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(54) **REMOTE CONTROL SYSTEM FOR A LOCOMOTIVE**

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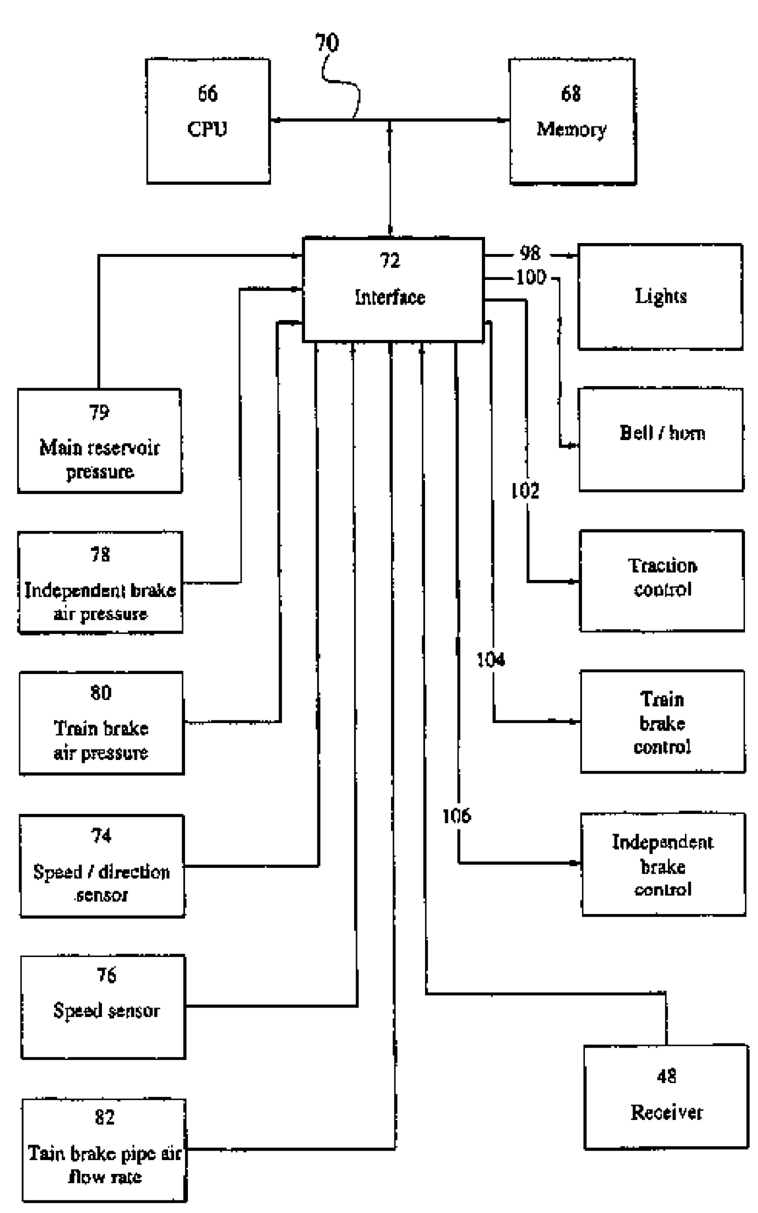
(57) **ABSTRACT**

A locomotive control system comprising a remote transmitter issuing RF binary-coded commands and a slave controller mounted on the locomotive that decodes the transmission and operates in dependence thereof various actuators to carry into effect the commands of the ground based operator.

50 Claims, 17 Drawing Sheets



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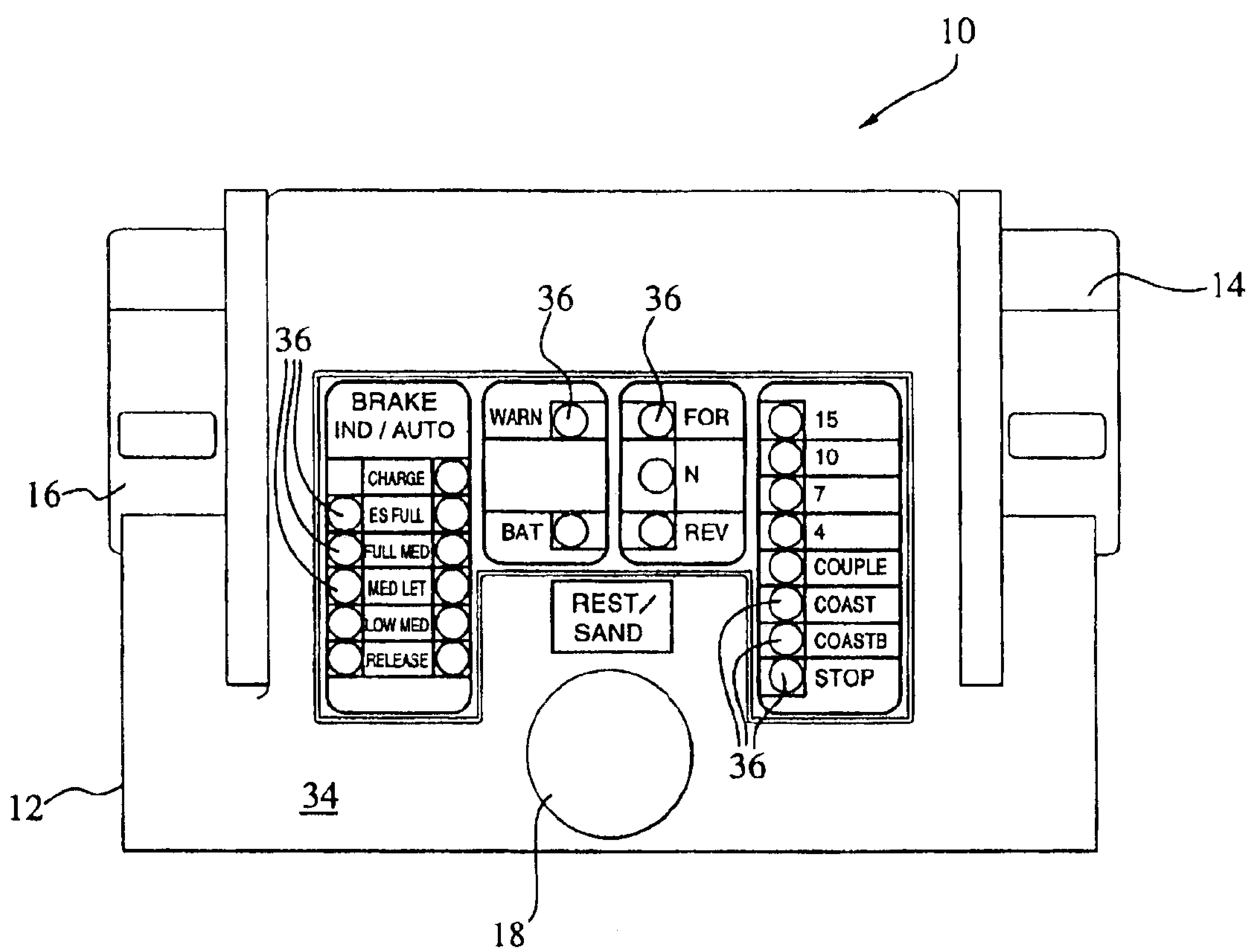

10
14
16
12
18
34
36
BRAKE
IND / AUTO
CHARGE
ES FULL
FULL MED
MED LET
LOW MED
RELEASE
WARN
BAT
FOR
N
REV
15
10
7
4
COUPLE
COAST
COASTB
STOP
REST/
SAND

