July 8, 1941. J. W. MILNOR ET AL 2,248,887

SUBMARINE CABLE PICTURE TRANSMISSION SYSTEM

Filed March 23, 1939 6 Sheets-Sheet 1

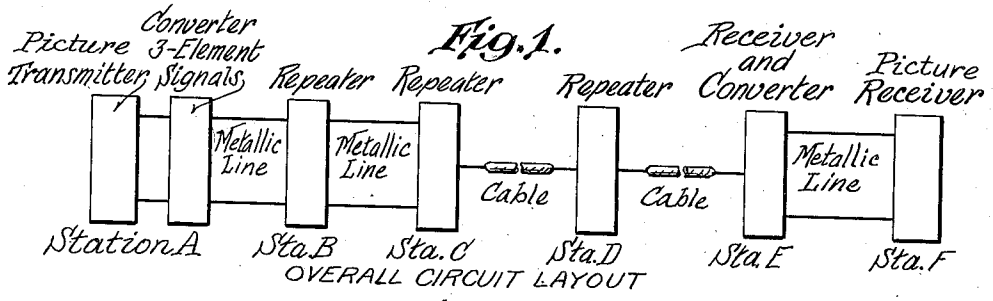


Fig. 1.

OVERALL CIRCUIT LAYOUT

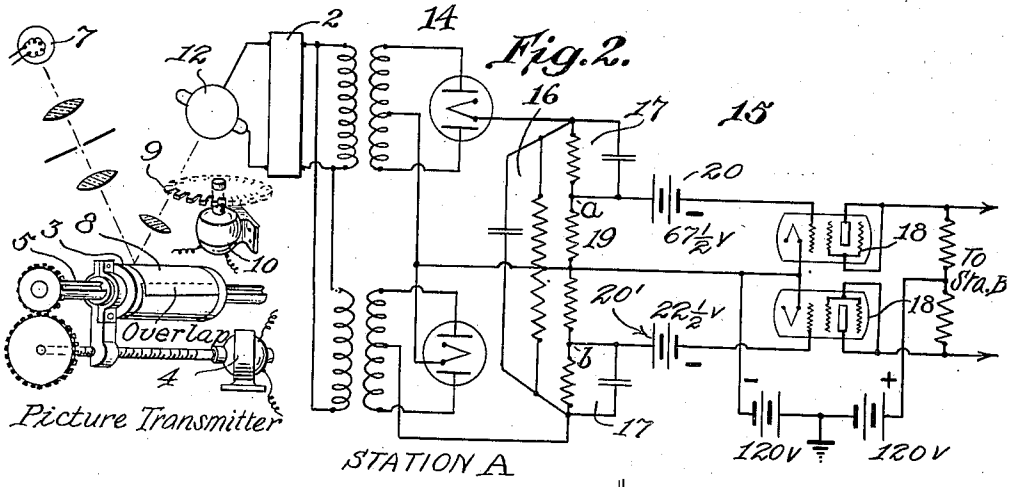


Fig. 2.

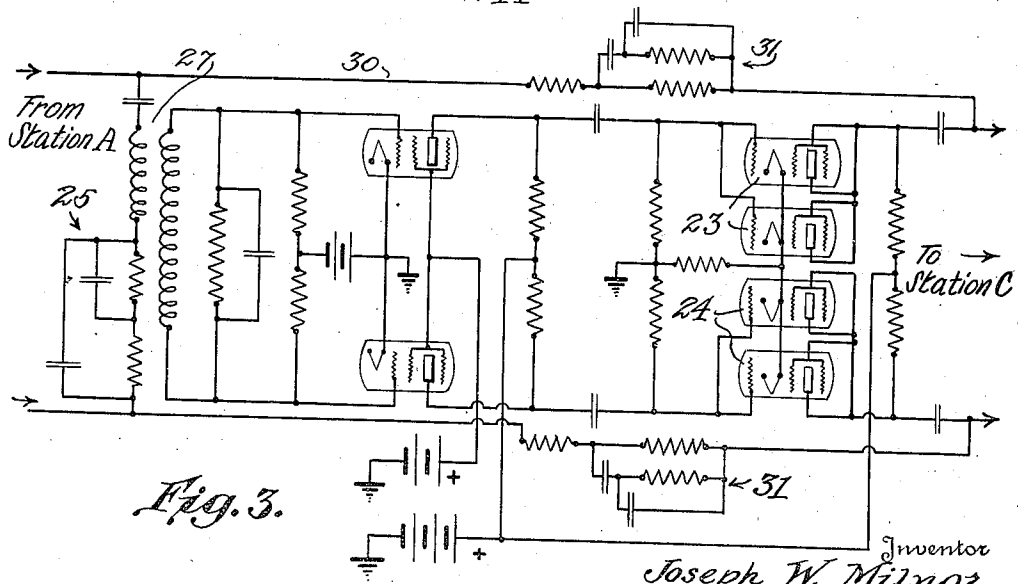


Fig. 3.

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Fig. 4.

Fig. 4a

		TUBE 43	RES. 48	POT 49
Signals (Loop currents)	+ −	low	*	low
	− +	high	*	high
Interference (Longitudinal current)	+ +	low	high	0
	− −	high	low	0

*Substantially Constant

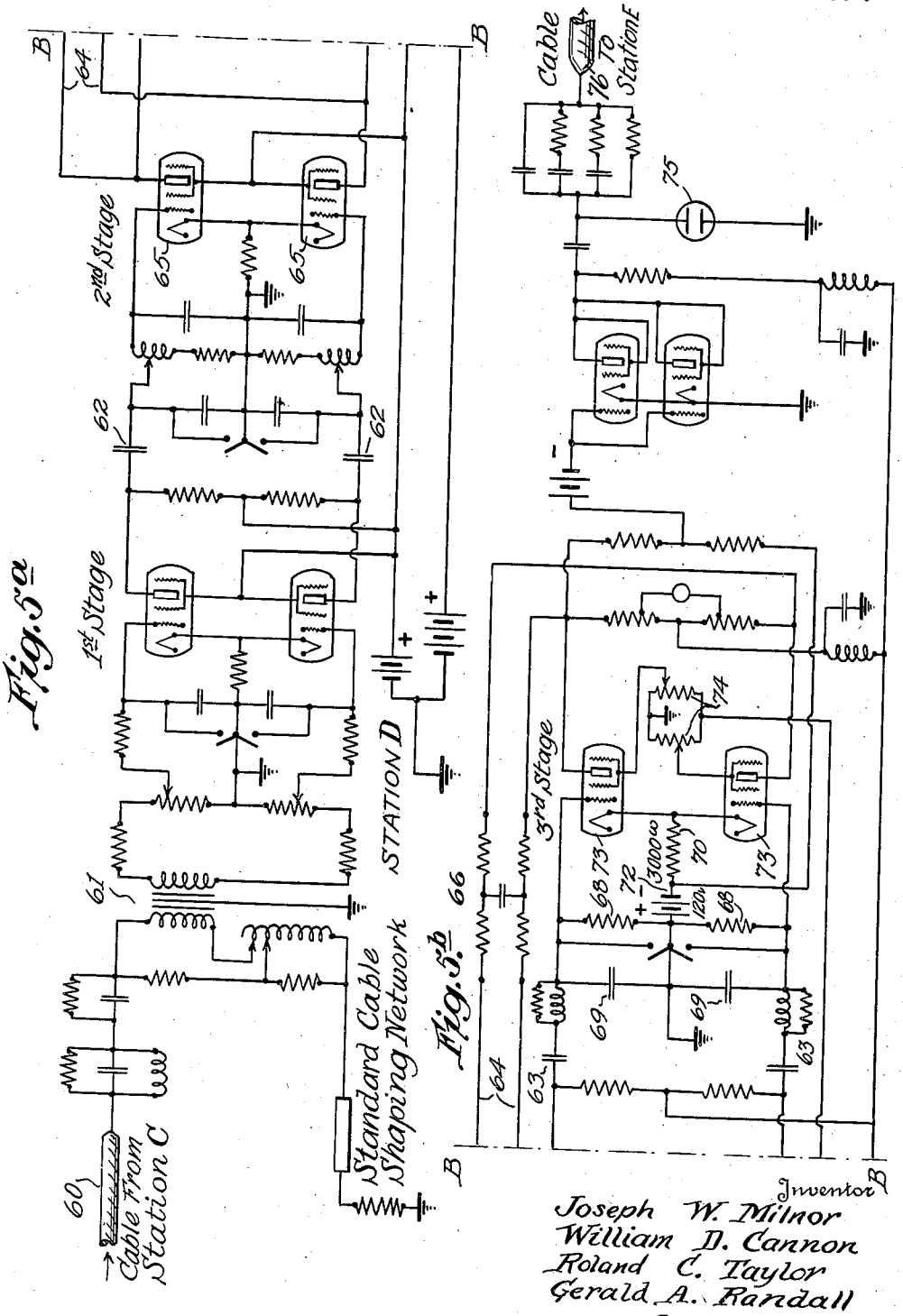
Fig. 6.

