day until Xtals are formed. They are taken out and cut up, and coated to preserve their crystalline properties. They are used in microphones, pickups, vibration detectors, etc.

CARE OF PHONES. A review.

1. Don't drop. May break caps, cords, binding posts, or knock out some of the magnetism.

2. Keep dry. Moisture corrodes wire, connections and diaphragms.

3. Don't hook phones to power stage of set, unless .1 mfd. bypass condenser placed in series. Strong currents injure phones.

4. Get polarity right. Run the tracer to positive (plus).

5. Hook up tie-cords. Protect phones and cords.

6. Connect most phones in series; not parallel.

7. Be careful about shocks. Some types with open posts on the back should be taped.

8. Reverse diaphragms now and then. Magnets draw them in.

9. Replace cords that are intermittent, or raspy. Do not repair them.

10. Phones, given proper care, should last a lifetime.

The End.

another MRL Handbook.... HB-1

Headphones: Operation AND Repair

by Elmer G. Osterhoudt

CONTENTS

"With Radio Since 1915." including:

Radio Operator, R.C.A. Marine Service
Radio Mechanic, Maximum, U.S.N.
Technician, Electrical Products Corporation
Southern California Edison Company
Majestic Electrical Products
U.S. Motor Company
Manchester Radio Electric Shop
Modern Radio Laboratories
Amateur and Radio Service
6NW (1919)

Litho. in U.S.A. by Modern Radio Laboratories.

FOREWORD

The necessity of this Handbook is agreed by anyone looking for 'phone information in the standard Radio texts, libraries, etc. The material has been slowly accumulated over a period of many years. Special appreciation is given to Mr. Paul A. Botorff, of Trimm Mfg. Co., Libertyville, Ill.; Mr. R.B.Nottingham of the Brush Development Company of Cleveland; Mr. Kenneth H. Dahlberg of Telex, Inc., Minneapolis and others, for their kind assistance in the preparation of this Handbook.

San Carlos, Calif. E.G.O.

Chapter I.
History

NAMES.

Instruments in this Handbook have been called by many names. Butter stamps (1880); Telephone receivers (1909-26); Watchcase receivers (1910); 'Phones (1917); Receivers (1920); Headphones (1924-on); Earphones (1927); Headsets (1927); Cans (ask any Amateur); and if dropped on the floor, by other names not within the scope of this dissertation!

DEFINITION.

Telephone receiver - an electro-acoustic transducer actuated by power from an electrical system and supplying power to an acoustic system; all wave forms corresponding. Simpler: An instrument that changes electrical energy into sound.

HISTORY.

Don Ameche didn't invent the telephone - as hundreds of Movie fans seemed to insist, as they wrote him asking about his inventions. Guess we'll have to lay it onto Mr. Bell!

"Telephone" was first used in the 1830's by Wheatstone, a well known physicist and inventor, when sound was transmitted thru wooden rods.

The Page effect was discovered in 1837, by Page, of Salem, Mass., when he found that the magnetizing and de-magnetizing of an iron rod would emit sounds - due to the re-arrangement of the molecules.

In 1854, Bourseul, of France, conceived the original idea of the phone, but didn't put it into actual practice. He used a vibrating disc (diaphragm) near a magnet, operated by the voice. This gave a similar vibration of a magnet and diaphragm at the other end of the circuit.

Philipp Reis, of Frankfort, invented the Reis' Telephone in 1860, by which he was able to reproduce voices at a distance.

However, for the first practical working model, Alexander Graham Bell, of Boston, was given the patent in 1876. Like Marconi "inventing the Wireless" - he made a practical working model and got the credit,altho many others were instrumental in laying the foundation beforehand.

Bell's father was an educator, specializing in sound, who originated "visible speech" for use by deaf mutes. Bell became interested and later became a professor. Experimenting was more important to him than teaching.

He reasoned that if he could make a current of electricity vary in intensity as the air varies in density during the production of sound, he could transmit speech electrically. That is, a continuous current intensified and diminished in proportion to the sound waves.

In 1875, he was experimenting with a harmonic telegraph. He had observed how certain strings on a piano vibrated when talked against. His idea was to have a string vibrate near an electromagnet and transmit sound. The first sound transmitted was a twanging clock spring. His experiments showed he required an undulating, or wavy vibration of a reed instead of a vibrating tone used on the telegraph.

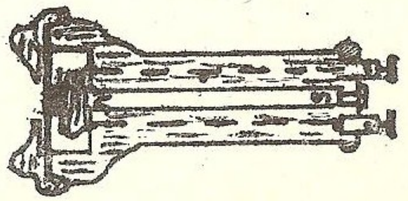
While adjusting the diaphragm on his first telephone receiver, he found the sound was picked up on another hooked to it. The next day, as he was hurrying to make an adjustment, he spilled some acid on his clothes. He called to his assistant "Mr. Watson, come here! I want you." Watson, on the other end of the line, came hurrying in - result, the first telephone. The principle is still the same.

Incidentally, Mark Twain was asked to loan Bell $500 for his telephone, but refused. Instead, he loaned it to a friend, who went bankrupt in three days.

Mr. Bell patented his telephone in 1876, after much litigation. An old letter was produced by Bell, written by Elisha Gray, his competitor, that admitted Bell was the inventor.

EARLY PHONES.

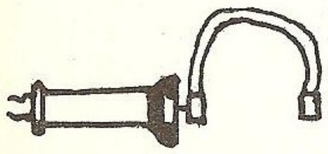
The Bell telephone receiver also served as a transmitter (See Batteryless telephone), until later, when microphones were invented. The first phone was called a 'butter stamp' from its resemblance. They used one bar



magnet, diaphragm and coil wound with silk-covered wire. Later a compound magnet was used. with

two coils, which gave a much stronger pull and greater sensitivity.

Phones have been gradually improved by study of the magnets, welded construction, dust-proof cases, special kinds of steel, spacing, and resulting in more naturalness of the voice. In 1920, conversation over the telephone was like talking 80 feet in a field. Now it is 15 feet. Handsets with mikes were first made in 1878.



Phone to both ears to shut out noise. No comment!

The biggest drawback to telephone development was public apathy. We heard a yarn about a skeptical farmer who promised to accept a phone if he could hear his wife talk from the house to his barn. Upon completion, the phones were taken up, as he said "hello, Eliza!" Just then, a bolt of lightning struck the wire and knocked him down. He staggered up, saying, "that's her, alright - put it in."

Phones were loaned in pairs to people to get them used to the new gadget. Many floors were torn up, to see who was underneath!

The first dial phone was patented in 1879, altho it took A. B. Strowger, a Missouri undertaker, to work it out with a bunch of collar buttons and pins in 1889. This was in retaliation for a switchboard error he had received, so he wanted to eliminate Central.

At first, subscribers had to belong to several phone companies, but these were later consolidated.

As electricity became weaker in transit, repeating transformers had to be installed. These were later changed to vacuum tube repeaters. In 1917, tubes ran 1000 hrs. In 1927 they would stand 25,000 hrs., or three yrs. of continuous service, due to better filaments, etc. In 1936, about 300,000 tubes were in operation in the U.S.A. as repeaters.

