

May 17, 1949.

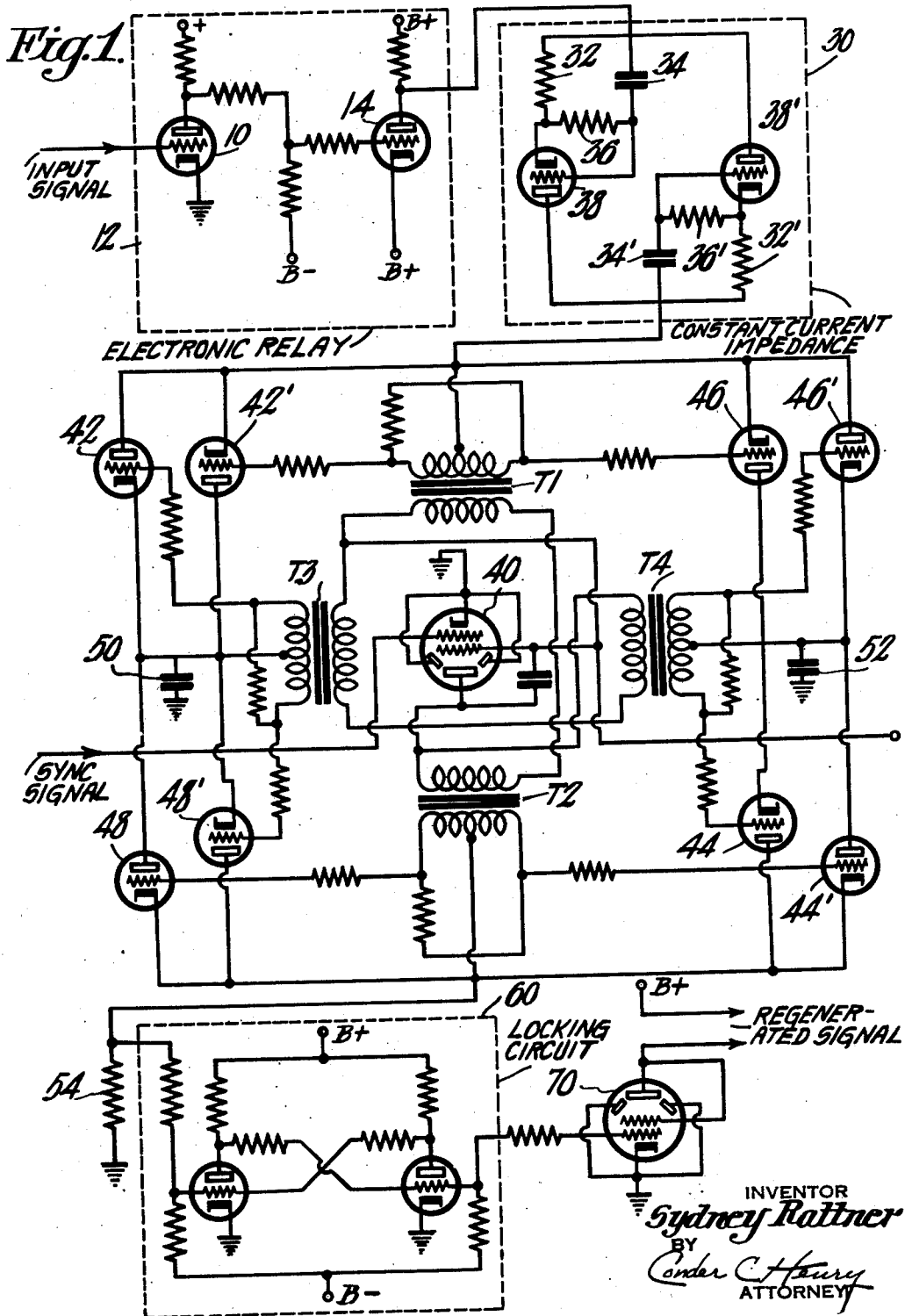
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2,470,722

