Oct. 18, 1955 J. E. FREEHAFER 2,721,258

TRAIN SPEED CONTROL SYSTEM

Filed Nov. 16, 1951 3 Sheets-Sheet 1

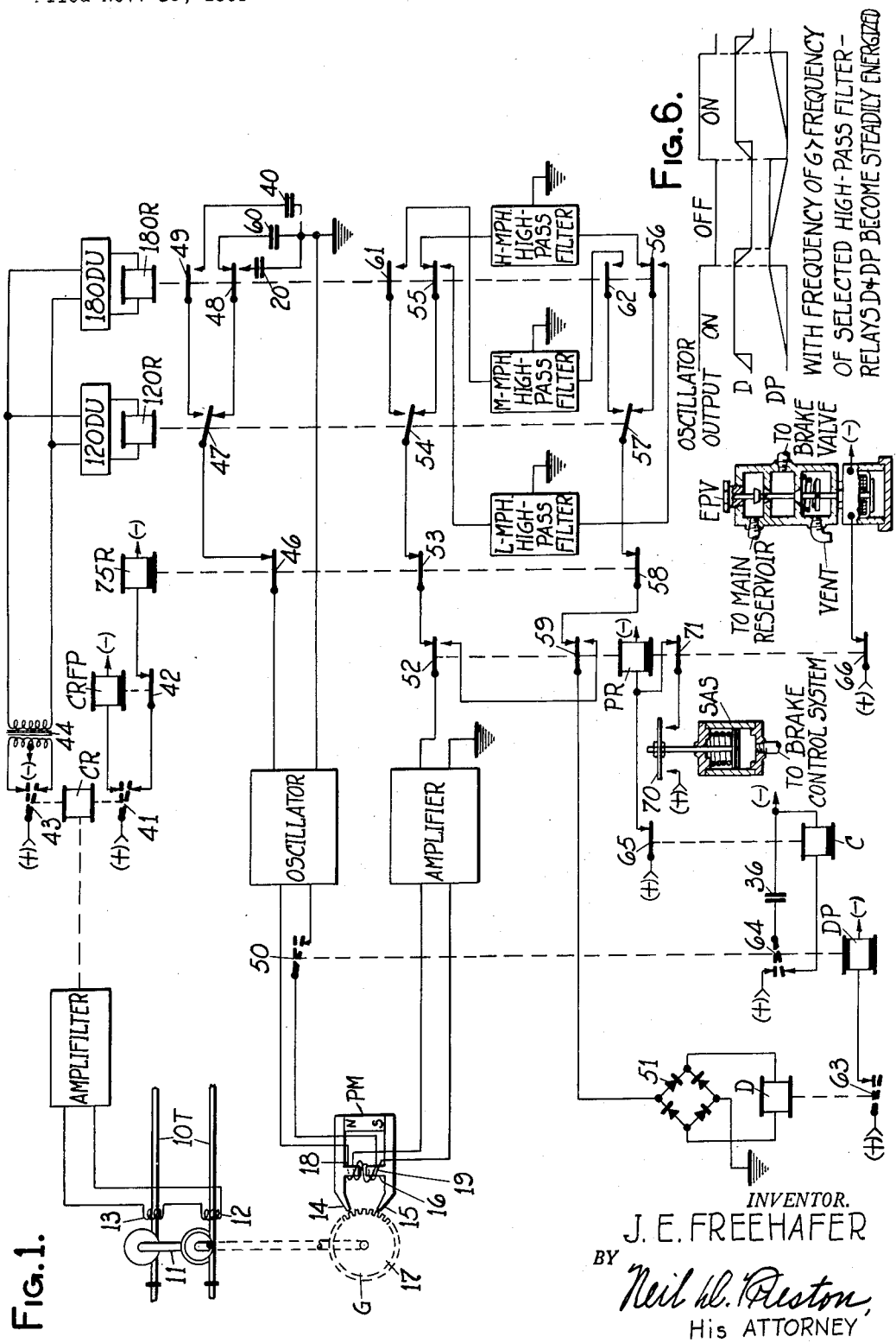


FIG. 1.

FIG. 6.

INVENTOR.
J. E. FREEHAFER
BY Neil W. Preston,
His ATTORNEY

Oct. 18, 1955 J. E. FREEHAFER 2,721,258

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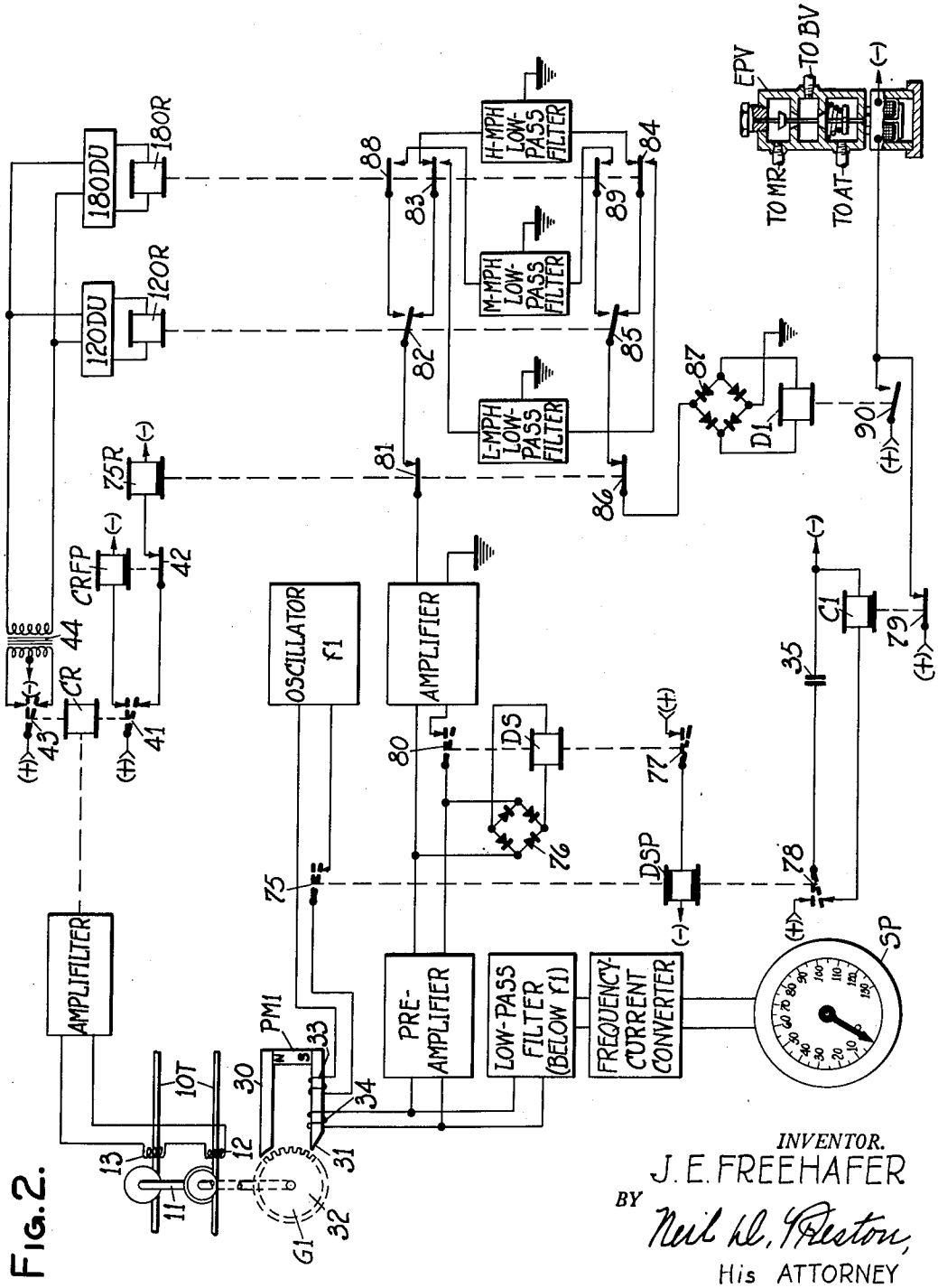


FIG. 2.

