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ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS

A WAVEMETER FOR 240 TO 1200 MEGACYCLES

Also

IN THIS ISSUE

● **TO STATE THE RANGE** of a wavemeter in megacycles appears to be an inconsistency, but since today "frequency" rather than "wavelength" is used to define the period of oscillations, the only alternative would be to discard the designation "wavemeter." However, a wavemeter is such a useful and time-honored piece of equipment that it hardly seems advisable to change its name. Moreover, the modern frequency meter is usually a heterodyne instrument (see General Radio *Experimenter* of July and August 1945), and the term implies a degree of accuracy that is not necessarily required for all measurements in the laboratory.

The new TYPE 1140 Wavemeter is intended for applications where

FIGURE 1. Two views of the TYPE 1140-A U-H-F Wavemeter. At the front, the butterfly is seen through a transparent window; at the rear, both the resonance indicator and the frequency scale can be read as the tuning control is turned.

ease of operation and small size are more important than high accuracy, and where direct reading indications over a wide frequency range are most desirable.

The new wavemeter has a single range from 240 to 1200 megacycles. The tuned circuit is of the butterfly type (see General Radio *Experimenter* of October 1944 and *Proceedings of the Institute of Radio Engineers* for July 1945). The inductive and capacitive elements are built integrally, and tuning is achieved by simultaneous variation of both. No sliding contacts are used.

Resonance is indicated on a microampere meter preceded by a crystal detector. Coupling between tuned circuit and indicator is relatively close, and the wavemeter is designed to make effective coupling to the unknown source possible without direct connections. Some accuracy has thus been sacrificed for high sensitivity. If sufficient power is not available to deflect the indicating meter, resonance can still be observed by the reaction of the wavemeter on plate or grid current of an oscillator of unknown frequency.

The detector, which consists of a silicon crystal and a tungsten wire, is contained in a ceramic cartridge and is easily replaced. Crystal detectors of this kind have recently been standardized, and the most suitable types are designated 1N21 and 1N22. The crystal detector is shunted by the indicating meter and, therefore, well protected against overload, since it cannot be damaged without producing several times full scale deflection.

The resonant frequency of the detector circuit is around 1600 megacycles. This high resonant frequency has been obtained by mounting the detector cartridge in a metal block and providing only a small loop for coupling to the butterfly circuit. The metal block, seen at the bottom of Figure 2, is part of the casting which supports the butterfly circuit on one side and the gear-drive and indicator drum on the other side.

The scale on the indicator drum is about 9 inches long. Three turns of the tuning knob are required to cover the full range corresponding to a 90° rotation of the butterfly rotor. The tuning unit and the indicating meter are mounted in a plastic housing which can be held conveniently in one hand. Two views of the complete wavemeter are shown in Figure 1. A transparent window in the housing shows the butterfly

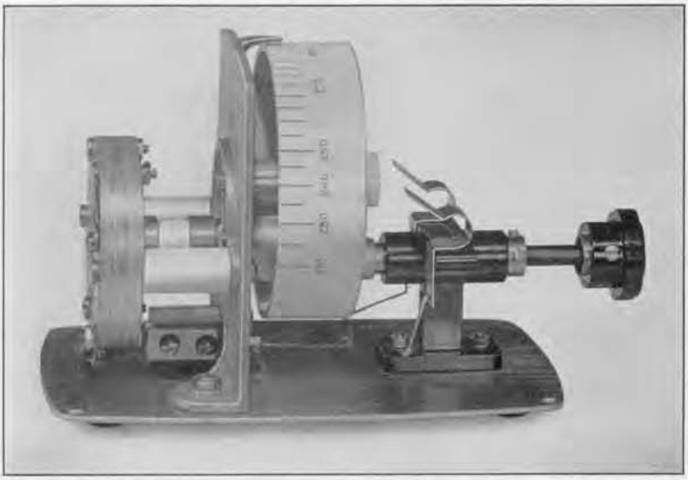


FIGURE 2. View of the interior of the wavemeter with case removed. The cartridge-type crystal detector is mounted in the metal block near the base at the rear of the butterfly. The two clips above the shaft bearing make contact with the terminals of the microammeter, so that both original assembly and removal for servicing are easily accomplished.

circuit and facilitates proper coupling to the unknown source which has to be measured. The interior construction is shown in Figure 2.

