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ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS

MICROFLASH SHOWS FLIGHT DEFECTS IN PROJECTILES

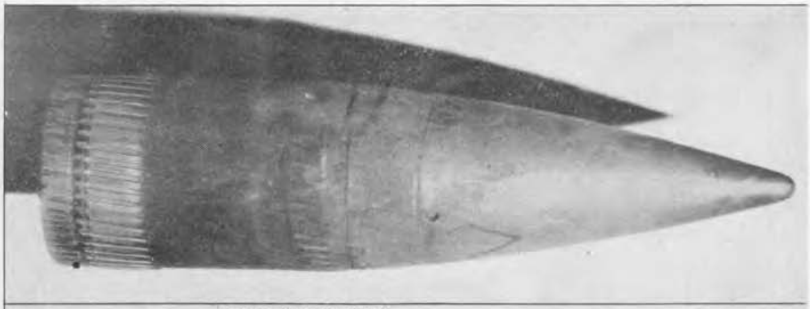
Also IN THIS ISSUE

● **THE MICROFLASH**, a high-speed, high-intensity light source for photography, was originally described in the *Experimenter* in 1941,* with the statement that it was designed for use on urgent defense projects and was not available for general sale. Since that time, a considerable number of units have been built and have proved extremely valuable in research connected with the war effort.

The flash of light produced by the Microflash is of extremely short duration (about 2 to 3 microseconds), and its intensity is sufficient to produce well lighted photographs with the high-speed film emulsions now available. The high speed of the flash permits photographs of objects moving at extremely high speeds. An interesting example of the use of the Microflash is the work that has been carried on at Jefferson Proving Ground on the flight of projectiles

*"The Microflash — a Light Source for Ultra-High-Speed Photography," *General Radio Experimenter*, XVI, 4 September 1941.

Figure 1. Microflash photograph of a 155-millimeter projectile 400 feet from the muzzle of the gun.



LINE OF FLIGHT

FIGURE 2. Arrangement of equipment for photographing projectiles 100 feet from the gun. At the left is the gun, at the right the box through which the projectile passes to be photographed. On the post between the two is the pressure switch which opens the shutter when the projectile passes.

as part of the proof acceptance testing of ammunition.

Two important factors affecting the flight of a certain type of projectile are the angle of yaw and the behavior of the windshield. It was known that some of the windshields were falling off the projectiles just after they left the muzzle of the gun, but no data were available on the behavior of those remaining on the projectiles.

Preliminary experiments indicated that photographs taken at night with the Microflash showed distinctly the condition of the windshield as the projectile passed in front of the camera. Following the advice of Dr. Harold E. Edgerton of M. I. T., an experimental pilot model, and later a more finished model, of a set-up for taking photographs in daylight were built.

Figure 2 shows the set-up used for these tests, consisting of a box containing the Microflash, and camera, and associated equipment: a diaphragm pressure switch mounted on a post and the gun. In Figure 3 is shown the interior of the box. Here the equipment consists of the camera and Microflash in permanent mountings, a microphone, and a card holder accessible through a sliding door in the side of the box.

Figure 2 shows the box set approximately 100 feet in front of the gun and the diaphragm pressure switch is about 15 feet from the box. The camera shutter is set at 1/100 second and cocked. As the projectile passes by the pressure switch, the pressure from the sound wave closes the switch, activating the synchronizing device, which in turn operates the magnetic tripper to open the shutter. During the 1/100 second interval while the shutter is open, the projectile passes through the box, the microphone picks up the sound wave from the projectile and trips the Microflash.

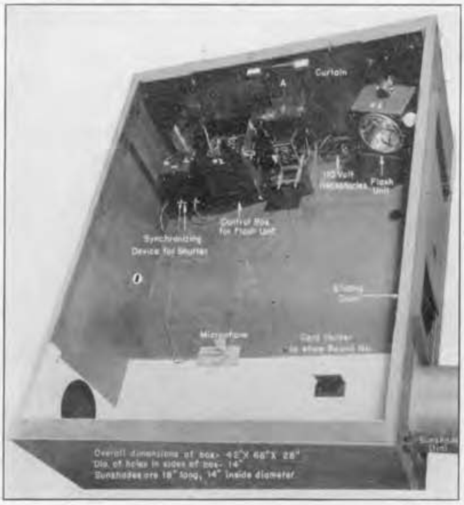


FIGURE 3. Interior of the box, showing Microflash, microphone, synchronizer, and other equipment.

