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TESTS OF RADIO RECEIVING SETS. III

Contents.

Note:~~6~~- This paper and the tests described herein are the result of work done in the Radio Laboratory of the Bureau of Standards by J.L.Preston, Physicist, H.J.Walls, Assistant Electrical Engineer, Bureau of Standards, and H.F.Harmon, Radio Laboratory Assistant, U.S.Department of Agriculture. Acknowledgment is due Mr.L.C.F.Horle for assistance in the development of the methods used in these tests.

1. Purpose of Investigation.

This paper is the third of a series describing an investigation of the characteristics and performance of radio receiving sets, which has been under way at the Bureau of Standards for a number of months. The first paper of this series, Letter Circular 90, "Tests of Radio Receiving Sets. I," describes the tests made on a number of "medium-wave" receiving sets, and the second paper, Letter Circular No. 93, "Tests of Radio Receiving Sets. II", describes the tests made on a number of crystal detector receiving sets. All the receiving sets on which tests are herein described use electron tube detectors supplemented in some cases by one or more stages of audio-frequency amplification, and are believed to be typical of the principal sets of that type which were on the market in the early part of the year 1923. Many of these sets have since been redesigned, and new and improved models are now on the market.

The tests reported herein were made at the request of the Bureau of Agricultural Economics of the Department of Agriculture, which sought the assistance of the Bureau of Standards on this problem in connection with the reception of crop, market and weather reports which that Department is sending out through Government and private broadcasting stations.

In order to make comperhensive tests of radio receiving sets it has been necessary to develop methods of measurement* and to formulate statements of the features which should be described as a result of an inspection of the mechanical and electrical design of the apparatus. In developing the methods to be followed and in reporting on the receiving sets tested, it has been the aim to determine the degree in which a set has such desirable features as sensitivity, selectivity, convenience of operation, substantial construction, and effectiveness in covering the particular range of frequencies (wave lengths) which it is desired to receive.

*The methods used in the tests reported in this paper are described in detail in a Technologic Paper entitled, "Some Methods of Testing Radio Receiving Sets."

No consideration has been given to the possible existence of any patents which might cover devices or circuits used in any of the apparatus described. The Bureau of Standards can not give authoritative information concerning the patent situation with respect to a particular device.

The particular receiving sets studied are referred to by arbitrary reference numbers rather than by a statement of the manufacturers' names and type or model numbers. It is believed that the methods followed and the examples given in this report on the receiving sets included in this part of the investigation will be of assistance to manufacturers in the development of methods of testing and describing their own products and thus improving them. It is believed that purchasers will also be

(2) Structural Details.--The receiving set is examined for ruggedness and quality of material, component parts, and workmanship. In doing this the device is given a very close inspection to determine the relative grades of materials from the mechanical viewpoint with particular reference to the materials under mechanical strain, the materials and parts which are likely to change because of the effects of moisture and mechanical shock and those which are likely to wear in use.

(3) Electrical Characteristics.--The receiving set is examined to determine the qualities of its materials from the electrical viewpoint, the care taken in working up these materials into component parts, and their disposition relative to one another. This inspection is made with special attention to the materials that constitute the high potential parts of the circuit, those which are under dielectric strain, and the protection of these parts from the effects of time and moisture.

e. Sensitivity Measurement.--This test consists of the determination of the magnitude of the response in the telephone receivers of the receiving set for a given voltage impressed on the antenna.

f. Selectivity Measurement.--This test consists of the determination of the ability of the receiving set to differentiate between signals of different frequencies (wave lengths).

g. Notes on Operation.--The receiving sets are connected to an antenna of measured constants and put in operation as specified by the manufacturer. The ease of operation and the precision and permanency of adjustments are noted.

3. Manufacturers' Specifications of Antenna, Frequency (Wave Length) Range, Detector and Telephone Receivers.

Complete specifications were not furnished with the receiving sets covered by this report.

4. Circuit Diagrams.

The circuit diagrams for the thirteen receiving sets included in this report are given in Figs. 1 to 13 inclusive.

5. Circuit and Panel Arrangements.

Receiving Set No. 1922-A.--This receiving set is made in two parts, (1) a tuner and (2) a detector-amplifier, and is so built that the detector-amplifier may be conveniently placed on top of the tuner. The tuner consists of two variable inductors of the rotating coil type and a "variocoupler" with switches, and other minor accessories. The detector-amplifier consists of an electron tube detector and a two-stage audio-frequency amplifier.

In the remainder of this report these two pieces of apparatus will be considered as a single receiving set. The circuit used

in this set is commonly known as the coupled or two-circuit non-regenerative type. The primary circuit consists of the primary of a variocoupler and is controlled in small and large steps by means of two multipoint switches. The secondary circuit consists of the secondary of the variocoupler, a variable inductor, and a grid condenser, and is tuned by means of the variable inductor in the grid circuit. For lower frequencies (longer waves) a second variable inductor may be connected into the secondary circuit as a loading coil.

No scales are provided on which to mark the frequency (wave length) calibration. Auxiliary knobs marked "vernier" are provided for fine adjustment of the variable inductors.

The functions of all the controls and terminals are marked on the panel. All terminals are on the rear of the panel.

The arrangement of the controls is very good. The tuning controls are mounted so that they may be manipulated with the forearm resting on the table. The rheostats and potentiometer which are seldom used are mounted above the tuning controls.

Receiving Set No. 1922-B.--The circuit is of the single-circuit regenerative type, consisting of a small variable capacity in series with a large tapped inductance, and an electron tube detector with the necessary auxiliaries, all mounted on a vertical panel. Regeneration is accomplished by means of a combination of inductive and capacity feedback.

The arrangement of the various controls upon the panel is convenient except the antenna variable condenser control. It is inconveniently located directly above the "tickler" or regeneration control. As the antenna condenser and "tickler" are the main tuning controls a better arrangement would be to have them both on the same level at a height so that the hand and forearm may rest upon the table while tuning.

The functions of all the controls and terminals are plainly marked on the front of the panel with the exception of the antenna condenser. This has no markings.

No provision is made for frequency (wave length) calibration markings on the dial nor for fine adjustment of the controls.

Receiving Set No. 1922-C.--The circuit employed in this receiving set is the single-circuit non-regenerative type. It consists of a two-slide antenna inductor with electron tube detector and its auxiliaries all mounted on a horizontal panel.

The functions of the controls or terminals are not marked or indicated on the panel. They are, however, indicated on a diagram attached to the cover of the set. No fine adjustment controls or scales for frequency (wave length) calibration are provided.

Receiving Set No. 1922-D.--The circuit employed in this receiving set is of the single-circuit regenerative type. The tuning apparatus consists of a variable condenser in series with an inductor. A crystal detector is supplied but will not be considered in this report. The detector used in making these tests was an electron tube. It is mounted in a separate case together with a two-step amplifier.

The arrangement of all the controls is very convenient and they operate smoothly except for the variable condenser. This control operates smoothly except at the position where it operates a switch which short circuits a portion of the antenna inductor. No fine adjustment controls nor scales for making the wave length calibration are provided.

The functions of all the controls are plainly marked on the panel. There is, however, no markings to indicate the functions of the various telephone jacks supplied.

Receiving Set No. 1922-E.--This receiving set is commonly known as the three-circuit type. The antenna circuit consists of a tapped inductor forming the primary of the variocoupler; the secondary circuit consists of the secondary of the variocoupler and a variable inductor in series; and the plate circuit includes a variable inductor to secure regeneration and the telephone receivers with by-pass condenser.

This set is designed to operate over a frequency band from 300 to 3000 kilocycles (a wave length band from 150 to 1000 meters). Over this entire range the antenna circuit is tuned by two multipoint switches which control the amount of inductance in the antenna in small and large steps. The secondary is broken up into three ranges - 800, 460 and 300 kilocycles (375, 650 and 1000 meters). Over the 800 kilocycle (375 meter) range the secondary is tuned by varying the inductance of the circuit by means of the variable inductor in the grid circuit. For the 460 kilocycle (650 meter) range two small fixed condensers in series are connected across the secondary of the variocoupler and grid circuit variable inductor in series. The circuit is then tuned by varying the inductance by means of the variable inductor. Regeneration for both the 800 and 460 kilocycle (375 meter and 650 meter) ranges is effected by the variable inductor in the plate circuit. For the 300 kilocycle (1000 meter) range the capacity across the secondary of the variocoupler and grid circuit variable inductor in series is increased by cutting out one of the small fixed condensers. The circuit is then tuned by varying the inductance by means of the variable inductor. The second small fixed condenser is connected from the plate of the tube to the grid, thereby increasing the plate to grid capacity so that the variable inductor in the plate circuit may still be used for regeneration.

The functions of all the controls and terminals are plainly marked on the front of the panel and also on the terminal board in the interior of the set.

The arrangement of the tuning controls is very convenient. They are symmetrically located and easily accessible. Tangent wheels are provided for close tuning. No scales are provided for frequency (wave length) markings.

Receiving Set No. 1922-F.--The circuit employed in this receiving set is the two-circuit regenerative type. The primary or antenna circuit consists of the primary of a variocoupler, primary loading coils, and a variable condenser that may be connected either in series or parallel with the antenna. The inductance is controlled by a multipoint switch. The secondary circuit consists of the secondary of the variocoupler, secondary loading coil, a variable condenser and an electron tube detector with its auxiliaries. Regeneration is accomplished by means of both inductive and capacity feedback.

The functions of all the controls and terminals are plainly marked on the panel.

The arrangement of the parts is convenient. Both tuning condensers and inductor controls are mounted low on the panel so that they may be operated with the forearm resting on the table. The regeneration control is mounted in the upper right hand corner. As this control is used quite frequently on the high frequencies (short wave lengths) it would be well if it could be located in a more convenient position.

Fine adjustment is provided on the secondary tuning condenser only. No scales are provided for marking the frequency (wave length) calibration.

Receiving Set No. 1922-G.--The circuit employed in this receiving set is the two-circuit regenerative type. The primary or antenna circuit consists of the primary of a variocoupler, and a variable condenser that may be connected either in series or parallel with the antenna. The secondary circuit consists of the secondary of the variocoupler, secondary loading coil, variable condenser and an electron tube detector with its auxiliaries. Regeneration is accomplished by inductive feedback.

The arrangement of the controls on the panel is very convenient. The primary and secondary condensers and "regenerator" control are all mounted low on the panel so that they may be manipulated with the forearm resting on the table. The fine adjustment controls are mounted to the right of the condensers which they serve. The output terminals are placed just below the secondary fine adjustment control and interfere somewhat with its operation.

All terminals and controls are plainly marked. No scales are provided for marking the wave length calibration.

Receiving Set No. 1922-H.--This receiving set is of the single-circuit regenerative type. It consists of a tapped inductor, a variable condenser, and an electron tube detector with necessary auxiliary apparatus. Regeneration is accomplished by inductive feedback.

The functions of all the controls and terminals are plainly marked. The arrangement of the controls is also very good. It is, however, not good practice to locate terminals of different potential as close together as has been done on the terminal board of this set.

No fine adjustments of controls or wave length calibration scales have been provided.

Receiving Set No. 1922-I.--The circuit employed in this receiving set is the coupled or two-circuit non-regenerative type. The primary circuit is made up of a tapped antenna inductor (primary of variocoupler) in series with a variable condenser. The secondary circuit is made up of the secondary of the variocoupler and a small variable condenser together with the detector and its auxiliaries. A two-step audio-frequency amplifier is also included in the set. All parts are mounted on a vertical panel.

The functions of all the controls and terminals are plainly marked on the front of the panel. Some of them are incorrectly marked, however; the switch controlling the antenna inductance is labeled "COUPLING" and the control for varying the coupling is labeled "TUNER" both of which are incorrect.

