A SHUTTER TESTING MACHINE.*

BY

ALFRED B. HITCHINS, Ph.D., F.R.P.S.,

Director, Ansco Company's Research Laboratory;
Member of the Institute.

AND

F. B. GILBERT.

THE want of an instrument of precision for testing the speed and efficiency of shutters has long been felt. To date the machines of Abney and the National Physical Laboratories have been the finest, but they have failed in one or more of the requirements of precision, simplicity of operation, or durability of construction.

FIG. 1.

In the design of the one to be described these three qualities have been kept in view, and it is felt that the work has brought forth an instrument of both laboratory precision and commercial utility.

Fig. 1 shows a complete view. *A* is a revolving drum mounted on a shaft between a powerful high-speed motor *M* and a Veeder precision tachometer *T*. The speed of the drum may be varied by altering the position of the brushes but its fine regulation is achieved by the brake *B*, acting on the shaft. The accuracy of the tachometer is 1 per cent. which with the speed generally used

* Communication from Ansco Company's Research Laboratory.

(1250 r.p.m.) only produces an error of $1/5000$ of a second in the measurement of a shutter speed of $1/50$ of a second.

The shutter to be tested is held in a universal iris *C* directly in front of a narrow horizontal slit. By means of an arc and a pair of condensers in the lamp house *L* this slit is illuminated by a very powerful spot of light, while its image is brought to focus on the drum by the lens *D*. Thus on exposure there is produced on a strip of film affixed to the revolving drum a band, the length of which at a given r.p.m. determines the speed of the shutter.

To make this band self-recording and avoid the tedium of many measurements it is split up into a series of lines by the

FIG. 2.

sector wheel *S* (Figs. 1 and 2) which revolves in front of the drum. The wheel contains 96 slots and by gearing to the main shaft is made to rotate at precisely the same speed as the drum: the series of lines in the image, being due to the interruptions of the sector wheel, have a definite time value. At 1250 r.p.m. each one of the lines then represents $1/2000$ of a second, so that, in order to estimate the speed of the shutter, it is only necessary to count these. These may be separated into blocks of ten by obliterating every tenth slot on the sector wheel, reducing the labor of counting. The images produced are shown in Fig. 3 for several different shutters.

Since the drum cannot be revolved at less than 400 r.p.m. with any accuracy or benefit to the motor due to the high braking necessary, shutter exposures of more than $1/50$ of a second cannot be measured without overlapping of the image in one or

FIG. 3.

FIG. 4.

more complete revolutions during the firing. To overcome this difficulty a "threader" *E* is used. (Fig. 4.) It is merely a flat piece of metal with a fine slit in it at right angles to the illuminated slit which can be swung into position between the drum and

the sector wheel; its function being to permit only a small dot of light from the slit image to reach the drum. By means of a worm and a threaded finger the slit moves across the drum at the rate of $1/20$ of an inch per revolution, thus threading a narrow dotted line around and around the drum as a bobbin winds a spool. The carriage carrying the threader is mounted on a shaft below the drum (see Figs. 5 and 5a). The screw is revolved at the same speed as the drum and motion translated to the carriage by the threaded finger *F*. The engagement and disengagement of this finger is controlled by the lever *G*, which also serves as a handle to draw the carriage back to its starting

FIG. 5.

position at the left where it will remain until the finger is engaged by depressing the lever, when it travels to the right at the rate given. When this attachment is being used the drum is run at 625 r.p.m. and the speed of the exposure is then measured by the number of complete revolutions, *i.e.*, winding of the thread line plus the number of dots over the last complete revolution. The dots at 625 r.p.m. equal $1/1000$ second each.

The actual technique of operation of the instrument for high speeds consists first of wrapping a piece of film tightly around the drum (in which position it can be affixed by merely moistening the ends and sticking them together), the shutter is set to the

speed to be tested, the drum is started and the arc struck. The speed of the drum is regulated by means of the brake *B*, until the tachometer reads 1250 r.p.m. Then the shutter is fired. In measuring the slow speeds the same procedure is followed except that the drum is revolved at 625 r.p.m. and at the moment

FIG. 5a.

before firing the shutter, the lever *G* is depressed, thus starting the threader *E* on its trip across the drum.

Fig. 6 shows the type of image produced by this threader.

Referring to Fig. 3, it will be seen the time of opening and the time of closing of the shutter is represented by the tapering

FIG. 6.

ends of the image. The length of this taper varies with different makes and types of shutters and the diaphragm opening used. It is the factor in determining the efficiency of the shutter. However, it is of interest to note that for the same shutter and diaphragm the length of the opening and closing periods is unvaried

by a change of the speed setting of the shutter. The following table gives the result on some shutters tested.

TABLE

Shutter	Marked speed	Actual Speed	Time fully open	Time of opening	Time of closing
No. 1	1/150 = .0066	.0235	.0165	.0045	.0025
	1/100 = .01	.0220	.0150	.0045	.0025
	1/50 = .02	.0235	.0160	.0050	.0025
	1/25 = .04	.2490	.....	.....	.....
	1/5 = .2	.2980	.....	.....	.....
	1/2 = .5	.3290	.....	.....	.....
	1 = 1.0	.2640	.....	.....	.....
No. 2	1/300 = .0033	.0150	.0080	.0035	.0035
	1/200 = .005	.0230	.0155	.0035	.0040
	1/100 = .01	.0255	.0180	.0035	.0040
	1/50 = .02	.0295	.0130	.0030	.0035
	1/25 = .04	.0360	.....	.....	.....
	1/5 = .20	.1940	.....	.....	.....
	1/2 = .5	.5570	.....	.....	.....
No. 3	1 = 1.0	.7140	.....	.....	.....
	1/100 = .01	.0190	.0113	.0038	.0039
	1/50 = .02	.0220	.0151	.0034	.0035
	1/25 = .04	.0810	.....	.....	.....
	1/5 = .2	.1460	.....	.....	.....
	1/2 = .5	.3590	.....	.....	.....
	1 = 1.0	.5040	.....	.....	.....
No. 4	1/150 = .0066	.0155	.0060	.0035	.0060
	1/100 = .01	.0165	.0040	.0030	.0095
	1/50 = .02	.0220	.0095	.0030	.0095
	1/25 = .04	.0810	.....	.....	.....
	1/5 = .2	.1000	.....	.....	.....
	1/2 = .5	.2110	.....	.....	.....
	1 = 1.0	.4960	.....	.....	.....
No. 5	2 = 2.0	1.0300	.....	.....	.....
	1/250 = .004	.0056	.0017	.0021	.0018
	1/100 = .01	.0070	.0034	.0020	.0016
	1/50 = .02	.0328	.0287	.0020	.0021
	1/25 = .04	.0810	.....	.....	.....
	1/10 = .1	.1180	.....	.....	.....
	1/5 = .20	.2220	.....	.....	.....
	1/2 = .50	.4970	.....	.....	.....
	1 = 1.0	.8460	.....	.....	.....

Shutter efficiency and the mathematics involved will not be dealt with in this paper. It is proposed in the near future to make a study of the influence of the various types and number of shutter leaves upon the efficiency and illuminating power of the shutter. The various driving mechanisms will be studied (*i.e.*, air, spring, and gear-driven) with a view to finding the most satisfactory method of actuating the shutter. These topics will be dealt with in a later communication.