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SIMPLE ELECTRICAL EXPERIMENTS

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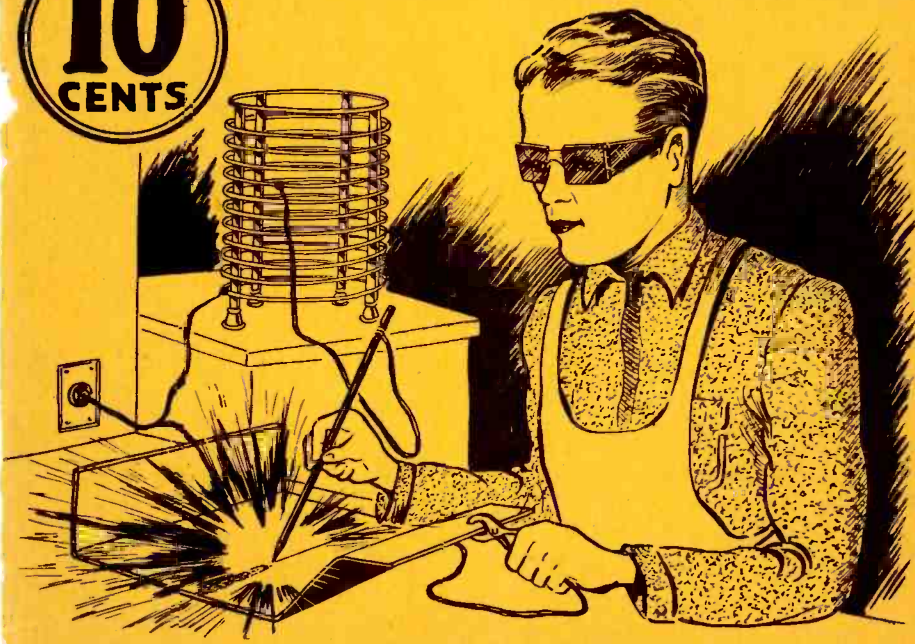

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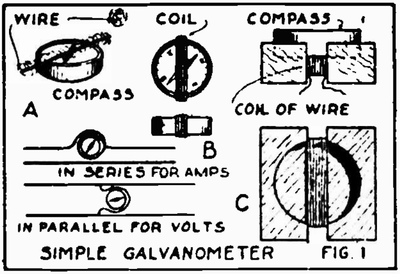
(Watch the List Grow)

Simple ELECTRICAL Experiments

A SIMPLE galvanometer, made by winding a few turns of insulated magnet wire around a ten-cent compass, has served to initiate many a person into the mystic realm of electricity. As the illustration (Fig. 1) shows, even holding a wire carrying a current over a magnetic compass will cause the needle to deflect to the right or left, depending on the direction of the current through the wire. Hold the wire under the compass also and you will note that the needle moves in the opposite direction, showing that there is a *whirl* of magnetic force surrounding the wire.

To intensify this effect, we proceed to wind a coil of many turns of insulated wire around the compass. If you have no compass, a magnetized sewing needle or piece of clock spring will serve our purpose nicely. Make a dent in the exact center of the steel strip, so that it can swing freely on the point of a needle or other pivot; the strip of steel can be magnetized by stroking with a magnet.



How to make a simple galvanometer

The more turns of fine wire you wind on the coil, the more sensitive the galvanometer and the weaker the current may be to which the instrument will respond. Also, the stronger the current passing through the coil, the greater the deflection of the needle; thus the galvanometer can be used as a gauge of the current strength (if wound with heavy wire) and as an indicator of the voltage strength if the coil is wound with fine wire. To

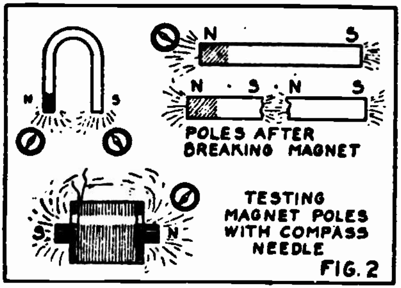


FIG. 2

North and South magnetic poles attract opposite ends of a compass needle

measure current the instrument is connected in series with the load, and for voltage indications the device is connected in parallel with the circuit — see diagram.

Fig. C shows a neat way in which to wind the coil of the galvanometer in a slot in a wooden block. The compass fits in the circular depression cut out of the block, as becomes apparent.

Testing Magnet Poles with a Compass

The compass is the electrician's best friend — see how it is used to tell north and south poles of a magnet in Fig. 2. The north pole attracts one pole (the north-seeking pole of the compass), while the south pole of the magnet attracts the opposite or south-seeking pole of the compass. The same results can be obtained by suspending a magnetized needle on a piece of thread. Fig. 2 shows how a broken magnet always manifests two poles, a north and a south, no matter how many times it is broken. A simple test with a compass will prove this. Also, explore the direction of the magnetic field about a magnet by moving the compass about the magnet. If you take an electric bell or other electro-magnet and connect it to a battery, the resulting magnetic field will be made manifest by exploring the vicinity of the magnet coil with a compass. A small compass is most useful for testing the poles of a magnet: the poles of a motor field are often tested in this way — the poles of a two-pole field should be north and south respectively. Electro-magnets always show a north pole at one end of the coil and a south pole at the other, the same as a permanent steel magnet. If alternating current is applied to a magnet coil, the magnetic polarity changes sixty times per second and thus cannot be indicated by a compass needle.

Making an Experimental Magnet

A simple electro-magnet for experiments can be made from a pair of electric bell or telegraph sounder magnets, as shown in Fig. 3. If such magnets are not handy, a powerful magnet

Be sure to connect magnet coils properly so as to produce North and South poles

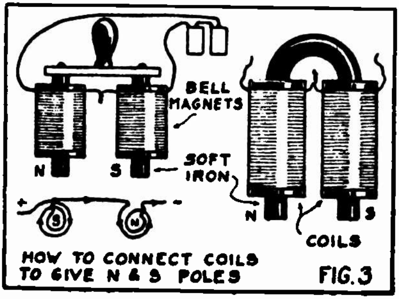
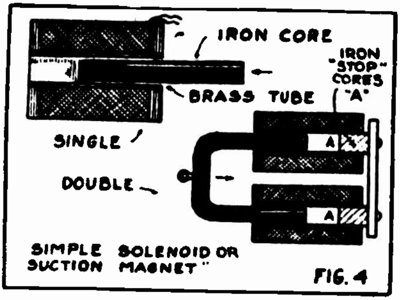


FIG. 3

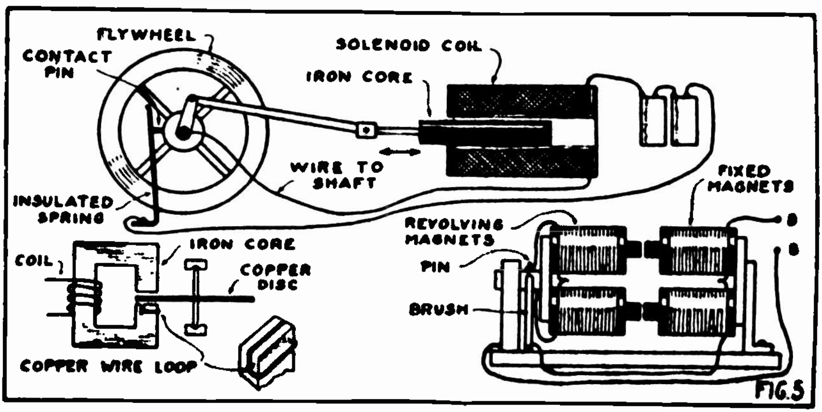
can be made by winding a dozen layers of whatever magnet wire you have, around a piece of soft iron bar. A piece of one-half inch iron bar (not steel but wrought iron) bent U-shaped as in the sketch, will serve as the core of a strong magnet. Each coil may comprise a dozen layers of No. 18 cotton covered or enameled copper wire, if the magnet is to be used on 4 to 6 volts: use 15 layers of about No. 22 magnet wire for battery voltages of 10 to 15 volts. Be sure to connect the two coils so that the current goes around the second coil in the opposite direction, so as to give north and south poles respectively: see diagram. If the current goes around the coil or core in a clockwise direction, a south pole results, and vice versa. In winding electro-magnets it is best to wind a piece of paper around the iron core before starting the winding.



Solenoids suck the iron core into the coil

Simple Motor

Fig. 4 shows how solenoids or suction type magnets are made: the core slides in a brass or copper tube on which the coil is wound. Simple electric motors can be made from a solenoid magnet connected to a flywheel and crank as Fig. 5 illustrates. Two pairs of magnets may be ar-



Two types of "magnetic engines"

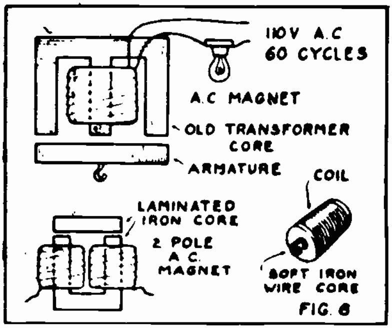


FIG. 6

In making A.C. magnets, the iron cores must be laminated

ranged as shown so that the current to the moving magnets is cut off just as the poles approach each other. The contact is interrupted by a pin on the shaft which bears against a spring. An old radio transformer (audio type) can be made into a motor by cutting a slot in the iron core and arranging a copper disc to rotate in the slot; the disc will have to be spun by hand to get it rotating unless a starting coil (one turn of heavy copper wire) is placed in a slot on one of the pole-pieces as shown. This simple loop of wire also gives the motor much greater strength.

To experiment with magnets on A. C. (alternating current) the iron cores should be laminated (built up of iron sheets or else iron wire). See Fig. 6. Old audio or other transformers serve admirably to experiment with; it is best to always connect a 110 volt lamp in series with all such experimental apparatus, in order to prevent blowing fuses. You can tell if A. C. is passing through a magnet by simply holding a screw-driver against the core: if it vibrates the current is *alternating* — if the pull is steady and non-vibrating the current is *direct*.

