THE General Radio EXPERIMENTER

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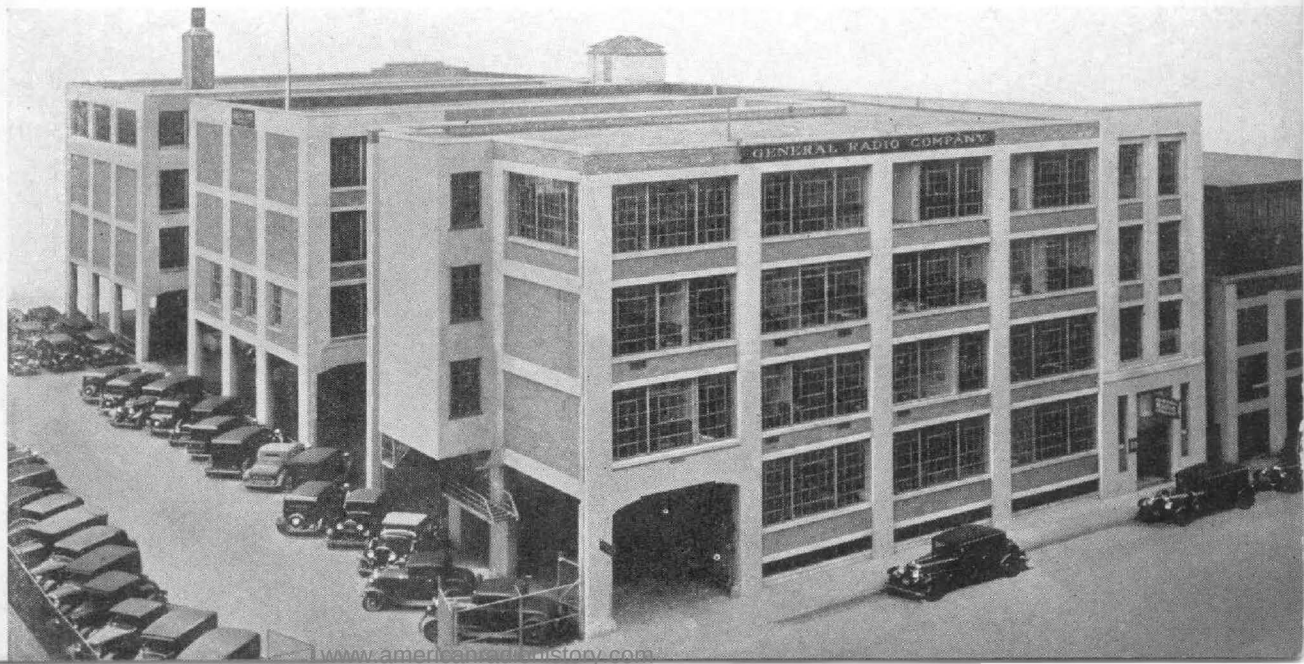
TWENTY-FIFTH ANNIVERSARY, 1915-1940

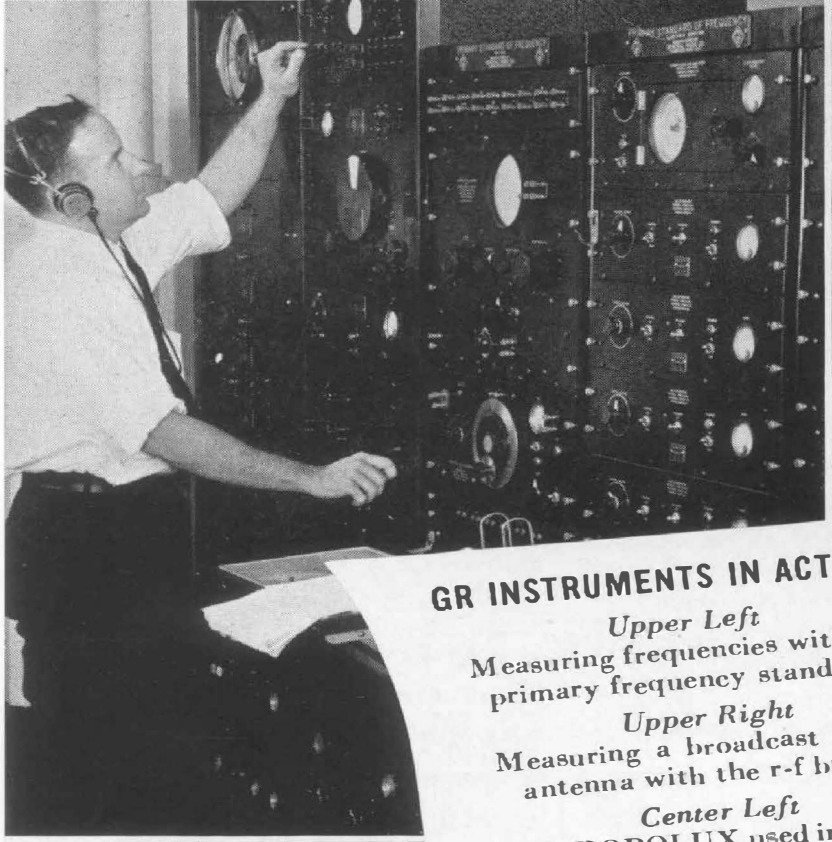
THE GENERAL RADIO COMPANY

● **IN THE TWENTY-FIVE YEARS** since its founding, the General Radio Company's products and markets have grown considerably beyond the limits implied by its name. Established in 1915 to supply laboratory measuring equipment to the infant radio industry, the Company now makes electrical instruments for varied applications, such as measuring the performance of broadcasting stations, the sensitivity of radio receivers, the noise generated by machinery, the speed of yarn spindles, and the vibration of crankshafts.

As its products and market have grown more complex, the General Radio Company has developed methods of handling engineering, sales, production, and personnel that are peculiarly suited to its type of business and its philosophy of management.

Questions asked by visitors to our plant have indicated a keen interest in our way of doing things, an interest which has prompted us to devote this anniversary issue of the *Experimenter* to a description of the General Radio Company as it is today.





GR INSTRUMENTS IN ACTION

Upper Left
Measuring frequencies with the primary frequency standard.

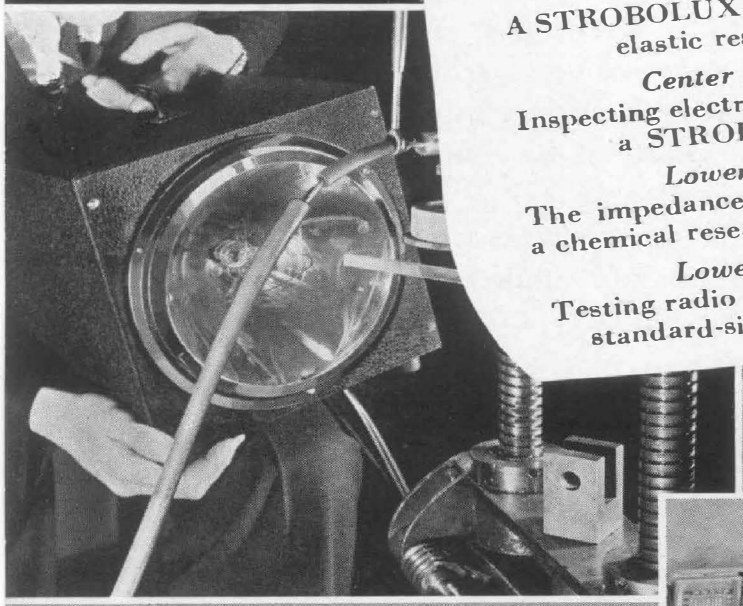
Upper Right
Measuring a broadcast station antenna with the r-f bridge.

