

Aug. 27, 1940.

A. G. COOLEY

2,212,808

SIGNALING METHOD AND APPARATUS

Filed May 12, 1939

3 Sheets-Sheet 1

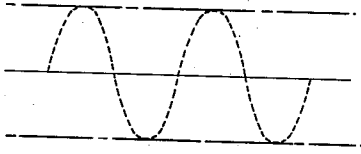


Fig. 1.

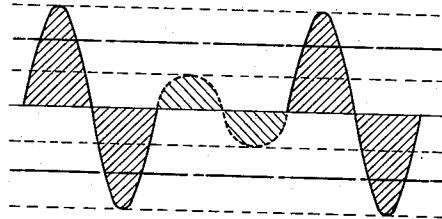


Fig. 1A

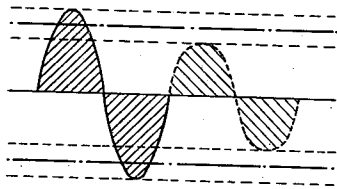


Fig. 1B

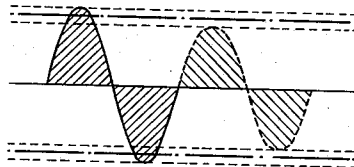


Fig. 1C

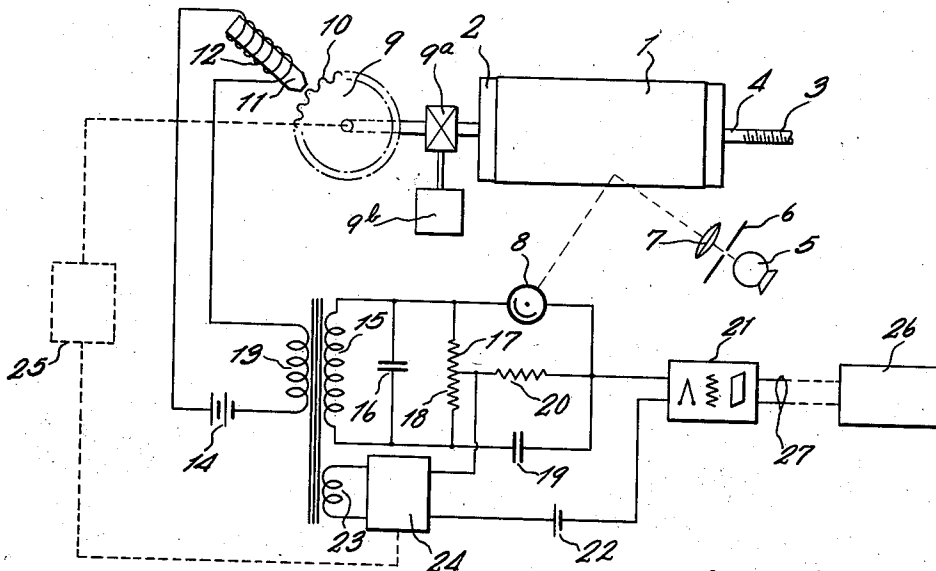


Fig. 2.

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3 Sheets-Sheet 2

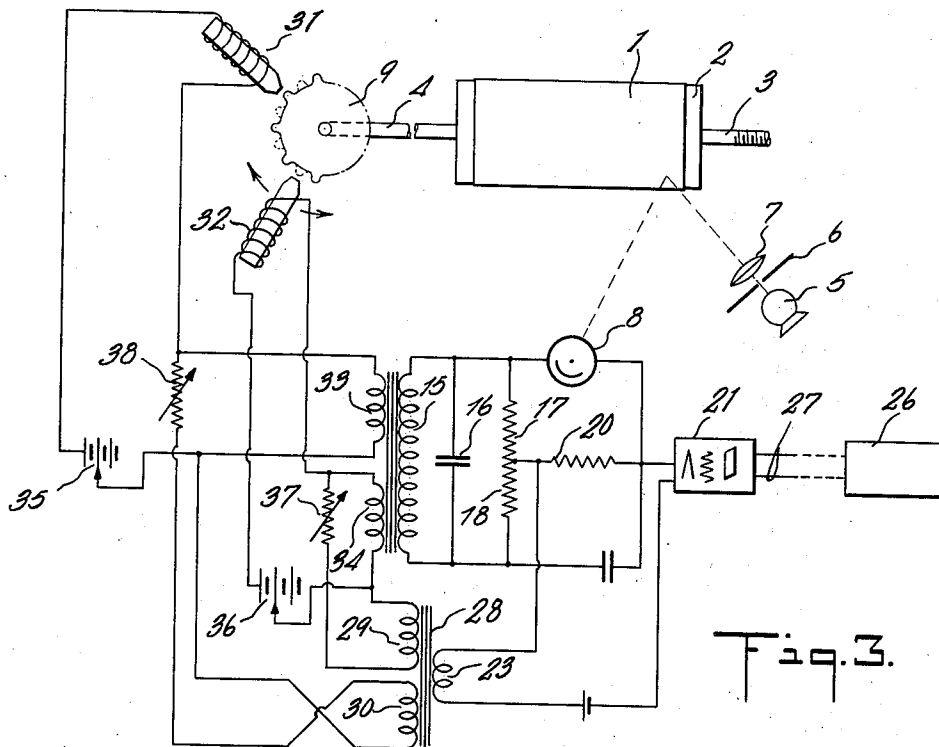


Fig. 3.