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SUBMARINE CABLE PICTURE TRANSMISSION SYSTEM

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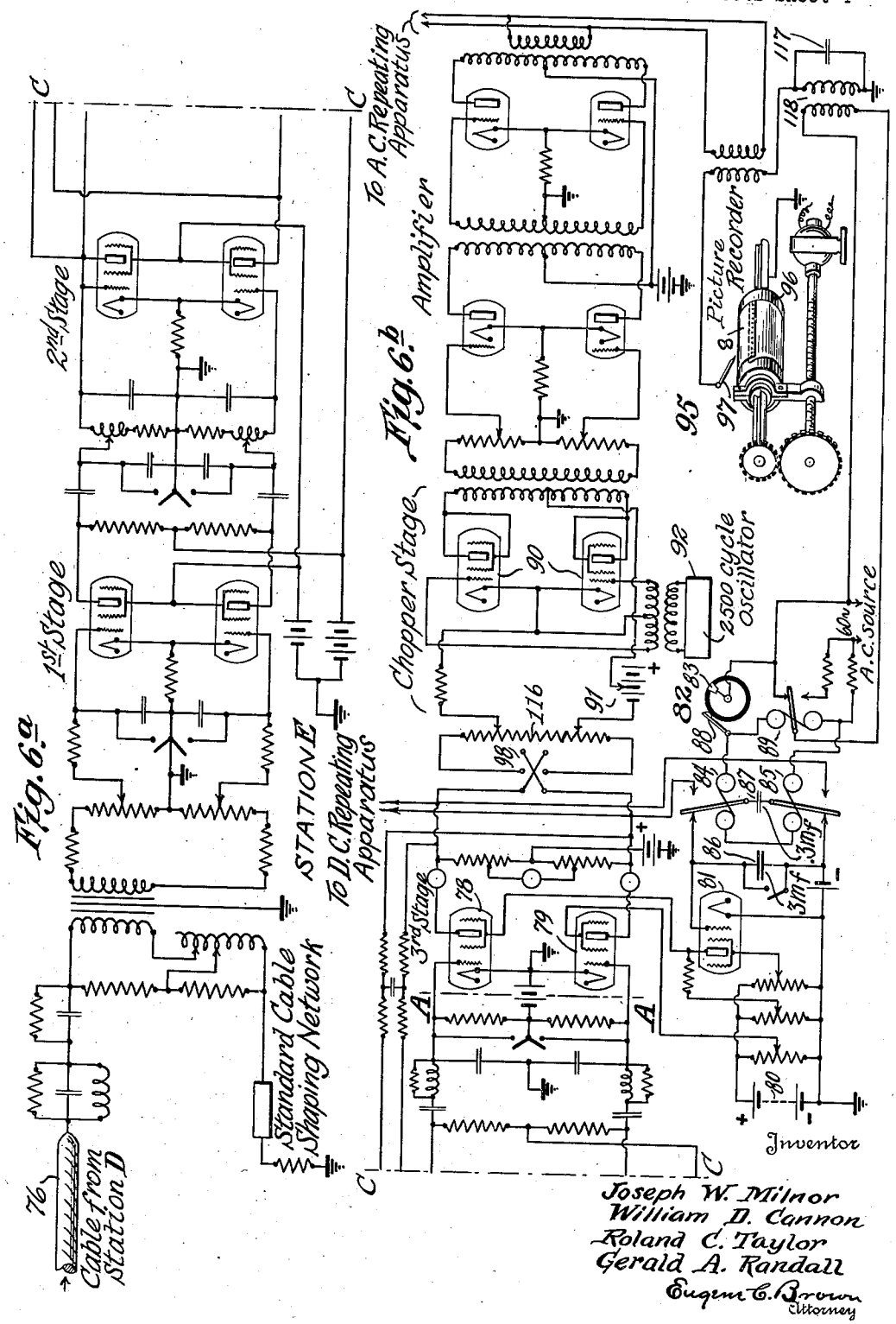
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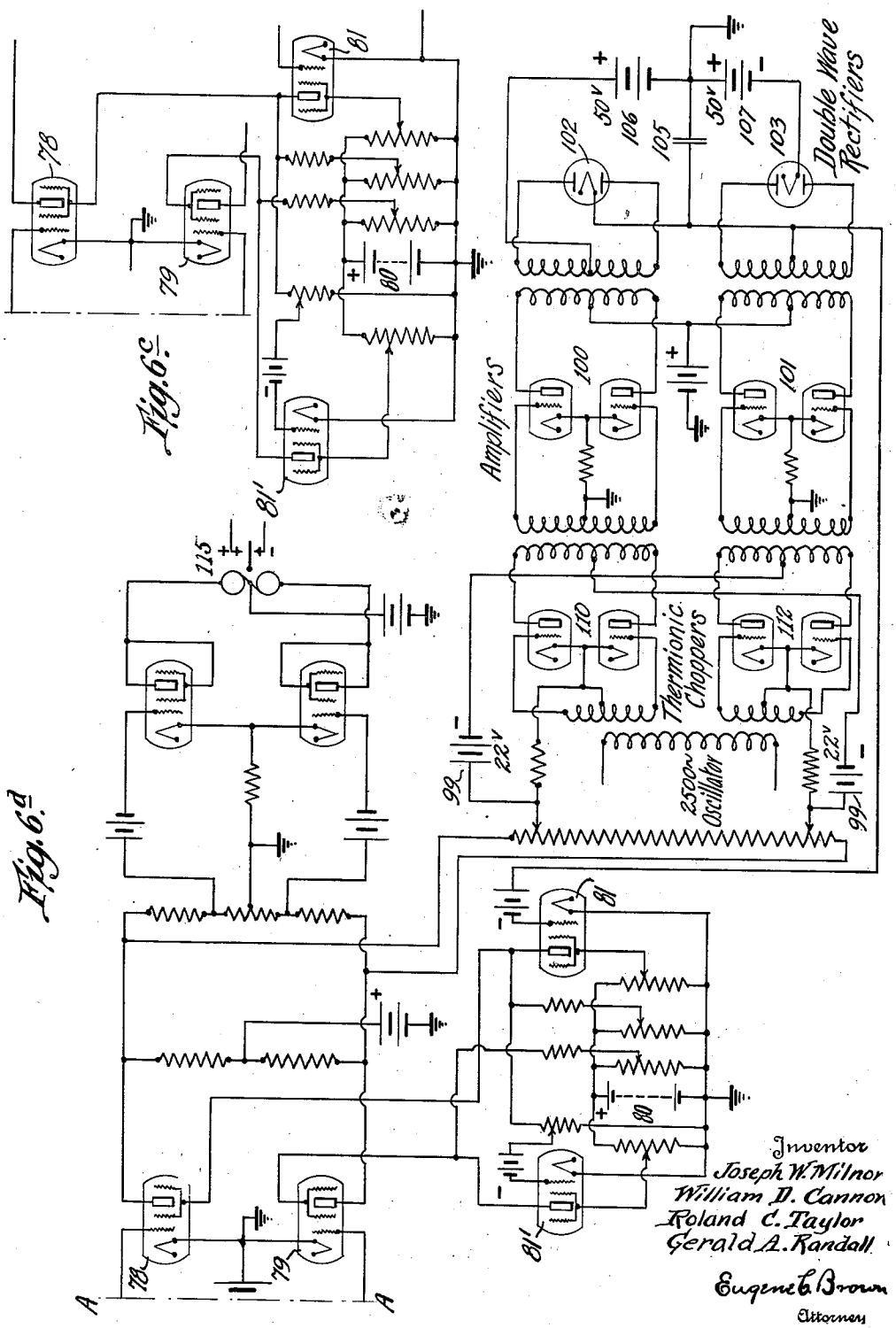
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SUBMARINE CABLE PICTURE TRANSMISSION SYSTEM

