# United States Patent [19]

**Alt**

[11] **3,743,935**

[45] **July 3, 1973**


[54] **METHOD AND APPARATUS FOR RECEIVING INFORMATION TRANSMITTED THROUGH RAILROAD TRACK CIRCUITS**


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[22] Filed: **Jan. 5, 1971**

[21] Appl. No.: **104,114**

[30] **Foreign Application Priority Data**

Jan. 7, 1970 France .............................. 7000325

[52] **U.S. Cl.** ......................... **325/51,** 179/82, 246/8, 325/55, 325/63, 325/64, 329/111, 340/47

[51] **Int. Cl.** ............................................ **H04b 1/00**

[58] **Field of Search** .................. 325/51, 55, 63, 64, 325/351, 62; 329/110, 111, 142; 340/47, 48, 224; 246/6, 7, 23, 27, 29, 30, 8; 179/15.55 R, 82


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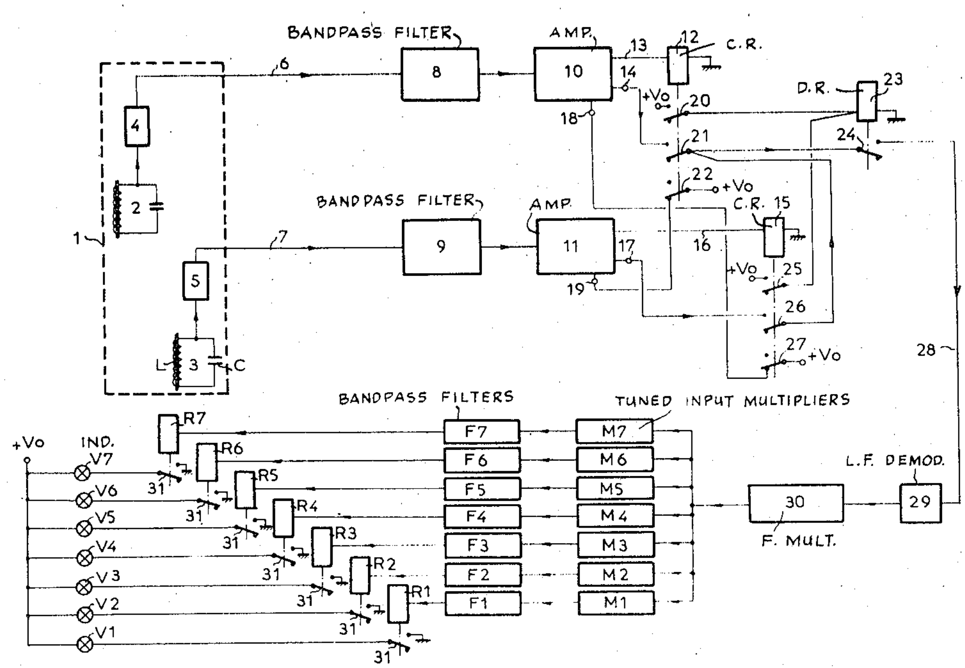
[57] **ABSTRACT**


A method and apparatus for receiving coded information transmitted through track circuits in a railroad block system to a vehicle moving along the railroad track. Successive track circuits encountered by the vehicle provide alternatingly different excitation frequency signals. Each excitation frequency is modulated by a given number of modulation frequencies each representing information to be transmitted. The modulation frequencies are very low to provide a sufficiently high modulation index. A receiver on the vehicle includes a detector for extracting the modulation frequencies from the exciting frequency, frequency multipliers for multiplying the frequency of the detected modulation frequencies, band-pass filters for separating the different multiplied frequencies and indicating devices associated with the filters. The receiver distinguishes between excitation frequencies from adjacent track circuits. Similar fixed receivers may be provided in each track circuit.


