

July 16, 1946.

J. N. WHITAKER

2,404,307

ELECTRICAL CIRCUIT

Filed March 31, 1942

2 Sheets-Sheet 1

Fig. 1.

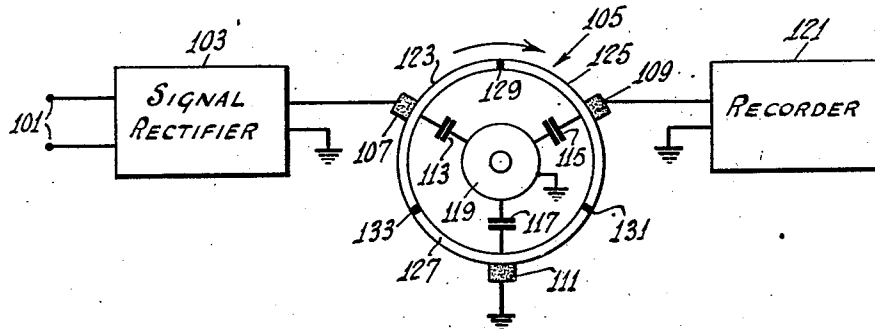


Fig. 2a.

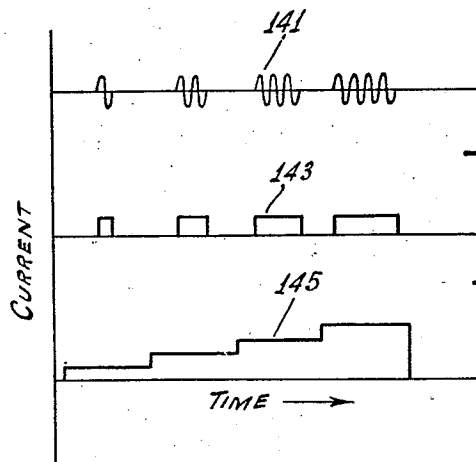


Fig. 2b.

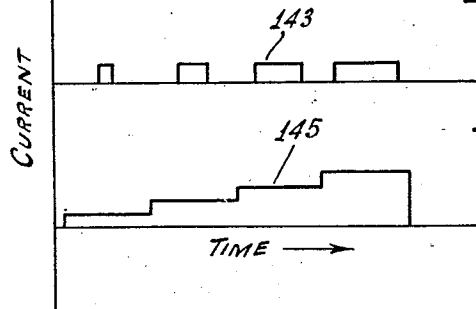
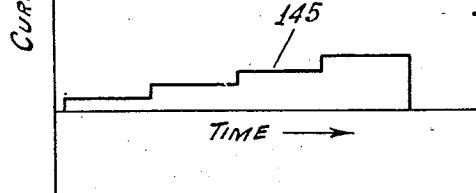


Fig. 2c.