INVENTOR.
J. E. FREEHAFER
BY Neil W. Preston,
His ATTORNEY

Oct. 18, 1955 J. E. FREEHAFER 2,721,258

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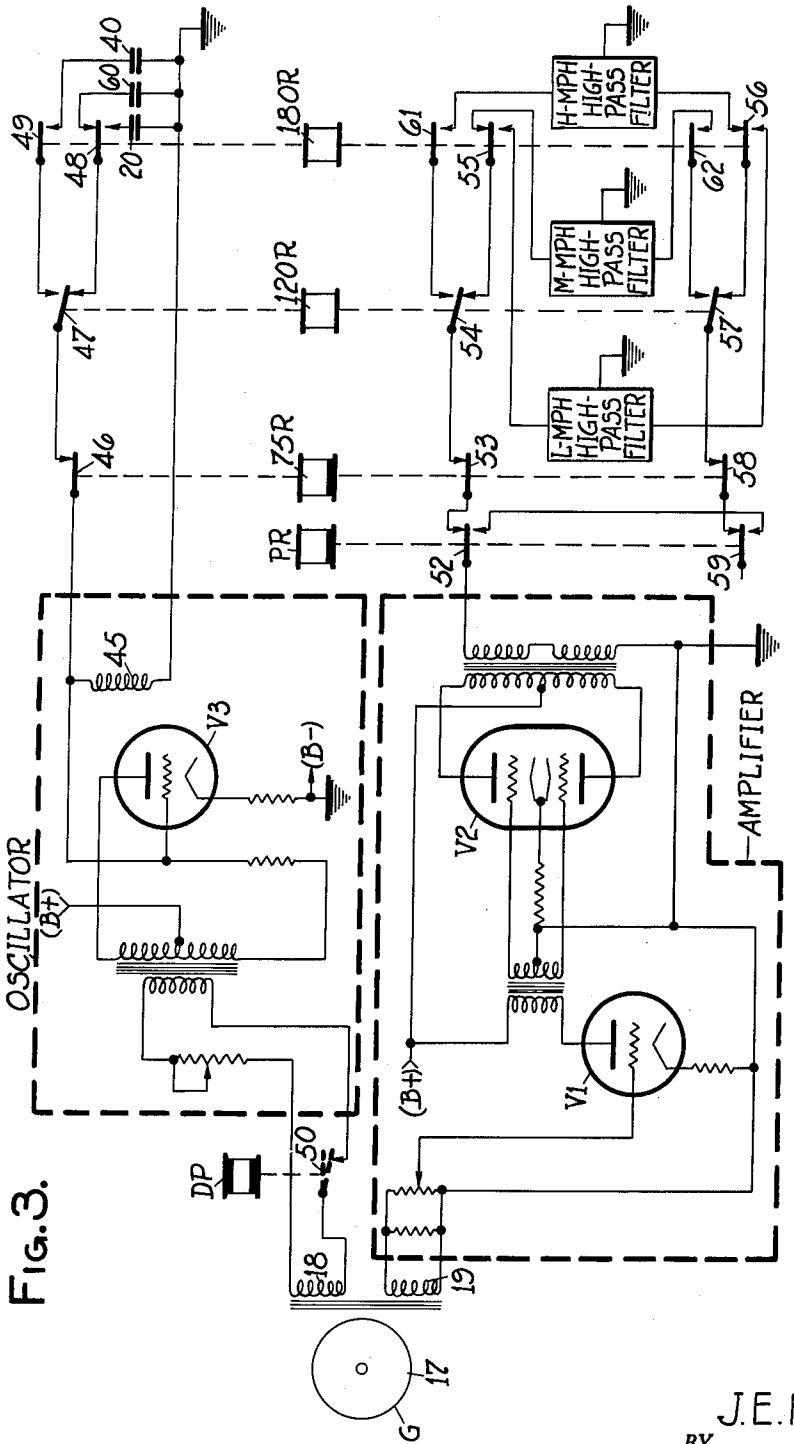


FIG. 3.

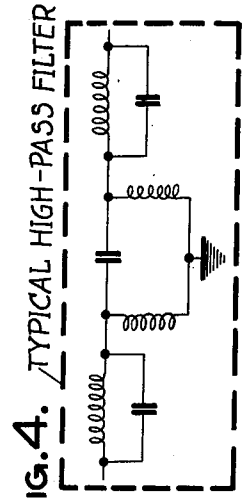


FIG. 4.

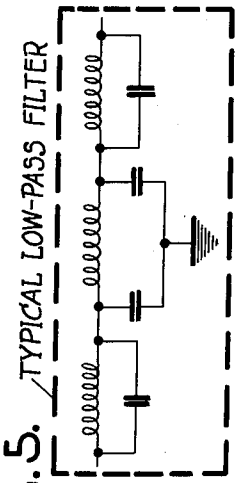


FIG. 5.

INVENTOR.
J.E. FREEHAFER
BY
Neil W. Preston,
His ATTORNEY

United States Patent Office

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TRAIN SPEED CONTROL SYSTEM

John E. Freehafer, Rochester, N. Y., assignor to General Railway Signal Company, Rochester, N. Y.

Application November 16, 1951, Serial No. 256,628

19 Claims. (Cl. 246—182)

This invention relates to train speed control systems for railroads, and it more particularly pertains to frequency responsive speed governing means for a train, together with circuit means for checking the integrity of the system.

In automatic train control systems it has been common practice to employ a centrifuge speed contactor mounted on a journal box of a locomotive as a part of a train speed control system. In such case, the contactor is subject to severe vibration, and circuit selections through the respective contacts have to be made by several different circuits having wires extending from the other train control equipment at a remote point on the locomotive to the contactor.

Generally speaking, and without attempting to define the scope of the present invention, the present invention contemplates the driving by an axle of a locomotive of a frequency generator, such for example as the generator disclosed in the application of O. S. Field, Ser. No. 256,634, filed November 16, 1951, which has resulted in Pat. No. 2,651,734, dated September 8, 1953. The generator output is fed to apparatus at a remote point on the locomotive where it is used through suitable amplifier and filter stages to govern an electropneumatic valve (commonly known as an EP valve) so as to cause a service application of the brakes in case of excessive speeds in speed restricted territory.

Because of the circuits for the control of the EP valve involving safety, it is desirable that the integrity of these circuits be checked and thus continuity of the safety circuits is checked by a check circuit to which energy is applied by an oscillator at a selected frequency. This oscillator energy is inductively applied to the output winding of the generator on the axle of the locomotive, from which it feeds through the safety circuits to check their integrity. In one form of the invention, the oscillator energy is of a frequency to pass through a selected high-pass filter, and by reason of there being continuity in the circuit, the oscillator output is applied intermittently, and it is only the intermittent energization of the check circuit that can be effective to maintain the EP valve energized, thus preventing an automatic application of the brakes. This intermittent operation is effective when the train is standing still, as well as when it is in motion.

If the speed of the train exceeds the speed permitted in a restricted area, the generated frequency is above the beginning of the pass band of the selected high-pass filter, and thus energy from the generator is fed through the filter to maintain steady energization of the detector relay, which is normally intermittently operated, and thereby set up a distinctive condition of energization which causes the deenergization of the EP valve. The check circuit, by its intermittent energization, is effective when the locomotive is stopped to prevent actuation of the EP valve.