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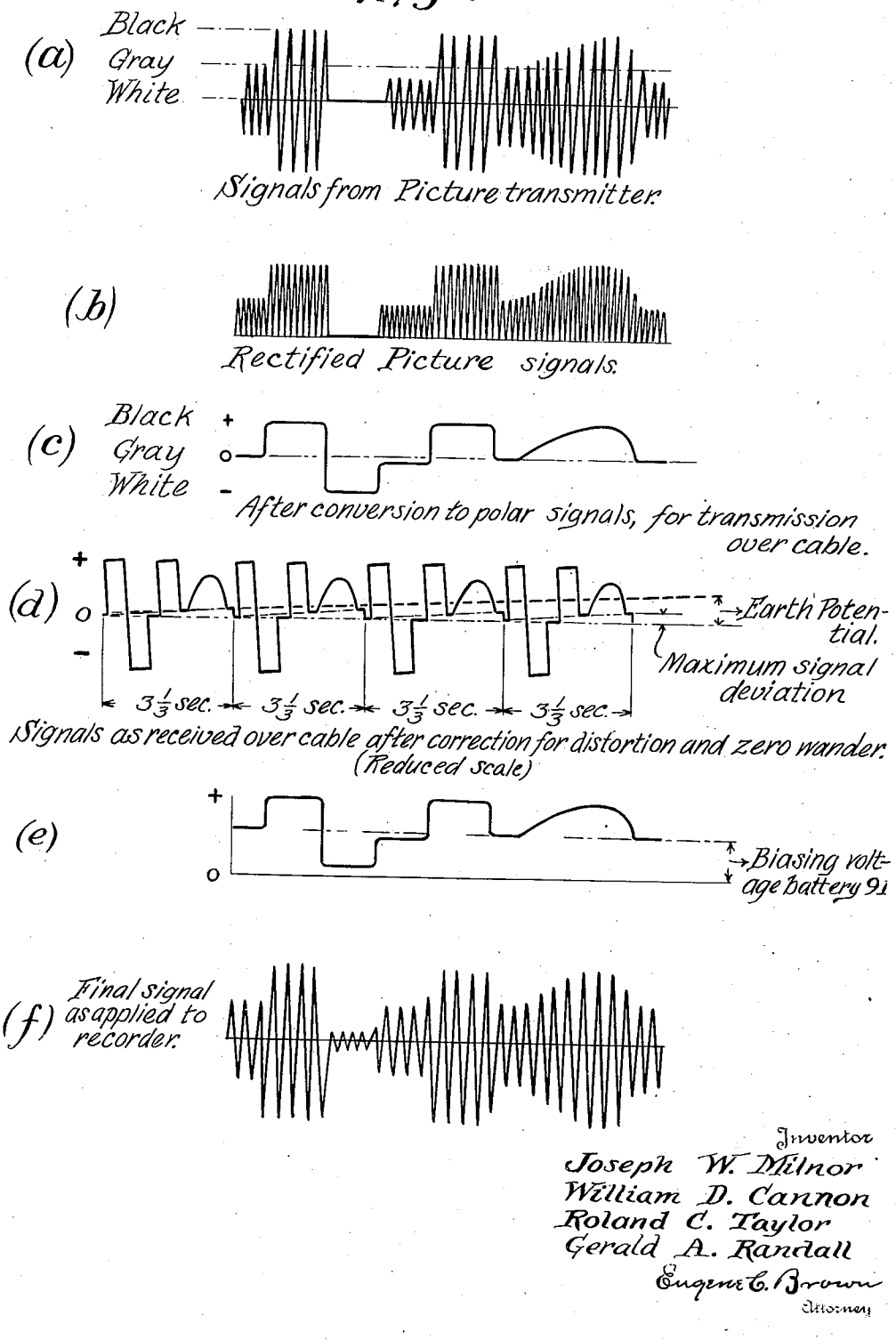
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SUBMARINE CABLE PICTURE TRANSMISSION SYSTEM

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Fig. 7.



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UNITED STATES PATENT OFFICE

2,248,887

SUBMARINE CABLE PICTURE TRANSMISSION SYSTEM

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Application March 28, 1939, Serial No. 264,622
In Great Britain November 28, 1938

33 Claims. (Cl. 178—5)

This invention relates to electrical signaling systems and particularly to transmission systems designed to transmit graphic or pictorial material long distances over circuits comprising various mediums such as land lines and submarine cables. Other media may be embodied in the system, such as radio transmission links employing standard methods of transmission, reception and regulation. In the organization described herein the cable sections are the limiting elements of the transmission circuit and accordingly the system is designed particularly to accommodate these sections.

Photographs or other like material suitable for transmission over electrical circuits generally, comprise an infinite variety of shades or tones varying from white to black with an intermediate shade which is termed as gray. In devising a signaling code for the transmission system it was deemed preferable to employ a system in which the transmitted currents vary from a positive maximum to a negative maximum of current with zero current corresponding to the intermediate gray and with the other shades represented by appropriate current values ranging between these limits. It will be apparent that this arrangement of current values bears a similarity to the usual three-element cable code and therefore involves a minimum of departure from established cable practice.

The signals produced in previously developed facsimile transmitting equipment consist of picture modulated alternating currents which are not suitable for use over long cable circuits. One of the objects of the present invention is to convert the modulated alternating current signals into variable amplitude positive and negative with intermediate zero current signals for transmission over land line circuits including repeaters, and submarine cable circuits including repeaters, with subsequent reconversion to alternating current signals.

Another object of this invention is to provide a photo-transmission system in which the shades or tones are represented by a direct current of varying value ranging from a maximum positive through zero to a maximum negative.

Another object of this invention is to provide an arrangement for converting amplitude modulated alternating current into polar direct current signals which vary in amplitude symmetrically with respect to a zero value.

Another object is to provide a method for restoring the relative values of distorted positive, negative and zero signals representing the shades or tones of a picture.

A further object is to provide a method for the conversion of varying amplitude positive, negative, and zero direct current signals to amplitude modulated alternating current signals. Other objects and advantages of the invention will be apparent from the following specification and drawings.

In order that the invention may be more readily understood, a specific embodiment thereof will be described with reference to the accompanying drawings, in which—

Figure 1 is an illustrative diagram of a system for the transmission of pictures or like material over long distances comprised of various mediums such as land lines and submarine cables,

Figure 2 is a diagram of a circuit arrangement embodying the invention as applied to the apparatus of the transmitting terminal;

Figure 3 is a diagram illustrating a repeating apparatus of the thermionic type designed to reinforce the signals received over one metallic line and to resend them over a similar metallic line.

Figure 4 is a diagram illustrating a circuit arrangement for a repeating apparatus designed for receiving the signals from a metallic line section and re-transmitting the signals, after correcting for distortion, over a grounded submarine cable section; Figure 4^a is a tabulated diagram explanatory of the relative potentials existing between certain points in the circuit; Figure 4^b shows a modification of the connection from the metallic line section to the grounded cable section;

Figure 5^a and 5^b show diagrammatically a circuit arrangement for a repeating apparatus designed for receiving the signals from one grounded submarine cable and re-transmitting the signals, after amplification with correction for distortion, over another grounded submarine cable;

Figures 6^a and 6^b illustrate diagrammatically a circuit arrangement of an apparatus for a complete receiving terminal designed to receive the signals from a submarine cable and to either reproduce the facsimile or picture from which the modulated signals were produced at the transmitting station or to re-transmit the signals into extended metallic land lines; Figure 6^c shows a modification of the zero correction device of Fig. 6.

Figure 6^d illustrates a modification of the or-

ganization shown in Figs. 6[a] and 6[b], in order to substitute a relay system adapted to function for ordinary cable signals instead of facsimile signals, with the provision of means to correct for zero wander to which regular cable signals are more susceptible than facsimile signals; Figure 6[c] is a diagrammatic illustration explanatory of the functions of the zero wander correction means.

Figure 7 comprises a series of curves designed to illustrate the progress and transformations of the signal waves from the original picture transmitter to the final receiving apparatus, showing the conversion of the signals from amplitude modulated alternating current facsimile signals to amplitude modulated direct current polar signals for transmission over the land line and cable and the subsequent restoration of the signals to their original alternating current form at the receiving end.

For the purpose of clearly disclosing the method of transmitting pictures over signaling systems, which include submarine cables and the apparatus and circuit organization embraced in the invention described herein, reference is made to the accompanying drawings which illustrate a system particularly designed for the transmission of picture-modulated signals.

The picture characteristics which modulate voice frequency alternating current carrier waves are produced at the sending station A in a picture transmitter of the type illustrated in Fig. 2. A drum **3** carrying the paper strip **8** or other medium bearing the pictorial representation to be transmitted, is slidably mounted and splined to a shaft **5**, which is geared to the worm shaft of the driving motor **4**.

A light beam from a light source **7** projected upon the surface of the picture **8** wrapped about the drum **3**, is reflected and is intercepted by the slotted periphery of a disc **9**, which is driven at a predetermined speed by a motor **10**. The slotted disc, which may be termed a "chopper," breaks the reflected beam into a series of closely spaced light waves, which are then directed upon a photo-electric cell **12**. It will be seen that the intensity of the reflected light beam and of the elemental light waves projeced upon the photo-electric cell is determined at every instant by the exact shade or tone value of the illuminated spot on the surface of the picture.

Since the output from the picture transmitter is in the form of a picture-modulated voice frequency carrier current, it is necessary to provide a converter for reducing these signals to the fundamental modulating current before transmission over the low frequency submarine cable. This converter may be conveniently located immediately adjacent to the picture transmitter and the transmission over the entire circuit, including land line and submarine cable sections, will then occur at the fundamental signal frequency rather than at the voice carrier frequency.

