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(19)

(54) AUTOMATIC CONTROL INSTALLATIONS FOR VEHICLES

(71) We, ENGINS MATRA, a French body corporate, of 4, rue de Presbourg, Paris, France, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:–

The present invention relates to automatic control installations for vehicles movable along tracks provided with vehicle presence detectors.

A number of automatic control installations for vehicles, such as trains, have already been developed and are in use. For the detection of the presence of trains, virtually all of these utilise short-circuiting by train axles, using so-called 'track circuits' constituted by the rails, a transmitter and a receiver.

Speed information is transmitted to the trains in accordance with one of the two following systems:

–energisation of one or two cables placed on the track and provided with geometrical markers (for example cable crossings in the case of two cables) which can be detected by the trains. An automatic driving mechanism controls the speed of the train in such a way that the train detects these markers at constant time intervals. The cable or cables are so disposed with respect to the track that it is possible, as required, to permit the trains to continue their normal running or stop them, as a function of the occupation of downstream sections. Moreover, modulation of the signal energising the track cable makes it possible to transmit special information to the trains.

–transmission of speed information to the trains by modulating signals transmitted by the track circuits.

These two systems make it possible to obtain good performance, but necessitate a large amount of fixed equipment, both for the detection of the trains by means of the track circuits and for accomplishment of the automatic driving function.

More recently, another system requiring only little fixed equipment has been developed for the Lille underground railway system in France. In this system, each train itself determines its position by counting passive markers located on the track and transmits this position to other trains. This system, which forms the subject of Franch patent applications 7 301 345, 7 324 010, 7 344 907 and 7 504 748, makes it possible to obtain a short gap between successive trains, but still ensuring a high safety level. However, it could only be extended with difficulty to existing railway systems or to extensions thereof, because existing tracks are already equipped with signalling circuits of a conventional nature. Moreover, detection by track circuits in which the train is entirely passive makes it possible to associate without difficulty automatically driven trains with manually driven trains or work trains.

According to the present invention there is provided an automatic control installation for vehicles movable along a track provided with vehicle presence detectors, wherein the track is divided into sections controlled by a single fixed apparatus which can communicate with the vehicles in the direction from the track to the vehicle by way of a transmission line that has crossings at given points to define track segments whose lengths are dependent on the track gradient, and wherein the fixed apparatus comprises a transmission device for transmitting, via the transmission line, information at a first frequency indicating the state of occupation of the segments, information at a second frequency indicating limit speeds, synchronisation signals at a third frequency, and coded signals, for driving the train, at a fourth frequency, each vehicle having driving means comprising a position determining device equipped with a counter for counting the number of crossings of the transmission line by the vehicle, a first comparator for comparing the vehicle position with information transmitted at the first frequency in order to deduce therefrom safe stopping information and a second comparator for comparing the said vehicle position with information supplied by the coded signals at the fourth frequency.

A preferred embodiment of the invention described hereinbelow detects trains by means of track circuits or any other presence detector (pedal, axle counter, etc) and is of high performance from the standpoints of safety and providing a limited gap between successive trains. The preferred installation can control trains which have different braking and traction characteristics. The preferred embodiment limits the speeds of the trains with high precision, and has a high degree of regulating flexibility.

The preferred installation is of high reliability, due particularly to the use of a certain number of already proven pieces of equipment, and has good compatibility with fixed equipment forming part of the infrastructure of existing installations, in particular track circuits.

The present invention will now be described in greater detail, by way of example, with reference to an automatic control installation embodying the invention for trains moving along a track provided with presence detectors in the form of track circuits, the installation being shown in the accompanying drawings, in which:

Figure 1 is a block diagram of the installation embodying the invention;

Figure 2 is a diagram of signals transmitted at respective frequencies F1, F2, F3 and F4;

Figure 3 shows the coding of coded signals transmitted at the frequency F4 with various possible meanings; and

Figure 4 is a speed diagram as a function of successive track segment limits, and shows in particular a programme followed by the train and emergency braking, current interruption (de-energisation) and preparation for current interruption (anticipated de-energisation) thresholds.

