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ELECTRONIC COMMUTATION OF CURRENTS

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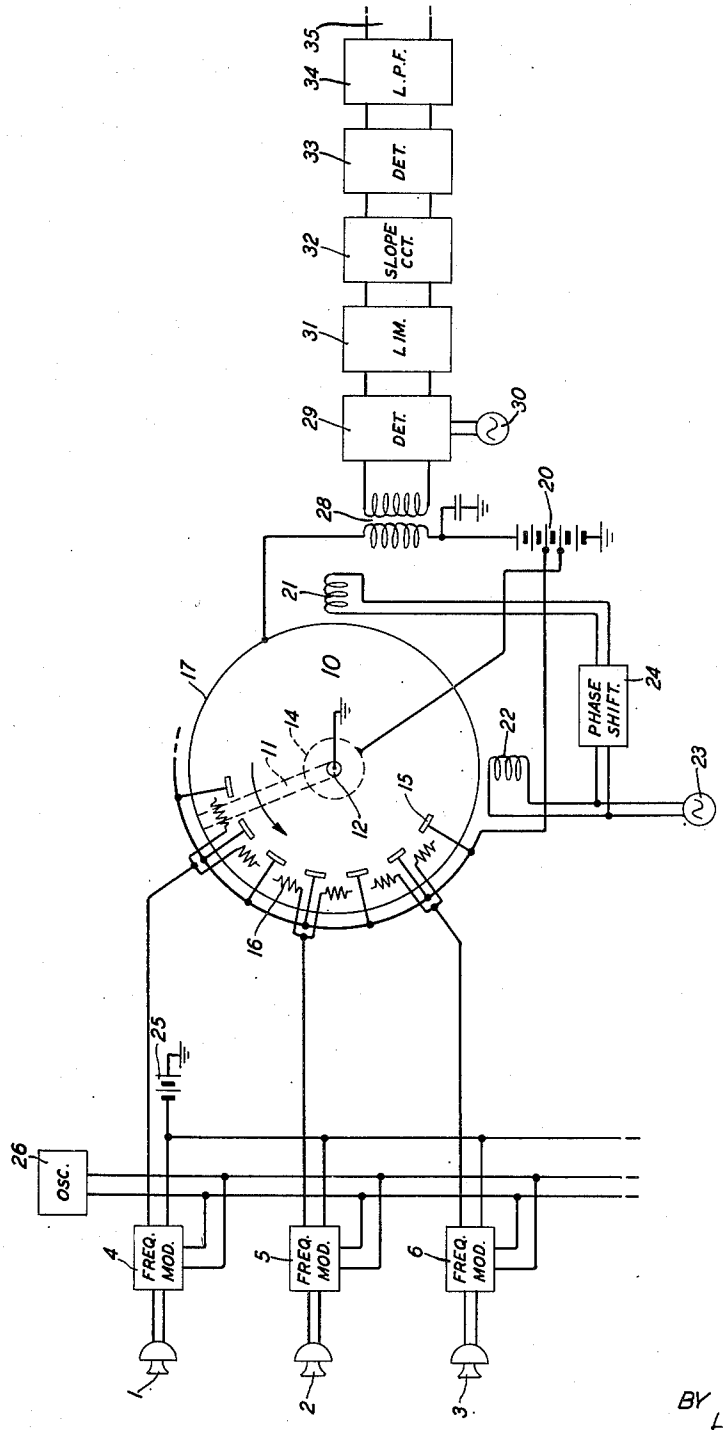

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ELECTRONIC COMMUTATION OF CURRENTS

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5 Claims. (Cl. 179—15)

The present invention relates to the commutation of electrical currents for signaling or other purposes, including electronic or other type of commutation.

An object of the invention is to eliminate or reduce ripple or other distortion effects such as may be caused, in the case of an electronic commutator, by the fact that the moving electron beam has finite width.

Electronic switching or commutation is favored in some types of transmission systems because of the almost unlimited speed at which the beam may be rotated. This speed may exceed many times over the highest speed possible with mechanical commutators. A drawback to electronic commutation is that the beam has finite width which means that in passing from one tube electrode to the next the beam may momentarily strike both electrodes, causing an overlap effect, or the beam may be partially cut off at certain instants by shield electrodes, for example, causing variations to occur in the beam strength which are unrelated to the signal.

