PATENT SPECIFICATION

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COMPLETE SPECIFICATION.

Improvements in or relating to the Instantaneous Electrical Control of a Beam of Light.

I, Dr. August Karolus, of Linnestrasse 5, Leipzig, Germany, a German citizen, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

The invention relates to a method of and apparatus for the instantaneous control of a beam of light by electrical fluctuation of voltage for use in optically representing or photographically recording periodic variations up to very high frequencies such as required in photo-telegraphy, in television, for sound and speech films, light telegraphy and telephony over short or great distances and similar purposes.

Whilst the methods of light control used in the art for such purposes up to now were limited as regards their usefulness and efficiency partly by the lag, i.e. distortion at high frequency, partly by the small intensity of the light, partly by other faults such as small effectiveness of control, great loss of energy, impossibility of obtaining sharp impressions of the source of light (when using glow light discharges), the invention provides a means for quantitative image true control of practically any amount of light with negligible losses, up to frequencies of over ten million. It permits also, if necessary, a sharp reproduction of the source of light on the receiving surface.

The light control is effected according to the invention by means of Kerr cells i.e. by utilizing the known phenomenon of electrical double refraction in a manner similar to the decomposition of polarized light into two components of different velocity of propagation vide Phil. Mag. (4) 50 page 337, 1875. The Kerr cell provided for the passage of the light to be controlled, and containing an electrode arrangement acting as a condenser, is provided with electrical doubly refracting media, usually liquids, emulsions, colloids of small insulation current and similar dielectric losses, so that a wattless or practically wattless control is effected up to the greatest intensity of light used in practice. In consequence of the high insulation of the media used, the plates of the cell, between which the light passes for the purpose as parallel beams, can be brought as near together as possible and thus the required high field strength above can be obtained by voltages of such an order as the present day amplifying devices allow of using with negligible loss.

In the application to photo-telegraphy or television or code telegraphy according to the invention the weak current obtained in transmitting the picture or messages has its voltage increased by means of known amplifying devices working without lag, and is then led to the Kerr cell.

Before entering the Kerr cell the light is polarized by suitable means, such as a Nicol's prism, and after leaving the cell it passes through the analyser. The electric field on the plates of the cell then fixes by its strength and extent, the phase difference of the components of the beam and thus controls quantitatively the strength of the light after interference between zero and maximum.

As according to the invention, in practice, media are used in the Kerr cell which in consequence of their small dielectric loss do not load the source of voltage, the voltage necessary for the electrodes of the cell can easily be obtained by transforming the varying voltage generated in the microphone or similar transmitter into a suitably amplified fluctuating voltage for the case

[*Price* 1/-]

considered. In using certain liquids, e.g. nitrobenzene or derivatives, it is possible with simultaneous observation of conditions hereinafter set forth to succeed with a very short distance between the plates and with voltages of about 1000 volts or less. Such voltages are easily controlled by means of the present amplifying devices in combination with transformation especially with true voltage amplifying connections, and the means used therefor can be kept sufficiently free from loss; also the transformation-ratios of the transformer winding do not act disadvantageously in an electrical sense. This constitutes a substantial improvement, effected by the invention, as previously voltages of such a high order were considered necessary for producing the Kerr effect that it would be inconvenient to use the same in the industry.

The following are further features of the invention. It has been shown that the insulation of the media used for example, nitrobenzene, can be increased and the cell thus improved by applying a continuous current voltage to the cell for a short or long time. This is probably to be ascribed to electrochemical action which separates the constituent conductive particles, probably moisture or traces of acid at the electrodes. Of course especially pure substances are used and for this purpose the material resulting from suitable chemical pre-treatment (distillation, dessication etc.) is preferably utilised. It is advantageous to operate with a continuous current voltage applied to the cell, whereby, as will be seen from the electrical and optical action hereinafter mentioned, a steady constancy of the cell with regard to the nature of the medium is ensured.

By using suitable material for the vessel and contents of the cell, it is possible to control quantitatively invisible light also, for instance, ultraviolet light. For each kind of light, the total absorption on passage through the cell must be small, that is, the contents must be very transparent, since a rise in temperature is produced by optical absorption, which alters the value of the Kerr effect and can disturb the regulated path of the rays in consequence of cloudy streaks in the dielectric.

