SPECIAL ARTICLES

STROBOSCOPY BY MEANS OF IMPRESSED EYE MOVEMENTS OR MIRROR VIBRATION

THERE are two general conditions which have been met in producing stroboscopic effects. First, a series of impressions of similar objects appear at the same position on the retina. Second, there is a light stimulus which is intermittent at approximately the same rate as the number of objects passing a given point per second.

A familiar procedure in demonstrating stroboscopy is to revolve a disk with equidistant radii, shown in Fig. 1, and light it intermittently with a commercial

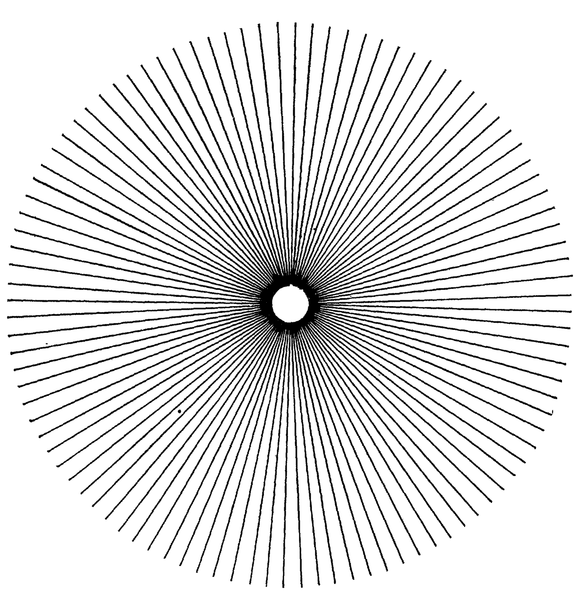

FIG. 1.

neon bulb placed in the A.C. lighting circuit. It is generally necessary to place the disk and neon bulb in a dark place. The disk has 100 radii and is revolved once per second on a phonograph turntable. An alternating current of 50 cycles per second gives 100 flashes of light per second, so that the number of radii on the disk passing a given point is the same as the number of flashes. Under these conditions the radii all come into view and appear to the eye to be stationary. The explanation is that, every time the light flashes, the imprint of the disk is the same on the retina. The successive impressions are fused because of retinal lag.

At the Ithaca meeting of the American Psychological Association in September, 1932, the writer read a paper explaining the method of producing stroboscopy by vibrating the eye instead of using an intermittent light stimulus. Since then it has been found that the same effects may be obtained by vibrating a mirror, viewing the effects in the mirror. Both procedures have their conveniences.

The original experiment was performed with a 50 dv. electrically-driven tuning-fork. It was pressed against the back of the head. When the disk with 100 spokes shown in Fig. 1 was placed on a phonograph turntable revolving 60 r.p.m., the spokes vividly appeared to be standing still. Any intense vibrator pressed against the bones of the head can be used.

If a vibrating tuning-fork is held against the bones of the head, the eye vibrates at the same rate as the tuning fork. Under such conditions, when one looks at a stationary field of vision, one sees the entire field in vibration, with two apparently stationary fields at the extremes of the vibration and a blurred field between. But looking at a stroboscopic disk with the number of radii passing a given point synchronized with the vibrations of the tuning-fork, one sees the radii. The radii in the direction of propagation of the impressed vibration show a slight elongation. An elongation of the disk radii in Fig. 1 to a distance of 1 mm from its center gives sufficiently satisfactory results. The actual amount of eye vibration is quite small.

The photographed vertical eye-movements of vibrations impressed by means of a barber's vibrator pressed against the back of the head are shown in actual size in Fig. 2 (the photograph has been inked).

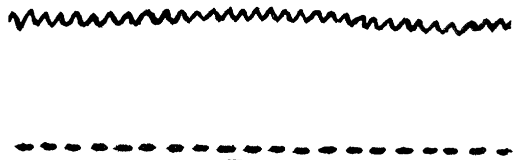

FIG. 2.

The device used was one designed by Mr. W. B. Clark in our laboratory. The motion of the light point image in the eye was amplified approximately 19 times. The retinal movement was calculated to be approximately .2 mm. Observers could detect no movement of the eye at the time of the picture, nor did the writer see any vibration of an after-image of the light source.