In 1878, the Ridge Telephone Company's line was installed between French Corral, Nevada Co., to Milton, Sierra Co., California, a distance of 60 miles. It was considered the first long-distance telephone line. It was used in handling business for a hydraulic mining firm for 20 years. There were 30 instruments on the line. They were called Edison phones, altho "American Speaking Telephone Company" was stamped on the boxes. They used square bells, many of which are found around as antiques. Edison worked with Western Union to perfect the phone, altho Bell got the patent. However, Edison microphones made Bell's invention practicable. The Ridge line provided instant control of the now-extinct hydraulic mines in the Mother Lode.

Chapter 2.

Our Ears..

As the final outcome of any Radio has to do with our ears, it is well to consider them.

It has been proven the perfect human ear can detect vibrations of 100/millionth of an inch. This is 1/10th of the diameter of a Hydrogen molecule, or less than can be detected by the modern Microscope. If "I" was enlarged to the height of the Empire State bldg., 100/millionth of an inch would be the thickness of a cigarette paper. When air vibrations hit the ear-drum, it is magnified 30 to 60 times by the lever action of the three bones on the fluid of the inner ear. Then 30,000 fibres of the auditory nerve carry the impulse to the brain.

By selection of the nerve fibres at the brain, by concentration (or tuning) we are able to favor certain tones. This enables an operator to "copy" certain signals while others are being heard. Likewise, two people talking in a city thru heavy street noises. Uncomfortably loud tones of 120 decibels become pain at 140 decibels. By practice, loud tones may become bearable as the continual listening to loud stations - or a boilermaker at work.

Normal ears respond to Audio frequencies from 20 to 20,000 cps. Everything in nature varies - so one person may hear tones not heard by another. There is a wide variation in hearing at different frequencies by an individual. Each ear seems to have its own fundamental vibrating point, just like a Radio operating better at some frequency on each coil. A baby may hear the dog whistle at 20,000 cps, while an old man may not hear normal voice at 5000 cps due to failure of nerve ends to respond. Lower sounds, as those of pipe organs, etc. may be felt as well as detected by the ear.

Dogs, cats, rats, insects, etc., produce weak high-frequency sounds perceptible to them, but not to us. Notice ants communicating between each other, thru their antennae, as they meet each other on a path.

However, it has been shown the ear is affected by HF Radio oscillations, altho not heard by us. A Radio frequency machine, setting up HF vibrations, uses prods placed in the ears. This results in artificial fever, which causes blood to rush to the affected tissues of the ears.

As best DX records are made by phone users after others in the family have retired, it may be phones become tiresome. The cost of rubber ear cushions will be repaid many times in protecting the ears, as well as excluding noises. Old Time Ops used to kid each other about their cauliflower ears. Ear cushions have been used since 1911.

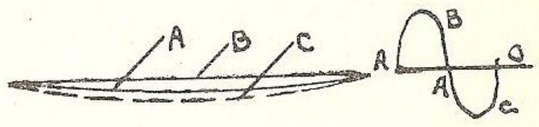
Adjust the headbands so the phones don't pinch the ears. At the same time, make them snug-fitting. Most headbands are now light, fabric-covered, and easy on the ears. A lot of difference between them and the "hair-pullers" we used to have.

The Telex Monoset (per se) hangs in the ears, thereby eliminating headband trouble.

Bell Laboratories made over 4000 measurements of heads of both sexes to determine headband sizes. Their headband, phone and microphone used by their operators, weigh less than 6 ounces.

Chapter 3.

Diaphragm Vibration.



Here is the position of the diaphragm in various stages:

(B) is the normal position of the diaphragm if you remove the PM (Horseshoe magnets); when it is on high amplitude of the top half cycle that *OPPOSES* the magnetic pull.

(A) is the position when held down by the PM; at zero current part of the cycle.

(C) is position at high ampli-

tude half of the cycle that is *AIDED* by the PM.

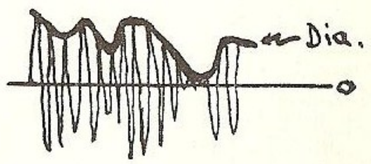
Remove the Horseshoe magnets from a phone and try to use it. It will be very weak on DC and almost useless as to reproduction of signals. This is the undulating tone principle Bell was looking for (see History). The disturbance in the electrical field, that is already pulling on the diaphragm, is what reproduces the sound wave. That is - on the C-side of the cycle the magnets work with the current; on the B-side they work against it. The poles alternately become stronger and weaker.

If pure DC is used from a battery it will pull the diaphragm down and hold it until the current is turned off, no matter in which direction the current is flowing. It then releases with a 'click. No sound is registered as long as pure DC goes thru a phone.

Audible vibrations of the diaphragm run between 20 and 20,000 cps. Even if the diaphragm could vibrate at Radio (high) frequencies, it could not be heard by the human ear. (See Our Ears).

Each phone reproduces certain tones better than others. This is called its **Resonant frequency.** It can be seen that weaker signals coming in at the resonant frequency can be reproduced more easily. Duddell found it took 430 micro-watts at 300 cps; and 7.7 micro-watts at 900 cps to give the same volume of tone. When spark transmitters were used in Wireless, the diaphragms were made of a certain thickness of ferrotype iron to tune to 1000 cps. These same receivers would distort the modern audio signals on a Radio. Present diaphragms of phones will produce sound at less than one/millionth of an Ampere of current flow.

If two frequencies are received at once, the diaphragm vibrates and tries to reproduce each frequency. This results in a mixed frequency, or chord, or beat note. The diaphragm produces a wave-form that conforms to the general contour of the high-frequency amplitudes received.



The Continuous current receiver (which see) uses a battery when in use. This pulls the diaphragm down to the point (A) and variations in the field occur the same as with a permanent magnetic field.

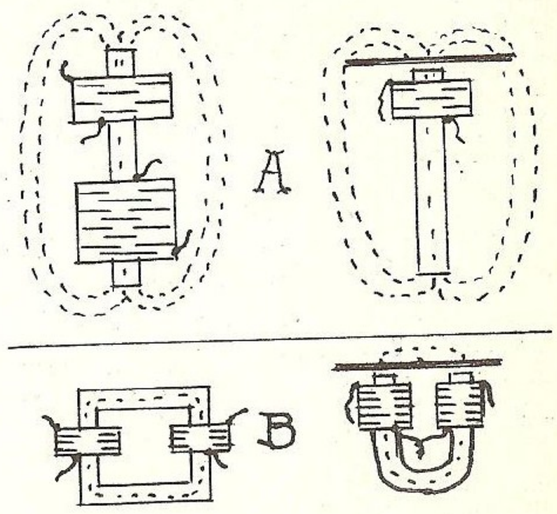
Chapter 4.
Resistance and Impedance.

Phones have been made with a resistance of 5 ohms, with a few turns of large wire. They have also been built with 8000 ohms, with thousands of turns of fine wire. The modern phone may have 10,000 turns of fine wire from No. 40 to no. 50 enameled.

