuit, the filter capacitors, C1 and C2, are connected with the opposite polarity than they are in Fig.4(B). Also, we've replaced the choke coil, L1, shown in Fig.4(B) by resistor R2. A resistor is normally used in this type of power supply because it is less expensive than a choke.

To obtain a negative voltage from a bridge rectifier circuit, such as shown in Fig.3, we once again simply reverse the

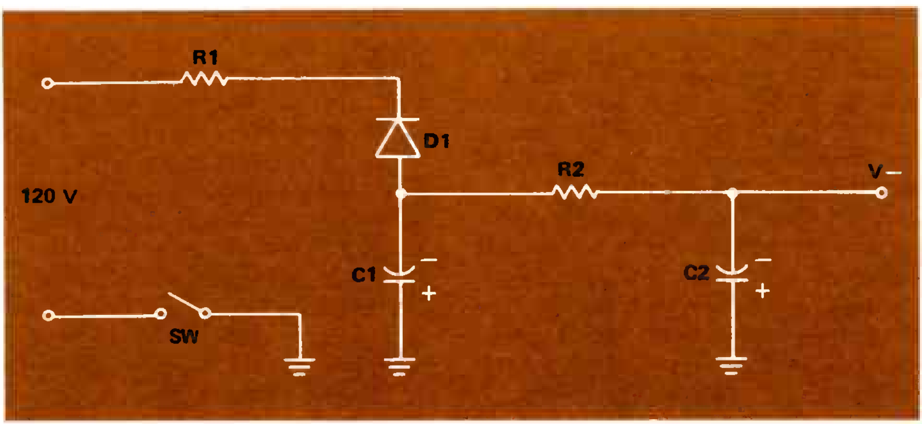



FIGURE 8. A HALF-WAVE RECTIFIER PRODUCING A NEGATIVE VOLTAGE.

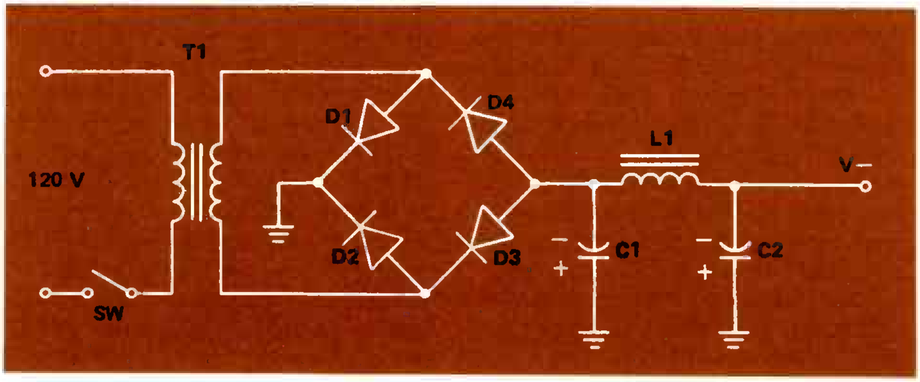



FIGURE 9. A FULL-WAVE RECTIFIER PRODUCING A NEGATIVE VOLTAGE.

diodes and capacitors. In Fig.9, the four diodes are connected with the opposite polarity than those in Fig.3.

In the circuit shown in Fig. 9, when the upper end of the transformer secondary is negative and the lower end is positive, current will flow from the upper end through D4, through the choke coil, and then through the transistors which form the load to ground. From ground, current will flow to the junction of D1 and through D2 since its anode is positive.

During the other half-cycle, when the lower end of the transformer is negative and the upper end is positive, current will flow from the lower end of the transformer through D3, through L1, and the load to ground. From ground, current will then flow through D1 since its anode is connected to the positive side of the transformer.

With either of the power supplies shown in Fig.8 or Fig.9, all voltages measured throughout the receiver will be negative with respect to ground. This is the situation you might expect to find in a receiver using pnp transistors.

The service information supplied with radio and television receivers usually gives the dc voltages of the various tube or transistor elements, or the various pins of an integrated circuit with respect to ground. These voltages might be positive or negative, depending upon the circuit requirements. In the case of circuitry operating from a power supply where the negative output is grounded, all voltages will be positive. However, as we pointed out in Fig.7, this does not mean that the polarity of the voltage between various elements of a device has to be positive. For example, in Q2 of Fig.7, the base is negative with respect to the emitter, which is a requirement to forward-bias the transistor even though all elements, the base, the emitter, and collector are positive with respect to ground.

Remember that ground is simply a zero potential point. It might actually be the chassis of a receiver, or it might be a large area of copper on a printed circuit board which is insulated from the chassis. Ground does not mean an actual ground connection.

**NOTE**: In this article we have discussed the meaning of the term "ground" as it applies to measuring dc voltages in electronic circuits. There is another use of the term "ground" when referring to ac signals in electronic circuits. This sometimes confusing concept will be the subject of a future article in the Journal.

# UPDATE: AUTOMOTIVE MECHANIC CERTIFICATION

## ED COCHRAN

Remember when, back in the late sixties and early seventies, the automotive repair industry came under heavy fire for high prices and shoddy workmanship? Ralph Nader led the attack, but a lot of other groups got into the act. These included Congress, other government agencies, consumer groups, and a lot of ordinary angry people. It was all very embarrassing to the industry because many of the complaints were valid.

One of the big problems was that there was no way for the average car owner to know where he could take his car and expect *good* repairs, regardless of price. The industry needed a program to recognize those mechanics who were fully competent and qualified to do expert repair work on the automobile. Mechanics who were to be recognized would be required to demonstrate their competence. The industry wanted its own voluntary program before the government came in with licensing regulations that everyone would have trouble living with.

The program that evolved was a series of tests for mechanics that lead to certification. The National Institute of Automotive Service Excellence (NIASE), located in Washington D.C., was formed in June 1972 to administer the program. The board of directors for NIASE is made up of representatives of all segments of the auto industry including manufacturers, dealerships, independent garages, and service station mechanics.

The original program was funded by the four major American auto manufacturers. Since then it has become self-sufficient. Although Detroit is well represented in NIASE, it does not dominate it.

It has been over five years now since the first Automotive Mechanic Certification tests were administered in the late fall of 1972. Since that time, over 130,000 mechanics have been certified as general mechanics, or in one or more of eight specialties. About 25,000 more persons took the tests in November 1977 and will be getting the results early this year. The voluntary NIASE program is alive and well and has really

National Institute
for
Automotive Service Excellence
WASHINGTON, D.C.

*Be it known that*

JOHN A. DOE

has successfully passed the examinations and met the experience requirements prescribed by the National Institute for Automotive Service Excellence and is awarded this CERTIFICATE in evidence of his qualification as a

CERTIFIED GENERAL AUTOMOBILE MECHANIC

AREAS OF DEMONSTRATED COMPETENCE

ENGINE REPAIR; AUTOMATIC TRANSMISSION; MANUAL TRANSMISSION AND REAR AXLE; FRONT END; BRAKES; ELECTRICAL SYSTEMS; HEATING AND AIR CONDITIONING; ENGINE TUNE-UP .

Given this 31ST day of OCTOBER, 1977 at Washington, D.C.

