DEVELOPMENT OF BROADCAST RADIO RECEIVERS

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RADIO FREQUENCY LABORATORIES, Inc
Boonton, New Jersey
U S. A.

PREFACE

THE purpose of this booklet is to acquaint radio engineers and manufacturers with the RFL organization, which has been built up during the past seven years with a view to aiding in the design and development of broadcast receivers.

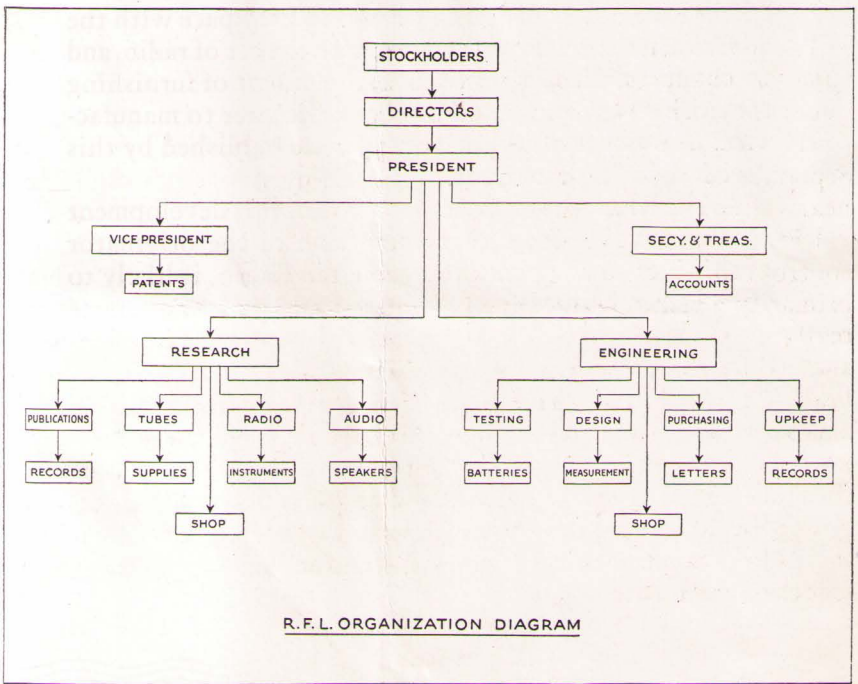
In addition to engineering service which this organization renders to its Licensees, it is frequently called upon to furnish special technical assistance in matters outside the scope of set design.

It is the aim of the Engineering Division to help our licensees with their production problems, and to furnish all the technical facts necessary to keep them fully informed about their own product and its relation to the contemporary art.

Our Research Division endeavors to keep pace with the advance in the science as well as with the art of radio, and to commercialize its research to the extent of furnishing something new and practical for the licensee to manufacture. A number of technical papers are published by this division during each year.

As the RFL goes on doing its share of this development work, it would seem that the vision of the originator of this idea of co-operative research in Radio, is likely to be fully realized.

R F L STAFF



R. F. L. ORGANIZATION DIAGRAM

RADIO Frequency Laboratories, Inc., began business early in 1922, shortly after popular radio broadcasting was begun. The work was started in a small laboratory at Boonton, New Jersey, with two research engineers.

For several years the work of laboratory research on a variety of electrical communication problems was carried on. This work included investigations of the properties of dielectrics at high and low frequencies, the rectifying properties of crystals, studies of the characteristics of vacuum tubes, studies of amplifying and repeater action at radio, intermediate, and acoustic frequencies, and the development of the amplifier circuits of Ballantine and others for use in radio receivers operating at broadcast wave lengths.

In 1924, a license was issued to the Stromberg-Carlson Telephone Manufacturing Company to build radio receivers under the RFL patent applications covering balanced bridge circuits. Shortly after this a second license was issued to the Kellogg Switchboard & Supply Company, and since then other licensees have been issued from time to time. The present list of licenses is as follows:

1. American Bosch Magneto Corporation.
2. Grigsby-Grunow Company.
3. Kellogg Switchboard & Supply Company.
4. National Carbon Company.
5. Stromberg-Carlson Telephone Manufacturing Company.
6. Standard Radio Manufacturing Co. (Canada).

The individual members of this group of licensees have spent large sums of money for national advertising and have sold more than one million RFL broadcast receivers in the past two years. Models of the 1929 line were on the market in January this year instead of September as in 1926 showing that the selling season has advanced nearly a year in that time.

RFL is the pioneer in the design and development of the single control radio receiver. It is not a manufacturing corporation, but primarily a research and patent holding company. The number of really good receiving sets in the hands of the public is not large, and, while the proportion of these sets made by our licensees and bearing the RFL trade-mark is gratifying, it is inconsiderable when compared with the total number of sets of all kinds made and sold during the past two years. The outlook for greater production in the Radio Industry is excellent, and engineering investigation is proceeding at a rapid rate, so much so in fact that it is far ahead of the public appreciation of the service that new apparatus will render in the future.

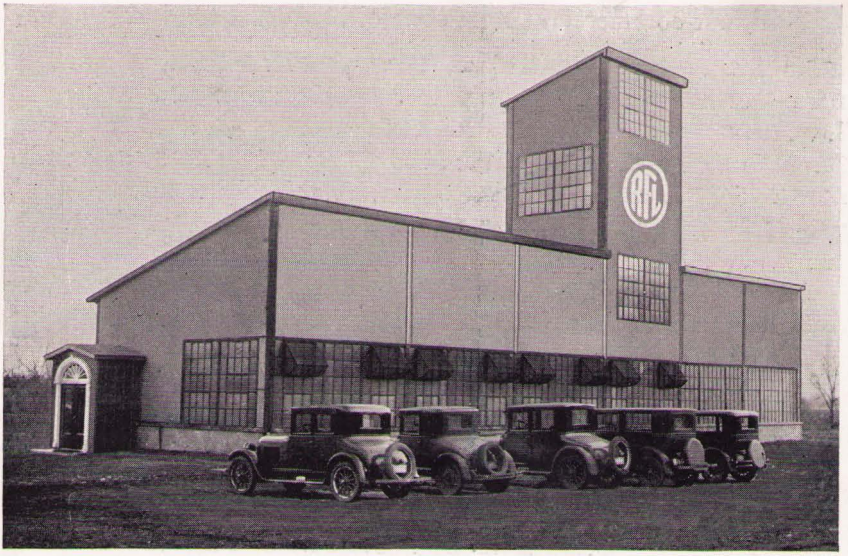
ROYALTIES paid to RFL are regarded by licensees rather in the light of payments for engineering service than as charges for patent protection. While the corporation owns and controls a large number of applications for letters patent, both in the United States and in foreign countries, in addition to those already issued, the value of any radio patent is problematical at least, and there would seem to be no way to secure complete patent protection in this industry.

Of the entire amount of money received by the corporation for royalties in 1928, over half has been put back into research and engineering for the future benefit of the licensees. Less than ten per cent of the total net income has been paid to stockholders of the corporation. The balance of net income has been put into the surplus account for the purpose of protecting RFL rights against infringers, for carrying on all the necessary interference proceedings in the Patent Office, and for patent litigation in the future. This general policy is believed to be good insurance for the licensees. It is much better for them in fact than lots of so called "patent protection" without any research or engineering, and yet it is consistent with the conservative policy of building up a large surplus against future needs.

