Oct. 25, 1949. D. D. GRIEG 2,485,591

PULSE TIME DIVISION MULTIPLEX SYSTEM

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Fig. 1.

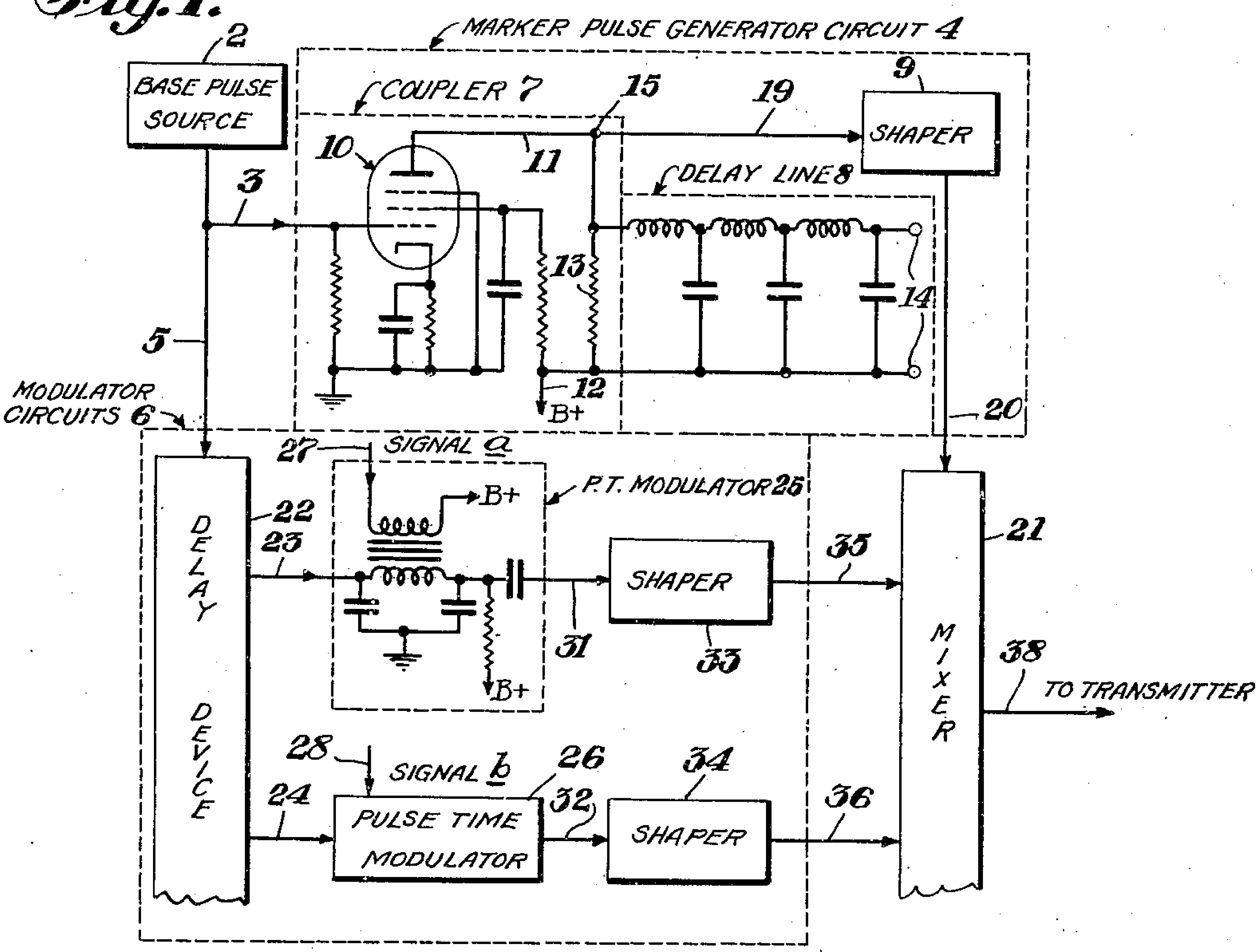

Fig. 2.