Herbert S. Fuhrman
HERBERT S. FUHRMAN, President

| IDENTIFICATION NUMBER | CERTIFICATE NUMBER | THIS CERTIFICATE EXPIRES |
|---|---|---|
| #000-00-0000 | #000 | 10/31/82 |

FIGURE 1. CERTIFICATE FOR A CERTIFIED GENERAL AUTOMOBILE MECHANIC.

caught on. It is praised by both the auto industry and the motoring public.

## HOW THE PROGRAM WORKS

To become a Certified Automobile Mechanic, you must pass one or more tests. There are eight tests covering different services for the automobile. When you pass any of the eight tests you will be certified in that speciality. When you have passed all eight tests you will be certified as a General Automobile Mechanic.

The tests are prepared and administered by the Educational Testing Service (ETS) of Princeton, New Jersey. This is a nonprofit organization that prepares such tests as the College Entrance Examination Board, Graduate Record Examination Board, the Law School Admission Test, the National Teacher Examinations, and various tests for vocational licensing and certification.

The tests are offered twice a year (in the spring and fall) in 260 major cities throughout the 50 states. To take one or more tests you must register in advance and pay a registration fee of $10 plus a fee of $7 for each test to be taken.

Besides passing the tests, you must present evidence of at least two years of work experience as an auto mechanic. You may substitute formal training for up to one year of work experience. You may take the tests before you have the two years experience, but you will not be issued a certificate until the experience requirement has been met.


FIGURE 2. INSIGNIA FOR CERTIFIED GENERAL AUTOMOBILE MECHANIC.

Each time you take a test, you will receive a Score Report showing the tests you have passed, the tests you will need to pass, and whether or not you have satisfied the experience requirement. If you have failed a test, your answers will be evaluated and you will be told in which areas you are weak. When you have been certified, your certificate will be good for five years. To remain certified, you must pass a test dealing mainly with new developments in the automotive service field. The first re-certification tests will be given this spring.

The mechanics who are certified receive a certificate like the one shown in Fig.1. They also receive appropriate insignia to wear on their work shirts or jacket. The insignia for a General Automobile Mechanic is shown in Fig.2. Mechanics who have not passed all of the tests will receive insignia like that shown in Fig.3 with stripes showing the areas in which they are certified. All certified mechanics receive a wallet card and a plastic card to be displayed in the shop's customer area.

The NIASE program now includes a six-test series to certify heavy-duty truck and bus mechanics. There are also two tests for mechanics who work in body shops – one for body work and one for painting. The examination procedures for these are the same as for automobile mechanics.

## ABOUT THE TESTS

The next series of tests will be given in May 1978. Each test is given at the same time and the same day throughout the country. The test site is usually a high school, technical school, or college. Tests are administered by members of the school staff.

All of the test questions are multiple-choice with four choices. Since a question left blank is considered wrong, you are encouraged to guess if you are not sure of the answer. You are given ample time to answer all the questions.


FIGURE 3. SHOULDER INSIGNIA FOR AUTOMOBILE MECHANIC CERTIFIED FOR BRAKES, FRONT END, AND TUNEUP.

## Table 1 Automobile Tests

| TO BECOME CERTIFIED IN: | YOU MUST PASS: | |
|---|---|---|
| Engine Repair (80 Questions) | TEST 1 | Valve train, cylinder head and block assemblies; lubricating, cooling, ignition, fuel and carburetion, exhaust, and battery and starting systems. |
| Automatic Transmission (40 Questions) | TEST 2 | Controls and linkages; hydraulic and mechanical systems. |
| Manual Transmission/Rear Axle (40 Questions) | TEST 3 | Manual transmissions, clutches, front and rear drive systems. |
| Front End (40 Questions) | TEST 4 | Manual and power steering, suspension systems, alignment, and wheels and tires. |
| Brakes (40 Questions) | TEST 5 | Drum, disc, combination, and parking brake systems; power assist and hydraulic systems. |
| Electrical Systems (40 Questions) | TEST 6 | Batteries, starting, charging, lighting, and signaling systems; electrical instruments and accessories. |
| Heating and Air Conditioning (40 Questions) | TEST 7 | Refrigeration, heating and ventilating, A/C controls. |
| Engine Tuneup (80 Questions) | TEST 8 | Oscilloscopes and exhaust analyzers; emission control and charging systems; cooling, ignition, fuel and carburetion, exhaust, and battery and starting systems. |

## Table 2 Heavy-Duty Truck Tests

| TO BECOME CERTIFIED IN: | YOU MUST PASS: | |
|---|---|---|
| Gasoline Engines (80 Questions) | TEST T1 | Valve train, cylinder head, and block assemblies; lubricating, cooling, ignition, fuel and carburetion, exhaust, and battery and starting systems. |
| Diesel Engines (80 Questions) | TEST T2 | Valve train and block assemblies; lubricating, cooling, air induction, fuel, and exhaust systems; air starting, fuel and air shutdown, and engine braking systems. |
| Drive Train (60 Questions) | TEST T3 | Manual transmissions, clutches, drive line, rear axles. |
| Brakes (60 Questions) | TEST T4 | Air, hydraulic, mechanical parking, and FMVSS-121 brake systems. |
| Suspension and Steering (60 Questions) | TEST T5 | Steering and front and rear suspension systems; tires and wheels. |
| Electrical Systems (40 Questions) | TEST T6 | Batteries, starting, charging, lighting, and signaling systems; electrical instruments and accessories. |

You are tested in three areas of knowledge and skill. The first is Basic Technical Knowledge (What part is it? How does it work?). You must be familiar with what is in a system and how the system operates. Procedures and precautions to be followed are also included.

The second area is Correction or Repair Knowledge and Skill (What is the likely source of a malfunction? How do you fix it?). You must understand and apply accepted procedures and precautions. You must also know how to use shop manuals and precision tools of the trade.

The third area is Testing and Diagnostic Knowledge and Skill (How do you find what's wrong? How do you determine the effectiveness of the work done?). You must be able to recognize the existence of a problem and to use generally available measuring and testing equipment to diagnose the difficulty.

Table 1 is a list of the tests for certification as an automobile mechanic. As stated earlier, you must pass all eight tests to be certified a General Automobile Mechanic, *but* you do not have to take all the tests at the same time. Test 1 and test 8 are in the same test booklet. If you want to take both tests at the same time, you will be tested on a total of 120 questions. (The first 40 questions are the same for both tests.)

Table 2 is a list of the tests for heavy-duty truck and bus mechanics. Again, if you want to be certified as a General Heavy-Duty Truck Mechanic you must pass all six tests. However, if you have passed tests 1 and 6 of the automobile tests before, you will not have to take truck tests T1 and T6 to be certified a General Heavy-Duty Truck Mechanic.

Table 3 lists the tests for Body Repair, Painting and Refinishing. There is no certification for a General Bodyshop Mechanic at this time.

Table 4 is the test schedule for the Spring 1978 test series.

## HOW TO GET STARTED

To begin, write to the National Institute for Automotive Service Excellence, 1825 K Street N.W., Washington D.C. 20006 and ask for the Bulletin of Information, Spring 1978. You will receive a copy of the bulletin that tells you all about the tests and contains 42 sample questions for practice (28 automobile, 8 truck, and 6 body and paint).

The bulletin includes a registration form that must be filled out carefully and completely. The registration form, together with a check or money order for the fees ($10 registration and $7 for each test), should then be mailed to Educational Testing Service, Certified Mechanic Program, P.O. Box 2611, Princeton, N.J., 09540. Note: To take any of the tests this spring (May 1978), you must send your registration and fees to ETS before April 3, 1978.