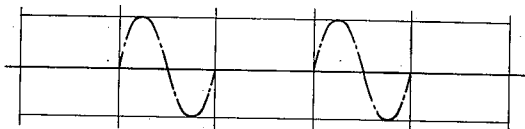


Fig. 4.

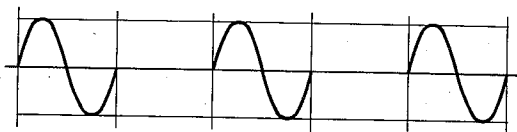


Fig. 4A.

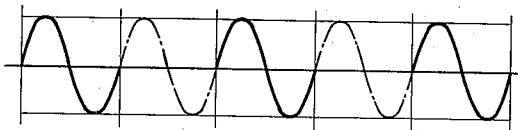


Fig. 4B.

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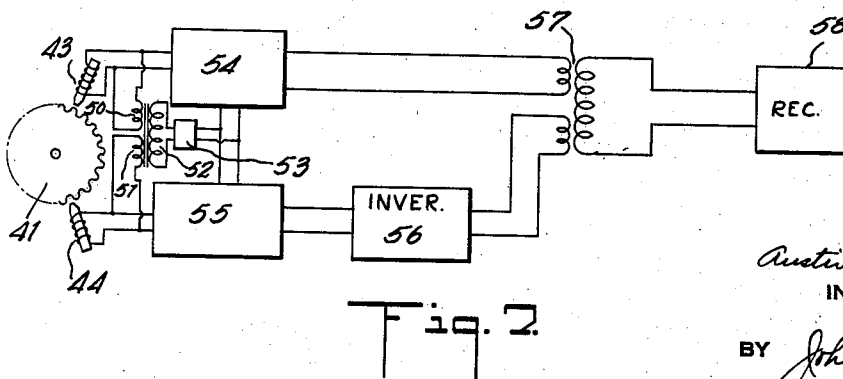
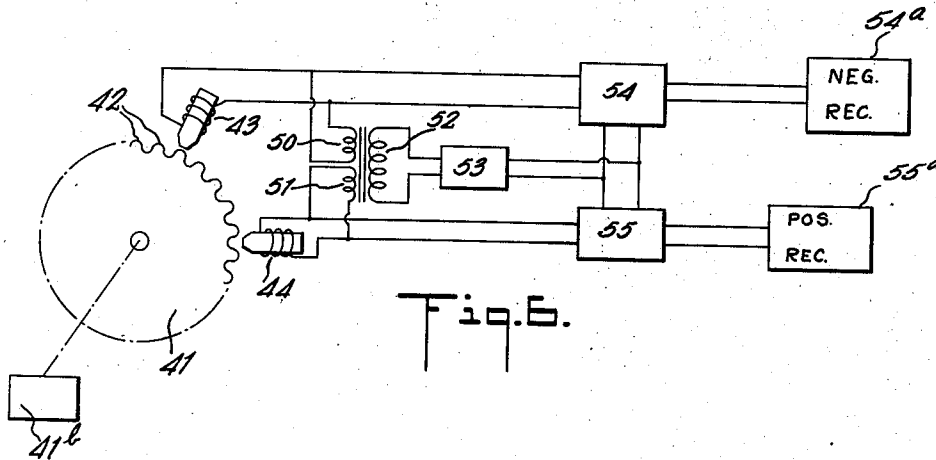
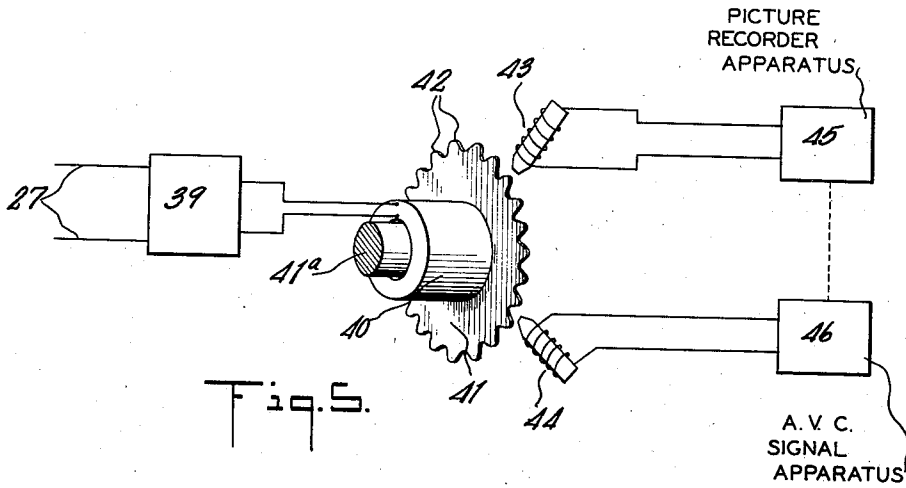
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SIGNALING METHOD AND APPARATUS

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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

2,212,808

SIGNALING METHOD AND APPARATUS

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Application May 12, 1939, Serial No. 273,162

37 Claims. (Cl. 178-6.6)

This invention relates to telecommunication systems and more especially to systems employing signals in the form of a signaling wave of predetermined frequency.

