Amplification without Distortion

Acme Apparatus Company

SIXTH EDITION

Amplification without Distortion

A Discussion on Radio with Particular Reference to the Construction and Operation of Radio Audio and "REFLEX" Amplifiers and Sets.

Have you ever stopped to consider what makes it possible for you to hear the distant broadcasting station, to fill the room with music, to communicate with the amateur hundreds of miles away? It is amplification—the key to Radio.

Amplification is used on both the transmitter and receiver, and with it the singer's voice in New York is transported to the farm in Ohio, or the President of the United States talks to the whole country just as though he were in millions of homes at the same time. But Radio without amplification would be a ship without a sail!

Amplification eliminates distance and permits a room or hall full of people to be entertained simultaneously, but the limits of radio and amplification should be clearly understood, especially in regard to distance. The transmission range of radio varies greatly between day and night, city and country, summer and winter, and from night to night, and in such a manner that no exact range can be specified for any particular set.

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At times the most simple radio set will pick up broadcasting stations at considerable distances away, but usually this reception is a freak, and cannot be duplicated at will. As the set becomes more elaborate (that is, as amplification is added) the reliable distance over which it will operate becomes greater and greater up to a safe estimate of 300 to 500 miles in the winter evenings when using a loud speaking telephone and loop antenna. By reliable distance is meant reception over the same distance night after night for a month or so. On some of these evenings, stations a thousand miles away will be heard, but the operator cannot be sure of tuning them in, cannot say to a room full of people, "I will now let you listen to such and such a station one thousand miles away."

Beware of Extravagant Claims

On the purchase or building of a set, beware of extravagant claims, and do not expect the unusual all the time. Obtain reliable apparatus and you will have a dependable radio set which will provide entertainment at will. Use amplification for distance and volume.

Distortion and Amplification

It is not enough, however, just to amplify. With the vacuum tube, amplification can easily be obtained, but to amplify without distortion is a feat which requires skill and knowledge acquired by long study and development. When you hear the opera singer's voice from New York sound like cat calls, you have amplification — but you also have distortion. The source is excellent, but the energy of the voice goes through so many pieces of apparatus and changes in form that, unless great care is exercised, it reaches your ears garbled and unrecognizable. Distortion causes more trouble in radio than static, yet books have been written about static, and distortion seems to have been taken for granted. Static is a natural, uncontrollable function of the elements; distortion is a controllable function of man-made apparatus.

Most of the books on Radio neglect the question of distortion, but reference is here made to Radio Engineering Principles, Lauer & Brown, McGraw-Hill Company, page 251:

> "In order to obtain a perfect speech reproduction, it is necessary that the current set up in the telephone receiver circuit at the receiving station be exactly and in all details proportional to the current in the microphone circuit at the transmitting station. It is therefore essential that no distortion whatever of the microphone current variations be permitted to occur in the amplification of the microphone current, in the modulation of the generated oscillations, in the transfer of these modulated oscillations to the transmitting antenna circuit, in the transmission of the waves between the transmitting and receiving stations, in the transfer of energy between the receiving antenna and the detector and amplifier circuits coupled thereto, and finally in the rectification and amplification of the received signals. If at any one of these stages a distortion of the speech is allowed to take place, the sound at the receiving station will not be a true reproduction of the voice at the transmitting station, and the speech will be distorted to a greater or less extent and may even become entirely unintelligible. The engineering which is necessary at each stage is therefore taken up briefly in the following paragraphs."

and on page 254:

> "The above discussion on distortion is far from complete and merely points to several of the more important sources of speech distortion. It is impossible in a book of this scope to enter into greater details, but this subject is one requiring careful consideration in designing actual circuits."

The Acme Apparatus Company have devoted the majority of the time of their engineering and experimental departments to the study of amplification without distortion, and as pioneer transformer and radio engineers and manufacturers have produced a line of amplifying apparatus and transformers which accomplish the results desired.

Good Broadcasting Stations Are Not Distorted

The modern broadcasting station transmits radio telephony with practically no distortion; that is, the public have available a source of radio energy for entertainment and education. The receiving process may briefly be described. The receiving antenna absorbs a small portion of the available radio energy, bringing it unchanged to the living-room table. Here it is transformed in one of several ways, depending on the type of radio receiver used, into audio energy. The Acme Apparatus Company have found the simple vario-coupler method (as shown in the diagrams) to be the best method of tuning and preparing the radio energy either for amplification while the energy exists at radio frequencies, or for detection, or the changing from radio to audio energy, and the vario-coupler does not distort.

The next step is to decide from what distance one wishes to receive broadcasting or signals, and whether head phones or a so-called loud speaker will be used. Let us start with the simple set known as the crystal detector outfit.

The Simplest Receiving Set

A crystal detector may be connected to a vario-coupler, as shown in Figure 1, and when using head phones, very good reception may be obtained. The slight chances of distortion lie only in the head phones, as the crystal detector is almost a perfect detector; in other words, the radio energy is changed to audio without distortion. As a rule, head phones have a natural audio period which makes voice frequencies of this period louder than those of other periods. This is known as resonance or the relatively free passage of energy at one frequency and the suppression of energy at other frequencies. On the head phones, however, this resonance phenomena is considerably reduced when worn against the ears, on account of damping or suppression of energy at all frequencies.

The crystal detector set is greatly limited in reception distance and restricted to the use of head phones. Therefore, in order to increase its receiving range or to add a loud speaker, amplifying apparatus must be employed, bringing in a new source of distortion unless care is exercised in the selection and use of this apparatus.

For Greater Distance

To increase the range of a crystal set, radio frequency amplification should be used; that is, the energy is increased at the receiving station while it exists

as radio, after transfer by the vario-coupler and before rectification or change from radio to audio by the crystal detector. For such amplification, as shown in Figures 2 and 13 a vacuum tube, a radio frequency amplifying transformer, and accessory apparatus are necessary, but with the proper apparatus, correctly connected, no distortion occurs, even though several stages of amplification are used.

The next simple set is the single vacuum tube detector set. Here the complicated nature of the detector tube characteristics, as compared with the crystal detector, allows a new source of distortion. More adjustments and variables enter into the operation, and its ability to oscillate opens up another phase. Just how to add radio frequency amplification to a vacuum tube detector is shown in Figures 3 and 15.

For Greater Volume

To increase the volume of a crystal detector or vacuum tube set, audio frequency amplification must be used; that is, the energy is increased at the receiving station after it has been changed from radio to audio by the detector. As shown in Figure 4, a vacuum tube, audio frequency transformer, and accessory apparatus are necessary. Fig. 13 shows how to increase the range and volume of a crystal set using one tube. Distortion is much more liable to occur in an audio frequency amplifier than in a radio frequency amplifier because the energy is being handled at frequencies most easily distorted.

The Heart of the Amplifier

The transformer is the heart of the amplifier. Here the voice currents are transferred from one circuit to another through a magnetic field. These two circuits are not conductively connected. Before the days of broadcasting, amplifying transformers were purposely made to have an audio resonance around 1,000 cycles, so that the prevailing spark frequencies used in radio telegraphy would have free passage through them. But telephony deals with many frequencies simultaneously so that it becomes necessary to eliminate resonance from the transformer. Resonance in the transformer allows one or a few frequencies to come through much more easily than others, causing great distortion. If two or three stages of audio frequency are used, any distortion occurring in the first stage is amplified by the succeeding ones in addition to whatever distortion these succeeding ones introduce. Acme Transformers do not distort.

Resonance in Radio

To understand the loud speaker, the meaning of resonance must be thoroughly appreciated. How distortion may occur in a telephone receiver or head set has already been mentioned. This is another example of resonance, which may be termed the friend and foe of radio. Without it we could not have radio, because we could not efficiently transmit or receive, yet with it we may have distortion. Hence resonance is a friend only while the energy exists at radio frequencies (example, tuning and selectivity), and a foe while it exists at audio frequencies (example, distortion).

A loud speaker is a telephone receiver removed from the ear and equipped with a horn or concentrator of sound similar to a megaphone. Horns, too, have

resonant points unless properly constructed. Hence, in developing and designing the Acme Kleerspeaker for exact reproduction by telephone, sound engineers outside the Acme radio laboratories were employed as the problem is not strictly one of radio.

Summary

In a crystal detector or vacuum tube set with radio frequency amplification, audio frequency amplification, and Kleerspeaker, properly connected and with properly constructed parts, the broadcasting is reproduced identically as transmitted.

To summarize, with improper apparatus or connections, distortion may occur at the following points:

Tuner
Radio Frequency Amplifying Transformer
Vacuum Tubes
Detector
Audio Frequency Amplifying Transformer
Telephone Receiver
Loud Speaker
Horn

There is another source of distortion which comes into the best of sets and which, under existing conditions, cannot be eliminated. This distortion is caused by radiating receivers or other broadcasting stations of approximately the same wave length interfering with the station from which the entertainment is being received. Fortunately, it does not always exist and can often be corrected by adjustments.

The Acme Apparatus Company manufactures a complete line of amplifying apparatus with the exception of vacuum tubes, and its products demonstrate their belief in amplification without distortion.

TYPES OF AMPLIFIERS

There Are Three Types of Amplifiers in General Use Today

1. The audio frequency amplifier used after detection and for increasing the volume of signals. More than three stages is not recommended.

2. The radio frequency amplifier used before detection and for increasing the distance from which broadcasting may be received. More than four stages makes a set too sensitive for every-day use.

3. The "Reflex" amplifier or combination of radio and audio amplification using the same vacuum tubes for each kind of amplification. With this amplifier both distance and volume can be obtained.