The arrangement of the tuning controls is not very convenient. The two tuning condensers, which are the controls most used, are mounted at the top of the set. Tuning could be effected much more easily if these controls were mounted at the bottom of the panel at a height such that the arms can rest on the table while tuning. No fine adjustment devices nor scales for marking frequency (wave length) calibration are provided on any of the tuning controls.

Receiving Set No. 1922-J.--The circuit employed in this receiving set is of the two-circuit type employing fixed coupling. Tuning is accomplished by two variable condensers, one in series with the antenna inductor and the other across the secondary inductor. All parts are mounted on a vertical panel.

The functions of the various controls are not indicated on the panel. None of the terminals have any markings to indicate their functions except those to which the batteries are attached and these markings are somewhat ambiguous.

The arrangement of the various controls is very good. No fine adjustment devices or scales for marking frequency (wave length)

calibration are provided on any of the tuning controls.

Receiving Set No. 1922-K.--This set consists of a single-circuit tuner together with a three-stage resistance-coupled amplifier mounted in a cabinet that somewhat resembles a phonograph. A loud speaker in the form of a telephone receiver on the end of a horn is also provided.

The circuit employed in this set is the single-circuit regenerative type. This set employs practically the same tuning apparatus as does receiving set No. 1922-L. The only controls are a single tuning control and a filament switch.

There are no markings on either of the controls to indicate their functions. No provisions are made for fine adjustment of the controls and no scales are provided for calibration markings. The terminals on the back of the case are labelled.

Receiving Set No. 1922-L.--The circuit employed in this receiving set is the single-circuit regenerative type. It consists of a small fixed condenser in series with a variable inductor and an electron tube with the necessary auxiliaries all mounted on a horizontal panel. Regeneration is accomplished by means of a combination of inductive and capacitive feedback.

Two frequency (wave length) ranges are provided. This is accomplished by changing the antenna lead from one binding post to another which cuts out a portion of the capacity in the series antenna condenser. No scales are provided for calibration markings. No provision is made for the find adjustment of the controls.

As this receiving set requires only a dry cell and small plate battery for operation it would be quite a convenience if the manufacturer would enlarge the case so as to include these batteries within it.

The functions of the filament rheostat and regeneration control are marked on the front of the panel. There are no markings on the tuner control to indicate its functions. The functions of the various terminals on the panel are not marked. To connect up this set it is necessary even for a man experienced with radio apparatus to read a card tacked in the cover of the cabinet and carefully follow a drawing in order to discover the functions of the various terminals.

No provision is made for frequency (wave length) calibration markings and the tuner and tickler controls are not provided with fine adjustments.

Receiving Set No. 1922-M.-- This receiving set consists of two separate units; (1) a tuner and (2) a detector and two-stage audio-frequency amplifier, mounted in separate cabinets. This arrangement permits the tuner to be used with a crystal detector

or an electron tube detector as desired. In this test, however, the tuner was used with the electron tube detector.

The circuit employed in this receiving set is the single-circuit regenerative type. The set consists of a variable condenser and a variable inductor so mounted that the inductance and capacity are both varied by means of the same control. Provision is made for the fine adjustment of the tuning control. Regeneration is accomplished by inductive feedback.

The functions of all the controls of the tuner and amplifier are plainly marked. The terminals on the rear are also labelled. No scales are provided for frequency (wave length) markings.

6. Structural Details.

Receiving Set No. 1922-A.- The panel upon which the various parts of the tuner are mounted is of laminated phenolic insulating material 15 inches long, 5 inches wide, and 1/8 inch thick, and has a dull finish. About 5 1/2 inches in the rear of this panel another one of like material but one inch smaller in size is mounted. Between these two panels and supported by them are mounted the different parts. The rear panel also serves as the rear of the cabinet. The case or cabinet is made of California baywood and is very well finished. The front panel is secured to the case by means of nine small nuts which fit on as many stud bolts in the case. This assures rigid support for the various parts and makes the complete interior of the set readily accessible. The detector-amplifier is in a similar case.

The variable inductors and the variocoupler are all of like construction. The windings are on a basket-like form of thin fibre. This form is so designed that there is a minimum of insulating material used. The design and construction of rotors and stators of the inductors is such as to give light weight and high mechanical strength. The forms are supported on both the front and rear panel which makes the tuner assembly very light and rigid. All of the inductors are wound with enameled silk-covered solid copper wire.

The grid condenser is made up of two heavy metal plates with mica insulation between them. The grid leak, which is a strip of resistance material in a glass tube, is mounted in spring clips upon the grid condenser.

All tube sockets are securely mounted on metal cross pieces. No cushioning is provided for eliminating vibration of the tubes.

Receiving Set No. 1922-B.-- The panel is of moulded phenolic composition, 8 1/2 inches high, 7 5/16 inches wide, and 1/8 inch thick, and has a dull grained finish. It is secured to the cabinet by seven small wood screws which are too small to effectively hold the panel in place because they are inserted in the end

grain of the wood making up the cabinet.

The cabinet is substantially made of California baywood and is reasonably well finished. A conveniently located compartment is furnished for the plate battery. A hinged top is provided for removal and replacement of the electron tube and battery.

The condenser supplied with this receiving set for tuning is of the rotary plate variable type and consists of three stationary plates and two movable ones. The end plates which support the movable plates are of moulded phenolic composition. One of the movable plate bearings is merely a hole in the composition end plate without any metallic bushing, the other an adjustable steel pivot seating in the brass shaft of the rotary plates. Good connection is made with the rotary plates by means of a flexible strip.

The antenna inductor consists of a tapped two-layer banked winding on a tube of laminated phenolic composition. No adequate provision is made for securing the windings to the tube and as a result the windings are easily displaced. The taps brought out from the inductor terminate on the contacts of a multipoint switch by means of which the amount of inductance in the circuit can be varied. The switch is designed to short-circuit the unused portion of the winding.

The feedback coil is wound on a moulded composition form which can be rotated through 360 degrees. The bearings supporting the form are screws passing through the walls of the antenna inductor tube. Connection to the rotary coil is effected by two flat springs in rubbing contact with the screws forming the shaft of the rotary coil. The stationary coil which is used for feedback purposes is merely a loose coil of wire insecurely fastened to the inside of the antenna inductor by short pieces of wire passing through the wall of the tube.

The grid condenser is constructed of mica and copper clamped between two blocks of laminated phenolic insulating material upon which pencil or ink lines may be drawn to form the grid leak.

The tube socket is moulded entirely of phenolic insulating compound. Sturdy springs are mounted on the bottom of the socket which make contact with the prongs of the electron tube. The socket is mounted directly on the panel with no provision for preventing vibrations of the detector tube which will cause noises in the telephones.

The rheostat consists of two coils of resistance wire mounted so that portions may be cut out by a sliding contact. The rheostat is mechanically imperfect and does not operate smoothly.

A telephone condenser constructed of copper and mica sheets is mounted directly on the panel.

Connections between the various parts of the receiving set are made with No. 16 bare copper wire insulated with varnished cambric tubing. The wire is sufficiently substantial but is not neatly arranged.

Receiving Set No. 1932-C.-- The panel is of laminated wood, 9 inches long, 713/16 inches wide, and 3/8 inches thick, which is enameled black. The cabinet is substantially constructed of poplar and is reasonably well finished. It is provided with a removable cover which is held on by means of four snaps. The cover is also provided with a carrying handle.

The antenna inductor consists of a single-layer solenoid wound with enameled wire. The inductance may be varied by means of two sliding contacts which make contact with a portion of the wire from which the insulation has been removed. These sliding contacts are controlled by two knobs on the panel. With this method of varying inductance it is difficult to obtain contact without shorting one or more turns of the inductor. The windings are varnished to exclude moisture and to secure the wire to the form.

The tube socket is constructed of moulded phenolic insulating material and is mounted on brackets below the panel. The tube is inserted through a hole in the panel.

Since most of the tube is below the surface of the panel it is partly protected but the tip of the tube, the part most easily broken, is left exposed.

Receiving Set No. 1932-D.--The panel of this receiving set, which is the front of the steel case, is 11 inches long, 9 1/8 inches high, and 1/16 inch thick, and is enameled green. Upon it is mounted a crystal detector, a telephone jack, and two control knobs for wave length and regeneration control.

All joints of the steel case are riveted or bolted. It is provided with a removable back and top which makes the interior readily accessible. A strip of laminated phenolic insulating material is mounted at the bottom of the case on the back and sides upon which the terminals are mounted. The case is extremely sturdy and can withstand any shocks to which it is likely to be subjected. This type of construction, however, results in a set that is very heavy.

The variable condenser supplied with this set is very sturdily built. Both the movable and stationary plates are of heavy brass and are substantially assembled on bases of laminated phenolic insulating material. The stationary plate assembly is mounted on a steel spider which also makes up the bearing for the movable plates. This bearing, which carries the entire moving system, is of the ball bearing type and is very substantial.

The design of the inductor assembly is not in keeping with the robust design of the condenser. The bearings which support the rotor are merely holes through a thin piece of spring brass. Connections to the windings on the rotor are made through the bearings. The inductor is mounted on a sub-base of insulating material by means of seven flat springs. Connection to the different windings are made through these springs.

A crystal detector is supplied and is mounted on the front of the panel. A telephone jack is supplied for connecting the telephones to the crystal detector. A telephone condenser is also supplied. Both the condenser and the insulating strips on jack have been impregnated with wax to exclude moisture.

The electron tube detector supplied with this set is mounted in a separate case together with a two-stage audio-frequency amplifier. The grid condenser is constructed of copper foil and mica encased in metal and impregnated with wax. The grid leak is of the sealed-in type. The tube socket is mounted on felt to prevent tube vibration. The rheostat is of large size and will carry its current without overheating.

The terminals are all mounted on a strip of insulating material placed at the bottom of the case on the back and sides. They are of the type in which the connecting wire is placed in a hole and a screw tightened down on the wire. In this set the terminals are very inconveniently mounted and are so placed that a long bladed screwdriver is necessary to make the connections. Because of the position of many of the terminals on the detector-amplifier it is almost impossible to connect the batteries without short-circuiting them with the screwdriver. In general the terminals are of a type not well suited for use on radio equipment and are very inconveniently located.

The wiring on both the tuner and the detector-amplifier is very well laid out and is very strong. No. 12 bare tinned copper wire is used throughout and the wires are so placed as to require no insulation.

Receiving Set No. 1922-E.--The panel on which the various parts of this receiving set are mounted consists of a strip of laminated phenolic insulating material 22 1/4 inches long, 6 11/16 inches wide, and 3/16 inch thick, having a dull grained finish. All controls, such as knobs, dials, etc., and binding post tops, are of moulded phenolic insulating compound, well made, and present a very pleasing appearance. All screw heads showing on the front of the panel are finished in dull black. The panel is secured to the cabinet by five wood screws.

The cabinet is well constructed of quartered sawed oak and is nicely finished in old English. A hinged cover provides easy access to the interior of the set and holes in the back of the cabinet are provided for bringing in leads from batteries.

All wiring is very neatly done. No.14 bare tinned copper wire is used throughout and is insulated with varnished cambric tubing where necessary. All joints are very neatly and securely soldered. Considerable care has been taken with the wiring. In one case a wire is placed directly over the grid condenser which interferes with drawing pencil lines for adjusting the grid leak.

The tube socket is of metal and is mounted on a large block of insulating material on which is also mounted the grid condenser, phone condenser, condensers for decreasing frequency (increasing wave length), and binding posts for plate and filament batteries.

The rheostat for controlling filament temperature is conveniently located and smooth in its operation. Its general design is very good but its construction is not very sturdy. The small spring clips that support the control wheel become bent and allow the wheel to loosen so that a poor connection is obtained with the resistance wire. It is then necessary to remove the clips and bend them back to their original position. This same defect can be found with the supports of the tangent wheels of the variable inductors and of the frequency (wave length) change switch.