**7 Claims, 2 Drawing Figures**



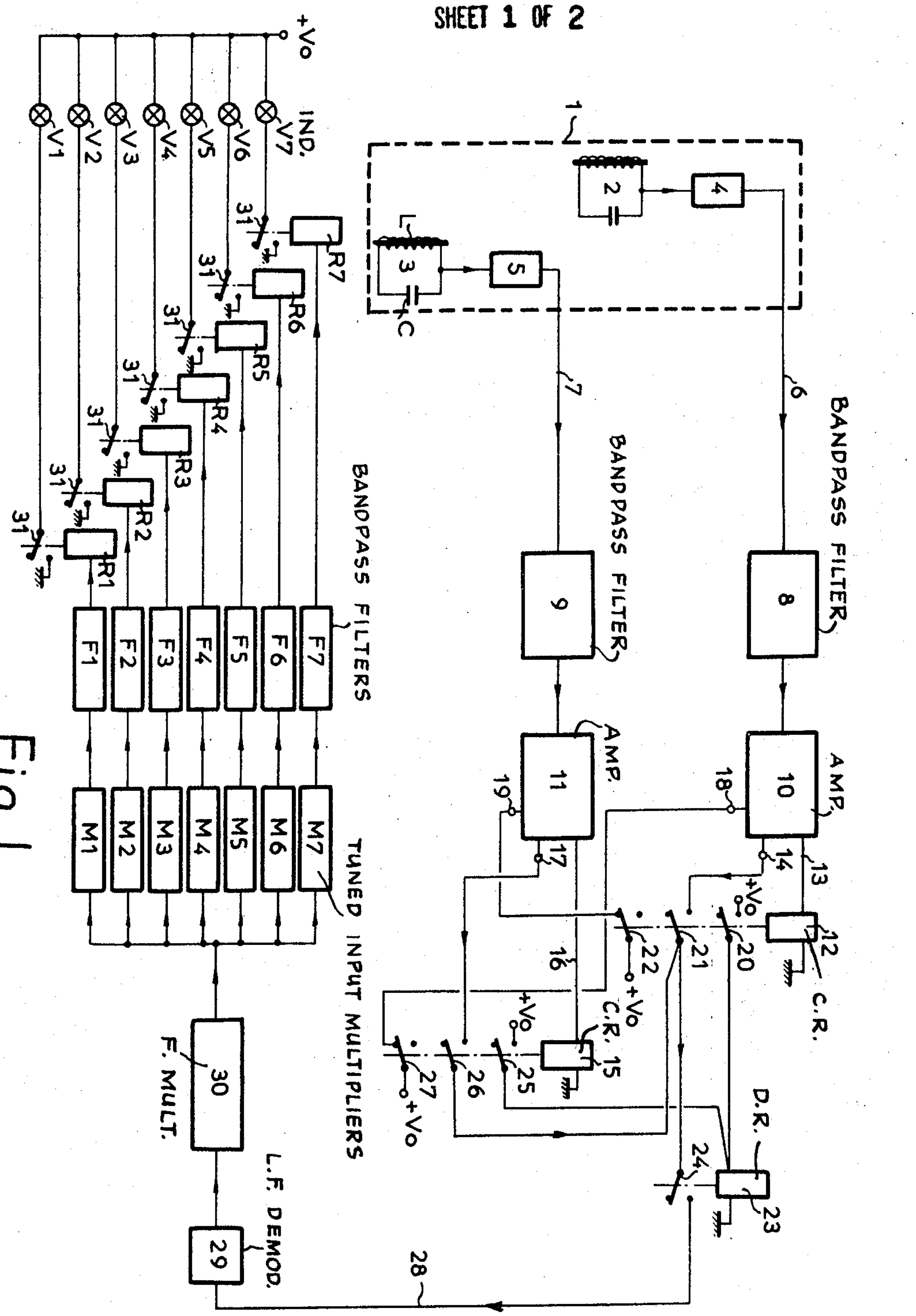

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Fig. 1

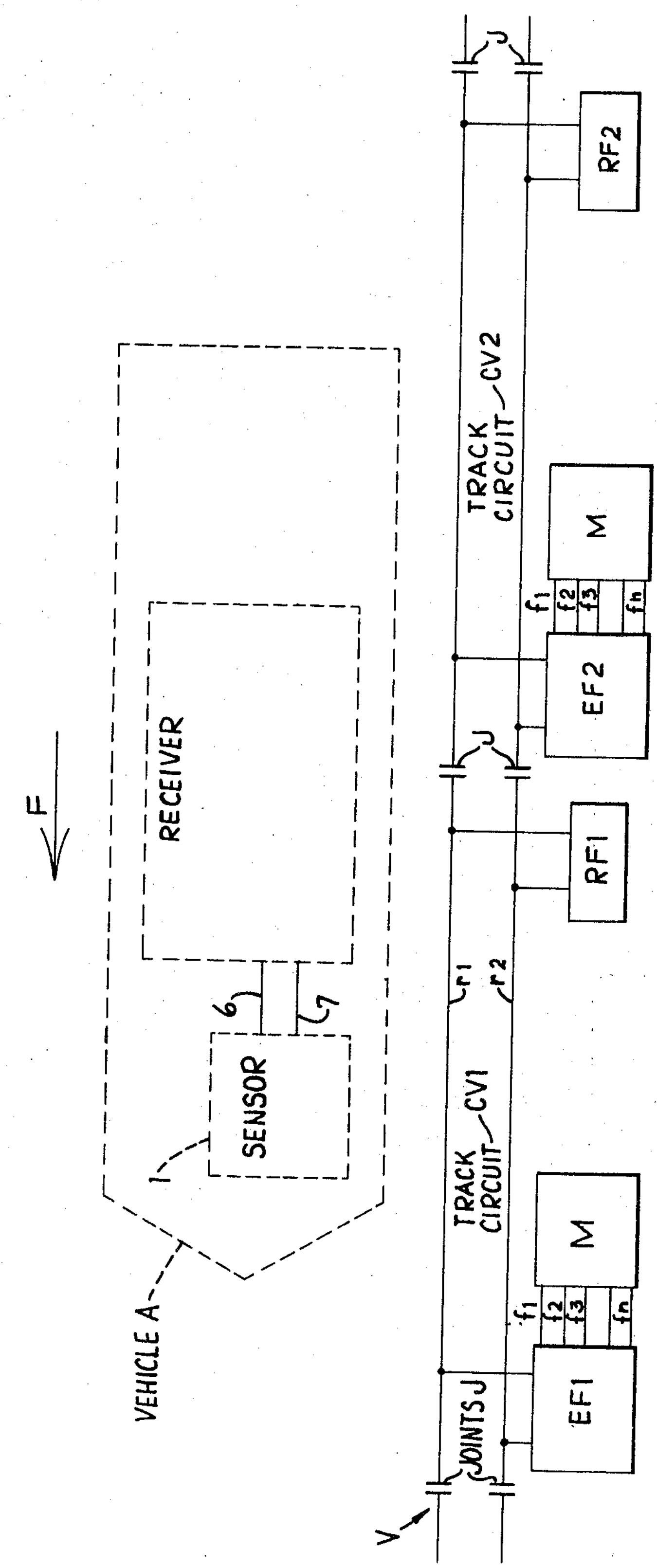
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Fig. 2

# METHOD AND APPARATUS FOR RECEIVING INFORMATION TRANSMITTED THROUGH RAILROAD TRACK CIRCUITS

The present invention relates to a method of coding track circuits and permitting the transmission of information to a vehicle moving along a railway track which is divided into a succession of blocks each provided with a track circuit, said successive track circuits being excited by different frequencies which are repeated along the whole track and the value or magnitude of which frequencies is controlled by the characteristics of these circuits, a method in which each of the excitation frequencies of the track circuits is modulated by a given number of modulation frequencies each representing information to be transmitted. The invention also relates to receivers for putting this method into practice.

It is known that the safety and regularity of railway traffic moving on railway tracks are ensured by signals spaced along the tracks and serving to transmit the information which is to be received by the driver of the train. At the present time these signals are generally controlled automatically by safety devices which are known under the name of track circuits and ensure safety by means of the block system.

Block systems have long been used to control railway traffic. A block system has been defined as a system by which a track is divided into short sections, or blocks, for example, of three or four miles length and trains are so run by signal apparatus (block signals) that no train enters a block until the preceding train has left it.

Nowadays there are trains the speed of which is such that the driver has only a short amount of time to notice a given signal and this increases the risk of accidents. In addition, with even faster trains which are at present under survey, for example turbine trains, it is absolutely impossible to envisage using the visual signals which are placed along tracks.

Therefore, it has been considered necessary to perfect a system which makes it possible to transmit directly to the interior of the cabin of the driver the information which is necessary to improve the running of the train. Such a system must naturally be devised so as not to interfere with the working of the track circuits which must continue in their function with complete safety.

Consideration has therefore been given to modulating the excitation frequencies of the track circuits with a given number of modulation frequencies each representing information to be transmitted, then to detecting these modulation frequencies directly on the train as well as at the end of each track circuit.

