

Nov. 6, 1928.

1,690,300

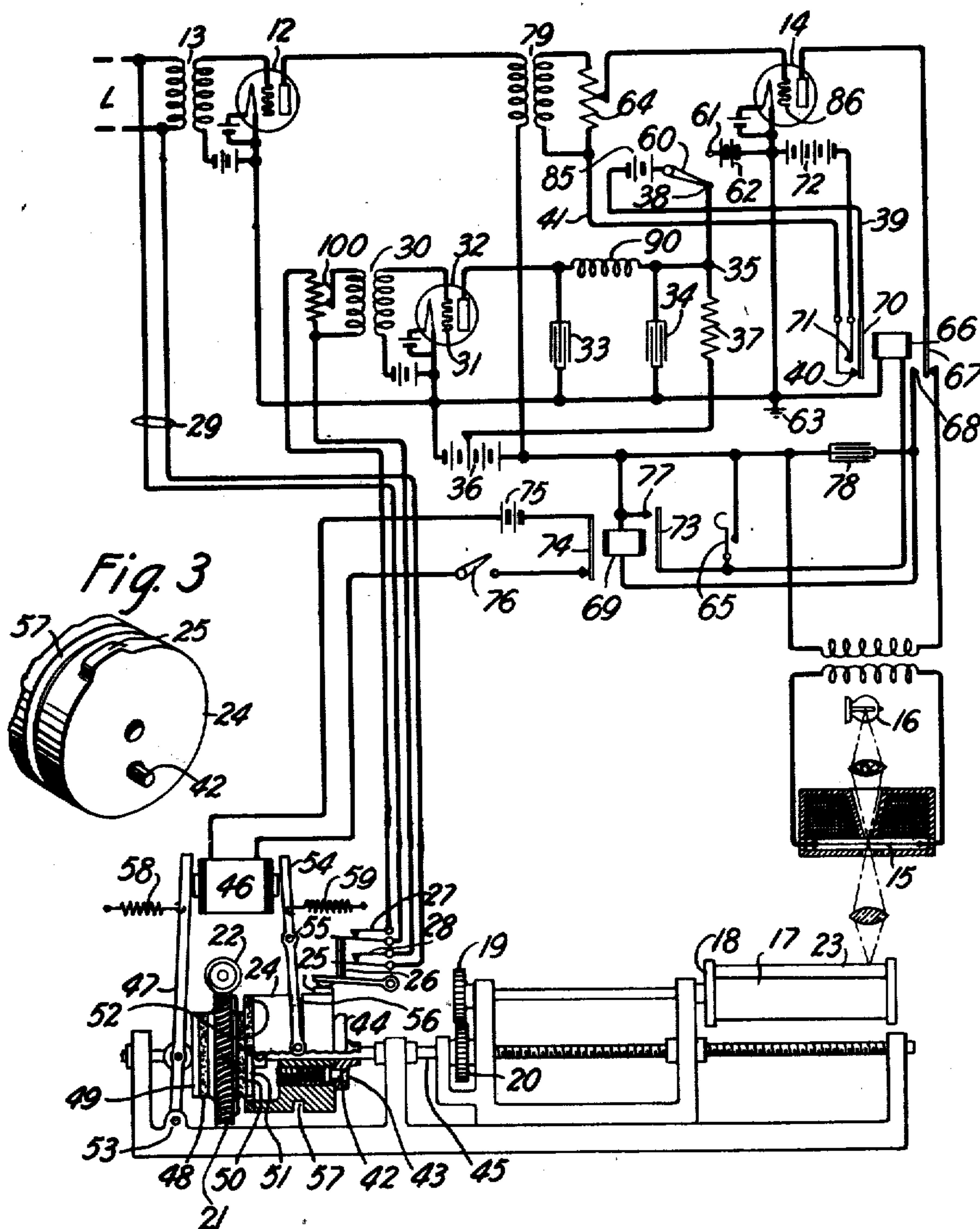
J. W. HORTON

TRANSMISSION OF PICTURES BY ELECTRICITY

Filed April 3, 1925

2 Sheets-Sheet 1

Fig.1.