A certain amount of care is required to avoid erroneous readings and spurious responses, which are not encountered with similar instruments at low frequencies. Misleading indications can be produced by resonance of the detector circuit with harmonics of the unknown frequency and by spurious responses of the tuning element. Spurious responses or modes, only too familiar to anyone working in the microwave regions, are caused by the fact that dimensions of the circuit elements are no longer small compared to wavelengths, and that current paths through these elements are possible in different directions. Fortunately circuit losses in spurious modes are ordinarily larger than the losses in the desired mode, and consequently the meter deflection will be higher and more sharply dependent on tuning if the wavemeter is set to the correct frequency.

— Eduard Karplus

SPECIFICATIONS

Frequency Range: 240–1200 Mc.

Accuracy: ±2% of the indicated frequency.

Temperature and Humidity: The accuracy of this wavemeter is independent of temperature and humidity effects over the range normally encountered in the laboratory.

Detector: A Type 1N22 Crystal Detector is furnished with the instrument.

Dimensions: $3\frac{7}{8}$ x $7\frac{1}{4}$ x $4\frac{1}{2}$ (height) inches overall.

Net Weight: $3\frac{1}{4}$ pounds.

Type		*Code Word*	*Price*
1140-A	U-H-F Wavemeter.............	WAGER	$65.00

MISCELLANY

● **ADRIAN W. CLEVELAND** has been appointed Purchasing Agent of the General Radio Company, succeeding the late Walter H. Sherwood. Mr. Cleveland was born at Oxbow, New York, and received his early education in the public schools of that state. He studied electrical engineering at Northeastern University, from which he was graduated in 1934 with the degree of Bachelor of Science. Coming to the General Radio Company the same year, he became thoroughly familiar with manufacturing operations by working in every branch of the production department before assignment to the purchasing department in 1937. He was appointed Assistant Purchasing Agent in 1939, and became Purchasing Agent in August, 1945.

A LIGHT SOURCE FOR MICROSECOND PHOTOGRAPHY

● **THE MICROFLASH**, a highly specialized type of stroboscopic light source has been added to General Radio's line of stroboscopic equipment. This device was perfected at the beginning of the war, and it has rendered good service in a score or so laboratories during the emergency. Now the Microflash is available for peacetime use in research work where short photographic exposures or flashes of light are required.

Commercially available stroboscopes, before General Radio offered the first Edgerton Stroboscope in 1932, were mainly shutter-type instruments, which operated by periodically interrupting the user's vision, so that illumination was low and only moderately high-speed motion could be arrested. The development of highspeed light sources for stroboscopy by Edgerton, Germeshausen and Grier of M. I. T. opened up new fields of usefulness for visual work and resulted in the well-known Strobotac and Strobolux. The latter instrument produces a flash of high intensity and of relatively high speed, and hence has been used as light source for photography. Its flash duration of 30 microseconds ($\frac{30}{1,000,000}$ of a second), however, is a limitation which makes it unsuitable for many applications where close-ups or even enlargements must be made of objects moving at very high speeds, as for instance, bullets and other projectiles. Flash durations of only 1 or 2 microseconds are necessary for this work.

These flash speeds have been obtainable for a number of years by means of spark discharge equipment, which is extremely cumbersome. Owing to the limitations of the spark as a light source, most spark photography was done in silhouette. Stroboscope design technique, however, offers a means of obtaining short, high-intensity flashes in a small compact unit, with only a small power demand.

Since the power required to operate a stroboscopic lamp varies directly with the flashing rate, much less power is necessary for flashing at intervals of

FIGURE 1. View of the Microflash unpacked and ready for operation.

FIGURE 2. Lamp housing and power supply lock together in a convenient assembly for transportation.

several seconds or minutes than for the high repetition rates used for visual work. The duration of flash can be greatly reduced by proper design of the lamp and by using a smaller condenser and charging it to a higher voltage.

