PHYSICS

"Quicker'n A Wink"

New Photographic Method "Freezes" Fastest Motions; Useful in Studies of Most Varied Physical Phenomena

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See Front Cover

QUICK as a wink is a great deal too slow.

This proverbial epitome of speed is beaten a dozen times over by the newest trick in scientific high-speed photography, which can take thirteen "frames" of motion pictures of a human eye during the fortieth of a second it spends in getting shut. It doesn't even need to extend itself in doing it, either, for it is able to make a perfectly clear and sharp picture in a hundred-thousandth of a second.

The new apparatus has been developed at the Massachusetts Institute of Technology by two engineers, Dr. H. E. Edgerton and K. J. Germeshausen. It can be used for either motion pictures or "stills," or for visual observation of rapid revolving or vibrating machinery.

The new method was not evolved just for amusement. Wink-measuring was done just as a stunt, to show how fast it can work. It is expected to earn its way in the world by aiding engineers in the study of such things as the fast-whirling rotors of electrical machines, the surging springs of automobile valves, the mechanisms of motion picture projectors—all those thousand important mechanical motions that are only a blur to our unaided eyes. It will be of use also in the scientific laboratories where the basic principles underlying all these machines are being investigated, both for further improvements and for the increase of human knowledge for its own sake.

The new device is not a camera, does not concern itself at all with photographic technique. Any old kind of a camera can be used with it, provided it has a decent lens and a fast film. The invention of the "Tech" engineers concerns itself with the other half of photography—the light source. It is simply a means of getting a full blaze of light on and off again in a hundred-thousandth of a second, and of timing that brief flash so that it will come exactly when needed, and as often as needed.

Ordinary cameras, both motion-picture and still, assume a steady source of light—the sun, Kleig lamps, or what have you. They slice off bits of this unending flow to suit their own convenience by adjusting the shutter time.

But a camera shutter is a mechanical device that requires time—even though a very short time—to operate. For some of the very fast motions in the mechanical world no shutter can be made to open and shut fast enough. Why not, then, devise a light that can be turned on and off with extreme quickness, thus delivering it to the camera already sliced up and thereby doing away with the need for a shutter?

Compact and Portable

This was the problem to which the two engineers addressed themselves. They were not in wholly unexplored territory. High speed photographic apparatus had been built several times in the past, some of it fast enough to catch bullets as they came out of the muzzles of guns. But this apparatus was elaborate and usually bulky, and anything that was to be studied had to be brought to it. Dr. Edgerton and Mr. Germeshausen wanted something compact and portable, that could be carried into the shop, the laboratory, the studio, and pointed anywhere, at anything. Their success in constructing such a machine marks the beginning of a new epoch in the scientific study of things that happen quickly.

The problem which the two engineers faced was twofold. First, there must be some kind of light that reached full brilliancy and then went to complete extinction in the smallest fraction of a second. Ordinary lamps wouldn't do: you can see them light up and fade out with the unaided eye. No hundred-thousandth-of-a-second work there!

An electric spark would do the trick. The spark that leaps across the gap in a spark-plug does so practically instantaneously. So does the much bigger spark we call a lightning-stroke, leaping the half-mile gap between a cloud and the earth. Good photographs can be taken by lightning, and good photographs can be made in the laboratory with artificially produced electric sparks. For some kinds of work sparks can be used with the new apparatus.

But for most purposes a steadier, more controllable light was desirable. The two engineers turned to the mercury vapor lamp. Lamps of this type consist essentially of a tube from which almost all the air has been pumped, and into the vacuum a little mercury vapor is introduced. Most lamps have a puddle of mercury as a part of their regular makeup. When electricity is discharged through this mercury-filled partial vacuum, it causes the vapor to shine with an intense bluish-violet light, especially good for photographic purposes. Also, a vapor lamp of this type flashes on and off just about as quickly as an electric spark.

The second part of the program was to get a lot of electricity piled up, and then to dump it through the spark gap or vapor lamp in as short a fraction of a second as possible, to make the light highly intense as well as practically instantaneous. For this, the right kind of a condenser was necessary. Under natural conditions, a cloud, an area of ground, serve as condensers, which eventually discharge through a lightning stroke. On a smaller scale, something of the kind was done artificially in the new apparatus. A sufficient electricity-accumulating surface was provided, with means for letting its load dump suddenly into the mercury vapor lamp at the will of the operators. This was so adjusted that it could be charged and discharged a thousand or more times a second, giving a brilliant flash of light each time the charge leaped through.

A Versatile Lamp

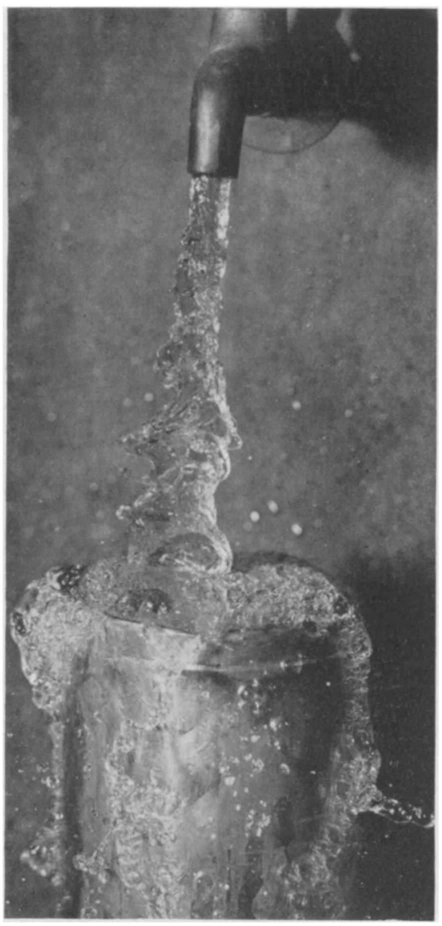
The application of this fast-flashing lamp is simple. There are several ways of making it work. One or two examples will suffice for illustration:

You have an electric motor spinning at a rate of 1800 revolutions a minute. You want to see how its rotor is working. You attach an electric contact to the shaft, so that every time it turns over it sets off the vapor lamp. The lights lasts only a hundred-thousandth of a second, while the rotor is in one position. The rest of the time it is dark.

But since that flash comes 1800 times a minute, it seems practically continuous light to the human eye, and you see the spinning rotor as though it were standing still. You can take photographs of it as though by sunlight.

A different kind of a problem: You are a golf ball manufacturer. You want to know what happens to your product when Jones or Sarazen takes a whack at it. This time independent means are provided for making the light flash on and off again several hundred times a second. A light wire electric trip is set just in front of the teed-up ball, so that the club-head will brush it a split-second before it strikes the ball and thus turn on the light.

Alongside is a motion picture camera, with the mechanism modified so that the film will run continuously, not with the start-stop motion used for ordinary purposes, in which the film has to be stopped while the shutter opens and closes, and then moves on again. In this camera the film keeps moving, but is timed with the light so that one "frame" will be exposed each time the light flashes.



LIKE A CRYSTAL ORNAMENT

Water pouring out of a faucet, "frozen" in its fall by camera that gets pictures in a hundred-thousandth of a second.

You swing. The light flashes on, the ball sails off; after a moment the camera stops. The job is done. When the film is developed, this is what you see: At the moment of impact, the ball flattens —flattens most decidedly against the club. It squeezes out, up-and-down, into a slightly egg-shaped form. Then, as it leaves the surface of the club, its good resilent rubber reacts, and it flattens and widens in the other direction, becoming egg-shaped on its crosswise axis. Then a second reaction sets in, and the vertical axis lengthens out a bit, but not so much as on the first compression. All these changes, studiable in detail, take place before the ball has got half an inch away from the face of the club!

These are only a couple of the many possible diverse uses to which the new apparatus can be put. Doubtless new ones which the inventors never dreamed of will develop as new investigators turn this new tool on their problems.

Even the "stunt" photographs they made with it while it was still in the developmental stage show curious and often beautiful effects. One can see, for example, how the splash a drop of liquid falling on a hard surface produces differs from that produced by a drop falling on a liquid surface. The drop falling into a film on a hard surface raises a thin rim around a cleared circle. The rim is lifted at even intervals into sharp little points, each crowned as with a bright pearl!

Solid Inflexible Water

The drop falling into a puddle, on the other hand, first makes a little depression or crater. Then the sides of the crater rush towards the bottom. They produce there a sharp little point or spine; it leaps upward so violently that it throws several tiny droplets straight up into the air.

Another curious and beautiful photograph was made of water pouring out of an ordinary kitchen faucet. So fast was the photography that the jet of liquid seems to be as solid and inflexible as the glass it is filling.

The golf club came into action again when the break-up of an electric lamp was studied. The lamp was screwed into a socket on the floor, and the club shattered it, striking it in the neck. The photograph shows that an electric lamp does not break all over at one "pop", as it sometimes seems, but that the major break comes first where it is hit, and the cracks spread over the rest of it, with something of a lag the farther they get away from the club-head.

Even these so-called "stunt" pictures suggest possible uses, both in technology and in straight research. Golf balls are not the only things that have to "stand and take it". There are all sorts of machine parts that have to stand up to hard blows, and either resist them or bend just the right amount and in the right direction before them. Automobile valve springs, for example. And the new method has already been applied to the study of the valve-spring problem, to show how the spring action travels in waves.

A Hint for Astronomers

Even the falling, splashing drops of liquid carry much promise for both engineering and physics. Things we do not know as yet about the speed and efficiency with which dropping oil spreads over bearings which it is to lubricate, or dropping water over surfaces it is supposed to keep moist, will doubtless be revealed by further studies of falling drops. Physicists can probably make use of strobo-movies of drops to gain more accurate knowledge of the viscosity, or "thickness", of liquids.

There may even be a hint for astronomers in the curious up-darting of a pointed "spine" when a drop falls into a mass of liquid. In many of the "craters" on the moon there are solid central spines that look like giant replicas of the tiny points in the strobo-movies. One theory of the origin of lunar craters holds that they were caused by huge meteorites splashing into the moon, either while it was still a semi-liquid mass or else partially liquefying the lunar crust at the point of impact. A study of these "splash-spines" might be worth while for the students of the skies.

The possibility of getting a dozen serial photographs of the same wink or other quick muscular action may prove valuable to physicians. It is not unlikely that a man with St. Vitus' dance or some other nervous disease will wink, or snap his fingers, or tap with his toe, quite differently from a normal person's corresponding action. It may be that future diagnosticians will study strobo-movie wink analyses as they now study pulse rates or knee-jerks.