5 A principal object of the invention is to provide a system for producing a signaling wave wherein alternate complete cycles are modulated in opposite directions and while the invention finds its immediate usefulness in the field of tele-
10 facsimile transmission, in certain of its phases it can be applied to wave signaling systems generally.

15 Another principal object of the invention is to provide a system for producing a signaling wave of a constant frequency wherein alternate complete cycles are modulated in accordance with different signals to be transmitted.

20 Another object is to provide a system for transmitting signals between transmitting and receiving apparatus requiring synchronization, and wherein a single signaling frequency is used to transmit the messages and to derive level control signals at the receiver.

25 When facsimile signals are to be transmitted over a connecting link which is subject to fading, particularly where the link includes a radio channel, it is usually necessary to employ some form of automatic level control at the receiver. In many cases radio carrier-frequency level control or A. V. C. at the receiver is not sufficient
30 and it becomes necessary therefore to transmit over a pilot channel a separate level control signal. However, I have found that such pilot signals do not always vary in the same direction and positions as the accompanying facsimile signals. Patents No. 1,737,503 and No. 2,054,657 disclose
35 a method of level control wherein a separate pilot frequency closely adjacent the facsimile signal frequency is employed. While it is possible to achieve level correction with the arrangement
40 of said patents, the utmost in accuracy is not often attainable because it is not practical to employ a pilot frequency extremely close to the facsimile signal frequency. In accordance with
45 the present invention, the pilot signal and facsimile signal are transmitted at substantially the same frequency, consequently any fading or phase discrimination affects both alike.

50 Another object of the invention is to provide a method of generating a wave of uniform frequency in which alternate complete cycles represent facsimile signals and intervening alternate complete cycles represent pilot or level control signals. As a result, it is possible to produce
55 at the receiving end of the system a level con-

trol or A. V. C. signal which truly represents the variations in level of the transmission link or medium.

A feature of the invention relates to a novel modulating system whereby a carrier wave of 5 uniform frequency has alternate complete cycles modulated by one signal and the intervening alternate complete cycles modulated by a different signal.

Another feature relates to a novel modulating 10 system for facsimile transmission whereby a signaling wave of uniform frequency has successive cycles modulated in opposite directions.

Another feature relates to a novel form of receiving system for use in connection with a re- 15 ceived uniform frequency signaling wave which has successive complete cycles modulated in opposite directions.

A further feature relates to the novel organization, arrangement and interconnection of parts 20 whereby the effects of fading, phase discrimination and the like are substantially reduced.

Other features and advantages not specifically enumerated will be apparent after a consideration of the following detailed descriptions and 25 the appended claims.

While the invention will be described herein as applied to a facsimile system, it will be understood that the invention is not limited thereto. Likewise, while the description refers to a system of transmitting a level control signal, this phase of the invention can be used in any situation where two separate messages are to be transmitted on the same signaling frequency. Likewise, only those parts of a complete system are shown as are required to explain the inventive concept. Accordingly in the drawings,

Fig. 1 is a curve diagram useful in explaining certain features of the invention.

Figs. 1A, 1B and 1C are curve diagrams similar 40 to Fig. 1 to explain certain conditions of operation of the invention.

Fig. 2 is a schematic circuit diagram of one form of modulating system embodying the invention. 45

Fig. 3 is a preferred modification of Fig. 2.

Figs. 4, 4A and 4B are curve diagrams explanatory of the operation of Figs. 2 and 3.

Fig. 5 is a schematic diagram of one form of receiver that may be used with either Fig. 2 or Fig. 3. 50

Fig. 6 is a schematic diagram of a receiving arrangement according to the invention.