Method for orientation of picture tone

As stated previously the picture tones range between maximum values centering about an intermediate gray, so that the gray tone may be represented by signal current of zero value with black corresponding to a maximum positive current and white corresponding to maximum negative current. The current values corresponding to black and white may be reversed if desired. In the operation of submarine cables it is customary to provide a series condenser at the transmitting end which may or may not be shunted by a resistance of rather high value. This condenser not only provides an essential compensating effect for the distorting properties of the cable and prevents the flow of earth currents, but also serves to protect the cable from the accidental application of dangerously high direct current potentials. Likewise, at the receiving end, a similar condenser or a transformer or both must be employed for the purpose of eliminating the relatively low frequency earth currents. These condensers, however, possess the marked disadvantage of preventing the transmission of relatively low frequency or direct currents and, consequently, make it impossible to distinguish at the receiving end between prolonged periods of steady tone transmission having different values.

It appears, therefore, that the transmission of pictures over submarine cables by the system originally outlined, imposes the requirement of handling current values ranging between positive and negative maximum limits and at frequencies ranging from substantially zero to the maximum transmission speed of the cable, while yet excluding the slowly varying earth currents, and other types of interference insofar as possible. Cable systems which have been developed for handling signals according to the common cable codes are not suitable directly for purposes of picture transmission according to this method and it has accordingly been necessary to extensively modify the basic system.

The difficulty here outlined has been met in the following manner. The drum of the transmitting machine, to which the picture is attached, is driven at the rate of one revolution in 3⅓ seconds although the period is, of course, not limited to this value. Within this period the earth potential currents on the cable will vary through only a narrow range. At the same time it is possible to design the circuit equipment so as to maintain a given condition for a period of this length in response to a steady received signal. Treating each 3⅓ second period as an individual element or line of the picture, the transmitter and receiver are set at the beginning of each period to an arbitrary reference value, which preferably corresponds to the gray tone or zero current signals. Thus a vacant strip portion or overlap is provided along the length of the sending drum, designed to transmit at the beginning of each revolution, a zero current signal of stated length. The drum of the picture recorder at the receiving terminal station F, which is rotated synchronously with the transmitting drum, initiates a series of events at the beginning of each revolution which resets the receiving system to reproduce the gray tone during the overlap period irrespective of the momentary value of the received current. It is seen, therefore, that the sending and receiving elements of the system are mutually set or oriented with respect to a common zero or base value at the beginning of each revolution.

Immediately as the transmitting drum rotates at the sending station A, the differing tone values of the picture are transmitted and while they are received at the receiving terminal F, superimposed upon the slowly varying interference currents, they will be reproduced on the receiving drum in their proper relative proportions, substantially unaffected by the momentary value of these currents and irrespective of any natural zero current position of the cable.

Station equipments—Station A

At the sending station, it is necessary to convert the picture-modulated carrier signals of approximately 1350 cycles, illustrated at Fig. 7a, to a picture-modulated direct current having current values ranging between certain positive and negative limits, for transmission over the metallic line. Apparatus for accomplishing this is shown in Fig. 2. This device consists essentially of a rectifier 14 connected to the usual amplifier 2 and followed by a bridge type transmitting amplifier 15. Since positive and negative signals are to be transmitted, it is necessary to employ a pair of transmitting tubes and it is further found desirable to divide the rectifier circuit likewise into two identical halves in order to avoid capacity unbalances. Networks 16, 17 are included for the purpose of suppressing the output ripple from the rectifier and to improve the shape of the direct current output wave. It is the function of the two amplifying vacuum tubes 18 to repeat the unidirectional current output of relatively low frequency produced by the rectifiers, illustrated at Fig. 7b, as polar signals symmetrically disposed with respect to a zero line corresponding to ground potential illustrated at Fig. 7c, while yet avoiding the interposition of condensers or transformers. These added devices would interfere with the transmission of very low frequency or direct current signals, and would require complex compensating devices. The unidirectional current in the rectifier circuit will give to the point *a* of the input coupling resistance 19, a varying potential which is always positive with respect to the point *b* of this resistance and thus the output of the two tubes will be continuously unbalanced. It is desired, however, that the center of this resistance be grounded and also that the transmitted current be zero when the gray or base tone is being transmitted. In other words, with an input current corresponding to the gray tone, the grids of the two tubes must have like potentials with respect to their cathodes, or ground. This potential is preferably the normal negative operating potential of the tubes, and as shown, is secured by including serially in the two grid circuits, the two dry cell batteries 20, 20' of such value that during the transmission of gray, the output currents of the two tubes 18 have values which are equal and correspond to the center of their operating characteristics. Obviously, other battery arrangements may be employed to secure this orientation of output currents.

The two amplifier tubes 18 of Fig. 2, in conjunction with their respective battery feed resistances, comprise a type of bridge circuit. In case it is desired to transmit a higher voltage to line, this bridge circuit may be modified in the well known manner by substituting a second pair of tubes for the two battery feed resistances and controlling the grid circuits by a second similar set of rectifiers.

Station B

At station B there is provided a thermionic repeater designed to re-enforce the signals received over the metallic line from station A and to resend them over a similar metallic line. As illustrated in Fig. 3 this repeater circuit comprises essentially a 2-stage push-pull resistance-capacity coupled amplifier employing two or more pairs of tubes 23, 24, in parallel in the output stage. This amplifier may contain internal signal shaping elements in accordance with principles well known in the submarine cable art. It has been found that only the high frequency components of the received signal have been so attenuated as to require amplification at this point, and hence only these frequencies are selected by means of the amplifier input transformer 27, along with an associated network 25. This amplifier system is of the type generally disclosed in U. S. Patent No. 1,378,170, dated May 17, 1921, but differs somewhat in the choice of frequencies to be by-passed and also provides a certain amount of distortion correction for these by-passed components. In this photo transmission system, frequencies ranging from zero or direct current up to a few hundred cycles may be involved. Since line attenuation characteristics vary so widely over this range, particular advantage is found in dividing the frequencies roughly into three groups; that is, very low frequencies and direct current, a second narrow group slightly above this range, and a third relatively wide range including the higher frequencies.

Accordingly, the input stage of the amplifier is coupled to the line via a network 25 selective of the upper range of frequencies while substantially excluding the intermediate and direct current components. In the by-pass circuit 30 the two identical networks 31 are provided for shunting around the repeater the direct current components and also the intermediate frequency components. These intermediate frequency components pass for the most part through the condenser paths which may be separately adjusted to produce a preferred configuration in the output signal. A system of amplification which also employs this mode of building up the ultimate signal through individual handling of the component frequency range is found in U. S. Patent No. 1,315,539.

Station C

At station C the signals received over the metallic line must be amplified and at least partially corrected as to form and then be retransmitted over the grounded submarine cable, which, because of the high transmission speeds involved, will probably be of the "continuously loaded" type. As illustrated in Fig. 4, this repeater functions to repeat between a metallic or balanced circuit pair of conductors from station B and a grounded or unbalanced circuit from station C to station D, with continuous or D. C. coupling throughout, except for the final cable transmitting condenser 56. To avoid repeating the longitudinal currents, such as earth currents, which flow in the same direction over the two conductors of a pair of wires, it is customary to provide a differentializing device, such as a balanced transformer or bridge arrangement, wherein the effects of the currents flowing in the two conductors are neutralized. However, in this amplifier the transformers or blocking condensers which must usually be used in such differentializing devices are inadmissible because of the very low frequencies which must be handled. For this purpose of repeating the signals comprising the signaling series or loop currents, while suppressing the longitudinal interference currents, a rather unique amplifier circuit is employed.

The first portion of the amplifier at station C (see Fig. 4), comprises first a balanced gain control and a shaping network 35, which, as shown, includes a combination of transformer coupling 36, for the higher frequency components and a

direct coupling 38 for the lower frequency components, which is then coupled to an amplifier 40, via a shunting resistance 41 having a grounded center tap 42. The amplifier tube 43 is of conventional resistance coupled type and serves only to repeat the signal or loop currents. All or a portion of the output of this tube may be applied to the input of the next or transmitting stage via the wire 45. In the case illustrated it is found preferable to use only approximately half of this output voltage as indicated at 46 and thus permit a smaller grid biasing battery 47 in the succeeding stage.

It is evident that the amplifier tube 43 would also repeat voltages which may appear across the upper half of the input potentiometer as a result of longitudinal currents flowing in the line wires 1. It is seen that the tube 43 comprises a conventional resistance coupled amplifier stage provided with a self-bias resistance 48, and in which the output appears across the potentiometer 49 as a positive voltage above ground potential. Assume that the switch 50 is closed to the point 51. Voltages appearing across the input potentiometer 41 of this stage would ordinarily be amplified and transmitted over the wire 45 into the output stage of the amplifier. These input voltages include both the cable signals which appear as loop or series currents in the input potentiometer 41, and also longitudinal disturbance currents, such as earth currents, which flow in the same direction through the two halves of the potentiometer 41 to ground at 42. It is desired to suppress these longitudinal currents at this point so as to prevent their transmission into the cable. To accomplish this purpose a second tube 44 is arranged to control a supplemental current flowing through the self-bias resistance 48.