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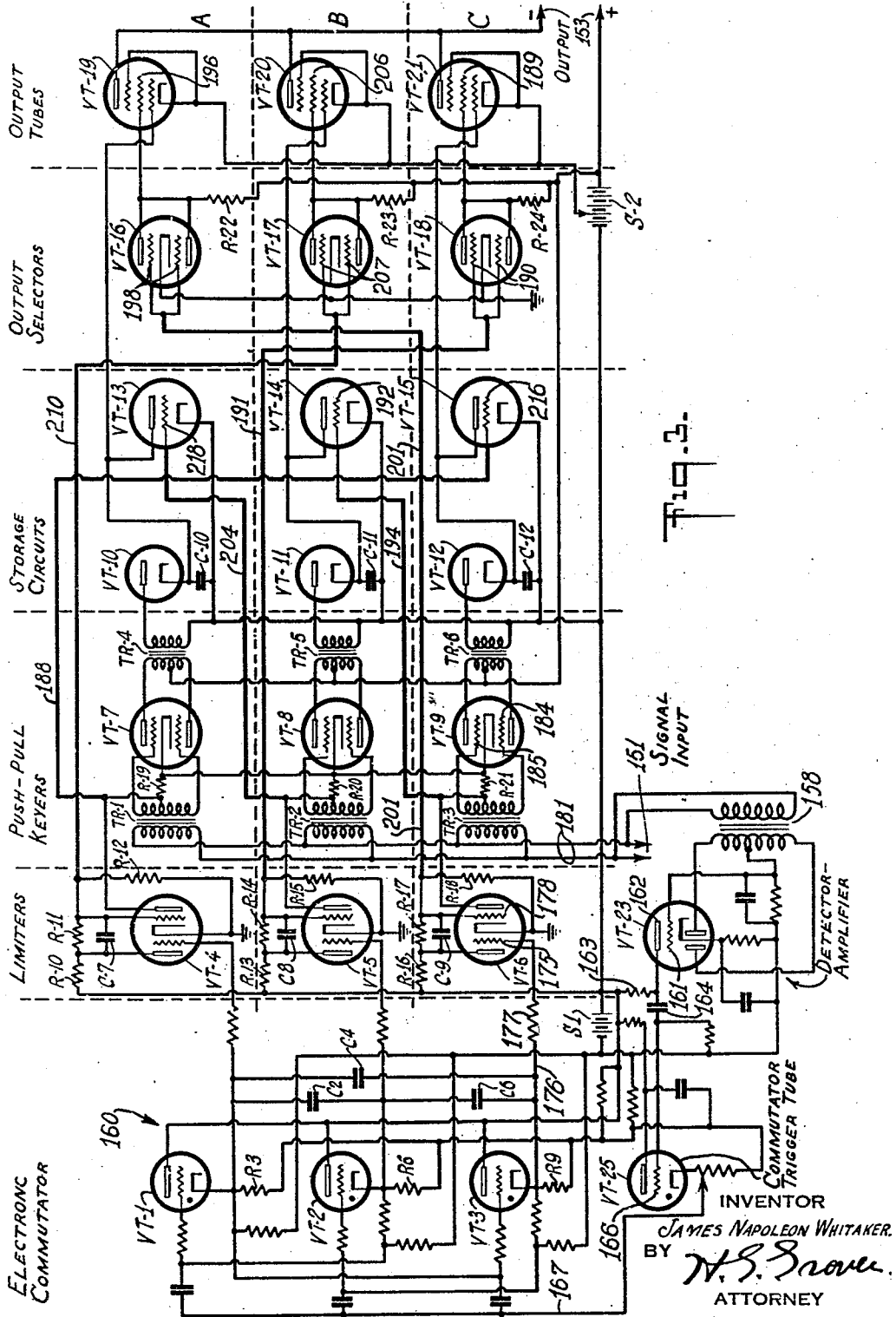
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2 Sheets-Sheet 2



UNITED STATES PATENT OFFICE

2,404,307

ELECTRICAL CIRCUIT

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12 Claims. (Cl. 250—20)

1

This invention relates to electrical circuits and, more particularly, to electrical circuits and methods for converting time-modulated impulses into amplitude variations.

In many applications in electrical signalling, it is desirable to signal by means of time variation of a signalling current in which the current has the value either zero or a predetermined constant finite value and in which the information is transmitted by varying the time duration either of the spaces between the pulses or the duration of the pulses themselves or a combination of variation of space and marking interval. At the same time it is desired to utilize the received energy in the form of amplitude variations. For example, in facsimile transmission over long distances, in order to overcome the effects of fading it is desirable to use the constant frequency variable dot type of transmission such as is exemplified by the Shore et al. Patent 2,083,245. On the other hand, for recording the transmitted picture it is desired to have a continuous variation between the signals representative of white to black so that the received picture appears to have continuous tones rather than a screen pattern, such as the recording of CFVD dots give. The reason for this is that where the pictures transmitted and received are to be used in printed reproduction the picture is ordinarily screened again by the photoengraver. The double screening produces a moiré effect which is very disturbing to the observer. Moreover, this effect tends to reduce the amount of detail in the picture. Other examples will be immediately obvious, as, for example, in measuring systems where it is desired to have continuous recording graphs rather than the broken line graph furnished by time-modulated signals.

Accordingly, by my invention, I provide a method and apparatus which will convert the time-modulated signals into amplitude-modulated signals or into signals of a unidirectional current whose amplitude varies with time. In accordance with my invention the incoming pulse signals are utilized to derive a charge whose magnitude is proportional to the time duration of the pulse. The stored charge is thereafter utilized to control the amplitude of a continuous unidirectional current such that the amplitude of the current is proportional to the stored charge. Thereafter the stored charge is dissipated. During the time the stored charge is controlling the amplitude of the output current a second impulse is being used to produce a second stored charge, and when the first stored charge is being dissipated, a third pulse is used to derive a stored charge while the second stored charge is used to control the amplitude of the output current. These cyclic steps are thereafter repeated. The output current therefore has a step by step

2

variation in amplitude, the magnitude of the amplitude being proportional to the time duration of the original pulses.