The "REFLEX" Amplifier Is Strongly Recommended

If you are going to build a set, the "Reflex" set is strongly recommended on account of the economy of vacuum tubes, a greater overall efficiency than the same number of stages of amplification in a straight radio and audio set, the excellent results, the ease of construction, the lack of tricky connections and the ease and selectivity of tuning.

The "Reflex" circuits lend themselves readily to board or panel and cabinet mounting and when constructed, the operation is extremely simple and the range and selectivity on both antenna and loop astonishing.

"Reflex" circuits do not distort.

Features every radio set should have.

No matter what radio set is built or purchased it should have the following features for satisfaction.

1. Quality.
2. Volume.
3. Range.
4. Ease of operation.
5. Ease of construction.
6. Non radiating.
7. Sharpness of tuning.
8. Ruggedness.
9. Small upkeep expense.
10. Low cost.
11. Reliable manufacturers products.

The Reflex Set fills these points best of all.

BEFORE CONSTRUCTING A SET BE SURE TO READ THIS BOOK.
IT CONTAINS MANY HELPFUL IDEAS

AUDIO FREQUENCY AMPLIFYING APPARATUS AND CIRCUITS

How to Get the Most Out of Your Audio Amplifier "Audio for Volume"

While the connecting together of a set of parts for an audio frequency amplifier is relatively simple, there are certain precautions which should be taken in order to obtain maximum efficiency and freedom from distortion. These are embodied in the diagrams given in this booklet and should be followed exactly to obtain the best results.

A properly designed audio frequency amplifying transformer for use on voices and music should have no marked resonance over a band of from 50 to 5,000 cycles. With the tubes now on the market, a ratio between 4 and 4½ to 1 should be used for obtaining the above result.

In order to eliminate marked changes in impedance and hysteresis losses in the iron with consequent distortion caused by too high flux densities in the iron, it is necessary to leave a slight air gap in the core.

When using transformers in which the above points have been disregarded, it is necessary to use resistances, condensers, different ratios in the different stages, and other expedients to reduce distortion. All of these cause losses and diminution of signal strength. As none of these things are necessary with the Acme Audio Frequency Transformer, they are not shown in the circuits.

The following points should be carefully observed in constructing an amplifier of maximum efficiency:

1. The grid of the tube should be connected to the outside leed of the secondary (3rd Binding Post). Marked G. This leed should be as short as possible and run at right angles to other closely adjacent leeds.

2. When using potentials of 66 volts or less on the plate, good results are obtained with all of the standard tubes now on the market by connecting the inside leed (4th Binding Post) marked A — of the secondary direct to the negative side of the "A" battery. With potentials over 66 volts, a grid bias or "C" battery should be used, as shown in Figure 6. The value of this battery potential will vary with the "B" battery potential and type of tube within limits of 2 to 12 volts. The exact value for best results should be found by trial, or the tube manufacturers instructions. This is extremely important with UV 199 tubes.

3. As the stray field from a properly designed transformer is very small, shielding is unnecessary. It is sometimes advisable, due to capacity effects to ground the transformer cores.

4. The rheostat should always be connected in series with the negative side of the filament, and the inside of the secondary (A-) connected to the battery side of the rheostat.

5. At the present time there is considerable misinformation being circulated regarding the advantage of using transformers having different ratios — that is, 9 to 1, 3 to 1, 5 to 1, etc. — in the different steps of a multistage audio frequency amplifier.

This is an attempt on the part of the writers of the articles in question to reduce the inherent distortion in the ordinary resonant amplifying transformers by combining transformers having different resonance points. For instance, a 9 to 1 transformer having a resonance point at say 1,200 cycles is combined with a 5 to 1, perhaps, having a resonance point at 800 cycles, and if a third stage is used, a 3 to 1 is added with a resonance point at possibly 600 cycles. Needless to say, this is only a compromise to somewhat broaden the ultimate resonance curve and the results will not be comparable with those obtained when two or three identical transformers of proper design are used.

Different ratio transformers are also advocated in an endeavor to prevent overloading the tubes in a multistage amplifier. Since this method can only succeed by using an inefficient transformer in the first stage, it should never be considered, as a large portion of the available energy is wasted.

The proper way to prevent overloading of the tubes on strong signals is to use a somewhat lower voltage on the first tube, increasing on the second and reaching a maximum on the third, as shown in Figure 6. It is seldom necessary to do this when employing but two stages of audio frequency amplification unless extremely loud signals are being received.

It is also sometimes advisable when using a three stage amplifier to connect two tubes in parallel in the last stage. This procedure eliminates all chance of overloading and delivers ample energy for the average loud speaker.

6. Due to the resistance of the "B" battery at audio frequencies, it is sometimes advisable to connect a 2 m. f. condenser across it.

7. The low voltage tubes now available are very microphonic and ring when any part of the set is touched. This is due to their delicate grid structure, and may be almost entirely eliminated by acoustically insulating their sockets. Soft rubber washers between the socket and its support will do this.

8. Some of the tubes now available take a rather high plate current and this causes distortion by saturating the iron core of the amplifying transformer. If this trouble is experienced, the air gap, used in all properly designed amplifying transformers, should be opened slightly by inserting a piece of cardboard or other non-magnetic material between the ends of the core. This rarely if ever happens in a properly constructed transformer. The air gap and wire in an Acme transformer is sufficient to stand great overloading.

MOST COMMON CAUSES OF IMPROPER OPERATION OF AN AUDIO FREQUENCY AMPLIFIER

What to Look for in an Inefficient Audio Amplifier

1. Inside of secondary (4th Binding Post) marked A—improperly wired to positive instead of negative side of "A" battery.
2. Defective tube. See that elements do not touch each other.
3. Discharged or low voltage "A" or "B" battery.
4. Open transformer winding.

   Note: This may be ascertained by connecting each winding in turn in series with a "B" battery and pair of phones. If a sharp click is not heard, the winding is open, and the complete transformer should be returned to the manufacturer for replacement. After five years' research this difficulty has been practically eliminated in Acme Transformers.

5. Loose connection or open circuit in wiring. All connections should be soldered, using resin flux. If this is not possible, the wires should be scraped clean and securely clamped under the binding posts or screws.
6. Loose connections or dirty contacts on jacks. Filament control jacks, if used, must be cleaned at frequent intervals to prevent a high resistance contact and consequent low voltage on the tube filaments.
7. If unusual noises such as squeals, howls, etc., are heard, their location may be ascertained by disconnecting the antenna. If the disturbance stops when this is done, it is coming from outside and is probably caused by oscillating receivers, beating carrier waves, grounded electric lighting wires, etc., and is beyond the control of the operator. If it does not stop when the antenna is disconnected, the trouble is in the set and is probably due to:

   Low "A" or "B" battery. Defective tube.

   Use of resonant transformer. Leaks across wiring due to use of corrosive soldering flux.

   Improper wiring, connections, or arrangement of parts.

See note on page 17 regarding Acme Service.

RADIO FREQUENCY AND "REFLEX" AMPLIFYING APPARATUS AND CIRCUITS

How to Get the Most Out of Your Radio or "Reflex" Amplifier "Radio for Distance"

The radio frequency and "Reflex" amplifying circuits given in this booklet have all been tested and are recommended to those desiring the best results. They should be followed as closely as possible, and under no circumstances should plate vario-meters or ticklers be introduced in an effort to obtain regeneration. If this is done, distortion will result, impairing the quality of the received speech and music, and the distance over which broadcasting can be received will be reduced.

All connections should preferably be soldered, using RESIN FLUX. If the builder is not familiar with soldering, however, all wires should be scraped clean and securely fastened to screws or binding posts.

All leeds, especially those to the grid and plate, should be made as short as possible, and should not run parallel to other leeds for any great distance. The best leeds are made by using No. 14 solid copper wire, bent into shape and fastened securely, as shown in Figure 21. This illustration also shows an ideal arrangement of parts. Never attempt to wire up a radio frequency or "Reflex" set using flexible leeds connecting together a heterogeneous arrangement of parts.

In order to prevent interaction between radio frequency transformers, they should be mounted end to end in the set.

Outlined below is an analysis giving the salient points that should be followed in assembling any radio frequency or "Reflex" receiver from the simplest to the most complicated:

If phones are used, the various stages may be cut in by connecting the phone terminals across the primary of the audio transformer in the desired stage.

Antenna

The function of the antenna is, roughly, to provide a "pick-up" for the incoming oscillations. Were it not for static, radiating receiving sets, carrier wave beats, and other forms of interference, the best antenna for broadcast reception would be a single wire about 100 to 150 feet in length from the instruments to the extreme end suspended as high as possible. But due to the above stated reasons, the use of this type of antenna should be limited to the less sensitive types of receivers or to points at some distance from centers of population.

With the more sensitive receivers, the interfering noise may be reduced at some sacrifice of signal strength by using a smaller antenna. A small indoor antenna or loop gives excellent results with the more sensitive sets.

For summer operation, the use of a small antenna or loop is preferable, due to static conditions. The small antenna may consist of either a wire run

down a hallway 20 to 30 feet in length and connected to the set through a load coil system such as shown in Fig. 8, or a loop used as antenna. The way to make a loop is shown on Page 22. The best results will not be obtained when a loop is used in a metal frame or wire lath building.

Do not connect a loop to a set with twisted lamp cord or telephone receiver cord. Use separate insulated wire spaced at least 2 inches apart.

Grounding

The ground connection should be a No. 14 wire run as directly as possible to a water pipe. It should be fastened to the pipe by means of a good clamp.

On a loop set grounding the negative post of the A battery often helps.

Coupler

If an antenna is used, the circuit shown in Figures 8 and 9 are necessary for sharp tuning. The specifications for the coupler are given here and also a type recommended.