A further advantage of the previously mentioned continuous current voltage consists in the avoidance of the doubling of frequency and in the increased sensitiveness of control. If one works in the neighbourhood of the zero-value of the voltage in the Kerr condenser, a maximum and minimum light intensity is obtained twice during each period of the controlling alternating current. If a suitable continuous current voltage is applied to the plates and the controlling alternating current is superimposed, the field retains its direction so that the control frequency and the frequency of the light variations are the same. This method also ensures that rather small alternating control voltages are necessary because the effect is proportional to the square of the field strength. By this fact it is possible to increase the controlling action considerably as follows. A voltage is applied to the cell under suitable fixed conditions, which is near to the limiting value for the extinction of the short-wave portions of the rays of the light passing through. Extinction commences of course at the short-wave end of the spectrum. The superimposed control amplitude will thus only be made of such value that extinction of the strongest actinic wave lengths around violet and blue just begins. The rays, after emerging from the cell and analyser, act on a photo-electric cell or like means reacting selectively to light waves for example a photographic plate or film, and thus there results an extraordinarily marked alteration in the reaction of these light sensitive organs, as a result of the extinction of actinic components effected in the spectrum.

A simple form of the invention is shown in Figures 1—5 of the accompanying drawings.

In these figures 1 denotes the Kerr cell with condenser plates 2 (of Fig. 1[a]) between which the electrical doubly refracting medium 3 e.g. nitrobenzene is placed. The beam of light proceeding from the source of light is then passed in the usual way through lenses *a* and polarization apparatus *b* between the plates of the condenser and thrown on the sensitive surface or the photographic paper. The Kerr cell may be provided instead of the two plates usual in a condenser with a system of several condenser-plates, which are arranged in the usual way as in multi-plate condensers. That is the plates are arranged side by side in a plane at right angles to the beam of light with a constant distance between adjacent plates in order to produce a constant field strength. The rays of the beam of light thus pass through the intervals between the plates parallel to one another and are thereafter optically condensed. In this manner a larger amount of light can be controlled with small voltages as adjacent plates can be brought very close together. The plates of the condenser may be

arranged at an angle to one another, instead of being placed parallel, so that the electric field between them will be non-homogeneous. Similar arrangements are used for effecting the hereinbefore described chromatic control the extent of which with given voltage on the condenser is determined by the local field strength and consequently by the geometrical relation (distance between the electrodes). 5 shows an electronic tube with anode current source 6, anode 7, incandescent cathode 8 and grid-electrode 9.

In the circuit shown in the drawings it is assumed for simplicity that the control of the light through the Kerr cell is effected from microphone currents. In Fig. 1, 12 indicates the microphone supplied from a source of current 11, the variation of current in the microphone being transferred to the grid circuit of the amplifier by means of a transformer 10. The variations of the anode current amplified by the tube are converted into suitable varying voltage by means of the transformer 4, which is connected to the plates of the condenser of the Kerr cell and by this means controls the beam of light according to the variations of the microphone current.

Figure 2 shows a voltage amplifying circuit using the tube 5 as a variable resistance. It differs from the arrangement of Fig. 1 in that the Kerr cell is placed in shunt across a resistance 13 connected in the anode circuit of the tube 5 which at the same time supplies the voltage for the cell. The amplified fluctuations of the anode current, corresponding to the microphone currents, control the Kerr cell by altering the potential drop.

Figure 3 gives a specially effective voltage circuit. The cell is placed in shunt across one of the two thermionic tubes 5 and 5^1 connected in series. The microphone current circuit acts on the two grids in opposite directions through the two transformers 10 and 10^1 so that when the resistance of one tube increases, that of the other drops. Thus practically the whole potential difference of the source of continuous current 6 oscillates backwards and forwards between the tubes, on small fluctuations of current; in other words the amplitude of the voltage on the Kerr cell is very great, and increases with a higher insulating power of the cell and with increase of voltage from 6.

