

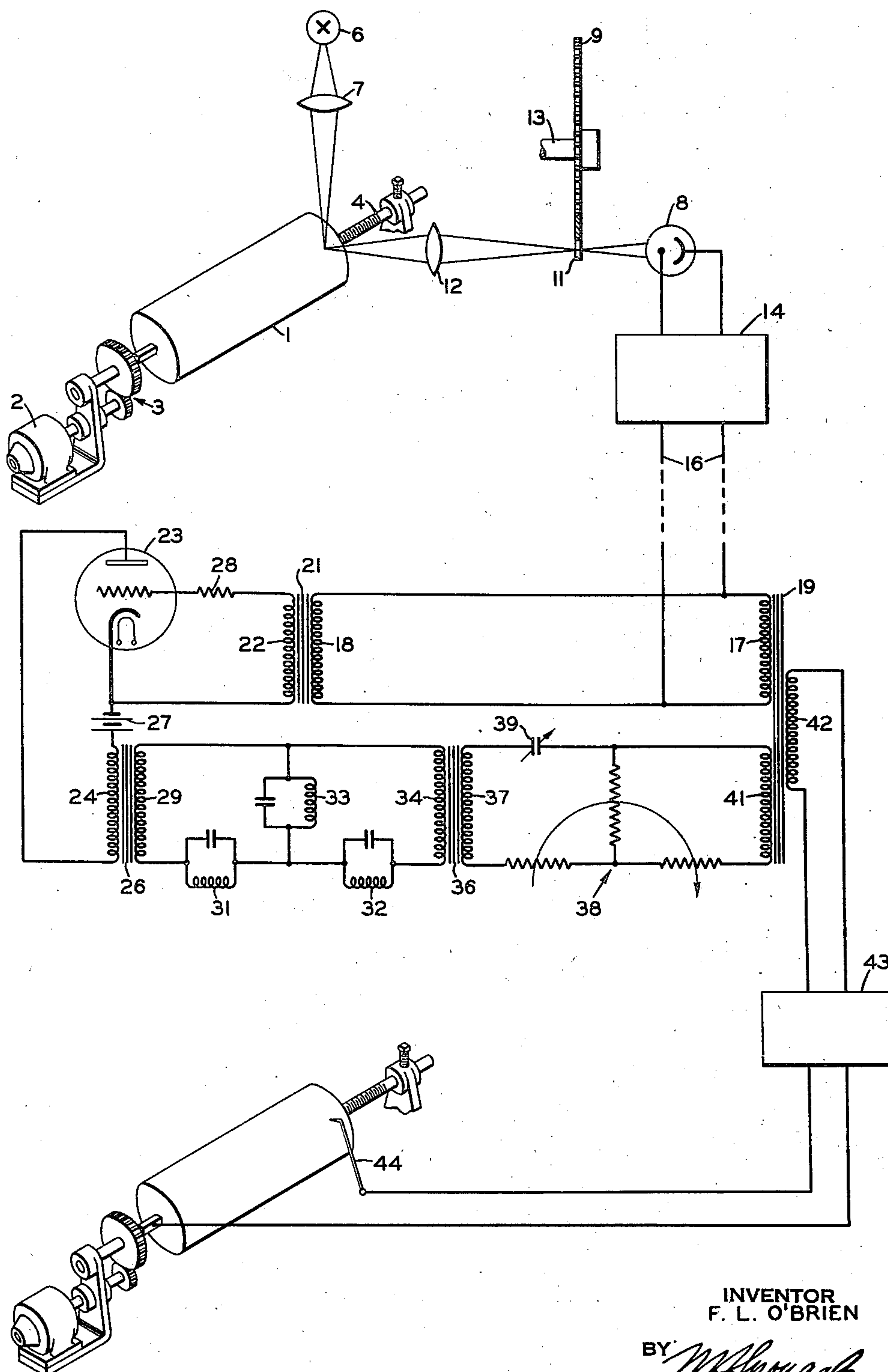
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FACSIMILE SIGNAL INVERTER

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## FACSIMILE SIGNAL INVERTER

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This invention relates to the art of signaling and more particularly to signaling by means of amplitude modulated alternating currents.

In certain types of facsimile telegraph systems a relatively high frequency train of oscillations is modulated in amplitude at a relatively low frequency in accordance with tone values of the subject matter being scanned. One form of a scanning device employs a light sensitive element such as a photoelectric cell to control the carrier modulation in accordance with the quantity of light reflected from the subject matter onto the photoelectric cell. Thus, an elemental area from which a large quantity of light is reflected is represented by signals having a relatively large amplitude and, conversely, a relatively dark elemental area is represented by signals having a relatively small amplitude. Such signals may be employed to record on a photographic film or equivalent recording means for the purpose of obtaining a negative copy of the scanned subject matter. However, in order to obtain a positive copy or an exact reproduction of the scanned subject matter, it is necessary to make a positive print from the film or other recording medium.