A. C. magnets can be made to vibrate a diaphragm or a steel reed (see Fig. 7); hold a tin pan against the iron core of such a magnet and it will vibrate at a great rate. A tin diaphragm held in a suitable clamping ring, in front of a magnet excited by A. C., may thus serve as a source of alarm instead of a buzzer or bell.

Electric Bells and Buzzers

Electric bells and buzzers operate on the principle that the current through a magnet is interrupted rapidly by means of a contact spring as seen in Fig. 8. Each time the iron armature is attracted toward the magnets, the circuit is broken; and this action is repeated over and over many times per minute, the frequency of the stroke being adjusted by turning the contact screw in or out. The circuit of a single-stroke bell is shown, the current not passing through the interrupter spring in this case.

Electric Shocker

An electric shocker is easily made from an electric bell or buzzer; see Fig 9. The metal handles are connected across the vibrator contacts. The larger the magnet coils the stronger the shock; the shock can be intensified by con-

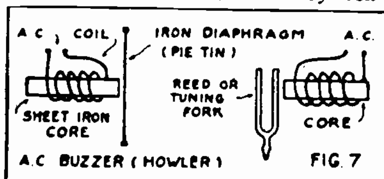
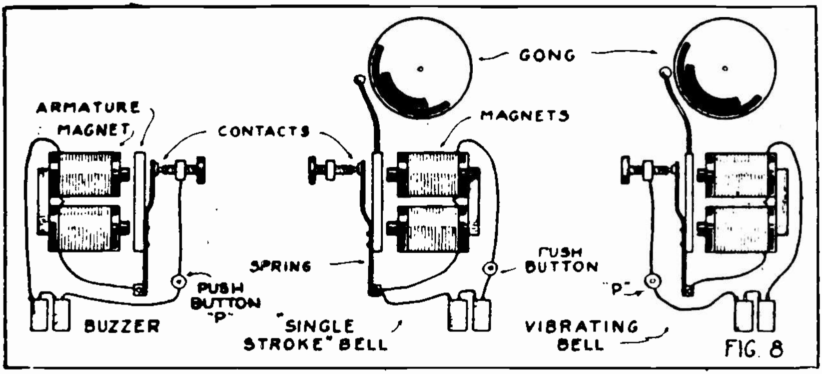


FIG. 7

Experiments with A.C. magnets



A buzzer — a single-stroke bell and a vibrating bell

necting an electro-magnet in series with the handles. To regulate the degree of the shock, a potentiometer of .1 to .5 megohm may be connected across the handle circuit. To produce a still stronger shock, coils of fine wire may be wound over the bell magnet coils, the handles being connected to the fine wire coils (the secondary *overwound* coils are joined in series in the usual manner, north-south fashion). All sorts of tricks can be played with a shocking apparatus like this: it may be carried in the pocket and operated from flashlight batteries, the shocking terminals taking the form of two pieces of metal mounted on a piece of fibre or bakelite carried in the hand. Boy — what a hot handshake your friends will get!

Tricks with Telephone Receivers

Telephone receivers can be used for some of the most interesting experiments imaginable. Two ordinary 75-ohm receivers can be hooked up to provide a complete telephone circuit, as Fig. 10 shows. With a dry cell or two properly connected in the circuit, the talking efficiency is enhanced: try reversing the terminals of the battery and the phones until the best results are obtained. For one-way speech, a crystal type or Baldwin type phone makes an excellent microphone (no battery required). At "C", the use of a telephone receiver as an A. C. buzzer is illustrated: use a lamp or other resistance in series to protect the phone. A horn fitted in front of the phone gives a much stronger sound. A feed-back howler is made by placing a telephone receiver in front of a microphone. A telephone receiver is unbelievably sensitive to weak currents; it will click if the current from a small battery is interrupted through the body. (Fig. E.) In fact, it has been said that a current of one ten-millionth of an ampere will cause a response in a telephone receiver. A Baldwin type radio head-phone has been used to make an excellent magnetic pickup for playing phonograph records (see Fig. 10).

Electric Lamp Experiments

Ordinary electric lamp bulbs can be used for many novel experiments. You can determine whether a current is *alternating* or *direct* simply by moving a magnet near the bulb. If the hot filament pulls out in one direction only, the current is *direct;* but, if the filament vibrates, it is *alternating*. An old-style carbon filament lamp is best for this experiment. If a light stick is vibrated back and forth in the fingers before a lighted bulb, the stick will appear to be stationary at times, as the vibration speed coincides with the frequency of the alternating current; if it is direct current, no such effect will be noticeable. The same optical effect is sometimes observed when an electric fan is operating in the light from an A.C. excited lamp (Fig. 11).

Neon Lamp Experiments

Neon lamps can be used for a simple stroboscope experiment, see Fig. 12. Here we use an induction coil to excite the neon lamp. By adjusting the vibrator on the ignition coil, it becomes possible to get the effect of making the fan blades stand still. Neon lamps are useful as fuse testers etc.; and they are handy for testing the ignition systems of auto engines, the bulb lighting on only one wire and showing high-voltage leaks, etc.

Many beautiful patterns can be produced by placing a neon bulb behind a television scanning disc (see Fig. 13), such as used a few years ago for television; the disc may be made of cardboard or fiber with a spiral of tiny holes around it. When this disc is fastened on to a fan motor shaft and whirled before a neon lamp connected to the loudspeaker terminals of a radio receiving set, very wonderful designs

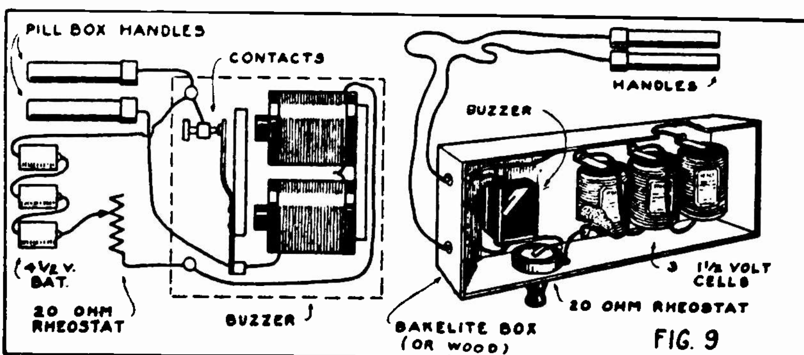
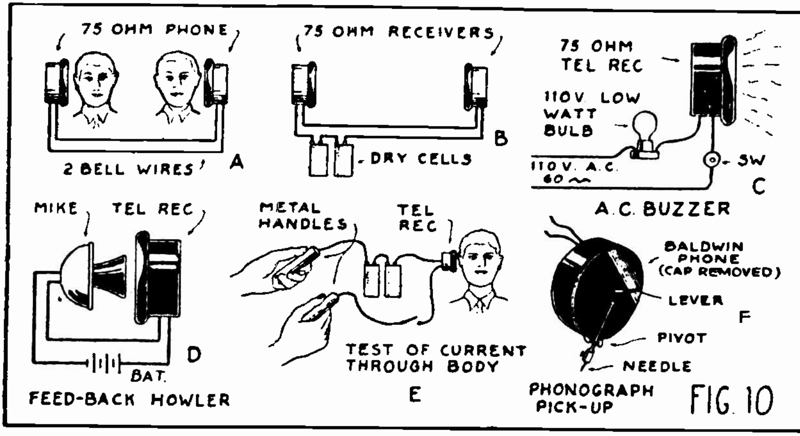


FIG. 9

Electric shocker made from a buzzer

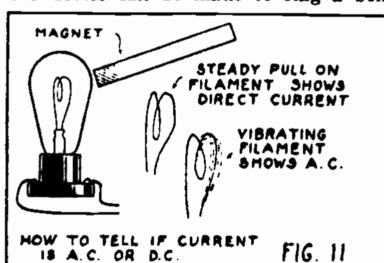


Experiments with a telephone receiver

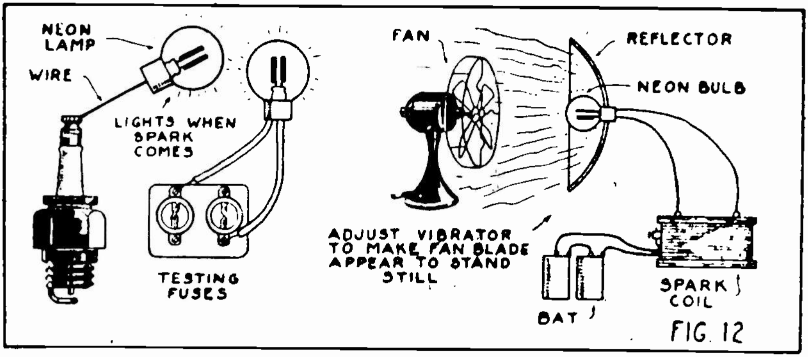
are visible as the voice and music modulate the current. Changing the speed of the motor also provides a change in the designs.

If you own a so-called *violet-ray* high-frequency apparatus, you will find that ordinary lamps as well as neon lamps may be lighted on only one wire! If you hold an ordinary lamp bulb in the hand and approach it to the high-frequency terminal of the Oudin coil, the lamp will glow with a purplish effluence (fine spark discharge) very pretty and very weird! (See Fig. 14). To make a striking effect, tie several lamp bulbs on a stick and connect the base of one with a tinfoil cap fitted over the glass end of the next bulb, etc. In this way you have a high frequency "wand" at slight expense. To obtain an unusual effect, fasten two or more neon (or plain lamp bulbs) on a piece of fiber or wood, so as to be revolved by a motor, and provide a brush or contact spring to carry the high-frequency current to the revolving bulbs.