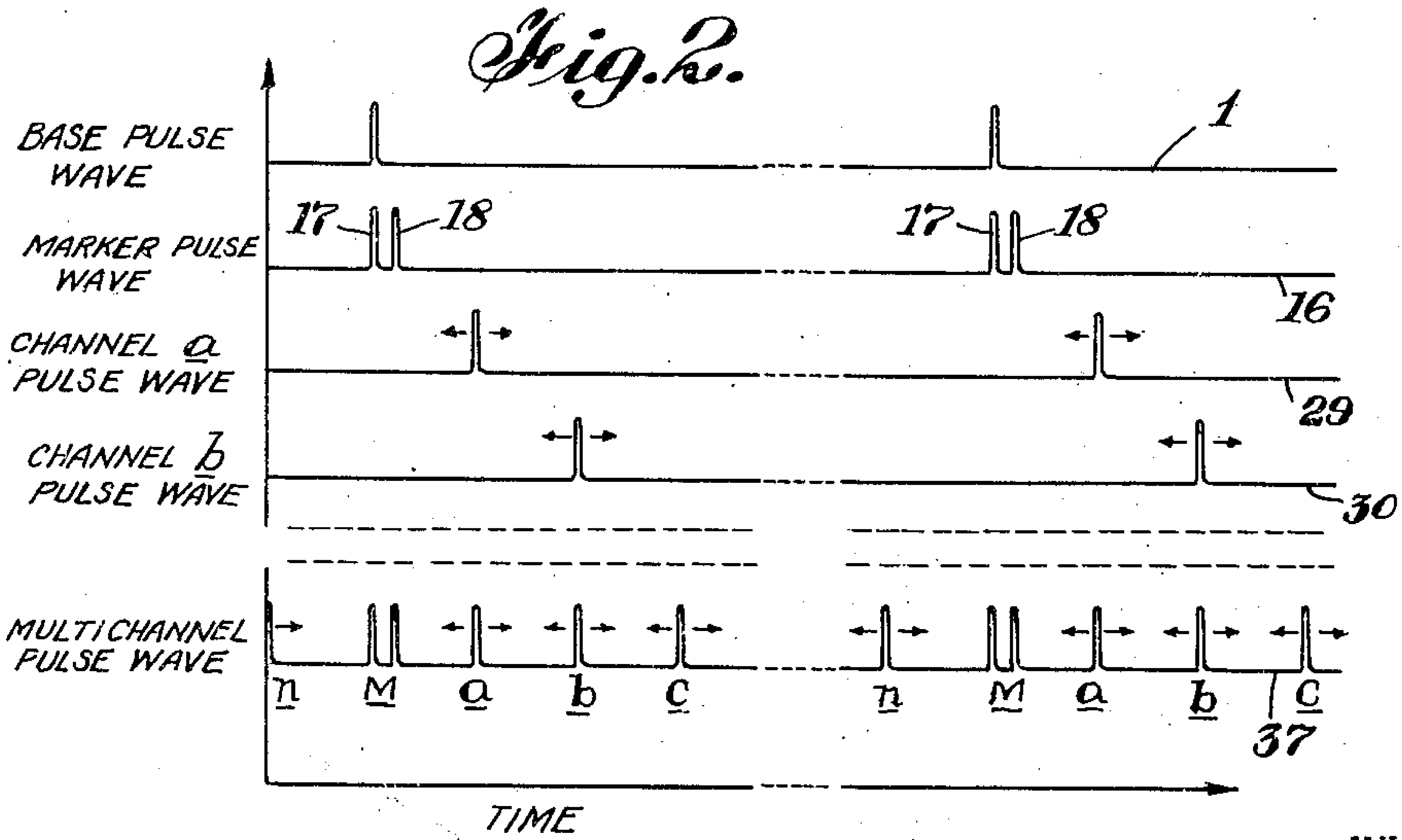

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Fig. 3.