Condensers

Condensers having low losses should be obtained and preferably be fitted with a noiseless friction reducing mechanism for fine adjustment, particularly in the secondary circuit. A vernier or fine adjustment must be used on the condenser in a loop receiver. The Acme condenser is particularly designed for radio and reflex receivers.

Keep the condenser at the input side of the set.

Keep the wire from the grid to the STATIONARY plates of the condenser as short as possible.

Tubes

For best results use 201A or 301A tubes.

All of the standard vacuum tubes now on the market may be used with Acme Audio and Radio Frequency Transformers, but special precautions should be taken for the control of the WD 11 and 12 tubes.

It is best to control the WD 11 by using a Twin Rheo, as shown in Figure 13 rather than a potentiometer across the "A" battery. This method of connection provides control by introducing damping in the secondary circuit. This tube is not recommended for radio frequency use.

With tubes having a low internal capacity, such as the UV 199 and DV3, it is necessary to connect a fixed condenser of approximately 10 mmf. capacity across the grid and plate of the first tube. This may consist of a piece of mica .005″ thick with two pieces of copper with an overlapping area of about ¼″ x 5/16″. This will equalize the sensitivity of the set over the entire broadcasting range.

With sets using more than 2 tubes best results will not be gained with WD 11 and WD 12 types. If dry batteries are desired 199 and 299 tubes will give best results.

Potentiometer-Rheostat

It is always necessary to use a potentiometer and rheostat for controlling the operation of the first tube in a fixed transformer radio frequency receiver; it is desirable, although not absolutely necessary, to use both in all stages.

In order to provide a compact unit for this purpose, the Acme Pot-Rheo was designed, and we recommend its use. Any good rheostat, however, having the proper resistance and a potentiometer having a resistance of from 200 to 400 ohms may be used. Both units must be smooth in operation, otherwise adjustments will be audible in the receivers.

For four .25 ampere tubes use 6 ohm pot rheo.

Crystal Detector

If a crystal detector is used be sure to obtain a good crystal. (Brownlie's Quick Contact is recommended.) A crystal detector is like a "B" battery in that it wears out due to oxidization. A good crystal should be efficient for from six to eight months. You will find that a good crystal will stay in adjustment for a whole evening's entertainment and often for days at a time. Static and loud signals do not knock out a crystal in a radio frequency or "reflex" amplifier on account of the buffer action of the vacuum tubes.

The contact spring should be made of silver wire about No. 32 guage. If other than silver wire is used it is necessary to clean it at frequent intervals with 00 sand paper rubbed on contact point. Use a light contact.

Do not attempt to clean the crystal with anything. Dust may be removed with a stiff tooth brush. Keep your fingers off the crystal.

Keep the Crystal Detector away from the output leeds.

The Acme Apparatus Co. have been searching for a good fixed crystal, but regret to report they cannot find one.

Improvement in Four Tube Reflex Shown in Figure 19

It should be noted that figure 19 in the present edition of this booklet differs from previous editions in that a .00025 mf. condenser is now connected across the secondary of the first audio transformer. In parallel with this condenser is connected a 50,000 ohm resistance. This resistance can be obtained in the form of a grid leak.

The terminal marked G on the secondary of the second audio transformer now connects to the post marked F on the R-3. The A- post on the audio transformer goes to the A- bus. All other connections remain the same. When connected in this manner, using the apparatus shown, howling and squealing due to imperfect B batteries is largely eliminated and it is recommended for use with sets that are already in operation as well as those about to be constructed.

If a 50,000 ohm resistance is not readily obtainable, a piece of ordinary fiber should be fastened across the condenser by means of the screws used for connections and with the filaments of the tubes adjusted to their normal voltage and the point off the crystal a lead pencil mark should be placed across the fiber adding lead until the squealing or howling stops. The addition of too much lead will reduce the strength of received signals.

On sets having less than three stages of A. F. Amplification this resistance is not necessary.

INSTRUCTIONS FOR CONSTRUCTING AND OPERATING RADIO FREQUENCY AND "REFLEX" RECEIVERS

Helpful Hints Found by Actual Trial in the ACME Laboratories

First of all, do not expect the extraordinary on the first night that any new radio receiving set is operated. The transmission of long distance radio is affected by many things, and the skill of the operator of the receiving set has a marked effect on its range. It is somewhat similar to driving a strange automobile, at first the car does not seem to respond and handle as well as your own, but after a while its flexibility and ease of operation are quite apparent and often astonishing.

Rheostats

Care should be taken to see that the manufacturers' recommendations are followed in selecting the rheostat used, as too low a value of resistance will result in injury to the tubes.

Radio Frequency Transformers

In Figs. 17, 18 and 19 one pot rheo is shown for all tubes. This is correct for tubes of .3 amperes filament current or less, but if tubes of larger filament current are used, it is necessary to use a rheostat for each.

Recently the wave length range of broadcasting stations has been changed from 360 to 400 meters to 220 to 550 meters. In selecting radio frequency transformers be sure they cover the range. Fig. 23 shows how the Acme Radio frequency transformers do cover the broadcasting range. Use Acme R-2 for the first stage, R-3 for second and R-4 for third.

Although other than Acme transformers may be used in a reflex set we strongly recommend ACME because of their ability to give maximum amplification without distortion. They are designed just right.

Sockets

Use good sockets as a leak will absorb practically all of the slight amount of energy received by the antenna or loop. Never use fibre base sockets.

Tubes and Tube Contacts

Examine the tube contacts for lead oxide which is a non-conductor. Be sure they are clean.

When testing a set try different tubes if available or change the order of the tubes in the sockets. One defective tube will often allow a set to work to a slight degree.

Any of the available types of vacuum tubes may be used with Acme Transformers and will give results depending upon the characteristics of the tubes themselves. In other words to obtain the advantage of dry battery operation it is necessary to make some sacrifice of sensitivity and intensity. All types of vacuum tubes should be operated at their rated voltage.

Variable Condensers

Many radio frequency and reflex sets fail to operate efficiently because of a high loss variable condenser in the tuning circuits. During the last eighteen months the Acme Apparatus Company has seen many radio frequency and "reflex" sets constructed by novices, and the majority of those which failed to operate were found to contain high loss variable condensers. In order that the full efficiency of Acme Transformers may be obtained, we found it necessary to manufacture and sell a condenser of equal efficiency, as a radio receiving set is weakest at its weakest part. The collection of dust in a variable condenser introduces a poor dielectric and greatly increases the losses. Clean your condenser often, unless it is enclosed in a dust proof container as in the Acme.

By-Pass Condensers

The By-Pass Condensers shown in the diagrams should be the mica type except in the case of the 2 m.f. condenser, which may be the ordinary telephone paper condenser. This latter condenser serves as a by-pass for both high frequency currents to prevent losses and for low frequency currents to prevent audio howls.

B Batteries

Use from 66 to 90 volts

Although the same B batteries are shown for both vacuum tube detector and amplifier, better results will be obtained by using a separate B battery for each, as some B batteries are of such high resistance, variation in amplifier current affects the detector. If a separate detector B battery is used, the negative of the amplifier B battery should be connected directly to the positive of the A battery.

Under no circumstances should so-called protective resistances be used in series with the "B-Battery" as they will cause howling and squealing.

The plate current necessary for operating the vacuum tubes available is of such a high order that a storage "B" battery is desirable for operating results and economy.

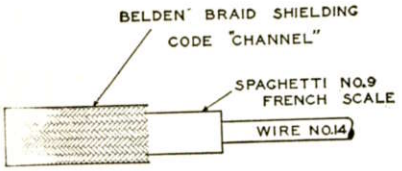
Wiring

The negative of the detector B battery should be connected to the arm of the detector tube potentiometer.

A shield may be made by placing a piece of spaghetti over the wire and over the spaghetti a piece of Belden braid or light weight copper tubing. (See next page). The braid or tubing should terminate ½" from the ends of the spaghetti and be grounded to the negative side of the A battery.

When grounding this shield use only resin flux on account of the chances of leaks.

If the B battery leeds are long put a 2 m.f. telephone condenser across the terminals at the set as a by-pass for the radio frequency currents.



Caution

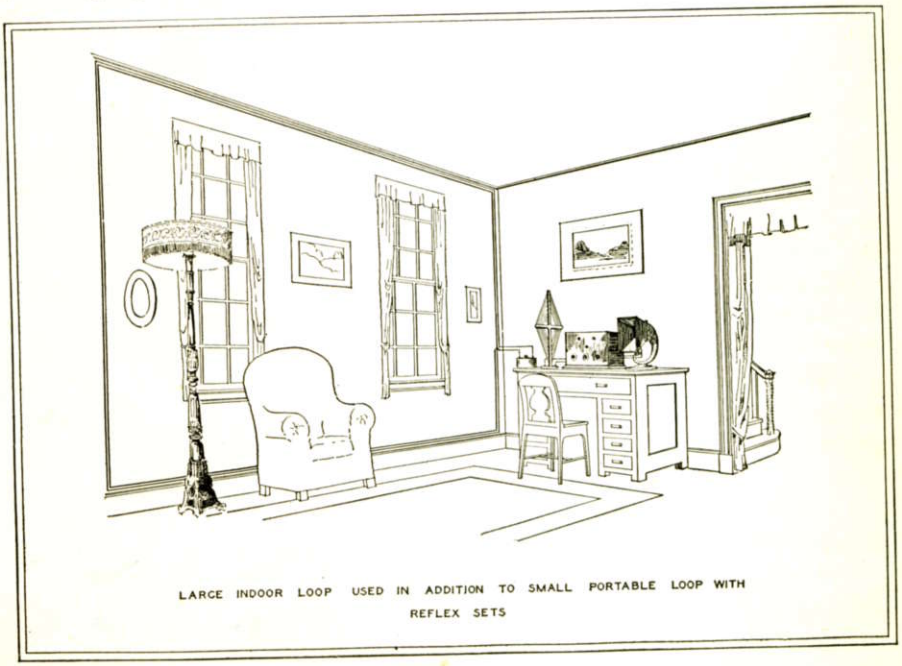
Be sure that the grid wire of the first tube is connected to the STATIONARY plates of the variable condenser. Failure to do this may cause almost total failure, due to body capacity effects.

