

Feb. 17, 1931.

F. SCHRÖTER
ELECTRIC LIGHT RELAY
Filed Jan. 5, 1927

1,792,766

Fig. 1

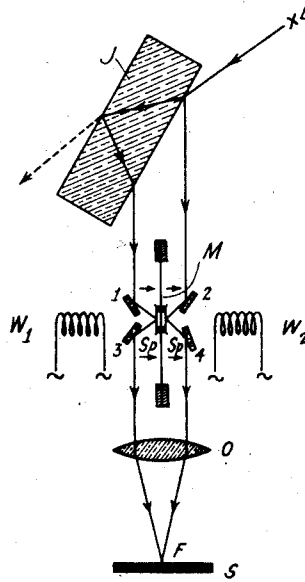
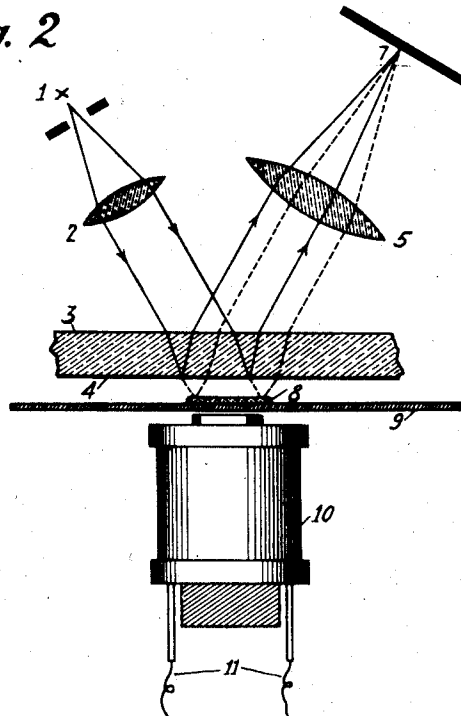


Fig. 2



INVENTOR
FRITZ SCHROETER
BY *Fra J. Adams*
ATTORNEY

UNITED STATES PATENT OFFICE

FRITZ SCHRÖTER, OF BERLIN, GERMANY, ASSIGNOR TO GESELLSCHAFT FÜR DRAHT-
LOSE TELEGRAPHIE M. B. H. HALLESCHES, OF BERLIN, GERMANY, A CORPORATION
OF GERMANY

ELECTRIC-LIGHT RELAY

Application filed January 5, 1927, Serial No. 159,077, and in Germany January 9, 1926.

The subject-matter of the invention is an electric light relay for controlling light in dependence with variations of electrical quantities. The invention distinguishes itself especially by its high sensitivity, and it can, therefore, be controlled by very feeble electric energies. A relay of this type is of varied and wide application, for instance, for measuring purposes, for the registration or recording of electrical quantities by light, as in fono-film recording work, and also adaptable to photo-telegraphy, high-speed telegraphy, and similar uses.

According to this invention, small motions occasioned by electric or magnetic controlling forces are utilized for changing the path, or changing differences in the paths, of interfering luminous rays. Hence, fundamentally speaking, the invention consists in that the primary electric variations cause changes in the path of light in an interferometer arrangement of convenient kind, so that, according to the phase differences thereby obtained, the amplitudes become added with positive or with negative signs. After combination of the light rays, there results, therefore, light or dark record, or an intermediate value governed by the difference in path of the interfering luminous rays. The light relay is quantitative in its action. Differences in path are accomplished, for instance, by means of mirrors which are actuated or moved by electric or magnetic forces either directly or indirectly.

Among the objects of my invention are, therefore, the production of a light controlling relay which is of high sensitivity; a relay which will respond to feeble electric currents; a relay in which a large effect is produced from a very small mechanical motion; as well as other objects which will be apparent when the following specification and claims are considered together with the accompanying drawing which forms a part of my disclosure.

Two embodiments of the invention are illustrated in the accompanying drawing, wherein:—

Fig. 1 is a diagrammatic showing of a system using parallel light rays; and

Fig. 2 is a diagrammatic showing of a similar system in which an electromagnetically operated diaphragm is employed.

Making reference to the drawing, Fig. 1 illustrates in diagrammatical form the underlying physical principle of the invention which can best be explained by referring to the path of the ray issuing from luminous source L. The ray whose path is shown more clearly by arrows impinges on a plane-parallel piece of glass J which may be, for example, Jamin plate or interference refractor, at a certain angle of incidence. Part of the light is directly reflected from the surface of J, while another part is refracted in the glass, and is then reflected at the rear wall thereof which, if necessary, is provided with a mirror or reflector surface, and this portion of the light issues parallel and coherent with reference to the directly reflected ray as shown on the drawings in Fig. 1. By making the silvered reflecting surface partially transparent, the light intensities of the directly reflected part and the part issuing after reflection at the rear wall of plate J are regulated so that they are more or less alike. It is possible to act electrically either upon only one of the rays on its path, or, if preferred, upon both of them.

