EXTENSION 4-H BULLETIN 65
1967

ADVANCED 4-H ELECTRICAL BULLETIN

AGRICULTURAL EXTENSION SERVICE
U. S. DEPARTMENT OF AGRICULTURE
University of Minnesota

The 4-H Advanced Electric Project

The beginner and junior phases of the 4-H electric project have given you some background knowledge and experience in working with electrical energy. You have learned that electricity is a very helpful friend when used properly. The advanced phase of this project will add to your electrical know-how by suggesting intriguing and challenging things to do and make. It also includes an electronics section. However, you need not be limited to things suggested in this bulletin. Use your imagination and ability to the fullest to explore the subject in depth.

Project Phases

Suggested ages for each project phase are: beginners 9-12; juniors 12-15; and advanced 15-19. Most club members will want to spend 2 or 3 years in each phase. Moving from one phase to the next will depend on your experience with and knowledge of electricity.

Purposes of the Advanced Project

- To help 4-H Club members increase their knowledge of electricity and how to use it effectively and safely.
- To encourage 4-H Club members to apply their knowledge of electricity by making useful electrical devices and by maintaining home or farm electrical equipment.
- To encourage 4-H Club members to concentrate on some phase of electricity, such as electronics.
- To help 4-H Club members learn about career opportunities in the electrical industry.

Project Requirements

Each year study four or more different units that interest you. Answer the questions at the end of each unit. Make electric items that are useful in your home or on your farm or help you learn more about electricity. Each unit suggests things to make and do, but again you need not restrict yourself to these—use your imagination along with your ability. If possible, give electric demonstrations at your 4-H meetings and county 4-H events.

Of course, your electronic work need not be limited to the units listed below. Design and build other electronic equipment you think will be useful. Or, assemble your own electronic kit if you are a beginner in electronics. This will help you learn electronic terms, identify parts, teach you to follow directions, and to assemble intricate parts. Many electronic companies offer free catalogs listing parts and kits. Two such companies are:

Heath Company
Benton Harbor
Michigan

Allied Radio Corporation
100 North Western Avenue
Chicago, Illinois

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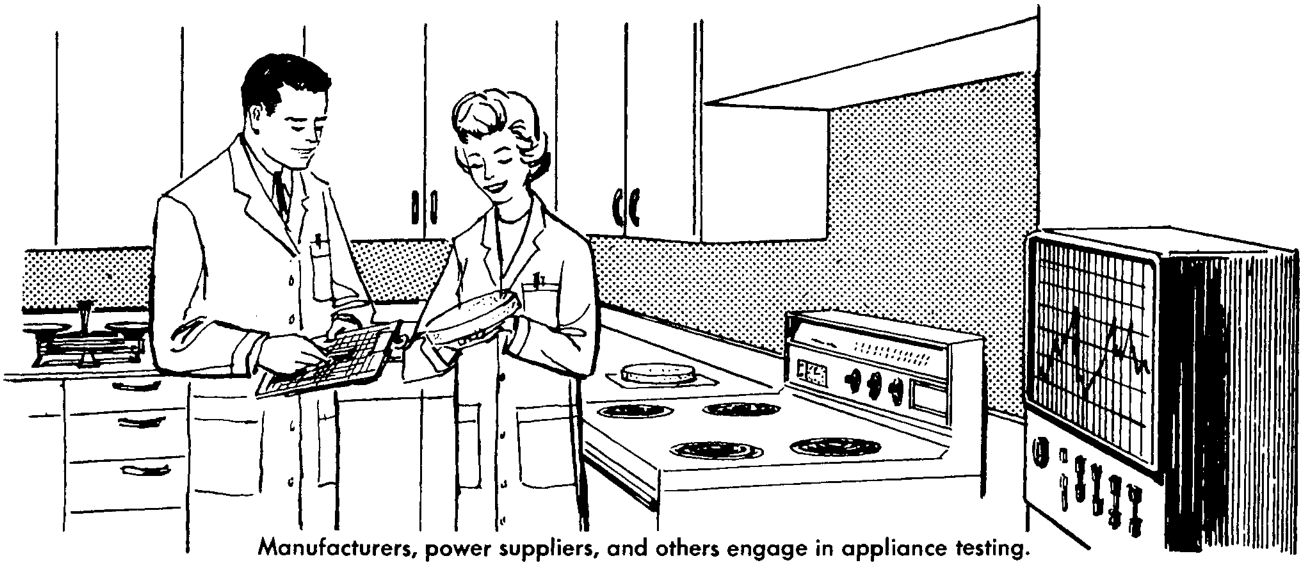
AN ELECTRICAL CAREER FOR YOU?



Manufacturers, power suppliers, and others engage in appliance testing.

What will your career be? Will you work at something you like, at something which rewards you according to your abilities and interests?

These are important questions for people of your age, and ones about which you already may have thought seriously.

Experience has shown that people work better and are happier doing the things that they like to do. If you are interested in electricity, then it is possible that you might do well in a career that is electrically-related.

What to Do

1. Acquaint yourself with some of the many electrically-related careers.

2. Visit, with other members of your group, one or more of the following: power supplier office, generating station, appliance or electrical equipment manufacturer or distributor or dealer, an electrical contractor or electrician.

3. Learn as much as possible about those careers that most interest you by:

Reading as much as you can about them, talking to people in your community who work at these jobs or who know about them, and writing to others for more information.

4. Help build up a library of information on electrically-related careers for use by others in your community or county.

Materials You'll Need

Pen or typewriter, pencil, paper, envelopes.
Books and folders on various electrically-related careers, available from larger employers and their trade associations.
Names, addresses, and/or telephone numbers of people who work in electrical jobs of interest to you, or who are in personnel work in some part of the electric industry.

Electric Industry Is Big

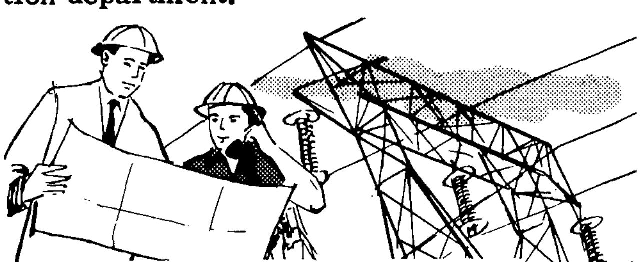
When you speak of the electric industry, you are referring to something that touches the life of almost every person, that reaches into every community, and that employs millions of people in hundreds of different kinds of jobs.

There are many ways in which you could divide the electric industry, but for our purposes, let's break it into four main parts: power supply, equipment or apparatus, appliance, contracting (wiring).

Power Supply

The power supply part of the industry is that which supplies the actual electricity to consumers. It does not always include all of the following functions, but it may: generation of power, transmission (long-distance high-voltage movement) of power, and distribution of power to the ultimate user.

This is a part of the industry that you may know something about--because you often see the employes of your own power supplier at work. You may see meter readers, linemen, and cashiers--and perhaps someone from the power supplier's sales or utilization department.


Men design, build, and maintain lines.

But there are many other career opportunities with power suppliers that you may hear about only rarely.

All of these different kinds of work must be performed by someone who is employed by a power supplier:

Managing the business (larger power suppliers have several levels of management); hiring, training, and looking after the safety and welfare of employes; billing and collecting consumer accounts; testing and installing meters; selling and demonstrating the benefits of electricity to consumers; designing and drafting plans for generating stations, substations, and lines; operating power stations; handling consumer problems; conducting information programs for employes, consumers, and the public; buying, storing, and keeping track of materials and supplies; buying real estate and rights-of-way; keeping countless kinds of records; typing, duplicating, and filing reports and correspondence; operating office equipment ranging from adding machines to the most complex computers; driving and servicing motor vehicles; building and maintaining lines and substations; planning; and researching new ways to do things.

Apparatus or Equipment

This is the part of the industry concerned with manufacturing, distributing, and selling electrical equipment used by power suppliers and by other industries including agriculture.

The things made and sold include everything from giant turbine-generators down to tiny fuses. The kind of work varies from that of the president of a giant corporation to that of a person whose only responsibility is keeping a warehouse clean.

This part of the industry employs thousands who work in its manufacturing plants, where they operate machines and handle raw materials and finished products. It has many other people whose job it is to explain and sell these products, either to the ultimate users or to distributors or jobbers, and to electrical contractors and electricians.

There are many records to be kept, and many letters and orders to be typed and filed. There are advertising materials to be prepared, and all kinds of purchases to be made. There is research to be done, and of course much management and supervision is necessary throughout.

Those who sell this equipment to the ultimate user often help plan the installation, and advise as to how it should be used. There are specialized farm electrical equipment manufacturers, distributors, and dealers who provide such service.

Appliance

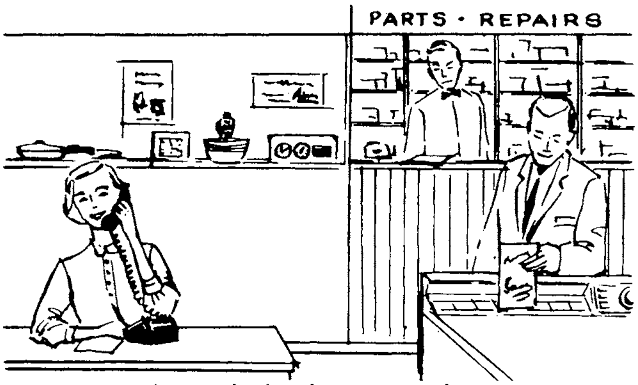
When people in the electric industry speak of appliances, they are usually referring to power-consuming equipment as used <u>in the home.</u>

There are dozens of manufacturers of appliances, hundreds of wholesalers, and thousands of dealers. In addition, there are many independent appliance repairmen.

Like the makers of apparatus and equipment for industry and agriculture, the manufacturers of appliances must buy and convert raw materials into finished products.

Then they must sell and distribute these products to distributors. Then the latter must sell the appliances to dealers, and the dealers in turn sell to consumers.

Of course there are career opportunities with the manufacturers and distributors, similar to those described under Apparatus or Equipment. These opportunities are more concentrated in centers of population.



Appliance dealers hire men and women.

Scattered over the whole country, however, are the places of business that sell appliances to consumers and provide the repair services needed. These businesses vary all the way from a giant department store to a one-man shop. In the larger stores, the functions of buying, advertising, selling, billing, handling parts, and repairing will be divided among many different people. In a small place, however, one person may do many different kinds of work.

Contracting (Wiring)

Electrical contractors and electricians are the ones who install and maintain the wiring in homes, stores, offices, factories, farms, mines, and public buildings.

Most of the people employed by this part of the giant electric industry are those who actually do the wiring, but there are others whose work is not so obvious. Included are those who supervise, plan, estimate costs, hire and train employes, purchase and keep track of materials, and handle office details.

Like the appliance dealers, electrical contractors vary in size from the very large to the very small, and the number of jobs performed by any one person will be fewer in the large establishment, greater in the small place.

Trade Associations

There are many organizations within the electric industry. Some are national, others are statewide, and some are local or regional. Many have full-time employes.

A small trade association may have only two employes--an executive secretary or director, and an office worker. But a large one may have a dozen or more--including an executive, plus specialists in many different fields such as safety, public relations, home economics, agriculture, and other areas.

What Kinds Of People?

Careers in the electric industry are open to people with a wide variety of interests, aptitudes, and training.

All parts of the industry employ both men and women. Women are needed in manufacturing for light assembly work, in the appliance and power supply businesses in both research and sales, and throughout the industry to handle office detail and special jobs like nursing.

Of course, all employers are looking for people who are honest, dependable, sincere, willing to work, and who are able to get along with others.

Training Essential

A minimum of a high school education is recommended for a job in the electric industry, but some jobs require much more training.

Here are the more common types of training that are helpful to those who would like to find a career in this field:

Electrical engineering--Many men, and even some women, have met the requirements for the jobs of their choice with this kind of training. Top positions throughout the industry are filled by such people.

Other engineering--Civil, mechanical, industrial, chemical, and electronics engineers also find employment in the industry, but to a lesser extent than electrical engineers.

Agricultural engineers are employed by many power suppliers in their rural sales departments, and by manufacturers of electrical farm equipment.

Business college--Women in particular will find this or similar training helpful. Some employers seek young men with business administration degrees as sales and management trainees.

Technical school--Many trained technicians, whose work does not require a college degree, are hired by the industry.

Apprenticeship--This form of on-the-job training is often the way that a newcomer qualifies himself for work in the field.

Home economics--Women with degrees in this field are sought by power suppliers for home service work; by appliance companies for research, testing, and selling; and by advertising and public relations departments and agencies.

Which Career For You?

Choosing a career is one of the most important things that you will do in your life.

Your chances of making the right choice will be better if you will do two things:

1. Learn something about a great many different careers, so that you will be more likely to find one that you are interested in and fitted for.

2. Learn as much as possible about yourself, so that you will know which careers you are qualified for.

Questions that will help you on point 2, above, are ones like these:

What are your special interests?
What are your hobbies?


What kind of a person am I?

Which activities do you enjoy most?
What has been your school record?
Do you like indoor or outdoor work?
Do you enjoy working with others, or do you prefer being by yourself?
Where do you live now? If a suitable career is not open to you there, would you be willing to move elsewhere, such as to a large city, or to a remote area?
What type of training is available to you?

What Did You Learn? (True or False)

1. The electric industry refers only to supplying power to consumers.

2. Meter readers, linemen, and cashiers are the three major groups of people who work for power suppliers.

3. Electronic computers are sometimes used by power suppliers.

4. A girl has no chance of a career in electrical equipment.

5. Everyone who works in the industry must have an electrical engineering degree.

6. Manufacturers, distributors, and dealers are parts of the appliance industry.

7. In a town of 2,000 population, there is a good chance that you could have a career strictly as an appliance parts man.

8. If a man works for an electrical contractor, chances are he's an electrician.

9. Honesty and dependability are not very important in the electric industry.

10. To know thyself is important in choosing a career.

For More Information

Consider part-time or vacation work in some part of the electric industry that interests you. Visit with your school guidance counselor. Write to the placement directors of technical schools and colleges. Ask your leader to secure one or more film strips or motion pictures on careers. Attend a careers program at your school.

MAKE A CONTINUITY TESTER

When something electrical won't work, the chances are that the current is not getting to where it should go, or else going somewhere that it shouldn't!

With a tester that you can make yourself, it's possible for you to find and correct many such failures. You'll also be able to know whether appliances are safe or not.

You'll find circuit testing and trouble shooting to be fascinating. It is also important to you and to your mother and father and other members of your family to find out if the equipment and appliances that they use are perfectly safe at all times.

What to Do

1. Make a battery-operated bell or buzzer continuity (circuit) tester.

2. Learn how to use it safely.

3. Use it to test some cords and appliances for short circuits, grounds, and open circuits.

4. Record what you found.

Tools and Materials You'll Need:

2 #905 dry cell batteries

10 ft. of flexible insulated one-conductor wire (or split a 5-ft. piece of brown rubber-covered lamp cord.

Bell or buzzer

Tape (plastic or friction)

2 small clips (either battery or "alligator" type)

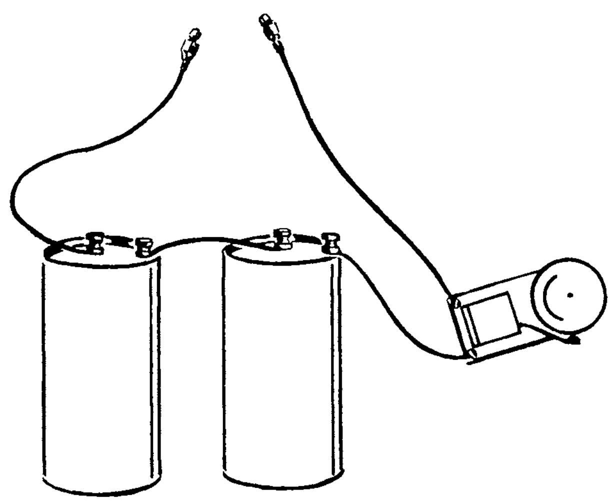
Knife

Electrician's pliers

Assemble Your Tester

Cut the wire into two 5-ft. pieces. Cut a six-inch piece from one end of each 5-ft. piece. Remove 3/4-inch of insulation from each end of all four pieces.

Attach the clips, one to each of the two longer pieces of wire. Then, connect the batteries and bell or buzzer as shown in the drawing.



Finally, tape the batteries together and the bell or buzzer to them, as shown in the upper picture.

Test Your Tester

When you touch the two clips together, the bell or buzzer should sound. Try it and see if it does this.

If it does, you are now almost ready to begin to use your tester.

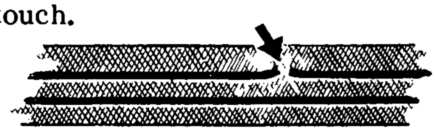
Always Disconnect First

Whatever you are testing must always be disconnected from its 115 or 230-volt alternating current supply before you attempt to check it with a battery-operated tester.

Always keep this in mind. You will not endanger yourself or anyone else if you observe this simple rule.

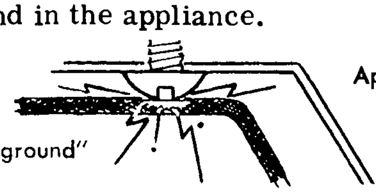
Make Three Kinds of Tests

By touching the two clips to two places along the path that electricity flows, you can quickly tell whether or not that path is complete. This is a check for an open circuit, and the bell will ring only if the circuit is continuous between the two points your clips touch.



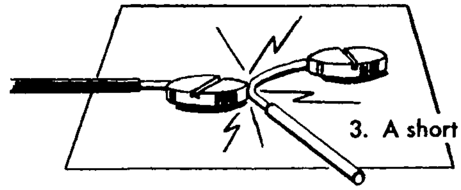
1. An open circuit in a cord

To check for a "ground" (flow of current to the frame of an appliance) touch one clip to the frame and the other to one of the insulated terminals. If the bell rings, there is a ground in the appliance.



2. A "ground"

If there is a short circuit in an appliance, we usually discover it through the blowing of a fuse or tripping of a circuit breaker. However, the use of your tester will help you to find the actual location of the short. To test for shorts, first disconnect the part of the appliance that actually uses the power, as close as possible to it. (On a lamp, for example, simply unscrew the bulb.) Then attach your clips to corresponding places along the two wires that supply power to the appliance, starting at the plug on the end of the cord.



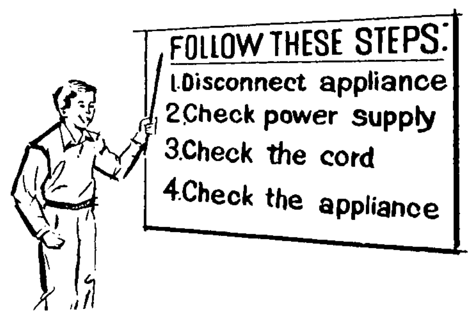
3. A short circuit

If the bell rings, you have discovered a short. Try to locate it by moving up to the next point where you can attach your clips, first disconnecting the cord where it enters the appliance.

Check from the Source to the Use

If an appliance fails to operate, we are apt to think that the trouble lies within the appliance itself. In many cases, however, this is not true. Instead, the reason it doesn't work is that it is not receiving electricity from the outlet or through the cord.

Because of this, and because of the wisdom of scientific practice, we should "move from the known to the unknown."

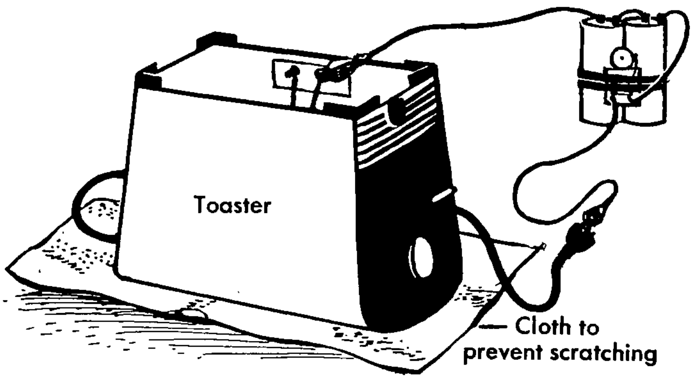


Follow these steps, then, in checking for trouble:

1. Plug another appliance or light into the same outlet. If it works, then you have eliminated possible trouble up to that point. If it doesn't work, go to the fuse or circuit breaker.

2. Check the plug and cord of the offending appliance. If it is a detachable cord (one with plugs on both ends), remove it from the appliance. Attach one clip to one of the wall plug prongs, and touch the other clip to the metal contact in one or the other of the slots in the appliance plug. One or the other should cause the bell to ring. Then move the first clip over to the other prong, and a touch of the second clip in the other slot should cause the bell to ring again. (If the cord has a temperature control or switch built into it, make sure that this is in the "on" position.)

3. If the cord and plug are attached, you follow a similar procedure, but it will be necessary to "open up" the appliance to get at the terminals to which the cord is connected inside.



4. If the cord and its connections are good, then you should start checking the appliance itself for a broken wire or a bad element or an open circuit. Touch the clips to various points along the wiring within the appliance to determine whether there's a path for the current.

If you cannot pinpoint the trouble, or if you cannot repair it when you do locate it, then you should take the appliance to an authorized service agency.

Check Appliances for Safety

It is good to check your appliances occasionally for shock hazard. To do this, touch one clip to the metal frame of the appliance. Touch the other to the cord plug prongs, one at a time. If the bell doesn't ring, there is no apparent shock hazard.

Be sure that the appliance is disconnected from the outlet while you are testing.

What Did You Learn?

1. When you touch the leads (clips) of your continuity tester together, they act like (a switch, an electromagnet).

2. The bell should ring (every time, half of the number of times) we randomly connect to a prong and a slot at opposite ends of a detachable appliance cord.

3. If current is leaking from within an appliance to its frame, we call it (an open circuit, a short, a ground).

4. If there's a break in one wire in an appliance cord, we call it (an open circuit, a short, a ground).

5. If the two wires in an appliance cord are touching, we call it (an open circuit, a short, a ground).

6. If an appliance fails to operate, the first place to look is (inside it, the outlet supplying it).

7. In checking for trouble, as in science, we always move (from the unknown to the known, from the known to the unknown).

8. When you are checking appliances with your tester, you should disconnect the 115 or 230-volt alternating current (always, only when you think there's danger).

Demonstrations You Can Give

Show and tell others how to assemble a tester, and how to use it to find shorts, grounds, and open circuits. Be sure to point out the safety precautions that must be followed.

For More Information

Ask an appliance repairman or an electrician how they use their test equipment. Ask your power supplier representative about the importance of test lamps to the safety of linemen.

Chart Your Results

Make a chart like this one and write down the appliances and cords that you have tested, what was found, and what you did to correct the trouble.

Appliance Tested	Condition	Action Taken
Clothes Dryer	Ground in motor circuit	Wrapped wire with tape

KEEP MOTORS HEALTHY

BE A MOTOR DOCTOR

Electric motors, like people, must be kept healthy if they are to work at their best. Motors, too, can get sick and, like people, need a check-up from time to time. It is important, therefore, that we know what can make a motor sick and, when signs of illness appear, remedy the trouble before it becomes serious or is too late.

You can and should learn what these common ailments are and examine your motors from time to time. In fact, it is well to frequently lend eye, ear, and nose to a motor when it is running, so you may see, hear or smell any trouble that may be in the making. If a motor doesn't look, sound or smell just right, or is otherwise ailing, doctor it without delay because the equipment in your home or on your farm that is run by motors cannot do its best if the motors do not run properly.

Motors Can Have Many Ailments

If motors could talk, probably some motor about your house, shop or barn would be shouting, "Help! I'm just shaking to pieces! Fasten me down," or "I'm burning out!" or "I'm getting sick! Do something quick."

HOW YOUR MOTOR BREATHES

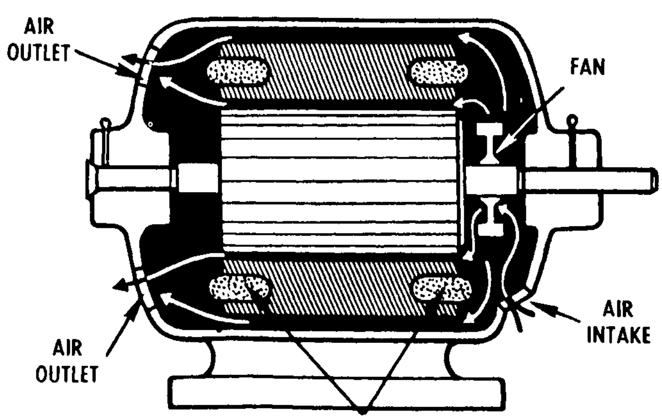


Figure 1

Dirt and dust, moisture, vibration, over-heating, greasiness, and sparking--any one or a combination of them--can cause a motor to be sick.

Dirt, Dust and Lint:

When open motors run, they breathe in air. All air contains some dust, and some air in which motors work is very dusty. As dust, lint and dirt is drawn into a motor, some naturally collects on the frame and on all the working parts. The motor cannot get rid of this dirt by itself and in time the air vents may become clogged so much that the motor cannot "breathe" as it should. This will cause the motor to heat and in extreme cases could cause the motor to burn out.

Dampness

Air contains some moisture. Moisture, whether you can see it or not, is an enemy of motors. In damp places and during damp, humid weather, moisture may condense on the motor windings and other motor parts and soak into the insulation in the motor to cause serious trouble. Water may drip on the motor or be splashed on it from a wet floor.

Vibration

One might say that motors do their work by pulling, turning, or pushing their load. That means that they must have solid footing and not be sliding, slipping or vibrating around if they are to work their best. A motor may stand a slight vibration for a time, but too much vibration, if it continues, can damage a motor by literally shaking it to pieces. Then, too, when an electric motor vibrates, some of the electricity is wasted. This increases your electric bill.

Over-heating

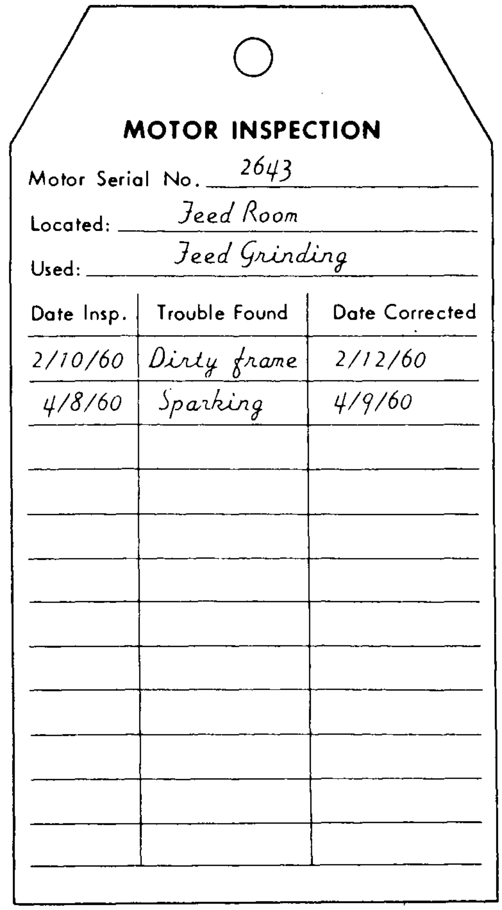
Motors like people, cannot work well when too warm or over-heated. Dirt and dust, vibration, over-loading or a combination of these, can cause a motor to overheat. If motor windings become too hot, the insulation can become damaged and if they stay too hot long enough, they can burn out. This can ruin a motor or at least it can cause an expensive repair job. Just the same as with vibration, over-heating is produced by wasted electric current that does only harm and increases the electric bill.

Oil and Grease

Oil and grease may leak out of bearings and when warmed by the motor can spread onto the windings and other insulated wires in the motor. Most insulation can be harmed by oil and grease. A good motor doctor will look for this ailment when he checks a motor.

Sparking

When the motor brushes become worn or the commutator on which they run become too rough, sparking may occur. Water or dust, also, may cause sparking. Sparks are wasted electricity and can cause heating at the brushes. If the motor sparks, it needs adjustment or repair, or both.



MOTOR INSPECTION

Motor Serial No. 2643

Located: Feed Room

Used: Feed Grinding

Date Insp.	Trouble Found	Date Corrected
2/10/60	Dirty frame	2/12/60
4/8/60	Sparking	4/9/60

Figure 2

What To Do

1. Inspect your motor or motors regularly.
2. Make an Inspection Tag for each motor.
3. Clean a motor.
4. Give a motor cleaning demonstration.