A preliminary design of the Microflash, TYPE P-509, was described in the *Experimenter* a few years ago.[1] The new TYPE 1530-A Microflash is now available for general sale and provides a means of photographing objects in much faster motion than was possible with equipment designed primarily for stroboscopy.

Functionally, the electrical circuit of the Microflash is simple, consisting of a rectifier power supply, a condenser which is charged to about 7500 volts from the power supply, and a lamp through which the condenser is discharged to produce the flash. The flash is "tripped" by an impulse from a spark coil which ionizes the gas in the lamp sufficiently to initiate the condenser discharge. The spark coil is excited by a thyratron, which in turn may be tripped by making or breaking an external contact, by pressing a button on the panel, or by an impulse from a microphone which picks up sound from the phenomenon to be photographed. A built-in amplifier with a manual sensitivity control is provided.

The external appearance of the Microflash is shown in Figures 1 and 2. The view of Figure 1 shows the instrument set up for operation with the microphone arranged to trip the flash. For transportation, the lamp and power supply cases lock together, as shown in Figure 2.

Two sockets are provided for plugging in the tripping circuits, one for the microphone, the other for a contactor. A two-position switch permits a choice of either make or break contactor-trip.

When the microphone is used, the time of the flash depends upon the distance the sound wave travels before reaching the microphone. As can be seen from Figure 1, the microphone is provided with a cable of considerable length so that the timing of the flash can be adjusted over a considerable range by moving the microphone with respect to the object being photographed.

In adjusting the time of flash, it is necessary to take into consideration an initial minimum delay of 10 to 15 microseconds. Although varying between these limits among different instruments, the delay is practically constant for any one unit.

The duration of the flash is about 2 microseconds, with a faint trailer lasting about 15 microseconds, as indicated in

[1] "A Light Source for Ultra-High-Speed Photography," General Radio *Experimenter*, Volume XVI, No. 4, September, 1941.

Figure 4. To eliminate any effect of the trailer, film should be under-exposed and over-developed.

Since the Microflash was originally developed for war research, its uses thus far have been largely in the testing of ammunition, particularly new types. A previous article[2] discussed a number of these tests.

The Microflash has many other applications in this field, among them investigations of the impact of bullets, of artificially induced yaw to deflect projectiles, and of the action of rotating bands on shells. It has also proved useful in studying the behavior of wads in shotgun shells, and resulted in radical changes in the design of the shells.

Other studies include the effects of underwater explosions on models; icing on airplane propellers; the disintegration of rotors at very high speeds, particularly turbine rotors and rayon buckets; the bursting of fluid containers under extreme pressure conditions, and the mechanism of self-sealing in bullet-proof fuel tanks for airplanes.

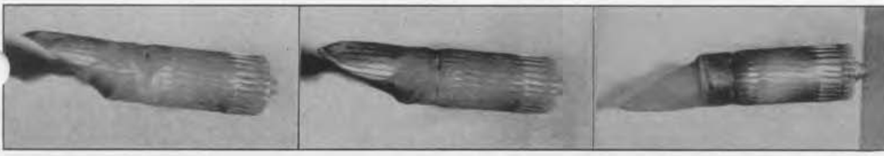
Other projected uses include the study of the propagation of fractures in materials, and of the mechanism of wear in automobile tires at high speeds. The Microflash also has possibilities for studying cutting and grinding operations with machine tools. For industrial research where the behavior of rapidly moving objects must be recorded, it offers a means of saving both time and money, and for many problems offers the only method of obtaining a satisfactory solution.

— H. S. Wilkins

[2]"Microflash Shows Flight Defects in Projectiles," General Radio *Experimenter*, Volume XIX, No. 11, April, 1945.

Figure 3. Microflash photo of the explosion of a shotgun shell as it leaves the muzzle of gun, which is out of the picture at the right. Note that the wads can be seen as well as the cluster of shot.

— *H. E. Edgerton*



—*Courtesy Jefferson Proving Ground, Ordnance Department, U. S. Army.*

FIGURE 4. Photographs of three rounds of ammunition showing both yaw and erratic behavior of windshields.