In order to eliminate this additional step the facsimile signals may be inverted. Numerous signal inverting systems have been proposed heretofore for inverting the signals as they are generated at the transmitter, but it is not always convenient to employ such apparatus because of the fact that skilled operators may not be available at the transmitting point to make the necessary adjustments. Also, it is often desirable to effect the simultaneous recording of facsimile signals to obtain both a negative and a positive copy of the transmitted subject matter. For the foregoing reasons and also because it may be more feasible to locate the signal inverting apparatus at the receiving point where the recorded copy may be used as a guide in making the necessary adjustments, it is desirable that means be provided for inverting the facsimile signals at the receiving station. It is very advantageous, in employing apparatus which is used for such a purpose at a point remote from the transmitting station, to maintain the apparatus in exact synchronism with the generator of the signals. In this way, any variation in the frequency of the modulated carrier wave is compensated for in the signal inversion apparatus.

Hence, it is the primary object of the invention to provide novel means for inverting fac-

simile telegraph signals subsequent to the generation thereof.

Another object of the invention resides in the provision of means for operating facsimile signal inverting apparatus in exact synchronism with the signal generator.

Still another object of the invention is to provide means for generating an unmodulated alternating current and for combining the generated alternating current with the modulated facsimile signals in a manner to produce other signals modulated inversely to the facsimile signals.

A further object of this invention is to provide means for deriving a constant amplitude alternating current from the modulated facsimile signals.

Other and more specific objects of the instant invention will appear in the following description of the invention taken in conjunction with the accompanying drawing, the single figure of which shows the circuit arrangement of a facsimile telegraph system embodying an illustrative form of the novel facsimile signal inverting system.

In its general aspect the invention contemplates the derivation from amplitude modulated facsimile signals of a constant amplitude alternating current. The amplitude of this derived alternative current is suitably adjusted and combined with the facsimile signals in phase opposition. Where the facsimile signals are generated by an optical scanning device or equivalent apparatus the relatively light areas of the scanned subject matter are represented by relatively large amplitude signals and the relatively dark areas of the scanned subject matter are represented by relatively small amplitude signals. By making the amplitude of the derived alternating current equal to or greater than the maximum amplitude of the facsimile signals, the resultant of the combination is signals in which the light areas of the scanned subject matter are represented by relatively small amplitudes and the dark areas of the scanned subject matter are represented by relatively large amplitudes. Thus, the signals so formed are suitable for making a positive copy by electrical recording apparatus wherein the relative darkness of the recorded mark is determined by the strength of the current.

The invention is disclosed and described in conjunction with a facsimile telegraph system employing an optical scanning device. It will be understood that the instant invention is not



limited to the specific combination of instrumentalities disclosed herein, but may be practiced in combination with substantially any form of facsimile scanning apparatus. Referring to the drawing, the subject matter to be scanned may be conveniently mounted on a drum 1. The drum is rotated at a suitable speed by means of a driving motor 2 which is connected thereto by means of a coupling device 3. Axial movement of the drum 1 is produced by a suitable means 4 so that the entire field of the message may be scanned. Light from a source 6 is concentrated by means of a lens 7 upon the surface to be scanned and is reflected into a photoelectric cell 8 or equivalent device. The spot of light which is projected upon the surface of the cylinder or drum 1 is thus caused to traverse the cylinder in a longitudinal direction as the cylinder rotates by reason of the axial movement thereof. The light which is reflected from the surface of the subject matter being scanned and which is incident upon the photoelectric cell 8 is interrupted by a shutter or light chopper 9. The shutter may be in the form of a disc as illustrated which is provided with a series of equally spaced openings or notches 11 adjacent its outer edge. In cases where the reflected light is to be interrupted, a lens 12 serves to bring the reflected light beam to a focus substantially in the plane of the disc 9 so that it may pass through the openings 11 successively. The disc 9 is mounted upon a rotatable shaft 13 which may be driven in any suitable manner from the motor 2, or, if desired, from a separate source of mechanical power. The number of openings in the disc and the speed of rotation of the shaft may vary within wide limits depending upon the desired rate of scanning, the constants of the communication circuit employed between the transmitting and receiving stations and other factors. The output appearing across the terminals of the photoelectric cell 8 is of such a character that a negative copy of the scanned subject matter will be reproduced by the usual recorder employed in facsimile systems of this nature.

