THE General Radio EXPERIMENTER

VOLUME XX No. 1 JUNE 1945

THIRTIETH ANNIVERSARY · 1915-1945

DEVELOPMENT ENGINEERING AT THE GENERAL RADIO COMPANY

EVERY fifth year, on the anniversary of the founding of the General Radio Company, we devote the June issue of the *Experimenter* to a description of some of our company operations and personnel. The subject chosen for this month is the Engineering Department — its organization and personnel, its activities during the war, and the post-war products that may result from war-time developments.

● **THE BUSINESS** of the General Radio Company is producing and selling packaged engineering to solve industry's measurement problems. Primarily responsible for the degree of excellence with which a General Radio instrument does its job is the development engineer. Given a measurement problem, the engineer devises a solution in the form of electrical circuits, and with the cooperation of the mechanical design engineer, puts it in a package that can be manufactured and that can be conveniently used.

At the General Radio Company, twenty-seven engineers are exclusively engaged in the development and design of electronic instruments. Drafting, model shop and secretarial employees boost the total of de-

FIGURE 1. View of the technical library.

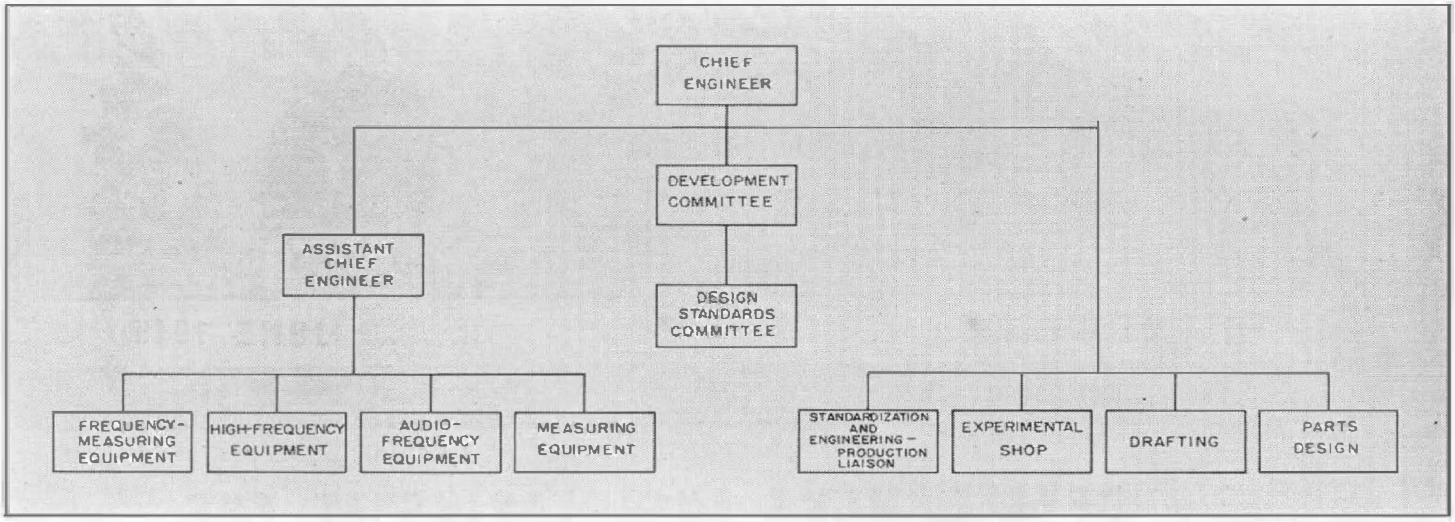


FIGURE 2. Functional diagram of engineering department organization.

PERSONNEL

EXECUTIVE

Chief Engineer — Melville Eastham
Assistant Chief Engineer — D. B. Sinclair
Engineer in Charge of Drafting — L. M. Burgess
Engineer in Charge of Frequency Measuring Equipment Development — J. K. Clapp
Engineer in Charge of Parts Design — Melville Eastham
Engineer in Charge of High-Frequency Development — Eduard Karplus
Engineer in Charge of Standardization — P. K. McElroy
Engineer in Charge of Measuring Equipment Development — D. B. Sinclair
Engineer in Charge of Audio-Frequency Development — H. H. Scott
Engineer in Charge of Experimental Shop — H. W. Wilkins

DESIGN

Paul Hanson
H. C. Littlejohn
Gilbert Smiley
F. W. Williams

DEVELOPMENT

A. G. Bousquet
W. F. Byers
C. A. Cady
D. H. Chute
R. F. Field
E. E. Gross
H. H. Hollis
H. W. Lamson
S. R. Larson
A. P. G. Peterson
D. A. Powers
R. J. Ruplenas
W. R. Saylor
W. R. Thurston
C. A. Woodward

DEVELOPMENT COMMITTEE

Chairman — Melville Eastham
Vice-Chairman — D. B. Sinclair
Secretary — Eduard Karplus
P. K. McElroy
H. H. Scott
C. T. Burke*

*Director of Planning

DESIGN STANDARDS COMMITTEE

Chairman — P. K. McElroy
Secretary — L. M. Burgess
H. C. Littlejohn
F. W. Williams
Gilbert Smiley
H. S. Wilkins
D. B. Sinclair†

†Designate from Development Committee

velopment engineering personnel to approximately fifty, or one in every eight General Radio employees. These are the people who are responsible for designing the new instruments that will be available to you after war work is completed.