Ten Year Efficiency

Radio engineers are prone to judge apparatus by a test showing its efficiency at that particular moment neglecting the five or ten year efficiency. When buying radio apparatus, ask yourself "will it stand up".

Follow the Diagrams Exactly

If you make a set according to the diagrams given in this pamphlet, follow them exactly. The continued success of the Acme Apparatus Company depends upon your getting results, and, therefore, we have spent considerable time in the laboratories to get the circuits right. We have tried to cover all the points regarding reflex sets in this pamphlet but we wish to again remind you that our engineering department is at your service for further information.



LARGE INDOOR LOOP USED IN ADDITION TO SMALL PORTABLE LOOP WITH REFLEX SETS

NOTE: On Increasing the Range and Selectivity of a Loop Set

Where the interference becomes a more or less negligible factor the loop set may be increased in range and selectivity by the use of a larger loop and variable condenser. The larger loop may be made by using about 100 feet of wire put up in the form of a one or two turn loop in a convenient part of the house, such as along the ceilings of two rooms, down the walls, and along the floor, connecting the two free ends to a .0005 variable condenser. This large loop has greater pick up and the coupling between it and the loop attached to the set is of such a loose order that sharp tuning may easily be obtained. The tuning adjustments then become two condensers and the coupling between loops.

This method is recommended where small loops (2 ft. per side and under) are used. See cut on preceeding page.

How To Operate a "Reflex" Receiver

1. After wiring up a "Reflex" receiver and putting the tubes in the sockets connect the "A" battery across the "B" battery terminals to make sure that they are not directly connected to the filaments. If they are the tubes will light, if not, it is then safe to put the "B" battery and "A" battery on.

2. Light the tubes by turning on the rheostat; gently tap each of the tubes and note if a ring is heard in the phones or loud speaker. This is by no means an indication of the sensitivity of the set, but shows whether or not the audio amplifier is working.

3. Tune in any signal or broadcasting station and adjust the crystal (if one is used) to a point of maximum sensitivity.

4. For tuning in stations on an antenna set the coupler to maximum coupling, turn the potentiometer arm to the positive end, rotate the secondary condenser until a station is heard and then tune the antenna circuit to maximum intensity with the antenna condenser. If no signals are heard or if louder signals are desired turn the potentiometer arm towards the negative end up to the point where the set squeals, the most sensitive operating point being slightly back towards positive from this position.

You will find that the potentiometer can be turned nearer the negative end on the longer wave lengths.

After a few nights' operation you will know just how much you can turn the potentiometer arm for maximum sensitivity for each setting of the secondary or loop condenser.

For sharper and more exact tuning reduce the coupling until the signal is just audible, then retune both primary and secondary. A little practice will show just what coupling value is best for a given station.

For loop tuning, place one hand on the condenser and the other on the potentiometer knob. Tune the condenser until a station is heard and turn the potentiometer arm toward the negative side for louder signals or greater sensitivity. These are the only tuning adjustments necessary outside of turning the loop.

With either the loop or antenna any given station may be tuned in at will after once being heard if a record is kept of the final adjustments.

MOST COMMON REASONS FOR FAILURE IN OPERATION OF A RADIO FREQUENCY OR "REFLEX" RECEIVER

What to Look for in an Inefficient Radio or "Reflex" Receiver

1. Short circuited lighting arrester.
2. Loose and high resistance connections in antenna, and defective insulation.
3. Low values of inductance in primary and secondary circuits of variocoupler — loose connections to rotor — short circuited turns in primary or secondary.
4. High loss, inefficient condensers.
5. Defective vacuum tube.
6. Discharged or low voltage storage battery.
7. High resistance leeds from storage battery to filament connection on sockets, causing low voltage at tube.
8. Dirty tube contacts.
9. Use of corrosive soldering flux, causing leakage.
10. Incorrect connections.
11. Use of tickler coil or plate variometer in an attempt to obtain regeneration.
12. Long leeds, particularly grid and plate connections.
13. Poor crystal in detector.
14. Exhausted or low voltage "B" battery.
15. Open potentiometer winding.
16. Poor ground or high resistance ground connections.
17. Incorrect transformers. For broadcast reception, these should be — Acme R-2 first stage, Acme R-3 second stage, and Acme R-4 third stage.
18. Poor grade of spaghetti.
19. Jacks in the Radio frequency circuits.
20. Use of too heavy cat whisker.
21. Use of incorrect loop leeds.
22. Attempt to combine R. F. transformer with regenerative set.
23. Poor soldered joints.

If, after following the above instructions, satisfactory results are not obtained, the Acme Apparatus Company will be pleased to have you communicate with their Engineering Department, describing the complete set and accessories with a sketch showing the location of the parts.

This service is given gladly and free of charge, for the Acme Apparatus Company does not consider a sale complete until the customer is satisfied. All Acme products are guaranteed against defects in workmanship and material, and should any such develop, will be repaired or replaced free of charge upon return to the factory with the guarantee tag attached for reference.

DIAGRAMS OF RADIO FREQUENCY SETS AND AUDIO AMPLIFIERS

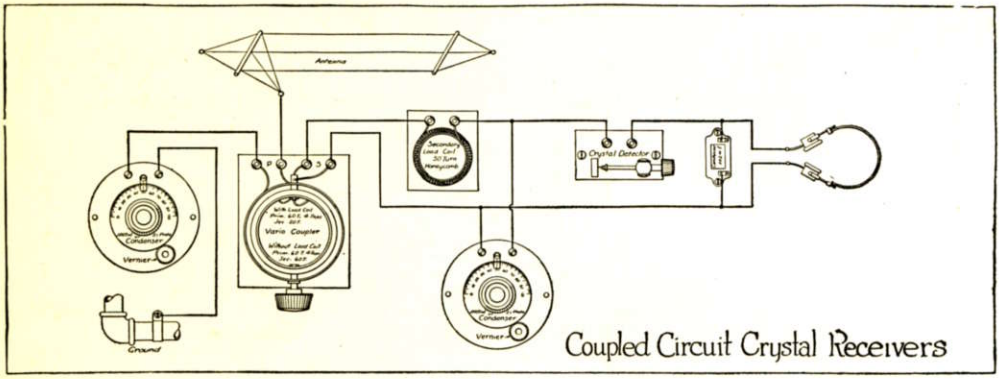


Figure 1

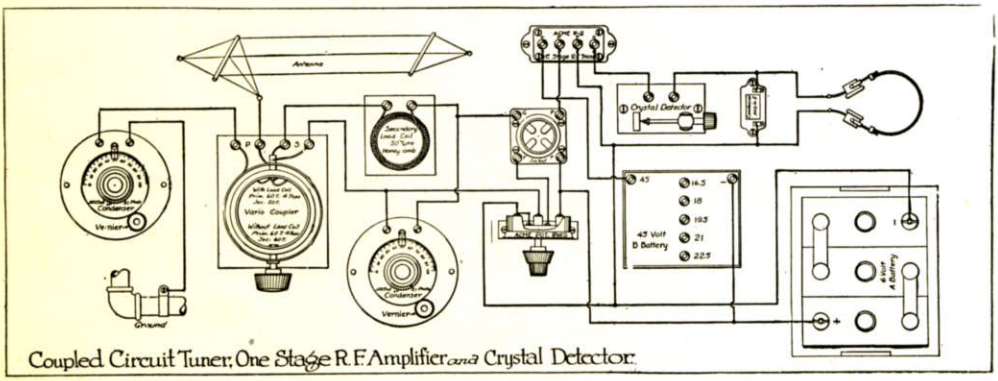


Figure 2

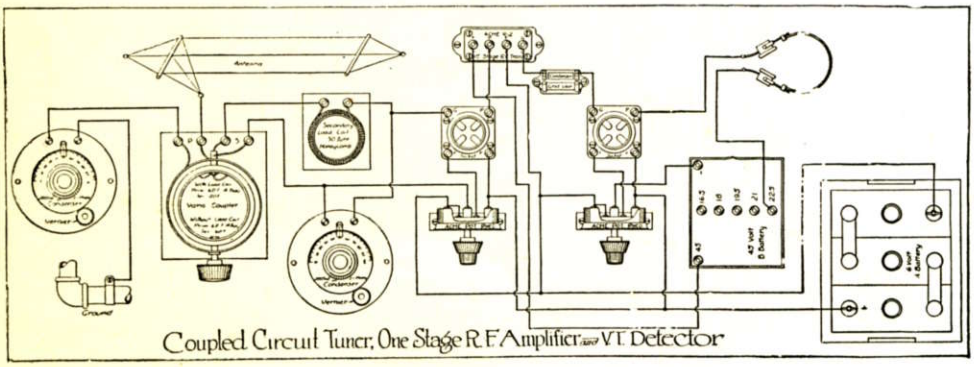


Figure 3

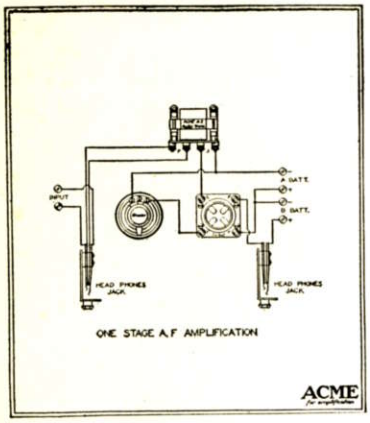


Figure 4

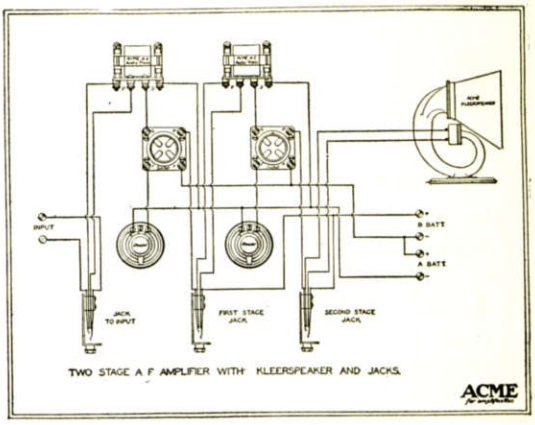


Figure 5

Either of the above circuits may be used with that shown in Fig. 7 by connecting the INPUT of the A. F. AMPLIFIER in place of the head phones shown in Fig. 7.