In the installation shown in block diagram form in Figure 1 and which serves for the automatic control of the driving of trains moving along tracks with which are associated presence detectors, such as track circuits (not shown), the track is divided into sections controlled by a single fixed apparatus 1 which communicates with the trains in the direction from the track to the locomotive of the train by means of a transmission line 2 that has crossings at given points to define track segments whose lengths depends on the track gradient. The fixed apparatus 1 has a transmission device for transmitting via the transmission line 2 information at different frequencies F1, F2, F3 and F4. Each locomotive has driving means 3, including a position determining device equipped with a transmission line crossings counter operative to count the number of times the locomotive crosses the transmission line 2 and comparators for comparing the locomotive position with information transmitted at the frequency F1 in order to deduce therefrom safe stopping information (i.e. the distance necessary to stop short of an earlier train as indicated by the information at the frequency F1) and also for comparing the position of the locomotive with information for driving the train supplied by coded signals at the frequency F4. Each locomotive also has on board safety devices 4. Interface devices 5 make it possible to adapt (i.e. render compatible) the fixed devices and the on-board devices. The transmission line 2 responsible for the track-locomotive transmission may be a high frequency cable.

The on-board safety devices 4 comprise a spacing safety device which controls the interruption of traction and/or emergency braking as a function of the number of segments separating a train from a stopping point, and a safety speed limiting device which compares the actual speed of the train with a limit speed and which can also control emergency braking.

The spacing safety device comprises a current interrupting means for deenergising electric drive motors of the train to discontinue traction if the speed of the train in any segment exceeds a predetermined deenergisation threshold, a speed programme for providing deenergisation thresholds for successive thresholds, an emergency braking means operative to effect emergency braking if the speed of the train in any segment exceeds an emergency braking threshold which is the same as the deenergisation threshold but displaced by one segment in the downstream direction, and means to provide for each segment an 'anticipated deenergisation' threshold for the following segment, as described below with reference to Figure 4.

The driving means 3 of each vehicle also comprises a computing/memory device for calculating stopping distances and a device for measuring the length of a segment. The length of each segment is chosen in such a way that it is dependent on the track gradient. More specifically, the length is inversely proportional to the deceleration which is required to slow the train by a predetermined amount so that the number of segments necessary for stopping is independent of the gradient. The driving means 3 also comprises a smoothing device for smoothing-out step-wise decreasing speed information occurring during slowing down as a result of the occupation of a track section ahead of the train by another train.

In order to obtain a good compatibility with existing fixed installations, more particularly track circuits, the latter are used solely as presence detectors, i.e. they are not used to transmit information to the train.

To adapt the structure described hereinbefore for use with a different type of train, it is merely necessary to modify the memories of the stopping distance computing/memory devices and the interface devices 5 for rendering compatible all the fixed and on-board equipment.

In the presently described embodiment, the track is subdivided into 1 to 2 km sections.

The transmission line 2 which serves for communication between the fixed apparatus 1 and the vehicle is crossed at relatively regular intervals, the distance between crossings being 20 m on the level. Hereinafter, the gap between two crossings of the transmission line is called a 'segment'.

The segment length differs in the case of upgrades and downgrades in such a way that it is inversely proportional to the deceleration required of the train to slow it by a predetermined amount, so that calculation of the stopping distances, expressed in segments, is independent of the gradient.

The segment length is equal to:

—14 m on an upgrade of 35/1000 for a deceleration γF of 1 m/s^2;

—20 m on the level for a deceleration γF of 0.7 m/s^2; and

—35 m on downgrade of 35/1000 for a deceleration γF of 0.4 m/s^2.

On the basis of fixed starting points corresponding to the starting points of the sections, each train determines its absolute position on the section by counting the crossings of the transmission line.

This position is compared with the stopping positions deduced from the information transmitted at frequency F1 in order to deduce therefrom the safe stopping information, and with the information supplied by the coded signals at frequency F4 for driving the train.

The respective frequencies F1, F2, F3, F4 which the transmission device transmits from the single apparatus 1 provide the following information to the trains (Figure 2):

—frequency F1: series transmission of the occupation of the track segments. Each section must correspond to a whole number of segments. The occupation of the section by another train which is detected by means of the track circuits which are connected to the apparatus 1 otherwise than by the transmission line 2, is transmitted to the train as simulating the occupation of the first segment of the section. This tranmsission is performed by ON/OFF amplitude modulation. An example of the corresponding subdivision of the track into segments and sections is shown on the respective scales *s* and *c* below the diagram of F1. For the sake of simplicity this view shows only three segments per section, though in practice the number of segments per section will generally be considerably greater.

—Frequency F2: transmission of a safe limit or maximum speed associated with the track, which is unchanged throughout a section, but which can vary in time as a function of the position of the trains known by means of the track circuits. Transmission is effected by varying the duration of transmission of a recurrent high frequency signal.