General Radio engineers are specialists in the application of electronic principles to industrial and scientific measurements. Within the general field of electronics, many of the staff specialize in certain types of circuits and measurements, but all have a broad background of general engineering and scientific training.

The organization of the department is outlined in Figure 2. For purposes of administration the engineering department is divided into groups, classified by the major activity of the group personnel. Lines of classification, however, are not rigidly drawn, and it is not unusual to find engineers in the audio-frequency group, for instance, designing u-h-f equipment or the u-h-f group working on power-frequency apparatus.

Group leaders are responsible to the Chief Engineer and Assistant Chief Engineer. Overall administration of the department is the responsibility of the Chief Engineer, who is guided, insofar as decisions on matters of development and design are concerned, by the Development Committee and the Design Standards Committee. It is the function of the Development Committee to set general specifications for a new development and to pass on completed developments before manufacture is started. The Design Standards Committee concerns itself with standard practice in mechanical design: parts, finishes, structural details, etc. It is a sub-committee of the Development Committee.

When new developments are scheduled, the leader in whose group the work is to be done is responsible for the general guidance of the project within the original specifications laid down by the Development Committee. The committee reviews all current projects at frequent intervals, making such changes and improvements in the general specifications as the progress of the development warrants.

The instrument takes form first as a breadboard assembly and next as a working model built in the experimental shop from the design engineer's sketches.

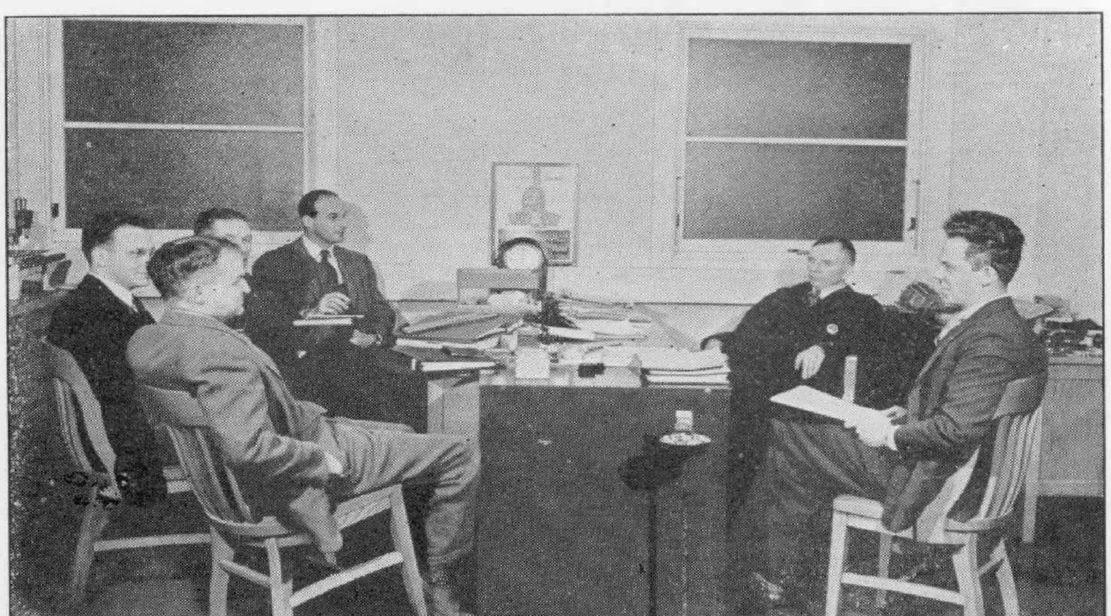


FIGURE 3. The Development Committee in session. Left to right around the circle: C. T. Burke, H. H. Scott, P. K. McElroy, Eduard Karplus, Melville Eastham, D. B. Sinclair

FIGURE 4. A meeting of the Design Standards Committee. Left to right: P. K. McElroy, L. M. Burgess, H. S. Wilkins, F. W. Williams, Gilbert Smiley, H. C. Littlejohn, D. B. Sinclair.

This model is submitted to the Development Committee, who suggest whatever changes seem advisable to improve its general acceptability and its adaptability to established manufacturing methods. Upon approval by the Development Committee, detailed manufacturing drawings are made in the drafting group, and the instrument is ready for manufacture. Before quantity production is started, however, a single unit is built to check the drawings, and a test run of (usually) ten units is made to prove tools and to iron out any production difficulties. Upon successful completion of the trial production lot, the instrument is ready for quantity production.

In addition to the development of instruments, the engineering department is responsible for the preparation of purchase specifications for parts and materials purchased from other manufacturers and for acceptance specifications on new material received.

