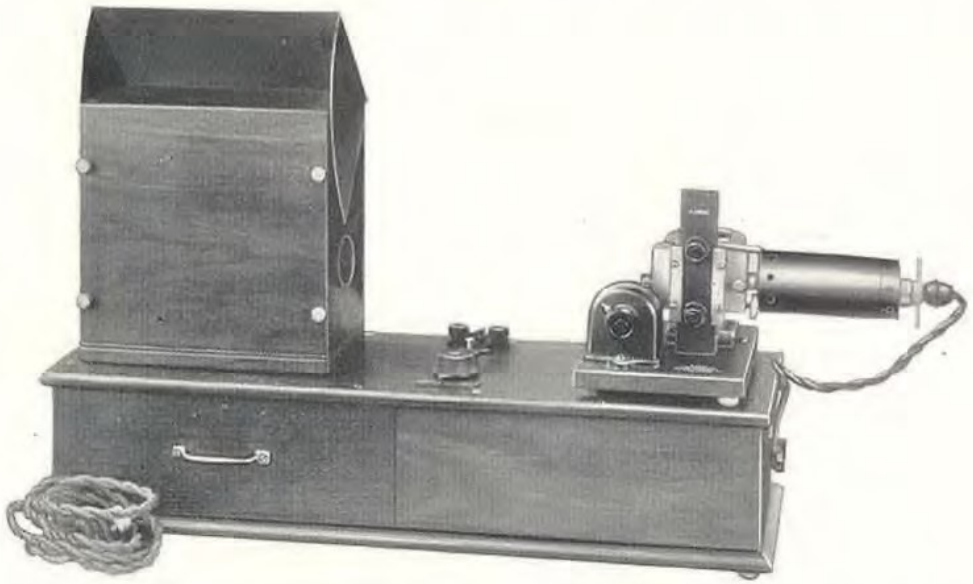
Type 338 String Oscillograph) which may be used for the following two distinct purposes:

1. As a string oscillograph which operates with much less power than is usually required by such instruments, but which affords a satisfactory means for the visual examination of wave forms over a wide range of frequencies. The wave of either current or voltage is traced by the shadow image of a very fine vibrating wire rather than by a spot of light reflected from a mirror attached to a moving system. The vibrating element can, accordingly, be made much lighter, resulting in an increased



sensitivity of the instrument. The uses for such an instrument are manifold, as, for example, the observation of large or small alternating currents in the laboratory, power house, or class room; the visual examination of telephonic currents in simple or complicated circuits; and when combined with some form of microphone or magnetophone, the study of mechanical vibration occurring in moving machinery or in bridges or other structures subject to intermittent stresses. For many such lines of work the portable nature of the equipment is of especial value. If the oscillograph is connected in series with the loud-speaker of a radio receiving set, an instructive and entertaining result will be obtained.

2. As a reliable vibration galvanometer, the string of which may be tuned to give a good degree of sensitivity at any desired frequency over a considerable range. In this respect the instrument is especially useful as a null-point detector in AC. bridge measurements when using low frequencies at which the telephone receiver becomes insensitive and otherwise unsatisfactory. As the galvanometer has no coil in the magnetic field, its

reactance is practically nil when the string is not vibrating, a feature which is desirable for certain applications.

An idea of the sensitivity of the instrument may be obtained from the following data. Using a string of 0.0004-inch tungsten wire, undamped, and tuned to the fundamental of the applied AC. frequency, the following potentials are required to produce a wave form having an amplitude of one millimeter:

At	60 Cycles	0.2 Millivolt
At	250 Cycles	1.0 Millivolt
At	500 Cycles	2.4 Millivolts
At	1000 Cycles	8.5 Millivolts

The DC. sensitivity of the same string when tuned at various frequencies is seen from the following data, which gives the DC. potentials required to give a deflection of one millimeter on the screen:

At	60 Cycles	0.0047 Volt
At	250 Cycles	0.065 Volt
At	500 Cycles	0.30 Volt
At	1000 Cycles	1.31 Volts

The resistance of the instrument strung with the 0.0004-inch tungsten wire is of the order of 65 ohms.

