

May 23, 1933.

H. BROADWELL
STROBOSCOPIC SYSTEM

1,910,982

Filed April 17, 1930

2 Sheets-Sheet 1

FIG. 1

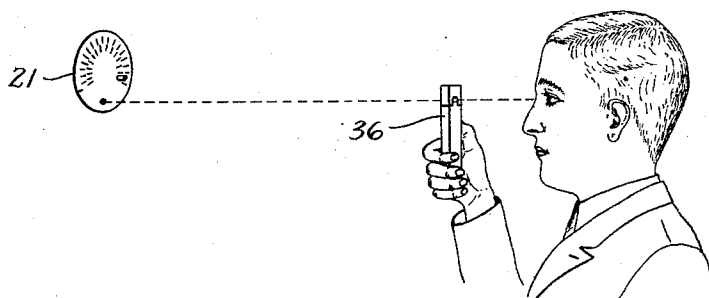


FIG. 2

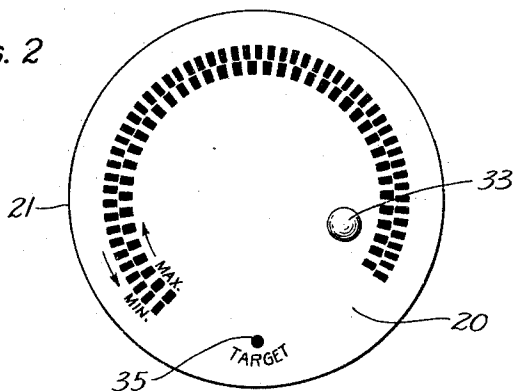
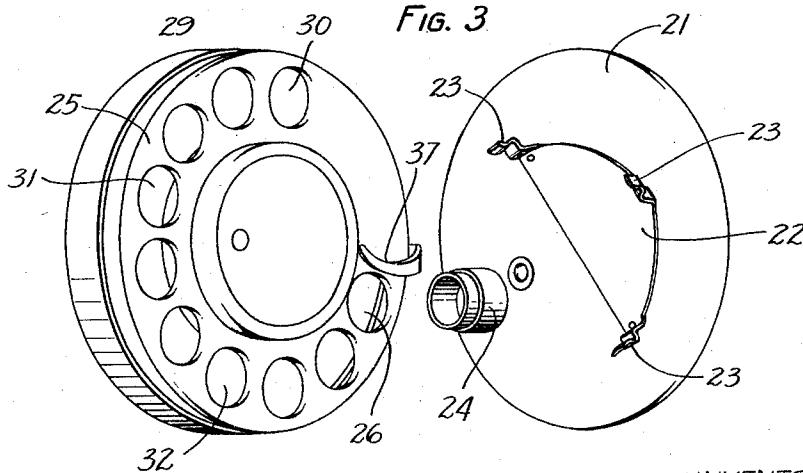