While the photograph shows a crystal microphone, this type was found too fragile to stand the terrific concussion from the muzzle blast of the gun and was later replaced. A receiver unit from an ordinary telephone handset has proved to be quite satisfactory.

In order to decrease the amount of light inside the box, a dark curtain is hung in the back, and the inside surfaces of the sunshades on the sides are painted flat black. With super ortho press film, a diaphragm opening of f:6.3 is used.

Results obtained with this technique are shown in Figure 1 and in Figures 6 and 7. In Figure 1 is shown a 155 mm projectile 400 feet from the muzzle of the gun. Figure 4 shows a 3-inch projectile 50 feet from the muzzle of the gun. Here the windshield with the nose cap attached has broken away from the projectile and is approximately 5 inches in front of it.

FIGURE 4. Photograph of a defective round showing windshield in front.

In Figure 6, three views showing erratic behavior of windshields are shown. Figure 7 is a group of photographs of 3-inch projectiles showing excessive yaw.

FIGURE 5. View of the Microflash Unit, consisting of light source, power supply, microphone, and connecting cables.

Work of similar nature has been carried out by the Combined Inspection Board of the United Kingdom and Canada at Valcartier, P. Q. Of particular interest is their use of the shadowgraph technique for the photography of shock waves in air. A diagram of the system is given in Figure 8. The Microflash lamp is converted to a point source (actually about ⅛-inch diameter) and placed some 6 feet from a ground glass screen. The camera is focussed on the side of the screen away from the lamp. The projectile is fired between the lamp and the screen at about 12 inches from

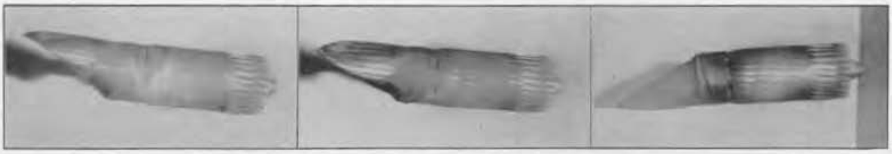
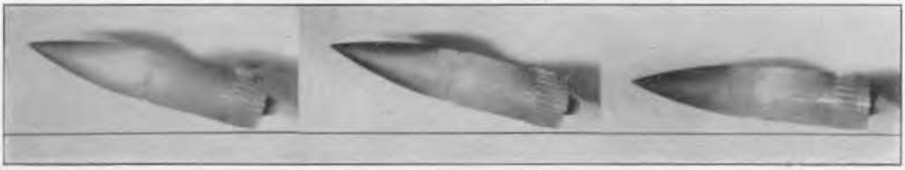


FIGURE 6 (above). Photographs of three rounds in which the windshields have become displaced from their normal positions.

FIGURE 7 (below). These three rounds show excessive yaw. The line below them indicates the line of flight.



the latter, and its shadow is recorded on the film along with the marks made by bow wave and other pressure waves in the air. Definition is limited to the size of the grain of the ground glass surface. Finer definition can be obtained substituting a sheet of film for ground glass, but this method must be used in darkness. The ground glass technique makes it possible to take shadowgraphs of projectiles by firing through the box in daylight.

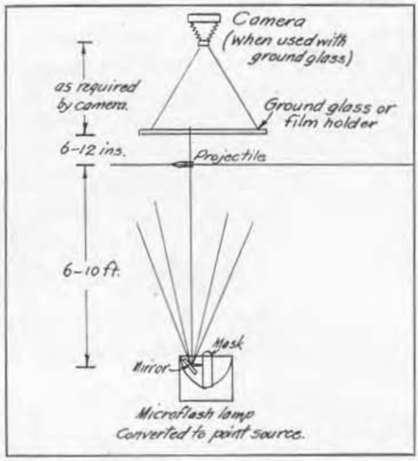


FIGURE 8. Diagram of the equipment used to take shadowgraphs of bullets and projectiles.

MEASURING 0.003 HORSEPOWER WITH THE STROBOTAC

● **MEASUREMENT OF THE VERY SMALL AMOUNT** of power consumed in the gears of a tachometer adaptor unit recently presented a problem at the Barbour-Stockwell Company, manufacturers of Reliance tachometers. Their engineering department solved this problem by means of an ingenious device used in conjunction with the General Radio Strobotac.

The measuring system consists basically of a torsion meter which indicates the torque required to drive the part to which it is coupled. This torsion meter must be capable of rotation at fairly high speeds, and means for reading the meter indications and for measuring the speed must be provided. The TYPE 631-B Strobotac performs these latter functions.