A small condenser constructed of mica and copper foil clamped between blocks of insulating material is provided to bypass the high-frequency currents around the telephones and plate battery.

The antenna inductor which makes up the primary of the variocoupler consists of a single layer winding on a tube of phenolic insulating material. The inductor is tapped in such a way that it is possible to get two-turn variation by means of two multipoint switches provided on the front of the panel. Provision is made for eliminating resonance in the unused portion.

The coupling coil or secondary of the variocoupler is wound on a form of moulded phenolic insulating material which is supported by two bearings, one of which is the panel itself, the other a bracket of insulating material. This is not to be commended, since warping or any misalignment of the panel will cause binding of the shaft.

The windings of both the antenna inductor and coupling coil are impregnated with varnish to exclude moisture and to secure the windings to the forms.

The variable inductors which are used for tuning the grid and plate circuits are very well made. The forms which hold the windings are of moulded phenolic insulating material. No rubbing contacts are used. The rear shaft of the variable inductor is hollow and through this passes one of the terminals of the rotor in varnished cambric tubing. The shaft itself forms the other

terminal. Since stops are provided for preventing the rotor from turning more than 180° a flexible lead is soldered to the shaft for connecting it with the rest of the circuit.

The bearings of the variable inductors are of ample size to give satisfactory service over a long period of time.

Fine adjustment of the controls is provided by a small rubber-tired tangent wheel acting on the dials. This gives a reduction ratio of about 5 to 1.

The general assembly of this receiving set is very orderly.

Receiving Set No. 1922-F.-- The panel upon which the various parts are mounted is of laminated phenolic insulating material 19 inches long, 12 inches high, and 1/4 inch thick, and is polished. It is secured to the cabinet by ten wood screws.

The cabinet is very substantially made of black walnut and is very handsomely finished. It is provided with a hinged top so that the interior of the set will be readily accessible.

The primary and secondary variable condensers are of the balanced type and are substantially built. Any insulating material used in their construction is so placed as to be in a comparatively weak field. The bearings are of brass and are provided with the usual adjustments to take up wear. The two sets of stationary plates on the secondary condenser are insulated from each other but may be connected together through a switch. Only half of the condenser is used for tuning up to position 5 of the secondary inductor switch. Including this position and beyond the entire condenser is used.

The grid condenser is also of the variable type. It is not as well constructed as the other condensers. Connection to the rotary plates of all the condensers is made through a flexible strip. A fixed telephone condenser is also provided. This is sealed in a glass tube.

All windings are on tubes of laminated phenolic insulating material. The tubes upon which the loading coils are wound are supplied with end plates of the same material and are securely fastened to the panel.

The variable inductor in the plate circuit is constructed of moulded phenolic insulating material. It is provided with generous bearings and is well constructed and mounted. Connections to the rotor are made through flexible strips.

The variocoupler is the inclined coil type. This design permits 180 degree rotation of control with only 90 degree rotation of the rotor. The complete coupler is mounted on a sub-base which is in turn mounted on the panel. Connections to the rotor are made through flexible wires. The primary of the variocoupler

is not well supported on its sub-base.

The various parts making up this set such as condensers, inductors, switches, variable inductors, varioccupler, etc., are mounted on separate bases of phenolic insulating material which are in turn mounted on the panel. This is very good construction as it prevents any warping of the panel from causing misalignment of the bearings.

The tube socket is substantially built and is mounted on two metal rods that project from the panel. The filament rheostat is very well constructed and is of a size such that it will easily carry its current without overheating. A voltmeter is provided to indicate voltage across the terminals of the filament of the tube.

A potentiometer is supplied for regulating the potential on the plate of the detector tube. This is quite desirable when a "soft" or "gas" tube is used as a detector.

The connections between the various parts are made with two sizes of wire. Leads from battery terminals and a few other connections are of No.14 bare tinned copper wire. Taps from the loading coils, however, are made with a much smaller wire encased in varnished camboric tubing.

Receiving Set No. 1922-G.--The panel upon which the various parts are mounted is of laminated phenolic insulating material 15 inches long, 8 7/16 inches high, and 3/16 inch thick, and has a dull grained finish. It is secured to the cabinet by seven small wood screws.

The cabinet is very substantially made of California bay-wood and is very handsomely finished. It is provided with a hinged top so that the interior may be readily accessible.

The primary and secondary condensers are the usual rotary variable type. The secondary condenser is very substantially constructed of heavy aluminum plates. The bearings are blocks of insulating material. A stop is provided so that only 180 degree rotation is possible. This stop is in the form of a piece of insulating material and since it acts only on one movable plate, this plate is likely to loosen and shift causing a change in the capacity of the condenser. Connection to the movable plates is made through a flexible strip. No adjustments are provided for taking up wear or centering the movable plates. The primary condenser is constructed in the same manner but much thinner plates have been used. The plates are too thin for sturdy construction. Fine adjustment condensers are supplied for both the primary and secondary circuits. These are mounted on brass rods extending from the panel. These condensers are not very serviceable but are somewhat misleading as no stops are provided nor any marking furnished to indicate when their capacity is maximum or minimum.

The primary inductor consists of a single-layer winding on a tube of laminated phenolic insulating material. This forms the primary of the variocoupler and is controlled by a multipoint switch. Resonance is eliminated in the unused turns by short-circuiting them.

The secondary inductor is made up of the secondary of the variocoupler and the secondary loading coil. The secondary winding of the variocoupler is on a form of black walnut wood. The loading coil is wound on a tube of laminated phenolic insulating material and the amount of the inductor in the circuit is varied by means of a multipoint switch. Resonance in the unused turns is eliminated by short-circuiting them. All wire used in both the primary and secondary is silk covered. No varnish is used on any of the coils to exclude moisture or to hold the windings in place.

Both the primary and secondary inductors are very substantially and neatly mounted, each being held by means of four square brass rods extending from the panel.

The rheostat is of the sliding contact type and will carry its current without overheating.

A telephone condenser constructed of mica and foil is provided across the output terminals.

Connections between the various parts of the set are made with No.12 bare tinned copper wire. All joints are well soldered and the wires are neatly arranged. Taps from the loading coils to their control switches, however, are made with the same wire as is used in winding the coils. These taps are encased in varnished cambric tubing and are of doubtful strength. The leads from the secondary of the variocoupler and from the tickler coil are of stranded wire insulated with varnished cambric tubing.

Receiving Set No. 1922-H.-- All parts are mounted on a vertical hard rubber panel 15 3/8 inches long, 5 3/4 inches high, and 3/16 inch thick. It is not securely fastened to the cabinet but fits in grooves cut in the ends of the cabinet. This is not good design for if the cabinet were turned upside down the panel would fall and would undoubtedly damage wiring that leads to terminals on the rear of the cabinet.

The cabinet is very substantially made of black walnut, well finished, and presents a very good appearance.

The feedback coil which rotates within the antenna inductor is insecurely mounted and is likely to give trouble. The shafts are not securely fastened to the coil form and the bearings through which they pass are holes in the antenna inductor form.

Receiving Set No. 1922-I.-- The panel is of moulded phenolic composition 18 inches long, 9 inches wide, and 3/16 inch thick, and has a dull grained finish. All metal parts on the front of the panel are nickel plated. The panel is secured to the cabinet by ten wood screws.

The cabinet is substantially made of black walnut and is very well finished. It is provided with a hinged cover and rubber feet.

The condensers supplied with this receiving set are the rotary variable type. The plates are heavy aluminum separated by brass washers. The end plates are made of insulating material and the bearings are merely holes through the end plates with no metallic bushings. Connection with the movable plates is made by a brush rubbing on the shaft.

The variocoupler which is made up of the primary and secondary inductors is of rather unusual construction. The primary is wound on a box shaped form made of laminated phenolic insulating material. This permits the use of less insulating material than other forms. The secondary is wound on a smaller box-like form and may be rotated through 180 degrees. Connection with the secondary is made of flexible wires. The primary is wound with silk-covered wire and the secondary with enameled wire. The primary winding is varnished to exclude moisture.

The set is provided with the usual grid condenser but no adjustable grid leak. The rheostat supplied is of the compression type and has no method for indicating the amount of resistance in the circuit. This is very unsatisfactory as it is difficult to tell whether the circuit is open or whether all the resistance is cut out. Jacks are provided so that the telephones may be quickly changed from the detector to the amplifier.

The detector and amplifier tube sockets are mounted on a heavy piece of insulating material securely attached to the panel. No provision is made for eliminating tube noises due to mechanical vibration of the tube. These noises are not noticeable when detector alone is used but when the amplifier is used they become very troublesome.

Connections between the various parts of the set are very neatly and substantially made with No. 14 copper wire encased in varnished cambric tubing.

Receiving Set No. 1922-J.-- The panel is of laminated phenolic insulating material 16 5/8 inches long, 11 1/8 inch high, and 3/16 inch thick, and has a dull grained finish. It is secured to the cabinet by eight wood screws.

The cabinet is reasonably well constructed of California baywood and is finished in mahogany. It is provided with rubber feet and a hinged door in the rear.

The condensers supplied with this set are of the rotary variable type. They are well made of aluminum plates, have brass bearings with adjustments to compensate for wear.

The inductors are of the basket wound type wound on forms of insulating material and are well varnished to exclude moisture.

Three of these inductors are mounted one behind the other with about 1/2 inch between them. The middle one is used for the antenna, inductor or primary. The outer two in series make up the secondary inductor. The coupling between the primary and secondary is fixed.

The grid condenser is loosely constructed of tin foil and varnished paper. No grid leak is provided. A one-stage amplifier is also provided. However, no provision is made for connecting the telephone receivers directly to the output of the detector tube. The rheostats are the sliding contact type and are substantially made. A switch is provided in the filament circuit for lighting and extinguishing the tubes.

Condensers loosely constructed of paper and tinfoil are provided across the primary of the amplifier transformer and across the telephones. They are supported only by their terminals which are soldered to the wires leading to the parts mentioned. A telephone jack is also supplied.

Connections between the various parts are made with substantial brass wire, though the general layout of the wires presents a very confused appearance.

Receiving Set No. 1922-K.--The cabinet is made of laminated wood securely put together. It is provided with a hinged cover to which a catch is attached to support the cover while open. The outer lamination of the wood of which the cabinet is made, is mahogany and is very well finished. Upon the top of the cabinet, under the cover, are mounted the tuning control, switch for controling filament current, and the detector and amplifier tubes with their ballast lamps. All exposed metal parts are finished in gilt.

The "B" battery for the detector and amplifier tubes is contained in the cabinet.

The tubes, ballast lamps, resistances and condensers are mounted on a strip of laminated phenolic insulating material which is attached to the top of cabinet through felt pads to decrease vibration of the tubes. All wiring is encased in varnished cambric tubing except where flexible leads are used.

The general assembly of this receiving set is very orderly.

Receiving Set No. 1922-L.-- The panel is of laminated wood 7 3/4 inches long, 6 1/2 inches wide, and 7/16 inch thick and is stained black on the bottom surface and enameled on the top.

It is secured to the cabinet by six wood screws.

The cabinet is substantially made of poplar wood and is well finished. It is provided with a hinged cover for protecting the controls and tube.

The fixed antenna condenser consists of strips of copper and mica clamped between metal plates.

The antenna variable inductor is of the rotating coil type. It consists of a long composition tube upon which is wound the stationary windings of two variable inductors - one at each end of the tube. The rotary windings are placed on a tube of like material but of smaller diameter which is substantially mounted directly under the stationary windings. One variable inductor is used as the antenna tuning inductance, the other is placed in the plate circuit to secure regeneration. All windings are well varnished to exclude moisture.