In cases where it is desired to make a positive record from facsimile signals generated as described, a signal inverter is employed, a novel form of which comprises the subject matter of the instant invention. Subsequent to the generation of the facsimile signals modulated in accordance with the tone values of the subject matter scanned as described, the signals may be amplified by means of a suitable amplifier 14 and transmitted over a pair of line conductors 16. At the receiving station the line conductors are terminated in windings 17 and 18 of transformers 19 and 21 respectively. The modulated facsimile signals are reproduced by induction in the winding 22 of transformer 21 which is connected to the input circuit of a thermionic device 23. The output circuit of the thermionic tube 23 includes the winding 24 of transformer 26 and a source of plate potential 27. In practicing the invention it is desirable that the potential 27 have a relatively low value so that the tube 23 may be saturated by the facsimile signals having a minimum amplitude. The input circuit of the tube 23 includes a relatively high resistance 28 so that the minimum amplitude as well as the maximum amplitude signals flowing there-through during the positive half cycles are proportionately reduced so as to arrive at the tube at a substantially uniform value. The tube is

operated at cut-off by negative half cycles of the facsimile signals. Such an arrangement produces current alternations in the output circuit from which they are impressed upon the winding 24 of transformer 26. These alternations have a constant amplitude irrespective of the amplitude of the facsimile signals from which they are derived.

It will be evident that some of the alternations induced in winding 29 of transformer 26 will be distorted by reason of the described operating characteristics of the vacuum tube 23. The minimum amplitude signals, however, will be substantially sinusoidal in wave form. In order that the invention be practised efficiently, it is desirable that all of the alternations of the derived constant amplitude alternating current be sinusoidal in form. This is accomplished by the use of a band pass filter by means of which the harmonics and other incidental interference currents are removed from the derived alternating current. Such a filter is shown in conventional form comprising series elements 31 and 32 and a shunt element 33. It will be understood that the instant invention is broad enough to include other types of filters whereby the desired result is obtained. The output of the band pass filter comprising a series of constant amplitude sinusoidal alternations is connected to winding 34 of transformer 36.

Similar alternations are induced in winding 37 of transformer 36. It will be obvious that the amplitude of the alternating current appearing in the winding 37 may be substantially greater than the maximum amplitude of the modulated facsimile signals by reason of the amplifying characteristics of the vacuum tube 23 which may be adjusted to produce such a gain.

One manner of practicing the invention is to adjust the amplitude of the derived alternating current to substantially the maximum amplitude of the facsimile signals. Hence an amplitude controlling device such as a T-pad 38 is employed for this purpose in the circuit connected to winding 37.

In order to utilize the derived alternating current in accordance with the instant invention, it is necessary that, in addition to suitably adjusting the amplitude thereof, the proper phase relation to the received facsimile signals be obtained. It is well known that one of the inherent characteristics of a transformer is that of producing substantially a 180° phase difference between the inducing and the induced currents. Therefore, it is obvious that if an odd number of such transformers be employed a 180° phase difference will exist between the inducing currents of the first of such transformers and the induced currents of the last of such transformers. In the instant disclosure three transformers 21, 26 and 36 are employed so that the constant amplitude alternating current appearing in the winding 37 of transformer 36 is substantially 180° out of phase from the modulated facsimile signals impressed upon the winding 17 of transformer 19. But, because of the presence of a number of inductive elements in the circuits employed for the derivation of the constant amplitude alternating current, there may be some small discrepancy in the exact out-of-phase relation existing between the received facsimile signals and the derived alternating current. Hence a condenser 39 is connected in series with the output circuit of the transformer 36 for the purpose of adjusting the phase of the derived alternating current to be in



exact opposition to that of the received facsimile signals. Consequently, when the constant amplitude alternating current is impressed upon a winding 41 of transformer 19, an induced current which is the resultant of the modulated facsimile signals applied to the winding 17 and the constant amplitude current applied to the winding 41 will appear in the winding 42 of this transformer. It will be evident that, by reason of the opposing phase relation described, the facsimile signals having the maximum amplitude will be deleted since they are combined with components of the alternating current which have the same amplitude but are of opposite phase. Components of the modulated facsimile signals having amplitudes less than the maximum are combined with components of the alternating current having relatively larger amplitudes so that the resultant signals will have amplitudes which are inversely related to the corresponding amplitudes of the facsimile signals.