Fig. 15 shows a simple and most useful thermostat: it is made from a piece of thermostatic metal and bends with changes in temperature. With contacts above and below it as shown, the device can be made to ring a bell



To tell if current is A.C. or D.C.

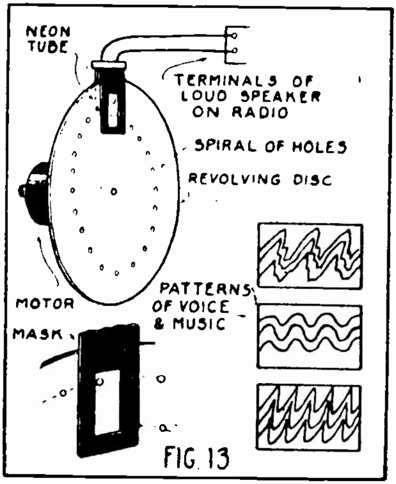


Neon lamp experiments — see page 6

for low temperatures and a buzzer or a lamp for high temperatures, or vice versa. The moving strip can be made from pieces of copper and steel riveted together. The use of a thermostat for controlling a furnace blower motor is shown. This device might be used to start an electric fan in the summer time and for a hundred and one other purposes.

Induction Experiments

Induction experiments are perhaps the most mysterious and entrancing to the layman. Your friends will be greatly mystified at some of the effects obtained by this apparatus. All you need is a pair of coils, old transformer windings or a pair of old motor field coils will do. Connect a 110-volt lamp, any size, in series with the coil used as the primary, to be on the safe side. A low-voltage lamp may be connected to the secondary coil and, as this coil is moved away from the primary coil, the lamp gets dimmer (See Fig. 16). If you own or can borrow an A. C. voltmeter, you can then demonstrate the marked change in voltage of the induced current in the secondary, as the coils are separated more and more. Next, try placing an iron wire or lam-



Voice patterns from a neon tube

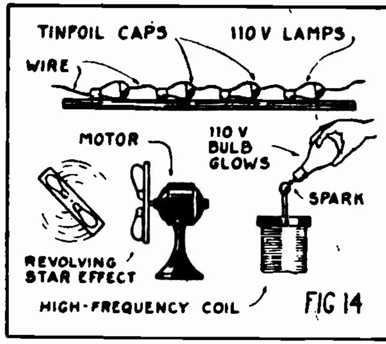
inated sheet iron core into the coils, and note the tremendous increase in strength of the induced current in the secondary.

The first experiments with induction were made without iron cores but engineers soon learned to improve the efficiency by using iron. It must be finely divided or else it will heat when alternating current is applied to the coils. Another experiment — try linking the iron-core circuit together so as to provide a continuous iron path for the magnetic flux and note what a difference this makes. That is the reason why commercial transformers have their windings well intermeshed with the iron core, in an effort to link the magnetic field as closely as possible with the windings.

A pretty experiment is to plunge a steel magnet into the primary coil, with a galvanometer connected to the secondary. As the field increases the current induced in the second coil flows in one direction, and as the field diminishes (with the withdrawal of the magnet) the induced current flow is in the opposite direction.

The Induction Balance

The Hughes *induction balance* is a sensitive device for demonstrating slight changes in the field of a coil. To make one you need to make four coils, *all exactly alike,* same number of turns and size of wire, etc. These four coils are connected as shown in Fig. 17, with special regard to the polarity. The primary coils can be excited by a buzzer, as indicated. The telephone receiver in the secondary circuit will indicate no sound when the coils are balanced. Each coil may have 100 turns of No. 28 magnet wire, wound on a 3 inch

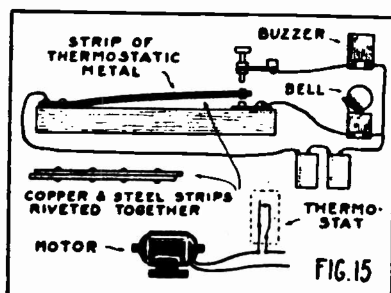


Home-made "glow tubes" for Tesla experiments

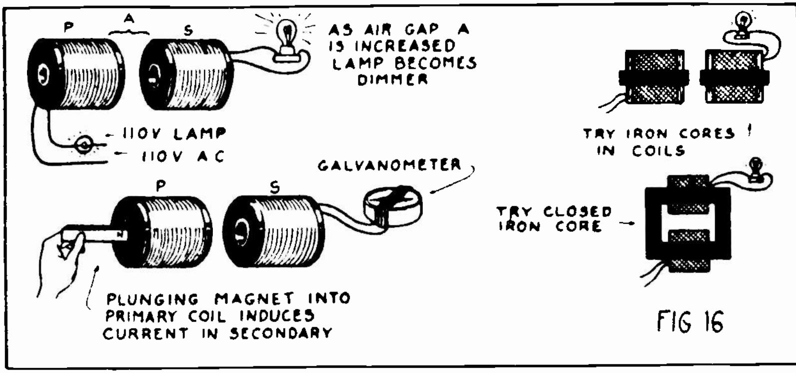
dia. spool, all the coils being wound in even layers and exactly alike. The coils are arranged on wooden sticks, so that coils of a pair can be moved apart till the bridge is balanced.

Fun with Condensers

Condenser experiments are always interesting: Did you ever hold the ball of a Leyden jar (or even a radio filter condenser terminal) near a rapidly moving belt, store up a charge in it



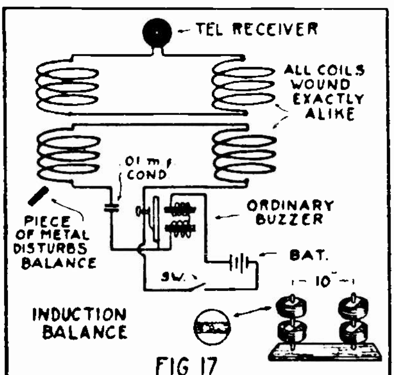
Experimental thermostat



Induction experiments — iron cores intensify the results

and then present it to an unsuspecting friend? Did we say friend!?

Fig. 18 shows how tinfoil and paper condensers can be tested by applying 110 volts A. C. through a lamp. If the condenser is of quite high capacity, the lamp will light bright: lower capacity condensers give a dimmer light. In this way the relative capacity can be judged. These radio type condensers often hold their charge for quite a while and many a shock has been experienced by suddenly shorting one of the filter condensers with the hands. The way to discharge such a condenser is by means of a piece of wire. The Leyden jar condenser is merely a (potash) glass bottle, coated inside and out with tinfoil, with a terminal from the inner foil coating brought out through the top of the jar to a brass ball. Ordinary (lead) glass dissipates the charge, and a glass free from lead or other metal salts must be used, if the jar is to hold its charge.



The induction balance

"Talking" Condensers

Talking condensers are startling indeed! The secret of this stunt lies in the use of loose tinfoil and paper elements. See Fig. 19. The condenser is excited or charged by sending talking currents into it from a telephone or other type induction coil. The fluctuating electric charges on the condenser leaves causes them to vibrate, thus giving rise to sounds corresponding to the voice originally spoken into the microphone. About a dozen waxed paper leaves 5 x 7 inches may be used, the tinfoil leaves being cut a little smaller all around than the paper. Alternate foil leaves are connected to the respective terminals as shown. A small spark coil may be used, if no telephone induction coil is handy. The "mike" is just an ordinary one of the carbon granule type and the battery may be one giving 6 to 12 volts: a small "B" or "C" battery may be used. Remember to leave the condenser leaves loose — a rubber band or two can be used to keep the assembled elements together in loose fashion. In this way the condenser can *talk*.

You may have heard talking transformers in a radio set — this often happens and is usually due to loose iron laminations in the core of the transformers. Talking condensers have also been heard in radio sets, due no doubt to loose paper and foil elements.

Home Made Microphones

Home-made microphones provide lots of experiments. The picture (Fig. 20 A) shows how the simplest *mike* is made from three carbon rods, one resting on the other two. A watch placed near this mike can be heard ticking in a telephone receiver, a dry cell or two being connected in series with the mike and the receiver. In all the experiments here mentioned a 75-ohm telephone type receiver is intended, not a 1000-ohm or higher resistance radio receiver, this type passing too small a current.

A second type *mike*, easily made (Fig. 20-B) employs polished carbon granules retained in a carbon or graphite cup behind a carbon diaphragm; the latter may be of tin or other metal, thin bakelite, etc., and in this case a carbon disc or button is to be cemented or riveted to the center of the diaphragm. As the diaphragm moves back and forth when spoken against, it creates varying pressures on the carbon granules, thus changing the resistance

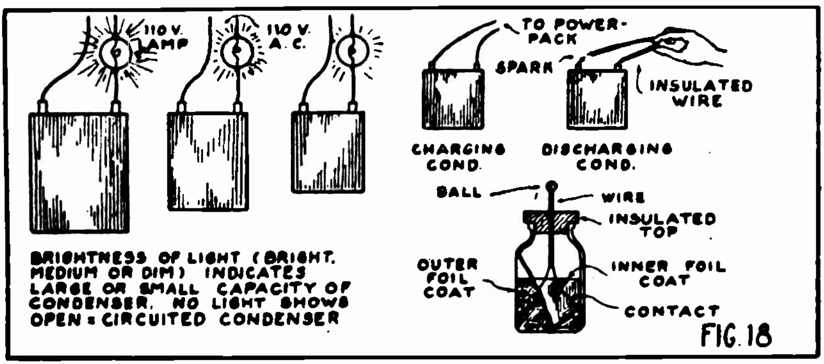
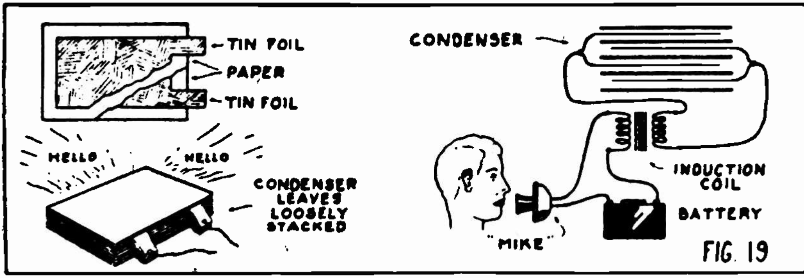


FIG. 18

Condenser tests easily made with 110-volt lamp



The talking condenser — see page 10

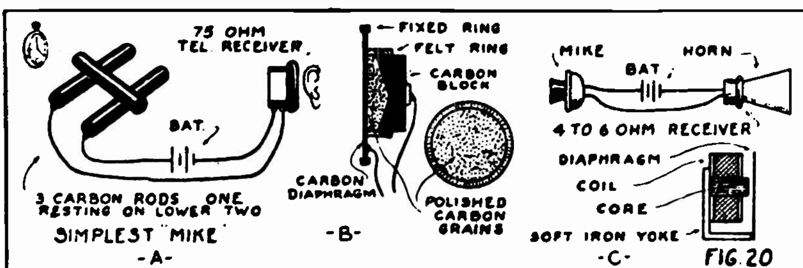
in the mike continually. The current in a receiver circuit connected to a mike will therefore fluctuate in exact conformity to the voice.

