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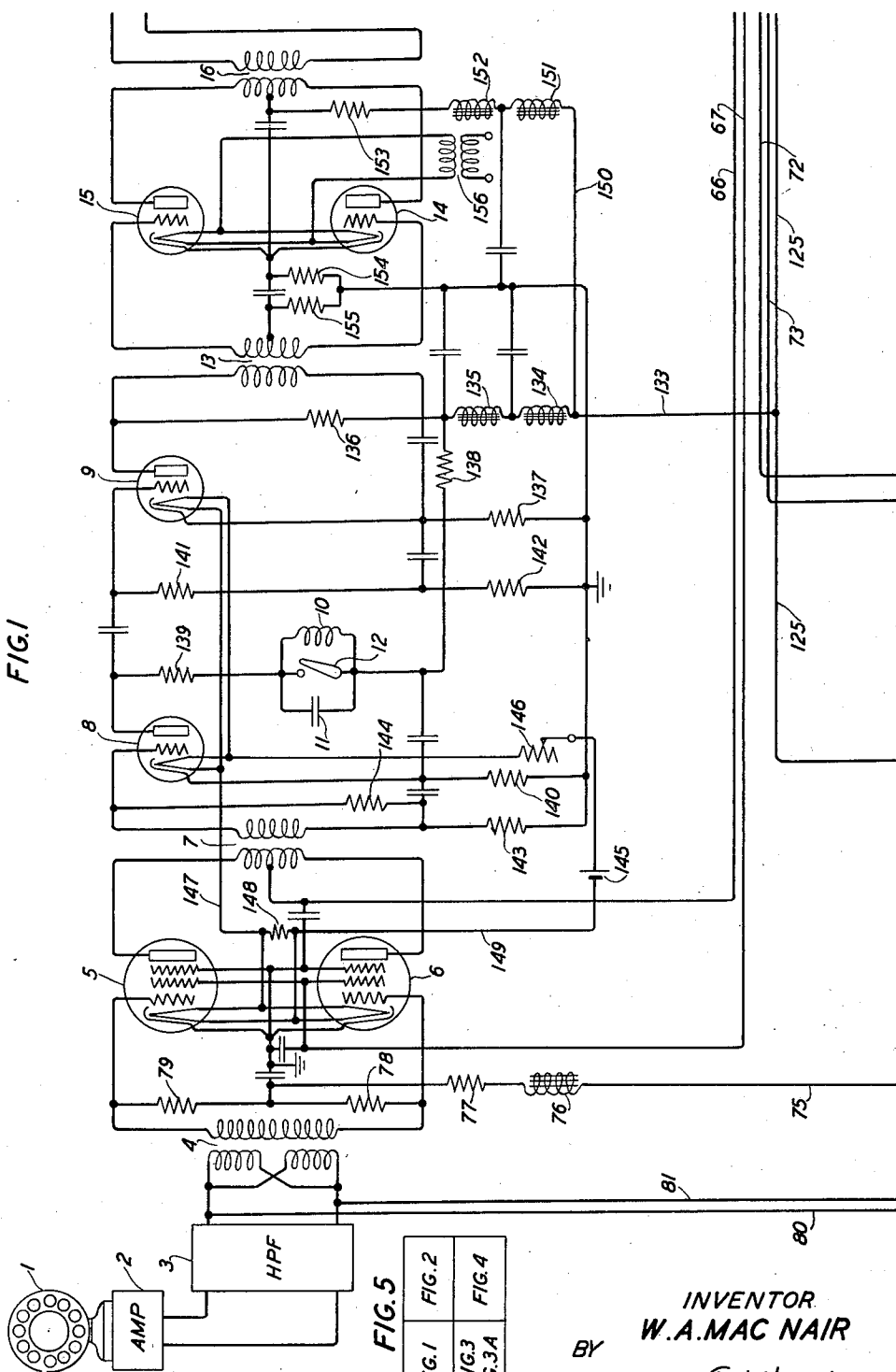
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2,018,374