The amplifying circuits described hitherto operate with low frequency, i.e. the variations of light are brought about by means of the Kerr cell, only in accordance with the frequency of the microphone current circuit. For certain purposes, for instance, for light telephony, easily transmitted over great distances by this invention, for photo-telegraphy and the like, it is preferable, however, for preserving secrecy and for obtaining a higher selectiveness of the receiving circuit, to control the Kerr cell by means of an audio-frequency modulated radio frequency. This high frequency amplification with its known advantages is made possible on the receiver side in that for example, in the case of light telephony, the received light impulses into which on the transmitting side the Kerr cell has transformed the microphone current, act on a photo-electric cell, which is connected up to a high frequency amplifier from which the amplified high frequency current is led to a detector or audion for the purpose of making the lower frequency audible. In the like light telephony, in which the light is to be controlled by audio-frequency modulated radio frequency, the source of high frequency is provided by a generator, preferably by a thermionic tube transmitter, self excited or driven by a master oscillator, in which arrangement the condenser circuit of the Kerr cell is connected with the working circuit of the generator or in which the Kerr cell forms part or all of the capacity of the oscillating circuit. The high frequency oscillation is modulated by the lower frequency in one of the numerous known connections, so that the Kerr cell is under the influence of a modulated high frequency. A tube transmitter with back coupled connections is shown in Fig. 4 as an example of one method of carrying out such an arrangement. 15 represents the tunable oscillating circuit with which the Kerr cell is suitably connected in loose coupling through the coil 14. The regulation of the grid 9 of the oscillation tube 5 is effected by the transformer 10 whose secondary winding is shunted for the passage of the high frequency by the condenser 16. 17 is the usual plate condenser, 18 and 18^1 the high frequency choking stops in the circuit of the anode current. In this arrangement as will be seen without further explanation, the Kerr cell is controlled by a lower frequency modulated high frequency.

It is evident, without any further explanation, that the circuits illustrated and described can be used not only for transmitting microphone currents but also for recording any other fluctuating currents, such as for example are obtained in photo-telegraphy by means of

the differences in light and shade of a picture by the use of a photo cell, or utilized in known manner for transmitting signals or the like.

A circuit for transmitting images is shown in Figure 5. A indicates a tube transmitter. The high frequency oscillations produced by the tube are modulated in the usual way by the light and shade of the image to be transmitted. B denotes the receiver, which co-operates with the usual receiving arrangements, composed of the high frequency amplifier C, the rectifier D and the low frequency amplifier E. The Kerr cell is connected, according to the invention, to the end of the low frequency amplifier, by which arrangement the rays of light are controlled in a manner corresponding to the flow of the modulated transmitting oscillations. The transmission of electric current from transmitter to receiver can be effected in the usual way both over wires or by wireless.

If the apparatus is to be used for the secret transmission of news the Kerr cell may be controlled by two or more independent modulated high frequencies which at the receiving end must be separated in known manner by a tuned oscillating circuit so that only the high frequencies modified by the oscillations transmitted are picked up.

I am aware that it has been suggested to record oscillations on a sensitive film by converting the oscillations and amplifying the same by means of thermionic tubes and to control a beam of light by the amplified current by producing an electromagnetic field to affect the plane of polarisation of the polarised beam, the method thus utilising the Faraday effect, and I make no claim to the utilisation of the Faraday effect in a method of recording sound or other oscillation.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. A method of transmitting and receiving pictures, messages or the like with or without wires consisting in amplifying the voltage of an electric current used for transmitting or receiving by means of a thermionic tube and controlling the intensity of a beam of light by said current combined with a Kerr cell provided with an electrically doubly refracting medium or media.

2. A method of transmitting and receiving as claimed in Claim 1 in which the doubly refracting medium comprises a liquid or emulsified or colloidal substance.

3. A method as claimed in Claim 1 in which the doubly refracting medium consists of nitrobenzene.

4. A method as claimed in Claims 1—3 in which the dielectric is carefully purified by chemical or electro-chemical means to effect particularly the removal of residual water and acidic constituents.

5. A method as claimed in Claim 4 in which the electro-chemical method of purification of the dielectric consists in applying a constant voltage thereto.

6. A method as claimed in Claim 1 in which the amplified voltage is led direct to the two terminals of the Kerr cell.

7. A method as claimed in Claims 1 and 4 in which the cell operates with a continuous current voltage on which is superimposed the control voltage.

8. A method as claimed in Claim 1 in which the cell is connected directly in the anode circuit of an amplifying tube and thus maintained permanently under continuous current voltage.

9. A method and arrangement as claimed in Claims 1 and 7 in which the value of the superimposed alternating current voltage and the continuous current voltage are so arranged in combination with means reacting selectively to light that, in order to increase the sensitiveness of the control, only a short wave range of the mixed light waves passing through the cell is lost.