An object of the present invention is to provide a purely electrical system for the selective control of an

EP valve in accordance with the output of a frequency generator coupled to a locomotive axle, and in accordance with permitted speeds of trains through selected different restricted speed areas.

Another object of the present invention is to maintain a constant check of the integrity of an electrical speed indicating system for the selective control of an EP valve.

Another object of the present invention is to employ the means for checking the continuity of the speed indicating system as a means for maintaining the EP valve energized when the train is not in motion, and thus when there is no voltage generated by the frequency generator which is driven by the locomotive axle.

Other objects, purposes, and characteristic features of the present invention will be in part obvious from the accompanying drawings, and in part pointed out as the description of the invention progresses.

In describing the invention in detail, reference is made to the accompanying drawings in which corresponding parts are identified by similar reference characters; and in which;

Fig. 1 is a schematic diagram illustrating a system for the control of an EP valve in accordance with the speed of a train wherein the EP valve is maintained normally energized by a check circuit, and is deenergized by the generated frequency increasing to a point above the frequency of a selected high-pass filter;

Fig. 2 is a schematic diagram illustrating a system for the control of an EP valve in accordance with the speed of a train wherein the EP valve is maintained energized when the train is in motion by the output of a frequency generator, but its energization is prevented by a selected low-pass filter when the speed of the train exceeds a particular selected restricted speed limit;

Fig. 3 illustrates typical detail circuits which may be employed for the oscillator and amplifier respectively indicated in block form in the organization according to Fig. 1;

Fig. 4 illustrated a form of high-pass filter that is satisfactory for use in a system provided according to the present invention;

Fig. 5 illustrates the organization of a low-pass filter suitable for use in a train control system such as that herein disclosed; and,

Fig. 6 is a sequence diagram illustrating the general mode of operation of the system according to the embodiment illustrated in Fig. 1.

The illustrations employed in the disclosure of the present invention have been arranged to facilitate the disclosure as to the mode of operation and the principles involved rather than for the purpose of illustrating the construction and arrangement of parts that would be employed in practice. Thus the various parts are illustrated by conventional symbols, some parts well known in the art being shown by block diagram. The symbols (+) and (—) are employed to indicate connections to the positive and negative terminals, respectively, of suitable batteries or other sources of direct current, and the symbols (B+) and (B—) have been used to designate connections to a suitable high voltage direct current "B" supply for electronic tube circuits.

FIG. 1 APPARATUS

With reference to Fig. 1, a track section **10T** is illustrated as being occupied by an axle **11** of a locomotive, such locomotive carrying train control receivers **12** and **13** disposed ahead of the front axle for picking up track circuit code transmitted through the track section **10T** according to conventional train control practice. Energy induced in the receivers **12** and **13** is applied through a suitable amplifier for the control of a code following relay CR. A slow acting front contact repeater relay CRFP

is provided for energization in accordance with the pulsing of front contact **41** of relay CR, and a low speed control slow drop away relay **75R** is normally energized whenever a code is being received so that the relay CR is active. A medium speed decoding relay **120R** is energized through an associated filter and rectifier unit designated as **120DU** only upon the reception of a 120 code rate, and similarly a relay **180R** is provided to be energized only in response to a 180 code rate through an associated filter and rectifier unit **180DU**. This code receiving equipment carried by the locomotive will be readily recognized as conforming to general practice, and details which have not been shown with respect to the organization of this apparatus can be readily supplied by those skilled in the art, particularly in view of the teachings of several prior patents, such, for example, as the U. S. patent of W. H. Reichard, No. 2,223,131, dated November 26, 1940.

The above described apparatus provides information indicative of the speed restrictions that should be imposed because of traffic conditions as set up by track circuit codes transmitted through the track rails, and this information is used in train control systems of the type disclosed in the above mentioned Reichard patent for comparison with means indicating the actual speed of a locomotive to determine as to whether the speed of the locomotive is within the limits indicated by the rate of code received.

According to the present invention, the axle **11** of the locomotive drives a suitable frequency generator, such, for example, as one of the frequency generators disclosed in the patent application of O. S. Field, Ser. No. 256,634, filed November 16, 1951. The frequency generator employed, however, may be of any suitable structure to generate a frequency directly variable with the speed of rotation of the axle **11**. Thus a suitable generator can be constructed according to the diagrammatic showing of the generator G in Fig. 1, employing a U-shaped magnetic structure having soft iron pole pieces **14** and **15**, a permanent magnet yoke PM across the ends of the pole pieces **14** and **15**, and a slotted magnetic shunt **16** across the pole pieces **14** and **15** between the permanent magnet PM and a toothed rotor **17**. One requisite of a generator of this nature is that it should be constructed to produce an output at a relatively low speed of the axle **11**, and the efficiency of such a generator at a low speed is particularly improved by the use of a magnetic shunt structure such as that diagrammatically illustrated in Fig. 1, or such as that specifically described in the above mentioned application of O. S. Field. The generator G according to Fig. 1 has two windings **18** and **19** about core structure which also serves as the magnetic shunt **16**, the winding **18** being used as a primary winding of a transformer to induce a generated checking voltage in the second winding **19** for checking circuit continuity and for maintaining the system properly active when the locomotive is not in motion, this secondary winding **19** being the winding from which an output of the generator G is taken.

The control of the brakes of the locomotive is accomplished by the selective energization or deenergization of an electro-pneumatic valve EPV, the structure of which is well known to those familiar with the art and is more specifically disclosed, for example, in the patent to C. S. Bushnell, No. 1,855,596, dated April 26, 1932. The electro-pneumatic valve EPV is normally energized to permit the brakes of the train to be released, and is effective when deenergized to reduce the air pressure and thereby cause application of the brakes of the train.

A slow acting penalty relay PR is provided for controlling directly the energization of the valve EPV, and its control is in turn dependent upon a slow drop away relay C and an air reduction switch SAS. It is to be understood, and it will be more readily apparent as the description progresses, that the present invention can be readily applied in association with practically any penalty and/or acknowledgment organization, and should not be considered limited by the penalty means herein disclosed.

The energization of a slow drop away control relay C for governing energization of the penalty relay PR is dependent upon the intermittent discharge of a condenser **36** through the windings of the relay C, the intermittent or cyclical charge and discharge of the condenser **36** being governed by a relay DP which is illustrated as having both slow pickup and slow drop away characteristics.

The intermittent operation of the relay DP is in turn dependent upon the intermittent operation of a detector relay D, which is energized as a result of the output of the generator G, as applied through a suitable amplifier and through a selected high pass filter L–MPH, M–MPH, or H–MPH, and through a rectifier **51**. Although it is to be understood that the structure of the amplifier and of the high pass filters L–MPH, M–MPH, or H–MPH may be a matter of choice in accordance with the requirements of practice, typical amplifier and filter circuit organization have been illustrated in Figs. 3, 4, and 5. Thus according to Fig. 3, a conventional push-pull amplifier is illustrated as having an input from the winding **19** of the frequency generator G and having an output applied for the control of relay D through a selected high pass filter L–MPH, M–MPH, or H–MPH. Figs. 4 and 5 illustrate specifically suitable typical high and low pass filters respectively, employing m-derived end sections.

A suitable oscillator is provided for generating a check frequency for use in checking the integrity of the system for the control of the relay D, and also for providing for energization of relay D when the locomotive is not in motion. Although various types of oscillators may be employed, with reference to Fig. 3, a typical organization employing a resistance stabilizer oscillator is illustrated for example.

