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ABSTRACT

Instructional materials included in this guide were developed to provide vocational services to mildly handicapped special needs students mainstreamed into regular schools. Material represents strategies or directions in specific areas of occupational education, rather than specific curriculum guides; it is addressed to both the teacher and the student. Five specific areas are covered in the manual: Automotive mechanics, electronic assembly, mechanical assembly, printing, and welding. Related math and vocabulary sections are included. Emphasis is on activities and operations which are concretely and specifically job related. (The manual is intended for use with four other manuals produced by the vocational strategies project.) (TA)

ED135984

TRAINING MANUAL

VOCATIONAL SKILLS

VOCATIONAL STRATEGIES FOR SPECIAL NEEDS STUDENTS

BOSTON STATE COLLEGE

BOSTON, MASSACHUSETTS

FUNDING SUPPORT:

Massachusetts State Department of Education

Division of Occupational Education

PROJECT:

#H-8376
Part B/Handicapped

PREFACE

The Vocational Skills manual is an outgrowth of two years experience in delivering vocational education instruction to a pilot population of special needs adolescents. The parameters for the strategies presented here emerge from the objectives described in the proposal for the Vocational Strategies project in its first and second years. The strategies for curriculum development and for appropriate input from business, industry, and labor unions to public schools are based on the day to day interaction of project staff with the Boston Trade School faculty, administration, and staff.

When the Vocational Strategies project first began, the schedule of Boston Trade High School provided for shop instruction on a one week in, one week out, basis. We found that the length of a school day which kept students in one shop for six hours was not realistic due to the limitations of our students (specifically, the individual learning differences identified in their educational plans). Consequently, in the winter of 1975, we arranged a schedule whereby the students were in the shops for half a day, and in the resource room for the other half. Depending on their educational plans, some students were integrated into regular classes for part of the non-shop time. Later, as a result of plans pertaining to Boston Trade High School submitted by the School Department, the half day schedule was adopted by Federal District Judge W. Arthur Garrity, and became the overall schedule for the entire school. Our model, then, called for mainstreaming students into the full shop activity and into the related academic course work suggested by their educational plans. Resource room support was provided when the students were "separated" from the regular school program.

At the height of the Boston Trade High School program component, the project was able to support five regular paraprofessionals per the 35 students matriculated. (There was another project component in vocational exploratory at the Martin Luther King Middle School.) The project also deployed a sixth Spanish dominant paraprofessional to work in the resource room with bilingual special needs students. Our resource room activity focused on vocationally related educational activity. (The details are demonstrated in the four companion manuals.) In addition to this, we were able to place some 75% of our students in after school jobs developed by our staff, and supervised by our job counselor. The project recommends the model it used for others working in the field.

Special needs students were integrated into 9 of the 12 shops available at Boston Trade School. In many of these shops, the quality of the experiences and the quality of an intensity of involvement did not prove productive, nor did they lend themselves to the "laying down on paper" of a set of recommended activities. Although a major part of early project activity was devoted to determining and writing, first, of curriculum guidelines, and later, of curriculum methods and activities, in the long run the Boston Trade planning team writing workshops were unable to produce a criteria-referenced curriculum for special needs students mainstreamed into shops. This is not to say, however, that the planning team did not work diligently. More than any other factor, the missing ingredient that inhibited the curriculum writing of the planning team in the first year, and the effective instruction of the students throughout, was the absence of a pertinent, productive contact with the business community, that is, with the industries and corporations where the special needs student might have the best chance for employment.

As we worked with our students at Boston Trade, providing them with the kind of work related education indicated as necessary and possible in their individual educational plans, we realized that the motivation of the students was in many cases tempered by their "developmental disability." This recognition led us to an even keener commitment to provide vocational training that was specific, realizable, and job oriented, as well as performance referenced and sequential. Overall, our students lacked the flexibility of the regular student population; thus the material here eliminates activities and operations which are not concretely and specifically job related. This should not be interpreted as an anti-intellectual position or as a disregard for cognitive learning. Related mathematics and related science have been included so that students will have a clearer understanding of the concepts and ideas that are an important background in performing the expected operations. We hope that our approach will eliminate those operations that tend to be unnecessary for student development in the work related setting, repetitive though they may be.

The curriculum material presented here represents strategies or directions in specific areas of occupational education, rather than specific curriculum guides. It is addressed to both the teacher and the student. We have made efforts to simplify the vocabulary and the concepts as much as possible. Yet, since the terms and operations are identical in most cases to those used in industry, the student will need the teacher's continuing assistance in defining and pronouncing words, understanding phrases, and working on related math. The "hands on" experience is critical for the student; much of the written material must be used with shop equipment. We have been careful to examine our experience in an effort to develop a productive set of performance criteria and the activities for demonstrating achievement of these criteria.

This vocational manual is to be used with the other four manuals which have been produced by the Vocational Strategies project. Just as the other manuals on vocationally related material might be used very appropriately by vocational teachers desiring to become more sensitive to the learning patterns and special needs of mildly handicapped high school youth, the vocational skills manual will perhaps be particularly helpful to special educators who must, as they develop educational plans and evaluate special needs students, become more familiar with vocational options and occupational job training.

One of the issues raised by this project's experience is the utilization (in a broad sense) of community resources by an urban school system. Perhaps the most significant contribution made to this project in this regard was the establishment of a team of experts by Raytheon Company in the Spring of 1976. At the instigation of Walter H. Palmer, Corporate Director of Public Affairs, an Affirmative Action Specialist in his office, Ross A. Burton, formed a team of experts from Raytheon which included Kent Jackman, Les Sturdevant, Warren B. MacInnes, John Key, Ralph Dolce, and Byron J. Ricketts. This team not only provided important information on curriculum design and job analysis, but also insisted on visiting Boston Trade High School to observe for themselves the teaching and learning processes in the shops, before they would discuss modifications in vocational education delivery. What emerged was Raytheon's commitment to assist us, insofar as they could, in the design and planning of curriculum strategies which are not available at Boston Trade High School at this time. The team's expertise, sensitivity, and perspective are particularly employed in the electronics, mechanical assembly and printing areas covered here. Raytheon is not alone; this project sought and received a great deal of help from industry overall. General Dynamics, through Arthur Kalvert in their Personnel Office, assisted in "thinking through" an appropriate welding curriculum for special needs students. Digital Equipment Corporation was helpful in discussing their own training programs. Walter Pienkos of Hewlett Packard, another electronics firm, also provided the curriculum used in their own training program, as did the others.

A large number of companies and union representatives (that joined to form our business/industry/union task force) and the planning team from Boston Trade High School worked very closely with the Vocational Strategies project in its first two years, to develop an outreach procedure for job sites for our students during the school year and in the summer. We are thankful to these employers and to the task forces, not only for the job sites provided, but also for the important information that students carried back to us, as this ultimately led us to realize the need for the formation of the Raytheon team and to the development of the particular strategies presented here. In two instances, our contact with the business community provided us with assistance not initially expected. On several occasions it was necessary to remove the students from the shops at the Trade School and instruct them elsewhere. We give our thanks to Excelsior Press in Boston and to Mechania, Inc. in Cambridge for unique cooperation.

This volume, as well as the other project manuals, could not have been completed without the diligent efforts of Mary Sochockyj, Assistant to the Project, and the efforts of Natalie Saunders (who assisted with typing), Bernard LaCasse (who designed the formats and covers) and our own staff at Boston Trade High School, who worked "above and beyond" their job descriptions. Melvin Calloway and Christopher Clark have been part of our paraprofessional staff throughout the project, and have served the students as a continuing link between their vocational training and resource room support. Shelley Stewart, our vocational counselor, reminded us of the importance of maintaining contact with the students in the shop, in the resource room, and on the job.

Dean Yarbrough, Jr., a staff member of the Boston Public Schools Information Center devoted innumerable hours assisting us in the writing of the electronics section and the mechanical assembly portion of this manual, drawing on the many years of experience he gained in industry before joining the Boston Schools. We give special thanks to Dr. Charles W. Leftwich, Associate Superintendent for Support Services in the Boston Public Schools, who initially had charge of this project in 1974/1975 when vocational planning responsibility was assigned to his office. While the Boston Public Schools changed administrative personnel (with two associate superintendents for special needs and one for vocational education leaving during the course of this project) it was Dr. Leftwich who had provided us with continuing commitment and direction.

The five specific areas discussed here (automotive mechanics, electronic assembly, mechanical assembly, printing, and welding) are but a beginning. It is incumbent upon those who concern themselves with the replication of the activities of this project within the school system, to make necessary changes in the existing (and our recommended) curricula. This project makes no apology for what has not been done, but hastens to call attention to what <u>has</u> been done, and is herein described.

Doreen V. Blanc
Project Director

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The material which follows here presents a strategy or technique for providing vocational information and vocational skill development in automotive mechanics to mildly handicapped students. The students who participated in our automotive program were, according to their educational plans, handicapped due to mild retardation, hearing loss or specific learning disabilities. None of our students were confined to wheelchairs, and all had good vision. The students were mainstreamed into the automotive shop at Boston Trade High School with the assistance of a paraprofessional aide trained by our program, Vincent Breen, Jr. Mr. Breen was involved extensively in the design and selection of material which is included in this section.

We were, at the beginning of this program in 1974, delighted that a disproportionate number of our students chose participation in auto mechanics to the exclusion of many of the other shops available at Boston Trade High School. As a result, we labored to determine the types of skills (in addition to bench assembly in the automotive trade) that our students would be able to pursue. It was Mr. Breen's opinion that the two skills detailed here would be the beginning of a good foundation for the special needs student who might seek employment in a service station, and who we could expect would be able to do more than simply "pump gas". However, when one reviews the areas under study here, it must not be interpreted that we have in any way claimed that expertise in the particular areas will make a student into a full fledged "mechanic". Instead, what we are discussing is an approach that is working.

The material in this section was developed after a review of materials made available to this project by the Portland (Oregon) Public Schools "Vocational Village" program, the State of Vermont curriculum for special needs students in automotive mechanics, and the Tennessee State Board for Vocational Educational material (a communications curriculum) for special needs students in automotive mechanics.

It is anticipated that the forthcoming evaluation of the Vocational Strategies project will demonstrate that our students have progressed beyong the simple operations detailed here. Some of our students have matured sufficiently in their mechanical skills development and have engaged in such functions as replacing shock absorbers and relining brakes. However, our intent here is to demonstrate the "breaking down" of even the most basic operations into simple, concrete units. We have stressed vocabulary, reading of diagrams, gauges, and other forms of measure. We have outlined step by step procedures which we expect will set a pattern for how other, more complicated car maintenance operations can be successfully taught to mildly handicapped students.

An old battery can be dangerous. Inside the battery there is an electrolytic solution (electrolyte). This is a combination of water and sulfuric acid.

Sulfuric acid is a very strong acid. It can burn you very badly. It can rot or easily destroy your clothes. It can even make holes in concrete.

Do not get any acid in your eyes. Always wear safety glasses. Acid can hurt your eyes very badly if it is not washed out right away.

If you get some acid on you, run a lot of water over your skins many times. Do not stop until there is no more tingling on your skin. This will wash away the acid. Also, put some sodium bicarbonate (baking soda) on the spill if you have some. You may have seen baking soda in a kitchen; people use it to bake cakes.

It is important to wash acid off your skin first, but you should also clean up any spills on your clothes or on the floor. Put some baking soda on the spot. Run the water over the spot for at least 10 minutes if you do not have any baking soda.

Vocabulary

electrolyte

electrolytic solution

sulfuric acid

sodium bicarbonate

Questions:

What is sulfuric acid?

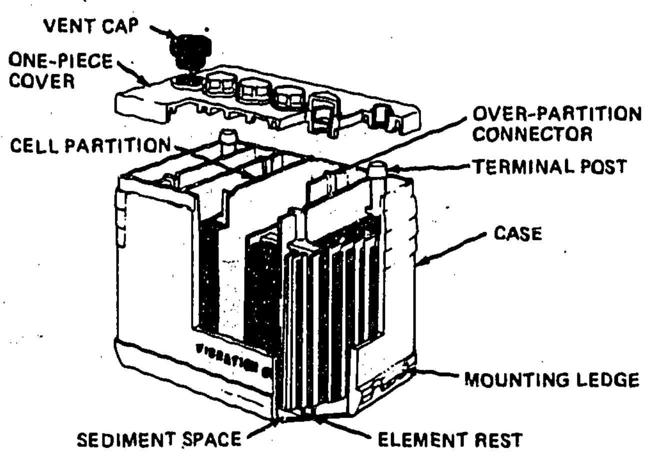
What happens to your skin if you get sulfuric acid on it?

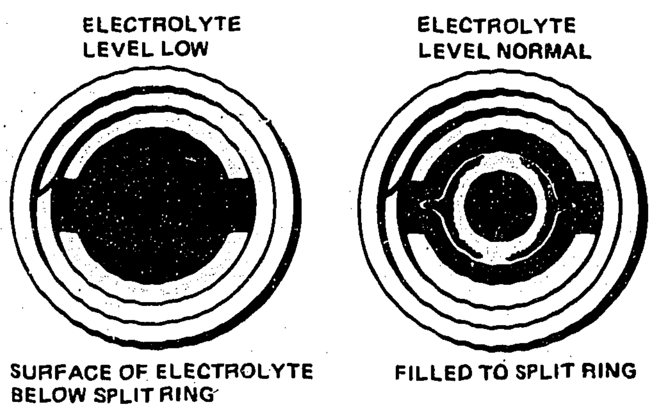
What is inside a battery?

What do you do if you get acid on skin?

What is an electrolyte?

How do you protect your eyes when working with a battery?





The battery supplies power to the whole car. To keep the battery working right, it is important to keep the electrolytic solution at a certain level. You should check the level at least once a month.

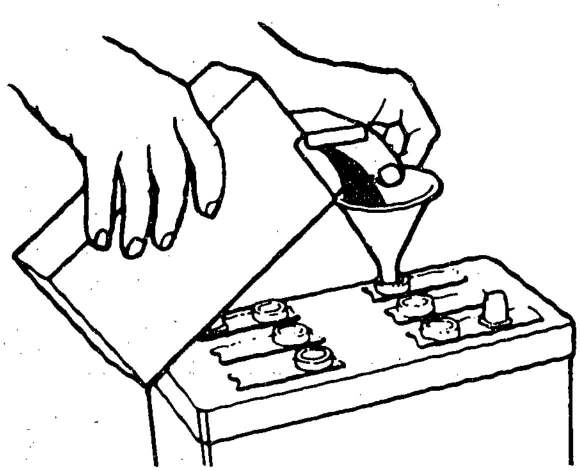
To check the level you:

1. Remove the cap.

2. See if the solution reaches the ring in the cell. You can see the ring in the filler hole.

3. If the solution does not reach the ring, add distilled water up to the ring. Do not overfill; that will weaken the solution.

4. Replace the cap.



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The level of the electrolytic solution is also called the water level. If the water level in the battery gets too low:

1.
The acid concentration could build up. The acid concentration is the amount of acid there is mixed in with the water. If there is too much acid in the water, it will damage the battery.

2.
The electrical activity could build up. This means there could be too much electricity working. This can cause an internal short, which will damage the battery. It is the same as when you plug too many things into one outlet in your house, and all the lights go out.

3.
The battery could get more voltage peaks (power) from the generator. (The generator is what produces the power.) This will blow out the lights in the car.

Vocabulary

level

filler hole

distilled water

water level

acid concentration

electrical activity

internal short

voltage peaks

generator

Questions

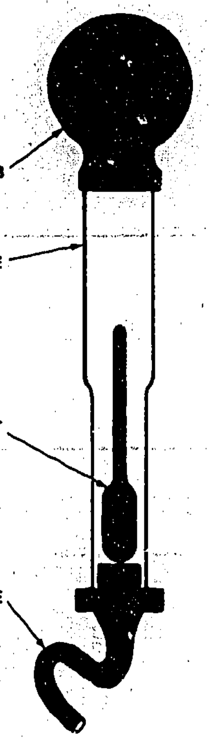
What does a battery do?

How can you check the water level in a battery?

How often should you check the water level?

What happens if you overfill the battery?

Why is it important not to let the water level get too low?



The density of the battery fluid tells you how strong the electrolytic solution is. You check the density by using a [illegible]meter. The hydrometer has a piece [illegible] numbers on it called a float. [illegible]an read the density by looking at the number on the float where th[illegible] water level stops.

To check the density you:

1. Remove the caps.

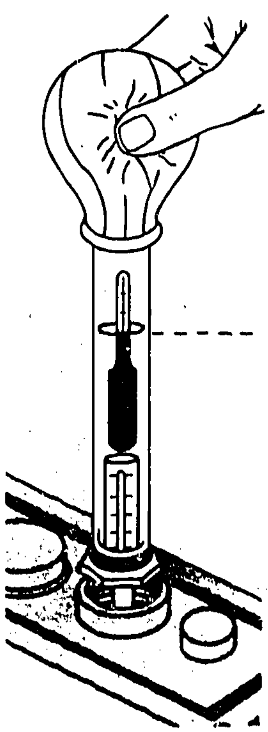
2. Put the hydrometer into the filler hole.

3. Squeeze the bulb on the hydrometer to draw in fluid.

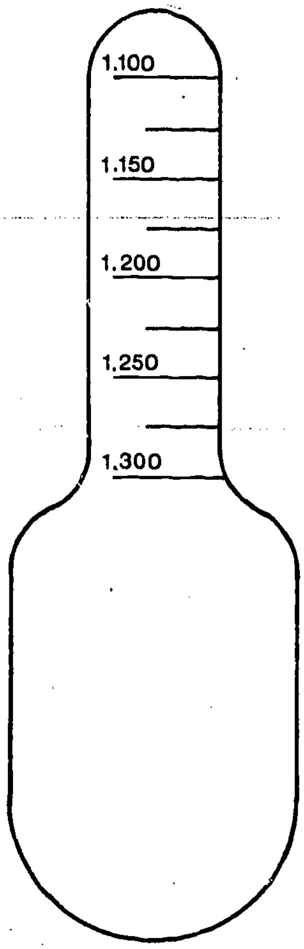
4. Read the density from the float.

5. Remove the hydrometer carefully. Try not to spill any acid. You can get burned. Wipe up any drips on your clothes or anywhere.

6. Put the caps back on right away.



Float



Looking at the number on the float tells you if the density is right. If the number is:

1. Between 1.275 and 1.30, the battery is at <u>full charge</u>.

2. Between 1.21 and 1.27, the battery is at <u>half charge</u>.

3. Between 1.15 and 1.21, the battery is <u>depleted</u> (weak) but still working.

4. Between 1.14 and 1.10, the battery is dead.

Vocabulary

density

float

full charge

half charge

depleted

hydrometer

Questions

What do you use to check density?

List the steps in using a hydrometer.

What happens if you spill acid from the battery on your clothes?

Use a pencil to mark on the picture of the float where the water level would be if the battery was:

at full charge

at half charge

depleted

dead

The battery should be clean, especially on top near the terminals and caps. If the terminals are corroded, your car may not start in winter.

Never work on the battery in damp clothes or shoes. This could give you a shock. Sometimes yo[illegible]n short out the battery with a t[illegible]. Then, even a small shock can [illegible]ause [illegible]eat burn.

To clean the battery terminals you:

1. Disconnect the grounded terminal first, usually negative. It is marked " - " (like a minus sign) or "neg.". Always disconnect the grounded terminal first. This will protect you from shock.