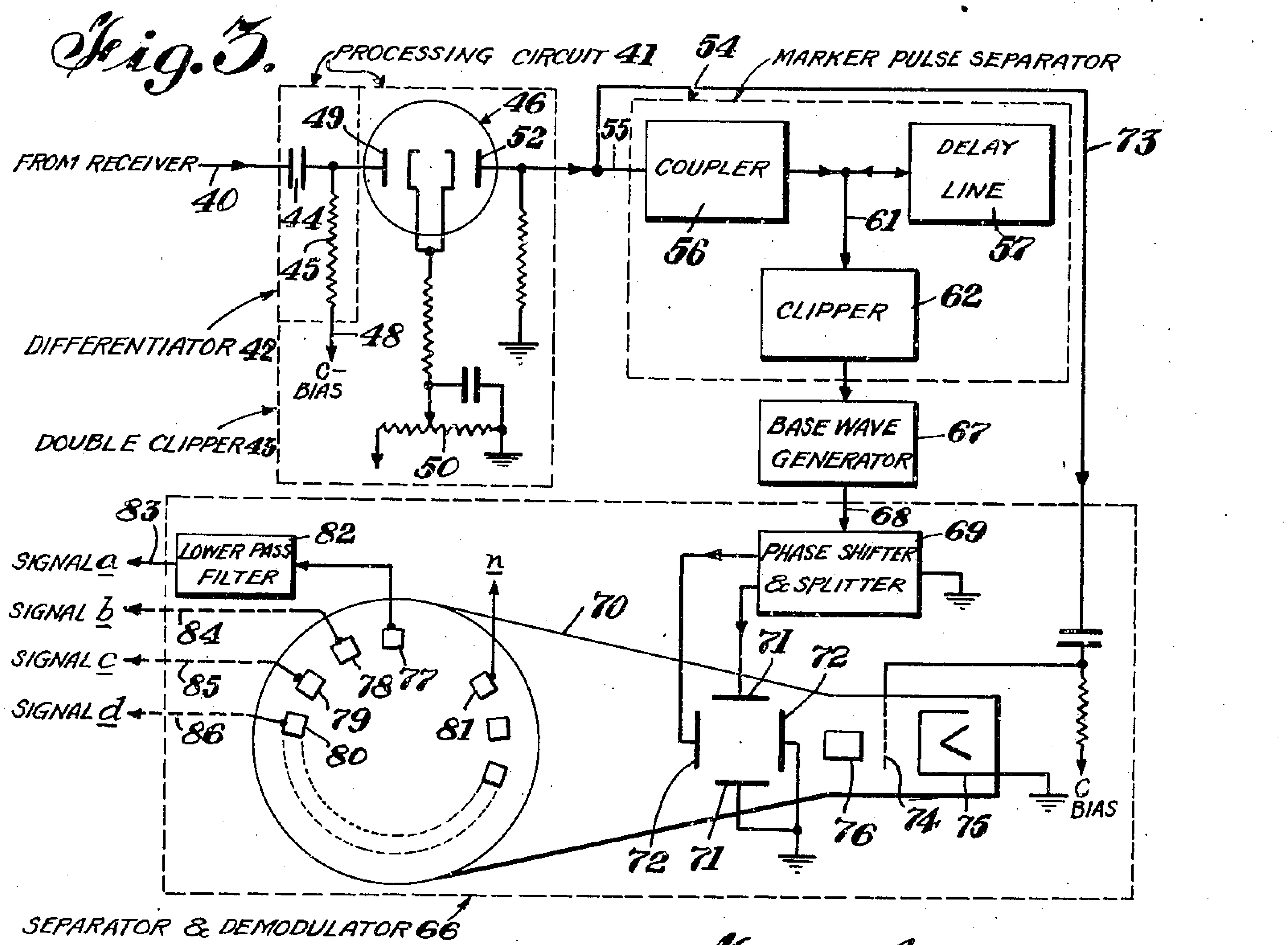


Fig. 4.