—Frequency F3: transmission of a safety synchronisation signal making it possible to correctly interpret the signals transmitted at frequencies F1 and F2. Frequency F3 can also be used for controlling the zeroing of the crossing counters. The synchronisation signal is in that case transmitted in the form of a single pulse.

—Frequency F4: transmission by coded signal of all the information necessary for the driving functions of the train: position of stations and access to stations, limit speeds, occupation of sections, etc. The modulation used is frequency modulation, the coded signals being constituted by binary information with two-phase coding. Each coded signal consists of 16 bit positions used in the following manner (Figure 3A):

—type of coded signal (position of stations, change of limit speed associated with the track, position of a stopping point when section occupied): first 2 bit positions;

—complementary code (type of station, value of new limit speed, etc.): next 6 bit positions; and

—reference of a point on the track: 8 positions. For example, it is possible to transmit coded signals relating to:

—station position PS (Figure 3B), after the 'type of coded signal bits' and, as a complementary code, access positions to a station;

—a limit speed change PC (Figure 3C) and the value of the new limit speed; and

—a stopping position PA on an occupied section or a wrongly positioned track shunting (Figure 3D).

The driving of the trains is ensured on the basis of:

—coded signals at frequency F4;

—a train position signal communicated by the safety spacing device (counting of the number of crossings of the transmission line) and the position of stations and limited speed zones; and

—the measurement of the length of the segments for determining decelerations which must be brought about during slowing down operations.

As indicated hereinbefore, safety is ensured by the safety spacing device and by the speed limiting device.

On slowing down due to the occupation of a section, the train sees successively decreasing speed indications, which are smoothed by the driving means 3.

According to Figure 4, the safety spacing device provides three pieces of information corresponding to three speed thresholds for each segment such as *n:*

—an anticipated deenergisation threshold (CCA_n) for preparing for deenergising, if necessary, in the following segment (n + 1);

—deenergisation threshold (CC_n) for the current threshold (n); and

—an emergency braking threshold (FU_n) for the current segment (n): the same threshold as deenergisation, but displaced in the downstream direction ($FU_{n+1} = CC_n$).

These three thresholds are staggered in time by one track segment relative to one another. Figure 4 shows these three thresholds ('anticipated deenergisation' (CCA), 'deenergisation (CC)' and 'emergency braking' (FU)) in each segment corresponding respectively to a speed programme (PT) followed by the train between approximately 60 and 0 km/h.

When a train receives an order to stop at a point on the track it retains in a memory the corresponding segment number until another validated coded signal is received in which no mention is made of this stopping point.

WHAT WE CLAIM IS:–

1. An automatic control installation for vehicles movable along a track provided with vehicle presence detectors, wherein the track is divided into sections controlled by a single fixed apparatus which can communicate with the vehicles in the direction from the track to the vehicle by way of a transmission line that has crossings at given points to define track segments whose lengths are dependent on the track gradient, and wherein the fixed apparatus comprises a transmission device for transmitting, via the transmission line, information at a first frequency indicating the state of occupation of the segments, information at a second frequency indicating limit speeds, synchronistaion signals at a third frequency, and coded signals, for driving the train, at a fourth frequency, each vehicle having driving means comprising a position determining device equipped with a counter for counting the number of crossings of the transmission line by the vehicle, a first comparator for comparing the vehicle position with information transmitted at the first frequency in order to deduce therefrom safe stopping information, and a second comparator for comparing the said vehicle position with information supplied by the coded signals at the fourth frequency.

2. An installation according to claim 1, wherein the information as to the state of occupancy of the segments is effected, in use, by ON/OFF amplitude modulation.

3. An installation according to claim 1 or claim 2, wherein the transmission line is a high frequency cable.

4. An installation according to any one of claims 1 to 3, wherein each vehicle has on-board safety devices comprising a safety spacing device operative to interrupt traction and/or effect emergency braking as a function of the number of segments separating a train from a stopping point, and a safety speed limiting device operative to compare the actual speed of the train with a limit speed and which can also effect emergency braking.

5. An installation according to claim 4, wherein the safety spacing device has a current interrupting means for deenergising an electric drive means of the vehicle and thus discontinuing traction if the speed in any segment exceeds a predetermined deenergisation threshold, a speed programme for providing deenergisation thresholds for successive segments, an emergency braking means operative to effect emergency braking if the speed in any segment exceeds an emergency braking threshold which is the same as the deenergisation threshold but displaced by one segment in the downstream direction, and means to provide for each segment an anticipated deenergisation threshold for the following segment.