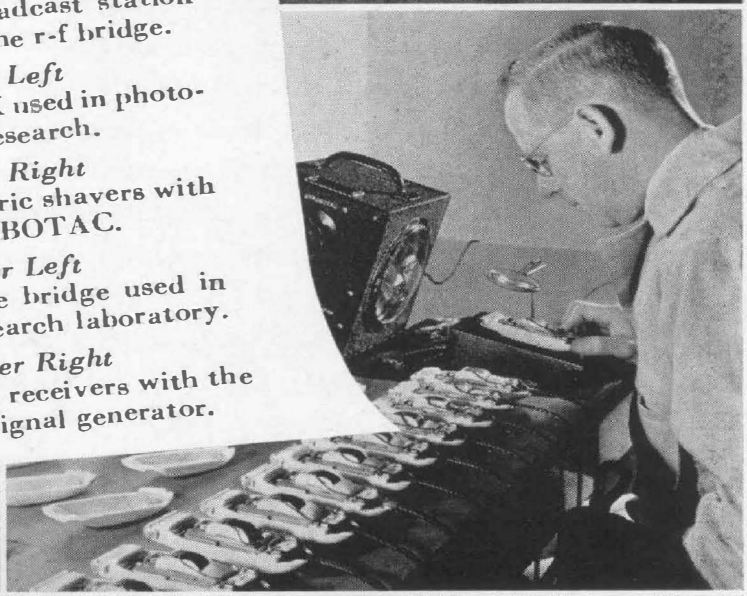
Center Left
A STROBOLUX used in photo-elastic research.

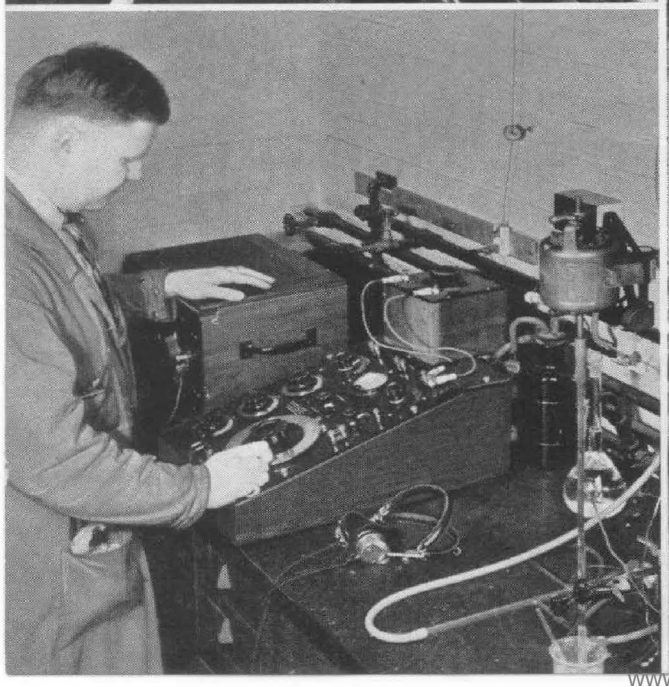
Center Right
Inspecting electric shavers with a STROBOTAC.

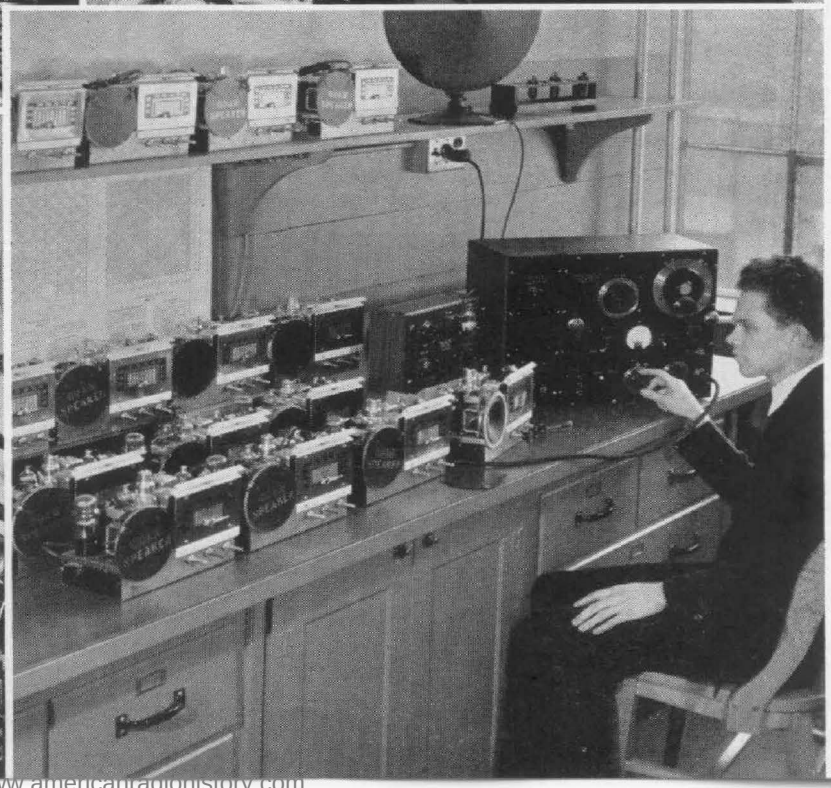
Lower Left
The impedance bridge used in a chemical research laboratory.

Lower Right
Testing radio receivers with the standard-signal generator.









INTRODUCTION

General Radio is a small manufacturing company, but a medium-sized instrument company. Its plant consists of three connected buildings of four floors each, providing about 75,000 square feet of floor space. Here 215 employees design, build, test, and sell more than a million dollars' worth of General Radio products each year.

Since most of these products are electrical instruments designed and built for the specialized types of electrical measurement and testing that are rapidly becoming a necessary part of modern industrial processes, it is evident that planning, designing, servicing, and selling are necessarily engineering functions. Consequently, men with engineering background predominate in many departments. In fact, of the complete personnel, about 20% have college degrees, most of them in the engineering field.

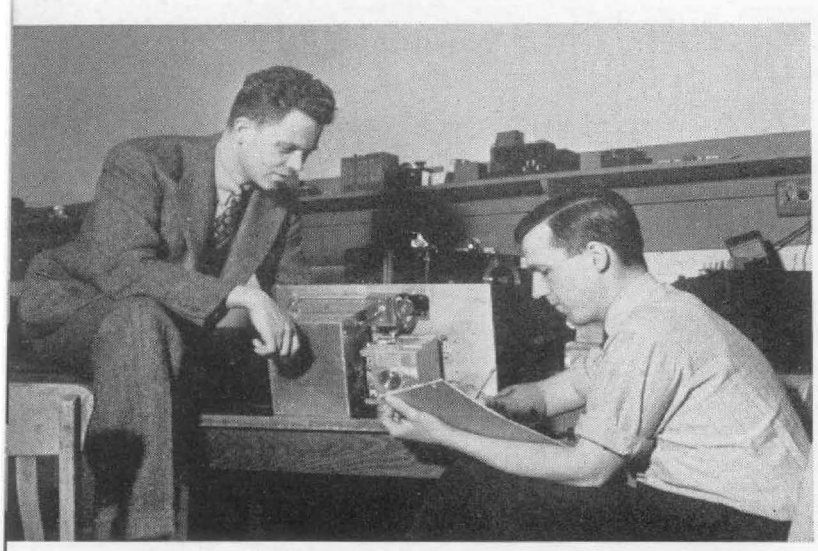
The management and administrative organization are in many ways unique. To allow as much latitude as possible for individual initiative and ability, the simplest possible form of organization has been the aim. This has resulted in the development of an organization in which management is centered, for functional purposes, in the work of committees.

Active management of Company affairs is in the hands of the Management Committee, which consists of Company officers and several men in responsible positions in various Company departments. This committee meets weekly to discuss management problems.

Henry S. Shaw (*left, above*) has been associated with the General Radio Company since 1917, beco ing Chairman of the Board in 1926. Melville Eastham (*right*) has been President of the Company since its founding in 1915.

Commercial, financial, and sales matters are supervised by H. B. Richmond, Treasurer (*right, above*), who joined the Company in 1919. At the left is F. L. Tucker, Comptroller. The patron saint of all treasurers looks down from the wall.

Prompt handling of all orders is the responsibility of the Commercial Department. In the photograph at the right, C. E. Hills, Jr., Commercial Manager (*right*), and H. P. Hokanson (*left*) look over the morning's orders.



Dr. D. B. Sinclair, Engineer (*left*), and C. A. Woodward, assistant, specialists in high-frequency measurements, are shown working on a new impedance bridge for use at high frequencies.

The primary frequency standard and the new broadcast frequency monitor were developed by J. K. Clapp, Engineer (*left*), and H. H. Hollis, assistant, General Radio's specialists in frequency standardization and measurement.

