THE General Radio EXPERIMENTER

VOLUME XIX Nos. 1 and 2 JUNE and JULY, 1944

ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS

NEW ENTRANCE—SAME LOCATION

Also

IN THIS ISSUE

● **VISITORS** are now being welcomed at a new front door — 275 Massachusetts Avenue, instead of 30 State Street. This does not mean that we have strayed far afield. In fact, in the twenty nine years of the Company's existence we have had only three addresses and they have all been within a circle not over five hundred feet in diameter. What has taken place is that, as we have grown, the "main entrance" has been moved to suit the changing conditions.

Our offices and research laboratories were formerly located in our main factory building. Gradual growth, quite aside from war demands, had made us consider the advisability of constructing a new building devoted only to research laboratories and administrative offices. War expansion made this imperative.

Architect's drawing of front of new building.

Last year a building adjacent to our present factory became available. This building, which adds thirty-eight thousand square feet to our plant, has been completely reconditioned and is now occupied entirely by our laboratories and general offices. The space vacated will be devoted to manufacturing.

War conditions prevent us from extending a general invitation to our friends to inspect these new laboratories, but we hope, as soon as war restrictions are removed, that many of our friends will visit us.

To those familiar with our old location we would call attention to the fact that the new entrance is on the side of our buildings almost diagonally opposite the former State Street entrance. The factory and offices now occupy most of the space in the block bounded by Massachusetts Avenue, Front Street, Windsor Street, State Street, and Village Street.

In reconditioning the building for office use, considerable attention has been paid to lighting and to ventilation. Liberal use of glass block in addition to normal window space takes full advantage of available daylight, while the interior lighting is fluorescent. A central circulating air system provides adequate ventilation for each individual office. In planning the system, provision was made for adding humidifying and cooling equipment after the war when it again becomes generally available.

Space has been allotted with a view to achieving the most efficient layout. Departments that are functionally related have been placed as near to one another as is possible. Thus the first floor is occupied by the Sales Engineering, Commercial, Service, and Publicity Departments; the second floor contains administrative offices, production office, and drafting room; while the third is devoted entirely to engineering, research, and the model shop.

The new engineering laboratories are

View of the interior of an engineering office designed for two men.

among the more interesting features of the new building. Our development and design engineers have been working under difficult conditions for some time. Scattered over two floors, they were necessarily grouped according to the problems on which they were working, with a resultant overcrowding of some of the laboratories. In the new quarters, adequate space has been provided, and the size of each room depends upon the number of men scheduled to occupy it. Bench and desk space is provided for each occupant.

Grouping the entire department on a single floor permits a more efficient use of available equipment and facilitates consultation between individuals and between groups. An engineering library, a standards room, and a model shop complete the present facilities. Later, when equipment becomes available, an instrument and stock room will be added.

MEETING THE WARTIME DEMAND

● **IN WAR** as in peace, the test equipment maker provides some of the vital tools of engineering and production. The nature of his product changes little in wartime; the volume of his production increases tremendously.

Long before Pearl Harbor it became evident to producers that test equipment production far in excess of previous levels would be needed to implement the war production program. Some procurement agencies recognized this; some did not. The production and materials agencies of the government had to be convinced and, because of this, much early production was held up for lack of materials and priority. All this was inevitable, in view of the rapid increase in national production of direct combat material. The bottlenecks were quickly broken, but test equipment production was delayed and expansion seriously hampered.

The General Radio Company manufactures hundreds of different items. It is the largest manufacturer of most of them and the only manufacturer of many. Their uses cover many kinds of industry — radio, telephone, telegraph, chemical, automotive, ordnance, electrical manufacturing, petroleum, textiles, aircraft, and transportation, to name a few.

In wartime, signal generators, vacuum-tube voltmeters, and oscillators are

(Continued on page 4)

OUR FOURTH ARMY-NAVY "E"

● **ON JUNE 14, 1944,** the General Radio Company was awarded for the fourth time the Army-Navy "E" for excellence in the production of war material. We are proud to be one of the few in our industry to receive the third star.