If you live over 50 miles from a scheduled test city, you can request a special test center in your area under these conditions:

1 At least 20 mechanics from your area will be taking tests at each test session.

2 All registration forms and fees for the mechanics requesting a special test center must be mailed in together in one envelope.

3 The request for the special test center must arrive at ETS before March 17, 1978. There is a form for requesting a special test center included in the Bulletin of Information.

## Table 3 Body Repair/Painting and Refinishing Tests

| TO BECOME CERTIFIED IN: | YOU MUST PASS: | |
|---|---|---|
| Body Repair (40 Questions) | TEST B1 | Body, frame welding, glass, trim, hardware, air and water leaks, and related mechanical repairs. |
| Painting and Refinishing (40 Questions) | TEST B2 | Equipment, preparation, undercoats, sanding, color application, safety, problem causes, and correction. |

## Table 4 Spring Test Series 1978

### Automobile Mechanic Tests

| Test Session | Test Date | Time | Test Given |
|---|---|---|---|
| A | Tuesday, May 2 | 7 p.m. to 10:30 p.m. | 4 Front End<br>5 Brakes |
| B | Thursday, May 4 | 7 p.m. to 11:30 p.m. | 1 Engine Repair<br>8 Engine Tuneup |
| C | Tuesday, May 9 | 7 p.m. to 10:30 p.m. | 2 Automatic Transmission<br>3 Manual Transmission and Rear Axle |
| D | Thursday, May 11 | 7 p.m. to 11:30 p.m. | 6 Electrical Systems<br>7 Heating and Air Conditioning<br>All eight recertification tests |

### Heavy-Duty Truck Mechanic Tests

| Test Session | Test Date | Time | Test Given |
|---|---|---|---|
| A | Tuesday, May 2 | 7 p.m. to 10:30 p.m. | T3 Drive Train<br>T4 Brakes |
| B | Thursday, May 4 | 7 p.m. to 11:30 p.m. | T1 Gasoline Engines<br>T2 Diesel Engines |
| D | Thursday, May 11 | 7 p.m. to 11:30 p.m. | T5 Suspension and Steering<br>T6 Electrical Systems |

### Body Repair/Painting and Refinishing Tests

| Test Session | Test Date | Time | Test Given |
|---|---|---|---|
| C | Tuesday, May 9 | 7 p.m. to 10:30 p.m. | B1 Body Repair<br>B2 Painting and Refinishing |

## TAKING THE TESTS

I took the first series of tests in November and December of 1972 and will take all of the recertification tests this spring. In the past five years I have talked to a great many mechanics who have taken the tests with varied degrees of success. Nearly all of those I talked with agree on several points.

First, the tests are fair and the questions are good. ETS did a great deal of research and tried the tests on hundreds of mechanics before using the tests for the certification program. ETS monitors the test results very closely in order to weed out those questions that seem to cause trouble through misinterpretation. Some of the questions are changed for each test series. The tests are administrated fairly. There is very little opportunity for anyone to cheat.

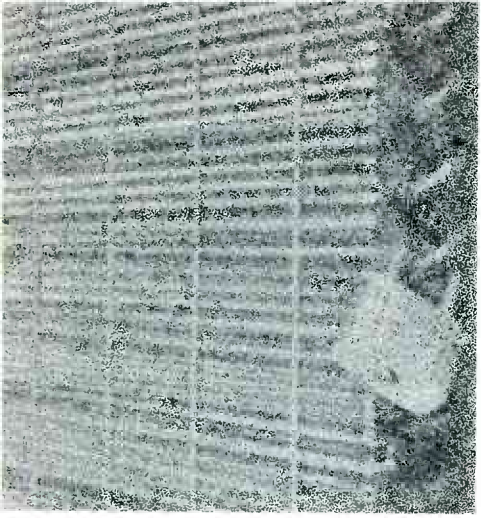
Second, to be fair to yourself, do some boning up before you take the test. Pay particular attention to areas that are not your specialty. If you are a graduate of the NRI Master Automotive Servicing Course, or are presently enrolled, you have some of the best possible review material available. Use it. Before each test, review the lessons that cover the subjects on which you are going to be tested. It's easy to become rusty when you don't work with something every day.

Third, *read the questions carefully*. This cannot be overemphasized. The questions are not tricky, but you must read them carefully to be sure you know what they are asking. Don't jump to conclusions. Don't read the first part of a question and think you know the correct answer. You will probably be wrong because you didn't read the whole question. Make sure you know what question is being asked.

I think the time, effort, and money spent in taking the tests and being certified are well worth it. It will give you recognition and prestige and usually an increased income. Many employers gladly pay the test fees for their mechanics and reward those who become certified with bonuses or increased hourly wages. The motoring public is becoming increasingly aware of the certification program, and they like it. Signs like the one shown in Fig.4 are becoming familiar sights in increasing numbers at automotive repair facilities.

One last note. For those of you who have read this and are not mechanics, but are interested in knowing where to find certified mechanics, NIASE publishes a Directory of Certified Automotive Mechanics that is available to the motoring public. The cost of the directory is $1.95. If you would like one or more, send a check or money order to NIASE and the directory(s) will be returned postpaid.


FIGURE 4. SIGN USED BY REPAIR FACILITIES THAT EMPLOY CERTIFIED MECHANICS.



**Mike Taylor:**

# Diagnosing Sealed Refrigeration Systems Without Gauges

Most of the problems that develop in the sealed refrigeration system can be diagnosed without pressure gauges. All it really takes is an understanding of how the system works, and your own senses (eyes, ears, and hands). Since most home refrigeration systems such as the home refrigerator and freezer do not have service valves, you will be diagnosing the symptoms without gauges anyway. However, there is no room here for guesswork.

An improper diagnosis of a refrigeration problem can be expensive for both you and your customer. You may not believe this, but most of the compressors returned to the manufacturer under warranty are found not to be defective. In these cases, the real problem is often moisture in the system, or an incorrect refrigerant charge. Both of these problems would be taken care of by following the procedures for replacing a compressor. But the point is that while the symptoms may disappear after the installation of a new compressor, there may well have been nothing wrong with the original compressor initially.

There are only three reasons why you should ever need to enter the sealed system. They are: (1) incorrect refrigerant charge, (2) a restriction blocking the flow of refrigerant, and (3) a defective compressor. Each of these problems can be diagnosed by one or more of the following symptoms: compressor won't start, compressor trips out on overload, no cooling, partial cooling, or a frosted suction line.

When diagnosing these symptoms, you will use your hands, ears, and eyes. You should also have a few basic tools such as: a motor test cord, a thermometer, and a volt-ohm-wattmeter. But to properly diagnose the symptoms you first have to know the operating conditions when the system is working properly.

A diagram of a typical refrigeration system is shown in Fig.1. In addition to the usual evaporator, condenser, and compressor, most small refrigeration systems will also have a capillary (cap) tube separating the evaporator from the condenser. Just about all refrigerators and freezers will have a precooler also. The precooler simply acts to cool the hot refrigerant gas as it is discharged from the compressor. This causes the refrigerant oil that may mix with the refrigerant vapor to condense and return to the compressor crankcase.