Fig.1

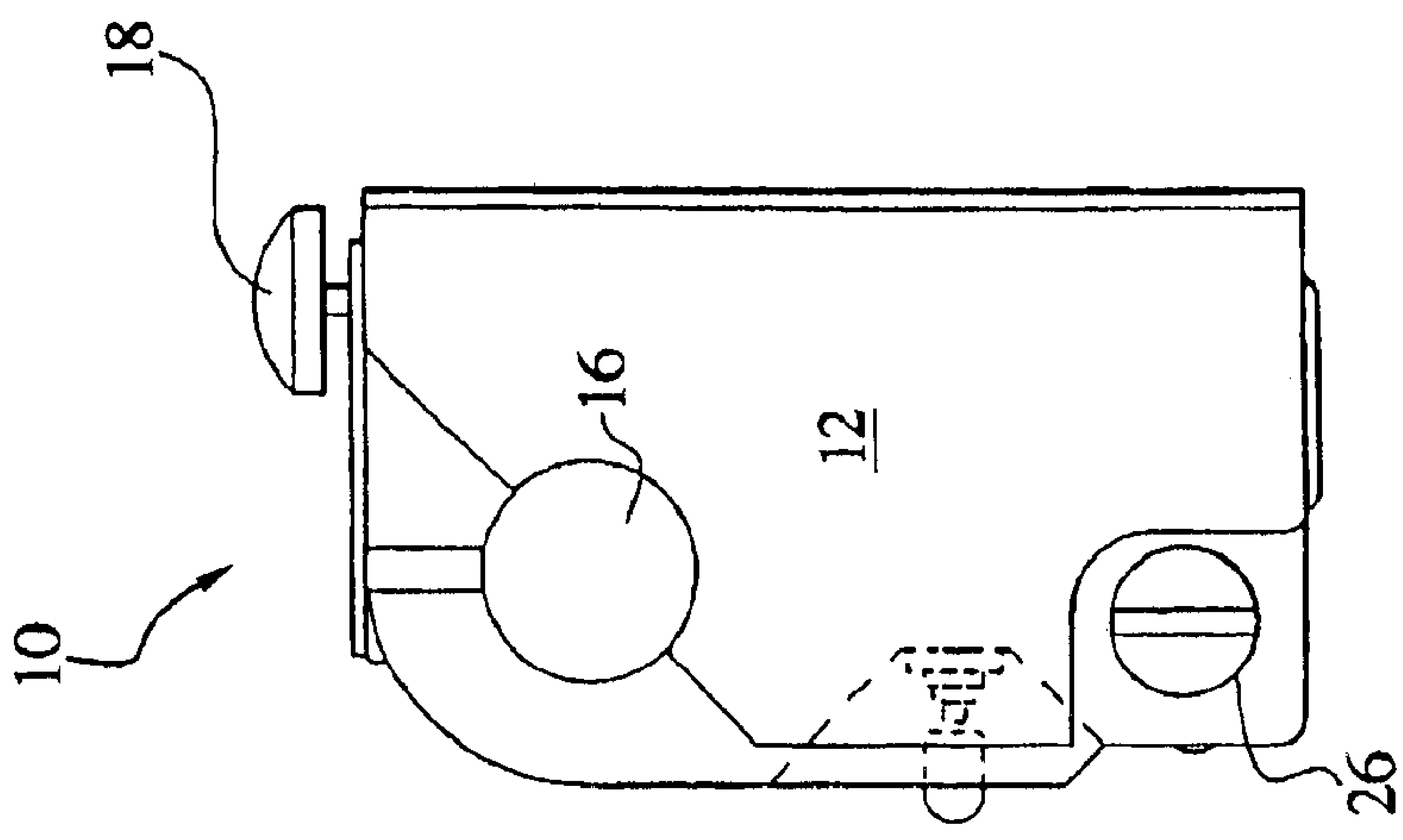


Fig.4

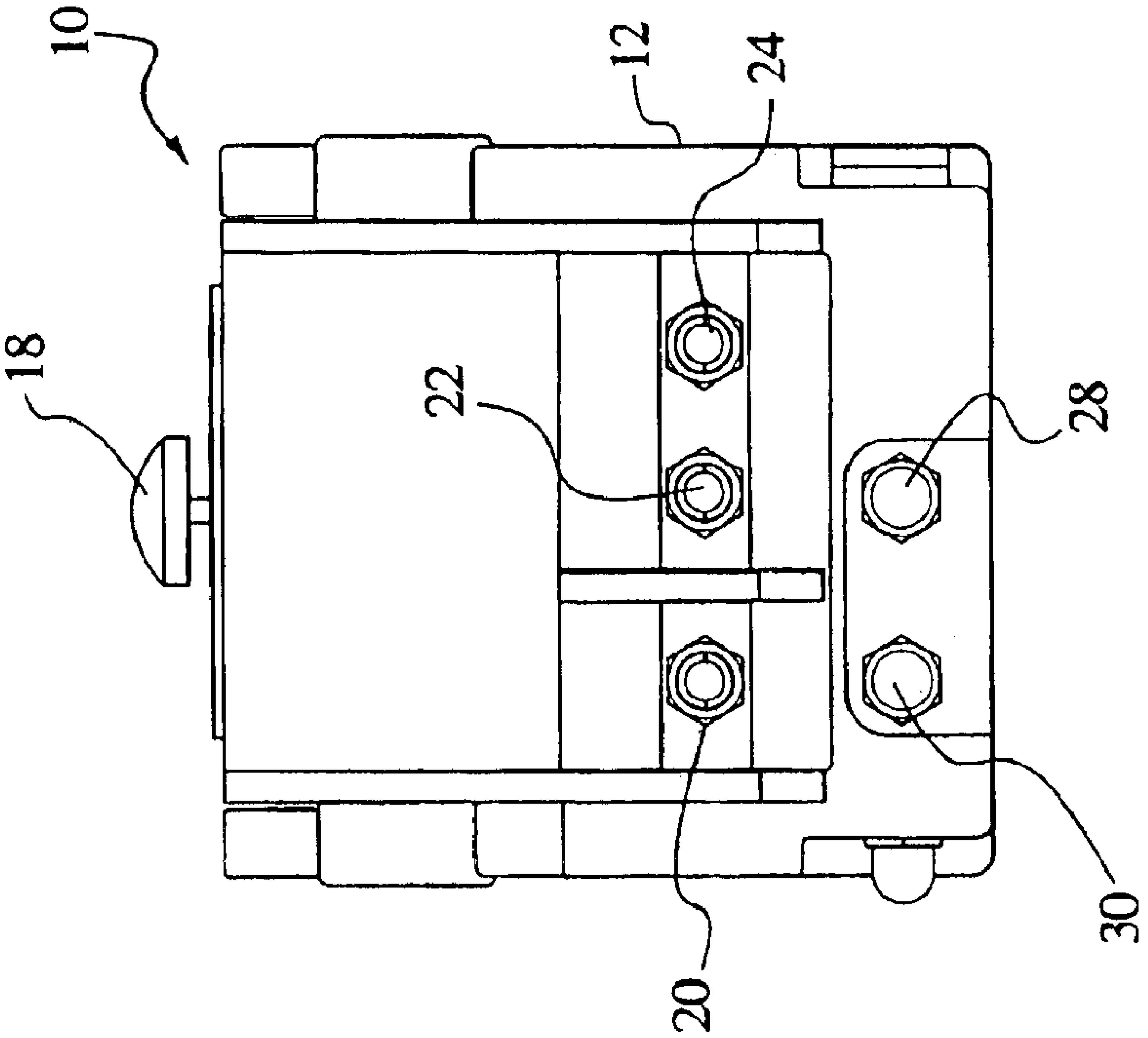


Fig.3

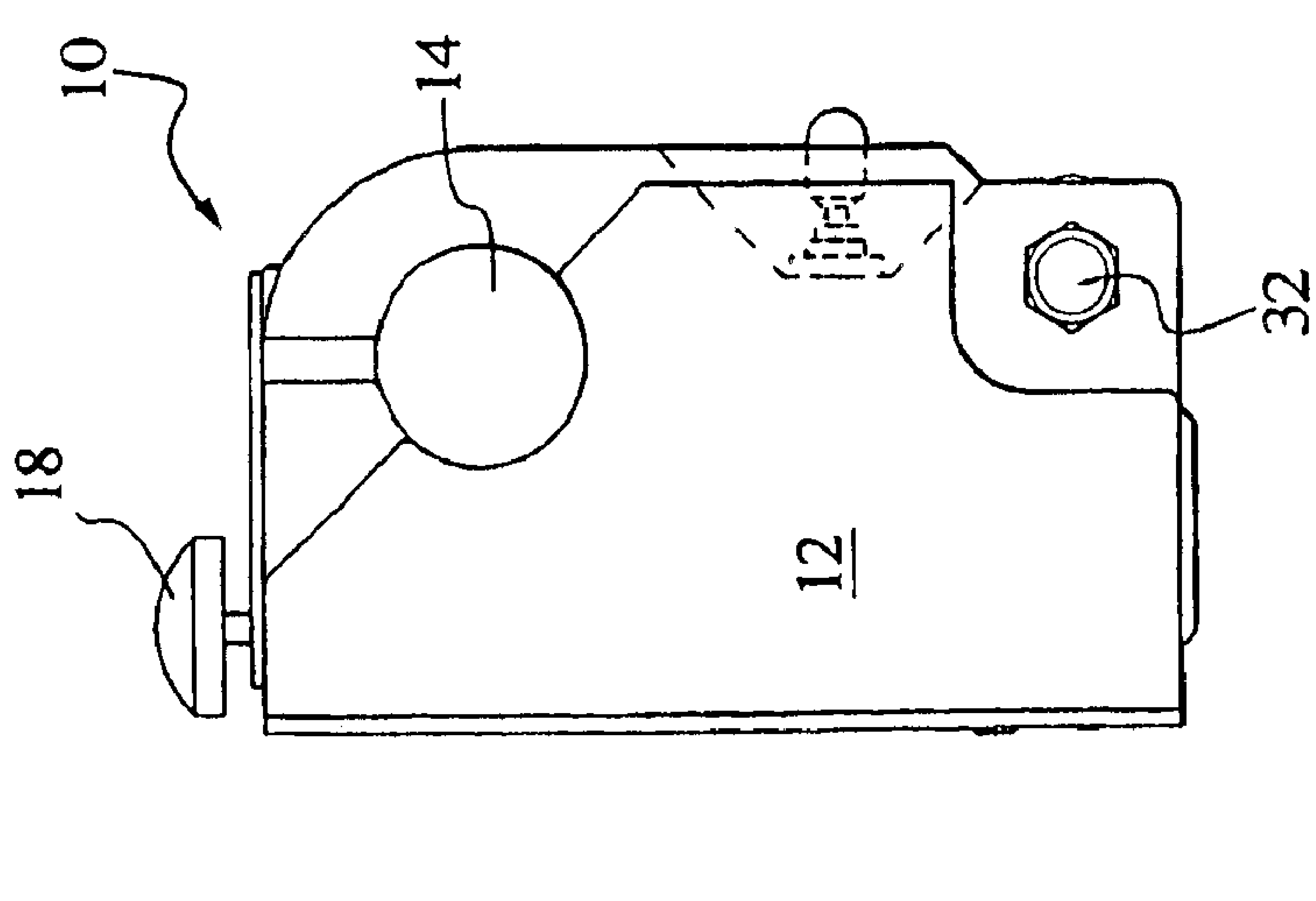


Fig.2