(Photo courtesy
Inspection Board of United Kingdom and Canada.)

High-speed photograph of a projectile in flight, taken with General Radio stroboscopic equipment. The exposure was of the order of 1 or 2 microseconds.

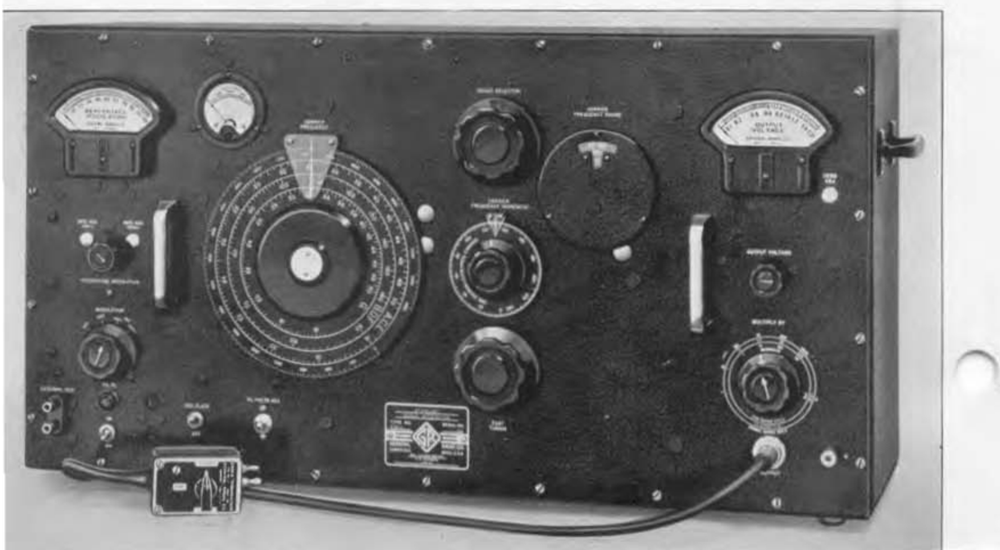
needed for testing combat radio and radar equipment used in aircraft, in ships, and on the ground; crystal manufacturers need frequency standards and frequency measuring equipment to calibrate the quantities of quartz crystals used in radio equipment; manufacturers of component parts need bridges, as do insulation manufacturers and wire and cable companies to meet stringent Army-Navy test specifications; stroboscopes and vibration meters are used in the design and test of motors, engines, vehicles, and airplanes, and in fundamental research on mechanical and hydraulic problems. All these vital war industries need test equipment in a volume commensurate with their own increased production.

Industrial laboratories, and those of the Army and Navy as well, have expanded to take care of the greatly increased research and development program necessary to produce the many new types of weapons that modern warfare requires. These must be equipped with electronic measuring equipment, as must the military service and repair depots all over the world that keep combat equipment in operating condition.

A further portion of General Radio's output goes to the armed forces in the form of specialized equipment for service and combat use. Supplied in moderate quantities in peacetime, these products are now in continuous large-scale production. Their importance cannot be discussed now, but will be an interesting postwar story.

Quality parts have always been an important part of General Radio's output. Wartime emphasis on precision and ruggedness has greatly increased the demand for these. Radio equipment for tanks, planes, and ships requires large

Radio manufacturers use the Type 805-A Standard-Signal Generator for testing and calibrating military receivers.

