July 8, 1947. E. PETERSON 2,423,466

TIME DIVISION MULTIPLEX

Filed Aug. 1, 1944

FIG. 1

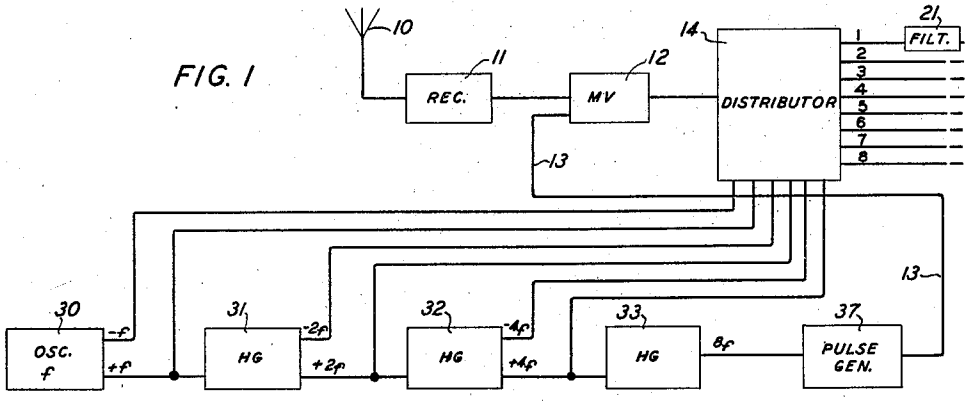


FIG. 2

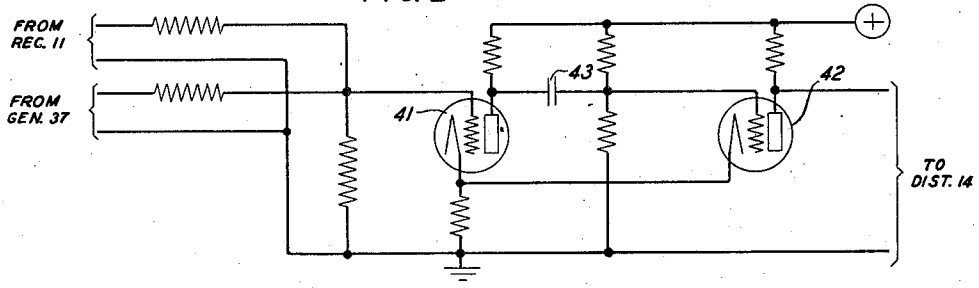
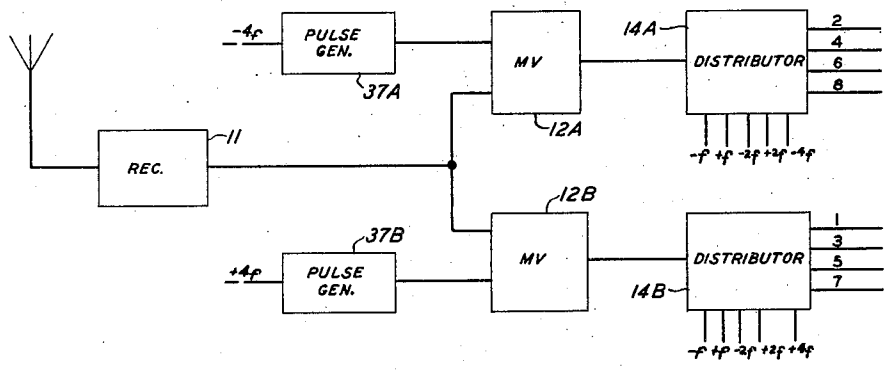


FIG. 3



INVENTOR
E. PETERSON
BY
George C. Ford
ATTORNEY

Patented July 8, 1947 2,423,466

UNITED STATES PATENT OFFICE

2,423,466

TIME DIVISION MULTIPLEX

Eugene Peterson, New York, N. Y., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application August 1, 1944, Serial No. 547,572

1 Claim. (Cl. 179—15)

1

This invention relates to time division multiplex, pulse position modulation communication systems and particularly to receivers therefor.

For various reasons which are not material here, and particularly in very high frequency radio systems, it is often desirable to transmit a continuous wave function such as a telephone or picture current by means of a series of discrete pulses rather than by the more usual continuous modulation process. Two of the pulse modulation methods used for this purpose have been termed pulse length modulation and pulse position modulation. In the pulse length modulation system there are employed pulses recurring at regular intervals but lasting for variable lengths of time according to the signal being transmitted. In such a system, the length of each pulse is a measure of the instantaneous value of the signal current. In the pulse position modulation system there are employed pulses of constant length that vary in their time of occurrence with respect to the average recurrence frequency according to the signal. In effect, such a system uses phase modulated pulses. The time of occurrence or phase of each pulse is a measure of the instantaneous value of the signal. In the case of both types of modulation, it is desirable that the pulse recurrence frequency be at least twice the maximum signal frequency.

