March 8, 1960 H. FEISSEL Re. 24,790

PULSE CODE MODULATION DEMODULATOR

Original Filed Oct. 23, 1948 2 Sheets-Sheet 1

FIG. 1.

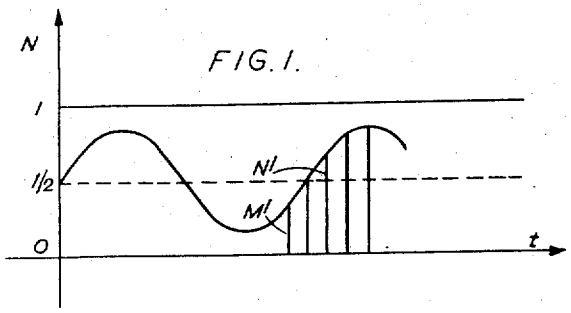


FIG. 2.

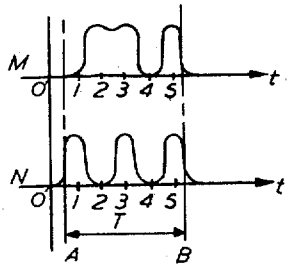
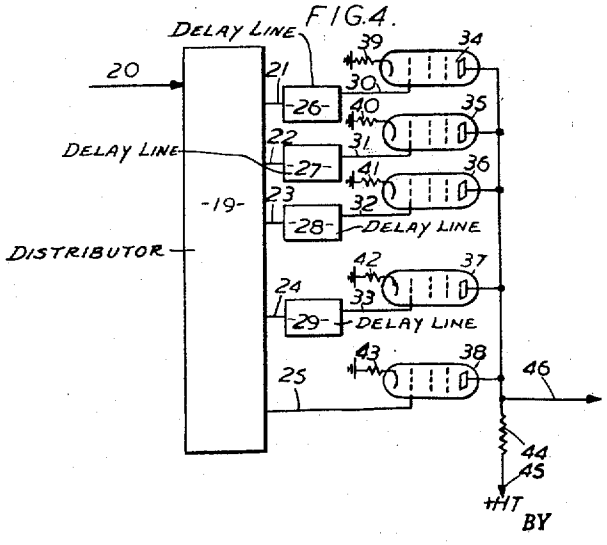


FIG. 4.



INVENTOR.
HENRI FEISSEL

R P Morris

ATTORNEY

March 8, 1960 H. FEISSEL Re. 24,790

PULSE CODE MODULATION DEMODULATOR

Original Filed Oct. 23, 1948 2 Sheets-Sheet 2

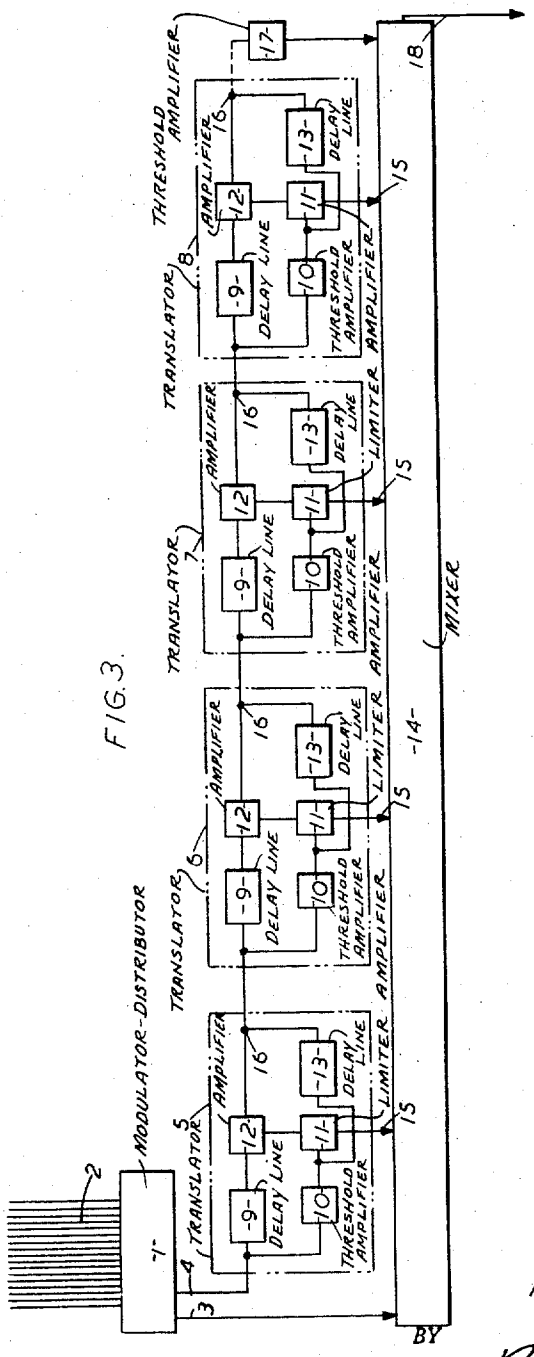


FIG. 3.