How to Do It

1. Inspect your motor regularly.

When you inspect your motors, look for:

- Dirt, dust, lint
- Moisture
- Sparking
- Vibration
- Stray oil and grease
- Over-heating
- Poor belt alignment
- Too tight or too loose belt

2. Make and keep an Inspection Tag for each motor.

Have a regular schedule for inspecting your motors. Make a tag for each motor (Figure 2). Then you'll have a case history on each motor, and can notice if the same difficulty keeps recurring. If it does, you can find out what causes the trouble, and have repairs made accordingly.

3. Clean a motor.

By being careful, you can clean a motor, put it together again, and have it running in apple-pie order. Once you've learned to do this, you can keep your motors in tip-top shape. Then you'll only need to take them to a shop when major repairs are needed, such as rewinding, repairing commutator or replacing worn parts.

You'll Need:

A motor
Wrench and screwdriver
Tire pump or vacuum cleaner with attachments for blowing
Rags (lintless)
Clean, dry paint brush
Non-flammable cleaning fluid (carbon tetrachloride is not recommended because

of its toxic effects, and its injurious effect on insulating varnish. A motor repair technician can recommend a good cleaning fluid).

Steps To Take:

1. Make sure that the motor is completely disconnected from the power line.

2. Remove the pulley from the motor shaft, if necessary.

3. Take the motor apart (Figure 3) by removing the rotor, shaft, and fan assembly. Be careful not to break any connections or wires. Before loosening the end bells, mark the position of the bells on the motor frame.

4. With a tire pump or vacuum cleaner attachment, blow loose dirt from the windings and from inside the end plates. Use a dry paint brush or rags to carefully wipe away any dirt that remains.

5. Wash metal parts with non-flammable fluid (Figure 4). Be sure to remove all dirt from air passages in the frame and in the rotor. Do not apply cleaning fluid to the coils of the motor unless absolutely necessary - then use a solvent-moistened cloth. Never immerse motor windings in the solvent.

6. Wipe motor parts dry.

7. Inspect the starting switch, the commutator and brushes, if any, to see whether they need repair.

8. Reassemble the motor. Be sure that all parts go back in their correct positions.

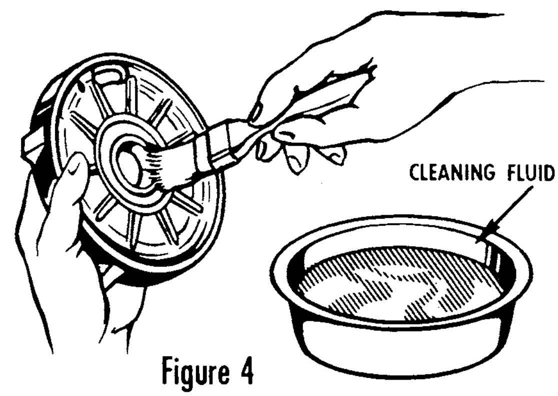


Figure 4

Tighten the end plate nuts one after the other, a little at a time, to pull the end plates up evenly. Make sure the shaft turns freely as you tighten the end plates.

9. If necessary, sparingly lubricate the motor bearings. The kind and amount of lubrication will be shown on the motor nameplate or in the manufacturer's instructions.

10. Reconnect the motor to check its operation.

4. Give a motor cleaning demonstration.

- Show how you took your motor apart for cleaning.
- Identify the parts and tell or show how each part should be cleaned.

For Further Information

Ask someone from your power supplier, or a motor repair technician to give a talk on common motor troubles and how you can correct them.

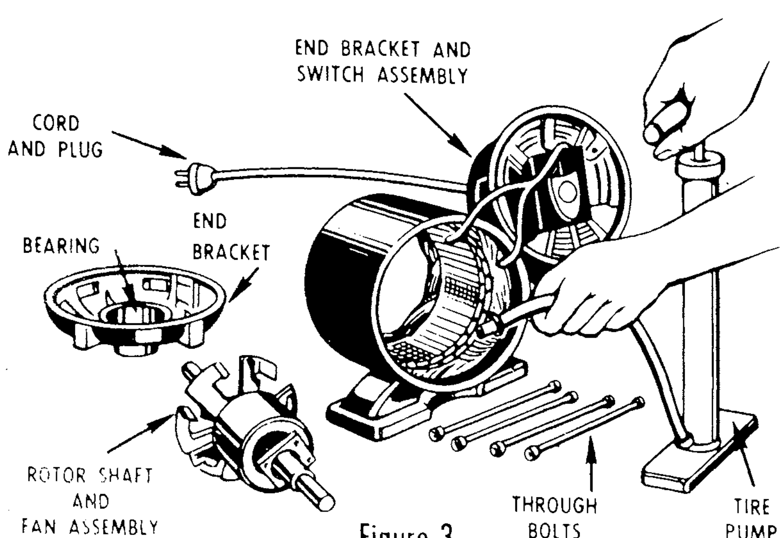


Figure 3

Some Common Motor Ailments and Their Remedy

TROUBLE	SOLUTION
Dirt, Dust, and Lint	Clean thoroughly. Use recommended cleaner.
Dampness	Clean and dry the motor and its parts. If possible, remove the cause of the trouble.
Vibration: Motor not properly supported	Firmly fasten the motor stand to the motor supports.
Motor not properly balanced	Have balanced and align properly.
Fan, pulley or shaft unbalanced	Have repaired and balance properly.
Over-heating: Caused by - Dirt, dust and lint	Clean thoroughly.
- Overload	Install larger motor, or lighten load.
- Dry bearings	Check the bearings. Follow the directions for proper lubrication.
- Belt being too tight.	Loosen bolts in stand. Move motor forward for proper tension.
Old or too much grease	Clean the motor. Use recommended kind and amount of lubricant at designated points.
Sparking: Caused by Worn brushes	Have brushes adjusted, repaired or replaced.
Rough or worn commutator	Clean the commutator. Consult service man or machinist about need for repair.

Make These Tests Before Calling A Serviceman

Mechanical

Be Sure:

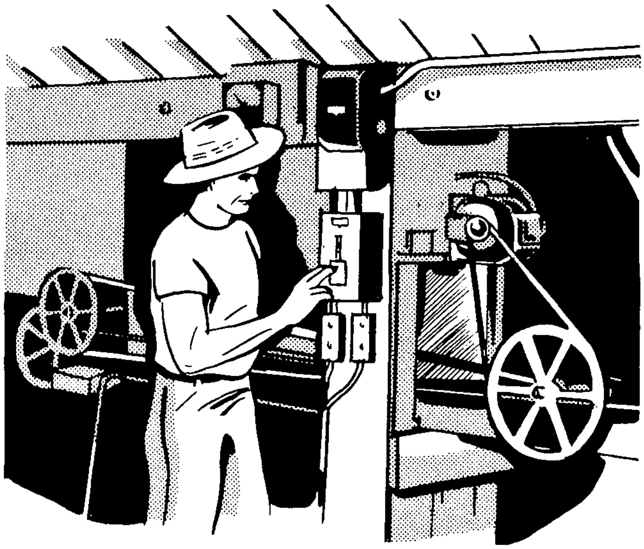
1. The armature is free to revolve.
2. The bearings are in good condition and properly lubricated.
3. There is no obstruction to prevent free rotation.
4. All bolts and nuts are properly tightened.

Electrical

Be Sure:

1. The motor is operating on its rated line voltage.
2. The fuses or overload protective devices are in good condition.
3. That all connections and contacts in the circuit and at the terminal are properly made.
4. The load operated by the motor is not stalled.

MOTORS instead of MUSCLES



WHETHER you live on a farm or not, did you ever stop to think how much time and effort has been used just to move things from one place to another?

People who run factories and warehouses call this "materials handling." They long ago learned that if they were to be successful in this competitive world, they would have to handle materials as economically as possible. They found that, in most cases, they could not afford to move things using manpower.

Long before this, they had discovered that the processing of materials was something that human power could not do nearly as economically as mechanical power (and in many cases humans couldn't do it as well!).

Now, homemakers and farmers are finding that these same things are true--that they cannot afford to move and process with human power, if a practical way can be devised to do these things mechanically.

What to Do

1. Prove to yourself and others that it's good business to substitute motors for muscles where you can.

2. Make a survey of jobs around your home or farm that could use motors to replace muscles. Make a list of jobs that have already been mechanized.

3. On a piece of equipment driven with a V-belt, check the speed of the motor on the nameplate, and measure the diameters of the two pulleys. (CAUTION: make sure the motor will not start while you are measuring.) Figure the rpm at which the equipment is turning.

1. Why Use Motors?

If you do a job that an electric motor can do, do you know what kind of wages you are earning? Use these materials to help you figure your wages:

Three 8-inch concrete blocks
Truck bed or heavy table
Watch
Rule

One member of the group moves blocks from the floor to the truck bed or table as fast as he can for a 30-second period. His partner replaces the blocks on the floor. Another member keeps time with the watch.

At the end of the run, count the number of blocks lifted and record in the formula. Weigh one of the blocks or estimate its weight (average 40 lbs.) and record in the formula. Measure the height from the floor to the table or truck bed and record in feet.

Multiplying the number of blocks by the weight times the height in feet gives the number of foot-pounds of work done. Multiplying this by 2 gives the work done in one minute. Dividing by 33,000 results in the number of horsepower (hp) developed.

$$\text{hp} = \frac{\text{foot-pounds per minute}}{33{,}000}$$

$$\frac{\_\_\_\text{ blocks} \times \_\_\_\text{ lbs. (wt./block)} \times \_\_\_\text{ ft. (table height)} \times 2}{33{,}000} = \_\_\_\text{ hp}$$

Your answer should be less than one hp, since a grown man cannot develop much over 1/10 hp for a very long period.

What would it cost to run a 1/10 hp motor for 10 hours with electricity selling at 2 cents per kilowatt-hour? (1 hp equals about 1,000 watts or 1 kilowatt)

There are other reasons for using motors instead of muscles:

Motors never get tired, as you probably did when you were lifting those concrete blocks from the floor to the table for just half a minute.

Motors are on duty 24 hours a day, with no extra pay for overtime or the night shift, or concern about holidays and vacations.

Motors will go into operation automatically whenever a sensing or timing device tells them to.

Motors can be remotely controlled, so that they can work where we would find it uncomfortable or dangerous.

2. What Motors Can Do

Electric motors can do thousands of jobs. Properly connected to the right kind of machines, they can move liquids, solids, and gases up, down, across, or just about any way we want to have them moved.

Motors can process, whether this be laundering clothes, stirring up a cake, lowering the temperature of milk, or washing fruit.

On our farms, materials handling with electric power is one of the greatest advances since the first tractor. Like tractors, however, electric motors must be carefully matched with the other equipment in the whole system. This is necessary so that one machine will not be underloaded, and perhaps the next one overloaded. As with anything, it pays to plan ahead.

What Kind of Motor?

There are several types of motors, and you should know which type to use for various jobs where single-phase electric service is available.

Split-phase motors are generally the least expensive, but their use is limited to jobs requiring from 1/4 to 1/3 horsepower, and which start easily.

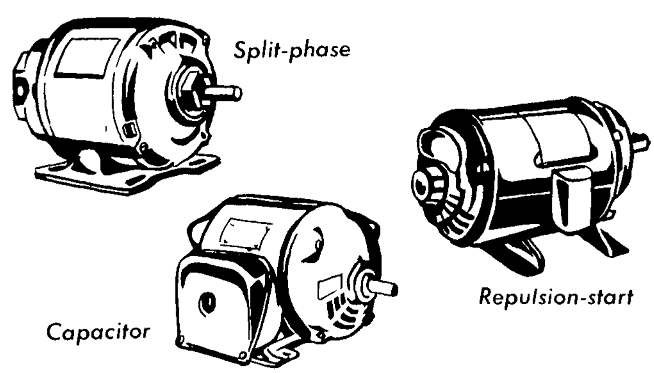
Capacitor motors are designed for medium to hard starting loads, and they are available in sizes from 1/3 horsepower on up.

Repulsion-start motors are for very hard-starting jobs, from 1/2 hp on up.

The position in which your motor will work is important. Any motor will work in a horizontal position. If your job calls for tilted or vertical operation, your motor must have ball bearings to take care of the end thrust.

You should also know of the power requirements. You can get this by looking at similar equipment that was fitted with a motor by the maker.

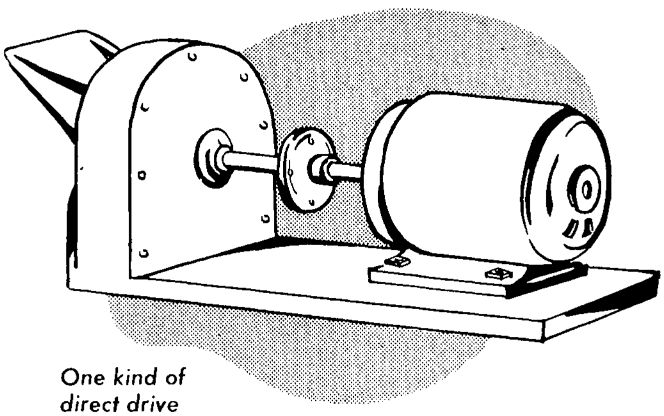
The kind of housing your motor should have is determined by the environment where it is to work. Drip-proof (the most common) housings will keep out water that drips from above. Splash-proof housings will keep out water that might splash up from below. Totally enclosed motors will keep out all water and dirt. Explosion-proof motors will prevent a spark in the motor from igniting dust or fumes.



The voltage at which you will operate your motor depends usually on its size. Those a half horsepower or smaller are usually operated on 115 volts, and bigger motors on 230 volts. If you try to operate motors bigger than 1/2 hp on 115 volts, you may have trouble.

3. How to Put Motors to Work

You will need some kind of a drive mechanism to connect the motor to the machine you wish to operate. One kind is called the direct drive and another is the belt drive. Both are practical.



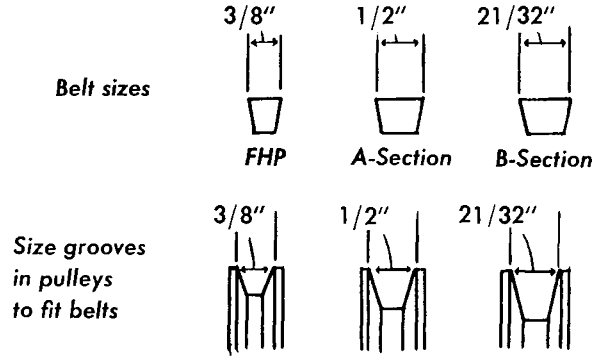
One kind of direct drive

The direct drive is not common, because it requires that the motor speed and the equipment speed be the same. Equipment such as vacuum cleaners, fans, and centrifugal pumps are often mounted directly on the motor shafts. Equipment that has separate bearings must have a flexible shaft or coupling between the motor and equipment shaft.

The most practical and popular drive is the V-belt and pulley. V-belts are easily installed and it's easy to get the speed you need. They also absorb shock and vibration, come in standard sizes, and almost never slip off the pulleys.

Use the Right V-Belts

V-belts and pulleys are made in various sizes. The pulley groove width should always match the belt width. Fractional-horsepower (often abbreviated FHP) belts are used for small motors equipped with pulleys that are 2-1/2 inches or less in diameter. A-section belts and pulleys are used for most farm jobs requiring 3/4 to 5 horsepower. Motor pulley size should be at least 3 inches in diameter. B-section belts and pulleys are used on 3 horsepower or larger motors. Here the motor pulley size should be 5-1/2 inches in diameter or larger.

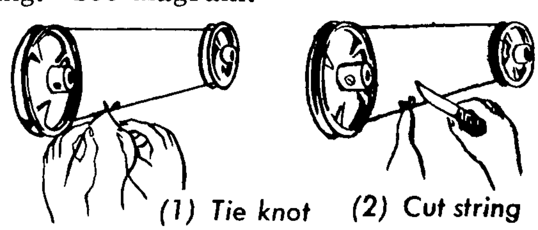


V-BELTS RECOMMENDED ACCORDING TO SIZE OF DRIVE PULLEY AND HORSEPOWER OF MOTOR.

Diam. Motor Pulley Inches	Number and Type of Belts Required Horsepower of 1750 RPM Motors							
	½	¾	1	1½	2	3	5	7½
2	1-A	2-A	X	X	X	X	X	X
2½	1-A	1-A	X	X	X	X	X	X
3	1-A	1-A	1-A	2-A	2-A	3-A	5-A	8-A
3½	1-A	1-A	1-A	2-A	2-A	3-A	4-A	7-A
4	1-A	1-A	1-A	1-A	2-A	2-A	3-A	5-A
4½	1-A	1-A	1-A	1-A	1-A	2-A	3-A	5-A
5	1-A	1-A	1-A	1-A	1-A	2-A	3-A	4-A
5½	1-A	1-A	1-A	1-A	1-A	1-B	2-B	3-B
6	1-A	1-A	1-A	1-A	1-A	1-B	2-B	2-B
7	1-A	1-A	1-A	1-A	1-A	1-B	2-B*	2-B
8	1-A	1-A	1-A	1-A	1-A	1-B*	1-B	2-B
9	1-A	1-A	1-A	1-A	1-A	1-B*	1-B	2-B

*Type A could be used instead of Type B.
X Pulleys less than 3 inches in diameter should not be used for motors 1 hp and larger.

To figure the proper length of a V-belt for a motor already mounted, measure the distance around the pulleys with a piece of string. See diagram.



(1) Tie knot in string *(2) Cut string* *(3) Measure string*

If the motor does not have to be mounted in a certain place, the following formula will give you the length of belt that will be most efficient:

Add:

5.6 x diameter of larger pulley, and 1.6 x diameter of smaller pulley, to get the total length.

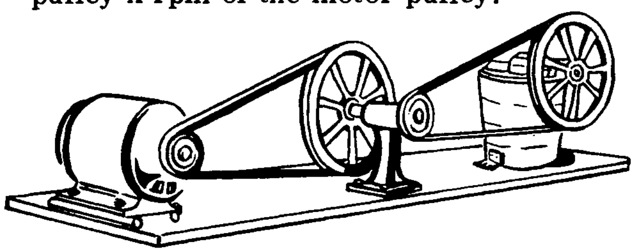
When you find the total length, buy the standard length belt that comes closest.

Pick the Right Pulleys

Most farm equipment does not operate at the same speed as its motor. For example, a hammer mill may require a speed of 3000 rpm; a tool grinder, 2000 rpm; a hay drying fan, 1150 rpm; and a feed auger a much lower rpm. To change the motor speed to the required equipment speed, you will need to use different size pulleys on the two shafts.

A simple way to figure proper pulley diameter is to use the formula:

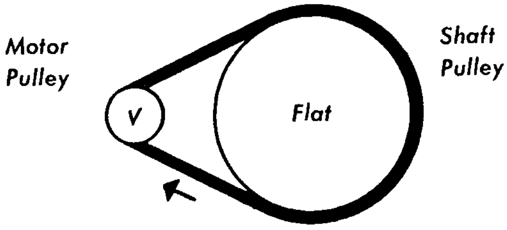
Diameter of the driven pulley x rpm of the driven pulley = Diameter of the motor pulley x rpm of the motor pulley.



It is not always possible to obtain the correct speed with one set of pulleys. A speed reducer or jack shaft can then be used. You will then need to apply the pulley formula twice--between motor and jack shaft, then between jack shaft and machine. Sometimes a roller chain is used between the jack shaft and machine.

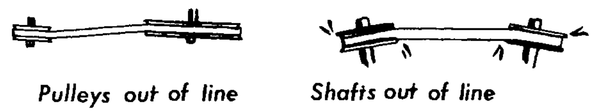
V-Flat Drive

In some instances, you will find it desirable to have a small V-pulley driving a large flat pulley. This is called a V-flat drive. Large V-pulleys are expensive and hard to obtain. This arrangement is particularly good if you are (1) running a machine that needs a pulley larger than 12 inches in diameter, and (2) are operating at 600 rpm or less. A standard V-belt is used that fits the V-pulley on the motor. If the distance center to center on the two pulleys is not greater than the diameter of the large pulley, very little slippage will occur.

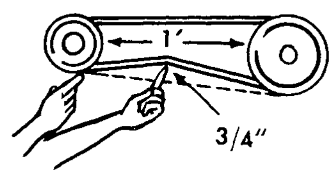


Tips for Good V-Belt Operation

1. Clean the pulleys—wipe out all oil, dirt, and grease.
2. Check pulley grooves—worn or bent pulleys wear out belts fast.
3. Release the take-up adjustment—do not "roll" a belt on a pulley.
4. Check pulley alignment. Use a straight edge against the two pulleys.



5. Get the right belt tension—neither too tight nor too loose. A good rule is to allow a 3/4 inch depression for each foot of distance between pulley shafts.

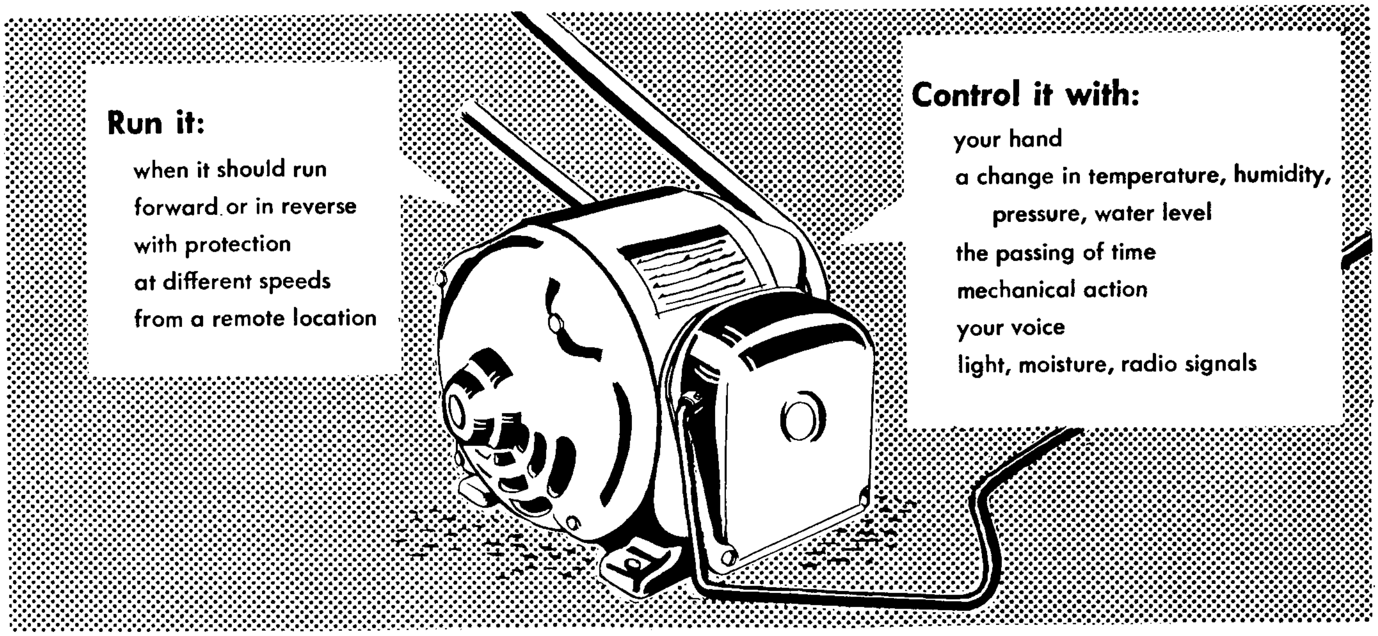


6. Always use "matched" belts in multiple drives.
7. Recheck the pulley alignment and belt tension periodically.
8. Never use a belt so worn that it rides the bottom of the groove.
9. Be sure the belt matches the pulley.
10. Try to have the bottom section of the belt do the pulling.

Demonstrations You Can Give

Show and tell about the three sizes of V-belts, and how to properly install a V-belt.

KEEP YOUR MOTORS UNDER CONTROL



One thing is certain about the electric motors that you know--not all of them run all the time!

Instead, they run only when they should--to refrigerate, ventilate, elevate, clean, mix, sew, move materials, and so on.

In addition, some of them run some of the time at one speed, then later at a different speed. Others run sometimes in one direction, at other times in another.

Did you ever wonder how all this starting and stopping and changing of speeds and direction is done?

The answer, of course, is that it is all done by means of the right kind of control device for each motor. Some controls also provide protection for the motor. (NOTE: Many of the control devices described may be used for lights and heating equipment, too.)

What to Do

1. Learn what the most common kinds of motor controls are, how they work, and where they are used.

2. List all the motors used in your home or on your farm. In a separate column, tell how each one is controlled, and whether overload protection is provided.

3. Inspect as many different types of motor controls as you can. If possible, help your club leader bring some of these to a club meeting so that you might better understand how they work.

4. Show others how some of these controls work, and tell how they are used.

How to Pick the Right Control

Selecting the right control for a motor depends on many things: Can the control be automatic, or will it be operated by some person? What safety measures should be taken? If manual, will it be near the motor, or at one or more remote locations? If automatic, what will be the changing condition that will make the control work? Will the control include overload protection for the motor? How large is the motor?

These are some of the questions that must be answered before the right control is picked.

Manual or Automatic?

What determines when the motor should be turned on or off? Is it a change in temperature or humidity? A change in water level? A change in air pressure? The passing of time? The movement of equipment that could cause damage?

Generally speaking, changes in temperature, humidity, fluid level, pressure, time, and location all can be used to control electric motors automatically. Other types of automatic controls are in use, but these are the most common.

How Many Locations?

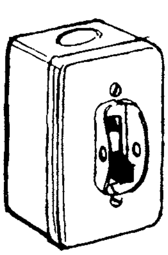
If a motor is to be controlled manually, it may be that control from more than one point is desired. If so, this will affect the type of manual control used.

Manual On-Off Switches

The only control that many small motors have is a cord and plug, but an on-off switch is much safer and more convenient.

Snap switches such as are used for lights are suitable for controlling motors, up to the limit of their current-carrying capacity. (Almost all motor controls have quick snap-action to cut down on the "arcing" or flow of current through the air when the circuit is broken.)

Three-way and four-way switches can be used to control small motors from two or more locations. (Compare rated capacity of the switches with the current requirements of the motor.)



Snap-action switch for small motors—with overload protection

Special small-motor snap switches that include overload protection are better, however, if the motor does not have such built-in protection. When you go to buy such a control, know the full-load current rating of the motor so that the store can supply you with the right size "heater" for it. This is the part that causes the switch to open if a dangerous overload does occur.

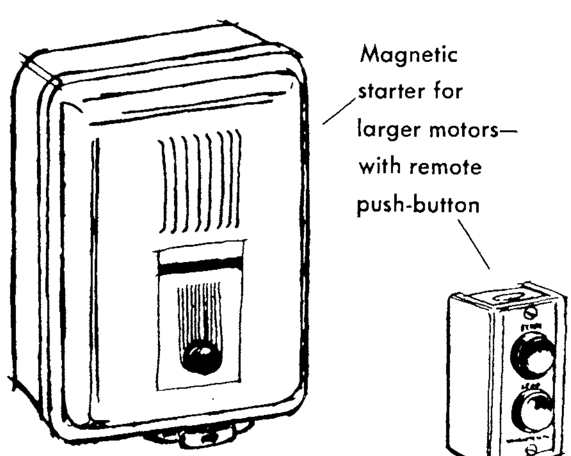
Other kinds of manual switches are those that spring back into the off position when you let go of them. These trigger switches are common on power shop tools. Treadles, that work when people, animals, or vehicles pass over them, use the same principle.

Magnetic Starters

Magnetic starters are made for motors ranging in size from one horsepower on up. The push of a button, either on the starter or at any one of several remote locations, closes a circuit that causes an electromagnet to snap the contacts together. It includes overload protection.

Because the control circuit does not carry the full motor current, this kind makes it possible to control a larger motor automatically. It can be actuated by the small amount of current that will safely flow through a thermostat or other sensing device.

It also permits the use of any number of control locations, and the wiring that connects these push-button stations is relatively light.



Magnetic starter for larger motors—with remote push-button

Reversing Switches

This kind of manual switch changes the motor connections to get reverse rotation when that is desired. It is used on two-way conveyors, certain fans, and shop equipment.

Variable Speed Controls

This kind of control uses varying amounts of resistance in the motor circuit, or changes from one motor winding to another.