It has also been possible to use the voice directly as a vibrator of the eye, but this procedure ordinarily requires training, since the eye-movements are so slight. One sees "shadowy" radii, rather than the clear picture of the radii obtainable with a tuning fork or other electrical vibrator. The vibrations from the larynx are carried by means of bone conduction to the regions surrounding the eyes. The lower pitches, with their greater amplitudes, are more effective than the higher pitches. The following conditions are aids to seeing stroboscopic effects by means of the voice:

(1) The stimulus objects should be long and narrow.

(2) The observer ordinarily should stand further away from the disk than his normal reading distance.

(3) The observer should experiment with the tilt of his eyes. The writer finds that looking at the disk from above with head up is most satisfactory. Evidently what could be called the "moveableness" of the eyes is dependent on the muscular relationships about the eye.

(4) Humming sends the vibrations up near the eyes. Holding a handkerchief to the nostrils makes possible a "bottling up" of the vibrations, letting the breath escape.

(5) The disk should be placed in a bright light, preferably direct sunlight.

The disk shown in Fig. 3 can be used for the deter-

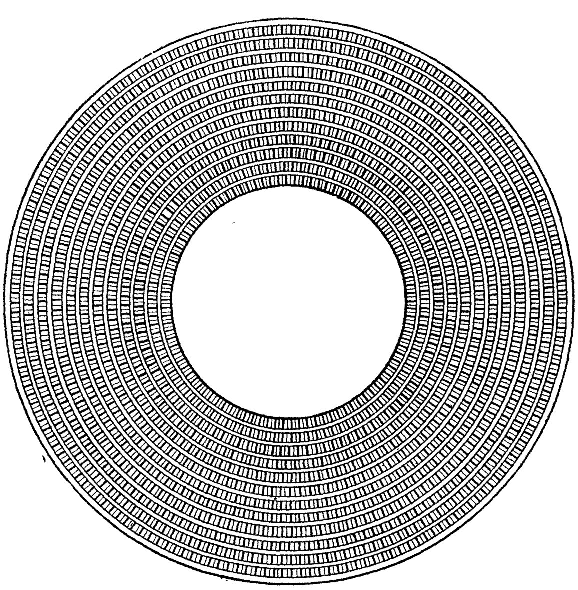

FIG. 3.

mination of the pitch of the voice without any vibrating apparatus other than the voice itself. When placed on a phonograph turntable revolving at a rate of 80 r.p.m., the inner annular ring will appear to be standing still when low C is sung. The successive annular rings, from inside out, have radial lines, the number of which correspond (at 80 r.p.m.) to the number of vibrations per second of each of the half-steps of the even-tempered scale, international pitch.

Another development which may be of interest is the photograph of the "natural period" of the eye shown in Fig. 4. The upper line is a photograph of the vertical eye-movements, and the lower that of the horizontal movements. The time marks represent 1/25 second. The bones to the left of the eye were

FIG. 4.

tapped sharply once to get this effect. The rate of eye-movement is about twelve dv. per second. This may help to explain some of the stroboscopic results obtained in watching automobile wheels. If, in walking, the eye is jarred so that the successive impressions of the spokes are in the same or approximately the same place on the retina, the reported results are definitely and continuously obtainable. The jarring from jaw movements in talking likewise is effective.

Several of us have been able to see the radii standing still continuously in shadowy form without any perceptible movement of the eye or body. Whether this is due to heart-beat, to an intermittent vision inherent in the visual process, or to some other cause we do not know at this writing. We used the disk in Fig. 1 revolving at 60 r.p.m. It should be emphasized that this effect is not the flash effect of the radii which one gets following a single eye-movement.

The use of mirror vibration for producing stroboscopy was first noted by observing the radii of Fig. 1 reflected from a shiny prong of a 100 dv. tuning fork. We are using mirrors on loud speakers instead of neon lights in measuring the pitch of the voice and other sound sources in connection with the disk on Fig. 3 and a new type of tonoscope. The advantages of this method are apparent, *viz.*, the singer need have no training in observation as in direct voice-eye vibrations, and he can observe pitch in the daylight of his studio instead of using a darkened room, as in the case of the present Seashore tonoscopes. The design of the new tonoscope is to be published subsequently with Mr. Harrison Musgrave, Jr.

To generalize, the explanations as to why stroboscopy is seen with both mirror and eye vibrations are similar. When the mirror is in rapid motion, the same vision cycle is present on the retina as in eye vibration. At the extremes of the vibration the visual field appears stationary, though actually intermittent. Between the extremes there is a blurring, also intermittent. Either eye-movement or mirror vibration provides intermittent stimulation of any given point of the retina, which is a necessary prerequisite for stroboscopic vision.

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