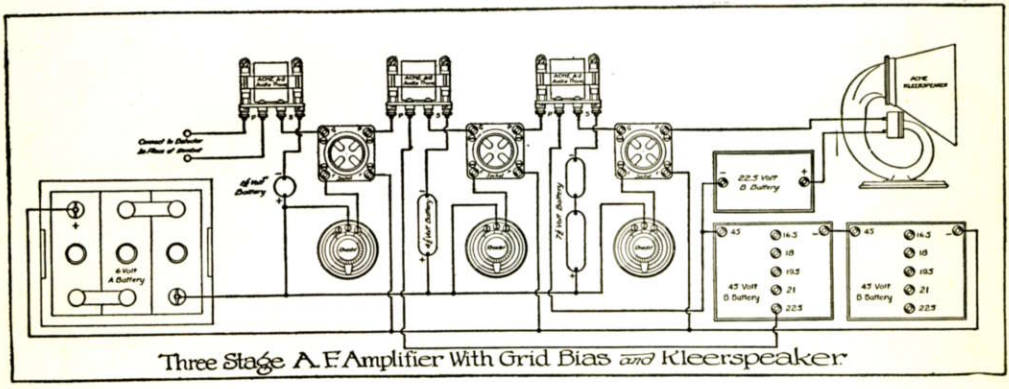


Figure 6

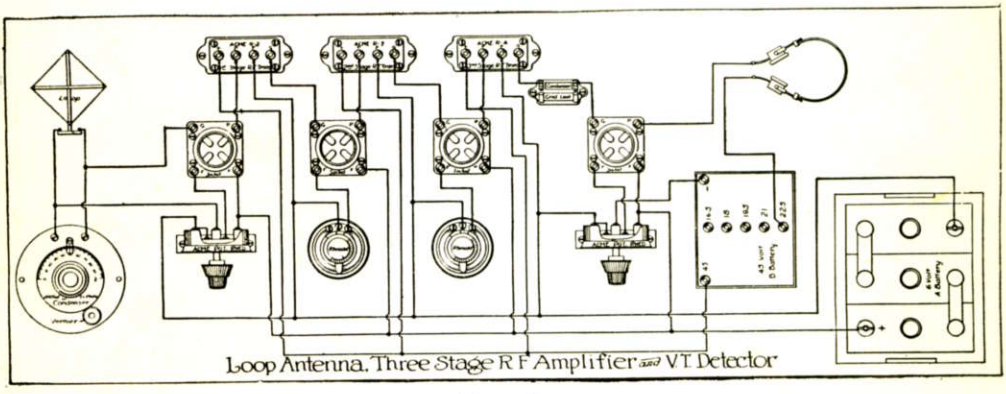


Figure 7

DIAGRAMS OF "REFLEX" SETS

For simplicity the diagrams of "Reflex" Sets are divided into Tuning Circuits and Reflex Amplifiers.

The "Reflex" Set is the logical set to build and is not any more complicated than the straight Radio and Audio set, and gives better results.

The difference between the Pot Rheo and the Twin Rheo is that the former is used as a potentiometer across the A battery for control, and the latter as a non inductive resistance in series with the secondary condenser for control. When low voltage tubes are used (1½ volts) the Twin Rheo must be used, while with 3 to 6 volt tubes the Pot Rheo method is the best. The twin Rheo should be used with Fig. 14 only.

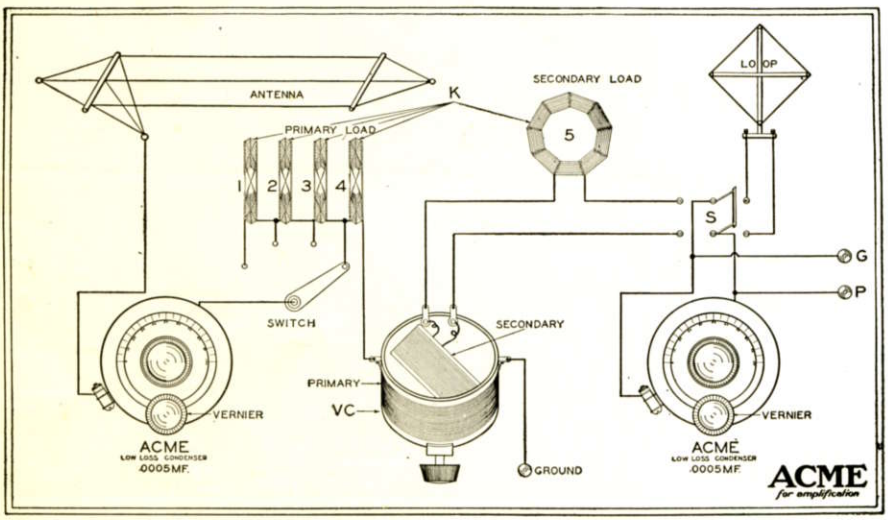


Figure 8

Loop and Antenna Tuning Circuit with Change-Over Switch

VC—"Shamrock Acme Reflex Coupler." Stator 28 turns No. 22 Enamelled spaced 1-32 inch, Rotor 18 turns No. 22 Enamelled spaced 1-32 inch.

S—Miniature D. P. D. T. switch to change from loop to antenna. Do not use Jack.

K—Spider Web Coils or equivalent. Coils No. 1, 2 and 5, 50 turns each, coil No. 3, 35 turns and coil No. 4, 25 turns. Mount primary load coil 7 inches from secondary load coils and at right angles to them.

G—Connect to grid of first tube.

P—Connect to Mid-Point of Pot-Rheo.

Note—The primary coils are for use with different antennas. For one antenna use one coil as found by trial.

For use with Reflex Amplifiers shown in figures 15, 16, 17, 18 and 19.

This is the Tuner of your set.

ANTENNA TUNING CIRCUIT FOR REFLEX SETS

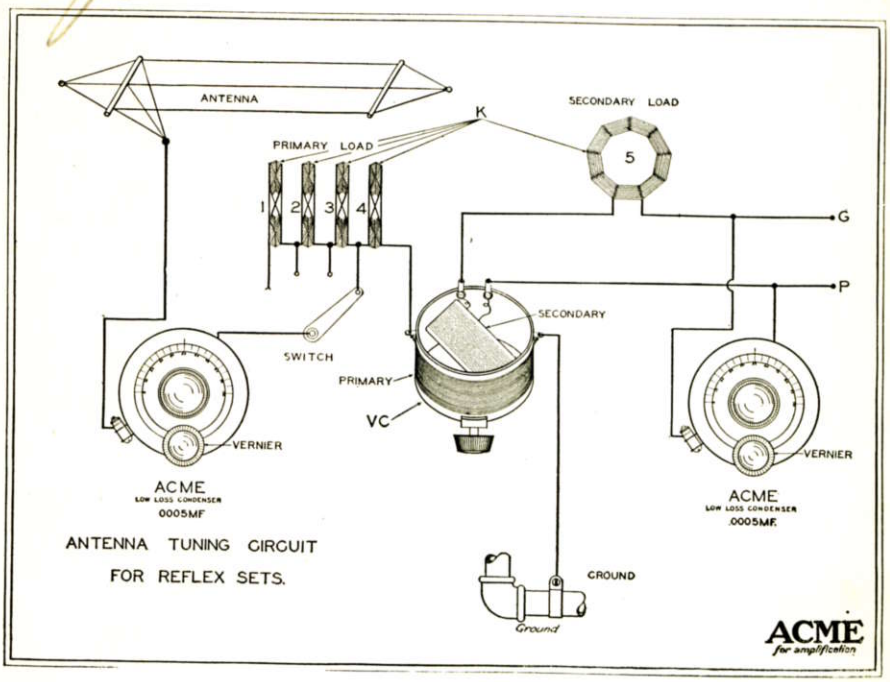


Figure 9

Loop and Antenna Tuning Circuit with Change-Over Switch

VC—"Shamrock Acme Reflex Coupler." Stator 28 turns No. 22 Enamelled spaced 1-32 inch, Rotor 18 turns No. 22 Enamelled spaced 1-32 inch.

S—Miniature D. P. D. T. switch to change from loop to antenna. Do not use Jack.

K—Spider Web Coils or equivalent. Coils No. 1, 2 and 5, 50 turns each, coil No. 3, 35 turns and coil No. 4, 25 turns. Mount primary load coil 7 inches from secondary load coils and at right angles to them.

G—Connect to grid of first tube.

P—Connect to Mid-Point of Pot-Rheo.

Note—The primary coils are for use with different antennas. For one antenna use one coil as found by trial.

For use with Reflex Amplifiers shown in figures 15, 16, 17, 18 and 19.