FIG. 2 APPARATUS

For convenience in simplifying the description of the embodiment of the invention illustrated in Fig. 2, those parts of Fig. 2 which correspond with the structure illustrated and described with respect to Fig. 1 are identified by corresponding reference characters, and reference is to be made to the description relative to Fig. 1 for detail consideration of these parts. The generator **G1** illustrated in Fig. 2 can also be of the type disclosed in the above mentioned application of O. S. Field, or as illustrated in Fig. 1, but it is shown diagrammatically as having pole pieces **30** and **31** connected by a permanent magnet PM1 as a back yoke, the pole pieces cooperating with respective teeth of a toothed rotor **32** which is driven by the axle **11** of the locomotive. The generator **G1**, like the generator G of Fig. 1, has respective primary and secondary windings, the primary winding **33** being subject to energization by a suitable oscillator generating a frequency *f*1, and the secondary winding **34** being subject to an induced voltage from the primary winding **33**, and being used for providing the output from the generator upon rotation of the toothed rotor **32**.

Although for simplification of the disclosure of the form of the invention illustrated in Fig. 2, no penalty means is provided, it is to be understood that a penalty relay PR can be employed in accordance with the requirements of practice for general purposes corresponding to those to be hereinafter more specifically considered with reference to the use of the penalty relay PR in the form of the invention illustrated in Fig. 1. Thus according to Fig. 2, a detector relay **D1** which is governed by the output of an amplifier through a selected low-pass filter provides directly for the energization of the electro-pneumatic valve EPV when the train is in motion, and a slow drop away relay **C1** is effective to provide for the energization of the valve EPV when the train is not in motion. The relay **C1** is a capacitor energized relay comparable to the relay C of Fig. 1, and the intermittent charge and dis-

charge of the condenser 35 associated with the relay C1 is governed by a relay DSP having slow pickup and drop away characteristics, which in turn is governed by a relay DS which is subject to energization, through a suitable pre-amplifier and rectifier, from the winding 34 of the generator G1.

In the embodiment of the invention according to Fig. 2, a speed indicator SP is illustrated as being governed by the output of the generator G1 through a suitable filter for removing the oscillator frequency *f*1, and through a frequency-current converter, which is adapted to convert frequency to current in a direct ratio so that the speed indicator SP is driven in accordance with the speed of the axle 11. The apparatus comprising the frequency-current converter is well known to those familiar with the art and it can be provided, for example, as disclosed on pages 264 and 268 of the January 1945 issue of "Electronics" magazine. Although the speed indicator has been illustrated only in the embodiment illustrated in Fig. 2, it is to be understood that it can be used in connection with the apparatus provided according to Fig. 1, if suitable means is employed to filter out the frequency of the oscillator, and it is to be further understood that the use of the speed indicator is optional in any form of the present invention.

Having thus considered the general organization of the apparatus according to the present invention, a more specific consideration will hereinafter be given of the circuit organizations when considering the mode of operation of the system under certain typical operating conditions.

Operation

To facilitate an understanding of the specific mode of operation as it will be hereinafter considered, consideration will first be given to the general mode of operation of the organization according to Fig. 1, without specific reference to the circuit organizations involved.

The general mode of operation of the track code received apparatus is well known to those familiar with the art wherein the track code is received by the receivers 12 and 13 disposed over the respective track rails on the front of the locomotive, the code pulses induced in these receivers being suitably amplified and filtered and effective to cause the pulsing of the code following relay CR. Relays CRFP and 75R are maintained steadily picked up in accordance with the pulsing of the relay CR, and if the code received is at a 120 or a 180 rate, the pulsing of contact 43 of relay CR is effective to energize the relay 120R or relay 180R in accordance with the code that is being received. Thus the relay 75R when picked up is indicative of the reception of a track circuit code of any rate, relay 120R when energized is indicative of the reception of the 120 code, and relay 180R is energized in accordance with the reception of a 180 track circuit code.

These relays when selectively energized will be readily recognized as being indicative on the locomotive of the speed restrictions intended to be applied to the train for respective areas along the trackway. If only the relay 75R is picked up, this is indicative of a low speed area, and thus the train must be operated within a low speed limit. Similarly the relay 120R when picked up with the relay 180R dropped away defines a medium speed limit, and the relay 180R when picked up with the relay 120R dropped away establishes a high speed limit.

When the locomotive is not in motion, or when the locomotive speed is below the limit defined by the track circuit code receiving apparatus, the detector relay D (see Fig. 1) is pulsed in accordance with the slow acting characteristics of its repeater relay DP which selectively opens and closes the output circuit of the oscillator. The relay DP must be pulsed in order to maintain the relay C picked up, which in turn energizes the penalty relay PR; and through the front contact 66 of the penalty relay PR, the valve EPV is maintained energized, and thus permits the brake pressure of the train to be maintained. The relay D is energized by the oscillator, because the oscillator frequency is always selected as being just above the frequency of the selected high-pass filter. In other words, the relay D is always subject to energization by the output of the oscillator as applied through the windings of the generator G, acting as a transformer, and through a suitable amplifier and a selected high-pass filter, irrespective of the speed at which the locomotive is being operated.

Also through a part of this same circuit organization, it will be readily apparent that the output of the generator G is applied to the circuit organization for the control of the relay D, and is prevented from energizing the relay D only when the frequency generated is lower than the frequency of the particular high-pass filter that has been selected by the train control receiving apparatus. It will thus be seen that as long as the frequency generated is below the frequency of the selected high-pass filter, no appreciable amount of energy can be applied from the generator to the control of the relay D, and thus the relay D is permitted to be pulsed in accordance with the operating characteristics of its slow acting repeater relay DP.

Assuming the above described mode of operation wherein it has been set forth that the pulsing of the relay D is required in order to maintain the valve EPV energized; it will be apparent that the output of the generator G is prevented from energizing the relay D solely by reason of the generated frequency being below the pass band of the selected high-pass filter, thus it will be seen that when the frequency generated by the generator G becomes high enough to fall within the pass band of the high pass filter that has been selected, the relay D becomes energized by the output of the generator, and therefore is maintained steadily picked up, resulting in the deenergization after a time of the valve EPV. Because of the relay D failing to be pulsed, its repeater relay DP is maintained steadily energized, and thus the control relay C is maintained steadily deenergized, and the dropping away of this relay effects the dropping away of the penalty relay PR (assuming that there has been no air reduction manually applied), and the relay PR when dropped away causes the actuation of the valve EPV for a service application of the brakes of the train.

Having thus described the general mode of operation of the embodiment of the invention illustrated in Fig. 1, a more detailed consideration will now be given as to the circuit organizations involved in providing the above described general mode of operation.

It has been pointed out that the oscillator employed for generating a check frequency can be of any suitable type such, for example, as of the resistance stabilizer type specifically illustrated in Fig. 3. This oscillator has its frequency determined by a tuned circuit including an inductance 45 selectively coupled in multiple with a condenser 20, 40, or 60 as selected by the code receiving relays 75R, 120R, and 180R. The condenser 20 is used to govern the frequency when it is connected in multiple with the inductance 45 through front contact 46 of relay 75R, back contact 47 of relay 120R and back contact 48 of relay 180R.

Similarly, the condenser 40 is connected in multiple with the inductance 45 to govern the frequency of the oscillator when relay 120R is energized so that condenser 40 is connected to the inductance 45 through front contact 46 of relay 75R, front contact 47 of relay 120R, and back contact 49 of relay 180R.

The frequency generated by the oscillator is determined by the connection of the condenser 60 in multiple with the inductance 45 when the relay 180R is picked up so that the condenser 60 is connected in multiple with the inductance 45 through front contact 46 of relay 75R, back contact 47 of relay 120R, and front contact 48 of relay 180R. As has been heretofore pointed out, the frequency of the oscillator is adjusted by these selected circuits to

be just within the pass band of the respective high pass filters L–MPH, M–MPH, and H–MPH, respectively. The output of the oscillator is applied to the winding **18** of the frequency generator G through back contact **50** of relay DP.