In accordance with the present invention, the signals or other waves are converted to frequency-modulated waves before they are impressed on a commutator with the result that amplitude variations in the commutated currents representing ripple and similar disturbances can be reduced in the process of converting back to the amplitude pulses that are to be used for transmission.

Reference will now be made to the following detailed description and the accompanying drawing for a more complete understanding of the invention, together with its various objects and features.

The single figure of the drawing shows a schematic circuit diagram of a terminal of a multiplex telephone system embodying the invention in an illustrative form.

Referring to the drawing, a number of separate telephone lines shown as extending from individual microphones 1, 2, 3, etc. are connected through respective frequency modulators 4, 5, 6, etc. to electrodes of an electron commutating tube 10 which has a rotating electron beam 11 adapted to sweep over electrodes of the tube.

The tube 10 may be of the type disclosed in Skellett Patent 2,217,774, granted October 15, 1940, comprising a centrally located cathode 12 and other electrodes arranged concentrically thereabout. These electrodes comprise, proceeding in order from the cathode 12 outwardly, an accelerating grid 14, shields 15, control grids 16, and a common anode 17, the latter being in the form of a cylinder. The surrounding envelope is not shown. Positive voltage is applied to the accelerating grid 14, shields 15 and anode 17 from suitable taps on battery 20, the negative pole of which is shown grounded as is also the cathode 12. The beam is caused to rotate by a rotating magnetic field generated in field coils two of which are shown at 21 and 22 supplied with alternating current of suitable frequency from generator 23. A phase shifter, such as a quarter phase network 24, is connected in circuit with the field coil 21 to provide the necessary phase shift for generating the required rotating field.

As the beam 11 rotates it strikes the shields 15 in succession and these shields have the effect of cutting off the electron current to the anode 17 momentarily while the beam is incident upon them. Pulses of anode current are produced when the beam falls between two of the shields 15 and is allowed to strike the anode 17. During the time when such an output pulse is being generated, the strength of the beam and, therefore, the strength of the output pulse can be modulated by placing variable potentials on the control grids 16. These control grids are shown connected in pairs with respective pairs connected to the output of individual frequency modulators 4, 5, 6, etc. If desired, individual grids may be connected to the frequency modulators instead of connecting the grids in pairs. The connection of the grids in pairs illustrates one way that a tube having a greater number of electrodes than the number of lines to be served may be used, by connecting pairs or groups of the grids in common to any one line. The grids 16 receive an initial bias, usually negative, from common grid bias battery 25.

A high frequency oscillator 26 is shown connected in common to all of the frequency modulators so that the mean frequency of the frequency-modulated waves produced in the various frequency modulators is the same throughout. These frequency modulators may be reactance control tubes of a type well known in the art, an example being disclosed in Patent 2,076,264 to Chireix et al., granted April 6, 1937. Another type of frequency modulator that may be used comprises a saturable core inductance and rectifier, this type being disclosed, for example, in L. R. Wrathall application Serial No. 354,357, filed August 27, 1940, which matured into Patent No. 2,311,796, February 23, 1943.

Output current from the anode 17 passes through the primary winding of output transformer 28 and into a heterodyning detector 29 supplied with heterodyne oscillations from source 30 for stepping the frequency of the frequency-modulated waves down to a convenient or desired level. Detector 29 is followed by an amplitude limiter 31 after which come a slope circuit 32, amplitude detector 33 and low-pass filter 34 leading to the outgoing transmission line 35.

In the operation of the system as shown in the drawing, speech waves from different talkers produced in microphones 1, 2, 3, etc. effect frequency modulation of waves supplied from the common oscillator 26 and the respective frequency-modulated waves are applied to individual pairs of control grids 16. As the beam 11 rotates past the shields 15 and comes in between a pair of shields the strength of the beam is varied in accordance with the frequency-modulated wave on the respective grid 16, setting up a corresponding frequency-modulated wave in the output transformer 28. These frequency-modulated waves occurring in spurts or pulses have variable frequencies representing signal modulations. Their frequencies are stepped down in the detector stage 29 and amplitude variations occurring in the pulse envelope are largely eliminated by the amplitude limiter circuit 31 which can be arranged to limit the maximum amplitude of the transmitted wave to as small a value as may be desired in accordance with well-known practice in the reception of frequency-modulated waves. The slope circuit 32 converts the frequency-modulated waves into waves of variable amplitude so that they are capable of detection in the amplitude detector 33. In this way a series of pulses comprising frequency-modulated waves are converted to a series of amplitude pulses or direct current pulses varying in amplitude in accordance with the respective signal variations. Low-pass filter 34 may be provided to suppress undesired carrier or other high frequency oscillations.