The photographs shown below were taken by H. E. Edgerton and F. E. Barstow and are reproduced through the courtesy of the Hartford-Empire Company

FIGURE 5. Uncompleted fracture in an experimental bottle. The heavy line is drawn with gold on the glass, which, when interrupted by a crack, opens the circuit to trip the Microflash. Note the faint lines at the ends of the cracks which indicate the direction the fracture lines will take. The velocity of propagation of the fracture has been determined by Microflash photography to be approximately 5000 feet per second.

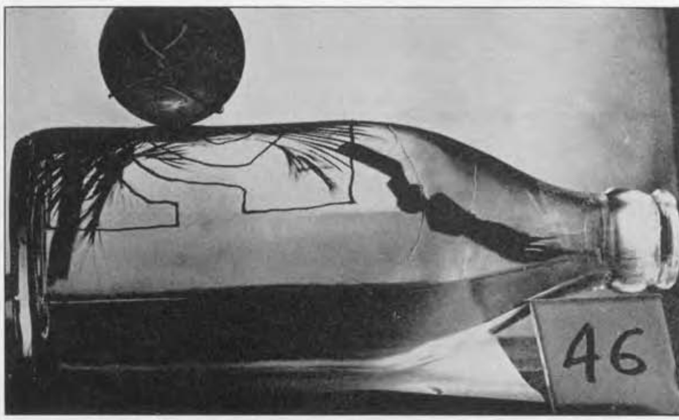
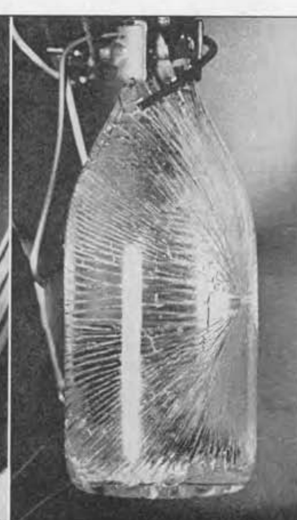


FIGURE 6. Experimental bottle breaking by severe impact on a steel plate. The Microflash tripping circuit is closed by a sheet of tinfoil driven against the steel by the bottle.

FIGURE 7. Fracture of an experimental bottle under 520 lb./sq. in. water pressure. The fracture started at the center of the radiating pattern. The Microflash was tripped by a crystal phonograph pickup with needle bearing against the glass.

FIGURE 8. Fracture of an experimental bottle under 730 lb./sq. in. water pressure. The tripping mechanism was the same as that used for Figure 10.



SPECIFICATIONS

Duration of Flash: Approximately 2 microseconds.

Power Supply: 105 to 125, 210 to 250 volts, 50 to 60 cycles.

Power Input: 70 watts.

Tubes:
1 — 5T4 (RCA) 1 — FG-17 (GE)
1 — 2V3G(RCA) 1 — 6AC7 (1852) RCA

Accessories Supplied: Microphone with cable; tripod; all tubes; spare pilot lamps and fuses; 2 spare flash lamps Type 1530-P1; plug for connection to contactor-trip jack.

Mounting: The power supply and trigger circuits are assembled in one metal case, the lamp in another. The two cases lock together for transportation, completely protecting the lamp and controls.

Dimensions: 24⅛ x 13¼ x 11¾ inches, overall.

Net Weight: 72 pounds.

Type		*Code Word*	*Price*
1530-A	Microflash	TAFFY	$525.00*
1530-P1	Replacement Flash Lamp	TONIC	15.00*

*Plus current Federal tax on photographic equipment.

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and under Patent No. 1, 790,153 and other patents covering electrical discharge devices and circuits with which said device may be used, owned by the General Electric Company or under which it may grant licenses.

ERRATUM

● **IN THE SPECIFICATIONS** for Type 816 Vacuum-Tube Precision Fork, described in the September *Experimenter*, the frequency designation was inadvertently omitted from the price list. The listing should have read as follows:

Type	*Description*	*Frequency*	*Code Word*	*Price*
816-A	Vacuum-Tube Precision Fork	50 c.p.s.	FERRY	$385.00
816-B	Vacuum-Tube Precision Fork	60 c.p.s.	FABLE	385.00

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