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2 Sheets-Sheet 2

Fig. 4

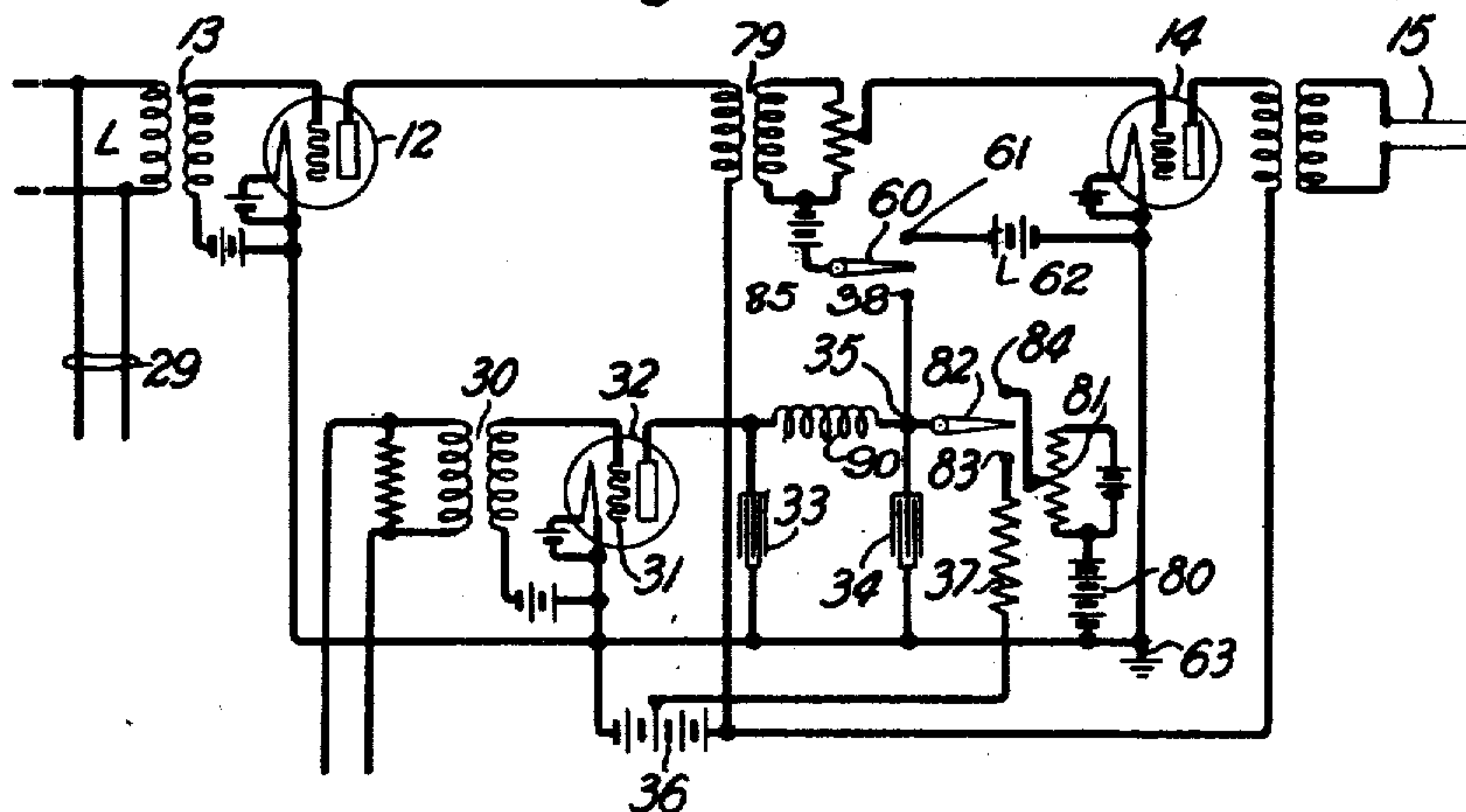