One of the richest assets the RFL has is the good will of each one of its licensees. Because these license agreements, patents, trademarks and other assets of this nature, cannot be even approximately appraised, we carry them on the books of this corporation at the valuation of one dollar.

This RFL idea of commercialized co-operative research is contrary to all accepted standards. The cry has always been to keep money-making away from research, and to keep each individual inventor off somewhere by himself. The idea is too new to be judged by the results so far, especially with the Electrical Division of the Patent Office three years behind in its work, but one thing is certain: no one scientific man or group of men in the very large corporations is going to be the only one to discover new principles in radio as time goes on. It is apparent also that much can be accomplished in a small laboratory organization with the right men, and in a much shorter time than is required by the large corporation.

The RFL method of co-operative development and research seems therefore to have a very definite economic place in the Radio Industry, as the success of these laboratories and their growing reputation testifies.

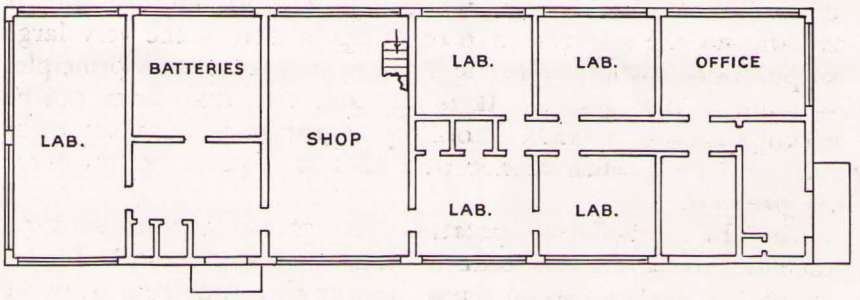


The Engineering Division

IN WRITING the history of this division it is obviously impossible to narrate in great detail the many steps leading to its major accomplishments. The method of treating this subject will therefore be a brief presentation in chronological order of the more important events and developments.

It may be readily understood that many experiments, measurements and miscellaneous time expenditures have led up to what may, at first thought, seem a simple development.

One of the first engineering and commercial developments was the Ballantine Vario-transformer. This was followed by the development of practical radio frequency amplifiers employing the RFL balanced circuits.



1ST FLOOR PLAN OF ENGINEERING LABORATORY

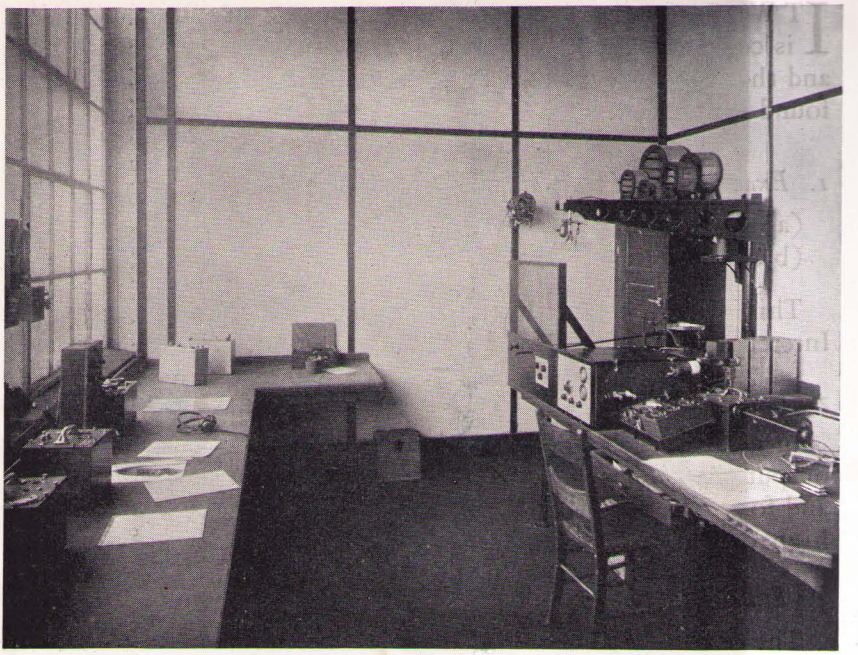
THE first commercial single control broadcast receiver was developed by this division, using a shielded cascade amplifier with RFL balancing network and gang variable condensers.

The Kellogg seven-tube RFL, single control direct current shielded receiver with electric illuminated drum dial or station selector, was the first set of this kind to appear on the market. This was followed by the Bosch model "27" seven-tube RFL single control receiver, and by the Crosley "RFL-60" a five-tube partially shielded receiver with dual control for the lower price class.

While the RFL licensees were busy manufacturing and selling these various models of direct current receivers, the engineering division, research division and tube laboratory were all busily engaged in adapting the RFL balanced bridge circuits to a new type of vacuum tube or valve which was shortly to appear on the market. This triode could be used with alternating current and did away with all batteries, eliminators, and devices which were previously used with the direct current sets. Good examples of this class of receiver on the market at that time were the Kellogg seven-tube A. C. receiver using the RFL circuit and special A. C. tubes of their own design and manufacture and the Bosch six-tube model "66-A. C." These were followed by the completely shielded all A. C. seven-tube receivers of Bosch, Eveready and Majestic as illustrated in this booklet.

The next step in set design taken by the RFL engineering division was to develop a broadcast receiver utilizing the screen-grid type of tube known as the "tetrode" for both A. C. and D. C. This new tube makes it possible to build a much better receiver without the use of the balancing network used with the old bridge circuits, and without the use of any of the so-called "neutralized" circuits. This new four element tube has a much higher amplification than the old "triode," and presents more of a problem to shield properly, but lends itself to the advanced art of high voltage detection where the voltage impressed upon the grid of the detector tube is about one hundred times greater than formerly used in A. C. sets.

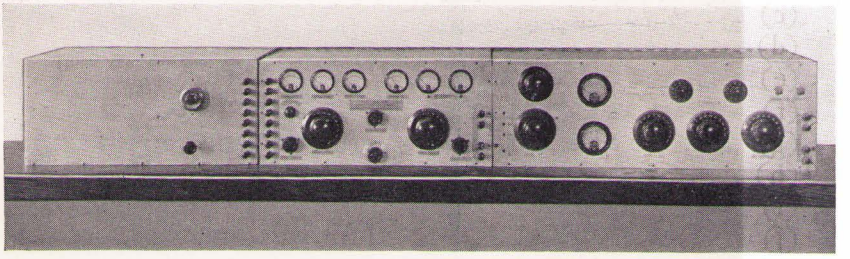
Several set manufacturers are planning to put out new models in 1929 designed to operate with these new four-element tubes. The number of new sets which will be manufactured and sold at first will depend upon the ability of tube manufacturers to produce these new tubes in very large quantities. This new set design is a distinct advance in the art of radio engineering.



BRIDGE ROOM

HAVING presented briefly the history of set design in the RFL-Engineering Division, it is but fitting to call attention to some of the many problems associated with the design of the modern broadcast receiver—problems which this division has had to solve before the licensee could get the first model of a new receiver.

The order in which these factors are listed represents the usual order in which they are investigated in designing an entirely new model.