FIG. 3



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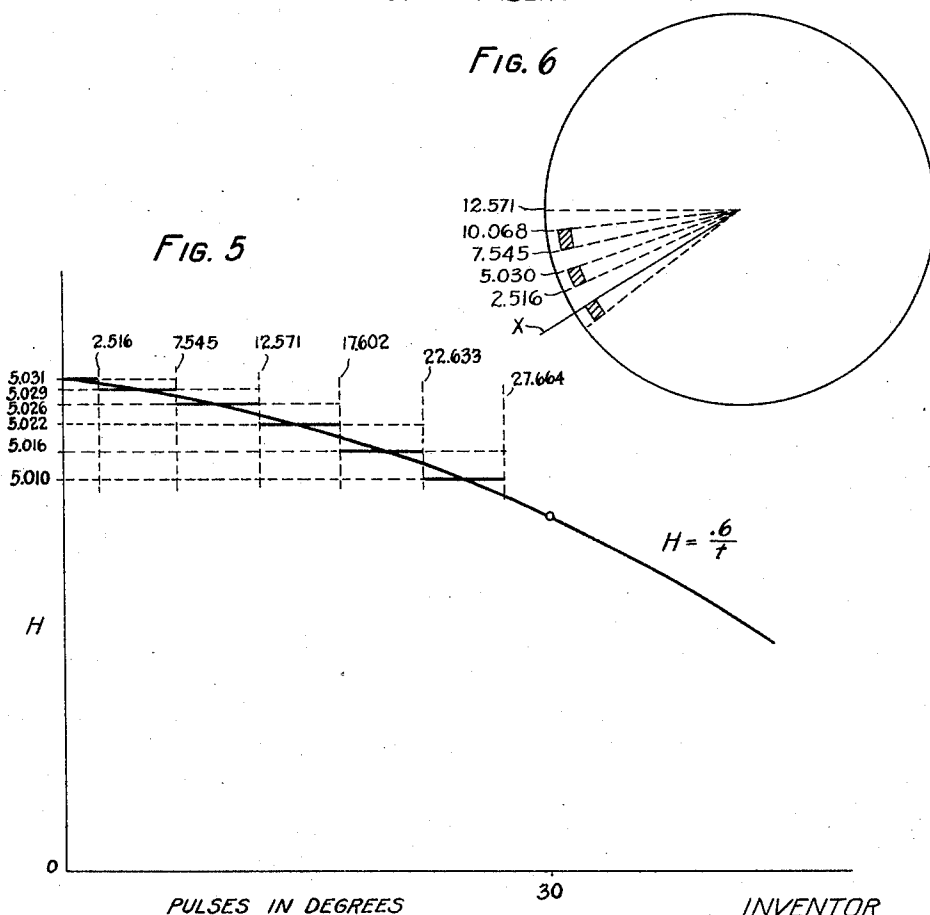
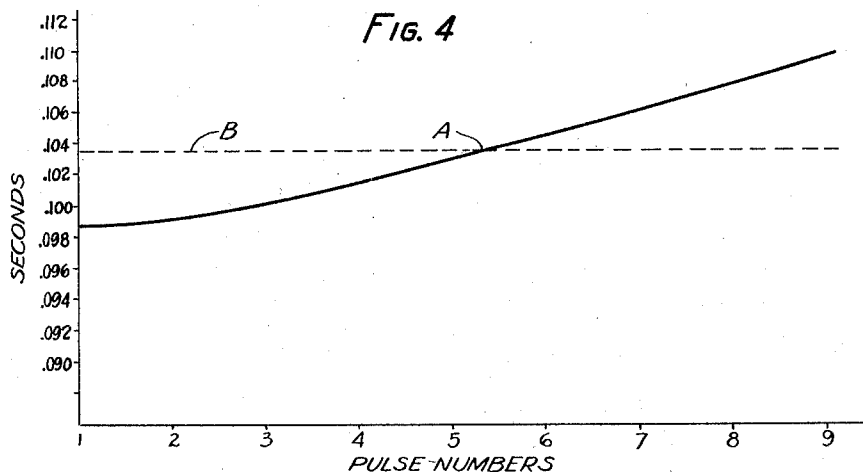
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2 Sheets-Sheet 2



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STROBOSCOPIC SYSTEM

Application filed April 17, 1930. Serial No. 445,182.

This invention relates to systems for determining variations in the speed of rotating bodies and more particularly to stroboscopic systems for observing speed variations in telephone dials.

accuracy upon the theory that a dial so observed, operates at a constant speed, that is, that the dial will be traveling at the same speed of rotation throughout its entire travel.

The present invention is applicable in substantially all situations where it may be desirable or necessary, to make determinations as to the speed or rate of travel of devices characterized by some form of periodic motion. The embodiment elected by applicant for illustrating the invention, discloses a stroboscopic system employed to determine whether the speed of operation of an impulse transmitting device, such as a telephone dial, is within the maximum and minimum speed limits required for the proper operation of telephone automatic switching apparatus controlled thereby. It is not intended, however, that the invention be limited to this particular adaptation.

Automatic switches as employed in telephone exchanges are designed to function accurately when the actuating or controlling impulses are received at a rate which is maintained within certain narrow limits. In order to insure the transmission of impulses within these limits, it is obviously necessary that the impulse transmitting mechanism should be so designed as to guarantee the proper rate of transmitted pulses.