The arrangement, as shown, operates symmetrically in order that harmful effects such as temperature differences of the equipment, etc., may be eliminated, and for this reason a differential arrangement is used. In the differential arrangement, the diaphragm M moved by the electric or magnetic controlling surfaces has a mirror Sp upon both faces. Each of these mirrors reflects one of the two separate coherent rays by the aid of mirrors 1 and 3, or 2 and 4, respectively, disposed at

the proper angles, whereupon both rays continue their course, being thereupon, in the shape of parallel rays, passed through the lens O and combined in focus F on the light-sensitive bearer or support S where they are caused to interfere. Support S may be a film, a photographic strip of paper, or the like, either stationary or in motion; furthermore, in case of measurements, a photo-electric cell or another light indicator capable of recording the laws or conditions of the diaphragm motion dynamically. It will be understood that the amplified current of a photo-electric cell would permit the graphic recording of the diaphragm motions at different frequencies in an exact manner, if the mirrors Sp (which is advantageous for all applications) are replaced by applying directly a silvered surface and by polishing the diaphragm surface M. This would seem only an indirect way, and it should be kept in mind that for small amplitudes of M direct photographic recording only by the aid of the vibration or motion of light rays reflected from Sp would not be accurate enough.

The movement of the diaphragm M is produced electromagnetically by means of turns $W1, W2$, of a coil surrounding a magnet (not shown); electro-dynamically, for instance, by means of a pot-shaped magnet and a current coil embraced by its field and connected with M; electrostatically by means based upon the same principle as the condenser telephone; thermally by utilizing the heat conversion of the controlling current in such a manner that M experiences a convenient deflection; or by any other known manner. It is a good plan to give M a very high natural frequency sufficiently above the frequencies to be recorded, or else to make it strongly damped, so that inside the working range all resonance may be flattened. In the range of very small amplitudes produced by M, in order to cause extinction of interference or brightening of the rays, the deflection of M can be made proportional to the acting force. In the arrangement shown, the permissible maximal shift of the diaphragm required for extinction of full light, which may be assumed to just correspond to the position of rest of diaphragm M, is of the order of magnitude of $1/8$ th of a light wave length; and this, in the case of blue light, of a wave-length of 400 micromicrons ($\mu\mu$) would correspond to 0.00005 mm.

In the light of what precedes, care must be taken so that the active forces will cause the diaphragm to be displaced unilaterally, if the device is to work in the manner of a detector or rectifier; in other words, if, for instance, the low frequency enveloping curves of a modulated carrier wave are to be recorded upon a traveling film in the shape of different degrees of blackenings. A case of this kind would arise, for instance, in connection

with phototelegraphy where the arrangement, as hereinbefore described, may be used to advantage with a view to responding even to feeble currents, in other words, very small amplifications.

Instead of working with exactly parallel rays as shown in Fig. 1 which are united at a point F, conditions in practice will mostly be such that rays coming from different direction are dealt with. In this case, according to the kind and nature of the arrangement, there will arise interference bands (fringes) or curves. These shift in proportion to such differences in path as may occur in the interfering rays. In order to utilize such an arrangement for a light relay, the picture of the interference fringes or curves is brought upon a diaphragm produced according to these, most preferably photographically, the diaphragm thus consisting of a congruent sequence of lines or stripes permeable and opaque to light. If the interference picture or image is displaced over this diaphragm by the highest admissible amount equalling half the width of a stripe, the quantity of light passing through the diaphragm varies between the two limiting values, for example, if in the initial position the opaque portions of the diaphragm just cover the light interference zones, it follows that the volume of light allowed to pass is equal to zero. However, in case of a shift equalling one-half the width of the stripes (fringes), the light interference stripes will fall upon the transparent portions of the diaphragm, and the passing light attains its maximum value. In the rear of the diaphragm, the rays can then be recombined by means of a lens system so as to constitute a luminous spot useful for photographic or other purposes. In this manner, the light source is utilized more efficiently.

Another form of construction according to the basic idea of the invention is shown in Fig. 2, this arrangement comprising electromagnetic controlling means. The rays coming from a luminous source of an illuminated slit 1 are rendered parallel by the aid of a lens 2, and are made to strike obliquely a plano-parallel glass plate 3. The portions which are directly reflected are not considered here; they amount to about 4%. The major part of the radiation, after refraction on the transparent mirror surface 4 on the rear of glass plate 3 is partly reflected, and partly allowed to pass and thereupon reflected at the plane mirror 8 carried on diaphragm 9, a directly applied mirror or reflector surface being used, if desired, instead of mirror 8. For vibrating the said diaphragm and the mirror 8 there is used the excitation of the telephone electromagnet denoted by 10 having supply leads 11. In order to insure unilateral displacement of the diaphragm, the same must be given bias by supplying coil 10 with D. C., or by means of polarized cores.