Dr. W. N. Tuttle, Engineer (*left*), and R. G. Alexander, assistant, look over the experimental model of a frequency-modulated signal generator. Dr. Tuttle is Chairman of the Engineering Planning Committee and has designed a number of General Radio instruments, including the TYPE 561-C Vacuum-Tube Bridge and the TYPE 726-A Vacuum-Tube Voltmeter.

ENGINEERING

In the Engineering Department, "while there are loose groupings for administrative and accounting purposes, there is no chief engineer, and no such thing as an organization chart exists. Direction is at a minimum, and a very great responsibility is placed on individuals, not only with respect to immediate problems, but also to a degree as to their own future development. The direction of engineering development consists to a large extent of the co-ordination of effort in harmony with Company plans rather than the supervision of technical details."*

This co-ordination is accomplished through the work of two committees, an Engineering Planning Committee, which plans the development engineering program, and a Design Committee, which supplements the work of the Planning Committee with detailed instrument specifications. Within the limits of these specifications the actual design of an instrument is largely the responsibility of the development engineer.

Other than purely engineering considerations enter into the planning and executing of the development program. Since it is the policy of management to provide, if possible, constant employment for all departments of the plant, the general state of business and the load in the production department must be considered. When work in the plant slackens, the effort must be placed on projects that can be completed quickly, and, conversely, when the plant is oper-

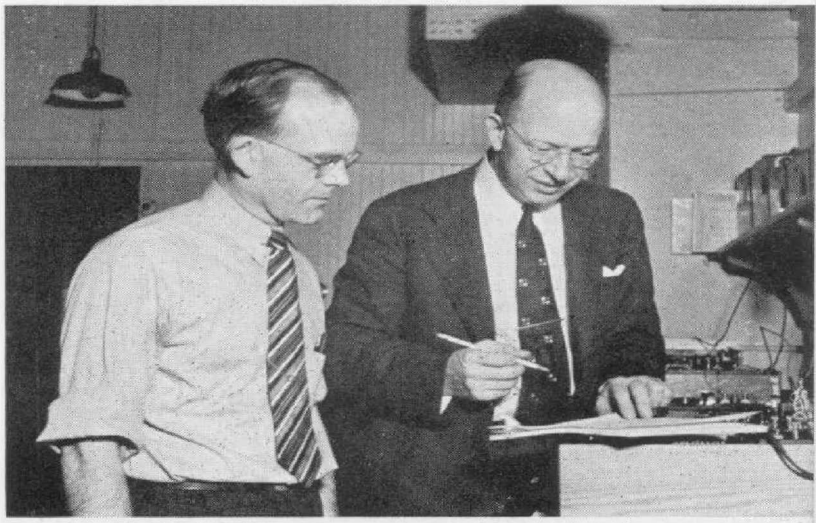
*C. T. Burke, "Engineering Administration in a Small Manufacturing Company," *Proceedings of the Institute of Radio Engineers*, January, 1940. Since this paper is a complete treatment of engineering administration in the General Radio Company, the subject is discussed only briefly here.

ating at capacity, more attention can be given to long-range projects.

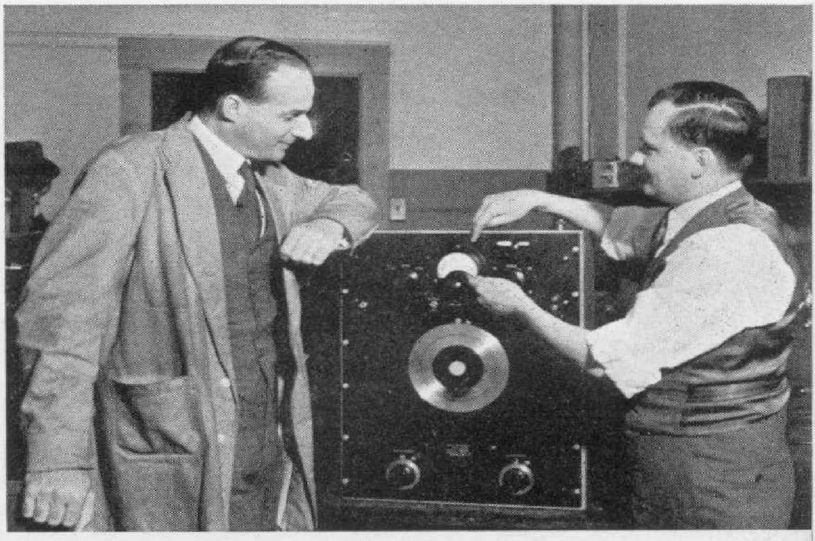
Another important consideration is the rapid change that is characteristic of the instrument business. New fields of measurement become important, and new tubes, circuits, and methods become available, necessitating the periodic redesign of old instruments as well as the development of new ones. About one-half the instruments sold in a given year have been developed or radically redesigned within two years.

Both engineering and sales effort are planned with a view to keeping the line of products diversified, so that no single product accounts for more than 10% of total sales.

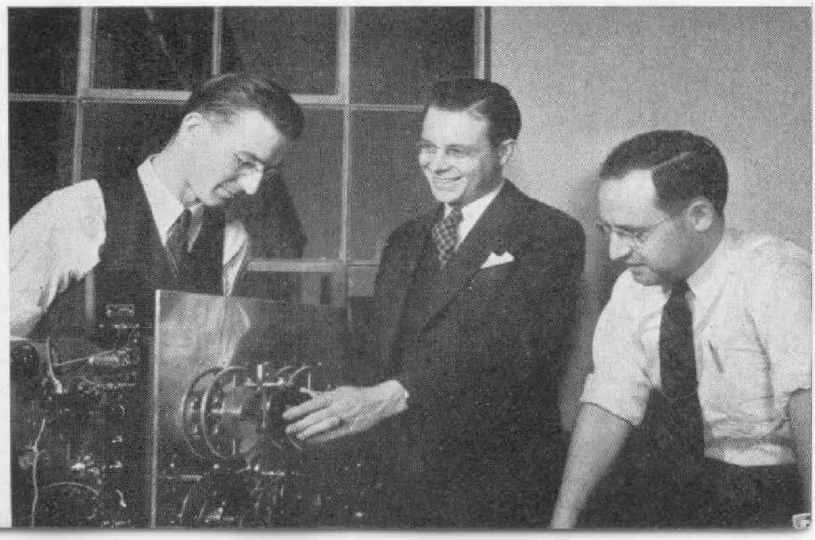
Development engineers work in individual laboratories that are equipped with bench, desk, and storage space. A completely equipped model shop, staffed by eight mechanics, is adjacent to the engineering laboratories. An engineering assistant is usually available to the development engineer for much of the detailed experimental work. Only about 60% of an engineer's time is devoted to assigned projects. The balance is spent on correspondence with customers, the preparation of technical papers, attendance at technical meetings, and reviewing technical literature. The development engineer prepares operating instructions and serves in an advisory capacity on advertising and sales promotional publications. Favorable reports from users, as well as complaints, failures, and service difficulties are referred to him for comment.



R. F. Field, Engineer, shown at the right, above, with D. H. Chute, assistant, works in the field of impedance measurement at commercial, audio, and radio frequencies. Mr. Field has designed many of the impedance bridges in our catalog.

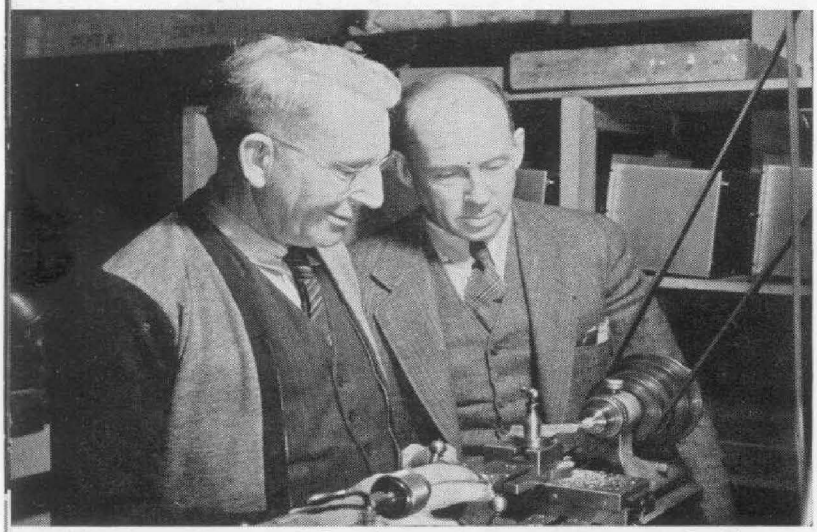


Eduard Karplus, Engineer (*left*), and A. G. Bousquet . Engineer (*right*), have collaborated on the design of many instruments, including the TYPE 605-B Standard-Signal Generator. Mr. Karplus is also one of the originators of the Variac.