It is used on some fans, food mixers, and sewing machines.

Time Switches

These use electric or spring-driven clocks to open and close contacts. Some kinds automatically start and stop motors at certain times each day. Others can be set for motors to be on for a certain number of minutes and off for a length of time.

Still others will stop operation the desired length of time after the motors have been started manually.

Kitchen appliances, off-peak water heaters, poultry and cattle feeders, fans, irrigation pumps, and incubators use time switch controls.

Thermostats

Thermostats depend on the expansion and contraction of gases, liquids, or solids to open and close contacts.

They come in "heating" and "cooling" types. The heating type is normally closed (contacts together). This means that the motor will run until the temperature comes up to a set level. This kind is used on brooders, and of course on many devices which have no motors but which merely have heating elements.

The cooling type is normally open (contacts apart). It does not complete the circuit until the temperature gets up to a set level. It is used on ventilating fans, refrigerators, and air conditioners.

There is a limit to the size of motor that can be controlled directly by a thermostat or other sensing device, and on a large motor it may be necessary to use a magnetic starter to carry the motor current.

Humidistats

A humidistat is a mechanical snap-action switch operated by an element, generally made of human hair (sensitive to changes in the amount of moisture in the air).

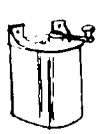
This device is used to control humidifiers, dehumidifiers, and ventilating fans.

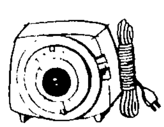
Pressure Switches

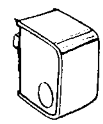
This kind of switch has a bellows or diaphragm that is linked to a snap-action switch. When certain pressures are reached, the switch is tripped on or off, according to the way it is adjusted.

Pressure switches can be actuated by changes in pressure of gases, liquids, and by the presence or absence of bulk materials such as grain in a bin.

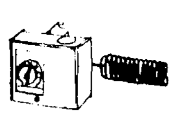
They are commonly used on water pumps and air compressors.

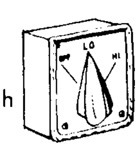

Reversing switch


Time switch

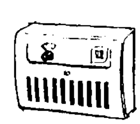

Pressure switch

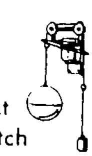

Limit switch


Thermostat



Variable speed switch


Humidistat


Float switch

Float Switches

This is a mechanical snap-action switch operated by a float. When the water or other liquid rises to a pre-determined level, the float rod actuates a trip-lever and opens the circuit. When the liquid level falls, the circuit is closed again. These are used on stock-watering tanks and also on sump pumps.

Limit Switches

There are certain types of equipment, such as motor-operated doors, windows, gates, elevators, and hoists that are safer and more convenient if they have a switch to open the circuit when they reach the end of their travel. A limit switch depends on mechanical action, something pushing on an external bar or roller to open a snap-action switch.

Miniature Snap-Action Switches

Trigger-type snap switches that operate with a very small amount of mechanical pressure are used to control many types of electrical equipment. They are available in normally-open and normally-closed types.

Electronic Controls

Through the miracle of electronics, motors can be controlled by many other means.

Electronic controls can be built or purchased that will operate when actuated by: the human voice, the presence of the human body, light, the presence of moisture, the passing of time, and radio signals.

What Did You Learn? (True or False)

1. A switch should open and close quickly to prevent arcing of the electric current.

2. Switches with overload protection are used only for large motors.

3. A pressure switch operated by a diaphragm does not have a snap action.

4. A pressure switch cannot be used to control air pressure.

5. The float rod of a float type switch operates a trip-lever that always opens the circuit.

6. Without a limit switch, an elevator could cause extensive damage.

7. You can use the same thermostat for a stable ventilating fan and for an electric room heater.

8. You can control a large motor directly with a humidistat.

9. Time switches can control only lighting circuits.

10. Radio signals are the only things that will actuate electronic controls.

Demonstrations You Can Give

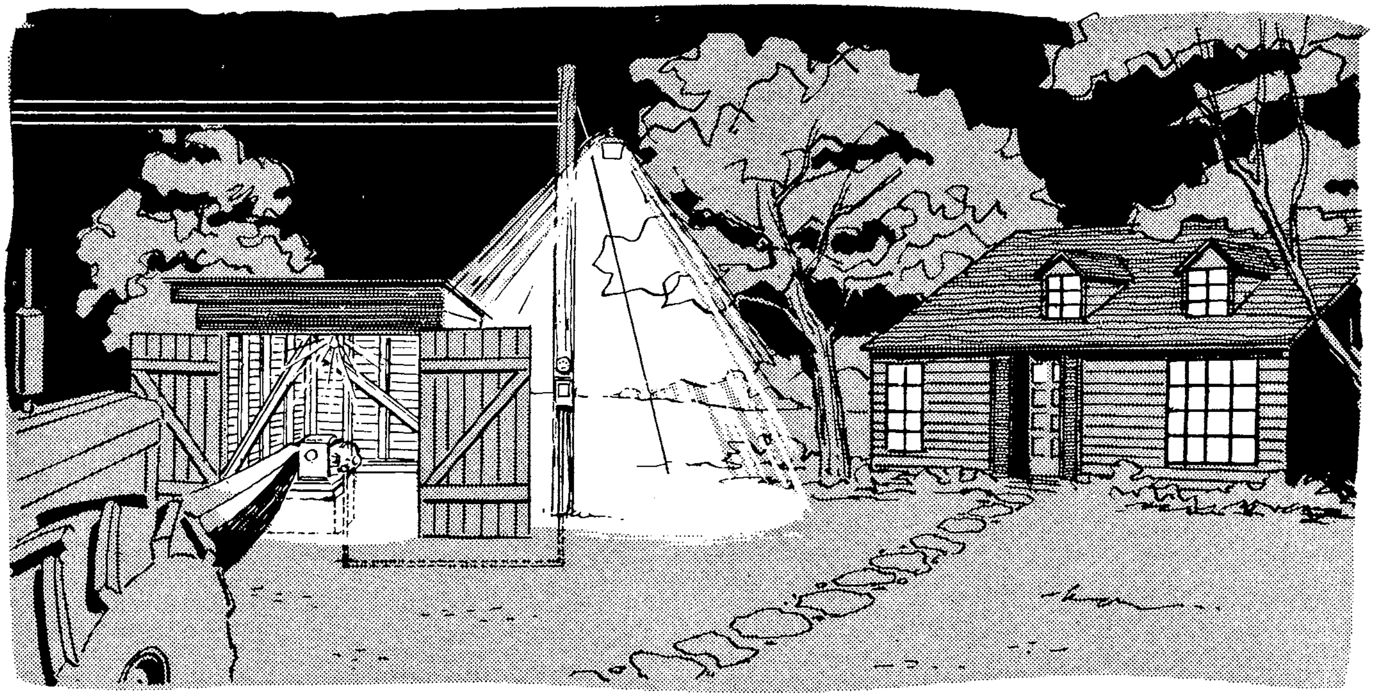
Borrow or otherwise get as many different kinds of motor controls as you can. After studying how they work, connect each of them to a separate light. Show others how each device will turn its light on and off, manually or automatically, as the case may be. (Use the warmth of your hand to actuate a thermostat, or the moisture in your breath to actuate a humidistat, and so on.)

For More Information

See the literature of manufacturers of control devices, or ask your power supplier representative.

Motor	H.P.	Control	Overload Protection?
Water Pump	1/4	Pressure Switch	No
Dehumidifier	1/6	Humidistat	No
Crop Dryer	5	Magnetic Starter	Yes

HOW TO GET BY if the power is off



Did you ever think about pumping water by hand for 50 or even 25 head of thirsty cattle? Or hand milking a big herd in the dark?

Fortunately for you, your power supplier has spent a lot of time and money to insure against your having to do this. They build their lines so well that only in the most severe storms can there be a power interruption. Also, they have provided more and more "two-way feeds" into the various areas that they serve. Where these exist, often it is only necessary for them to throw a switch to get the power on again.

But in spite of all this, an occasional longer interruption does occur, and because you are now so dependent on electricity, you should have a plan for such emergencies. Such a plan should provide for equipment and procedures.

What to Do

1. Put on paper a plan for an extended period of "no-power", including the equipment that will be needed for emergency lighting, heating, ventilating, pumping, refrigeration, and power. Do it now while there is no emergency. You won't have time when the emergency is upon you.

2. Talk it over with your parents and carry out as much of your plan as they think is practical at the present time. Keep the plan for future reference.

Emergency Light and Heat

Emergency lighting can be taken care of by candles, lanterns, oil lamps, battery light, or flashlights. Be sure you have a supply of kerosene and extra batteries in good condition.

A fireplace can temporarily solve your cooking and home heating problems. Portable grills, stoves, charcoal briquettes, kerosene, gasoline, or canned heat may be used.

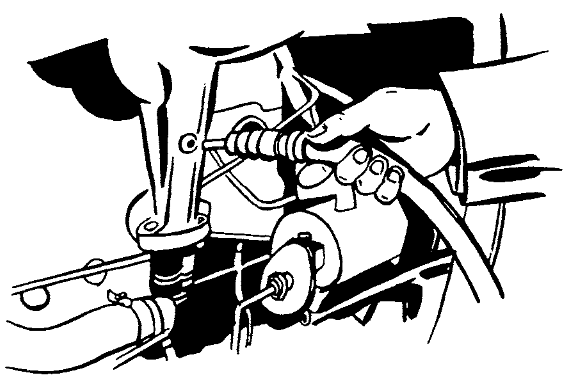
Emergency cooling could be a problem depending on the weather. If you have a food freezer and the power is interrupted, plan on keeping the freezer closed tightly. Don't even look in it for 48 hours. If it appears that the interruption will be longer, try to get some dry ice and put it in the freezer. Use gloves so that your hands will not become frostbitten. Unfrozen perishables could possibly be kept in running water, ice, a cold spring, or outdoors in cold weather.

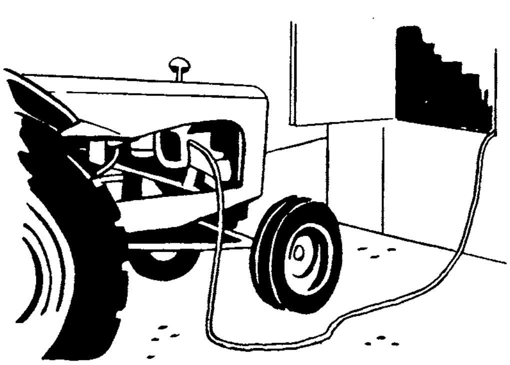
Emergency brooding on a large scale usually turns out to be a hopeless task. However, on a small scale, a metal box, can, or earthen crock can be filled with hot coals, hot sand, or hot water. Heated stones or bricks also help. Portable stoves or heaters might also be considered.

Regulating your doors and windows will help to take care of emergency ventilating. But for pumping, milking, cooling, and other tasks, power is needed to get the jobs done.

Use an Engine

The intake vacuum of a tractor or truck can be adapted to run a milking machine. Plan now to install an aircock, by means of a threaded reducer, on the intake manifold. Run a hose from the aircock on the tractor outside to the pipeline in the barn.





If you have magnetic-type milkers, ask the dealer for wiring information and instructions on operating this kind of equipment in an emergency.

Don't overlook the possibilities of a spare gasoline engine for some of the jobs requiring power, such as pumping water, hay drying, gutter cleaning, and milk cooling. Many times a reel type lawn mower can be adapted for the smaller tasks, or the farm tractor for the larger ones.

Standby Generators

Electric power for emergency operations can be provided through a standby generator.

Should you buy such a unit? Your decision on whether to buy a unit should depend on the size of your operation, the type of farm, and the amount of inconvenience and loss that could result from a power interruption.

How Big a Unit?

What is the largest horsepower motor on your farm? Let us say it is a 5 hp motor. A 10 kilowatt or 10,000 watt generator is needed to start this motor. (Table 1)

This does not mean that nothing else can operate after this motor has been started. In our example, Table 1 again tells us the running wattage of the 5 hp motor is only 4500 watts. This leaves 5500 watts for starting other motors or for lighting.

A good rule is to allow up to 2500 watts (2.5 kw) for each horsepower to get a motor started and 1000 watts (1 kw) per horsepower for running. Remember, the largest motor today may not be your largest motor in a few years. Plan your standby equipment to serve future electrical equipment. Use the chart to estimate total load and generator size.

Table 1

Approximate Wattage and Power Required to start and run most Electric Motor Powered Equipment

Horsepower	Approx. Running Watts*	Approx. Starting Watts Full Load**	Size Generator Normal Operation	Minimum Driving Engine (Tractor)
1/4	300	1200	0.75 KW	1.5 HP
1/3	400	1600	1.0 KW	2 HP
1/2	550	2300	1.5 KW	3 HP
3/4	800	3345	2.0 KW	4 HP
1	1000	4000	2.0 KW	4 HP
1 1/2	1500	6000	3.0 KW	6 HP
2	2000	8000	5.0 KW	10 HP
3	3000	12000	7.5 KW	15 HP
5	4500	18000	10.0 KW	20 HP
7 1/2	7000	28000	15.0 KW	30 HP

*For estimating total motor load, single phase motors—120 or 120/240 volts.

**For checking generator size needed for largest motor. Starting load watts given in this table are for capacitor motors. Most split phase motors will draw approximately 25% more power and most repulsion induction motors will draw approximately 25% less power during starting. Estimate accordingly.

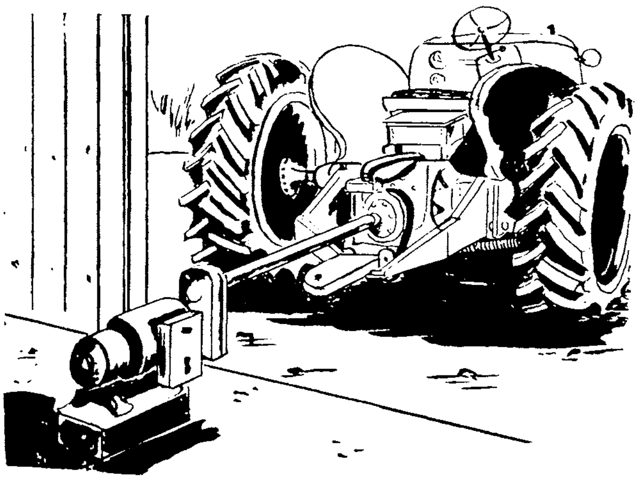
What Kind?

There are several types of standby generators that might be used for emergencies. These are:

(1) Self contained units with the engine attached. These may be fully automatic or manually controlled.

(2) Belt-driven tractor units

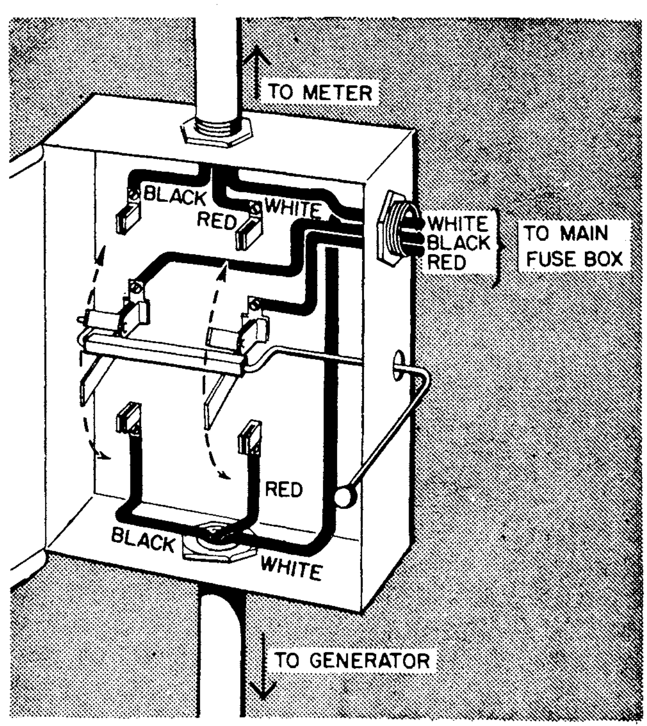
(3) Power takeoff driven units



The kind you select will depend on the importance of continuous power (hatcheries often have automatic units), the amount of money you wish to spend, and whether you have any use for a portable electric power source (to operate power tools or lights at remote locations).

How to Install

A manual double-throw switch is necessary to disconnect from the power supplier's wiring and connect to the generator. Otherwise, you could endanger a repair lineman's life or overload your generator. A transformer can step up voltage as well as step it down. This means your generator could apply the regular high tension voltage out on the line. This current would be deadly to any lineman working in the area.



You will want to locate your generator in a dry, well ventilated, and convenient place. It should not be covered with old sacks or boxes. Naturally, exhaust fumes should be carried to the outside.

A voltmeter should be mounted on the generator to let you know when the generator is operating at the correct speed. An ammeter, recommended for the larger units, tells you when you have reached the limits of the generator capacity.

Be sure you have the correct pulley and belts for proper speed of the generator. Then the throttle setting can be varied up or down according to the load.

If the generator is to be driven by an attached engine or a belt from the tractor, it should be mounted on a permanent base. This could be close to where the tractor is normally parked.

A neon type pilot lamp connected between the meter and transfer switch will tell you when normal power has been restored.

Costs

Prices of generators vary from $75 to $100 per kilowatt capacity. Direct connected engine driven models will often run $150 per kilowatt.

Safety

You must be absolutely certain that your standby generator will operate safely. Your power supplier representative will be glad to help you locate your generator, suggest necessary wiring, and inspect the finished job.

Do not use the unit if your own wiring has been damaged or is defective.

Maintenance and Operation

Like other equipment, your standby generating unit must be kept in good running order at all times. This means normal maintenance and periodic "dry runs". The combination generator-engine unit should be put into operation at least once a month. Spark plugs, battery, and other parts should not be removed to be used as replacement parts for other farm equipment.

Instructions for operating the units should be carefully preserved and kept nearby for inspection. Oiling and greasing should be closely followed. Align the drive shaft for the power take-off drive to prevent vibration. The speed of the tractor should be regularly checked and adjusted for correct voltage output. An extra flashlight should be placed in one convenient location.

Your Plan

Make a list of all electrical equipment on your farm. Include everything, and don't forget the appliances in the home. Now go over the list and check off those pieces of equipment that must be on at any one time. Remember, this is an emergency requiring some inconvenience. On the other hand, don't forget part of mother's range for hot food.

Rate all the checked items either in watts or horsepower. What is the largest horsepower motor on your checked list? Check Table 1 for necessary generator capacity. What size did you select? How many watts of capacity are left over for other equipment? Is this enough to handle your list of checked items and allow some extra capacity? What size generator did you finally select?

Demonstrations You Can Give

Show how to modify a tractor intake manifold so that it can be used to operate a nonmagnetic milker.

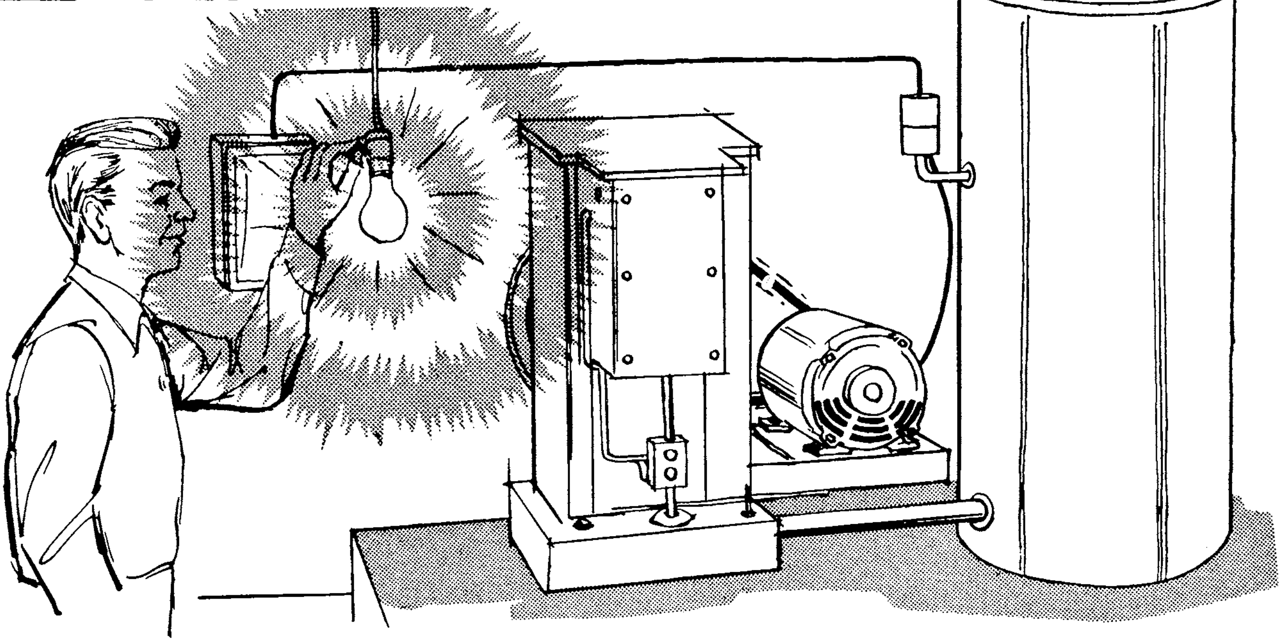
Show how a double-throw switch is used to insure safety in the operation of a standby generator.

For More Information

Ask your County Extension Agent for a bulletin on standby generators. Get the literature of one or more manufacturers of this equipment. Ask your power supplier representative to tell you of the things they do to prevent extended interruptions. He also will be glad to look over your standby plan.

Visit a farm or public building where this kind of equipment is installed. Visit a dealer who sells standby generators.

PLANNED FARM WIRING



Do you know what it feels like to be starved?

Your electric servants (lights, motors, appliances) can be starved, too. The chances are good you have seen symptoms of this kind of starvation whether you recognized them or not. Someone has estimated that 90 percent of the electrical wiring in use today is not heavy enough to supply the equipment it serves. This means circuit breakers trip and fuses blow for no apparent reason. Lights blink when motors start, or flicker when equipment is running. Heating appliances and equipment such as ranges, water heaters, and brooders are slow to reach proper temperature.

When these things happen on your farm, don't blame the electrical equipment. It's probably doing all it can on a starvation diet of electricity. Chances are that it is suffering from a very common "ailment"--low voltage caused by a lack of capacity in your wiring. This condition has been building up over the months or years while you've been adding electrical equipment. If your wiring is overloaded, it's being asked to shoulder a much heavier electrical load than was originally intended. Just as your tractor or any other piece of farm equipment, your wiring system should be checked and overhauled occasionally.

Do your appliances and lights show some "starvation" symptoms?

What to Do

1. Check your wiring system first.

2. Plan what changes you would recommend, and discuss them with your parents.

For Safety, Convenience, Economy

A well-planned farm wiring system is safe, convenient, adequate, easily expanded, and efficient.

Safety will be satisfied if your electrician follows the National Electrical Code. The other requirements depend on careful planning. Farmstead wiring should be planned with outlets conveniently located for the use of modern electrical farm and home equipment.

Service entrances, feeders, and branch circuits should be large enough to deliver current at proper voltage. You should be able to make changes and additions easily and at minimum expense.

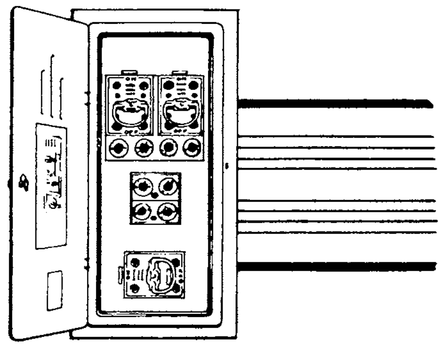
It is better to do a good job at the start, because it is difficult and costly to make changes later. The experience on countless numbers of farms shows that heavier wiring is needed and should have been installed in the first place.

Plan All Four Parts

Your farm wiring system can be divided into four parts. These are the circuits and outlets, building service entrances, feeder wires to the buildings, and the main service entrance.

Circuits

A circuit consists of a pair of wires providing a path for the flow of electricity. It is the last link in the permanent electrical wiring before the power reaches the various outlets where it is converted into light, heat, or power. Circuits start from the distribution panel or fuse box. The number needed will depend on the uses made of electricity in the particular building. Provide for enough circuits to take care of your present and future needs.



There are three types of outlets--lighting, convenience, and special purpose. Various lighting fixtures are attached to a lighting outlet. A convenience outlet is the familiar plug-in receptacle for small appliances, motors, heaters, etc. Both lighting and convenience outlets are usually 115 volts.

A special purpose outlet is one that is designed for particular equipment at a certain location. Examples of this type are outlets serving ranges, clothes dryers, farm welders, hay dryers, or cattle feeders. Special purpose outlets are usually 230 volts.

Branch circuit wires are usually rated to carry 15 or 20 amperes. At 115 volts, the total load on a 15 ampere circuit should not be more than 1725 watts. On a 20 ampere circuit, the load should not be more than 2300 watts. There should be enough circuits so that these limits will not be exceeded.

Number 14 wire was used extensively in old wiring and should not be fused at more than 15 amperes. In modern wiring, Number 12 wire, properly fused at 20 amperes, should be considered. Branch circuits serving convenience outlets for small motors and heavy duty lights must be Number 12 or larger.

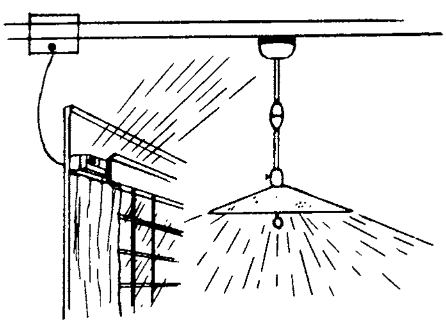
The total amperage on all the circuits in one building makes up the total connected load that must be supplied through the service entrance switch.

Building Service Entrance

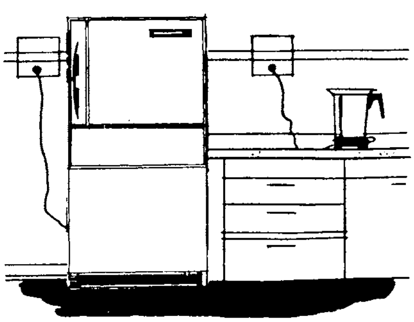
The "service" to an individual building consists of the service drop or feeder wires, entrance cable, the disconnecting switch, fuses, or circuit breakers, and a grounding connection. It is through the service entrance switch that electricity is supplied to a building in such a way that it may be distributed further to various outlets. It also provides a way to disconnect all the circuits of that building from the source.

Feeder Wires

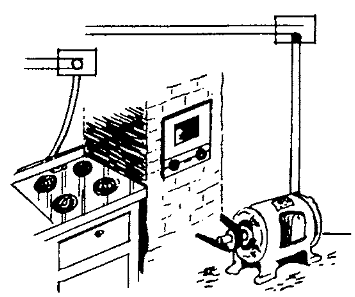
Feeder wires are the conductors that carry electricity between buildings or from the meter pole to the buildings served. It is very important that feeder wires be large enough to serve for a long time. Wires that are too small cause extensive line loss and poor equipment performance. These wires may be overhead or underground.



Lighting outlets



Convenience outlets



Special purpose outlets

When the maximum probable demands for the various buildings are known, with allowance for future needs, the sizes of the feeder wires may be calculated. The size depends on two things--the size of the load and the distance from the meter location. Following is a guide to adequate overhead feeder wire sizes:

Weatherproof Copper Wire		
Load in Building	Distance in Feet from Meter to Building	Recommended Size of Feeder Wire for job
Up to 25 amperes, 115 volts	Up to 50 feet	No. 10
	50 to 80 feet	No. 8
	80 to 125 feet	No. 6
20 to 30 amperes, 230 volts	Up to 80 feet	No. 10
	80 to 125 feet	No. 8
	125 to 200 feet	No. 6
	200 to 350 feet	No. 4
30 to 50 amperes, 230 volts	Up to 80 feet	No. 8
	80 to 125 feet	No. 6
	125 to 200 feet	No. 4
	200 to 300 feet	No. 2
	300 to 400 feet	No. 0

Main Service Entrance

The main service entrance is the point where the power supplier delivers electricity to you. It must be large enough to supply all the buildings on the farm. The main entrance should be on a centrally located building or pole. Your local power supplier will be glad to furnish you the information you should have before you plan this part of your wiring.