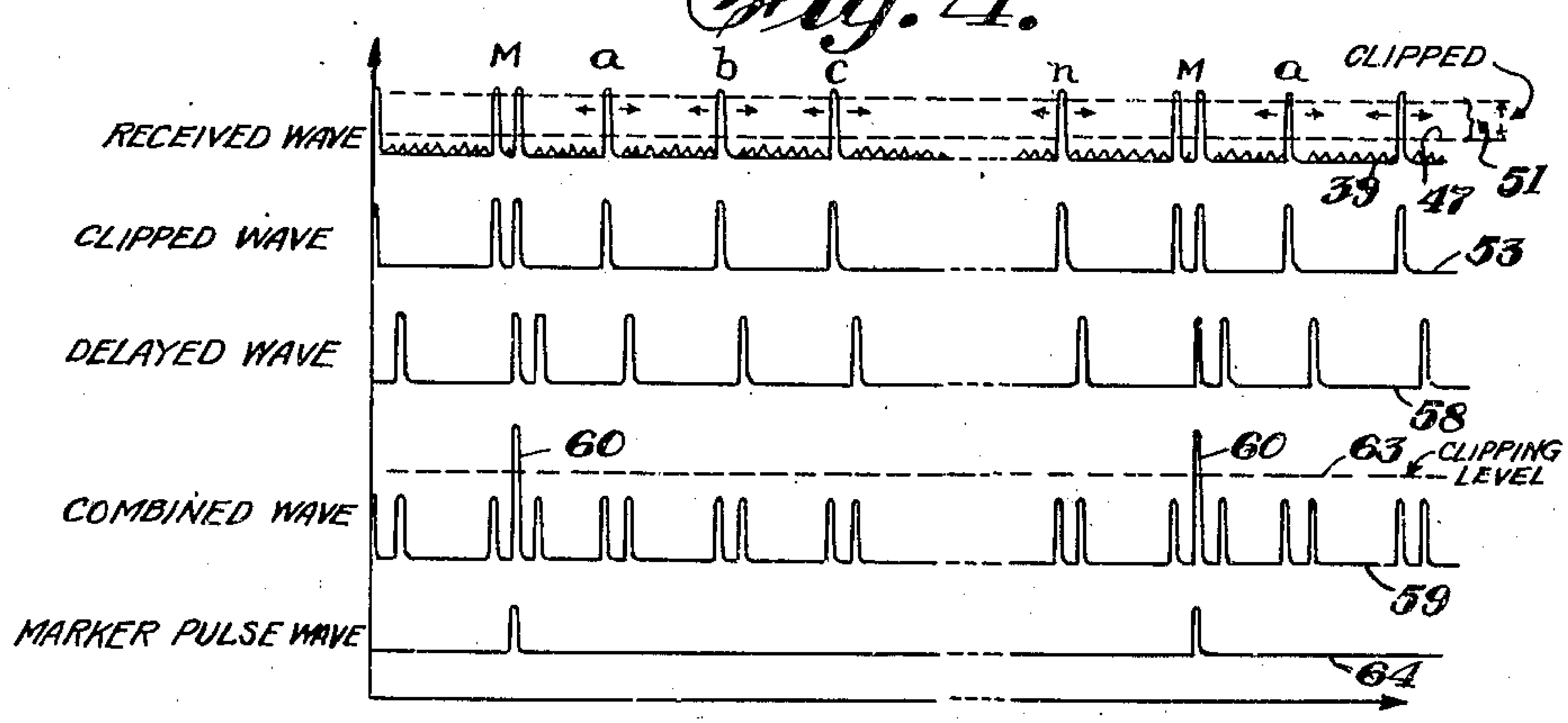
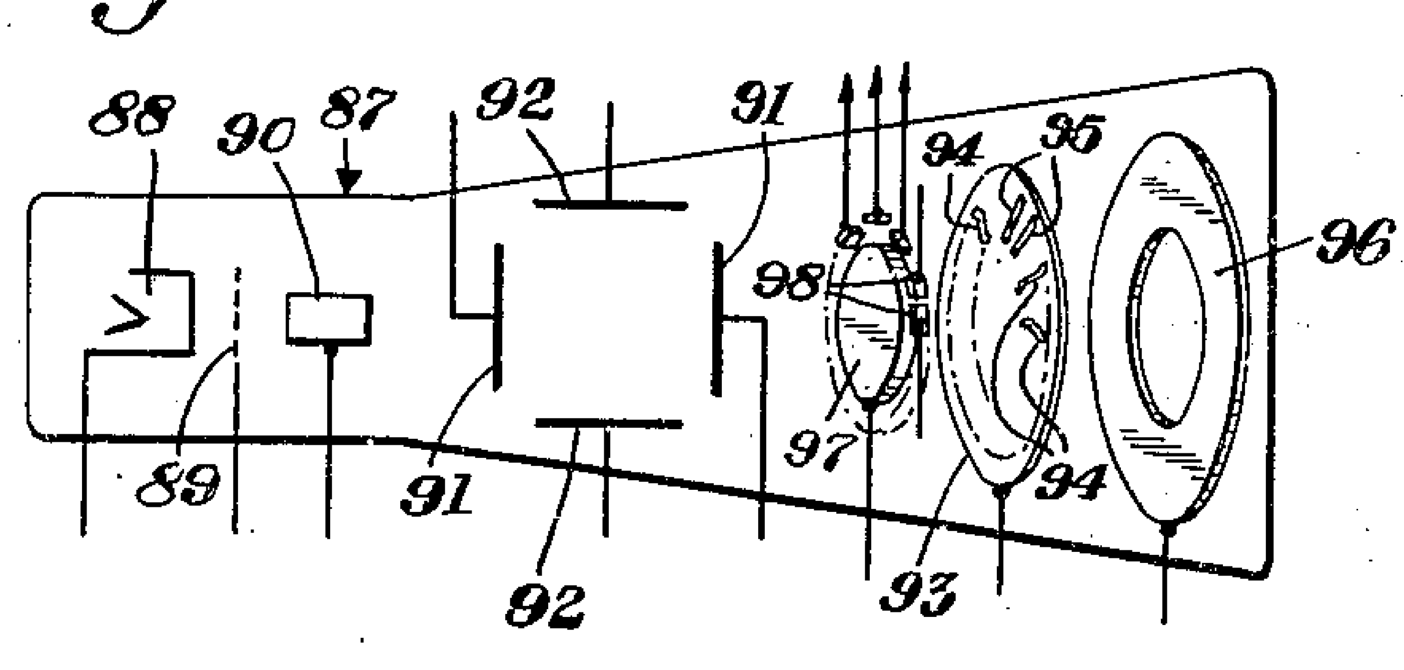


Fig. 5.