Loud-Speaking Telephone

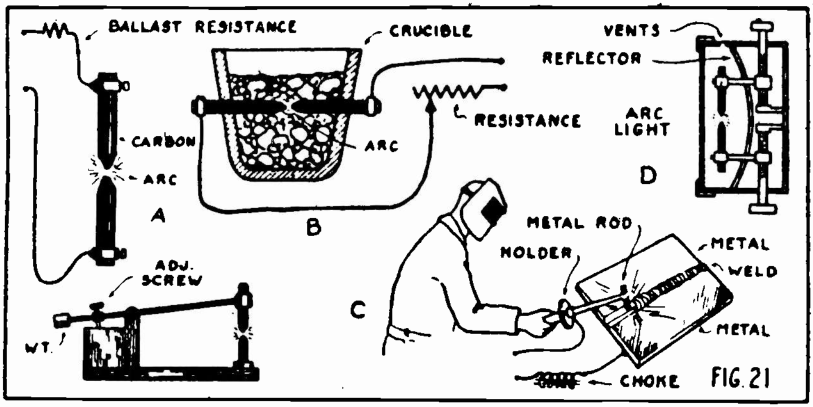
A loud-speaking telephone can be made by winding the magnet coil of the special receiver shown at Fig. 20-C, to have a resistance of about 4 ohms. The coil might be wound with No. 18 magnet wire. The battery current or voltage is varied to suit the length of the circuit and the particular microphone used.

Arc Lamps, Furnaces and Welding Experiments

Arc lamp and welding experiments are easily carried out, the main thing to watch here being your eyes! Don't look directly at the electric arc, unless you first don a pair of dark smoked glasses! Also, remember that an arc has very low resistance when the carbons are in contact; so always connect some form of resistance in series with it. As soon as the arc has been struck, its resistance increases and a fair resistance will ballast the arc. The arc works much better with this ballast resistance, which helps to stabilize it. On A. C. circuits a choke coil is preferable and may consist of a few layers of No. 14 magnet wire wound on a brass spool (slit the spool to prevent its heating), and a movable lam-



Simple home-made telephone apparatus



Electric Arc, Furnace and Welder

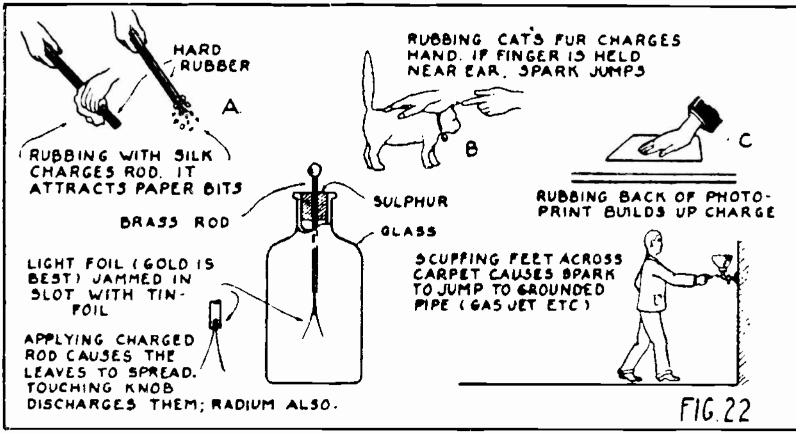
inated iron (or iron wire) core can be slid in and out of the coil for best regulation. In any event the resistance (or choke coil) should be adjusted until the arc strikes and pulls out to about ½-inch length, the current being about 5 to 6 amperes after the arc is struck.

Fig. 21-A shows a simple arc lamp with balanced feed arm. Fig. B illustrates an arc furnace, the two carbons being placed through holes in a crucible. A variable resistance is, of course, connected in series with the furnace. Fig C shows the principle of electric arc welding, the metal wire being slowly drawn along the seam or joint. The surfaces should be well cleaned, and smoked glasses used to protect the eyes. A resistance or a choke coil is connected in series with the welding arc. A searchlight is easily fashioned as in Fig. D, housing the arc in a metal box with suitable ventilating holes to carry off the heat.

Static Electricity

Static electricity is all about us. Ever walk over a piece of carpet, dragging your feet, and find that a spark would jump to a gas jet and light the gas? *Static electricity* is the answer! (Fig. 22.) Rub a hard-rubber comb, rod or fountain pen with a silk handkerchief, and you will find it has become electrified and will attract light pieces of paper or pitch balls. Rub a cat's fur briskly just after the cat has come in out of the cold—then present one finger to his ear. Zowie — a spark jumps and you're both surprised! It always works for the author.

Another source of static charge is that resulting from rubbing the back of a photo print briskly with a handkerchief — a spark can be drawn by presenting a knuckle to the shiny side of the photo. An interesting demon-



Instructive experiments with static electricity

stration of static electricity is to charge an electroscope, made as per sketch (Fig. 22). Thin gold foil leaves are desirable, but thin metallized paper or bronze foil, etc., has been used successfully. The main point about the electroscope is to thoroughly insulate the metal rod supporting the foil leaves, by means of a sulphur bushing. If a charged hard-rubber rod is applied to the ball terminal of the electroscope, the foil leaves diverge and, if the insulation is good will hold the charge for quite some time.

This is the famous method for detecting the presence of radium. Radium has the faculty of causing ionization in the vicinity of the electroscope and, when this occurs, the charge on the leaves leaks off! In this way lost radium has been located several times — once in an ash pile!

Electro-Plating

A simple experiment in plating without the use of batteries or dynamo is illustrated in Fig 23-A. A regular plating bath set-up is shown at B. The object must be very thoroughly cleaned for good results. At C a wax or other impression of a medal, etc., is illustrated; to plate it, a coating of powdered graphite must be given it. One method is to obtain a tube of graphite lubricant from an auto supply store and squeeze some of the lubricant on to the object; then it is brushed over it till an even bright coat results.

In the simple plating cell at A, a dilute solution of sulphuric acid is put in a cell or container made by wrapping a few layers of blotting paper or wrapping paper around a mandrel or stick. This unit is in turn placed in a larger jar filled with a solution of copper sulphate. The object to be plated is suspended in the copper sulphate and the graphite-coated object is connected by a copper wire with a zinc rod placed in the tube filled with the sulphuric acid solution. In the plating cell set up shown at B the anode is a piece of pure copper for copper plating, and the object to be plated is suspended from the negative wire or terminal as indicated. The solution in the cell is copper sulphate for copper plating, nickel salt solution for nickel-plating, and in this case the anode is a piece of pure nickel. Reference to any good book will yield the data for the solutions to be used for gold and silver-plating, etc.

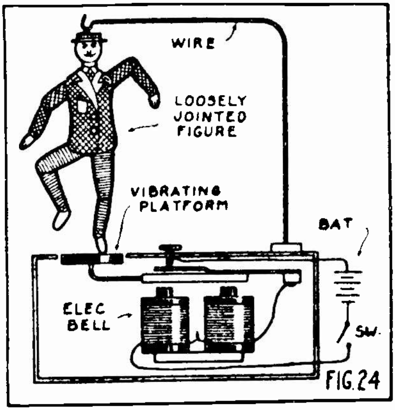


FIG. 24

Dancing Figure

An electric bell can be utilized to make a very entertaining toy or show window attraction, as Fig. 24 shows.