Fig.5

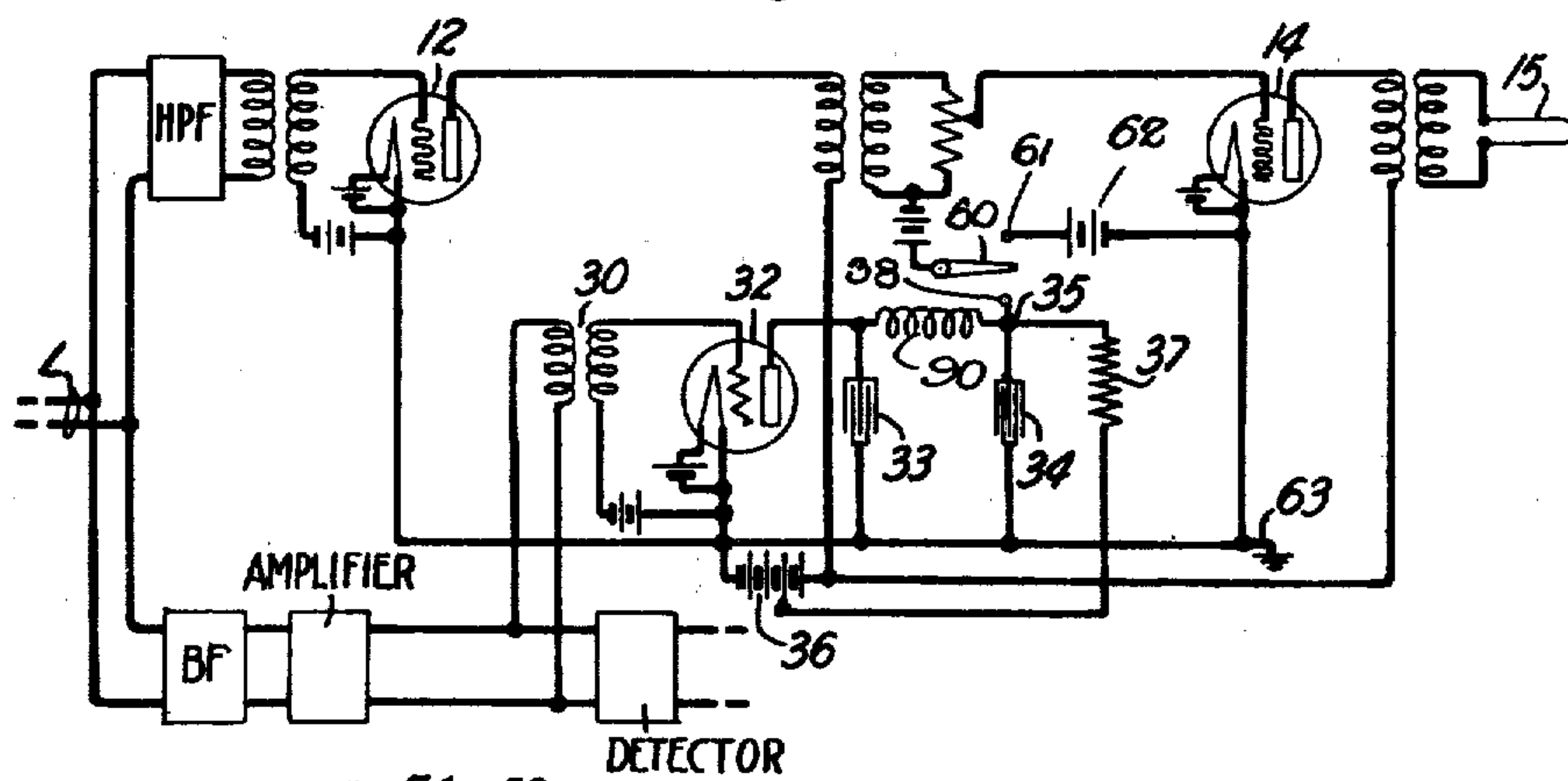
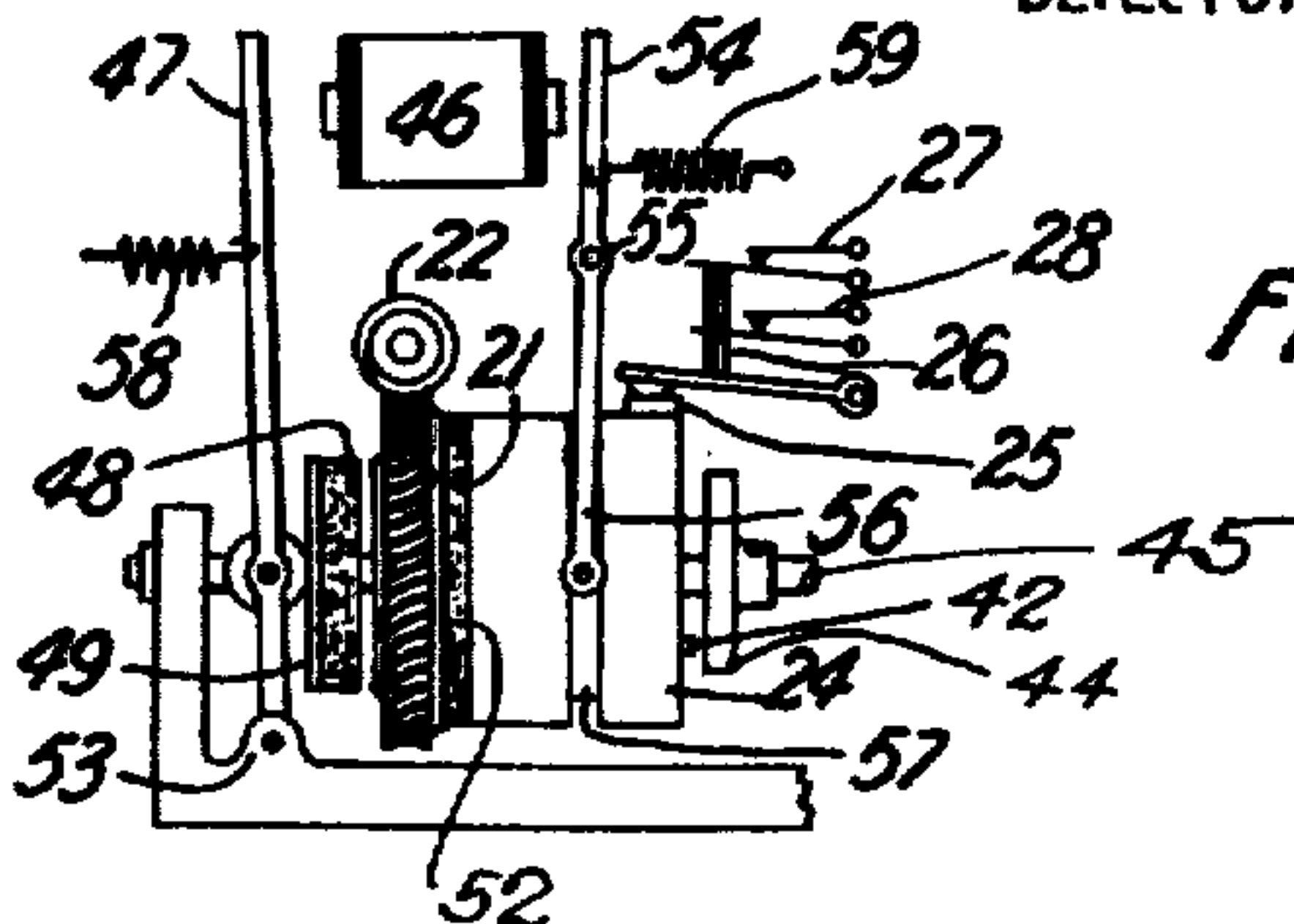