Facilities

Working facilities in the Engineering Department have been arranged to afford a maximum of adaptability to the work of the department. The working space is a combined office and laboratory, with desk, telephone, and filing facilities, as well as the required laboratory bench space. Senior engineers have, as a rule, individual offices; for junior engineers and assistants one office is shared by two people. There are in all nineteen such offices, all on the same floor, in addition to the departmental facilities, which include the library, secretaries' office, conference room, measurements room, instrument room, frequency standard, and experimental shop.

The library, which is in charge of a full-time librarian, contains over 1000 volumes on general and specialized technical subjects and subscribes regularly to some sixty journals and periodicals.

In the measurements room, standards of resistance, inductance, capacitance and voltage are maintained, and standard equipment is provided for the measurement of impedance over a frequency range of 0 to 100 Mc. This equipment is available for use by engineers at all times. One important function of this laboratory is the determination of the electrical characteristics of new insulating materials and new circuit components. As new types of capacitors, resistors, inductors and dielectrics become available, their properties are measured, and the results are made available to the development engineers for use in instrument design.

The Engineering Department is well equipped with General Radio instruments. These, when not in use, are kept in an instrument room and are available to any engineer needing them. Individual laboratories are canvassed about once a week to pick up unused items for return, so that maximum usefulness can be obtained from the stock available. The instrument room is under the supervision of a technician, and all instruments are kept in repair and are periodically sent to the standardizing laboratory for recalibration and test.

The primary standard of frequency for the whole plant is located in the Engineering Department. It consists of four independent standard-frequency crystal oscillators, with means for intercomparing and recording their frequencies. The output frequency is known at all times to better than one part in ten million. Frequency multiplying and dividing circuits provide hundreds of standard frequencies for use in measurement and calibration work. These are distributed through shielded lines to the engineering laboratories and to various production departments, where they are needed for calibration and test operations.

The experimental shop produces the wide variety of special parts and assem-

FIGURE 5. A view of the Experimental Shop. The total shop personnel is twelve. In the center foreground is K. A. Johnson, Foreman, who is also General Radio's senior employee. H. S. Wilkins, Engineer-in-Charge, is shown in the right foreground.

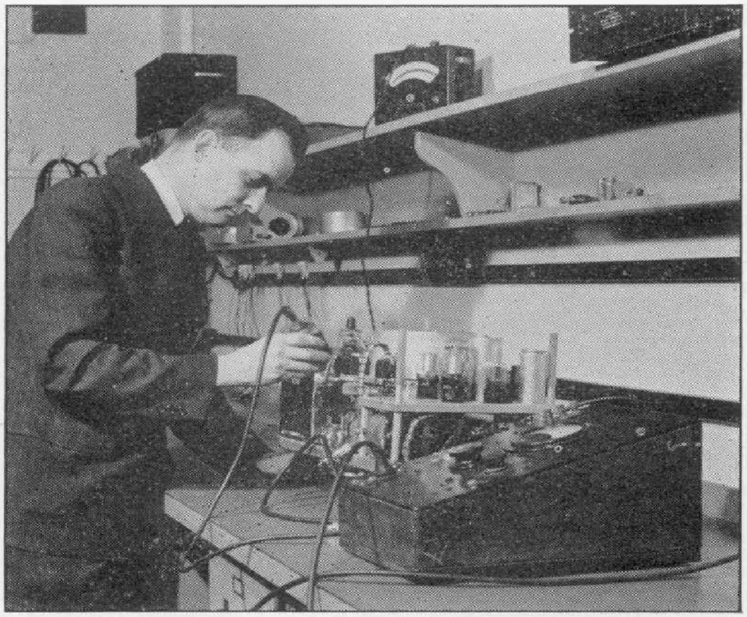


FIGURE 6. A. G. Bousquet of the High-Frequency Group, who has designed a number of General Radio's signal generators, vacuum-tube voltmeters and power supplies, is shown here testing a preliminary model of a standard-signal generator.

blies needed in engineering development work and constructs the working models of new instruments after development is completed. The shop is equipped with a variety of machines, capable of precision considerably greater than that required in a production shop. Personnel are selected for special skills and include machinists, assembly men, and electrical technicians.