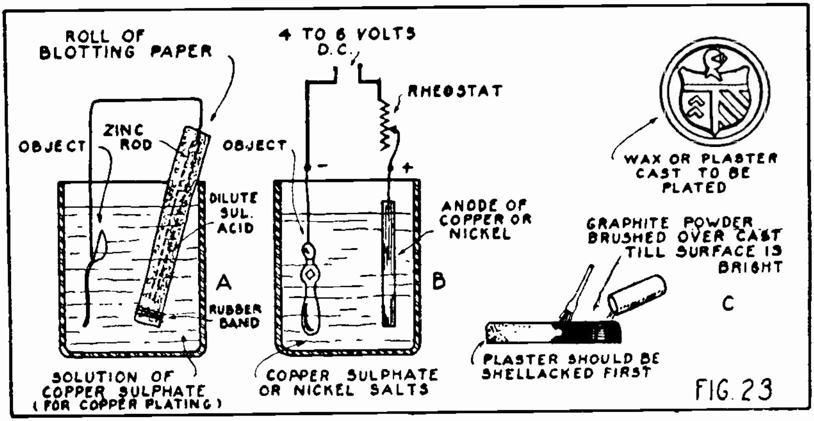
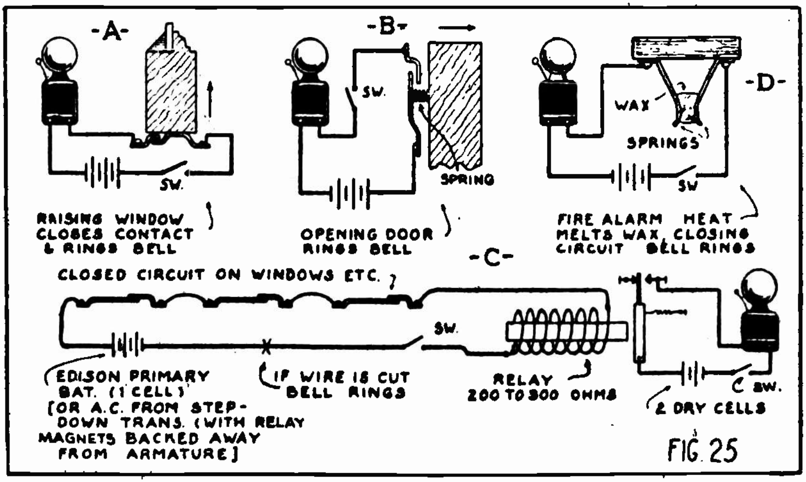


FIG. 23

Electro-plating is inexpensive



Burglar alarm circuits, including a closed circuit; if wire is cut, bell rings

The bell is mounted in a wood or other box with a small piece of wood or fiber fastened on the clapper of the bell, so that it will vibrate directly under the suspended figure. The doll is easily constructed from pieces of cardboard pivoted at all joints so that the limbs hang loosely and ready to move quickly whenever the bell and platform vibrates.

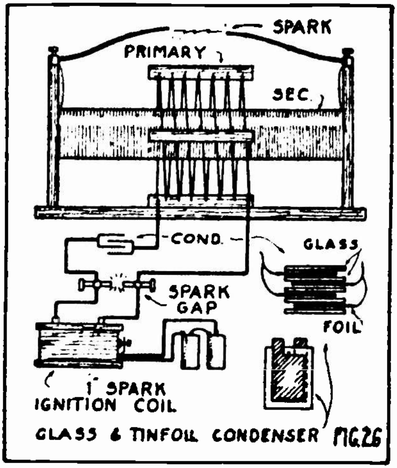
Burglar Alarm

Fig. 25 illustrates a simple thief alarm: at A we see how an open-circuit spring is held open as long as the window is down, keeping the bell from ringing. If the window is raised the bell starts ringing. Fig. B shows how a door alarm is arranged: if the door is opened, the spring contact closes and the bell rings. To fool the wise thief who elects to "cut" the wire, a closed circuit alarm is employed — see Fig. C. A gravity battery or an Edison primary battery may be used and, in some cases, low voltage A. C. from a bell-ringing transformer has been used to keep the relay closed. With A. C. the air gap on the relay between the magnets and the armature should be opened up well to prevent the contact chattering. A couple of dry cells are used in the local bell circuit of the relay: the relay may have 200 to 300 ohms or more. To make a simple *fire alarm*, a piece of wax may be placed between two springs as indicated at D. Fire melts the wax and springs close the circuit.

TESLA COIL WITH FORD SPARK COIL

Fig. 26 shows one of the most exciting experimental apparatus, a *Tesla coil.* It can be operated on a small spark coil, such as a Ford ignition type or one giving a spark ¾ to 1 inch long. The high-frequency coil is readily made from odds and ends found about the home "lab". The primary of the Tesla coil is composed of 8 to 10 turns of No. 10 or 12 copper wire on a diameter of 4 inches, the turns spaced ⅜ inch apart. The secondary coil is wound on a cardboard tube about 2 inches in diameter and 10 inches long, the winding being one layer of No. 28 enameled or cotton covered magnet wire. The high-voltage condenser is composed of half a dozen glass plates 4 by 5 inches with tinfoil leaves between them. The foil leaves are cut half an inch smaller all around to prevent leakage; and alternate foil leaves are connected to common terminals, as the diagram shows. The spark gap, across the secondary of the ignition coil, may be a couple of zinc rods: brass or copper will also do. This gap is set short, about 3/16 inch, and the number of Tesla coil primary turns included in the condenser circuit is varied until best results are obtained. A 2 to 3 inch high-frequency Tesla spark may be obtained, when the best adjustments of the primary turns and number of plates in the H. T. condenser are found, by a little experimenting. The sparks from the Tesla coil secondary can be drawn to the hand without shock, holding a piece of metal in the hand preferably.

Ordinary lamps may be lighted by presenting the brass base of the lamp to one of the terminals of the high frequency coil. Other vacuum tubes, such as those used for medical purposes and the well-known Geissler tubes, may also be illuminated by the high frequency discharge.



This small Tesla coil will amaze you

FENCE SHOCKER

An electric cattle fence shocker can be made as in Fig. 27. A spark coil, such as a Ford ignition type, is useful for the purpose; and the high voltage "hot" wire from the secondary is

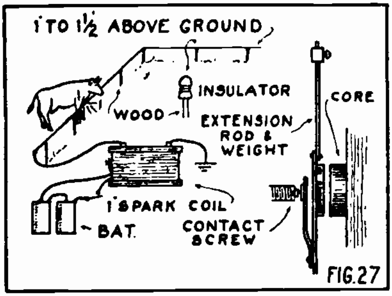


FIG. 27

Electric fence shocker — it saves miles of wire and hours of time

connected to the fence wire, a single copper or other wire suspended about 1 foot above the ground, using glass or porcelain insulators on sticks driven into the ground. To intensify the shock action, and also to lower the frequency, an extension rod is sometimes fastened to the vibrator spring, with a movable weight secured to the upper end of this rod.

Photo-Cell Experiments

Fig. 28 shows a few experiments with photo cells and for these experiments we need a source of light, such as a battery lamp in a box with lens and reflector. The beam of light from the light box is focused on the photo-cell for example: if a hand is interposed in the light beam, the cell's resistance will change and the bell or other indicator device joined to it will sound. As a fire alarm the device responds if smoke passes up through the light beam. Another use for the photo cell is to automatically count people as they pass through the light beam, the cell and its relay connecting to a ratchet fitted with numbered dials.

Induction Radio Telephone

A short-range wireless telephone, one of the first ever demonstrated, is illustrated in Fig. 29. A couple of coils about 2 feet in diameter are suggested; the transmitting coil, comprising about 50 turns of No. 22 insulated wire, and the receiving loop 100 turns of No. 32. The transmitter involves an ordinary microphone, a battery of a few dry cells and a telephone induction coil. The receiving loop connects to the primary of a telephone induction coil and the secondary to a pair of 2000-ohm phones. A little experimenting may be necessary to obtain best results, such as changing

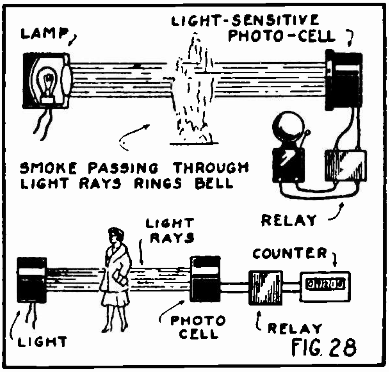


FIG. 28

Photo-cell experiments

the number of turns in the loop and varying the voltage in the microphone circuit.

At the transmitter a single button mike may be connected in series with a battery of 4½ volts or so and the loop antenna. For a simple receiving circuit you may experiment with a pair of 75 ohms head-phones connected directly to the receiving loop. A better impedance match and therefore stronger signals can be obtained by connecting a matching transformer or induction coil through the loop or pair of phones. This transformer is particularly desirable if you should happen to use a pair of 2,000 ohm or higher impedance headphones, which would make a considerable mismatch with the loop impedance.

Where a longer distance than 15 ft. or so is to be negotiated with this induction type radio-phone, the receiver may have its sensitivity increased by using a stage or two of audio amplification. The A.F. transformers used may be of about 3 to 1 ratio and battery type tubes such as the 1.4 or else the 2-volt type can be used, with about 90 volts of "B" battery to supply the plate current. With such an amplifier a sensitive permanent — magnet type — loud speaker may be substituted for the phones if desired.

Another suggestion where greater range is required is to make the loops considerably larger, say about 4 to 5 ft. square instead of 2 ft. Also a vacuum tube amplifier stage or two may be inserted between the microphone and the loop at the transmitter, so as to give a much stronger magnetic field and longer transmission distance between the loops.

Electricity from Fruit

Stick copper and zinc strips into a lemon and an electric current will be indicated on a galvanometer or a milliammeter. See Fig. 30. Try other fruit and also vegetables — a potato for instance. A source of current is thus obtainable for tests in an emergency.

Many other odd sources of current are to be found besides those described. In some cases emergency test current has been obtained by inserting zinc and copper strips into moist earth. Another expedient is to immerse two strips of metal into a cup of vinegar. Another earth battery used by one experimenter consisted of two pieces of metal buried at different levels in the ground and connecting these two buried metal plates to the test apparatus by lengths of insulated wire.

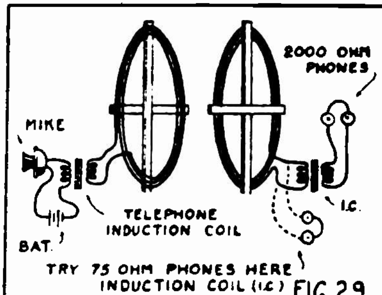


FIG 29

Talking by induction

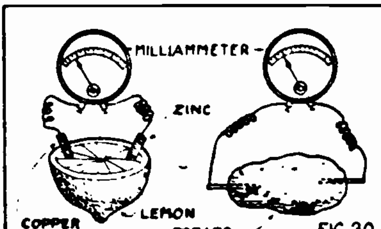


FIG. 30

Yes — lemons and potatoes produce electricity

HOW TO MAKE MAGNETS

A steel screw driver may be magnetized by stroking it back and forth on steel magnet as Fig. 31 shows. Stroke the tool from the center of the magnet toward one end, but always the same end. At C the magnet is stroked over the tool to be magnetized. Fig. B shows how a steel tool or other piece of hardened steel can be magnetized by placing it in a coil of several layers of insulated magnet wire, fed from a battery, either storage type or a few dry cells.