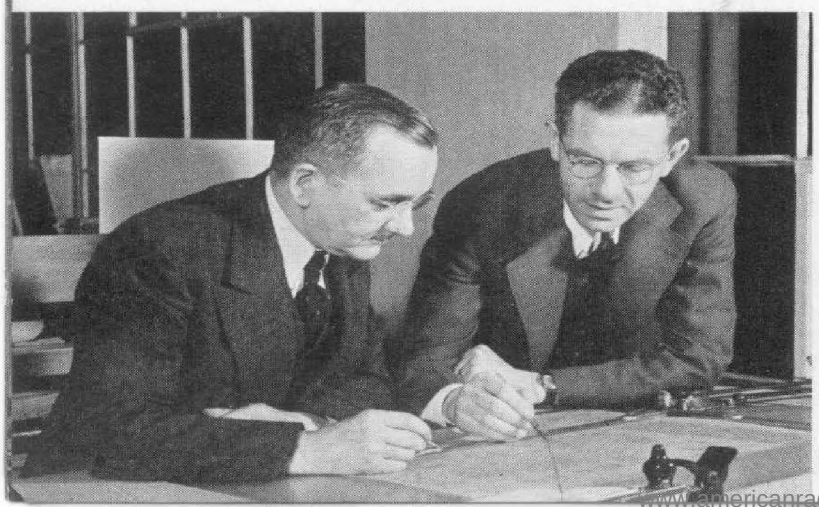


Shown here with the experimental model of a new standard-signal generator are H. H. Scott, Engineer (*center*), H. Chrystie (*left*), and E. E. Gross (*right*), assistants. Mr. Scott has developed a wide variety of instruments, including the TYPE 759-A Sound-Level Meter, the TYPE 760-A Noise Analyzer, the TYPE 608-A Oscillator, and TYPE 814-A Amplifier.

H. W. Lamson, Engineer (*left*), is one of the old timers on our staff, joining the Company in 1921, and Dr. S. A. Buckingham, Engineer (*right*), is one of the newest members. Mr. Lamson has developed many catalog and special instruments, including tuning fork oscillators and magnetostrictive devices. Dr. Buckingham specializes in the design of Variacs.



Engineering models of new instruments are built in the experimental shop, supervised by H. S. Wilkins, Engineer (*right*). Knut A. Johnson (*left*), foreman of this shop, has been with the Company since its founding in 1915.



The link between engineering and production is the drafting department, a situation that makes it a target for both sides. Shown here looking at drawings of a new instrument are P. K. McElroy, Engineer-in-Charge, and A. C. Rohmann, Chief Draftsman.

SALES

Practically all products offered to the domestic market are sold directly from the factory, and each product has only one price regardless of the commercial classification of the ultimate user. It is, of course, a standard commercial practice for manufacturers to establish a fictitious list price, and from this list price to offer discounts which vary with the class of customer, one scale for jobbers, another for educational institutions, and so on through a very complex system. Since, however, the major part of General Radio products are sold to organizations entitled to these so-called trade discounts, and since no dealer or distributor organization is employed, there is no necessity for using this cumbersome discount system. Accordingly, all published and quoted prices are net.

Users of General Radio instruments include government, educational, and research laboratories, and manufacturers of such products as machinery, radio receivers, telephones, chemicals, paper, and textiles. Although this diversified market presents an unusual selling problem, instrument applications are almost invariably in engineering fields. Consequently, sales and advertising are handled by engineers, many of whom have had considerable experience in instrument development and who are familiar with manufacturing problems. A considerable part of the everyday work of the engineers engaged in sales is in the handling of correspondence, supplemented by periodical trips to principal markets and to the plants and laboratories of the customers.

Users are made acquainted with the

product chiefly through catalogs and other advertising media, and through correspondence with the factory or the two factory branch offices. These offices, one in New York City and one in Los Angeles, are maintained for the purpose of getting accurate information to and from the customers efficiently, and keeping in touch with the developments and requirements of the many fields where General Radio products find their applications.

Direct-mail advertising effort is centered in the general catalog and in the *Experimenter*. These publications are circulated to about 23,000 individuals, nearly all of whom are associated with engineering or scientific work. Most of the articles in the *Experimenter* are of a technical nature describing instruments and their applications and are nearly all contributed by the engineering staff.

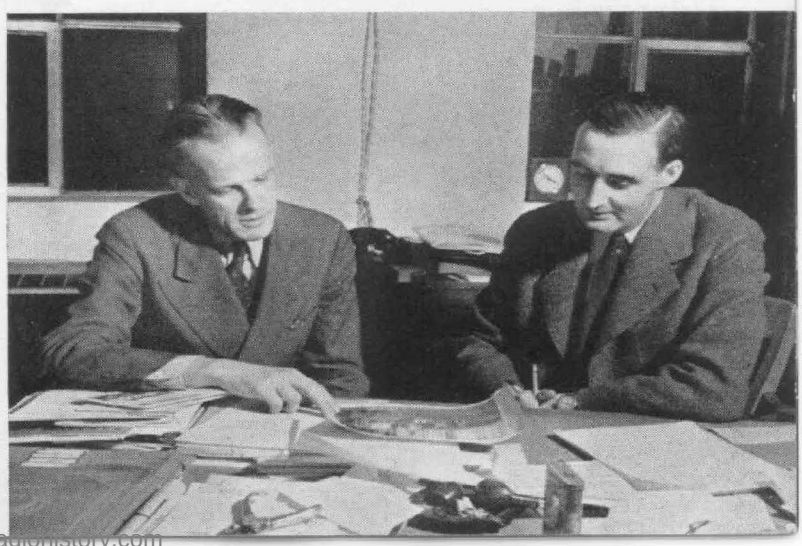
Bulletins describing specific instruments with specific applications are distributed periodically to selected groups from our mailing list. An attempt is made to send the literature only to individuals who will be interested in the equipment described, and not to send out bales of material for stuffing wastebaskets.

The direct advertising is concentrated in journals of technical societies and technical or trade magazines, about thirty all told. Research and experience have shown these to be the ones that most effectively reach our market. The aim of the advertising is to give complete, factual, useful information, and every advertisement carries the actual net price prominently displayed.

Foreign sales are an important part

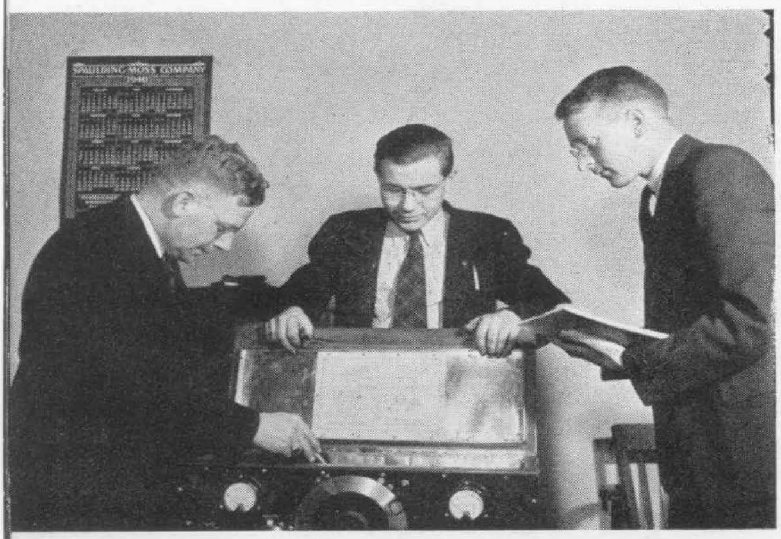
Selling General Radio instruments is the main activity of a group of application engineers, headed by A. E. Thiessen, Commercial Engineering Manager (*above, right*), who is also in charge of government contract work. At the left is M. A. Gilman, Engineer.