2. Disconnect the insulated terminal, usually positive. It is marked " + " (like a plus sign) or "pos.".

3. Clean both terminals with a wire brush called a terminal cleaner.

4. Clean the top of the battery with a cloth wipe.

5. Inspect the battery for leaks or cracks.

6. If there is just a little seepage you can stop it with commercial sealer or corrosion inhibitor.

7. Reconnect the terminals.

8. Put corrosion inhibitor or petroleum jelly on the terminals.

9. If there is a lot of seepage, you may have to put in a new battery.

Vocabulary

terminals

caps

terminal cleaner

seepage

commercial sealer

corrosion inhibitor

Questions:

Why should the battery terminals be clean?

How do you clean battery terminals?

Is it O.K. to work in damp clothes? Why?

Why is it important to disconnect the negative terminal first?

How do you know when to put in a new battery?

A battery charger gives power to a battery. It causes a chemical reaction which recharges the battery, or makes it work again.

Some battery chargers have two settings. One is a trickle, which is slower, and the other is a fast charge, which is faster. You should charge the battery with the trickle setting first because it is safer. This will prevent sulfation, which causes a short circuit.

Never take the caps off the battery when you are recharging it. Always shut off the charger and disconnect it if you need to take off the caps.

To use a battery charger:

1. Disconnect the battery terminals. Clean the terminals if they are dirty.

2. Check the water level in the battery. Add distilled water if the level is low. Put the caps back on.

3. First connect the charger to the positive terminals. Then connect the negative terminals.

4. Make sure the terminals are in good contact with the charger. Then turn the charger on.

5. Look at the meter on the charger. The rate of charge should be between 3 and 5 amps. It should go down to 2 amps or less as the battery charges. Some chargers have timers to tell you how long to charge the battery. You can also check the charge with a hydrometer.

6. When the battery is fully charged, shut off the charger. Disconnect the charger. Reconnect the battery.

7. Check the water level, and add distilled water if needed.

8. Reconnect the battery.

Vocabulary

chemical reaction

trickle

fast charge

sulfation

good contact

rate of charge

timers

Questions:

What does a battery charger do?

How does a battery charger work?

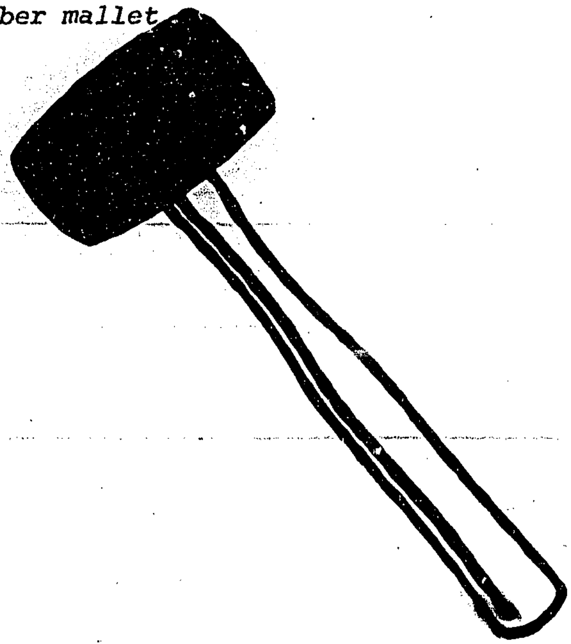
Can you fix a battery that is almost dead? How?

What settings do battery chargers have?

Which setting is best to us? Why?

What are the steps in using a battery charger?

Rubber mallet



Vocabulary

hub cap

threads

lug wrench

air wrench

mallet

reposition

balanced

To remove wheel:

1. Remove the hub cap. Clean the threads on the bolts with a wire brush. Use a little penetrating oil if they are very rusty. Give the oil about ten minutes to do its cleaning.

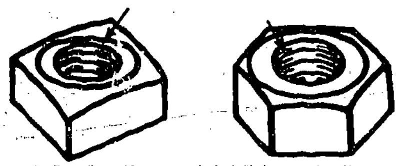
2. Jack up the car a little. Don't let the wheel come off the ground. Loosen each nut with a lug wrench. Then jack up the car the rest of the way and take off the nuts. If you have an air wrench, you can jack up the car all the way in the beginning but you must use the air wrench right away.

3. Put the nuts in the hub cap, so they won't get lost. Don't let any dirt into the threads.

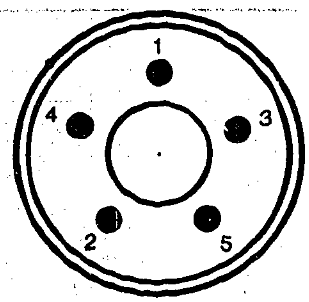
4. Pull the wheel off. If you can't get it off, tap it loose from behind with a rubber mallet.

5. If you are moving the wheel to work on brakes, you can pull off the wheel without moving the tire. Mark a nut bolt and the rim next to it. Then you can reposition the wheel in the exact spot it was. This will keep it balanced. Then, take off the hub cap. But leave the wheel attached.

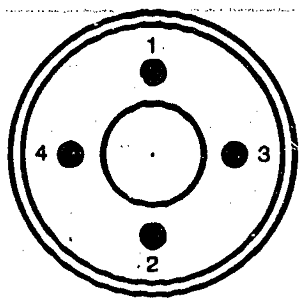
Threads



Lug nuts



Wheel with five bolts



Wheel with four bolts

Vocabulary

lug threads

lug nut

solvent

flush

cross thread

rim

cross pattern

Removing a wheel with an air wrench is easy. Putting it back on right is harder. You should do it very carefully.

1. Check the lug threads carefully for damage and dirt. Put a little grease on the lug threads. This will keep the nut from rusting and will make it easier to remove next time.

2. Check each lug nut for damage and dirt. Clean the nuts with solvent if they are dirty.

3. Put the wheel on the hub. Line up the holes. Push the wheel flush against the hub. Do not cross thread the nut. It will help if you start each nut by hand.

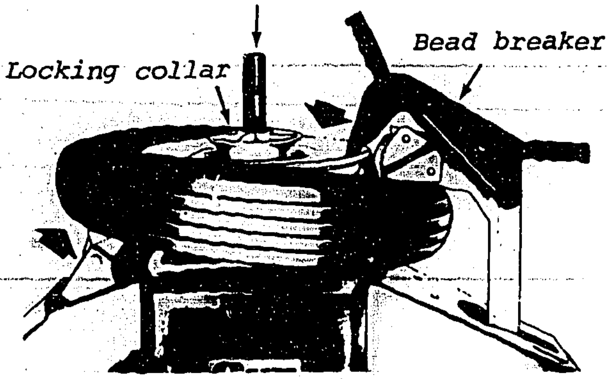
4. After all the nuts are in the right place, turn them until they are on the rim. Spin the wheel slowly to make sure it is centered right on the nuts. Then tighten the nuts.

5. If you have an air wrench, tighten the nuts in a cross pattern. Look at the drawing with the numbers on it. Tighten #1 first, and then #2, and so on.

6. If you have a lug wrench, lower the car on the lift or jack slowly until it just touches the ground. Do not put the full weight of the car on the wheel. The wheel should have just enough weight on it so that it will not turn. Then follow the pattern to tighten the nuts.

7. Check to make sure the nuts are tight. Replace the hub cap.

If you need to remove the tire from the rim:



1. Take the tire off the car.

2. Put the tire on the tire machine. The outside of the rim should be facing up.

3. Put the locking collar on the stem. Turn the collar until it is tight against the rim.

4. Take off the stem with a valve stem remover. Take out the valve to let the air out of the tire.

5. When all the air is out of the tire, you will need a bead breaker. Some bead breakers are electric, and some work by using air pressure. Put the edge of the bead breaker next to the rim and separate the rim from the tire. Some machines separate both the top and bottom at the same time. If the machine you are using does not do this, you will need to do steps #3, 4, and 5 again.

6. There is a slotted bar under the edge of the tire. Put the curved end of the slotted bar between the tire and the rim. Pull down the slotted bar. The slotted bar should fit over the flat spots.

7. Start the machine motor with the foot switch while you are holding the slotted bar on the stem. The machine will move one side of the tire off the rim.

8. You will need to do steps #6 and 7 again to take off the other side of the tire.

Vocabulary

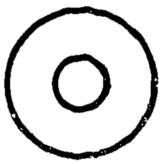
locking collar

stem

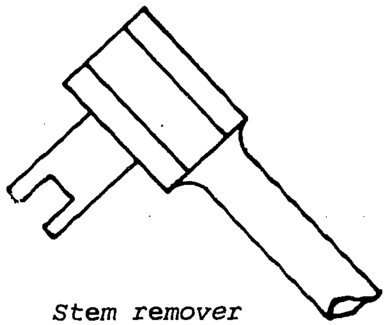
valve stem remover

bead breaker

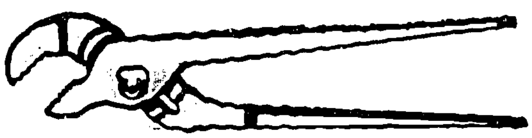
slotted bar



Washer



Stem remover



Vice grip pliers

A new valve stem should be installed every time a tire is mounted on a rim. This will keep you from having tire failure. Most valve stems look like they are made of rubber. Valve stems which are made of metal can be used more than once. They have nuts and washers attached to them. They also have round rubber rings between the stem and the rim to make an air seal. This means that air cannot get through.

To remove a valve stem:

1. Cut the rubber off the inside of the rim.

2. Pull the stem out from the outside of the rim with vice grip pliers.

To install a valve stem:

1. Put some rubber lubricant on the stem hole.

2. Push the stem into the hole. Then you will need a valve stem tool. A valve stem tool has a treaded section that fits on the stem cap threads. Pull the stem through until it is tight.

3. Check the inside of the rim to make sure the stem is in the right place.

Vocabulary

mounted

washers

air seal

valve stem tool

treaded

stem cap threads

vice grip pliers

1. Put the rim on the tire machine.

2. Turn the locking collar until it is tight against the rim.

3. The inner edge of the tire is called a <u>bead</u>. Put some rubber lubricant on the bead.

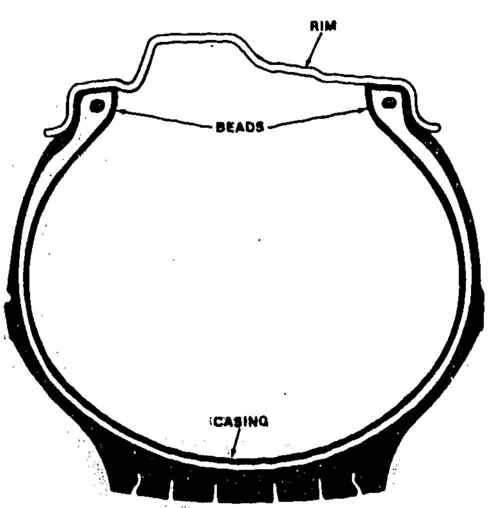
4. Put the tire on top of the rim so that part of the bead is below the edge of the rim.

5. Put the slotted bar on the rim. It should be above the bead.

6. Start the machine with the foot switch while you are holding the bar in place. Turn the bar around the rim. Now one edge of the tire is on the rim.

7. If you are working on a tubeless tire, do steps #4, 5, and 6 with the second bead.

If you are working on a tube tire, put the tube in the tire. Push the valve stem through the hole in the rim. Inflate the tube 5 lbs. so that the tube will stay inside the tire bead. Check to make sure the tube is not twisted or bunched up in the tire. Be careful not to pinch the tube between the tire and the machine.

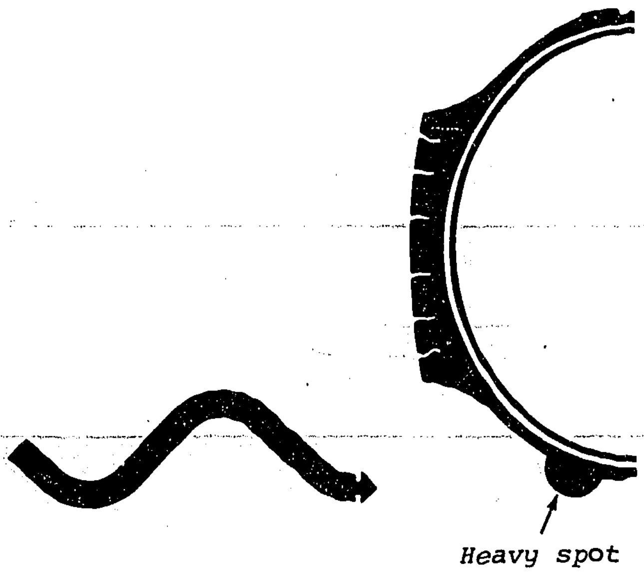


8. Put some more rubber lubricant on the tire beads.

9. Put the bead expander over the tread of the tire. It should force the bead against the rim. If the tire has a colored dot on it, line it up with the valve stem.

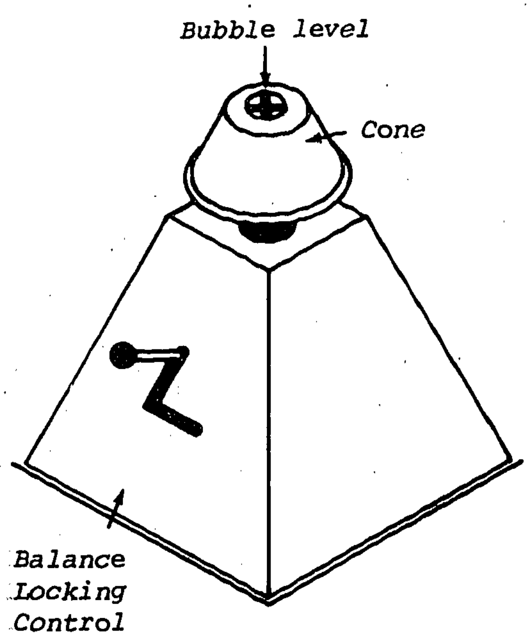
10. Take the air hose and begin to inflate the tire. The bead should move against the edge of the rim. If it doesn't, tighten the bead expander. Then put some rubber lubricant on the bead. Start to inflate the tire again.

11. Check the tire to make sure the bead is evenly spaced. The bead should be in full contact with the rim. If it is not, deflate the tire and use the bead breaker to free the tire. Then go back to step #8.



Sometimes a tire wobbles because the weight on one side of the rim is different from the weight on the other side. When you balance a tire, you fix an imbalance in the rim and tire. This makes the tire turn smoothly around its axle. The whole idea in balancing is to put weights on the tires so that there is no heavy spot that makes the tire wobble.

There are two ways to balance tires. If you are working on a car that is not usually driven on expressways, you do static balancing. If the car is driven at high speeds for a long time, you do dynamic balancing. Both kinds make the weight even on both sides of the rim, but dynamic balancing also evens up the weight from one side of the tire to the other side.



To do static balancing, you need a level stand. The level stand holds the tire in a horizontal position. It lets the tire tilt to the heavy side. The level stand might have a control on it that makes the stand stay in one place when you hammer on the weights. These are the steps in balancing:

1. Set the balance on the level stand and put the control in the lock position Put the tire on top of the cone.

2. Release the lock so that the balancing level will stay the same.

3. Choose a few weights. Put them on the edge of the rim. Move the rim around so that the level is in the

center of the cone. You can do this best by putting two weights at an angle to the heavy spot. If the weights are in the wrong place, there will still be an imbalance.

4. Use as few small weights as you can. You can trim the weights with a pair of cutters if you need a size between the ones you have.

5. After you find the right weight and the right number of weights, lock the balance stand. Tap the weights into the right place with a hammer.

6. Release the lock. Check the tire again.

7. Put the wheel back on.

Vocabulary

imbalance

axle

heavy spot

static balancing

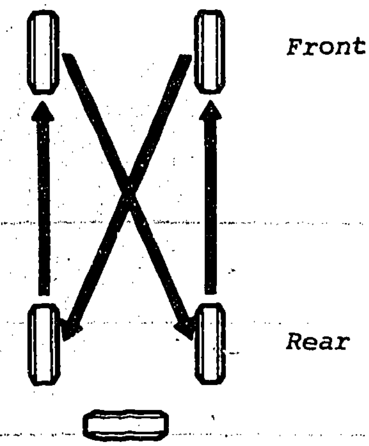
dynamic balancing

level stand

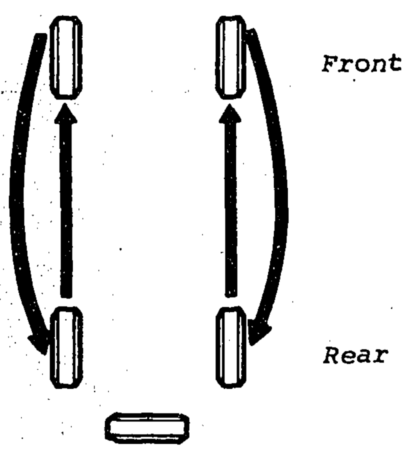
balancing level

horizontal

angle



Bias



Radial

The owner's handbook for your car will tell you how often to rotate the tires. You need to rotate the tires so that they will wear evenly.

Never put a radial tire on the same axle as a bias ply tire. You can have an accident if you do.

Look at the drawings which show you how to rotate tires.

With a bias ply tire you move

The right front to the left rear

The left rear to the left front

The left front to the right rear

The right rear to the right front

With a radial tire, you move

The right front to the right rear

The right rear to the right front

The left front to the left rear

The left rear to the left front

1. Student will be able to list safety precautions when working with a battery.

2. Student will be able to list reasons why water level in battery should be checked and will demonstrate filling the battery to the correct level.

3. Student will demonstrate use of a hydrometer, including reading of the float.

4. Student will be able to demonstrate the following operations, and to name the safety precautions that should be taken:

Cleaning battery terminals
Using the battery charger
Removing a wheel
Installing a wheel
Removing a tire from a rim
Removing and installing valve stems
Installing a tire on a rim
Balancing tires
Rotating tires

5. Student will be able to define all words listed in vocabulary.

A few of our students were successfully placed in the electronics shop at Boston Trade High School under the supervision of Ralph Hall of the electronics staff. Although our students experienced difficulty with even the simplest electronic theory, they made progress on some of the more fundamental techniques such as soldering. However, we observed the lack of continuing update from industry as a drawback in the electronics program in the school, since the electronics industry is a very important growth industry, particularly in the Greater Boston area.

The material presented here has grown out of extensive meetings and on site visits with a number of companies, most notably Raytheon Company. Les Sturdevant of Raytheon's Equipment Division was particularly helpful. In meetings with Dean Yarbrough and the project director, he provided extensive training materials. He made available to us a most useful tool box and directed members of his staff to build the simple wiring harness which is described in this manual. Under Mr. Yarbrough's careful guidance, we further modified several of the basic units which Mr. Sturdevant presented to us on behalf of Raytheon Company. We have chosen to focus on but a few of the fundamental electronics operations in the expectation that the further development of the curriculum in this spirit will be forthcoming.

The material here explains the use of six basic electronic components, proceeds with a demonstration of the steps in techniques such as soldering, and concludes with a detailed discussion of the construction of a simple wiring harness.

Workers in the field of electronics help to make many items that people use every day. In the home, there are many appliances that work with electronic parts. Some of these appliances are quite large. This group includes such items as color television sets and radar ranges or stoves. There are also small items that are made with electronic parts and are found in the home or office. These include transistor radios, cassette tape recorders, and hand or pocket calculators. All of these products, big and small, are made from the same type of electronic parts. These parts are called components. Components, or electronic parts, are also used to make even more complex devices. In fog, for example, airplanes are helped to land by electronic systems that are on runways. Cars are already being made with electronic ignitions. The Apollo moon flight was directed by electronic controls. It is important to learn that a large electronic machine that can assist a huge airliner to land on the ground has the same components as a small transistor radio that you carry in your pocket.