Wartime Development Engineering

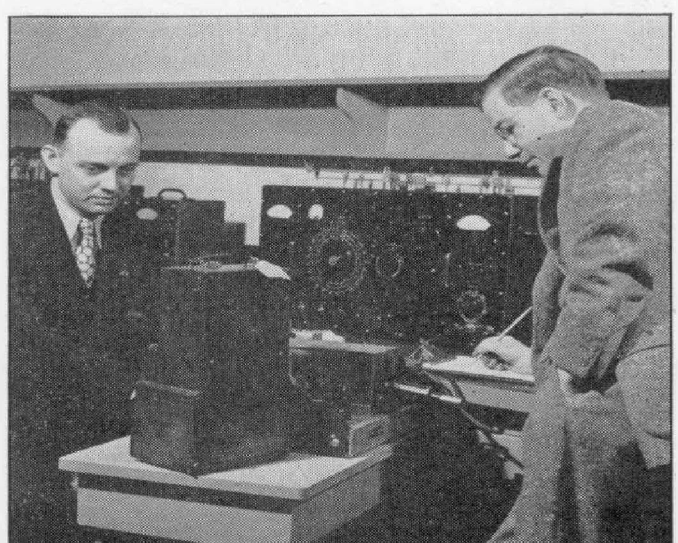
During the war, General Radio engineers have been engaged in a variety of war projects. Many new instruments have been developed, among them a number of specialized types of signal generators, test oscillators, high-frequency receivers, and frequency meters. No production by General Radio beyond a few models of these items was possible, because our manufacturing facilities were completely engaged in the production of urgently needed standard items, for most of which deliveries were scheduled by the War Production Board. Millions of dollars worth of equipment, based on these designs was, however, built by other manufacturers. The design of much of this equipment stemmed from the butterfly circuit,* developed by General Radio, which made possible compact tuning assemblies and single-dial control in u-h-f circuits. Developed under the direction of D. B. Sinclair, E. Karplus, and A. P. G. Peterson, all these items except the butterfly itself was classified for security reasons, and descriptions cannot yet be published.

Other one-of-a-kind items have been developed for use in conjunction with development programs carried on by other organizations. In this group directed by H. H. Scott, a total of eighteen separate instruments, many of them for use in f-m systems, have been designed, constructed, and delivered for a single project, which is still secret.

Considerable work has also been done, under the direction of J. K. Clapp, on the design and production of low-frequency quartz bars to meet extreme

*E. Karplus, "The Butterfly Circuit," *General Radio Experimenter*, Vol. XIX, No. 5, October, 1944.

FIGURE 7. W. F. Byers (left) and S. R. Larson (right) of the Audio-Frequency Group conduct a test run on a finished model.



stability specifications in equipment of considerable urgency. After the engineering work was completed, and a small quantity of bars produced to get the program started, production was turned over to other companies.

In the field of frequency measurement, General Radio has for many years supplied equipment for the ships of the U. S. Navy. Shortly before the war, new designs were completed, and the resulting equipment has been in continuous production since the start of the war. Through close engineering contact with the production process, uniform quality has been maintained and service difficulties have been kept at a minimum.

War research and production in the aircraft, automotive, and ordnance fields have required large numbers of stroboscopes. In addition to our standard types, many of specialized design have been needed. Although the demand for these was limited, the need was urgent, and several small quantity lots have been made under the supervision of H. S. Wilkins. Two items of particular interest are the Microflash, for high-speed, single-exposure photographs, and the Power Stroboscope and continuous-film camera for ultra-speed motion pictures. An interesting example of the use of the Microflash was described in a recent *Experimenter*.* The high-speed movie equipment has been used for aircraft engine research, cavitation studies, and a number of other research programs in mechanics that had immediate application in the design of military equipment.

FIGURE 8. J. K. Clapp (right), in charge of the development of frequency-measuring equipment, looks over a newly developed quartz bar with H. H. Hollis (left).

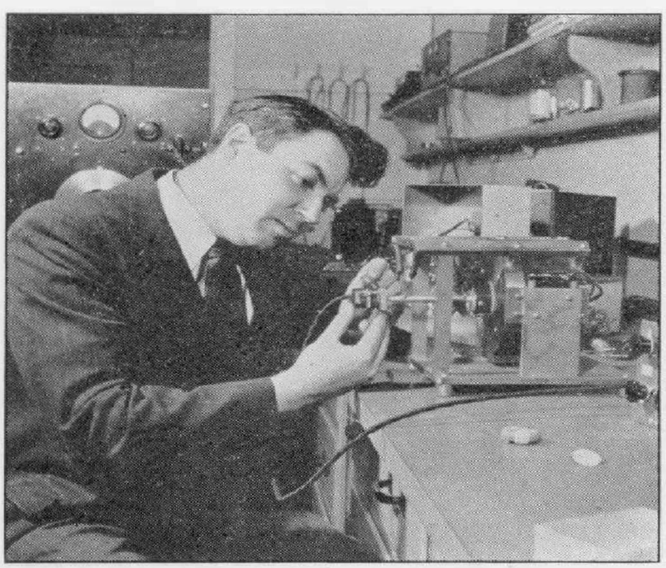


FIGURE 9. W. R. Saylor, who specializes in sound and vibration measurement, testing an experimental vibration pickup.

Owing to our location, in proximity to the Radiation Laboratory of Massachusetts Institute of Technology, the Radio Research Laboratory of Harvard University, and other NDRC organizations, cooperation with these laboratories has been close. In a consulting capacity, the skill and experience of our engineers have been available to them constantly, in most cases without charge. Special parts have been designed for them under the direction of H. S. Wilkins, and standard instru-

*"Microflash Shows Flight Defects in Projectiles," *General Radio Experimenter*, April, 1945.