Here's the electrical load for a typical farm:

Buildings	Connected Load (Amperes)	Switch Required
Dwelling House	70	100
Dairy Barn or Poultry House	70	100
Farm Shop	45	60
Total Connected Load	185 amperes	

At least a 200 ampere main service entrance would be recommended. When calculating the size of service entrance equipment, always allow for extra capacity to take care of future expansion.

Meter Location

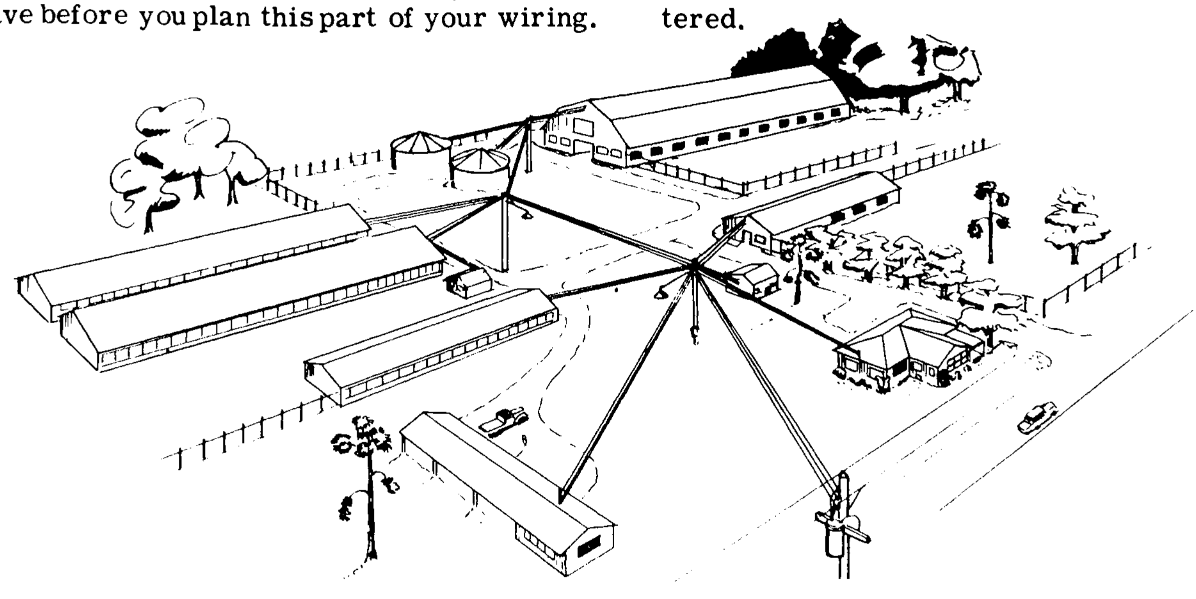
The location of the electric meter is important because it affects wiring costs and how well the electricity you pay for does its job.

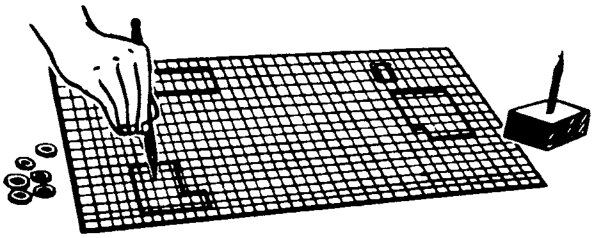
There are a number of advantages of pole metering:

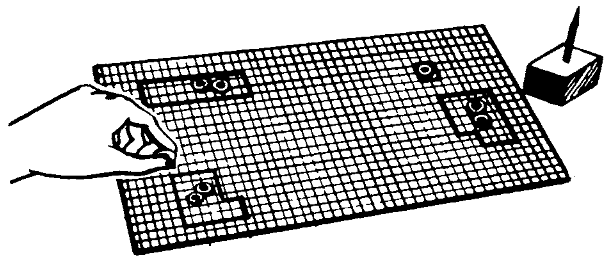
1. The meter pole is the center of the electrical load. Because this means shorter feeder wires to the various buildings, it also means that these feeder wires can be smaller.

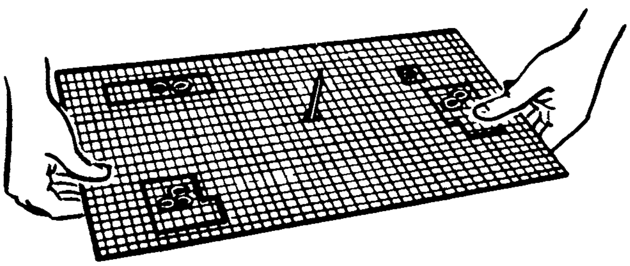
2. In an emergency, each major building can be cut off without disturbing service to any other building.

3. If the load in a particular building ever exceeds that planned for, only one set of feeders and entrance would need to be altered.









Locate Your Load Center

You can locate the actual center of the electrical load for your farmstead by the following procedure:

1. Make a map of the farmstead. Use a convenient scale and show the location and size of each building. Cross-ruled paper 8-1/2 x 11" is convenient to use.

2. Paste this map on a piece of lightweight cardboard of the same size.

3. Determine the load that will be on at any one time in each building. Allow for future electrical loads.

4. Place at the center of each building on the map one penny or washer for each 1000 watts (kilowatt) of load.

5. Balance the map on the point of a nail held in a vise or driven through a block. Press the nail up through the balance point. This hole indicates the position of the electrical load center. If this is in the center of a driveway or a garden, some adjusting of the center will be required. The corner of a building may be considered if it is near the calculated load center.

What Did You Learn?

(Cross Out One)

1. Slow heating of an electric brooder is probably due to a (slow thermostat, inadequate wiring).

2. The regulations of the National Electrical Code cover (only safety, all) requirements for adequate wiring.

3. Experiences in the past indicate (heavier, lighter) wiring should be installed on most farms.

4. A 1/2-horsepower motor on a ventilating fan should be on a (115, 230) volt circuit.

5. Maximum wattage on a No. 14 wire circuit should be (1725, 2500) watts.

6. Feeder wire size is determined by size of load and (size of entrance cable, distance).

7. The main service entrance should be located on the (meter pole, corner of the house nearest the transformer pole).

8. If the barn were on fire and you could not disconnect the main switch, the feeder wires should be cut one at a time (at the barn, at the meter pole).

9. If the electrical load center falls in the middle of the lane (the pole should be moved to one side, the road should be relocated).

LET'S GO SHOPPING

Would you like to go shopping for an electric appliance for someone else or for your own home?

This may seem a long way off, but sooner than you think you will be doing just that. For example, you may want to buy an electrical gift for your parents' anniversary or for someone's birthday. Someday, too, there may be those shower and wedding gifts to be bought for friends.

Shopping for a small appliance can be fun. And it's something that you can do intelligently, if you start now to learn what to look for when you buy.

What to Do

1. Make a list of as many small electric appliances as you can.

2. Collect as many advertisements and as much literature as you can on small appliances, but only on those that you think you might be most likely to buy someday.

3. Visit several appliance stores to see the various models on display. Ask questions about them from the dealer.

4. Make a chart to help you compare the information you have assembled. Use the chart to help you reach a buying decision.

Materials You'll Need

Recent issues of magazines with small appliance ads in them

Retail, mail order, and other catalogs

A 9" x 12" or larger file folder or envelope

Scissors

A pad or notebook and pencil

What Are "Small Appliances"?

"Small appliances" are those which are portable, and which usually are used on a table or counter. Toasters, coffeemakers, portable fans, and griddles are good examples.

("Major appliances" are those which are not so readily portable, and are either free-standing or built-in. Ranges, refrigerators, washers, and dryers are examples.)

Make your own list of small appliances, using what you have seen and read to help you make it as complete as possible. Check the ones that you have in your home.

Choose One That Will Be Used

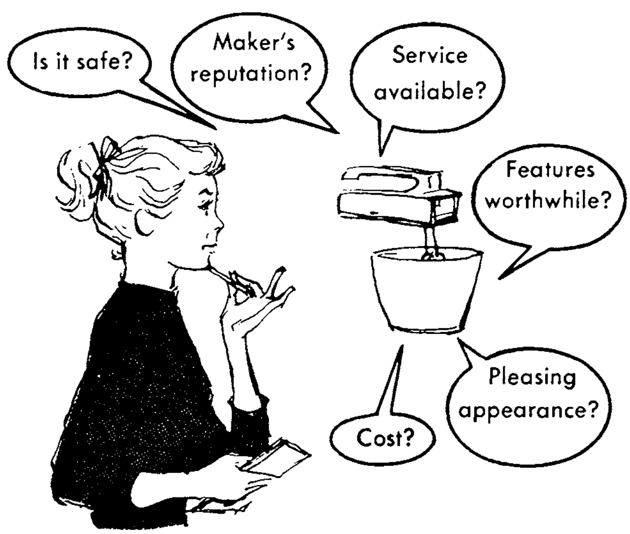
Everything that we buy, whether it is for ourselves or for someone else, should be selected to give maximum return for what we spend. In other words, we always try to "get our money's worth."

This money's worth may come in the form of convenience, savings in labor, better quality of work done, or just in the pleasure we get from what we buy.

The general rule for selecting a small appliance is: Get the one that best meets an actual need, and which will be used often enough to justify its cost. No appliance that sits unused for months at a time gives its owner her money's worth.

Choose The Model That Suits Best

Once you have decided which appliance you are shopping for, you must decide on one of the many different models made available to you by the manufacturers whose products are sold where you live.



To choose wisely, you should consider many factors. Among them are:

Safety to the user - Your best assurance of this is the presence of the Underwriters (UL) label on the appliance.

Reputation of the maker - The maker with a good reputation is anxious to protect it, and does so by building quality appliances.

Availability of service - Replacement parts and competent repair service should be easy to get.

Worthwhile features - Look for those things that will pay off in more use, longer life, and more convenience.

Appearance - Appliances should be pleasing to the eye, as well as functional.

Cost - The lowest-priced appliance is not always the best buy, when all other factors are considered.

Get All The Information You Can

The basis for good judgment in buying is good information, and there are lots of ways you can get it.

1. Talk to users. If you evaluate it carefully, you will find this kind of information to be of real help to you. Ask people who own this type of appliance how much they use it, how they like it, whether (and how long) it has performed satisfactorily for them, and whether they've been able to get service and parts promptly.

The danger is in relying too much on just a few users, whose experiences are limited to only a few models. Another danger lies in the fact that their experience may be with models that are no longer on the market, or that have been changed a great deal.

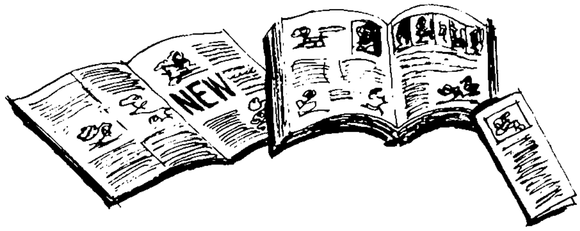
2. Read the ads. Advertising is the means that manufacturers use to tell us about their products. These messages tell us much about a product's appearance, its cost, its features, and its capabilities.

Advertising is especially helpful as a source of news about new products, product improvements, new uses, price changes, where to buy, and techniques for care and maintenance.

3. Study manufacturers' literature. Much more complete than most magazine and newspaper advertising are the folders and brochures prepared by manufacturers. Usually included are specifications, sizes, colors,

and ratings, as well as a complete description of the product's features. Special models and optional accessories--things that may meet your needs exactly--are also described in literature.

4. Study the catalogs. Many retail stores, mail order houses, and premium companies publish catalogs which give some information about small appliances. While not as complete as manufacturers' literature, catalogs often do have a great deal of information in them.



5. Visit the stores. You can see the actual appliance, feel it, and ask questions about it and the service, in only one place--the dealer's store. If there is a special price on the appliance, this is the place to find out about it.

The danger lies in buying the first one you look at. Instead, visit several stores, and you'll find that you add to your information with each stop.

Ask for literature while you're at the store. Read the labels and information tags. Make notes on prices, guarantees, and service.

Organize Your Information

You will soon realize that there is a lot of information to be obtained on each appliance. Collect it in your large envelope or file folder. To help you compare the different appliances point-by-point, you should organize your information. One way to do this is to make a chart like the one shown.

After you've written down the information you have, you may want to try to get any facts that are missing.

Then you are in a position to make your comparison, and from that your buying decision.

Appliance	Maker	Model	U.L. Label	Features	Guarantee	Dealer	Parts and Service	Price	Remarks
Mixer	XYZ Co.	Standard	Yes	Multi-speed motor, 2 beaters, 2 stainless steel bowls. Optional attachments: meat grinder, shredder, knife sharpener, can be used as a portable	1 year parts only	Jones Appliance Store	Available	$29.95	Aunt Ginny likes hers

After You Buy

If you buy the appliance for yourself, then this suggestion is for you. Read and reread the instruction booklet or card that comes with the appliance. Avoid that temptation to use it before you have learned how. Then, be sure to save this information, preferably in a file set up just for this purpose. Write the purchase date on this material, and be sure that the model number's on it, too. If the appliance has a serial number, make a note of this, also.

If there's a guarantee card that's to be filled out and mailed, do so at once. Be sure to give all the information asked for.

Remember, too, that your new appliance will perform no better than the wiring that supplies it. If it's a heating appliance, and is slow to heat, or a motor-driven one and it lacks power, or if lights dim when you are using it, then you may need to add a new wiring circuit.

If you see any of these symptoms of poor wiring, then your power supplier should be asked to check it and make recommendations for correcting the situation.

What Did You Learn? (True or False)

1. A 30-inch electric range is an example of a small appliance.

2. An electric can opener would be a good gift for a person who uses mostly frozen food.

3. The UL label on an appliance is an assurance of safety.

4. Price is always the most important consideration in buying.

5. Advertising is a good source of information for prospective buyers.

6. The availability of service and parts is not important.

7. It's easier to compare information if you organize it in some way.

8. If a new appliance does not work properly, the trouble may be in your own wiring.

Demonstrations You Can Give

Obtain as many makes of a particular appliance as you can. (Maybe you can borrow one from a neighbor. Ask one or more of your local electric dealers to let you take an appliance for this demonstration. You must be very careful to return the appliance in as good condition as when taken out.) Show the advantages of each, using a poster or blackboard. Make clear that each buyer should select the model of appliance that will best meet his or her need.

Show an early model of some appliance, such as a toaster. For comparison, show a new model and point out the advantages it offers.

For More Information

Ask your County Extension workers and your power supplier representatives for bulletins or suggestions on buying.

HOT FACTS on a COLD SUBJECT

DO YOU KNOW all of the things that electric refrigeration does for us?

It keeps a supply of fresh food safe from spoiling right in our kitchens; it preserves food for future use; it helps make many of our most popular desserts; it cools milk and eggs to safe storage temperatures right at the farm; it conditions and dehumidifies the air in our homes.

What to Do

1. Experiment with melting ice and boiling water to see what happens to heat in each of these processes.

2. If possible, look at an open type refrigeration unit (one that is not hermetically sealed and preferably one without an enclosure around it). Perhaps your leader could arrange to have such a unit brought in, or you could go to see one at a food store or dairy plant. Try to name the main working parts. Ask someone who knows to help you identify them. If the unit is operating, feel the difference in temperature of the working parts. Explain what is happening.

How Refrigeration Works

Although all electric refrigeration works on the same principle, suppose we stick to the household refrigerator.

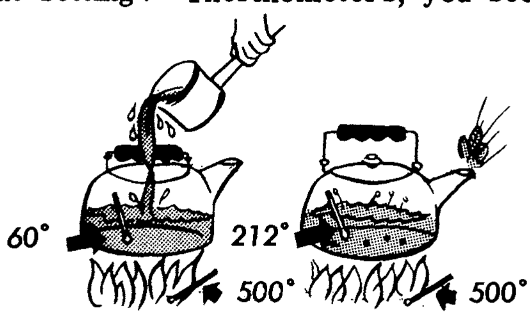
It is a simple mechanism that works much like a teakettle boiling on a range. That may seem far-fetched, but actually a refrigerator cools only because a liquid boils inside it.

There is no such thing as "cold". Your feet on a winter day are uncomfortable only because heat has been taken away from your shoes. "Cold" is simply the lack of heat. We can't make things cold directly but we can remove heat they contain. As a result, they will become cold. This is the main job of a refrigerator, a device for removing heat.

The next thing we must know is that heat only moves one way--from a warm object to a colder one. When you hold your hands out toward the fireplace, heat flows from the hot fire to your cold hands. When you make a snowball, heat always flows from your hands to the snow. In a refrigerator, the freezing coils are colder than the stored food, so heat is drawn out of the warm food by the coils.

Measuring Heat

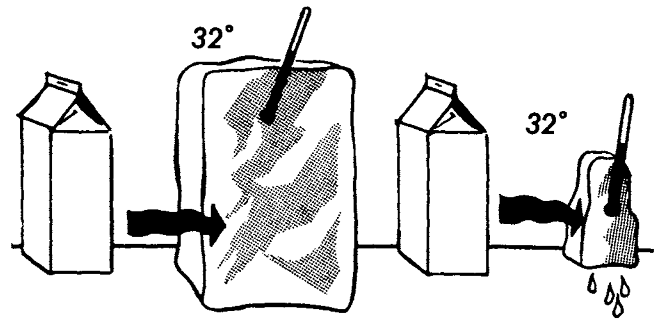
A <u>thermometer</u> will show you that a source of heat is just as hot when you first put a teakettle on as it is when the water finally boils. Then why doesn't the water boil right away? And why does it take longer to boil a <u>quart</u> of water than a <u>cupful</u> using the same heat setting? Thermometers, you see, in-



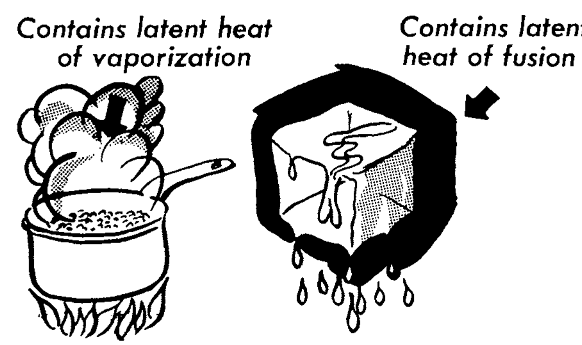
dicate only the <u>intensity</u> of heat. But, there is no instrument for measuring the quantity of heat. Instead, scientists have agreed that a unit of heat would be the amount necessary to make one pound of water one degree warmer. We call this quantity of heat a British Thermal Unit (Btu).

Heat "Disappears"

Sometimes heat seems to disappear. Consider an old-fashioned icebox. Why did your grandparents have to put ice in it? Wouldn't a pan of really cold water have done the same job? It was a good idea but it didn't work. Remember, each Btu of heat added to a pound of water makes it one degree warmer.



Use a thermometer and see what happens to a cake of ice in an ice chest or cooler. Put the thermometer on top of the ice and soon it will read 32°. Hours later check again and the thermometer will still read 32°. Even when most of the ice is melted, the thermometer continues to read 32°. All this time the ice has been soaking up heat, yet it never gets warmer regardless of how much heat is drawn from the food. This heat, which has been absorbed by the ice-turned-water, is called the "latent heat of fusion". Latent means hidden and fusion means melting--the hidden heat of melting.

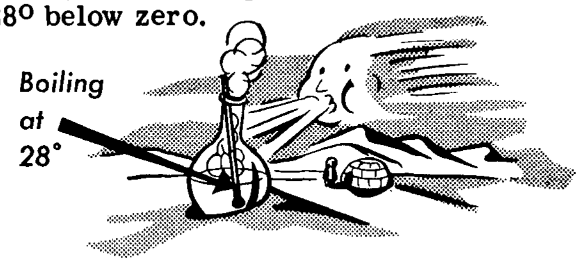


Let's continue our simple experiment. If we heat water in a teakettle, the thermometer tells us that the water gets hotter until it starts to boil. Then the mercury seems to stick at the 212° mark. Even though many won't believe it, you can't make water hotter than 212°, unless you confine it tightly as you do in a pressure cooker. As a liquid is changed into a gas, large amounts of heat are absorbed without any increase in temperature. This is called "latent heat of vaporization" or simply the hidden heat of evaporation.

It may seem as though we have drifted into a story about heat instead of refrigeration. But, in doing so, we have learned how heat moves, which is what refrigeration is.

Steaming Cold

Whenever we think of anything boiling, we think of it as being very hot. However, that's not always true. Some substances would have to be put into a blast furnace to make them bubble and give off vapor. Others, like pure ammonia, will boil violently while sitting on a cake of ice. Household ammonia is so highly diluted that it is practically all water, but in its pure form it would boil at 28° below zero.



Maybe that doesn't mean very much until we picture a flask of ammonia sitting on the North Pole boiling away just like a teakettle on a stove. If you put this same flask inside a refrigerator cabinet, it would boil, getting its heat from everything around it. In fact, at one time ammonia was the most popular refrigerant used. Today, better and safer refrigerants are manufactured.

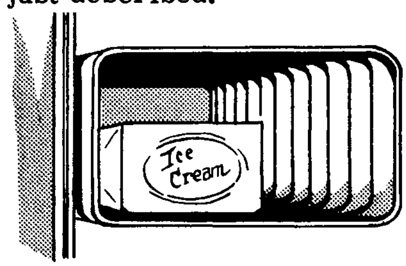
Now we can begin to see the similarity between a boiling teakettle and a refrigerator. Both draw in heat to boil although they do so at different temperature levels. Also, in comparing the icebox to the refrigerator, water from melting ice literally carried heat out of the icebox while vapors now do the same job in the refrigerator.

Water is cheap and can be thrown out, but ammonia or any other refrigerant is too expensive to let float away into the air. Some way must then be found to remove the heat from the vapor and change it back into a liquid so it can be used over again. If the kitchen were very cold, this could be done easily--but room temperatures are quite high. How can you cool the gases with only warm air available?

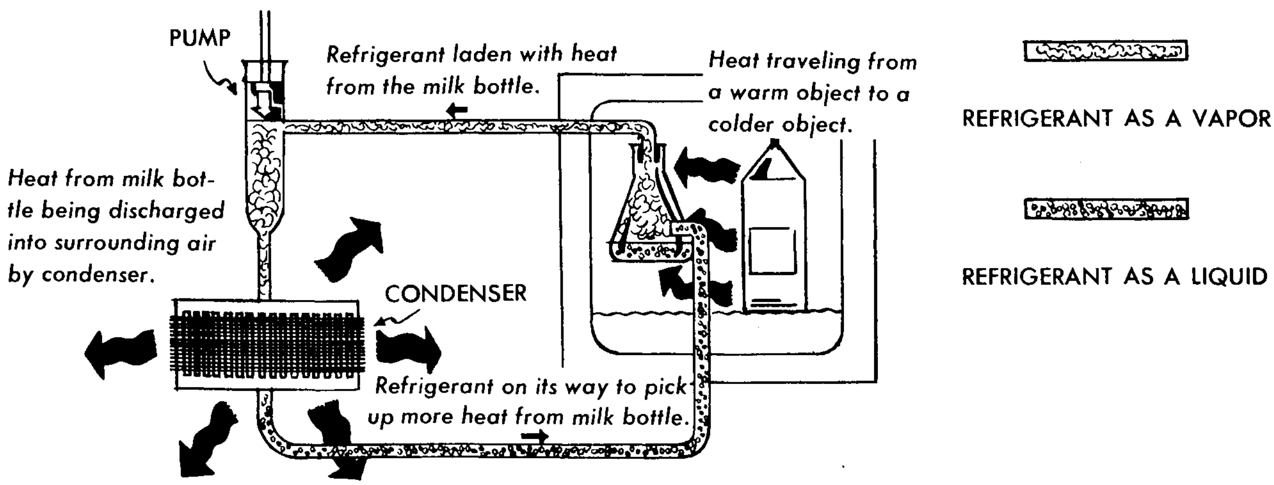
This is where pressure comes to the rescue. With pressure we can compress the vapor, thereby concentrating the heat it contains and raise the temperature without adding heat. While blowing up a bicycle tire, you may have noticed that the pump got hot. This is another example where compression raised the temperature above the surrounding air. With enough compression we can make the refrigerant vapors so hot that they can be condensed back to a liquid using air from the kitchen. We've now covered all the scientific rules that apply to refrigeration.

Meet Your Refrigerator

Now let's open the door of the refrigerator at home to see how closely it resembles the one we just described.



There are three main working parts of the refrigerator. These are the freezer (sometimes called evaporator), compressor, and condenser. The freezer is a double-walled tank or coil that provides a place for the refrigerant to boil, absorbing heat as it does.

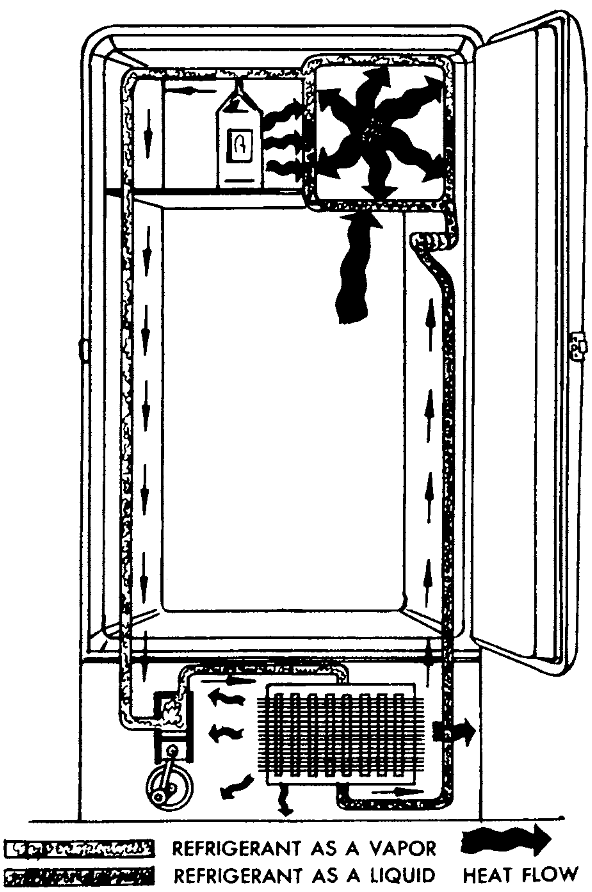


If you listen carefully with the door open and the motor off, you can even hear a faint gurgling noise inside the freezer. This is the sound of the refrigerant boiling and changing into a vapor.

Actually the vapor coming off the freezer through a pipe outside the cabinet is very cold. The problem is to cool this enough with room air to change it back to a liquid. It is the job of the compressor to exert pressure to make the vapor hot enough to lose its heat, and at the same time help it to condense.

When it leaves the compressor, it is still a vapor although it is quite hot and ready to give up the heat it has carried out of the cabinet. One of the easiest ways to cool it is to send it through a radiator called a condenser. In giving up its heat, the refrigerant vapor condenses back into a liquid which collects in a pool at the bottom of the condenser.

The refrigerant then moves back to the freezer. Its flow is restricted by means of a valve or capillary tube--thus controlling the rate of evaporation and maintaining a pressure for the compressor to work against.



These then are the main working parts in any typical refrigeration system. The freezer inside the cabinet is the place where the refrigerant boils and changes into a vapor, absorbing heat as it does so. The pump or compressor concentrates the refrigerant so it can get rid of its heat. The condenser outside the cabinet helps discharge the heat into the surrounding room air.

Demonstrations You Can Give

Explain what a Btu is. Use a pound of water in a container, apply some heat and with a thermometer show how many Btu's have been added. Illustrate a Btu using ink or food colors. Let one drop equal one Btu. Different numbers of drops in three glasses of water represent three quantities of heat.

To make something hotter without adding heat--use a tire pump to blow up a tire. Have someone feel the pump. Explain how this shows the principle of the operation of a refrigeration compressor.