When the system is operating properly, most of the liquid refrigerant will be in the evaporator. A layer of frost will cover the evaporator, but the frost should not extend down the suction line

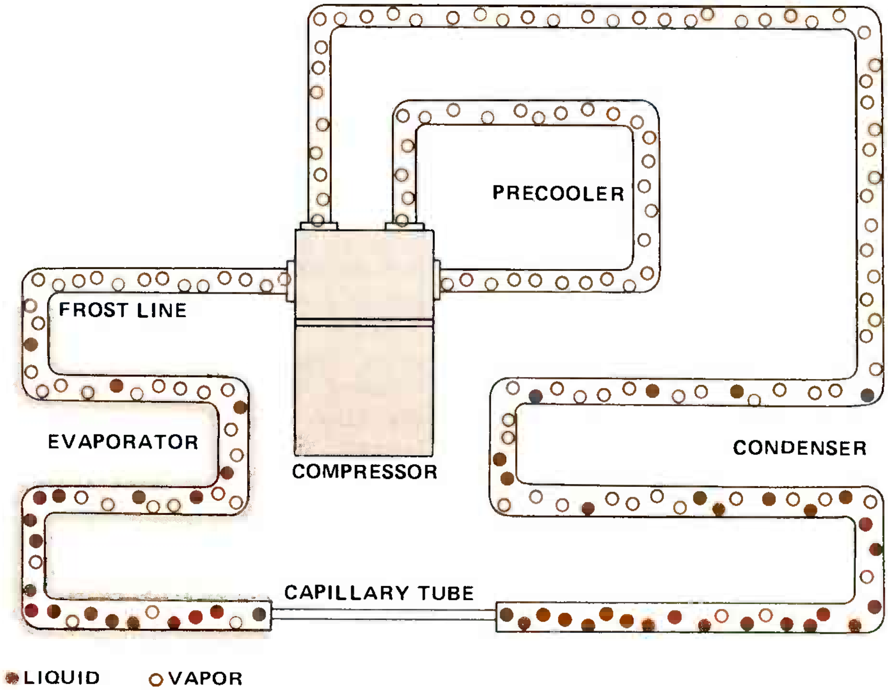



FIGURE 1. THE NORMALLY OPERATING REFRIGERATION SYSTEM.

to the compressor. As heat is picked up by the evaporator, the liquid refrigerant begins to vaporize. Only vapor will reach the suction line to the compressor; all of the liquid has turned into a vapor.

The vapor is then drawn out of the evaporator by the compressor. The compressor forces the vapor through the precooler into the condenser. The condenser gives up the heat picked up in the evaporator and condenses the refrigerant vapor back to a liquid. When the system is operating properly, only liquid will enter the cap tube.

Remember, the cap tube will have a very small inside diameter (ID) and will act to restrict the liquid refrigerant flow. This restriction causes the liquid entering the evaporator to be metered so that only the correct amount of liquid will enter the evaporator. Generally, you will find very long cap tubes in a freezer, and shorter cap tubes in a refrigerator. A window air conditioner will have a larger-diameter (but also shorter) cap tube than a refrigerator. In each of these cases, the temperature of the evaporator is controlled by the proper metering of the liquid refrigerant going into the evaporator.

Now that you have some idea of how the refrigeration system is supposed to operate, let's diagnose the system when something goes wrong.

## PARTIAL LOSS OF REFRIGERANT CHARGE

A small refrigerant leak will, after some time, result in a partial loss of refrigerant. The customer's complaint may be something like: "The freezer is too cold, but the food section is too warm, and the refrigerator seems to run constantly." Of course the refrigerator will run constantly, since the thermostat is located in the food compartment and is never satisfied. But why should the freezer be too cold?

With a partial loss of refrigerant, there is insufficient liquid to flow through the entire evaporator. All the liquid refrigerant that does enter the evaporator turns into a vapor before it reaches the suction line. Only the section of the evaporator that contains liquid refrigerant will get cold. The outlet of the capillary tube feeds liquid refrigerant to the freezer section. The liquid refrigerant that does not vaporize in the freezer drops to the food compartment evaporator. If there is only enough liquid to fill the freezer section, only the freezer will get cold.

In analyzing this problem, you will see that, as shown in Fig.2, the evaporator in the freezer is only partially frosted. Since there is a definite frost line, it is an easy condition to detect. Stop the compressor and defrost the entire evaporator. When the unit is restarted, the frost will return to about the same frost line within a few minutes.

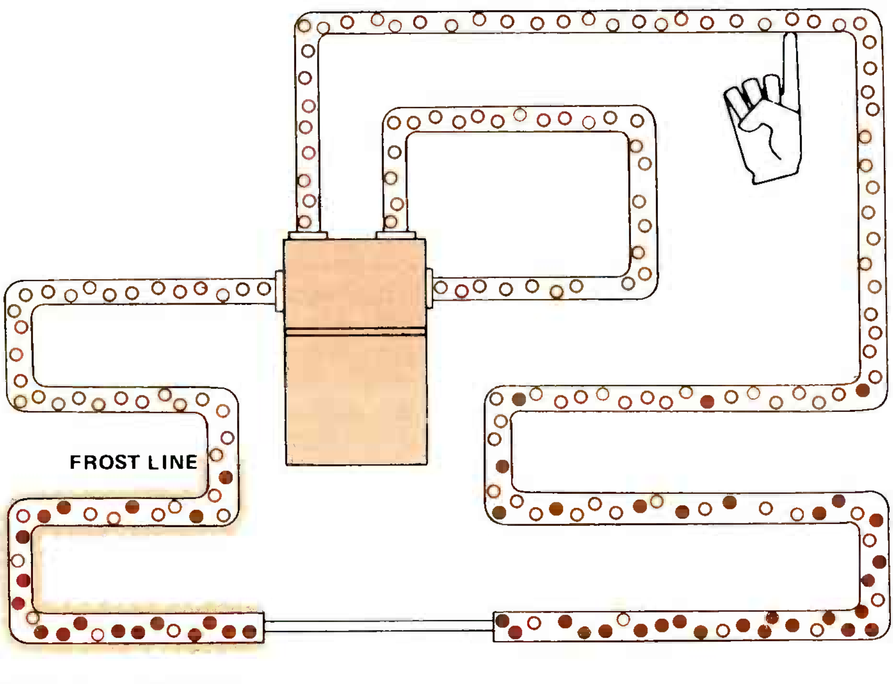



FIGURE 2. A PARTIAL LOSS OF REFRIGERANT. THE CONDENSER TEMPERATURE WILL FEEL ABOUT NORMAL.

Since the compressor will not be pumping as much refrigerant, its current draw and wattage will be low. By touching the condenser and precooler, you will find their temperatures about normal or slightly cooler. The key here is the frost line and the time it takes for the frost line to reappear after defrosting.

If the refrigerator is the automatic defrost type, the freezer compartment and food compartment will never seem to reach the desired temperature. However, all other symptoms will remain the same. Eyeballing the evaporator, you will see a definite frost line. The frost line will appear, after defrosting, to about the same point in just a few minutes. The trick here is gaining access to the evaporator.

Of course, the next step would be to completely leak-check the system. Since the leak is probably very small, a good leak detector will be necessary. In most cases of this type, the leak will be at a joint where two sections of tubing connect. If at all possible, try to repair the leak before opening the system. This will keep air and moisture out of the system for as long as possible. Rebrazing the joint may be all that is required.

