The General Radio Company

1915-1965

DONALD B. SINCLAIR, Sc.D.

MEMBER OF THE NEWCOMEN SOCIETY

PRESIDENT

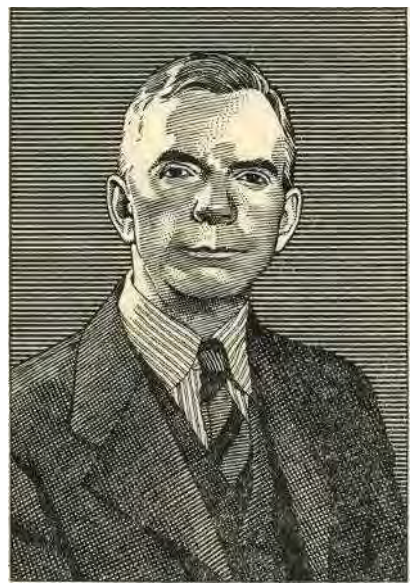
GENERAL RADIO COMPANY

WEST CONCORD

MASSACHUSETTS

THE NEWCOMEN SOCIETY **IN NORTH** AMERICA

NEW **YORK** DOWNINGTOWN PRINCETON **PORTLAND**



Melville Eastham

Founder

1885—1964

INTRODUCTION OF DR. DONALD B. SINCLAIR AT BOSTON, ON MAY 13, 1965, BY MR. ARTHUR E. THIESSEN, CHAIRMAN OF THE BOARD, GENERAL RADIO COMPANY; MEMBER OF THE NEW ENGLAND COMMITTEE IN THE NEWCOMEN SOCIETY IN NORTH AMERICA.

My fellow members of Newcomen:

SOME thirty years ago, in 1934 actually, I regarded myself as quite a senior hand at the General Radio Company, having been there for all of six years as a development engineer; my route had been via the Bell Telephone Laboratories in New York and Johns Hopkins University.

The Company was small in those days, some 150 employees, and the arrival of a new man, even on summer status, especially in our small Engineering Department, was an important event and of almost personal significance. The new man that year was our speaker this evening. He was in the process of acquiring his doctorate in science from M.I.T., having already received his Bachelor of Science degree in 1931 and his Master of Science degree in 1932.

The new man made quite an impression on all of us old-timers, and we were delighted when he joined us on a permanent basis in 1936, following a brief tour as a research associate at M.I.T.

At about that time his professional interests and mine began to diverge a little. I became involved in marketing and he in the research on and development of what were, for their time, some highly sophisticated measuring instruments.

His talents were soon recognized and in 1944 he became Assistant Chief Engineer, at the time that I became Vice-President for Sales. Traditionally, engineering and sales departments don't always get along too well, but that was not true at General Radio. I never knew a more sales-minded engineering executive.

When Melville Eastham, the founder of General Radio and its President and Chief Engineer from its beginning in 1915, retired

in 1950, our speaker succeeded him as Chief Engineer, became Vice-President for Engineering in 1954 and a Director in 1955.

He was named Executive Vice-President and Technical Director in 1960 and was elected President in 1963.

During all these years it has been my privilege to have him for a close personal friend. We share a number of interests in common, including uncommonly high golf scores.

He has found time for wide-ranging outside activities, especially in the professional field, having served the Institute of Radio Engineers (now, after merging with the American Institute of Electrical Engineers, called the Institute of Electrical and Electronics Engineers) as its Treasurer, its President in 1952, and as a Director for ten years. He is on Visiting Committees of M.I.T. and Carnegie Tech and is a Director of the American Standards Association and The National Shawmut Bank of Boston. There is much more, but perhaps this synopsis will serve to illustrate his broad range of interests.

It is now my great pleasure to introduce my long-time friend and colleague, who will, on the occasion of its fiftieth anniversary, tell us the story of the General Radio Company—DR. DONALD B. SINCLAIR.

My fellow members of Newcomen:

FIFTY years ago it was radio, not electronics, but the fascination of experimenting with scientific devices was as compelling to the young Melville Eastham, then, as it is today to the young space-age entrepreneurs along Boston's Route 128 and San Francisco's peninsula. Radio, itself, was just about as fashionable a word as electronics is now, and Eastham's General Radio Company may now well be the oldest company in the world with that word in the company name.

There were, of course, some differences between starting a technological company then and now. The new company's founder had ten years' practical experience, supplemented by enormous enthusiasm and ingenuity, but his formal education had stopped with his graduation from high school in Portland, Oregon. Today's equivalent is more likely to be a Ph.D. from M.I.T. or Cal Tech.

The common element, however, is a flair for innovation, or—an older word—invention, and this Melville Eastham had in abundance. His restless search for a job that would absorb his talent took him from Portland first to San Francisco and, at twenty, to the East. Only a couple of years out of high school, he was briefly associated with Willyoung and Gibson, an Instrument manufacturing firm in New York, before going to work for Earle Ovington, an aircraft pioneer who headed the Ovington X-Ray Company. Within months his association with the chief engineer of that company, W. 0. Eddy, and a sales engineer, J. Emory Clapp, led to what would today be called a spin-off. The three young men decided to start their own company in Boston.

Thus, in 1906, was founded the Clapp, Eddy and Eastham Company at 100 Boylston Street, Boston, to manufacture x-ray machines. Clapp, who came from Boston, supplied the venture capital, Eastham the enthusiasm, and Eddy the experience. In 1907 Eddy withdrew from the triumvirate, and the Clapp-Eastham Company emerged.

The basic objective of the company remained the manufacture of x-ray equipment, but Eastham was quick to notice that the high-

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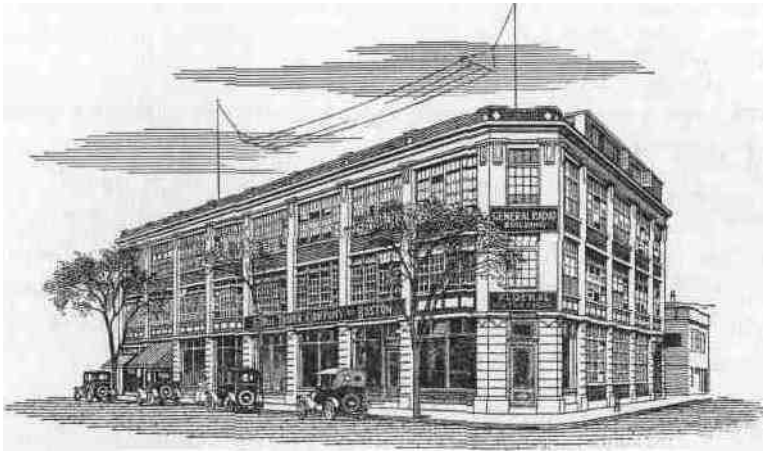


Early General Radio Company Plant

voltage spark coils used to excite the x-ray tubes were becoming popular with the radio amateurs, or hams, for their transmitters. This discovery, which would be called serendipity today, led the company into the manufacture of heavy-current keys, tuning coils, spark gaps, crystal detectors and the many other components used by the hams, as well as by the professionals, of those days. As this segment of the business grew, the x-ray portion contracted, and Clapp, whose interests were primarily in x-ray equipment, sold out, in 1910, to 0. Kerro Luscomb. This same year, the company, by now a favorite supplier of radio experimenters, moved across the river to larger quarters at Kendall Square in Cambridge, where its customers included such famous radio pioneers as R. A. Fessenden, E. H. Armstrong, G. W. Pickard, G. W. Pierce, John Hays Hammond, Jr. and John Stone Stone.