The voltage across the potentiometer 49 comprises the sum of the voltages appearing across the tube 43 and the self bias resistance 48. To compensate the effect of longitudinal voltages in the output of tube 43, an auxiliary tube 44 is provided which produces a compensating effect via the self-bias resistance 48. It is seen that the circuit of this tube includes only the positive plate battery 52 and the resistance 48. In the handling of loop currents the current through the resistance 48 is maintained substantially constant so that the amplification becomes largely a function of the tube 43. The manner in which the system functions to produce a summation voltage which is independent of the longitudinal currents may be understood by reference to the table shown in Fig. 4ª. This table represents qualitatively the voltages appearing across the tube 43 and the resistance 48, to produce the output signal as found across the potentiometer 49, corresponding to different polarities occurring at the two extreme points 1 and 2 of the input potentiometer 41. Assume first that a signal or loop current is being received which makes point 1 positive and point 2 negative. The impedance of tube 43 will then be low, and its voltage drop will be low, and a large current will flow through the resistance 48 from tube 43. However, the impedance of tube 44 will be high and the consequent small current through this tube will have only negligible influence on the IR drop across resistance 48. The output voltage across the potentiometer 49 for this condition, is the sum of the voltages occurring across the tube and the resistance 48, and since the tube voltage is low, the output voltage will be but slightly more than the IR drop across the resistance 48, and thus will have a low positive value corresponding to the input signal, but reversed in phase by 180° as in all resistance coupled amplifiers. Assume now that the loop current is of the opposite polarity; that is, point 1 is negative and point 2 is positive. The voltage drop across tube 43 will now be high but inasmuch as the impedance of tube 44 has been lowered due to its positive grid, the current through the resistance 48 will remain substantially constant, and the output voltage, determined by tube 43, will be high to produce a positive output signal. This composite current through the resistance 48 which has been shown to remain constant for the two extreme conditions of potential between the points 1 and 2 will also remain unchanged for all intermediate values, and as a consequence the output potential for the amplifier stage is at all times determined by the voltage drop produced across tube 43. From the foregoing analysis, it is evident that under the influence of signal voltages the two tubes 43 and 44 cooperate to produce an amplified output voltage. The slight degenerative effect which accompanies the use of self bias resistances has been neglected.

Considering now the effect of longitudinal currents flowing in the same direction in both wires, and assume that points 1 and 2 are both positive. Under these conditions a low voltage will appear across tube 43, but a high voltage will exist across the resistance 48 due to the increased current which flows through tube 44. This combination of a low and a high voltage condition will tend to neutralize and thus produce no effect upon the output potentiometer 49. For the reverse condition in which the points 1 and 2 are both negative, a high voltage will exist across tube 43 and a low voltage across the resistance 48 to again produce a null output voltage for this condition.

The value of the resistance 48 must be of sufficient magnitude, for example, about 3000 ohms, so that the IR drop produced will be large enough to compensate the voltage changes occurring in the tube 43. Since this resistance also functions as a self bias for the tube 43, the bias for normal conditions would be excessively negative. To oppose this excessive bias and to provide a normal operating bias for the tube 43, a grounded battery 52′ is connected in series with the cathode of the tube by moving the switch arm 50 to the contact 54.

One disadvantage of conductively coupled amplifiers is the requirement of a large negative biasing battery for each grid for the purpose of overcoming the potential of the positive plate battery of the preceding tube. This requirement has been relieved in the amplifier stage just described by the utilization of said grounded battery 52′ in series with the cathode of the tube 43. As a consequence, the biasing battery 47 of the succeeding stage may be reduced to a relatively small value, or may be entirely omitted, thus achieving a directly coupled amplifier which requires no grid biasing battery for the intermediate stages.

In the preceding description qualitative values only have been given but by adjustment of input voltages and resistance values, it is possible to provide a highly exact neutralization of the longitudinal interference voltages, while at the same time securing full gain in this stage for the signal currents.

The output conductor 45 connects to an output stage comprising two or more tubes 55 in par-

allel arranged to transmit through a resistance-capacity coupling and shaping network **58** into the submarine cable **60**. It has been found preferable to include a condenser **56** of quite large capacity in series with the cable circuit in order to avoid accidentally subjecting the cable to dangerously high potentials. This condenser introduces some unavoidable distortion due to the signals but it has been found that this distortion may be satisfactorily compensated by shaping networks included in the circuit, particularly at the sending end of the cable. The inclusion of additional discontinuities, such as condensers or transformers, would multiply the difficulty of this compensation.

In order to avoid the use of the condenser **56** the connection from the metallic line section to the cable section may be made entirely conductive in the manner illustrated in Fig. 4[b] wherein a battery **57** is used in place of the condenser **56**. The voltage of this battery would be equal to the mean or zero potential at that point which is due to the amplifier plate battery and thus provides a normal zero potential termination for the cable.

Station D

For reception of signals from the long submarine cable **60**, there is provided a receiving amplifier of a conventional type, shown in Figs. 5[a] and 5[b], embodying the customary distortion compensating and interference suppressing features of cable amplifiers. It is preferred to employ in the amplifier, balanced stages up to the final transmitter stage, in order to minimize distortion and the introduction of interference due to local battery or other sources. The balanced circuit also facilitates the use of a feedback circuit **64**. The coupling condensers **62, 63** and the transformer employed in this amplifier, interfere somewhat with the transmission of low frequency signal components and accordingly, the feedback circuit **64** is provided from the third to the second stage for the purpose of feeding back low frequency components to increase the amplification in that range. It will be noted that the feedback circuit connects to the anodes of the tubes **65** of the preceding stage. This connection avoids the insertion of a condenser in the feed-back circuit, which would otherwise be necessary in order to isolate the positive anode potentials from the negative grids. Further, if the network **66**, of the feedback circuit were connected directly across the grids of the third stage tubes **73**, the shunting effect of the network would seriously impair the time constant of the input circuit as determined by the resistances **68** and the capacities **69**, and the signal voltage would fall off too rapidly. Accordingly, it has been found preferable to connect the feedback circuits to the anodes of the tubes **65**, of the preceding stage, where the network will be sufficiently isolated from the input circuit of the power stage as to produce only negligible impairment of the time constant.

Another feature of this amplifier stage lies in the large resistance **70** (3000 ohms) included in the common cathode, or self-bias circuit. This large resistance produces a considerable degenerative effect upon interference currents flowing longitudinally in the amplifier and arising usually from pick-up or from battery sources. This resistance has no effect upon normal signal currents. The high biasing resistance **70** necessitates a large value (120 volts) of grid biasing battery **72** in order to restore the grids of tubes **73** to their normal operating potential relative to the cathodes. It is noted that the output of this amplifier is returned to the negative terminal of the battery **72** and thus a relatively small grid battery suffices for the succeeding stage.

Tetrode type tubes are preferably employed throughout the amplifier. In the push-pull stages, the balance of these tubes may be adjusted via potentiometers **74** in the screen grid battery circuits as indicated in the third stage. Inasmuch as the succeeding section of the signaling circuit in this case comprises another cable section **76**, a transmitting organization substantially identical with that used at station C is employed. It may be desirable to provide as indicated, a protective gaseous discharge device **75** of definite breakdown potential for the purpose of protecting the cable from the accidental application of excessive potentials.

Station E

At station E there is provided a receiving system which may be employed either as a complete picture reproducing system or as a repeater for retransmitting the signals into extended land lines either in the low frequency form as received from the cable, or, after conversion into alternating currents, they may be transmitted over carrier current channels. As indicated in Figs. 6[a] and 6[b], a submarine cable receiving amplifier is provided, which up to the line A—A is substantially identical with the signal shaping amplifier previously described for station D. There must be included, however, preferably in the third or final stage of the amplifier, a device arranged to correct any departure from symmetry of the positive, negative and ground signals. This correcting stage of the amplifier is followed by a device arranged to convert the relatively low frequency picture signals into an alternating current adapted either for retransmission or for final recording by the picture recording apparatus.

As mentioned earlier in this description, the absolute values of the received currents vary extensively, due to the presence of low frequency interference such as earth currents, and the natural "zero wander" of the cable. These variations, however, may be rendered harmless as regards the reproduction of the picture or message, if the relative values of the signals and their correspondence to the relative tone values of the pictures are maintained. The third amplifier stage of the receiving system is arranged to perform a regular correction designed to maintain this relative condition. This correction comprises the establishment of the zero current signal (corresponding to the gray tone) at the transmitter and at the receiver, at the beginning of the 3⅓ second interval corresponding to each revolution of the drums of the transmitting and receiving apparatus. The signals at the recorder will then vary through their normal range corresponding to the tone values of the original picture, irrespective of the momentary value of the slowly varying earth currents and other interference.