EQUIPMENT FOR DESIGN OF UNIT STAGE

IT WILL of course be understood that a great deal of design data is contained in the technical files of the Engineering Division and that the answer to many of the problems listed below may be found in these files.

1. *Examination of Amplifier Tubes.*

(a) For RF amplifier.
(b) For AF amplifier.

This involves measurements of static and dynamic characteristics. Interelectrode capacities. Input-output characteristics.

2. *Examination of Detector Tube.*

In addition to the above mentioned measurements, the input-output characteristics must be determined for various values of K, and for the various types of detection, e.g. low voltage detection; high voltage detection and power detection.

3. *Examination of Power Amplifier Tubes.*

The input-output characteristics must be measured and the available undistorted power output determined.

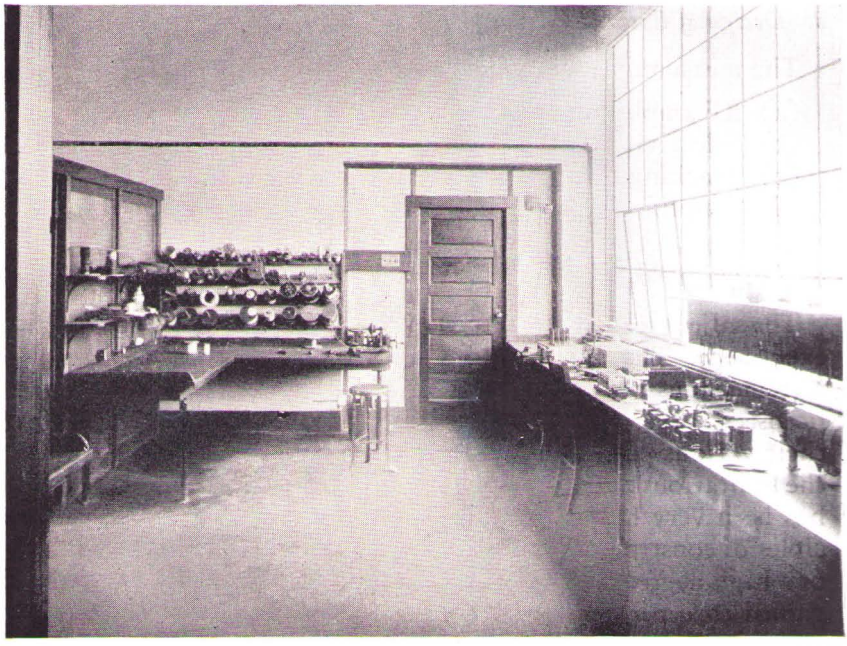
4. *Design of Antenna Coupling System.*

This involves measurements of:

(a) Transmission factor.
(b) Interference factor.
(c) Practicability.

5. *Design of RF Transformer.*

(a) Repeater gain.
(b) Stage gain.
(c) Primary rise.
(d) Balance capacity.
(e) Balance tolerance.
(f) Power factor of secondary.
(g) Influence of magnetic shield structure upon power factor.
(h) Requisite capacity in tuning.
(i) Input-output characteristics.
(j) Existence of parasitic oscillations.
(k) Slope of gain curve.
(l) Selectivity.



COIL WINDING ROOM

6. Design of Detector Circuit.

The factors to be measured here are:

(a) Influence of input conductance on the impedance of input circuit.

(b) Detector grid circuit distortion, i. e. the attenuation of the higher audio frequencies due to the grid condenser and leak.

(c) Detector plate circuit distortion, i. e. the attenuation of higher audio frequencies resulting from the RF by-pass capacity in the plate circuit.

7. Design of Audio Transformer.

(a) For low plate impedances.

(b) For high plate impedances.

(c) For push-pull amplification.

(d) For output circuits. This involves the measurement of voltage step-up in the transformers and of the effective use of the voltage appearing in the plate circuit. These measurements must be made over the frequencies appearing in the musical range.

8. Design of Cascade RF Amplifiers.

The measurements involved here are:

(a) RF amplification both overall and stage by stage.
(b) Selectivity both overall and stage by stage.
(c) Tracking of variable condenser gang.
(d) Amplifier regeneration.

9. Design of Structure for RF Amplifier.

The salient features here are learned solely thru the hard school of experience. The personnel of the Engineering Division have spent a tremendous amount of time in the many radio factories of the licensees, have discussed with the engineers, foremen and workers their various problems arising in manufacture, and have observed the limitations of the various forms of construction. This experience has been very broadening and has shown that certain basic principles of construction are essential to the structure of RF amplifiers of a high degree of amplification and selectivity. This knowledge, gained thru personal experience, is applied in the design of structures.

10. Miscellaneous Auxiliaries pertaining to Radio Receivers.

(a) By-pass condensers. Measurement of impedances at radio frequencies. Adjustment of the series-resonant frequency.

(b) The RF volume controls—measurement of the effect of high resistance potentiometers shunting anti-resonant circuits upon sensitivity and selectivity.

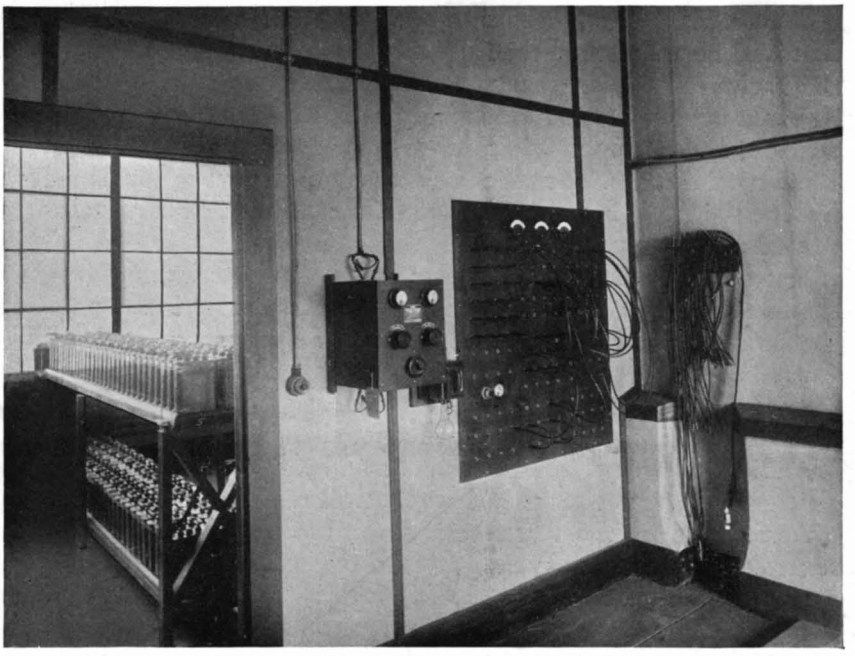
(c) The DC type of volume control—measurement of the various effects associated with:

(1) Filament voltage variation.
(2) Grid bias variation.
(3) Shield grid bias variation.
(4) Plate voltage types of volume control.

(d) The automatic form of volume control.

(e) The power pack. Design and measurement of the following features:

(1) Terminal voltages in load.
(2) Ripple voltages.
(3) Voltages and currents throughout network.
(4) Line regulation.