What Did You Learn? - True or False

1. There is no such thing as cold because cold is regarded as the absence of heat.

2. The purpose of the refrigerant is to boil inside the condenser.

3. A cake of ice remains at 32° the entire time it is melting.

4. Fifty pounds of water at 32° will absorb as much heat as 50 pounds of ice.

5. Water can be heated to over 212°F. under normal pressures by increasing the heat.

6. A flask of ammonia will boil at 128° below zero.

7. The principle of the latent heat of fusion applies to the operation of the icebox.

8. With an unlimited supply of refrigerant, a compressor and condenser would not be needed on a refrigerator.

9. Ammonia is still one of the most popular refrigerants used.

10. Frequent defrosting is necessary to permit the refrigerant in the freezer to boil easier.

LIVE WITH LIGHT—OUTDOORS

With light, you can make the outdoors around your home a place that is safe and convenient, a place in which you can have more fun, a place in which you can get more work done, and a place that you'll be proud to show to your friends.

What to Do

1. Pick an outside area around your home that you would like to see well lighted. Decide the purposes for which you would like to light it - for safety, play, work, or beauty.

2. Make a plan for lighting it. List the wiring materials, fixtures, lamp bulbs, and the cost.

3. Make one or more spike-pole outdoor lights similar to the one pictured here, or one or more garden lighting shields.

Light for Safety, First

Does your home have porch or entrance lights? It probably does, and it may well have a post lantern or some other kind of yard light.

The main reason for such lights is safety. When they are turned on, they help people to see stairways and other obstacles over which they might fall.

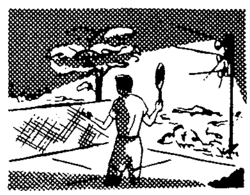
Porch, entrance, and yard lights also discourage vandalism, intruders, and thieves. They are regarded as essential.

Light for Convenience

Outdoor lights also make it convenient for us to walk around outdoors without having to bother with a flashlight. This is especially true on the farm, where people must travel between the house and other buildings, often with their hands full.

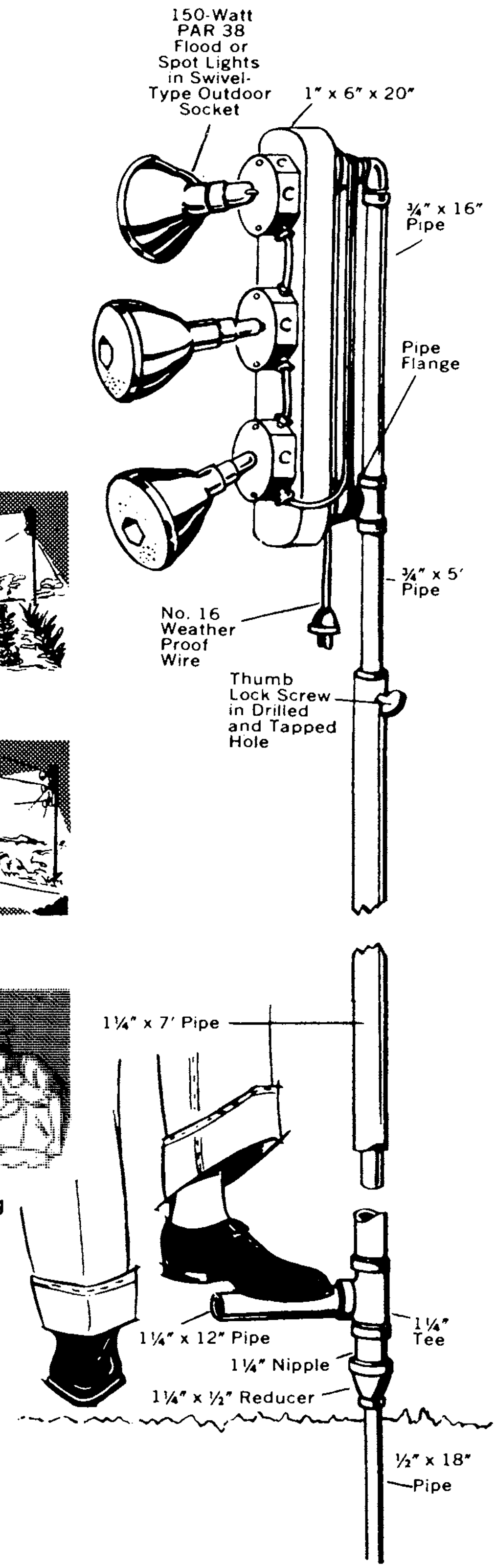
Just how convenient such lights are depends on how many there are, how well they are placed, and the way in which they are controlled.

For work



For play

For cooking and eating



Generally speaking, lights for safety and convenience should be placed as high as possible without shadowing heavily traveled areas. (A light high above the back porch might make the roof cast a shadow on the steps.)

Such lights can be located on poles and will cover more area than if mounted on a building. Use 150-watt PAR 38 floodlamps, located 10 to 20 feet above the area to be lighted, or regular pole lighting fixtures.

For walks near the house, you can use dome type units about 16 feet apart with 25 to 50-watt bulbs.

They can be controlled with three-way or four-way switches, with low-voltage controls, with photoelectric controls, with time switches, or with a combination of the last two methods.

Are the outdoor areas around your home lighted for safety and convenience?

Light for Play

Have you ever had some friends at your place in the evening, and wished that you had enough daylight to let you play croquet, horseshoes, badminton, or some other outdoor game?

You should light the areas for such games in a generally uniform manner. Be sure to keep direct light out of the players' eyes. A light source well above eye level on a building or pole is usually best.

Light for Cooking and Eating

Most everyone agrees that food tastes better outdoors. Lighting of the cooking and eating area will help the cook and make backyard picnics easier and more fun.

To light the outdoor fireplace or barbecue, use 150-watt PAR 38 floodlamps, located 10 to 20 feet above the ground, and aimed in several directions to soften shadows.

The table can be lighted in the same way, or you can use two 10-inch weatherproof plastic "bubble" fixtures with 60 to 75-watt bulbs, suspended three to five feet above and slightly to one side of the table. When you put lights near the table or fireplace, use the yellow bulbs that do not attract insects.

Light for Work

Do you ever run out of daylight when you have some important work to do on your outdoor 4-H project?

You can do many jobs after sundown if light is available. In fact, the cool of the evening is often the best time to mow the lawn or work in the garden. Portable flood lights will do for this kind of work.

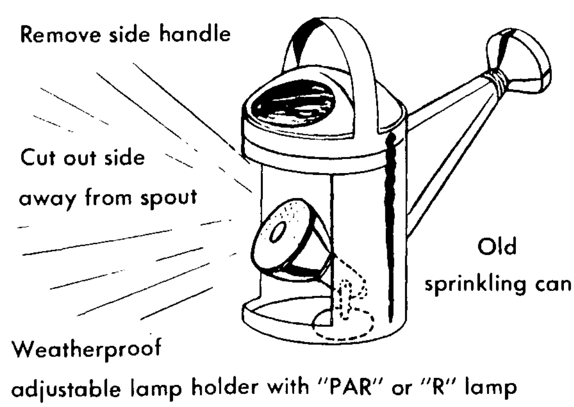
Jobs such as painting and other do-it-yourself projects require uniform light of fairly high intensity, and freedom from shadows.

Light for Beauty

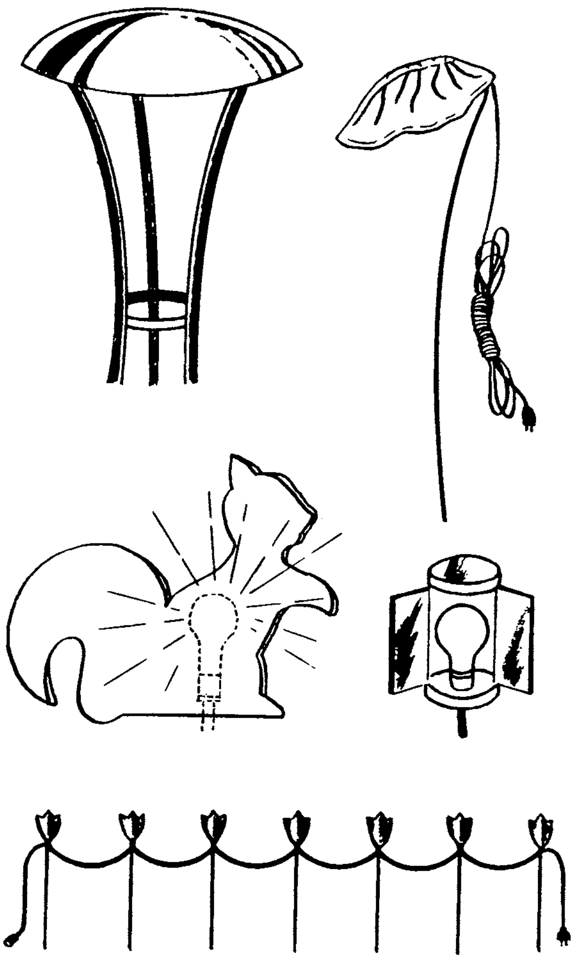
Are you especially proud of the 4-H flower garden you have planted, or of the way you have beautified the grounds around your home?

If you will light them at night, you can enjoy them more yourself and can share more of their beauty with other people.

Sidelighting or backlighting works best, because front lighting makes things look flat and uninteresting. There are several kinds of commercial garden lighting fixtures available. The dome or mushroom type is most common. Use 25 to 40 watt bulbs in them, 12 to 14 inches above the flowers. Or, conceal a weatherproof lampholder in a sprinkling can or other kind of shield.



Be careful about shadows. When they are carefully controlled, they add to the beauty. Out of control, they can produce some weird effects.



Various types of holders. Some you can make; others you can buy.

You can light trees or shrubs to accent unusual foliage, bark, or shapes. Select open, artistic forms instead of solid masses of foliage.

An evenly lighted area seldom creates an interesting picture. This usually means using several small lights rather than one large one.

Restrain the amount of light used. Do not try to produce a daytime appearance. Too little light is better than too much, and a soft glow is better than a glare. Conceal wires and hide the light bulbs as much as possible, using plants or shields.

Consider your neighbors. Carelessly located lights can be very annoying. Place or shield your lights so they will not disturb other people by shining on their property.

Use These Kinds of Bulbs

Equipment for outdoor lighting should be durable, moisture proof, rustproof, and preferably grounded to prevent electrical shock. Indoor fixtures and extension cords are unsatisfactory and can be dangerous. Use weatherproof porcelain sockets, sealed with a gasket.

First, let's take a look at the light bulbs available for outdoor lighting.

1. Projector (PAR) Lamps - are available for spot or flood lighting. Try both since they throw quite different beams. They are made of hard glass and will not break when water strikes them. You may need a snap-on shield or reflector to eliminate glare. Colored covers are also available as shielding devices and fit directly on the rim of the lamps.

2. Reflector (R) Lamps - also come as spot and flood lights in various colors. However, they must be protected from the weather. A spatter of rain or snow can break them when they are hot.

3. Inside Frosted Lamps - may be used outdoors unprotected in wattages of 15 and 25 watts. Higher wattages should have shielding from moisture.

4. Yellow lamps are sometimes called "bug lights". Since insects see only the blue part of the light spectrum, yellow bulbs eliminate most of the light that attracts them. Remember, however, that yellow light deadens the color of foliage.

5. Mercury Lamps - produce a blue-white light that flatters most foliage. They are available in PAR bulbs and in tubes. They need special sockets and auxiliary ballast to operate properly.

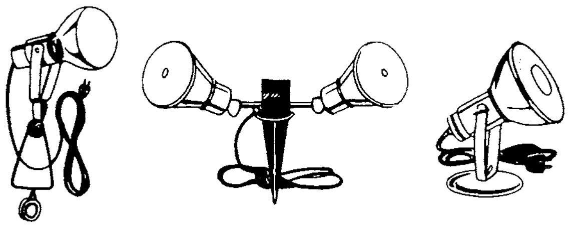
6. Sign Lamps - are weatherproof and useful for garden, and decorative lighting. They come in white and eight other colors.

7. Christmas Lamps - come in varied colors and are very effective for a party atmosphere or holiday decorations.

8. Fluorescent Lamps - Use them where you want light on vertical surfaces such as fences or hedges.

These Fixtures Work Best

1. Adjustable Holders - are used for PAR projector lamps and others. In singles or clusters, they are available with spikes for ground placement, plates that attach to walls, and clamps for use on trees and poles.



2. Dome or Mushroom Units - are used for general lighting on a terrace or where you want the light directed down. The stem will vary from two to five feet. The bulb wattage is optional.

3. Flush and Surface Mounted Units - direct the light horizontally and down. These are located along paths or walks near buildings. The lamp size usually varies from 6 to 25 watts depending on the unit.

Flush | Surface | "Bubble"

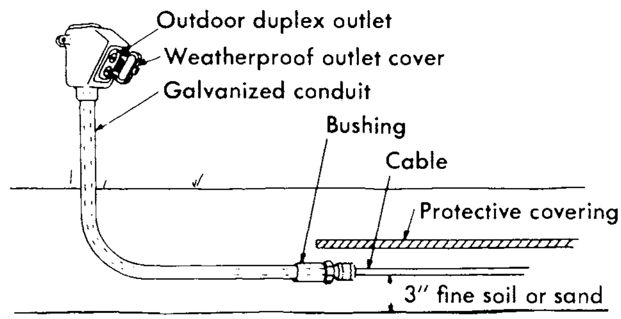
4. Diffusing Plastic Shade - or "bubble" unit is attached to a suspended socket. It is used for general terrace lighting with a roof or overhang. They are available in 10" diameters on up. Wattages vary from 40 to 150 watts in the larger sizes. With smaller bulbs inside, they are very decorative.

5. Telescopic Poles - use holders for PAR lamps or enclosed floodlamp holders. They fit into pipe sleeves driven into the ground or have a floor base.

Wiring Should Be Right

For full enjoyment of outdoor lighting, adequate wiring is essential. It may be temporary or permanent, but permanent wiring has a number of advantages. It makes installation of lighting equipment easy, avoids the hazard of cords stretched across lawns and walks, permits the use of appliances and small power tools outdoors, and because it must be grounded, is much safer.

Portable Cords - Most outdoor lighting equipment has up to 12 feet of weatherproof cord. Weatherproof portable cord sets, which handle several lighting units, are available. Some lighting fixtures have built-in outlets to connect additional units. (WARNING--these outlets may not be intended to carry appliances or power tools.) Plugs, sockets, and splices on cords should be molded in rubber to keep the cords weatherproof.



Permanent Wiring - offers maximum safety and convenience. Plastic wire types USE or UF can be buried without enclosing them in conduit. If the soil is rocky, place a layer of sand or fine soil in the trench as a bed for the cable. A slight "S" should be made in the cable where it enters the house to allow for expansion or contraction. Separate circuits for outdoor lighting equipment should be provided for in the main house panel. Be sure that one or more convenient controls are installed.

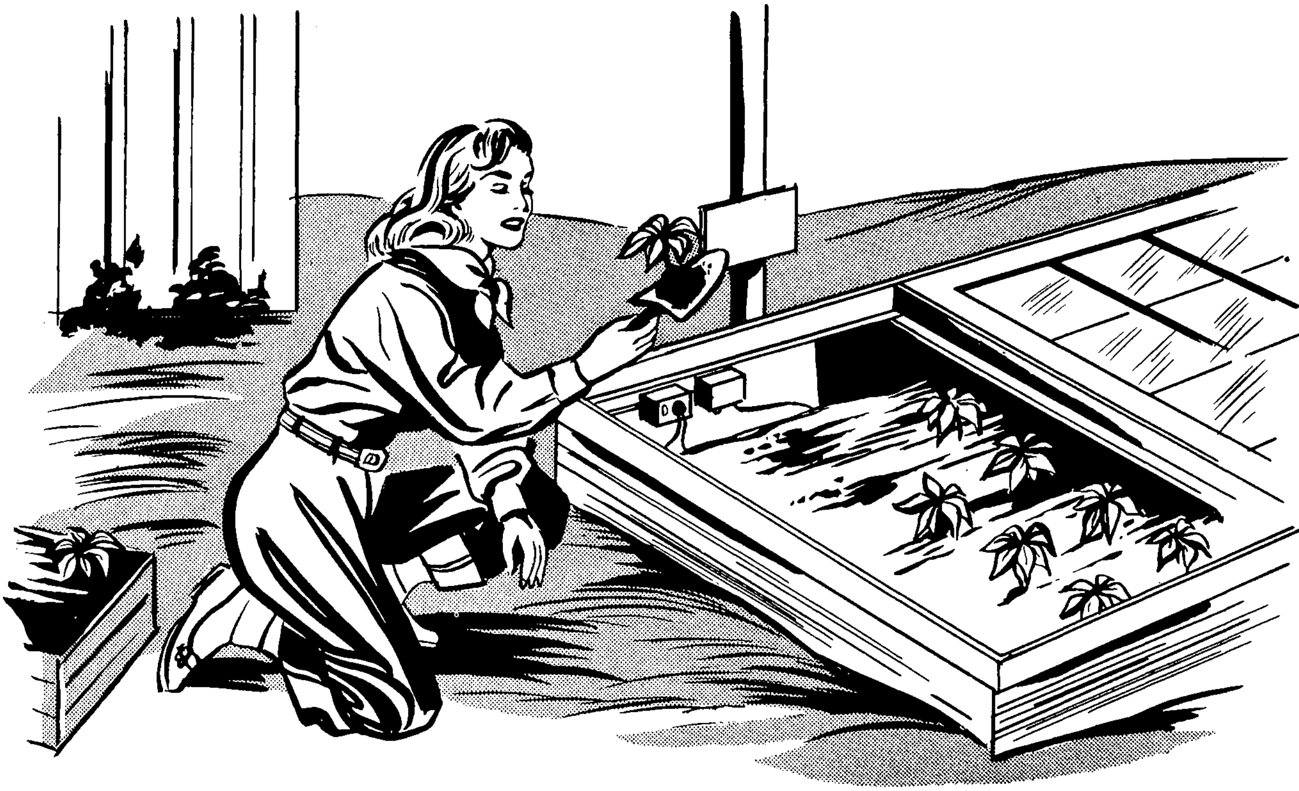
Demonstrations You Can Give

Show various bulbs and fixtures suitable for lighting outdoor areas, and tell what each is best adapted for. Show some "before" and "after" pictures of an area that has been properly lighted.

For More Information

Ask the home or farm representative of your power supplier, or your county Extension or home demonstration agent.

HOW TO BUILD AN ELECTRIC HOTBED



Do you have a 4-H vegetable garden or flower project? Are you interested in the science of plant development? Or, would you like to earn some extra money by growing and selling plants?

One of the best ways to grow better plants is to get a jump on the weather. With a good electric hotbed you can gain several weeks on the growing season.

What to Do

Construct an electric hotbed. Talk over with your parents the plans given. Follow the steps as outlined. Have your parents help you make some of your decisions. Keep an account of your costs and itemize them and the materials.

Pick a Good Location

You should pick a good location--it's essential for satisfactory operation of a hotbed. Select a place where the soil has good natural drainage so there is no chance of water standing in the bed. It should be close to a source of electricity and a water outlet.

Buildings or other objects such as trees should not block sunlight from the bed. The bed should have a southern exposure so that it receives maximum amount of sunlight. If the ground slopes, a southern slope is preferred. Some form of a windbreak on the north or windward side will help reduce operating costs.

Size According to Need

Almost any size hotbed can be electrically heated. Beds 12 feet wide have been operated successfully but a narrower bed is easier to work. The size of the bed will depend on the kind and number of plants, and spacing between plants and plant rows.

A standard hotbed sash is 6 by 3 feet. If you plan to use this type of covering, a practical width for a bed is 5 feet 8 inches. The length should be a multiple of three such as 6, 9, or 12 feet. Cable is usually designed to fit 2, 4, or 6-sash beds, although special units are available for small beds.

Cables and Controls

Various types of electric heating cable are available. Both lead-covered and plastic-covered give satisfactory results when used properly. In selecting cable, you must know how many watts per square foot of bed area are needed to provide enough heat. In southern areas, 10 watts per square foot have proved adequate. In northern areas, during extremely cold weather, as much as 16 watts per square foot may be needed.

The cables vary in length and heating capacity. Some are 60 feet long and are rated at 400 watts on 115 volts. Others are 120 feet long and rated at 800 watts on 230 volts. Still others are 60 feet long and rated at 300 watts. Various other cable lengths and wattages are available. Use your judgment in selecting the proper size cable for the bed you plan to build. Your power supplier or equipment dealer can assist you in selecting your heating cable.

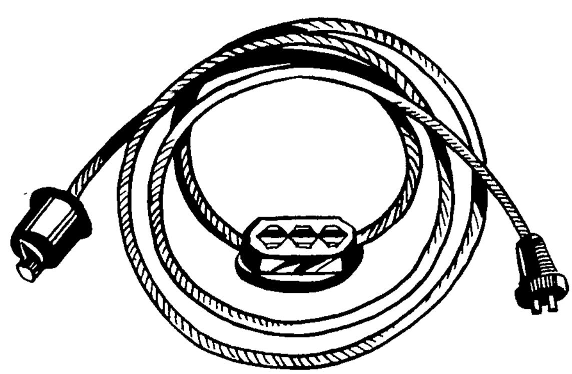


Figure 1

Select a <u>thermostat</u> with an operating range of from around 30° to 120°F. One whose sensing device can be buried will work satisfactorily in a small bed. It must have sufficient current-carrying capacity to handle all the cables that are connected to it.

Place the thermostat 1/3 of the way across the width of the bed and about the same distance from the end wall. Some growers bury it about one inch in the soil near the northwest corner. Others set it in a vertical position with the bottom half buried. Here it is affected by both soil and air temperatures. Do not place the thermostat or bulb directly above a heating cable or allow it to come in contact with a cable.

Covering

Glass sash is the best type of covering for hotbeds, but is also the most expensive. Other materials such as plastic film, plastic coated fabric, and treated muslin work in warmer climates and help cut costs.

Materials

Most beds are constructed with wood sidewalls. They should be two inches thick and made of tongue-and-grooved lumber. If this is not available, use 2-inch lumber dressed on all sides, and weatherstrip the joints. Treat the wood with copper napthenate or some other product that retards decay but will not injure the plants. <u>Do not use creosote.</u> It is harmful to plants.

Instead, you may wish to use 4-or 6-inch masonry blocks. They should have a good footing to prevent frost damage. Use mortar in laying the masonry blocks. Poor joints permit air leakage and increase operating costs.

Ground Work

The bed area must be level. If sloping land is leveled, be sure that runoff water will not enter or stand around the bed. It may be necessary to place cinders or gravel under the bed to insure proper drainage. If so, dig the bed area to a depth of about 8 inches. After the walls are built, tamp cinders or gravel to a depth of 6 inches in the excavated space. Cover the cinders or coarse gravel with burlap to prevent sand from sifting down.

Add a two-inch layer of sand. This is important. It protects the heating cable from mechanical or chemical damage.

Construction

Build the back or north wall 18 inches above the level at which the heating cable is placed. Side walls usually slope toward the front about one inch per foot of width. If the bed is 6 feet wide, the front wall will be 12 inches high when the back is 18 inches high. With six inches of soil this will provide six inches of space along the front edge. This is ample room for plants.

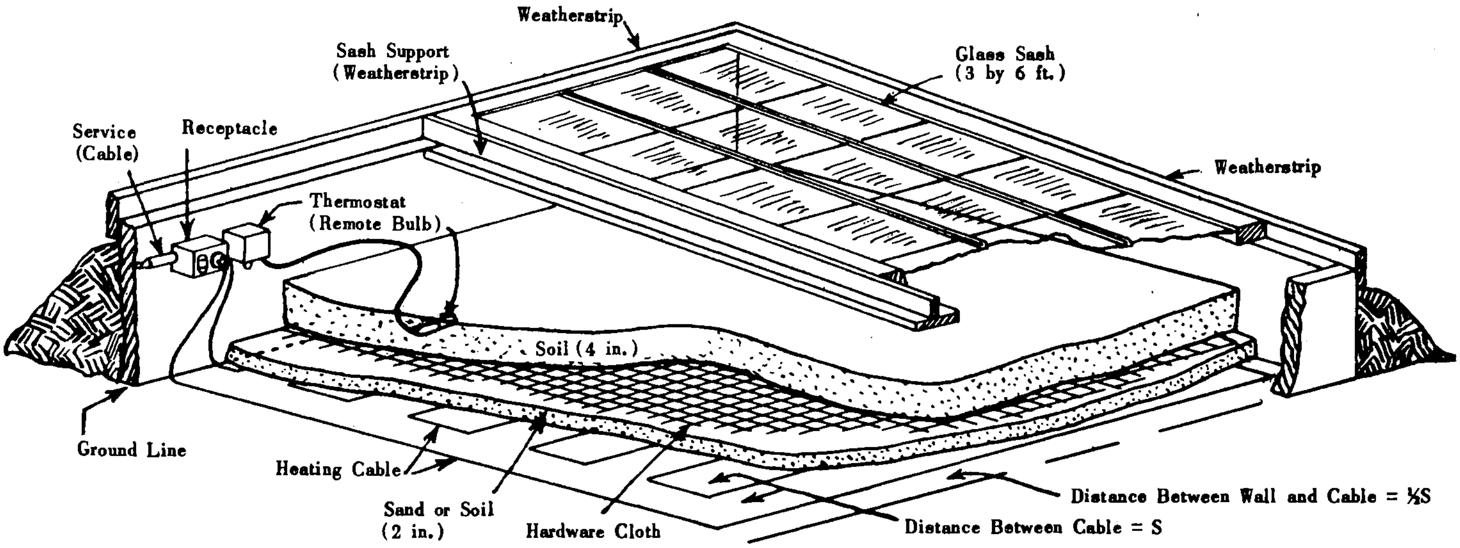


Figure 2

If the bed area was excavated, extend the walls down to the bottom of the excavation. If the area was not excavated, extend the walls down to about four inches below the level at which the heating cable is placed.

Nail one-by-four inch boards to the outside top edge of the back and side walls, as shown in figure 2. The boards serve as weather stripping and reduce heat loss between walls and sashes. Bank soil against the outside of the walls to prevent air leakage.

Laying the Cable

Lay the cable on level soil at the bottom of the bed. If the bed was excavated, lay it on the sand covering the cinders or gravel.

Uniform spacing between loops or sections of cable is important. The distance between the outside loops and the wall should be one-half the distance between the inside loops.

After the cable is in position, cover it with 2 inches of loose soil or sand. Then place a 1/2-inch mesh hardware cloth on top of the soil or sand. This will prevent damage to the cable when digging in the bed.

Precautions

Do not cross one cable over another. This creates a hot spot and could result in a short. Also never shorten the length of a cable. A shortened cable may become hot and burn out.

Electric Wiring

Small beds of three sashes or less can be operated satisfactorily on a 120 volt electric system. A weatherproof service switch, properly fused and grounded, should be installed on a pole adjacent to the bed. The wiring to the switch must be large enough for the distance and heating load. Make all connections to the heating cable water-tight to exclude moisture.

Larger beds, of 4 or more sashes, should have a 3-wire, 230-volt service line.

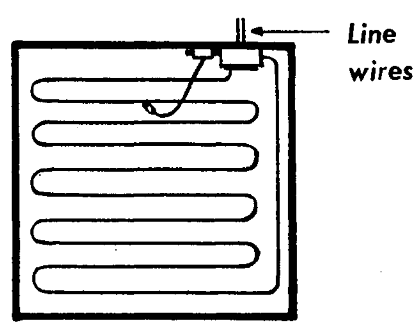


Figure 3

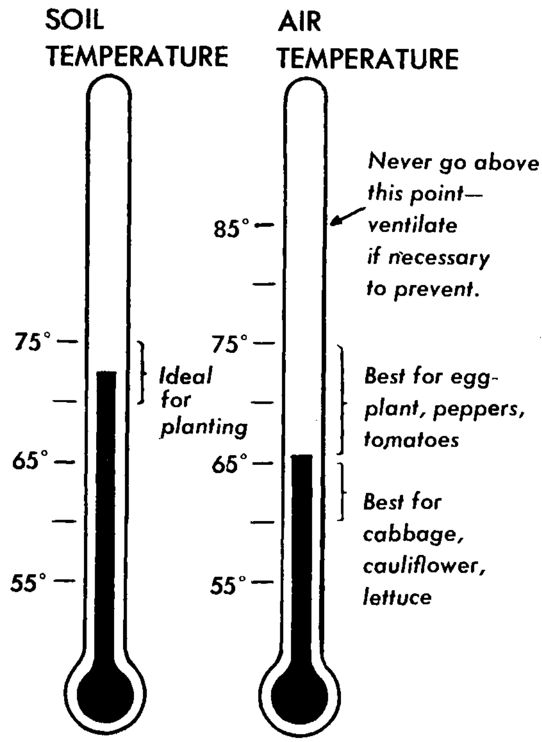
Operating the Bed

Place four to six inches of soil in the bed. Use rich soil that is free of weeds and diseases. It is desirable to sterilize the soil with heat or chemicals to kill the weed seeds and reduce the possibility of disease.