The complete equipment of the string oscillograph comprises the following items:

1. A galvanometer, Type 338-20.
2. A rotating mirror box, Type 338-21.
3. An oscillograph base cabinet, Type 338-22.
4. A carrying-case, Type 338-12, for storing or transporting the instrument readily.
5. A convenient piece of auxiliary apparatus consists of an adjustable rheostat, Type 340, having a total resistance of 100,000 ohms. This rheostat, placed in series with the oscillograph, enables the oscillograph to be used with voltages up to 500. This rheostat, which will be found described on Page 30, and the price of which is $20.00, is not included in the price of either the complete oscillograph or galvanometer.
6. Another useful piece of auxiliary equipment consists of a step-down transformer, Type 285-N, to adapt the oscillograph so as to obtain efficient operation in high-impedance circuits. This transformer, described on Page 125, is also not included in the complete oscillograph or galvanometer prices. Its price is $8.00.

The appearance of the instrument may be seen from the photograph. A walnut base cabinet serves to support and to align the

several elements. In the left portion of this is a drawer for holding spare string mounting and other equipment.

The galvanometer is mounted upon the right-hand end of the cabinet. It is sensitized by two permanent magnets, thus eliminating the need of a source of direct current for producing the necessary magnetic field. Two specially shaped pole pieces afford a long, narrow, vertical gap in which the string vibrates, and at the same time serve to support the optical system, which consists of a large and a small condenser lens, together with a microscope objective. The large lens and the standard automobile headlight bulb used are located in the lamp chamber seen on the extreme right, while the two small lenses are located within a tube passing through the pole pieces. All three lenses are adjustable along the optical axis, while the lamp is adjustable in three dimensions. This makes it easy to focus the system to give a uniform field of illumination. A thumbscrew, located on the left end of the lamp chamber, slides the optical system as a whole with reference to the string and thereby focuses the shadow image of the same upon the observing screen.

The string is mounted upon a metal rocker arm, which, in turn, is attached to the rear of a vertical bakelite strip as shown in the photograph. Two adjustment screws will be seen protruding through the front of this strip. One of these varies the tension on the string, while the other serves to move the string across the light beam in order to center the image on the screen. Provision is made for damping the vibration of the string, if desired, by means of two drops of oil. The whole string assembly is readily removed, electrical contact being made through two springs on the galvanometer base. Two string mountings are provided with the equipment, each strung with a fine tungsten wire of about .0004-inch diameter. These strings, which are 4½ inches in length, may be overloaded considerably without damage. As they carry no mirror, if they are accidentally broken their replacement is a comparatively simple operation.

On the left of the galvanometer base is mounted an enclosed potentiometer for adjusting the potential applied to the string, and hence controlling the amplitude of vibration.

On the left of the cabinet is mounted the mirror box, which is likewise made of walnut. It contains a rotating octagonal metallic mirror which affords the necessary time element of linear motion perpendicular to the vibration. The mirror is mounted on the shaft of a small induction motor and is provided with jewelled bearings. This motor is of simple construction, consisting of a circular disc, the periphery of which passes

through a gap in a rectangular, laminated core. The core is energized by a high-impedance coil carrying a 60-cycle current, and around one-half of the cross section of each pole are two copper rings acting as "shading coils." The unsymmetrical distortion of the resulting field affords the driving torque. This motor is not inherently synchronous, as its speed may be controlled over a wide range merely by varying the voltage impressed on the energizing coil. This is done by means of a potentiometer, the knob of which seen in the center of the cabinet. A very constant speed of any desired value may be maintained in this manner, making it easy to synchronize the motor to any frequency impressed on the string, producing thereby a stationary wave pattern. For observing transient phenomena of some duration, it is desirable to have the mirror run quite slowly, whereas the maximum speed of the motor is necessary to separate the individual wave forms at the higher frequencies. The 60-cycle wavelength at maximum speed is from 2½ to 3 inches, giving a wavelength of about 1/16 inch at 3000 cycles.