With reference to Fig. 3, the output winding **19** of the generator G is connected directly to the input of a conventional push-pull amplifier. This amplifier can be of any suitable type so as to provide output power sufficient to insure proper operation of the detector relay D at times when the output frequency is high enough to fall within the pass bank of the selected high-pass filter in the circuit for the control of the detector relay D.

With reference to Fig. 1, one of the output wires is connected to ground, and the other is connected through contact selections and through the rectifier **51** to the winding of relay D. Thus, if it is assumed that the relays **75**R and **180**R are picked up, in accordance with the reception of the 180 track circuit code, the circuit for the control of relay D in accordance with the output of the amplifier is through front contact **52** of relay PR, front contact **53** of relay **75**R, back contact **54** of relay **120**R, front contact **55** of relay **180**R, high-pass filter H–MPH, front contact **56** of relay **180**R, back contact **57** of relay **120**R, front contact **58** of relay **75**R, front contact **59** of relay PR, and rectifier **51**.

If the relay **120**R is picked up instead of relay **180**R, in accordance with the reception of the 120 track circuit code, the circuit just described for the relay D is open at front contacts **55** and **56** of relay **180**R, and the relay D can be energized through front contact **52** of relay PR, front contact **53** of relay **75**R, front contact **54** of relay **120**D, back contact **61** of relay **180**R, filter M–MPH, back contact **62** of relay **180**R, front contact **57** of relay **120**R, front contact **58** of relay **75**R, front contact **59** of relay PR, and rectifier **51**.

If it is a 75 track circuit code that is being received, the circuit just described for the relay D is open at front contacts **54** and **57** of relay **120**R, and at front contacts **55** and **56** of relay **180**R, but the relay D can be energized through front contact **52** of relay PR, front contact **53** of relay **75**R, back contact **54** of relay **120**R, back contact **55** of relay **180**R, filter L–MPH, back contact **56** of relay **180**R, back contact **57** of relay **120**R, front contact **58** of relay **75**R, front contact **59** of relay PR, and rectifier **51**.

Relay D when picked up closes an obvious circuit at front contact **63** for the energization of its slow acting repeater relay DP, and the picking up of the relay DP opens the output circuit of the oscillator at back contact **50**. It will thus be seen that if the detector relay D is solely dependent for energization upon the oscillator, as when the speed of the train is below the limit determined by the track circuit code receiving apparatus in combination with the high-pass filters, the opening of contact **50** deenergizes the relay D and thus causes relay D to be dropped away, and thus causes the subsequent deenergization of relay DP by the opening of front contact **63**.

It is thus provided that the picking up of relay DP causes the dropping away of relay D, which in turn causes the dropping away of relay DP after a time determined by the slow acting characteristics of relay DP. In this manner, it will be seen that when the speed of the train is below the predetermined allowable speed limit, the relay D is intermittently operated, together with its repeater relay DP, and by the pulsing of contact **64** of relay DP, the control relay C is maintained picked up by the intermittent discharge of the condenser **36** (condenser **36** being charged through front contact **64** of relay DP). By the closure of front contact **65** of relay C, relay PR is maintained picked up, and the relay PR is effective when picked up to apply energy through its front contact **66** to the valve EPV so as to permit the air pressure in the brake control system to be maintained.

It will be noted from the organization that has been described, that the maintaining of the penalty relay PR picked up is dependent upon the relay C being maintained energized by the pulsing of contact **64** of the relay DP, and thus for normal operation of the train (without the brakes being applied) it is required that the relay DP be pulsed by its associated detector relay D as a check that continuity is maintained for a circuit extending through the winding **19** of the generator G, through the amplifier, contact selections, and selected filter to the winding of relay D. Thus it is determined that the relay D is conditioned to be steadily energized at any time when the frequency generated by the frequency generator G falls within the pass band of the particular high-pass filter selected to be included in the circuit in accordance with the restrictions required by the track circuit code receiving apparatus.

It it is assumed, for example, that while the detector relay D is pulsing in accordance with normal progress of the train below its speed limit for the particular area it is passing through, consideration will now be given to the condition where the speed of the train exceeds the speed permitted so that the frequency of the output of the generator G is above the frequency of the high-pass filters L–MPH, M–MPH, or H–MPH (whichever one has been selected). When this happens, with the high-pass filter including m-end sections as is illustrated in Fig. 4, and as has been heretofore described, immediately upon the frequency of the generator G exceeding the frequency of the selected high-pass filter, sufficient energy passes to the relay D from the generator G, through the filter, to maintain the relay D steadily energized.

As a margin of safety to insure that there will be sufficient energy to maintain the relay D energized by the output of the generator G, it is preferable that the relative voltages of the oscillator and generator G respectively as applied to the input terminals of the amplifier be substantially in the ratio of one to two respectively. In other words, a margin of safety is assured by the output voltage of the generator being substantially twice the output voltage of the oscillator.

When the relay D becomes steadily energized, its repeater relay DP becomes steadily energized because of the closure of front contact **63** of relay D, and thus the pulsing of contact **64** of relay DP ceases, with the result that the relay C is dropped away, and the dropping away of this relay opens the circuit for the penalty relay PR at front contact **65**.

With the relay C dropped away, a warning device (not shown) is actuated in accordance with the usual train control practice to advise the engineer that his speed must be reduced. Subsequent to the actuation of the warning device, it may be required that the engineer actuate acknowledging means, or take other steps in accordance with the requirements of practice in order to forestall an immediate emergency application of the brakes of the train. Such acknowledgment and suppressed braking means can be provided in accordance with the teachings of any one of a number of different prior patents.

For the purpose of simplification of the disclosure of the present invention, only a very simple form of suppressed braking has been illustrated as a typical example, and this is in the form of the service air reduction switch SAS which is actuated to close its contacts upon a manual application of the brakes so that the penalty relay PR can be held energized by a stick circuit including contact **70** of the air reduction switch SAS, and front contact **71** of the penalty relay PR. It is thus provided that the application of the brakes manually forestalls an automatic application by maintaining the penalty relay PR energized so as to maintain energy applied to the valve EPV through front contact **66**.

If, on the other hand, there was no manual application of the brakes when the speed exceeded the speed limit, the contact **70** of the air reduction switch SAS would have been open and thus the relay PR would have been

permitted to drop away, according to its slow drop away characteristics, after the opening of its circuit at front contact 65 of the control relay C. Thus relay PR when dropped away would have opened the circuit for the energization of the valve EPV at front contact 66 to cause the actuation of the valve to apply the brakes of the train in a manner well known to those familiar with the art.

If it is assumed that the penalty relay PR has been dropped away to cause an emergency application of the brakes of the train, the high pass filters are shunted out of the circuit for the control of the relay D by a connection through back contacts 52 and 59 of relay PR, and thus the relay D is maintained picked up by energy from the generator G, irrespective of the frequency of the generated voltage, until the train substantially comes to a stop so that there is insufficient voltage generated by the generator G to maintain the relay D energized. This condition will be recognized as that being comparable to the mode of operation generally required in train control systems where an automatic application of the brakes has been applied, which requires the train to be brought substantially to a stop before release of the brakes can become effective.

Thus, when the train reaches a very low speed so that the relay D becomes dropped away, the dropping away of its repeater relay DP by the opening of front contact 63 closes a circuit to connect the output of the oscillator to the winding 18 of the generator G, and thus the relay D becomes picked up as a result of energy feeding from the oscillator, and the intermittent operation of the relays D and DP is resumed as has been heretofore described, the relay D being energized at this time, however, through the shunt applied through back contacts 52 and 59 of the penalty relay PR, shunting the high-pass filters out of the circuit.