ELECTRONIC SYNCHRONOUS SIGNAL REGENERATOR

Filed Feb. 15, 1949

2 Sheets-Sheet 1



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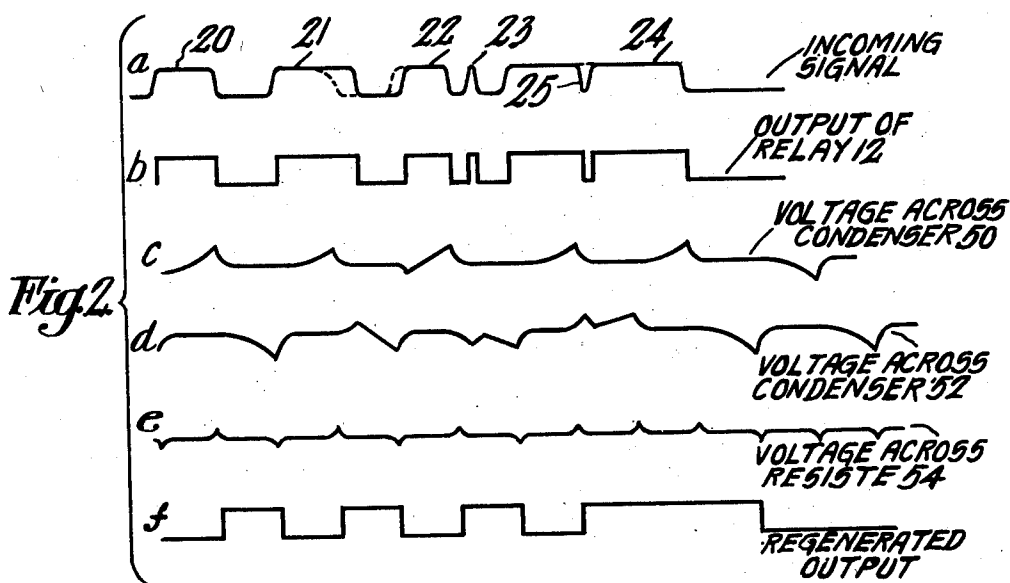
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ELECTRONIC SYNCHRONOUS SIGNAL REGENERATOR

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2 Sheets-Sheet 2



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ELECTRONIC SYNCHRONOUS SIGNAL
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Application February 15, 1949, Serial No. 76,532

4 Claims. (Cl. 178-70)

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My invention relates to a synchronous regenerator and more particularly to an improved device for reforming or regenerating received telegraph signals.

In the field of synchronous telegraphy, it has long been the practice to shape or reform the received signal prior to its utilization. Several schemes have been utilized, one of which is shown in United States Patent No. 2,359,649, granted to Kahn and Anderson, October 3, 1944. In so far as applicant is aware, most of the prior art approaches to the problem are dependent upon the selection of a small portion of the signal and utilizing that portion as a reference point to regenerate the signals. These methods have proven quite satisfactory provided that the signal is not distorted at the instant of selection of the reference point.

Two types of distortion in the received signals give rise to erroneously regenerated signals when using the prior art systems. The first of these is a signal "split," occurring when, during the reception of a mark element of the signal, the received power drops to a value insufficient to energize the receiving apparatus. Although such "splits" may occur for only a fraction of a second, if the occurrence is at the time of selection, a wrong character will be regenerated.

The second of the aforementioned types of distortion is a fill, occurring when, during the reception of a space element of the signal, power is received which is strong enough to energize the receiving apparatus. Here again, the occurrence may last for only a fraction of the signal element, but if it occurs during the instant of selection a wrong character will be regenerated.

One solution to this problem has been suggested in the copending application of Warren A. Anderson, Serial Number 755,447, filed June 18, 1947. While that application eliminates the distortions outlined above, it suffers one defect in that in modern day multiplex telegraphy the speed of transmission is so great that polar relays can no longer be relied upon to follow accurately the received and regenerated signals.

Accordingly, it is an object of my invention to provide an improved signal regenerator which will accurately regenerate received signals despite distortions therein.

It is a further object of my invention to provide an improved device of the character described which will be relatively simple in operation and which may be easily added to existing equipment.

Still another object of my invention is to pro-

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vide an entirely electronic regenerator which will accurately reproduce high speed signals.

Briefly, in accordance with the invention, the energy storage facilities of condensers, in conjunction with a synchronously driven electronic telegraph distributor and a vacuum tube locking circuit, are utilized to measure the energy content, "mark" or "spaced," of each unit interval of a received signal throughout the full unit length and to regenerate the signal in accordance with the prevailing nature of the element. By unit interval is meant the time length of the shortest unit in the code under consideration. Thus, in the Morse code, the unit interval would be the time length of a dot.

The above and other objects and advantages of the invention will become apparent upon a consideration of the following detailed description when taken in conjunction with the accompanying figures, in which:

Fig. 1 is a schematic diagram of a preferred embodiment of the invention, and

Fig. 2 is a series of curves illustrative of the operation of the invention in the presence of various types of distortion in the incoming signals.

The circuit illustrated is adapted for signals having mark elements which produce positive potentials and space elements which produce zero potentials. However it will be clear that suitable modifications could be easily made to accommodate other signalling systems.