Fig. 7 is a modification of Fig. 6. 55

Referring to Figs. 1 to 1^c inclusive, a description will be given of typical modulating conditions used when the invention is applied to an electrooptical system such as a facsimile transmission system or the like. Fig. 1 shows a normal signal of uniform amplitude and frequency, such as an audio-frequency carrier and for purposes of explanation, in Figs. 1, 1^a, 1^b and 1^c, the dot-dash line represents the normal uniform amplitude throughout the figures. It will be assumed that the electrooptical system is arranged so that a white area of the subject matter being transmitted, is represented by a strong signal. The circuit arrangements according to the invention are, under this condition, such that the alternate complete cycles of the wave of Fig. 1 are positively modulated i. e. the amplitude of each alternate cycle is correspondingly increased, and the amplitude of the intervening alternate cycles are correspondingly decreased. Such a modulated signal representing a white area is shown in Fig. 1^a. Thus in Fig. 1^a, the cycles indicated by the full lines are positively modulated, and the intervening alternate complete cycles represented by the dotted lines are negatively modulated. Under the same arrangement, a grey or medium tone area will be represented by the curve of Fig. 1^b and a black area will be represented by the curve of Fig. 1^c. It will be understood of course, that the electrooptical circuits may be arranged or poled so that the curve of Fig. 1^a represents a black area, in which case the curve of Fig. 1^c will represent a white area. In either case, the picture signal for a given shade modulates successive complete cycles in opposite senses or directions. Whether the signal represents white, grey or black, the general average for any shade is constant. The average received signal level for any shade or tone value should therefore likewise be constant. If any change occurs in the transmission efficiency or level of the connecting link e. g. a radio or wire link, then as described hereinafter, the level at the receiving end can be maintained constant by suitable A. V. C. control. In any event, whatever type of A. V. C. control is used at the receiver, it will be operating on the same frequency as the signals to be recorded, and will on an average be substantially free from selective fading or phase shift. When the transmission is by radio, the freedom from selective fading can be further improved by "wobbling" the radio carrier a small amount in frequency and at a high rate. The side bands also may be "wobbled" in frequency slightly.

Referring to Fig. 2, there is shown a typical modulating arrangement for achieving the objects of the invention. In this figure, only the more important parts of a facsimile transmitter are shown, it being understood that any well-known form of facsimile scanning equipment and associated apparatus may be used. As is well-known, the picture 1 or other representation to be transmitted, is mounted on the drum 2 which is rotated around its axis and advanced longitudinally by a suitable lead screw 3 on the drum shaft 4. Associated with the drum is any well-known form of photo-electric translator comprising for example a light source 5, an apertured plate 6, and a lens system 7, for illuminating the picture 1 with a scanning light spot of elemental area. The light reflected from each successive scanned area is picked up by the photocell 8 in the known manner. Associated with drum 2 so as to run in geared relation therewith

by motor 9^b and gears 9^a, is a rotary inductor comprising a rotary armature 9 having a plurality of poles or teeth 10 whose number is determined by the desired picture signal frequency to be used. For example, if the picture signal frequency is to be 1800 cycles per second, the rotor 9 may be provided with 60 teeth and it may be rotated at the rate of 1800 R. P. M. Mounted in slightly spaced relation to rotor 9 is a stator 11 carrying a winding 12 whereby there is introduced into said winding impulses having a frequency of 1800 cycles per second. Preferably winding 12, is connected to the primary winding 13 of a coupling transformer through an energizing battery 14 of suitable potential. The transformer secondary 15 is preferably shunted by a condenser 16 for tuning out undesired harmonics and shaping the signal to a substantially sinusoidal form. The secondary 15 feeds into a network of the Wheatstone bridge type of which two of the ratio arms are constituted by the resistors 17 and 18, and the other two ratio arms are constituted respectively by the photocell 8 and condenser 19. The unbalanced bridge current flows through a resistor 20 which is preferably a high resistance e. g. of the order of a megohm. The voltage drops across resistor 20 are applied to the control grid or input circuit of a suitable amplifier 21 of any well-known type, the control grid of which is preferably biased negatively in the usual way by a biasing battery 22 which has also connected in circuit therewith a winding 23 through an automatic reversing switch arrangement 24, so as to reverse the phase of the current from winding 23 for each alternate complete cycle of the current impressed on winding 15. Thus the switching mechanism 24 may be coupled by a suitable shaft and gearing arrangement 25 to the shaft of rotor 9. It will be understood of course, that any other well-known method of reversing the phase of the currents in winding 23 with respect to winding 15 may be employed.

In the absence of the winding 23, if the bridge were completely balanced, there would be no signal on the control grid of amplifier 21. However, winding 23 when in circuit, provides for the flow at all times of some signal current to the amplifier even when the bridge is balanced. This minimum current may be used to regulate the average level of the signal from the output of the amplifier.

When the impulses from winding 23 are in phase with the signals across resistance 20 which signals result from unbalance of the bridge, the modulation of the 1800 cycle signal applied to the amplifier 21 will be positive. That is, the light falling on cell 8 will effectively produce a signal in phase with the signal from winding 23 and cause a strong signal to be applied to the control grid of amplifier 21. On the other hand, if the picture signals as represented by the voltage drops across resistance 20 are out of phase with the impulses from winding 23, each complete cycle of the 1800 cycle current applied to amplifier 21 will be negatively modulated. That is, a signal resulting from light applied to the photo-electric cell will be out of phase with the signal from winding 23 and the net result will be a decrease in signal rather than an increase in signal. Consequently, the 1800 cycle signal in the output of amplifier 21 will have alternate complete cycles modulated in opposite directions as explained above in connection with Fig. 1^a for example.