10. A method as claimed in Claim 7 in which the superimposed alternating voltage and continuous current voltage are adjusted so that no doubling of the control frequency takes place and the resultant voltage on the cell is not reversed.

11. A method as claimed in Claim 8 in which the maximum value of the superimposed alternating voltage is selected so small that only the short wave region of the visible spectrum increases in intensity or is extinguished, a medium reacting selectively to light of this kind for example a photographic film being utilised as an indicator.

12. A method as in Claim 1 in which the medium used in the Kerr cell is treated chemically or electro-chemically so that the insulating power is thereby increased and the cell acts as a substantially loss free condenser.

13. A method as in Claim 12 in which the treatment of the medium so as to maintain its efficiency is effected by applying a continuous current voltage to the cell during its operation or prior to the same.

14. A method as claimed in Claim 1

in which the Kerr cell used in transmitting or receiving is controlled by a low frequency modulated high frequency.

15. A method as claimed in Claim 14 in which a high frequency amplifier is provided in the receiver.

16. A method as claimed in Claim 1 in which the Kerr cell is controlled simultaneously by a plurality of independent frequencies.

17. A method as claimed in Claim 1 in which the condenser of the Kerr cell forms together with a coil an oscillating circuit, which is connected to the working circuit of a high frequency generator.

18. In a method of instantaneous light control as claimed in Claim 1 the provision of the smallest possible interval between the condenser plates in the Kerr cell so as to obtain a relatively strong electric field in the Kerr cell with relatively small potential differences.

19. A method as claimed in Claim 1 in which the electric field employed in the Kerr cell is non homogeneous.

20. Apparatus for use in the transmission and reception of pictures, messages and the like arranged for operation substantially as described with reference to the accompanying diagrams.

21. A method of transmitting and receiving pictures, messages and the like, substantially as described with reference to the accompanying diagrams.

Dated this 22nd day of May, 1925.

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Chartered and Registered Patent Agents.

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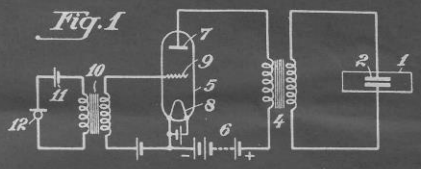
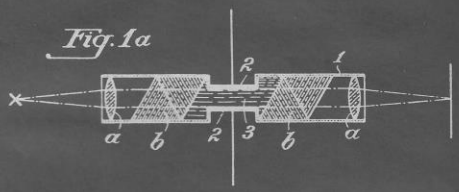
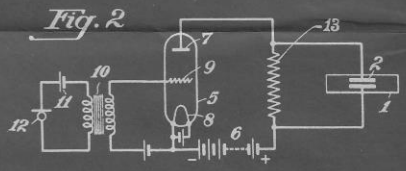
SHEET 1







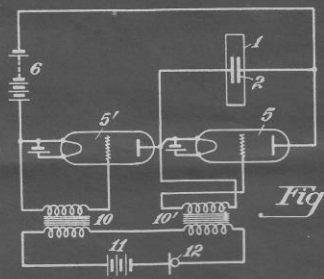
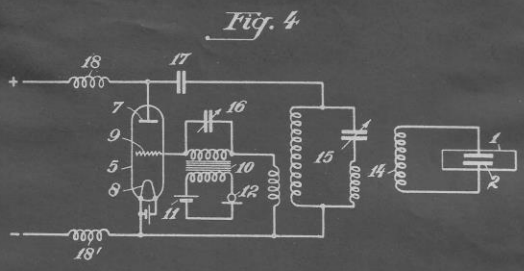
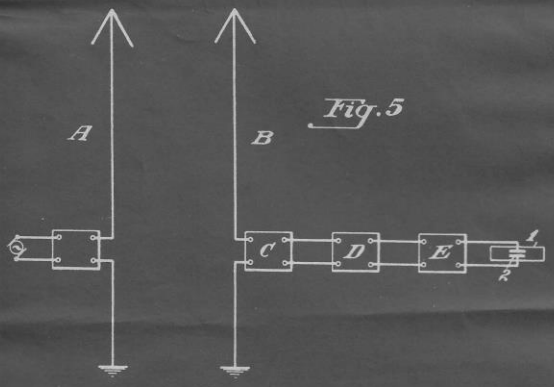


Fig. 3

SHEET 2





[This Drawing is a reproduction of the Original on a reduced scale.]

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