United States Patent Office

Re. 24,790
Reissued Mar. 8, 1960

24,790

PULSE CODE MODULATION DEMODULATOR

Henri Feissel, Paris, France, assignor to International Standard Electric Corporation, New York, N.Y., a corporation of Delaware

Original No. 2,651,716, dated September 8, 1953, Serial No. 56,243, October 23, 1948. Application for reissue May 6, 1955, Serial No. 506,682

Claims priority, application France November 8, 1947

6 Claims. (Cl. 250—27)

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

The present invention relates to impulse transmission systems and more particularly to a system for translating amplitude modulated pulses into coded pulse groups.

It is an object of the invention to provide an improved and simplified pulse code modulation modulator and an improved and simplified pulse code modulation demodulator.

The above mentioned and other features and objects of the invention will become more apparent and the invention itself, though not necessarily defined by said features and objects, will be best understood by reference to the following description of an embodiment of the invention taken in conjunction with the accompanying drawings wherein:

Figs. 1 and 2 are sets of curves useful for the understanding of the invention;

Fig. 3 is a block diagram of a coding arrangement incorporating features of the invention;

Fig. 4 is a block and schematic diagram of a receiving circuit for the coded impulses transmitted by the device shown in Fig. 3.

Referring to Fig. 1, I show a modulating signal and a sequence of impulses modulated in amplitude according to said signal. It will be assumed in order to facilitate the description that the amplitudes of these impulses vary between two reference levels, 0 and 1.

According to a feature of the invention, a certain combination of constant amplitude impulses are transmitted in time sequence for each amplitude modulated impulse. The signals transmitted are characterized by the fact that impulses are or are not transmitted at given instants. It is known that the possible number of combinations of such a code comprising a maximum of n impulses is equal to 2^n. To this effect the first impulse is made to correspond to the implitude ½, the second to amplitude ¼, the third to amplitude ⅛ and the n^{th} to amplitude $\frac{1}{2^n}$.

For any given amplitude comprised between the reference levels 0 to 1 it is thus possible to find a code combination of n pulses corresponding to the said amplitude with an approximation of $\frac{1}{2^n}$.

The purpose of the coding arrangement is to translate an impulse of a given level into the corresponding nearest code combination of constant amplitude impulses, and the purpose of the decoder is to translate said code combination into single impulse whose level approximates the amplitude of the original impulse.

According to a preferred embodiment of the invention a coding arrangement will now be described.

Let I be an impulse of level N_1 comprised between two reference levels 0 to 1. The amplitude N_1 is compared to level ½; if N_1 is greater than ½ a first code impulse is transmitted and an impulse I_2 of level

$N_2=2(N_1-½)$ is produced. If N_1 is less than ½ no first code impulse is transmitted and an impulse I_2 of level $N_2=2N_1$ is transmitted to the following stage. In either case the impulse N_2 transmitted to the next stage is comprised between 0 and 1.

The impulse of amplitude N_2 is then compared to level ½. If N_2 is greater than ½ a second code impulse is transmitted and an impulse I_3 of level $N_3=2(N_2-½)$, is produced. If N_2 is less than ½ no second code impulse is transmitted and an impulse I_3 of amplitude $N_3=2N_2$ is transmitted to the next stage. In both cases N_3 is comprised between 0 and 1. This process is repeated n times, at which time the desired degree of approximation is attained.

The operation of the coding arrangement will be better understood from the following description of the embodiment shown in Fig. 3, which represents a coding arrangement for a 5 unit code.

This coding arrangement comprises a modulator-distributor **1** to which are connected a number of transmission channels **2**, for example voice frequency telephone channels. The modulator-distributor produces on line **3** reference impulses which are used for synchronization and on line **4** amplitude modulated impulses which are directed respectively to devices **5, 6, 7, 8** and **17** which are provided for translating amplitude modulated impulses into coded pulse groups.