The direction in which the company was moving was very much to Eastham's liking, but he found himself, in some respects, frustrated by the commercial competition that was beginning to develop among the large communication concerns. In particular, patent licenses called for royalty payments that would be considered extortionate today. The fee demanded for one license, for instance, was 15 percent; in a recent patent case, in contrast, General Radio's proposal of a 2 percent rate was characterized as "harsh."

Becoming restive under the restrictions that were beginning to hamper the company in the manufacture of communication equipment, he began to think seriously about instrumentation, which was his real love and which he recognized as a pressing need for the developing radio field. In 1915, in consequence, he withdrew from active participation in Clapp-Eastham and started the General Radio Company to make instruments. Luscomb agreed to continue as active manager of Clapp-Eastham, but also took a substantial interest in the new Company.

Capital was still a problem for the two young men, but they each agreed to contribute patents, ideas, and their specialized skills for a quarter-interest apiece, and they were successful in persuading three individual investors, Ralph C. Emery, Ralph C. Watrous, and Cyrus P. Brown, to put up a total of $9,000 in return for the other half. Space was rented on the third floor of a small flatiron building that still stands at the Corner of Massachusetts Avenue and Windsor Street in Cambridge, and Eastham, with Knut Johnson, a skilled machinist who had gone to work for Clapp-Eastham two years earlier, went to work. Knut ultimately retired in 1945, but still attends meetings of the GR Retirement Club. He recalls that jobs were hard to come by in 1913. In answer to an advertisement in the *Boston Post,* he took the subway to Kendall Square and found "about 500" men already in line for the one machinist's job. He almost gave up in discouragement but decided to join the line and was finally interviewed. Much to his surprise and delight he soon received a letter offering him the job—on Friday, the 13th—at a starting 35 cents an hour!

Eastham had a number of new instruments in mind for the new Company, and he promptly started to design them. It then took much less time than now to get a new instrument to the market. Instruments for high frequencies were literally nonexistent, and it -was not necessary to refine and polish every detail as it is for today's highly sophisticated market. Still, it did take time—and money, of which the Company had very little. A commission to -make a special device for a solvent customer was therefore most -welcome, and the job of building a nine-phase, synchronous, commutator-type rectifier for the American Telephone and Telegraph Company was gladly undertaken as a parallel effort.

This rectifier played a part in the very early history of the radio-telephone. A. T. and T. had successfully completed the first transcontinental telephone call by land lines early in 1915, thanks to recent improvements in the vacuum tube. The war in Europe now threatened to interrupt communications to the Continent, and the Telephone Company was anxious to see if radio could be used to extend telephone communication across the Atlantic if the transatlantic cable should be put out of business or denied to the United States. A. T. and T.'s research organization was given the task of pursuing this objective, and found an enthusiastic partner in the French Bureau des Postes, Telegraphes et Telephones, which installed a receiver on the Eiffel Tower to receive the American signals. A transmitter was set up in Arlington, Virginia, using five hundred 15-watt vacuum tubes connected in parallel. General Radio's synchronous rectifier was to supply the very high voltage required. While the occasion was historic, it must be confessed that the experiment was not very successful. Although much was learned, it was yet to be many years before a practical, reliable transatlantic telephone would come into being.

General Radio, in the meantime, pressed on with its development program and, in 1916, published its first instrument catalog. Among the products listed were a Precision Variable Air Con denser ($25.00), a Decade Resistance Box ($19.00), a Precision Variable Inductance ($24.00), and an Absorption Wavemeter ($60.00). Among the earliest customers for these were A. T. and T., The General Electric Company, and the National Bureau of Standards.

When the United States entered the First World War, in 1917, General Radio became caught up in the national effort and found demand for its products soaring. Not only were there immediate needs for General Radio's catalog Instruments, but the Company undertook to manufacture great quantities of portable wavemeters and crystal sets for trench-warfare communications. Harold 0. Erb, hired as a coil winder on September 25, 1917, recalls the dramatic expansion from twenty-four employees to over two hundred: "All kinds were hired. We had, for instance, one long bench with twenty to twenty-five Greek young men, most of

whom spoke no English. A lad of Irish extraction supervised and instructed them by pantomime. They did minor assembly work. We had some fellows who had been salesmen, clerks, etc. trying to do mechanical work, and it was sometimes pretty pathetic."

At this time another General Radio part played a small role in another historic radio event. Among the instruments first shipped for war use were a number of precision air capacitors or, as they were then called, condensers. One of these, in due course, found its way to an Army laboratory in France, where Lieutenant E. H. Armstrong was experimenting with a new circuit to improve the performance of radio receivers. He promptly appropriated and incorporated the capacitor, his new circuit was a sensational success, and one of General Radio's first products tuned the first superheterodyne receiver. Today this superheterodyne circuit is used in substantially every television, radar, and communication receiver in the world.

World War I stimulated many Americans to a high pitch of patriotic fervor, and General Radio was the fortunate beneficiary of one important decision to aid in the war effort. Henry Southworth Shaw was a radio ham who had made Eastham's acquaintance through purchases of General Radio equipment, and who had formed a very high regard for him. Late in 1917 he came to Eastham, somewhat diffidently, to ask what he could do to help, and Eastham immediately hired him—to do design work. Son of a textile-mill treasurer, and a liberal-arts graduate of Harvard, Shaw's strengths lay elsewhere, and he quickly wound up as bookkeeper and office manager. However, his concern for the fiscal health of the Company and the welfare of the people who made it go were to turn out, over the years, to be influences of comparable strengths to Eastham's in establishing General Radio's unique method of operation.