This 1800 cycle signal can then be transmitted by any known method to a receiving station 26 where suitable mechanism is provided whereby the picture reproduction is effected and controlled by an A. V. C. signal derived from the average level of the received 1800 cycle signal. In view of the fact that the modulation direction varies for each complete cycle of the 1800 cycle signal, the average for any shade value at the transmitter remains constant, and the A. V. C. signal at the receiver is less likely to be affected by selective fading, phase shift or the like in the transmission link 27. This is particularly true where the link 27 includes a radio channel and more especially where the radio channel is subjected to selective fading as regards frequency.

Referring to Fig. 3, there is shown a preferred modification of the arrangement of Fig. 2. The arrangement is substantially similar to that of Fig. 2 and corresponding parts are designated by the same numerals. In this arrangement, the phase control winding 23 forms part of a separate transformer 28 having two primary windings 29, 30, each supplied by an associated inductor stator 31, 32, which stators are associated with the toothed rotor 9 in such a way that one winding, for example the winding 29, will produce impulses in winding 23 in phase with complete alternate cycles of picture signals across resistor 20, while the other winding 30 will produce impulses 180 degrees out of phase with the intervening complete alternate cycles of the picture signals across resistance 20. To accomplish the above, the rotor 9 will be similar to that of Fig. 2, but will have each alternate tooth 10 removed, so that it has 30 teeth and revolves at the rate of 1800 R. P. M. The stators 31 and 32 are mounted to produce the necessary phase relation between the respective currents induced therein and preferably one or both of the stators is adjustable circumferentially around rotor 9 as indicated by the arrows. The transformer which feeds the signals to the bridge arrangement comprises the secondary 15 and two primary windings 33, 34. Winding 33 is connected through an adjustable battery 35 to stator winding 31 and winding 34 is connected through an adjustable battery 36 to winding 32. The winding 29 of transformer 28 is likewise connected to winding 32 preferably in series with a variable resistor 37; and likewise winding 30 is connected to winding 31 in series with a variable resistor 38. The winding 31 will therefore produce in the winding 15 of the transformer a complete cycle each time a tooth of rotor 9 passes stator 31 and these complete cycles will be spaced as represented in Fig. 4. Likewise, the stator 32 will cause to be impressed upon the winding 15 spaced complete cycles as shown in Fig. 4A alternating with the complete cycles of Fig. 4. The two signals combined in the winding 15 will have the resultant as shown in Fig. 4B. The balancing and unbalancing of the bridge network by the photo-cell 8 will be the same as that described in connection with Fig. 2. However, the winding 23 will receive signals from both stators 31 and 32 so that each alternate complete cycle in winding 23 is out of phase with the corresponding alternate complete cycle across resistor 20. Consequently, as described above in connection with Fig. 2, one cycle of impulses impressed on winding 23 will result in a positive modulation or increase of amplitude of the corresponding complete cycle applied to amplifier 21 and the succeeding cycle of impulses impressed on winding

23 will result in a negative modulation or decrease in amplitude of the corresponding cycles across resistor 20. The purpose of the variable resistors 37, 38, is to provide the proper amplitude relation between the negative modulated cycles and the positive modulated cycles. The reversely modulated waves are transmitted to the receiving station 26 over any suitable channel 27. If the channel 27 is a radio or carrier channel, the receiving equipment 26 will include a detector for detaching the 1800 cycle signal wave and will be provided with an amplifying system having any well-known form of A. V. C. control, the A. V. C. signal being derived from the level of the received 1800 signal.

In accordance with a modification of the invention, each alternate complete cycle instead of representing a picture signal may be used as a level control signal in which event the stator 32 instead of feeding a transformer winding 30 will feed directly into the amplifier 21 so that alternate complete cycles will be of a uniform amplitude. In this embodiment therefore, the picture will be represented by alternate complete cycles of 1800 cycle current modulated in accordance with the picture and the intervening alternate cycles will be of uniform amplitude. At the receiving station, the picture will then be printed or reproduced in any well-known manner under control of the complete alternate picture cycles and the intervening complete cycles of otherwise steady amplitude can be used to provide a suitable A. V. C. signal for the recording amplifier. In that case, any well-known form of distributor may be employed to segregate the picture cycles into the picture recording circuit and the A. V. C. cycles into the A. V. C. circuit for the picture recording amplifier as is well-known in the art. If desired however, the recording amplifier can be operated by both the picture cycles and the steady cycles. Where however, the picture is to be recorded only by the spaced picture cycles such as shown in Fig. 4, it is necessary to separate the modulated picture cycles from the steady level control cycles. Any well-known form of distributor may be employed for this purpose which distributor will be synchronized in any well-known way with a rotor 9. If desired, the received 1800 cycle wave itself may be utilized to synchronize the distributor at the receiver with the rotor 9. One typical form of distributing arrangement that may be used is schematically illustrated in Fig. 5. The 1800 cycle signal after detection and amplification in the apparatus 39 is impressed on a stator winding 40 which energizes the rotor 41 of a rotary inductor. The shaft 41^a carrying rotor 41 is brought up to speed by a separate motor (not shown) and synchronism may be maintained by another motor as described for example in application Serial No. 261,134, filed March 11, 1939. The stator 40 preferably surrounds the rotor hub as shown so as to energize the rotor teeth uniformly. Rotor 41 is provided with a series of teeth 42 corresponding to the teeth on rotor 9 at the transmitter. Mounted adjacent the rotor teeth are two secondary poles 43, 44, which are positioned with respect to the rotor similarly to the positioning of the poles 31, 32, at the transmitter and arranged so that one complete cycle is induced into the pole 43 and the next complete cycle is induced into the pole 44 corresponding for example to the curves of Figs. 4 and 4A. The rotor 41 is phased in any well-known manner with the rotor 9 so