BATTERY ROOM

(f) The acoustic generator (loud speaker). Measurements of sound pressure (in dynes) in open air, in typical living room, in especially designed acoustic chamber, throughout the musical range. Effects of baffle, of structure, of cabinet, acoustic feed-back into RF and AF amplifier.

(g) The phono pickup. Characteristics are determined by measurement of voltage developed in unit over the range of musical frequencies.

Finally, the following general licensee services may be added:

(1) Determination of requisites of sensitivity, selectivity, fidelity, and power output of modern receivers in consideration of their list price.
(2) Consulting work on new designs.
(3) Construction of models.
(4) Engineering service on problems within the factory.
(5) Keeping the manufacturer abreast of the art, and showing the relative standing of broadcast receivers manufactured by the RFL licensees in the contemporary art.

IN FURTHER explanation of some of the factors in set design, it will be understood that any investigations or examinations of the various amplifier, detector and power tubes must necessarily be based upon what the tube manufacturer can do in quantity production, and not upon what our own tube laboratory can do with a few special tubes. The tube or valve is much further developed in Europe than it is here in the United States, but the set itself is far behind us at the present time.

Antenna coupling systems have undergone a series of changes; the fixed choke, the sliding sleeve type of variable inductor, and the broadband amplifiers with selective antenna or tunable band filter.

Radio frequency transformers have been greatly reduced in size and their efficiency increased by proper shielding.

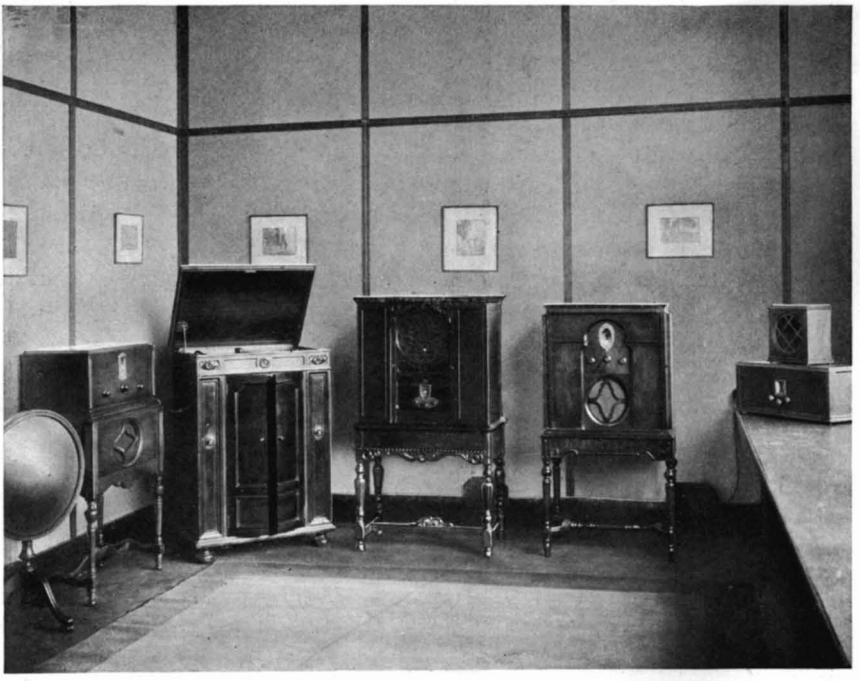
Audio frequency transformers have been much improved in quality of out-put over the entire musical range.

Accessories to the set itself; the power pack, the speaker, volume controls, voltage regulators, and other auxiliaries in this class, have all been greatly improved, due to the necessity of meeting higher commercial standards, higher technical efficiency and a general improvement in finished products throughout the set.

Testing technique has improved in nearly every factory in the Radio Industry during the past two years. This is due partly to the higher commercial standards established by the set manufacturer and partly to the general use of new testing apparatus and equipment not available a few years ago. Even now it is often necessary for a research worker to spend much valuable time in designing special measuring instruments which cannot be purchased.

The RFL Engineering Division has assisted in this progress in testing technique, by designing and building a number of special measuring instruments, and by aiding with the installations of these radio measuring instruments in the testing departments of the licensees whenever called upon to do so.

The broad and general character of the service rendered by RFL to its licensees is best indicated by a concrete example. In the case of a licensee manufacturer without any previous experience in making sets, RFL made a complete lay-out of all the testing equipment, with a very comprehensive schedule for balancing and testing each receiving set in the production line. At the end of the first year this factory made and sold over four hundred thousand RFL sets.



DEMONSTRATION ROOM

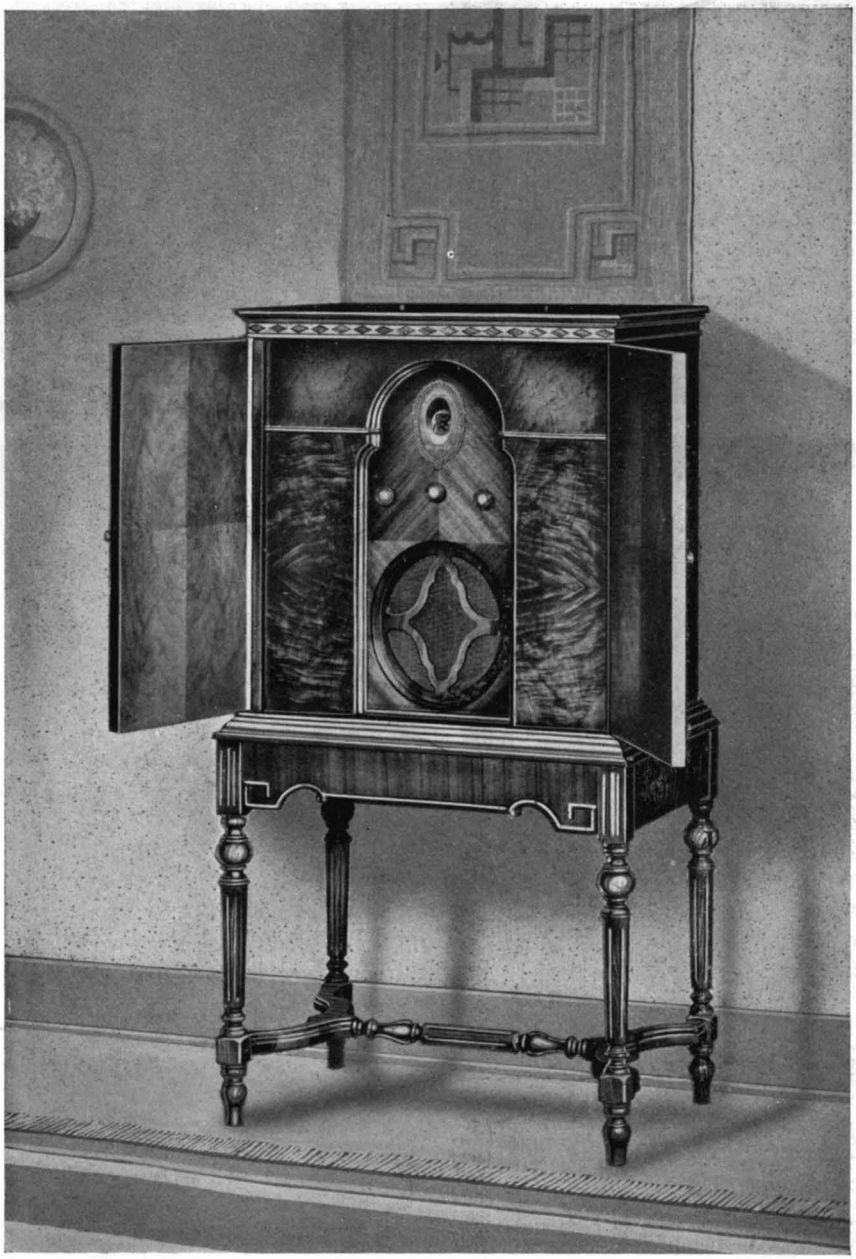
AFTER a new RFL model chassis is demonstrated to the satisfaction of the licensees, their factory engineers take it and build several production models like it. Then what is generally known as a "*provisional release model*," embodying all of the special requirements characteristic of every factory, is submitted to RFL for approval. This new set is usually in a finished cabinet or console complete with the loud speaker just as it is to be offered for sale.