The end of the war, in 1918, witnessed a general cancellation of military contracts, and General Radio shared with many other companies the resultant slump. The loss of business made it necessary to decide promptly what course the Company should take, and it quickly became evident that there were two schools of thought. Eastham was primarily interested in measuring instruments and was therefore oriented towards high quality, his partners, Brown,

Emery, and Watrous, leaned to mass production of parts, radio transmitters, and receivers, and were therefore oriented towards high quantity. Both sides felt strongly in this disagreement, and it was ultimately settled only when the three high-production enthusiasts were bought out.

Eastham opposed their proposal for many reasons: His major interest was in precision devices, and he felt that, in the long run, these would be high-value items that would produce more profitable business; the patent situation was becoming so confused and restrictive that he foresaw major difficulties ahead for those engaged in radio-set and transmitter production; and, most important, he recognized that it would be very difficult to maintain the kind of working atmosphere that was already beginning to develop at General Radio if the Company were to grow substantially in size and to reorient itself towards low-cost, high-volume production in a highly competitive field.

This line of reasoning, so parallel to his own, impressed Henry Shaw, and, in 1919, he was able to buy out Brown, Emery, and Watrous for $32,000—who thereby more than tripled their investment in four years. This money, fortunately available from a man of independent means, was the last outside capital required. Except for minor stock purchases by individual employee-stockholders, all financing since that time has come from earnings, either distributed as stock-purchase bonuses or retained as earnings reinvested in the business.

Eastham and Shaw now each held a half-interest and served as directors. When Emery and Watrous, who had been directors, left the Company, Lawrence Mayo, Shaw's uncle by marriage, was elected as a third director.

As the postwar readjustment proceeded there were other important comings and goings. In 1917, Homer E. Rawson had joined the Company and became Vice-President; in 1919 he left to join Arthur J. Lush in starting the Rawson Instrument Company to manufacture sensitive direct-current meters. In 1916, Ashley C. Zwicker, a Clapp-Eastham alumnus, had joined General Radio as its first foreman; in 1920, now Superintendent, he left to found the Acme Apparatus Company as a manufacturer or

transformers, rectifiers, and battery eliminators. Later as the Delta Manufacturing Company, Acme was to become an important component of the Raytheon Company.

In 1918, Errol H. Locke came to General Radio by way of Harvard College; in 1919, Harold B. Richmond, by way of M.I.T. and a wartime lieutenancy in the coast artillery. These two men, with Eastham and Shaw, were to make up the top management of the Company and guide it for the next thirty years.

In 1921, as the Company struggled out of the postwar depression and resumed the design and manufacture of instruments it contracted with the Navy to make hydrophones, developed by Professor G. W. Pierce of Harvard, to detect underwater sounds. To augment its 135 employees, the Company now hired two full-fledged engineers, H. W. Lamson and P. K. McElroy. Recent Harvard graduates and assistants to Professor Pierce, they were ideally suited for the job, and the project turned out to be highly successful for both the Navy and General Radio. It is a tribute to Eastham's fertile mind that he had done nearly all the engineering, single-handed, until their arrival. Although the Company was now back in the business of making instruments, with the exception of this one government project, it was to encounter one more major diversion before it was able to devote full attention to this pursuit.

In 1920, the Westinghouse Electric Company pioneered commercial broadcasting, over KDKA in Pittsburgh, with the returns of the Harding-Cox election. The dramatic success of this first program stimulated the construction of broadcast stations all over the Country and, within a year, about thirty were on the air. There were, however, almost no receivers except those built by the radio hams. The "ham shacks" soon became popular neighborhood rendezvous and, almost overnight, the home-bullt-receiver craze developed, as plain citizens decided that they could do it too.

General Radio, which had been supplying the hams with high-quality components for years, now found itself swamped with orders for tens of thousands, where previously there had been demand for only hundreds. This demand persisted for just about three years, when complete sets began to become available at rea-

sonable prices, and the do-it-yourself fad died as quickly as it had been born.

This was the beginning of the broadcast-receiver industry. The manufacturers of broadcast sets, as they became aware of the value of quantitative Information, became some of General Radio's best customers. But this recognition came slowly. At first, design and testing were empirical; the emphasis was on production and sales promotion. However, as competition grew, and customers became more critical, the importance of quantitative measurements became more and more obvious, both for reducing costs of manufacture and ensuring uniformity and quality of performance. It was at th

to the measurement business in earnest and began the development and commercialization of its long line of instruments, so many of which were firsts in the field.

An important part of the General Radio story is the story of these devices. But an equally important part is the story of the development of the Company's business philosophy and how it was put into effect.

In addition to his unusual talents as an innovator in the technological field, Eastham had unusual talents as an innovator in the social field. He felt strongly that a company exists not just for the stockholders, but for the employees as well. It should therefore provide a pleasant environment in which to work; it should establish as short a workweek and as liberal a vacation and holiday schedule as possible, consistent with efficient operation; it should grow in a controlled manner and be financed from earnings; it should provide maximum job security, with no layoffs or shutdowns; it should encourage individual Initiative and cooperative effort with incentive systems; and it should share its profits among the stockholders, the management, *and the em-ployees.* These were radical concepts in 1915, but they formed the underpinning of General Radio's policies and they have stood up well with the passage of time.

As early as 1917 the Company instituted a profit-sharing bonus plan, most unusual in its day. Every employee who had been with the Company for more than one year received one week's extra

pay, twice a year, on June 15 and December 15, or could, if he wished, take one extra week of vacation with pay instead of one of his semiannual bonuses. Those with less than a year's service, but more than six months', were entitled to half a week's pay. Also generous for that time was the regular two-week paid-vacation period.

The following year saw $1000 life-insurance policies, with premiums paid by the Company, taken out on every employee. This must surely be one of the first of the now-common group-insurance plans.

In 1919 two important changes in working conditions were introduced. The first was the 40-hour week. It had previously been 44 hours at General Radio, and, in industry in general, it averaged 46.3; to supplement this change, in providing more leisure time, the annual number of paid holidays was increased to nine. The second was a change in the bonus system to substitute for the original plan's fixed two weeks' pay a more generous one, but one that was also geared directly to the Company's earnings. This added the element of incentive to the concept of sharing among owners, managers, and employees. The new plan paid substantial bonuses to all employees in good times and, conversely, small ones or none in bad. Many refinements of the manner of distribution have since been worked out, but the basic principle has remained unchanged.