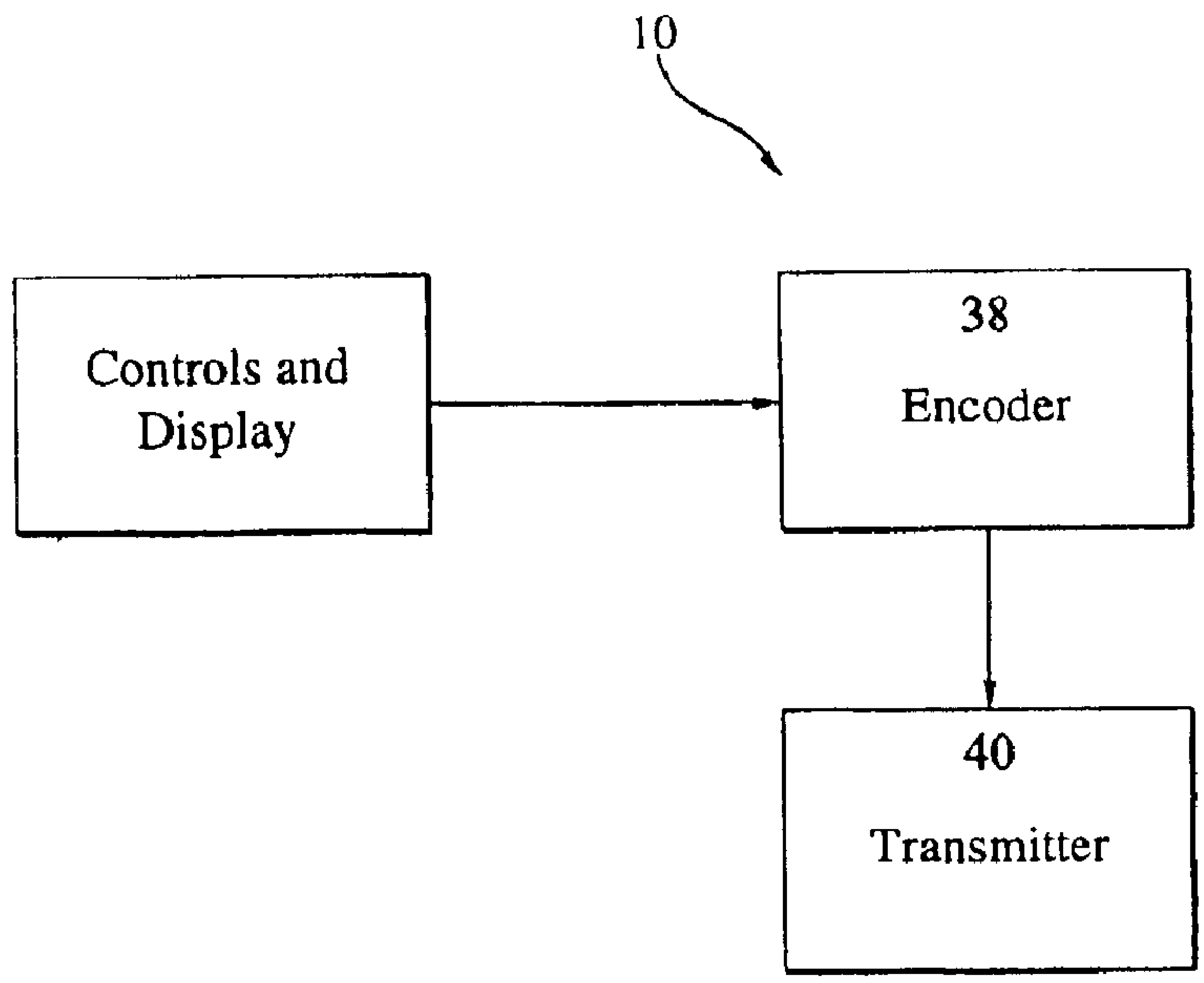

10
Controls and Display
38
Encoder
40
Transmitter

Fig.5

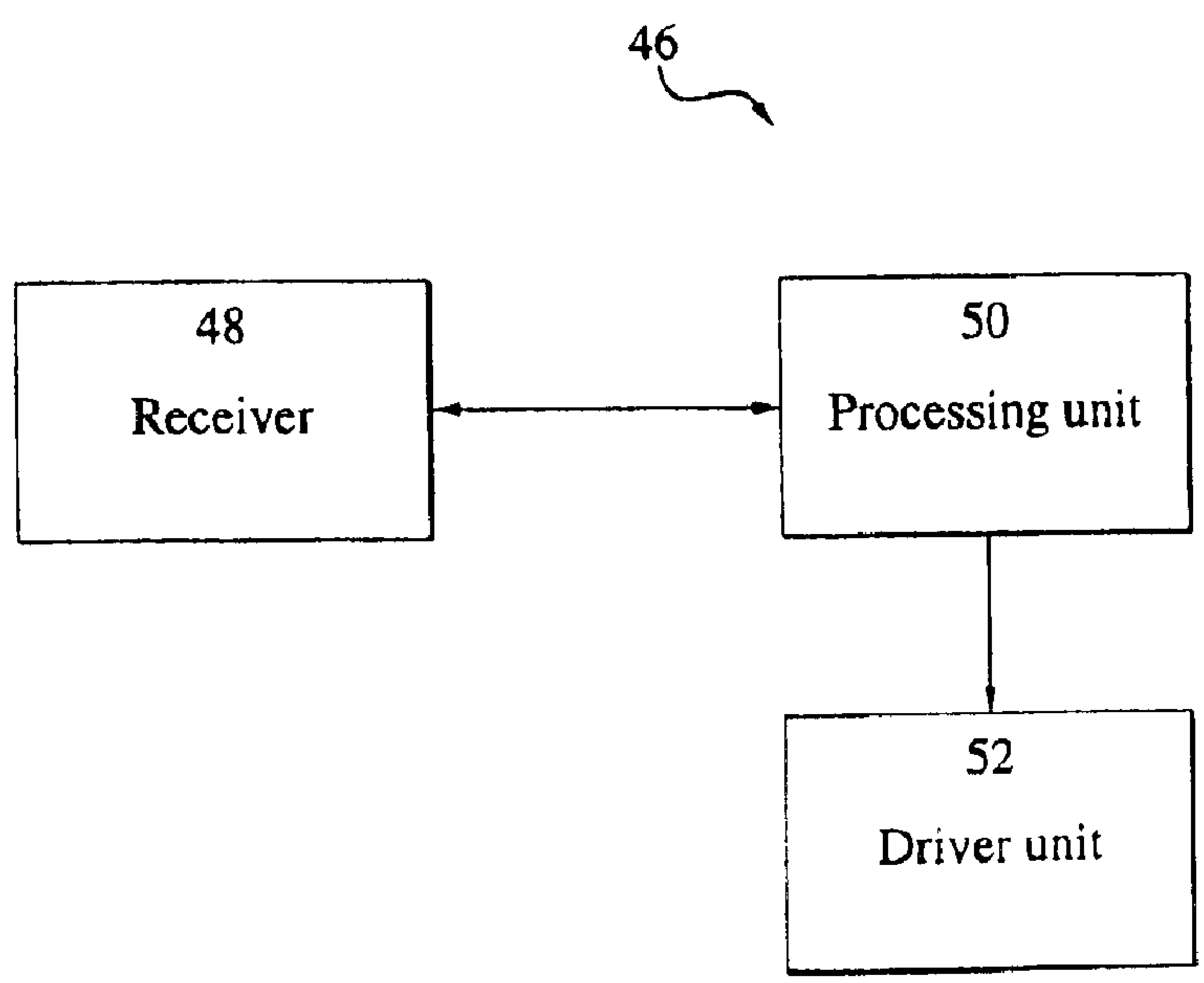

46
48
Receiver
50
Processing unit
52
Driver unit