Further, in accordance with my method, I have provided apparatus for carrying out the described method of operation, utilizing thermionic tubes and without requiring the aid of mechanical commutators. This is necessary in order that the requisite speed of operation can be obtained with a minimum of maintenance and freedom from faulty operation.

Accordingly, it is the main object of my invention to provide a new method and apparatus for converting time-modulated pulses into amplitude-modulated currents.

Another object of my invention is to provide a method of converting impulses whose time duration varies into a continuous unidirectional current whose amplitude varies continuously.

A still further object of my invention is to provide apparatus embodying a thermionic commutator for converting a series of pulses into a unilateral current whose magnitude is proportional to the time duration of the received pulses.

Another object of my invention is to provide apparatus suitable to produce improved pictures from received CFVD signals.

Another object of my invention will become apparent to those skilled in the art upon reading the following detailed description in connection with the drawings.

In the drawings, I have shown in Figure 1 a schematic sketch embodying a mechanical commutator to illustrate the principles of my method and apparatus, and have shown in Figures 2a, 2b, 2c representative graphs of the received currents and output currents, while in Fig. 3 I have shown in considerable detail an electrical circuit diagram showing the commutator, limiters, keyers, selectors, such as are utilized in my apparatus.

Turning now to Figure 1, I have shown a signal rectifier 103 having terminals 101 across which the signalling currents in the form of A. C. impulses are applied. The input current at the terminals 101 has the form 141, as shown in Figure 2a. The output of the signal rectifier 103 thereafter will have the form 143 shown in Figure 2b. The outputs of these signals are fed through the brush 107 to the commutator 105 comprising three segments 123, 125, 127, separated by suitable insulation 129, 131, 133, respectively. A centering ring 119 is grounded and provides a common terminal point for the three storage condensers 113, 115, 117. The rectified impulse is consequently stored up in the condenser 113 during the time the segment 123 is under the brush 107. During the time the charge is being stored by the condenser 113 the previously stored charge of condenser 115 serves to actuate the recorder 121

through the brush 109, the magnitude of the recording current being proportional to the stored charge of the condenser 115. At the same time, the charge, which had been stored on condenser 117 previous to the storing of the charge on the condenser 115, is discharged to ground by way of a brush 111. As the commutator 105 continues to rotate the condenser 113 comes under the brush 109 to control the magnitude of the recorder current, while condenser 115 is discharged through the brush 111 and condenser 117 receives a new charge corresponding to the duration of the second pulse received and the operation is cyclically repeated during the transmission of the picture. The recorder 121 will have a recording current whose form is that shown as 145 in Figure 2c. It will be readily appreciated that the use of mechanical commutators is not wholly desirable in view of the fact that it limits the speed of operation and, in addition, requires constant attendance in order to avoid improper operation due to accumulation of dirt under the brushes, as well as the difficulties introduced by changes in leakage path of the insulating members. Accordingly, I have provided a thermionic equivalent in Figure 3 of the circuit shown in Figure 1 for purposes of illustrating the method of operation of my invention, which equivalent is substantially of any speed limitations and which requires a minimum of supervision in operation.

In Figure 3 I have indicated by means of horizontal dotted lines three channels A, B, C, and by vertical dotted lines the component parts of each of the channels in order to simplify the understanding of the operation of the circuit. The component parts of each of the channels comprises a commutator, a limiter, a push-pull keyer, an output selector including a storage circuit, a discharge tube, an output selector, and an output tube. These parts are identified on Fig. 3 of the drawings between the vertical dotted lines.

The operation of channel C will be described in detail and the mode of operation of channels A and B will be readily understood as each of the channels A, B, and C operates in a similar manner.

The input signals are consequently fed to the three push-pull keyers VT7, VT8, and VT9 through the transformers TR1, TR2, TR3, as well as to the rectifier-amplifier tube VT23 actuating the trigger tube VT25 of a commutator indicated in its entirety by reference character 160 comprising the three tubes VT1, VT2, VT3. The tubes VT1, VT2, VT3, and VT25 are gas tubes, and as shown in both the patent and the publication mentioned below, they may, for example, be RCA 885 tubes.

The rectifying portion of the tube VT23, which is fed from the input terminals 151 through the transformer 158, functions in the manner of a conventional full wave detector of radio or other carrier signals, such for example as the detector 10 of Fig. 1. The signals applied to the terminals 151 may be signals 141 of Fig. 2a of the drawings. These signals, after rectification, are applied to the grid 161 of the amplifying portion of VT23. The plate 162 of the latter is connected to a plate supply source S1 by way of the usual load resistor 163. A coupling condenser 164 couples the amplified output of the tube VT23 to the grid 166 of the tube VT25 which serves as a trigger tube for the electronic commutator 160. The control pulses for the commutator 160 are furnished to the commutator over a conductor 167.