Flexible connections are used to connect the windings of the rotating parts to the remainder of the circuit. The bearings which support the rotors on the knob end of the shaft, are metal plates which are secured to the wooden panel. Collars are provided at this end to prevent end play. The bearings at the other end of the shafts are merely holes in the insulating tube.

The grid condenser and leak are mounted in an insulating tube with brass ends and supported by two spring clips.

The base of the detector tube does not fit the standard tube socket. The terminals of the tube are brought out to four metal prongs mounted on the base which are of different sizes and are not symmetrically placed. This is so that the tube may be placed in the socket in one way only.

The socket consists of a small piece of insulating material with holes so placed that the prongs on the tube will fit into them. Connection is made with the prongs by means of spring strips lining the holes. At times it is extremely difficult to insert or remove the tube due to the binding of the prongs in the holes.

The socket is mounted on the bottom of a wooden block attached to the panel. A hole passes through the panel and block in which the tube is inserted. This partly protects the tube from breakage but leaves the tip of the tube - the part most easily broken - in an exposed position. No provision is made for protecting the tube from mechanical vibrations or shock.

The rheostat for controlling the filament current consists of resistance wire wound on a fiber strip and mounted on a porcelain base. The amount of a resistance wire included in the circuit is varied by a sliding contact. The rheostat is very sturdily built and operates smoothly.

A telephone condenser in a sealed metal container is supplied for bypassing the radio-frequency currents around the phones and plate battery.

Connections between the various parts of this receiving set are made with different sizes of wire encased in varnished cambric tubing. In most cases the wiring is of doubtful strength. The wires are arranged irregularly. All joints are well made and are securely soldered.

Receiving Set No. 1923-M.-- The panels of both the tuner and amplifier which form the front of this receiving set are of laminated phenolic insulating material 6 11/16 inches wide, 9 5/8 inches high, and 1/4 inch thick. They have a beveled edge and a dull grained finish and are secured to the cabinet by means of four machine screws engaging in metal blocks which are in turn secured to the cabinet by machine screws. This gives very sturdy construction.

The cabinets are made of mahogany and are very substantially built and well finished. Rubber feet are provided to prevent marring the surface upon which they are placed. Holes are provided in the rear of the cabinets through which the terminals of the tuner and detector-amplifier project.

The condenser is of the rotary variable type and is mounted on a second panel of laminated phenolic insulating material. Upon this panel is also mounted the antenna inductor, "vernier,"* and multipoint switch for controlling regeneration. The condenser is very substantially constructed of heavy plates. The bearings are of liberal size and little trouble is to be expected due to wear. The "vernier" is nothing more than a small condenser to secure fine adjustment and consists of one movable plate which is rotated between two stationary plates. This condenser is very well made and should give little trouble. Provision is made on both condensers to take up any wear that may take place. Connection to the movable plates of the main condenser is made through the bearing while the connection to the "vernier" condenser movable plate is a flexible strip.

* The term "vernier" is incorrectly applied in this case. A vernier is an auxiliary scale used to read fractional parts of the subdivisions of a main scale.

The antenna variable inductor is of the rotating coil type. Both the rotary and stationary coils are wound on tubes of insulating material and are well varnished to exclude moisture. The rotary coil is attached to the end of the variable condenser shaft and rotates with it.

The detector tube and the amplifier tubes are supported by a rubber strip for preventing noises due to vibrations of the tubes. This rubber strip shows signs of deterioration and it is doubtful if it would give satisfactory service for a very great period of time.

7. Electrical Inspection.

Receiving Set No. 1922-A.-- The circuit employed in this receiving set is shown in Fig. 1. The inductors are of the rotating coil type and are continuously variable. They are wound on fibre forms with solid copper wire insulated with silk and enamel. No varnish is used to exclude moisture from the windings. The fibre used for the inductor forms have the unfavorable characteristic of being very hygroscopic.

The detector supplied with this set is the usual electron tube type employing grid rectification.

A metal shield is provided on the front of the tuner panel to prevent detuning due to presence of body. All wiring is encased in varnished cambric tubing and is well arranged. Fine adjustment is provided on both variable inductors in the form of miniature variable inductors.

The main controls are knobs made of insulating material attached to metal dials. A switch is provided for connecting the amplifier into the circuit. No convenient method is supplied, however, for connecting the telephone receivers to the output of the first stage of the amplifier.

Receiving Set No. 1922-B.-- A diagram of the circuit used in this receiving set is given in Fig. 2.

The inductor is a banked wound coil of double cotton covered solid copper wire on a laminated phenolic insulating tube. No provision has been made to exclude moisture from the windings. This will probably seriously affect the operation of the set during damp weather or in humid climates. The gentle heating of the electron tube will to a limited extent tend to keep the windings free from moisture.

The detector supplied with this receiving set employs grid rectification.

No shielding other than the metal dials is provided to prevent capacity changes caused by the presence of the hands while tuning. These, however, reduce the detuning effect considerably.

Receiving Set No. 1922-C.--The detector supplied with this receiving set is the usual type employing grid rectification. See Fig. 3 for circuit diagram.

The grid and telephone condensers are constructed of mica and foil clamped between blocks of insulating material. The grid leak is of the pencil line type and is adjustable. It is mounted on the panel and is protected by a metal cap. The rheostat is a sliding contact type and is well constructed.

All connections are very substantially made of No. 14 tinned copper wire. No shielding is provided to eliminate detuning due to body capacity. Provision is made for the reception of signals on lower frequencies (longer waves) in this receiving set by the insertion of an additional coil of the universal wound type.

Receiving Set No. 1922-D.-- The variable condenser supplied with this set is provided with a unique switching arrangement. An attempt has been made in this set to produce a combination of capacity and inductance that would tune to frequencies from 500 to 1500 kilocycles (wave lengths from about 600 to 200 meters) and require only one control. The rotation of the movable plates from 0° to 180° increases the capacity of the variable condenser for minimum to maximum. At the 180° position of the condenser a switch is opened which short circuited a portion of the antenna inductor. When the 180° position is passed the capacity of the condenser is reduced again to minimum and increases to maximum as the movable plates are turned to the 360° position. This scheme has the objection that an overlap of wave length occurs but one would infer from the markings on the dial that there was continuous variation and no overlap.

The antenna inductor consists of a single layer winding on a form of phenolic insulating material. This winding is of rather small solid copper wire insulated with silk and is well varnished to exclude moisture.

Two types of detectors are supplied - a crystal detector (which was not considered in these tests) and an electron tube detector. Grid rectification is employed in the latter.

Regeneration is accomplished by means of an inductance in the plate circuit inductively coupled to the antenna inductor. The coupling may be varied by rotating the coil. This winding is also of fine silk covered wire on a tube of insulating material and is well varnished to exclude moisture.

No shielding is required in this set as the metal case is a very effective shield.

Receiving Set No. 1922-E.-- The detector supplied with this receiving set is the usual electron tube employing grid rectification. The grid condenser is constructed of copper foil and mica clamped between blocks of insulating material. Pencil or ink lines may be drawn upon one of the blocks to form the grid leak.

The windings of the variable inductors are impregnated with varnish to exclude moisture. From an electrical viewpoint an excess of varnish has been placed on the stator coils but this is apparently necessary in order to overcome the mechanical difficulty of supporting the windings.

Since no electrical connection is made to the shaft to which the control knob and dial are attached little interference from body capacity effects is to be expected. Shields, however, are provided to prevent capacity changes caused by the presence of the hands while tuning. The shielding is very effective and practically entirely eliminates all detuning due to the presence of the hands.

Regeneration is very good except for the lower frequencies (longer wave lengths) of the 460 kilocycle (650 meter) range. It was at times difficult to get the set to generate at these frequencies probably because of insufficient inductance in the plate circuit variable inductor.

Receiving Set No. 1922-F.-- The antenna inductor consists of two single layer and eight banked wound coils which are controlled by a multipoint switch. The two single layer coils and four of the bank wound coils make up the primary of the variocoupler. The remaining four coils are wound on another tube and are used as loading coils. The secondary inductor consists of the secondary of the variocoupler and seven banked wound loading coils. Three of these coils are inductively coupled to the variable inductor in the plate circuit so as to secure regeneration on the lower frequencies (longer waves). Between the four remaining loading coils are three smaller banked wound coils which are connected in series with the plate circuit. These are to secure regeneration on very low frequencies (extremely long waves). The three plate circuit loading coils together with the secondary loading coils are controlled by two multipoint switches which are actuated by one control on the front of the panel. There is also mounted on this switch another switch which closes at position 5. This cuts in the remaining half of the secondary condenser.

All windings are varnished to hold them in place and to exclude moisture. The effectiveness of the kind varnish used for excluding moisture is doubtful, however.

Regeneration is accomplished by means of a variable inductor in the plate circuit on the higher frequencies (short waves) and by the inductive coupling between the plate and secondary circuits on the other waves as described above.

Loss by resonance in the unused portions of the primary, secondary and plate loading coils is minimized by short-circuiting a part of the unused portions.

The detector supplied with the set is the electron tube type employing grid rectification. A variable grid condenser is provided and upon this is mounted the grid leak sealed in a glass tube.

No shielding is provided to prevent detuning due to body capacity other than the metal dials. The secondary condenser

and the variable inductor in the plate circuit are provided with an insulating joint in their shafts between the control and the instrument proper. This reduces body capacity considerably. The shaft of the fine adjustment control of the secondary condenser which is connected electrically with the rotary plates of the condenser is not provided with an insulating joint. As this control is most used an insulating joint would be more serviceable in this shaft than in the main shaft. On high frequencies (short waves) detuning due to body capacity is very noticeable on this control and it is quite noticeable on the long waves. No shielding is provided between the primary and secondary circuits. This would be desirable in order to eliminate the capacitive and inductive coupling between the primary and secondary loading coils.

Receiving Set No. 1922-G.--The detector supplied with this receiving set is of the electron tube type and employs grid rectification. The grid condenser is well constructed of foil and mica. The grid leak is a strip of material having high resistance mounted on the base of the socket and extending from the grid terminal to the filament terminal.

Regeneration is accomplished by means of an inductance in the plate circuit which is coupled to the secondary loading coil. This winding is on a form of black walnut and is mounted on a hollow brass shaft. The bearings for this shaft are the holes through the tube and panel. Connections to the winding is made through flexible leads passing through the hollow shaft. Stops are provided to prevent more than 180 degree rotation. The secondary of the variocoupler is mounted in a like manner. On the lower frequencies additional regeneration may be secured by means of a second inductance in the plate circuit which is wound on one end of the secondary loading coil tube and coupled with it. It is controlled by means of a multipoint switch on the panel.

No shielding is supplied other than the metal dials on the controls. These do not effectively prevent detuning due to body capacity.

Receiving Set No. 1922-H.- The detector used with this receiving set is an electron tube employing grid rectification.

No shielding is provided to prevent detuning effects.

The variable condenser supplied with this set is the usual rotary variable air condenser. The plates are aluminum and are of sufficient thickness to give them the required strength. The end plates are of laminated phenolic insulating material. Holes through the end plates serve as bearings for the rotary plates. Connection with the rotary plates is made through a piece of metal pressing on the end of the shaft.

The inductor consists of a tapped single-layer winding on an insulating material form. A multipoint switch is provided for varying the inductance. No provision has been made to exclude moisture from the windings or securing them to the form.

The grid and telephone condensers are constructed of mica and foil clamped between blocks of insulating material. A grid lead consisting of a strip of paper coated with resistance material is mounted on the socket. The socket is substantially built and is mounted directly on the panel with no provision for preventing vibration of the tube. The rheostat is of the sliding contact type and is of substantial construction.