In the lessons which follow, you will learn about electronics by studying the following topics: (1) parts or component identification, (2) soldering, and (3) wiring (or cable) harnessing.

Electronics - The industry that makes (or produces) devices made from electronic parts.

Appliances - A device (or machine) that usually is run by electricity and often is found in the home.

Electronic parts - The various components (or parts) that are used in making (or manufacturing) electronic instruments (or items).

Components - A part of a bigger system; in the electronics industry, components are the parts (such as resistors) that form a more complex electronic appliance or device.

Electronic systems - A group of electronic machines (or devices) that work or act together (interact) to do a job.

Electronic ignitions - Electronic devices for cars that improve "starting-up" of car engines.

1. What are some things you have seen in class, at home, or in the newspaper that are made with electronic parts? How do you know?

2. Make a collage from newspapers and magazines that shows different items that are made by the electronics industry.

3. What is a component?

4. How big do you think components are? Bigger than a pencil? Bigger than a box of Kleenex? Bigger than a 12" ruler? Ask your teacher to get some pictures of component parts.

There are six basic parts or components that are used in the electronics industry. These parts are:

a. resistors

b. capacitors

c. inductors

d. transformers

e. diodes

f. transistors

You can learn to identify them by their different shapes. Here are some examples of how components look. Remember, when they are put together in different ways in an assembly, they become the "building blocks" of many products or machines that we know.

Resistor

a. Resistors - Resistors look like a tiny tin can with wires sticking out of each end.

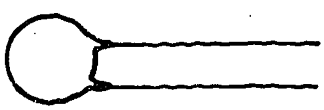
b. Capacitors - In electronics, there are several kinds of capacitors. Here are examples of three kinds of capacitors. A capacitor keeps (or stores) energy (or electric charge) for a short time, or temporarily.

Capacitors come in these shapes and values most often:

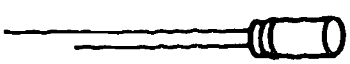
Disc capacitor

Electrolytic capacitor

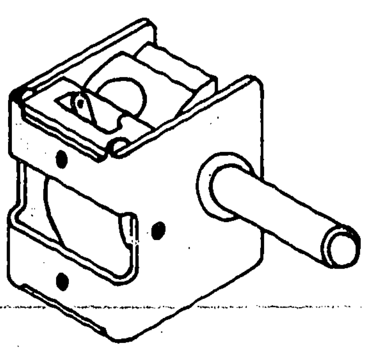
Variable capacitor



Disc capacitor



Electrolytic capacitor

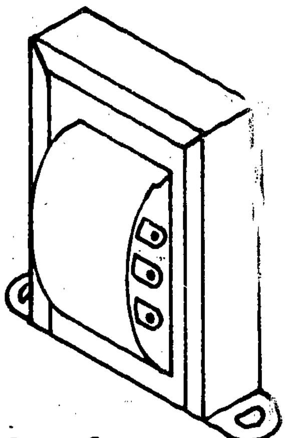


Variable capacitor

c. Inductor - Inductors are important components. Inductors can look like coils of wire. Here is a picture of an inductor.

Inductor

d. Transformers - A transformer is another component or part. A transformer looks like a special arrangement with coils of wire where two or more wires are wound together. Here are examples of transformers.

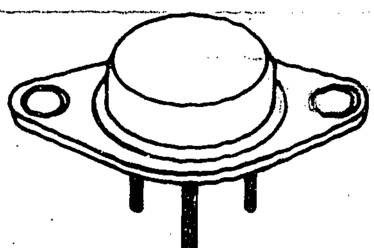


Transformer

e. Diodes - Another kind of component is a diode. A diode lets the current flow in one direction only.

Diode

f. Transistors - Transistors are another kind of component. Most transistors have three leads (or wires) coming out of them. This is what transistors look like.



Transistor

Components - In the electronics industry, components are the parts that are used to put together a bigger electronic appliance or machine. We are learning about six different kinds of components: resistors, capacitors, inductors, transformers, diodes, and transistors.

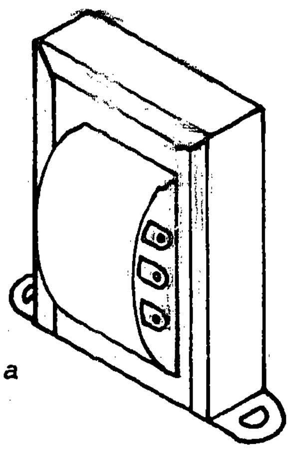
Electronics industry - The companies that make and sell electronic equipment.

Identify - To learn what something is by knowing what it looks like. We all know what an inductor looks like and so we can identify an inductor when we see one.

Assembly - The putting together of manufactured parts to make a completed product, usually a machine.

1. What are the six kinds of components you have learned to identify?

2. Fill in the blanks by identifying the correct component in each picture.



a

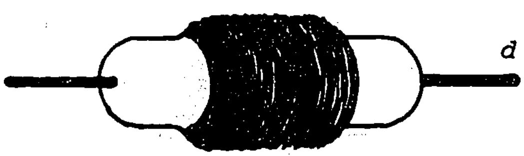
a. This is a ______________________.

b

b. This is a ______________________.

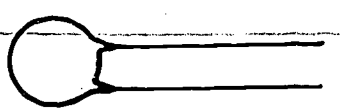
c

c. We can tell that this component is a ______________________ because it looks like a little tin can with a wire sticking out of each end.



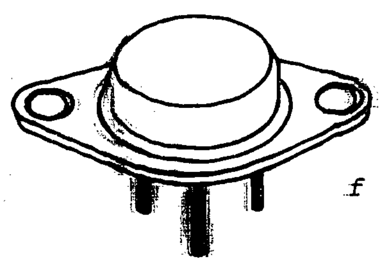
d

d. We can tell that this component part is a ______________________ because we can see its coil.



e

e. This is a ______________________ component.



f

f. This is a ______________________.

3. Circle the following items listed below if you think they are made with electronic components:

a. A cassette tape recorder

b. An automatic dishwasher

c. A bathtub

d. A baseball bat

e. A box of breakfast cereal

f. A "digital" watch

g. A color television

h. A pencil

i. A pocket calculator

j. A radar system

k. A thumb tack

l. A tin can

Explain your choices.

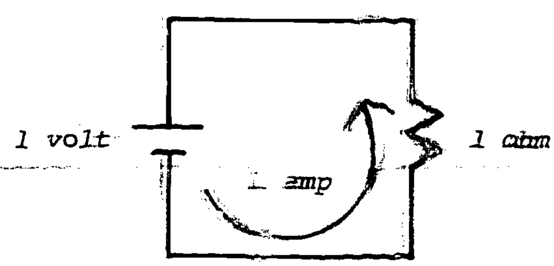
Resistor

What is a resistor?

We already have seen a picture of a resistor. A resistor looks like this.

A resistor looks like a small tin can with wire sticking out of each end. The most common type of resistor is the fixed carbon resistor which contains a mixture of carbon and other materials. What does a resistor do? It resists or works against the flow of electrical current.

There is a very famous rule which describes what a resistor does. This rule is called Ohm's Law. It says: A resistor has a resistance of 1 ohm (1Ω) if the voltage across it (in volts) divided by the current flowing through it (in amperes) equals 1. As an example of this, take a 1 volt battery (this is the symbol for battery) and put it across a resistor (this is the symbol for resistance Ω).



We can say this in a shorter way or in a formula

$$\frac{E}{I} = R$$

E = The voltage in volts

I = The current in amperes

R = The resistance in ohms

If the 1 volt battery causes 1 ampere to flow through the resistor, then its resistance is 1 ohm.

We must know three facts before we can identify a fixed carbon resistor: its wattage rating, its resistance value, and its tolerance.

Wattage rating

The wattage rating tells us how much electrical current can flow through a resistor before it heats up and possibly destroys itself. The most common wattage ratings are 1/2, 1, and 2. We can tell the wattage rating by its size. As resistors get bigger in size they have higher wattage ratings. This means they will carry more current.

All 1/2 watt resistors are this size:

1/2 watt

All 1 watt resistors are this size:

1 watt

All 2 watt resistors are this size:

2 watt

What is "resistance value"?

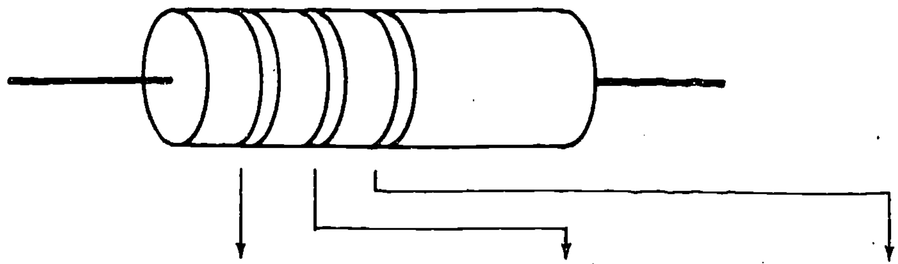
The value of a resistor is a number which tells how much resistance a resistor will offer to the flow of an electrical current. We refer to this number in "ohms". A big number means big resistance, and a small number means small resistance to the flow of current. (A 50 ohm resistor will offer 10 times more resistance to the flow of current than a 5 ohm resistor.) The symbol Ω can be used for ohm. We can write 50 ohms as 50 Ω.

There are two ways to know the value of a resistor. One way is to read the number on the resistor. Another way is to look at the color bands on the resistor. There will usually be 4 bands. Sometimes there will be 3 bands.

The first three color bands is a code which gives the value of the resistance in ohms. Each color stands for a number. This is the standard resistor color code:

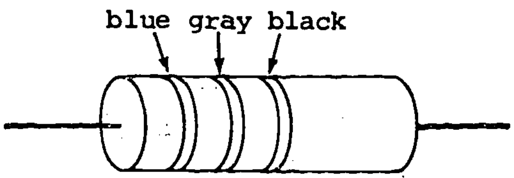
Black = 0	Brown = 1
Red = 2	Orange = 3
Yellow = 4	Green = 5
Blue = 6	Violet = 7
Gray = 8	White = 9

Here is how we apply this code to a resistor:

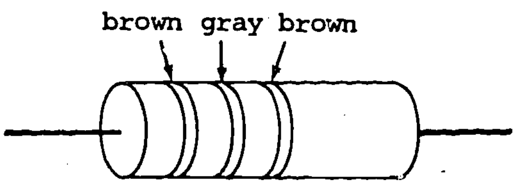


Color	First number	Second number	Third number
Black	0	0	add nothing
Brown	1	1	+ 1 zero
Red	2	2	+ 2 zeros
Orange	3	3	+ 3 zeros
Yellow	4	4	+ 4 zeros
Green	5	5	+ 5 zeros
Blue	6	6	+ 6 zeros
Violet	7	7	+ 7 zeros
Gray	8	8	+ 8 zeros
White	9	9	+ 9 zeros

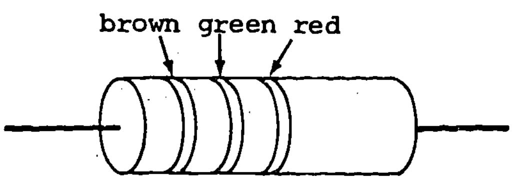
Some examples:



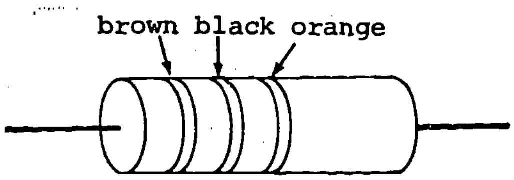
= 68 Ω



= 180 Ω

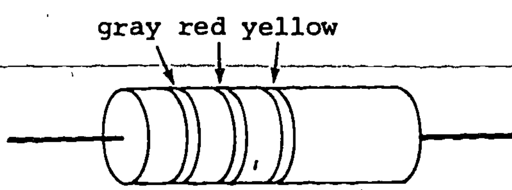


= 1,500 Ω

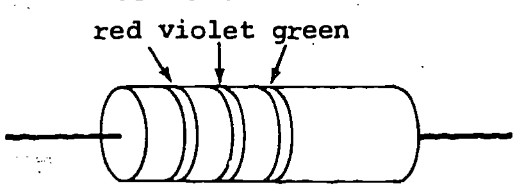


= 10,000 Ω

K = 1,000
Then 10,000 Ω can also be written 10 KΩ



= 820,000 Ω or 820 KΩ



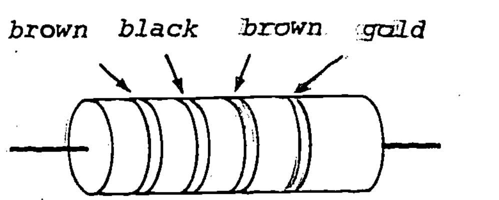
= 2,700,000 Ω

M = 1,000,000
Then 2,700,000 Ω can be written 2.7 MΩ

What is tolerance?

Is a 10 Ω resistor exactly 10 Ω ?

To answer this question we have to know about tolerance. We can know the tolerance of a resistor by looking at the fourth band. The fourth band is either gold or silver. Gold means that the actual resistance value is within ± 5% of the color bands on it. Silver means that the actual resistance value is within ± 10% of the color bands on it. The symbol (or sign) ± means "plus or minus" or "more or less".

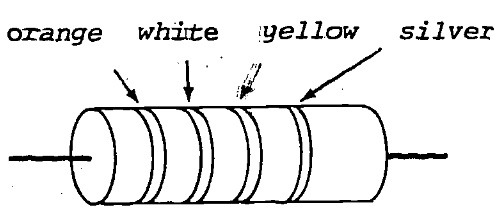


For example:

When the last color band is gold the resistance value is ± 5%.

What does 100 Ω ± 5% mean?

5% of 100 is 5. The resistance may be any number between 100 and 105 or 100 and 95. This means that 100 Ω ± 5% can be 100 Ω or 101 Ω or 103 Ω or 104 Ω or 104.93 Ω or 105 Ω. This also means that 100 Ω ± 5% can be 99 Ω or 98 Ω or 97 Ω or 96.36 Ω or 95 Ω.



For example:

When the last color band is silver the resistance value is within ± 10%.

10% of 390 kΩ is 39 kΩ. The resistance may be any number between 390 kΩ and 429 kΩ or between 351 kΩ and 390 kΩ.

Resistor - An electronic component that resists (or works against) the flow of electrical current.

Carbon - An element which is not metallic.

Ohm's law - A rule in science named for a German scientist, Georg Ohm.

An Ohm - A unit of electrical resistance. Its sign is Ω (named after Georg Ohm).

Volts - Measure of electric potential.

Amperes - A unit of electric current. It is often shortened to "amps".

Battery - A device for making (or generating) an electric current (often by chemical reaction).

Formula - Statement of a rule in math or science.

Color code - The rule for knowing what the resistance value (how much resistance) of a resistor is by looking at the color bands on the resistor.

Tolerance - How much current flow a resistor "can take" or "can bear". The tolerance of a resistor can be learned from noting whether a gold or silver band is on the resistor.

3.

Fill in the blanks:

1. The symbol for Ohm is _____.

2. The symbol for battery is _____.

3. This is an example of a _____ watt resistor.

4. Another way (or sign) for saying electric current is _____.

5. On the standard resistor color code, the color violet = ____. The color orange = ____. The color blue = ____.

1. You have just learned to tell the "tolerance" of a resistor by looking at the gold or the silver band on the resistor. Practice reading "tolerance" amounts by working on these problems:

a. Think of 10 numbers between 100 and 105, like 101.00 or 104.93. Write them down. When the fourth band on the resistor is the color ___________, we know that the "tolerance value" is ± 5.

b. Think of 10 numbers between 95 and 100, like 96.36 or 97.00. Write them down.

c. Think of 10 numbers between 100 and 110, such as 104 or 108. Think of 10 numbers between 90 and 100 such as 94.03 or 91.00. When the last band on the resistor is the color ___________, we have to count ± 10 to find the tolerance value.

2. Percentages. When we work with ± 10 of a number we are thinking about a "percentage" of that number. Another way to write per cent is _____.

a. How can we find 10% of 390?

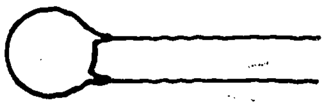
b. How can we find 5% of 380?

3.

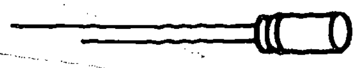
0 ———————————————————— 1000

3. Imagine that you have a number line that goes from 90 to 1000, like the one you see here.

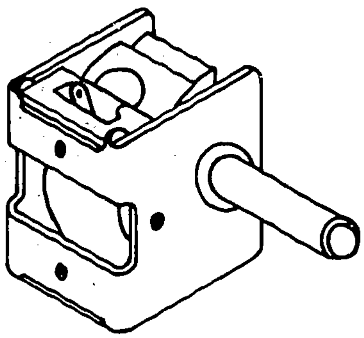
a. Where would 500 be on the line?
b. Where would 100 be on the line?
c. Where would 400 be on the line?
d. Where would 95 be on the line?
e. How did you know where to put these numbers?



Disc capacitor



Electrolytic capacitor



Variable capacitor

We already looked at three kinds of capacitors. You will recall that these three types were:

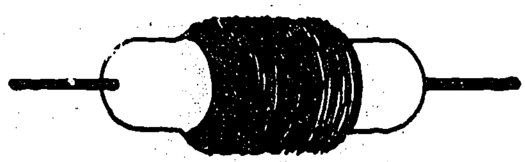
The disc capacitor

The electrolytic capacitor

The variable capacitor

A capacitor is another important component part in most electronic assemblies. There is a capacitor in an electronic flash camera. In the flash camera, the capacitor stores energy. When you press the button to take the picture, the capacitor "dumps" its energy into the flash bulb which gives off a bright light.

Capacitance is measured in microfareds (uF) or in the case of very small values, capacitance is measured in picofareds (pF). There is only a certain amount of voltage that can be dumped on a capacitor. The capacitance value (for example, .047 uF) is stamped on the capacitor. Also, the maximum working voltage (for example, 16 volts) is stamped on the capacitor.

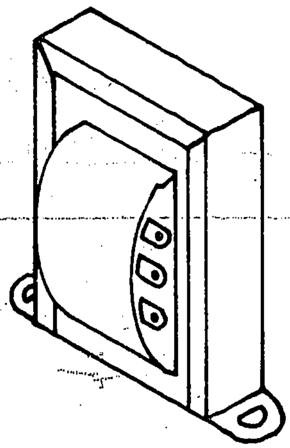


Axial lead choke

What is an inductor? An inductor is another type of component. Inductors are coils of wire. Sometimes an electrical current flowing through an inductor changes; for example, it gets turned off. When the current changes, the inductor chokes out (stops) the change. When the current first gets turned on and begins to flow through the inductor, the inductor tries to keep the current from going on or flowing. When you turn off a switch while the current is flowing through an inductor, the inductor tries to keep the current flowing. This means it tries to keep things the same instead of letting the change happen.

Here is a drawing of an inductor which is called an "axial lead choke".

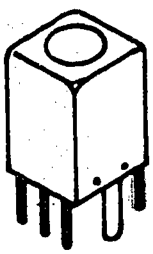
Inductance is usually measured in milli henry (mH). There is usually a maximum (the most possible) current marked so that the choke will not be put in a circuit where too much current will damage it.

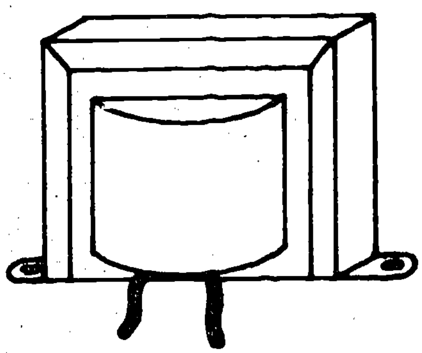


What is a transformer? A transformer is another type of component. A transformer is a special coil arrangement where two or more wires are wound together. A transformer is used to increase (make bigger) or decrease (make smaller) voltage.