Fig.7

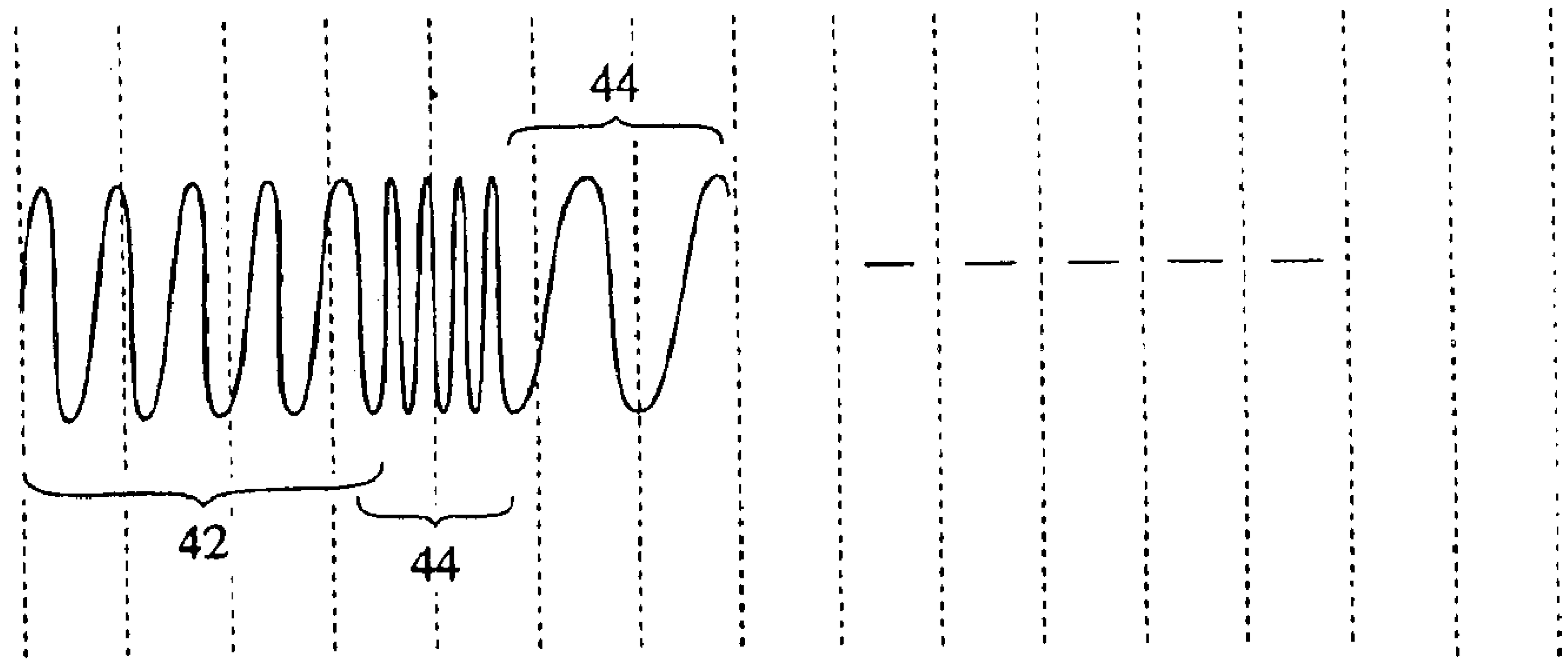


Fig.6

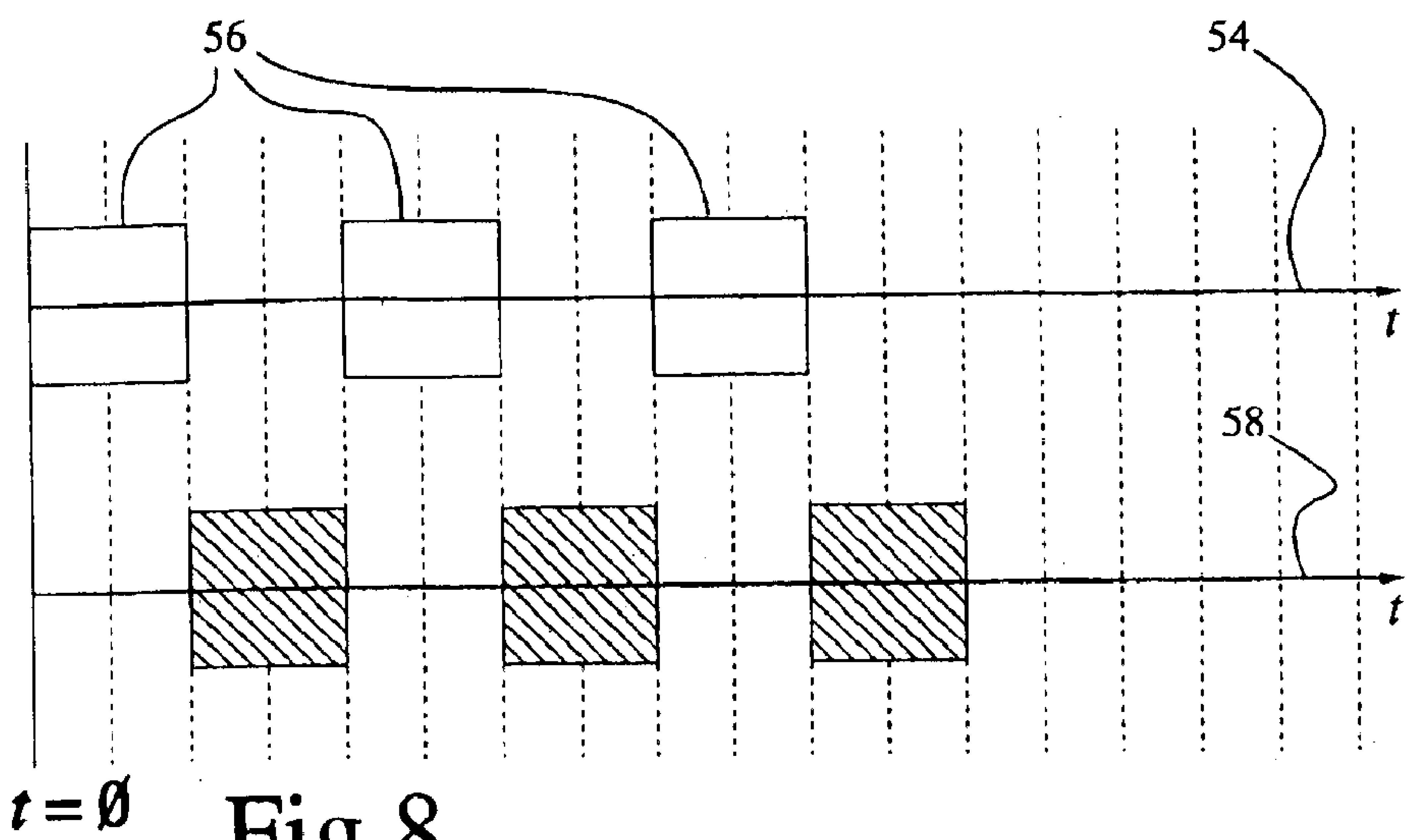


Fig.8

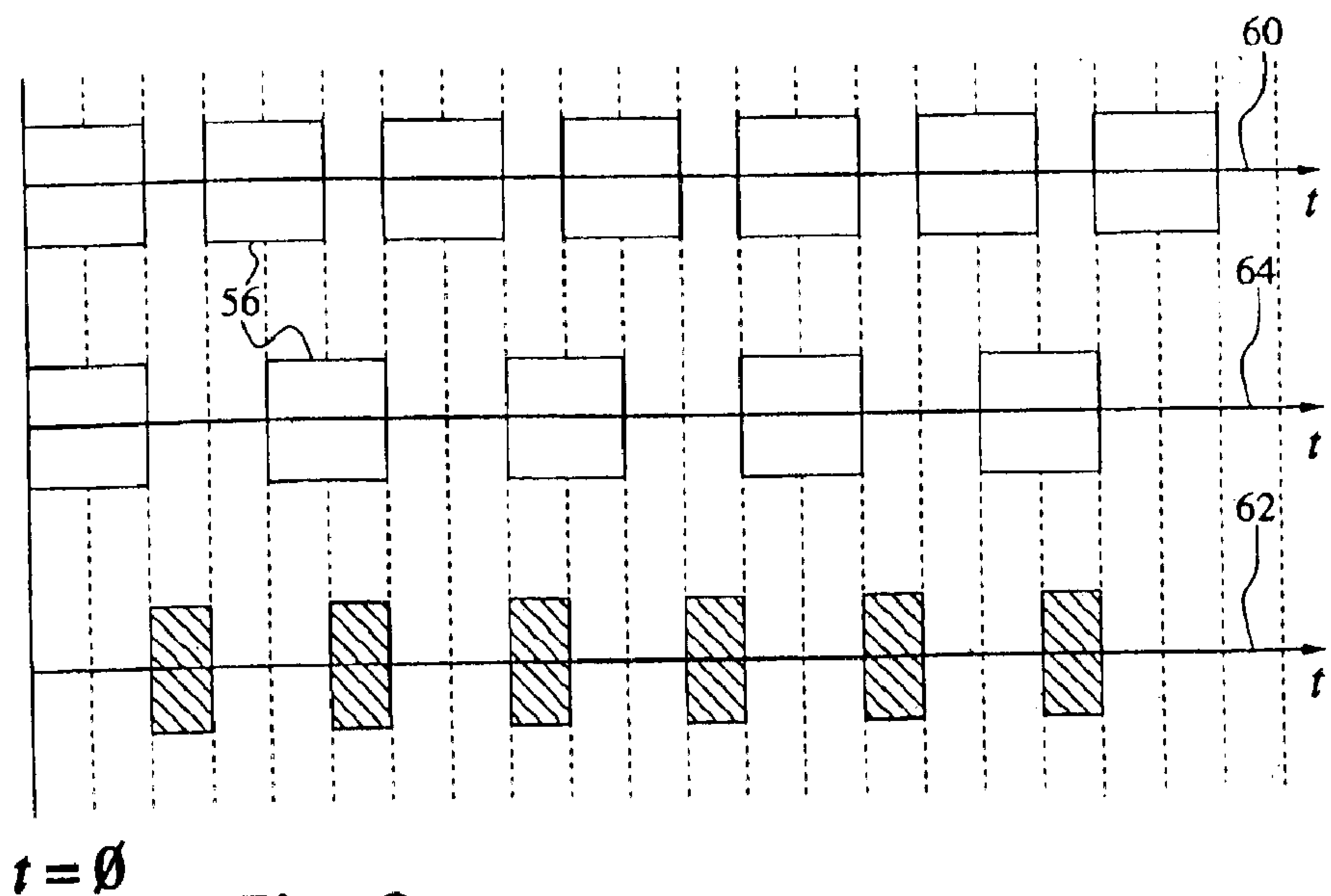


Fig.9