The photograph shows a brass tube, about 15 inches long, coupled to the motor shaft at one end while the other end runs in a bearing and carries a drum-type dial. Within this tube is a straight

FIGURE 1. Mr. Frank Wilkins of the Barbour-Stockwell Company reading the relative positions of the drum dials by means of the Strobotac.

length of 0.037-inch steel piano wire, rigidly attached at the motor end and fixed at the other end to a small shaft that turns freely in a bearing within the end of the tube. This shaft carries a small drum with an index mark on its periphery which indicates the angular displacement against the scale on the adjacent dial attached to the brass tube. The short shaft then passes through the outer bearing and a coupling to the rotating member on which the power loss is to be measured. Thus it is seen that when the motor is stationary, manual rotation of the output coupling shaft results in rotation of the index dial as the piano wire is twisted against its restoring torque.

When the motor is started, the acceleration puts a high torque on the wire, which might be broken except that the index dial has its motion with respect to the other dial limited to 180° by means of stop pins. The load is driven directly, therefore, when starting or stopping. Under running conditions, however, the Strobotac is adjusted to give a stationary image of the dials, and the position of the index with respect to the dial marked in degrees of arc is readily observed. If the motor speed varies enough to make it difficult to obtain a steady image, the contactor socket of the Strobotac may be connected to a cam arrangement on the motor shaft which will insure a steady image of the rotating dials. Since each flash of the Strobotac occurs at the moment that the contactor leads are short-circuited, it is best to arrange the contactor cam so the circuit can be shorted at any chosen point in the rotation of the cam.

The torsion meter is easily calibrated in a stationary condition by comparing applied torques on the output shaft to resulting dial readings. The results should give a linear curve. Power measurements are then made by observing, with the Strobotac, the reading of the torsion dial and the speed of rotation. Calculation of power from the product of torque and speed is then a simple matter.

FIGURE 2. Close-up of the torque meter. The two drum dials, one carrying an index, the other a scale, are shown between the two vertical supports.

The equipment illustrated has been used to measure power losses as small as 0.003 horsepower at speeds of 600 rpm with an accuracy of ±5%. With smaller equipment using a finer wire, there seems to be no reason why this arrangement cannot be used for measuring very much smaller amounts of power.

— KIPLING ADAMS

PHOTOTUBE CAPACITANCE MEASUREMENT WITH THE TYPE 650-A IMPEDANCE BRIDGE

● SINCE INTERELECTRODE capacitance has a marked effect upon the frequency characteristics of a phototube, it is important in many applications that the capacitance be accurately known.

The Type 650-A Impedance Bridge has been found quite satisfactory for this measurement when an external Type 602 Decade-Resistance Box is used to give the required precision of balance.

The necessary connections are shown in Figure 2. The bridge controls are set for capacitance measurement. Since for this connection, 1 ohm is equivalent to 0.1 $\mu\mu$f,

$$C = \frac{\Delta R}{10}$$

where ΔR is the change in setting of the resistance box when the phototube is connected.

To connect the external decade-resistance box, it is necessary to break the connection between the arm of the CRL potentiometer and ground. This can be done by removing the connecting wire from the potentiometer terminal and bringing out a new lead from the terminal. An equally satisfactory and more convenient method is to insert a slip of paper between the potentiometer arm and the winding. The decade box can then be connected between the J terminal of the bridge and ground.

For measurements over a range of 0.6 to 3.0 $\mu\mu$f, balance to 0.1 $\mu\mu$f could be obtained with a decade box providing unit steps in resistance. A tenth-ohm decade gives increments of 0.01 $\mu\mu$f, and with an amplifier as indicated in Figure 2 the bridge is sufficiently sensitive so that balance to 0.01 ohm or 0.001 $\mu\mu$f is easily obtained. Since hundredth-ohm decades are not generally available, it would be necessary to use a slide wire to obtain this degree of precision.

When a wire from the CRL potentiometer is brought out to the decade, the zero capacitance of the bridge, which amounts to approximately 10 $\mu\mu$f, can be balanced out by means of an initial setting of the CRL dial. If the CRL potentiometer is disconnected by insulating the contact arm from the winding, the decade box must be large enough to balance this zero capacitance, and a four-dial box consisting of hundred-, ten-, one-, and tenth-ohm decades should be used.

In order to keep the conductance component small, the phototube should be shielded from light during the meas-

Figure 1. Panel view of the Type 650-A Impedance Bridge.