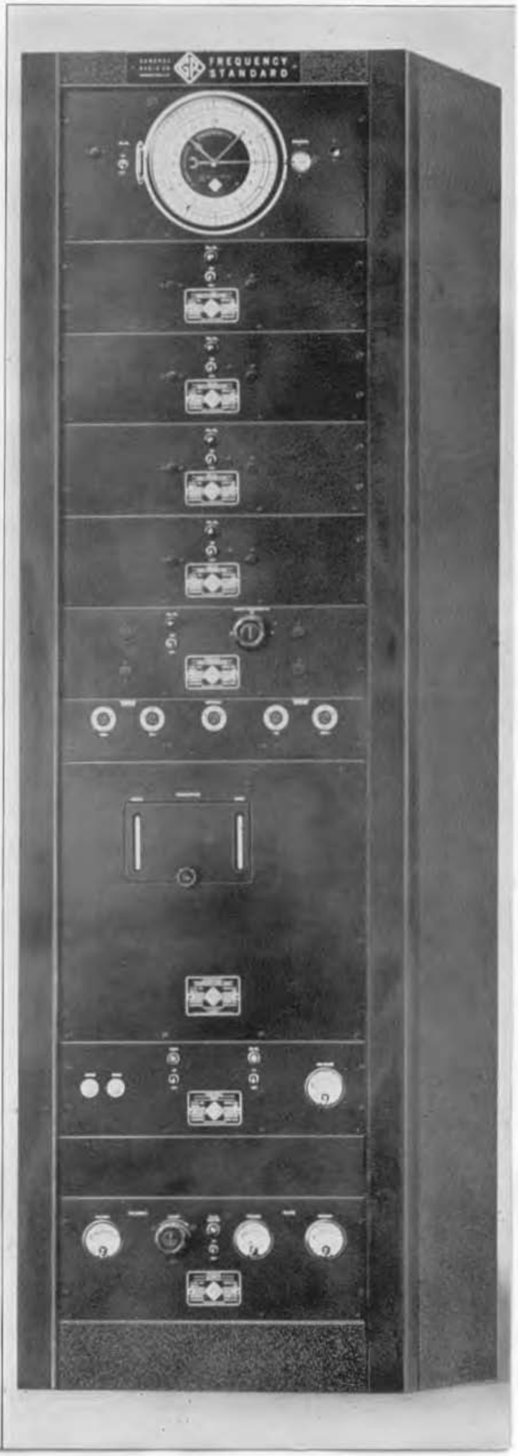


quantities of Variacs, rheostats, precision condensers, knobs and dials, and plugs and jacks — on all of these the rate of production has been stepped up many times.

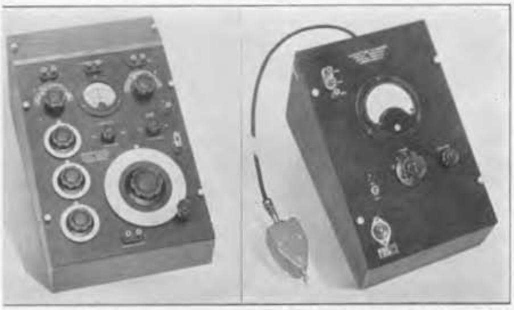
Even before Pearl Harbor, the demand was heavy; we expanded to meet it, and have been expanding ever since. Through greatly increased personnel, the leasing of outside space, and widespread subcontracting, we have been able to meet most of the demand. When quantities ordered reach the point where production facilities are not sufficient in our plant, designs and full manufacturing information are turned over without charge to other manufacturers who have free facilities and are equipped to do the job and to maintain the quality of the product.

Owing to the unprecedented demand, a good part of which was not anticipated at the beginning of the war, there is currently a shortage of some kinds of test equipment, particularly of the higher quality types. All producers of this class of material are heavily loaded but are doing their best to alleviate the shortage. Although the time now required for delivery may be several months, this actually represents a very short production cycle.

The contribution of our engineering department to the war effort has been important. Many specialized items of test equipment, for which the demand was small but the need urgent, have been designed and produced in our model shop. The experience and background of our engineers have been applied to highly specialized development projects where no manufacture by General Radio beyond a sample or working model was contemplated. In some cases no other manufacturer had the facilities to carry out the contract.