SOUND RECORDING SYSTEM

Filed July 28, 1934

4 Sheets-Sheet 1



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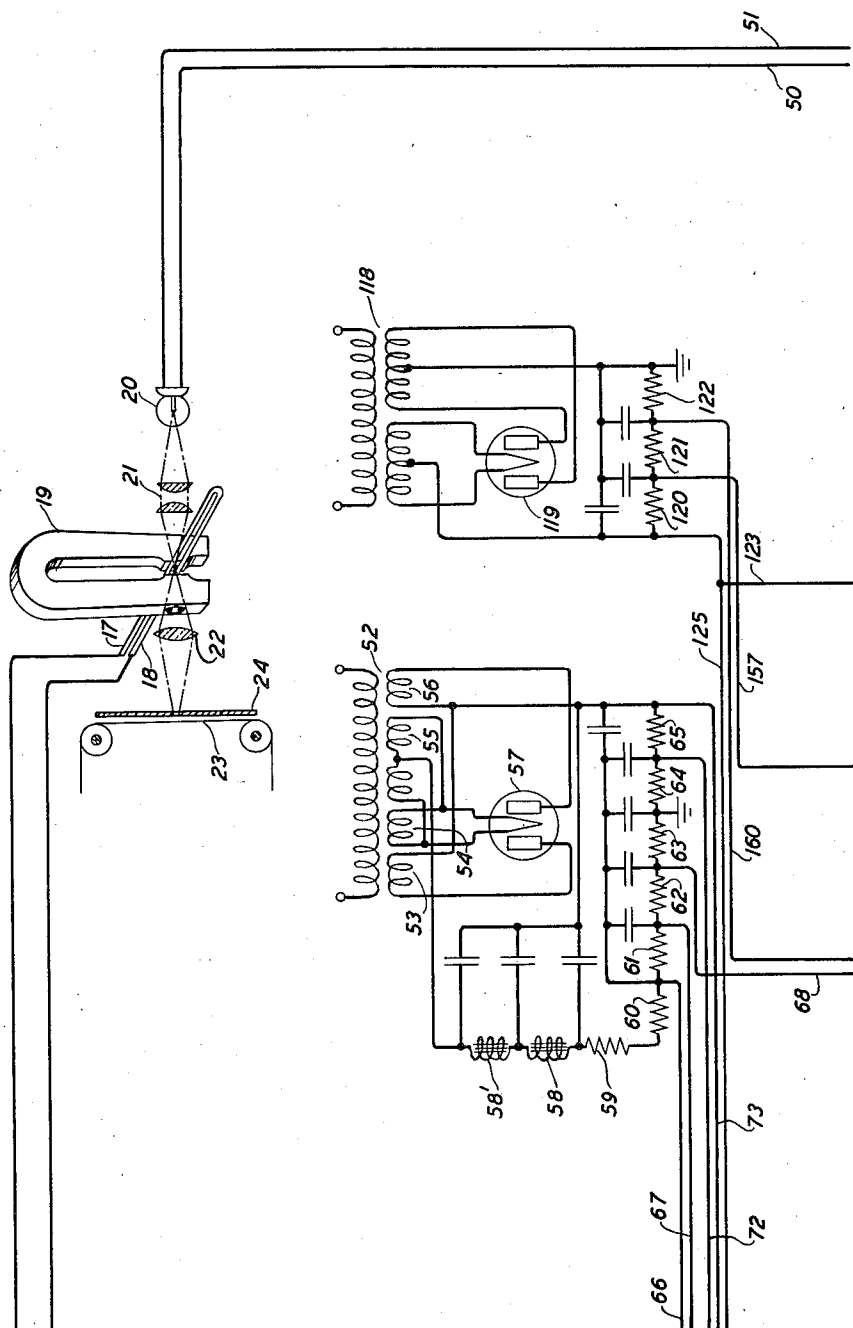
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FIG. 2