Here are some examples of transformers. We saw this example earlier.

But there are other types of transformers, such as these.





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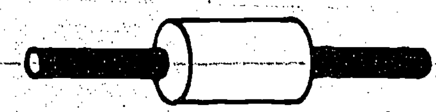
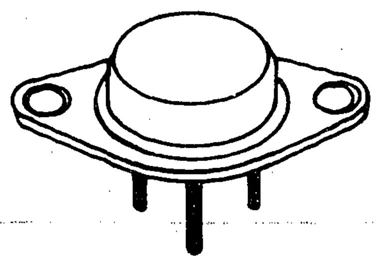


A diode is a device which allows the current to flow in one direction only. You can tell the type of diode by a number that is usually stamped on it. Diodes come in many shapes. Diodes are electronic components.

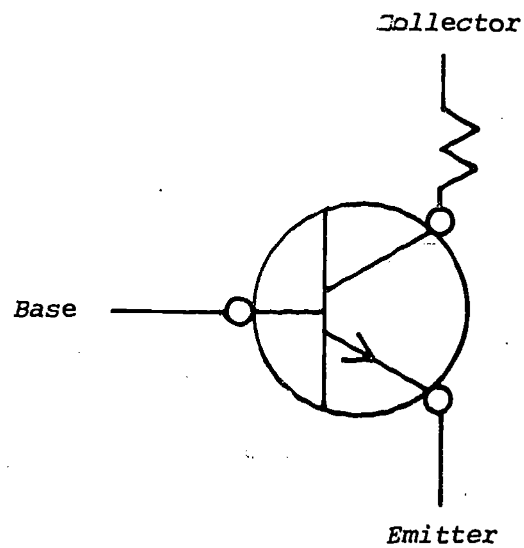
Since the current only flows in one direction, we have to be able to tell which way the current will flow through the diode. The drawings you will use in class and on the job will show the cathode end of the diode. The cathode end, or the end that supplies the current, has a band on it. Since you can see the cathode end, you will be able to do the assembly correctly. The LED (light emitting diode) is a special kind of diode that lights up. When you read the time from the kind of watch that has the time in numbers (a digital watch) without hour and minute hands, you are reading a number from a light emitting diode.



Transistor

We have already seen a drawing of a transistor. We looked at an example of a transistor like the one here.

In a transistor the current flows from the emitter to the collector. The signal on the base controls this current flow. To see how a transistor works, let us take an example of something you know. When you put your thumb over part of a drinking fountain, the stream shoots up. You are controlling the flow of water with your thumb. This is like the base in the transistor. The signal on the base controls the current flow through the transistor.



The symbol for the transistor is the letter "Q".

Most transistors have three leads (or wires) coming out of them.

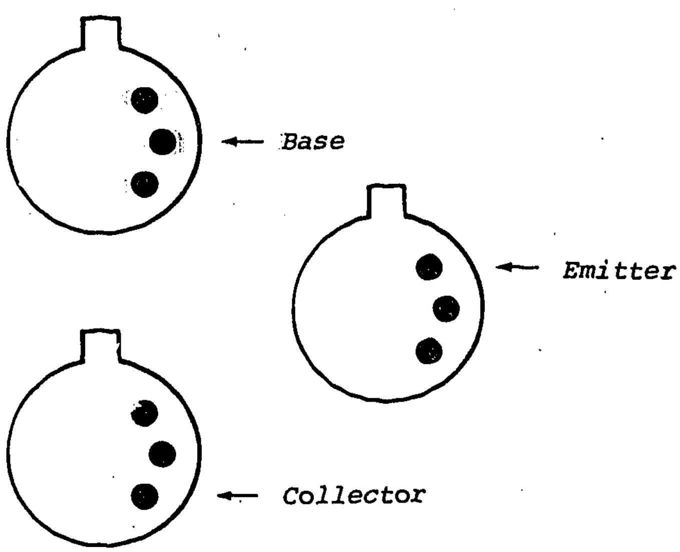
These leads are called:

base
emitter
collector

The base will always be the middle lead.

The emitter will usually be next to the locating tab.

The collector will always be opposite the emitter.



Capacitor - Electronic component that stores energy.

Microfared - Shows how much "energy" a capacitor has. The symbol for microfared is uF.

Picofared - Shows how much "energy" the capacitor can store when that number is very small. The symbol for picofared is pF.

Inductor - Another type of component; a coil of wire which chokes out or stops a change in the flow of electric current. The sign for inductance is mH or milli henry.

Transformer - Electronic component or part that is used to get a bigger voltage or smaller voltage.

Voltage - Measure of electric potential. We came across this word before when we learned about resistors.

Diode - An electronic component that allows the electric current to flow in one direction only.

Cathode - The cathode end in a diode is the part that supplies the current.

LED/Light emitting diode - A special kind of diode that lights up. This type of diode is found, for example, in digital watches which light up with the correct time.

Transistor - An electronic part used for switching the current flow.

1. Fill in the blanks:

The symbol for ohm is _________.

The symbol for battery is ________.

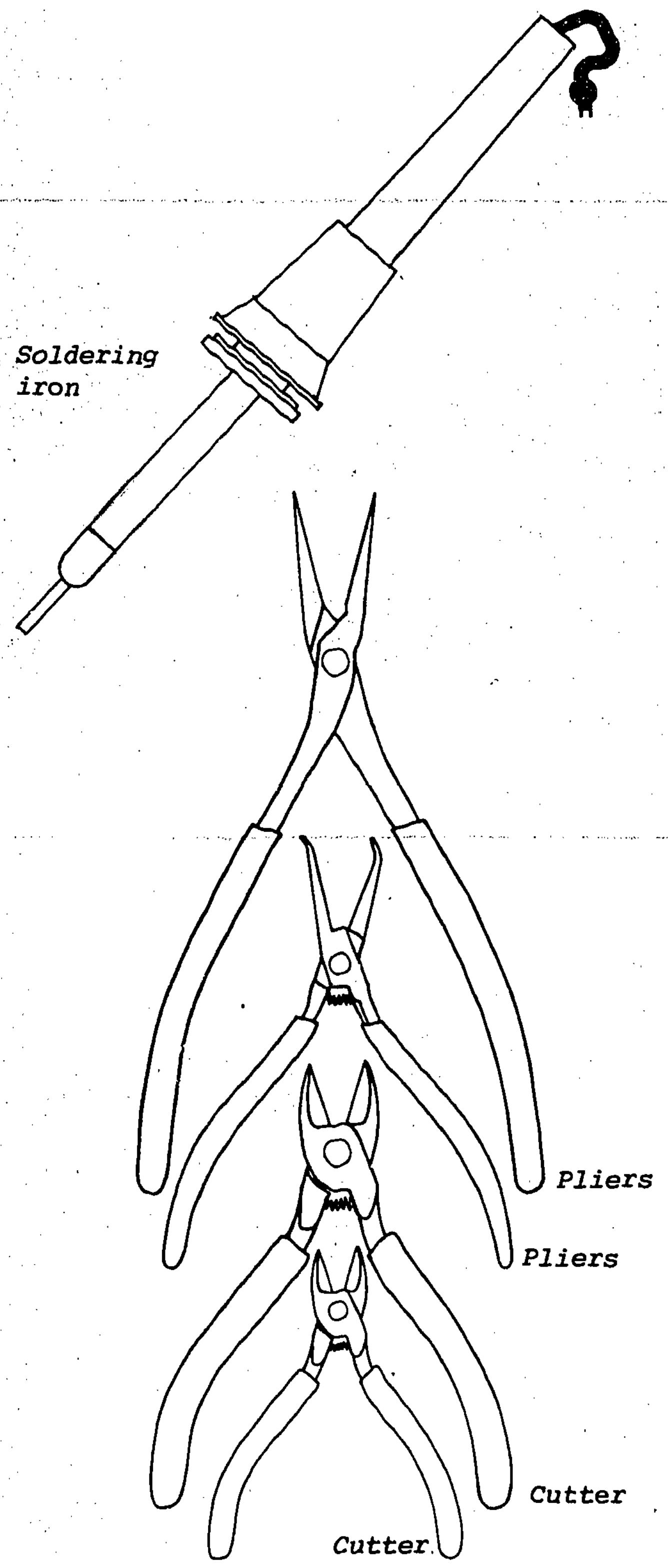
The symbol for microfared is _________.

A picture of a resistor is this _______.

The symbol mH means __________.

2. A "digital watch" is an example of what kind of electronic component?

3. If you put your thumb on the spout of a drinking fountain, your thumb "controls" the water. When this happens, your thumb is like what kind of component? Why?



What is solder?

Solder (pronounded "sodder") is a soft metal used to fasten two pieces of metal together so that current can flow through the place where the two pieces are joined. Solder melts when you heat it with a soldering iron, and hardens when the heat is removed. Solder is made from tin and lead. Most solder that you will use is the flux core kind. This means that flux is in the solder. You can see it at the center (or core). Flux is dark at the center. (Flux is an important cleaning material which must be used to make the soldering work.) Soldering is using solder. We will look at the tools and materials, the mounting of components, and how to solder.

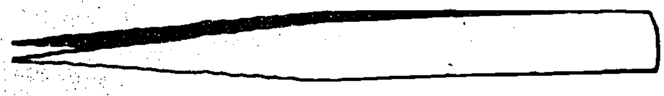
What do you need to solder?

In order to solder, certain tools are needed.

A good soldering iron is the most important tool in soldering. A wedge tip soldering iron is good when you are working with printed circuit boards. A larger iron is good for heavier work.

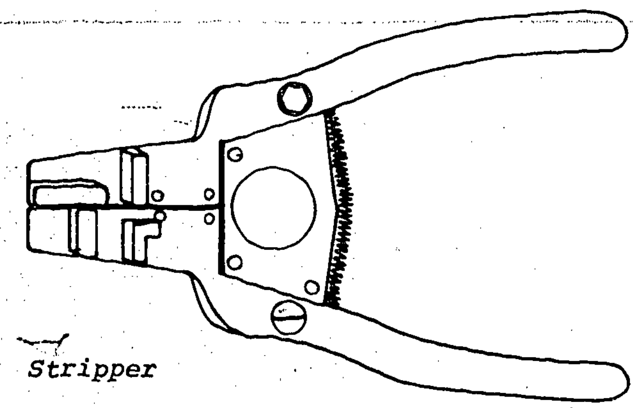
Pliers are for picking up and bending all types of wires and leads. Leads are ends of wires that come out of resistors, capacitors or other component parts.

Cutters are used to cut wire and to shorten the leads. Flush cutters are used for close work.



Tweezer

Tweezers come in many shapes and sizes and are used for picking up small wires.



Stripper

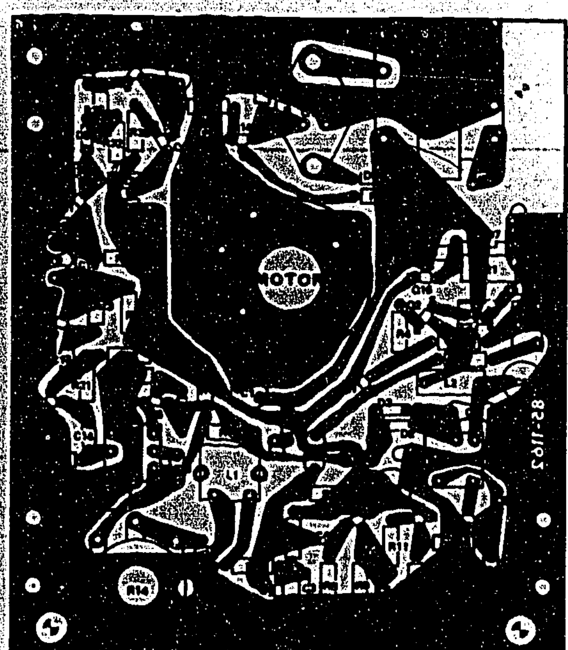
The stripper has a numbered cutter for each thickness of wire. When you use the strippers, you must check each wire for damage before tinning. Be sure the wire is not nicked or cut.

When you solder you need tools and the solder metal. You also need something to fasten the parts onto. Usually you can fasten the soldered wires to a printed circuit board.

What is a printed circuit board?

Many years ago electronic circuits had wires to join various parts. For example, if you were working twenty years ago and you wanted to join two resistors and a capacitor, you would have a series of wires and terminals.

Now, when you work in electronics, you often work with wires (or circuits) that are printed (or stamped) onto the board itself. We call this board a "printed circuit board". When people who work in electronics say they are going to "mount components", what they mean is that they are going to fasten electronic components, such as resistors, capacitors, transistors and diodes to a printed circuit board.



Printed circuit board

Before you can solder, you will need to tin the wires you are working with.

Tinning makes the wires stiff. It makes the wire keep its shape when you form it or bend it. It is easier to solder the wire after it is tinned. To tin a wire:

1. Put some solder on the tip of the iron.

2. Hold the wire and slowly put it through the solder. The solder fills in the spaces between the different strands.

3. Remove the wire from the iron.

4. Let the wire cool.

Now you have a tinned lead which you can easily bend and use.

Now you are ready to solder. The steps are:

1. Heat the wire which you have just "tinned" and the piece that you are connecting to it. You could be connecting the wire to a printed circuit board, or a terminal. Do not burn the insulation on the wire.

2. Use only enough solder to wet the wire and the connection very well.

3. Remove the soldering iron.

4. Let the connection harden before you move the wire. The connection should be smooth and bright.

5. Check the connection.

6. If you have a poor connection, for instance, you could have a lot of dull excess solder. You should reheat the connection again until it becomes smooth and bright.

It will be important if you work in electronics to work carefully. Your work in soldering, for instance, will have to be neat and exact. Usually your work will be part of a bigger assembly. If your work is good, and the work of the other persons who add to the assembly is also good, you together will produce a device or machine that will do the job that it should do.

Solder - A soft metal used to connect or hold two pieces made of metal, usually wires.

Soldering - Using solder to join two metal pieces.

Flux - A cleaning material, dark in color, that helps to make the solder hold its connection.

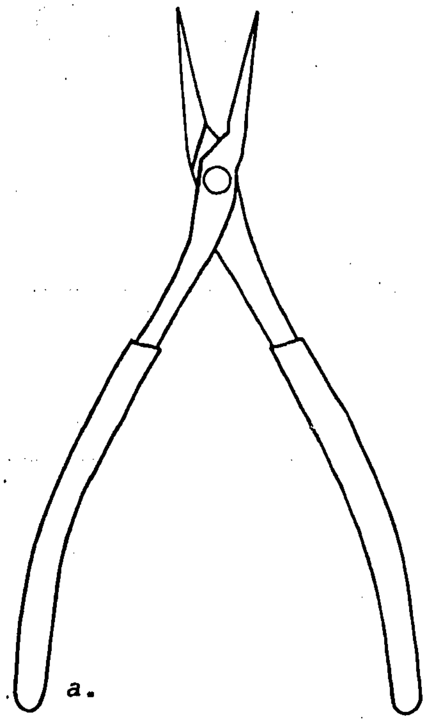
Connection - A link.

Printed circuit board - The board to which soldered wires often get fastened.

Thickness of wire - Size of wire, also called "gauge".

Tinning - Making wire stiff so that it will keep its shape.

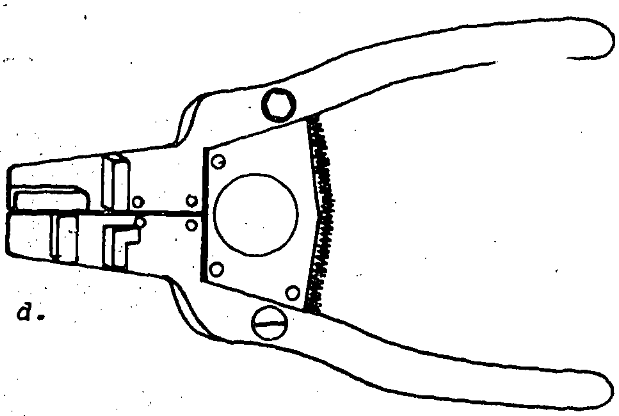
Terminal - The end of something; place in an electric circuit where electrical connection is made or broken.



a.

b.

c.



d.

1. What are the steps, in order, in soldering a wire:

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

2. There are certain tools that are used in soldering. Can you identify them in the spaces after each picture?

a. This is a ____________________.

b. This is a ____________________.

c. This is a ____________________.

d. This is a ____________________.

WIRING HARNESS
(ALSO CALLED CABLE HARNESS)

Many electronics companies have jobs that use cable harnessing. The kind of harness you will see here is often found in electronic devices as simple as washing machines and as complicated as weapons systems. When you work on the type of harness shown here you will understand how any harness is made, whether it is big or small. A harness, like this one, sometimes connects terminal boards and printed circuit boards.

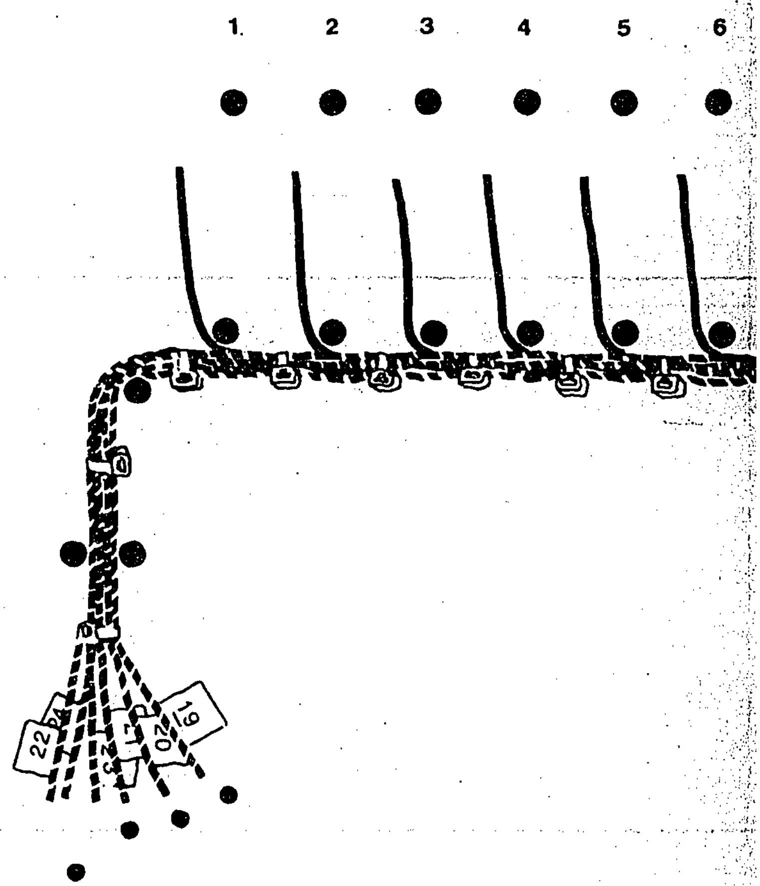
Definition

A wiring harness is a group or bunch of wires which are tied or laced together so that they can be connected or disconnected easily. It will be important when you work on a wire harness to read the numbers carefully and to proceed carefully in putting together the harness. Other workers will continue to use your harness in a larger assembly after you have completed your work.

Construction

Putting together (or constructing) a wiring harness is easy. The wiring harness assembly instruction drawing is fastened to a board on the work bench. The nails for the harness are already on the board. (This was the procedure in the samples we observed at Raytheon Company.)