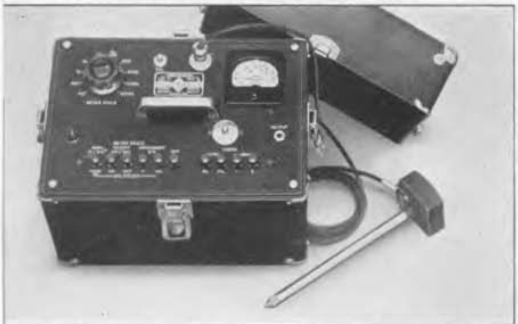


Standards of frequency, like the primary standard shown here, are necessary for the calibration of quartz crystals.



Two instruments used in military and industrial laboratories—left, Type 650-A Impedance Bridge and right, Type 726-A Vacuum-Tube Voltmeter.

Another important test instrument is the Type 700-A Wide-Range Beat-Frequency Oscillator.



The Type 761-A Vibration Meter is used by builders of mechanical equipment to measure the magnitude of vibration as a step in its elimination.

Many of these developments have been completed. Of some items only a sample was made, of others a production lot, and of still others complete working drawings were supplied in order that other manufacturers could produce them in quantity.

Among the specialized small quantity items produced by General Radio for war use are receivers, signal generators, pulse generators, stroboscopes, frequency meters, and oscillators. Although these specific types are not generally available now, the experience gained in designing them will eventually mean new and better instruments.

Our engineering department is in close contact with several of the large laboratories engaged in research on new weapons. General Radio engineers have devoted much time to their assistance, sometimes as consultants, occasionally as part-time staff members, always without compensation to the individuals or to the Company. In addition, special parts and assemblies have been made for these laboratories in our model shop.

(*Left, below*) Cables, transmission lines, and circuit elements are held to rigid specifications for military radio equipment. The Type 821-A Twin-T Impedance Measuring Network is used to measure reactance, resistance, power factor, characteristic impedance, and other quantities at radio frequencies.

(*Right, below*) Both the military services and manufacturers of military equipment use Strobotac for testing, for speed measurement, and for tachometer calibration.

Company executives have given freely of their time to the supervision of outside war research problems and in serving on advisory committees set up by war agencies.

In spite of substitute materials and inexperienced personnel, the general level of quality of our instruments has been maintained. Service difficulties have been held at a minimum. Wartime use puts a severe strain on equipment designed for peacetime service. This problem was recognized at an early date, and facilities were set up for handling an unprecedented volume of repairs and service correspondence. Service manuals were made available, repair parts were stocked, and repair facilities were expanded. Seldom do urgent repair jobs take more than one or two weeks in our plant, unless delayed by parts or repair work which must be done outside our plant by the original manufacturer. Hundreds of repairs each month go through our Service Department, but the proportion of repairs to total output is being steadily reduced.

HEAT CAN CONQUER HUMIDITY

● **WE HAVE BEEN TAKEN** somewhat to task for the pessimistic note on which the article on "The Effect of Humidity on Electrical Measurements," reprinted in the April General Radio *Experimenter*, ended, when it stated that "little can be done to eliminate this type of error (from humidity), short of air conditioning." Two palliatives were, however, mentioned, both applicable to the measuring equipment, namely, placing a desiccant or a source of heat inside the instrument. The former decreases the relative humidity, and also the absolute humidity, by removing the moisture, while the latter decreases only the relative humidity, leaving the total moisture content unchanged.