To maintain the strength of steel magnets, keep a bar of iron or steel across the poles when the magnet is not in use.

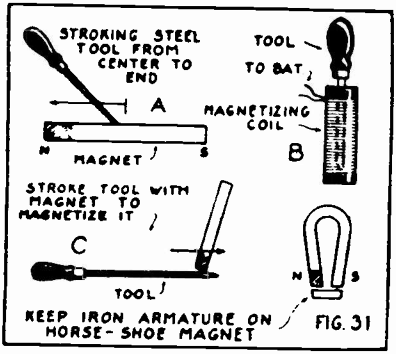
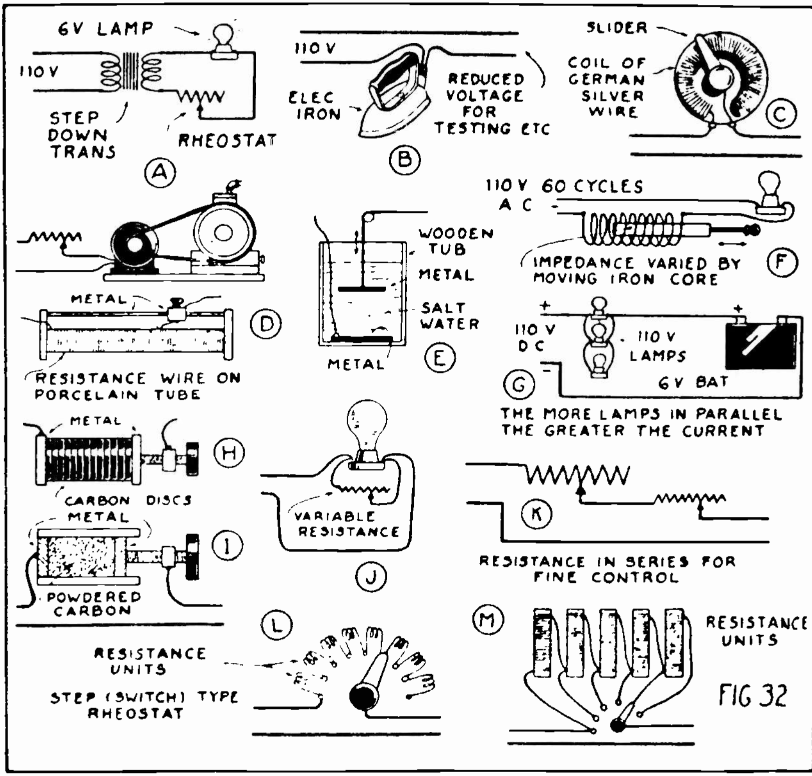


FIG. 31

RHEOSTATS AND HOW TO USE THEM

Fig. 32 shows the application of rheostats to various circuits. Many of these experiments can be carried out with a step-down transformer, a bell-ringing type for example. The rheostat, or variable resistance for low-voltage circuits, can be made of several dozen turns of iron or German-silver wire, wound on a porcelain tube or an asbestos one, with a slider arranged to move over the wire In this way a lamp can be dimmed, or the speed of a motor changed at will. At B we see an electric sad iron used to cut down the voltage for a test circuit. C shows a resistance coil bent in the form of a circle, to provide circular motion of the slider. D shows a rheostat used to regulate the speed of a motor; the more resistance cut into the circuit, the slower the motor runs, and vice versa. In a pinch, electricians often make use of a water rheostats; here two metal plates (E) are placed in a wooden pail or a barrel filled with salt water or baking soda water. One of the plates can be moved up or down to vary the resistance; the plates can be of any metal available.

For A.C. circuits an adjustable impedance coil, Fig. F, proves valuable. A movable laminated sheet iron (or iron wire) core is slid in or out of the coil to dim a light or vary the speed of a motor. The coil can be several layers of insulated magnet wire, the size depending on the current to be passed through the circuit. For experimental purposes, try 5 to 6 layers of No. 16, bringing out taps from the 3rd, 4th, and 5th layers. Fig. G illustrates how several 110-volt lamps can be connected in parallel to control the current



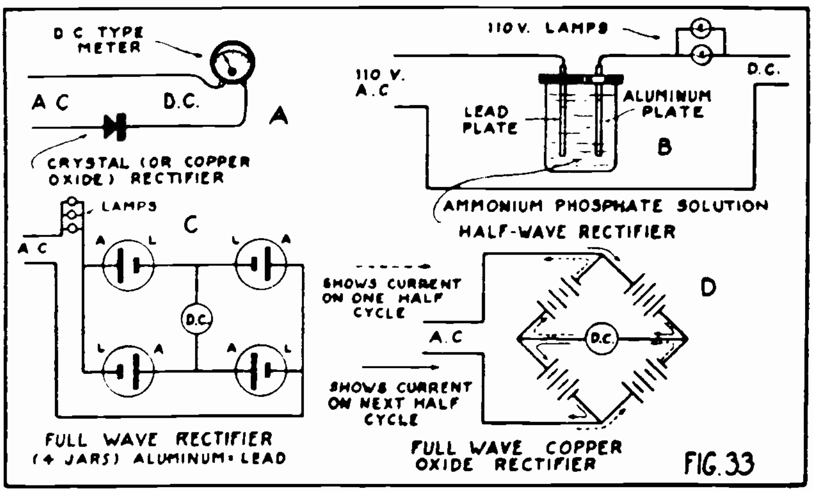
Electric regulating resistances take many forms

to a storage battery being charged from a 110 Vt., D.C. line; Fig. H, a carbon or graphite disc rheostat; I—crushed carbon type; J, how a lamp can be dimmed by shunt-type resistance control; K — coarse (high resistance) rheostat for rough adjustment, with a low resistance rheostat for fine control. L, a rheostat made with a switch and contact points, the resistance wire often being wound on asbestos tubes (as at M).

RECTIFIERS

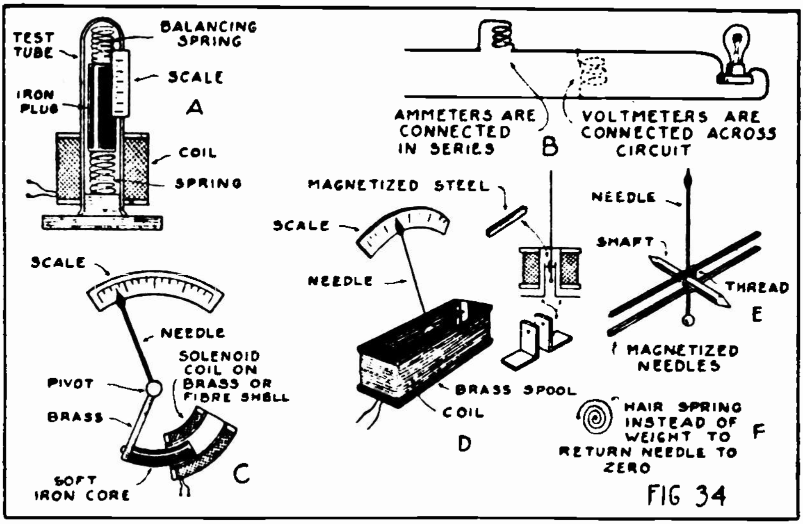
One of the simplest rectifiers for converting A.C. to D.C. is a crystal detector formed of a metal point or needle bearing against a crystal such as carborundum. This device has the faculty of clipping off the half-waves in one direction and passing all those in the opposite direction. In this way, for example, we can use a direct-current meter on an alternating-current circuit. Fig. 33-A shows a crystal rectifier in series with a meter: only a small current is passed by such a crystal rectifier of course. For larger currents the rectifier at B may be used: here an aluminum plate and a lead plate are immersed in a jar containing a saturated solution of ammonium phosphate (a solution which will absorb no more of the salts). This cell will pass current in one direction, but not in the other. With plates about 4 by 5 inches the cell will pass about half an ampere or so.

One cell delivers only *half-wave* rectification and, to obtain *full-wave* rectification, four cells are hooked up as shown at C. The path followed by the current at each half-cycle in such a rectifier is indicated at D, this last diagram being for a copper-oxide dry-plate rectifier. With electrolytic rectifiers of the aluminum lead-plate type it is often necessary to connect a load of a few lamps across the rectifier, until the plates "form" (a thin gas film forms on the plate).



Rectifiers of several types

SIMPLE MEASURING INSTRUMENTS



Home-made electrical Measuring Instruments

One of the simplest instruments for measuring voltage or current is that illustrated at Fig. 34-A. A coil when carrying a current exerts its magnetic pull on a soft-iron core resting on a spring, as the drawing shows. A light spring may be used on top of the iron core to "stabilize" it, and a calibrated scale is pasted on the glass or celluloid tube. The stronger the current, the greater the pull on the iron plug; for measuring amperes, the coil is wound with heavy wire and for volts the coil is wound with fine wire. No. 16 insulated magnet wire is about right for currents of 1 to 6 amperes: for voltages of 1 to 10, the coil may be wound with No. 28 or 30 magnet wire. The coil bobbin can be 1½ inches long and 1½ inches in diameter; the glass tube may be about ½ inch in diameter, and the iron core small enough to slide freely inside the tube. A voltmeter is connected across a circuit as shown in

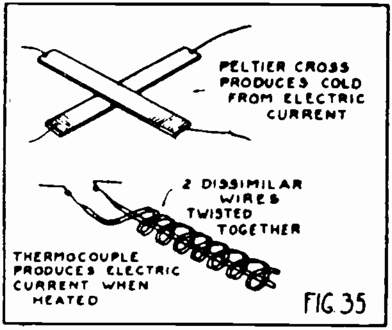
Fig. B, and in series with the circuit for current measurements.