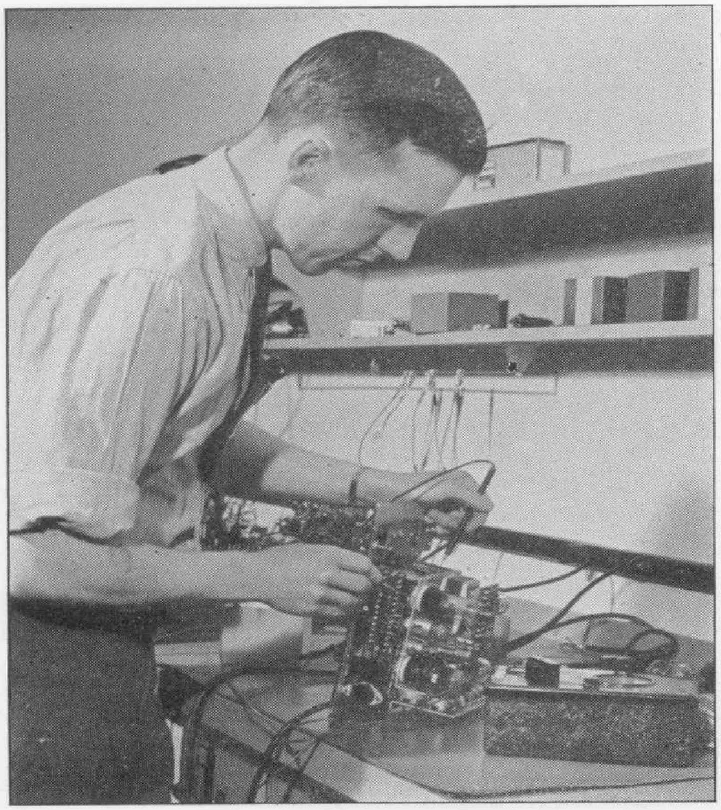


FIGURE 10. C. A. Woodward, of the Measurement Group, with the preliminary model of a high-frequency voltmeter.

ments have been modified to meet specialized requirements.

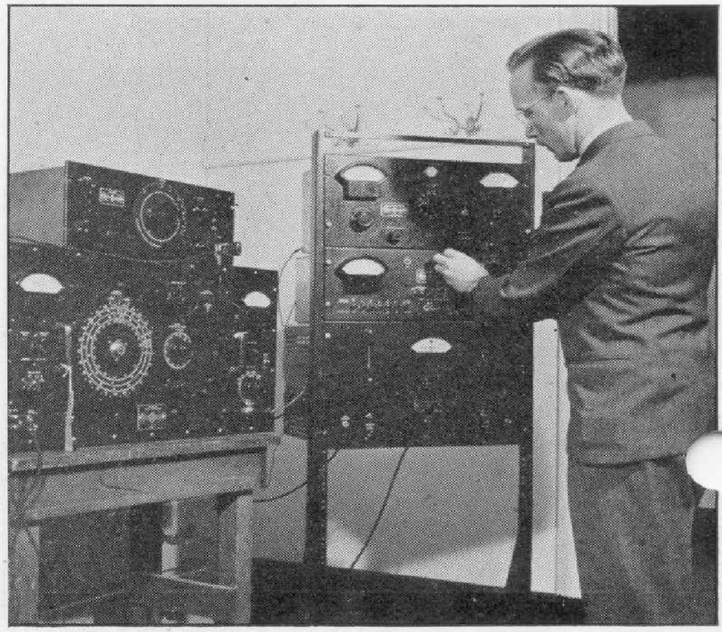
Our chief engineer, Melville Eastham, was on leave of absence for some months, devoting all his time to the administration of a division of the Radiation Laboratory. Dr. D. B. Sinclair, Assistant Chief Engineer, served part time as research associate and consultant at the Radio Research Laboratory and was a technical observer for the AAF in the North African theater at AFHQ for a considerable period. Several other members of the staff are members of the NDRC or have served on NDRC sub-committees.

Post-War Development

The accelerated research of wartime compresses into a short period advances that normally would require several times as long to achieve. The experience gained by General Radio engineers through war work will be reflected in new and better instruments in the post-war period. New developments in circuits, new and better circuit elements, new techniques of measurement, and new methods of construction are available and can be applied to the design of instruments to achieve levels of performance, stability, and accuracy considerably better than were possible before the war.

While war projects leave little time for thinking about post-war products, the trend of wartime development has made it possible to predict with considerable accuracy what advances in the art will mean in terms of new peacetime instruments. Circuits developed for military equipment have obvious applications in industrial instruments. New parts and materials have shown the engineer how to get better overall performance from a given circuit, or to extend the ranges over which acceptable performance can be maintained. New techniques of measurement lead to entirely new instruments, and improved

FIGURE 11. C. A. Cady, of the Audio-Frequency Group, checks the distortion in a newly-developed oscillator.



methods of construction can mean more economical designs, greater convenience of operation, easier maintenance, or longer life.

In the field of broadcast monitoring equipment, for instance, new models will be smaller, will require less r-f power, and will be easier to install and operate. Frequency monitors will operate directly from an amplitude-modulated signal. The frequency range and sensitivity of distortion meters will be increased.