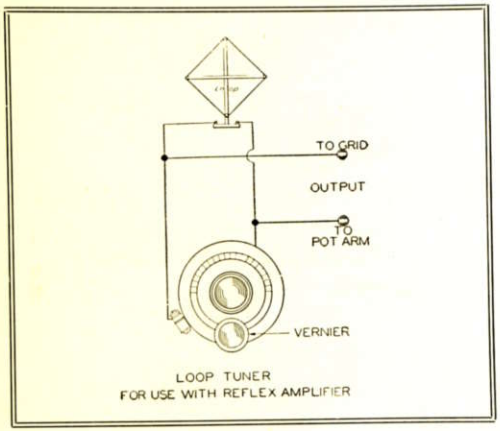


Figure 10

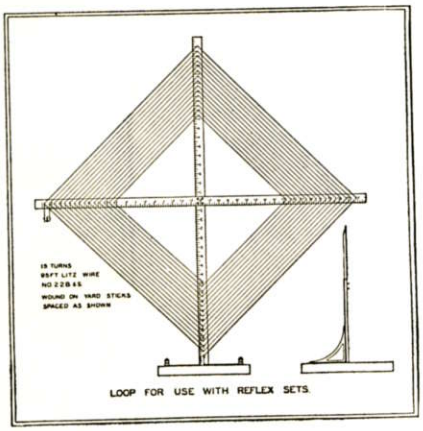


Figure 11

The above circuit on left is for use with Reflex amplifiers shown in figures 17, 18 and 19.

How To Make a Loop

The loop shown may be made with yard sticks. Drive escutcheons into yard sticks $\frac{9}{16}$″ on centers. This will space the wires $\frac{3}{8}$″ apart. Use Litz wire. To remove insulation from enameled Litz wire unwind silk covering for 1″ of length, twist the strands, heat the enameled strands exposed, red hot, and quickly plunge into alcohol.

Loop Reception

With three and four tube reflex sets in congested districts the loop receiver gives the best all the year 'round reception on account of interference from radiating receivers. In apartments and hotels the loop is almost imperative. With a loop and four tube reflex set the distant stations may be heard on a loud speaker all the year 'round. (See pages 15 and 16).

LOOP TUNER WITH FILTER

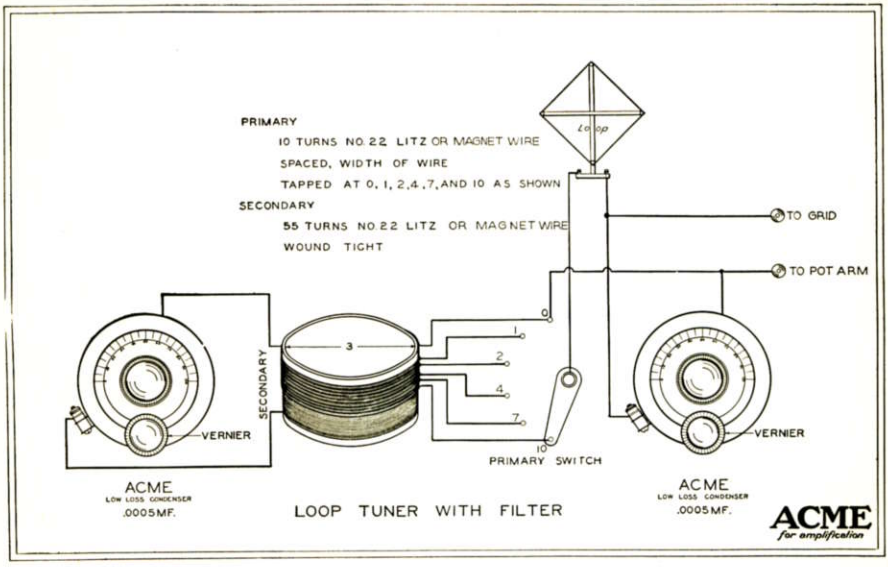


Figure 12

If interference is experienced when using a loop, the above circuit will be found to give an extremely efficient filter. Such interference may come from local broadcasting stations too powerful to otherwise cut out on such sensitive sets as Reflex.

The filter shown above is operated as follows:

1. With the filter coil switch at O tune in the undesired station to maximum intensity as usual.
2. Cut in two or more turns of the filter coil and adjust the filter condenser until the signal is absorbed in the filter circuit.
3. Proceed in the regular way to tune in other stations.

It is important that the specifications for the above coil be closely followed. The primary must be wound as close as possible to the end of the secondary which is connected to the movable plates of the condenser.

TUNED RADIO FREQUENCY AMPLIFICATION

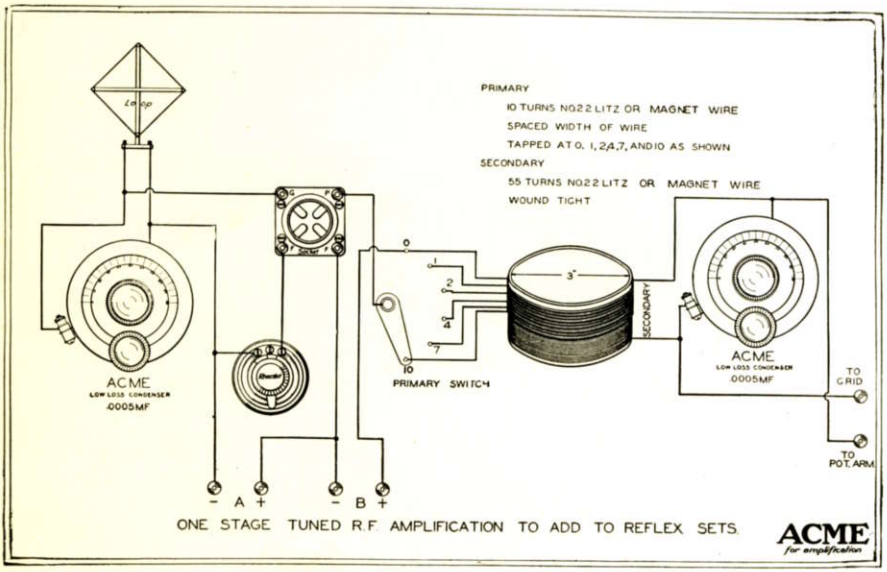


Figure 13

For even greater distance and selectivity the circuit shown above for one stage of tuned radio frequency is strongly recommended. This circuit acts much as a filter and will not only eliminate nearby stations but will improve the quality of any set due to cutting out interference.

A loop is shown in the diagram but the circuit may be used with an antenna as well by simply substituting the secondary circuit of the variocoupler for the loop.

The single stage of tuned radio frequency amplification shown above is operated by tuning its coil to the same wavelength as the loop circuit. The necessary calibration may be obtained either by trial or with a wavemeter. Once each condenser setting is found it will remain the same unless the wavelength of the station is changed. With the condensers properly set, the switch on the amplifier coil and the potentiometer on the reflex set should be adjusted for maximum signal strength. With a little practice the adjustment of this unit becomes very simple.

REFLEX AMPLIFIERS

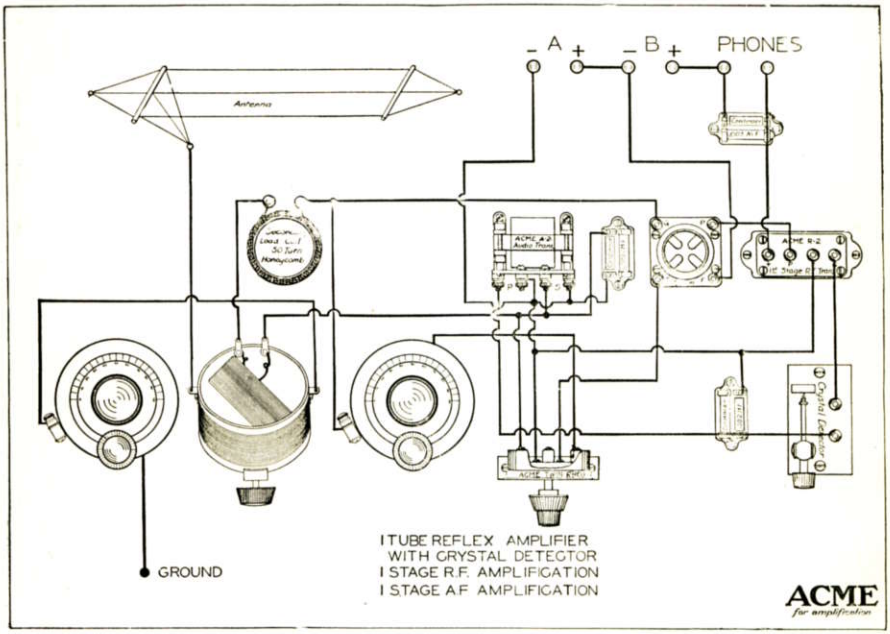


Figure 14

The above circuit is the simplest type of "Reflex" amplifier. This set is extremely simple to operate and when dry battery tubes are used it is readily portable for use in automobiles, summer camps or cottages.

Loud speaker signals of moderate intensity are readily obtained from local stations when an antenna of moderate size is used. Under similar conditions using head phones, a large receiving radius is obtained with the well known superior tone quality present when radio frequency amplification is used to obtain distant signals.

As it is undesirable to have a variable grid bias on a tube used simultaneously for radio and audio amplification the non-inductive Twin-Rheo is shown for the tube control.

Note: Use honeycomb coil shown in diagram only with variocouplers having less than 20 turns on rotor.

For list of parts see page 32.