6. An installation according to any one of claims 1 to 5, wherein the driving means of each vehicle comprises a stopping distance memory.

7. An installation according to any one of claims 1 to 6, wherein the driving means of each vehicle comprises a device for measuring the lengths of the segments.

8. An installation according to any one of claims 1 to 7, wherein the length of each secment is dependent on the track gradient in such a way that it is inversely proportional to the deceleration which is required to slow the train by a predetermined amount, so that the number of segments necessary for stopping is independent of the gradient.

9. An installation according to any one of claims 1 to 8, wherein the transmission device is operative to transmit information at the third frequency to control zeroing of the crossings counter.

10. An installation according to any one of claims 1 to 9, wherein the driving means comprises a smoothing device for smoothing-out step-wise decreasing speed information which occurs during a speed reduction due to occupation of a track section ahead of the vehicle by another vehicle.

11. An automatic control installation for vehicles movable along a track provided with vehicle presence detectors, the installation being substantially as herein described with reference to the accompanying drawings.

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Fig.1

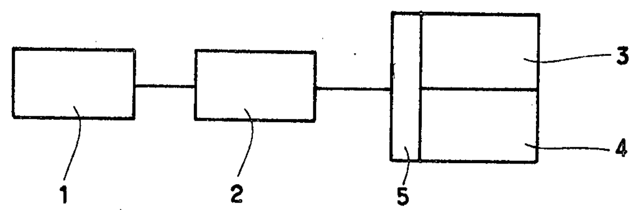
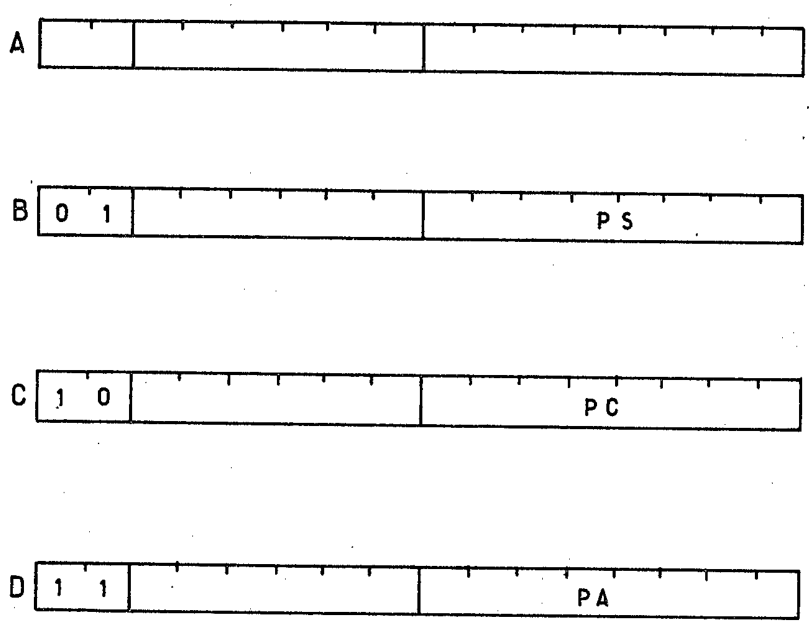


Fig.3



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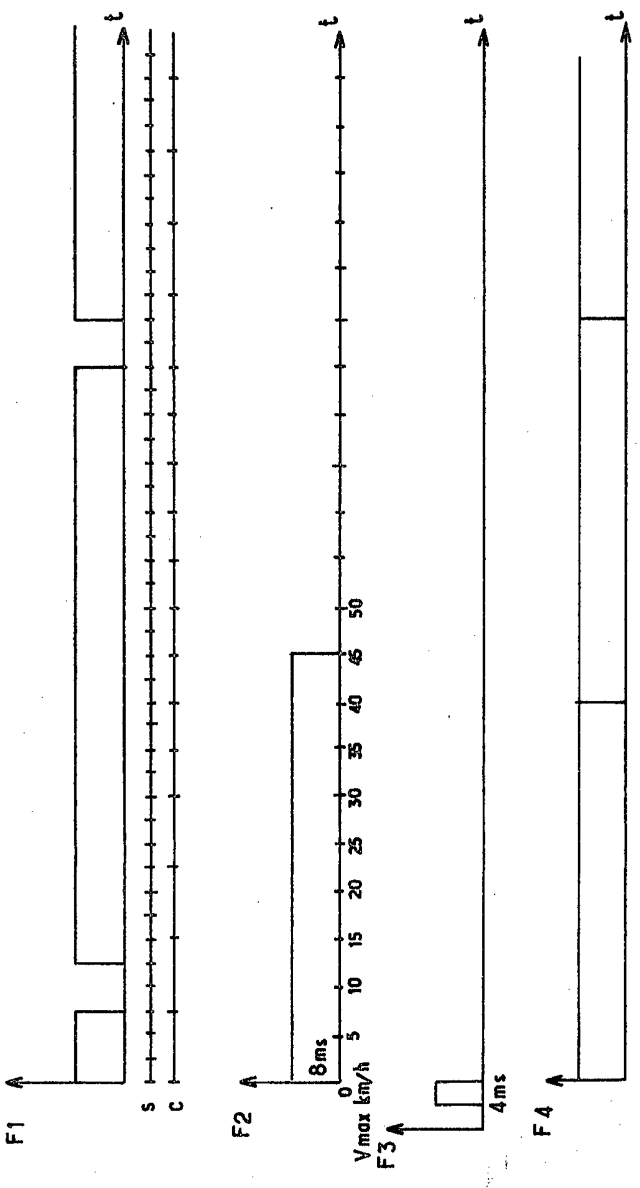
3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