The ideas that underlay these practices were Eastham's, but he was not alone in forward thinking. A brilliant forerunner was Professor Ernst Abbe, of the University of Jena and the optical firm of Carl Zeiss. Zeiss, a skilled machinist, started making optical instruments on a small scale in 1846. Although his microscopes were of the highest quality, he believed that they could be greatly improved, and, in 1866, he convinced Abbe that he could help by applying his knowledge of physics to the study and improvement of optical glasses. Abbe, with the help of the eminent chemist, Otto Schott, soon proved him right, and so began a productive partnership that created one of the world's great technological enterprises. In 1888, when Zeiss died, Abbe bought out the Zeiss family interest and became sole owner. Like Eastham, however, he felt that a commercial organization owed some-

thing to many areas of society and should not be responsible solely to any single individual. In furtherance of this view he established, in 1896, a foundation in the name of Carl Zeiss, and deeded to it his entire ownership.

The charter, a remarkable document, was formally put into effect on the company's fiftieth anniversary, drawn up personally, and in detail, by Abbe after two years' study in sociology and law. All those who contributed to the enterprise—employees, the com munity, the university, related branches of science and technology —were to have a share of the profits. The administering authority was to be the Department of Education, which had charge of the University of Jena. But this authority was to be guided by a set of rules worked out in minute detail by the author.

Paid vacations, sick benefits, the eight-hour day, severance pay, invalid and old-age pensions for workers and their families, representation in management were all provided—in 1896! Abbe's social contribution in showing that these humane principles could be sustained in a competitive world was, perhaps, as important as his contributions in physics and brought him recognition from the University of Jena, which made him an honorary Doctor of **Laws.**

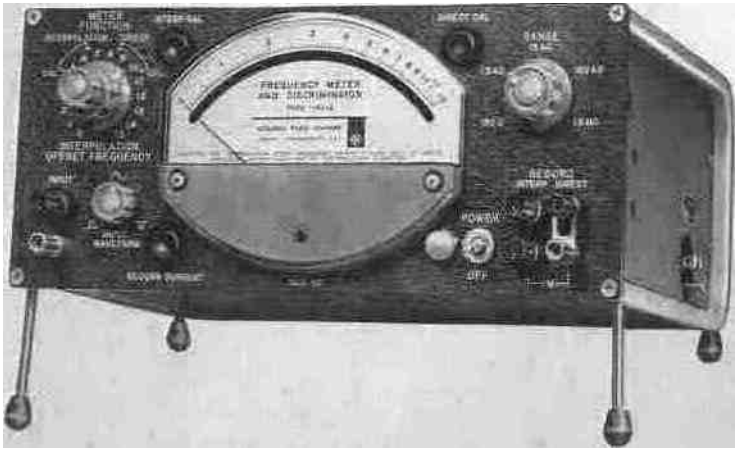
The history of the Carl Zeiss Works is a fascinating story, which Eastham first heard in the middle twenties and which later took him to Jena to study that company's policies and practices. What he found there impressed him greatly, reinforced his own viewpoints on employee relations, and stimulated new ideas about ownership.

Shaw and Eastham, who owned the Company jointly, had already begun, in 1920, to transfer some of their holdings to Locke and Richmond in the form of a bonus. The stimulation derived from their study of Zeiss led them to extend this practice to include the then Chief Engineer, and, in December, 1929, seven other employees. From this has grown the Company's present widely disseminated internal ownership, which has contributed so strongly to employee morale and incentive to produce.

The plan, under which ownership has now spread to 153 stockholders, is simple and straightforward. Direct ownership is ex-