However, the value or magnitude of the excitation frequencies of the track circuits is controlled by the characteristics of said circuits. If normal modulation frequencies capable of being separated by means of conventional filters are used, the modulation index is extremely weak and the greatest difficulty is then experienced in detecting these modulation frequencies with an adequate margin of safety.

Naturally lower modulation frequencies could be used, but then the filters capable of separating such frequencies present difficulties.

The aim of the present invention is to eliminate these disadvantages and, for this purpose, it provides a method of the above-mentioned type which is essentially characterized in that is consists of using very low



modulation frequencies so that the modulation index is sufficiently increased to detect these different modulation frequencies on the train and at the end of each track circuit, and then multiplying their frequency by a given factor in order to obtain frequencies which can be easily separated by means of conventional band-pass filters.

It can be easily understood that a relatively simple and economical method of transmission is obtained in this way, said method also ensuring complete safety which is required particularly by railways. In particular, the use of a track circuit modulated in frequency provides the system with a remarkable immunity from the eddy currents produced by electric tractions. It also appears that the decoding of the information corresponding to different modulation frequencies makes it possible to differentiate the information received at the end of each track circuit and therefore to avoid the connections which are usually produced by cable in the "block" system. Therefore, everything concerning the reception and decoding of information on the machine likewise applies to the reception of this information at the end of each track circuit. In a particular application of the invention, the excitation frequencies of the track circuits are measured in kilohertz and the modulation frequencies in 10 hertz, whereas the multiplication factor is equal to the power of 2 the exponent of which is at least equal to 4.

Such a multiplication factor makes it possible to obtain safety and frequencies of more than 200 Hz, i.e., frequencies which can be easily separated by means of conventional band-pass filters.

A receiving device for putting into practice the method of transmission according to the invention is characterized in that it comprises a detector for extracting from the collected signal the different modulation frequencies, a frequency multiplier for multiplying the frequency of detected modulation frequencies, and a series of band-pass filters for separating these different multiplied frequencies, each filter being associated with an indicating device controlled by the signal coming from the corresponding filter.

On the machine, the indicating devices comprising for example luminous signals possibly associated with electric bells, are actuated selectively as a function of the modulation frequencies which are detected and therefore directly provides the driver of the train with the necessary information.

The indicating devices associated with receivers which are positioned on the track are themselves usually formed by safety relays the position of which corresponds to the permitted speed on each track circuit.

In a preferred embodiment of the invention, the frequency multiplier comprises a first multiplier stage insensitive to the frequency, followed by a second multiplier stage forming a series of circuits, each being tuned to one of the frequencies which is capable of being delivered by the first multiplier stage.

The multiplication factor of the first multiplier stage is preferably equal to 2, whereas the multiplication factor of the second multiplier stage is equal to 8.

A practical embodiment of the invention is described below by way of an example, with reference to the accompanying drawings in which

FIG. 1 is a synoptic diagram of a receiver for putting into practice the method of transmission according to the invention. The description will of FIG. 1 only concern the receiver positioned on the railway vehicle, the receivers of each track circuit being identical with the exception of the collector which is an element peculiar to the vehicle.

FIG. **2** schematically discloses structure associated with the track circuits.

Firstly, it will be recalled that the method of transmission according to the invention is intended for the transmission of information to a vehicle moving along a railway track which is provided with successive track circuits excited by different frequencies. In order to clarify the description, it will be assumed that these successive track circuits are excited by two different frequencies, for example 1,700 Hz and 2,300 Hz, which are repeated alternately along the entire track.

In accordance with the invention, each of these excitation frequencies of 1,700 Hz and 2,300 Hz is modulated by a given number of very low fixed modulation frequencies, each representing a piece of information to be transmitted to the vehicle. If, for example, there are seven different pieces of information to be transmitted, these modulation frequencies can be advantageously produced between 12 Hz and 20 Hz. The modulation index is therefore relatively increased.