The wiring connecting the various parts of this set is very loosely arranged. The wire used is stranded having a diameter approximately that of No. 22 B & S gauge, and is covered with rubber. It is entirely too small for the purpose intended. No care has been used in placing the wires. Wires of highly different potentials leading to the terminal board on the rear of the cabinet are all cabled together for quite a distance. This permits capacitive coupling between wires of different potentials.

Receiving Set No. 1922-I.--The electron tube detector supplied with this receiving set employs grid rectification.

No shielding is provided to prevent detuning due to the presence of the hands.

All of the inductance in the secondary circuit is coupled to the primary circuit. Due to the large mutual inductance between the primary and secondary circuits a small change in coupling produces quite a change in wave frequency (wave length) which would not take place if the ratio of mutual inductance to total inductance in the secondary circuit were small.

Receiving Set No. 1922-J.-- The detector supplied with this receiving set is the usual electron tube employing grid rectification.

No provision is made for varying the coupling between the antenna and secondary circuits. This results in a combination that from the standpoint of selectivity is undesirable, as an improperly coupled circuit will resonate at two different frequencies. One of the chief advantages of coupled circuits is lost by this arrangement.

No shielding is provided to eliminate the effect of the presence of the hands while tuning.

Receiving Set No. 1922-K.-- The most important differences between this set and receiving set No. 1922-L are that the detector of this set is connected for plate rectification and that the regeneration or feedback is fixed. Regeneration may be changed, however, by shifting a tap on the plate circuit inductance.

In this set the rheostats have been replaced by ballast lamps for controlling the filament current.

Shielding is provided to prevent detuning effects.

Receiving Set No. 1922-L.-- The detector tube supplied with this receiving set is a specially designed low-current tube. It has a coated filament and operates at a dull red temperature. One dry cell is sufficient to operate it as the filament requires a current of only about 1/4 ampere.

Grid rectification is used in this set.

Regeneration is secured by a combination of inductive and capacitive coupling. This is accomplished by means of a variable inductor in the plate circuit to which is coupled a portion of the antenna inductor. With this combination it is not necessary to readjust the tickler control with each setting of the tuner as is necessary when capacitive coupling alone is used. As the amount of regeneration remains practically constant over a small band of frequency, the rebenerative action is very smooth throughout the entire range of the tuner controls.

Shielding is provided to prevent the effects of the presence of the hands while tuning. It does not eliminate detuning, however, since the hands when near the front side of the case cause considerable detuning.

Receiving Set No. 1922-M.-- This receiving set covers a rather wide frequency (wave length) band with only one control. This is accomplished by arranging the variable condenser and inductance so that they are both varied simultaneously by means of the same control. On a receiving set this feature is very desirable.

In accomplishing the above, another desirable feature can be effected, namely a constant ratio between inductance and capacity (provided proper values have been chosen).

The detector supplied with this set employs grid rectification.

Regeneration is accomplished by varying an inductance in the plate circuit which is coupled with the antenna inductance. Since this inductance is varied by means of a multipoint switch close adjustment cannot be obtained.

The tuner is very thoroughly shielded so that the presence of the hand while tuning has no effect on the settings of the controls. The shielding is accomplished by a grounded metal plate mounted on the rear of the panel and by the use of insulating joints in the shafts leading to the controls.

8. Frequency (Wave Length) Ranges.

The frequency (wave length) ranges of the several receiving sets were determined by operating them in connection with an actual antenna of approximately 0.0005 microfarad capacity and determining by means of a buzzer-driven wavemeter, the

frequency (wave length) range of the combination of each inductor step of the primary and secondary with the antenna or secondary condenser set at both their minimum and maximum values. The frequency (wave length) ranges throughout which the receiving set will generate radio-frequency current were determined with this same setup. The procedure consisted of determining the setting at which the receiving set ceased to generate when maximum tickler coupling was used and measuring the frequency (wave length) at these settings. The data secured by these measurements are given in tables 1 to 14 inclusive.

From the frequency (wave length) range data, secured as described above, the band of frequencies (wave lengths) common to each of two successive inductor steps was determined. This common band is termed "overlap." The ratio between the width of this band and the greater of the two limiting frequencies (wave lengths) of which it is the difference is termed the percentage overlap. The values of the percentage overlaps have been calculated and are given with the frequency (wave length) range data in Tables 1 to 14 inclusive. It is to be noted that a high percentage overlap is distinctly desirable in a secondary circuit and is most essential in the primary circuit. In the secondary circuit a high percentage overlap is desirable since it allows certain bands of frequencies (wave lengths) to be obtained by two or more combinations of inductance and capacity and therefore may give the opportunity of choosing such values of inductance, capacity and resistance as will be best suited to the detector used or of such relative values as to give a choice of selectivity. This advantage applies also to the antenna circuit with the addition, however, that the maximum frequency (wave length) of any inductor tap is determined in the main by the antenna capacity, and the minimum by the series tuning capacity, thus the greater the percentage overlap, the smaller may be the minimum antenna capacity that will give complete frequency (wave length) continuity and hence the greater will be the range of antenna capacities that may be used with the receiving set. The actual values of antenna capacity which may be used with the various sets has not been determined.

Table I.

Frequency (Wave Length) Ranges of Receiving Set No. 1922-A.

Position of Inductor control			Frequency, Kilocycles per second	Wave Length Meters
		Primary		
Large Steps	Small Steps			
1	6		---	---
1	5		1370	219
1	4		1310	229
1	3		1219	246
1	2		1150	261
1	1		1048	286
2	1		777	388
3	1		625	480
4	1		565	531
5	1		493	608
6	1		437	686
Large Steps	Small Steps	Antenna Loading Coil		
6	1	1	437	686
6	1	2	260	1152
6	1	3	172	1737
6	1	4	126	2380
6	1	5	99	3050
		Secondary		
0			1817	165
20			1694	177
40			1127	266
60			910	330
80			850	353
100			802	374
100 plus grid loading variable inductor			532	564
100 plus grid loading coil			646	464
100 plus grid loading variable inductor and grid loading coil			509	589

Table 2

Frequency (Wave Length) Ranges of Receiving Set No. 1922-B

Tap	Capacity				Overlap		Percent Overlap
	Minimum		Maximum		Kilocycles	Meters	
	Frequency Kilocycles per second	Wave Length, Meters	Frequency Kilocycles per second	Wave Length meters			
1	1744	172	1067	281	118	28	10
2	1185	253	702	427	152	76	18
3	854	351	539	557	48	46	8
4	587	511	359	835			

Table 3.

Frequency (Wave Length) Ranges of Receiving Set No.1922-C.

Position of Inductor Control	Frequency, Kilocycles per Second	Wave Length, Meters
0	1589	189
10	1017	295
20	666	451
30	510	589
40	399	752
50	334	898
60	293	1024
70	266	1129
80	248	1208
90	247	1215

Table 4

Frequency (Wave Length) Ranges of Receiving Set No.1922-D.

Position of Condenser	Frequency, Kilocycles per second	Wave Length, Meters	Percent. Overlap.
0	1705	176	
1	1586	189	
2	1107	271	
3	910	330	
4	807	372	
5	743	404	
6	706	425	
7	679	442	
8	658	456	
9	644	466	
Overlap of	234	124	27
10	878	342	
11	827	363	
12	616	487	
13	526	571	
14	463	648	
15	437	687	
16	412	728	
17	393	762	
18	380	790	
19	370	810	

Using crystal detector the calibration was about the same as with the electron tube.

Table 5.

Frequency (Wave Length) Ranges of Receiving Set No. 1932-E

Position of Capacity Change Switch	Inductance						
	Minimum		Maximum				
	Frequency Kilocycles per second	Wave Length Meters	Frequency Kilocycles per second	Wave Length Meters	Overlap of Kilocycles	Overlap of Meters	Per-cent. Over-lap
Secondary							
375 meter range	1948	154	746	403	264	105	26.1
650 meter range	1010	297	392	768	164	226	29.5
1000 meter range	556	540	228	1315			
Primary							
Turns on Primary of Coupler							
2			1345	233			
4			1280	234			
8			1127	266			
12			996	301			
22			730	411			
32			602	498			
42			500	600			
52			437	687			
62			375	800			
72			313	958			

Table 6

Frequency (Wave Length) Ranges of Receiving Set No.1932-E.

Taps	Condenser Capacity				Overlap		
	Minimum		Maximum				
	Frequency Kilocycles per second	Wave Length Meters	Frequency Kilocycles per second	Wave Length Meters	Kilocycles	Meters	Per cent.
			Secondary				
1	1735	174	608	494	302	164	33
2	910	330	357	840	0	0	0
3	357	840	213	1410	37	210	15
4	250	1200	100	2990	8	210	7
5	108	2780	42.1	7120	15.7	1930	27
6	57.8	5190	24.0	13500	3.8	1700	14
7	27.8	10800	12.4	24200 [1]			
			Primary (Condenser in Series)				
1	-	-	-	-	[illegible]	[illegible]	[illegible]
2	1775	169	639	470	109	69	15
3	748	401	395	776	22	56	7
4	417	720	230	1300	22	110	8
5	252	1190	141	2130	27	350	16
6	168	1780	86.1	3485	21.9	705	21
7	108	2780	64.4	4660	21.3	1160	25
8	85.7	3500	43.5	6895	9.5	1335	20
9	53.0	5560	28.3	10600			
			Primary (Condenser in Parallel)				
1	1380	218	1190	253	-313	-89	-26
2	877	342	559	537	-213	-329	-38
3	346	866	184	1630	4	30	1.8
4	188	1600	95.0	3160	26	670	21
5	121	2490	61.4	4890	13.6	800	16
6	75.0	4090	38.0	7900	19.9	2720	34
7	57.9	5180	29.0	10350	6.3	1850	18
8	35.3	8500	17.8	16800	3.9	3000	18
9	21.7	13800	12.4	24200 [2]			

1 Condenser set at 85 degrees.

2 Condenser set at 87 degrees.

Table 7

Frequency (Wave Length) Ranges of Receiving Set No. 1922-G.

Tap	Condenser Capacity				Overlap		
	Minimum		Maximum				
	Frequency Kilocycles per second	Wave Length Meters	Frequency Kilocycles Per Second	Wave Length Meters	Kilocycles	Meters	Per cent.
			Secondary				
1	1570	191	645	465	818	260	56
2	1463	205	434	691	622	407	59
3	1056	284	399	753	563	440	59
4	962	312	355	845	439	467	55
5	794	378	292	1038	304	525	51
6	596	503	232	1290	228	638	49
7	460	652	185	1630	188	815	50
8	373	805	155	1940	167	1009	52
9	323	931	135	2235	153	1185	53
10	288	1040	121	2480	149	1367	55
11	270	1113	113	2660	137	1463	55
12	250	1197	102	2955			
			Primary, Condenser in Series.				
1	1390	216	1095	274	215	45	16
2	1310	229	718	418	507	173	41
3	1235	245	562	534	488	248	46
4	1050	286	491	611	469	299	49
5	960	312	404	743	454	400	54
6	858	342	357	840	416	452	54
7	773	388	303	989	358	535	54
8	661	454	253	1184	319	659	56
9	572	525	239	1254	238	626	50
10	477	628	226	1325	194	611	46
11	420	714	198	1515	182	725	48
12	380	790	176	1705	189	823	48
13	365	882	156	1920			
			Primary, Condenser in Parallel.				
1	1127	266	1050	286	-330	-132	
2	720	418	562	534	+ 13	- 13	
3	549	547	380	790	95	158	20
4	475	632	324	925	74	173	19
5	398	752	277	1084	68	213	19
6	345	871	254	1180	29	120	10
7	283	1060	210	1435	48	265	18
8	258	1160	170	1770	37	320	18
9	207	1450	137	2185	23	425	19
10	170	1760	114	2630	36	628	24
11	150	2002	99	3030	34	768	25
12	133	2252					
13	116	2585					

Table 8

Frequency (Wave Length) Ranges of Receiving Set No. 1922-H.