that the pole 43 is energized in synchronism with the pole 31 and consequently the modulated picture signals are therefore applied to the picture recording mechanism 45. On the other hand, the pole 44 feeds a signal which was transmitted as a constant amplitude signal into the amplifier-rectifier 46 which may be used to generate a biasing signal for controlling the amplification of the amplifying system in mechanism 45 in any well-known manner. So long as the transmission efficiency of the connecting link 27 does not vary, the output of device 46 is uniform and the A. V. C. signal is likewise uniform. Should the transmission level vary, the A. V. C. signal likewise varies, correspondingly varying the amplification of the recorder amplifier. One conventional method is to have the A. V. C. signal from coil 44 amplified, rectified and the rectified current is applied to control the bias on one or more stages of the amplifier of device 45.

If the system at the transmitter produces alternate complete cycles positively modulated according to the picture areas and intervening complete cycles also modulated according to picture areas as described in connection with Figs. 2 and 3, a distributor arrangement such as shown in Fig. 6, may be used at the receiver. The rotor 41 may be the same as rotor 41 of Fig. 5 which is energized under control of the received 1800 cycle picture signals as described, rotor 41 being brought up to speed by a separate motor 41^b as described in said application Serial No. 261,184. Associated with rotor 41 are two pick-up stators 43, 44, similar to the corresponding pick-up coils of Fig. 5. Connected across coil 43 is the primary winding 50 of a transformer, and connected across coil 44 is the primary winding 51 of the same transformer. The transformer secondary 52 feeds the combined signal into an amplifier-rectifier 53. The output of device 53 applies an A. V. C. control grid-bias potential to the amplifier 54, and also to amplifier 55. Amplifier 54 feeds a picture recorder 54^a which reproduces the picture as a photographic negative from which positive prints can be subsequently made. The amplifier 55 feeds a picture recorder 55^a which is preferably of the type which reproduces the picture directly as a positive so as to act as a continuous monitor on the recorder 54^a. Thus, two records are made of the picture, one corresponding to alternate positively modulated complete cycles (recorder 54^a) and the other corresponding to the intervening negatively modulated complete cycles (recorder 55^a), both of which recorders are applied with A. V. C. signals derived from the same frequency as the picture signals and the picture signals themselves being used for that purpose.

When a single record is to be made corresponding to all the complete cycles, then an arrangement as schematically shown in Fig. 7 may be employed. The amplifiers 54 and 55 may be similar to the corresponding amplifiers of Fig. 6, and arranged to be fed by corresponding controls such as the elements 41, 42, 43, 44, 50, 51, 52, 53 of Fig. 6. The output of amplifier 54 corresponding to the positively modulated complete cycles (full line curve of Fig. 1^A for example) is applied to a transformer 57. The output of amplifier 55 corresponding to the negatively modulated complete cycles (dotted line curve of Fig. 1^A for example) is passed through a modulation inverter 58 of any well-known type whereby the negative modulations are inverted into corre-

sponding positive modulations. These inverted modulations are applied to the transformer 57. Consequently, the picture recording apparatus 58 is fed with 1800 cycle signals, all the cycles of which are positively modulated for a given shade value of the transmitted picture.

Wherever in the foregoing specification and in the claims, reference is made to a modulation of a carrier wave "in the same direction" it is not intended to be limited to a uni-directional wave. "In the same direction" therefore, refers to the amplitude or envelope area of the modulated wave as compared with the amplitude or envelope area of the unmodulated wave. The main object so far as gain control is concerned, is that for message signals of the same signal strength, the average amplitude or the average envelope area of the transmitted wave is approximately the same where the wave is modulated or demodulated. In its broader phases however, it is not necessary that the positive and negative modulations be of equal amounts so long as for a given signal strength the ratios of the positive and negative modulations bear a predetermined ratio. Likewise, while "amplitude" of the carrier wave is referred to, it is intended to refer either to the average amplitude over a half cycle or to the area of the envelope of the carrier corresponding to a signal modulation.

What I claim is:

1. The method of signaling which includes the steps of generating a signaling wave of uniform frequency, modulating alternate complete cycles in one direction in accordance with signals of a certain character, and modulating the intervening complete cycles in the opposite direction in accordance with signals of the same character as the first-mentioned signals.