Your Extension Agent can give you information about sterilization of the soil. He can also help you with testing the soil to determine what fertilizer is needed.

A soil temperature of 70° to 75°F. is ideal for planting most seeds. After the seeds germinate, adjust the temperature to suit the particular plant. Cool season crops such as cabbage, cauliflower, and lettuce, require an air temperature during the day of 60° to 65°F. Warm season crops such as egg plant, peppers, melons, and tomatoes require 65° to 75°F. air temperature. Night temperatures can be 5° to 10° lower than day temperatures.

Check both soil and air temperatures with thermometers. Air temperature over the bed should never go above 85°F. Some ventilation will probably be needed on all mild sunny days. Avoid cold drafts or rain on the young plants.

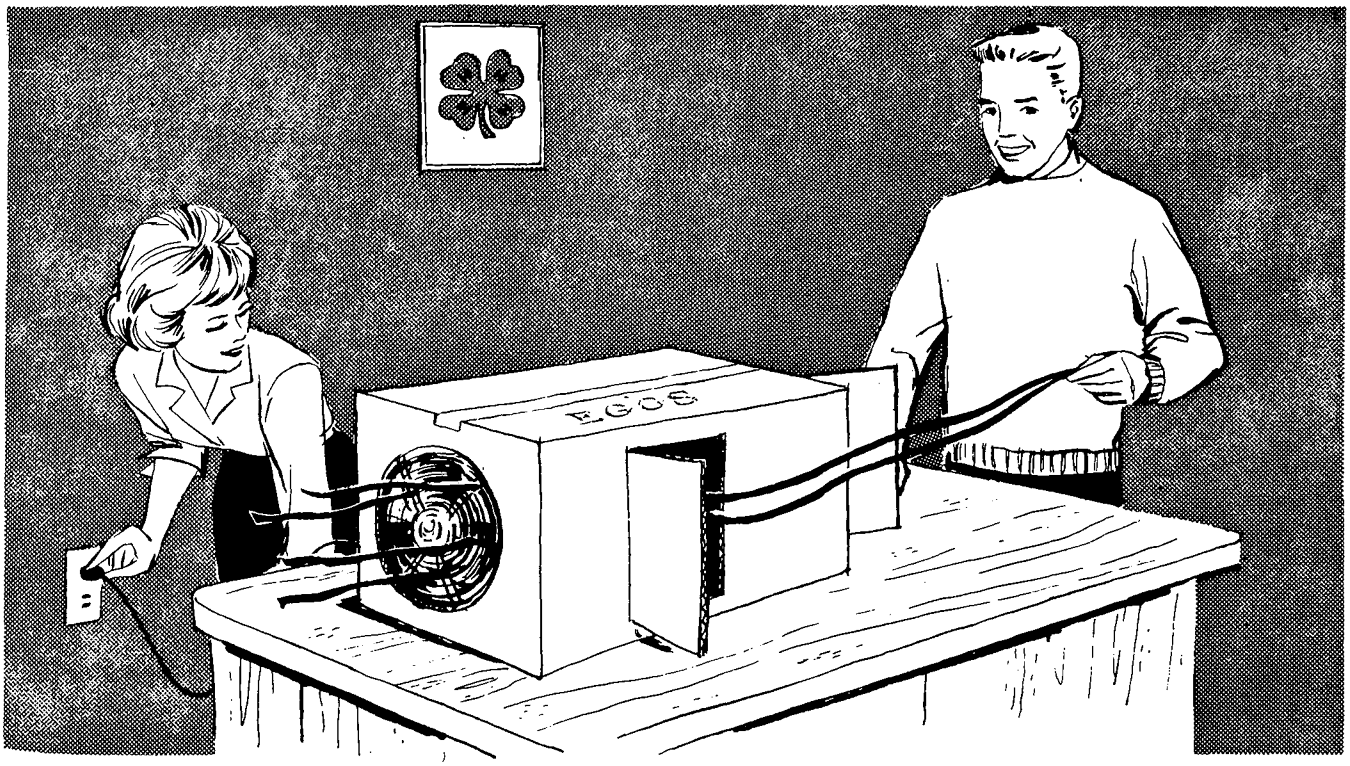


Keep the bed moist at all times, but do not apply too much water. Apply water in the morning so that plant foliage will dry off before evening. Be sure all joints are windtight. Cover the sashes during extremely cold weather. You can expect a 3 x 6 foot bed to use one to two kilowatt hours of electricity per day.

What Did You Learn? See if You Can Match These

Maximum amount of sunlight	18 inches
Standard glass sash	10 watts per square foot
Minimum heat requirement	6 inches of gravel or cinders
Height of North side above the cable	Southern slope
Operating range of thermostat	Shorten cable
For poor drainage	3 by 6 feet
Weather-stripping	70° to 75° F.
Cover for cable	1 to 4 inch boards to top edge of the back and side walls
An unsafe practice	30° to 120°F.
Ideal soil temperature for planting	2 inches of sand and hardware cloth

VENTILATION—Moving air with a purpose



Good ventilation is something you aren't likely to miss until you are without it.

Have you ever attended a meeting where the air was "stuffy" and where you had trouble keeping awake, or where you even got a headache?

Or maybe you have walked into the house when cabbage was being cooked, and wondered if you wanted to stay for supper!

Proper ventilation can solve both of these problems, as well as others.

What to Do

1. Learn what proper ventilation can do.

2. Learn the basic principles of good ventilation.

3. Select a size and type of fan that would be right for some job in your home or on your farm.

4. Determine the proper location and method of control for this fan.

5. Demonstrate the principles of ventilation to others using a portable fan.

Ventilate the Sure Way

If we were to take a glass bottle, and put a cork tightly in the top, we would come pretty close to having "no ventilation" inside. But most homes and other buildings designed for humans or animals are far from being that tight. As a result, every such place has more or less natural ventilation. This is the movement of air through or around doors and windows, and through other tiny cracks in the structure.

In many cases, natural ventilation is enough, but in many other situations it is inadequate. We often try to increase natural ventilation by adjusting doors and windows, but the wind and outdoor temperature may change, or rain may blow in. The result is that this method often is not dependable.

An electric fan, properly sized and installed, and equipped with a suitable control and anti-backdrafting device, is a very dependable and positive means of providing the ventilation we need.

Ventilate to Remove Heat

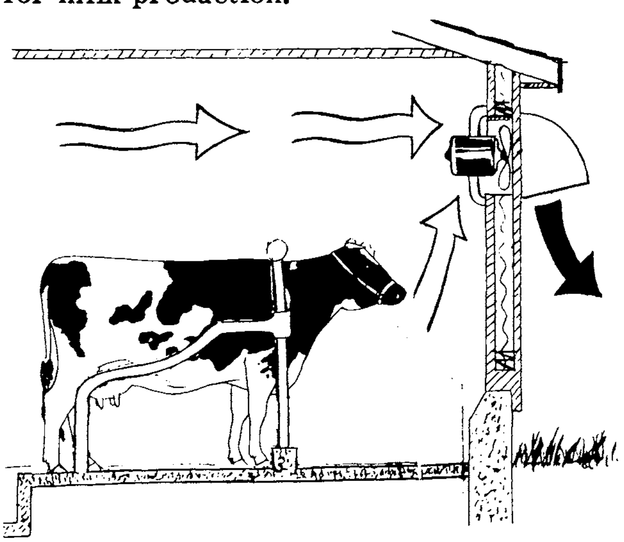
Ventilation is sometimes used to remove excessive amounts of heat in situations like these:

In a kitchen where much cooking is being done, we have an excess of heat, as well as odors and moisture.

In a meeting hall, the heat given off by a crowd of people, together with that produced by the heating system, makes the room too warm.

In bedrooms during warm weather, the buildup of heat during the day is often so great as to interfere with comfortable sleeping at night.

In dairy stables, the heat produced by the cows often raises the temperature above the 50-55 degrees that's been proven best for milk production.



Ventilate to Remove Odors

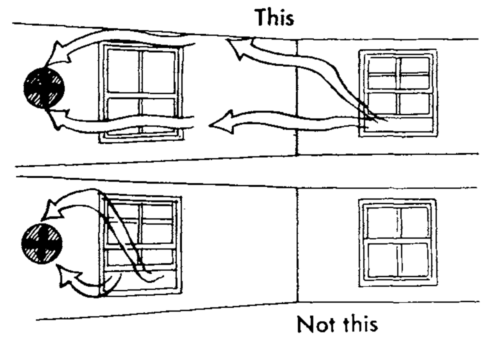
We talked about removing odors from the kitchen, but there are other areas from which odors should be removed, including: places where dry cleaning or painting are being done, bathrooms and powder rooms, and poultry houses.

Ventilate to Remove Moisture

If there's too much moisture vapor in a room, it condenses on windows, mirrors, woodwork, and walls to cause an unsightly appearance and eventual peeling of paint and rotting of wood. Ventilation is used to help remove such moisture in kitchens, basements, bathrooms, milking parlors and milkhouses, dairy stables, and poultry houses.

Intakes Are Important

The area to be ventilated must be located between where most of the air enters, and where it is exhausted. This means that you can't open a window right next to a fan - you'll get an air "short circuit"-and the rest of the room will not be ventilated properly.



If drafts are to be avoided, the air intakes must be small in size and more or less uniformly distributed. In warm weather, we usually aren't much concerned about drafts, and we can often open windows on the opposite side of our fan-ventilated room without any ill effects.

In cold weather, however, there's the danger of making persons or animals ill as a result of large quantities of cold air striking them.

Sometimes the natural small cracks and openings in a building are enough to admit the air that a fan exhausts. However, if a fan speeds up when you open a door, that's a sign that you should open one or more windows very slightly to let more air in.

Get the Right Size Fan

The size of fan needed depends on the size of the room and the job to be done, or on its animal population.

General ventilation of rooms and buildings is that amount needed to remove excess heat, moisture, and odors.

Comfort cooling, on the other hand, is ventilating to create a cooling breeze, and calls for more air movement.

Here s a table that tells how frequently you should change the air--for both types of ventilation in various kinds of rooms:

Frequency of Air Change--In Minutes

Kind of Room	General Ventilation	Comfort Cooling
Assembly Halls	3-10	1-2
Attics	3-6	1-3
Churches	2-4	1
Kitchens - home	2	1
Kitchens - other	2-3	1
Offices	2-6	1-2
Rest Rooms	5-10	1-2
Schools	5-10	1-2
Stores	5-10	1-2

Fans are rated according to their ability to move air in cubic feet per minute or cfm. You can easily see that to pick out the right fan, you should find the number of cubic feet of air to be moved per minute.

To get this, you must first find the cubic contents of the room. Multiply width by length by height (in feet).

Then, look in the table for the frequency of air change in minutes recommended for general ventilation or comfort cooling (whichever you want). Divide the number of cubic feet in the room by this figure. Check your answer.

Animal shelter ventilation is usually based on the number of animals, and you should see your Extension agent for the recommendations for your part of the country. Multiply the number of animals by the recommended cfm per animal.

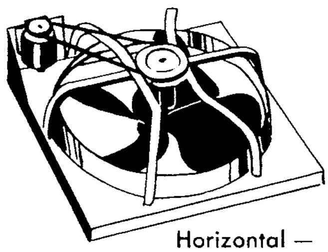
Select a fan or combination of fans that will move this amount of air. (Use the fan rating given for 1/8-inch pressure--about equivalent to the resistance that the average fan works against.)

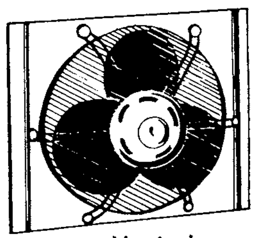
Get the Right Kind of Fan

Fans can be equipped with motors that are either totally enclosed or are of the open type. The open type are suitable for relatively clean installations, but the enclosed models should be used in dairy barns or poultry houses where dust and dirt could cause trouble. If the fan will run for long periods, the motor should be of the "continuous duty" type.

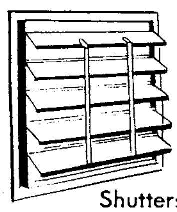
If the fan is belt-driven, the motor should be of the right speed, size, and type for it.

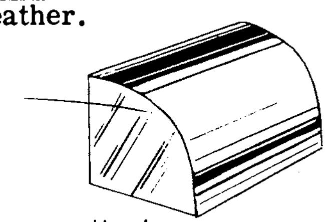
Any belt-driven or direct-driven fan can be operated in a wall. If the fan is to be installed in a ceiling, however, it should be equipped with ball bearings throughout (in motor and fan if belt-driven).


Horizontal — Ball bearings required


Vertical

Every exhaust fan should have some kind of anti-backdraft device. These are called shutters or louvers, and they should work freely so that they will always close promptly when the fan is shut off, and open when it turns on again. A hood will protect fan and shutters from the weather.


Shutters


Hood

A wire guard or removable grill should be provided to keep fingers and hands away from moving parts. It should permit cleaning and oiling.

Pick the Right Location

Consider noise, appearance, the source of whatever it is you're removing, and construction of the building when you plan to install a fan.

A kitchen fan is placed directly over the range, because that is the source of most of the odors, moisture, and excess heat. But such a fan may be connected to a hood on another wall of the house for the sake of appearance.

Sometimes a fan is installed in the cold part of a dairy stable so as to use heat in the air to help warm that area.

Avoid installing a fan near a loose-fitting door so as not to get an air "short-circuit." In an exposed building, you may want to locate the fan away from prevailing winds.

Use the Right Control

Fans can be controlled with manual switches, thermostats, and time switches, and by other means.

Most kitchen and other exhaust fans are controlled with a manual switch, but an attic fan could be controlled with a thermostat. The fan in a powder room could be wired in with the light switch so that it would always run when the light was on.

Animal shelter ventilating fans are almost always controlled with a thermostat. (Select a thermostat of the "cooling" type--that is, one that turns the power on when the temperature rises.) The location of such a thermostat is important--it should sense the average temperature in the shelter.

What Did You Learn?

(Underline the right answers)

1. Most buildings have (no, some) natural ventilation.

2. Always locate a fan (near, away from) places where air can enter freely.

3. (Comfort cooling, general ventilation) means ventilating to create a cooling breeze.

4. Select a fan based on its delivery at (zero, one-eighth inch) pressure.

5. Exhaust fans should (always, never) be equipped with shutters.

6. Cfm is an abbreviation for (cubic feet per minute, central fan measurement).

7. Moisture must be in the form of a (liquid, vapor) to be exhausted by the ventilating fan.

8. If a thermostat control is used for ventilation, a (cooling, heating) type is needed.

Demonstrations You Can Give

Secure a corrugated paper box, longer than it is wide. An egg case or citrus box would be fine. Using a knife, cut a round hole in one end and position a small portable fan in it so that air can be exhausted from the box. Attach paper streamers to the output side of the fan. Next, make one hinged door in the side of the box adjacent to the fan, and another in the end opposite the fan. Seal the top with tape.

1. With both doors closed, operate the fan, pointing out that not enough air is entering the box (you may have to insert nails in the edges of your doors so that they aren't drawn inward.)

2. Open the door opposite the fan just slightly, and operate the fan. Show that the fan is now getting enough air for general ventilation.

3. Open this same door all the way, showing that the fan is now moving air at full capacity, and is comparable to comfort cooling.

4. Close this door to the position it had in 2, and open the side door all the way. With some paper streamers, show where most of the air is entering and tell about air "short circuits."

5. If possible, get a second fan and some automatic shutters. Let the second fan represent the wind and aim it at the first fan (with the first fan off) both with and without shutters in place over the first fan. Explain how the wind can cause a serious draft by blowing in through a fan that's not running.

For More Information

Ask your county Extension agent, power supplier, or a ventilating fan dealer for literature on ventilation.

BUILD A CRYSTAL RADIO

ELECTRONICS SERIES — PART I

Electronics is a fascinating hobby or a profitable lifetime occupation.

Radio, a part of electronics, had its beginning about 1895 when Marconi succeeded in transmitting a "wireless" message over a distance of a mile and a half.

Marconi did not invent radio, nor was he alone in its early work. However, from that small beginning radio has advanced until today its influence is felt in every phase of our lives.

Through radio and television the world's greatest entertainers, educators, and politicians virtually step into our living room. Electronics provides communications across continents, oceans and into outer space. It aids police in enforcing the law, guides airplanes along the skyways and brings automation to our factories.

Many people regard radio and television as a deep mystery. By learning about electronics from the beginning, a step at a time, you can easily unravel whatever mystery it holds for you.

What to Do

Begin learning about electronics by building a crystal radio.

Figure 1

How Does Radio Work

Most radio transmission and reception makes use of waves. There are sound waves and radio waves. Sound waves travel slower and not nearly so far as radio waves.

Radio waves travel extremely fast. They also travel great distances although they do get weaker the farther they travel.

Let's trace a sound wave from a radio studio to your radio receiver and to your ear. See figure 2.

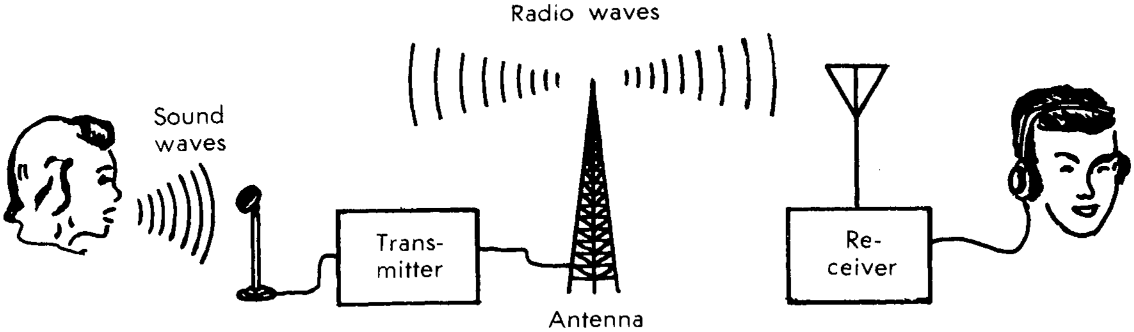


Figure 2—Following a signal from the studio to your earphones

Basic Radio Parts

Radio receivers have many parts but the four basic ones are (1) antenna-ground (2) tuner (3) detector and (4) reproducer. The crystal radio you will build has these four parts. Another part that you may study later is the amplifier.

1. The antenna-ground system collects the radio waves. If you string a copper wire with one end up in the air and the other end connected to an electrical ground you have an antenna-ground system. Radio waves from a broadcasting station, striking this wire will cause a small electrical current to flow up and down the wire.

2. The tuner, made up of a coil and a condenser selects one radio wave and rejects all others. Using a variable condenser you can select various radio wave frequencies from different broadcasting stations, one at a time.

3. The detector takes the energy which the tuner has selected from the antenna and transforms it into electrical impulses that can operate a reproducer.

4. The reproducer changes the electrical impulses from the detector into sound waves that you can hear. In the earphones that you will use the electrical impulses flow through an electromagnet causing a diaphragm to vibrate and set up the sound waves.

Crystal Detector

Several kinds of crystals can be used as detectors. All of them have the peculiar characteristic of allowing current to flow in only one direction.

Crystal detectors are variously known as crystal diodes and semiconductors. Sometimes they may be referred to as rectifiers all because of that inherent characteristic of allowing current to flow in only one direction. By this means they change an alternating current to a pulsating direct current.

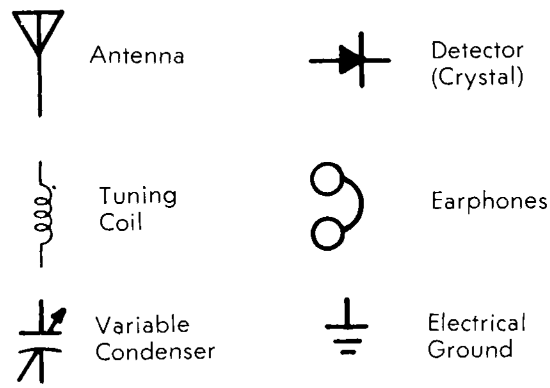


Figure 3—Radio symbols you should know

Materials You Will Need

1 - Piece of wood 3/4" x 5-1/2" x 5-1/2"
1 - Paper tube 1-1/2" x 4"
4 - Fahnestock clips, with solder lugs
2 - Pieces sheet metal 1/2" x 1-1/2"
1 - Variable condenser, 15 to 400 mmf.
1 - Crystal diode, 1N34 or 1N66 or equiv.
60' - Magnet wire, enameled 24 gauge
50' - Antenna wire, stranded bare copper
3' - Thermoplastic hook-up wire 20 gauge
1 - Pair earphones, 2000 ohm
1 - Steel corner angle 1" x 1" x 1/2"
1 - Grounding clamp
1 - Cap screw, 6-32 x 1/2"
2 - Bolts and nuts, 6-32 x 1/2"
6 - Brass wood screws, #6x1/2" round head
2 - Screws, flat head, #4x1/2"
1 - Knob for variable condenser

Coil and Board Assembly

Drill two 1/16" holes 1/4" apart in tube 1/2" from one end of the paper tube.

Thread the end of the magnet wire thru these twice, leaving a 4" end.

Wind 20 turns on the tube so each loop touches the next. Put the spool of wire in a drawer held closed with your knee and use both hands to turn the tube. The harder you push the drawer the tighter the loops of your coil will be.

Make two more holes 1/4" apart right next to the 20th turn. Cut off the wire with about 6" left over. Thread this end thru the two holes twice.

Drill two more holes about 1/8" away from the 20 turns and start the next coil similar to the first one.

Wind 30 turns, twist a small loop in the wire and continue winding 80 more turns. Finish off the coil the same way, with about 6" of wire left over.

To mount the coil bend the pieces of sheet metal (cut from a can) into a Z shape. Drill a 5/32" hole in each end. Drill holes in each end of the tube so that when mounted the wire ends will be on the side. The 20 turn coil should be to your right.

Fasten each Z strip to the tube with a 6-32 x 1/2" bolt and nut. Fasten the Z strips to the wood block with #6 x 1/2" brass screws. Drill 3/32" holes to start the screws. Center the coil on the left side of your board.

Next mount the variable condenser at the right top corner. Fasten the corner angle to wood with flat headed screws. Fasten the variable condenser to corner angle with the 6-32 x 1/4" cap screw.

Fasten four Fahnestock clips to the board with #6 x 1/2" brass screws. Consult figure 4 for locations.

Mark the clip at the top ANTENNA, the one at the bottom GROUND and the two at the right bottom EARPHONES.

Your crystal radio is now complete. Check all the soldered joints. Move the wires so they do not touch each other, and double check your circuit against the schematic wiring diagram.

Provide a good ground. Attach the grounding clamp to a metal water pipe or to a rod driven 8 feet into the ground. Fasten a piece of antenna wire to the grounding clamp screw. Attach the other end of this wire to the clip marked GROUND.

For a temporary antenna, stretch out about 30 feet of antenna wire. Do not let it touch the ground, or any conductive material in contact with the soil. You can use dry wood posts or stakes. Connect the wire to the ANTENNA clip.

Now fasten the earphone leads to the two clips in the right hand lower corner. Turn the variable condenser slowly and you should be able to hear one or more local stations.

Electrical Connections

Follow the schematic wiring diagram, figure 5 and check with the sketch, figure 4.

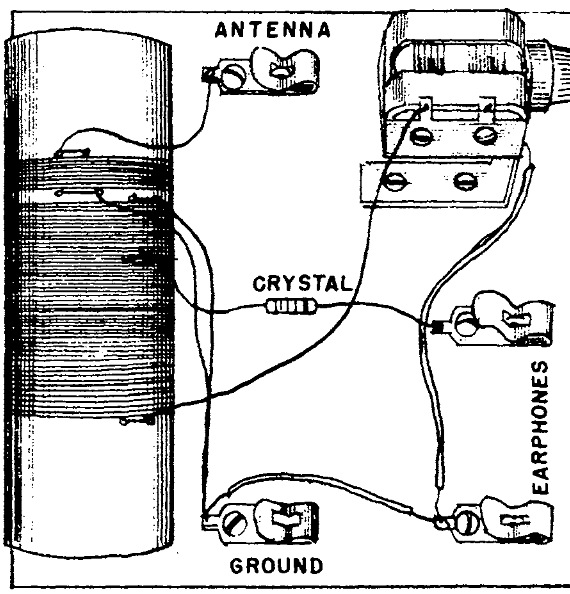


Figure 4—Crystal radio

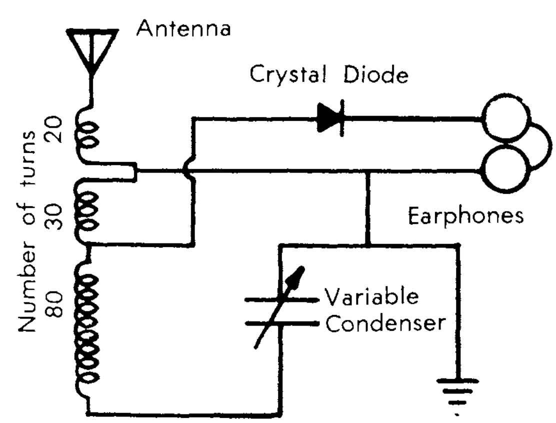


Figure 5—Schematic wiring diagram

Each coil end wire should be pulled to its point of connection, measured for length and cut off. Scrape the enamel from 1/2 inch at the end, bend the wire and hook it onto the solder lug. Solder after all wires are hooked on.

The wire from the top of the 20 turn coil goes to the ANTENNA clip. The other end of the 20 turn coil and the beginning end of the big coil go to the GROUND clip.

The bottom of the coil is connected to the insulated terminal of the variable condenser.

Cut a piece of hook-up wire, bare the ends, connect the GROUND clip and the lower EARPHONE clip together.

Now solder all of the joints made so far, except on the earphone clip. Another wire will go on here later. Be sure all metal to metal joints are clean and tight. Dab a little solder paste on each joint and touch the hot soldering iron to it. Now HEAT THE JOINT AND TOUCH SOLDER TO IT. The joint should melt the solder, not the soldering iron. Use only a very little solder.

Hook the frame of the condenser to the lower earphone clip.

Now connect in the crystal diode. Since heat may be harmful to it, hold the crystal diode with a wet cloth. Hook one end to the twisted loop between the 30 and 80 turn coils. Be sure to scrape the enamel from this loop.

The wire from the other side of the crystal diode goes to the upper earphone clip. You may need a piece of hook-up wire to reach it. Keep the wet cloth on the diode for several seconds after removing the soldering iron to be sure the heat does not travel up the wire and harm the diode.

What Did You Learn?

1. How many radio broadcast stations did you receive with your crystal radio?.......

2. What are the call letters of the strongest station you received?................. Frequency?...........Kilocycles. Power? ....Watts. Distance.........Miles.

3. Radio is a form of (sky travel) (wireless communication) (television).

4. When a person speaks he creates (sound waves) (radio waves) (electrical impulses).

5. The coil you wound was used as part of the (detector) (tuner) (reproducer).

6. The crystal detector 1N34 is (a rare mineral) (a transmitter) (man made).

7. The earphones (reproduce) (amplify) (detect) the sounds made in the broadcasting studio.

8. An antenna-ground system (detects) (collects) (tunes in) radio waves.

9. The variable condenser is part of the (reproducer) (tuner) (detector).

10. An electrical ground is made by (attaching a wire to a metal water pipe), (covering one end of the antenna with dirt) (soldering a copper wire to a steel wire).

Demonstrations You Can Give

Show others your crystal radio. Let them listen. Then explain to them what happens in each of the four parts.

Exhibits You Can Make

To show your crystal radio at a fair, construct a large card (about 18 inches square) that will stand behind the radio and describe it in words. You can stretch ribbons between the words and the appropriate parts of the radio.

For More Information

There are many books and pamphlets available. Look for titles like "Basic Electronics", "Getting Started in Electronics", "Dictionary of Electronic Terms", "Elements of Radio" and so forth.