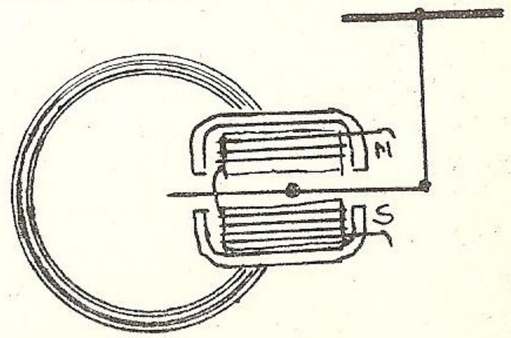
Phones are rated in total resistance, altho it is the number of ampere-turns of wire on the core - rather than the resistance, that determines sensitivity. Therefore, resistance is the result of all the fine wire.

The strength of a field **(MMF)** produced by an electro-magnet is the product of the strength of the current (I) times the number of turns (n) in the exciting coils, i.e., the number of ampere-turns. A current of 2 Amperes passing thru 10 turns is said to have 20 ampere-turns of magnetomotive force (MMF). Likewise - 10 Amperes thru 2 turns also gives 20 ampere-turns. If one is small; the other must be large. MMF is the measure of magnetic flux in a magnet, similar to EMF being the measure of volts. MMF must be as large as possible in sensitive phones.

A single magnet can be compared to an open-core transformer **(A)**. A bi-polar magnet can be compared to a closed-core transformer **(B)**. The lines of force at **(A)** must go thru air part of the trip. At **(B)** they go thru the diaphragm, or other leg of transformer. As iron is a better conductor of magnetic lines of force than air, the **Reluctance** to the lines of force is less with the bi-polar magnets **(B)**. Therefore, they are more efficient.



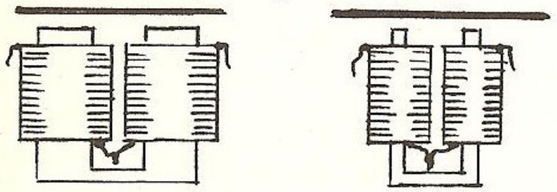
Single-pole magnets have an advantage that offsets some of the reluctance. They work from the center of the diaphragm, which is the most sensitive part - nevertheless, the bi-polar is still the more sensitive.



In the old Baldwin-lever principle, the reluctance of the magnetic lines of force is less than the single-pole magnet. Also, the lever action works on

the center of the diaphragm. You will see the lines of force have an iron path most of the way with this set-up. This system makes this receiver one of the most sensitive known.

If magnets were made wound on a bi-polar phone, their pole-pieces would pull near the edge of the diaphragm. This is the



reason for making the cores rectangular - in order to mount them close together, and near the center of the diaphragm.

If a magnet is wound with more turns of wire than the thickness of the core - the additional wire adds resistance, without any good effect. It is quite a problem to get the ampere-turns into a small apace. No. 50 wire is about the size of a human hair, and very hard to wind. If fine ribbon wire could be used, it would have better conductivity. However, space forbids.

2000 ohm phones are about 80% more sensitive than 75 ohm line phones for Radio work. Low resistance phones will work in a Radio circuit, but phones with a larger number of ampere-turns (resistance) are much more sensitive.

Current detectors, as the old Magnetic and Tikker detectors used phones of about 80 to 250 ohms. Old Electrolytic detectors used phones around 8000 ohms. Tube and modern Crystal receivers use about 2,000 to 5,000 ohms per set. Greater sensitivity takes a higher resistance.

It has been suggested that phones connected in parallel give a stronger signal on a Perikon, or Carborundum Crystal, due to their matching a lower resistance across the line.

Many phone companies rate their phones in Impedance rather than Resistance. It is the more accurate method of rating them, altho it takes a little engineering to figure it out. **Impedance** is the total opposition of a circuit which retards, or hinders the flow of alternating current. Resistance opposes the flow of DC, Impedance retards AC.

A condenser may impede AC, but will stop DC. A phone coil may have resistance, capacity between turns, and magnetism at various frequencies, which, together, impede AC. Hooking an Ohmmeter in series with a phone gives a resistance test in Ohms, i.e., shows how much the fine wire opposes the flow of DC electricity.

Resistance formula:

$$R = \frac{E}{I} = \text{Ohms Resistance.}$$

Impedance formula:

$$Z = \sqrt{R^2 \times X_L^2} = \text{Ohms Impedance}$$

where R is resistance; X is reactance; L is inductance.

In headphones, the impedance is roughly about 5 times that of the DC resistance. A phone set of 24,000 ohms impedance is about 5000 ohms DC resistance. One of 8000 ohms impedance is about 1600 ohms DC resistance.

You can see there is a big difference if a firm advertises a phone set at 8000 ohms - when it really means "8000 ohms impedance." Often the advertising department isn't aware of the great difference in the omission of the word "impedance."

If pure DC goes thru a phone, it makes no sound, other than a click on contact and another on the breaking of the current. There must be a variation of the incoming signal in the form of a wave before it is reproduced in phones.

Chapter 5
Line vs. Radio Phones.

Line phones are used by telephone companies in distinction from Radio, Operator's or Watch-case receivers.

Line phones of the long hand type have two bar magnets. A block of iron is welded to the lower end and a piece of brass at the top, between which is held the coils. In the hand-set, the magnets, coils, etc. are all in one unit and make two contacts on the bottom. In case of breakage, they are more easily repaired.

Line phones are wound with a larger wire as the current is stronger and less sensitivity is required. They are wound in resistances from 30 to 100 ohms; 70-80 ohms being the most common resistance. Radio phones have 1000 to 2500 ohms per phone.

Line phones are considered a low-impedance phone; Radio, a high-impedance type. The impedance to voice currents of 800 cycles is about 300 ohms. Line phones should be sensitive to audio ranges from 80-3,000 cps, against Radio phones' 20-20,000.

For train-dispatching circuits - some receivers are wound for a resistance of 600 ohms and impedance to voice currents of about 2500 ohms, where a number of stations are bridged across the line.

A continuous current receiver is also used in some phone work, with an electro-magnet energized by external line source. That is - no permanent magnets are used, the magnetism being furnished by batteries. This eliminates the induction coil and makes a less expensive phone set for some installations.

Chapter 6
Phone Repairs.

A receiver should be overhauled now and then. Taking off the cap doesn't damage it if you are careful. About once a year, it is a good idea to take off the cap and clean out any dust or filings. Test screws, etc. to see if they have worked loose. Also, screw the caps on good,

being careful not to get them cross-threaded. Click across a dry-cell to see if both phones work Okeh.

An old trick for testing sensitivity of phones is to wet the phone tips. Put the phones on and click the tips together without any battery. If a click or raspy sound results, your phones are "super."

When your phones are hooked up to a set, and one side goes out, hook a 50,000 ohm carbon resistor across the burned out phone. Enough energy may get thru to let you finish the program. If using a double set - just short out the burned-out phone.

Every manufacturer seems to make a different sized cap and thread for their phones. However - there are some that may match. This information is hard to obtain. We have the following from experience:

Trimm 607 Rex and Acme caps fit Frost phones.
Trimm 604 W and K caps fit the Western Electric 528.
Trimm Professional and Dependable caps fit Murdock model 56.
Old Rex caps fit Little Spitfire and Frost 174.
Cannon Ball fits Crosley and Federal 53-W phones.
Empire caps fit American Bell, Cannon Ball and Dixie phones.
Brandes Bakelite or Aluminum caps fit all Brandes.