1531-A Strobotac® Electronic Stroboscope

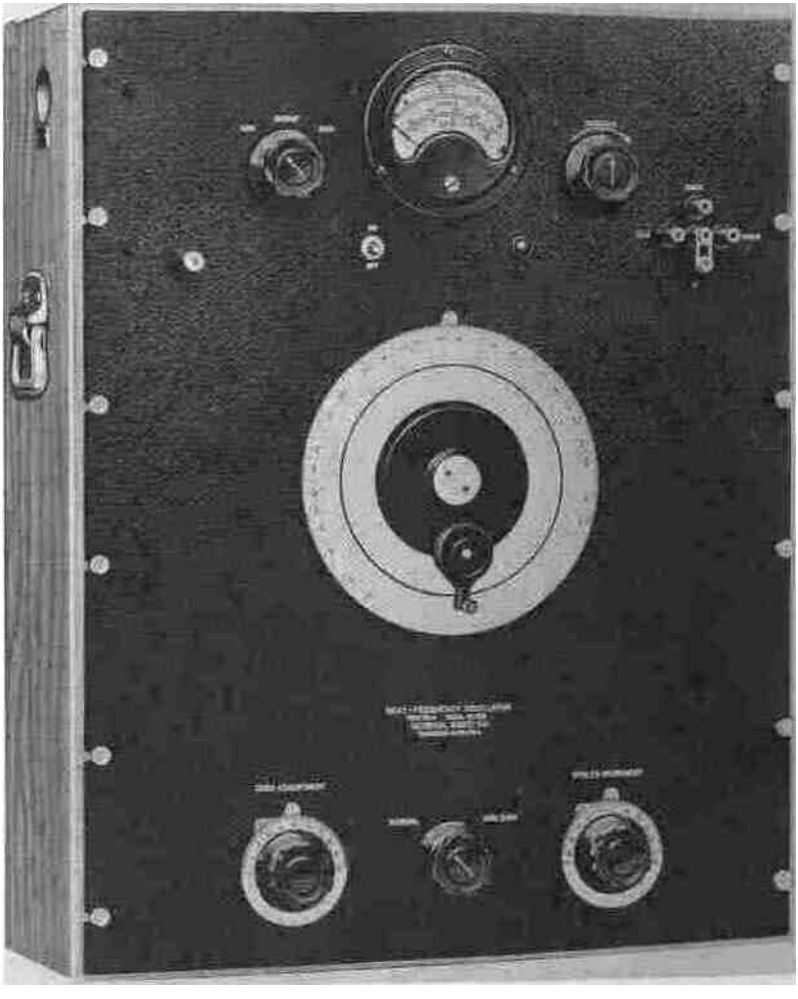
1650-A Impedance Bridge



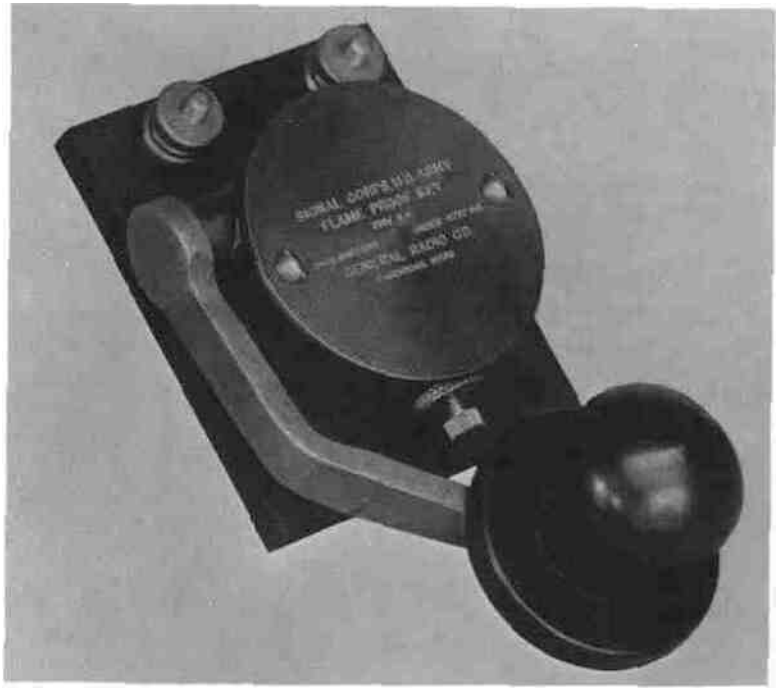
1142-A Frequency Meter and Discriminator

1151-A Digital Time and Frequency Meter

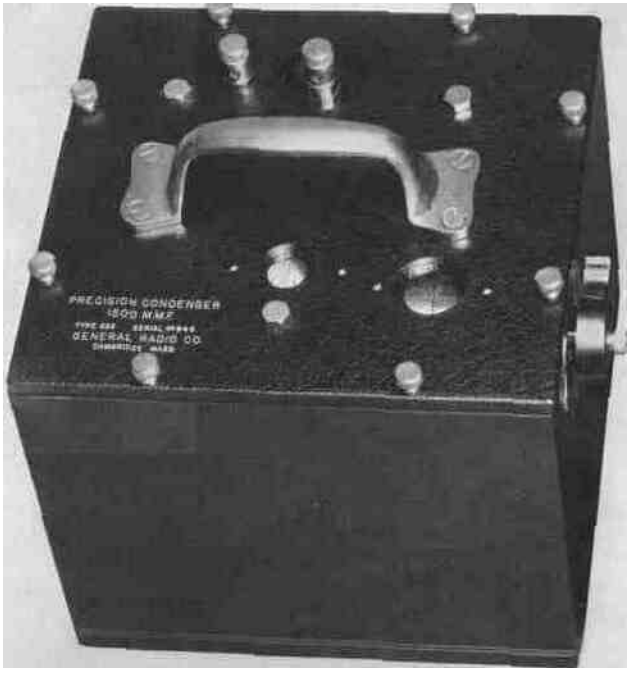
1162-A Coherent Decade Frequency Synthesizer



713 Beat-Frequency Oscillator — 1935



Flame Proof Key — 1918



222 Precision Condenser — 1921

tended to selected supervisory employees and to those in professional positions through stock, distributed annually as a bonus. The time at which an individual becomes eligible, and the amount of stock that he receives, is discretionary with the Board of Directors. When an employee leaves the Company he must, in accord ance with the terms of the stock certificate, surrender his stock at the current estimated book value. A cash supplement to pay the in come tax makes the acquisition of ownership truly cost-free to the recipient.

Through this plan the ownership is continually being passed on to those younger members of the Company who, according to the best ju

future managers. No individual owns as much as 6 percent of the stock; the employee ownership is therefore truly widespread and not reduced to a token status by the existence of a controlling interest in any single pair of hands.

The advantage of this type of ownership is that, since stockholders and employees are one and the same, there can be no conflicting interest, and the Company is therefore free to take whatever course of action is to the best advantage of the group, considered from either standpoint. A disadvantage is that, at book value, the stock is traded at a figure below what it would be if publicly held.

There is also a penalty that must be continually paid. Under this plan the Company must, so to speak, repurchase itself, year by year, in addition to generating earnings sufficient to take care of expansion.

The business climate in 1929, when the first large group of stockholders was admitted, was superheated and the great depression was imminent. Despite the stock-market crash in October, the Company shipped that year a total of $940,000 worth of instruments; in 1930 this figure slipped only to $850,000, and net worth went up to $1,000,000. But in 1932 shipments dropped to $600,000, and, for the first time since 1918, the Company showed a loss. In 1932, billings hit bottom at $520,000; in 1933, they were little better, and net worth was down to $786,000.

To make matters worse, the Country's banks were deep in

trouble, in particular the Central Trust Company, where many General Radio employees had accounts. When this bank closed its doors, in early 1932, the Company stood back of its employees with traditional loyalty. Feeling that the employees banked there because the Company did, and that the Company was therefore to some extent responsible for their losses, the Directors gave cash to each employee in the amount that he had on deposit. It was many years before a small part of this money was recovered in the reorganization of the bank as today's County Bank and Trust Company.

The commitment of the Company to a policy of no layoffs was now under its greatest strain. With sales down to little more than half their previous rate, hours of work in the shop had to be cut proportionately. But, if it were to stay in business, the Company had to resolve another problem promptly—how to meet the monthly payroll of the engineers and managers.

Other companies were cutting pay drastically, but this did not appeal to Eastham and Shaw. Temporary pay cuts always seemed somehow to become permanent. Also it seemed unfair to cut pay without reducing hours of work, and the engineers were urgently needed full-time, or more, to design and prepare for production the new instruments that would turn the sales curve up and put the Company back in the black. To cope with this dilemma, Eastham proposed a plan that would not only ease the load on the Company immediately but that would also guarantee the employees a return to normal Income at the earliest opportunity.

The "K" plan, as it came to be known, was simply to make monthly salaries move up and down, month by month, with the level of business. K is a constant, set each month, by which salaries of monthly paid people are multiplied. Over the years the formula for determining K has been varied, modified, and tinkered with, but today's is a simple one. The determining factors are orders received, which determine the level of operation, and shipments, which bring in the dollars. At the beginning of the year a quota is established for the manufacturing departments, which takes into account inventory balances, back orders, projected demand, and the myriad other factors that enter business judgment. This quota

is divided by the number of working days in the year to obtain a daily quota; any monthly quota is then the product of this daily quota and the number of working days in that month. K is set at 1.1 when the average of orders received and shipments, at the end of the month, equals the monthly quota, and goes up and down proportionately as the average exceeds or fails to meet it. The saving to the Company in bad times is obvious; an incentive to the employee to make them better is equally inherent. To work under this system involves some risk, and the 10 percent premium, at normal projected business levels, is to compensate the employee for accepting this risk. Only those in a position to influence business by their individual efforts are given the opportunity to participate in this plan, and it has become a symbol of progress in the Company. Over the thirty-two years of its existence, K has averaged 1.24, a measure of the extent to which it has motivated these influential people, and, perhaps, an indication of why it has remained popular with them.