More particularly, by long known theory (Set forth, for example, in the electronic treatise *Techniques de l'Ingenieur*, 1953, installment E 3100, pages 1, 3 in the Article "Modulation de Frequence Modulation par impulsions" by Pierre Besson), the modulation index $k$ can be expressed as:

$$k = \Delta F/f,$$

where $F$ is the carrier (excitation) frequency, $\Delta F$ is the carrier frequency deviation (increase or decrease in excitation or carrier frequency) and $f$ is the modulation frequency. Thus, if, for example, the excitation frequency is increased or decreased by 10 Hz (i.e. $\Delta F =$ 10 Hz), there will be a modulation index between 0.5 ($f = 20$ Hz) and 0.8 ($f = 12$ Hz)

To avoid mutual interference with normal functions of the track circuits, the deviation $\Delta F$ and pass band is kept low. The modulation frequencies $f$ are kept low to provide a sufficiently high modulation index $k$. As stated, if higher modulation frequencies (e.g., $f = 100$ Hz) capable of being separated by conventional filters are used, the modulation index k is extremely weak (e.g., k = 10/**100** = 0.1) and difficulty is experienced in detecting these modulation frequencies in the receiver with reliability.

Moreover, it should be noted that as a result of the modulation, carrier frequencies of 1,700 Hz and 2,300 Hz no longer appear in the track circuits. In fact, with an increase or decrease in frequency equal to 10 Hz, either 1,690 Hz or 1,710 Hz will be obtained for example in a given track circuit, whereas in two adjacent track circuits a modulated frequency of 2,290 Hz or 2,310 Hz will always be obtained.

The different means of modulating, during transmission, the excitation frequencies of different track circuits according to the invention are all known and will therefore not be described in detail. However, reference may conveniently be made to FIG. 2 which discloses schematically a track V comprising two rails $r_1$ and $r_2$ along which a vehicle, usually a locomotive, A moves, e.g., in direction F. The railroad track V is provided with successive track circuits $CV_1$, $CV_2$, etc. extending between joints J. The track circuits are excited by the two different frequencies $F_1$ and $F_2$, e.g., 1,700 Hz and 2,300 Hz, repeated alternately along the track, provided by suitable generators E. The excitation frequencies $F_1$ and $F_2$ are modulated by the low, fixed modulation frequencies $f_1, f_2, f_3$, etc., provided by suitable modulators M, and each representing a piece of information to be transmitted to the vehicle. The different means are associated with a receiver carried by the vehicle the aim of which is to collect and detect the modulated frequencies generated in the successive track circuits in order to extract the information therefrom. Such a receiver is synoptically represented in FIG. **1** and described in detail below. Generally similar receivers, indicated for example at $RF_1$ and $RF_2$, may be associated with corresponding track circuits.

This receiver comprises firstly a collector **1** to be positioned on the vehicle, usually a locomotive, in the vicinity of the railway track on which it runs and preferably equidistant from the two rails. In the described embodiment the collector comprises two resonant circuits **2** and **3**, each being tuned to one of the excitation frequencies of the track circuits, 1,700 Hz and 2,300 Hz respectively. These resonant circuits comprise simply a capacitor C in parallel with an inductance coil L provided with an iron core, and they are respectively connected to the in-puts of two amplifiers **4** and **5** which are enclosed in the collector **1.** Moreover, each of these amplifiers is tuned to the corresponding frequency of the associated circuit.

The collector **1** is tuned to the remainder of the receiver which is advantageously enclosed in a box positioned inside the driving cabin of the train, by two leads **6** and **7** connecting the out-puts of the two amplifiers **4** and **5** to the in-puts of two band-pass filters **8** and **9** respectively. These two band-pass filters are respectively tuned to frequencies of 1,700 Hz and 2,300 Hz and are followed by two amplifiers **10** and **11** likewise tuned to these two frequencies.

The amplifier **10** controls the functioning of a first commutating relay **12** via a lead **13,** whereas the amplified signal appears at an out-put terminal **14.** Similarly, the amplifier **11** controls a second commutating relay **15** similar to the first via a lead **16** whereas the amplified signal appears at an out-put terminal **17.** These two amplifiers **10** and **11** are fed by means of two feed terminals **18** and **19** via a voltage supply +V*o*.

The relay **12** comprises three contact breakers, **20, 21** and **22.** The contact breaker **20** which is normally open is positioned between the voltage supply +V*o* and the exciting winding of a delaying relay **23** comprising a single contact breaker **24.** The contact breaker **21** which is likewise normally open is positioned between the out-put terminal **14** of the amplifier **10** and the contact breaker **24** of the relay **23.** As for the contact breaker **22,** it is not normally closed and located between feed terminal **19** of the amplifier **11** and the voltage supply +V*o*.