Even application engineers develop instruments. Here L. E. Packard, Engineer (*left*), whose usual field is sales, discusses a new power-factor bridge with C. T. Burke (*right*), Engineering Manager and Chairman of the Design Committee.



Advertising, the *Experimenter*, catalogs, instruction books, and similar mater al are prepared in the Engineering Department. (*Left*) J. M. Clayton, advertising, and (*right*) C. E. Worthen, publications.

When the Los Angeles Office was opened in 1937, M. T. Smith, Engineer, was placed in charge. Before going to Los Angeles, Mr. Smith was in charge of the New York Office.



Instruments returned for repair are sometimes twenty years old. Service Manager H. H. Dawes (*left*) looks over a returned instrument with S. R. Larson (*center*) and K. Adams (*right*).

Frederick Ireland, Engineer, is in charge of the New York Office. He was formerly associated with engineering and sales activities at the factory.

of the total. About 30% of the plant output goes to foreign countries, and about 6000 of the 23,000 addresses on the *Experimenter* mailing list are foreign. Sales abroad are handled by resident sales representatives located in the principal countries of the world, who carry stocks of equipment and on whose staffs are trained engineers. Many of the General Radio publications are translated by these representatives into the language of their country before being sent to their own mailing lists.

The functions of the Service Department are closely allied to those of engineering and sales. This department is responsible for all repairs and replacements, and for correcting any operating difficulties that customers experience with General Radio instruments.

PRODUCTION

The production problem of the General Radio Company is basically one of manufacturing over 500 individual catalog items ranging in price and complexity from a 10-cent switch contact to a 2500-dollar frequency standard. There is no quantity production in the usual sense, although sales of small parts such as switch contacts amount to many thousand units per year. Instruments, in general, sell in numbers varying from 200 to 2000 during their useful life, which varies from two to five years. Production, therefore, is keyed to small lot manufacture. The smallest production lot of instruments is usually 10 units, the largest 200. The complete production cycle for the average instrument is three to four months, and the same instrument may repeat at six-month intervals.

In accordance with the Company policy of attempting to give constant employment to all departments of the plant, schedules are set up so as to utilize constantly the facilities of all departments. To this end, orders are issued by the sales department to the plant for at least a six months' production period, and production operations are scheduled that far in advance.

After the engineering model of an instrument is completed, and passed by both the development engineer and the Design Committee, layouts are made in the drafting department and a sample production unit is built. Detailed manufacturing drawings, tools, and directions for the details of manufacturing are then drawn up. A test production run of 10 units follows, which serves to prove drawings, tools, schedules, etc. Routing and operations are thus determined, so that scheduling larger scale production is a matter of duplication of the test-run schedules.

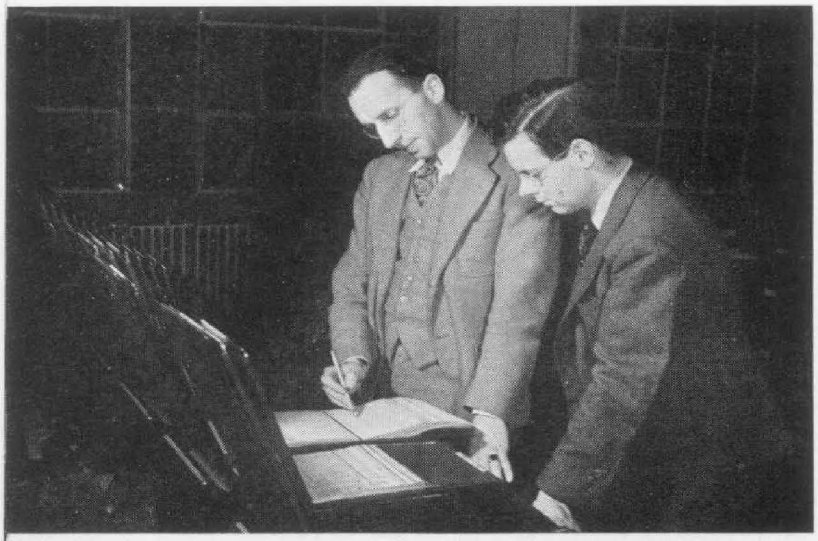
Production operations in general call for skilled handwork rather than automatic machines, and consequently schedules are set up in man hours rather than machine hours. In contrast to mass-production methods, there are no moving assembly lines. For assembly, instruments are arranged on long benches designed to accommodate twenty-five of the largest units, and the scheduled set of operations is performed on each instrument in turn. The man moves, not the product.

Although the quantities handled are not large, every instrument of a given type must be exactly like all others of that type in appearance and perform-

The production department is supervised by E. H. Locke, Vice-President (*left*), and C. C. Carey, Superintendent (*right*). Mr. Locke has been associated with the Company since 1918 and has been Vice-President since 1920.

The scheduling and routing of production operations, and the subsequent follow-up in the plant, is the responsibility of R. J. Patterson (*left*) and W. T. Regan (*right*).

Purchasing is handled by W. H. Sherwood (*left*), Purchasing Agent, assisted by M. J. Folan (*center*) and A. W. Cleveland (*right*).



Production cost records tell not only what an existing instrument costs to build, but are also useful in estimating costs on new items. Shown here at the cost record system are (*left to right*) A. I. Corkum, cost accountant, and G. H. Sharp.

Finished parts stock is under the supervision of N. M. Mitchell (*right, above*) and S. H. Beck (*left*) shown seated at the perpetual inventory record of over 8000 items.

ance. This uniformity is achieved through complete interchangeability of component parts with a concomitant emphasis on narrow production tolerances. While many manufacturing operations are functionally similar to those of radio receiver manufacture, for example, they are more exact and require a far higher degree of skill on the part of the operators.

Assembly, for instance, is not a matter of repeating routine operations, because it includes many mechanical and electrical adjustments to produce smooth operation of moving parts and electrical contacts, and because appearance and permanence are important factors in the result. Consequently, many of the details of the assembly operation are left to the skill and ingenuity of the man performing the work.

Mechanical tolerances on the moving parts in rheostats, condensers, and switches are closer than is usually considered necessary for these products. Stainless steel shafts and their bearings for condensers and rheostats, for instance, are machined to ±.0005 inch; steel-core and bakelite shafts are held to ±.001 inch. This insistence on close tolerances makes it possible to stock completely interchangeable parts, so that a defective part can be replaced immediately by a good one, and it also assures uniform fit, smoothness of operation, and predictable wear on all moving parts. These factors are important when rheostats are to be used (as many of them are) in automatic indicators and recorders for long periods without replacement, when condensers must be capable of holding precise calibrations, and when slight

Production test runs of new instruments are made to prove tools and schedules. The supervision of the mechanical details of these runs is the responsibility of C. E. Rice (*right*) and H. T. Anderson (*left*).

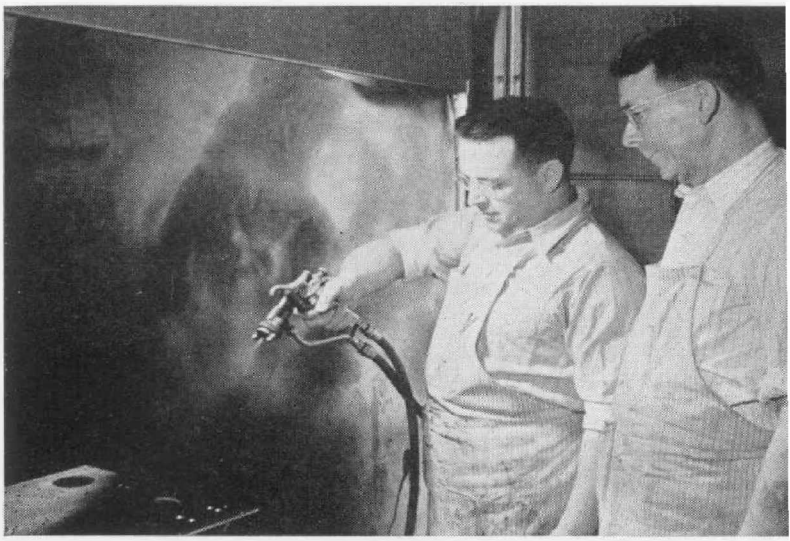
misadjustments in switches will lead to extreme wear and short life.