Improved tuned circuits, output systems, and dial drives will make possible a considerable improvement in the accuracy and reliability of standard-signal generators. Both a-m and f-m models are now planned and will collectively cover frequencies from the low-radio range to the u-f-h bands, a total frequency span of about 100,000:1. U-h-f models will use the new butterfly and cylinder-type tuning units.

In instruments for voltage measurement, the upper frequency limit will be extended for vacuum-tube types and a d-c voltage measuring feature included.

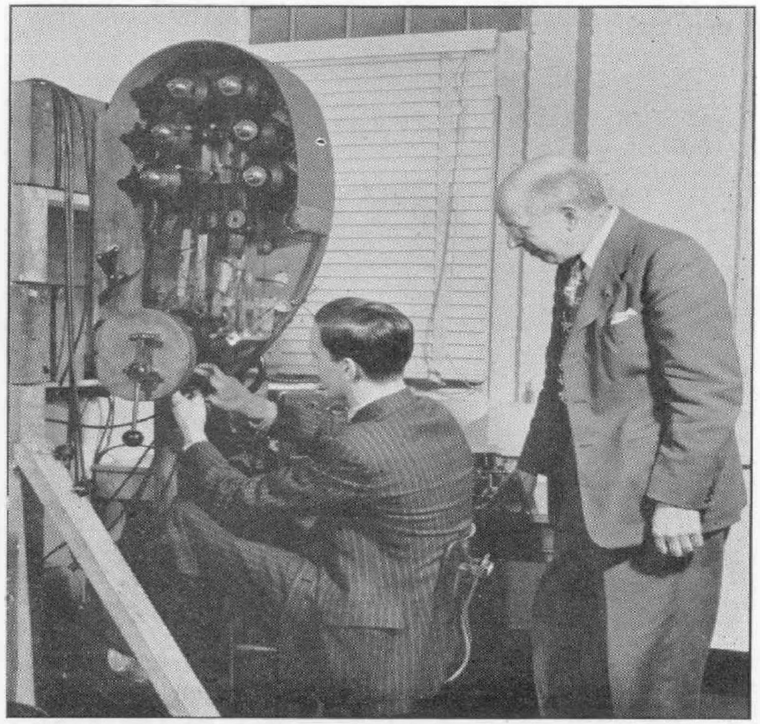
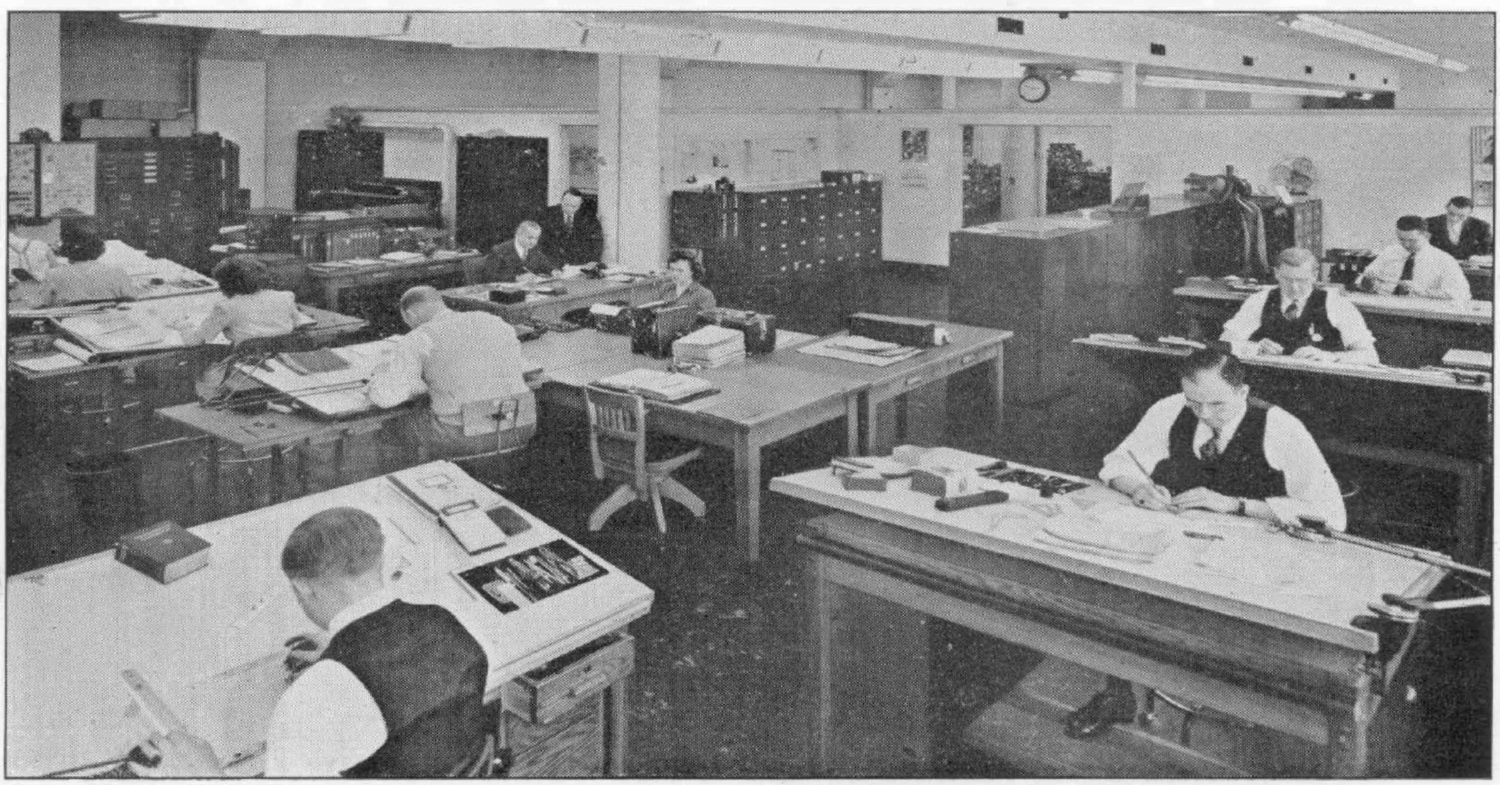