The inverted signals which appear in the winding 42 of transformer 19 may be suitably amplified by any convenient device 43 designed for that purpose and applied to the recording apparatus. Such apparatus, as disclosed herein, is substantially similar to the transmitting apparatus previously described with the exception that instead of the optical scanning instrumentalities, the recording apparatus is provided with a stylus 44 by means of which recording may be effected electrically in a manner known in the art. Thus, it is seen that, by employing the signal inverting apparatus described, the recording apparatus functions in such a manner that marks are made on the recording medium having tone values varying between white and black in accordance with the variation in the current amplitude of the signals impressed upon the recording stylus 44.

It is possible to adjust the amplitude of the derived alternating current so that any desired background effect may be produced. For example, if instead of canceling or deleting entirely the components of the modulated facsimile signals having a maximum amplitude it is desired that they be given some small value, the amplitude of the derived alternating current which is combined with the facsimile signals may be increased to a value suitably greater than the maximum amplitude facsimile signals. In the apparatus disclosed, the amplitude controlling device 38 may be omitted or rendered ineffective in which case the amplitude of the derived alternating current which is impressed upon the winding 41 of transformer 19 may be determined solely by the amount of gain produced by the vacuum tube 23. It will be apparent to those skilled in the art that by properly selecting the amplitude of the derived alternating current a precisely inverted reproduction of the received facsimile signals may be obtained. It will be understood that the absolute value of the recording signal amplitudes in relation to a reference amplitude is relatively unimportant so long as the proper amplitude ratios between the various components comprising the recording signals is inversely proportional to the ratios of the facsimile signals as generated by the transmitter.

It also will be understood that a constant amplitude alternating current may be derived from numerous other sources well known in the art and suitable means employed for maintaining the necessary synchronism between the generated facsimile signals and the derived alternat-

ing current. It is contemplated that all such prior art devices be included within the scope of the instant invention. Also the conductors 16 may be employed to connect the scanning apparatus with the inverting apparatus both of which may be located within the same station and that the output of the amplifier 43 be connected to any suitable communication channel.

Numerous other modifications of the apparatus employed to practice the invention will occur to those skilled in the art and it is contemplated that only such limitations be placed upon the invention as are set forth in the appended claims.

What is claimed is:

1. In a facsimile telegraph system, means for generating facsimile signals comprising carrier currents modulated in amplitude between maximum and minimum limits in accordance with tone values of subject matter, means for deriving from said currents an unmodulated alternating current of the same frequency as the generated carrier currents, and means for combining said unmodulated alternating current with said modulated carrier currents in a predetermined phase relation to produce recording carrier currents inversely modulated in amplitude to said generated signals.

2. In a facsimile telegraph system, means for generating facsimile signals comprising carrier currents modulated in amplitude between maximum and minimum limits in accordance with tone values of subject matter, means for deriving from said currents an alternating current of the same frequency as the generated carrier currents and having a constant amplitude, and means for combining said constant amplitude currents with said generated signals in phase opposition to produce recording carrier currents inversely modulated in amplitude to said generated signals.

3. In a facsimile telegraph system employing transmitted signal energy comprising alternating currents modulated in amplitude in accordance with tone values of subject matter, means for dividing said signal energy into a plurality of portions each retaining the modulation characteristics of the transmitted signals, means for amplifying the modulated components of one of said portions by factors inversely related to the amplitudes of the respective components, and means for combining said amplified signal energy with the signal energy of another of said portions in a predetermined phase relation to produce recording signals modulated inversely to said transmitted signals.

4. In a facsimile telegraph system employing transmitted signal energy comprising alternating currents modulated in amplitude in accordance with tone values of subject matter, means for dividing said signal energy into a plurality of portions each retaining the modulation characteristics of the transmitted signals, means including a vacuum tube for amplifying the components of one of said portions in a manner to produce uniform amplitude of all of said components, means for shaping said amplified signals to the same wave form of said transmitted signals, and means for combining said amplified and shaped signal energy with the signal energy of another of said portions in phase opposition to produce recording signals modulated inversely to said transmitted signals.

5. In a facsimile telegraph system employing transmitted signal energy comprising alternating currents modulated in amplitude in accordance



with tone values of subject matter, means for dividing said signal energy into a plurality of portions each retaining the modulation characteristics of the transmitted signals, means including a vacuum tube operated so as to be saturated by those of the signals of one of said portions having a minimum amplitude, a band pass filter connected to the output circuit of said tube to produce alternating current having a

constant amplitude equal to those of said transmitted signals having maximum amplitudes, and means for combining said constant amplitude alternating current with the signals of another of said portions in phase opposition to produce recording signals modulated inversely to said transmitted signals.

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