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PULSE TIME DIVISION MULTIPLEX SYSTEM

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Application October 30, 1945, Serial No. 625,650

4 Claims. (Cl. 179—15)

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This invention relates to a multichannel communication system. More particularly it deals with a method and means for producing synchronizing pulses along an electromagnetic wave carrying a plurality of signal modulated undulations.

Previously, synchronizing pulses were distinguished from signal time modulated pulses or undulations on a multichannel pulse wave by their width, which was usually constant and greater than that of the substantially instantaneous signal modulated pulses. These synchronizing pulses were separated from multichannel pulse waves by means of a width discriminator and then subsequently utilized in establishing the base waves for channel separation, demodulation, and synchronization of return signal channels. However, such width synchronizing pulses have certain disadvantages under practical operating conditions. One disadvantage is that, with some types of repeater equipment, critical adjustment is necessary in order to prevent a cumulative loss of the width characteristic of the synchronizing pulse through decrease in the slopes of its leading and trailing edges. The effect of such loss in width is usually to widen the synchronizing pulses so that both the leading and trailing edges of successive pulses are out of synchronism with each other. Another disadvantage is that a system of this type is susceptible to noise entering on the trailing edge of the pulses. But reduction of noise by differentiation cannot be employed because differentiation of the width synchronizing pulses destroys their width characteristics as well as their identity. Thus, in transmitting, repeating and receiving multichannel waves containing width synchronizing pulses, stringent equipment requirements are necessary to prevent their distortion and deterioration.

Accordingly, it is an object of this invention to produce synchronizing pulses in a simple and novel manner which are not distorted by ordinary communication equipment.

Another object is to produce synchronizing pulses of substantially the same shape as the signal modulated pulses on a multichannel pulse wave so as not to be affected by pulse sharpening and noise reducing circuits.

Another object is to produce a synchronizing unit comprising a pair of synchronizing pulses, each pulse of the pair being a very short duration and being spaced closely together so as to be distinguished from the channel pulses.

Another object is to produce synchronizing pulses on a multichannel pulse wave which are

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not adversely distorted by repeater equipment, or by differentiation.

Another object is to produce synchronizing pulses on a multichannel pulse wave which are of such a characteristic as to greatly minimize the usual distortion effects of noise.

Another object is to separate such a pair of synchronizing pulses from a multichannel pulse wave in a novel and effective manner.

Another object of this invention is to provide means for carrying out the previous objects.

Still other objects of the invention will appear from time to time in the description which follows.

Generally speaking, this invention relates to a multichannel communication system having a multichannel pulse wave containing spaced pairs of synchronizing pulses located at intervals between groups of signal modulated pulses. The multichannel pulse wave may be composed of a plurality of trains of different signal modulated pulses. Means may be provided for producing a plurality of such signal modulated pulse trains from the same pulse wave source and for combining the plurality of pulse trains on a single multichannel pulse wave wherein the trains of pulses may be interleaved or similarly combined so that the pulses of one channel will not interfere with those of other channels. It is desirable, that the signal channel modulated pulses are time modulated either with respect to a given synchronizing pulse or to each other, such as, for example, by one of the systems disclosed in my joint copending applications, E. Labin et al., Ser. No. 529,923, filed April 7, 1944; E. Labin et al., Ser. No. 591,065, filed April 30, 1945, now Patent No. 2,429,631, issued Oct. 28, 1947; or in the copending application of E. Labin, Ser. No. 546,378, filed July 24, 1944, now Patent No. 2,445,783, issued July 27, 1948.

The pair of synchronizing pulses of this invention may be produced from any pulse sources, but preferably the same source as used for producing the signal modulated pulses. In such a case, the pulse wave may be coupled to a suitable reflecting delay line to produce two pulses of very short duration and spaced very closely together, usually not further apart than the two edges of the previously used width synchronizing pulses mentioned above. It is important that the time space between the two pulses of the marker pair is less than the space between them and any other pulses or between any other pulses in said multichannel pulse wave. This is necessary to readily distinguish the synchronizing pulses from the other or signal modulated pulses on the multichannel pulse waves. It is desirable that the pair of synchronizing pulses have substantially the same shape as the signal channel modulating pulses. However, the signal modulated pulses to be synchronized may differ in shape from the synchronizing pulses of this invention, i. e., the synchronizing pulses may be of any desired shape and amplitude. If the pulses are only timed displaced on the multichannel pulse wave, both the signal time modulated pulses and the double synchronizing pulses may be shaped to insure sharpness before and/or after being combined on the multichannel pulse wave.