Each of the devices **5, 6, 7** and **8** comprises a delay line **9** for delaying the impulses by a length of time equal to the time interval separating two successive coded impulses. Each also comprises a threshold amplifier **10** with a voltage amplification equal to 2 and arranged such that it amplifies the fraction of the input impulse applied to it which exceeds the one-half level. Each of the devices **5, 6, 7** and **8** also comprises a limiter-amplifier **11** which limits the amplitude of the impulse from **10** to a constant level chosen for the coded impulses. Each also comprises an amplifier **12** with a voltage amplification equal to 2 associated with a blocking device which operates under the action of an impulse from **11**. The blocking device is provided so that amplifier **12** is blocked for a duration overlapping the retarded impulse from **1**. This may be obtained by a delay line or a time constant device for widening the blocking impulse applied from **11**.

A delay line **13**, similar to delay line **9**, is provided after the threshold amplifier **10** to delay the impulses going through it by a length of time equal to the time interval which separates two successive coded impulses.

There are thus four identical arrangements, each comprising elements such as **9, 10, 11, 12** and **13** which have just been described. The last stage **17** is a limiter-amplifier which, similarly to the preceding circuit **10**, comprises a threshold device which lets through or not the fifth code impulse according to whether the impulse coming from circuit **8** is greater or smaller than the one-half reference level. A mixer **14** mixes the synchronizing impulses from **3** and the coded impulses from devices **5, 6, 7, 8** and **17**.

Referring again to Fig. 1, I show a set of amplitude modulated impulses and the envelope of these impulses which are comprised between the reference levels 0 and 1. As an example two impulses M_1 and N_1 of respective amplitudes 0.43 and 0.66 have been shown respectively below and above the one-half reference level. The corresponding coded impulses are shown in Fig. 2. The time interval T during which the coded impulses are transmitted is shown as AB. This time interval is divided into five equal intervals which are called elementary intervals 1, 2, 3, 4, 5 (in the case of a 5 element code). According to the code combination one impulse is or is not transmitted during each elementary interval.

When an impulse is transmitted in the third time in-

terval, for example, we say that the third impulse is transmitted, and on the contrary that the third impulse is not transmitted if no impulse is transmitted during this time interval.

The upper part of Fig. 2 shows the coded impulses corresponding to amplitude M_1 (equal to 0.43) and the lower part of the figure those corresponding to amplitude N_1 (equal to 0.66).

The impulse M_1 of amplitude 0.43 which reaches circuit **5** of Fig. 3 cannot pass through amplifier **10** since its level is less than one-half. The first impulse is not transmitted and impulse M_1 is delayed by delay line and its amplitude doubled by amplifier **12**. It reaches the following circuit **6** during the second elementary time interval with an amplitude equal to 0.86, i.e. with an amplitude greater than one-half reference level, and therefore passes through the threshold amplifier **10**. A code impulse is transmitted in position 2, and an impulse with an amplitude $2(0.86-0.5)=0.72$ is transmitted to circuit **7** through delay line **13**. This impulse reaches the following circuit **7** during the third elementary time interval, with an amplitude equal to $2\times0.36=0.72$. An impulse is transmitted by this circuit **7** in position 3, since the level applied to it exceeds the one-half reference level. On the contrary, the impulse transmitted to the next circuit **8** has an amplitude equal to $2(0.72-0.5)=0.44$ i.e., it is less than one-half, and no code impulse is transmitted in position 4. This impulse is amplitude doubled and applied with a level of 0.88 to the final limiter device **17** which lets an impulse pass into position 5 since the level exceeds the one-half reference level. It may be noted that a distinguishing feature of the coder is that the reference level remains constant on each comparison.

The code combination transmitted is that shown in the upper part of Fig. 2. It is easily seen that in the case of impulse N_1 of Fig. 1, which has an amplitude of 0.66, coded impulses are transmitted in positions 1, 3 and 5 as shown on the bottom part of Fig. 2.

The duration of the coded impulses depends upon the operating conditions of the transmitter. They may be very narrow or broad enough for two successive impulses to be adjacent.

Fig. 4 shows an example of an embodiment of a decoding arrangement adapted to transform a set of coded impulses into an impulse whose amplitude is approximately equal to that of the original amplitude modulated impulse. This arrangement is designed for a 5 unit code, but may be extended to a code comprising more or less than 5 elements.