The process for resetting the amplifier output current to zero at the beginning of each revolution of the picture transmitting drum is as follows: It will be noted that the fourth electrodes or screen grids, of the tetrode tubes **78** and **79**, are variably connected to a source of positive battery **80**. The screen grid potential for the tube **78** may be varied by controlling the grid poten-

tial of the tube 81. This control of the tube 81 is accomplished as follows. A revolving commutator 82 containing a single conducting segment 83, of width corresponding approximately to the width or period of overlap of the picture strip on the drums, is rotated in synchronism with the sending drum 3 of the picture transmitter. At the beginning of each revolution a 60 cycle current flows through this conducting segment 83 to vibrate the armatures of the two relays 84 and 85 which are normally biased to their left-hand contacts. The right-hand contacts of these two relays are connected across the receiving amplifier circuit, while the left-hand contacts connect to the input of tube 81, across which is shunted a relatively large condenser 86, of say 3 mf. Connected to the tongues of the two relays 84 and 85 is a smaller condenser 87 of say .3 mf. and arranged to alternately receive a charge from the amplifier output circuit and then to deliver this charge to the 3 mf. condenser of the input circuit of tube 81. The charge upon the 3 mf. condenser then influences the grid of tube 81 so as to vary the potential of the screen grid circuit of tube 78, thus controlling the plate current of this tube. This accumulated charge will always be so poled as to cause the output current of the amplifier stage to return to zero through balancing of the plate currents of the tubes 78 and 79. The functioning of the circuit is as follows: Assume that at the incidence of a correction period (i. e. during the passage of the overlap of the edges of the picture strip on the drum when no signals are transmitted) and when the brush 88 engages the revolving contact at 83, the output of tube 79 is positive. Then through the operation of the relays 84 and 85, a positive voltage will be transmitted to the grid of tube 81 to reduce the impedance of this tube and thereby lower its plate potential. As a consequence, the positive potential applied to the screen grid of tube 78 will be reduced and according to the well known characteristics of tetrode tubes the plate voltage of tube 78 will consequently increase or become more positive. The output potential of tube 78 will continue to increase until it is equal to or balances the output voltage of tube 79 and hence produces a zero output voltage for the amplifier for the condition of zero or no input voltage from the cable signals. The variable connection for the screen grid of tube 79 is for the purpose of initially adjusting the receiving system to zero at the beginning of the tour of operation. In the particular case illustrated, tetrode type tubes are used and the correction voltage is applied to the screen grid. It is to be understood however that the correction could be applied to the other tube elements or to the associated circuits. Where other types of multi-grid tubes are used the correction voltage may be satisfactorily applied to any of these grids.

As shown in Fig. 6[b], the zero correction is operative upon only one of the two tubes of the amplifier stage. Should this correcting range be insufficient, it is impossible to apply a like but opposite correction to tube 79 as well, thus doubling the correcting capacity of the auxiliary apparatus. A possible scheme for accomplishing this is shown in Fig. 6[c] in which tubes 78, 79, and 81 function as already described, while a second tube 81′ provides a correction for the amplifier tube 79. The input for tube 81′ is variably connected to the output of tube 81 and thus operates similarly but displaced in phase by 180°, to control the second tube 79 of the amplifier.

In the foregoing description a zero current value was chosen for the correcting or reference signal as a matter of simplicity and convenience. If desired, however, any other value within the signalling limitations of the cable could be used, it being necessary only that the reference signal bear the same relation to all other signal values at the two ends of the circuit respectively. For example a current corresponding to black could be transmitted by using a black overlap area at the transmitter, and simultaneously at the receiver providing for a maximum output current. A maximum output current can be secured while maintaining a zero potential difference across the condenser 86, by introducing a biasing battery of the proper potential into any of the four leads to the contacts of relays 84 and 85. The same result may be achieved by other methods, e. g. by a proper initial adjustment of the screen grid potential of tube 79.

As previously mentioned the primary function of the tone orienting system is to secure freedom from low frequency interference. The correcting system should of itself be as free as possible from all interference, and this is realized to a satisfactory extent through the utilization of the series of incremental pulses as determined by the operation of the relays 84 and 85 under the influence of the alternating operating current. By thus employing a number of pulses distributed over the overlap period, random interference peaks will tend to average out and give a mean correcting value to the potential of condenser 86. Should there be any periodic interference such as power interference present, the relay operating current, here indicated as 60 cycles, should be chosen to be widely different in frequency from the interference so that the interference peaks will not accumulate to adversely influence the correcting potential.

At the output of the 3rd stage of the amplifier the picture signals are in the form of relatively low frequency polar currents with zero current corresponding to the neutral or gray tone and with the other shades ranging from maximum positive current for black to maximum negative current for white. The picture recording apparatus previously referred to, however, requires for its operation an alternating current modulated in amplitude in accordance with the varying picture tone. A system for converting the polar signals as received, into a suitable current for recording purposes will now be described.

The signals from the output of tubes 78, 79 of the third stage of the amplifier are in the same form as originally transmitted into the cable, illustrated in Fig. 7 at curve (*c*). If these reversals were applied without modification to the circuit comprising the tubes 90, currents of only one polarity would be transmitted in view of the unidirectional nature of the circuit. Consequently, it is necessary to interpose a biasing battery 91, having a potential at least equal to the maximum signal amplitude in order to insure that the direction of current flow will always be continuously in the direction in which the tubes are conductive. The effect produced by adding the biasing battery 91 is indicated in Fig. 7 at curve (*e*).

Now in order to convert these signals of the form shown at curve (*e*), into the rapidly alternating form originally produced by the picture transmitter, as shown in Fig. 7 at curve (*a*), an oscillator 92 of a frequency, for example, of 2500 cycles, is coupled through a transformer to the

grids of said tubes 90, to render the tubes alternately conductive. With this arrangement the pair of tubes serve as a thermionic chopper or interrupting device. The output voltage resulting from the "chopper" stage will now have the form shown in Fig. 7 at curve (*f*), which is the same form as the signals produced at the picture transmitter, and may be amplified by any suitable arrangement of amuplifiers to the proper voltage for application to the recording stylus 97 of the picture recording apparatus 95.

The picture recording apparatus 95 is provided with a motor driven drum operating in a similar manner to the picture transmitter at the sending station. The drum 96, upon which the strip 8 of sensitive paper is wrapped, is metallic and is grounded through the frame of the apparatus. The varying value of the current issuing from the stylus 97, passes through the sensitized paper to the metal drum, thereby making a picture record in tones varying from white to black corresponding to the shades of the original picture at the transmitter.

Most of the types of sensitized recording paper require an initial or threshold voltage before a noticeable change in tone from white is produced. In practice, therefore, it is desirable to transmit a minimum current to the recording stylus corresponding to white, which is equal to this threshold value for the paper. Signal voltages higher than this value will then produce a corresponding linear tone response. The threshold voltage is determined by the excess of the voltage from the battery 91 over the signal voltage. The range between the maximum and minimum signal voltages, corresponding to black and white, is then determined by the setting of the input potentiometer 116, for the chopper stage. This potentiometer may therefore be termed a "contrast" control, inasmuch as it determines the difference in current between the white and the black conditions and, consequently, the tone values lying therebetween. This feature is of particular value in adjusting the receiver of the photo transmission system for recording on different types of paper, or in some cases for different types of sensitized material.

It will be noted that the 60 cycle circuit which operates the relays 84 and 85 is connected also to a third relay 89, which is arranged to apply the 60 cycle current through its armature to the recorder 95. The purpose of this connection is to produce a row of distinctive dots or marks upon the overlapping portion of the sensitized paper on the drum during the overlap period as a means of checking the operation of the receiver. The dots on the paper indicate the instant when the brush 88 contacts with the segment 83 of the synchronously driven commutator to initiate the operation of resetting to zero the output of the final stage of the amplifier. The location of said rows of dots within the overlap space thus provides a supervisory indication on the recorder picture as to the condition of synchronism and as to the number of correcting operations performed by the relays 84 and 85 during each revolution. As indicated, the 60 cycle current is applied to the recording stylus 97, via a transformer 118 inserted in series with the regular signaling circuit. A condenser 117 shunts the 60 cycle transformer to by-pass the higher frequency picture currents and, in addition, the back contact of the relay is arranged to short circuit the transformer primary to further reduce its impedance during the signaling periods.

By means of the reversing switch 98, positive or negative pictures may be produced at will.