On the following pages are shown a few examples of modern RFL "all A. C." radio receivers, manufactured in large quantities by our licensees. Each company manufactures several models in many different cabinet designs.

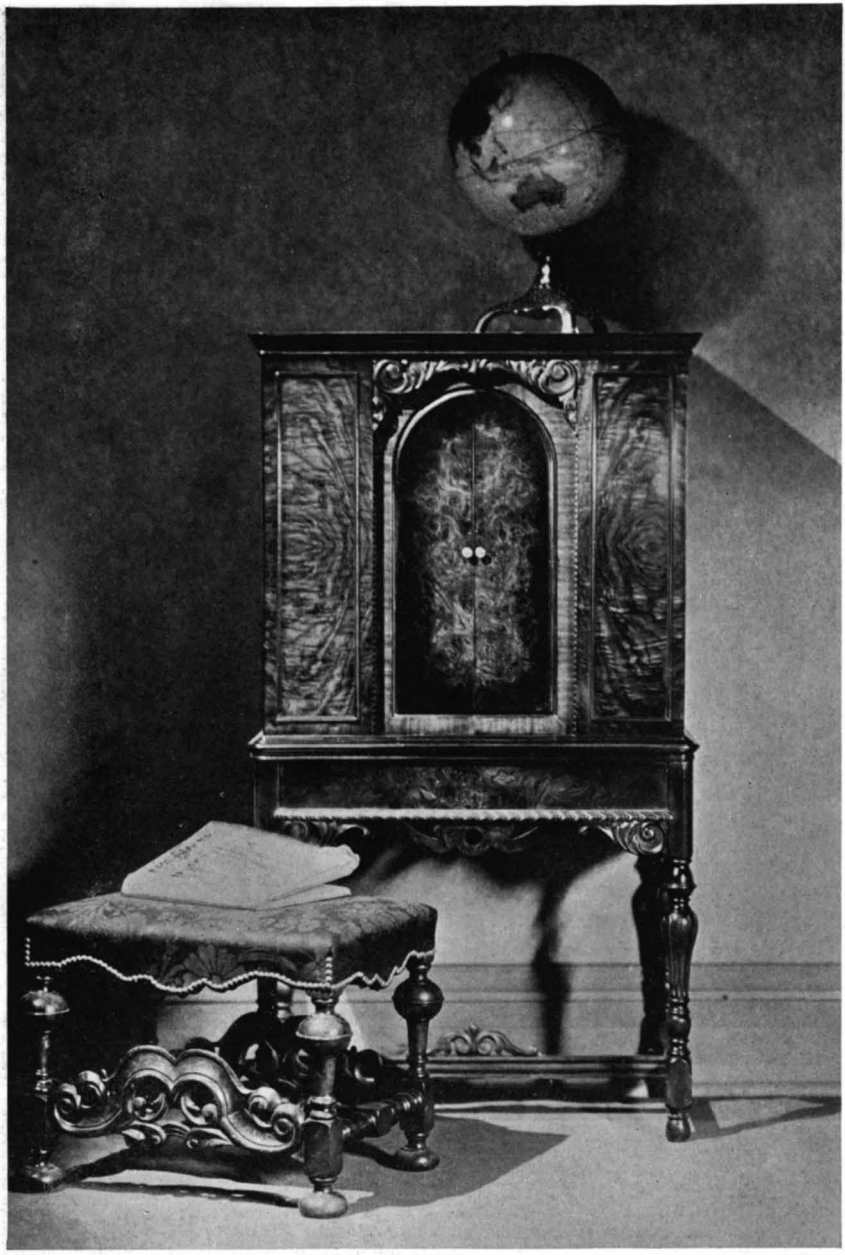
Furthermore, progress in the Radio Industry is so rapid that, while this booklet is being printed, new sets with entirely different characteristics and different tubes are almost ready for the market.

It is evident that in order not to upset trade conditions and manufacturing schedules which often run to several thousand sets a day, this engineering development must progress in a very systematic and orderly manner.

KELLOGG RADIO



MAJESTIC RADIO



BOSCH RADIO

EVEREADY RADIO

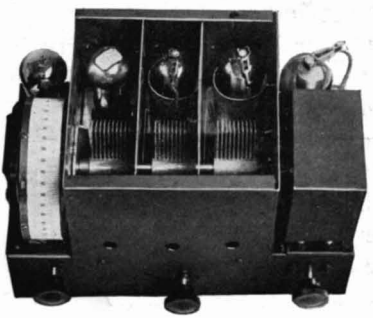
THE latest development in set design is built around the screen grid tube or four element tube known as the "tetrode." With this tube, which has an amplification factor much higher than the A. C. tubes used in last years sets, it has been possible to design a highly sensitive receiver, and to utilize several other inventions such as detection by grid and plate rectification at high signal voltages and the automatic volume control.

It has also been possible to build a very sensitive receiver, using the D. C. tetrode, and having a low current drain suitable for battery operation where alternating current is not available.

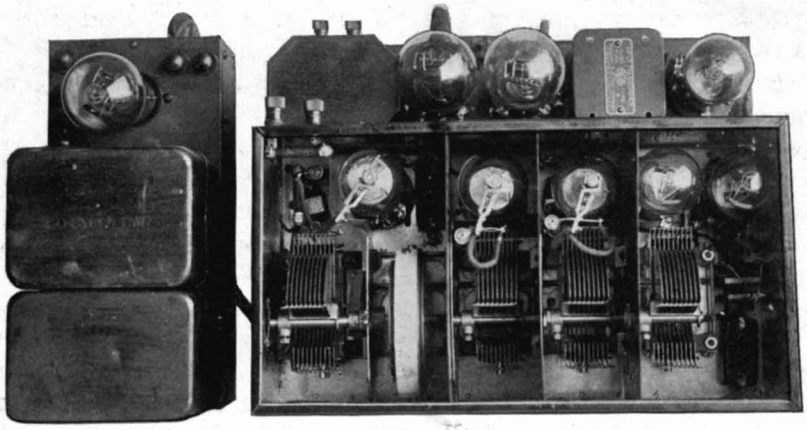
Three new RFL receivers employing shielded A. C. tetrodes were submitted to the licensees in January, 1929. All of these receivers were designed around and built with the A. C. tetrodes developed and manufactured in the RFL experimental tube laboratory. A description of the method of measuring the grid-plate capacity and other characteristics of these shielded tetrodes is embodied in a confidential report to the licensees.