Tap	Condenser Capacity				Overlap		
	Minimum		Maximum				
	Frequency Kilocycles per second	Wave Length Meters	Frequency Kilocycles per second	Wave Length Meters	Kilocycles	Meters	Per cent.
1	2400	125	1187	253	1053	119	47
2	2240	134	770	390	1220	139	36
3	1990	151	705	427	1105	161	38
4	1810	166	653	460	977	276	60
5	1630	184	588	511	857	303	59
6	1445	208	540	557			

Table 9

Frequency (Wave Length) Ranges of Receiving Set No. 1922-I.

Tap	Condenser Capacity				Overlap		
	Minimum		Maximum				
	Frequency Kilocycles per second	Wave Length Meters	Frequency Kilocycles per second	Wave Length Meters	Kilocycles	Meters	Per cent.
			Primary				
1	2460	122	1123	267	663	99	37
2	1786	168	666	451	1030	273	60
3	1686	178	591	508	731	281	55
4	1323	227	453	664			

Secondary

Position of Condenser Degrees	Frequency Kilocycles per second	Wave Length Meters
0	2112	142
30	1704	176
60	1523	197
90	1321	227
120	1172	256
150	1067	281
180	991	3033

Table 10.

Frequency (Wave Length) Ranges of Receiving Set No. 1923-J.

		Frequency, Kilocycles per second	Wave Length, Meters
Primary	Minimum	3950	76
	Maximum	813	369
Secondary	Minimum	1775	169
	Maximum	437	686

Table 11.

Frequency (Wave Length) Ranges of Receiving Set No. 1923-K

Position of Inductor Control	Frequency Kilocycles per second	Wave Length, Meters	Per cent. Overlap
	Short Wave Connection		
0	1375	218	
1	1350	340	
2	1111	270	
3	1017	295	
4	909	330	
5	838	358	
6	781	384	
7	739	406	
8	698	430	
9	676	444	
10	665	451	
Overlap of	233	117	26
	Long Wave Connection		
0	898	334	
1	838	358	
2	743	404	
3	676	444	
4	633	474	
5	590	508	
6	559	537	
7	523	574	
8	493	608	
9	478	628	
10	463	648	

Table 12.

Frequency (Wave Length) Ranges of Receiving Set No.1928-L.

Position of Inductor Control	Frequency, Kilocycles per second	Wave Length, Meters	
	Short Wave Connection		
0	1478	203	
1	1439	210	
2	1381	227	
3	1195	251	Overlap of 66 kilo-
4	1103	272	cycles per second
5	1017	295	(39 meters). Per cent.
6	938	330	overlap 7.7%
7	882	340	
8	838	358	
9	807	372	
10	798	376	
	Long Wave Connection		
0	864	347	
1	838	358	
2	780	385	
3	733	415	
4	662	456	
5	638	478	
6	596	503	
7	559	537	
8	532	564	
9	516	583	
10	509	589	

Table 13.

Frequency (Wave Length) Ranges of Receiving Set No.1932-M.

Position of Tuner	Frequency, Kilocycles per second.	Wave Length, Meters
0	1840	163
10	1570	191
20	1127	266
30	878	342
40	734	409
50	648	463
60	591	508
70	536	560
80	487	616
90	451	665
100	423	710

Table 14.

Fre Summary of Frequency (Wave Length) Ranges.

Receiving Set No.	Frequency (Wave Length) Range Damped or Modulated		Continuous Wave Reception		Frequency (Wave Length) ranges specified by manufacturers.	
	Frequency Kilocycles per second	Wave Length Meters	Frequency Kilocycles per second	Wave Length meters	Frequency Kilocycles per second	Wave Length Meters
1922-A	1370 to 532	219 to 564	Non-regenerative receiving set			
1922-B	1744 to 359	172 to 835	1744 to 359	172 to 835	1715 to 364	175 to 825
1922-C	1589 to 247	189 to 1215	Non-regenerative receiving set			
1922-D	1705 to 370	176 to 810	1705 to 730	176 to 810		
1922-E	1345 to 313	223 to 958	1345 to 313	223 to 958	2000 to 300	150 to 1000
1922-F	1725 to 12	174 to 25,000	1725 to 12	174 to 25,000		
1922-G	1390 to 102	216 to 2955	1390 to 102	216 to 2955		
1922-H	2400 to 540	125 to 557	2400 to 540	125 to 557		
1922-I	2112 to 991	142 to 303	Non-regenerative receiving set			
1922-J	1775 to 813	169 to 369	Non-regenerative receiving set			
1922-K	1375 to 463	218 to 648	Feedback insufficient for generation			
1922-L	1478 to 509	203 to 589	1478 to 509	203 to 589		
1922-M	1840 to 423	163 to 710	1840 to 423	163 to 710		

9. Vibration Test.

Information regarding the mechanical strength of the sets, particularly as to their ability to withstand the shocks of transportation was obtained by fixing the receiving set to the table of a vibrating machine, and operating the machine for a period of fifteen minutes. This machine simulates the vibrations and shocks to which the receiving set would likely be subjected in transit. A photograph of the vibrating machine used is given in a separate paper entitled, "Tentative Methods of Testing Radio Receiving Sets."

This test was passed satisfactorily by receiving sets Nos. 1922-A, 1922-C, 1922-E, 1922-F, 1922-G, 1922-L, and 1922-M.

The following sets failed to pass the shipping test satisfactorily -

No. 1922-B.	Condenser knob and dial loosened from condenser shaft.
No. 1922-D.	Detector crystal cup loosened.
No. 1922-H.	Wire connected to filament rheostat broken. Wire connected to antenna inductor switch lever broken due to twisting of wire as lever was moved. Condenser stop loosened. Rear shaft of rotor loosened. It was necessary to repair the receiving set before tests could be completed.
No. 1922-I.	Rheostat and tuner knobs loosened.
No. 1922-J.	Knob of filament control switch loosened.
No. 1922-K.	Core of adjustable choke coil loosened.

10. Sensitivity Measurement.

The results of the sensitivity measurements are given in Tables 15, 16 and 17. Sensitivity measurements were made at three frequencies, 1500, 834 and 625 kilocycles per second (200, 300 and 480 meters), even though several of the receiving sets are designed to cover a wider range of frequencies.

For this measurement the receiving set was carefully tuned to the desired frequency and a known voltage (unmodulated) was impressed on the dummy antenna. The signal current flowing in the telephone receiver circuit was then measured. From these measurements sensitivity was calculated by the formula -

$$\text{Sensitivity} = \frac{\text{Signal current in microamperes}}{\text{Impressed voltage in millivolts}} \times 100 \text{ - - -} \quad (1)$$

These measurements were made at minimum and maximum regeneration both with 0 and 12 ohms resistance inserted in the antenna circuit. It was found that the values for sensitivity at maximum regeneration were approximately the same for both 0 and 12 ohms antenna resistance.

For a more complete description of the methods used in making sensitivity measurements reference should be made to a separate paper entitled, "Tentative Methods of Testing Radio Receiving Sets."

Table 15

Sensitivity

Frequency, 1500 Kilocycles per second - Wave Length, 200 meters

Receiving Set No.	Minimum Regeneration						Maximum Regeneration		
	No resistance added to antenna circuit			12 ohms resistance added to antenna circuit					
	Antenna voltage, millivolts								
	15	30	50	15	30	50	15	30	50
1922-A	3.3	10	38	*	1.6	6.0	Non-regenerative		
1922-B	1.3	1.6	4.0	1.3	1.6	4	166	166	139
1922-C	53	83	120	27	42	64	Non-regenerative		
1922-D	1.3	1.3	4	1.3	1.3	4	400	383	300
1922-E	200	353	358	87	146	171	1130	857	660
1922-F	20	30	46	20	30	46	1400	917	670
1922-G	53	97	120	6	57	70	920	620	480
1922-H	*	*	*	*	*	*	1330	734	760
1922-I	13	23	36	10	20	32	Non-regenerative		
1922-J	20	33	56	3	3	14	Non-regenerative		
1922-K	*	*	*	*	*	*	*	*	*
1922-L	133	147	148	53	67	84	453	317	216
1922-M	3.3	5.0	8.4	3.3	5.0	8.4	840	547	340

*Sensitivity too low to measure under these conditions.

Table 16.

Sensitivity

Frequency, 833 kilocycles per second - wave length, 360 meters

Receiving Set No.	Minimum Regeneration						Maximum regeneration		
	No resistance added to antenna circuit			12 ohms resistance added to antenna circuit					
	Antenna voltage, millivolts								
	15	30	50	15	30	50	15	30	50
1922-A	1.3	6	10	*	0.6	3.6	Non-regenerative		
1922-B	0.6	1.6	1.6	0.6	1.6	1.6	260	193	157
1922-C	13	23	36	10	17	26	Non-regenerative		
1922-D	2.7 [1] * [2]	4.7 *	6 *	2.7 *	3.3 *	5 *	950 300	770 250	520 *
1922-E	47	80	100	20	33	50	1000	587	600
1922-F	10	11.7	20	6.7	10	1.9	967	683	520
1922-G	*	1.6	4	*	*	3	452	350	316
1922-H	*	*	1	*	*	1	1600	1050	800
1922-I	20	37	56	10	20	32	Non-regenerative		
1922-J	20	47	76	18	43	68	Non-regenerative		
1922-K	*	*	*	*	*	*	*	*	*
1922-L	93	123	133	57	80	96	467	327	244
1922-M	2.7	5.0	10	2.7	4.6	9.8	646	553	460

[1] Short wave position
[2] Long wave position

*Sensitivity too low to measure under these conditions.

Table 17.

Sensitivity

Frequency, 625 kilocycles per second = wave length, 480 meters.

Receiving Set No.	Minimum regeneration						Maximum regeneration		
	No resistance added to antenna circuit			12 ohms resistance added to antenna circuit					
	Antenna voltage, millivolts								
	15	30	50	15	30	50	15	30	50
1922-A	*	*	3	*	*	0.4	Non-regenerative		
1922-B	1.3	0.6	1.0	1.3	0.6	1.0	253	180	142
1922-C	25	51	80	13	28	44	Non-regenerative		
1922-D	1.3	1.6	2.0	1.3	1.6	1.8	1160	684	480
1922-E	15	25	42	6.6	13	21	767	577	470
1922-F	*	1.6	2	*	1.6	2	754	540	360
1922-G	*	1.6	4.4	*	1.3	3.6	265	237	228
1922-H	*	*	1	*	*	1	1665	1050	836
1922-I	6.6	17	26	3.3	6.6	12	Non-regenerative		
1922-J	13	20	33	10	16	26	Non-regenerative		
1922-K	*	*	*	*	*	*	*	*	*
1922-L	53	90	108	23	40	52	446	327	240
1922-M	4.6	8.3	14	4.0	7.3	10	630	660	520

*Sensitivity too low to measure under these conditions.