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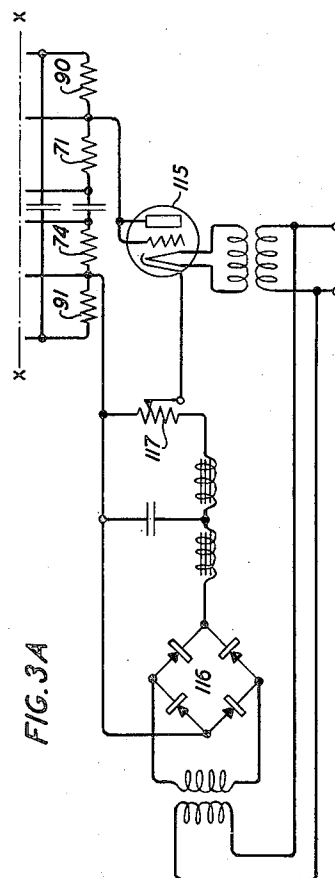
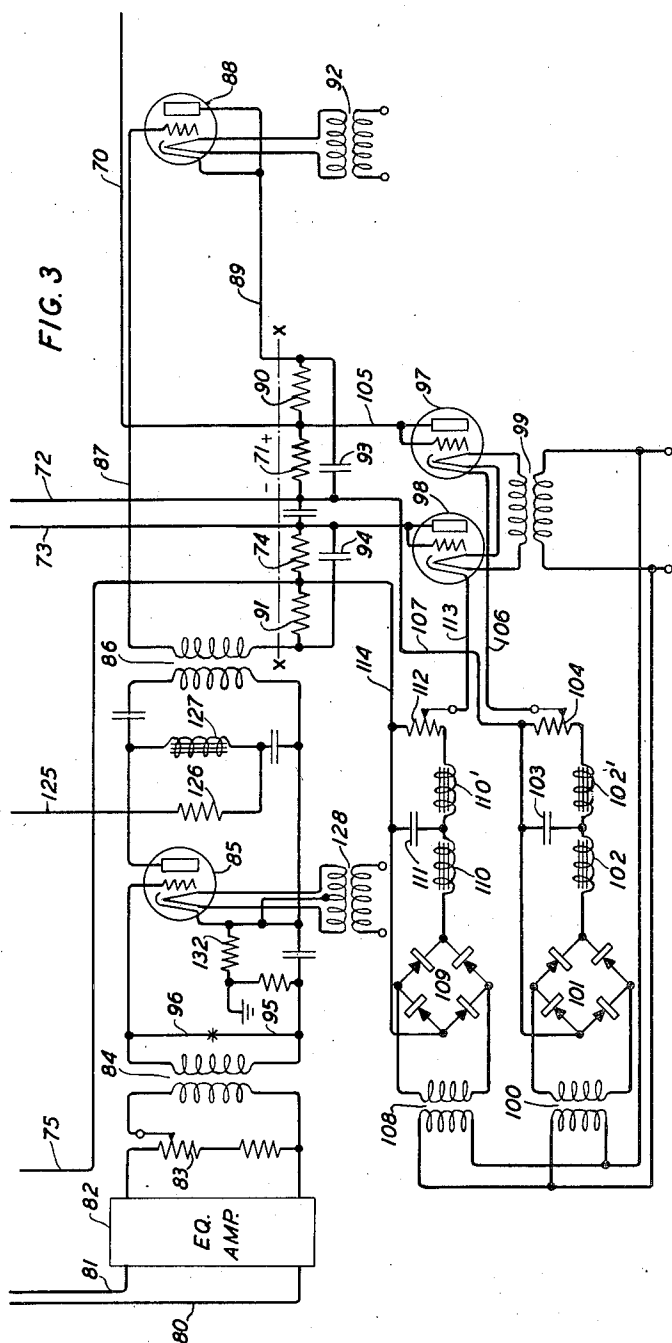
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4 Sheets-Sheet 3



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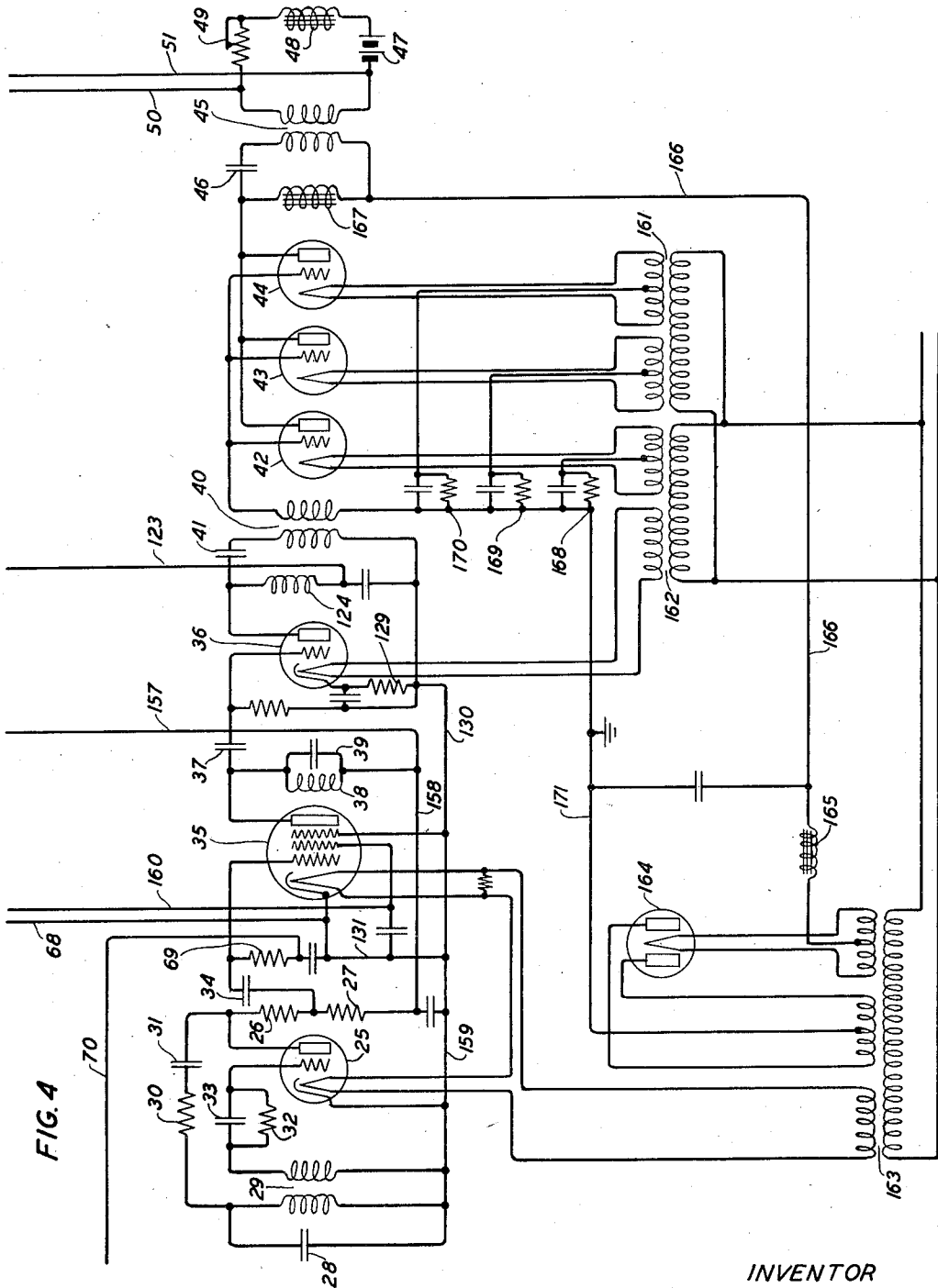