WIRING TABLE				
LINE	AWG	COLOR	FROM	TO
1	22	BLACK	1	7
2			8	2
3			3	9
4			10	4
5			5	11
6		BLACK	12	6
7		STRIPED	13	19
8			20	14
9			15	21
10			22	16
11			17	23
12	22	STRIPED	24	18



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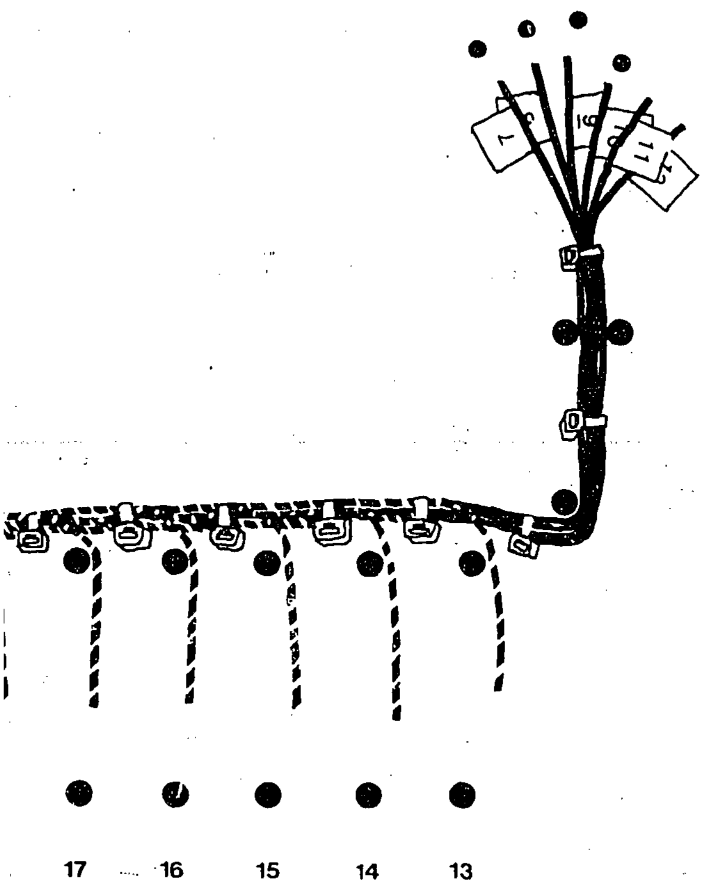
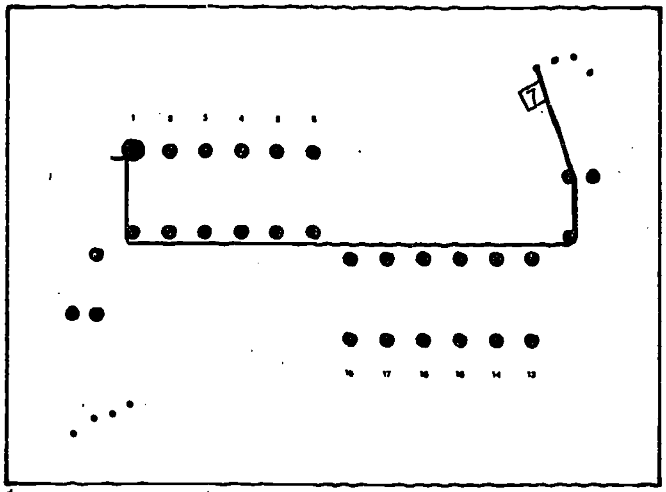
1	TRAIN.NG HARNESS		11/15/7[illegible]



ASSEMBLY INSTRUCTION	
DRWG. VOCATIONAL STRATEGIES	
STD. HRS.____ MIN.____	
OPER.	SHT 1 OF 1



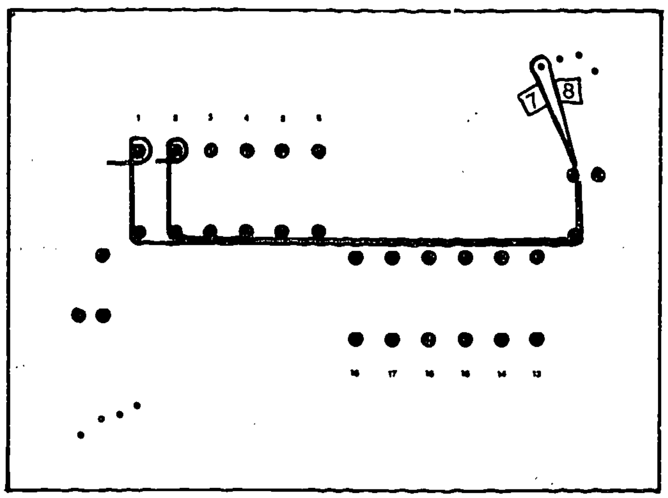
1.

This is how you make a simple harness.

1. Look at the first line of the wiring table.

AWG	COLOR	FROM	TO
22	Black	1	7

Take a spool of black 22 gauge wire. (Gauge means the thickness of the wire.) Wrap the end of the wire around pin 1. Carefully lay the wire between the pins (look at the foldout to see how this is done). Wrap the wire around the pin between 7 and 8. Place a tab marked 7 on the wire.

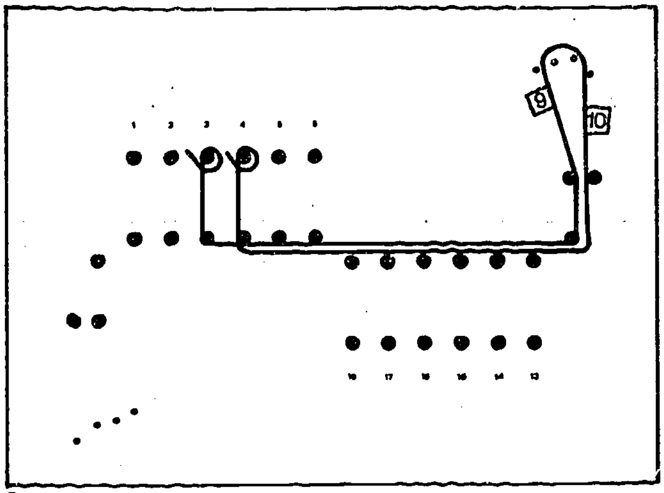


2.

2. Look at the second line of the wiring table.

AWG	COLOR	FROM	TO
22	Black	8	2

Place a tab marked 8 on the loose end of the wire at the pin between 7 and 8. Carefully lay the wire between the pins and wrap it around pin 2. This will lay the wire back in the other direction. Cut off the wire the way it is in the foldout.

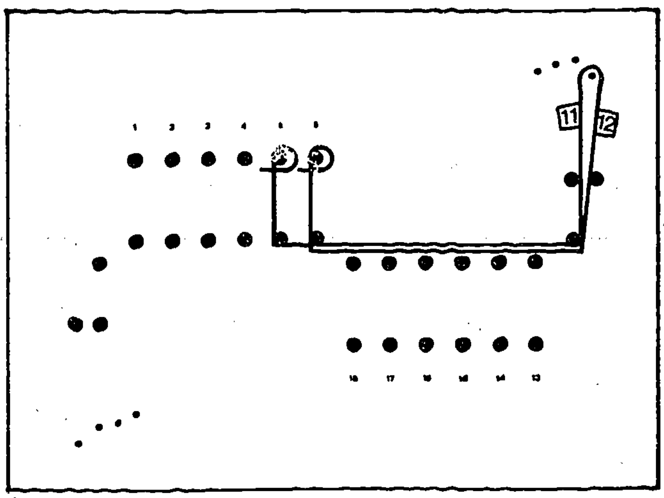


3.

3. Look at the third and fourth lines of the wiring table

AWG	COLOR	FROM	TO
22	Black	3	9
22	Black	10	4

Take the spool of black 22 gauge wire and wrap the end around pin 3. Carefully lay the wire between the pins (look at foldout). Wrap the wire around pins 9 and 10. Place the tabs marked 9 and 10 on the wires. Carefully lay the wire between the pins and wrap it around pin 4. Cut off the wire the way it is in the foldout.

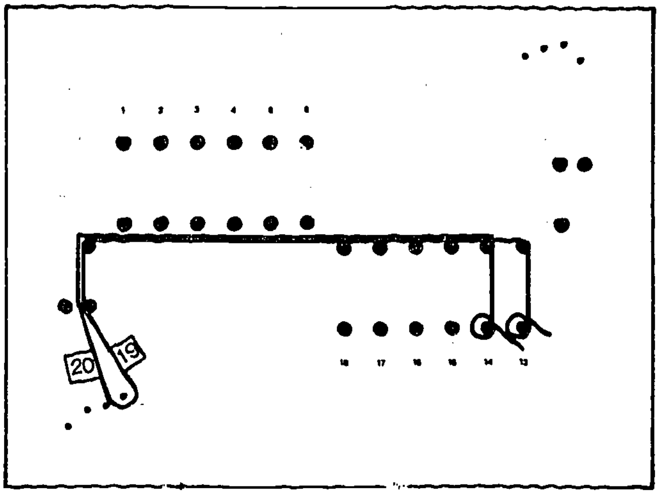


4.

4. Look at the fifth and sixth lines of the wiring table.

AWG	COLOR	FROM	TO
22	Black	5	11
22	Black	12	6

Take the spool of black 22 gauge wire and wrap the end around pin 5. Carefully lay the wire between the pins (look at foldout) and wrap it around the pin between 11 and 12. Place the tabs marked 11 and 12 on the wire. Carefully lay the wire between the pins and wrap it around pin 6. Cut off the wire as in the foldout. Now you've finished the first leg of the harness.

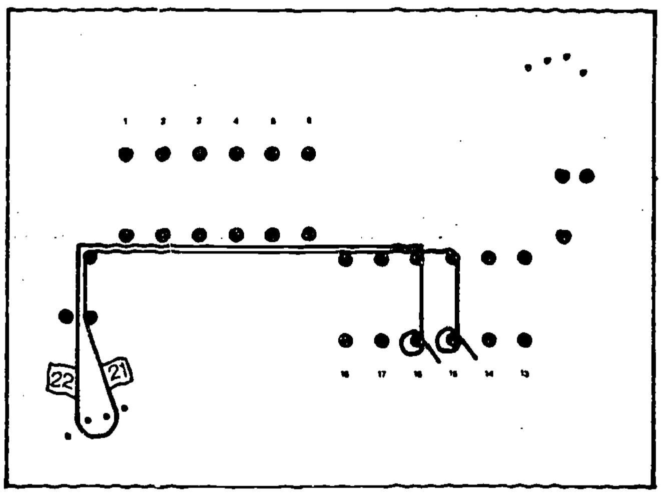


5.

5. Look at the seventh and eight lines of the wiring table.

AWG	COLOR	FROM	TO
22	striped	13	19
22	striped	20	14

Take a spool of striped 22 gauge wire and wrap the end around pin 13. Carefully lay the wire between the pins and wrap it around the pin between 19 and 20. Place the tabs marked 19 and 20 on the wire. Carefully lay the wire between the pins and wrap it around pin 14. Cut off the wire as in the foldout.



6.

6. Look at the ninth and tenth lines of the wiring table.

AWG	COLOR	FROM	TO
22	striped	15	21
22	striped	22	16

Take the spool of striped 22 gauge wire and wrap the end around pin 15. Carefully lay the wire between the pins and wrap it around the pins at 21 and 22. Place the tabs marked 21 and 22 on the wire. Carefully lay the wire between the pins and wrap it around pin 16. Cut off the wire as in the foldout.

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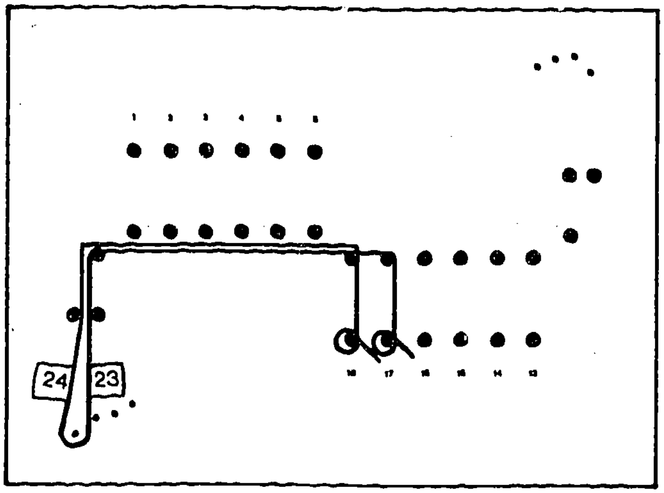
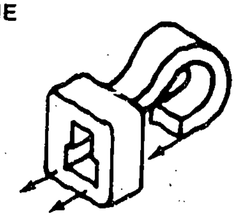


7. Look at the eleventh and twelfth lines of the wiring table.

AWG	COLOR	FROM	TO
22	striped	17	23
22	striped	24	18

Take the spool of striped 22 gauge wire and wrap the end around pin 17. Carefully lay the wire between the pins (see foldout) and wrap it around pin between 23 and 24. Place the tabs marked 23 and 24 on the wire. Carefully lay the wire between the pins and wrap it around pin 18. Cut off the wire as in the foldout. You have now finished the second leg of the harness.

TIE



Use the tie wraps (these are the nylon fasteners which hold the wires together) at the points shown in the foldout.

Cut the wire where it wraps around the nail between points 7 and 8; where it wraps around the nail between points 9 and 10; between points 11 and 12; between points 19 and 20; between points 21 and 22; between points 23 and 24. Remove the harness from the board.

Strip all the loose ends so that they can be either soldered to the connectors or fastened to the terminal boards. Now the harness is ready to be fastened (attached) to an assembly.

Wiring harness - Group or bunch of wires which are tied or laced together so that they can be connected or disconnected easily. Wiring harness is also called cable harness.

Terminal boards (terminal) - Place in electric current where electrical connection is made or broken; place where wiring harness can be attached.

Printed circuit board - Board where wires or components can be fastened and connected to other wires.

Gauge - The thickness of wire you are using, perhaps in a wiring harness job.

1. Student will correctly point out each of the following components located at a work bench:

a. Resistor

b. Transistor

c. Diode

d. Inductor

2. Student will tin the leads (wires) on a component and will neatly solder the component to a printed circuit board at the proper place on the board.

3. Using a board for a cable harness, the student will accurately connect one wire, according to directions in diagram. Tabs will be fastened correctly and wires cut evenly.

None of our students have been engaged in "mechanical assembly" per se; we feel, however, that this would be a suitable trade area, both for training and for eventual placement. A number of our students were mainstreamed into the machine shop at Boston Trade High School which was the closest available area related to mechanical assembly. John Key, a machinist at Raytheon's Norwood plant, reviewed our machine shop curriculum as well as the machines available, and concluded that although the machines in the shop were fairly adequate, our students (who were making tools such as screwdrivers and candlestick holders) were "a long way" from the training they would need to be skilled machinists. Mr. Key explained that in his own work, many of his responsibilities were rather complex, and often merged into the engineering area. He agreed with us that any of our students in the machine trade would profit from simultaneous training in mechanical drawing, which at present is not available as a "joint offering."

The project director subsequently met with Warren MacInnes of Raytheon Microwave and Power Tube Division in Waltham. Mr. MacInnes, also a member of the Raytheon observation team, agreed with the project director that the machine shop was not the most appropriate placement for special needs students; he provided us with a number of strategies for developing a full curriculum in mechanical assembly. Subsequent sessions with Mr. MacInnes and Mr. Yarbrough produced the assembly of the choke coil which follows, only one example of a number of assemblies which have been made available to us by Raytheon Company. We expect that a teacher working with students in this area can generalize from the simplified, straightforward approach here to any number of mechanical assembly problems.

We have included a section on related math, stressing spatial relations, measurement, and computational skills. It should be noted that in the Spring of 1976 five of our students were given special weekly workshops by Gerald Shertzer, a member of the visual studies department of Phillips Andover Academy. The students progressed through a number of visual learning exercises in symmetry and color, figure ground, and perspective. It is our hope that vocational instructors will include visual studies materials if and when they implement this unit. Materials from student meetings as well as reports and materials from a two week workshop conducted by Mr. Shertzer for Boston teachers are available at the project offices, 53 State Street, Boston.

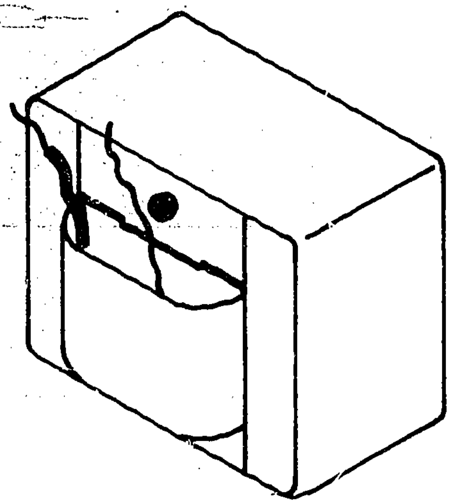
Assemblers put together parts for many manufactured products. Many assemblers work on items that move automatically past them and their work stations on conveyors. Most parts of automobiles are put together in this way. Other assemblers work at putting circuit boards and chassis into large cabinets. Usually the workers stand in front of the cabinets, which are very large.

Still other assemblers work at benches and are called bench assemblers. Bench assemblers put together small parts to make "subassemblies" or small complete units. Assemblers use many different tools depending on the product and the work that they are doing. Pliers, screwdrivers, soldering irons, power drills and wrenches are some of the tools that assemblers use. Assemblers use diagrams or blueprints to guide them in their work. The choke coil that we will look at is an example of bench assembly.

Machines are used in some assembly work. In putting together circuit boards, for instance, automatic machines sometimes are used to put components on boards and to solder connections; hand assembly is needed for working with some items, such as some types of resistors and diodes.

Hand assemblers may perform only a single operation as components move down the production line, but some put together complete assemblies. Assemblers need to work carefully and accurately. Often they will repeat the operation they are doing many times in the same day. It is important that each time the job is done, it is done well.

WORKING WITH A CHOKE COIL



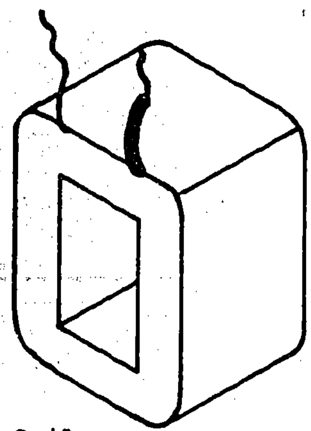
Choke coil

Inductor

This is a picture of a choke coil. This coil is drawn "to size." This means that the picture is the size of the real coil. How big is the coil? How wide? How high? In inches? In centimeters?

The choke coil was mentioned earlier in the section on inductors. You will remember that a choke coil tries to keep the current that is flowing through it from changing. You will remember this was the picture you saw of an inductor.

Inductors and chokes do the same kind of work. When you turn off the switch which is attached to the coil while the current is flowing through the coil, the choke coil tries to keep the current flowing. When the current first gets turned on, and begins to flow through the choke coil, the choke coil tries to prevent the current from flowing.



Coil

These are the parts of a choke coil.

a. coil

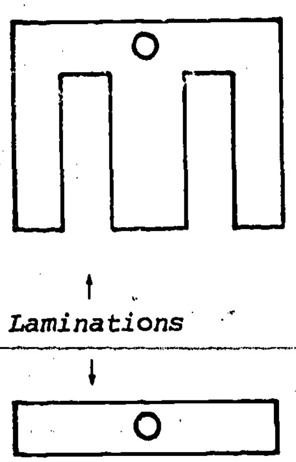
b. laminations

c. screw, nut and lock washer

Measuring laminations:

Let us call the width of the lamination "w".