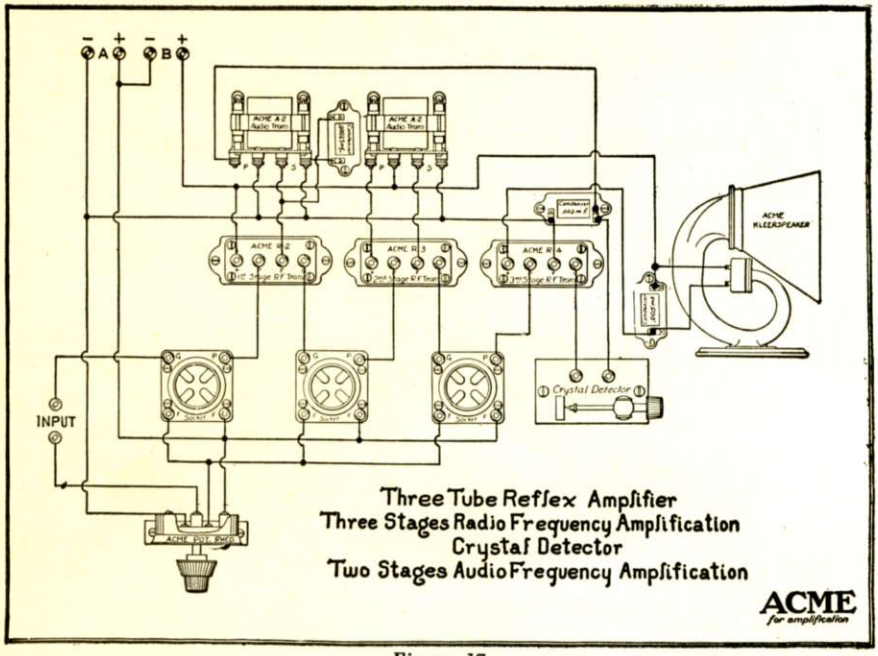


Figure 17

The above Reflex amplifier will give the maximum results obtainable with three tubes. A crystal detector is used to insure distortionless tone quality, ease of adjustment and freedom from foreign noise. While it may be used on an antenna, excellent results will be insured by using a loop exclusively.

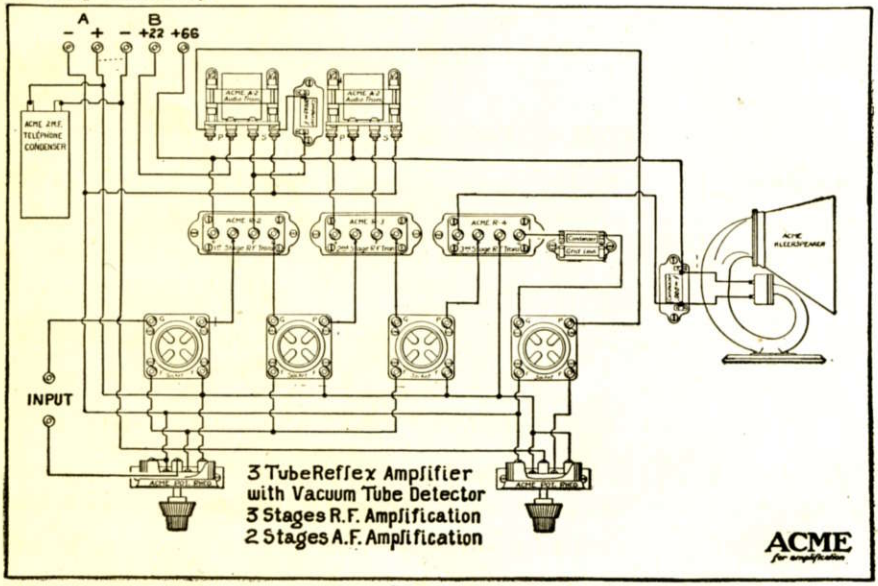


Figure 18

The above Reflex amplifier is the same as that shown in Figure 17, except that a V. T. detector is shown for the use of those preferring it to a crystal. Louder signals will be obtained at some sacrifice of quality, ease of adjustment and quietness.

In both of the above circuits it is advisable to shield the lead connecting the first audio transformer to the detector. The method of shielding is shown in Fig. 19.

For list of parts see page 32.

Miss Newcomb
This is the amplifier
of your set.

FOUR TUBE WITH C BATTERY AND JACK

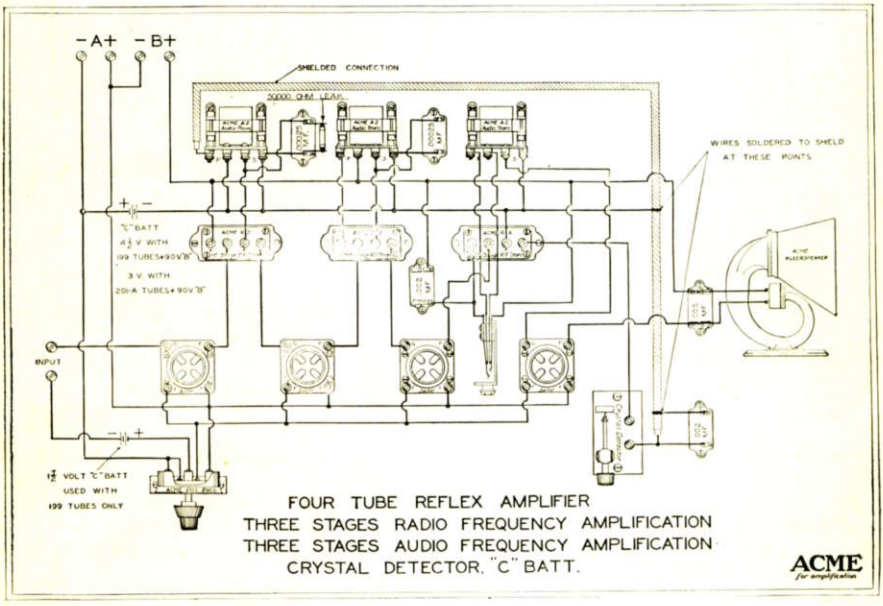


Figure 19

THIS IS THE SET TO BUILD

In order to save B battery current and clarify reception when using high B battery voltages a "C" battery may be connected in the circuit as shown above. This may be added at the same points to any of the reflex diagrams shown.

For list of parts see page 32.

For the best way to build a four tube Reflex Set see Acmeflex Kitset, page 34.

CABINET SETS

For those desiring to build Reflex Sets with panel and cabinet full size drawings may be obtained from the Acme Apparatus Co. postpaid as listed below.

No. 1 Four Tube Reflex Set for Loop Operation (2 prints) .....$.50 per set

No. 2 Four Tube Reflex Set for both antenna and loop (2 prints) .50 per set

No. 3 Four Tube Reflex Set with single stage of tuned R. F. (2 prints) .50 per set

No. 4 One stage of tuned R. F. (1 print) ..... .25 per set

Please order prints by number.

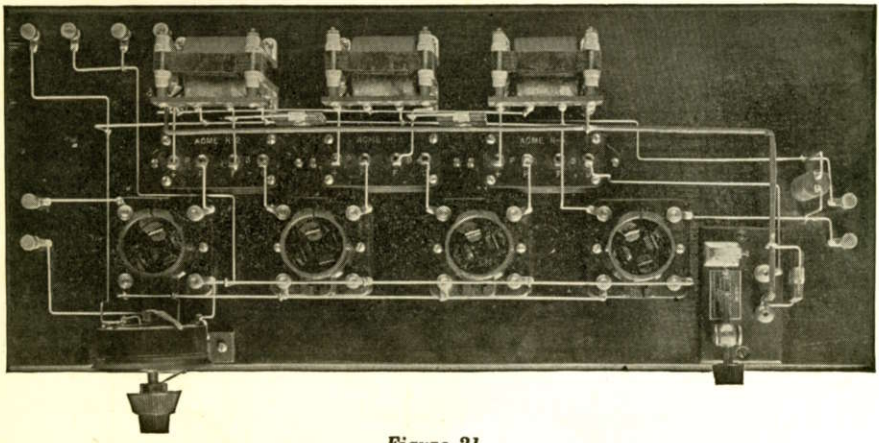


Figure 21

Four Tube "Reflex" Amplifier

(See Figure 19 for Diagram)