A very simple solenoid (suction type) meter is shown at C; the action is — the soft iron core is drawn into the coil in proportion to the strength of the current or voltage, the same rules holding — *i.e.*, heavy wire for ammeters and fine wire for voltmeters. The coil can be wound on a brass or fibre bobbin, or copper will do. Cover the inside of the spool with paper, glued on, before winding on the wire.

A type of measuring instrument easy for the experimenter to build is observed at D. The coil may be wound on a brass or fiber bobbin; the moving element is a small piece of clock spring, magnetized and fitted over the shaft so as to turn with it. It may be glued in place if necessary. A few steel sewing needles may be used instead of the clock spring, as shown at E, and in either case the steel armature is to be magnetized by stroking with a steel magnet before assembling the meter, the pivots being obtained from an old clock or other source. The bobbin may be about 2½ inches long, ⅞ inch wide and ¾ inch high. For an ammeter wind the bobbin full with No. 16 magnet wire, and for measuring volts wind it full of No. 28 to 30 magnet wire. In any case, the best way to calibrate the meter is to borrow another calibrated one. For a voltmeter you can mark divisions on the scale as follows: one dry cell 1½ vts; two dry cells 3 vts; etc. To return the armature to zero it is a simple matter to fit a hair spring on the shaft of the meter (at F), or you may just depend on a balance weight fastened on the shaft.

HEAT OR COLD FROM JUNCTION OF DISSIMILAR METALS

Fig. 35 shows how a current passing from bismuth to antimony, in a "couple" containing these two metals, will produce a *cold* effect: on the other hand, if the current passes through the couple or juncture in the opposite direction, a *heating effect* is produced. The thermoelectric couple is now widely employed to measure temperatures of furnaces, etc. The so-called *Peltier effect* of *cold* has not been put to industrial use so far, at least not on a large scale; so here is a chance for our experimenters to put Mr. Peltier's discovery to work! The thermoelectric couple works on the principle that, if we apply heat to the juncture of two dissimilar wires twisted together, then an electric current is produced whose strength depends upon the degree of heat applied. A microammeter connected to the couple indicates the degree of temperature and, in the commercial instruments, the meter is calibrated in degrees of heat (Fah or Cent., etc.).



Thermocouples are used in heat-measuring instruments

HANDY WIRE GAUGE

If you have on hand coils of wire of unknown size, this size may be easily found by winding a coil one inch in length on a form of any sort. When this has been done, count the turns, which should be as closely spaced as possible. Then refer to a table that gives the number of turns per inch for various sizes and types of wire. For example, a one-inch winding of No. 24 s.s.c. will consist of 45 turns, as the table shows.

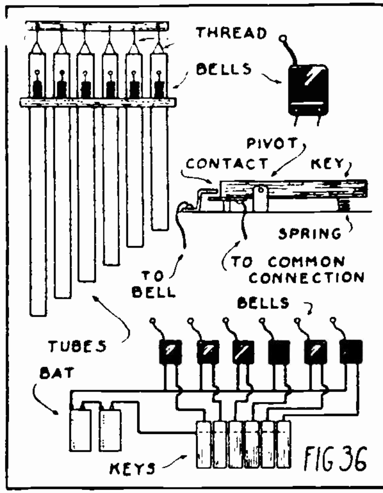
WIRE TABLE

B. & S. GAUGE	DCC	SCC	DSC	SSC
18	19.6	22.3	22.3	23.6
22	30.0	34.0	34.0	36.6
24	35.5	41.5	41.5	45.3
30	55.5	71.3	71.3	83.1
34	70.0	97.0	97.0	120.0

B. & S. GAUGE	ENAM.	ENAM. SCC	ENAM. SSC
18	24.0	21.7	22.9
22	37.7	32.7	35.0
24	47.2	39.7	43.1
30	92.3	67.4	77.9
34	145.0	91.7	112.0

MUSICAL INSTRUMENTS

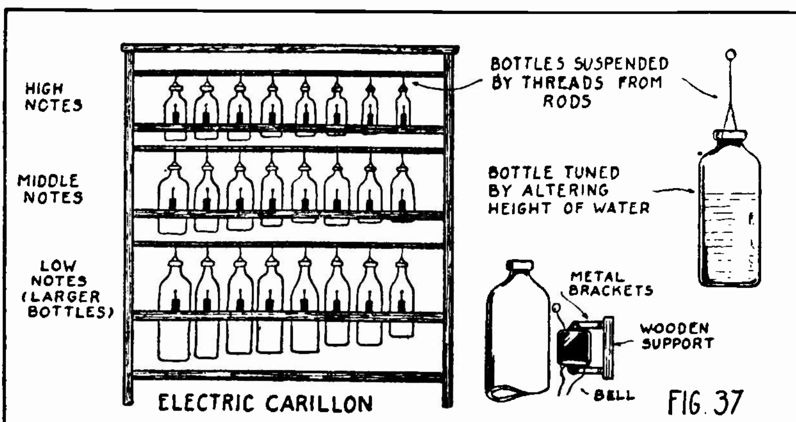
Fig. 36 is a picture of an easily made electric chime, comprising a series of brass or bell-metal tubes, with an electric bell mounted near each tube to strike it whenever the current is switched into it from the keyboard. The keys may be old piano keys, or home-made ones of wood, mounted on a pivot bar as shown. As each key is pressed, it closes a circuit to the proper bell, and the vibrating hammer plays that particular chime. The bells can be made single-stroke if desired.



Electric Carillon

This was built by Hugo Gernsback in his early experimental days and is shown at Fig. 37. You can make as many octaves as desired and the music is produced by electric bells playing or vibrating against bottles filled with wa-

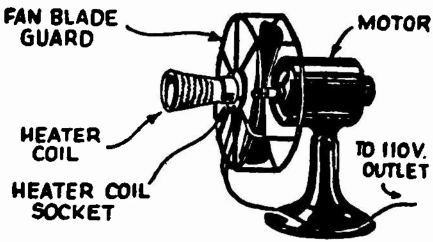
Carefully selected bottles give pleasing sounds on this carillon

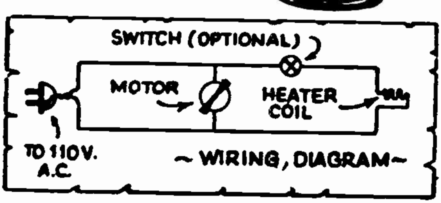


ter to different levels. The bottles can be tuned by means of a piano or other musical instrument: the small bottles are used for the high notes and the large bottles for the lower notes. The bottles are suspended on cords and the strikers on the bells are fitted with wooden balls, instead of metal, to give a better tone. You can try single-stroke on the bells by cutting out the vibrator circuit but the writer prefers the vibrating tone. To tune the bells, different heights of water are tried until the desired note is obtained when the bottle is tapped with a wooden mallet.

Film Dryer

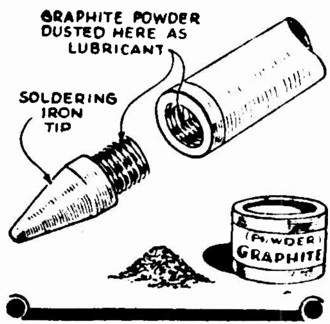
● AN old electric fan and a heating unit from a radiant type heater are assembled to provide a blast of warm air to dry film rapidly. A poreclain electric light socket is clamped to the center of the wire fan guard. This socket is connected in parallel with the line feeding the fan motor, and a switch is put in series with it. The heating coil is a standard one, obtainable at any 10c. store. When the fan and heating unit are turned on, a warm, gentle breeze dries prints or negatives in no time at all!





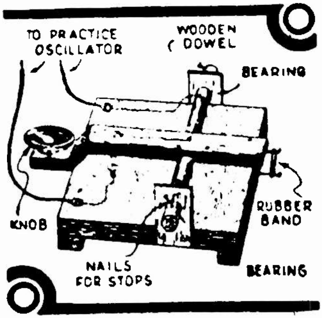
Removable Iron Tip

The tips of soldering irons soon become corroded from the heat and are almost impossible to remove when replacement is necessary. The way to avoid such trouble is to remove the tip immediately upon purchasing a new iron and to dust graphite lubricating powder onto the portion of the tip which fits into the barrel of the iron, and also sprinkle the graphite into the socket in which this tip fits. This lubricant permits the tip to be removed at any time, while greases would be baked and become useless.



Home-made Key

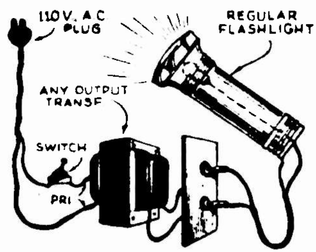
Wanting a practice key and not wishing to spend any money on one, I constructed one out of apparatus found in the odd parts box. Almost the entire key is of wood, as the drawing shows. The only metal parts are the stops and contacts. Should metal be available, the arm may be made of this instead of wood, and in this case one of the connecting wires may be directly soldered to the arm at the point where it is attached to the bearing rod. Nails are provided in the bearing plate and the dowel rod which carries the key arm. These are to keep the arm from



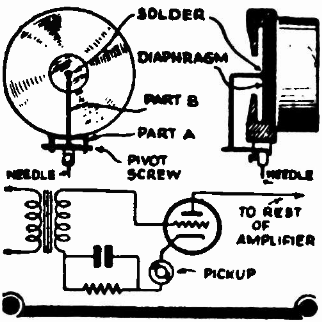
rising too high or otherwise getting into an inconvenient position. Contacts may be made through nails, screws or any other metal driven through the arm and baseboard.