FIG. 4

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2,018,374

SOUND RECORDING SYSTEM

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Application July 28, 1934, Serial No. 737,347

4 Claims. (Cl. 179-100.3)

This invention relates to sound recording systems, particularly film sound recording systems in which the light impressed on the film is modulated in accordance with the quality characteristics of the sound, and the quantity of light impressed on the film is simultaneously varied in accordance with the volume characteristics of the sound.

The object of the invention is the provision of a system which will be more certain and flexible in operation, and in which the recording devices can not be overloaded by a surge of current due to a sudden sound of large volume.

A feature of the invention is the provision of means for supplying rectified sound currents to vary the quantity of light impressed on the film.

Another feature of the invention is the provision of unilaterally conductive means associated with the rectifying means to limit the rectified sound currents which may be supplied to the recording device.

Sound recording systems are known in which the intensity of the recording light varies with the volume characteristics of the sound while the beam is simultaneously modulated in accordance with the frequency characteristics of the sound and others in which the intensity of the recording light is modulated in accordance with the frequency characteristics of the sound while the width or position of the recording beam varies with the volume characteristics of the sound. A system of this character is shown for example in U. S. Patent 1,855,196 patented April 26, 1932 to W. H. Offenhauser, Jr. In such systems, the modulated currents corresponding to the frequency characteristic of the sound are supplied through a controlled amplifier to the recording device. Due to the control exercised over the gain of the amplifier, the modulated currents supplied to the recording device are of substantially constant amplitude. The gain of the amplifier may conveniently be controlled by means of a slowly varying potential obtained from a detector supplied with sound modulated currents. A second detector also supplied with sound modulated currents supplies a slowly varying current to control the intensity of the lamp inversely to the variation in the gain of the amplifier.

As the gain of the amplifier is varied by means of detected sound modulated currents, when the amplitude of the sound modulated currents changes, a certain time will elapse before the gain of the amplifier has been changed to correspond with the change in amplitude. When the recording system has been operating for an appreciable

time on sound modulated currents of fairly large amplitude, the gain of the controlled amplifier will still be fairly large. If a modulated current of still larger amplitude is suddenly applied to the system, before the gain of the amplifier can be reduced, this current, highly amplified, will be impressed on the recording device and may overload the recording device. Also, when this fairly large current was being recorded, the recording lamp was at nearly full brilliancy. Thus, if a modulated current of still larger amplitude is now applied to the system, the recording lamp also may be burnt out. To avoid these difficulties, in accordance with the present invention, unilaterally conductive devices are placed in parallel relation with the voltage supply from the control detectors. A source of biasing potential is associated with the control detectors in such manner that, when the control voltage exceeds a predetermined value, current will flow through the unilaterally conductive devices and prevent the control voltage from further increasing.

The drawings show in diagrammatic form a film sound recording system incorporating the invention.

Fig. 1 shows the signal amplifier;

Fig. 2 shows the recording device and power supply;

Fig. 3 shows the control circuit;

Fig. 4 shows the power supply for the recording light;

Fig. 5 is a keysheet showing the arrangement of the other figures.

In Fig. 1, the microphone 1 and amplifier 2 form a source of signal currents. Any other convenient source of signal currents may be employed such as a plurality of microphones connected to a mixer circuit, a radio receiving set, a telephone circuit, or the signal currents reproduced from a record such as a phonograph record or a sound film. The signal currents may be transmitted through a high pass filter 3, having a lower cut-off at say 40 cycles. This filter eliminates any low frequency noise which may accompany the signals and aids in stabilizing the circuit.