Once the leak has been repaired, you can then go ahead and discharge the remaining refrigerant. If the system has a filter-drier, replace it. Then evacuate the system and recharge it with the correct amount of refrigerant. Be careful not to overcharge. An overcharge can cause more problems and perhaps damage the compressor. While we are on the subject, let's see what will happen with an overcharge.

## TOO MUCH REFRIGERANT

Contrary to popular belief, too much refrigerant will not cause everything to get too cold. Too much refrigerant will only put a heavier load on the compressor. The excess liquid refrigerant will enter the suction line to the compressor. The suction line will frost up, sweat, and drip water. If the overcharge is excessive, liquid refrigerant may enter the compressor. Since the compressor is designed only to compress a vapor and not a liquid, the compressor may become very noisy and eventually fail.

You will usually run across an overcharge condition only after someone else has worked on the system. The only sure way to correct the problem is to slowly discharge the refrigerant from the system. Be careful not to blow out the refrigerant oil. Then evacuate and recharge the system with the correct charge. If the refrigerator then appears to work properly, it is a pretty safe bet that the compressor has not been damaged.

So far we have talked about too much refrigerant and a leak resulting in insufficient refrigerant. Next, let's see what happens if a leak has caused almost all of the refrigerant to be lost.

## LOSS OF REFRIGERANT CHARGE

When a refrigeration system has lost almost all of its refrigerant, it will look like Fig.3. Of course, both freezer and food compartments will be warm, and the compressor will run constantly. If you listen carefully at the outlet of the capillary tube, you will hear an intermittent hissing or spitting sound. This is what is left of the liquid refrigerant as it enters the evaporator. Also, since the compressor has very little work to do, it will draw lower than normal current and the wattage reading will be below normal. The condenser and precooler will probably be just a little warmer than room temperature.

You should not suspect the compressor because of the intermittent hissing

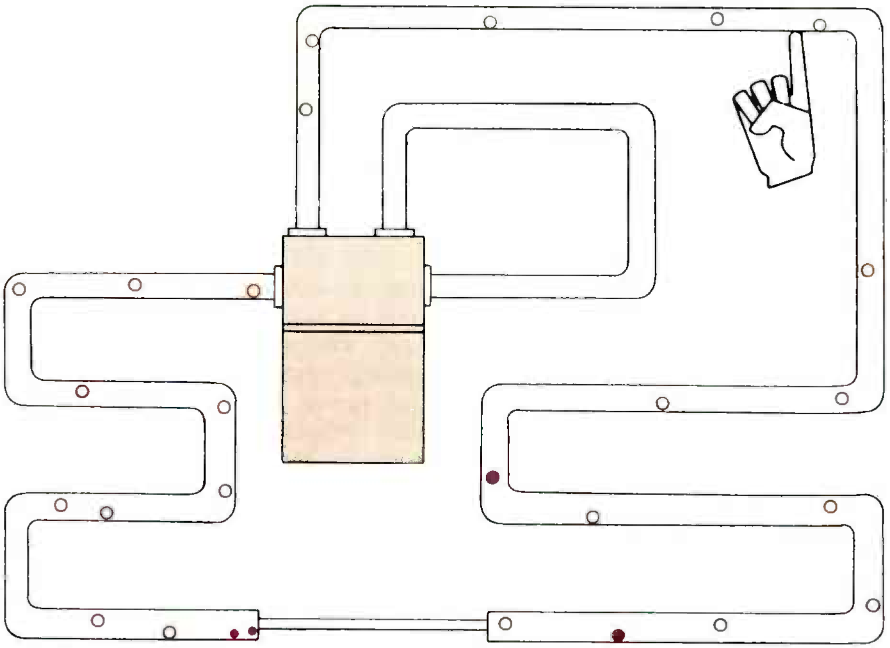



FIGURE 3. AN ALMOST COMPLETE LOSS OF REFRIGERANT. ONLY A FEW DROPS OF LIQUID WILL INTERMITTENTLY ENTER THE EVAPORATOR. THE CONDENSER WILL FEEL COOL, JUST ABOVE ROOM TEMPERATURE.

sound at the capillary tube and the low wattage reading. A defective compressor with these symptoms is very rare, and you are pretty safe in suspecting a loss of refrigerant charge.

As in repairing a partial loss of refrigerant, leak-check the system. You may find it necessary to add refrigerant in order to locate the leak. Make the necessary repairs and go ahead with the evacuating and recharging procedures.

We have now covered most of the possibilities for having an incorrect refrigerant charge. This was our No.1 reason for entering the sealed system. Now let's cover No.2 – a restriction blocking the refrigerant flow.

## A COMPLETE RESTRICTION

Should any tube of the sealed system become plugged, it will affect the entire operation of the system. This will usually occur at the cap tube because it is so small. Dirt, metal filings, or foreign material must be removed before they can enter the cap tube. A filter-drier is usually installed just prior to the capillary tube as shown in Fig.4.

The filter section of the filter-drier catches the dirt and metal filings that may float through the system. The drier section removes any moisture or water that may enter the system with the refrigerant or refrigerant oil.

The complete removal of all moisture is very important in the sealed system. Just a few drops could cause a complete restriction. If the filter-drier does not catch all of the moisture, the moisture will immediately freeze and form ice when it reaches the cap tube outlet. The ice, of course, will block the refrigerant flow into the evaporator.

A complete restriction like this will cause symptoms similar to a loss of refrigerant charge. The compressor wattage will be lower than normal. The condenser and precooler both will get very warm when the unit is first started, and then will cool to about room temperature.

To tell the difference between a complete restriction and a loss of refrigerant charge, first listen to the outlet of the cap tube. If you hear a spitting or hissing sound, it is a pretty safe bet that the problem isn't a complete restriction.

To determine if the restriction is caused by moisture, shut the unit off and listen at the cap tube outlet. If you still do not hear the hissing sound, apply heat to the cap tube outlet. After a short time, you will hear a sudden hissing sound indicating that the ice has melted and freed the restriction.

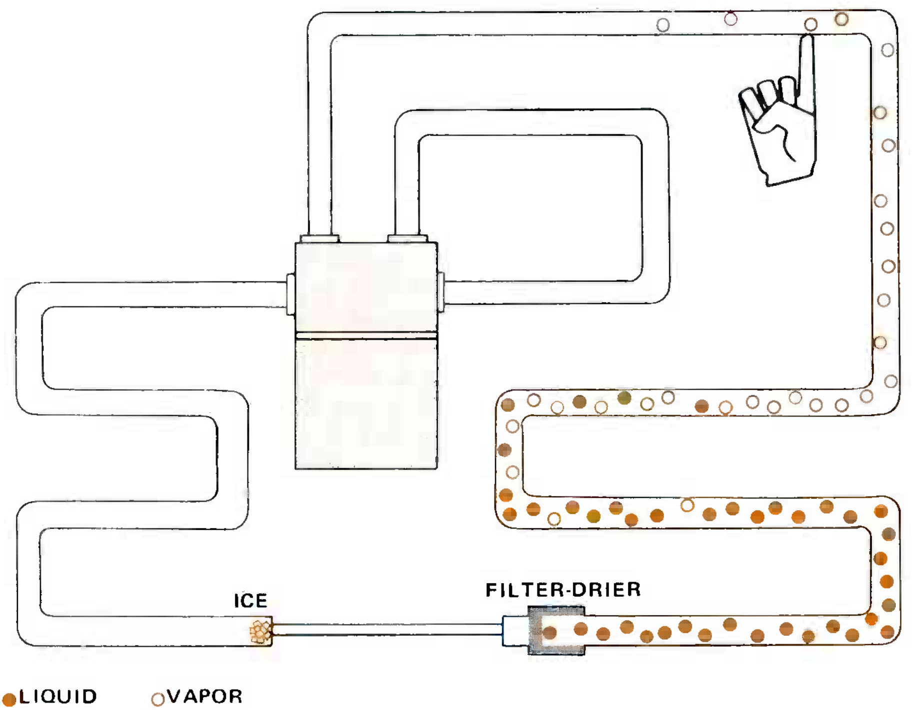



FIGURE 4. MOISTURE IN THE SYSTEM WILL CAUSE ICE TO FORM AND BLOCK THE REFRIGERANT FLOW AT THE CAPILLARY TUBE. THE CONDENSER WILL FEEL COOL.