Caps may sometimes be mended with Bakelite cement, but usually it is only temporary. As long as the cap holds the diaphragm down to correct position, it is alright to use it.

When screwing on caps, be sure not to get them cross-threaded - rotate them slowly. Test each phone to see if it sounds like its mate. If not, possibly one cap is on tighter than the other one.

DIAPHRAGMS.

Sensitive phones must have a diaphragm that vibrates easily on weak signals. Thickness runs about .004". Plain steel may be used, but it is better to use tinned or enameled diaphragms. This prevents rust which makes the diaphragm brittle and less sensitive. A new diaphragm may improve lots of phones.

If phone diaphragm is bent toward the pole pieces it may rattle. If too far away, it will lack sensitivity on the weaker signals. Turn the diaphragms over occasionally as the constant pull on them may draw them too much toward the pole pieces. If magnets get out of adjustment by dropping, a thin paper washer may be inserted between shell and diaphragm, if they rattle.

Diaphragms may be ordered just a little less than diameter of shell and still be OK. When cutting from a sheet of steel, mark awl, or scriber around the shell and cut just inside the line. Use a pair of scissors held **Exactly** at right angles with the metal to keep edge from bending.

Diaphragms of the old Baldwin phones may be mica or corrugated Aluminum. (see Baldwins).

CORDS.

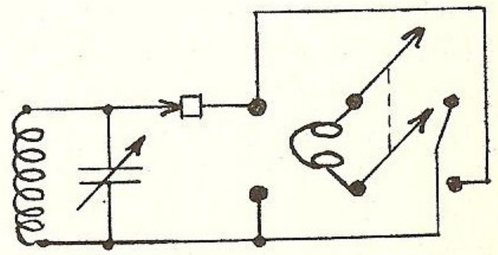
Neoprene, a synthetic rubber, is often applied over the phone cords where subject to a lot of use. The Army and Navy specify rubber-covered cords to prevent kinks, keep out moisture, etc. They may be cleaned with a very "quick" application of lacquer thinner, or Carbon tetrachloride and wiped off.

Most all cords use tinsel, similar to that used in Xmas tree ornaments, due to its flexibility. They all break in time. If you have one that is raspy when moved around - don't attempt to repair it, as in time it will all go out. Replace it!

The tie-cord, or piece of string at end of a phone cord is very important in protecting the life of the cord. Attach upper end to the headband; the lower to phone plug, if used. Take up the slack so pull will be on the tie-cord, in case the cord is suddenly jerked.

Most cords are marked with a red tracer, which signifies polarity. This should go to the plus side of B-battery, or power supply. Running phones in the wrong direction, connected to a power-supply, will soon de-magnetize them. Phones with poor magnets de-magnetize sooner, due to steel being softer and cheaper.

When using a Crystal set - try phones on a DX station, reversing them, to see which direction has the greatest sensitivity. Here is a circuit using a D.P.D.T. knife switch:



Check your new phones, or ones just overhauled, for polarity before using on a power set. It is always possible magnets may have been assembled wrong. Remove caps and diaphragms. Get a compass, or magnetized needle on a thread. Hold it close to (but not touching) the pole pieces. Touch the tips of cord to a 4½ v battery. If tracer is on positive, the needle will be slightly deflected (1/32") toward the pole piece, if cord is marked correctly. If it deflects away, they are marked wrong. Reverse them on the phones. Care should be taken when replacing cords to mark the phones plus or minus. Some phones, as Brandes, are marked at the binding posts.

FITTING LUGS TO CORDS.

(1) Cut off cord - so it is square - a good clean cut.

(2) Pull back cotton and all insulation to about 1/8" from the end of cut.

(3) At 1/8" past insulation, tightly wrap some No. 36 Cat-whisker wire over the insulation - allowing free end to go under the winding. Wrap down over the tinsel, and bring to a tip. Use all the wire from a 6" length.

(4) Take a crimp lug and, by means of heavy pliers, crimp half over the insulation, and other half over tinsel. **Do not solder,** as string will burn and it will corrode tinsel wire.

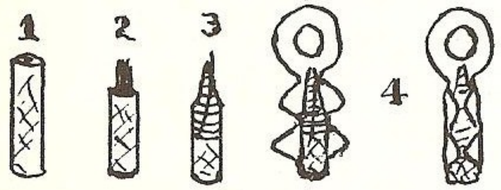
FITTING TIPS TO CORDS.

(1) Cut off cord as above.

(2) Wrap the same as (2), (3) above.

(3) Tin the wire with rosin solder.

(4) Place tip of phone tip in a vise, preferably a wooden one. Fill tip with rosin solder.



(5) **CAUTION:** Use goggles, or glasses before proceeding. Hold cord with long-nosed pliers and force it in, holding iron at the side of tip. Solder may fly out.

(6) When clear in, remove iron and let cool. Pull on cord to see if taut. If not, do it over.

Some cords have a crimped lug on them to fit into the phone tip. Cut this off, and use the wrapped tip, as described above, as lug may be too big, or may come off during soldering.

RE-MAGNETIZING.

A power supply, or batteries, tend to assist the phones if poled the right way. If wrong, - it will de-magnetize them and render phones useless. The tracer, which may be of various colors, goes to the positive (plus) side of the supply.

The South pole of a compass needle points toward the North. Unscrew cap and hold a compass near the North pole, and mark it red. A magnetized needle on a thread will serve if you haven't a compass. When you remove magnets from phones, be sure to mark them with a red grease pencil, so they will get back correctly, and maintain polarity.

Various methods of magnetic induction are used to re-magnetize phone magnets. Some companies place the magnets on pole pieces of a generator.

Other Experimenters, without dis-assembling phones to any extent, wrap 12 turns of No. 24 Enamel around each magnet. On second magnet, reverse the direction of wire to keep polarity right. Hook to a storage battery and hold a compass over the pole pieces. If it spins, it is poled wrong - then reverse battery.

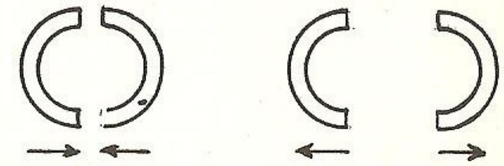
Leave it just long enough to re-magnetize it as the wire may get hot. Test magnets by touching diaphragm on pole pieces and pulling away. You will soon learn to "feel" the pull on the diaphragm correctly.

The method we used for a long time was to remove magnets from phones, marking their original positions with red grease pencil. Use a large, strong horseshoe magnet. Fasten a phone magnet on a string, and let it go to pole that attracts it. Lay it on good and flat across the magnet. If it won't reach, add an iron strap as shown in diagram (A). A couple of magnets may be hooked in series as shown (B).

As many may be hung in series as the horseshoe will hold, just so you get polarity right; North goes to South, etc.

They may be left overnight, or the magnets may be tapped sharply with a ballpein hammer to set the magnetism. This re-arranges the atoms in a north-south position in the magnet, and makes it completely charged. Contrariwise - if phones are dropped, the magnetism may be lost in the same manner.