Let us call the length of the lamination "l".



Laminations

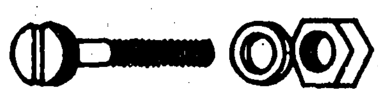
Using your ruler, measure the width and lengths of the laminations:

"E" Lamination is __________ inches wide.

"E" Lamination is __________ centimeters wide.

"I" Lamination is __________ inches long.

"I" Lamination is __________ centimeters wide.



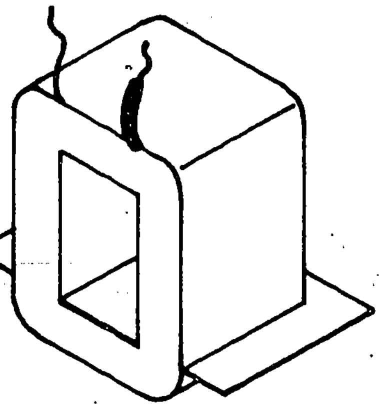
Screw, lock washer and nut

The laminations and the coil should get assembled in this way:

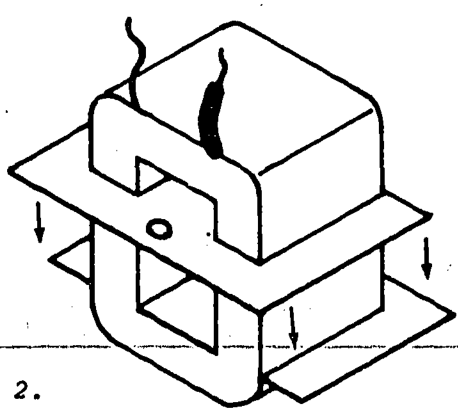
1. Place the first "E" shaped lamination through the coil. In the example of this particular choke coil, the coils will be assembled before you get the coil. This means that you will not be wrapping the wire; you will be working with the laminations.

2. Place the second "E" shaped lamination through the coil, but from the other side of the coil.

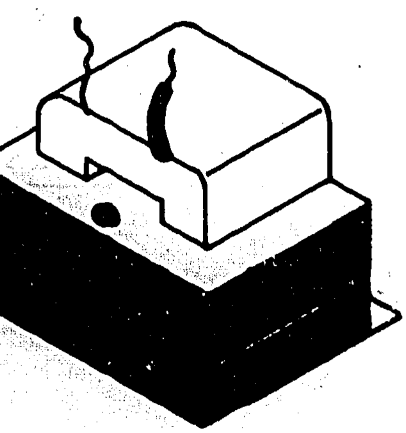
3. Repeat Step 2 until most of the "E" shaped laminations are in place (in this particular choke coil there are 57 "E" shaped laminations altogether).



1.



2.



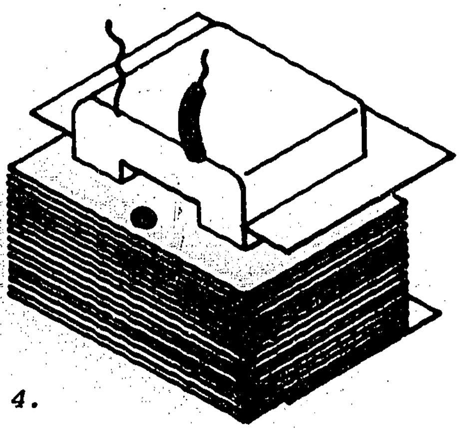
3.

4. Put an "E" shaped lamination in from the other side. This will be like step one. This will be the top "E" shaped lamination.

5. Take the remaining "E" shaped laminations and feed them into the middle of the pile until they are all in place.

6. Take the "I" shaped laminations and stack them together as shown. Place two "I" shaped laminations on the other side.

7. Put the screws through the laminations and tighten the lock washer and nut on the other side. Tighten with a screwdriver and spin tite.



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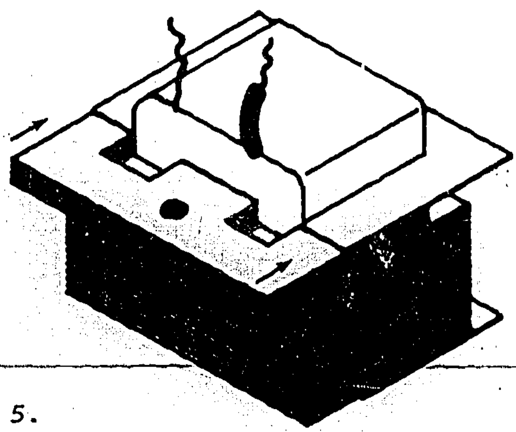

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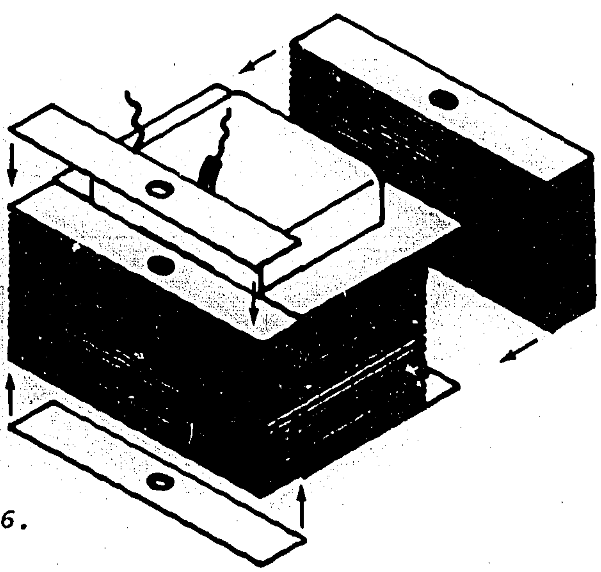

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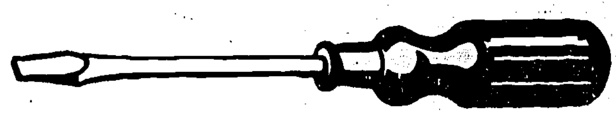
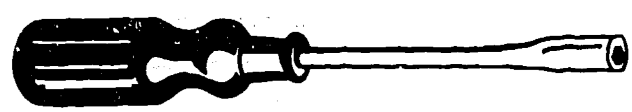
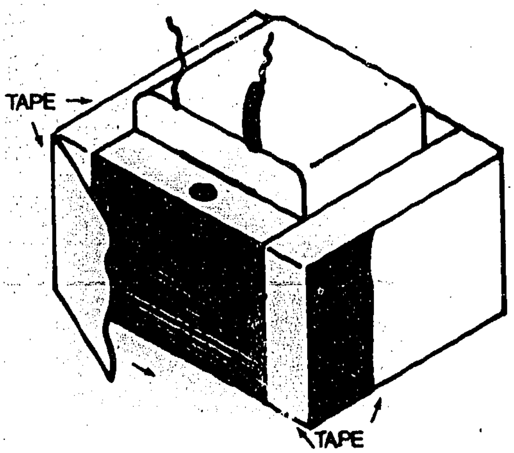


Screwdriver



Spin tite



8. Tape the laminations with tape.

9. Tin two leads. (Review how you tin leads in the electronics section on the job of soldering.)

10. Now you are finished with the work that you can do on this choke coil. You will now take the coil and pass it on to a technician.

72

Conveyer - A moving belt that carries materials from one place to another.

Circuit board - A board to which soldered wires often get fastened.

Chassis - The frame on which electronic parts are put.

Bench assemblers - People who assemble materials at a workbench.

Diagram - A sketch or drawing which helps to explain how different parts of something work.

Blueprint - A technical drawing, often made with white lines on a blue background.

Inductor - An electronic component, or part, that tries to keep current flowing; it looks like a coil.

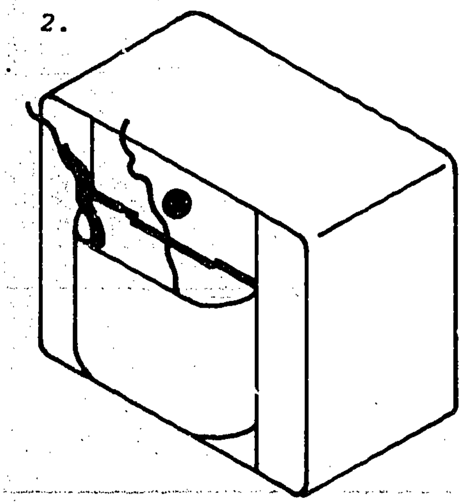
Laminations - Thin sheets or layers.

Tin - To make a wire stiff so that it will keep its shape.

Soldering - Using a soft metal to hold pieces of metal together.

Insulation - Material that is used to keep heat or sound or electricity out of something.

2.



QUESTIONS

1. What is an assembly?

2. This is a sketch of a _____________.

It works in a way that is like the

____________________.

3. These are some parts of the choke coil:

a.________________________________

b.________________________________

c.________________________________

d.________________________________

e.________________________________

f.________________________________

74

A. Measurement and counting skills are important to people who work in mechanical assembly. Here are some easy measurement problems to start with: (A ruler marked off in inches and centimeters will be needed for some of these exercises).

1. Look at your ruler.
How long is it in inches?
How long is it in centimeters?

2. This line is one centimeter long. Check it with your ruler.

2.

1 cm.

1 in.

3. This line is three and a half (3 1/2) centimeters long. Check it with your ruler.

3.

4. Close your eyes for about one minute. Open your eyes when you think one minute is over.

5. How long is this line? In inches, in centimeters?

5.

6. Pick any number.
Double it.
Add ten.
Divide by 2.
Subtract the original number.

B. Here are more measurement exercises, where fractions are used. (You will need a ruler with inches and centimeters marked off.)

1. Draw a line one inch in length.

a. Compare the inche line to one centimeter on your ruler.

b. How many centimeters in an inch?

2. What do the lines between the numbers on your ruler mean?

3. Draw a line 1/2 inch long.

a. What does 1/2 mean? (1/2 means 1 part of something divided into 2 equal parts.)

b. Does 1/2 inch mean the same as 1/2 centimeter? Why not?

4. Draw a line 6 3/4 inches long.

a. What does 3/4 mean?

b. What is the difference between an inch and a centimeter?

c. What is the difference between

2/3 inches and 2/3 centimeters?
3/8 inches and 3/8 centimeters?
3/5 inches and 3/5 centimeters?

C. You will need to understand and make precise measurements in two and three dimensions. When you measure in "two dimensions," you will need to know the "length" and "width" of things.

1. Define length.

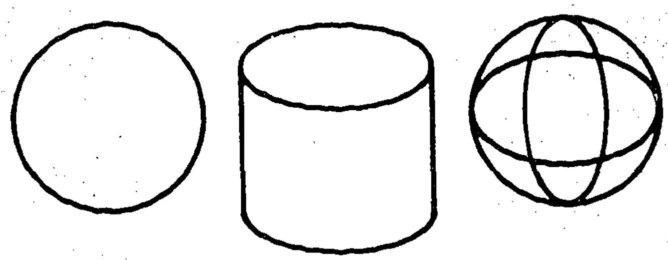
2. Define width.

D. When you measure in "three dimensions" you will also need to know the "depth" of things.

1. What is depth?

2. What are some objects that have depth? Can you give examples of a circle (e.g., a ring), a cylinder (e.g., a tin can), and a sphere (e.g., a tennis ball) that you know?

3. Roll a sheet of paper into a tube (a cylinder). How can you look at the cylinder to see just a circle?



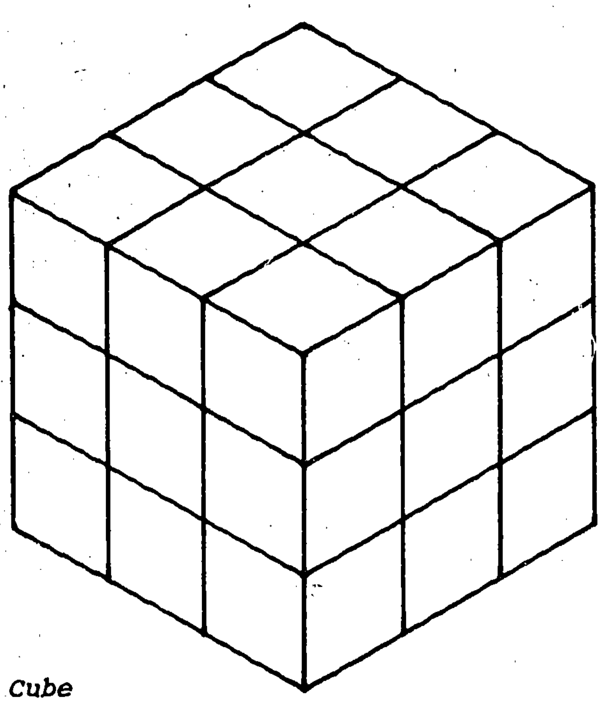
Circle *Cylinder* *Sphere*

E. Here is a cubical counting block. This exercise will give you practice in seeing depth in a drawing.

1. The cube is ____cubes long, _______cubes wide, and_______cubes high.

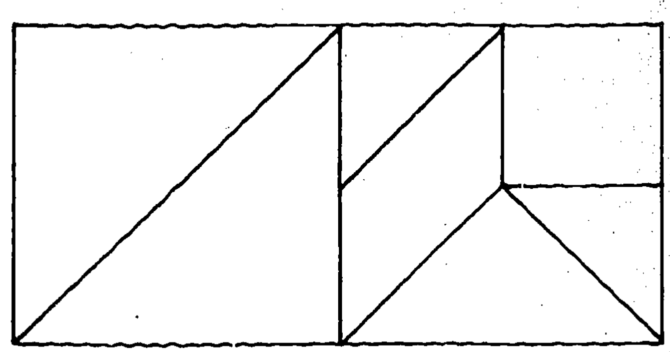
2. Is there any difference between the length, width, and height?

3. How many sides does a cube have?

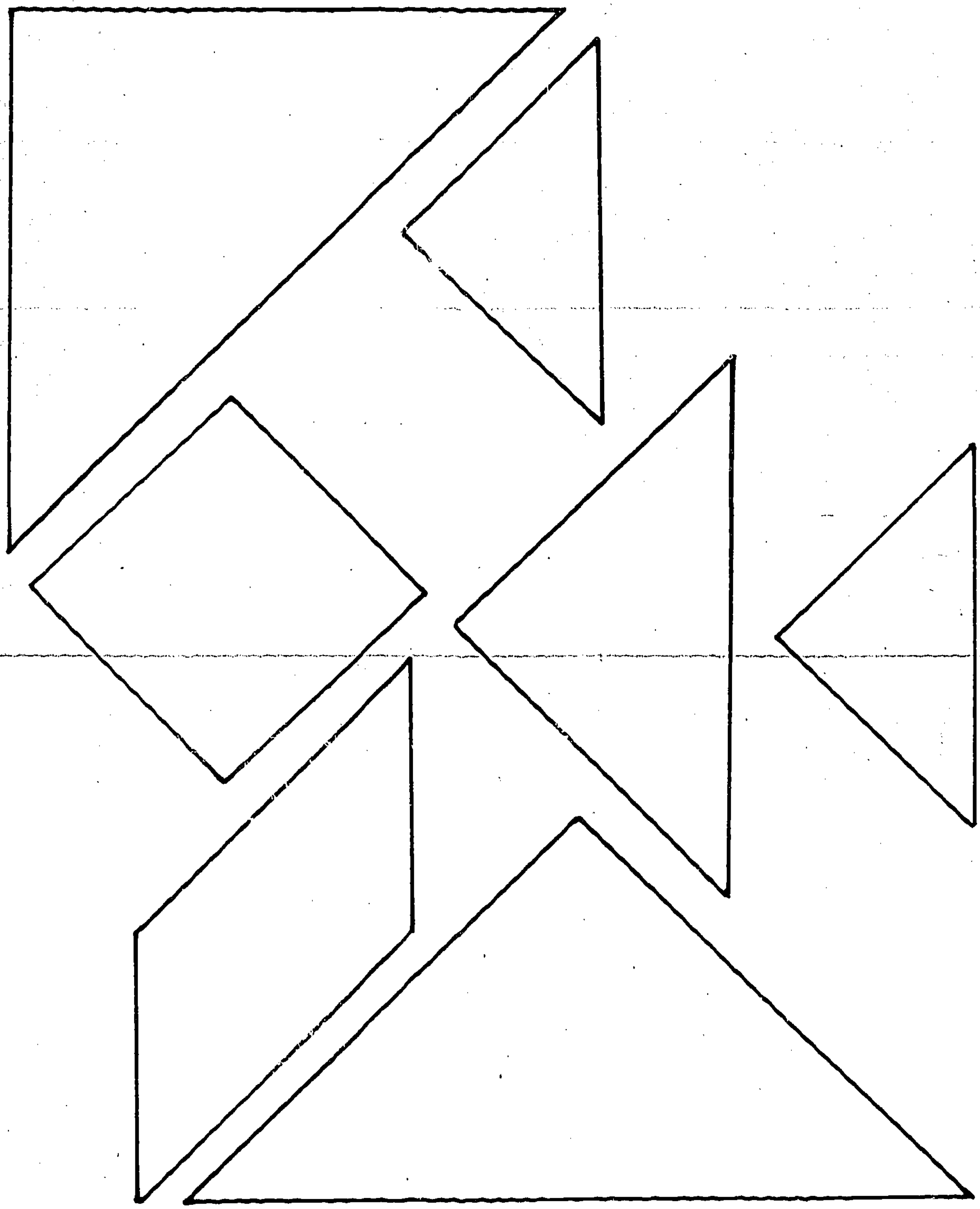


Cube

There are seven geometric shapes on the next page. Cut them out and put them in this block. They must only be used once, and you must use them all.



Here are the geometric shapes to use for the exercise on the page before this one.



PERFORMANCE CRITERIA

1. Student will point to objects in the classroom or shop which display a circle, a sphere, a cylinder, an inductor, a lamination.

2. Student will demonstrate knowledge of right and left sides, opposite sides, length, and width. S/he will measure the length and width of objects in the room (a carton, a stapler, a pad of paper) first in inches, then in centimeters.

3. Student will correctly assemble a choke coil, in steps similar to those shown here. Student will show ability to follow directions for assembly in order, from beginning to end.

4. After a verbal review of tinning and soldering, student will perform these tasks as needed to complete the particular mechanical assembly that is put together.

NOTES

Our problems in mainstreaming special needs or mildly handicapped students into the printing shops at Boston Trade High School represent to us a microcosm of difficulties we expect other, similar projects have experienced in vocational planning, irrespective of locale. There are two print shops at Boston Trade High School. One is specifically devoted to offset work, and is far too complex for most of our students; the other printing shop is simply outmoded.

With guidance from Ralph Dolce of Raytheon's Burlington plant, and with consultation from a number of printing houses in downtown Boston, we have selected the material here as an example of operations and functions that the special needs student can perform in the printing trade.

There are some easily recognizable drawbacks to this material and to the printing placement in general. First, some printing machinery mentioned here is quite expensive, and many schools do not have these machines available. Second, most small print shops expect workers to be much more versativle than, for example, simply knowing "collating". It is our feeling after working with students in the printing area for two years, that the printing trades have become rather sophisticated, and may not be a feasible placement for mildly handicapped and, particularly, mildly retarded students.