The signals are transmitted through the transformer 4 and impressed on the input circuit of the amplifiers 5 and 6, connected in opposed or push-pull relation. As described in greater detail hereinbelow, the amplifiers 5 and 6 are variable gain amplifiers having a substantially constant output for the major variations in amplitude of the signals.

The output of the variable gain amplifiers 5 and 6 is transmitted through transformer 7 and

further amplified in the two stage resistance coupled amplifiers 8 and 9. An interstage equalizer formed of an inductor 10 and capacitor 11 may be placed in the output circuit of the amplifier 8 to cause an overamplification of the higher frequencies of the signals to compensate for the expected degradation of the higher frequencies in recording. The equalizer may be short-circuited by the switch 12 when not required.

The output of the two stage amplifiers 8 and 9 is transmitted through transformer 13, and impressed on the input circuit of the amplifiers 14, 15 connected in opposed or push-pull relation. The output of the amplifiers 14, 15 is applied through the transformer 16 to a recording device of any convenient type.

For convenience of description, the recording device disclosed in Fig. 2 is of the type described in an article, "The Principles of the Light Valve," by T. E. Shea, W. Herriott, and W. R. Goehner published in the Journal of the Society of Motion Picture Engineers vol. XVIII pages 697-730 June, 1932. It will be apparent to those skilled in the art that the present invention is not limited to the specific light valve disclosed, but is applicable to all similar recording devices. The present invention may also be used in conjunction with many types of recording systems, such as the systems shown in U. S. Patents 1,853,812, April 12, 1932 to C. W. Hewlett 1,854,159, April 12, 1932 to L. T. Robinson, 1,921,037 August 8, 1933 to K. F. Morgan, 1,933,267 October 31, 1933 to C. R. Keith, et al. and many others.

The output from the transformer 16 is supplied to the stretched conducting ribbons 17, 18 Fig. 2 immersed in the steady magnetic field of the magnet 19. The magnetic field due to the signal currents flowing in the ribbons 17, 18 will react with the magnetic field of the magnet 19 and cause the ribbons 17, 18 to oscillate in accordance with the signal currents. Light from a light source 20, is focussed by the lens system 21 through apertures pieced in the pole faces of the magnet 19. The light emerging from the apertures is focussed by the lens 22 on a film 23 traversed in known manner past a slot in an opaque plate 24. The ribbons 17, 18 define the height of the film 23 which, at any instant, is exposed to light from the source 20.

In Fig. 4, the oscillator 25, supplies oscillating power to the resistors 26, 27. The oscillating current has a frequency outside the range of frequencies present in the signals, and for sound recording, may have a frequency of say 12,000 to 15,000 cycles. The frequency of oscillation is determined by the tuned circuit formed by the capacitor 28 and the transformer 29. The resistor 30 and capacitor 31 feed back energy from the output circuit to the input circuit to maintain the oscillations. The resistor 32 and capacitor 33 control the bias applied to the control electrode of the oscillator. While a particular form of oscillator has been disclosed, other known types of oscillators may be used.

The oscillating potential developed across the resistor 27 is applied through the capacitor 34 to the control electrode of a variable gain amplifier 35. As described in detail hereinbelow, the variation in the gain of the amplifier 35 is in the opposite sense to the variation in the gain of the amplifiers 5, 6 in Fig. 1.

The amplifier 35 is coupled to a second amplifier 36 through a capacitor 37 and an impedance formed of an inductor 38 and a capacitor 39 in parallel relation and tuned to the frequency of

the oscillator 25. The output of the amplifier 36 is supplied to the transformer 40, through a capacitor 41. The output of the transformer 40, further amplified in the power amplifier formed of the three amplifiers 42, 43, 44 in parallel relation, is supplied to the transformer 45, through the capacitor 46.

Current from a battery 47 flows through an inductor 48 and a resistor 49, through wire 50 to the source of light 20, Fig. 2 thence through wire 51 back to battery 47. This current is adjusted by resistor 49 so that, in the absence of signal currents, the light from the source 20 falling on the film 23 is small. If the record produced on the film 23 is of the conventional variable density type, the light falling on the film 23 may be adjusted if desired to produce an exposure at the lower end of the region of correct exposure. The output from the transformer 45 also flows through wires 50 and 51 and the source 20 and increases the intensity of the light from the source 20 in accordance with the power supplied from the transformer.