Caution: Here is the rub! If 2 magnets go in one phone and you didn't mark them, here is a good test. No matter if they go end to end, or stacked, arrange them so they **repell** each other. This is to keep the North to the North, etc. If this rule isn't



observed, the magnets will buck each other, and refuse to work. Most phones have 2 magnets facing each other. Others, to give stronger magnetism, use 2 magnets, stacked.

You must have a close joint for magnetic induction. Therefore, be sure to screw the magnets and coils down tightly.

RE-WINDING.

Some phones have coils sealed, or riveted in, and not profitable to repair. However, most phones can be dis-assembled by removing a couple of screws. Before taking apart, be sure to mark magnets so they go back the same way.

Before re-winding a phone, be sure to check connections to the binding posts because leads are often corroded by moisture and electrolysis where they are soldered together. Test each coil with an Ohmmeter, or battery and phone, to see if it is open. Mark the one to be removed.

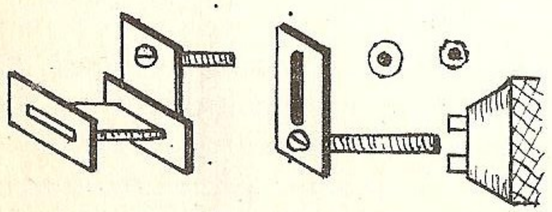
Windings on coils go in opposite directions, so be sure to mark near the inner hole, the direction of the wire before going further.

Start peeling cover off slowly - watching for breaks. Most breaks occur near the start. If a break is found, clean and resolder. Don't worry about 50 or 100 turns - it won't be noticeable in volume, so no need to replace them.

When un-winding - place coil inside a small jar, and let it bounce around. If you desire to re-wind all the wire - cut it off with a sharp knife.

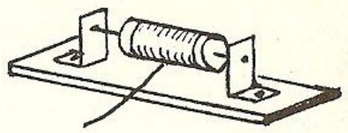
One fellow uses an extension on a phone coil, and re-winds it on a bobbin-filler of a sewing machine.

We had good luck using a hand-drill. Remove bobbin and core, the latter usually has an "L" on it, with a hole for mounting. As different brands have various measurements, we made a slot in our jig. Aqjust screw so bobbin



centers on the shaft. Put shaft in chuck of drill. Place drill in a vise at about 45 degrees.

Next make a holder for your wire spool, similar to the dia-



gram. When winding, place spool off about 2 ft. so wire can be able to stretch a little before it breaks.

Use starter and finisher leads of about 4" of No. 28 or No. 30 DCC magnet wire, or stranded, if you can get it. These re-inforce the connections to binding posts - and are not found on cheaper phones, as fine wire goes direct to binding posts. When starting wire (in right direction), let heavy wire go a couple of turns around the bobbin and solder onto the enamel wire- after scraping it good.

Wire may be scrambled. If it breaks; don't worry. Scrape off enamel, solder and continue. The joint may be painted with coil cement if desired.

When finishing winding and the heavier wire is brought thru the binding holes - wrap winding with a little piece of cellophane tape. If winding bulges out too much to get coil in - press it together with fingers.

Solder 2 inside windings together, as coils go in opposite directions making North and South poles together. Mount the coils, magnets, and then solder to binding posts - leaving a

little bit of slack.

Put on cords and check for polarity. (see Re-magnetizing). Check with an Ohmmeter between binding posts and case to see if there is a short, or it may burn you later!

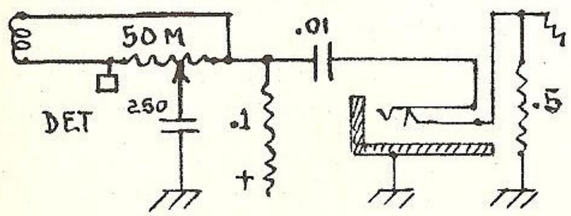
You may hold a scale over the case - and note that pole pieces just miss the scale. Put on cap and diaphragm and test for sound.

Chapter 7
The Practical Use of Phones.

HOOKING PHONES TO SETS.

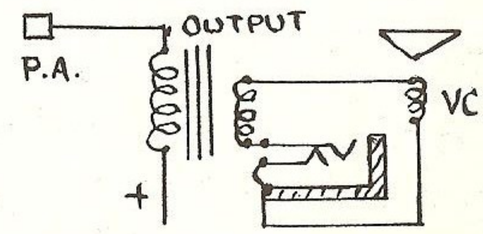
Over 6 or 7 milliamps will damage the windings of phones, especially the inside turns that cannot cool off. Phones are seldom damaged on 1-tube rigs, altho it is a good idea to get the polarity right.

However, 2 or more tube sets are a little more strenuous, especially if polarity is wrong. The most successful arrangement on first audio, or driver stage, is to use a double-shorting jack with frame grounded to panel.



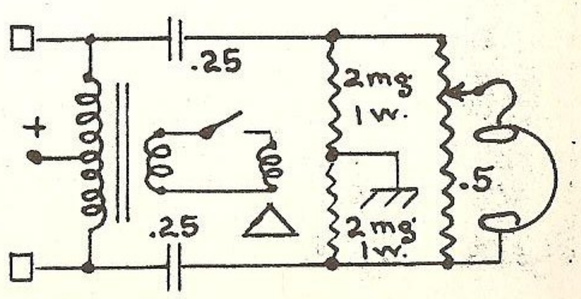
Let the free connection go to grid and ½ meg. resistor. This has 2 advantages. It prevents a shock, and the plate impedance is not changed enough to warrant re-adjustment of regeneration control when phones are taken out, and speaker comes on.

A simple method working on the voice-coil of a Dynamic or PM speaker is shown. A double-shorting jack is connected to



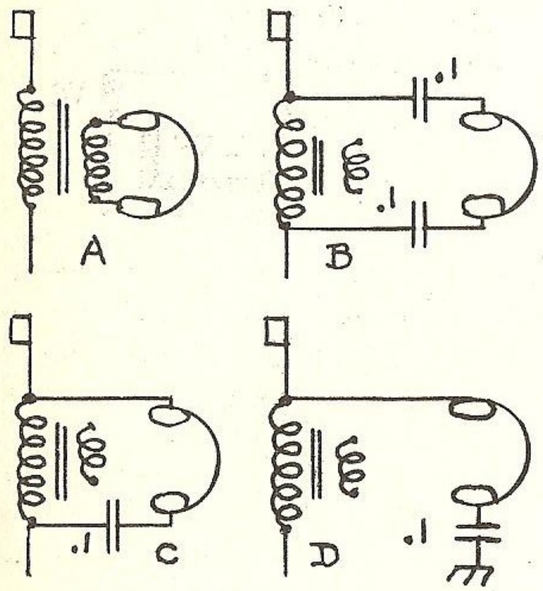
complete the circuit when phones are removed. Voice-coils are very particular about their matching impedance. When phones are hooked in series - the VC refuses to work because phone resistance is too high for a 4 ohm voice coil. Another good point is that no high voltage exists in the VC circuit. This is especially an easy way to hook to a modern set - as speaker leads are usually exposed. It cannot hurt the set in any way.