Fig. 2



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UNITED STATES PATENT OFFICE.

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TRANSMISSION OF PICTURES BY ELECTRICITY.

Application filed April 3, 1925. Serial No. 20,321.

This invention relates to compensating apparatus for maintaining a constant overall transmission equivalent in an electrical circuit and more particularly to a gain control device for use in connection with the electrical transmission of pictures.

It is well known that the attenuation of the impulses transmitted in electrical communication varies greatly with weather conditions, temperature and atmospheric changes as well as uncontrolled line and instrument variations. These variations result in changes of the impulses actuating the receiving apparatus. The signals whether transmitted by carrier current or radio, vary in intensity depending upon the attenuation changes of the line or transmitting medium.

In some forms of apparatus for the transmission of pictures by means of electrical impulses, this attenuation change or "fading" results in varying photographic density in separate portions of the picture being received.

In accordance with the present invention, injury to the picture due to fading out of the signals is avoided by providing a compensating means to change the amplification of the incoming impulses in proportion to the changes in attenuation. In this manner, the overall transmission equivalent is maintained constant independently of the attenuation changes of the incoming waves. In other words, the ratio of the amplitudes of the transmitted impulses to that of the amplified received impulses is maintained substantially constant.

As an illustration of the invention, it will be shown and described in the following specification and drawings as applied to a picture transmission apparatus, but it is not intended to limit the invention to the specific embodiment shown as other modifications and arrangements will obviously fall within the scope of the invention.

The term "light" as used herein includes not only radiations within the visible spectrum but also radiations having wave lengths above and below those of the visible spectrum.

It is to be understood that the terms used herein, both in the specification and claims, do not limit this invention to the production of a picture record at the receiver from a picture record at the transmitter. The inven-

tion is equally applicable to systems, for example, in which a transitory image is produced at the receiver, as in certain forms of television systems.

This invention is well adapted for use with the form of picture transmitting apparatus shown and described in a Patent No. 1,606,227, Nov. 9, 1926, of J. W. Horton, H. E. Ives and M. B. Long. In that system a transparency of the picture to be transmitted is scanned in a series of lines for the purpose of transmitting electrical variations which may be utilized in reproducing the picture at the receiving station. For this purpose, the transparency is mounted on a rotatable drum which moves lengthwise of its axis as it rotates so that the entire area is passed over progressively by a beam of light. The varying transparency of portions of the picture causes a varying amount of light to fall upon a light sensitive cell which thus varies the current flowing in a circuit which modulates carrier current being transmitted to the receiving station. At the receiving station, the impulses are amplified and impressed on the light valve circuit to reproduce the picture. In this way, the impulses control the amount of light falling upon a light sensitive film mounted on a drum which is rotating in synchronism with the rotating drum at the transmitting station. The synchronization of the rotating drums at the sending and receiving stations is accomplished by means of a current of one frequency while the picture reproducing signals are modulations of another carrier frequency impressed upon the same line. Separation of the two carrier waves at the receiving station is accomplished by means of filters.

Various means have been employed previously for compensating for the attenuation changes of signaling waves. In the prior art, numerous means have been employed to control the resistance in the circuit of an amplifier by mechanical means. The present invention avoids the use of such mechanical means for regulating the gain in that the amplification ratio of the circuit is controlled directly by the impulses received.

One of the principal objects of this invention is to compensate for changes in attenuation of electrical signaling impulses. Another object of the invention is to automatically compensate for changes in the attenua-

tion of signaling waves by means of the impulses received. A further object of the invention is to effectively control the gain of amplifying apparatus used in connection with the transmission of pictures by electrical impulses.