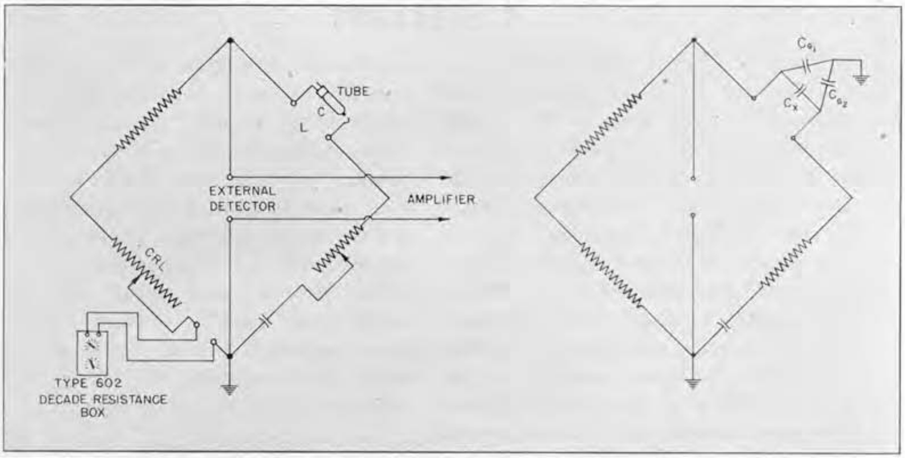


FIGURE 2 (*left*). Circuit diagram of the bridge, showing the decade resistance box connected in series with the CRL dial.

Figure 3 (*right*). By tying the terminal capacitances C_{G1} and C_{G2} to ground, as shown here, the direct capacitance C_X can be measured.

urement. If the tube is exposed to light, an additional decade resistance across the standard condenser is needed for balancing the parallel conductance, in order to avoid a serious sliding balance.

The accuracy obtainable with the TYPE 650-A in the measurement of capacitance of this magnitude is limited largely by the unavoidable connection errors. Since connection errors of the order of 0.1 $\mu\mu$f are difficult to eliminate,* these errors will usually determine the absolute accuracy of the measurement.

It should be noted that this method measures direct capacitance rather than total capacitance and hence is applicable to a number of other problems where small values of capacitance must be measured. It can be seen from Figure 3 that capacitance to ground from the low unknown terminal is in parallel with the detector, while that associated with the high terminal is across the standard arm of the bridge and, when not small enough to be considered negligible, can be corrected for. For measurements of capacitance increments where connection errors do not exist, as, for instance, with plug-in elements, highly accurate measurements can be made.

One possible application is in the measurement of the interelectrode capacitances of vacuum tubes, where the socket is connected to the bridge, and the capacitance increment resulting from plugging in the tube is measured. For these measurements, all unused electrodes should be grounded, so that only the direct capacitance between the two significant electrodes is measured. For accurate measurements of the smaller capacitances such as the grid-to-plate capacitances of screen grid tubes, shielded sockets are necessary to avoid connection errors larger than the capacitance being measured.

— L. E. PACKARD

*R. F. Field, "Connection Errors in Capacitance Measurement," *General Radio Experimenter*, XII, 8 January 1938.

MISCELLANY

● **DR. A. P. G. PETERSON** of the General Radio Engineering Staff addressed a group from the New York Section, Institute of Radio Engineers at Red Bank, New Jersey, on March 16. His subject was "Wide-Range Tuned Circuits for High Frequencies."

A paper on "High-Frequency Measurements" was delivered by Dr. Donald B. Sinclair, Assistant Chief Engineer, before a meeting of a group of Middle West radio engineers arranged by the Chicago Office of the General Radio Company on March 21. This paper was also presented at the Radio Engineers' Club in Chicago on March 22, at the London, Ontario, Section of the IRE on March 23, and at the Toronto, Ottawa, and Montreal Sections on March 26, 27, and 28, respectively.

● **QUALITY PARTS** sometimes mean the difference between a good job and one that doesn't make the grade. A manufacturer recently completed several hundred equipments on a project that was highly secret and very urgent. They were OK, except for the rotary switches, which failed in use. Several General Radio switches of the type used in our decade resistors were available and these were dismantled and reassembled in a 3-gang combination. These worked satisfactorily and were rugged and reliable. Result — an urgent call for switch parts. Luckily, we were able to scrape up a small quantity for immediate needs and to schedule the balance for production on a high priority.

● **IN WARTIME** expense is often no object if the need is urgent. A secret development project recently needed ten General Radio Precision Forks, and only eight were available. To wait for a delivery of the next production lot was out of the question; the project was too urgent. The last previous delivery, it turned out, was to a foreign ally, and believe it or not, one of Uncle Sam's planes went right over there and brought back two of the units.

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