The relay **15** also comprises three contact breakers, **25, 26** and **27,** respectively. The contact breaker **25** which is normally open is located between the voltage supply +V*o* and the exciting winding of the delaying relay **23.** The contact breaker **26** which is also normally open is located between the out-put terminal **17** of the amplifier **11** and the contact breaker **24** of the delaying relay **23.** As for the contact breaker **27,** it is normally closed and located between the feed terminal **18** of the amplifier **10** and the voltage supply +Vo.

The working contact of the delaying relay **23** is connected by a lead **28** to the in-put of a very low frequency demodulator **29** which is connected in series with a multiplier **30** which is relatively insensitive to frequency. This multiplier **30**, the multiplication factor of which is equal to 2, is capable of multiplying directly the frequency of a variable frequency signal, i.e., of signals of differing frequencies.

The out-put of the multiplier **30** is simultaneously connected to seven multipliers $M_1$ to $M_7$, the in-put of each of these circuits being tuned to one of the seven frequencies capable of appearing at the out-put of the circuit **30**. These tuned multipliers $M_1$ to $M_7$ are conventional in design and their multiplication factor is equal to 8 . The multiplier **30** is of known type, for example, the type "Doubler of Frequency" of M. De Joly described in the Agenda Dunod Electricity, **1942** edition, Paris, France, pages **219** and **220** (with FIG. **75**). The multiplier **30** likewise may be similar to multipliers **M1-M7** but with greater band width.

Each of the multipliers $M_1$ to $M_7$ is connected in series to a band-pass filter, $F_1$ to $F_7$ respectively, the out-put signal of which controls the operation of a relay $R_1$ to $R_7$. Each of these seven relays $R_1$ to $R_7$ is associated with a contact breaker such as **31** and selectively insures the functioning of seven indicating devices $V_1$ to $V_7$, comprising for example luminous signals. For this purpose, each of the signals $V_1$ to $V_7$ is connected between the voltage supply +V*o* and the earth by means of the contact breaker **31** of one of the relays $R_1$ to $R_7$.

The receiver which has just been described operates as follows:

It should first be assumed that at a given moment the collector **1** attached to the locomotive is located above a portion of the track circuit excited by a signal having a frequency of 1,700 Hz. In this case, the tuned circuit **2** picks up the signal and transmits it to the amplifier **4**. It should be remembered at this point that the collected signal is not actually a signal of 1,700 Hz, but a modulated signal having alternatively frequencies of 1,690 Hz and 1,710 Hz, in harmony with the modulation signal in use which represents the information to be transmitted to the locomotive. Moreover, it should be remembered that in accordance with the invention this modulation signal has a very low frequency between 12 and 20 Hz.

The amplified signal appearing at the out-put of the amplifier **4** is therefore transmitted by the lead **6** to the band-pass filter **8**. This band-pass filter is tuned to a frequency of 1,700 Hz and its aim is to eliminate the harmonics which may have been generated. The filtered signal is then transmitted to the amplifier **10** which is fed with current from the constant voltage supply +V*o* via the closed contact **27** of the relay **15**.

The amplifier **10** is designed in such a manner that when it receives a signal at its in-put, it causes excitation of the commutating relay **12** by way of the lead **13**, which causes the contact breaker **22** to open and the contact breakers **20** and **21** to close.

The opening of the contact breaker **22** cuts off the current supply to the amplifier **11** which is therefore rendered inoperative. Consequently, no signal can be transmitted by the second track which comprises the tuned circuit **3**, the amplifier **5**, the filter **9** and the amplifier **11**, and which is reserved for frequencies of 2,300 Hz.

The simultaneous closing of the contact breaker **20** causes the current to be fed to the delaying relay **23**, the contact **24** of which is closed with a given time lag of a second. The modulated signal at the out-put terminal **14** of the amplifier **10** is therefore transmitted to the demodulator **29** by means of the closed contacts **21** and **24** and the lead **28**. The delayed-response relay **23** therefore delays transmission of the collect signal at the demodulator **29**, so that it is possible to avoid the transmission of transient phenomena which occur when the collector **1** passes over the cross-overs between the successive track circuits. When the collector **1** passes over a track circuit excited by a signal having a frequency of 2,300 Hz, the tuned circuit **3** accepts the modulated signal and transmits it to the amplifier **5**. This modulated signal has alternate frequencies of 2,290 Hz and 2,310 Hz, in harmony with the modulation signal in use at that time.