But in March, 1933, when it went into effect, it was 0.5. The Country's banks had closed and a man was lucky to have a job. One man in three was unemployed. In April, K went up to 0.6, by year end it had averaged 0.86, and it has never again been so low. The long, slow climb from the Great Depression to the Second World War was underway.

This period, so frustrating to business in general, was one of great fruitfulness to General Radio. A small but excellent engineering department grew slowly, and its members produced a group of new instruments that not only met the rapidly developing needs of the radio industry but that were, in many cases, unique.

In this class, for instance, were the first commercial instruments for measuring and monitoring the performance of the Country's broadcasting stations. During the many years when this industry was growing, General Radio supplied almost all the equipment that was needed to assure compliance with the standards developed and established, first, by the Federal Radio Commission and, later, by the FCC.

At the other end of the link between performer and listener was the radio set and loudspeaker, and here the Company made

equally significant and original contributions. Before the depression, while the broadcast receiver industry burgeoned, General Radio had already produced the first commercial vacuum-tube voltmeter to measure radio-frequency voltages, the first standard-signal generator to measure the sensitivity and selectivity of radio receivers, and the first power output meter to measure the electrical power available to drive their loudspeakers. Now came the first commercial sound-level meter to measure the fidelity of the sound produced by the loudspeaker, the first wave analyzer to measure the distortion that prevents faithful reproduction, the first radio-frequency bridge to measure the characteristics of antennas, and the famous General Radio Type 650-A Impedance Bridge, which became an industry standard for measuring components and which set the amazing longevity record, in this fast-changing field, of twenty-six years without a redesign.

So far as can be determined, these instruments, like the ones that will be mentioned hereafter, were original. Some, in fact many of them, utilized known principles, circuits and components, but all of them made available, for the first time, devices that could be purchased ready for use. Like machine tools, they made it possible for customers to concentrate on results undeflected by the need to cobble up the means of achieving them.

This characteristic of General Radio equipment has been basic throughout the Company history. The nature of the business has been, concisely, that we sell a packaged product, with operating instructions, off the shelf. In contrast with process-control instrumentation companies, for instance, we sell a stock instrument, not individually tailored engineering design or assistance in installation. This policy, in turn, has naturally led to our adopting a direct-sales organization, which fosters the closest possible connection between the Company and the customer.

This method of selling developed as a direct result of the decline in the home building of radios. Up to this time, components had been sold through dealers and had reached the public through the usual retail channels. Buyers of instruments, however, are advanced experimenters, engineers and scientists. They need, indeed insist upon, accurate and complete specifications and upon

close liaison between supplier and user in analyzing and solving complex problems. The substitution of a direct-sales organization, in 1926, not only established this liaison, but led to the adoption of another characteristic General Radio practice. Because there was no longer a need for distribution discounts, the Company adopted the policy of publishing only net prices. Prices thereupon became a definite part of specifications, and they have ever since been a feature of every piece of sales promotion material.

Delivery from stock, as contrasted with the practice of manu-- facturing and shipping against individual customer orders, has led to still another characteristic General Radio practice. From a commercial standpoint, the advantages in quick delivery and customer service are obvious. What is equally important, in maintaining a no-layoff policy, is that finished inventory becomes a flywheel in evening out employment. With proper planning—and adequate •financing—employees can be kept busy building for stock in bad times. Conversely, sales can be made from inventory in good times •without automatically creating a need for expansion of the manufacturing force. Taken in conjunction with conservative financial management, this inventory policy has been a major contributor to the Company's record, since its adoption, of never letting a man go for hard times.

A notable commercial feature, in the thirties, was the rapid climb in export sales. In 1932 about 18 percent of all shipments were made abroad; by 1937, this climbed to the all-time high of 39 percent. The largest customers were, in order, the U.S.S.R., England, France, Holland and Belgium. The radio industry in Europe had lagged, and its growth came at a time when the Company's reputation had become well established internationally. Sales to the U.S.S.R. were made through the New York office of Amtorg; in the other European countries we developed our own group of representatives among individual entrepreneurs.

Another significant feature was the parallel development of General Radio's family relationship. As early as 1929, the Direc-tors had establis

in final emulation of the Carl Zeiss Stiftung, Henry Shaw generously donated 2,255 shares of General Radio stock—nearly 25 percent of the total outstanding—to this fund, and it was formally established as the Genradco Trust. It has been used, over the years, not only as a shield and buckler for employees in desperate straits, but as a medium for providing such medical help as free medical consultation for all employees and free eye examinations and eyeglasses for those who need them. It is something of a wry development that, recently, this phase of the Trust's activities has been ruled out of bounds for an exempt trust by the Bureau of Internal Revenue. Fortunately, an acceptable revision of the trust document makes it possible for the trust to continue to serve as the bulwark against disaster that it was intended to be, and the Company has been able to assume these medical expenses as a direct burden.

As the war clouds gathered, in the late thirties, television broadcasting had begun in Great Britain and was approaching commercial form in the United States. Ten years before, General Radio had pioneered the cathode-ray oscilloscope, when the best available tubes were imported from Germany. As satisfactory American tubes reached the market, and substantial demand for servicemen's oscilloscopes developed, much low-priced competition began to appear. Concluding that this kind of instrumenta--tion could be supplied better by others, the Company had dropped out of the business. Now, however, the new techniques underlying television and, later, radar rekindled interest, and the Company developed, in 1938, a wide-band oscilloscope. This instrument, unfortunately, was ahead of its time; it was never produced, because it was deemed too expensive and complicated. Today, oscilloscopes far more sophisticated and expensive have created a market many times larger than the total instrument market at that time—but General Radio does not make them!

The Company entered World War II, however, with two major products, from the thirties, that played yeoman parts in the war effort—the Vanac™ continuously adjustable autotransformer, and the Strobotac[110] short-flash light source. The first of these is a device for controlling electrical power efficiently. Patented in 1934, it was another General Radio first, and one, incidentally,

which has created an industry that now supports four major competitors. The second was the progenitor of the electronic-flash units, well known to today's photographers, and was a direct outcome of the work of Professor Harold E. Edgerton, of M.I.T. It makes possible the observation, in slow motion, of cyclically recurring events, and the tasks that it has been called upon to perform have been limited only by users' imaginations. The patents, in this case, belonged to Professor Edgerton and his collaborator, Kenneth J. Germeshausen, and General Radio has maintained an exclusive licing their ideas for over thirty years.