A more complicated method with push-pull stages is shown. This has a ½ meg. volume control. The



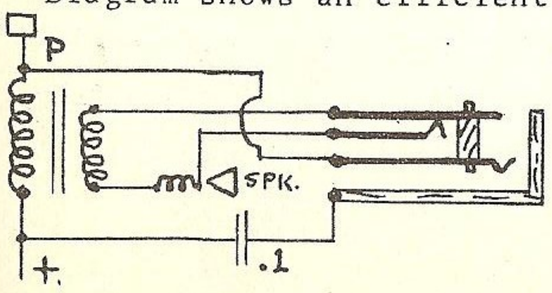
changing of control does not affect the power circuit. A switch must be used on the VC circuit. The phones are not "hot."

Here are various methods of hooking to a 1-stage pentode power circuit, in order of their efficiency. (A) is a transformer



matched to the plate impedance of the tube and the phones. This removes headphone capacity. (B) uses (2) .1 x 600 v. bypass condensers. (C) uses a .1 mfd. condenser. (D) tho recommended by many, it always gives a hum and we do not use it.

Diagram shows an efficient

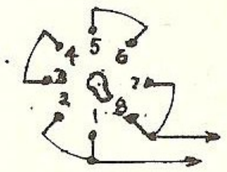


method of using a power stage and cutting the speaker VC in or out by a special-made jack. When phones are removed, the voice coil is in circuit. Be sure to use an insulated strip between the prongs. A hole may be drilled in each prong, and fibre is sharpened to fit in the holes.

PHONES IN SERIES.

Phones of same resistance should be hooked in series. If one is 1000 ohms and the other 2000 - one may act as a loading coil for the other and reduce volume. Volume is also reduced if phones are used in parallel.

Here is a good way to connect 1 to 3 prs. of phones in series, using an Octal 8-prong wafer socket. Short connections 1-2,

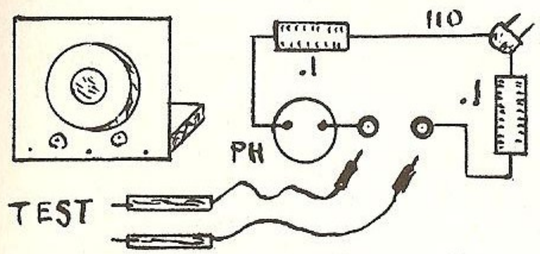


3-4, 5-6 as shown. Phone tips slip into sockets OK - if not, bend fittings a little. When using 1 phone - connect at 1-8, When 2 prs. are used, connect at 2-3 and 4-7. For 3 prs. use 2-3, 4-5 and 6-7. Mount rear of set.

FREAK PHONE RECEPTION.

It has been reported a person could hear music by holding the phone tips in his hands. It is possible signals came from an oscillating receiver by induction, as the body is a conductor

PHONE AS TESTER.



An old phone may be used as a quick tester with very little work. May be mounted on an angle on plywood if you wish. Hook a couple of .1 x 600 v. bypass condensers in series with 110 v. line as shown. It will give a hum and click up to about 100,000 ohms. Will click up to 1 meg. May be used for testing appliances, fuses, small Radio parts, etc. as well as other phones. A circuit like this will not harm a phone unless condensers become shorted which isn't likely at 600 v. rating. A good short checker with phone and dry cell is shown in HB-2.

PHONES AS SPEAKERS.

Before cone speakers appeared, phones were used entirely for reproduction. They may still be used temporarily.

A set of phones may be placed in a bucket or dishpan for some amplification. On shipboard, we used to hang them up in front of us for general listening on the 600 meter calling wave.

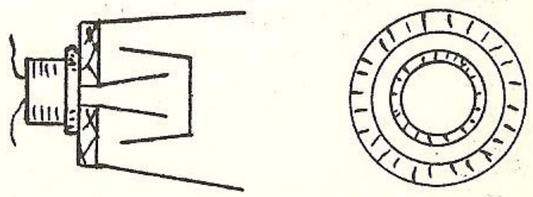
A phone may be attached to a phonograph horn for good reproduction.

A phone is made to go underneath the pillow if Radio keeps others awake. An ordinary earphone is very effective if you raise the cap away from pillow so the sound may go out. One of these on the market measures 4" in diameter and 1" thick, and is hermetically sealed.

For powerful sets the ordinary phone may rattle on loud signals due to touching of diaphragm to the pole pieces. A heavy paper washer may be placed underneath diaphragm to raise it up so it won't blast. The only drawback to it's permanent use is that a phone is wound with fine wire, that may burn out. Connecting a .1 mfd. bypass condenser in series may prevent this. Large speaker units have larger diaphragms, lower resistance and take a heavier current.

When horns increase in diameter like a snail's shell, they are called Exponential. This amplifies the volume. Any type of horn will be good for reception of code (CW) signals, as it is easier to read than a dynamic speaker. If you can place a good phone on one of these old Exponential horns - you have a good reproducer for a small set.

The reflex phone speaker was used for many years. It has a



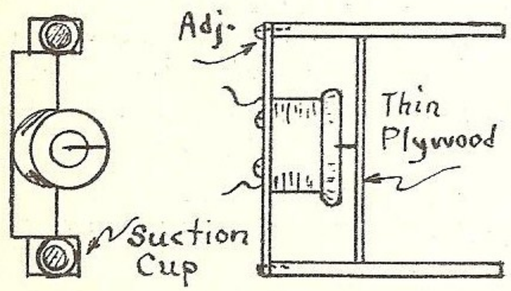
phone fitted into a wooden holder. Round cardboard horns are

fitted according to diagram. This takes a small space, but has the amplification of a larger horn.

PHONE AS MICROPHONE.

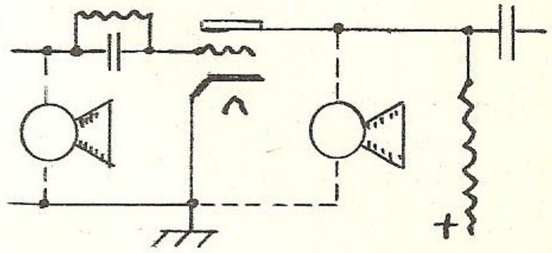
Earphones make the simplest form of microphone and may be used singly or as a set. The point to remember is to talk directly into them in order to vibrate the diaphragm. The old Baldwin Mica diaphragms work best for this as they vibrate easily. Speech is reproduced more easily than music, as the former is more accented. Phones may be plugged into a Phonograph pickup jack for reproduction in most combination sets. A switch may be hooked in series with the phones for "fake" announcements, heckling, etc.

Phones may be hooked to a steel guitar by means of a brass



escutcheon pin fastened to the diaphragm of phone, and just fit to touch the instrument frame. Also, the pin idea may be put into a box with a 1/8" plywood front as sounding board for a microphone.

Some connect from grid to the ground of detector tube. Others connect from plate to Cathode when using phone as microphone.

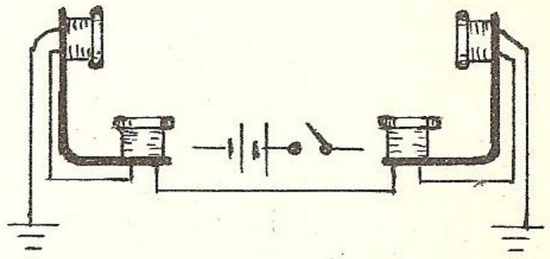


See which one works best for the particular circuit you may use.