Upon the pulsing of contact 64 of relay DP, relay C becomes picked up, and the picking up of this relay is effective by the closure of its front contact 65 to cause the picking up of the penalty relay PR, which in turn applies energy to the valve EPV through front contact 66 so as to permit the release of the brakes of the train. The penalty relay PR in picking up removes the shunt applied in the circuit for the relay D across the high-pass filters by the opening of back contacts 52 and 59, and the closure of front contact 52 and 59 re-establishes the circuit for the normal operation of the relay D as it has been heretofore described.

It has been pointed out that the frequency of the oscillator is selected by contacts of the track circuit code receiving apparatus on the locomotive to correspond with, or fall just within the pass band of the respective selected high-pass filters. In this way, the integrity of the high-pass filters is checked by the oscillator on the side of safety in that should the frequency of the selected high-pass filter shift to a higher frequency than that for which the filter was originally designed, the filter would not pass the frequency of the oscillator because the oscillator frequency would then be below the frequency of the high-pass filter. Under these conditions, the relay C would become dropped away, and would cause an automatic application of the brakes should the penalty be applied.

It is particularly for this reason that the frequency of the oscillator is selected by the track code receiving apparatus, rather than being a fixed frequency sufficiently high to fall within the pass band of the highest speed high pass filter, H–MPH. It is to be understood, however, that if this feature of checking the integrity of the high-pass filters is not considered to be necessary, the oscillator can be operated at any predetermined frequency sufficiently high to fall within the pass band of the high-pass filter H–MPH.

The embodiment of the present invention illustrated in Fig. 2 discloses a system by which similar principles of train control can be applied using low-pass filters rather than high-pass filters, and employing the principle of having the respective low-pass filters cut out the energization of a detector relay D1 in case the frequency of the generator G1 becomes higher than the frequency passed by the selected low-pass filter. This arrangement is on the "fail safe" principle in that steady energization of the detector relay D by reason of a generated voltage of the generator G1 is always required for the energization of the valve EPV whenever the locomotive is in motion. However, this organization in itself does not provide for energization of the valve EPV when the locomotive is not in motion, and therefore the oscillator illustrated in Fig. 2 as generating a frequency *f1* is used for pulsing the relays DS and DSP by a mode of operation comparable to that which has been described for the pulsing of relays D and DP of Fig. 1, except that the intermittent operation of these relays is effective principally only when the locomotive is not in motion.

More specifically, the closure of back contact 75 of the relay DSP connects the output of the oscillator of Fig. 2 to the winding 33 of the generator G1, and a voltage is induced in the secondary winding 34 of the generator G1 which is applied through a pre-amplifier and through rectifier 76 to the detector relay DS. Relay DS in picking up causes the picking up of the relay DSP by the closure of front contact 77, relay DSP having slow pickup and drop away characteristics so as to provide by the selective opening and closing of back contact 75 in the output circuit of the oscillator for the intermittent operation of the relays DS and DSP. The pulsing of contact 78 of relay DSP alternately charges the condenser 35 and discharges it through the winding of relay C1 to cause the relay C1 to be picked up and close its front contact 79 to apply energy to the winding of the valve EPV.

It will be noted that the control relay C1 can be picked up to apply energy to the valve EPV through front contact 79 only so long as the relay DSP is intermittently actuated, and thus when the locomotive is in motion, the relay DSP fails to pulse, and the relay C1 is dropped away to open front contact 79. The relay DSP fails to pulse because the relay DS is steadily energized by the output voltage of the generator G1 that is generated due to motion of the train, and thus the front contact 77 of relay DS applies energy steadily to the repeater relay DSP.

When relay DS is picked up, the closure of its front contact 80 applies energy from the output terminals of the pre-amplifier to the amplifier illustrated in Fig. 2, and the output of this amplifier is applied through a selected low pass filter to the detector relay D1.

Thus, if a 75 code is being received, the output of the amplifier of Fig. 2 is applied to relay D1 through front contact 81 of relay 75R, back contact 82 of relay 120R, back contact 83 of relay 180R, low pass filter L–MPH, back contact 84 of relay 180R, back contact 85 of relay 120R, front contact 86 of relay 75R, and rectifier 87.

If it is a 120 rate code that is being received, the output of the amplifier of the organization according to Fig. 2 is applied to the relay D1 through front contact 81 of relay 75R, front contact 82 of relay 120R, back contact 88 of relay 180R, low pass filter M–MPH, back contact 89 of relay 180R, front contact 85 of relay 120R, front contact 86 of relay 75R, and rectifier 87.

If it is a 180 code rate that is being received, the relay D1 of Fig. 2 receives energy from the output of the amplifier through front contact 81 of relay 75R, back contact 82 of relay 120R, front contact 83 of relay 180R, low pass filter H–MPH, front contact 84 of relay 180R, back contact 85 of relay 120R, front contact 86 of relay 75R, and rectifier 87.

Relay D1 when picked up applies energy to the winding of the valve EPV through front contact 90 which is connected in multiple with front contact 79 of the relay C1. It will be seen that because of the slow drop away charac-

teristics of the relay C1, the detector relay D1 will have sufficient time to become picked up prior to the dropping away of the relay C1 when the locomotive is first put in motion, so that there is no interruption in the energization of the valve EPV.

It will be apparent from the circuit organization that has been described that the relay D1 is subject to deenergization whenever the speed of the locomotive is such that the frequency of the generator G1 exceeds the frequency of the low-pass filter selected in accordance with imposed speed restrictions of the track circuit code. Thus the dropping away of the relay D1 under these conditions is effective to cause the deenergization of the valve EPV to cause an emergency application of the brakes.

Although no suppressed braking means has been illustrated in the system according to Fig. 2, it is to be understood that any suitable system of suppressed braking and/or acknowledgment familiar to those skilled in the art may be employed, and that the organization involving the use of a penalty relay PR of Fig. 1 could as well be applied to the organization according to Fig. 2, except that the penalty relay would interrupt the circuit to the detector relay D rather than shunt the filters as in Fig. 1.

If the speed indicator SP is to be used as is illustrated in Fig. 2, the frequency *f*1 of the oscillator must be above the frequency generated by the generator G1 at the highest speed of the train. Under these conditions relay D1 is at no time subject to operation by energy from the oscillator, because this frequency *f*1 is above the frequency of any of the low-pass filters L–MPH, M–MPH, or H–MPH.

Having described a train speed control system with reference to two specific embodiments, it is desired to be understood that the forms disclosed have been selected to facilitate the disclosure of the invention, particularly as to the principles involved, rather than to limit the number of forms which the invention may assume, and it is to be further understood that various adaptations, alterations, and modifications may be applied to the specific forms shown to meet the requirements of practice, without in any manner departing from the spirit or scope of the present invention, except as limited by the appending claims.

What I claim is:

1. A train control system having train carried apparatus comprising in combination, an axle driven frequency generator, an electro-pneumatic valve effective when deenergized to cause application of the brakes of the train, a condenser, a slow acting relay effective when picked up to cause energization of said electro-pneumatic valve, said slow-acting relay being subject to energization only by the discharge of said condenser, a high-pass filter, an oscillator effective to generate a given frequency within the pass band of said high-pass filter, a two-position control relay having contacts effective in one position to charge said condenser and in the other position to discharge said condenser through the winding of said slow-acting relay, and electro-responsive means for intermittently energizing said two-position control relay from said oscillator through said high-pass filter and thereby maintain said electro-pneumatic valve energized, said electro-responsive means being effective to steadily energize said two-position control relay when the frequency of said generator is above the frequency of said high-pass filter and thereby cause the actuation of said electro-pneumatic valve to apply the brakes of the train.

2. A train speed control system having train carried equipment comprising in combination, an axle driven frequency generator, an electro-pneumatic brake control valve effective when deenergized to cause the application of the brakes of the train, a control relay for said brake control valve effective when picked up to maintain said brake control valve energized, and effective when dropped away to cause the deenergization of said brake control valve, electro-responsive receiving apparatus distinctively actuated in accordance with the code rate of energization of the track rails, a high-pass filter, and electro-responsive means including said high-pass filter for maintaining said control relay steadily picked up to thereby energize said electro-pneumatic valve except when the frequency of the output of said axle driven generator falls within the band pass of said high-pass filter.