With a good stable of electronic instruments, and these two "bread and butter" Industrial devices, the Company found itself inundated with orders when World War IPs industrial mobilization began. Every ounce of effort, in the manufacturing departments, was required to provide the needed quantities of things in being. General Radio's technical staff threw itself directly into the stream of technological development that submerged private programs, and individuals became associated with many phases. Melville Eastham was an early member of M.l.T.'s famous Radiation Laboratory, where he was responsible for the development of the Loran system of navigation, Harold B. Richmond became Chief of Division 5 of the National Defense Research Council, in charge of the development of guided missiles, W. Norris Tuttle pioneered operations research with the Eighth Air Force in Great Britain. Their contributions won for them, respectively, two Presidential Medals for Merit, and the Medal of Freedom! Others of us became involved in communications and radar countermeasures, and in radar itself, at the Company, under contract, and as staff members of the Radiation Laboratory and the Radio Research Laboratory at Harvard University.

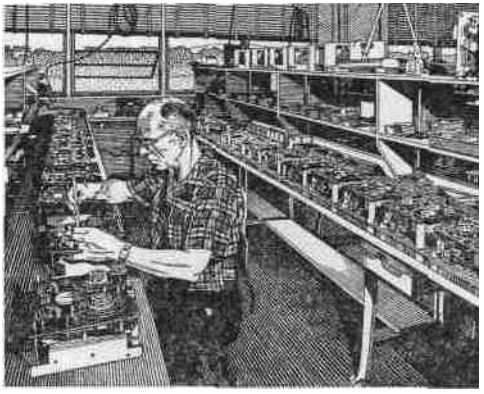
From a manufacturing standpoint, meanwhile, the Company faced a formidable problem: how to turn out equipment, at a rate never before contemplated, in the face of shortages in materials, manpower, and manufacturing space.

The first of these problems was one that required governmental education. The instrument industry is not a large user of mate-

rials, but it is a demanding one. Instruments, to be of any use at all, must be accurate and reliable. High quality in the end product demands high quality in what makes it up; substitute materials, in most cases, turned out to be disastrous mistakes. Fortunately, the War Production Board, which established the priority system for allocation of scarce materials, was early persuaded that General Radio's production was of the highest importance in supporting the very fabric of the Nation's technological war effort, and, after a period of some difficulty, materials flowed in quantities adequate to win the Company five Army-Navy "E" awards for excellence in the production of war materials.

The second problem was how best to utilize the skilled people and specialized facilities that already existed, and how to expand and supplement them where possible. To explain the difficulties in achieving solutions, it is again desirable to digress. To produce instruments requires highly skilled people, yet the quantities required are sufficient to warrant regular production methods rather than job-shop techniques. The secret of success is to go just far enough in tooling to achieve a proper balance between labor cost and investment in machinery and fixtures. It is one that is acquired through experience, and it involves innovative thinking. General Radio, in arriving at its own solution, has evolved a strong set of principles and practices that not only yield a satisfactory solution to the small-lot-production problem, but that comport with the Company's general attitudes.

As many jobs in the plant as possible are paid for on individual incentive systems. Coupled with this practice goes the corollary—as much control of the methods of work as possible is left with the individual, and as much responsibility for the complete job. In assembly, as a prime example, a man will often be given the entire responsibility for putting together and wiring up a major subassembly or even a complete instrument. He will, in general, work alone in a bay composed of benches about twenty feet long, on which are placed twenty-five groups of parts to be assembled into twenty-five instruments. He moves from one assembly to the next, performing the necessary operations in whatever sequence best suits him, until the job is completed. He therefore does a.



Instrument Assembler at Work

variety of things, in a variety of ways, thereby developing multiple skills at the same time that he is acquiring a vested interest in the instrument itself.

A necessary result of this method of work is that, unlike the impersonal production line, which demands only that a pair of hands put nut "A" on bolt "B", this batch system carries the stamp of the individual. When a man finishes his day's work, he alone knows what he has done, what remains to be done, and how it can best be accomplished economically. It is not a system that lends itself well to shift operation, and, even under wartime pressures, the Company maintained its traditional single-shift work-day. Hours were lengthened, the work schedule became alternate J2-hour and 44-hour weeks, and ingenuity again came to the rescue, this time in the use of outside facilities and people.

The New England Confectionery Company, Necco for short, was an industrial neighbor that was completely put out of business by the wartime sugar shortage. A deal with Necco for use of their work force, in their factory, turned out to solve the problems of both companies. General Radio had enough simple, repetitive assembly operations to perform to warrant training and using Necco's girls. Skilled men were hard to come by, indeed, and, under General Radio supervisors, the Necco girls made a substantial and useful contribution. General Radio has traditionally been an all-male preserve in the production departments, and it came hard to accept this help from the distaff side. A small group of girls was trained to do inspection jobs in the General Radio

factory, and the acronym GRIEF, for General Radio Inspection (Emergency) Force, was promptly adopted to designate them.

The third problem, adequate space, was greatly eased by the Necco arrangement, but permanent additions were also needed. Fortunately, the neighboring building, which had been an automobile showroom and garage, became available to add 39,000 square feet of office space and bring the Company total to 125,000 square feet. It is a tribute to the conservative financial policies of the Company that only short-term loans, which were promptly repaid, were necessary to finance this expansion at the same time that volume went up from $1,400,000 in 1939 to a wartime peak of $6,100,000 in 1942 and back down to $2,600,000 in 1945.

With the ending of the War, the Company entered upon a new world. The explosion of scientific knowledge had begun. Instead of being a lone, pioneering venture, struggling to create a market for quantitative measuring equipment, General Radio now found itself in company with dozens, scores, and ultimately hundreds of small, new companies, short of capital but long on ideas and enthusiasm. From almost a monopoly position, the Company had moved to one of participation in a hotly competitive industry. Volume, over the twenty years that have since passed, has gone up about eight-fold. How have General Radio's policies and practices stood up to these changed conditions?

A characteristic General Radio attribute, iconoclasm, has certainly not changed. While the electronic world was expanding at breathtaking speed, General Radio published a famous advertisement, in 1941, captioned "We Don't Want to Grow Too Large". While the industry was "going public" in the great stock-market surge of the fifties and sixties, General Radio stuck by its guns and continued to widen its ownership among its own employees. In the face of a flood of outstanding technological contributions from other sources, stimulated by and, in many cases, supported with government money, it has continued to contribute its own share, developed with its own funds. And it has continued to lead the field in its employee relations.