BATTERYLESS TELEPHONES.

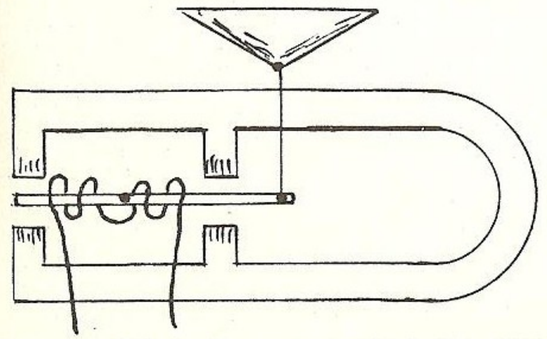
History repeats itself. The receiver is still used as a Mike by Phone men, in case of an emergency to call Central when the power supply fails. It isn't considered efficient by the Telephone Company.

We have several reports of successful operation of phones connected as French phones, in series as per diagram. Distances



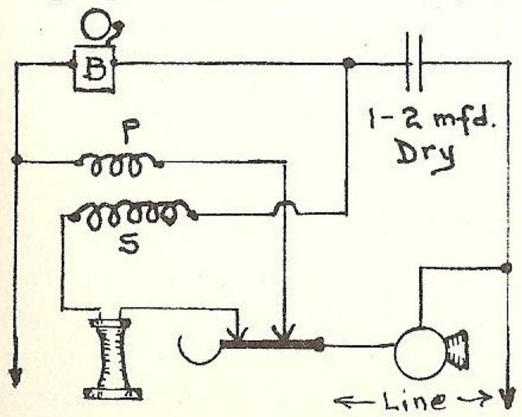
up to 150 ft., and across the street have been reported, altho some say it will work a mile with no batteries. It is best to use 1 to 4 drycells for efficient operation. The ground acts as 1 leg of the circuit. Accentuation of the diaphragm breaks the lines of force, that generate energy to operate the other phones. Some lay it onto static, but this is probably not noticeable. Call bells, etc. may be added, if desired.

Bell Labs. have developed a more efficient phone along this line, but using a balanced armature, like the old cone speakers. The diaphragm is Duralum-



inum, which is connected to one end of the armature, like the Baldwin phones. Moving of the diaphragm breaks the lines of force, and emits more energy than vibration from a regular phone. Each instrument serves as a transmitter and receiver. Calls are made by a toothed iron disc run close to the magnets (like our old 400 cycle generator for code practice in 1920). Each unit weighs 2 lbs. and in a waterproof box 3" square.

This is a regular telephone circuit, using induction coil to step up the volume. Primary (P)



runs thru the mike; the unevenness of its contact makes and breaks the primary circuit. This induces stronger currents into secondary (S), which increases the distance of operation. Core is ½" dia. x 3" long, packed with iron stove-pipe wire. Pri. is 2 layers of No. 20 DCC; Sec. is 12 layers of No. 34 Enameled. Cond. may be several bypass condensers stacked, to make 1 to 2 mfd. Do not use electrolytics.

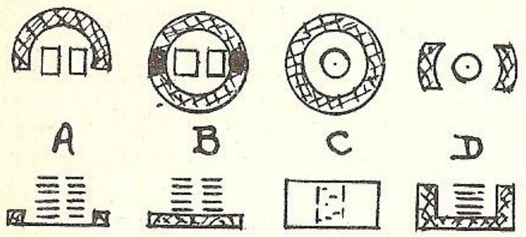
Chapter 8.
Classifications.

We will attempt to classify phones into 5 general groups. (1) Fixed coil, which may be sub-divided into (a) Standard, (b) Miniature and (c) Continuous current; (2) Fixed coil-acoustic; (3) Fixed coil-balanced armature; (4) Dynamic and (5) the Piezo-electric.

FIXED COIL.

(a) Standard phones. Heretofore, most data has concerned this type of phone. The majority of phones come under this class. The principle is the permanent magnet with an electro-magnet of fine wire, working a diaphragm. Phones of this group have been manufactured in various forms for over 70 years, but the principle is the same.

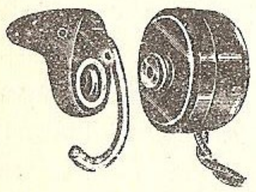
Many manufacturers have seen fit to make their's a little different. While most phones use a double coil, some may use a single. The diagram shows some methods of using the permanent magnet. (A) the magnet may be



single, and used in most phones, or it may be stacked. (B) magnets may be one on each side of the pole pieces, as the Brandes. (C) Magnet may be a tube-type with an edge pulling on the outer edge of diaphragm and the other pole going thru the coil. (D) the bar magnet may be bent and coil fastened in the center. Some units are open; some covered, while others may be sealed in wax.

Under this class of phones are the Trimm, Acme, Brandes, Trimm group hearing-aids, Murdock, Cannon Ball, Frost, etc. to list just a few. For repairs, see Chapter 6 "Phone Repairs."

(b) Miniature phones. These are the hearing-aid phones and the small Army phones used during the War. The principle is the same as Standard phones but they are shaped differently.



Courtesy Trimm.

Hearing-aid phones usually are made with individual ear-molds to fit each ear. The diaphragm is located directly outside the mold, in the cap of the unit which contains the magnets. The magnets are 36% Cobalt steel. Furnished in resistances from 1 to 2000 ohms DC.

One company makes a hearing-aid phone similar to an ear-ring for the ladies. An almost invisible plastic tube carries the sound from the phone to the ear. Various designs are produced.

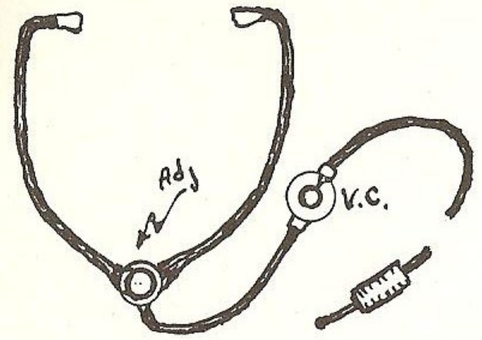
The Army unit is slightly larger than a hearing-aid, and uses a headband to hold it in place. A rubber tip fits into the ear. Pressure on a small ¼" rubber ring often made the unit unbearable against the ear. They are low-impedance units, using a transformer built into the cord. Weight is taken up by a clip on the clothing. Impedance 128 ohms Alnico magnets; response 100 to 10,000 cycles.

All hearing-aid phones should be returned to the factory for repair.

(c) Continuous current phone. Described under chapter 5 "Radio vs Line Phones." No information on them, except they do not use a permanent magnet - current being furnished by external batteries. Entirely a line phone proposition.