Batteryless Flashlight

Flashlights are often used around the shack or work bench, and while it does not keep one broke to buy batteries for them, such expenditures are not needed. I hooked up an old output



transformer, as shown in the accompanying sketch, as power for the flashlight used to inspect receivers in my service shop. Any output transformer will provide the low voltage high current necessary for flashlight bulb operation or, if one prefers, a filament transformer can be used, in which event standard pilot light bulbs can be operated in the flashlight at their normal brilliancy. And it's always ready when needed.



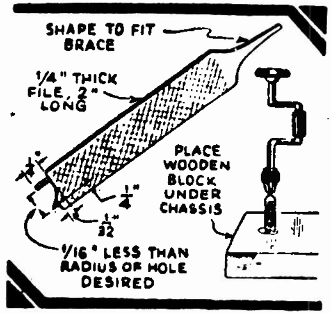
Home-made Pickup

A simple and inexpensive phonograph pickup can be made from the parts of an old non-electric pickup head and an earphone.

The needle holder for the electric pickup is removed from the old pickup head and attached to the earphone in the following manner: A ⅛″ hole is drilled in part "A" of the needle holder and is countersunk to accommodate a 6-32 flathead screw. A hole is then drilled in the bakelite cap of the earphone and is threaded with a 6-32 tap. The part "A" is then attached to the earphone cover by the short flathead screw. The end of part "B" is soldered to the diaphragm of the phone. The lacquer on the surface of the diaphragm must be scraped off first and care must be taken so as to not bend the disc.

Part "B" is then placed between its pivot points and the points tightened to give the desired tightness. Vibrations of the diaphragm, caused by the record, produce an alternating current in the windings of the earphone; this alternating current is fed to an amplifier which is in turn connected to a loudspeaker; a simple coupling system is shown in the drawing. The quality of the pickup unit is fairly good.

●

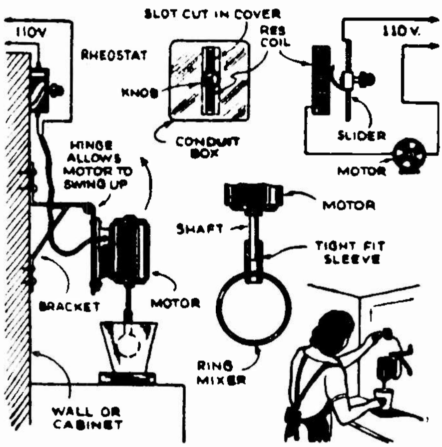


Circle Cutter

A cheap and effective circle cutter is an essential when building sets on metal chassis or when cutting panels. The drawing herewith shows a cheap but highly effective cutter of this type, which can be made from an old file. The file may be softened by annealing it in a gas stove. This is done by heating the file to cherry red, then allowing it to cool slowly. The end is then sawed and filed into the form shown in the illustration. After this, it is reheated to cherry red and plunged into cold water to temper it. The tang (or handle end) should be filed down to fit the jaws of a standard brace. If it does not fit securely it will wobble, resulting in a ragged cut. This home-made tool will prove an aid to the experimenter.

HOME - MADE ELECTRIC DRINK MIXER MOUNTS ON WALL

● SMALL electric motors are avaliable on the market today at a very low price; one of the most useful applications of such a motor is for the purpose of mixing drinks, or the stirring of solutions in the chemical laboratory. Our illustration shows how such a motor may be screwed to one leg of a large iron strap hinge, so that the motor with its attached mixer may be swung upward out of the way when not in use. The rheostat for regulating the motor speed is optional, but is very desirable in the photo or chemical laboratory. It may be made from a porcelain tube or an asbestos covered iron tube, wound with a layer of about No. 16 German silver or other resistance wire. The turns of the wire are placed a slight distance apart and a spring slider is mounted so as to slide along a brass bar as shown. In this way the current supply to the motor may be regulated by changing the amount of resistance in the circuit. The mixing attachment may be picked up in the "5 and 10" or it may be simply a wire ring soldered or riveted to a brass sleeve which will fit snugly on to the end of the motor shaft.



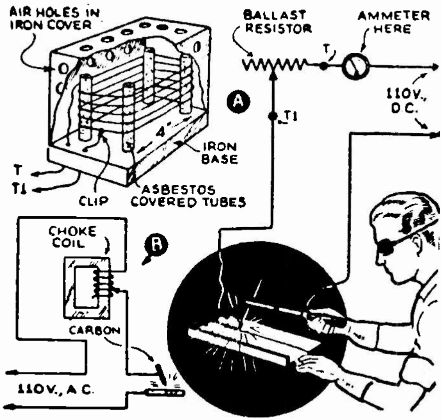
Variable speed mixer mounts on wall or cabinet, and can be used for stirring drinks or batter, whipping cream and other kitchen tasks

SIMPLE ARC WELDER FOR HOME OR SHOP METAL WORK

● A SIMPLE electric arc welder can be made cheaply from the few parts shown in the accompanying sketch. First of all, do not forget to thoroughly protect your eyes with a pair of dark glasses or goggles. To control the amount of current passed through the arc (which should be held down to a value of 5 to 10 amperes) a ballast resistance is connected in series with the arc. A resistance coil (or grid) works very well on direct current but for A.C. circuits an impedance or choke coil (primary winding of a small transformer will serve the purpose very well) works much better and allows a more stable arc to be drawn.

The ballast resistance may be made by winding about 20 ft. of either German silver or other resistance wire around 4 porcelain tubes (or asbestos covered iron rods) laid out on a square 4" x 4" as shown. One side of the circuit is connected to an adjustable clip, so that the current can be regulated, and if you can obtain an ammeter it would be well to connect it in series with the circuit and the current adjusted to a suitable value.

For A.C. operation an old transformer core may be picked up for a few cents and a winding of several



layers of No. 14 D.C.C. copper wire placed on one or both of the longer legs of the core. It is well to bring out taps from each layer after the second, and diagram B shows how the adjustable choke coil is connected in series with the arc.

The welder has a multitude of uses. It can be used to make long seams, join dissimilar metals, perform spot-welding operations, repair leaks, etc.

COPPER WIRE TABLE

Gauge No. B&S	Turns Per Linear Inch D.S.C.	Turns Per Linear Inch S.C.C.	Turns Per Linear Inch Enamel	Feet Per Pound D.C.C.	Feet Per Pound S.C.C	Feet Per Pound Bare	Current Capacity (Amp.)
00	.....	.....	.....	.....	.....	2.482	88.9
0	.....	.....	.....	.....	.....	3.130	70.9
1	.....	.....	.....	.....	.....	3.947	55.7
2	.....	.....	.....	.....	.....	4.977	44.1
3	.....	.....	.....	.....	.....	6.276	35.0
4	.....	.....	.....	.....	.....	7.914	27.7
5	.....	.....	.....	.....	.....	9.980	22.0
6	5.44	5.60	.....	.....	.....	12.58	17.5
7	6.08	6.23	.....	.....	.....	15.87	13.8
8	6.80	6.94	.....	19.6	19.9	20.01	11.0
9	7.64	7.68	.....	24.6	25.1	25.23	8.7
10	8.51	8.55	.....	30.9	31.6	31.82	6.9
11	9.58	9.60	.....	38.8	39.8	40.12	5.5
12	10.62	10.80	.....	48.9	50.2	50.59	4.4
13	11.88	12.06	.....	61.5	63.2	63.80	3.5
14	13.10	13.45	14	77.3	79.6	80.44	2.7
15	14.68	14.90	16	97.3	100	101.4	2.2
16	16.40	17.20	18	119	124	127.9	1.7
17	18.10	18.80	21	150	155	161.3	1.3
18	20.00	21.00	23	188	196	203.4	1.1
19	21.83	23.60	27	237	247	256.5	.86
20	23.91	26.40	29	298	311	323.4	.68
21	26.20	29.70	32	370	389	407.8	.54
22	28.58	32.00	36	461	491	514.8	.43
23	31.12	34.30	40	584	624	648.4	.34
24	33.60	37.70	45	745	778	817.7	.27
25	36.20	41.50	50	903	958	1031	.21
26	39.90	45.30	57	1118	1188	1300	.17
27	42.60	49.40	64	1422	1533	1639	.13
28	45.50	54.00	71	1759	1903	2067	.11
29	48.00	58.80	81	2207	2461	2607	.084
30	51.10	64.40	88	2534	2893	3287	.067
31	56.80	69.00	104	2768	3483	4145	.053
32	60.20	75.00	120	3137	4414	5227	.042
33	64.30	81.00	130	4697	5688	6591	.033
34	68.60	87.60	140	6168	6400	8310	.026
35	73.00	94.20	160	6737	8393	10480	.021
36	78.50	101.00	190	7877	9846	13210	.017
37	84.00	108.00	195	9309	11636	16660	.013
38	89.10	115.00	205	10666	13848	21010	.010
39	95.00	122.50	215	11907	18286	26500	.008
40	102.50	130.00	230	14222	24381	33410	.006
41	112.00	153.00	240	17920	30610	42130	.005
42	124.00	168.00	253	22600	38700	53100	.004

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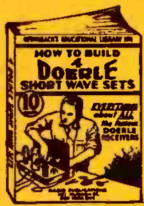

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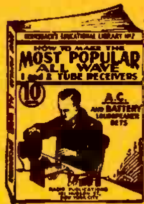

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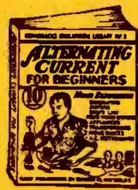

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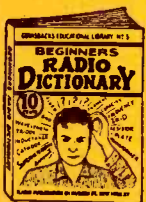

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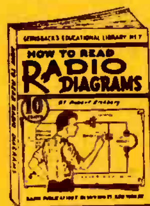

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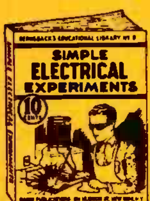

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