On the other hand, the tuned circuit **2** no longer picks up any signal because it is tuned to 1,700 Hz. The commutating relay **12** therefore returns to its initial state, which causes current to be fed to the amplifier **11** by way of the closed contact **22**. As this amplifier **11** receives at its in-put the collected and modulated signal, via the amplifier **5** and the band-pass filter **9**, it causes the commutating relay **15** to be excited by the lead **16** which in turn causes the contact **27** to open and the contacts **25** and **26** to close.

The opening of the contact **27** cuts off the current being fed through the amplifier **10** of the 1,700 Hz track, thereby rendering said track inoperative whereas the closing of the contact **25** effects the feeding of the delayed-response relay **23**. When the contact **24** of this relay is closed, the modulated signal at the out-put terminal **17** of the amplifier **11** is transmitted to the in-put of the de-modulator **29**.

Therefore, when one of the tracks, for example that which is reserved for 1,700 Hz, is in operation the other track is rendered inoperative and vice versa, so that interference between the two tracks can be avoided. In addition, the delayed-response relay **23** causes the modulated signal to be transmitted with a certain time lag to the demodulator **29** in order to avoid transient phenomena occurring at the cross-overs between the different track circuits.

The demodulated signal appears at the output of the demodulator **29** in the form of a succession of pulses the recurring frequency of which corresponds, at a given time, to the modulation frequency in use at the same time. This demodulated signal is therefore a variable frequency signal. In this particular embodiment being described, it is capable of providing seven different frequencies between 12 and 20 Hz, each of said frequencies representing one of the seven pieces of information to be transmitted to the driver of the train.

The frequency of the demodulated signal collected at the output of the demodulator **29** is first multiplied by two in the multiplier **30**. This circuit **30** is insensitive to the frequency of the input signal. Therefore, at its output a signal is collected which is always of variable frequency but the frequency of which is doubled, i.e., a signal capable of providing seven different frequencies between 24 and 40 Hz. This double frequency signal is then applied to the input of the seven tuned multipliers $M_1$ to $M_7$ the multiplication factor of which is equal to eight. It follows that the seven frequencies at the output of the different multipliers $M_1$ to $M_7$ are produced between 192 Hz and 320 Hz, which makes it possible for them to be filtered by means of band-pass filters $F_1$ to $F_7$, each being tuned to one of said seven frequencies.

When one of the filters $F_1$ to $F_7$ receives a frequency corresponding to its tuning frequency, the associated relay is excited and its contact **31** closed by causing one of the signals $V_1$ to $V_7$ to be lit, which enables the driver of the train to receive the corresponding information.

It should be assumed for example that at a given time the collector **1** picks up a signal modulated in frequency by 12 Hz, corresponding to given information which is to be transmitted to the driver of the train. The frequency of the demodulated signal collected at the output of the demodulator **29** is therefore equal to 12 Hz, which gives a frequency of 24 Hz at the output of the circuit **30**. This frequency of 24 Hz is then multiplied by eight in the multipliers $M_1$ to $M_7$, the input of which is tuned to a frequency of 24 Hz, for example the circuit $M_1$. The filter $F_1$ therefore receives at its input a frequency of 192 Hz corresponding precisely to its tuning frequency, which causes excitation of the associated relay $R_1$ the contact **31** of which is closed. Consequently, the signal $V_1$ is lit up and therefore indicates to the driver of the train the information corresponding to the modulation frequency of 12 Hz. When the modulation frequency changes, another signal is lit and the lighting of each signal corresponds therefore to a specific piece of information.

Therefore the driver directly receives inside the driving cabin of the train the different information which is required to ensure the good running and complete safety of the train. In this particular example being described, each of these pieces of information is manifested by the lighting of a luminous signal, but it is obvious that numerous alternative indicating devices could be used.

At the end of each track circuit, the information is decoded by means of a receiver similar to the one described above, and a relay peculiar to each indication can be excited. The number of transmitted pieces of information is only limited by the value of the coefficient of modulation and can easily be of the order of 20 to 30.

