

DEVELOPMENT
OF
BROADCAST
RADIO RECEIVERS



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RADIO FREQUENCY LABORATORIES, INC
BOONTON, NEW JERSEY
U S A.

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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.

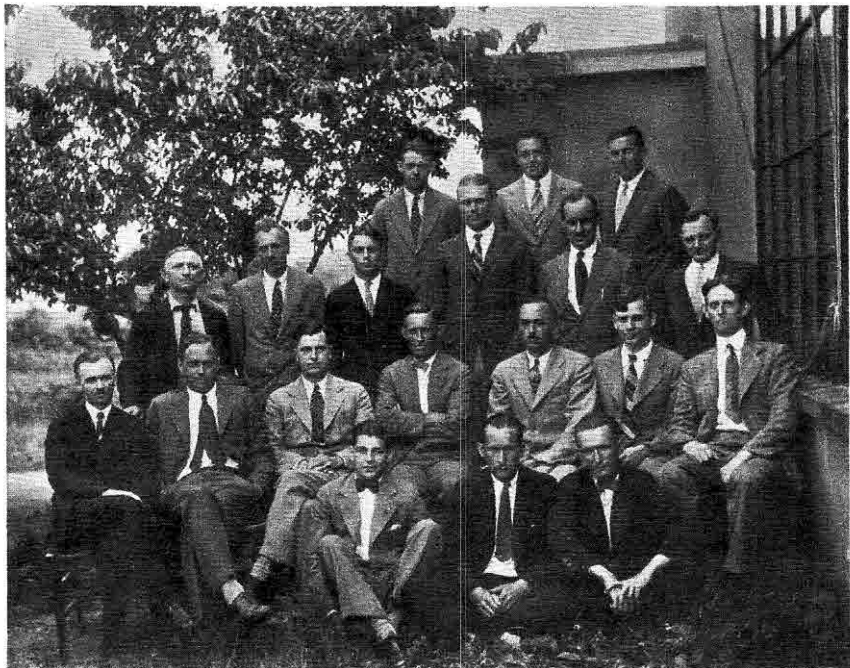
In addition to engineering service which this organization renders to its Licensees, it is frequently called upon to furnish special technical assistance in matters outside the scope of set design.

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.

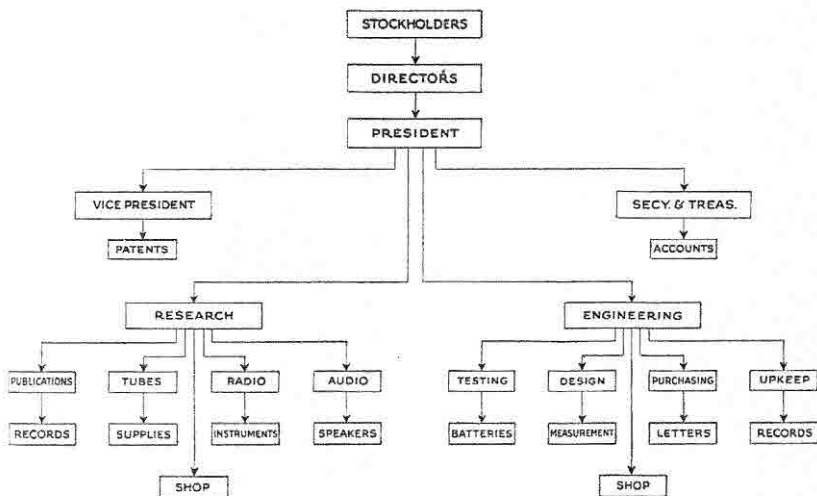
Our Research Division endeavors to keep pace with the advance in the science as well as with the art of radio, and to commercialize its research to the extent of furnishing something new and practical for the licensee to manufacture. A number of technical papers are published by this division during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