2. The method of signaling which includes the steps of generating a wave of uniform frequency, modulating each complete cycle of said wave by signals, cyclically varying the amplitude of said modulated waves by other waves of the same frequency but with alternate complete cycles of said other waves out of phase with the first waves whereby the resultant wave has alternate complete cycles modulated positively and intervening complete cycles modulated positively but with both cycles representing the same character of signal.

3. The method of signaling which includes the steps of generating at a uniform frequency spaced groups of waves and at the same frequency other spaced groups of waves, cyclically varying the amplitude of said other waves in one direction by signals, and cyclically varying the amplitude of the other waves in the opposite direction, both sets of varied amplitude waves representing the same character of signal.

4. The method according to claim 3 in which cyclical variation of said waves is effected at the same frequency.

5. The method of signaling which includes the steps of applying to a modulation network waves of uniform frequency and signal waves, and applying to said network uniform waves of said frequency but having alternate complete cycles 180° out of phase with the first waves whereby there is produced a modulated wave of said frequency with alternate complete cycles modulated positively and intervening cycles modulated negatively but with successive cycles representing the same character of signal.

6. The method of signaling which includes the steps of generating a wave of uniform frequency,

modulating alternate complete cycles proportionately to signals while maintaining the intervening complete cycles of uniform amplitude.

7. The method of transmitting a signal of a certain character which includes the steps of generating a wave of uniform frequency, increasing the amplitude of alternate complete cycles under control of said signal, and decreasing the amplitude of the intervening complete cycles by said signal, whereby successive complete cycles represent the same character of signal.

8. The method of transmitting a signal over a transmission link which is subject to fading which includes the step of translating the signal into a uniform frequency wave of at least two complete cycles of uniform frequency, one cycle being modulated positively proportionate to the signal and the other complete cycle being modulated negatively proportionate to the same signal.

9. The method of signaling which includes the step of generating a wave of uniform frequency wherein alternate complete cycles are modulated in one direction for one signal strength and the intervening complete cycles are modulated in the opposite direction for the same signal strength whereby the average of the wave amplitudes remains substantially constant for said one signal strength.

10. A signaling system including means for generating waves of uniform frequency, means to produce a signal of a given character, and means to modulate alternate complete cycles of said uniform frequency waves in one direction by said signal and the intervening complete cycles in the opposite direction by the same character of signal whereby the average amplitude of the modulated carrier over said alternate complete cycles is substantially uniform.

11. A signaling system having means to generate a wave of uniform frequency, and means to modulate said wave so that alternate complete cycles are modulated positively and intervening complete cycles are modulated negatively, whereby the average amplitude of the modulated wave over complete cycles representing the same signal carrier is substantially uniform.

12. A signaling system having means to generate a wave of uniform frequency, and means to modulate said wave so that alternate complete cycles are modulated in opposite directions and the average value of the wave for a uniform signal strength remains substantially constant.

13. A signaling system having means to generate message signals, a network upon which said signals are impressed, said network including means to convert the signals into a uniform frequency wave with certain cycles modulated in one direction according to a given signal strength and other cycles modulated in the opposite direction according to the same signal strength.

14. A signaling system according to claim 13 in which said network is in the form of a Wheatstone bridge having means to impress across one diagonal of the bridge, a uniform frequency wave having the modulation phase reversed at regularly recurrent intervals.

15. A signaling system according to claim 13 in which said converting means includes a modulator, means to impress on said modulator carrier waves, and means to impress on said modulator other waves of the same frequency as said carrier waves but with alternate cycles reversed in phase with respect to the carrier cycles.

16. A signaling system comprising a source of message signals, a modulator network, means to control said network by said signals, means to control said network by a carrier frequency wave, said signals normally coacting with said carrier frequency to produce in the output of the modulator a carrier wave having the amplitude modulated in the same direction for a given message signal, and means to impress upon said modulator another wave and the same frequency of said carrier but having alternate cycles 180° out of phase with the carrier wave whereby the output of said modulator consists of a modulated wave of said frequency wherein the average wave amplitude for a given signal is approximately the same as the unmodulated carrier wave.

17. A system according to claim 16, in which the means to impress said other waves on the modulator network includes a constantly operating reversing switch.

18. A signaling system comprising a source of message currents, a modulator network, means to impress upon said network carrier frequency waves, said message currents normally coacting with said carrier waves in said network to produce a carrier having its amplitude modulated in one sense corresponding to like message signals, and means to cause said signals to modulate the wave so that for like signals, the average amplitude of the modulated wave is approximately the same as the amplitude of the unmodulated wave, the last-mentioned means including means to impress upon said modulator two sets of waves of said carrier frequency, one set being continuously in phase with said carrier frequency and the other set being 180° out of phase with said carrier frequency.

19. In a signaling system, a source of message signals, a modulator network having an input branch and an output branch, means to control the input branch by said signals and by a source of carrier frequency, and means to control the output branch by current of said carrier frequency but with alternate complete cycles 180° out of phase with the corresponding alternate complete cycles of said carrier frequency.