The commutator is of the Shumard type de-

scribed in the Shumard Patent 2,146,862, as well as the article entitled "Some Electronic Switching Circuits" in the May 1938 issue of "Electrical Engineering," at page 209 through page 220. Consequently, a detailed explanation of the operation of the commutator circuit will not be given, since these circuits are already well known. It is merely necessary to point out that the operation of the commutator is such that, assuming channel C is operating, the tube VT3 is passing current, while tubes VT2 and VT1 are cut off. Upon the arrival of the second impulse tube VT3 is cut off and VT2 is actuated. Upon the arrival of the third impulse tube VT2 is cut off and VT1 is actuated, and the cycle repeats. In this fashion the commutator is synchronized with the incoming signals.

Assuming that a pulse from VT25 has actuated the tube VT3 so that it conducts, a positive pulse from the tube VT3 is applied to the input grid 175 of the limiter tube VT6 over a conductor 176 and a grid resistor 177, the pulse being derived from the drop across the cathode resistor R9. As a result, plate current in the tube VT6 flows through the resistor R16 producing an IR drop which causes the grid 178 of the second half of the tube VT6 to become negative with respect to its cathode. The negative potential on this grid blocks the flow of plate current in the second half of the tube VT6, reducing the IR drop across the resistor R21 to zero. This permits the push-pull stage tube VT9 to act as an amplifier for the incoming signal, which is applied over conductors 181 to the grids 184 and 185 of tube VT9 through the input transformer TR3, since the cut-off bias obtained from across the resistor R21 has been removed.

This removal of the cut off bias occurs since the grid 178 of the second section of the tube VT6 is negative at this stage of the operation with respect to its cathode as stated above.

The amplified signal is applied to the storage circuit comprising the tube VT12 and the condenser C12 through the transformer TR6. The rectifier tube VT12 permits current to flow in only one direction and consequently the condenser C12 will begin to charge up. The storage of the charge continues as long as the signal pulse is applied. It is to be noted that the capacity of the condenser C12 is made sufficiently large so as to prevent its charging beyond the linear portion of the charging characteristic during the operating cycle. The discharge tube VT15 is prevented from operating by the IR drop across the resistor R19 in channel A which is applied over a channel cross connection 188 and the output tube VT21 is held inoperative by the plate current drawn by the tube VT18 through the resistor R24 which reduces the screen voltage on the screen grid 189 of the tube VT21 below the point at which plate current can flow.

The grid 190 of the tube VT18 is connected to R15 in channel B over a channel cross connecting conductor 191 and therefore is positive with respect to the cathode as long as channel B is not operative. As a result, a charge is being stored up in condenser C12. At the same time the grid 192 of the tube VT14 in channel B is no longer biased by the drop in R21 over a channel cross connection 194 so that plate current will flow if there is any charge on condenser C11 in channel B, and consequently, the charge of condenser 11 in channel B will be dissipated or discharged by the tube VT14 so that the condenser

5

C11 will be ready to receive a new charge upon the arrival of the second impulse.