Another method for producing the pair of synchronizing pulses may involve a cathode ray device similar to the one disclosed in my joint application, E. Labin et al., Ser. No. 591,065, filed April 30, 1945. According to my present invention the synchronizing pulse aperture in the target plate consists of two parallel narrow slits instead of one wide slit as shown in said application.

The resulting multichannel pulse wave may be transmitted, repeated and received over suitable communication means such as by radio or by wire, etc. Upon reception of a multichannel pulse wave, and before the pair of synchronizing pulses thereon are separated from the wave, the pulses thereof may be processed and sharpened such as by a differentiator and clipper, if the pulses are of the same duration as the channel pulses.

One method for separating the synchronizing pulses may be to pass them through a suitable trigger circuit to make a width pulse out of each pair (providing there is an even number of pulses in between each pair of synchronizing pulses). The resulting width synchronizing pulses may have their leading edges corresponding to the first of the pair of the synchronizing pulses and their trailing edges corresponding to the second of the pair of the synchronizing pulses. These width synchronizing pulses then may be separated by known width discriminating means.

Another system for separating the synchronizing pulses is to reflect the received multichannel pulse wave in a delay line in which the delay is sufficient to cause the first of the synchronizing pair to be superimposed or stacked upon the second of the synchronizing pair of the received pulse wave. This combination of the synchronizing pulses produces output pulses of substantially double amplitude, and may be obtained from the pulse train by amplitude discrimination. From the synchronizing pulses thus obtained, suitable deblocking means or phasing means may be operated for separating the channels on the original multichannel pulse wave. The separating and demodulating circuits may be of any suitable design, such as a multivibrator circuit for producing a deblocking wave for separating the pulses, or a cathode ray separating device such as disclosed in my joint copending application, E. Labin et al., Ser. No. 565,152, filed November 25, 1944, now Patent No. 2,465,380, issued March 29, 1949.

These and other features and objects of the invention will become more apparent upon consideration of the following detailed description of embodiments to be read in connection with the accompanying drawings in which:

Fig. 1 is a schematic wiring diagram of a system for producing multichannel pulse waves containing the double synchronizing pulses of this invention;

Fig. 2 is a graph of wave forms useful in explaining the operation of the system of Fig. 1;

Fig. 3 is a schematic wiring diagram partially in block of a system for separating the synchronizing pulses from a multichannel pulse wave of the type produced in the system of Fig. 1 and for separating and demodulating the signal channels on such a multichannel pulse wave;

Fig. 4 is a graph of wave forms useful in explaining the operation of the system of Fig. 3; and

Fig. 5 is a schematic showing of a further embodiment of the invention.

Referring to Fig. 1, the base pulse wave **1** may be produced in a suitable pulse wave generator **2** and may be then passed through line **3** to a synchronizing pulse generator circuit **4** and also through line **5** to a suitable system of modulator circuits **6**.

The synchronizing pulse generator circuit **4** may comprise a suitable coupler **7**, a delay line **8**, and, if desired, a shaper **9**, such as a differentiator and/or amplifier, or the like. The coupler **7** may comprise a pentode **10** with suitable circuits to prevent the reflected pulses from the delayed line **8** from being fed back through the lines **3** and **5**. The output from the tube **10** is passed through line **11** and is joined to the B+ terminal **12** through an impedance **13** across one end of the delay line **8**. This impedance **13** is matched with that of the delay line **8** to prevent distortion and reflection of the reflected pulses. The delay line **8** may comprise a network of inductances and condensers which are coupled in series and parallel respectively, to assimulate a transmission line. It is important that the end **14** of the delay line opposite the impedance **13** be open so that the pulses are reflected without inversion. The reflected pulses, together with the pulses of wave **1**, Fig. 2, are combined at junction **15** to produce the synchronizing pulse wave **16** comprising a train of double pulses **17** and **18**. Wave **16** is then passed through line **19**, and may be passed through shaper **9**, before being withdrawn from the synchronizing pulse generator circuit **4** through line **20** to a suitable mixer **21**. As seen from Fig. 2, the first of the pair of pulses **17** corresponds to the pulses on the wave **1** while the second pulse **18** of the pair of pulses corresponds to the delayed and reflected train of pulses from the delay line **8**. The spacing between the pair of pulses **17** and **18** may be very small.