Power from a suitable alternating current source is supplied to the primary winding of the transformer 52, Fig. 2. The output of the secondary windings 54 and 55, connected in parallel, heat the cathode of the rectifier 57. The winding 55 is center tapped for the positive connection of the rectified current. If desired, a single winding may replace the windings 54 and 55. The outer ends of the secondary windings 53 and 56 are connected to the anodes of the rectifier 57; the inner ends of these windings are connected together to the negative connection of the rectified current. Full wave rectified current flows from the tap on winding 55, through the smoothing inductors 58, 58', and the potential dividing resistors 59, 60, 61, 62, 63, 64, 65 to the junction of windings 53 and 56, thence alternately from each anode to the cathode of the rectifier 57. Smoothing capacitors may be connected across the resistors as shown. Positive potential is supplied by wire 66 to the anodes of the amplifiers 5 and 6, Fig. 1. A smaller positive potential is supplied by wire 67 to the screen grids of the amplifiers 5 and 6.

Positive potential is supplied by wire 68 to the cathode of amplifier 35, Fig. 4. The control electrode of amplifier 35 is connected through resistor 69 wire 70, resistor 71, Fig. 3, wire 72 to the junction of resistors 64 and 65, Fig. 2. The control electrode of amplifier 35 is thus steadily biased negatively by the potential difference developed across the resistors 63 and 64.

A negative potential is supplied by wire 73, through resistor 74, Fig. 3, wire 75, smoothing inductor 76, Fig. 1 and resistor 77, balancing resistors 78 and 79 to the control electrodes of the amplifiers 5 and 6. The cathodes of the amplifiers 5 and 6 are grounded, and the junction of the resistors 63 and 64 is grounded. Thus the control electrodes of the amplifiers 5 and 6 are steadily biased negatively by the potential difference developed across the resistors 64 and 65.

Signal currents from the output of the high pass filter 3, Fig. 1, are supplied through wires 80 and 81 and amplifier 82, Fig. 3 to a potentiometer 83 across the transformer 84. The output of transformer 84, suitably amplified in amplifier 85 is supplied to transformer 86. The output of transformer 86 flows along wire 87 through the rectifier 88, wire 89, resistors 90 and 71, wire 72, resistor 65, Fig. 2 wire 73 resistors 74 and 91 back to transformer 86. The rectifier 88 is shown as

a thermionic triode, with indirectly heated cathode. Rectification takes place between the cathode and control electrode, while the anode is connected to the cathode to stabilize the action. The heater is supplied with power from any suitable source such as the transformer 92. The rectified signal currents flowing in the resistor 71 will produce a potential difference which will decrease the biasing potential on the control electrode of the amplifier 35, Fig. 4 due to the steady potential difference across resistors 63 and 64. The rectified signal currents flowing in resistor 74 will produce a potential difference which will increase the biasing potential on the control electrode of the amplifiers 5 and 6, Fig. 1 due to the steady potential difference across resistors 64 and 65.

When the signal currents are of small amplitude, the biasing potential on the amplifiers 5 and 6 is small, thus the signal currents are highly amplified and produce substantially maximum amplitude of oscillation of the ribbons 17, 18 of the light valve. At the same time, the biasing potential on the amplifier 35 is quite large, thus the high frequency currents from the oscillator 25 are only slightly amplified by the amplifier 35 and the lamp 20 is operating at low intensity. The original or negative record will thus be of low density, that is, the transmission is large. When this original record is printed in the usual manner, the positive print will be correspondingly dark, that is the transmission is small. The amplitude of the reproduced signal currents is proportional to the product of the degree of modulation multiplied by the average transmission. As the modulation is large, approaching 100 per cent, and the average transmission is correspondingly small the recorded signal currents are not distorted and the reproduced signal currents will be of correct amplitude or volume.

Now, when the signal currents increase in amplitude, the rectified current from the rectifier 88 increases, and increases the potential difference produced across the resistors 71 and 74. The increased potential difference across resistor 74 increases the biasing potential on the control electrode of the amplifiers 5 and 6 and decreases the amplification of the amplifiers 5 and 6 proportionally to the increase in amplitude of the signal currents. The increased signal currents thus still produce substantially maximum amplitude of oscillation of the ribbons 17, 18 of the light valve. At the same time, the increased potential difference produced across the resistor 71 decreases the biasing potential on the control electrode of the amplifier 35, the high frequency currents are amplified to a greater degree, and the intensity of the light from the lamp 20 increases. The original or negative record will thus be of increasing density. Thus, when this original record is printed, the mean transmission of the positive print will be greater than for signal currents of small amplitude. Again, the amplitudes of the recorded signal currents are not distorted and the reproduced signal currents will be of correct amplitude or volume.