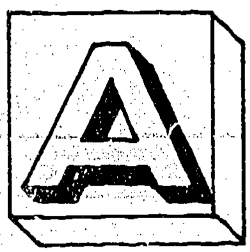
There are four main kinds of printing. They are called:

Letterpress

Gravure

Lithography

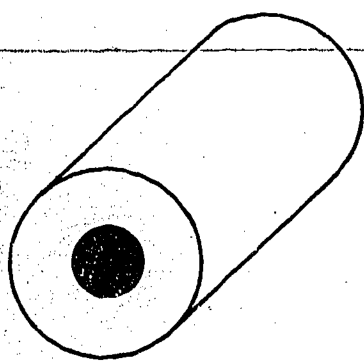
Screen



Raised letter

Letterpress uses metal plates. Each metal plate has a raised letter on it. The ink touches only the raised letters and puts them on paper. For example, if you have a plate with the letter A on it like the one here, the ink would only cover the A, not the rest of the plate. Only the A would show up on paper.

Letterpress is the oldest kind of printing. It is used to print books, newspapers and magazines. It is also good for printing price lists (such as menus in restaurants) or schedules (such as bus timetables) because a few letters can be easily changed, without changing the whole set of type.



Cylinder

Gravure printing uses depressions to get the letters or pictures. For example, the letter A would be "carved out" of the metal. The metal will usually be a copper cylinder. The cylinder is rolled in a container of ink, and the ink gets into the engraved parts. Then the ink is wiped off the other parts with a kind of steel called doctor blade.

Gravure printing is good for printing pictures, but it is very expensive to make the plates, so it is only used when many copies are being printed. This is called a "long run". The magazine section of your Sunday newpaper is probably printed with gravure. Large mail order catalogues, wallpaper, and postage stamps are also usually printed with gravure.

Lithography is also called offset printing. It uses thin metal plates that are flat. They are not raised or depressed. It works because grease and water do not mix. The parts for the letters pick up grease (ink) and are water repellent. (A raincoat is water repellent.) The parts for the background pick up water, but are ink repellent. First the plate is wet with water, then with ink. The water is used first so that the background areas are not wet with ink. Then the ink is offset (taken off) the plate onto a rubber blanket. Finally the ink is offset from the rubber to paper.

Because the rubber blanket used in offset is softer than metal, the impressions (such as letters) on the paper are clearer than with the other kinds of printing. There are many different sizes of offset machines, so you can print everything with this process, from encyclopedias to simple form letters when you want many copies.

Screen printing has also been called silk screen. It uses a screen that is attached to (mounted on) a frame. The screen is made of silk, Nylon, Dacron, or stainless steel. Then a stencil is made on the screen. When ink is put on the screen, it is forced through little holes in the stenciled part. You may have seen a teacher using a kind of stencil with letters punched out of a piece of cardboard. The ink goes through the holes onto another piece of paper.

Screen printing can be used on any kind of surface. You would use screen printing if you wanted to print an ad on a piece of wood, glass or plastic. Screen printing is also used for printing special kinds of curtains and wallpapers.

BACKGROUND

How many kinds of printing a printing shop can do depends on how big it is. The smaller printing shops usually only have machines to do small amounts of printing (short runs). A small shop will probably have an offset press, as well as some copiers and duplicators. A small shop will also have several machines that are not used for printing, but are related to the printing business.

We will look at some of the simple machines that might be in a small printing shop. They are:

The Jogger

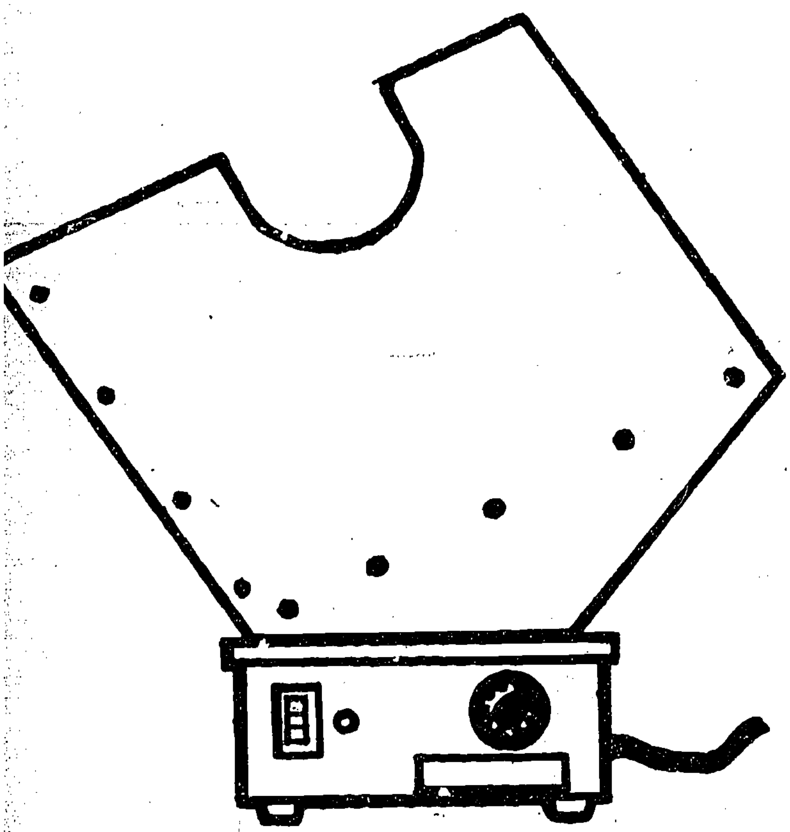
The Electric Stapler

The Paper Drill

The Spirit Duplicator

We will also learn a little about collating, folding, and about binding.

The jogger is an electric machine that straightens out piles of paper. It shakes the pieces of paper until they are in a very even pile. The jogger has a jogging bin, which is where you put the pieces of paper. It also has a vibration control switch. This switch makes the shaking faster or slower. It has numbers on it, and the lower numbers make it go slower. When it is set on 4, it goes slower than when it is set on 7.



Jogger

To use the jogger:

1. Pick up the pile of paper you are using. This paper is called stock.

2. Flip through (riffle) the edges of the paper and straighten out the stack.

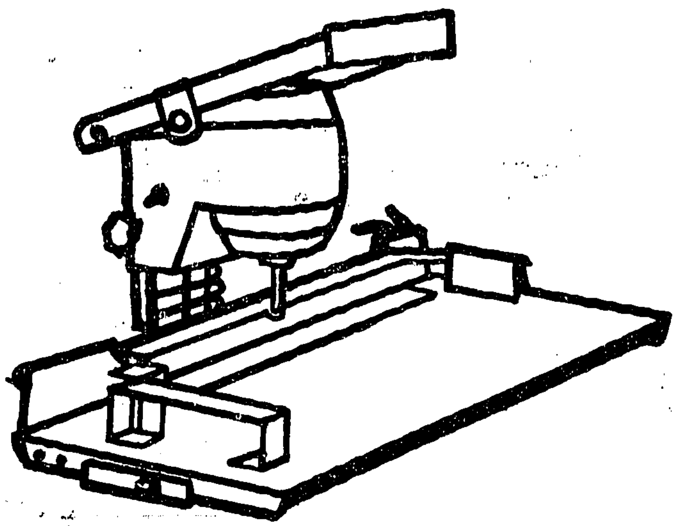
3. Put the stack of paper in the jogging bin.

4. Turn the jogger ON.

5. Check the vibration control switch. It is usually better to start at a slow speed (1 or 2) than to start with a high one (10).

6. When the pile of paper is very even, turn OFF the machine.

7. Take the paper out of the machine.



Paper Drill

The paper drill is used to make holes in paper (stock). It drills the kinds of holes you see on the pages you put in a loose leaf notebook.

To use:

1. Take a 1 inch stack of paper. Figure out where you want the holes.

2. Turn the lever rod to set it where you will want to drill.

3. Take a sheet of paper you are using, and fold it in half. Now you have a center mark which you can line up in the drill.

4. Lift up the clip lever and put the stock under the pressure board. You should be able to line it up right because you have lined up the center mark.

5. Let the clip lever go back down, to hold the stock in the right place.

6. Press the crutch stopper. The paper is on the base pla' '. Move the base plate to the right spot for your first hole.

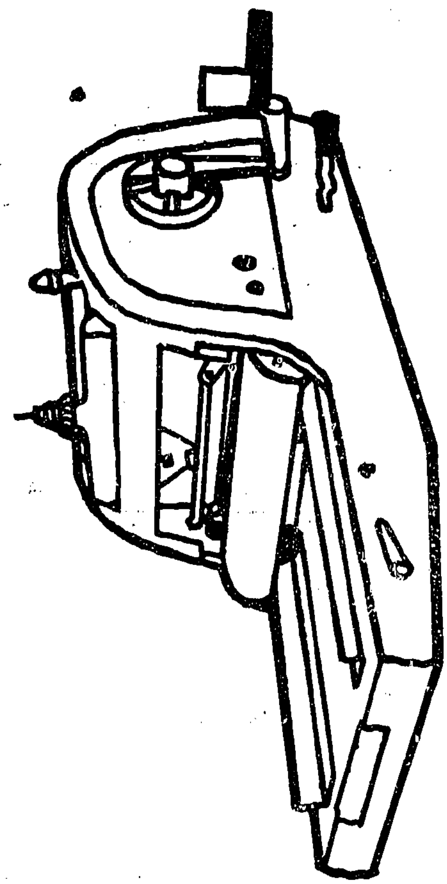
7. Plug in the machine and turn ON the switch.

8. Pull the handle down so that it drills the hole.

9. Let the handle go back up after the first hole is drilled.

10. Press the crutch stopper again to move the base plate to the right spot for the next hole. Go through the same steps again, until you have drilled all the holes you need.

11. Unplug the machine, and check the dust case. If it seems to be quite full of little paper cirles, empty the case and clean it.



Spirit Duplicator

The spirit liquid duplicator is used to make copies of memos, and reports. You might have seen some copies that were made on a spirit duplicator in your classroom. Your teacher might have passed out sheets that were copies from a stencil used with a spirit duplicator.

To use:

1. Turn the lever from right to left to set the <u>wick pressure</u>.

2. Check to see that there is enough <u>fluid</u> in the tank. Turn over the tank so that it will <u>feed</u> fluid.

3. Move the <u>impression pressure lever</u> into the first notch.

4. Put the guide rails in the right place for the paper you are using.

5. Press down the loading lever.

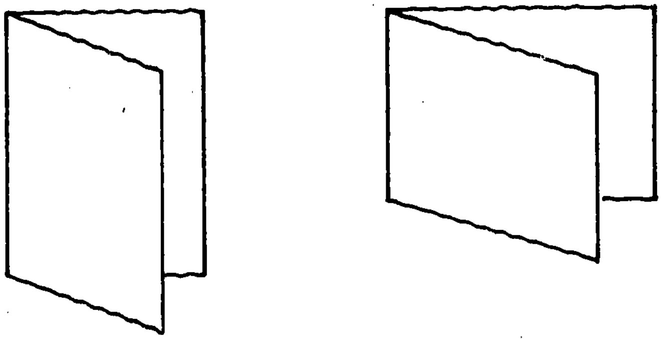
6. Put some paper on the <u>feed table</u>. Push up the <u>paper loading lever</u>.

7. Put the stencil on the <u>cylinder</u>. Push the rollers down. Turn the counter to the number of copies you want. Turn the handle on the machine counterclockwise (the opposite way a clock's hands go).

8. When you have run off a few sheets, look at them. Change the settings on the machine if you need to.

9. When you have run off all the copies you need, take the stencil off the cylinder. You can save the stencil if you will be using it again.

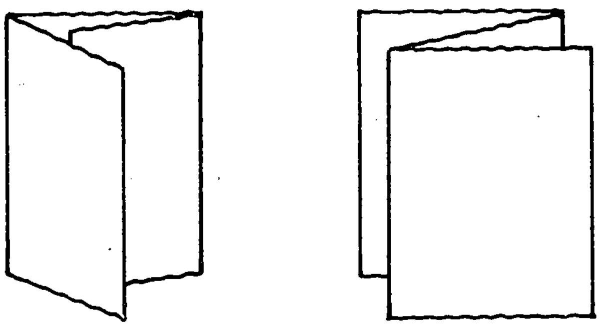
10. Turn over the tank. Move back the lever for the wick pressure. Move the impression pressure to OFF. Press down the paper loading lever.



Four page folders

Books, magazines, and pamphlets are folded in many different ways. Which way you fold them depends on what size you are using for the printing, and what size you want the booklets to be when you are finished.

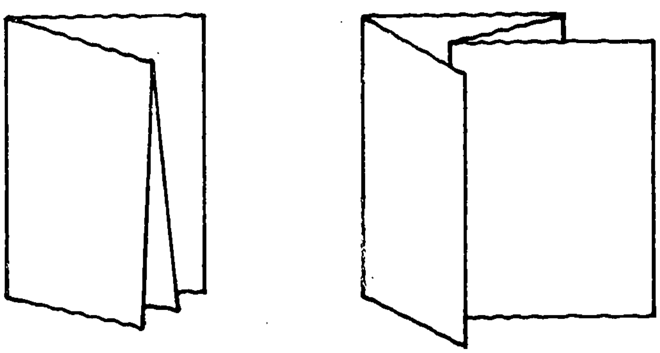
The simplest way to fold is called a four page folder. If you take a piece of paper and fold it exactly in half, you have a four page folder, whether you fold it the long way or the short way.



Six page folders

Another kind of fold is the six page folder. It is a way of folding paper in three. You can either fold the paper accordian style, or in the regular way you would fold a letter.

There are three ways to do an eight page folder. First, you can fold the paper in half, with the top half of the paper over the bottom half. Then you fold the left side of the paper over the right side. This is also called french fold. It looks like some greeting cards you have seen.

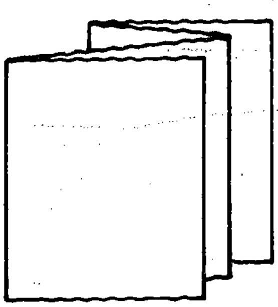


Accordian style

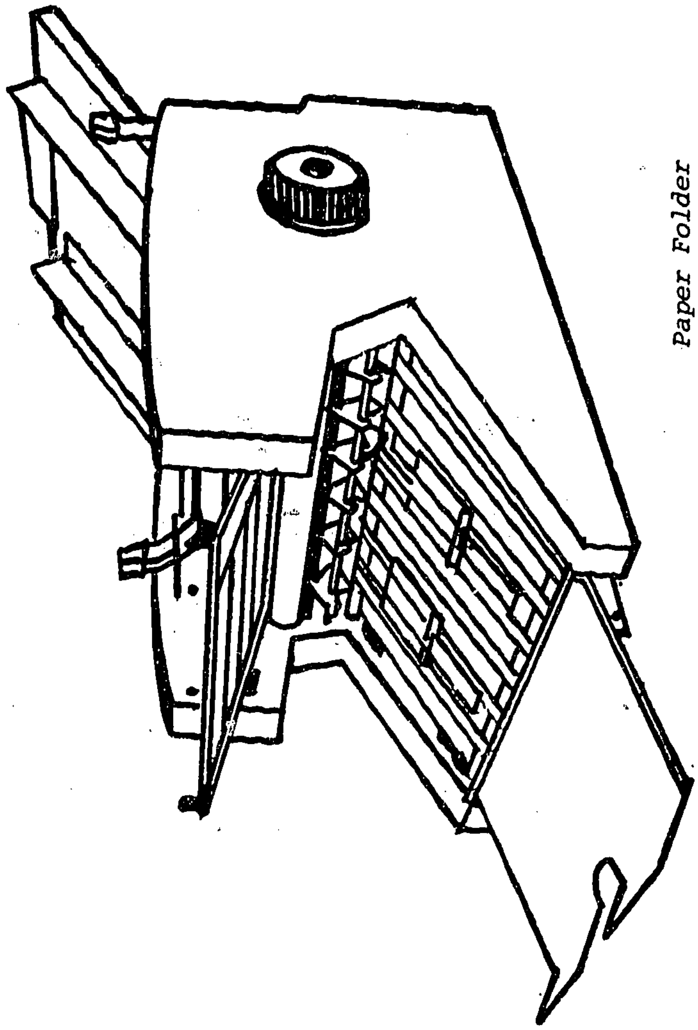
Another way to do an eight page folder is to take a very long piece of paper and fold the left side over the right side, and then fold the left side over the right side again.

One more way to do an eight page folder is accordian style.

You can do many more kinds of folds by using these combinations.



THE PAPER FOLDER



Paper Folder

You have seen some ways paper can be folded. Sometimes there are many pieces of paper to be folded. The paper folder can do the folding job quickly.

1. Check the size of the paper and figure out how you want to fold it.

2. Look at the fold chart that goes with the machine. Make the settings that the chart tells you for the fold you want.

3. There are some knobs on the <u>paper stop</u> on the <u>fold plate</u>. Loosen the knobs and put them in the right place (check the chart). Then make sure the knobs are tight.

4. Put the guide rails in the right place for the paper you are using.

5. Put the paper on the <u>feed table</u>.

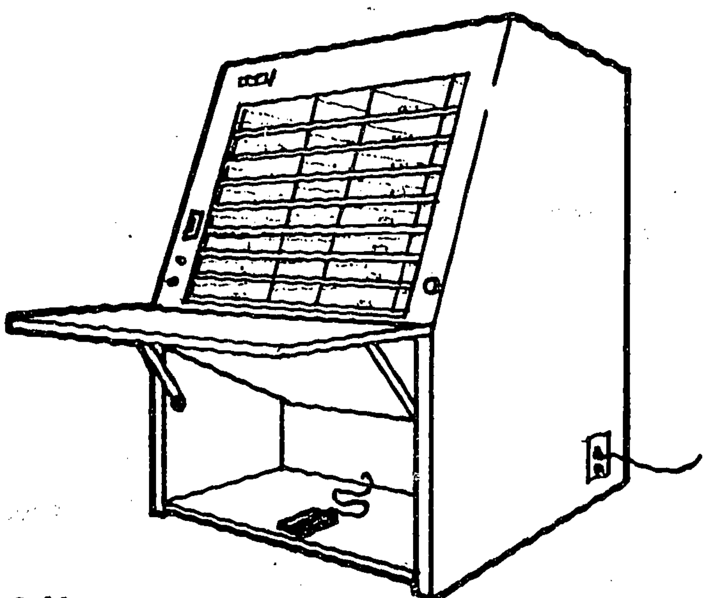
6. Plug in the machine. Turn ON the machine.

7. Try one sheet of paper in the machine. Check the paper, and fix the <u>separator roll</u> if you need to.

8. Run the rest of the paper in the machine. You can slow down the machine or speed it up while you are running the paper.

9. Pick up the paper. Turn OFF the machine.

To collate means to sort out and put in order. For example, you have one stack of pages marked #1, and one stack of pages marked #2 and still another stack of pages marked #3. You take one sheet from the #1 stack, one sheet from the #2 stack, and one sheet from the #3 stack, and put them together. This is collating.



Collator

If you only have a few pages to collate, you can do it by hand. If you have a lot of pages to collate, you might use a machine called a collator to do it more quickly.

To use a collater:

1. Pull out the knob that raises the fingers in the bins in the machine. Make sure the rubber rollers on the fingers are facing down.

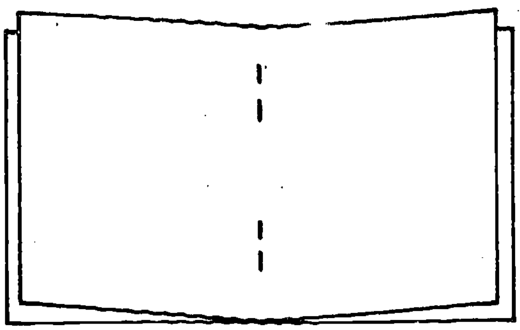
2. Set the length of each bin to the size you need for the paper you will collate. You do this with the knob in each bin.

3. Put the stack that you want to be the first page in the top bin on the left side. Put the stack you want to be the next page in the next bin on the left side, and so on.