The grid 192 of the discharge tube VT14 in channel B is connected to the resistor R21 in channel C over the channel cross connection 194 and therefore is at zero potential with respect to its cathode when channel C is receiving a triggering or control impulse. At the same time the output tube VT19 of channel A is in an operative condition and will draw a plate current in proportion to the amount of charge appearing across the condenser C10 of channel A. VT19 operates because the selector tube VT16 of channel A is not drawing plate current due to the fact that its control grid 198 is connected over a cross channel connection 201 to the resistor R18 of channel C which applies a negative bias (or a less positive bias) to the grid 198 of VT16 of channel A. The screen grid 196 of the output tube VT19 in channel A is connected to the plates of the tube VT16 which, at times, draw plate current through the load resistor R22. When the channel C is cut off, the flow of plate current in the tube VT16 reduces the screen voltage on the screen grid 196 of the tube VT19 below the point where plate current can flow. The screen grid 206 of the output tube VT20 in channel B is connected to the plates of the tube VT17. When channel A is cut off, a bias is applied to the grids 207 of the tube VT17 over a channel cross connecting conductor 210. When channel A is cut off, the flow of plate current reduces the screen voltage on the screen grid 206 of the tube VT20 below the point where plate current can flow. It will be noted therefore that the following functions are performed simultaneously. The storage circuit in channel C is receiving a charge from the incoming signal. The storage circuit in channel B is being cleared for a new charge, and the output tube of channel A is operating, drawing plate current in proportion to the circuit of condenser C10 of the storage system in channel A. As soon as the commutator shifts to the next position, which is channel B, the following action takes place. VT9 of channel C is rendered inoperative due to the IR drop across the resistor R21. The tube VT14 is rendered inoperative by a bias applied to its grid 192 over the conductor 194 for the same reason. The tube VT18 is rendered inoperative over the conductor 191 because of the reduced IR drop across the resistor R15. The tube VT21 is permitted to operate because there is no IR drop across the resistor 24 due to the flow of plate current in the tube VT18, and, finally, the tube VT13 dissipates the charge across the condenser C10. The tube VT13 is rendered operative for this purpose over a channel cross connecting conductor 204 which is connected to the resistor R20. Thus, the action continues throughout each cycle of operation so that when one channel is receiving a charge the charge of the following channel is being dissipated, while the output tube in the previous channel is operating. The commutator switching is substantially instantaneous (less than 0.1 micro-second), leaving no space or overlap between channels so that the output is substantially continuous and of an amplitude proportional to the signal.

It will thus be perceived that the commutator system operates each channel separately, permitting each storage circuit to receive a charge, the amplitude of which will be proportional to the length of time a signal is being passed by the push-pull keyer stage (in CFVD picture signal re-

6

ception this length of time will be governed by the length of the transmitted dot with the commutator synchronized at the dot frequency). After one storage circuit has received its charge, the push-pull keyer in that particular channel is rendered inoperative by the action of the commutator and the next channel is made operative at the same time over one of the channel cross connecting conductors 194, 204, or 188, with the output tube in the first channel becoming operative by virtue of one of the cross-connections 201, 191, or 210 between the commutator limiter of the second channel and the output selector of the first channel.

When the storage circuit of the second channel has received its charge, and the output tube in the first channel has done its work, the push-pull keyer in the second channel is rendered inoperative along with the push-pull keyer tube in the first channel. Control of the push-pull keyer tubes VT7, VT8, and VT9 is provided by the resistors R19, R20, and R21 in the plate circuits of the tubes VT4, VT5, and VT6 as explained above. The output tube in the second channel is permitted to operate by virtue of the fact that the selector tube of the second channel is cross-connected to the commutator-limiter of the third channel. These cross connections as indicated previously are 210, 191, and 201. The output tube of the first channel is rendered inoperative because of the cross-connection between the first channel output selector and the second channel commutator-limiter. The charge stored in the storage circuit of the first channel is dissipated in a discharge tube in the storage system because the grid of the discharge tube is cross-connected to the output of the commutator-limiter system of the third channel. These cross connections are designated 188, 204, and 194 and are connected to the grids 216, 218, and 192 of the tubes VT15, VT13, and VT14 respectively. The amount of current appearing in each output tube is dependent upon the magnitude of the charge built up in the storage circuit which, in turn, is dependent upon the time duration of the signal during the charge period. Thus a complete cycle is set up which continues as long as signals are fed to the input terminals 151.

The output current is obtained from the output terminals 153 and they operate any suitable recorder, such as is known in the prior art, which may for example be a light valve or a pyro recorder. It will be appreciated that other types of tubes may be used without going outside the scope of my invention, and, of course, other modifications of the circuits which I have shown will immediately suggest themselves to those skilled in the art, and therefore it is desired that the disclosure be construed as covering all forms of converting systems which fall clearly within the spirit and scope of the hereinafter appended claims.

Various alterations and modifications of the present invention may become apparent to those skilled in the art and it is desirable that any and all such modifications and alterations be considered within the purview of the present invention except as limited by the hereinafter appended claims.

Having now described my invention, what I claim is:

1. The method of converting time-modulated signals into amplitude-modulated signals which comprises the steps of receiving time-modulated signals, deriving an electrical charge proportional

to the time duration of the signals, and utilizing the derived charge to control the amplitude of a unidirectional current in proportion to the magnitude of the derived charge.

2. The method of converting time-modulated signals into amplitude-modulated signals which comprises the steps of receiving time-modulated signals, deriving an electrical charge proportional to the time duration of the signals, utilizing the derived charge to control the amplitude of a unidirectional current in proportion to the magnitude of the derived charge, and thereafter dissipating the derived charge.