Referring to Fig. 1 it will be seen that the incoming signal is applied to the grid of one tube, 10, of the electronic relay circuit enclosed in the dotted rectangle, 12. This relay comprises a pair of electron tubes, 10 and 14, together with their associated circuit components and power supplies. Such circuits are well known in the art and their operation will be clear to those skilled in the art. For purposes of illustration I have shown the relay of that type in which, when the input tube, 10, is in the nonconducting or minimum conducting state, the plate of the output tube, 14, becomes negative with respect to ground. This condition corresponds to a space or no signal applied to the input tube. Similarly, when the input tube is in the maximum conducting state, the plate of the output tube becomes positive with respect to ground. This condition corresponds to a mark or positive signal applied to the grid of the input tube. It will be understood that this result is easily accomplished by the proper selection of the potentials applied to the input and output tubes, in-

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dictated as + and B+ respectively, and the choice of the correct circuit components. Thus, potential at the plate of the output tube will vary, plus or minus, in accordance with the mark or space state of the incoming signal.

To the plate of the output tube of the electronic relay is connected a constant current impedance device enclosed within the dotted rectangle, 30. The device shown within the block 30 has been referred to as a constant current impedance. In other words, a device that passes constant current irrespective of the voltage drop across it. Such a device, of course, exists only in theory. The vacuum tube arrangement shown within the block 30 is an approach to this theoretical ideal.

The device is built in two halves, one reversed with respect to the other. This has been done to provide for the conduction of current in both directions. Since the operation of each half is identical only one side will be described. Corresponding parts in each half have been given similar numbers with the exception of the fact that corresponding part numbers are primed in one of the halves of the device.

The circuit is arranged so that the tubes are normally operative at zero bias. However, the sudden flow of current through resistor 32 at the appropriate transition of the electronic relay biases the tube until condenser 34 can charge through resistor 36 to the voltage across resistor 32. The rate of change of grid to cathode voltage is in opposition to the rate of change of plate voltage. Consequently, the current that flows through tube 38 tends to remain constant despite extremely wide plate voltage variations.

The balanced circuit in the center of Fig. 1 represents a preferred embodiment of an electronic distributor. The distributor required for the purposes of the present invention may be considered to be a double-pole, double-throw switch which reverses itself in synchronism with the incoming signals at unit interval rate. Mechanical devices for accomplishing this result are well known. However, in order to permit high speed signalling I have provided an electronic system.

To accomplish this result, synchronizing signals, which may be derived locally, from a channel separate from the transmitter or along with the transmitted signal, are supplied to the amplifier tube 40. The output from this tube is fed, through transformers, T₁, T₂, T₃ and T₄, and line resistors to the grids of the tubes of the commutating circuit. These tubes are arranged in pairs and by a suitable choice of circuit components and the polarities of the aforementioned transformers it is possible to arrange the circuit so that during one unit interval the tubes of the upper section of one side of the commutator, 42 and 42', and the tubes of the lower section of the other side of the commutator, 44 and 44', form conducting paths while the remaining pairs of tubes 46, 46' and 48, 48', form nonconducting paths. In this state the left condenser, 50, will be charged by the current from the constant current impedance device, 30, through the tubes of the upper left section of the commutator and any charge on the right condenser, 52, will discharge through the tubes of the lower right section across the load resistor, 54. Since the remaining sections of the commutator are non-conducting there will be no possibility of the left condenser discharging or the right condenser charging during the entire unit interval.

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At the next synchronizing signal, the conditions of conduction and nonconduction of the various sections of the commutator are reversed. Hence, a discharge path is provided for the left condenser through the lower left section of the commutator across the load resistor, 54.

From the above discussion, it will be apparent that the polarity of the potential produced across the load resistor, 54, will be in accordance with the polarity to which the condensers, 50, 52, were charged during the previous interval. The reason for having the tubes in the different sections of the commutator arranged in pairs but reversed polarity will be clear when it is realized that the output of the constant current impedance device is either plus or minus in accordance with the incoming signal. Hence, a path is provided for either condition.

The output of the commutator, appearing across the load resistor 54, is applied to a locking circuit shown within the dotted rectangle 60. This circuit is keyed by the pulses appearing across the load resistor and produces an output potential in accordance with the polarity of the pulses. The output from the locking circuit which represents a fully regenerated signal, may be used directly or, as shown may be used to actuate an amplifier tube 70 which, in turn, may actuate any desired telegraphic apparatus.

The operation of the device as thus far described, may best be understood from a consideration of Fig. 2. For purposes of illustration, it has been assumed that the incoming signal corresponds to the letter V, which in the Morse code is represented by three dots and a dash.