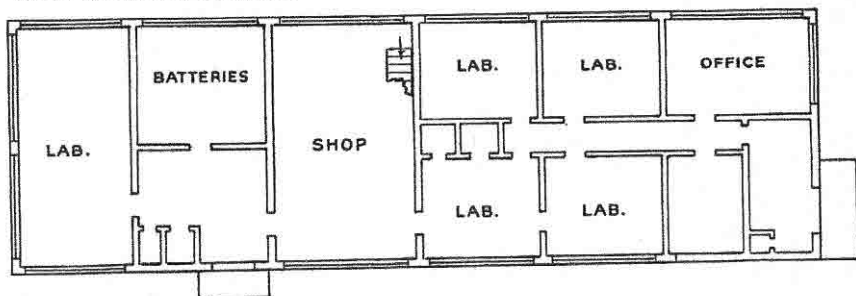


The Engineering Division

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

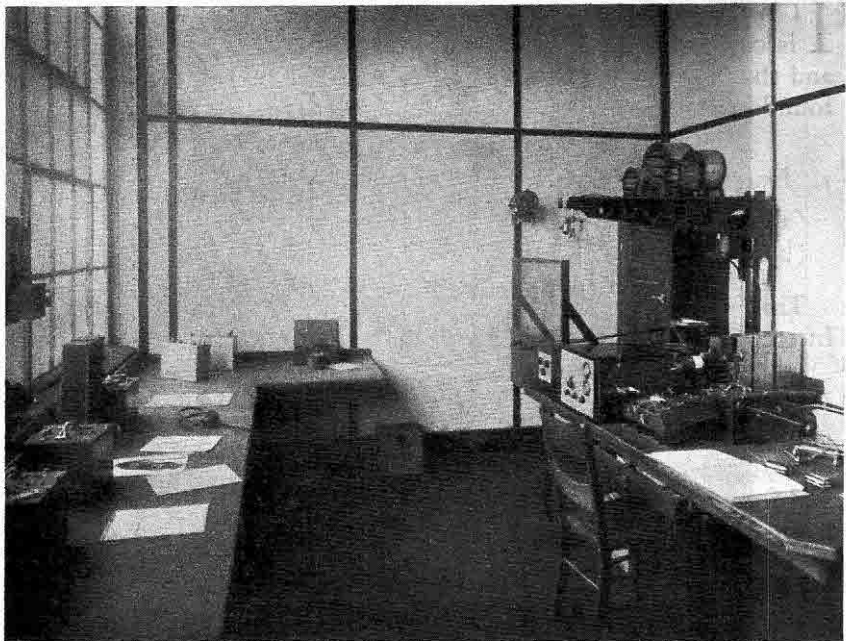
THE first commercial single control broadcast receiver was developed by this division, using a shielded cascade amplifier with RFL balancing network and gang variable condensers.

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.

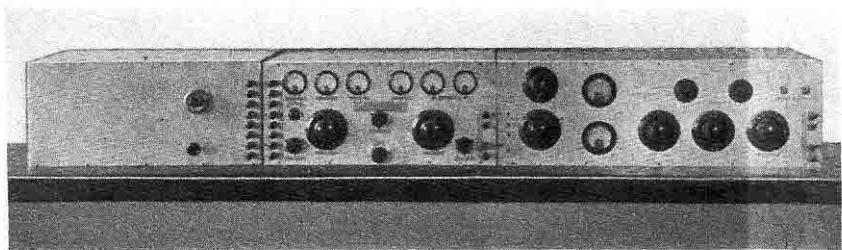
Several set manufacturers are planning to put out new models in 1929 designed to operate with these new four-element tubes. The number of new sets which will be manufactured and sold at first will depend upon the ability of tube manufacturers to produce these new tubes in very large quantities. This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

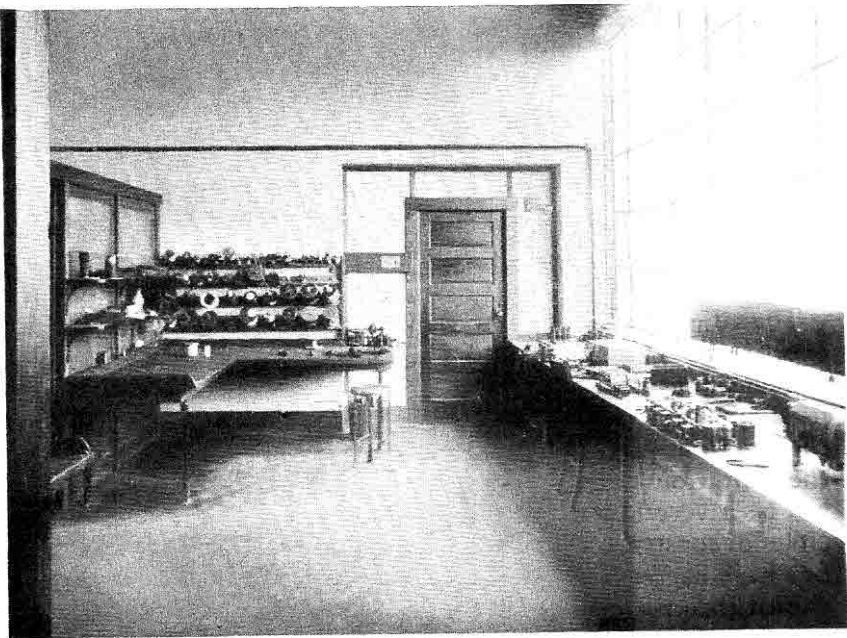
4. *Design of Antenna Coupling System.*

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.

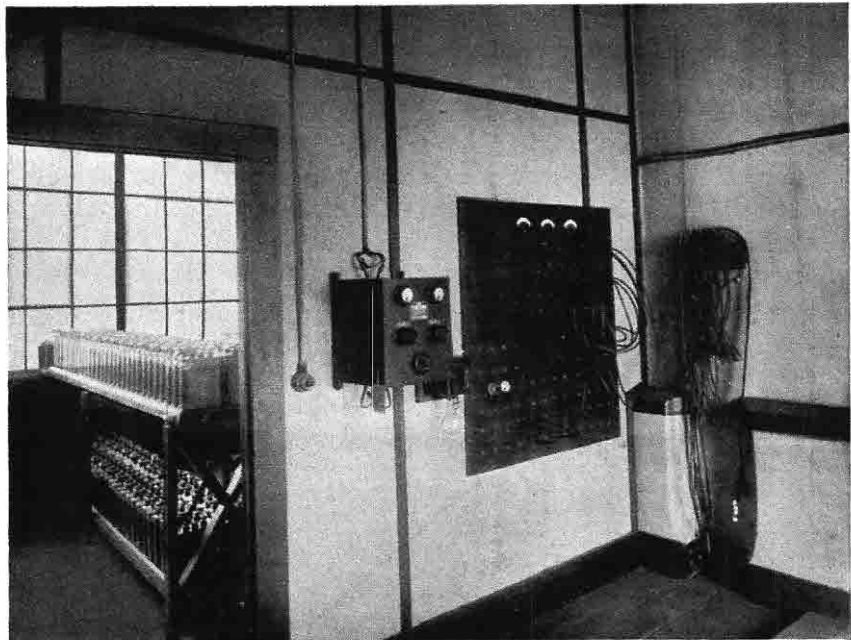
(c) The DC type of volume control—measurement of the various effects associated with:

- (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.