The rays reflected from mirror 8 over different paths are indicated by broken lines. All of the rays are brought to interfere through a lens 5 in the focus 7 on surface 8.

5 The resultant light action, as will be seen, is here caused or changed only by the amplitudes of one reflector 8. The reflector effect or the transparency of 4 is again so regulated that the partial ray reflected at 4 has the same intensity as the one coming from 8 after re-
10 entrance in the glass. In this case, the ray indicated by the solid line and the one shown by the broken line possess the same intensity when striking 6, so that, on coming to inter-
15 fere with a phase (path) difference equalling an even multiple of the wave-length, they result in maximum brightness, while they result in minimum brightness in the presence of a phase difference of $1/2$ wave length, $3/2$ wave length, $5/2$ wave length, etc. Slight
20 phase or path differences associated with slight lateral displacement of the dotted ray in case of parallel motion of mirror 8 due to different thickness of the lens, do not play
25 any part as to their order of magnitude.

Instead of electromagnetic control by the turns of coil 10, will be readily understood, also in this case electrodynamic, thermal, or capacitive movements of the diaphragm or
30 membrane 9 can be provided. In case of choosing the capacitive (telephone) arrangement, the reflector 8 and the upper coat of the dielectric can be combined.

The diaphragm 9 or M, of Figs. 2 and 1 re-
35 spectively, hereinbefore provided is not absolutely required for the movement of reflector 8 or $SpSp$, respectively, as other electrically or magnetically actuated elements which are as free from mass and inertia as
40 possible could be substituted, such as, for example, reeds, cords, or the like. Instead of a mirror, other optical means of small mass or low inertia may be employed, for instance, glass wedges. Differences in intensity of the
45 interfering components may be compensated by grey wedges shiftable parallel to one another in the path of one of the rays.

Having described my invention, I claim:—

50 1. In an electric relay system, a path of interfering luminous rays, vibratory means for changing the path and phase relationship of each of said interfering rays, means for directing said changed rays to a light sensitive recording means whereby a record of the
55 light intensity as a function of the said vibratory motion is produced.

2. In an electric relay system, a plurality of luminous rays, light reflecting means in the path of said rays, vibratory means in the
60 path of said reflected light for changing the phase relationship of both of said reflected light rays and producing interfering light rays, means for redirecting said changed light rays from said vibratory means, and a
65 light sensitive recording means for receiv-

ing said redirected changed light, and producing a record of the light intensity as a function of the said vibratory motion.

3. In an electric relay system, a light source, a plurality of luminous rays issuing from said source, a reflecting surface in the
70 path of said luminous rays for reflecting a part of said rays at a predetermined angle with respect to said surface, a vibratory means associated with said reflecting surface, a second reflecting surface carried by said
75 vibratory means for reflecting the part of said luminous rays passing beyond said first named reflecting surface, means for vibrating said vibratory system in accordance with variations in electrical energy pulses where-
80 by the part of said luminous rays reaching the reflecting surface carried by said vibratory system are redirected from said vibratory system with a difference in phase
85 proportional to a signal intensity controlling said vibratory system, and a recording means for recording said redirected rays from the path of said reflected surface and producing records of varying intensities in proportion
90 to the phase difference of said reflected light.

4. An interferometer comprising a light source and a pair of reflecting surfaces from which appropriate portions of the light
95 beams issuing from said source are reflected, and means for producing vibrations in each of said surfaces in accordance with applied energy pulses.

5. A light valve consisting of an interferometer, and means for oppositely varying
100 the optical length of each of the coordinate light paths in said interferometer in accordance with applied energy pulses.

6. A light valve consisting of an interferometer, and vibratory means for varying
105 the optical length of both of the coordinate paths of light through said interferometer.

7. In an interferometer construction, a light source and a pair of light reflecting
110 bodies in the path of the rays issuing from said source, and reflecting the said beams along different paths, and means for changing the position of both of said bodies in accordance with applied energy pulses for varying the light interference between said
115 reflected beams as a function of the applied energy pulses.

8. An interferometer comprising a light source, a screen, a pair of light reflecting
120 bodies for reflecting light from said source along coordinate independent paths to said screen, and means for varying the length of each of said coordinate paths in accordance with applied energy impulses, and thereby varying the interference between the said
125 light upon said screen from each of said paths.

9. An interferometer comprising a light source, a screen, a pair of light reflecting
130 bodies for reflecting the light beams issuing

from said source along a pair of coordinate paths to said screen, and a vibratory means for moving both of said reflecting bodies in a vibratory manner in accordance with energy pulses impressed thereon for varying the light opposition between the light beams traversing each of said paths.

10. A light valve comprising an interferometer, and a vibratory means for producing opposite variations in the optical length of each of the coordinate light paths through said interferometer in accordance with the strength of energy impulses applied thereto.

FRITZ SCHRÖTER.

15

20

25

30

35

40

45

50

55

60

65