It is noted moreover that the information furnished by this method of coding the track circuits can likewise be used independently of the track mechanism relation when it is simply desired to increase the selectivity of the receivers of the track circuits in order to reduce more effectively the stray currents circulating in the rails and particularly produced by the mechanisms producing strong harmonics of the driving current such as the mechanisms of Thyristors and the machines of Choppers or Hacheurs.

In this case, the quantity of necessary information can be greatly reduced and limited with a single modulation which could thus be advantageously realized by using a submultiple of the proper frequency of the track circuit. Beginning with the oscillator furnishing the carrier frequency, a classic vernier arrangement dividing the frequency by a fixed number gives the frequency modulation which directly modulates the signal of the oscillator before amplification and the receiver proves to be simplified for it is sufficient to detect a single type of modulation.

What we claim is:

**1.** A method of coding track circuits and permitting the transmission of information to a vehicle moving along a railway track divided into a succession of block sections each provided with a track circuit, said successive track circuits being excited by different frequencies which are repeated along the entire track and the value of which frequencies is determined by the characteristics of said track circuits, the method comprising the steps of modulating each of the exciting frequencies of the track circuit by a specific number of modulation frequencies, each modulation frequency representing a piece of information to be transmitted, the modulation frequencies being very low in order that the modulation index may be sufficiently increased to enable detection of these different modulation frequencies on the railway vehicle and at the end of each track circuit; detecting said modulation frequencies; then multiplying the frequency of the detected modulation frequencies by a given factor in order to obtain frequencies which can be easily separated by means of conventional band-pass filters; and using such filters to separate said multiplied modulation frequencies.

**2.** A method as claimed in claim **1**, characterized in that the exciting frequencies of the track circuits are of the order of a kilohertz and the modulation frequencies are measured in 10 hertz, whereas the multiplication factor is equal to the power of 2 the exponent of which is at least equal to 4.

**3.** In apparatus for use in coding track circuits and permitting the transmission of information to a vehicle moving along a railway track divided into a succession of block sections each provided with a track circuit, successive track circuits being excited by different frequencies repeated along the entire track and the value of which frequencies is determined by the characteristics of said track circuits, each of the exciting frequencies of the track circuit being modulated by a specific number of modulation frequencies each representing a piece of information to be transmitted, the modulation frequencies being very low in order that the modulation index may be sufficiently increased to allow detection of these different modulation frequencies on the railway vehicle and at the end of each track circuit, a receiver comprising: a demodulator for extracting the different modulation frequencies from the collected signal to provide demodulated frequencies, a frequency multiplier following said demodulator for multiplying the frequency of said demodulated frequencies to provide different multiplied frequencies, and a plurality of band-pass filters following said frequency multiplier to separate said different multiplied frequencies, and an indicating device associated with each said band-pass filter controlled by the signal coming from the corresponding filter.

**4.** A receiver as claimed in claim **3**, characterized in that the frequency multiplier comprises a first multiplying stage which is insensitive to the frequency, followed by a second multiplying stage which is formed by a plurality of multiplier circuits, each being tuned to a different one of the frequencies which can be delivered by the first multiplying stage.

**5.** A receiver as claimed in claim **4**, characterized in that the multiplication factor of the first multiplier stage is equal to 2, whereas the multiplication factor of the second stage is equal to 8.

**6.** A receiver as claimed in claim **3**, including collector means having a pair of resonant circuits each tuned to a corresponding one of the excitation frequencies for receiving from the track circuits corresponding modulator excitation frequencies in alternation as the vehicle passes from block section to block section, commutating relays and means connecting ones of said commutating relays to corresponding ones of said resonant circuits for actuation thereby, means responsive to actuation of one said commutating relay by one said resonant circuit for preventing actuation of the other commutating relay from the other resonant circuit, means responsive to actuation of a one of said commutating relays for providing a time delay connection of the input of said demodulator to said means connected to a corresponding one of said resonant circuits.

7. A receiver as claimed in claim 6, in which each said means connected to a resonant circuit comprises a band-pass filter tuned to the corresponding exciting frequency for eliminating spurious harmonics and an amplifier connected between such band-pass filter and the corresponding commutating relay for driving such commutating relay, each such commutating relay including a contact for shutting off the supply of operating potential to amplifiers connected to other resonant circuits so as to positively prevent application of spurious signals to said demodulator from resonant circuits other than those tuned to the particular track circuit along which the vehicle is passing.

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