The RFL engineering division has developed a system for the complete analysis of broadcast receivers. This is a rational and dependable method of testing receivers for sensitivity, selectivity, regulation and fidelity. In order to accomplish this it was first necessary to develop what is now known as a "Standard Signal-Generator." This apparatus which was first called a "Microvolter" was designed by RFL engineers for the General Radio Company and is now on the market in small portable form and generally available.

With the overall fidelity of the receiver itself it has been necessary to measure the acoustic fidelity of the loud-speaker. Much work has been done with all kinds of commercial sound reproducers, in connection with different types of receivers. This includes measurements of the dynamic, the inductor, and the condenser or electro-static types of speakers, using an improved method of measuring sound pressures which will be described more in detail later on.



MODEL RECEIVER CHASSIS UTILIZING D. C. TETRODE



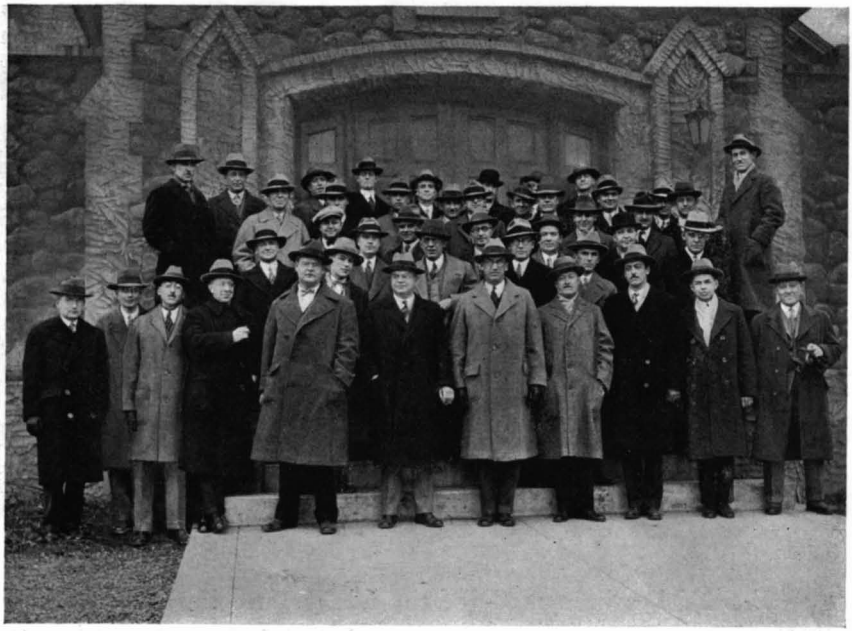
MODEL RECEIVER CHASSIS UTILIZING A. C. TETRODE AND EMBODYING THE AUTOMATIC VOLUME CONTROL

A STUDY has been made of the fidelity and input mechanical impedance of various electrical phonograph reproducers, or magnetic pick-ups used by the licensees. A special study has been made of an automatic phonograph or record shifting device, which is designed to play any type or size of flat disc record, with variable time intervals between records and in connection with an improved automatic stop. This device is designed for the higher priced radio receivers, where the sound reproducer can be built into the cabinet and actuated by the most advanced type of Audio frequency amplifier.

During the past six years the Engineering Division of RFL has worked with the Boonton Rubber Manufacturing Company, the pioneer molder of Bakelite, in the development of many new designs of molded parts for radio manufacturers. One of the outstanding accomplishments has been a new insulating composition with a lower power factor or low-loss at radio frequencies.

Recently much work has been done with the engineers of Aircraft Radio Corporation, in the development of a special radio receiver for airplanes, to work on the radio beacon system which is being installed throughout the country by the Department of Commerce. This receiver is battery operated, light in weight and so very sensitive that it can be used with a short fixed antenna.

Before proceeding to describe some of the activities of the RFL Research Division, attention is called to a conference of engineers held the early part of this year.



ENGINEERING CONFERENCE

An Engineering Conference, attended by officials and engineers of the licensee companies was held at Boonton on January 9, 1929. The purpose of this conference was to acquaint the licensees collectively with certain new developments by the Research Division, to discuss engineering problems of current interest and to demonstrate models of new RFL receivers intended for 1929–30 production. At a short technical session the following papers were presented:

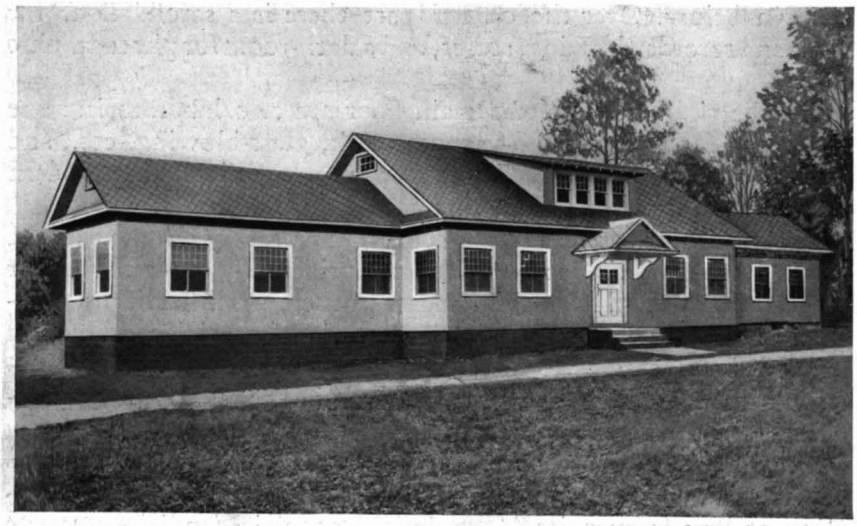
L. M. Hull: "Aircraft and Broadcast Radio in Europe"

Stuart Ballantine: "Research Projects of Commercial Interest"

P. C. Farnham: "Report on the Design of R. F. Amplifiers Employing the Shielded Tetrode (Published as RFL Contr. No. 10)

Malcom Ferris: Standing of the RFL Licensees' Receivers in the Contemporary Art (Published as RFL Contr. No. 11)

As a result of the success of this meeting it is planned to hold general conferences of this type bi-annually or annually as circumstances may require.

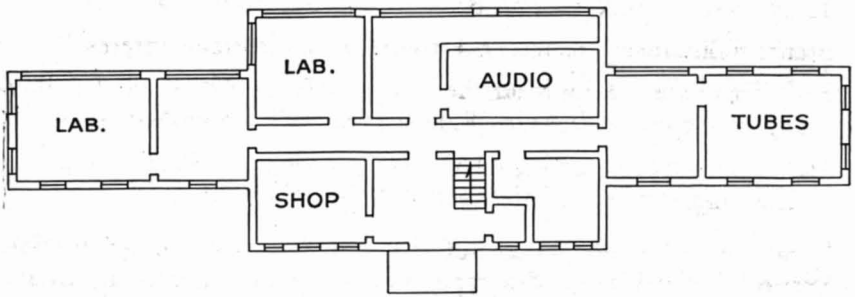


Research Division

THE economic function of research has been sufficiently discussed and its value is now quite generally recognized by business people. Research is neither luxury, nor window-dressing, but a sound investment in the future; and for a large and well-established business, a sort of insurance that the advances in an art will not leave that business stranded, or at best in the position of paying heavy royalties. This is especially important in a rapidly developing art like radio.