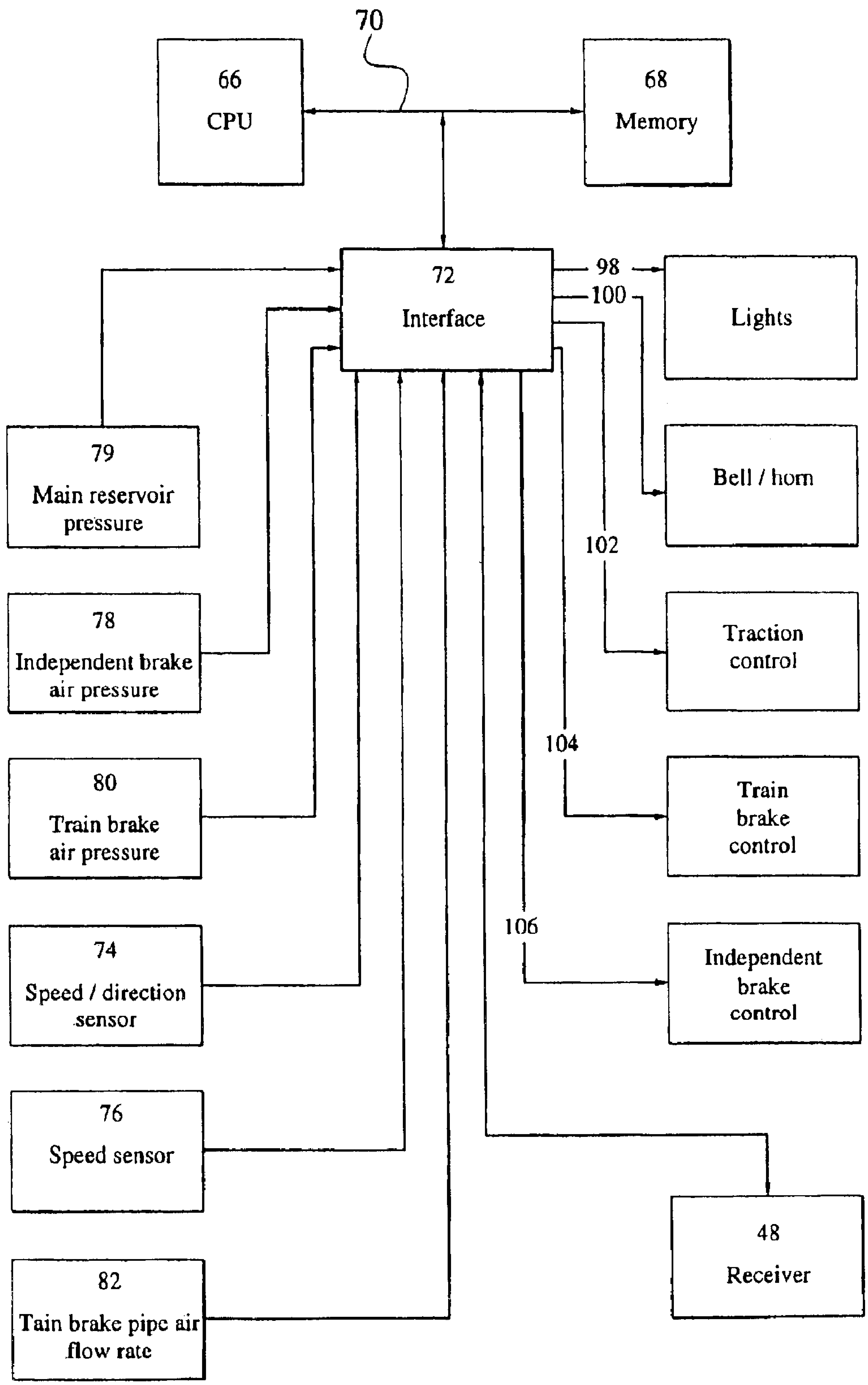

70
66
CPU
68
Memory
72
Interface
98
100
Lights
Bell / horn
102
Traction control
104
Train brake control
106
Independent brake control
48
Receiver
79
Main reservoir pressure
78
Independent brake air pressure
80
Train brake air pressure
74
Speed / direction sensor
76
Speed sensor
82
Tain brake pipe air flow rate