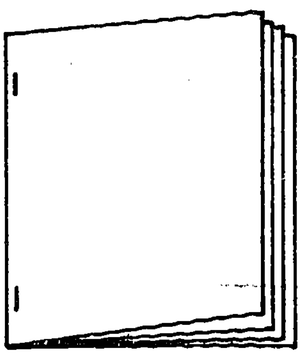
4. Lower the fingers in the bins by pushing in the finger control knob. Set the counter on zero. Turn ON the machine. Lift up the tray in front of the machine.

5. Press down on the foot control lever and then let up on it. It will not work right if you keep your foot on it without letting up.

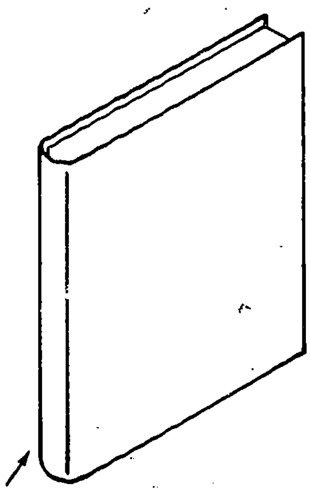
6. Take the sets of paper from the bin on the side of the machine. Check the order of the pages.



Saddle stitch



Side stitch



Spine or Backbone

There are many different ways of holding pages together after you have printed them, and collated them. Most pamphlets and magazines are stitched together with staples. There are two ways to do this. One way is called saddle stitch, and the other way is called side stitch. Which kind you will use depends on how thick the magazine or pamphlet is. A pretty thin magazine (like TV Guide) is saddle stitched. This means that the staples are put on the fold of the booklet. Magazines like National Geographic are side stitched. This means that the staples are put next to the edge of the spine of the book. Books that are side stitched cannot be opened completely flat.

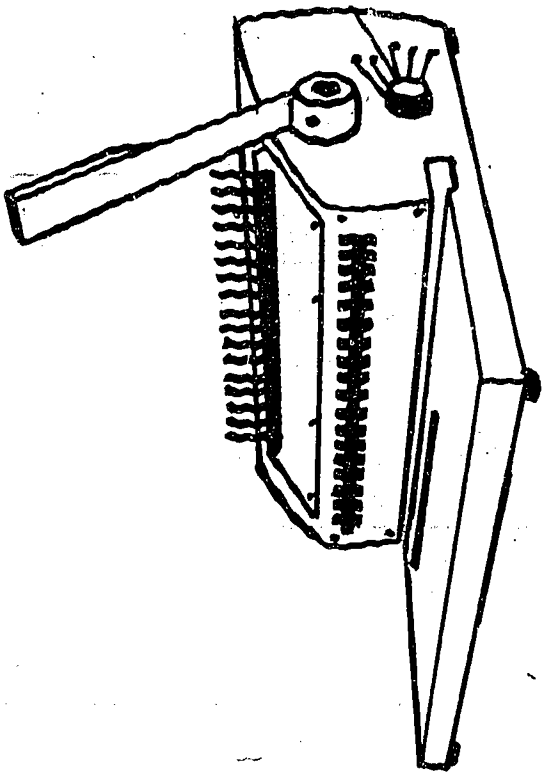
Larger books are held together by different kinds of binding. The ones you see most are edition binding, perfect binding, and mechanical binding.

Edition binding is very strong. The edges of one side of the pages are sewn together (with strong thread) by a special sewing machine. Then the sewn edges are coated with glue. Then a machine rolls the spine, so that it is a little rounded instead of flat. Next, a piece of gauze is glued to the spine (or backbone). Then, still another machine puts paste on the sewn pages and attaches them to the covers. Finally, the books are dried.

BINDING

Perfect binding is used on some paperback books and on the telephone directory. It is not as strong as edition binding, but it can last for quite a while. First a special strong adhesive (a kind of glue) is put on the edges of one side of the paper. Then a special lining is put over the spine, and then the cover is glued on.

Mechanical binding is used for notebooks and other kinds of books that you will use open flat. Spiral notebooks are held together with a kind of mechanical binding. This manual is held together with plastic that was put on by mechanical binding.



Plastic Binder

Many booklets are held together with plastic binding. The book you are holding is held together with plastic binding. It does not have enough pages so that they need to be sewn together, the way a library book is. It would not stay together as long if it were glued together the way some paperback books are. The plastic binder puts together stacks of pages and covers with plastic binding.

To use:

1. Take some scrap paper that is the same size and weight as the paper stock you are using. Line it up under the punch holes on the front of the machine.

2. Use the guide thumb screw on the side to find the right place for the holes you will need.

3. Pull out the metal arms so that you will not have any wrong holes in the paper.

4. Set the guide in the back to the size you will need for the plastic binding you are using.

5. Punch holes in the scrap paper, and check them. You might need to change the settings a little if the holes are not in the right place, or if they are not the right size.

6. Punch the sheets of paper you are binding.

7. Put the binding element on the binding head.

8. Push back the lever. Put the sheets of paper into the open rings. Line up the holes in the paper with the rings. Pull the lever in. This will bind the paper with the plastic.

1. Student will be able to name four kinds of printing processes.

2. Student will be able to demonstrate ability to operate the

Jogger
Electric Stapler
Paper Drill
Spirit Duplicator

3. Student will be able to define collating, and demonstrate the use of the collater.

4. Student will be able to demonstrate various types of folds and the use of the folder.

5. Student will define three binding methods and demonstrate use of the plastic binder.

Students in the Vocational Strategies project were mainstreamed into the welding shop at Boston Trade High School, as well as into the sheet metal shop (taught as two separate shops at Boston Trade High School). After consultation with members of the personnel staff, as well as with instructors in the welding school in the General Dynamics shipyard in Quincy, the Vocational Strategies project staff is now "rethinking" its placement of mildly handicapped students in welding. We suggest that probably another year of integration of these students is needed in order to fully determine the appropriateness of the welding placement.

The curriculum at the Trade School in welding emphasizes oxyacetylene welding techniques, as well as arc welding techniques. Whereas the arc welding skills would be particularly suited to work in a large shipyard, such as General Dynamics, our discussions with General Dynamics made it apparent that many of their welding jobs require decision making skills which our special needs students would not, in all probability, be capable of acquiring.

Although our students have been successfully mainstreamed into the Trade School welding program under the watchful supervision of James Farrenkopf, it is our feeling after discussions with Mr. Farrenkopf and others, that resistance or "spot" welding might be the most useful area in welding for our students' concentration, in addition to "tacking" and "brazing". Resistance welding is described as "strictly mechanical" because it only entails making adjustments on machines. We maintain, however, that knowing "what a good weld looks like" and "how to test a weld" will hold a student in good stead in a job of resistance or spot welding.

Thus, for this purpose, we advocate simple arc welding techniques in the expectation that the special needs student will put the repetitive early steps in "striking an arc" and in "running beads" into practice in resistance welding where machine (rather than human) adjustments are used extensively.

We acknowledge the assistance that Mr. Farrenkopf provided us in the early stages of our curriculum investigation. We give special thanks to Joseph King, a retired welding instructor from the Boston Navy Yard, who presently serves as a volunteer in welding with the School Volunteers for Boston. Mr. King's patience allowed us to examine the most basic elements of the welding processes.

Welding is one of the most common ways to permanently join metal parts. Parts of many products in the house, such as kitchen appliances, have been joined by welding. In larger equipment, such as cars and airplanes, welding is used to join parts, too. In bridges and buildings, welding is used to join together the structural metal, the beams, and the steel reinforcing rods. Welding happens when two materials, usually metals, are melted together. The most basic types of welding are resistance welding and arc welding.

Resistance Welding

Resistance welding is also called spot welding. In this kind of welding, much of the welding is done by using a machine that makes the adjustments for you.

Arc Welding

According to the *Occupational Outlook Handbook*, 1976/77 edition, arc welding is the type of welding that is used more than any other type. In arc welding, heat comes about when electricity flows across an airspace from the tip of the welding tool to the metal.

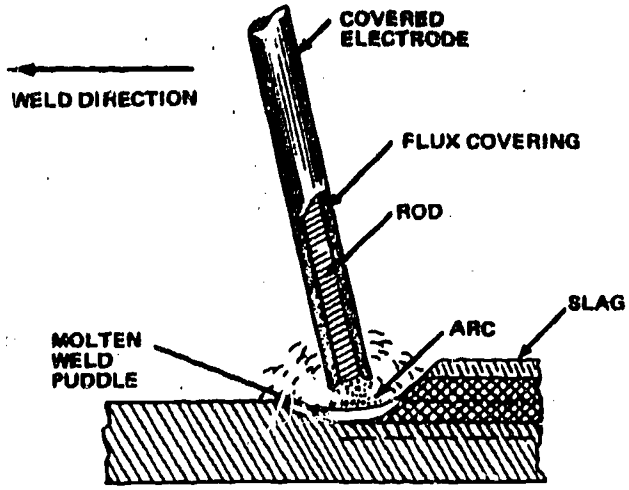
Ship welders who join the steel plates and beams that are used to build ships usually use arc welding because it welds the steel plates better than using gas. In ship welding, some joints that have to be welded are on the floor of the ship, some are on the wall, and some are overhead on the ceiling. All of these different positions require perfect welding jobs so that a ship will not break apart in rough seas. Because of this, a person doing ship welding must practice welding in different positions where sometimes the job is above your head, or down near your feet, or in a tiny corner. Building construction jobs, where there are steel frames, use arc welding to weld and bolt together the frames.

There are a few important things you will need to know about arc welding. These are:

Striking an arc

Choosing an electrode

Running a bead



Striking an arc is used to start the arc weld. These are the steps.

1. Clean the surface you are using. There must not be any "spatter" on the tabletop.

2. You should be wearing clothing that will protect you. Do not wear sneakers; shoes with leather tops are better. It is best to wear a long sleeved shirt or blouse. You should also wear a leather jacket or bib.

3. Clamp or fasten the work lead to the table.

4. Put the "fine controls" on the right setting.

5. Make sure the electrode holder does not touch the table.

6. Turn on the machine.

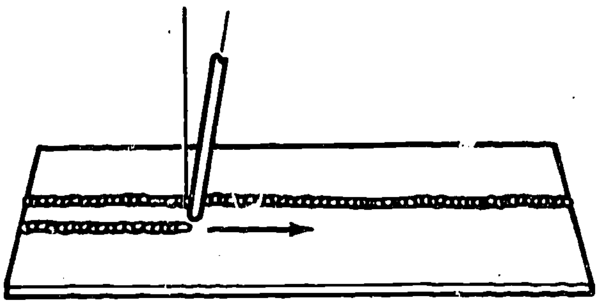
7. Now you can strike an arc in one of two ways.

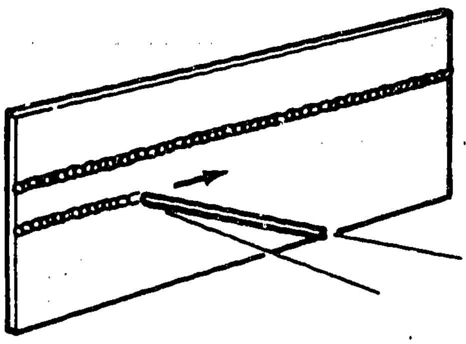
a. By scratching: this can mark the table or surface you are working on.

b. By tapping: this is probably a better way to do it.

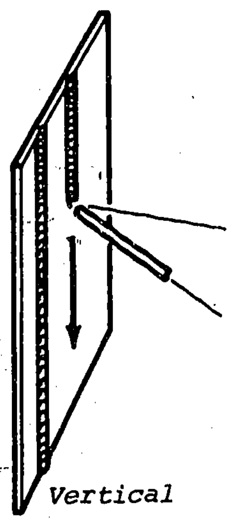
Vocabulary

Resistance welding
Arc welding
Adjustments
Electrode
Striking an arc
Running a bead
Fine controls

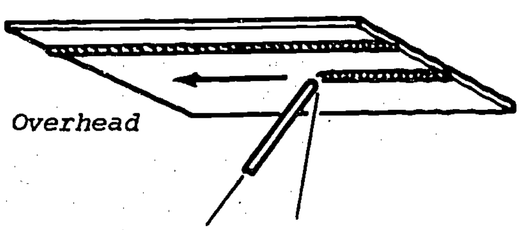




Horizontal



Vertical



Overhead

Filler metals are also used so that joints will be strong and uniform. Most welding processes (gas as well as electric) use filler materials. These are often called electrodes or welding rods. They are usually melted in with the metal to make the joint stronger. When the welder takes the heat away, the metal and filler materials harden and the parts are joined. In welding, the welder heats the metal and filler material so that they melt together correctly and, once they are hardened, they form the strong joint that is needed. Electrodes have numbers stamped right on them. The last two numbers tell you how to use the electrode. The next to the last number tells you the position of welding.

There are four basic welding positions. These are:

Flat
Horizontal
Vertical
Overhead

You use different positions for different jobs. Some jobs might be on the floor or floor surface, and some jobs might need the weld that you do right in the corner, at the height of your shoulder. Still other welding jobs call for the work to be done over your head (overhead) or up near what would be the ceiling or top of whatever you are working on.

You might get a rod with this stamped on it: Exxlx.

You need to look at the last two numbers (or digits). This will tell you how you can use the rod, and in what position you will be working. This is called usability. When you look at the last two digits, you should look at them as two separate numbers. This will explain why.

The next to the last digit tells you what position you will use when you use this particular electrode (or rod). Let's say you have this information:

Exxlx
Exx2x

Look at the next to last digit in Exxlx. This is a 1. This tells you that this rod can be used in "all positions." Now look at the code Exx2x. You have 2 as the next to the last digit. This tells you that you can use the rod in the flat and horizontal position. This will be true for all electrodes or rods marked this way.

The⸱ : is other information for you tr .se when you look at the numbered code on the rod. Look at these codes:

Exx10
Exx11
Exx22

When you look at the last number (or digit) you will know the type of welding that the electrode is used for.

Look at Exx10. Look at the last digit. It is 0. This tells you "dc, reverse polarity only."

Look at Exx11. The last digit is 1. It tells you "ac or dc, reverse polarity."

Look at Exx12. You will see that the last number is 2. This tells you "dc, straight polarity."

Vocabulary

dc (direct current)

ac (alternating current)

straight polarity

reverse polarity

electrode

rod

flat

horizontal

vertical

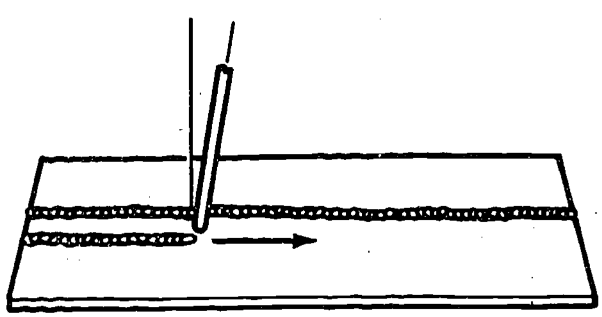
overhead

usability

digit

First, review how to strike an arc. This is like lighting a match: you can either scratch it or you can tap it. Then, move away the diameter of the electrode; now an arc will be formed. If you are using a 1/8 electrode, you come back about 1/8 of an inch; if you use a 3/16, you come back 3/16 of an inch. After this the next step is to "run a bead". At first you will have a tendency to "stick" at this point; you will touch the plate with the electrode and will "stick" there. Practice will help you not to do this.

Running a bead is like the kind of thing you might see happening at a large foundry. You may have seen pictures of furnaces at a foundry. What happens is that metals (usually scrap metals) are heated in large furnaces until they are molten (melted). Running a bead is melting metal in an arc form. The flux that is on the wire forms a barrier to keep oxygen from getting through the melting area.



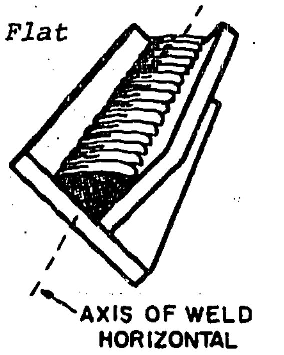
This is the reason you see the molten metal being formed into a pool when you look into the "arc". Then you see the flux which is left in the form of slag. Slag is there to protect the pool of metal from impurities in the air.

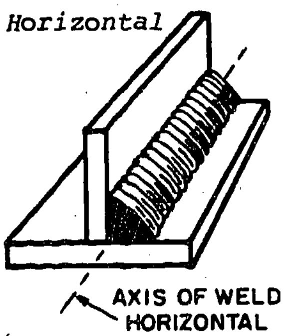
You should clad a series of beads on a plate. Start with a 5 by 10 plate, 3/8 inches thick. Start at the upper side of the plate, and run beads across the plate. Run a straight bead. Do it over and over again. As you run the beads, you will begin to see that the quality of the beads will be getting better. Running a bead will be important work if you are going to do tack welding, or spot welding, or arc welding.

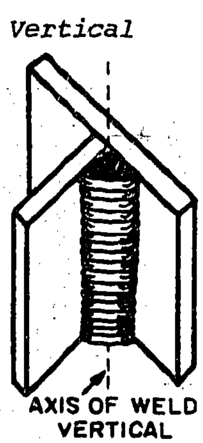
It is important to run multiple beads. It is important to "get as much mileage" out of every piece of scrap material as you can. After you have run a half dozen beads, you are ready to go on to the fillets.

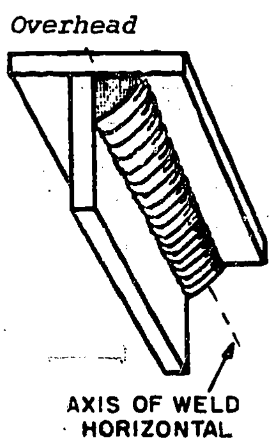
Vocabulary

Diameter
Electrode
Foundry
Molten
Flux
Slag
Impurities
Clad
Multiple beads
Scrap materials









This is how you make a fillet weld.

1. Strike an arc.

2. Run beads. Practice on a flat plate. Have your teacher line the plate with chalk so that you can follow the lines.

3. Keep close to the lines. Make lines with beads. The lines of the beads are formed by the junction of the metal.

After you can make the flat fillet weld, you can go on to the vertical fillet. Run a half dozen beads in the vertical fillet position. Then try the overhead position.

There are different types of joints that you will be using when you weld. Here are the different types:

Butt

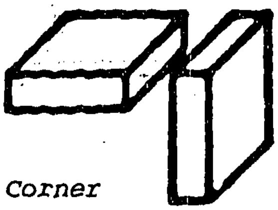
Corner

Edge

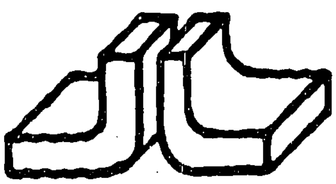
Lap

Tee

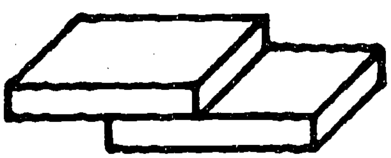
Butt



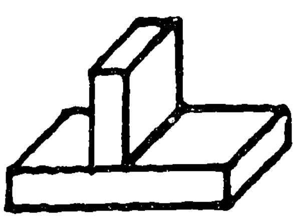
Corner



Edge



Lap



Tee

1. Student will explain in what way s/he is wearing proper clothing for welding and show how to safely hold necessary welding equipment.

2. Student will list the steps for the two ways of "striking an arc" and will proceed to strike an arc correctly.

3. Student will practice "running beads" in flat position.

4. Student will demonstrate how to clad a series of beads in three positions.

5. Student will make fillet welds in two positions.