LEARN ABOUT VACUUM TUBES

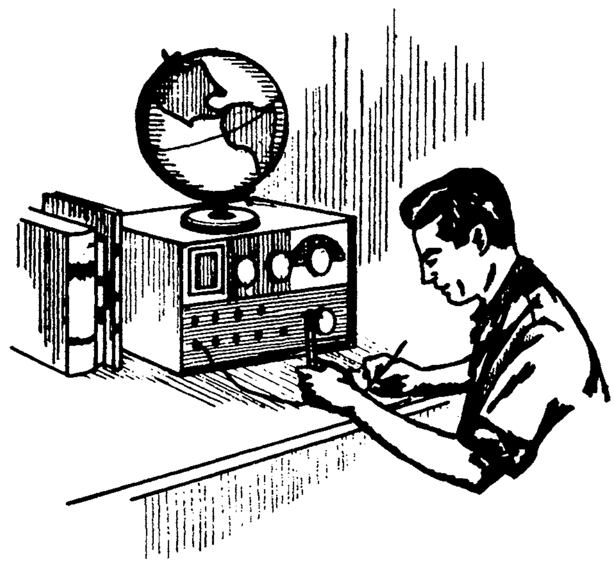
ELECTRONICS SERIES — PART II

The crystal radio you built in part I of the Electronics Series received and reproduced radio signals, but was it up to your expectations? What did it lack? Was it weaker than you expected?

In any detector, electrical current can flow in only one direction. This is true of the crystal detector and it is also true of a vacuum tube.

Let's replace the crystal detector with a vacuum tube and see if there is much difference. We still won't have any amplification so the reception may not be any louder, but it will help us understand electronics.

Vacuum tubes have been used in radio from the beginning. Although transistors are frequently used in their place now there are still many, many uses for which vacuum tubes excel. Television sets have many tubes. They are used in such modern equipment as computers, electric organs, and automatic controls.



What to Do

1. Learn about electronic vacuum tubes, Replace the crystal detector of your crystal radio with a vacuum tube.

2. Open a discarded vacuum tube and study its parts.

How Does a Vacuum Tube Work?

The basic operation of a vacuum tube involves the flow of electrons within the tube.

Electrons are minute parts of any substance. They are movable, they are negatively charged, and when they move they create magnetic lines of force.

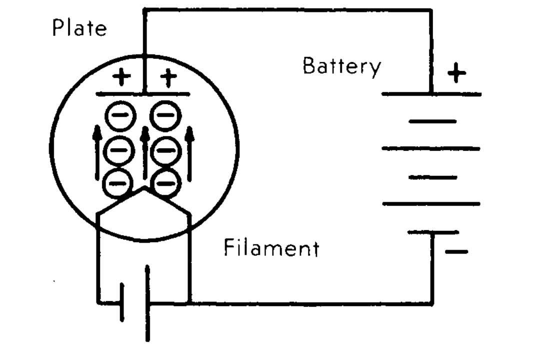
Heating a material makes its electrons move faster. Thus when a wire is heated the electrons move very fast and some of them actually "fly off."

In a vacuum tube the heated wire may be called the filament. If this hot filament were in air, two undesirable things would result. First the filament would burn up, and second the electrons would not go very far because of air resistance. Therefore, the air has been removed from the tube leaving a vacuum.

Remember that electrons are negatively charged. Therefore, to direct those that fly off we attract them with a positive charge. Thus an electronic vacuum tube needs two electrodes. One is the filament described above. The other is called the plate.

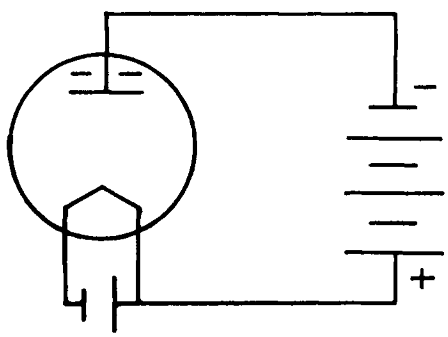
If we apply a positive charge to the plate, and heat the filament, electrons will fly off the filament and travel to the plate. This is what happens and we call it current flow. We also call it electron flow.

If a negative charge is applied to the plate the electrons will not be attracted to it. In-



Electrons will flow when the plate is positive

stead they will be repelled by it. Thus even though the filament is hot, and electrons may fly off there will be no current flowing from filament to plate. Since the plate is not heated and does not give off electrons there can be no flow of electrons from the plate to the filament.



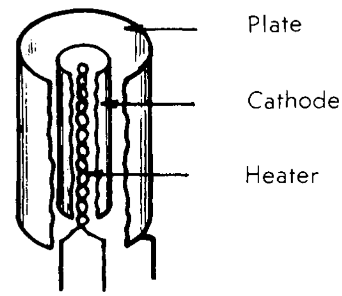
Electronics will not flow when the plate is negative

Therefore, current can flow <u>one way only</u> through a vacuum tube. This characteristic makes it suitable as a detector. It was the same characteristic that made the crystal suitable as a detector.

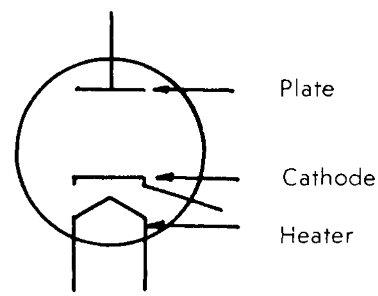
A vacuum tube with two electrodes, the filament and the plate is called a diode. The prefix <u>di</u> meaning <u>two</u>.

In the diode tube discussed above the electrons were given off directly from the filament wire. The filament wire was heated by forcing electric current through it.

Another way is to place the filament inside a metal sleeve. When the metal sleeve becomes hot it emits electrons. In this case we call the metal sleeve a <u>cathode</u> and the fila-



Parts of a diode tube



Symbol for a diode tube

ment a <u>heater.</u> The sleeve is coated with a special substance which emits electrons. The 6AV6 tube used here has a cathode and heater.

Materials You Will Need

The crystal radio you made

1 -- Piece of wood 5-1/2" x 5-1/2" x 3/4"

1 -- 6AV6 Vacuum tube

1 -- 7-pin bakelite miniature tube socket with steel saddle

1 -- 6-volt lantern battery with screw terminals

2 -- Pieces copper tubing, 1/8" x 3/4"

2 -- Roundhead wood screws, #4 x 1"

4 -- Fahnestock clips

24 inches hook-up wire

2 or more used electronic vacuum tubes

Mount the Vacuum Tube

Mount the vacuum tube socket in the center of the wood block. Use 1/8" x 3/4" copper tubing spacers to support the socket above the board. Fasten to the board with #4 x 1" roundhead screws.

Mark on the board around the socket the numbers 1 to 7 for each pin. With the keyway (space between holes) up and looking at the top of the socket, No. 1 is left of the keyway. Number the remaining pins in a counter clockwise direction ending with No. 7 to the right of the keyway.

Fasten four Fahnestock clips to the board as shown. Label the two on the left INPUT and the two on the right OUTPUT.

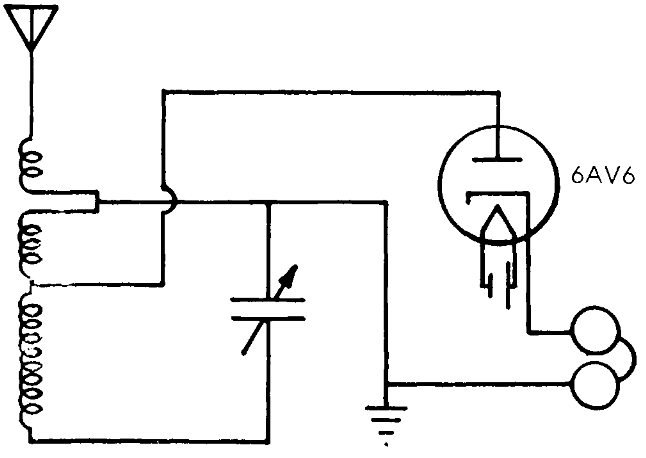
Solder 8" lengths of hook-up wire to pin 3 and pin 4. These pins connect to the heater in the tube. The other ends of the wires will connect to the battery later.

The cathode is pin 2. Solder a piece of hook-up wire from it to the upper OUTPUT clip.

The diode plate is pin 6. Solder a piece of wire from it to the upper INPUT clip.

Connect the two lower clips together by soldering in a piece of hook-up wire.

Disconnect the crystal diode from your crystal radio. In its place solder a short piece of wire.



Schematic wiring diagram

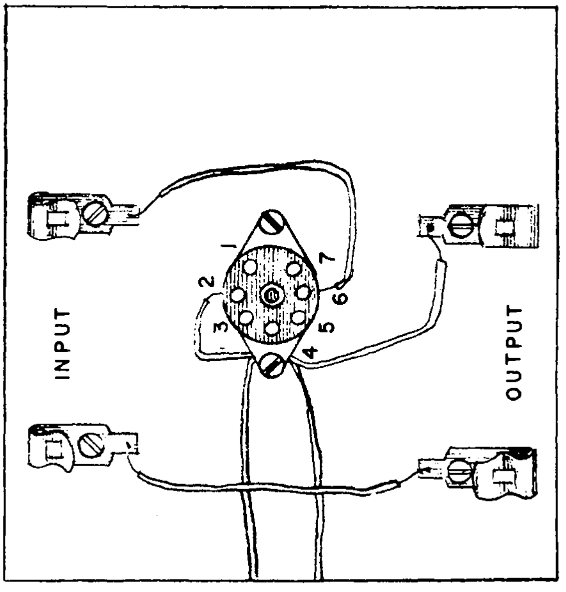
Attach the antenna and ground wires to their respective clips.

With two short wires connect the EARPHONES clips of the "crystal" radio to the INPUT clips on the vacuum tube board.

Attach earphones to the OUTPUT clips and the 6-volt battery to the wires from pins 3 and 4.

Insert the 6AV6 tube in the socket and you should be able to tune in the same stations as with the crystal detector.

How does the reception compare with the crystal diode?



Examine a Vacuum Tube

1. Obtain one or more discarded radio tubes from a radio repair shop.

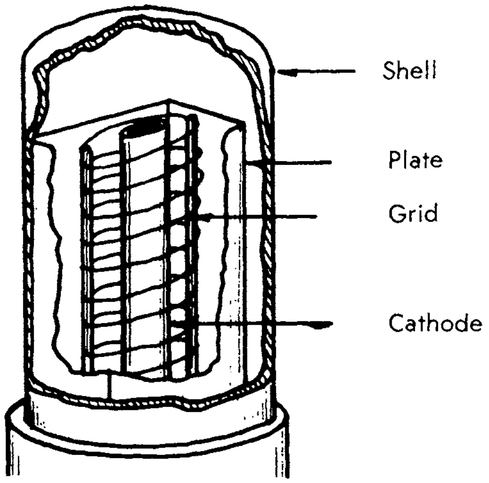
2. Record the tube type number. This number is usually stamped on the glass or metal envelope. It is not the printed number sometimes found on the base of the tube.

   Tube Type Nos......................

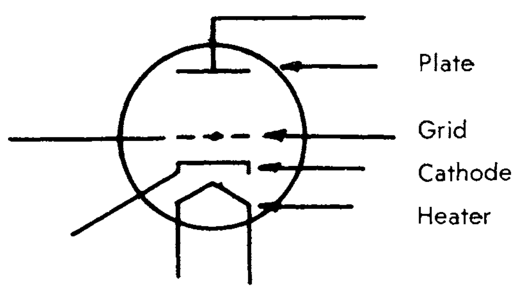
3. To open a glass tube wrap at least four thicknesses of cloth around it, lay it on a concrete floor and hit it a light blow with a hammer.

4. Dispose of all broken glass. Use long nose pliers to pick off remaining fragments. Use goggles to protect your eyes.

5. Identify the parts such as plate, grid, cathode, and heater.



Parts of a triode tube



Symbol for a triode tube

6. Draw symbols here for the tubes you have inspected.

Tube Type No. ____________ Tube Type No. ____________

Draw in the symbols for the parts you found in each tube and label them correctly. Note: You may find more than one of any or all parts. If you do, draw all of them in and label them.

If you find more than one grid (spiral of wire around the cathode) indicate it with another dotted line between the cathode and the plate.

What Did You Learn

1. The diode tube can be used as a detector because (current can flow through in both directions) (current can flow in only one direction) (it has a heater).

2. Vacuum tubes are used in (television only) (radio only) (many types of electronic equipment).

3. Electrons are (negatively charged)(positively charged) (not charged).

4. Electrons are (attracted to) (repelled by) (unaffected by) a positively charged plate.

5. The cathode is usually heated by (gas) (an electric range) (a heater wire).

6. The plate of a vacuum tube usually (surrounds) (sits on top) (touches) the cathode.

7. A spiral of wire around the cathode is called a (filament) (grid) (plate).

8. The heater of the 6AV6 tube requires (2 volts) (6 volts) (10 volts).

9. Cathodes are usually coated with (electrons) (white paint) (a special electron emitting substance).

10. A tube with one grid is called a (triode) (pentode) (diode).

Demonstrations You Can Give

Show others how you replaced the crystal detector with a vacuum tube.

Show how to open a used vacuum tube.

Identify for others the various parts of a vacuum tube.

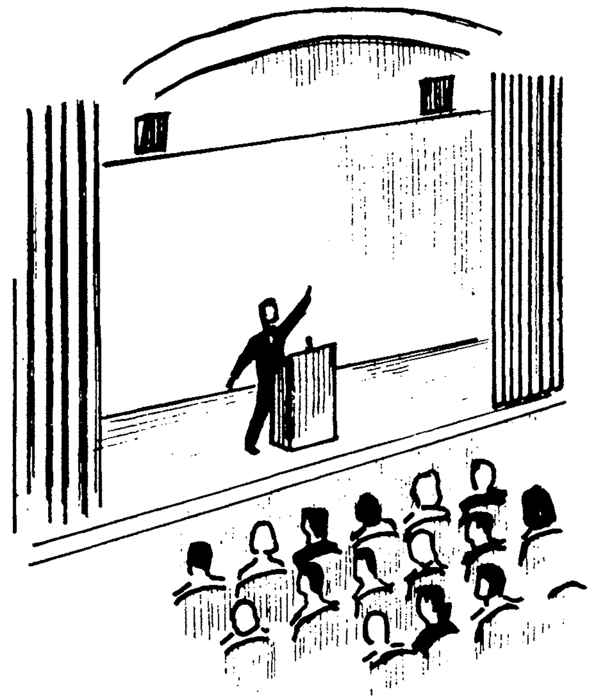
For More Information

Obtain and study a Receiving Tube Manual.

LEARN ABOUT AMPLIFIERS

ELECTRONICS SERIES — PART III

You have learned that radio signals can be detected with either a crystal or vacuum tube. With neither of these was sound reproduced very loudly. You could just barely hear it in the earphone.



Now let's take this weak signal and make it stronger with an amplifier.

Amplifiers can be used to increase the size of the radio waves or they can increase the size of the sound waves after they have been separated from the radio waves. Most radios amplify in both stages. An amplifier increasing the size of the radio wave is called a RF Amplifier. RF means radio frequency. An amplifier increasing the size of the sound waves is called an AF Amplifier. AF means audio frequency.

Amplifiers can be made using either vacuum tubes or transistors. In this lesson we will use a vacuum tube. In another we'll use transistors. It is important to learn how each works.

What to Do

1. Build a triode tube amplifier.
2. Learn how a vacuum tube amplifies sound.

How Does a Vacuum Tube Amplify?

A vacuum tube used as an amplifier needs at least one more element than the diode's plate and cathode-a grid.

You probably saw a grid in the tube you opened in a previous lesson. It is a spiral of wire placed between the cathode and the plate.

You learned that the negatively charged electrons were attracted to the plate when the plate received a positive charge and that no electrons would flow when the plate was negative.

By placing the grid wire between the cathode and plate and putting an electric charge on it we can either help or hinder the normal flow of electrons from cathode to plate.

Let's make the grid positive and visualize what happens. When the grid is positive it will attract the negative electrons being emitted by the cathode. The electrons, then, will fly towards the grid. However, only a relatively few will actually strike the grid wire since it occupies only a small proportion of the space. Those electrons that do not happen to strike the grid wire will continue on through the grid area. They will continue on their way because the positive plate is also attracting them.

Because the grid is closer to the electron emitting cathode, it exerts a great influence on the electrons as they leave the cathode. As they get nearer the plate, the plate charge has more influence on them. Thus a positive grid causes more electrons to flow from cathode to plate.

Now let's theorize on what happens if the grid is made negative. Naturally a negative grid will repel a negative electron. Thus the electrons being emitted from the cathode will not be drawn toward the grid. Instead they will tend to be pushed back toward the cathode. Only if the positive charge on the plate is very strong compared to the negative charge on the grid will any electrons reach the plate.

The grid, then, is sort of a control valve for the tube. By making it positive we increase the electron flow. By making it negative we decrease the electron flow. Also the amount of positive or negative charge affects the amount of electron flow. This, then, is the reason the grid is frequently referred to as the control grid.

In the following diagrams, with tiny ammeters in the plate circuit, we could actually measure electron flow. Electron flow is current flow and measured in amperes. In ordinary triode tubes the current is rather small so we measure it in milliamperes. A milliampere is one thousandth of an ampere.

Now visualize what happens if we apply an alternating voltage to the grid of a triode tube. When this voltage is positive more current will flow and when it is negative less current will flow. The plate current then will vary in direct proportion to the voltage applied to the grid.

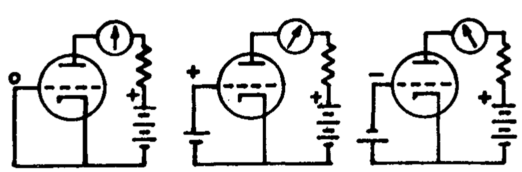


Plate current is controlled by the polarity and amount of grid voltage

The average plate current flow is also proportional to the amount of positive charge placed on the plate. Thus the bigger the battery in the plate circuit the more plate current will flow. Therefore, the greater the voltage of the B battery the greater will be the amplification of the circuit.

A small fluctuating voltage or signal applied to the grid of a tube will make a large fluctuation in the plate current. Hence we have amplification - making a weak signal stronger.

Materials You Will Need

The crystal radio you made

The 5-1/2" x 5-1/2" x 3/4" piece of wood on which you have already mounted a 7-pin miniature tube socket and four Fahnestock clips

1 -- 6AV6 tube

1 -- 6-volt lantern battery

1 -- 67-1/2 (or more) volt B battery

1 -- Battery clip for B battery

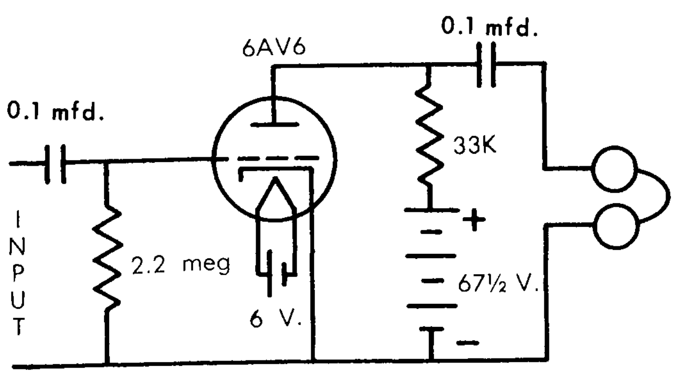
2 -- 0.1 MFD, 200-volt tubular capacitors

1 -- 2.2 megohm resistor, 1/2 watt

1 -- 33K (33000 ohm) resistor, 1/2 watt

2 -- Fahnestock clips (additional)

12" Hook-up wire



Schematic wiring diagram

To Build a Vacuum Tube Amplifier

Return the crystal diode to the crystal radio. Hold it with a wet cloth while soldering.

Remove the wires from the vacuum tube diode detector board you made previously. Note: You can leave the battery wires connected to pins 3 and 4 of the tube socket.

Solder one end of a 0.1 MFD capacitor to the upper INPUT clip.

Solder one end of the 2.2 megohm resistor to the lower INPUT clip. This resistor is referred to as the "grid leak."

Solder the opposite ends of the 0.1 MFD capacitor and the 2.2 megohm resistor to pin 1 of the tube socket. Pin No. 1 is the grid of the 6AV6. Refer to the schematic diagram to understand these connections.

Pin No. 7 connects inside the tube to the triode plate. Hook a 0.1 MFD capacitor between pin 7 and the upper OUTPUT clip. Before soldering hook one end of the 33K resistor to pin 7 also. Now solder.

Attach two more Fahnestock clips to the piece of wood. The one at the top will be B+, for connecting the positive side of the "B" battery. The bottom clip will be for B- battery connections. Mark them B+ and B- respectively.

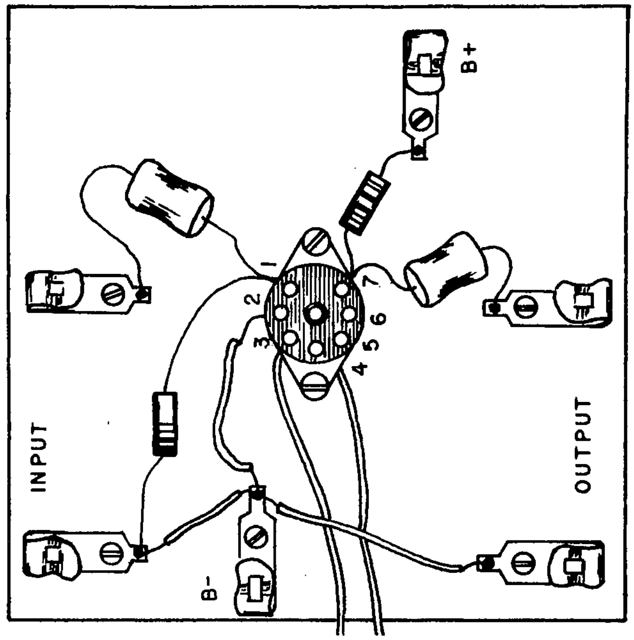
Solder the other side of the 33K resistor to the B+ clip.

Pin No. 2 is the cathode of the 6AV6. Connect it to any one of the three lower clips and connect all three of these lower clips together. Solder all joints.

Check your wiring against the schematic wiring diagram and the photograph. Are all joints solidly soldered?

Attach an antenna and ground to your Crystal Radio. Check with the earphones to be sure it is working.

Remove the earphones and hook them into



the OUTPUT clips of the Amplifier Board.

With short pieces of wire hook the EARPHONE clips of the Crystal Radio Board to the INPUT clips of the Amplifier Board.

Connect the 6-volt battery to the wires attached to pins 3 and 4 of the tube socket.

Attach the battery clip wires to the B+ and B- clips respectively. Caution: The 67-1/2-volt battery can give you an electric shock. Be careful.

Insert the 6AV6 tube in the socket.

Snap the battery clip onto the "B" battery.

Put on the earphones. Is the station coming in louder?

You should be able to get other stations. Turn the variable condenser and see what you can pick up.

List the call letters and location of broadcasting stations you can get now, that you could not even hear without the amplifier.

Call Letters	City	Approx. Distance

Still more amplification could be obtained from the 6AV6 triode tube by applying a greater B+ voltage. If you would like to try it, just hook two 67-1/2-volt "B" batteries in series. Connect the plus side of one to the B+ clip, the negative side of the other to the B- clip. Connect the remaining terminals of the batteries together.

Another way of getting greater amplification is to build and hook in another vacuum tube and its accompanying parts. With two tube amplification stages properly designed and built you would probably have enough power to operate a loudspeaker. It is not recommended that you add another stage because of the expense involved. Also the size of resistors and other parts would be different.

What Did You Learn?

1. To amplify is to (increase) (decrease) (applaud).

2. Radio waves (can) (cannot) be amplified.

3. The vacuum tube that is used to amplify is called a (diode) (triode) (corrode).

4. A positive charge on the grid of a triode tube will (decrease) (not affect) (increase) the flow of electrons from cathode to plate.

5. The grid in a triode is placed between the cathode and the (heater) (filament) (plate).

6. The abbreviation for "thousand ohms" is (meg) (K) (MFD).

7. The abbreviation for "million ohms" is (meg) (K) (MFD).

8. The size of a resistor is listed in (ohms only) (ohms and watts) (watts only).

9. The output of an amplifier should be the same as the input except for (color) (position) (size).

10. To get more amplification out of a triode tube increase the (grid leak) (plate voltage) (heater current).

Demonstrations You Can Give

1. Show others that the sound in the earphones is louder with the amplifier than without.

2. On a large chart of the schematic wiring diagram tell what happens from input to output of an amplifier.

For More Information

Study triode tubes in a Receiving Tube Manual. Compare the 6AV6 with other triodes.

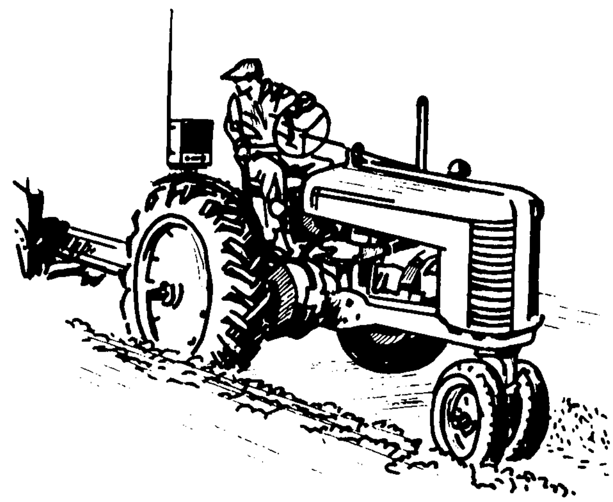
LEARN ABOUT TRANSISTORS

ELECTRONICS SERIES — PART IV

The transistor was developed at Bell Telephone Laboratories in 1948. It's a younger sister of the vacuum tube and is becoming a marvel of the electronic age.

Transistors have already replaced many of the vacuum tubes in hearing aids, radios, computers and electronic "brains."

Some of the advantages that transistors have over vacuum tubes are their light weight and extremely low power requirements. They are highly efficient since no heat is generated or required in their operations. They can be made very rugged to withstand vibration-hence their adaptability for use on tractors and in aircraft, missiles and industrial applications.



What to Do

1. Build a two-transistor amplifier.
2. Amplify the signal from your crystal radio.
3. Learn about transistors and transistor circuits.

What Is a Transistor?

A transistor is a small device which acts very much like a triode tube in an electronic circuit, but which looks and is made substantially different.

Transistors are made of crystalline materials such as germanium and small amounts of other materials such as boron and arsenic. These impurity materials are added in very small but specific amounts. They make the crystalline material either positive (P) or negative (N), depending upon the impurity.

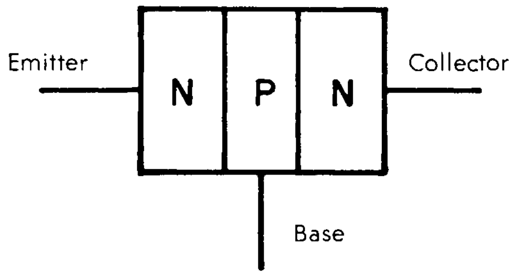
Transistors are sandwiches made of three layers of these P and N materials. You may want to think of them as being similar to a cheese sandwich with a slice of bread on each side of a slice of cheese. A transistor may have slices of the negative crystalline material on each side of a slice of positive material (NPN) or slices of positive material on each side of the negative (PNP).

The leads are attached, one to each of the three layers. With these leads the transistor can be connected into an electronic circuit.

The layers of material in the transistor are called the emitter, base and collector. Thus the leads are also termed emitter, base and collector and must be connected accordingly.

The middle of the sandwich is called the base. One outside layer is the emitter and the other side is the collector.

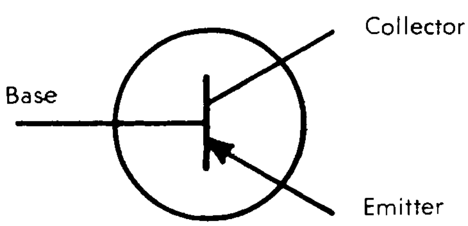
The junctions between the N and P slices each have characteristics similar to a crystal diode-that is, the junction will conduct current (electrons) much better in one direction than it will in the other.



The transistor sandwich

Another way of saying this is to say that the junction offers greater resistance to the flow of current in one direction than in the other.

If a small DC voltage is applied to the transistor, the positive side to the emitter and negative to the collector, current will flow and approximately equal amounts will flow through each junction. Since power equals current squared, times resistance, there will be greater power through the junction with high resistance. Thus when an alternating voltage signal is applied to the low resistance side, it is reproduced on the high resistance side but in greater magnitude. This is amplification.