FIGURE 12. R. F. Field (right) and D. A. Powers, with a machine for winding polystyrene capacitors, a new type developed under Mr. Field's supervision.

FIGURE 13. View of the Drafting Department. The total personnel of this department is eleven, in addition to L. M. Burgess, Engineer-in-Charge and A. C. Rohmann, Supervisor



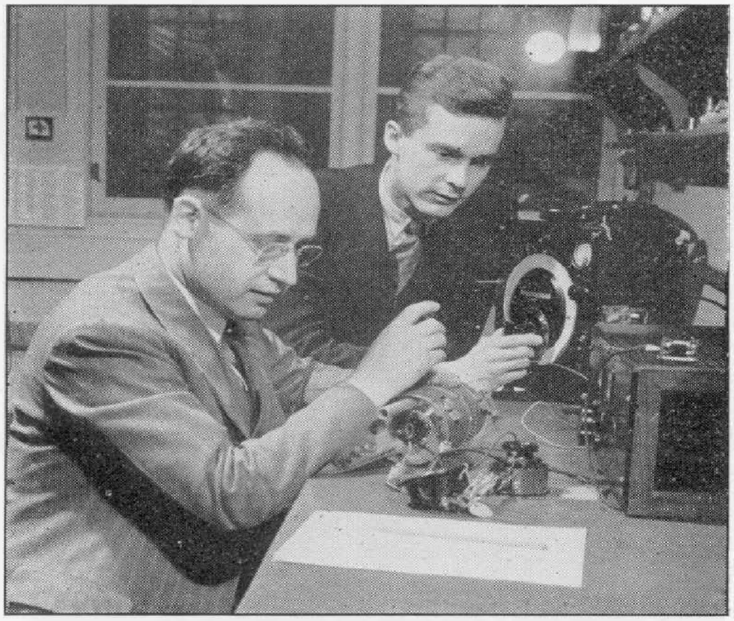
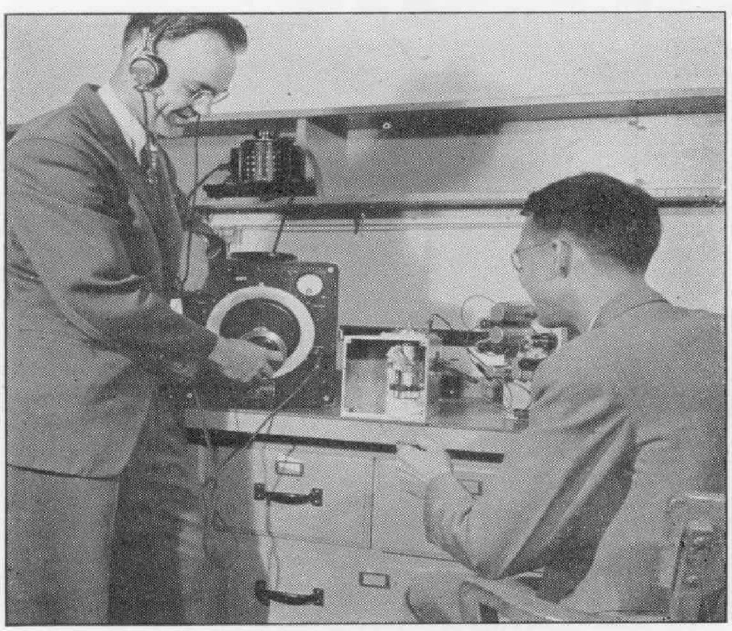


FIGURE 14. E. E. Gross (left) and W. R. Thurston, of the High-Frequency Group, working on a u-h-f oscillator of the coaxial butterfly type.

Smaller circuit elements, particularly vacuum tubes, and refinement of mechanical design, direct outgrowths of war developments, make it possible to produce a probe of higher resonant frequency than heretofore. Where high-frequency performance is not important, sensitivity can be considerably increased. Beyond the useful upper frequency of vacuum-tube types, crystal rectifiers will be used.