Fig.10

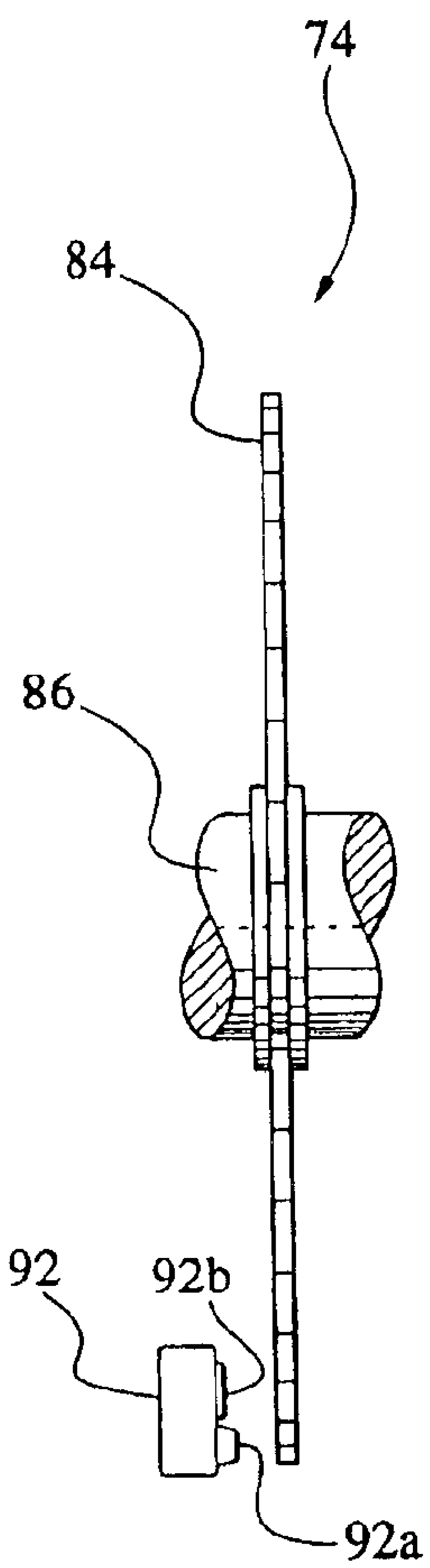


Fig.12

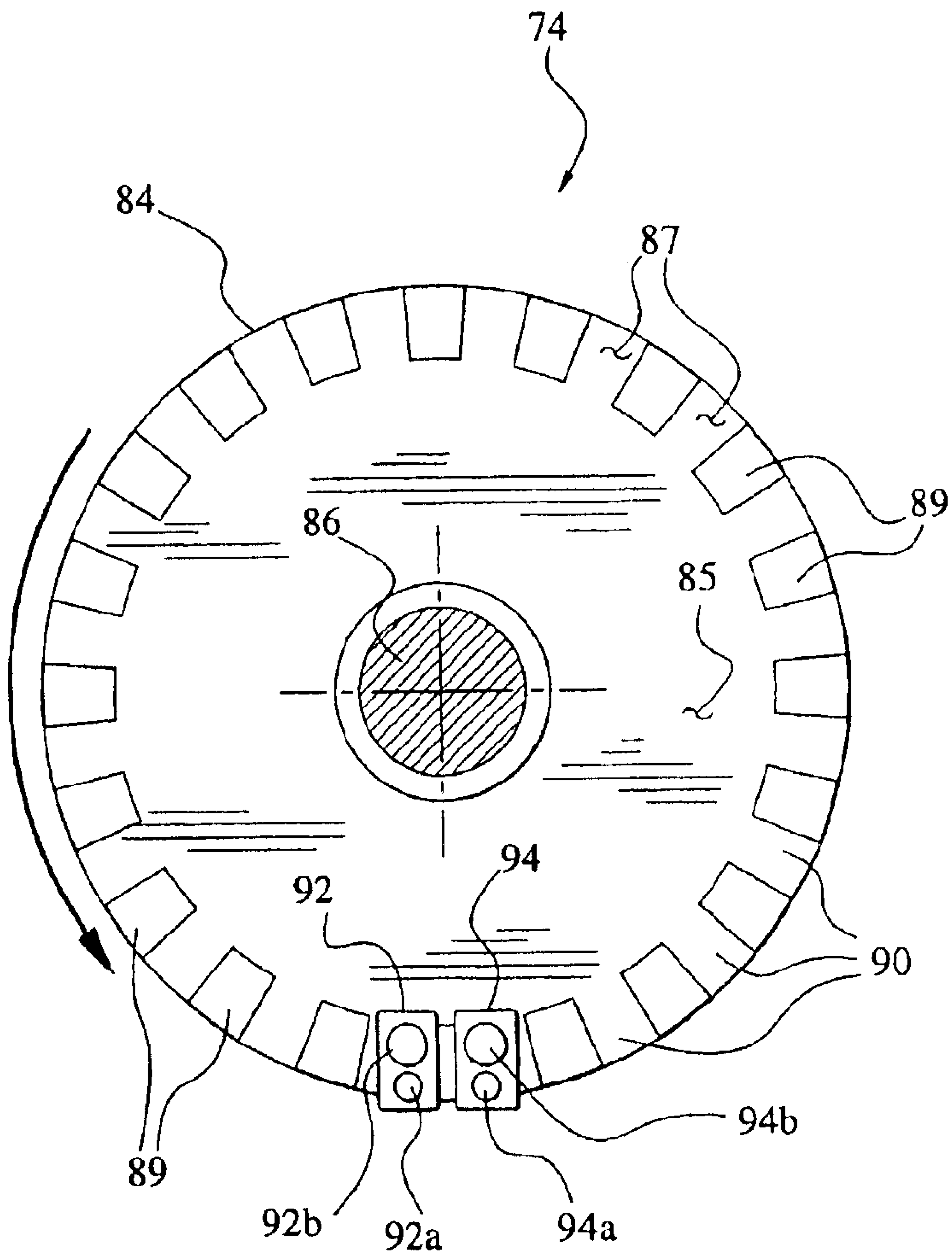


Fig.11

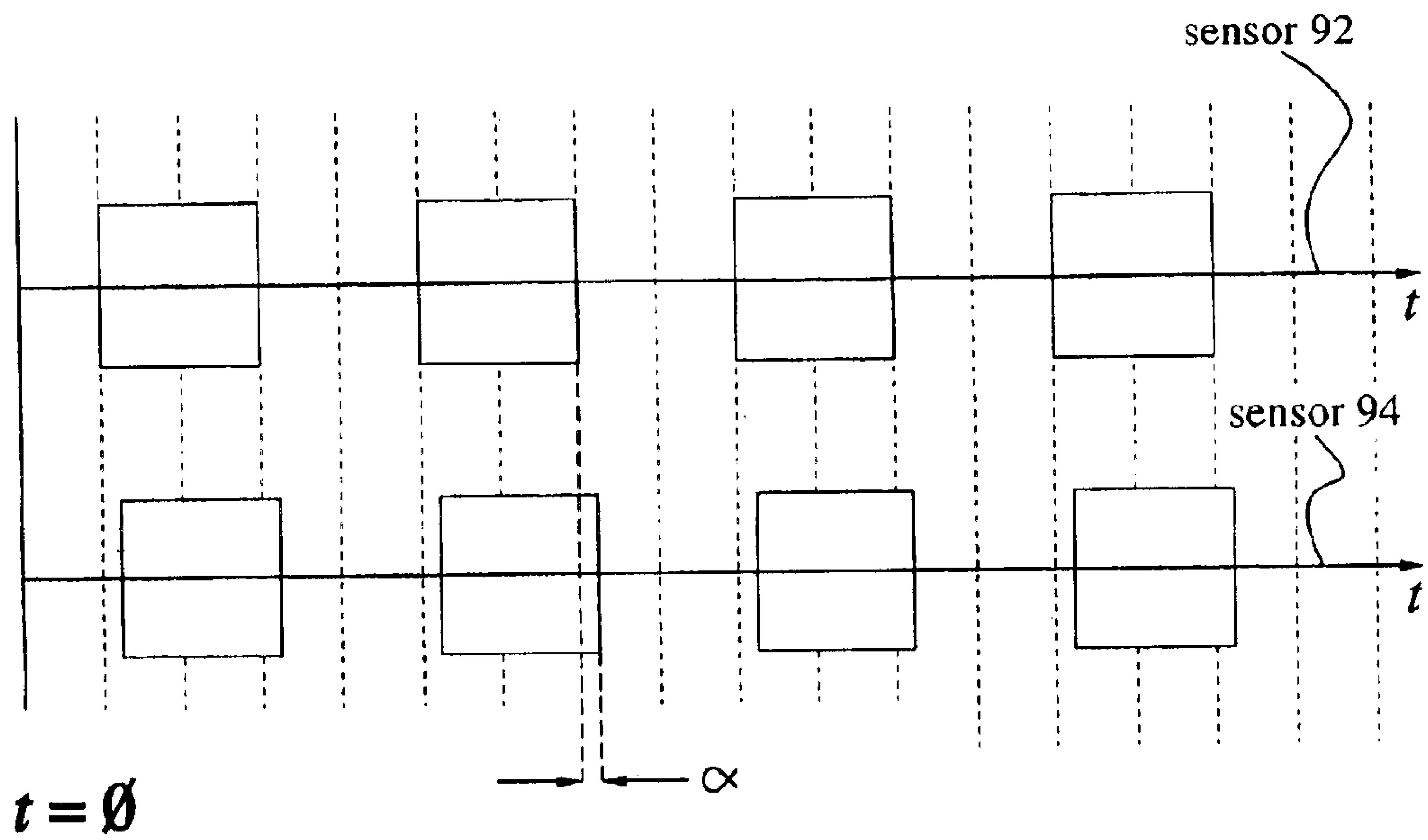


Fig.13

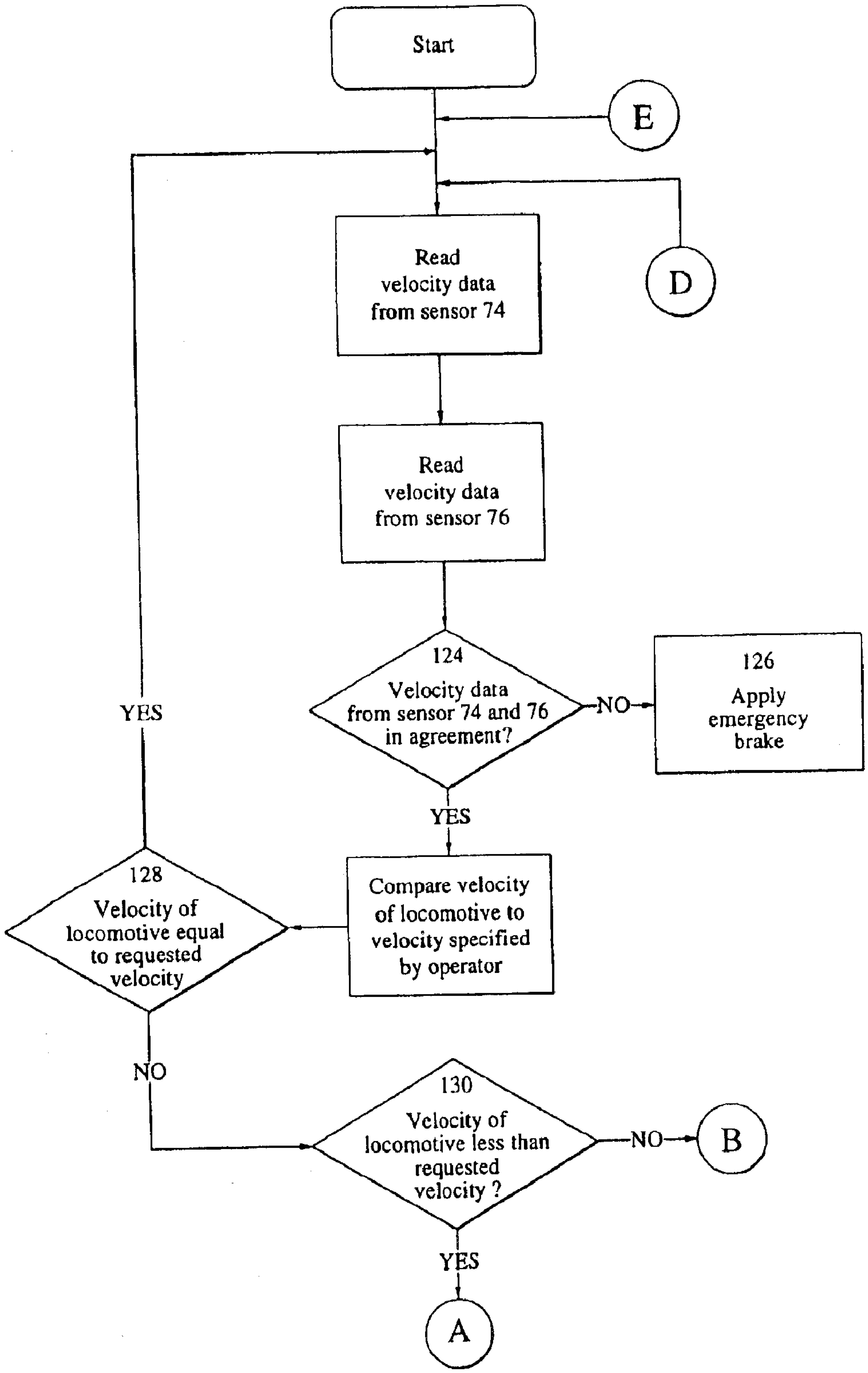

Start
E
Read
velocity data
from sensor 74
D
Read
velocity data
from sensor 76
124
Velocity data
from sensor 74 and 76
in agreement?
NO
126