It may be readily demonstrated that the length modulated pulses contain the signal frequency and also harmonics of the recurrence frequency together with signal side-bands of these harmonics. By the use of a low-pass filter, the signal may be obtained directly from the pulses, substantially free of such disturbing oscillations. One method that has been found satisfactory for obtaining the signal from the position modulation pulses is to convert each such pulse into a length modulated pulse. The use of a low-pass filter then permits a good quality signal to be obtained from the length modulated pulses produced by the conversion process.

Such pulse modulation systems are very readily adaptable to multichannel operation by interlacing the pulses from several signal channels to give a time division multiplex system. At the receiving end the channel pulses may be separated by the use of a distributor preferably one of the electronic type. In a pulse position modulation system each channel pulse is then converted into a length modulated pulse from which the signal can be readily obtained as described previously. Such a conversion process requires a rather complicated circuit and where the system employs a large number of channels a considerable quantity and bulk of apparatus is required.

An object of this invention is to improve and simplify the receiver of a time division multiplex, pulse position modulation system.

A further object of the invention is to utilize

2

efficiently all of the circuit components of a receiver for time division multiplex, position modulated pulses.

In accordance with a feature of this invention all of the received pulses of a time division multiplex, pulse position modulation system are converted to length modulated pulses which are then diverted to their respective signal circuits by means of a distributor.

These and other objects, features and aspects of the invention may be more readily understood from the following description in connection with the drawing in which:

Fig. 1 is a schematic block circuit diagram of one embodiment of the invention;

Fig. 2 is a schematic circuit diagram of the multivibrator converter for Fig. 1; and

Fig. 3 is a schematic block circuit diagram of a modification of the embodiment shown in Fig. 1.

Fig. 1 shows a receiver for a time division multiplex, pulse position modulated system. United States Patent 2,262,838 to Deloraine et al., November 18, 1941 in Fig. 10 discloses one type of transmitter that could be used for producing pulses of this type. In particular the receiver shown is for an eight-channel system. The pulses of radio frequency energy received in the antenna 10 are amplified and detected in the radio receiver 11 and the resulting signal pulses are impressed on a multivibrator 12 that operates to convert all of the position modulated pulses into length modulated pulses. For this purpose the multivibrator 12 is designed to be normally inoperative but is set into operation periodically by reference control pulses supplied through the connection 13. The signal pulses from the receiver 11 impressed on the multivibrator 12 cause its operation to be interrupted. Thus, for each channel there is generated a pulse the starting time of which is determined by the reference pulse and the termination of which is determined by the signal pulse corresponding to the respective channel. The result is that the position modulated pulses in the output of the radio receiver 11 are converted into length modulated pulses.

A distributor 14 is provided for routing the length modulated pulses in the output of the multivibrator 12 to their respective channels. This distributor is preferably of the type described in British Patents 344,444 of February 27, 1931, and 363,403 of December 30, 1931. Such a distributor operates on the basis of the pyramiding of harmonically related waves for each channel. The channel outputs from the distributor 14 each includes a low-pass filter 21 (only one of which is shown) in the output of which the modulating signal appears free of disturbances.

An oscillator 30 is provided as the base source for the reference pulses for controlling the multivibrator as well as the harmonic waves for oper-

ating the distributor 14. The oscillator 30 is preferably designed to produce square waves, though a sinusoidal generator may be employed. It operates at a frequency f which is the frequency of channel repetition or the frame frequency of the system. Obviously, it must be maintained in synchronism with the equivalent control oscillator at the transmitter. For this purpose constant frequency oscillators may be used at both ends of the system or some means of frequency control or synchronism as well understood in the art may be employed. One of the channels of the system may be employed for this purpose, for example.

There are taken from the oscillator 30, two outputs differing from each other in phase by 180 degrees and marked $-f$ and $+f$ on the drawing. The output of the oscillator 30 is fed to a series of tandem connected harmonic generators 31, 32 and 33 each operating to produce an output of twice the frequency of the input thereto. These harmonic generators are preferably of the multivibrator type producing square wave outputs. Both the positive and negative outputs (that is, waves differing by 180 degrees) are taken from the harmonic generators 31 and 32. These together with the positive and negative outputs from the oscillator 30 are supplied to the distributor 14 for its operation.