New Research Laboratory

A general view of the new building to be devoted exclusively to research activities appears above. The general floor plan is



1ST FLOOR PLAN OF RESEARCH LABORATORY

shown below. Over the central part there is a second floor for files and records, drawing, stores, and a dark-room for photographic work.

In the right wing of the main floor are two laboratories: one equipped for general high-vacuum work, glass-blowing, etc., and the other especially fitted for vacuum tube work including modern machinery for rapid construction of experimental tubes.

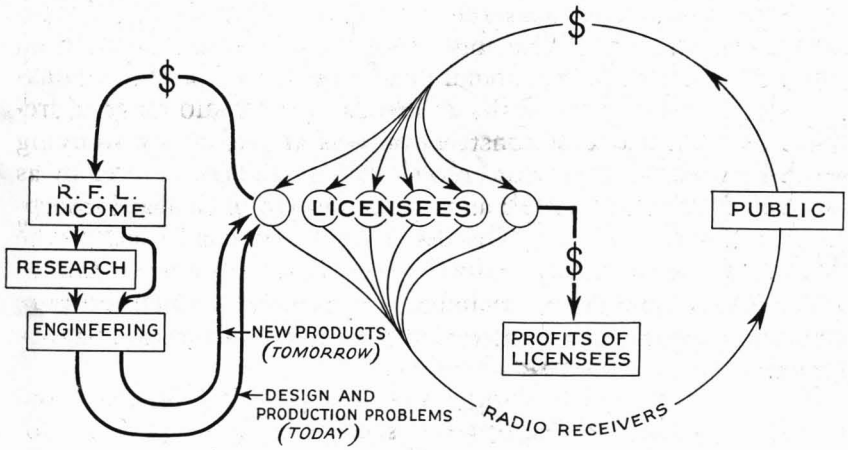
Of particular interest is the acoustic laboratory, located in the main section. This has been designed principally for loud-speaker investigations and for measurements of the overall fidelity of complete radio receivers. The inner room is of special construction intended to insure perfect sound insulation as well as the elimination of reflection by the walls of sounds in the audio range of frequencies. The mode of construction was arrived at by studying several failures with previous rooms which had been covered by as much as 6 inches of hair felt and which showed inadequate absorption at low frequencies. The desired acoustic conditions of the open air are satisfactorily realized in the present structure. Auxiliary electrical apparatus, including an automatic sound-pressure recorder, is installed in the space remaining between the laboratory enclosure and the acoustic chamber.

The symmetrical left wing contains a private laboratory and room for standard test equipment, such as bridges, apparatus for measurement of audio and radio amplifiers, oscillographs, field-intensity apparatus, standard signal generator and attenuator, etc.

Engineering concerns itself with the present, research with the future, yet the two are interdependent. The relation is not unlike the building-up process in a regenerative electric amplifier. The most difficult step is in getting research started. Usually it must be fed financially for several years before, with the final administrations of engineering, it pays dividends. The novel unicontrol, completely-shielded, monodic (i. e. balanced against feedback) broadcast receivers pioneered by RFL, which in the competent hands of the RFL licensees have had such significant commercial success, depended upon inventions made several years before. The new receivers demonstrated at the RFL Engineering Conference in January, 1929, depend upon the research work of 1922–28, and in the same way the research being carried on today will perhaps pave the way for the commercial products in 1933. Once started this process, like the regenerative amplifier, builds up indefinitely and the cost goes down steadily.

The relation of RFL research in the economic scheme is shown in

the accompanying diagram. Of the two functions performed by the RFL—engineering service and research—the latter is probably the more intrinsically important of the two, for reasons which are easily perceived. Group-financed research has long been a Utopian idea. This idea rests on the basic proposition that two people with limited research budgets can do more than twice as much research operating together as could be accomplished by either working alone. It is an economic solution of the research problem for small



manufacturers who would normally, in the face of the enormous amounts spent by large corporations, be at a serious disadvantage in a rapidly advancing art. The RFL represents a unique reduction to practice of this idea in the radio industry, and its success is evidence of the soundness of the fundamental proposition—"*Grant a laboratory the right to work untrammeled and both science and industry gain.*"

The experience gained by RFL engineers while working in different factories of the licensees, with their engineers, shop foremen, and factory workers is invaluable. The same opportunity is not open to any one scientific worker or group of engineers in any one manufacturing organization no matter how large the company may be, or how much money is spent for their own individual engineering departments.

Classification of Research

In selecting work for this division the general policy followed is to choose projects which have some promise of commercial exploitation by the manufacturing licensees.

The work may be classified as follows:

(1) Investigation and development of new ideas originating in this organization, brought in by others, or suggested by licensees;

(2) Study of contemporaneous work of other laboratories as reported in the literature, including actual repetition of novel experiments in the laboratory whenever possible;

(3) Study of special problems submitted by the Engineering Division.

(4) Development of new test apparatus and methods.

(5) Theoretical work.

(6) Supervision of technical publications—"*Contributions from the RFL.*"

The fields of main interest are broadcast receivers, electrophones, measuring apparatus and entertainment devices such as the phonograph.

Radio Frequency Amplifiers

Since the establishment of the RFL in 1922 a subject of major interest has been radio frequency amplification. Six different types of circuits have been devised for reducing the feedback from the plate circuit through the grid-plate capacity of the triode. Two or three of these have been extensively used during the past five years in receivers manufactured by the RFL licensees. Uni-controlled completely shielded, cascaded monodic (one-way, or repeater) r. f. stages were pioneered by RFL.

High-Voltage Detection

The subject of detection, commonly ignored, has been under investigation since 1922. In particular it was anticipated in 1922 that 100% modulation would be used sooner or later, and that in this event the distortion produced by ordinary low-voltage detectors would be prohibitive. The use of high signal voltages in promoting linear detection was advocated and a patent broadly covering this has been recently issued to Ballantine and Hull. The required high-voltages are now economically produced by the tetrode

r. f. amplifier, and this type of operation allows the supply of the electrophone directly from the plate circuit of the detector, or at least eliminates one audio stage.