Fig_2



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Sheet 3

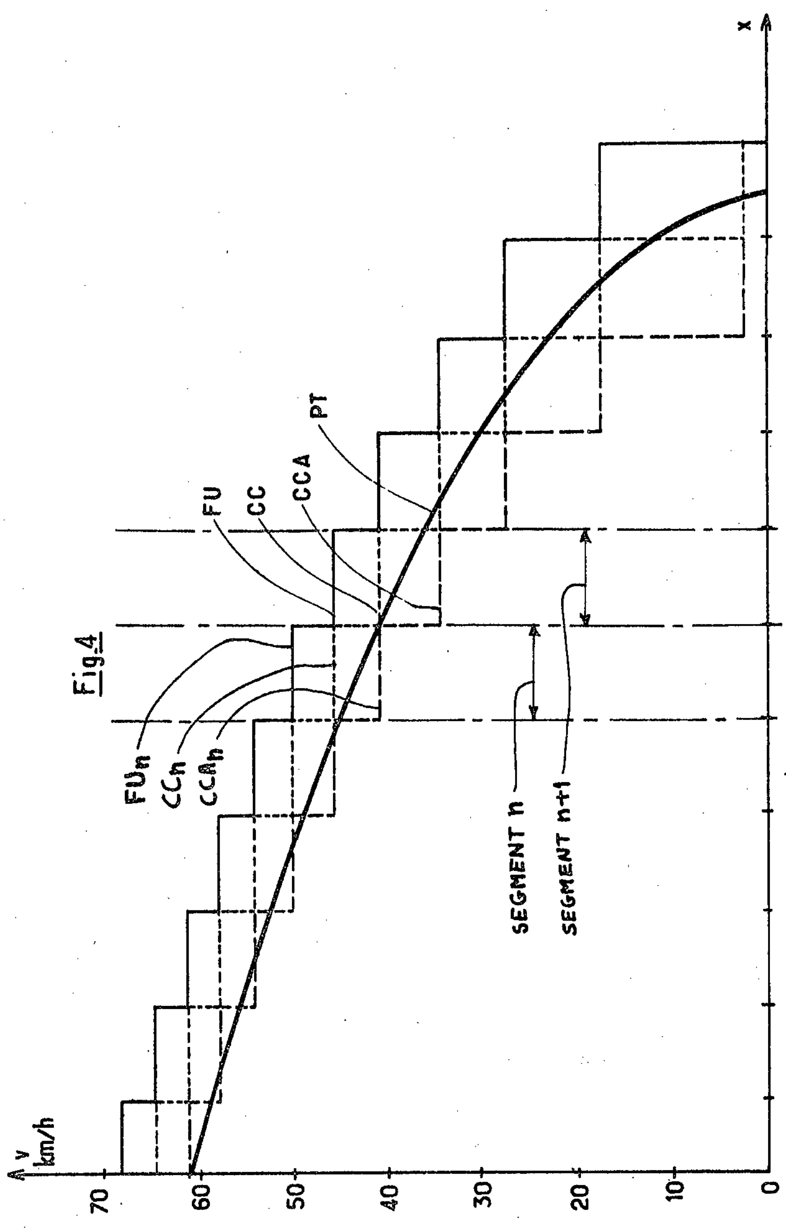

Fig.4