It will be observed that the pulses transmitted over the line 35 are of the same general character as pulses used in time division multiplex systems such as illustrated in Fig. 12 of the Skellett patent above referred to or in such patents as Mertz 2,185,693, granted January 2, 1940, but by virtue of the use of frequency modulation in accordance with this invention certain ripple components or other undesired amplitude peaks or variations representing distortion are largely eliminated. The transmitted pulses may, therefore, be received by any suitable type of time division multiplex receiver, such as that shown in Fig. 12 of the Skellett patent, or in the Mertz patent referred to. It will be understood that the commutating means used to receive the messages from the transmitter shown in the drawing must be operating in proper synchronism and phase with respect to the beam 11.

As explained above, the beam 11 has a finite width or thickness so that as the beam passes over the various electrodes in the tube 10 amplitude changes will occur in the space current depending to a considerable extent upon whether the plate hits the beam squarely or is partly cut off by one of the shields 15. In an ordinary amplitude modulated system in which, for example, the speech signals are directly applied to the grids 16, these variations in the space current would introduce components of noise into the sent signals. By the use of frequency modulation, however, as described, these amplitude variations are greatly reduced provided they are not sufficient to shut off the space current completely. This is because the amplitude limiter 31 serves to wipe out such changes in amplitude as are produced by the type of variations mentioned, caused by movement of the radial beam across the tube electrodes. Further, it is to be noted that overlap produced by the beam striking partially on two neighboring grids at the same instant, which might result in cross-talk, is reduced since such effect will disappear as soon as a difference of 6 decibels or more in strength appears between the two signals.

The invention is not to be construed as limited to the particular circuit arrangements that have been disclosed herein for illustrative purposes but the scope is defined in the claims which follow.

What is claimed is:

1. In a signal commutating circuit, means to translate signals into frequency-modulated waves, a rotary beam electronic commutator tube having beam modulating electrodes and an output circuit, means to place the frequency-modulated wave potentials on said electrodes in accordance with the signals to cause a frequency-modulated wave to appear in said output circuit whenever said beam sweeps past a beam modulating electrode, means to remove incidental amplitude variations from said frequency modulated waves appearing in said output circuit, and means in said output circuit for detecting said frequency-modulated waves.

2. In a signaling system, a plurality of signal input circuits, a rotary beam electronic commutator tube, having input electrodes arranged to exert successive control on said beam, an output circuit for said tube, means to translate signals in said input circuits into frequency-modulated waves and to impress the latter on respective control electrodes of said tube whereby to set up frequency-modulated waves in said output circuit in successive times, and means in said output circuit for removing incidental amplitude variations from said output waves and thereafter converting said output waves into varying amplitude signal currents.

3. In a signal system, signal input circuits, a rotary beam electronic commutator having a beam adapted to move past a succession of control electrodes, a common anode and output circuit therefor, a source of high frequency oscillations, means to modulate the wave-length of said high frequency oscillations by signals in said input circuits, means to impress the modulated oscillations on respective control electrodes whereby to produce in said output circuit wave-length modulated oscillations representing said signals in successive times, and means to convert said output oscillations into amplitude variations including an amplitude limiter ahead of the converting means.

4. In a rotary beam electronic commutator having control electrodes for successively modulating the strength of the beam in its rotation and a common output circuit, means for reducing distortion of input waves arising from the fact that the beam has a width comparable to the width and spacing of said control electrodes comprising means for first converting input control waves to wave-length modulations of high frequency oscillations, and means to impress the latter on said control electrodes, and means in

said output circuit for removing amplitude variations from the wave-length modulated oscillations and converting said oscillations into varying amplitude currents.

5. In a signal transmission system, sources of signal waves, means to frequency-modulate a high frequency wave in accordance with each signal, a common transmission path, a commutator for switching the frequency-modulated waves into said common transmission path in succession, means in said common path for suppressing amplitude variations in the waves in said path, and means in said common path to detect the frequency-modulated signals.

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