The Transitor Symbol

Materials You Will Need

1 -- Piece of wood 5-1/2" x 5-1/2" x 3/4"

1 -- Piece of sheet metal 3" x 3"

2 -- 3-pin Transistor sockets with mounting rings-ELCO 3304

2 -- Transistors RCA 2N405

2 -- 220,000 ohm resistors, 1/2 watt

1 -- 10,000 ohm resistor, 1/2 watt

2 -- 0.1 MFD Disc Capacitors, 50 volt

1 -- 1-1/2-volt Battery, pen light size AA

1 -- Battery holder, Keystone type 139

4 -- Fahnestock clips with solder lugs, Type 5

8 -- Brass screws, #6 x 1/2", round head

18" Hook-up wire, 20 ga. Thermoplastic

Build the Amplifier

Follow both the sketch and the schematic wiring diagram.

1. On the piece of sheet metal draw a pencil line across the center, indicating two halves each 1-1/2" x 3". In one half, drill 5/32" holes for mounting to the board with two screws. In the other half, fit the two transistor sockets.

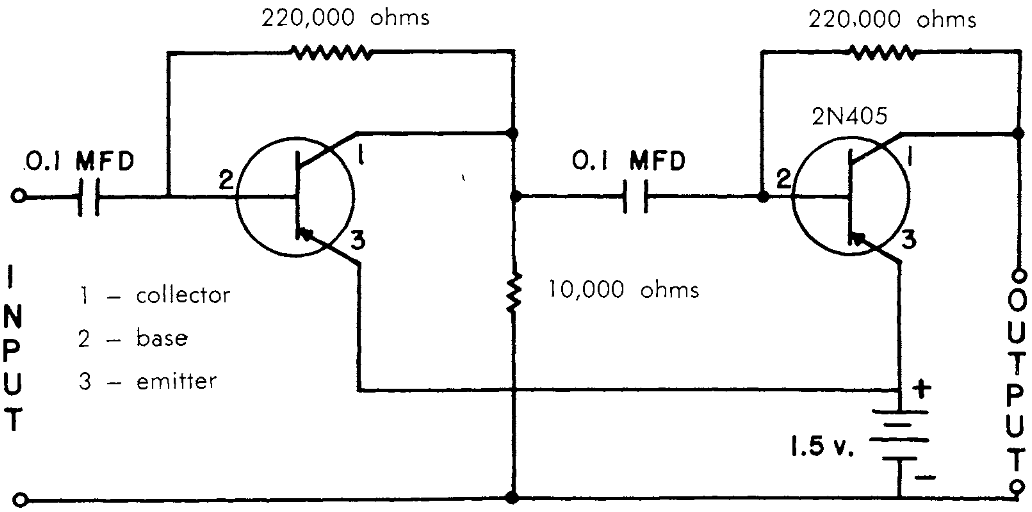
2. For the transistor sockets (Elco 3304), drill 11/32" holes in the center of this half and about 3/4" in from each end.

3. Now bend the sheet metal to a 90^{o} angle along the center pencil line. Attach it 1/2" down from the top of the board and install the sockets.

4. Attach the four Fahnestock clips, mark the two on the left INPUT and the two on the right OUTPUT.

5. Install the battery holder to the right of center. See sketch.

CAUTION: Be sure transistors are not in the sockets while you are soldering. Heat is damaging to them.



Schematic wiring diagram

6. Each socket has 3 holes in line across the center. The fourth hole, at one side, will not be used.

Of the three holes you will use, the one by itself is Pin 1.

The other two are close together, Pin 3 is closest to the outside edge and Pin 2 is towards the center.

Solder 3" pieces of hook-up wire to Pin 3 of the left socket and Pin 1 of the right socket.

7. Solder 2" lengths of wire to the other four pins.

8. Solder one lead of a 0. 1 MFD Capacitor to the upper INPUT clip.

9. Make a loop in the hook-up wire attached to Pin 2 of the left socket and solder the other lead of the INPUT capacitor, plus one lead of a 220, 000 ohm (220K) resistor, to this loop.

10. Make a loop in the wire attached to Pin 1 of the left socket, and solder in:

(1) The other lead from the first 220K resistor.

(2) A lead of the 10, 000 ohm resistor and,

(3) A lead of another 0. 1 MFD capacitor.

11. Make a loop in the hook-up wire attached to Pin 2 of the right socket, and solder in (1) the other lead from the second capacitor and (2) one lead of another 220, 000 ohm resistor.

12. Solder the other lead from the 10, 000 ohm resistor and a 3" length of hook-up wire to the lower-INPUT clip.

13. Solder the other lead from the second 220, 000 ohm resistor, and the wire from Pin 1 of the right socket to the upper-OUTPUT clip.

14. Solder the wires attached to Pins 3 of both sockets to the top (plus) terminal of the battery holder.

15. Solder the wire from the lower-INPUT clip to the lower (negative) terminal of the battery holder, and another short piece wire from here to the lower-OUTPUT clip.

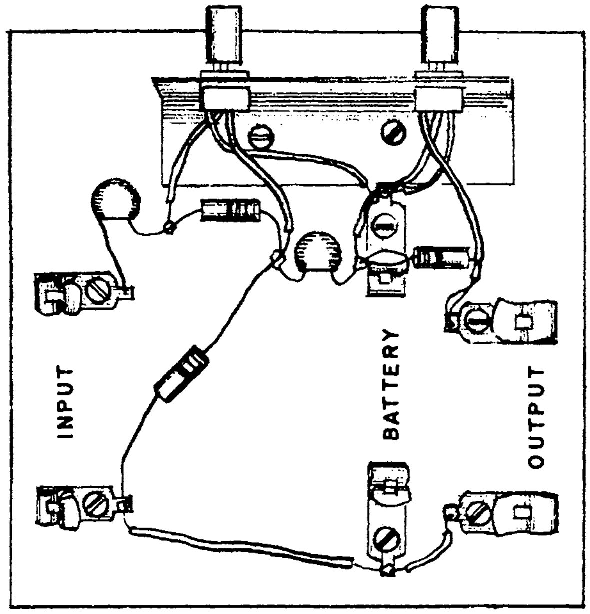
16. Now check your board and connections carefully. Are all joints solidly soldered? Check all connections against the schematic wiring diagram. Is each transistor socket pin connected to all of the proper points?

17. When you are sure the connections are correct, plug in the transistors. A red dot on the case indicates which lead is Pin 1. The one in the center is Pin 2, and on the other side is Pin 3. Push them into the sockets, being sure

that pins 1, 2 and 3 are in the holes corresponding to pins 1, 2 and 3 of the socket.

18. Plug the 1-1/2-volt battery in its holder. Be sure the positive (brass button) end is in contact with the terminal connected to Pins 3 of the sockets.

19. Connect a signal from the crystal radio to the INPUT clips and earphones to the OUTPUT clips. You should have the best reception yet.



What Did You Learn?

1. A transistor is a sandwich of (crystalline materials)(bread and cheese) (Positive and Negative electrons).

2. The polarity of germanium can be made either positive or negative by (using a bar magnet) (adding an impurity) (vibrating it).

3. Transistors (can) (cannot) be made to withstand considerable vibration.

4. The amplification of a transistor is due to its (resistance) (capacitance) (inductance).

5. A transistor has an advantage over a triode tube because it (requires heat) (requires moisture) (does not require heat).

6. One reason transistors are so well adapted to hearing aids and aircraft radios is because of their (negative polarity) (positive polarity) (small size).

7. Transistors must not be in their sockets while soldering because (heat) (solder) (moisture) is damaging to them.

8. The extra power for a transistor amplifier actually comes from the (battery) (transistors) (resistors).

9. The size of a capacitor is listed in MFD which means (mail free delivery) (megohms) (microfarads).

10. A transistor acts electronically very much like a (diode) (triode) (pentode).

Demonstrations You Can Give

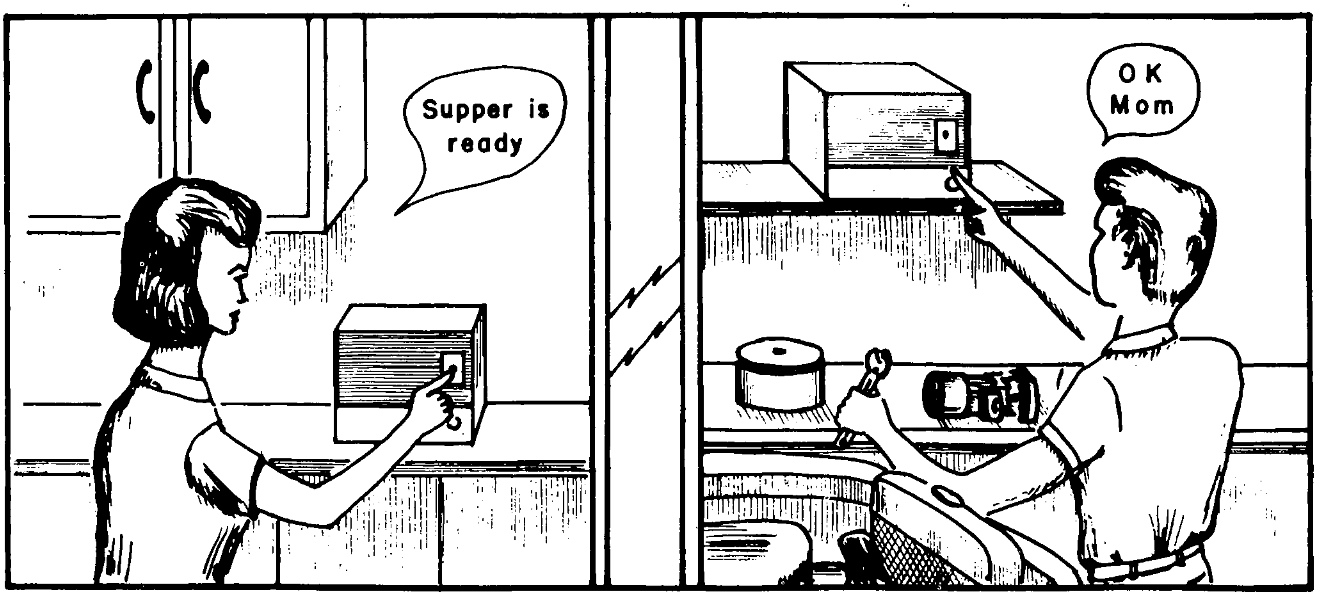
Show your transistor amplifier board to others. First let them listen to radio reception from the crystal radio only. Compare the reception using a triode tube amplifier and the transistor amplifier. Explain differences.

For More Information

Obtain and study a book on transistors. Look for titles like "Understanding Transistors," "Getting Started in Electronics" and the like.

BUILD AN INTERCOM

ELECTRONICS SERIES — PART V



Have you ever envied the executive who talked through "the box" on his desk to his secretary in another room? Have you been interested in how the girl in the garage office summoned the shop foreman to the telephone by means of an intercom system?

You can build an intercom to use around your own home or between buildings on your farm. At the same time you can learn much more about electronics.

Intercoms may seem rather complicated and they are, but you can assemble one quite easily by obtaining a kit. A kit will include every part you need from the correct vacuum tube down to the last screw and nut. Directions for assembling the kit will come with it. These are given in detail, and you will be wise to follow them to the letter.

All the parts of the kit are numbered or named so you will be able to recognize them. This will be a big help to you in learning what the various electronic parts look like, as well as something about how they work.

What to Do

1. Obtain a vacuum tube intercom kit and assemble it.
2. Learn to recognize the various electronic parts.
3. Learn the basic principles of an intercom system.
4. Make your home or farm more convenient by installing and using your intercom.

What Is an Intercom?

The word "intercom" is a contraction of the words inter-communication.

The Intercom makes use of amplifiers to carry sound from one room to another or even between buildings. The Intercom you will build uses wire to carry the electric impulses. There are intercoms available that use radio waves, instead of wire, as a carrier. Also there are intercoms that use transistor amplifiers instead of tubes.

By building an intercom using wire transmission and vacuum tubes, you will learn about this type of equipment. In other lessons you will have the opportunity to use transistors.

Your intercom should include two amplification stages. Here is the schematic diagram of the first stage:

How the Speaker and First Amplifier Work

1. Sound waves striking the cone of the speaker cause it to vibrate.

2. The vibrating cone is physically connected to a coil which can slide back and forth on the permanent magnet. As the coil moves in the magnetic field it generates a voltage and causes current to flow in the primary (P) of the audio transformer.

3. The current flowing in the primary (P) induces a voltage in the secondary (S) of the audio transformer.

4. This voltage, still fluctuating in tune with the vibrations in the speaker, causes current to flow through the resistance of the volume control.

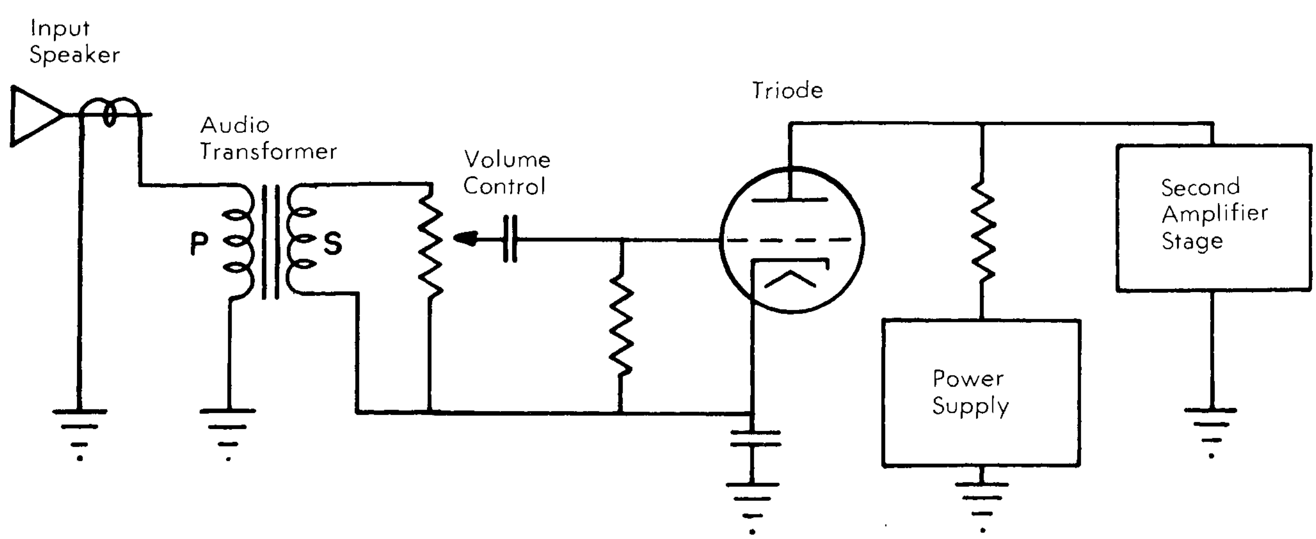
5. The desired portion of the voltage across the volume control (potentiometer) is applied to the grid of the triode tube.

6. The variable voltage (electrical charge) on the grid causes the plate current to vary.

7. As the varying plate current flows through its load resistor, an amplified voltage is built up and applied to the second amplification stage.

8. The second amplifier stage works practically the same as the first. It takes the signal voltage which has been amplified in the first stage and amplifies it again. Now it is big enough and has sufficient power to operate a loud speaker.

9. The signal is built up by the triode tube circuits, but the extra power actually comes from the 120-volt outlet through a part of the Intercom circuit known as the power supply.



Schematic diagram of speaker and first amplification stage.

A Power Supply

You may have noticed that there are no batteries needed to operate this Intercom. Instead you plug it into a 120-volt wall outlet.

The vacuum tubes have heaters that require electricity and their plates require relatively high positive charges.

The 120-volt wall outlet will furnish alternating electricity only, but the plate voltage must be a steady positive voltage. Therefore, the power supply must change the alternating current (AC) to one-way current (Direct current or DC).

How a Power Supply Operates

1. The heaters H_1, H_2, and H3 of all the tubes in the Intercom are connected in series across the 120-volt line. If the voltage ratings of the several tubes do not add up to 120 volts, a resistor R_1 is placed in the circuit to use up the excess voltage.

2. The voltage supplied to the plates of the tubes must be DC. It is designated as the B+ voltage and the more constant it is, the better.

3. A diode tube is used as a rectifier because electrons, or electric current, can flow through it in only one direction.

The current flowing in only one direction also flows only one-half the time. The time that AC would normally flow the other way is left with no current flow.

4. Current thus flows in only one direction, but its flow is intermittent or jerky. To overcome this, a filter composed of resistor R_2, condensers C_1 and C_2 are used. This in effect holds part of the current back when it would normally be high and pours it through when there would normally be none flowing.

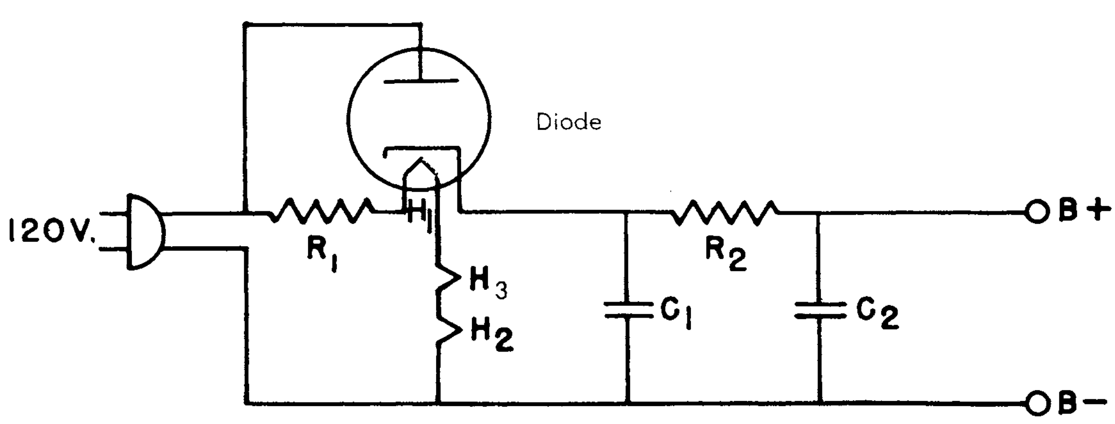
Thus the power supply makes DC out of AC for the B+ voltage to the plates of tubes.

Where to Install Your Intercom

Install your intercom where it will be most useful to you and your parents.

Do you have a workshop in the basement or outside within 50 feet of the house? If so, you may want to install the master station near the kitchen and the remote station in your workshop.

Any room where you, or whoever will use the intercom, spends considerable time is the place for one station. The other station should be in another part of the house, not within easy conversation distance. Having them on two separate floors is desirable.



Schematic diagram of the power supply

When you have decided where to install them make a good permanent installation. Run the wires out of sight as much as possible. Fasten them to walls, floors, mouldings and the like, with small staples. Be careful not to injure the insulation on the wire.

Where did you install the master station?

____

Where did you install the remote station?

____

How far apart are they? ______________ ft.

Describe how they are used. ____________

____

____

____

____

____

What Did You Learn?

The assembly manual for your Intercom contains a schematic diagram. Refer to it to answer the following questions:

1. The tube in the first amplification stage is a (12AV6) (50C5) (35W4).

2. Heaters for the three tubes are connected in (series) (parallel) (tandem).

3. The largest capacitors are found in the (first amplifier circuit) (the second amplifier circuit) (the power supply circuit).

4. One terminal of the remote speaker is connected to ground. With the switch in the "talk" position, the other terminal connects to the (input transformer) (output transformer) (power supply).

5. All of the points where the "ground" symbol is indicated are electrically connected (to a resistor) (to transformers) (to the chassis).

6. All of the tubes used in this Intercom have (grids) (cathodes) (diodes).

7. The volume control also has a switch operated by the same shaft. This is the (listen-talk) (press to talk) (on-off) switch.

8. The power amplifier tube has (one) (two) (three) grids.

9. The first amplifier stage is coupled to the second stage through a (very large) (very small) (variable) capacitor.

10. The power tube is a (diode) (triode) (pentode).

For More Information

Read about Power Supplies and Filtering in a book with a title such as "Elements of Radio."

BUILD A PORTABLE RADIO

ELECTRONICS SERIES — PART VI

Listen to ball games, newscasts, weather reports or music while you are walking or riding to school or doing your chores.

Be prepared for emergencies. In the case of a national emergency, instructions on how to stay alive will be given from regular broadcast stations. You can receive these instructions on any radio as long as power lines are operating, but only with a battery-operated radio can you receive them when electric power fails. Thus every family should have a battery-operated radio. If your radio is of the portable transistor type you can use it anytime, anywhere, and still have it for emergencies. Just be sure it is always in operating condition and that the battery is in good shape.

Excellent do-it-yourself portable transistor radio kits are available. By putting a kit together yourself you not only get a good portable radio at a reduced cost but you have an opportunity to learn a great deal about all of the electronic parts from which it is made. You can even begin to understand the theory of how these parts operate to bring you radio reception.

What to Do

1. Obtain a 6-transistor, 2-diode Portable Radio Kit and assemble it.
2. Learn more about electronic parts and their uses.
3. Learn to build on a printed circuit board.
4. Learn about superheterodyne circuits.

Understanding the Superhetrodyne Receiver

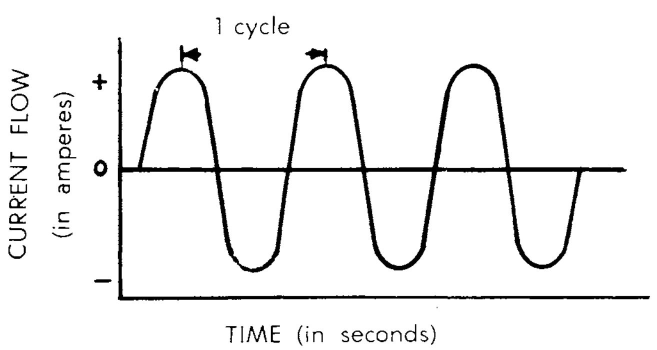
The portable radio kit you will obtain and assemble will include an instruction manual. This manual will include a complete list of parts, information on soldering, preparing parts and step-by-step procedures on assembly. It will also contain information about the parts such as transistors, resistors, and capacitors. In addition, it will contain information on troubleshooting, a circuit description, and a glossary of radio terms. Needless to say, the instruction book is a very valuable part of the kit. It should be studied thoroughly, followed religiously, and kept for future reference.

To understand how the radio operates, study the "Circuit Description" and follow it through on the schematic diagram, word for word and part by part.

In studying the circuit description, you will come across such new terms as autodyne converter, heterodyne, automatic volume control, oscillator, push-pull amplifiers and "matching" parts.

Oscillator is the term applied to an electronic circuit, which will generate an alternating current from a direct current source. An oscillating circuit is composed primarily of a coil, a capacitor, a power source and a triode tube or transistor.

The rate of current direction change is called frequency and is measured in cycles per second, one cycle being from maximum flow in one direction to maximum flow in the opposite direction and back to the maximum flow in the first direction.



Alternating current flow in a conductor
Flow in one direction is indicated as (+)
and the opposite direction as (—)

The frequency of the alternating current in an ordinary power line is 60 cycles per second (cps). Frequencies audible to the human ear range up to 16,000 cycles per second. Radio frequencies range from around 100,000 cycles per second to perhaps several hundred million cycles per second.

Electronic oscillators generally operate in the range from 1000 cycles per second to 100 million cycles per second. The frequency of any oscillator is determined by the sizes of the coil and capacitor. Oscillators of variable frequency are made by using variable coils or capacitors. Since the capacitor is most easily made variable, it is most commonly used to change frequency of an oscillator.

Heterodyning means the mixing together of frequencies. When two frequencies are mixed or "beat" together, we get either the sum or difference of the two.

Heterodyning can be demonstrated on a piano. Strike middle C. The sound you hear has a frequency of 256 cps. Now strike the note B below middle C. Its frequency is 240 cps. Now strike both keys together the sound you hear is neither B or C, but a mixture of the two. If you listen closely, you will notice that this new sound rises and falls in loudness. If you could time this rise and fall, you would notice that it occurs 16 times per second, the exact difference between C (256 cps) and B (240 cps).

In radio heterodyning two frequencies are mixed to obtain a certain intermediate frequency (IF). For example, if a radio station frequency of 1,000,000 cps is being received and we produce, with an oscillator, a frequency of 1,455,000 cps and mix the two together the difference will be a frequency of 455,000 cps.

This 455,000 cycles per second, written 455 kc (kc means kilocycles and kilo means thousand) is the intermediate frequency (IF) of the receiver you will assemble. It is the IF quite universally used in superheterodyne receivers.

The oscillator circuit in this, as well as other superheterodyne receivers, is made so its frequency can be changed to always be 455 kc higher than the frequency of the radio frequency being received. This is accomplished by "ganging" the variable capacitor of the tuning circuit and the variable capacitor of the oscillator circuit on the same shaft. When one turns, the other turns the same amount.

The advantage of the heterodyne, or so-called "superheterodyne" receiver, lies in the fact that most of the amplification can be done at one frequency: 455 kc. It is much simpler to design and build an amplifier that has excellent qualities at one frequency rather than to design and build one that will have good qualities over a range of frequencies.

AUTODYNE CONVERTER is another term applied to the oscillator. The prefix "auto" means self. The suffix "dyne" refers to the movement of electricity. To convert is to change from one status to another. Therefore an autodyne converter changes the incoming frequency to another frequency by beating it with a frequency produced by itself.

AUTOMATIC VOLUME CONTROL, generally referred to simply as AVC, automatically reduces amplification on signals that are too strong and increases amplification if the signal is too weak.

We have manual volume control to set the volume at a comfortable level. The AVC attempts to maintain the volume at this level.

Suppose you tune in a fairly weak station and turn the volume up so you can hear it. Then you decide to tune to another station. As you turn the dial you may pass a more powerful station. Since the volume is turned up high it may come in with an ear-splitting blast. The AVC tends to restrain it by immediately reducing the amount of amplification.

Another and perhaps even more important point is the "fading." Because of weather conditions, or other phenomena, radio signals do rise and fall in intensity. AVC senses this and automatically reduces or increases the amplification to maintain steady power on the loudspeaker.

A PUSH-PULL AMPLIFIER is made with two triode tubes or transistors. They are hooked up so that when one amplifier is positive and building up a voltage to push electrons through an output transformer, the other amplifier is negative or pulling the electrons down through the same transformer coil. In other words one amplifier pushes while the other one pulls electrons through the same coil, all in the same direction. Thus we get good amplification. This arrangement also gives a truer amplification of the input signal. We call it "less distortion."

MATCHING parts refers either to parts that are identical or that have equal effects. In the radio you will build, there are a pair of matched transistors. These are practically identical in every way, especially in their amplification characteristics. Incidentally, these two are used in the push-pull amplifier and will give you a truer tone from your radio.

Other parts in the radio may be "matched" as far as size of one certain characteristic is concerned. For example, the output transformer is designed to have the proper impedance (much like resistance) for its transistor input circuit and also the proper impedance for the speaker circuit.

What Did You Learn?

1. All resistors are listed as 1/2 watt. This means they all have the same ability to dispel (current) (electrons) (heat).

2. In the resistor color code, the color green indicates (one) (two) (five).

3. The conducting parts of the printed circuit board are (metallic) (phenolic) (plastic).

4. The cases of the IF transformers are (air tight) (glass) (grounded).

5. Either speaker wire from the circuit board can be soldered to either speaker lug because it carries (alternating current) (direct current) (no current).

6. No pilot light is provided because it would (heat the transistors) (wear out the battery) (be too expensive).

7. If a frequency of 1000 kc is mixed with a frequency of 1, 455, 000 cps, the resulting intermediate frequency will be (55kc)(400, 000 cps) (455 kc).

8. An oscillator creates (AC) (DC) (electrons).

9. The push-pull amplifier uses (one) (two) (three) transistors.

10. If all radio signals were always equal, we wouldn't need (MFD) (AVC) (PNP).

Demonstrations You Can Give

1. Show others how many stations you can get.

2. Explain heterodyning on a piano.

For More Information

There are many books on electronics. Select one or more and study the various electronic parts and their characteristics.

Mention of commercial names does not imply endorsement by the Minnesota Agricultural Extension Service; failure to mention a name does not imply criticism.

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