The modulator circuits **6** may comprise a delay device **22** having taps therealong **23**, **24**, and etc., at different intervals from which are removed trains of pulses, similar to wave **1** but delayed to be out of phase with each other and with the synchronizing pulses produced in circuit **4**. These separate trains of pulses may then be pulse time modulated according to different signals in the modulators **25**, **26**, etc., into which are introduced different channels of signal energy *a*, *b*, *c*, *d*, etc., through lines **27**, **28**, etc., respectively. From these modulators are correspondingly withdrawn modulated pulse trains similar to **29**, **30**, etc., for channels *a*, *b*, etc., through line **31**, **32**, etc., respectively. These pulse trains may be passed through suitable shapers **33**, **34**, etc., similar to shaper **9**, before being introduced into the mixer **21** through lines **35**, **36**, etc., respectively. The mixer **21** should comprise a suitable device for combining the trains of pulses from the separated pulse channels *a*, *b*, *c*, *d* *** *n*, so that the energy in one train will not be fed back into the circuit of another. Suitable means for doing this is to provide a parallel network of triodes in which the pulse trains are applied to the grids and the plate circuits are combined. The resulting combined multichannel trains of synchronizing and signal modulated pulses **37** is withrawn through line **38** for transmission.

A system for the separation and demodulation of the multichannel pulse waves produced by the system shown in Fig. 1 is shown in Figs. 3 and 4. After transmission the multichannel pulse wave **37**, shown in Fig. 2, may be slightly distorted as shown by the wave **39** in Fig. 4. In order to sharpen up the wave **39** which is received over line **40** it may be passed into a suitable processing circuit **41** which may comprise a differentiator **42** and a double clipper **43**. The differentiator **42** may comprise a condenser **44** and resistor **45**. The differentiator is coupled to the input circuit of the double diode **46** of the double clipper circuit **43**. The clipping level line **47**, shown in Fig. 4, is determined by the amount of bias applied at **48** through resistor **45** on to the anode **49** of the double diode **46**. The variable resistor **50**, in the cathode circuit of the double diode **46**, determines the width of the clipped sector **51**, above the level **47** shown in Fig. 4. From the other anode **52** of the tube **46** is withdrawn a suitable sharpened pulse train **53** which may then be passed into a suitable synchronizing pulse separating circuit **54** through line **55**.

The synchronizing separator circuit **54** may comprise a coupler **56**, and a delay line **57** coupled thereto in a manner similar to coupler **7** and delay line **8** with one end of the delay line coupled across a matched impedance while the other end is open as shown in Fig. 1. The delay in line **8** is sufficient to cause the second pulse of the pair of synchronizing pulses of wave **53** to be aligned with the first pulse of the synchronizing pulses of wave **58**. These two pulse waves **53** and **58** are then combined to produce the pulse wave **59** wherein the two aligned synchronizing pulses above mentioned are superimposed, one upon the other, to produce the increased amplitude pulses **60**. Wave **59** is withdrawn through line **61** into a suitable clipper **62** for clipping the pulses **60** from the wave **59** above the line **63** to produce a synchronizing pulse wave **64** which is withdrawn from the clipper through line **65**. Wave **64** is a synchronizing pulse wave similar to and in synchronism with the wave **1** produced in the pulse generator **2** of Fig. 1. With this pulse wave **64**, suitable deblocking and separating circuits may be operated for separation of the different channels on the multichannel pulse wave **53**.

One circuit for separating the pulses of the wave **53** may comprise the cathode ray device described in my joint copending application E. Labin et al., Ser. No. 565,152, filed November 25, 1944, previously mentioned. A schematic reproduction of such a separating circuit is shown at **66** in Fig. 3. Since this circuit comprises a cathode ray device, the synchronizing pulse wave **64** is passed through a phase wave generator **67** for producing a base wave which in turn is passed through line **68** into a phase shifter and splitter circuit **69** for generating the rotary sweep potentials for the electron beam in the cathode ray tube **70**. The energy from the phase shifter and splitter circuit **69** is connected to the vertical and horizontal plates **71** and **72** respectively