The output from the harmonic generator 33 of frequency $8f$ is supplied to a pulse generator 37 which is preferably of the type employing a saturable core inductor. Such a pulse generator used for producing harmonics is disclosed in Patent 2,117,752 to L. R. Wrathall May 17, 1938. In such a circuit sharp pulses are produced as the input wave goes through the zero value. Two such pulses of opposite signs are generated for each cycle of the input, and the pulse generator 33 preferably includes a rectifier or biased amplifier for eliminating the negative pulse. The positive pulse is supplied through the lead 13 to the multivibrator 12.

Fig. 2 shows a circuit for the multivibrator 12. This comprises two vacuum tubes 41 and 42 connected as a typical one-shot multivibrator. In the absence of any grid input to the tube 41 that tube is blocked while the tube 42 draws space current. When the positive pulse from the pulse generator 37 is applied through the connections 13 to the grid of tube 41 it causes that tube to conduct. The resultant drop at the plate voltage of tube 41 is transferred to the grid of tube 42 causing that tube to cut-off. In the absence of further applied voltage this condition would continue until the voltage on the coupling capacitor 43 drops below the cut-off voltage of tube 42. The time constant of the circuit is so designed that this period is somewhat longer than required for any length modulated pulse. When a signal pulse from the receiver 11 which is designed to give output pulses of negative polarity is applied to the grid of tube 41 it causes that tube to cut-off transferring a positive voltage to the grid of tube 42 and causing that tube to conduct. The resulting pulse appearing at the output 44 is fed to the distributor 14. The effect of the action just described will be to generate a pulse the length of which is determined by the time between the occurrence of the reference pulse from the generator 37 and the appearance of a signal pulse from the output of receiver 11. In other words, a pulse modulated in length in accordance with the positive modulation of the signal pulses from the receiver 11.

Fig. 3 shows a modification of the receiving system of Fig. 1 which may be found desirable in certain applications. Thus, if a large number of multiplex channels are employed or if each channel pulse is modulated over a wide range of time positions (corresponding to wide phase modulations) or both, there may not be sufficient time between the periods allotted to adjacent channel pulses for the multivibrator 12 to recover or relax. This situation would be particularly troublesome under the condition when one channel pulse is at a maximum positive time excursion and the adjacent channel pulse at a maximum negative time excursion. In the system of Fig. 2 such a difficulty is overcome.

In the system of Fig. 3 two multivibrators 12A and 12B are employed for converting the received position modulated pulses to length modulated pulses, the two multivibrators operating on alternate channel pulses. In order to obtain such operation there are employed two pulse generators 37A and 37B each of the same type as the pulse generator 37 of Fig. 1. In this case the negative and positive outputs ($-4f$ and $+4f$) of the harmonic generator 32 are supplied to the respective inputs to the pulse generators 37A and 37B. In this way the multivibrator 12B will be triggered off for each odd-numbered channel period and the time allotted to the even numbered channels will be available for its recovery. Similarly, the multivibrator 12A will operate on the even-numbered channel pulses.

With this system, two distributors 14A and 14B of the same type as the distributor 14 of Fig. 1 are employed. Distributor 14A is connected to the output of multivibrator 12A and selects the outputs for the even-numbered channels 2, 4, 6 and 8 while distributor 14B selects the odd-numbered channels from the outputs of the multivibrator 12B.

The control harmonic waves for the operation of the distributors 14A and 14B are obtained from the oscillator 30 and harmonic generators 31 and 32 as in Fig. 1 but not duplicated in the showing of Fig. 2.

What is claimed is:

A receiver for a time division multiplex, pulse position modulation system comprising two sources of recurrent reference pulses each recurring at a rate one half the average recurrence rate of the received multiplex pulses and differing in time of occurrence by the average time of occurrence of said multiplexing pulses, a pair of normally inoperative multivibrators, connections for applying reference pulses from one of said sources to one of said multivibrators for initiating its operation, connections for supplying reference pulses from the other of said sources for initiating its operation, connections for supplying the received multiplex to said multivibrators for terminating their operation, a plurality of signal circuits, and distributors for diverting the resultant length modulated pulse outputs of said multivibrators to the respective signal circuits.

EUGENE PETERSON.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,266,401	Reeves	Dec. 16, 1941
2,262,838	Deloraine et al.	Nov. 18, 1941
2,048,081	Riggs	July 21, 1936