A screen bent on the arc of a circle is seen by looking down into the box, which is provided with an adjustable metallic cover that serves as a hood for shielding the screen when desired. The observer may stand at some distance from the screen and still watch the wave form while manipulating other apparatus. This is a convenient feature. A cylindrical lens is mounted in the mirror box for concentrating the light beam into a narrow line. This sharpens and intensifies the image considerably. The front vertical wall of the mirror box is easily removable for inspection and adjustment of the enclosed parts.

Terminal posts, together with a cord and plug, are provided for attaching the equipment to a source of 60-cycle, 110-volt current which may be turned on or off conveniently by a small toggle switch mounted on the center portion of the cabinet. This is the only source of power required, as the lamp is lighted through a step-down transformer mounted in the cabinet. The whole instrument takes about 40 watts.

The cabinet contains a 3 MF. paper condenser which is frequently useful for eliminating a DC. component from the string.

Type 338-L Oscillograph, with Carrying-Case.....$225.00

Dimensions, 30″ x 11″ x 17″. Weight, 61 lbs.

Code Word: OFFER.

When the instrument is desired for use only as a vibration galvanometer it may be procured without the mirror box, but with a tube having a small translucent screen for observing the image of the vibrating string. In front of this is a small cylindrical lens for concentrating the light beam and intensifying the image. A metallic support is provided

for the outer end of this tube.

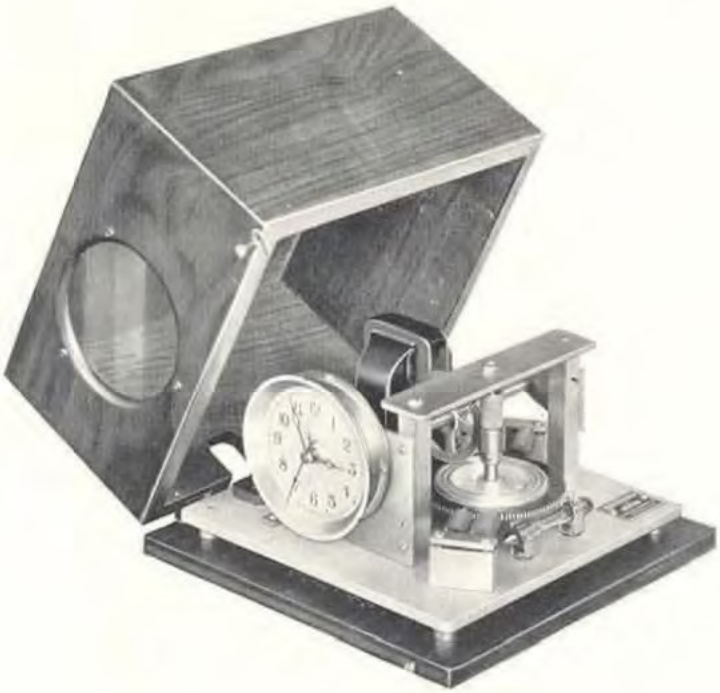
Type 338-G Vibration Galvanometer, with Carrying-Case.....$160.00
Dimensions, 30″ x 11″ x 17″. Weight, 53 lbs.
Code Word: OFTEN.

TYPE 338-D DOUBLE STRING HOLDER

The Type 338-D Double String Holder provides two strings, permitting the comparison of two wave forms. This holder may be substituted for the standard holder, the terminals of one string making contact to the springs on the oscillograph. The terminals of the other string are brought out to the binding posts.

Type 338-D Double String Holder.....$30.00
Code Word: OLIVE.

TYPE 411 SYNCHRONOUS MOTOR



In checking a source of constant-frequency current, great accuracy may be attained by using the source to drive a synchronous motor, and counting the motor revolutions over a long period. Synchronous motors may be built which will operate properly at audio frequencies. Higher frequencies may be checked by stepping down the frequency by means of a series of oscillators, with harmonics of the lower frequency