FIGURE 15. A. P. G. Peterson (right) and R. J. Ruplenas with an experimental u-h-f signal generator.



Both better constructional methods and circuit design are factors which will simplify some of the more complex instruments. Frequency standards, in particular, will be smaller and more compact, while auxiliary frequency measuring equipment will be more flexible in application and more convenient to operate.

Ranges of frequency measurement have of necessity been extended to higher frequencies during the war, and both wavemeters and heterodyne frequency meters in compact, portable models for the u-h-f and v-h-f ranges will be available for post-war use.

Improvements in oscillators will include lower distortion, wider ranges, and higher power output. A double-beat-type of instrument is also planned for use in the measurement of distortion resulting from cross-modulation.

Unit construction offers possibilities for inexpensive and flexible laboratory equipment. Simple oscillators and amplifiers made to plug into a power supply unit will avoid unnecessary duplication of equipment and will be priced at a level within the reach of the smaller laboratories.

The advances made over the past several years in our understanding of the nature of dielectrics have indicated that measurements should be made over wide ranges of frequency in order to predict accurately the electrical properties of insulating materials. Consequently, wide-range bridges will be available for the measurement of dielectric constant and dissipation factor. Another new instrument for insulation testing is a high-voltage, direct-reading megohm-meter for taking current-time curves.

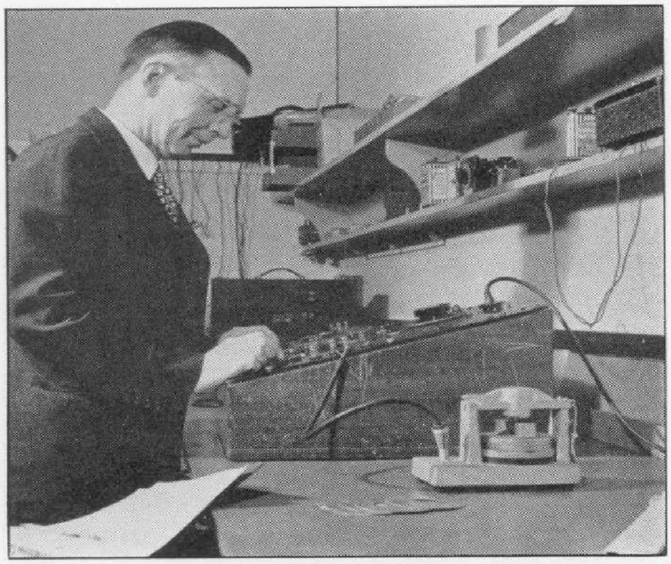


FIGURE 16. H. W. Lamson makes a few check measurements on his newly-developed magnetic test set.

In the v-h-f and u-h-f bands, transmission lines are now widely used for impedance, voltage, power, and attenuation measurements. One drawback to their use has been that a given length of line is usable over only a narrow range of frequency. A set of coaxial connectors is under development, which will permit the necessary line elements for any given frequency to be assembled quickly and conveniently.

Other new standard parts will include variable air condensers, rheostat-potentiometers of improved linearity and accuracy, and a completely new line of Variacs. New core materials and improved mechanical and electrical design have produced a Variac that is smaller, more efficient, more rugged, and easier to service.

The increasing use of radio-active tracer isotopes, produced in the cyclotron, for analyzing chemical, physiological and metallurgical processes has produced a need for various types of counters. One projected new instrument is a counting-rate meter for use with a Geiger-Muller counter tube.

New and improved stroboscopes will result from war designs, for both visual and photographic use. Among the possible new features are higher-intensity lamps, shorter flash duration, and higher repetition rates.

In broad outline, these are some of the general improvements that can be expected in post-war instruments. Designs must await the completion of war engineering work, and production, the release of materials.

FIGURE 17. D. H. Chute, in charge of the measurements room, balances a precision capacitance bridge.

FIGURE 18. Paul Hanson of the Design Group examines a model of a new wire wound variable resistor.

VOLUME XX

● **THIS ISSUE** of the *Experimenter* is Volume XX, Number 1, and marks the start of the twentieth year of continuous publication. Volume I, Number 1 was a four-page 9- x 12-inch paper and was dated June 1926. At that time, an important part of the General Radio Company's business was the manufacture of parts for home-built radio receivers, although a considerable line of laboratory measuring instruments was also produced. Articles of interest to the amateur and home experimenter were published, therefore, as well as a considerable amount of more technical material.

As measuring equipment became the predominant part of our business, nearly all of the articles in the *Experimenter* were directed to technical men. In 1929, beginning with Volume IV, Number 1, the present 6- x 9-inch, 8-page format was adopted.

The present circulation is approximately 24,000 copies, of which 20,000 go to the United States and Canada.

THE General Radio EXPERIMENTER is mailed without charge each month to engineers, scientists, technicians, and others interested in communication-frequency measurement and control problems. When sending requests for subscriptions and address-change notices, please supply the following information: name, company address, type of business company is engaged in, and title or position of individual.

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