In Patent 1,160,356, issued to A. H. Adams on November 16, 1915, there are disclosed and described a method and means for checking and adjusting the speed of rotation of impulse transmitters whereby it may be determined whether or not the transmitter or dial is functioning at a predetermined rate necessary to transmit pulses within the limits set for the proper functioning of automatic telephone switches. This patent proposes the use of an indicator card provided on its face with series of circumferentially arranged printed or stamped projections, which may be observed through shutters associated with the tines of a tuning fork. Though the system disclosed in this patent readily permits a visible record to be made of variations in dial speed beyond set limits, it depends for its

That there is a variation in the speed of rotation of a dial during a single operation thereof, is well known, and has been observed and recorded by various methods of test. It is apparent therefore, that a system for checking the speed of rotation of a rotating body such as a spring controlled telephone dial, which does not operate at a constant speed throughout its travel, should be such as to compensate for this speed variation in order that the results obtained stroboscopically may be an accurate picture of the workings of the dial and a true record of the dial speed variations within certain set maximum and minimum limits.

It is therefore an object of this invention to provide an improved stroboscopic system whereby variations in the speed of rotation of a rotating body having a non-uniform speed characteristic may be accurately observed.

This object is attained in accordance with a feature of the invention by the provision of an indicator card or stroboscopic target on the face of which is impressed a series of indications, the space occupied by each of which having been determined from the speed characteristic of the rotating body to be tested.

The invention will be readily understood from the following detailed description made with reference to the accompanying drawings which include curves employed in calculating the indicator card or target.

Fig. 1 shows in perspective, the manner in which the improved method and apparatus embodying the features of this invention may be utilized;

Fig. 2 is a view of a stroboscopic target attained in accordance with the method to be hereinafter described;

Fig. 3 is a view of a telephone dial and the target adapter employed in mounting the target on the dial;

Fig. 4 is a graphic representation showing the relation between pulse number and the

average pulse value in seconds of a certain lot of dials;

Fig. 5 is a graphic representation showing how the width of each target indication is obtained; and

Fig. 6 is a view of a target in the making and discloses the method by which the indications are laid out thereon.

The following description is directed in detail to the method employed in obtaining an indicator card, for use in connection with a vibrating tuning fork or an interrupted light source, the indications impressed thereon being so positioned on the indicator and of such size that the number thereof per second, visible when viewed through a vibrating tuning fork or by means of an interrupted light source at any particular point in the revolution, is proportional to the instantaneous speed of the rotating body at that point.

The method to be described for computing the spacings on the indicator or target, is particularly desirable when a great number of dials have to be tested and an average computation of their speed characteristics is essential. However, it is to be understood that the speed characteristics of each dial to be checked could be determined and an indicator designed accordingly. This obviously is impractical, as it would necessitate the calculation of an indicator card for each dial, and when dials by the thousands are to be checked, such individual calculations would be prohibitive. An average indicator card calculated by observing a number of dials over an extended period of time has been found to be satisfactory and truly representative for the checking of all dials.

Applicant has elected to describe in detail the exact procedure followed in obtaining an average indicator card and accordingly, has resorted to the use of specific data obtained during an exhaustive study of dial operations.

Pulse rate data may be obtained by observing a number of dials and the time for each pulse taken over a period of years. From this data may be calculated the average time consumed by each pulse, and a grand average of the total average pulse determined. Such data is shown in the following Table #1.

Table #1

Pulses	1	2	3	4	5	6	7	8	9
0 yrs.....	Sec. .105	.105	.106	.107	.109	.110	.111	.113	.114
2 yrs.....	.096	.097	.098	.100	.101	.103	.104	.106	.108
4 yrs.....	.097	.098	.099	.100	.102	.104	.105	.106	.108
6 yrs.....	.097	.098	.099	.100	.102	.104	.105	.106	.108
8 yrs.....	.098	.099	.100	.101	.103	.104	.106	.107	.109
10 yrs.....	.098	.100	.100	.102	.103	.105	.106	.107	.109
Average.....	.0985	.0995	.1013	.1017	.1033	.1050	.1062	.1075	.1093

Grand average of the nine pulses=.1035 sec.

This average data is then laid out to large scale and a smooth curve (A) (see Fig. 4) carefully drawn with the average pulse rate plotted as ordinates, against pulse number as abscissæ. The grand average (.1035 sec.), is drawn as a horizontal line "B" at the proper place on the curve and the plus and minus deviations from this line for each pulse read off and tabulated as in Table #2.