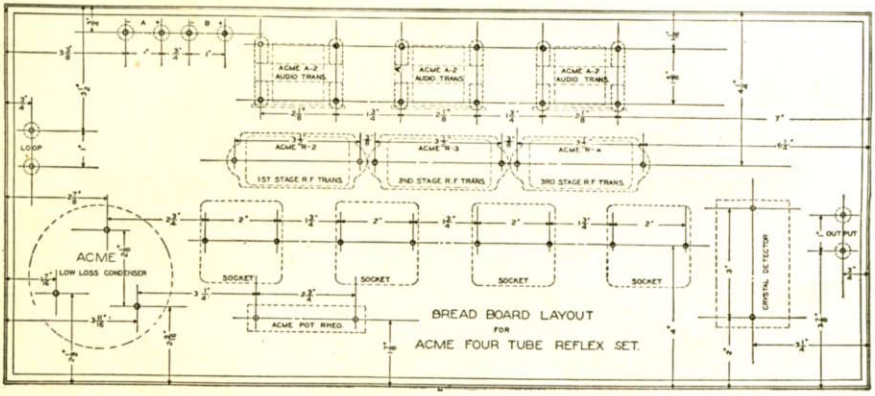


Figure 22

Layout for Four Tube "Reflex" Amplifier

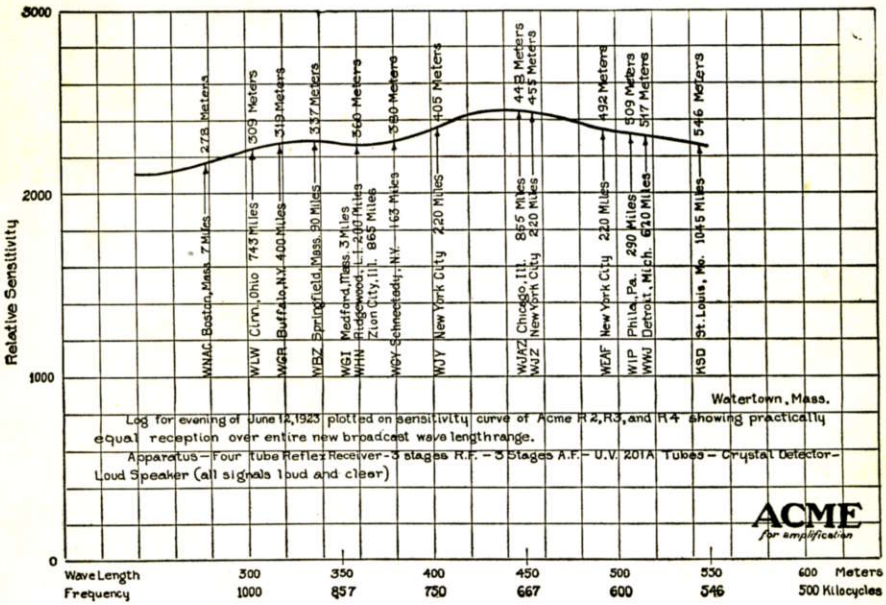


Figure 23

Amplification Curve of ACME R. F. Transformers with actual results as given

LIST OF APPARATUS USED IN REFLEX AMPLIFIERS

List of Apparatus for Fig. 14

1 Acme A. F. Transformer
Type A-2
1 Acme R. F. Transformer
Type R-2
1 Acme Twin Rheo.
2 Acme Low Loss Condensers .0005 M.F.
1 Vario Coupler
1 50 Turn Honeycomb Coil
1 Good Crystal Detector
1 Good Socket
1 .005 m. f. Mica Condenser
1 .002 m. f. Mica Condenser
1 .00025 m. f. Mica Condenser
7 Binding Posts
20 ft. No. 14 solid wire

List of Apparatus for Fig. 15

1 Acme A. F. Transformer
Type A-2
2 Acme R. F. Transformers
Type R-2, R-3
2 Acme Pot Rheos'.
6 ohm with .25 amp. tubes
30 ohm with .060 amp. tubes
3 Good Sockets
1 Acme 2 m. f. Telephone Condenser
1 .00025 m. f. Mica Condenser
1 .005 m. f. Mica Condenser
1 Grid Leak and Condenser
9 Binding Posts
10 ft. No. 14 Solid Wire
1 set Good Head Phones

List of Apparatus for Fig. 16

1 Acme A. F. Transformer
Type A-2
2 Acme R. F. Transformers
Type R-2, R-3
1 Acme Pot Rheo.
6 ohm with .25 amp. tubes
30 ohm with .060 amp. tubes
2 Good Sockets
1 Good Crystal Detector
1 .00025 m. f. Mica Condenser
1 .002 m. f. Mica Condenser
1 .005 m. f. Mica Condenser

List of Apparatus for Fig. 17

2 Acme A. F. Transformers
Type A-2
3 Acme R. F. Transformers
Type R-2, R-3, and R-4
1 Acme Pot Rheo.
6 ohm with .25 amp. tubes
30 ohm with .060 amp. tubes
1 Acme Kleerspeaker
3 Good Sockets
1 Good Crystal Detector
1 .00025 m. f. Mica Condenser
1 .002 m. f. Mica Condenser
1 .005 m. f. Mica Condenser
10 ft. No. 14 Solid Wire
8 Binding Posts

List of Apparatus for Fig. 18

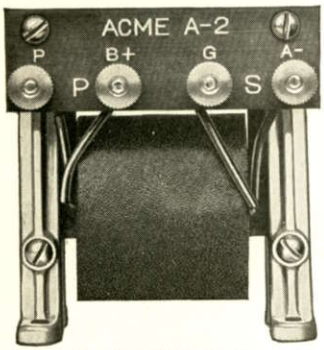
2 Acme A. F. Transformers
Type A-2
3 Acme R. F. Transformers
Type R-2, R-3, and R-4
2 Acme Pot Rheos'.
6 ohm with .25 amp. tubes
30 ohm with .060 amp. tubes
1 Acme Kleerspeaker
4 Good Sockets
1 Acme 2 m. f. Telephone Condenser
1 .005 m. f. Mica Condenser
1 .00025 m. f. Mica Condenser
1 Condenser and Grid Leak
10 ft. No. 14 Solid Wire
9 Binding Posts

List of Apparatus for Fig. 19

3 Acme A. F. Transformers
Type A-2
3 Acme R. F. Transformers
Type R-2, R-3, and R-4
1 Acme Pot Rheo.
1 Acme Kleerspeaker
4 Good Sockets
1 Good Crystal Detector
1 .00025 M.F. Mica Condenser with grid leak clips
2 .002 m. f. Mica Condensers
1 .00025 m. f. Mica Condenser
1 .005 m. f. Mica Condenser
10 ft. No. 14 Solid Wire
8 Binding Posts
2 ft. Spaghetti No. 9 French Scale
2 ft. Belden Braid Shielding Code "Channel"
1 50,000 ohm resistance

LOUD and CLEAR

With ACME audio frequency amplifying transformers A-2



Ratio 4.25 to 1

For loud clear broadcasting use the Acme A-2 Audio frequency transformer. It is the product of transformer, telephone and radio engineers and manufacturers who have devoted much time and expense to the study of amplification without distortion. Although no exact figures are available, we do not hesitate to say that there are more Acme Transformers used in the country today than any other make. The efficiency of the product coupled with our policy of standing back of it has made the Acme Transformer the leader.

Price $5.00 each

ACME
for amplification

LONG DISTANCE

With ACME radio frequency amplifying transformers Type R

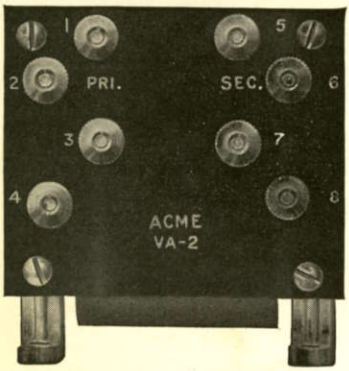
For distant broadcast reception use the Acme Radio frequency amplifying transformer R-2, R-3 and R-4. Months of development work have been put into them by engineers who have been associated with Radio long before broadcasting was contemplated. Radio frequency amplification, especially in the "Reflex" form is coming into general use because with it a loop may be used to reduce static and other forms of interference.

Price $5.00 each

ACME
for amplification

ANY RATIO YOU WANT

With an ACME variable ratio audio frequency amplifying transformer.



Although the Acme Apparatus Company is not in sympathy with different ratio audio frequency transformers, we have produced the VA-2 variable ratio transformer for those who desire to follow the advices of the other school of radio engineers who advocate such apparatus. As great differences of opinion exist among them as to the proper different ratios to use the Acme VA-2 with its fifteen ratios gives the operator the ability to experiment for his own best results.

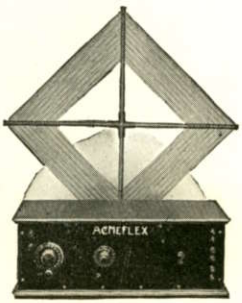
Price $7.00 each

ACME
for amplification

EASY TO BUILD

an

ACMEFLEX KITSET



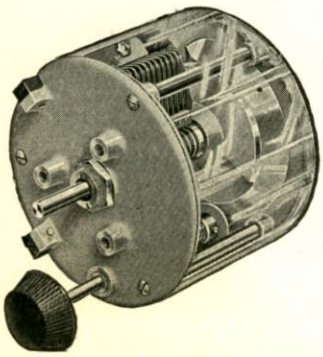
The famous Acme Reflex circuit made so easy that no technical knowledge or workmanship is necessary. You can put it together and operate it on the front porch or take it in an automobile. All of the parts for this circuit and a loop, with full sized drawings and complete instructions are included in this set, and no soldering is necessary. The only tools required for assembling are a screw driver and a pair of pliers which are contained in the kit.

Price $65.00

ACME
for amplification

CONSERVE ENERGY

The antenna receives only a little energy. Don't waste it



Enclosed with Dust Proof Covering

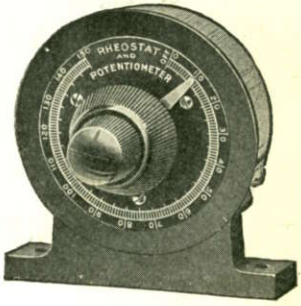
When you consider the small amount of energy picked up by an antenna or loop, it is easy to understand how highly important it is not to waste any of it. The Acme Condenser is desgined to properly handle that little energy and deliver it to the amplifier without appreciable diminution. The Acme condenser embodies many other desirable features which are readily apparent on examination and use.

Price $6.50 each

ACME
for amplification

ONE for BOTH

A combined potentiometer and filament rheostat.



The uses of the Acme Pot Rheo and Twin Rheo are shown in the diagrams of this pamphlet. The advantages of concentric control and economy of space are quite apparent. The design and construction of this unit is of such a high order that it stands out among radio apparatus. Only the best of materials are used to insure proper operation and satisfaction for the purchaser.

Price $3.00 each

ACME
for amplification

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DDTROIT—714 Lafayette Building
CAMBRIDGE, MASS.—Factory

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Transformer and Radio Engineers
and Manufacturers

Cambridge, Mass., U. S. A.