Similarly, both the casting and finishing of cast metal parts such as condenser frames are carried out with a greater degree of precision than that ordinarily required and receive the individual attention normally given to samples.

While it might be inferred that this emphasis on precision would lead to a relatively slow, master-craftsman type of production, experience has shown that the required precision can be obtained with a high degree of production efficiency, and that production can be operated on a premium system of pay so that efficient work is rewarded in proportion to individual output.

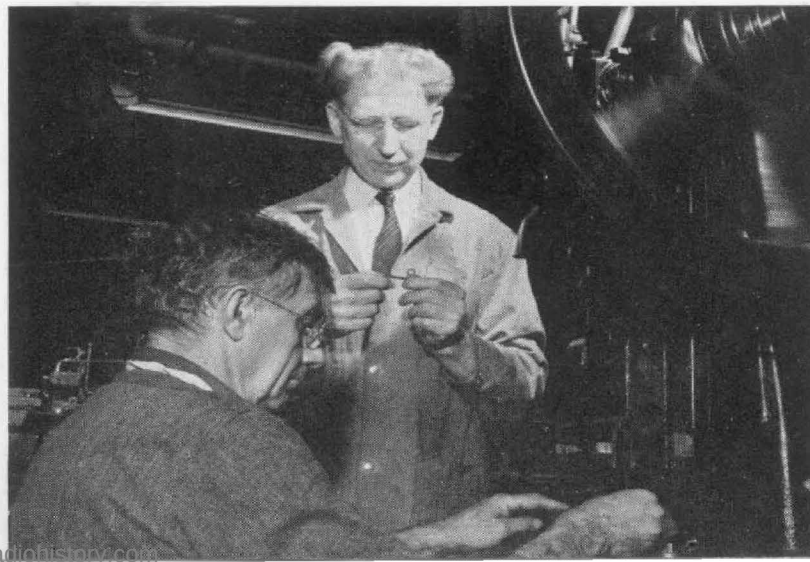
Close tolerances imply rigid inspection. While mechanical inspection is handled by relatively few men, parts and materials are carefully checked for both appearance and conformity to specifications. Sampling is used wherever manufacturing experience indicates its validity, but controls are set up so that defective lots of sampled parts can be detected and corrected with a minimum of waste. An excellent example of the degree of inspection used is afforded by the operations on an aluminum panel, which seems as trouble-free a part as might be encountered. Inspection occurs first after sawing, drilling, and finishing are completed, again after lacquering, a third time after engraving, and a fourth after complete assembly.

Even moderately precise operations on a production basis involve the use of a multiplicity of punches, dies, forming fixtures, jigs, and other tools. These are



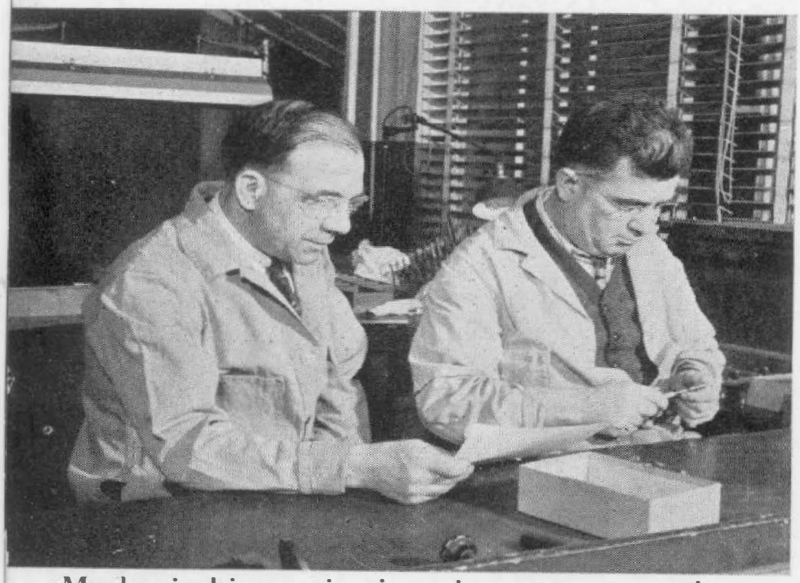
Lacquer to produce the distinctive GR crackle finish is being sprayed on a panel by H. J. Goodall, while T. Palmer, foreman of the plating and finishing department, looks on.

The sheet copper linings of many General Radio cabinets are fitted by H. H. Chute (*left*), oldest employee of the instrument assembly department, under the direction of W. H. Fish (*right*), foreman of the department.



Condenser plates, laminations, and other sheet metal parts are made on punch presses. (*At the right*) J. D. Murray, foreman of the machine shop, examines a stamping produced at the punch press by C. Bertini.

Measuring a condenser frame casting preparatory to making a drilling jig. (*Left to right*) E. S. Page (who is also president of the GR Credit Union) and G. G. Oberbeck, foreman of the tool and screw machine department.



Mechanical inspection is an important operation when close tolerances are imposed. (*Left to right*) W. A. Lewis, foreman of the inspection department, and J. L. Martin.

all made in the General Radio plant by skilled tool and die makers. In the small plant the supervision and the work of tool making are more closely connected to the production process than in a large plant, so that the desired result is obtained more quickly and easily when the tools are made inside and can be hand-tailored to the job in the plant itself.

In the standardizing laboratory, twenty technicians, many of them with engineering degrees, test and calibrate all General Radio instruments. Each instrument is required to meet a rigid set of performance specifications. The accuracy specification, for test purposes, is set substantially closer than the published catalog figure. In order to simulate operating conditions in countries all over the world, each new design is subjected to tests under varying conditions of line voltage and frequency, ambient temperature, and humidity. This work is not performed in the engineering department, but is carried out as a production operation. Performance requirements are specified by the development engineer, but details of testing specifications and procedure are worked out in the production department.

Standardized procedure and equipment permit these performance tests to be carried out efficiently on production quantities of instruments. Laboratory benches, like assembly benches, are arranged to handle a substantial number at one time. Like development engineers, laboratory men tend to specialize. Some work on audio-frequency instruments, and some on radio-frequency, while others are specialists in "trouble shooting."

Several thousand panels a year are engraved in this department. Operating the engraving machine is W. J. Marvin (*left*) with J. F. N. Park, foreman (*right*).

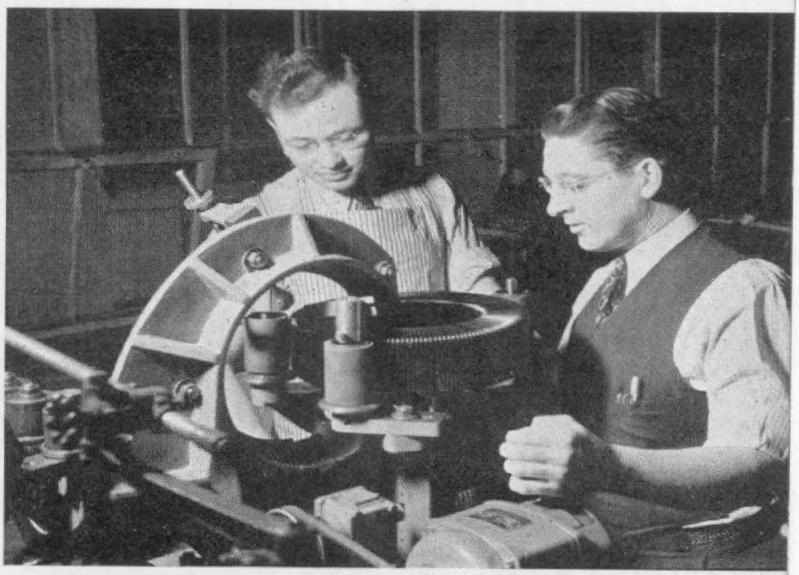
Standards of resistance, capacitance, and inductance are maintained as a basis for accurate instrument calibrations. Intercomparisons between units in each class are made periodically and absolute measurements are made yearly by the U. S. Bureau of Standards. The accuracy with which these standards are known is, of course, considerably in excess of commercial requirements. At the present time, our resistance standards are known to .005%, capacitance to .02%, and inductance to .04%. Frequency calibrations are made in terms of the Engineering Department's primary standard of frequency, which has an accuracy of .00001%.