Another object of the invention is to adjust the amplification ratio of signal receiving mechanism during intermittent periods of non-signaling. Other objects and advantages of the invention will be apparent from the following specification and drawings.

In accordance with the invention, a rectifier controlled by signaling impulses determines the static potential of a point in the grid circuit of the amplifier. In this way a change in the amplitude of the signaling waves impressed on the rectifier causes a change in the static potential on the grid of the amplifier of such sign and magnitude as to alter the amplification ratio in the proper proportion.

In applying the invention specifically to the form of picture transmission apparatus described above, reference is had to the accompanying drawings in which Fig. 1 illustrates one form of the invention as applied to picture transmission apparatus, showing the mechanism in position for receiving pictures. Fig. 2 illustrates the clutching mechanism of Fig. 1 in position for adjusting the apparatus. Fig. 3 is a perspective of the cam member employed to operate the switch of the gain control mechanism. Fig. 4 illustrates a modification of the form of invention shown in Fig. 1. Fig. 5 is a further modification of the invention in which the gain control mechanism is operated by the synchronizing current controlling the driving motor.

In applying the invention to signaling apparatus, and in particular to picture transmission apparatus, such as that described in the patent of Messrs. Horton, Ives and Long, referred to above, the picture modulated carrier current is received from the line "L" and impressed upon the amplifier 12 by means of the repeating coil 13. The output of this amplifier is impressed upon the input circuit of amplifier 14 through repeating coil 79. Amplified current then flows in the output circuit of space discharge device 14 and is impressed on the circuit of light valve 15. This current has variations corresponding to the current flowing in the circuit containing the light sensitive cell at the transmitting station. The received impulses cause the light valve 15 to operate to reproduce the picture at the sending station by permitting a greater or less amount of light from source 16 to fall upon the light sensitive film 17 mounted on drum 18. The receiving drum is rotated by gears 19 and 20 which are driven by the driving gear 21 and the operating shaft 45. The driving gear is itself driven

by means of a worm gear 22 attached to the shaft of a synchronous motor (not shown) which is controlled by the same synchronizing current that controls the motor of the sending apparatus. In this way, the two drums rotate in exact synchronism. Further provision is made to insure that the portion 23 of the drum 18 which lies between the ends of the film on the receiving drum is presented to the light valve during the same time that a corresponding portion of the sending drum is presented to the source of light scanning the transparency at the sending station. This interval is termed the underlap period. The term "underlap period" as used throughout the specification and claims designates that period of time during the transmission of signals between successive signals or when the recording apparatus is not being actuated.

For the purpose of compensating for changes in the attenuation of the impulses transmitted it is proposed to utilize a wave of constant amplitude generated at the transmitting station. Since the carrier current is unmodulated and consequently of constant amplitude during the underlap period, it is also proposed to employ this current for operating the gain control apparatus.

In order to regulate the gain of the apparatus only during the underlap period, a separate means is employed for closing the input circuit of the compensating apparatus only when the opaque portion of the drum faces the source of light. For this purpose, a rotating collar 24 of the driving mechanism illustrated in Figs. 1 and 2 is provided with a peripheral cam 25 which operates the arm 26 to close the contacts 27 and 28 of the gain control circuit only during the underlap period of each rotation or at corresponding intervals as will appear hereinafter. As the collar 24 rotates, the cam 25 causes the contacts 27 and 28 to be closed and impulses corresponding to the maximum line current will flow through the conductors 29 and contacts 27 and 28 to repeating coil 30, varying the potential of the grid 31 of electron discharge device 32. In this way, the output impedance of rectifier 32 in the interval during which the rectifier is connected to the line will be constant so long as the line current impressed on the grid is constant.

The output circuit of the rectifier 32 includes condensers 33 and 34, inductance 90, the point 35, resistance 37, and the left hand portion of battery 36. In this case, the condenser 34, unless already at the potential of the battery 36, is continuously charging to this potential through the resistance 37. Condenser 33 is likewise charging to this potential through inductance 90. The plate-filament impedance of the rectifier tube is infinity except during the underlap period so that the charge on condenser 33 builds up during the reception of a picture but during

the underlap period, when the rectifier 32 is in the circuit, a portion of the charge from condenser 33 is dissipated through the plate circuit of the rectifier. The condenser 33 is recharged slowly through inductance 90, receiving a portion of its charge from condenser 34 and a portion from battery 36 through resistance 37. The charge on condenser 34 does not decrease suddenly during the discharge of condenser 33 due to the action of the inductance 90. As a result the potential of point 35 is maintained substantially constant at some potential less than that of battery 36. In other words, the plate circuit conductance of the rectifier is a periodically varying quantity determined by the amplitude and duration of the signal wave impressed on the rectifier grid. Due to the filtering action of condenser 33, inductance 90 and condenser 34, the conductance between the point 35 and ground is constant at some value determined by the amplitude and duration of the signal wave impressed on the rectifier grid. Thus a substantially constant current is maintained through resistance 37 as long as the amplitude of the input wave is constant thereby causing a constant voltage drop. The potential of the point 35 is equal to the potential of battery 36 less this resistance drop.