Don't use a match or torch to heat the cap tube. It may score or stain the inside metal cabinet. If the inside cabinet is plastic, the heat may actually distort or burn the plastic. Dampen a piece of cloth with hot water. Apply the hot cloth to the cap tube element, and after a few moments the ice will melt.

Once you have decided that the problem is moisture, open the system and discharge the refrigerant. Remove and discard the filter-drier, and replace it. The drier section of the original is saturated with water and is useless. As a matter of standard procedure, you should always replace the filter-drier whenever you open the system. Then evacuate the system and recharge with the correct amount of refrigerant.

A crimped or kinked cap tube caused from an excessively tight bend can also cause a complete restriction. All of the symptoms would be identical to a moisture restriction. To tell the difference, try the heat trick mentioned above. If this doesn't work, and all other symptoms fit the picture of a restriction, it is safe to say that the restriction is permanent and not just moisture.

If the compressor is the piston-type, turn the unit off. Wait a few moments, and then try to restart. A permanent restriction will not let the pressures equalize. The compressor will try to start, but due to the high condenser pressure, the compressor will most likely kick out on the overload. A rotary compressor, on the other hand, may continue to run, but the wattage draw will be low.

In most cases, a kinked section of tubing will not cause a complete restriction, but rather a partial restriction. A partial restriction of the cap tube would be like doubling the length of the cap tube. The evaporator will be colder, but only part of the evaporator will become frosted. Remember, a partially frosted evaporator is one of the symptoms of a low charge. Let's see how we can tell the difference.

## A PARTIAL RESTRICTION

A partial restriction is checked in much the same manner as you would check for a low charge. Make a note of the frost line on the evaporator and stop the compressor. Defrost the evaporator and restart the compressor.

When the unit is first started, a layer of frost will cover the entire evaporator. Then the frost will gradually recede back to the original frost line. The frost will be slow in returning to the frost line. It is the time difference in returning to the original frost line that tells you the problem is a partial restriction rather than a loss of charge.

Although a partial restriction of this type will usually occur at the cap tube, a partial restriction may also result if the filter-drier should become clogged. Another possibility would be a kinked or crimped section of condenser or evaporator tubing. To locate the restriction, simply run your hand across the tubing. At the point of the restriction, you will note a definite temperature difference between each side of the restriction. The temperature difference is due to the pressure difference at the restriction. As the liquid or vapor passes through the restriction, it will have a definite cooling effect.

If the restriction is somewhere along the cap tube, you should replace the entire cap tube. Be sure to use a replacement of the same ID and length. If the restriction is somewhere along the evaporator or condenser tubing, you may be able to replace just that section of tubing.

That just about covers our No.2 reason for entering the sealed system. Now let's see what happens if something goes wrong with the compressor.

## DEFECTIVE COMPRESSOR

Most problems that occur with the compressor are electrical in nature. You should never assume that the compressor is defective before making a complete electrical check. The odds are stacked against you. Compressors are designed to last far beyond their warranty period; most compressors are designed to last ten years or more.

In Fig.5, we show the electrical diagram for the compressor. If you encounter a compressor that does not run, check to see if power is being supplied to the compressor. If not, the problem is likely due to a defective thermostat or perhaps the defrost timer.

If power is being supplied to the compressor, make continuity checks of the overload protector, start relay, and motor windings. Check both the start and run windings.

The compressor that runs but does not pump is very rare. To track down these rare cases, you will not be able to rely on your senses alone. You will have to open the system and install service valves to attach pressure gauges. If the compressor is operating, you will see a definite pressure difference between the suction and discharge sides. However, it is still possible for the compressor to become inefficient. This is like having too small a compressor for the system. The freezer and food section may not get quite cold enough, and the compressor will seem to run continuously. Again, a pressure check with gauges will be necessary.

Another check of the compressor would be to completely discharge the system of refrigerant. Connect a motor test cord directly to the compressor terminals and start the compressor. A good compressor will develop a vacuum on the suction side, and an increase in pressure on the high side. If these conditions don't exist, it is a safe bet that the compressor is defective.

In summary, when you come across a refrigeration system problem, stop and identify the symptoms first. Then use these symptoms to locate the exact cause of the problem. Remember, you repair the problem, not the symptom. Repairing the problem will take care of the symptoms.

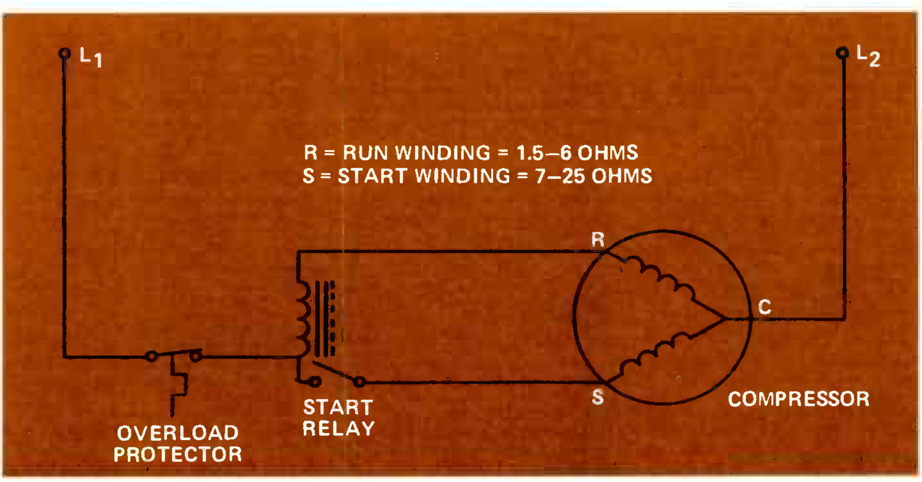



FIGURE 5. THE ELECTRICAL DIAGRAM FOR THE COMPRESSOR.

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Weight 3 pounds
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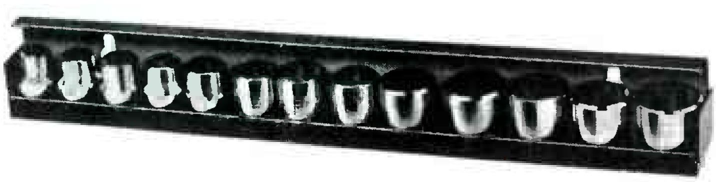

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Weight 1½ pounds
Stock No.TO366
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# Ham News

## Ted Beach
## K4MKX

Well, here it is 1978 already, and we have finally received our copy of the March 1977 edition of the FCC Rules and Regulations, Part 97. So guess what? After reading over the rules changes we have been putting in the box in this column in abbreviated form, and comparing these with the real regulations in Part 97, we have decided to stick with the abbreviated form published here before.