3. A train control system having train carried apparatus comprising in combination, an axle driven frequency generator, an electro-pneumatic valve effective when deenergized to cause application of the brakes of the train, a plurality of filters, each filter being effective to block a different range of frequencies, track circuit code receiving means effective to select one of said filters dependent upon the particular track circuit code rate receiver, a detector relay having a slow acting repeater relay, an oscillator having its output applied to a winding of said generator through a contact of said repeater relay, circuit means including a winding of said generator and said selected one of said filters for energizing said detector relay and thereby actuate said slow acting relay to open said contact in the output of said oscillator, a control relay, circuit means for maintaining said control relay picked up only provided that said slow acting relay is intermittently actuated, and circuit means dependent upon said control relay being picked up for energizing said electro-pneumatic valve.

4. A train control system having train carried apparatus comprising in combination, an axle driven frequency generator, an electro-pneumatic valve effective when deenergized to cause application of the brakes of the train, a filter effective to block frequencies outside of a particular predetermined frequency range, a detector relay having a slow acting repeater relay, an oscillator having its output applied to a winding of said generator through a circuit including a contact of said slow acting relay, circuit means including a winding of said generator and said filter for energizing said detector relay and thereby actuate said slow acting relay to open said contact in the output circuit of said oscillator, a control relay, circuit means for maintaining said control relay picked up only when said repeater relay is intermittently actuated, and circuit means dependent upon said control relay being picked up for energizing said electro-pneumatic valve.

5. A train control system having train carried apparatus comprising in combination, an axle driven frequency generator, an electro-pneumatic valve effective when deenergized to cause application of the brakes of the train, a plurality of filters, each filter being effective to block a different range of frequencies, track circuit code receiving means effective to select one of said filters dependent upon the particular track circuit code received, a detector relay having a slow acting repeater relay, circuit means including said selected one of said filters for energizing said detector relay from the output of said generator, an oscillator having its output applied to said circuit means through a contact of said repeater relay to thereby cause actuation of said repeater relay intermittently except when said detector relay is energized by the output of said frequency generator, a control relay, circuit means for maintaining said control relay picked up provided that said repeater relay is intermittently actuated, and circuit means for energizing said electro-pneumatic valve provided that said control relay is picked up.

6. A train control system having train carried apparatus comprising in combination, an axle driven frequency generator, an electro-pneumatic valve effective when deenergized to cause application of the brakes of the train, a plurality of high-pass filters respectively effective to pass current above different frequencies, track circuit code receiving means effective to select one of said filters dependent upon the particular track circuit code received, a filter having a lower frequency pass band being selected for a lower rate code, a detector relay having a slow acting repeater relay, circuit means including the filter selected by said receiving means for energizing said

detector relay from the output of said generator, an oscillator generating a frequency falling within the pass band of the selected high-pass filter having its output applied through a back contact of said repeater relay to said circuit means to check the integrity of the circuit means for the energization of said detector relay from said generator, whereby said repeater relay is intermittently actuated by reason of energy originating at said oscillator, a control relay, circuit means for maintaining said control relay picked up provided that said repeater relay is intermittently actuated, and circuit means for energizing said electro-pneumatic valve provided that said control relay is picked up.

7. A train control system having train carried apparatus comprising in combination, an axle driven frequency generator, an electro-pneumatic valve effective when deenergized to cause application of the brakes of the train, a plurality of filters, each filter being effective to block a different range of frequencies, train control receiving apparatus effective to be conditioned by cooperative electrical control with wayside apparatus, said receiving apparatus being effective to select one of said filters, a detector relay having a slow acting repeater relay, circuit means including the filter selected by said receiving apparatus for energizing said detector relay from the output of said generator when the output frequency is high enough to fall within the pass band of the selected filter, an oscillator generating a frequency above the frequency of the selected filter having its output applied through a back contact of said repeater relay to said circuit means to check the integrity of the circuit means for the energization of said detector relay from said generator, whereby said repeater relay is intermittently actuated by reason of energy originating at said oscillator, a control relay, circuit means for maintaining said control relay picked up provided that said repeater relay is intermittently actuated, and circuit means for energizing said electro-pneumatic valve provided that said control relay is picked up.

8. A train control system having train carried apparatus comprising in combination, an axle driven frequency generator, an electro-pneumatic valve effective when deenergized to cause application of the brakes of the train, a high-pass filter effective to pass frequencies above a particular frequency comparable to a speed limit frequency of said axle driven generator, a detector relay having a slow acting repeater relay, circuit means including said filter for energizing said detector relay from the output of said generator when the frequency of the generator is above the frequency of said filter, an oscillator generating a frequency within the pass band of said filter having its output applied through a back contact of said repeater relay to said circuit means to check the integrity of the circuit means for the energization of said detector relay from said generator, whereby said repeater relay is intermittently actuated only when the frequency of said generator is below the pass band of said filter, a control relay, circuit means for maintaining said control relay picked up provided that said repeater relay is intermittently actuated, and circuit means dependent upon said control relay being picked up for energizing said electro-pneumatic valve.

9. A train control system having train carried apparatus, comprising in combination, an axle driven frequency generator, an electro-pneumatic valve effective when deenergized to cause application of the brakes of the train, a plurality of high-pass filters for different frequencies comparable to frequencies of said generator at predetermined train speeds, train control receiving apparatus effective to be conditioned by cooperative electrical control with wayside apparatus, said receiving apparatus being effective to select one of said high-pass filters, an oscillator generating a frequency within the pass band of the selected high-pass filter, a detector relay having a slow acting repeater relay, circuit means for energizing said detector relay from the output of said oscillator through said selected filter provided that said repeater relay is actuated to a particular position, whereby said detector relay is intermittently energized at a rate determined by the slow acting characteristics of said repeater relay, said circuit means also rendering said detector relay subject to energization from said generator through said selected filter when the frequency of the generator is within the pass band of the filter, and electro-responsive means for maintaining said electro-pneumatic valve energized provided that said detector relay is intermittently actuated.

10. In a train control system, train carried apparatus comprising in combination, an axle driven frequency generator, an electro-pneumatic valve effective when deenergized to cause application of the brakes of the train, a plurality of high-pass filters for different pass bands starting at the respective frequencies of said generator at predetermined train speeds, an oscillator, train control receiving apparatus effective to be conditioned in response to wayside apparatus, said receiving apparatus being effective to select one of said high-pass filters, and said receiving means being effective to select a frequency for said oscillator substantially corresponding to the boundary frequency between pass and stop of the filter selected, a detector relay having a slow acting repeater relay, circuit means including the filter selected by said receiving apparatus for energizing said detector relay by the output of said generator, whereby said detector relay is picked up by energy from said generator only when the frequency of the generator is within the pass band of the selected filter, said circuit means also being effective to energize said detector relay by the output of said oscillator through a contact of said repeater relay, and through said selected filter, and electro-responsive means for maintaining said electro-pneumatic valve energized provided that said detector relay is intermittently actuated.

11. In a train control system, train carried apparatus comprising in combination, an axle driven frequency generator, an electro-pneumatic valve effective when deenergized to cause application of the brakes of the train, a plurality of low-pass filters for different frequencies comparable to the frequencies of said generator at predetermined train speeds, train control receiving apparatus operable in response to wayside apparatus, said receiving apparatus being effective to select one of said low-pass filters, an oscillator, a first detector relay and an associated repeater relay, circuit means for energizing said first detector relay by the output from said generator, and from the output of said oscillator, means responsive to the actuation of said repeater relay to a particular position for rendering said oscillator ineffective to apply an output to said circuit means, whereby said first detector relay is steadily energized when there is an output from said generator and is pulsed when there is no output from said generator, a second detector relay, circuit means for energizing said second detector relay by the output of said generator through a contact of said first detector relay and the low-pass filter selected by said receiving apparatus, and circuit means for maintaining said electro-pneumatic valve energized in response to the intermittent operation of said repeater relay and in response to the energization of said second detector relay.