A decrease in the amplitude of the incoming wave results in a decrease in the direct current through resistance 37 thereby causing the potential of point 35 to increase.

The static potential on the grid of the amplifier 14 is maintained at some negative value by battery 85 acting in opposition to the potential of point 35. Any increase in the potential of point 35 therefore makes the static potential on the grid of the amplifier less negative and thereby increases the amplification ratio. Thus an increase in the amplitude of the incoming waves will cause an increase in the direct current through resistance 37 and the potential of point 35 will decrease resulting in a decreased opposition to the battery 85 and an increase in the negative potential of the grid of amplifier 14 which thereby decreases the amplification ratio accordingly.

Since contacts 27 and 28 are closed for a portion of each revolution of the drum, the gain setting will be tested for each line traced on the film 17. If there is no change in attenuation, the gain setting will be the same for successive rotations. In this manner, changes in attenuation are automatically compensated and uniform signaling impulses flow in the output circuit of the receiving apparatus.

In order to close the contacts 27 and 28, only during the underlap period, it is necessary that the cam 25 be in engagement with the arm 26, which operates contacts 27 and 28 only during that period. Since it is neces-

sary to make adjustments of the apparatus under ordinary working conditions and at the same time independently of the rotating drum 18 a separate clutch mechanism is provided. For this purpose, the collar 24 is provided with a spring pin 42 adapted to engage in the recess 43 of the collar 44 which is fixed on the operating shaft 45. Mounted on shaft 45 and freely rotatable thereon is the driving gear 21, driven by the worm gear 22, attached to the synchronous motor (not shown). Collar 24 has a cylindrical extension surrounding the collar 51 which carries a frictional engaging surface 52 held in contact with the driving gear 21 when no pictures are being received and the driving gear is idling on shaft 45 as illustrated in Fig. 2.

In order to set the receiving drum in operation, gear 21 is clutched to the operating shaft 45 and collar 24 is thrown out of engagement with the gear. For this purpose, when the apparatus is in readiness for the transmission of signals, relay 46 is energized, attracting armature 47, pivoted at 53, which forces the friction bearing member 48 carried by the bushing 49 against the face of driving gear 21. This moves the driving gear a very small distance into engagement with the frictional surface 50 of the collar 51, positioned within a recess in the collar 24 and rigidly attached to shaft 45. The driving gear is then held between two frictional surfaces and rotates the operating shaft 45. When relay 46 is energized, it also attracts armature 54, pivoted at 55, which is provided with a shifting fork 56, the engaging ends of which lie in a groove 57 in the outer surface of collar 24. This throws the collar 24 out of engagement with the driving gear 21 and into engagement with the collar 44 carried by shaft 45. If the pin 42 is not in alignment with the recess 43 in collar 44, there will be relative movement between the collar 44 mounted on the shaft and the collar 24 until the recess 43 comes opposite pin 42. The pin and cam are so positioned with reference to the recess 43 that when the pin is in engagement with the recess, the cam 25 will rotate in fixed relation to the underlap portion 23 of the receiving drum 18. When the cam comes to the proper relative position to the underlap portion, the recess 43 will be opposite the pin 42 and the latter will snap into engagement under the influence of the spring, thus maintaining the proper relation until relay 46 is deenergized and armatures 47 and 54 are retracted by the springs 58 and 59.

When it is desired to transmit a picture, the apparatus is adjusted to the proper gain setting and desired light intensity. These adjustments are made under conditions similar to working conditions by transmitting synchronizing and carrier currents corresponding to minimum light intensity to drive the

motor and to operate the cam member for the gain control contacts 27 and 28. The angular position of the cam with reference to the underlap portion is of no importance during
 5 adjustment of the apparatus as the sending and receiving drums are not rotated. However, the portion of each revolution that contacts 27 and 28 are closed must be the same as during actual operation in order to obtain the
 10 proper gain setting to correspond to the dark condition of picture transmission which is that of maximum amplitude of carrier. To make adjustments, carrier current is received from line "L" and amplified by vacuum tube
 15 device 12, the second stage of amplification being obtained by amplifier 14. The current in the light valve is then adjusted to the proper value by potentiometer 64.