The capacitor 93 is bridged across the resistors 90 and 71 and will be charged by the rectified signal currents. The charge will tend to leak off through the resistors 90 and 71. The capacitor 94 is similarly connected across the resistors 91 and 74. These capacitors affect the timing of the controlling circuit so that, when the signal currents increase in amplitude, the control circuit responds fairly rapidly, whilst when the signal currents decrease in amplitude, the control

circuit restores rather slowly. The control circuit thus will not follow the low frequency variations of the signal currents but approximately follows the variations in the mean amplitude integrated over several cycles. The reciprocal changes in the amplification of the amplifiers 5 and 6 and the amplifier 35 must be equal in effect and take place within the same time. As the filament of the lamp 20 has appreciable thermal inertia, the control circuit must not operate faster than the intensity of the light can be changed. Thus, if the system is recording signal currents of about maximum amplitude, the lamp 20 will be of maximum brilliance and the ribbons 17, 18 of the light valve oscillating at full amplitude. To modify the input wave applied to the control circuit so that the light valve will be fully modulated for a wide range of inputs, two "Thyrite" resistors 95 and 96 are shunted across the output winding of the transformer 84, Fig. 3. 20 These resistors have the property of a comparatively high resistance for low voltages, and a low resistance for voltages exceeding a certain critical value. The properties of "Thyrite" resistors are given in detail in the General Electric Review, 25 vol. 33, No. 2, February 1930 page 92 and No. 6 June 1930 page 350.

The modification of the wave shape afforded by the "Thyrite" resistors however, is not sufficient to prevent a sudden transient from overloading the valve or burning out the lamp 20. For further protection, a rectifier 97 is shunted across the resistor 71 and a similar rectifier 98 is shunted across the resistor 74.

The rectifier 97 is shown as a thermionic triode, 35 with the anode and control electrode connected together to form a thermionic diode. Other forms of rectifiers may obviously be used. Power from a suitable alternating source is supplied through transformer 99 to the heater elements 40 of the rectifiers 97 and 98. Power from the same or a similar source is supplied through transformer 100 to the full wave rectifier 101, which may be of the known copper-copper oxide type. The output of the rectifier 101 is smoothed by 45 the inductors 102 and 102' and capacitor 103 and supplied to the variable resistor 104. The potential difference developed across the resistor 71 by the signal currents rectified in the rectifier 88 is applied along wire 105 to the anode of 50 the rectifier 97, thence along wire 106 to the wiper of the variable resistor 104, and from resistor 104 along wire 107 to the other end of resistor 71. A part of the potential developed across resistor 104 is thus opposed to the potential developed across resistor 71. So long as the potential developed across resistor 71 is less than the potential developed across the part of resistor 104, practically no current will flow in rectifier 97. However, when the potential developed 60 across resistor 71 exceeds the potential developed across resistor 104 by a small amount, a comparatively large current will flow in the rectifier 97. The potential developed across resistor 71 cannot further increase due to the low resistance 65 path through the rectifier 97. Thus, large transients are prevented from affecting the control circuit. By adjusting the resistor 104 the maximum voltage which is permitted to develop across the resistor 71 may be changed. From the operation it is obvious that the rectifier 97 may be any asymmetrically conductive device having a large resistance in one direction of flow and a small resistance in the other direction of flow.

In a similar manner, power from a suitable 75

source is supplied to transformer 108, rectified by rectifier 109, smoothed by inductors 110 and 110' and capacitor 111 and produces a difference of potential across the variable resistor 112. The potential developed across the resistor 74 is applied to the anode of the rectifier 98, thence from the cathode along wire 113 to the wiper of the variable resistor 112, and along wire 114 to resistor 74. As before, a part of the potential developed across the resistor 112 is opposed to the potential developed across the resistor 74. When the potential developed across resistor 74 exceeds the value determined by the setting of the wiper on resistor 112, current will flow through the rectifier 98 and the potential developed across resistor 74 will not rise any further.

In Fig. 3A, a single rectifier 115 is connected across both the resistor 71 and the resistor 74. As before, a biasing potential is supplied from the full-wave rectifier 116 to the variable resistor 117. In this case, when the combined potential difference developed across the resistors 71 and 74 in series exceeds the biasing potential determined by the setting of the slider on resistor 117, current will flow in the rectifier 115 and the potential difference will not rise further. The control shown in Fig. 3A is cheaper and simpler than the control shown in Fig. 3, but is not as flexible in adjustment.