12. A train speed control system having train carried apparatus comprising in combination, an axle driven frequency generator, an electro-pneumatic valve effective when deenergized to cause application of the brakes of the train, a condenser, a slow drop away relay effective when picked up to energize said electro-pneumatic valve, said slow drop away relay being subject to energization only by the discharge of said condenser, a high-pass filter, an oscillator effective to generate a frequency above the pass band of said high-pass filter, a condenser charge-discharge control relay having contacts selecting respectively the charge of said condenser and the discharge of said condenser across the winding of said slow drop away

relay, electro-responsive means effective to energize said charge-discharge control relay intermittently by energy from said oscillator feeding through said high-pass filter, said electro-responsive means being effective to steadily energize said charge-discharge control relay by energy from said generator feeding through said filter when the frequency of the generator is above the frequency of the high-pass filter, whereby the steady energization of said charge-discharge control relay by reason of the frequency of the frequency generator being within the pass band of said high-pass filter causes the dropping away of said slow drop away relay and the actuation of said electro-pneumatic valve to apply the brakes of the train.

13. A train speed control system having train carried apparatus comprising in combination, an axle driven frequency generator, an electro-pneumatic brake control valve effective when deenergized to cause the application of the brakes of the train, a control relay for said brake control valve effective when energized to maintain said electro-pneumatic brake control valve energized and effective when deenergized to cause the deenergization of said electro-pneumatic brake control valve, electro-responsive receiving apparatus distinctively actuated in accordance with the character of energization of the track rails, a high-pass filter, and circuit means including said high-pass filter for maintaining said control relay picked up to thereby energize said electro-pneumatic valve except when the frequency of said frequency generator is at a frequency within the pass band of said high-pass filter.

14. In a train control system, train carried apparatus comprising, and axle driven frequency generator, an electro-pneumatic valve effective when deenergized to cause application of the brakes of the train, a filter effective to block frequencies outside of a particular frequency range, a detector relay having a slow acting repeater relay, an oscillator having its output applied to a winding of said generator, means effective upon the actuation of said repeater relay for rendering said oscillator ineffective to provide an output to said winding of said generator, circuit means including a winding of said generator and said filter for energizing said detector relay and thereby actuate said slow acting relay to render the output of said oscillator ineffective, a control relay, circuit means for maintaining said control relay picked up only when said repeater relay is actuated at frequent intervals, and circuit means dependent upon said control relay being picked up for energizing said electro-pneumatic valve.

15. In a train control system, train carried apparatus comprising, an axle driven frequency generator, an electro-pneumatic valve effective when deenergized to cause application of the brakes of the train, a plurality of filters, each filter being effective to block a different range of frequencies, track circuit code receiving means effective to select one of said filters dependent upon the particular track circuit code received, a detector relay having a slow acting repeater relay, circuit means including the filter selected by said track code receiving means for energizing said detector relay from the output of said generator, an oscillator having its output applied to said circuit means, means effective upon the actuation of said repeater relay for rendering said oscillator ineffective to provide an output to said circuit means to thereby cause actuation of said repeater relay intermittently except when said detector relay is steadily energized by the output of said frequency generator, a control relay, circuit means for maintaining said control relay picked up provided that said repeater relay is intermittently actuated, and circuit means for energizing said electro-pneumatic valve provided that said control relay is picked up.

16. In a train control system, train carried apparatus comprising, an axle driven frequency generator, an electro-pneumatic valve effective when deenergized to cause application of the brakes of the train, a plurality of high-pass filters respectively effective to pass current above different frequencies, track circuit code receiving means effective to select one of said filters dependent upon the particular track circuit code received, a filter having a lower frequency pass band being selected for a lower rate code, a detector relay having a slow acting repeater relay, circuit means including the filter selected by said receiving means for energizing said detector relay from the output of said generator, an oscillator generating a frequency high enough to fall within the pass band of the selected high-pass filter, said oscillator having its output applied to said circuit means to check the integrity of the circuit means for the energization of said detector relay from said generator, means responsive to the actuation of said repeater relay for rendering said oscillator ineffective to provide an output to said circuit means, whereby said repeater relay is intermittently actuated by reason of energy originating at said oscillator, a control relay, circuit means for maintaining said control relay picked up provided that said repeater relay is intermittently actuated, and circuit means for energizing said electro-pneumatic valve provided that said control relay is picked up.

17. In a train control system, train carried apparatus comprising, an axle driven frequency generator, an electro-pneumatic valve effective when deenergized to cause application of the brakes of the train, a plurality of filters, each filter being effective to block a different range of frequencies, train control receiving apparatus effective to be conditioned inductively by wayside apparatus, said apparatus being effective to select one of said filters, a detector relay having a slow acting repeater relay, circuit means including the filter selected by said receiving apparatus for energizing said detector relay as a result of the output of said generator when the output of the generator is high enough to fall within the pass band of the selected filter, an oscillator generating a frequency within the pass band of said selected filter having its output applied to said circuit means for checking the integrity of the circuit means for the energization of said detector relay as a result of the output of said generator, means responsive to the actuation of said repeater relay for rendering said oscillator ineffective to provide an output to said circuit means, whereby said repeater relay is intermittently actuated as a result of the output of said oscillator and is steadly picked up as a result of a frequency output of said generator high enough to fall into the pass band of the selected filters, a control relay, circuit means for maintaining said control relay picked up provided that said repeater relay is intermittently actuated and circuit means for energizing said electro-pneumatic valve provided that said control relay is picked up.

18. In a train control system, train carried apparatus comprising, an axle driven frequency generator, an electropneumatic valve effective when deenergized to cause application of the brakes of the train, a high pass filter effective to pass frequencies above a particular frequency comparable to a speed limit frequency of said axle driven generator, a detector relay having a slow acting repeater relay, circuit means including said filter for energizing said detector relay in response to the output of said generator when the frequency of the generator is above the frequency of said filter, an oscillator generating a frequency within the pass band of said filter, said oscillator having its output applied to said circuit means to thereby govern said detector relay, means responsive to the actuation of said repeater relay for rendering said oscillator ineffective to provide an output to said circuit means, whereby said repeater relay is subject to intermittent actuation in response to the output of said oscillator and is subject to steady energization when the frequency of said axle driven generator is high enough to fall into the pass band of said filter, and circuit means for maintaining said electro-pneumatic valve energized provided that said detector relay is actuated at frequent intervals.

19. A train control system having train carried apparatus comprising in combination, an axle driven frequency generator, an electropneumatic valve effective when deenergized to cause application of the brakes of a train, a plurality of filters for blocking different ranges of frequencies respectively, track circuit code receiving means effective to select one of said filters in accordance with the particular track circuit code received, a detector relay having a slow acting repeater relay associated therewith, an oscillator, circuit means for energizing said detector relay by the output generated by said frequency generator when it is being driven, and said circuit means being effective when said generator is not being driven to intermittently energize said detector relay in accordance with the output of said oscillator, the output of said oscillator being intermittently opened by a contact of said slow acting repeater relay, control means for governing the energization of said

electropneumatic valve, said control means being effective to maintain said electropneumatic valve steadily energized when said generator is not being driven in accordance with the intermittent operation of said detector relay, and said control means being effective when said generator is being driven to deenergize said electropneumatic valve when the frequency of the output of said generator exceeds a limit determined by a selected one of said filters.

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