While the addition of heat has been recommended for preventing moisture condensation when in a fluctuating ambient the measuring instrument is below the dew point, the effectiveness of a rise in temperature of 10 to 20 degrees in reducing relative humidity has not been appreciated. The change in relative humidity with temperature, assuming that the weight of water in a unit volume remains constant, is shown in Figure 1, first shown in the article on "Relative Humidity at Boston" in last month's General Radio *Experimenter* and ampli-

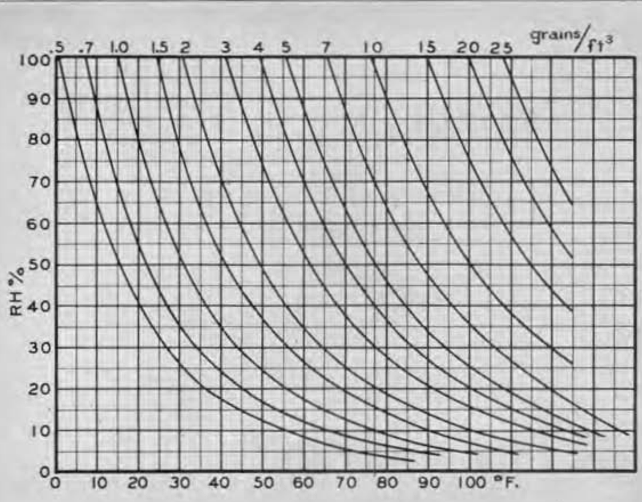


FIGURE 1. Curves showing the relation between relative humidity and temperature for various densities of aqueous vapor expressed in grains per cubic foot. Plotted from Table XII, Psychrometric Tables, by C. F. Marvin, Weather Bureau, U. S. Department of Agriculture, Government Printing Office, Washington, D. C., 1937.

fied here to apply to the higher temperatures. At high relative humidities only a moderate rise in temperature is required to decrease the relative humidity by a factor of two. Suppose that ambient conditions are 91% RH at 80°F. Then entering the chart at this point and following down the curve of 10 grains per cubic foot, a rise of 18°F. (10°C.) decreases the relative humidity by 37% RH to 54% RH, while a rise of 36°F. (20°C.) produces a drop of 58% RH, to 33% RH. Since the curves of constant water content have about the same shape over a considerable temperature range, these figures are representative. Thus the application of enough heat to raise the temperature of the air inside an instrument 20°C. above ambient will reduce even 100% RH to the safe value of 36% RH. Since the safe temperature rise of component parts of an instrument is usually 40°C., a rise of 20°C. will be perfectly safe and will not impair accuracy.

Considerable care should be taken in choosing the source of heat. The heating element should be completely shielded with a grounded shield to prevent 60-cycle induced voltage from appearing in the measuring circuit, which, unless filtered out by a selective detector, would produce errors when the measurements are being made at 60 cycles.

The heater should also operate at a low temperature, preferably not much more than 40°C. above its surroundings. A high temperature source, such as a lamp, will heat surrounding objects directly by radiation, while what is wanted is that the air itself be heated. The addition of a fan to circulate the air and to direct it onto the heater might be desirable in a large instrument. Heater and fan could be combined, as in a hair drier. The fan motor must be of the induction type, without a commutator, to prevent radio interference.

The power needed to maintain the instrument and its contained air at an elevated temperature depends mainly on the area and surface condition of the instrument case. A value of 0.04 watts per square inch of exposed surface will raise that surface about 10°C. above ambient and provide an inside air temperature 10°C. higher both for a rack mounted instrument with a nickel-plated dust cover and for a copper-lined walnut cabinet. The total power for the Type 716-B Capacitance Bridge with a surface area of 1126 square inches is 45 watts, and for the Type 722-D Precision Condenser with an area of 425 square inches is 17 watts. It will be somewhat difficult to prevent the heater from rising more than 40°C. above its surroundings, for it can dissipate only about 0.3 watts per square inch of surface for that temperature difference, or 145 sq. in. for 45 watts and 55 sq. in. for 17 watts. Forced circulation would be very desirable for the larger heater.

— Robert F. Field

Note: In the article by Mr. Field entitled "Relative Humidity at Boston," in the May issue, the figure numbers for Figure 3 and Figure 4 were transposed.

—Editor

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