In Fig. 2, power from an alternating source is supplied to transformer 118, rectified in full wave rectifier 119 and supplied to the potential divider formed by the resistors 120, 121, 122 in series. Current flows through wire 123, and shunt feed inductor 124 to the anode of amplifier 36. Fig. 4 thence from the cathode through biasing resistor 129, wires 130, 131, 68, resistor 63, to the grounded end of resistor 122. Current flows along wire 125, resistor 126 and shunt feed inductor 127 to the anode of amplifier 35, Fig. 3, thence from the cathode through biasing resistor 132 and ground to the grounded end of resistor 122. The heater element of amplifier 35 is energized by power from a suitable alternating source through transformer 128. Power also flows along wire 133, Fig. 1, through the smoothing inductors 134, 135 and resistor 136 to the anode of amplifier 9, thence from the cathode through biasing resistor 137 to ground and back to the grounded end of resistor 122. Current from the inductor 135 flows through resistor 138, inductor 10, resistor 139 to the anode of amplifier 8, thence from the cathode through biasing resistor 140 to ground and back to the grounded end of resistor 122. Resistor 141 is the usual grid coupling resistor. Resistors 142 and 143 reduce the hum that might be caused by variations in the current supplied to the amplifiers. Resistor 144 improves the frequency response characteristic of the transformer 7. Current from battery 145 flows through resistor 146 through the heater elements of amplifiers 8 and 9 in parallel, along wire 147, through the heater elements of amplifiers 5 and 6 and resistor 148 all in parallel along wire 149 back to battery 145. The battery 145 may be replaced by any other suitable source of power if desired.

Current also flows from wire 133 through wire 150, smoothing inductors 151, 152, resistor 153, primary winding of transformer 16, anode-cathode circuit of amplifiers 14 and 15, biasing resistor 154 to ground and thence to the grounded end of resistor 122, Fig. 2. Resistor 155 reduces the hum that might be impressed on the control electrodes of amplifiers 14 and 15. The heater ele-

ments of amplifiers 14 and 15 are energized from transformer 156 connected to a suitable source of alternating current.

Current flows along wire 157 Fig. 2, through inductor 38, Fig. 4 to the anode of amplifier 35; and along wire 158 through resistors 27, 26 to the anode of oscillator 25. The combined currents flow from the cathodes of amplifier 35 and oscillator 25 along wires 159, 131, and 68 through resistor 63, Fig. 2, to ground thence to the grounded end of resistor 122, Fig. 2. Current also flows along wire 160, to the screen grid of amplifier 35, thence to the cathode and joins the combined anode-cathode currents of amplifier 35 and oscillator 25.

In Fig. 4, power from a suitable alternating supply is supplied through transformer 161 to the filaments of the amplifiers 43 and 44; through the transformer 162 to the filament of amplifier 42 and the heater element of amplifier 36; and through transformer 163 to the heater elements of oscillator 25 and amplifier 35 and the filament of the full wave rectifier 164. Power is also supplied through transformer 163 to the anodes of the rectifier 164 thence alternately to the filament of rectifier 164, through smoothing inductor 165, wire 166, shunt feed inductor 167 to the anodes of the amplifiers 42, 43, 44, through the amplifiers to their respective filaments, and transformer windings, thence respectively through biasing resistors 168, 169, 170 and wire 171 to transformer 163. The control electrodes of amplifiers 42, 43, 44 are connected together and through transformer 40 to the resistors 168, 169, 170.

What is claimed is:

1. In a recording system, a source of modulated currents, means for amplifying said currents including a controlled amplifier, a circuit for supplying the output of said amplifier to a recording device, a detector energized by said modulated currents and having an element controlling the output of said controlled amplifier, an asymmetrically conductive device in parallel relation with said element, and a source of potential in serial relation with said asymmetrically conductive device and connected to oppose the potential difference developed across said element.

2. In a recording system, a recording medium, a recording lamp, a modulating device interposed between said lamp and said medium, a source of modulated currents, means for amplifying said currents including a controlled amplifier, a circuit for supplying the output of said amplifier to said modulating device, means for controlling the output of said amplifier including a detector energized by modulated currents, means for controlling the light from said recording lamp including a second detector energized by modulated currents and having an element controlling the light from said lamp, an asymmetrically conductive device in parallel relation with said element and a source of potential in serial relation with said asymmetrically conductive device and opposing the potential difference developed across said element.

3. In combination, a source of modulated currents, means for amplifying said currents including a controlled amplifier, a device actuated by the output of said amplifier, an impedance element in the input circuit of said amplifier, a second impedance element in serial relation with said first impedance element, a third impedance

element in serial relation with said second impedance element, a rectifier energized by modulated currents, in serial relation with all said impedance elements, an electrical storage device in parallel relation with all said impedance elements, an asymmetrically conductive device in parallel relation to said first and said second impedance elements, and a source of potential in serial relation with said asymmetrically conductive device and connected to oppose the potential difference developed across said first and said second impedance elements.

4. In combination, a source of modulated currents, means for amplifying said currents including a controlled amplifier, a device actuated by

the output of said amplifier, an impedance element in the input circuit of said amplifier, a second impedance element in serial relation with said first impedance element, a rectifier energized by modulated currents in serial relation with both said impedance elements, an electrical storage device in parallel relation with both said impedance elements, an asymmetrically conductive device in parallel relation to said first impedance element, and a source of potential in serial relation with said asymmetrically conductive device and connected to oppose the potential difference developed across said first impedance element.

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