2. FIXED COIL-ACOUSTIC.

We believe this class is confined to the Telex Monoset make. Instead of a headband, this goes under the chin like a stethoscope. It is very light, being but 1.2 ounces complete. Due to its arrangement, claim is made that it may be used for long



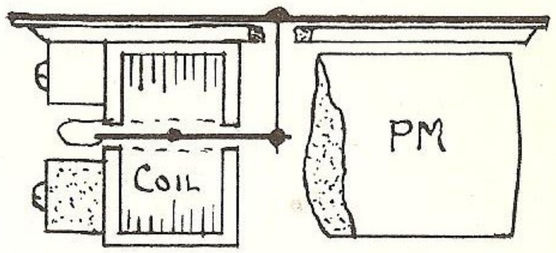
periods of time without tiring. The only unit having a built-in volume control.

The phone uses a midget phone unit, placed at the junction of the cord and the two Tenite plastic tubes running to the ears. Tubes have replaceable plastic ear tips. Tips may be placed inside the ear cavity for weak signals, or hung in the ear to hear room sounds, also.

They are made in impedances of 128, 500 and 2000 ohms. An output transformer must match the 128 and 500 ohm sizes, but the 2000 ohm may be used like other phones. The loudest signals will determine correct polarity, so try the tips both ways. Like the other phones, they should not be used on powerful sets without a bypass condenser in series. The frequency response is 50 to 3000 cps. Units are repaired at the factory.

3. FIXED COIL-BALANCED ARMATURE PHONES.

Called Mica-diaphragms, or Amplitone phones. Formerly sold under the name of Nathaniel Baldwin, of Salt Lake City. Like many a scientist, Mr. Baldwin was a genius, but not up to the pitfalls of business. If many of us could experiment along our own line, without the trouble of making a living, it would be a sweet life. I suppose the patents prevent others from making this phone, which has long been off the market. It was hard to equal on weak signals, but would blast on strong ones. The phones of today hit a better average. See Chapter 3 "Diaphragm Vibration" for an explanation of its principles.



The phones were made with Mica diaphragms, and later with corrugated Aluminum for use as speaker units. Thousands of these units were sold. Of course the mica type was more sensitive to weak signals, while the Aluminum type carried the stronger signals better. Then, the pin ran thru the center where it was able to vibrate better. The armature was pivoted in the middle-which allowed a pull on each end to help it along. On one end was the pin that ran to the center vibrating point of diaphragm. A wire guide helped control some of the louder tones.

The magnets very seldom, if ever, needed re-magnetizing. They were formed in a circle and as they came together in a lap -

the coil was placed in between.

If the pinhead thru the mica becomes loose, fix it solidly by applying a drop of 1 part each of Rosin and Beeswax over the pinhead with a hot iron. Kink also used on old Phonograph reproducers.

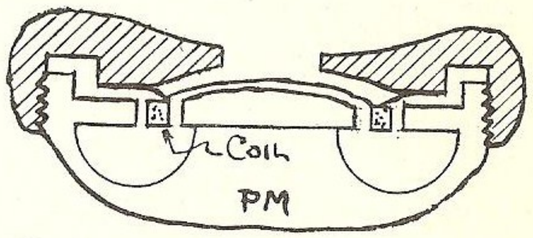
If the diaphragm becomes warped, pulling the armature over to one side, here is a way to fix it in a jiffy. Push a small pc. of calling card in each side of armature - to make it even on each side and in the center. Then touch a soldering iron to the soldered pin and armature at the contact. You will hear it click, as solder melts - to make a new joint. Remove iron and cards, and your Baldy's will be centered good as new.

In re-winding Baldy's - remove the coil and unsolder pin from armature. Pull wire off while coil unwinds in a jar (see Chapter 6 "Phone Repairs"). Test each break to see if you get a thru circuit. If only a few layers off - no need to re-wind it. If it takes a lot of wire, proceed as follows: Stick pin in alongside armature, and solder it down to armature so it doesn't flop around. Snip head off the pin and place in hand-drill. Put latter in vise, then it is easy to re-wind. At the finish, place stranded lead back on, and assemble. Test for continuity. Fix pin as done in above paragraph. Being one magnet, it can be rewound in any direction.

Besides trouble on loud stations, these phones are heavier than standard phones now used.

4. DYNAMIC PHONES.

"Dynamic" means magnetic induction produced by a moving magnetic field on another field or body. A PM speaker is still a dynamic, as it's voice coil moves in the field of a permanent magnet. Modern dynamic speakers furnish their own excited field of DC. Their principles are the same.



Dynamic phones use a voice coil on a self-supporting ribbon attached to diaphragm, which moves in and out when it acts on the permanent field magnet of the phone, just like a dynamic speaker.

In 1930, the Bell Labs. had their B-598, moving coil phone, or Dynamic. Advantages given were abscence of static force, constancy of force factor over a large frequency range, and freedom from distortion. The modern dynamic speakers took away the distortion caused by diaphragms and armatures beating against

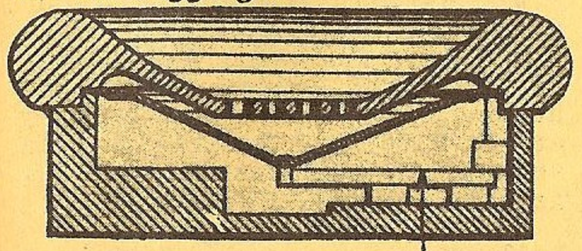
pole pieces of old horn and cone speakers. Response was given as 2 to 10,000 cps. Bell also had a moving coil Mike in 1930.

Army dynamic phones were made by Magnavox during the War to be used in Tank inter-com. equipment. They are approximately 2" dynamic loud-speaker units, set inside a housing held to the ears. At the end of the War, the Army and Navy Air Forces combined on a more advanced design, a few of which were manufactured. None are being made now. Shockproof, weatherproof and altitude proof.

5. PIEZO-ELECTRIC PHONES.

Piezo-electric means a power to convert electrical to mechanical energy, or vice versa. Application of electricity causes the crystals to vibrate at their fundamental frequency. Conversely, bending or squeezing of the crystals cause them to give off electricity, which may be measured.

There are more than 100 combinations of Xtals that have this property of oscillation. Manufactured Xtals are gradually replacing expensive Quartz. During the first World War, Rochelle salt Xtals recorded enemy trench diggings.



Courtesy Brush Xtal

As a result, the Brush Development Co., of Cleveland, apply this vibrating principle to earphones. A form of Rochelle salt .03" x ½" x ½" is used. Vibration of Xtal is transferred by a lever magnifying action to a Bakelite diaphragm, which is made flat as well as conical. Crystal has a life up to 10 yrs. if not placed in dampness, over 130 deg. F., or exposed to heavy direct current.

Advantages of Brush phones are their light weight. They do not affect compasses, or instruments affected by magnets. They may be hooked across a hi-impedance circuit without any shorting effect. Response from 100 to 10,000 cps. Rugged and shockproof.

They connect like other phones with the same care for hi-power circuits. Some Brush phones have a condenser and resistor built in for tonal qualities. A volume control of 100,000 ohms can be connected across the phones.

As Brush phones are housed in hermetically sealed cases, it is necessary to return them to the factory for salvage and replacement.

Brush has an efficient Crystal growing 'farm' at Cleveland. They are grown similar to rock salt. Supersaturated Rochelle salt solutions are poured into great vats. Tiny Xtal bars, which have been cut like seed potatoes, are lowered into the solution. Temperature is started at 100 deg. F are slowly dropped 1 deg. per