11. Selectivity Measurement.

To determine the selectivity of the receiving sets, measurements were made of the sharpness of resonance when connected to a phantom antenna. The results are given in Table 18. These values were obtained by substituting in the following general formula -

$$S = \frac{\sqrt{\frac{I_r - I_o}{I_o}}}{\frac{f_1^2 - f_2^2}{f_1 + f_2^2}} \qquad (2)$$

The measurements were made as follows: the receiving set was carefully tuned to the desired frequency with minimum regeneration and the input voltage adjusted until a current of 40 microamperes (I_r) was flowing in the telephone receiver circuit. The frequency of the generating set was then increased until the current was reduced to 20 microamperes (I_o). The frequency (f_1) of the radio-frequency current generated by the generating set was then measured. The frequency was then decreased until 20 microamperes signal current was obtained on the other side of resonance. The frequency was again measured. This was called f_2. By taking I_o equal to $\frac{1}{2}I_r$ the computation is much simplified as this makes the numerator of formula (2) equal to unity. It is convenient to designate the value of sharpness of resonance when obtained in this manner as $S_{\frac{1}{2}}$. Formula (2) then simplifies to the following -

$$S_{\frac{1}{2}} = \frac{f_1^2 + f_2^2}{f_1^2 - f_2^2} \qquad (3)$$

The reason for choosing I_r = 40 microamperes was because it was a convenient value to read on the microammeter scale and because it was thought desirable to have I_r the same for all the sets. These measurements were made both with and without the insertion of a resistance of 12 ohms in the dummy antenna.

In finding the sharpness of resonance at maximum regeneration the value at minimum regeneration was first found. After the receiving set had been again carefully tuned the input voltage was adjusted until a current of 2 microamperes (I min.) was flowing in the telephone receiver circuit. The regeneration was then increased to a point where generation was just about to begin and the set retuned for maximum signal. The signal was then measured (I max.). Sharpness of resonance at maximum regeneration was then obtained from the formula below -

$$\text{S max. regen.} = \text{S min. regen.} \times \sqrt{\frac{\text{I max.}}{\text{I min.}}} \qquad (4)$$

These measurements were found to have approximately the same values even when a resistance of 12 ohms was added to the antenna circuit.

For a more complete description of the method of making these measurements of sharpness of resonance, reference should be made to a separate paper, entitled "Tentative Methods of Testing Radio Receiving Sets."

Table 18. Sharpness of Resonance, $S_{\frac{1}{2}}$

Receiving Set No.	Type of circuit	1500 Kilocycles (200 meters)			834 Kilocycles (360 meters)			625 Kilocycles (485 meters)		
		Minimum Regen. 0 ohms added Ant. Res.	Minimum Regen. 12 ohms added Ant. Res.	Maximum Regeneration	Minimum Regen. 0 ohms added Ant. Res.	Minimum Regen. 12 ohms added Ant. Res.	Maximum Regeneration	Minimum Regen. 0 ohms added Ant. Res.	Minimum Regen. 12 ohms added Ant. Res.	Maximum Regeneration
1922-A	C	55.5	24.0		78.3	39.1		65.4	32.1	
1922-B	S	21.0	19.0	120	15.5	13.2	113	8.5	8.5	64.2
1922-C	S	20.0	15.0		26.0	22.0		35.0	26.0	
1922-D	S	11.7	11.4	118	21.8[3] 13.5[4]	18.4 13.4	231 138	15.6	15.3	178
1922-E	C	73.0	65.0	343	33.2	30.1	285	28.0	18.0	226
1922-F	C	42.3	39.2	454	48.1	43.3	521	17.2	17.1	163
1922-G	C	46.6	28.1	233	20.9	10.2	137	39.0	21.1	278
1922-H	S	2.3	2.2	37	2.9	2.8	46	3.9	3.6	63
1922-I	C	38.1	29.7		70	45		68	43	
1922-J	C	67	31		62	62		72	60	
1922-K	S	27.5	23.1	28.5[1] 23.5[2]	24.0[3] 39.8[4]	32.3[3] 26.5[4]	26.8[1] 39.9[1] 25.9[2] 30.2[2]	32.3	25.5	38.4[1] 29.1[2]
1922-L	S	126	50	550	89.2[3] 74 [4]	74[3] 41.8[4]	432 348	66.0	48.5	361

1922-M	S	23.4	20.5	146	34.5	28.0	275	33.4	30.5	308

1 - No added antenna resistance.

2 - 12 ohms added antenna resistance

3 - short-wave position

4 - long-wave position.

12. Notes on Operation.

Receiving Set No. 1922-A.- Since this is a non-regenerative set continuous-wave signals can not be received unless an external heterodyne is used.

The arrangement of the controls is very good, being so placed that the hand may rest on the table while tuning. The filament rheostats and switch and the potentiometer are located directly above the tuning controls.

Because this is a two-circuit tuner it is more difficult to tune than a single-circuit set.

Receiving Set No. 1922-B.- With this receiving set, only three adjustments are necessary for tuning in the desired station. These are, the antenna inductance, the antenna tuning condenser, and the regeneration. The antenna inductance gives large variations in wave length, the antenna condenser small variations. The "tickler" control varies the amount of regeneration. Adjustments when once made are permanent except for slight detuning on higher frequencies (shorter waves) due to body capacity.

Feedback action or regeneration was very good for the lower frequencies (longer waves) but at times it was difficult to get the set to generate on the higher frequencies (shorter waves).

Receiving Set No. 1922-C.- This set is fairly easy to tune as there are only two tuning controls. It is, however, difficult at times to so place the controls that the sliding contact touches only one wire of the inductor.

Receiving Set No. 1922-D.- The arrangement of the controls on this receiving set is very good. Only two controls are supplied for tuning - "Wave Length" and "Intensity" (regeneration). The "Wave Length" control gives variation in frequency (wave length) but as explained under "Electrical Characteristics" there is an overlap of frequency (wave length) which is in no way indicated on the dial.

The controls operate smoothly except for a portion of the "Wave Length" scale where that control operates a switch. If the set is generating a very loud noise is heard in the receivers as this point is passed.

Regenerative action was very smooth throughout the range of the set. Adjustments were permanent when once made and no detuning due to body capacity was noticed.

Receiving Set No. 1922-E.- Tuning this receiving set is more difficult than one of the single-circuit type. About five adjustments are necessary while only three are necessary with a single-circuit receiver. The adjustments required are antenna inductance, secondary inductance, regeneration, coupling and a

readjustment of the secondary inductance.

Considerable skill is required to operate this set at its maximum efficiency. This skill, however, is not difficult to acquire.

This type of receiving set will not reradiate as strongly as the single-circuit type. This feature is particularly desirable when the set is used in districts where a large number of sets are in use.

Receiving Set No. 1932-F.- Tuning this set is more difficult than tuning a single-circuit set as it requires the adjustment and readjustment of seven controls as compared with the siggle-circuit's three.

The controls are all very effective on the higher frequencies (shorter waves) except possibly the coupling control. Due to the large primary and secondary loading coils, which are located very close to one another without being shielded, there is considerable capacitive coupling between the primary and secondary that can not be controlled. This greatly reduces the effectiveness of the coupling control. On the low frequencies (long waves) the coupling control is very ineffective due to the increased magnetic coupling between the primary and secondary loading coils.

On the extreme high frequencies (short waves) regeneration is not very smooth and the set will howl if this control is not carefully manipulated. On waves of medium frequency (wave length) the regenerative action is very smooth and easily controlled. On waves greater than about 75 kilocycles (4000 meters) there is no control over regeneration except by varying the filament temperature of the tube.

The arrangement of the tuning and detector controls is such that the hand and forearm may rest on the table while the main tuning adjustments are being made. The regeneration control, which is used quite frequently when receiving short waves, is located in the upper left corner.

Receiving Set No. 1932-G.- The arrangement of all the controls on this receiving set is very good as the controls which are most usually used are mounted low on the panel so that the hand and forearm may rest on the table while tuning.

This set is more difficult to tune than a single-circuit receiver. There are six controls to adjust in tuning in a station.

When the coupling or regeneration is changed there seems to be quite a change in frequency (wave length) of the secondary circuit, making considerable readjustment of that circuit necessary.

Regeneration is not smooth and it is necessary to carefully manipulate the regenerator control to prevent howling.

Receiving Set No. 1922-H.- With this receiving set only three adjustments are necessary to tune in the desired station. These are antenna inductance, antenna condenser, and regenerator. The antenna inductance gives large variations in frequency (wave length), the antenna condenser small variations. The regenerator controls regeneration. Adjustments when once made are permanent except for detuning due to body capacity.

Feedback action is not good as the set howls badly if the regeneration control is not adjusted very carefully.

Receiving Set No. 1922-I.- It is difficult to tune this receiving set because all of the secondary inductance is coupled to the primary. With even a small change of coupling it is necessary to readjust both antenna and secondary condensers. About six adjustments are necessary to tune in a station to its maximum loudness.

Reception, even from local stations, is not entirely satisfactory because of the noise in the telephone receivers due to the mechanical vibration of the tubes.

The fact that the secondary circuit would not tune to a frequency much lower than 1000 kilocycles (300 meters) was very noticeable. Frequencies as low as 500 kilocycles (wave lengths up to 600 meters) could be received but not very satisfactorily below 1000 kilocycles (300 meters) because below that frequency only the antenna circuit could be tuned.

Receiving Set No. 1922-J.- This set is easily tuned as there are only two adjustments. The fact that the primary would not resonate to waves whose frequency was lower than 810 kilocycles (greater than 370 meters) was very noticeable. On lower frequencies the primary was aperiodic and the only secondary was tuned.

Receiving Set No. 1922-K.- Tuning this set is very simple as there is only one control to adjust. Some regeneration is employed but not enough to cause generation.

This receiving set was designed for use near a broadcasting station by users who are more interested in the program or service to be received than mechanism of the apparatus or its manipulation to receive weak signals from distant stations.

Receiving Set No. 1922-L.- The two tuning controls of this receiving set are well arranged, easily manipulated, and very effective.

The regenerative action is very smooth throughout the entire range of the tuner.

The method for changing from low frequencies (long waves) to high frequencies (short waves) is very awkward and inconvenient. Two binding posts are provided, one for high frequencies, the other for low frequencies, and in order to receive one or the other it is necessary to shift the antenna lead from one post to the other.

Shielding is insufficient to completely prevent detuning due to body capacity. This is particularly noticeable when the hands are near the front side of the case.

Noises in the receivers due to mechanical vibrations of the tube are bad. If the table on which receiving set rests is jarred the tube noise will greatly interfere with the signals being received.

Receiving Set No. 1928-M.- The tuning controls of this receiving set are conveniently arranged and with the exception of the regeneration control operate very smoothly. The regeneration control is a multipoint switch which is designed so that the lever will rest on one contact only, and hence does not operate smoothly. Considerable noise is heard in the telephone receivers when this control is operated. This set is very easy to tune as there are in effect only two controls, tuner and regeneration. The regeneration can not be adjusted closely because continuous variation is not possible with the multipoint switch.

Department of Commerce,
Washington, D.C.