Table #2

Pulse	1	2	3	4	5
Dev.....	-.00476	-.00420	-.00318	-.00180	-.0028
Pulse	6	7	8	9	
Dev.....	+.00124	+.00276	+.00428	+.00584	

These deviations from the average value are then expressed as percentages, and this percentage

Average pulse deviation

Grand average pulse value

is employed as a factor which is used in the computation of the indicator for various dial speeds such as 8.0 pps., 9.5 pps. etc. The new deviations thus obtained, when added algebraically to the time of one pulse at the new average rate being considered, say 8.0 pulses per second, gives the actual time (t) of that particular pulse:

For example,

Pulse #1 at 8.0 pps. (pulses per second)

$$\frac{-.00476}{.1035} \times \frac{1}{8.0} = -.00575$$

$$-.00575 + \frac{1}{8.0} = .11925 = t$$

Knowing the time (t) for each pulse, it is now possible to calculate the size of the division corresponding thereto on the stroboscopic target or indicator card, as follows:

Letting H=number of degrees per whole division

t=time of one pulse, as above

D=total number of divisions in 360 degrees if (t) were uniform throughout the revolution

N=revolutions of dial per second to produce pulses of uniform value (t)

F=tuning fork speed in views per second (the value of F is predetermined and in the case in consideration equals 50.)

Then $H = \frac{360}{D}$, where $D = \frac{F}{N}$ and $N = \frac{1/12}{t}$ (one pulse representing 1/12 revolution, since the dial is laid out on a 30 degree basis.)

Substituting and reducing, $H = \frac{6}{t}$ degree.

From this formula, after determining (t) for each pulse, as shown above, the corre-

sponding angles H can be directly computed. Thus for #1 pulse at the average or nominal rate of 8.0 pps.,

$$H = \frac{.6}{t} = \frac{.6}{.11925} = 5.031 \text{ degrees.}$$

A smooth curve of H versus pulse number is then plotted to large scale, the first pulse number being indicated on the curve as starting at zero degrees, and the succeeding pulse numbers being shown thirty degrees apart. (See Fig. 5.)

At the zero degree or first pulse position, the width of the first division on the target is taken directly from the curve (Fig. 5), and in the case considered, this value equals 5.031 degrees. This division is laid in horizontally on the graph (Fig. 5), with its center on the zero center line. The end of this division therefore stands at half this distance, or 2.516 degrees from the zero position. The end of the second division will stand at approximately $2.516 + 5.031$ or 7.547 degrees, ignoring for the moment the effect of the drop of the curve. Plotting in a vertical line through point 7.547 degrees, a horizontal line representing the second division is drawn with its midpoint passing through the curve. The height of this line measured from the base line, or 5.029 degrees is then the length of this division to three decimal places. Succeeding divisions are determined in the same manner, stepping along the curve as described below until the full pulse range of the dial is covered.

One half the length of the first division of 2.516, plus the true length of the second division or 5.029 equal 7.545 degrees, which is the distance from the zero position at which the end of the second division will be located. In like manner the end of the third division will be located from the zero position a distance equal to 7.545 plus the true length of the third division as read from the curve (5.026 degrees) or 12.571 degrees. These computations are continued and the values 2.516, 7.545, 12.571 etc. or tabulated. This data is then laid out accurately to large scale and the spaces divided in two, one half being filled in black and the other left white.

From the foregoing it is evident that the exact length of each division throughout the entire range of the dial may be read from the curve, and it will be noticed that instead of each division being of the same length (5.031 degrees), as would be the case should the dial operate at an exactly uniform speed of rotation, each succeeding division is smaller as accounted for by the drop in the curve.

A reference line X on the indicator card (Fig. 6) is now chosen and the divisions, as determined above, drawn in. The first whole division (5.031 degrees) will be bi-

sected by the reference line, a black division (2.516 degrees) lying on one side of the reference line and a white division (2.516 degrees) lying on the opposite side. The end of the next black division will then be

$$2.516 + \frac{5.029}{2}$$

or 5.030 degrees from the reference line and the end of the succeeding white division $2.516 + 5.029$ or 7.545 degrees from the reference line. The indicator card or stroboscopic target may contain as many circumferentially plotted series of divisions as are found desirable, though two rows have been found to be the most practical.

The target shown in the drawing Fig. 2, discloses two series of divisions one plotted for the minimum dial speed (eight pulses per second) and the other for the maximum dial speed (eleven pulses per second).