One of the first problems to be settled after the war was what hours of work should be established. It seemed obvious that the

long-term trend to shorter work weeks would continue, and a decision to adopt a thirty-five hour week was reached in October, 1945, with overtime at time-and-a-half to accrue beyond that point. Four-week vacations were granted for all employees with twenty-five years of service in 1948, in 1958 these years of service were reduced to twenty, and five-week vacations were adopted for all employees with forty years of service. For employees over 60 years of age, with thirty or more years of service, an additional week was added in 1964.

Every effort is made, at General Radio, to treat employees on as nearly equal a basis as possible, taking account of the differences in the nature of their work. Executive privileges are therefore avoided, rather than sought, and benefits are worked out with the general good in mind. The war years, in illustration, saw the development of a funded pension plan and a profit-sharing trust, both of which are administered under a common set of rules for all employees. These plans form a typical General Radio package; the funded plan provides safety, through annuities purchased by contributions of both the Company and the employee on a three-to-one basis; the profit-sharing trust sets aside a fund for the employee, drawn exclusively from profits, that supplies a disaster fund and pension supplement, and that grows with the Company's success. About a third of the fund is invested in General Radio stock, a third in other equities, and a third in bonds, commercial paper, and cash. Through this trust, every employee and not just the stockholders has a direct stake in the Company as well as a hedge against inflation. The General Radio Profit-sharing Trust, as a matter of interest, has never failed to make an annual contribution to the employees' accounts since its inception in 1943, and its assets now add up to a sum nearly as large as the total value of the Company!

Something should now be said about General Radio's organization. In keeping with the breadth of ownership of the Company has been the development of committee management. Areas of responsibility are clearly defined but general management by agreement has worked well and has precluded the creation of indispensable men. This has gone hand in hand with the development of a rather "flat" organization, in which titles have been

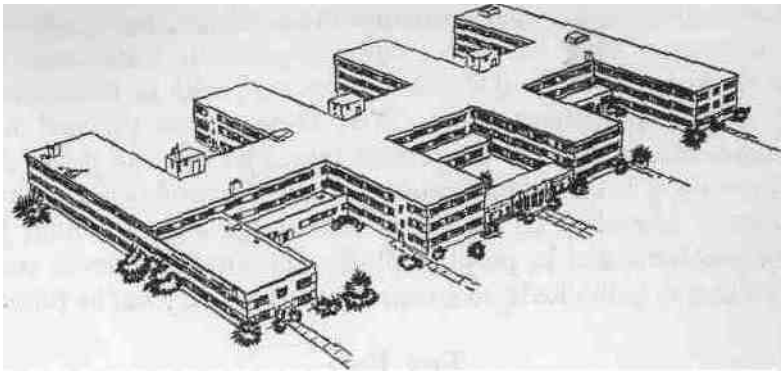
played down. Taken in conjunction with the encouragement of individual initiative, this has, in turn, made it possible for the Company to attract and hold capable people in considerable depth. As the early postwar years passed by, these characteristics of the Company organization paid off handsomely.

The four men who had guided the Company since the end of World War I all passed the mandatory retirement age of sixty-five during the period from 19^0 to 1957, turned in their stock, and left. Plans had been laid for these changes as early as 1944, in 1955, when Locke retired, he was replaced as President by Charles C. Carey, formerly Vice-President for Manufacturing; in 1960, soon after Richmond retired, he was replaced as Chairman of the Board by Arthur E. Thiessen, formerly Vice-President for Sales. Prudent financial planning made possible the repurchase of their substantial ownership without difficulty, and the second-generation senior management assumed control.

While these changes were going on, the Cambridge buildings were becoming more and more inadequate, and the Company was making plans for expansion. It seemed most desirable to move out of the city, for ease of access and parking, and, in 1948, a study was made to see what area would be most accessible, on the average, for the employees. It turned out that west and north of Boston seemed most convenient, and a search was instituted for suitable property to build on. An 83-acre tract in West Concord, Massachusetts, with good access by road and rail turned up, and, in i9j'2, General Radio's first suburban building was put into operation.

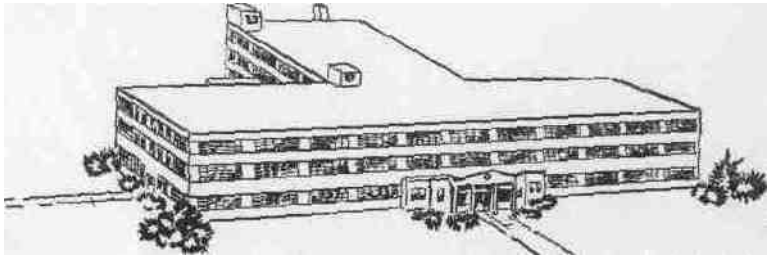
This building was the first wing of a planned four-wing H-type structure. Like Necco during the war, it was used as an overflow, high-production facility. But it was not so convenient. Necco was just across the street; Concord was eighteen miles away. Operation on a functional rather than a product-line basis made it necessary to ship things—and people—back and forth more than was desirable. It was therefore a day of rejoicing, in i95'9, when the remaining three wings were built, the Cambridge building sold, and all General Radio again under one roof.

Since 1959 many changes are becoming clear. The tremendous growth in electronics and in scientific research generally which has



West Concord—Main Office & Plant

marked the postwar period has slowed. It seems probable that it will pursue a more modest course from now on. The instrument industry is becoming mature in the sense that standard articles of commerce are becoming recognized. Yet there always remains wide-open opportunity for innovation and growth. Many years ago the innovation was in components which individuals put together in home-built equipment. Then came innovation in circuits when companies put together components in novel ways to produce instruments that would perform desired measurements. Now the innovation is in assemblies of instruments in systems to perform some desired function. But there is always the element of innovation to stimulate the engineer. As the demands of the customer become more sophisticated, there is also the need for more comprehensive facilities to satisfy them, and, in consequence, expanding opportunity for a company with adequate capital and demonstrated technical competence.



New Plant—Bolton, Mass.

General Radio has these attributes in abundance. Its reputation in the market place for high-quality, dependable instruments is unsurpassed; its technical staff is outstanding; with its new building in Bolton, patterned after West Concord and planned for divisionalization, it has both present space and room to grow. As it enters upon its second half-century it looks forward to continuing success in providing its customers with imaginative solutions to their problems, and its people with the opportunity to make contributions, as individuals, to a venture of which they can be proud.

THE END

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"Actorum Memores simul affectamus Agenda!"

A cknowledgment

The author makes grateful acknowledgment to Mr. Arthur E. Thiessen whose recently completed volume "A History of the General Radio Company" was employed as a source for much of the material contained herein.