In order to make the most effective use of the submarine cable, it should be possible to rapidly convert the associated equipment for handling either picture signals or ordinary message code signals. Preferably the general method of signaling should be disturbed as little as possible so that minimum alterations are required, and particularly the intermediate stations should not be disturbed. Basically such a change involves only the substitution of a metallic cable signal transmitter instead of the picture transmitter and rectifier at the sending end, and at the receiving end the substitution of a relay system including appropriate amplifiers. The fundamental signal shaping amplifier comprising the first three stages shown in Figs. 6^a and 6^b, function equally well whether for picture signals or for ordinary cable signals. The output of this amplifier, however, should be connected to additional amplifying stages for cable signals to provide the requisite relay operating current. Fig. 6^d shows such an amplifier stage of the direct coupled type commonly used for the amplification of low frequency signals, which may be connected to the circuit shown to the left of line A—A in Fig. 6^b.

Regular cable signals are somewhat more susceptible to transmission loss from earth currents and zero wander than are the picture signals and, of course, it is not desirable to interrupt this circuit at frequent intervals for purposes of reestablishing the zero as was done in the picture system. Accordingly, a somewhat different type of zero correction has been introduced in the arrangement of Fig. 6^d. The zero corrector comprises two thermionic chopper devices of the type previously described, connected in parallel to the output of the shaping amplifier stage, consisting of tubes 78 and 79 of Fig. 6^b. The two choppers are oppositely poled so that they respond respectively to the positive and negative signals, but due to the biasing batteries 99, only the peaks of these waves which exceed normal amplitude are repeated. These interrupted or modulated signal peaks are then separately amplified by amplifiers 100 and 101 and applied to separated double wave rectifiers 102 and 103 for the purpose of differentially charging a condenser 105. The two rectifiers are biased by individual batteries 106 and 107, so that no current can flow until the applied voltage exceeds a certain minimum. These biasing batteries are provided for the purpose of blocking noise or pick-up voltages of low value which, if unbalanced as to polarity, would cause a charge to accumulate upon the condenser 105 and thus interfere with the normal correction.

So long as the amplitudes of the positive and negative pulses are equal, the output of the two rectifiers will be equal and no charge will accumulate upon the condenser 105. However, should the mean potential of the cable depart from zero, one polarity of the signals will predominate and the condenser will assume a charge of that polarity. This potential will then be applied to a preceding stage of the amplifier via a correcting system which, as illustrated, is identical with that of Fig. 6^c. This device, by altering the screen grid potentials of the tubes 78 and 79, restores the mean output signal to zero thereby providing unbiased signals. It is apparent that condenser 105 will receive as a charge only that portion of the correction impulses which is in excess of the 50 volt rectifier biasing batteries 106 and 107, as indicated in

curve (*d*) of Fig. 6e, the final correction voltage then being in the form indicated in curve (*a*).

In order to follow the action of a single correction operation, assume that the output of tube **78** is excessively positive due to the effect of zero wander. A positive correction voltage, sufficient to override the battery **99**, will then be transmitted via the chopper and amplifier stages to the lower rectifier **103**, whence it will produce a positive charge upon the condenser **105**, after overriding the battery **107**. The input potentiometer adjustment and the amplifier gain are such that an operative correction voltage is normally well in excess of 50 volts and thus will override the opposing biasing battery. The negative charge of the condenser will now be transmitted to the grid of tube **81**, whence it will cause an increase in voltage of the plate of this tube and thus increase the screen voltage of tube **78** to bring about a decrease in the plate voltage of this tube. This voltage change is in such a direction as to produce an equalization of the output voltages of the two tubes **78** and **79** and thus remove any bias to the signals as a consequence of the acumulated charges created by the zero wander effect.

A further function of the biasing batteries **106** and **107** should be referred to. It is seen that the condenser **105** is connected in parallel with two oppositely poled rectifiers **102** and **103**, which, if the batteries were absent, would tend to shunt any charge applied to the condenser. Due to the biasing batteries, however, the two rectifiers are non-conductive at potentials less than 50 volts. The working charge on the condenser comprises the excess of the applied signal voltage above 50 volts. This correction voltage is normally substantially less than the biasing voltage.

The action of "the chopper" tubes **110** and **112**, in association with the two rectifiers **102** and **103**, may be further explained by referring to the curves of Fig. 6e. Curve (*a*) indicates the received signal approximately as it occurs across the output of the amplifier tubes **78** and **79**. The signal potential will have a value approximating the potential of the chopper biasing batteries **99** which may be, for example, 22 volts. So long as the signals are unbiased the voltage applied to the choppers **110** and **112** is zero and a zero output voltage will result. However, should the mean potential or the zero line vary to the positive side in a manner such as is indicated by the dotted line *x*, the signal potential will at times exceed the bias potential and the excess will appear as a signal modulated alternating current as indicated in curve (*b*). This potential is rectified whence it produces a positive charge upon the condenser **105**, which in turn reacts upon the corrector tubes **81** and **81'** to increase the current through tube **78** and decrease the current through tube **79** to restore the symmetry of the positive and negative signals. Similarly, a correction in the opposite direction is performed for signals which may digress negatively, as shown in curve (*c*).

It is seen that with the alterations at the sending and receiving termini, as just described, the cable system is now in condition to handle ordinary message signals on the regular cable relays **115**, at the maximum working speed of the cable. While normally the intermediate stations will not be altered, thus averting the problem of coordinating the work of the personnel at these various points as well as maintaining simplicity in equipment. In some cases advantage may reside in providing equipment for monitoring or for zero correction purposes at strategic intermediate points, for example at station D. Since the station D amplifier is substantially identical with the receiving terminal amplifier, the manner of incorporating either a receiving picture equipment or a cable signal equipment is obvious.

We claim:

1. The method of transmitting graphic or pictorial material for long distances over circuits of various mediums including metallic land line sections having balanced sending and return conductors, and submarine cable sections having ground return, with repeaters therebetween, which comprises producing the picture characteristics of the pictorial material as modulations of an alternating current, converting the picture modulated current into direct current polar signals varying in complitude with graduations of picture tone between maximum limits of opposite polarity, transmitting the signals over the circuits and interposed repeaters, and reconverting said polar signals into an alternating current to reproduce the original picture modulated current.

2. The method of transmitting pictorial material as set forth in claim 1, wherein the signals are reshaped and amplified while being repeated from one section to an adjacent section.

3. The method of transmitting pictorial material as set forth in claim 1, wherein the intermediate zero of the polar signals is periodically oriented with respect to ground potential to eliminate the effects of interference due to varying earth currents or other causes and thereby maintaining the original relative values of positive, negative and zero signals representing picture tones.

4. In a signaling system for electrically transmitting pictures wherein the transmitted signals representing picture tones vary in amplitude from maximum positive polarity to maximum negative polarity with intermediate zero at ground potential, the method of restoring the relative values of distorted positive, negative and zero signals, which comprises the periodic orientation of the zero signals with respect to ground potential.

5. The method of transmitting signals for long distances over circuits of various mediums including metallic land line sections and submarine cable sections with ground return and having repeaters for conductively repeating the signals between the sections, which comprises producing signal modulated alternating currents, converting said signals into variable amplitude positive and negative with intermediate zero signals for transmission over said sections and repeaters, and reconverting said last-named signals into alternating current signals for recording.

6. In a signaling system, an equipment constructed and operable to convert amplitude-modulated alternating current signals into polar direct-current signals which vary in amplitude symmetrically with respect to zero value, said zero value being at ground potential.

7. A signaling system as set forth in claim 6, said equipment embodying signal shaping elements, and conductive means for the transmission of the signals into a balanced line circuit.

8. In a signaling system for electrically transmitting pictures, means for producing signals corresponding to the different shades or tones of the picture, said signals being constituted by

a direct current of varying value ranging from a maximum positive through zero at ground potential to a maximum negative.

9. In a signaling system having a section comprising a pair of electrically balanced conductors, and a grounded submarine cable section terminating in a grounded transmitting device, a repeater constructed and arranged to conductively convey signals from said balanced section to said transmitting device.

10. A signaling system comprising a section having a circuit comprising a pair of conductors in electrically balanced relation and a section having a circuit comprising a ground conductor, and a repeater for transmitting signals from said balanced circuit to said grounded return circuit, said repeater having means to prevent the transmission of longitudinal currents flowing in the same direction over both conductors of said balanced circuit.

11. In a signaling system as set forth in claim 10, said repeater embodying a thermionic tube amplifier having a large self-bias resistance in circuit therewith and an opposing battery connected in the grid circuit to restore the normal bias of the tube and thereby cause the signal currents to be amplified efficiently and without distortion.

12. In a signaling system as set forth in claim 10, said repeater embodying a thermionic tube amplifier having a large self-bias resistance in circuit therewith, an opposing battery connected in the grid circuit to restore the normal bias of the tube and thereby cause the signal currents to be amplified efficiently and without distortion and an auxiliary tube connected in parallel with the first-named tube and in series with said resistance to control the IR drop across said resistance.