It is evident from the foregoing description that applicant has devised a stroboscopic target, the indications of which, to be viewed through a vibrating tuning fork, or by means of an interrupted light source are designed as to size and location on target, in accordance with the speed characteristic of the rotating body with which it is to be used. It is equally apparent that a rotating body equipped with a target of this design may be more accurately and more readily studied and its variations in speed of rotation from certain set limits more precisely determined.

Referring now to Figs. 1, 2 and 3, the target which in itself consists of a thin relatively stiff cardboard disc 20, or the equivalent, is mounted in any suitable manner on the adapter 21. Secured to the underside of the adapter 21 is a semi-circular element 22 provided with three downwardly extending prongs 23. A cylindrical cap-shaped element or stud 24 is also rigidly mounted on the under surface of the adapter. The cap 24 and prongs 23 are so positioned that when the adapter is fitted on the dial 29, the stud fits into the zero hole 26 of the finger wheel 25 and the prongs 23 engage the inner surface of the finger holes 30, 31 and 32. The prongs 23 are so formed as to effect a positive engagement of the adapter with the finger wheel. A handle 33 rigidly mounted on the adapter, is provided as a means for manually rotating the target. The stud is located in the zero hole of the finger wheel in order that the full pulse range of the dial to which the target was laid out may be obtained. The position of the target on the adapter is so chosen that the mark 35 stands conveniently towards the observer when the dial is fully wound.

When in operation the target is clamped to the finger wheel by means of the cap 24 and prongs 23. The observer then grasps a

tuning fork preferably of the type shown in the copending application, Serial No. 378,157, filed July 13, 1929, and sights the target indication 35 through the fork tines, which may be partially distended to permit a clear view of the indication 35. Maintaining the fork shown at 36 in this position, the observer grasps the handle 33 and rotates the finger wheel 25 until the cap-shaped element 24 strikes the finger stop 37. The fork tines are then actuated and the finger wheel released. On the return movement of the dial the two rows of indications may be observed, and any apparent relative movements of the indications will determine whether or not the dial is operating at the desired condition of speed. Should the outer row of indications appear to stand still the dial will be operating at its minimum speed limit, in the present case, eight pulses per second. If the inner row appears to stand still the dial is working at its maximum speed, or eleven pulses per second. A clockwise movement of the inner row of indications and a counter-clockwise movement of the outer row when viewed through the vibrating tines of the fork indicate that the dial is operating at a speed within the two limits. In observing the dial through the tuning fork 36 the most accurate results when the divisions appear to be nearly standing still are obtained when the fork is held close to the dial and the eye of the observer at a distance from the sighting aperture in the fork mechanism. At other times the fork may be held for convenience, as shown in Fig. 1.

What is claimed is:

1. In combination with a rotating body having a non-uniform speed of rotation, an indicator suitably mounted on said body and bearing a plurality of irregularly spaced indications the size and location of which on the indicator bear a direct relationship to the non-uniform speed characteristic of said rotating body.

2. In combination, a rotatable body having a non-uniform speed of rotation, an indicator suitably mounted on said body and bearing a plurality of irregularly spaced indications the size and location of which on the indicator bear a direct relationship to the non-uniform speed characteristic of said rotating body and means for stroboscopically viewing the indications on the indicator during the rotation thereof.

3. In combination, a rotatable body having a non-uniform speed of rotation, an indicator mounted on said body and bearing a plurality of irregularly spaced indications the size of each of which bears a direct relationship to an instantaneous speed value of said rotatable body and each of said indications located on said indicator in such a manner that when the indicator is positioned

on the rotatable body each indication may be observed stroboscopically at the instant in which the rotatable body is traveling at the instantaneous speed value corresponding to the indication observed.

4. In combination with a rotating body having a non-uniform speed characteristic, an indicator associated with said rotating body and having a plurality of irregularly spaced indications, the sizes of which bear a relationship to the non-uniform speed characteristic of said rotating body and means for stroboscopically viewing the indications on the indicator during rotation of said rotating body.

5. In combination with a rotatable telephone dial having a non-uniform speed characteristic, means supported by said dial bearing an annular non-uniform series of indications rotatable in unison with said dial and means for stroboscopically viewing the indications, the size of each of said indications bearing a relationship to an instantaneous speed value of said non-uniformly rotatable dial.

In witness whereof, I hereunto subscribe my name this 16th day of April, 1930.

HOWARD BROADWELL.