The reason is that if we were to print the full text of the various changes, there would be very little room for anything else here, even with our expanded format! By doing this, we can keep you up-to-date on the intent of the rules, but it is still up to you to dig out the actual rules for your own information. It appears that the FCC may still make some changes so there will very likely be several more additions to the table before the next edition of the rules in March.

Among the many proposed changes are several that are aimed directly at deregulation of the Amateur service. We feel these are all for the betterment of the amateur, and we will comment on some of them in future editions as time permits.

I can remember not too long ago writing in this column, issue after issue, about the many talents and activities of one of our very active and versatile students, Brother Bernard Frey, O.F.M., WA2IMP. Brother Ben, as he is affectionately called, (now a distinguished graduate) is once again in the headlines.

We received a copy of the *Golden Times* newspaper from Joseph J. Boris, in which he had bylined an article entitled "Amateur Radio: A Hobby – A Service." This article, written for non-amateur readers, detailed the involvement of Brother Ben in the International Mission Radio Association (IMRA). This association is made up of a group of radio amateurs who provide

| | 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 |

various services to missionaries and volunteer workers of all denominations. Brother Ben is presently the president of this organization. As part of his job, he travels to various countries to help set up amateur radio stations to provide communications to the missions during emergencies when normal communications are not available.

On one trip in 1970, Brother Ben traveled to Honduras, Central America. After loading up three mules with 150 pounds of radio gear each and riding on the back of a fourth mule for nine hours, he reached the mission at L'Incarnacion. The station he set up there is powered by a generator, as the local electrical supply (when available) fluctuates erratically between 60 and 200 volts. Such wild variations tend to be rather hard on radio gear!

It has been some time since we have heard from (or about) Brother Ben, and we are indeed grateful to Mr. Boris for sending us the article. If any of you ever "make" the local news, send us a clipping of the article and we'll certainly pass along the news in these pages.

One other item before we get to the correspondence from students and graduates. As those of you who have been following this column for any time at all know, I have recently become interested in microcomputers, particularly their use and application to amateur radio. One of the things I have been working on is a program for the computer to "read" Morse code and display it in readable form. Unfortunately, up till now I have not made a great deal of progress, and have only gotten as far as defining the problem in terms of a flow chart.

Then I got the November issue of "73" magazine, and lo and behold an article on page 100 by WB3GCP and WB8VQD entitled "Receive CW With A KIM." Well, I could hardly wait to punch the coding into my KIM! I guess all things eventually *do* come to those who wait. Now I don't have to reinvent the wheel, as the program works as advertised and will display received cw either on a terminal or on the seven-segment displays of KIM, depending on a few lines in the program.

The routine is adaptive as far as speed is concerned, and can track an electronic keyer from about 10 wpm to at least 35 wpm without adjustment. Thirty-five wpm is the upper limit for me since that is all the faster I can manipulate the paddle. However, I'm sure the program can adapt to a much higher rate. The next step is to hook it up to the receiver and see if it will copy W1AW code practice. Real neat!

All this is just by way of showing some of the fine things one can do with a microcomputer. Try getting in on the fun – you might like it.

Now let's see who we have heard from since last time. As you can see, quite a few more people have gotten in

| | | | |
|---|---|---|---|
| Dave | WB3AKI | G | Bethel PA |
| John | WB3JYQ | N | Laurel MD |
| Bob | WA4CSI | A* | Fayetteville TN |
| Jim | WD4IRU | G | Labelle FL |
| Wayne | WB5HMB | A | Garland TX |
| Mike | WA7ZPQ | N | Miles City MT |
| Neil | WD8CHA | G* | Bucyrus OH |
| Ricky | WA2RSW | G | Freeport NY |
| William | W3AMQ | G* | York PA |
| Frank | WB4GXR | T | Ashland KY |
| Hoyt | WD4MOM | T* | Fairhope AL |
| Mike | W6DYC/HZ | – | Saudi Arabia |
| Ted | WB7TEV | A | Sweet Home OR |
| John | WD8EOE | G | Sawyer AFB MI |
| Tom | WD8IBW | A | Quincy MI |
| Jim | WB8ZUL | A | Woodsfield OH |
| Clyde | WD9GMR | T | South Bend IN |
| Dan | WDØBRZ | G | Norton KS |
| Warren | WDØNPT | G* | Virginia Beach VA |
| Dennis | KØPYB | A | St. Louis MO |

*Just upgraded—Congratulations!

touch with us than did last time. Perhaps this is a good omen of things to come in 1978. As usual, those listed first are students and graduates of NRI's amateur courses, while those listed last are students and graduates of other NRI courses.

WB3JYQ, John, phoned us the other day saying he had just gotten his Novice ticket and that he was just about to set up an antenna at his mobile home QTH. John says about the only kind of antenna he can get up is a vertical because of space restrictions. Should work all right, John, and do keep us informed of your progress.

WA4CSI recently upgraded from General to Advanced as a result of his studies. Bob runs a Heath HW-101 with an SB-200 linear into a TA33 beam atop a seventy-foot tower. He is also active on two-meter fm with a Kenwood TR-7400A and an 11-element beam. Bob is a high school senior and enjoys DXing. In addition, Bob would like very much to contact other NRI amateurs on the air with the possibility of setting up some sort of net. This has been tried before, with varying degrees of success, so if anyone would like to have a go at it, drop Bob a line at WA4CSI, Rt. 8, Box 145-E, Fayetteville TN 37334.

WD4IRU went rather rapidly from Novice to General, and expected to try for Advanced in November. Hope you made it, Jim. Just keep hitting those books! Jim also has a Heath HW-101 which he has hooked to a Hy Gain 18 AVT vertical or a multi-band dipole, operating mostly on 10 and 15 meters.

WB5HMB is a graduate of the Amateur program and is now enrolled in the TV Audio course. When he is not studying, Wayne hangs out on 40-, 15-, and 10-meter phone, sometimes going down to 75 or 80. To cover all these bands, Wayne uses a long wire antenna and tuner with his Tempo 1 rig, although he is looking for a tower to put under a two-element tri-band beam. He is also looking for some contacts with other NRI amateurs and is almost always on 28520 Sundays at 2100 Central time, and Thursdays at 2000 Central time. Sundays and Mondays Wayne works out on 40 meters at 7275. Listen for him around 1400 Central time.

Wayne also asked about the CET program and how one goes about getting more information on the program. Well, we're planning an article in a future issue of the *Journal* on just this topic, but briefly, it is a certification program designed to ensure the qualifications of electronics technicians employed mainly in TV-audio repair fields. You can write for more information on the program to: International Society of Certified Electronics Technicians, 1715 Expo Lane, Indianapolis IN 46224.

WD8CHA is another one who has made great strides through the amateur ranks. Neil started from ground zero and went rapidly through Novice and Technician to General. While he is looking around for some good ssb gear, Neil operates 40 meters with an old Heath DX-100 and a new HR-1680.