In purchasing, the primary emphasis is placed on suitable quality rather than on price, and much purchasing effort is directed toward finding sources of supply capable of meeting specifications that have been laid down by the Engineering Department. Once a satisfactory source of material is located, substantial quantities of staple items and raw material are carried in stock. It is not uncommon to set ordering points at a level that will insure two years' normal supply. In this way production needs can be met regardless of temporary delivery situations.

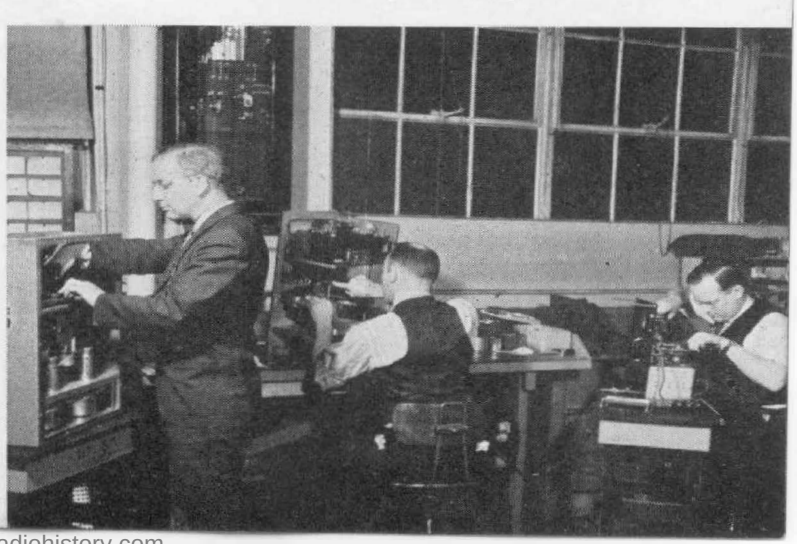
WORKING CONDITIONS

One of management's primary functions is the maintenance of constant employment. Some measure of its success may be indicated by the record of the last ten years, in which there have been no lay-offs or discharges because of lack of work. Only twice in this decade has it been necessary, because of external conditions, to operate on shorter-than-

Parts assembly — L. L. Scott, a specialist in condenser assembly for 16 years, is shown working on a group of TYPE 755 Condensers, under the direction of H. J. Comrie, foreman.



One of the jobs of the winding and transformer assembly department is to produce Variacs. C. W. Whitehead (*left*) operates the machine winding a TYPE 50 Variac. At the right is R. W. Searle, foreman.



A department for special and small-lot production handles repairs, modification of standard instruments, and one-of-a-kind items. (*Left to right*) D. J. Martin, supervisor, J. E. Lundgren, and C. A. Batchelder.

normal hours of work, and during these periods the available work has been shared, as nearly equally as possible, by all production departments. This degree of stability has been achieved largely by carrying a flexible finished parts stock and a finished instruments stock as a buffer between sales and production. The finished stock is built up during periods when sales are low and serves as a reservoir to draw upon in the sudden buying periods that usually follow.

During periods of normal operation, all employees receive a semi-annual bonus, in which the share of each individual depends upon his contribution to the profitable operation of the Company. This contribution is determined by as equitable and impartial a system as the Company has been able to devise.

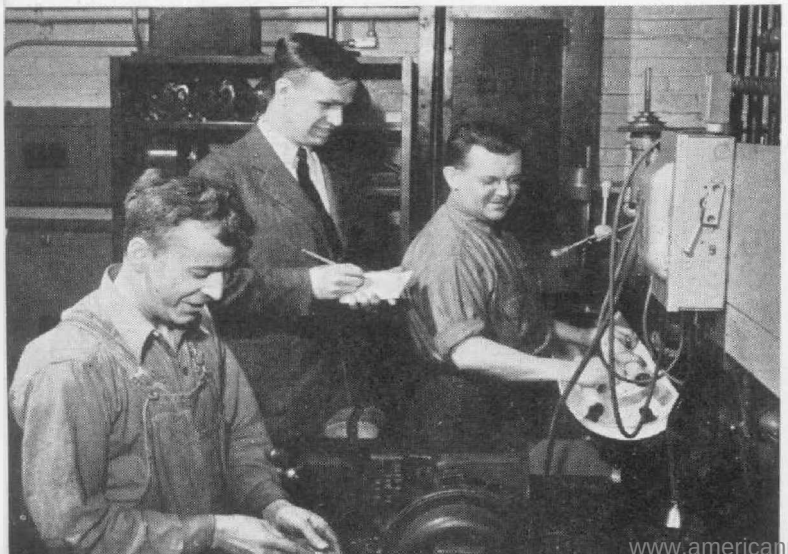
Since 1919 the Company has operated on a five-day week, and has anticipated by many years other working conditions, many of which are now being required by law. All manufacturing employees who have been with the Company one year or more receive two weeks' vacation with pay and an additional week's pay on the 15th of each December. Non-manufacturing employees receive three weeks' vacation with pay.

A group insurance plan provides $1000 of life insurance for each new employee after a 90-day trial period. Each year thereafter, $100 is added to the policy until a maximum of $2000 is reached. The cost of this insurance is borne entirely by the Company.

The employees operate a Mutual Benefit Association, which pays sickness and death benefits, and sponsors a summer picnic, parties, and other group activities. Employees also operate their own Credit Union to encourage thrift and to lend money for provident purposes. In the ten years that it has been in operation, the Credit Union has accumulated assets of more than $40,000.

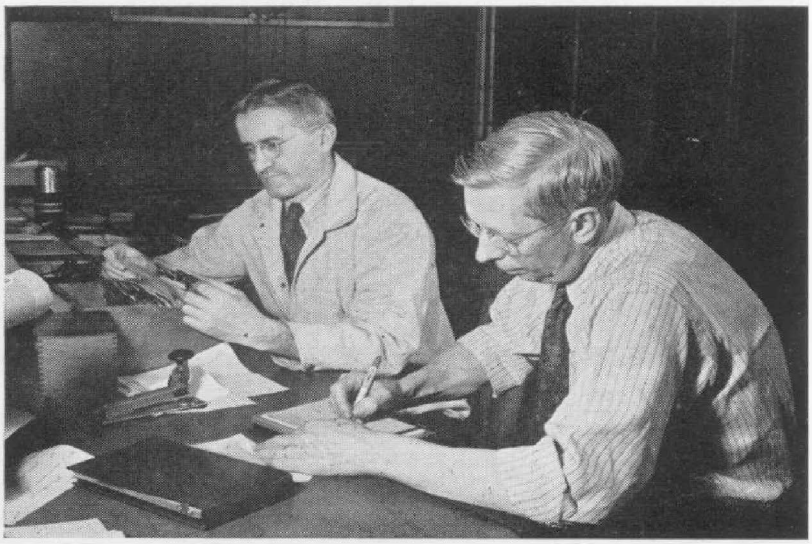
Among the other organized employee activities are a baseball team, a bowling team, golf and tennis tournaments, and a dramatic club. While the General Radio Company encourages all such activities and contributes to their support, it does not direct or control them.

The standardizing laboratory is under the direction of W. G. Webster, Engineer (*left*), and M. C. Hobart, foreman (*right*). Great responsibility rests with this department, which performs the final test and inspection on all instruments.