It comprises for instance a distributor **19** which receives from line **20** the reference or synchronising impulses and the coded impulses. This distributor, which may be of any known type, distributes the successive coded impulses belonging to the same group to wires **21**, **22**, **23**, **24** and **25**. Delay lines **26**, **27**, **28** and **29** are respectively provided on each wire, in such a way that these coded impulses reach respectively wires **30**, **31**, **32**, **33** and **25** at the same moment. The impulse on wire **25** is the last impulse leaving the distributor and does not need to be delayed. The delay line **29** delays the impulse which flow through it by length of time equal to the time interval separating two successive coded impulses; delay line **30** delays the impulses which flow through it by a length of time equal to the time interval elapsing between three consecutive coded impulses, and so on. These impulses therefore reach the control grids of the vacuum tubes **34**, **35**, **36**, **37** and **38** at the same time. The cathode resistances **39**, **40**, **41**, **42** and **43** of these tubes are of such a value that the plate current in the respective vacuum tubes is proportional to the level corresponding to the impulse with which it is associated. All these currents add together in the plate resistance of the vacuum tube **44**, which is connected, on the one hand to the plate of the tubes, and on the other hand to a source of high potential **45**. In this way an impulse is obtained on wire **46** whose amplitude is approximately equal to that of the initial amplitude modulated pulse. A device (not shown) is used for directing to their respective channels the modulated impulses leaving the decoder according to a well known technique, where they are used to regulate the original modulating currents.

While I have described a particular embodiment of my invention for the purposes of illustration, it should be understood that various modifications and adaptations thereof may be made within the spirit of the invention as set forth in the appended claims.

What is claimed is:

1. An electrical translator for converting *sequential pulses in each of a plurality of* sequentially timed pulse code groups *into* [to] corresponding amplitude modulated pulses comprising delay means for the individual pulses of *each* said code group to cause said individual pulses to be equally timed, a combining circuit, said combining circuit comprising [a plurality of amplifiers of different gains] *means* for adjusting the amplitudes of said individual pulses in accordance with a predetermined code, means for applying said equally timed pulses to said combining circuit and means for adding together said pulses at the outputs of said [amplifiers] *means*.

2. An electrical translator according to claim 1 wherein said delay means comprises a distributor and a plurality of delay devices each connected to an output circuit of said distributor.

3. An electrical translator according to claim 1 wherein said *means for adjusting the amplitudes comprises* amplifiers each [comprise] *includes* a vacuum tube each having its gain adjusted in accordance with said code.

4. In a communication system a terminal for receiving time division multiplex code groups of signals representing a signaling wave, a plurality of delay lines, multiplex distributing apparatus for distributing received signals to a plurality of said delay lines, each of said lines having different delay intervals so related to each other and to said multiplex distributing apparatus that the signals of each multiplex group applied to said delay lines arrive at their output terminals substantially simultaneously and means for reconstructing a series of pulses corresponding to the signaling wave from said simultaneously occurring signaling conditions.

5. In a communication system, a terminal for receiving time division multiplex code groups of signals, a time delay device for each signal of a code group of signals, a multiplex distributor for distributing received signals of each code group to said delay devices, said delay devices having delay intervals so related to each other and to said multiplex distributing apparatus that the signals of each multiplex group applied to their inputs in successions arrive at the output terminals substantially simultaneously and combining means for combining said output signals from said delay devices into a single electrical output.

6. In a communication system, a terminal for receiving time division multiplex code groups of signals, time delay lines for each signal of a code group of signals, a multiplex distributor for distributing received signals of each code group to said delay lines, said delay lines having delay intervals so related to each other and to said multiplex distributing apparatus that the signals of each multiplex group applied to their inputs in successions arrive at the output terminals substantially simultaneously, combining means for combining said output signals from said delay lines into a single output pulse, the succession of output pulses representing the complex wave.

References Cited in the file of this patent or the original patent

UNITED STATES PATENTS

1,951,454 Tiefenbacher ---------- Mar. 20, 1934

(Other references on following page)

UNITED STATES PATENTS

2,145,332	Bedford	Jan. 31, 1939
2,272,070	Reeves	Feb. 3, 1942
2,361,766	Hadekel	Oct. 31, 1944
2,401,405	Bedford	June 4, 1946
2,403,561	Smith	July 9, 1946
2,409,229	Smith	Oct. 15, 1946
2,437,707	Pierce	Mar. 16, 1948
2,438,908	Goodall	Apr. 6, 1948
2,443,198	Sallach	June 15, 1948
2,449,467	Goodall	Sept. 14, 1948
2,451,044	Pierce	Oct. 12, 1948
2,453,454	Norwine	Nov. 9, 1948
2,453,461	Schelleng	Nov. 9, 1948
2,465,840	Blumlein	Mar. 29, 1949