Tubes

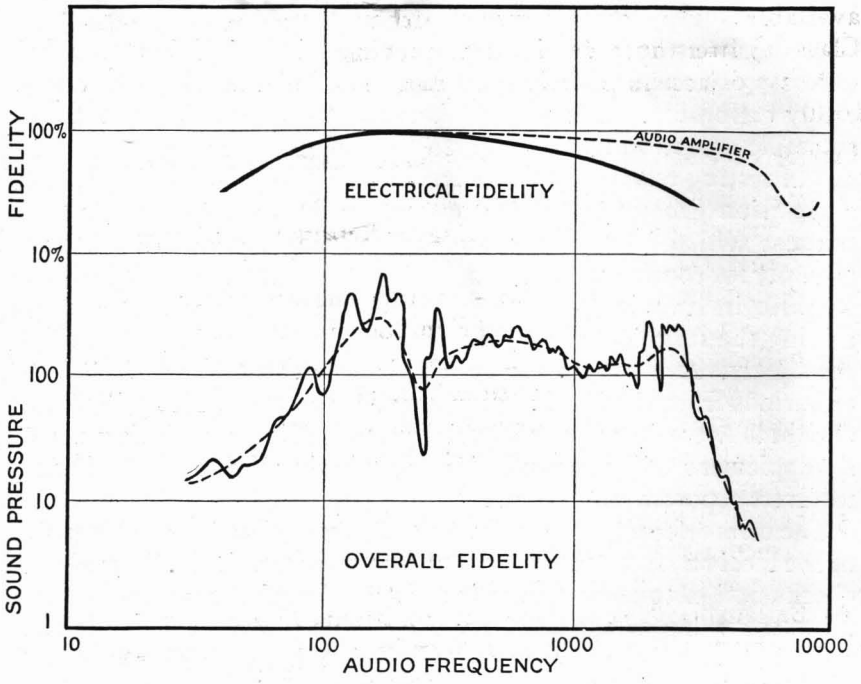
The tetrode (four-electrode vacuum tube) has been investigated for several years and a completely shielded tube with indirectly—a. c.—heated cathode has been developed experimentally. These experimental tubes have served as a basis for the further development of r. f. amplifiers of considerable gain. These amplifiers are particularly useful in supplying the proper high-signal voltages in the Ballantine-Hull high-voltage patent of detection noted above.

Receiver Performance Tests

As early as 1923 receivers were tested in this laboratory by means of actual locally generated modulated signals, accurately calibrated. This practice is now becoming universal. Considerable attention has been given to working out standard methods of testing receivers for fidelity, selectivity and sensitivity, and a precision generator and attenuator has been developed for this purpose which is regularly used by the Engineering Department not only for routine measurements and comparisons of their designs, but also in studying receivers of all makes with a view to ascertaining the standing of the RFL licensees' receivers in the contemporary art. A complete survey of this type was reported in "Contributions from the Radio Frequency Laboratories, No. 5," copies of which were issued confidentially to the licensees during 1928. A supplement will shortly be issued, bringing the total number of receivers reported upon to 37.

The tests referred to above cover the overall *electrical* performance of the receiver, from antenna to loud-speaker terminals. While this checks design to some extent it tells nothing about the final entertainment value of the receiver; the whole story can be obtained only by actually measuring the relation between the standard antenna signal and the alternating pressure in the sound-wave emanating from the loud-speaker. This is especially worth doing in those cases—rapidly increasing in number—where the loud-speaker is definitely associated with the receiver and sold as part of the equipment. The final significance of such measurements, assuming perfect transmission and average acoustic conditions in the receiver installation, is obvious. This additional step in receiver tests has been taken. For measurement of the sound-pres-

sure a high sensitivity Wente-microphone of special design is employed, accurately calibrated by means of the thermophone, and mounted in a spherical shell so that the effect of diffraction around it can be allowed for (*vide* "*Contr. RFL*," No. 9). Fidelity measurements of a specimen RFL receiver are shown in the annexed figure, which clearly brings out the relation between electrical and acoustic performances. In comparison with the acoustic (overall) curve the electric fidelity is smooth and uninteresting. Examination of these results has led to the establishment in this Research Division, of a section devoted specially to acoustical work, since further improvement in the receiver will undoubtedly take place along these lines.



Publications

In order to systematize, and secure proper supervision of technical publications by members of the RFL staff, to provide a means for keeping the licensees informed about the work in Boonton, and to obtain a permanent record of RFL work, it was decided in January, 1928, to establish an official publication to be

called "Contributions from the Radio Frequency Laboratories" borrowing a title employed by the Mount Wilson Observatory of the Carnegie Institution and the Jefferson and Cruft Laboratories at Harvard University.

These publications may be divided into the following classes:

(1) Confidential reports to licensees;

(2) Reprints of papers originating at RFL and published in other technical journals, presented at scientific or technical meetings, etc.;

(3) Original papers which are not of a confidential nature, published for the first time.

The papers of class (2) and (3) are regularly distributed to libraries and accredited individuals; those of Class (1) are immediately available only to RFL licensees, although they may be placed in Class (3) after the lapse of a sufficient time.

A list of papers published to date or in process of publication follows:

List of Contributions from the Radio Frequency Laboratories

1. Ballantine, Stuart.—Propagation of Sound in the General Bessel Horn of Infinite Length (Reprinted from Jour. Frank. Inst., Jan. 1927)
2. Ballantine, Stuart.—Non-uniform Lumped Electric Lines I. Conical Line (Reprinted from Jour. Frank. Inst., April 1927)
3. Ballantine, Stuart.—The Lorentz Reciprocity Theorem for Electric Waves (Reprinted from Proc. I. R. E., April 1928)
4. Ballantine, Stuart.—Detection by Grid Rectification with the High-Vacuum Triode (Reprinted from Proc. I. R. E., May 1928)
5. Ferris, Malcolm and Loughlin, W. D.—Report of Measurements of the Sensitivity, Selectivity and Fidelity of Modern Broadcast Receivers; June 1, 1928. (Confidential)
6. Ballantine, Stuart.—The Chireix-Mesny Directive Antenna for Short Waves (Reprinted from Proc. I. R. E., Sept. 1928)
7. Ballantine, Stuart.—Schrot-Effect in High-Frequency Circuits (Reprinted from Jour. Frank. Inst., Aug. 1928)
8. Drake, F. H.—Aircraft Radio Receiving Equipment with Rod Antenna for Reception of Beacon and Weather Service (Reprinted from Aero Digest, Oct. 1928)
9. Ballantine, Stuart.—Effect of Diffraction around the Microphone in Sound Measurements (Reprinted from Phys. Rev., December 1928)

10. Farnham, P. O.—Report on the Design of R. F. Amplifiers Employing the Shielded Tetrode (Confidential; Presented at RFL Engineering Conference, January 9, 1929)
11. Ferris, Malcolm.—Status of the RFL Licensees' Receivers in the Contemporary Art. (Confidential; Presented at RFL Engineering Conference, January 9, 1929)
12. Drake, F. H.—Aircraft Receiver for use with Rod Antenna. (Reprinted from Proc. I. R. E., Feb. 1929)
13. Asserson, Raymond.—Report on the R. F. Impedance of By-pass Condensers (Confidential)
14. Asserson, Raymond and Ballantine, Stuart.—Report on the Fidelity and Mechanical Input Impedance of Electrical Phonograph Reproducers (Confidential)
15. Ballantine, Stuart.—Measurement of the Overall Fidelity of Radio Receivers, including the Loud-Speaker (Class 3)
16. Ballantine, Stuart.—Measurement of Modulation (Class 3)
17. Ballantine, Stuart.—Technique of Acoustic Measurements.
    I. Design of the Wente-Microphone
    II. Instructions for Calibration of the Wente-Microphone.
18. Farnham, P. O. and Loughlin, W. D.—Report on Antenna Coupling Systems (Confidential)
19. Ballantine, Stuart.—Reciprocity Theorems (Class 3)

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