To provide a normal working grid potential independent of the gain control apparatus, a supplementary grid polarizing battery 62 is provided. In order to make use of
 20 battery 62, the switch arm 60 is thrown to engage contact 61 to complete a circuit through battery 62 to the grid 86 of amplifier 14. Since battery 62 takes the place, during
 25 adjustment, of the potential between the point 35 and ground 63, the positive terminal of battery 62 is connected to the terminal 61. After adjustments of the light valve have
 30 been made for the proper photographic density of the picture the switch arm 60 is thrown again to engage contact 38 and the input circuit of rectifier 32 is adjusted by means of
 35 potentiometer 100 to give the same working potential to the grid of amplifier 14.

In order to set up the circuit in readiness for the transmission of a picture, key 65 is closed, causing current to flow from battery
 40 36 through key 65 to relay 66. The relay being energized attracts armatures 67 and 70. Armature 70 makes contact at 71 and breaks contact at 40. This causes the high voltage battery 72 to be substituted as grid polarizing
 45 source for vacuum tube 14 in place of the comparatively low voltage source previously connected, thereby converting the vacuum tube device 14 from an amplifier to a detector. Armature 67 breaks the circuit to the light
 50 valve making contact with 68 which causes the rectified output current of tube 14 acting as a rectifier to flow through contact 68 and relay 69 from battery 36, energizing relay 69. When relay 69 is energized, armatures 73 and
 55 74 are attracted. Armature 73 completes a circuit through battery 36 and contact 77 to relay 66 so that the key 65 may be released and the current maintained through relays 66 and 69. Armature 74 opens the circuit of
 60 relay 46 so that the switch 76 may be closed without causing the energization of relay 46. The circuit is ready now for the transmission of a picture. That is to say, the switch 76 is closed, relays 66 and 69 are energized attract-
 65 ing armatures 67, 70 and 73 and 74, respec-

tively. Key 65 is open, and the switch arm 60 is thrown to contact 38. The sending station is then notified that all is in readiness for the transmission of the modulated carrier.

To start the operation, carrier current is
 70 shut off at the sending station for an instant, after which transmission of the picture is begun. As soon as the carrier current stops, the flow of current through detector-amplifier 14 falls below that necessary to operate relay 69
 75 and armatures 73 and 74 are released. Armature 73 breaks the circuit through relay 66, releasing armature 67 to complete the light valve circuit. At the same time the armature 70 makes contact at 40 and breaks the contact
 80 71, thus substituting battery 85 and the gain control apparatus for the detecting grid polarizing battery 72. The armature 74 of relay 69 completes the circuit through relay
 85 46, attracting armatures 47 and 54 to clutch the driving gear 21 to the operating shaft 45, starting the rotation of drum 18. The armature 54 withdraws the collar 24 from engagement with the driving gear 21 and clutches it
 90 to collar 44 causing the cam 25 to close contacts 27 and 28 in the gain control circuit during the underlap period. In this way the receiving equipment is started from the sending station, insuring simultaneous actuation
 95 of all the parts, when the modulated carrier current is started. The light valve is actuated and a picture reproduced on the light sensitive film 17, the gain control apparatus operating during the underlap period of each
 100 rotation.

Since the gain control apparatus adjusts itself to compensate for changes in attenuation with each revolution of the drum, uniform photograph density of the entire picture
 105 is insured. The gain setting of the mechanism is automatic and the initial adjustment having been determined, there will be no need of re-adjustment of the apparatus so long as impulses of the same initial intensity are being
 110 supplied.

In the form of the invention illustrated in Fig. 1, condensers 33 and 34 may assume an abnormal charge, if the carrier is shut off for any reason. In that case, the first few revolutions of the drum will be required before the
 115 condensers have reached the proper potential. In the form of the invention illustrated in Fig. 4, this difficulty is overcome by substituting for the resistance 37 and battery 36, during any period when the carrier current is cut
 120 off for an appreciable time an adjustable potential consisting of the battery 80 and potentiometer 81. While the carrier is still coming in the switch arm 82 is thrown from contact 83 to contact 84 and the output current of discharge device 14 is restored to its
 125 normal value by adjustment of the potentiometer 81. The operation of switch 82 prevents change in the potential of the condensers after the original adjustment of the
 130

apparatus has been made. When the resistance 81 has been adjusted, the battery 80 will retain the rectifying circuit at the proper potential keeping the potential of condensers 33 and 34 constant after the carrier current is shut off due to the fact that no current flows through the rectifier 32. If it is desired, the switch 82 may be operated automatically upon the start of carrier current setting the receiving mechanism in operation in order that there will be no lapse of time to permit the condensers to change their potential.