3. The method of converting time-modulated signals into amplitude-modulated signals which comprises the steps of receiving time-modulated signals, deriving an electrical charge proportional to the time duration of the signals, utilizing the derived charge to control the amplitude of a unidirectional current in proportion to the magnitude of the derived charge, thereafter dissipating the derived charge, simultaneously deriving a second charge from a signal following the first signal and concurrently controlling the amplitude of the unidirectional current by a charge derived from a signal preceding the first signal and cyclically repeating the aforesaid steps.

4. An electrical circuit for converting time-modulated signals into amplitude-modulated signals which comprises means for receiving time-modulated signals, means for deriving an electrical charge proportional to the time duration of the signals, and means for utilizing the derived charge to control the amplitude of a unidirectional current in proportion to the magnitude of the derived charge.

5. An electrical circuit for converting time-modulated signals into amplitude-modulated signals which comprises means for receiving time-modulated signals, means for deriving an electrical charge proportional to the time duration of the signals, means for utilizing the derived charge to control the amplitude of a unidirectional current in proportion to the magnitude of the derived charge, and means for thereafter dissipating the derived charge.

6. An electrical circuit for converting time-modulated signals into amplitude-modulated signals which comprises means for receiving time-modulated signals, means for deriving an electrical charge proportional to the time duration of the signals, means for utilizing the derived charge to control the amplitude of a unidirectional current in proportion to the magnitude of the derived charge, means for thereafter dissipating the derived charge, means for simultaneously deriving a second charge from a signal following the first signal, means for concurrently controlling the amplitude of the unidirectional current by a charge derived from a signal preceding the first signal, and means for cyclically repeating the aforesaid steps.

7. An electrical circuit for converting time-modulated signals into amplitude-modulated signals which comprises means for supplying time-modulated signals to a plurality of amplifying channels, means for deriving a charge proportional to the time duration of the signals connected in each of the said amplifying channels, means to control the amplitude of a unidirectional current by the said derived charge connected to each of the channels, and commutator means to sequentially and cyclically select each of the control means to control the amplitude of the out-

put current by only one of the said control means.

8. An electrical circuit for converting time-modulated signals into amplitude-modulated signals which comprises means for supplying time-modulated signals to a plurality of amplifying channels, means for deriving a charge proportional to the time duration of the signals connected in each of the said amplifying channels, means to control the amplitude of a unidirectional current by the said derived charge connected to each of the channels, commutator means to sequentially and cyclically select each of the control means to control the amplitude of the output current by only one of the said control means, and means to dissipate one of the derived charges.

9. An electrical circuit for converting time-modulated signals into amplitude-modulated signals which comprises means for receiving time-modulated signals, means for deriving an electrical charge proportional to the time duration of the signals, means for utilizing the derived charge to control the amplitude of a unidirectional current in proportion to the magnitude of the derived charge, means for thereafter dissipating the derived charge, means for simultaneously deriving a second charge from a signal following the first signal, means for concurrently controlling the amplitude of the unidirectional current by a charge derived from a signal preceding the first signal, means for cyclically repeating the aforesaid steps, and means operated by the received signals to control the initiation of the cyclic repetition.

10. An electrical circuit for converting time-modulated signals into amplitude-modulated signals which comprises means for supplying time-modulated signals to a plurality of amplifying channels, means for deriving a charge proportional to the time duration of the signals connected in each of the said amplifying channels, means to control the amplitude of a unidirectional current by the said derived charge connected to each of the channels, and commutator means synchronized by the supplied signals to sequentially and cyclically select each of the control means to control the amplitude of the output current by only one of the said control means.

11. An electrical circuit for converting time-modulated signals into amplitude-modulated signals which comprises means for supplying time-modulated signals to a plurality of amplifying channels, means for deriving a charge proportional to the time duration of the signals connected in each of the said amplifying channels, means to control the amplitude of a unidirectional current by the said derived charge connected to each of the channels, commutator means to sequentially and cyclically select each of the control means to control the amplitude of the output current by only one of the said control means, means to dissipate one of the derived charges, and synchronizing means controlled by the supplied signals to regulate the period of said commutator means.

12. An electrical circuit for converting time-modulated signals recurring at predetermined time intervals into amplitude-modulated signals which comprises means for deriving an electrical charge proportional to the time duration of the signals during each time interval of a signal, and means for controlling the amplitude of a unidirectional current in proportion to the magnitude of the derived charge.

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