13. In a signaling system for the transmission of graphic or picture material comprising a plurality of cable sections, a multi-stage amplifier connecting adjacent sections, each stage having a balanced push-pull arrangement of thermionic tubes and a feed-back circuit connecting the output of one stage to the plate elements of the tubes of the preceding stage, said feed-back circuit being provided with a low pass network.

14. In a signaling system comprising two submarine cable sections with ground return, a repeater for repeating signals from one section to the other section, said repeater having a multi-stage amplifier, at least two stages comprising a balanced or push-pull arrangement of thermionic tubes and having a feed-back circuit connecting the output of the second stage with the plate elements of the tubes of the first stage.

15. In a signaling system comprising a plurality of sections, and a repeater connecting adjacent sections, said repeater having a multi-stage amplifier, at least two stages comprising a balanced or push-pull arrangement of thermionic tubes and having a feed-back circuit connecting the output of the second stage with the plate elements of the tubes of the first stage, a high biasing resistance connected between the cathodes and the grids of said second stage tubes, and a large voltage battery interposed between said resistance and said grids to restore the grids to their normal operating potential relative to the cathodes.

16. A picture transmission system having metallic land line sections and submarine cable sections, said land line sections having its conductors in electrically balanced relation, transmitting apparatus constructed and arranged to produce polar direct current signals varied in accordance with the varying tones of the picture to be transmitted and embracing a frequency range of a few hundred cycles per second, and repeating equipment provided with a balanced or push-pull amplifier connecting two of said sections for repeating said signals, said frequency range being divided into several groups, the highest frequency passing through said amplifier and the lower groups being by-passed around the amplifier through a correcting or shaping network.

17. In a picture transmission system, having a plurality of line sections for conducting signals embracing a frequency range extending from zero to a few hundred cycles per second, repeating equipment provided with an amplifier connecting two of said sections for repeating said signals, said frequency range being divided into several groups, the highest frequency passing through said amplifier and the lower groups being by-passed around the amplifier through a correcting or shaping network.

18. In a signaling system for transmitting signals having a wide frequency range, a multi-stage amplifier for transmitting signals having a frequency range of 1000 to 1, comprising a balanced or push-pull arrangement of thermionic tubes in each stage, a feed-back circuit connecting the output of one stage with the plate elements of the tubes of the preceding stage and having a network permitting the passage of low frequency signal components, a large self-bias resistance connected in the cathode-grid circuit of the tubes of said last-named stage to eliminate interfering currents flowing in the same direction in the opposite conductors and an opposing battery connected serial between said resistance and said grids to restore the normal grid bias of the tubes, whereby the signal currents are amplified efficiently and without distortion.

19. In a transmitting system for electrically transmitting pictures wherein the transmitted signal potentials representing picture tones vary in amplitude from maximum positive polarity to maximum negative polarity with intermediate zero at ground potential, the method of restoring the relative values of positive, negative and zero signals which comprises passing the signals through an amplifier having a pair of thermionic tubes in push-pull arrangement, and periodically equalizing the output circuits of said tubes to represent zero signals.

20. A signaling system for electrically transmitting pictures, which comprises means for producing direct current potentials varying from a maximum positive polarity to a maximum negative polarity with intermediate zero at ground potential, in accordance with the varying tones of the picture to be transmitted, means at the receiver for periodically orienting the zero signals with respect to ground potential to restore the relative values of the signal potentials, means actuated by said signals to reproduce a picture on a suitable medium and means to produce on said medium a supervisory indication of the functing of said signaling system simultaneously with said orientation.

21. A signaling system for electrically transmitting pictures, which comprises means for producing direct current potentials varying from a maximum positive polarity to a maximum nega-

tive polarity with intermediate zero at ground potential, in accordance with the varying tones of the picture to be transmitted, means at the receiver for periodically orienting the zero signals with respect to ground potential to restore the relative values of the signal potentials, a modulator connected to receive said corrected signals, said modulator including a pair of three element thermionic tubes having their cathode-anode circuits in parallel with each other and in series with a biasing battery large enough to maintain said anodes always positive with respect to said cathodes, said signals being applied to the cathode-anode circuits of said tubes, means for applying potentials of carrier current frequency to the grids of said tubes to render them alternately conductive, whereby the amplifier output consists of a signal modulated carrier current corresponding to the transmitted signals.

22. In a picture signaling system as set forth in claim 21, means for determining contrast in the reproduced picture comprising a modulator, an adjustable battery for determining the minimum output from said modulator, and an adjustable potentiometer for determining the maximum output from said modulator.

23. A device for modulating direct current polar signals on a carrier current comprising a pair of three element vacuum tubes connected in balanced relation and having divided input and output circuits, means for superposing polar signal currents upon a continuous current produced by a battery in the common portion of said output circuit, and a source of carrier current connected to said input circuits for alternately varying the conductivity of said tubes to produce a modulated carrier current in a circuit coupled to the divided output circuit of said tubes.

24. A signaling system for transmitting signals over long distance circuits of various mediums including metallic land line sections and submarine cable sections having ground return, with repeaters between adjacent sections, which comprises means for transmitting variable amplitude positive and negative with intermediate zero signals, a repeater comprising a pair of thermionic screen-grid tubes in push-pull arrangement, and means for restoring the relative values of the positive, negative and zero signals by periodically orienting the zero signals with respect to ground potential, said means comprising the application of a potential to the screen-grid of one tube corresponding to the displacement of the zero potential from ground potential to thereby produce equal and opposite tube output potentials.

25. A signaling system as set forth in claim 24, wherein said means for restoring the relative values of the signals comprises an auxiliary tube having its output connected to the screen-grid of one of said tubes and varying the input of the auxiliary tube during the reception of the periodic zero signals in accordance with the displacement of the zero signals.

26. In a submarine cable system for transmitting signals which vary in amplitude, the method of maintaining the relative values of said amplitudes which consists in periodically establishing a reference current value bearing a predetermined relation to the maximum current signal amplitudes, and simultaneously adjusting the receiving system with respect to a corresponding reference level.

27. In a signaling system as in claim 26, the method of determining the reference level at the receiving end which consists in receiving a series of short pulses distributed over the period during which the reference current is being transmitted, charging a condenser in accordance with each pulse, transferring these charges individually to a second condenser where they accumulate to form a total charge proportional to the reference level and free of momentary variations in the level of the reference signal.

28. In a submarine cable system for receiving signals a pair of normally balanced vacuum tubes each containing a cathode, anode, control grid and an auxiliary control element, the input potentials applied to the control grids of said tubes tending to become unbalanced and means for equalizing the output currents of said tubes comprising a regulating device operating to adjust the potentials of an auxiliary control element of said tubes.

29. A regulating device as in claim 28 comprising vacuum tubes connected in each auxiliary element circuit, said vacuum tubes having cathode, anode, and grid elements, said grid elements being simultaneously oppositely influenced by unbalanced signal potentials to produce variations in the plate currents of the tubes, whereby the potentials of the auxiliary elements are varied in opposite directions.

30. A pair of normally balanced signal amplifying devices whose mean output is subject to variations of low period to cause maximum signals of excess amplitude, a regulating circuit connected across the output of said amplifying stage including means for distinguishing the polarity of said excess amplitudes, converting said excess amplitudes to an alternating current, amplifying and rectifying them and applying them to a regulating device adapted to control the potential of auxiliary elements of said amplifying tubes whereby the variations in mean output are eliminated.

31. A pair of normally balanced amplifying devices whose mean output is subject to variations of low period to cause maximum signals of excess amplitude, a regulating circuit connected to the output of said amplifying devices and arranged to receive said excess amplitudes and to apply a correcting potential in accordance therewith to an auxiliary element of one of said amplifying devices whereby the variations of low period are substantially eliminated.

32. The method of transmitting graphic or pictorial intelligence over a medium adapted only to transmit a narrow low frequency range and subject to the presence of spurious low frequency currents, which comprises expressing said intelligence as variations of a continuous current ranging in value between maximum limits of opposite polarity with an intermediate zero at ground potential, and transmitting said signals over said cable while making periodic corrections at the receiver for the effect of said spurious low frequency currents.

33. A submarine cable transmission system subject to disturbances of low period provided with picture sending and receiving apparatus and telegraph sending and receiving apparatus, said picture apparatus being constructed and arranged to transmit polar signals continuously variable between maximum positive and negative values to represent picture tones and including means responsive to said disturbances for peri-

odically reorienting the received signals to compensate the effect of said disturbances, said telegraph apparatus being constructed and arranged to transmit polar signals having single positive and negative values and including means responsive to said disurbances for continuously compensating the effect of said disturbances, whereby said cable may be used alternatively for the transmission of picture or telegraph signals.

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