W3AMQ wrote to tell us of some of his activities up in York PA. William said that at long last he built up his courage, went down to take the General test and amazed himself by passing it. He says that he is keeping busy right now writing a history of the York Amateur Club (founded in 1932, so I'm sure they have quite a lot to write about). When he finds the time, he operates two-meters with a GTX2 and the low bands with a Kenwood TS520S.

WB4GXR sent us a copy of his homemade QSL card which we found quite attractive. Thanks, Frank. He also informed us that he intended to take the General test by Christmas so that he could make full use of his Drake R4B and TX4. Frank likes to work 80 and 40 meters with the Drake gear, and uses a Genave GTX-10 on two meters.

Hoyt, WD4MOM, writes that he recently passed both the Novice and Technician exams and hopes soon to be on the air. Hoyt is a medical doctor down there in Fairhope, Alabama, and says he gets a lot out of being a radio amateur.

Mike, W6DYC writes from Saudi Arabia that he was in Bangkok the weekend of the SEANET DX contest. Mike says he was itching to get on-the-air but couldn't because he did not have a valid HS license. He did have dinner with several local hams while in Bangkok, and says he can hardly wait to get relocated to an area where he can once again get on-the-air.

Tom, WD8IBW, writes that he is just about to complete the two-meter transceiver he is building as part of the Communications Course, and I'm sure that by now he has finished it up. Tom says he particularly likes the modular construction of the rig because it is easy to see just how the various pieces fit together to make the complete transceiver. Well, that's the way we had it planned, and we're glad to see that it works that way for those who are on the receiving end! Tom is studying also for the Extra test, and has not quite gotten his code speed up to 20 wpm. For the time being, he is using the Heath SB400 and SB303 on the low bands, cw only, as he doesn't even own a microphone! Fine business, Tom, and best of luck on the Extra and Commercial tests.

Well, that just about wraps it up for this time. Let us hear from you so that we can keep up-to-date on what the NRI amateurs are doing. Let us know what you would like to see discussed here in these pages as well. We have had several suggestions for topics to write on, and are doing some research at the present time for future columns, but we always welcome any input from you people out there.

Very 73, Ted – K4MKX

# Alumni News

Harry Taylor

## PITTSBURGH CHAPTER HOLDS SERVICE MEETING

The regular November 3 meeting was devoted to servicing a Zenith color receiver. The set had a dim picture and no color. It was found that a 24-volt zener diode was open and that a color module needed replacement. Both the oscilloscope and the voltmeter were used as service instruments and almost all the members joined in checking the receiver, thereby contributing to their knowledge.

The next meeting will be devoted to the election of officers and the planning of a Christmas party sometime in December.

## SPRINGFIELD CHAPTER ENTERTAINS GUESTS

The Springfield Alumni Association Chapter opened its second meeting with 12 members present, one excused, and a woman guest. Mr. Federice Ablog of Mystic can take credit for our guest. The Alumni was pleased to have a woman guest and stated that they would like to see more women take an active interest in electronics. The minutes of the last meeting were read and accepted. The Treasurer reported a sum of $117.75 in the treasury. Chairman Norman Charest said that during the coming months the Chapter would concentrate on repairing the Zenith color TV owned by the Chapter.

Under new business, it was suggested that each member give some thought in the coming months as to where the next picnic should take place. Mr. Park suggested it be held somewhere within a reasonable distance of all members. Also, a new location would enhance the picnic and make it even more enjoyable than the last.

Mr. G. Vaidya proposed an amendment to the bylaws to raise the yearly dues from $6 per member to $8 per member. This was seconded by Mr. Cheymn and adopted by the Chapter.

Chairman Charest stated that Tom Nolan and Harry Taylor would be visiting the Springfield Chapter during the first part of December. The Secretary will send Mr. Lymon Brown and Mr. Rufe an invitation to attend Mr. Nolan's lecture.

The meeting was adjourned at 9 o'clock followed by refreshments.

## FLINT-SAGINAW VALLEY CHAPTER ENTERTAINS NRIAA OFFICERS

The Flint Saginaw Valley Chapter met at South Lane Bowling Lanes on the evening of October 7. The meeting was led by Chairman Andy Jobbagy. Andy discussed a new type of cement that can be used to bond most materials together. He pointed out a few applications and listed several places where it could be obtained in the Flint area.

The meeting was attended by Tom Nolan, who is retiring as Executive Secretary of NRIAA, and Harry Taylor, who will replace Tom as Executive Secretary.

Tom Nolan lead a discussion on the new NRI two-meter transceiver and its servicing techniques. He explained how frequency synthesizers are used in the transceiver to obtain any frequency

### 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.

between 146 and 148 MHz. He also showed how the plug-in circuit boards simplify the work of assembling and servicing the transceiver.

Later, Tom discussed the use of a test jig in servicing color TV receivers. He reminded the members that regardless of the equipment available, a serviceman needs a thorough understanding of receiver circuitry in order to be able to work efficiently. At the conclusion of the meeting, Andy Jobbagy gave a farewell gift to Tom Nolan and presented a Honey Bee's CB QSL card to Harry Taylor.

## DETROIT CHAPTER MEETS NEW EXECUTIVE SECRETARY

The Detroit Chapter met on October 8 at St. Andrews Hall in Detroit. Our new Executive Secretary Harry Taylor attended and was introduced to the members. Harry outlined some of the changes that he expected to make in the Alumni Association, including broadening the membership to include more graduates of the automotive and air conditioning courses.

Tom Nolan gave an interesting talk on electronic theory and procedures for troubleshooting electronic equipment. The members agreed to look into the possibility of buying a permanent home for the Chapter. They also expressed the hope for a Fiftieth Anniversary National Convention to be held in Washington, D.C. in 1979.

## SOUTHEASTERN MASSACHUSETTS CHAPTER ENTERTAINS EXECUTIVE SECRETARIES

The Southeastern Massachusetts Chapter held its September meeting at the home of Chairman Daniel DeJesus. The Chapter was visited by outgoing Executive Secretary Tom Nolan and his successor, Harry Taylor. The technical session centered on a talk by Tom Nolan on transceiver circuits, amateur repeaters, and the servicing of TV sets.

Refreshments were served and everyone enjoyed meeting the new Executive Secretary.

**The following ballot lists the names of those nominated to serve as officers of the NRI Alumni Association for the 1978 term. Please fill out your ballot and return it to NRI as soon as possible. The names of those elected will be announced in the next issue of the Journal. POLLS CLOSE AT MIDNIGHT ON JANUARY 31, 1978.**

### 1978 Ballot

**For President (vote for one):**

- ☐ **Boyd A. Bingaman** — Folcroft, Pennsylvania
- ☐ **Joseph M. Burnelis** — Pittsburgh, Pennsylvania

**For Vice President (vote for four):**

- ☐ **Norman Charest** — Springfield, Massachusetts
- ☐ **James L. Dawson** — Franklin, Indiana
- ☐ **Daniel DeJesus** — Fair Haven, Massachusetts
- ☐ **Barry A. Goodwin** — Scranton, Pennsylvania
- ☐ **Sam Antman** — Brooklyn, New York
- ☐ **David Leech** — Farmington, New Mexico
- ☐ **Al Mould** — Kearny, New Jersey
- ☐ **Eldred M. Breese** — Pineville, Ohio

**Your Name** ______________________________

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**B →**

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