Fig. 5 illustrates a further modification of the invention in which the gain control mechanism is operated by means of a separate pilot current. In this form of the invention, as in the previously described system, the current received from the line L is passed through filters. The high pass filter HPF passes the modulated carrier to operate the light valve and the band filter BF passes only the control current which in this case may also control the synchronous motor. The operation of the gain control will be the same as in the previous forms of the invention, but the adjustment of the apparatus will necessarily be altered. This form of the invention has the added advantage of compensating for impulse changes directly as they occur and does not require the special operating mechanism of the previous forms of the invention. Moreover, the gain control mechanism is continuously operative without reference to the underlap period. An attenuation change in the transmitting medium causes a change in the impulses impressed upon amplifier 12 and at the same time a corresponding or proportional change in the impulses impressed upon the rectifier 32 from the synchronizing current. In this way, the output of the rectifier will be altered, varying the charge on condensers 33 and 34 and thus controlling the potential of the point 35 which determines the gain of the amplifier 14. The compensating potential impressed on the grid of the electron discharge device 14 will then vary with the attenuation insuring a constant output current to operate the light valve 15.

The invention is not limited to picture transmission apparatus as it may obviously be employed with other signaling devices, especially those employing synchronizing systems or motors.

Any one of the sources of potential of an electron discharge device, or the current therefrom, may be controlled in a manner similar to that described in connection with the grid potential of the amplifier 14 or in any well known manner which would accomplish the same purpose. Thus the plate potential may be controlled or the filament current varied to alter the amplification ratio and maintain a constant overall transmission equivalent.

What is claimed is:

1. In a signaling system comprising a gain control circuit, the method of obtaining a desired current level at a receiving station which comprises automatically adjusting a potential of the gain control circuit from the transmitting station during regularly recurring periods.

2. In a signalling system comprising a gain control element, the method of maintaining uniform operation of said system which comprises automatically operating said gain control element during regularly recurring periods only.

3. The method of obtaining a desired current level at a receiving station which comprises periodically controlling the gain of a repeater at automatically regulated intervals and automatically maintaining the gain substantially constant during non-control periods.

4. In a signaling system comprising carrier current transmission apparatus and a gain control circuit, the method of maintaining a constant overall transmission equivalent which comprises operating the gain control circuit only during regularly recurring periods when the carrier current is unmodulated.

5. In a signaling system comprising a gain control element, the method of maintaining a constant overall transmission equivalent for signaling energy which comprises energizing said gain control element during non-signaling periods with energy derived from said system to maintain at constant value the overall transmission equivalent for signaling energy, and automatically preventing energization of said element during signaling periods.

6. The method of signaling which comprises producing a carrier current transmitting alternately said carrier current unmodulated and said carrier current modulated in accordance with signals, obtaining signaling current from the modulated carrier current, and controlling the strength of the signals in accordance with the strength of the unmodulated carrier current.

7. In a signaling system, a signaling circuit, receiving apparatus for translating received signals into intelligible records, and a gain control circuit associated with said receiving apparatus for maintaining a constant overall transmission equivalent, said circuit being automatically operative only during periods when no signals are being recorded.

8. In a picture transmission system comprising transmission apparatus, a recording cylinder and means for rotating said cylinder, a gain control circuit for maintaining a constant overall transmission equivalent controlled by the means rotating said cylinder.

9. In a signaling system, a receiving circuit comprising a space discharge device and a control element therefor, two sources of potential for said control element both controlled by received signals, one of which

sources of potential comprises two direct current sources in series and opposing each other and a resistance in series therewith, the potential drop across said resistance being controlled by the signal current.

10. In a picture transmission system, a carrier current signaling channel, a light valve operated by signals transmitted over said channel and a gain control circuit for maintaining uniform operation of said light valve and controlled by signals transmitted over said carrier current channel.

11. In a picture transmission system comprising a signaling channel, transmission apparatus associated therewith, and a light valve operated by signals transmitted over said channel, a gain control circuit for maintaining a constant overall transmission equivalent in said channel controlled by signals transmitted over said channel.

12. In a picture transmission system, transmission apparatus, a receiving circuit, a gain control circuit for maintaining a constant overall transmission equivalent in said apparatus and means for automatically including said gain control circuit in the receiving circuit during intermittent periods of operation.

13. In a picture transmission system, receiving apparatus including a recording cylinder, means for rotating said cylinder, a light valve for forming records upon said recording cylinder and a gain control circuit for maintaining uniform operation of said light valve comprising a switch operated by the means rotating said cylinder for bringing the gain control circuit into operation during the underlap period.

In witness whereof, I hereunto subscribe my name this 2nd day of April A. D., 1925.

JOSEPH W. HORTON.

CERTIFICATE OF CORRECTION.

Patent No. 1,690,300.

Granted November 6, 1928, to

JOSEPH W. HORTON.

It is hereby certified that the above numbered patent was erroneously issued to Bell Telephone Laboratories, Incorporated, of New York, N. Y., a corporation of New York, whereas said patent should have been issued to "Western Electric Company, Incorporated, of New York, N. Y., a corporation of New York, said corporation being assignee by mesne assignments of the entire interest in said invention, as shown by the records of assignments in this office; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 11th day of December, A. D. 1928.

(Seal)

M. J. Moore,
Acting Commissioner of Patents.

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