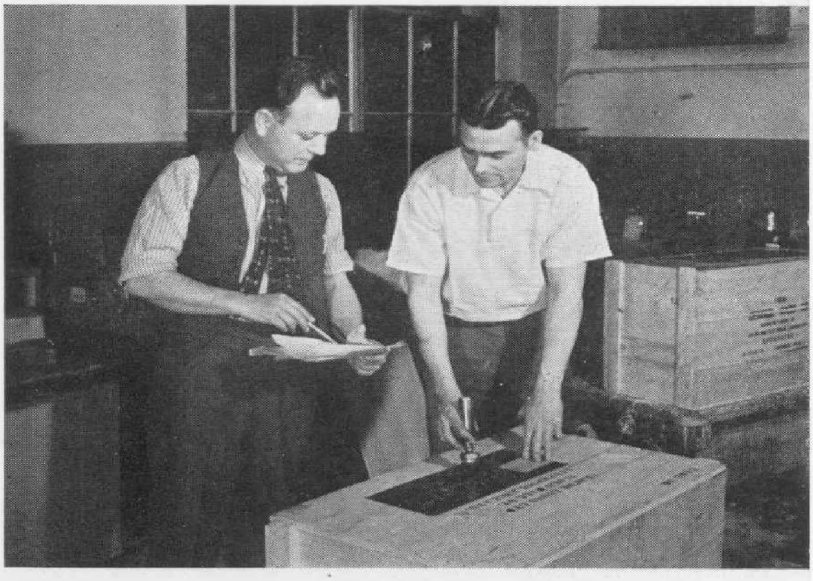


Building maintenance is supervised by Paul Hanson, Engineer (*center*), shown with R. Cameron (*left*) and J. D. Polley (*right*), electricians.

In 1934, the Genradco Trust was formed, largely through the generosity of the Chairman of the Board of Directors, but assisted by a contribution from the Company itself. The funds of the Trust are entirely separate from those of the Company, and the income is used for the improvement, welfare, and benefit of employees of the General Radio Company and their families and for the aid of some scientific enterprises outside the Company, but with allied interests. The Genradco Trust assists in meeting unusual expenses beyond the means of employees, whether caused by sickness or by other unforeseen circumstances. It provides the services of a physician who is available several hours each week in the plant for consultation. At present a plan is being tried that extends, on a free-clinic basis, ordinary medical treatment to employees' families.

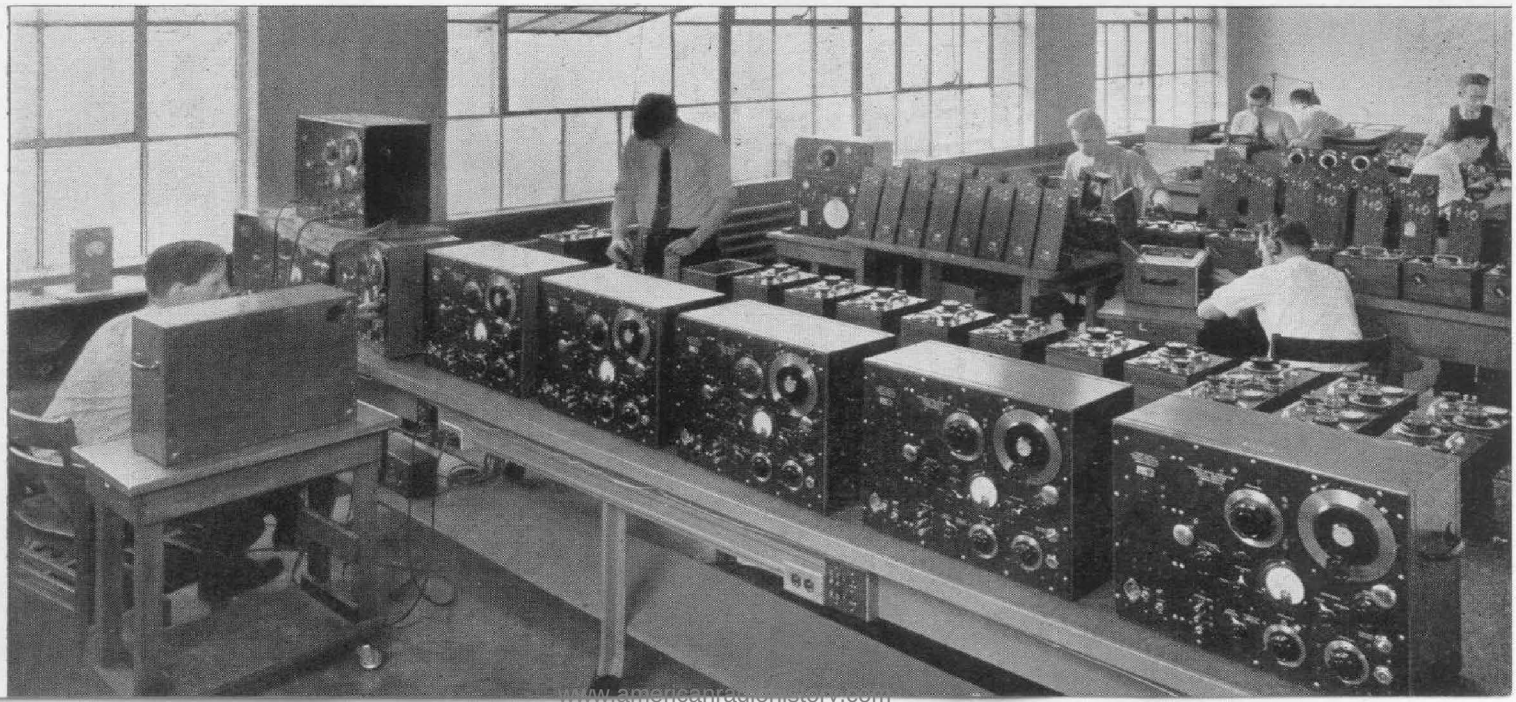


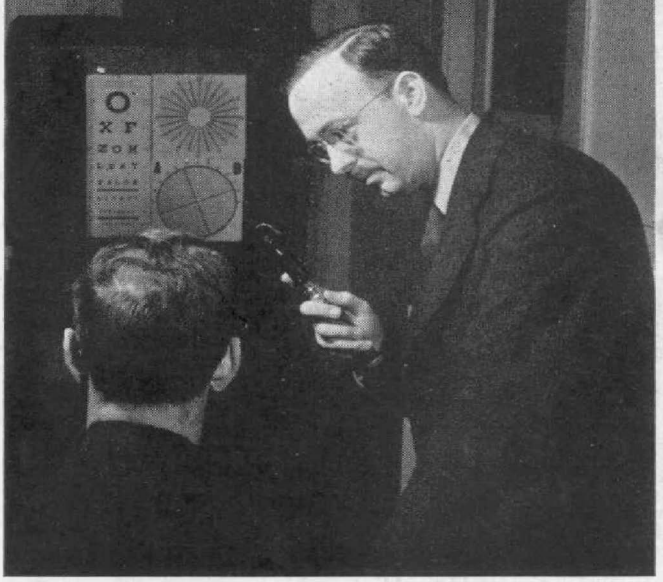
The receiving room is in charge of F. A. Howland (*right*); raw stock is handled by A. Stierli (*left*).



Everything from a switch contact to a frequency standard is carefully packed before shipment. Shipping room activities are supervised by F. W. Beck, foreman (*left*), and C. H. Riemer.

This view of the instrument calibration laboratory shows how instruments are handled in groups on long benches. In the foreground are TYPE 605 Standard-Signal Generators and just behind them a group of TYPE 419 Wavemeters.





Dr. M. T. Easton is shown here making an ophthalmic examination.

Recognizing that good eyesight is necessary for good craftsmanship, the Trust also provides the services of an ophthalmologist, who examines and treats eye difficulties, and glasses are supplied without charge to employees who need them. Space for these health activities is provided in the plant, and a registered nurse is in attendance during working hours.

It has never been the desire of the General Radio Company to become a large organization. It has always emphasized quality rather than quantity, and, accordingly, has kept its size at a point where every employee is personally known to those responsible for the management of the Company, and where every employee may feel free to discuss with the management questions pertaining to his work and even personal matters where help and advice are needed.

By these and other policies, the management endeavors to make the General Radio Company a desirable place in which to work, realizing that the continued successful operation of the Company depends upon attracting and keeping skilled employees. The measure of the success of these policies is that the average length of service of all employees is nearly eleven years. This is particularly significant because in the past dozen years the number of employees has just doubled and because the length of service of girls in the office is considerably less than that of factory employees. Only male labor is employed in the factory, and the Company has been fortunate in obtaining men of unusually desirable personal qualities.

Dr. Roy E. Mabrey (*center*) is in charge of medical work. Miss F. J. Ellinwood, R. N., is in attendance at the plant every day. The patient is C. F. Uhlendorf, Company photographer.

GENERAL RADIO COMPANY

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BRANCH ENGINEERING OFFICES

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