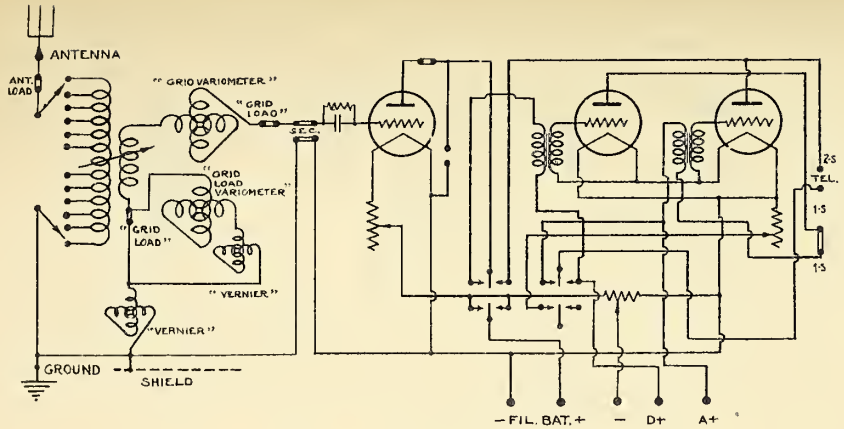

FIG. 1. CIRCUIT DIAGRAM OF RECEIVING SET NO. 1922-A

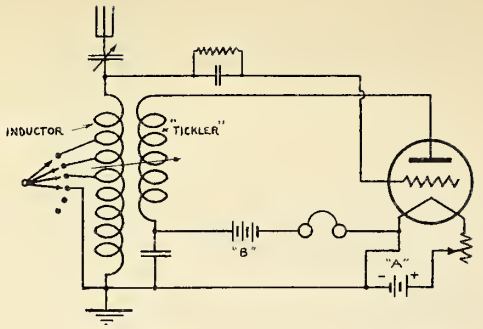

FIG. 2. CIRCUIT DIAGRAM OF RECEIVING SET NO. 1922-B

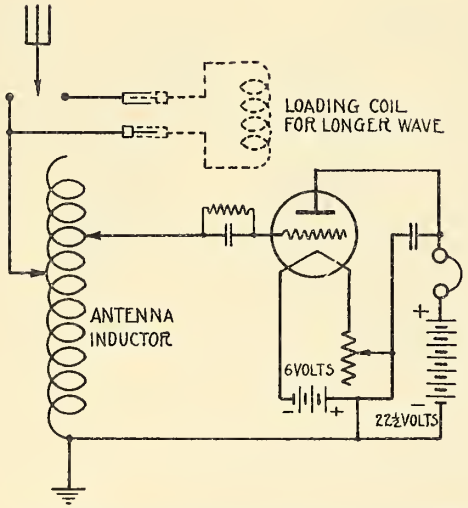

FIG. 3. CIRCUIT DIAGRAM FOR RECEIVING SET NO. 1922-C

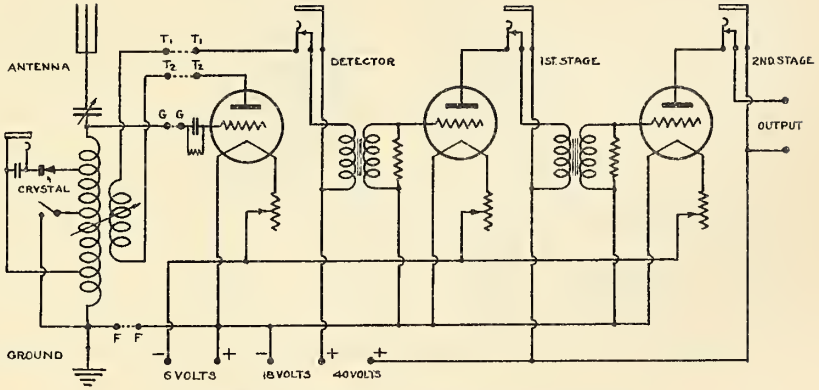

FIG. 4. CIRCUIT DIAGRAM OF RECEIVING SET NO. 1922-D

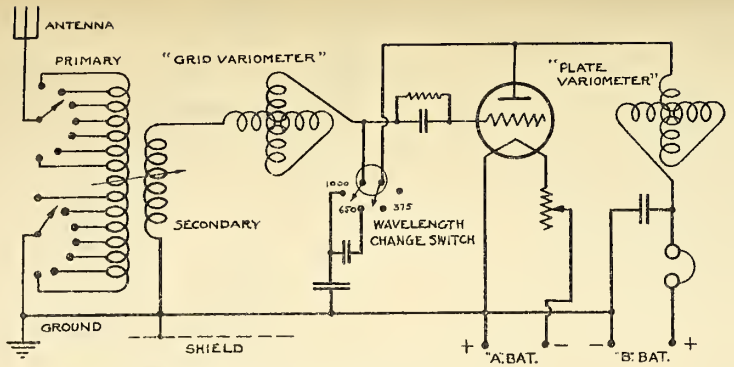

FIG. 5. CIRCUIT DIAGRAM OF RECEIVING SET NO. 1922-E.

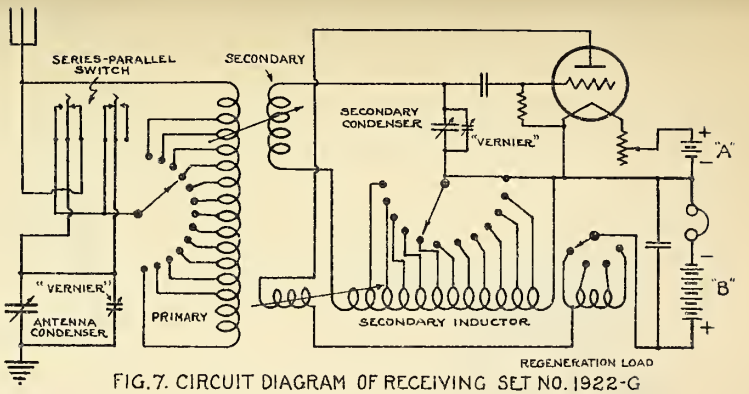

FIG. 7. CIRCUIT DIAGRAM OF RECEIVING SET NO. 1922-G

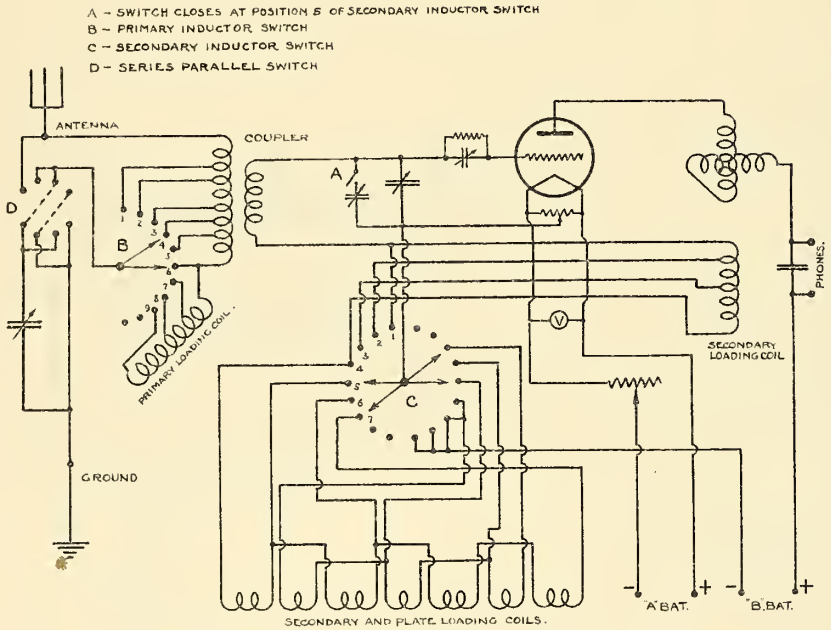

FIG. 6. CIRCUIT DIAGRAM OF RECEIVING SET NO. 1922-F

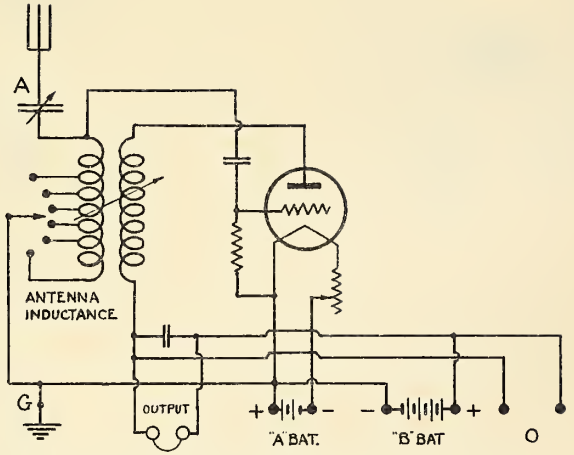

FIG. 8. CIRCUIT DIAGRAM OF RECEIVING SET NO. 1922-H

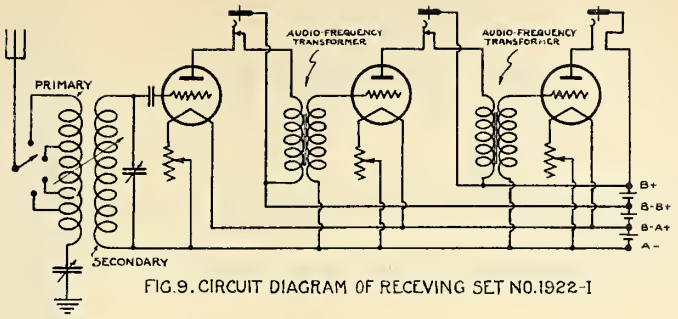

FIG.9. CIRCUIT DIAGRAM OF RECEIVING SET NO.1922-I

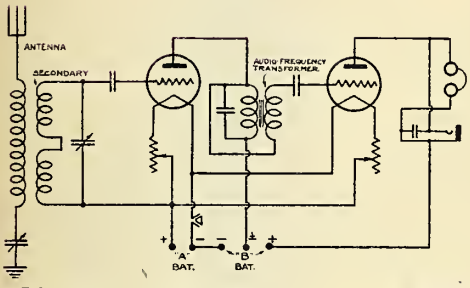

FIG.10. CIRCUIT DIAGRAM OF RECEIVING SET NO.1922-J

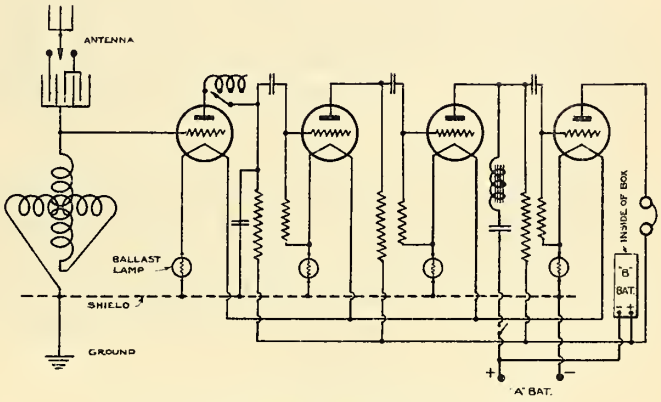

FIG.11 CIRCUIT DIAGRAM OF RECEIVING SET NO.1922-K

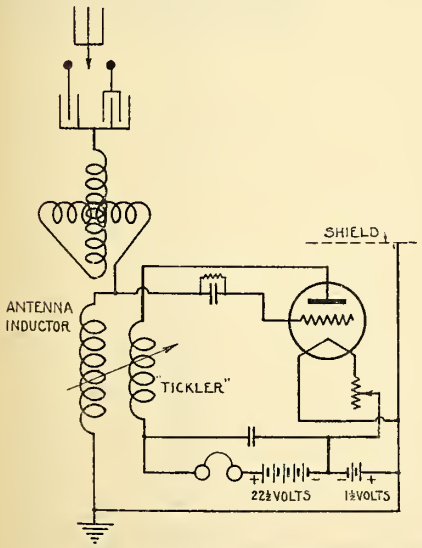

FIG.12. CIRCUIT DIAGRAM OF RECEIVING SET NO.1922-L

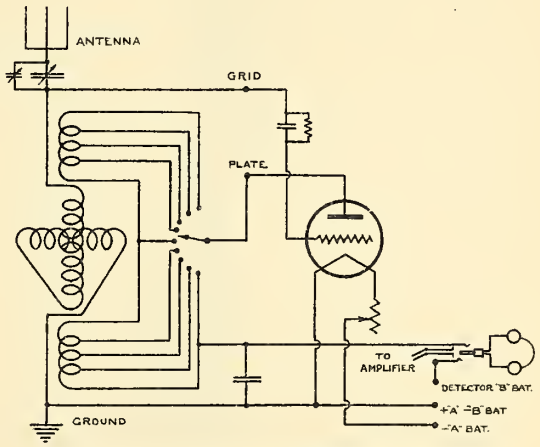

FIG.13. CIRCUIT DIAGRAM OF RECEIVING SET NO.1922-M