20. A system according to claim 19, in which the last-mentioned means includes a transformer having a pair of primary windings and a secondary winding and means to energize said primary windings at said carrier frequency but at 180° out of phase with each other.

21. A system according to claim 19, in which the last-mentioned means includes a pair of transformers, each having a pair of primaries and a secondary, means to energize a primary of each transformer in phase synchronism at said carrier frequency and means to energize the other primary winding of each transformer at said carrier frequency but at 180° phase displacement.

22. A system according to claim 19, in which the last-mentioned means includes a rotary inductor having a pair of pick-up windings energized thereby, the energization being displaced by 180° .

23. In a signaling system, a source of message signals, a modulator network, a rotary inductor, a pair of pick-up coils for said inductor, means to rotate said rotor so that one coil is energized in spaced complete cycles with the spacings of complete cycle length, the other coil being energized in spaced complete cycles during the spacings when the first coil is deen-

ergized, means to control said network by said message signals, means to control said network by the current from said pick-up coils whereby the output of said modulator network for a given
5 signal strength consists of a modulated current of uniform frequency but with the average wave amplitude approximately the same as the amplitude when no signals are being impressed on said network.

24. In a signaling system, a source of message signals, a modulator network, a grid-controlled amplifier having its input fed from said input, means to control said modulator by said message signals and by a carrier frequency and
15 means to vary the bias on said tube at said frequency so that alternate complete cycles are 180° out of phase with the cycles impressed thereon from said modulator network, whereby successive cycles representing the same signal character are modulated in opposite directions.

25. A system according to claim 24 in which the last-mentioned means includes a transformer having a pair of primaries and a secondary, said primaries being energized in spaced complete cycles at said carrier frequency with the energizations alternating and said secondary
25 being connected to the input circuit of said tube.

26. A signaling system including means for generating waves of uniform frequency, means
30 to modulate said waves by a signal of a given character so that succeeding cycles are modulated in opposite directions whereby said average amplitude of the modulated wave representing said signal remains substantially uniform,
35 and receiving apparatus including means to reproduce said signals and means to control the gain in the receiving apparatus under control of the received signals.

27. A signaling system having means to generate a wave of uniform frequency, means to
40 modulate said wave so that for a given signal, succeeding cycles are modulated in opposite directions whereby the average amplitude of the modulated wave representing said signal remains substantially uniform, a receiver having
45 means to reproduce the signals under control of the received waves, and means to control the gain in the receiver, the average amplitude of the received wave for said given signal closely approximating the average amplitude of the received wave when unmodulated.

28. A signaling system having means to generate a carrier of uniform frequency, means to
55 modulate said carrier by a signal of a given character so that the average amplitude of the modulated carrier closely approximates the amplitude without modulation, a receiver for reproducing said signals, means to utilize certain cycles of the modulated waves for signal reproduction,
60 and means to utilize other cycles for controlling the gain in the receiver.

29. A system according to claim 28, in which the last-mentioned means includes a distributor for diverting the signal reproducing cycles into
65 one channel and the gain control cycles into another channel.

30. A signaling system having means to generate a wave of uniform frequency, means to modulate said wave so that for a signal of a given character certain cycles are positively modulated and other cycles are negatively modulated
5 whereby the average amplitude of the modulated wave representing said signal remains substantially uniform, a receiver and a distributor associated with said receiver for diverting the positively modulated waves into one channel and the negatively modulated waves into another channel.

31. A system according to claim 30, in which one of said channels is a signal reproducing channel and the other is a gain control channel.
15

32. A system according to claim 30, in which each of said channels is provided with a separate signal reproducer.

33. A signaling system according to claim 30, in which one of said channels is provided with a reproducer for producing a positive visual record of the signals and the other channel is provided with a reproducer for producing negative visual records of the signals.
20

34. A signaling system having means to generate a wave of uniform frequency, means to modulate said waves for signals of a given character, so that certain cycles are positively modulated and other cycles are negatively modulated,
25 a receiver, a distributor associated with said receiver for diverting the positively modulated waves into one channel and the negatively modulated waves into another channel, means in said other channel to invert the modulation envelope of the waves therein, the output of both said
30 channels being applied to said receiver to reproduce the signals.

35. A system according to claim 34, in which each of said channels is provided with gain control means which is controlled by the amplitude of the received waves.
40

36. The method of signaling which comprises generating a uniform frequency wave with certain cycles positively modulated by a signal of a given character and other cycles negatively
45 modulated by the same signal character, receiving the positive and negative modulated wave, diverting the positive modulated wave into one channel, diverting the negative modulate wave into another channel, and reproducing the signal
50 under control of the output of said channel, one of said channels being used as gain control for the other channel.

37. The method of signal transmission employing a uniform frequency wave which includes
55 the steps of modulating said wave so that for signals of the same character, the average amplitude of the wave is approximately the same as the average amplitude of the unmodulated wave, receiving said modulated wave, applying
60 alternate complete cycles to control a reproducer and applying alternate intervening cycles to control the gain in said reproducer.