Line *a* represents the incoming signal to be regenerated. The first dot, 20, has been shown in its proper length as has the interval between it and the next dot of the coded character. The second dot, 21, has been shown as being elongated at the trailing edge, extending into a portion of the succeeding space element. The third dot, 22, has been shown as starting late but ending at the proper time. The following space element has indicated therein a "fill" 23, such as might be caused by some atmospheric disturbance or the like. The dash 24 has been shown as covering the proper interval but contains a "split" 25. The dotted portions of curve *a* are representative of an undistorted signal.

Line *b* represents the action of the electronic relay, 12. It will be seen that the output of the relay follows exactly the incoming signal including the "splits" and "fills."

Line *c* represents the voltage across the left condenser, 50. As the commutator sections vary between the conducting and the nonconducting states as explained above, this condenser is alternately charged and discharged. The sense in which the condenser is charged is dependent upon the polarity of the output of the electronic relay, 12. Since the commutator is alternating in synchronism with the transmitting apparatus, the discharge of the condenser, 50, will occur at equal unit intervals and will be in a sense which is equal to the predominating state of the received signals during the band interval during which the condenser was charging. Thus, the appearance of a distortion such as a "fill" 23 or a "split" 25, while reducing the value to which the condenser is charged will not change the sense in which it has been charged.

Line *d* represents the charging and discharging of the right condenser 52. It will be clear that the condenser 52 is charged and discharged

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similarly to the charging and discharging of the left condenser 50, with the exception that the cycle is repeated a single unit interval later.

Line *e* represents the voltages which are developed across the load resistor 54 by the discharges of the condensers 50 and 52. As will be apparent, the condensers are rapidly discharged. These discharges appear as pulses of voltage which are applied to a locking circuit (shown within the dotted lines 60). The sense of these pulses will be dependent upon and in accordance with the sense in which the condensers, 50 and 52, were charged.

Line *f* represents the regenerated signal output produced by the locking circuit 60.

It will be seen that there has thus been provided an apparatus which will faithfully and accurately regenerate received signal intelligence regardless of the occurrence of splits and fills. The device will accurately reproduce the signals to a point where only 50 percent of the received signal is correctly received. Furthermore, this 50 percent does not have to occur over any particular portion of the signal element.

Although the invention has been described with particularity, it is to be understood that the particular apparatus shown and described has been chosen for purposes of illustration only and not by way of limitation. Other devices and methods of carrying out the invention will occur to those skilled in the art and are to be contemplated as falling within the scope of the invention.

Having described my invention, what I claim is:

1. Electrical apparatus comprising, in combination, a source of signal intelligence composed of mark and space elements, an electronic relay actuated under the control of said signal intelligence for producing a first reference potential during said mark elements and a second reference potential during said space elements, a plurality of charging devices, an impedance device, an electronic commutator alternately and cyclically at unit interval frequency charging said devices by said potentials at a constant current rate and discharging said devices through said impedance, the charging of said devices taking place over substantially the entire unit interval, and means for producing regenerated signals in accordance with potentials developed across said impedance.

2. Electrical apparatus comprising, in combination, a source of signal intelligence, composed of mark and space elements, an electronic relay actuated under the control of said signal intelligence for producing positive potentials during said mark elements and negative potentials during said space elements, a constant current im-

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pedance device energized by said potentials, a plurality of charging devices, an impedance device, an electronic commutator alternately and cyclically at unit interval frequency charging said devices by said currents and discharging said devices through said impedance, the charging of said devices taking place over substantially the entire unit interval, and means for producing regenerated signals in accordance with potentials developed across said impedance.

3. Electrical apparatus comprising, in combination, a source of signal intelligence composed of mark and space elements, an electronic relay actuated under the control of said signal intelligence for producing positive potentials during said mark elements and negative potentials during said space elements, an electronic commutator, a plurality of sections in said commutator, a first charging device connected to alternate ones of said sections, the other side of said first charging device being grounded, a second charging device connected to the others of said sections, the other side of said second charging device being grounded, an impedance device, said commutator alternately and cyclically at unit interval frequency charging said devices by said potentials at a constant current rate throughout substantially the entire unit interval and discharging said devices through said impedance and means for producing regenerated signals in accordance with potentials developed across said impedance.

4. Electrical apparatus comprising, in combination, a source of signal intelligence composed of mark and space elements, electronic means actuated under the control of said signal intelligence for producing positive potentials during said mark elements and negative potentials during said space elements, a constant current impedance device energized by said potentials, an electronic commutator, a plurality of sections in said commutator, a first charging device connected to alternate ones of said sections, the other side of said first charging device being grounded, a second charging device connected to the others of said sections, the other side of said second charging device being grounded, an impedance device, said commutator alternately and cyclically at unit interval frequency charging said devices by said currents throughout substantially the entire unit interval and discharging said devices through said impedance and means for producing regenerated signals in accordance with potentials developed across said impedance.

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No references cited.