of tube **70**. The time modulated pulses from the pulse wave **53** is withdrawn from processing circuit **41** through line **73** to the grid **74** of the tube **70**. The tube also comprises a suitable electron gun **75** and accelerating electrodes **76** for projecting a beam of electrodes between the plates **71** and **72** so that it may be rotated around the path of the separate target plates at the opposite target end of the tube. Each target plate **77**, **78**, **79**, **80**—**81**, corresponds to a different channel *a*, *b*, *c*, *d*, *e*, *** *n*, respectively. It should be noted that there is a space between the target plate **77** and **81** to provide for the space of the synchronizing pulses M shown on the wave **53**, so that they will not affect any channel target in the tube. The location of the channel pulses on wave **53** is synchronized with the rotation of the beam by the synchronizing pulses M and the gate grid **74** controlled by the time delay of the channel pulses determines how much the electron beam is permitted to contact each target plate each revolution of the beam. Thus, output pulses are produced from each target whose amplitudes correspond to the degree of coincidence of the beam and the target. These output pulses may be passed through a low pass filter such as that shown at **82** in the circuit from target **77**, for converting the new pulse train into a single wave which is withdrawn through line **83**. Similarly, the new pulse trains withdrawn from the other targets are passed through suitable demodulator circuits and signals are withdrawn through lines **84**, **85**, **86**, etc., corresponding signal channels *b*, *c*, *d*, *** *n*, etc.

As previously stated, the pair of synchronizing pulses may be produced in a cathode ray device similar to that shown in my joint copending application, Ser. No. 591,065, filed April 30, 1945. Such a cathode ray device is schematically shown in Fig. 5 of the drawings wherein the device comprises a cathode ray tube **87** having a suitable electrode gun **88**, control grid **89** and accelerating electrode **90**, as well as horizontal and vertical deflecting plates **91** and **92**, respectively, for rotating the beam of electrons around the inside of the tube. At the end of the tube **87** opposite that of the gun **88** is an aperture plate **93** containing two different types of slots, those which are at an angle to the radius of the plate, which are the signal channel modulating slot **94**, and the pair of synchronizing slots **95**, which are narrow, close together, and substantially radially disposed on the plate **93**. As the electron beam from gun **88** passes over these slots, it contacts the target plate **96**, which may be a collector or a secondary omission electrode. Also provided in the device **87** is a radial deflecting electrode **97** having disposed therearound a series of channel deflecting electrodes **98** corresponding to each signal channel modulating slots **94**.

In the operation of this device shown in Fig. 5 the electron beam is deflected radially by the different signal energies applied to the electrodes **98** as it is swept around past each of them and across the slots **94** in the plate **93**. The greater the radial deflection caused by the signal energy on the electrode **98**, the greater is the time displacement of the spurt of electrons which passes through the angular slot **94** onto the target **96**. The time modulation of the signal channel pulses is measured with respect to the time positions of the synchronizing pulses produced when the rotating electron beam passes over the slots **95**. The cathode ray device as shown in Fig. 5 may be employed instead of the modulator circuit 6 shown in Fig. 1.

While the principles of the invention have been described in connection with several specific embodiments, it is to be clearly understood that the above descriptions are made only by way of example and not as limitations on the scope of the invention as defined in the objects and the accompanying claims.

I claim:

1. In a multichannel pulse wave communication system, a pulse source, a delay device for delaying the pulses from said pulse source, a plurality of sources of signal energy, a plurality of pulse modulators for time modulating pulses from said delay device according to said signal energy to produce a plurality of time modulated pulse trains, means to produce a pair of synchronizing pulses of the same polarity spaced at intervals along said pulse wave, the spacing between the pulses of said pair being less than the spacing between any other adjacent pulses on said wave, and means for combining said pair of synchronizing pulses and said trains of signal modulated pulses to produce said multichannel pulse wave.

2. The system of claim 1 wherein said means for producing said pair of pulses comprises an open circuit reflecting delay line with a balanced impedance at the closed end thereof.

3. In a multichannel pulse wave communication system, a pulse source, a delay device for delaying the pulses from said pulse source, a plurality of sources of signal energy, a plurality of pulse modulators for time modulating pulses from said delay device according to said signal energy to produce a plurality of time modulated pulse trains, means to produce a pair of synchronizing pulses of very short duration and of the same polarity spaced at intervals along said pulse wave, the spacing between the pulses of said pair being less than the spacing between any other adjacent pulses on said wave, means for combining said synchronizing pulses and said trains of signal modulated pulses to produce said multichannel pulse wave, means for transmitting and receiving said pulse wave, means for separating the pair of synchronizing pulses from the received pulse wave, means controlled by the separated synchronizing pulses for separating the different channels of signal energy into separate trains of modulated pulses and means for demodulating said trains to reproduce said signals.

4. The system of claim 3 wherein said means for separating said pairs of synchronizing pulses comprises an open circuit reflecting delay line with a balanced impedance at the closed end thereof.

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