Apply
emergency
brake
YES
YES
Compare velocity
of locomotive to
velocity specified
by operator
128
Velocity of
locomotive equal
to requested
velocity
NO
130
Velocity of
locomotive less than
requested
velocity ?
NO
B
YES
A

Fig. 14 a

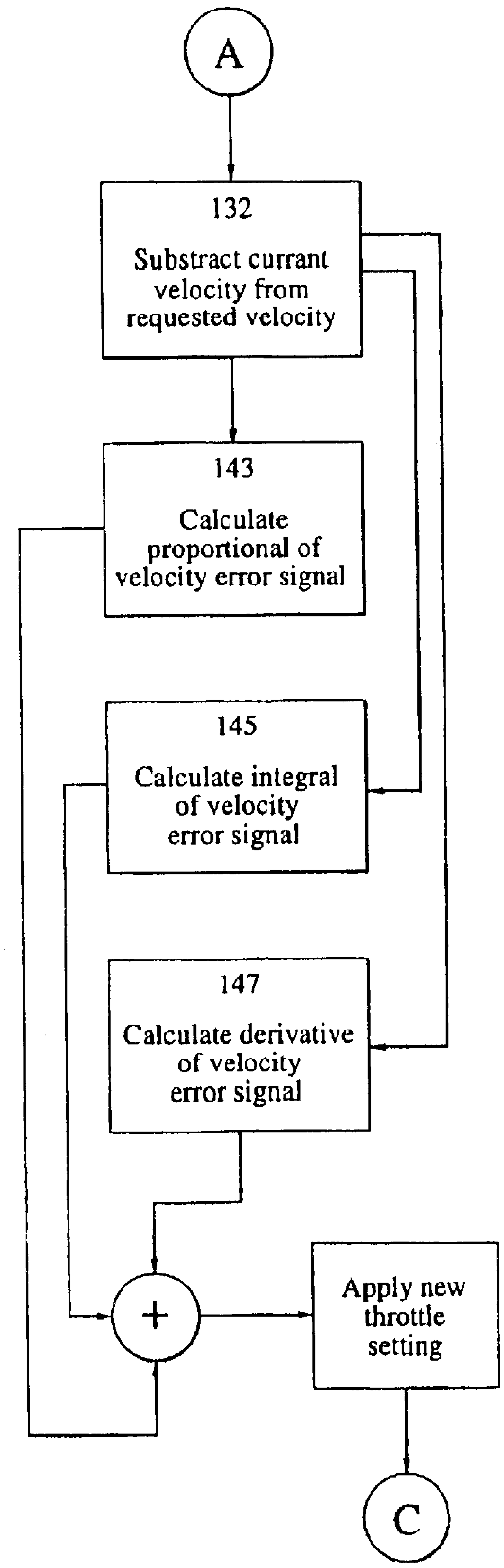


Fig. 14b

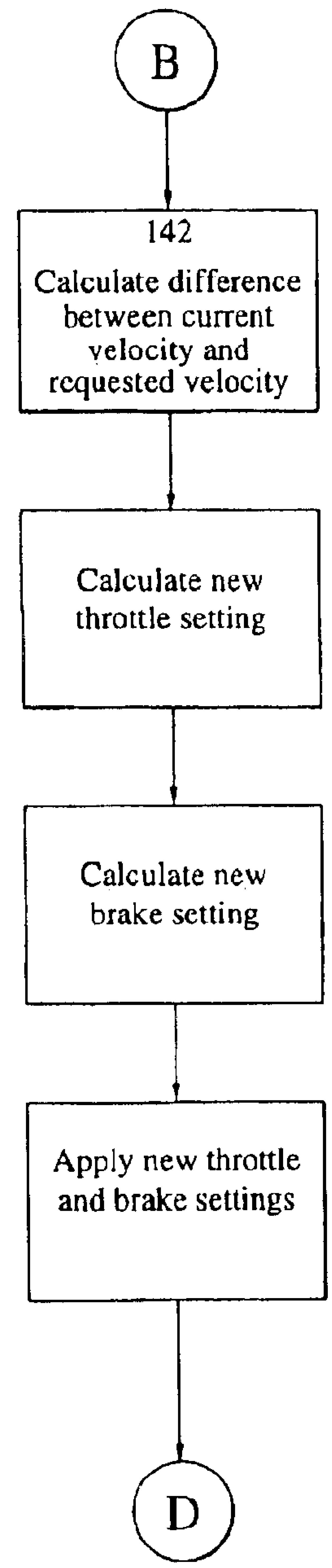


Fig. 14c

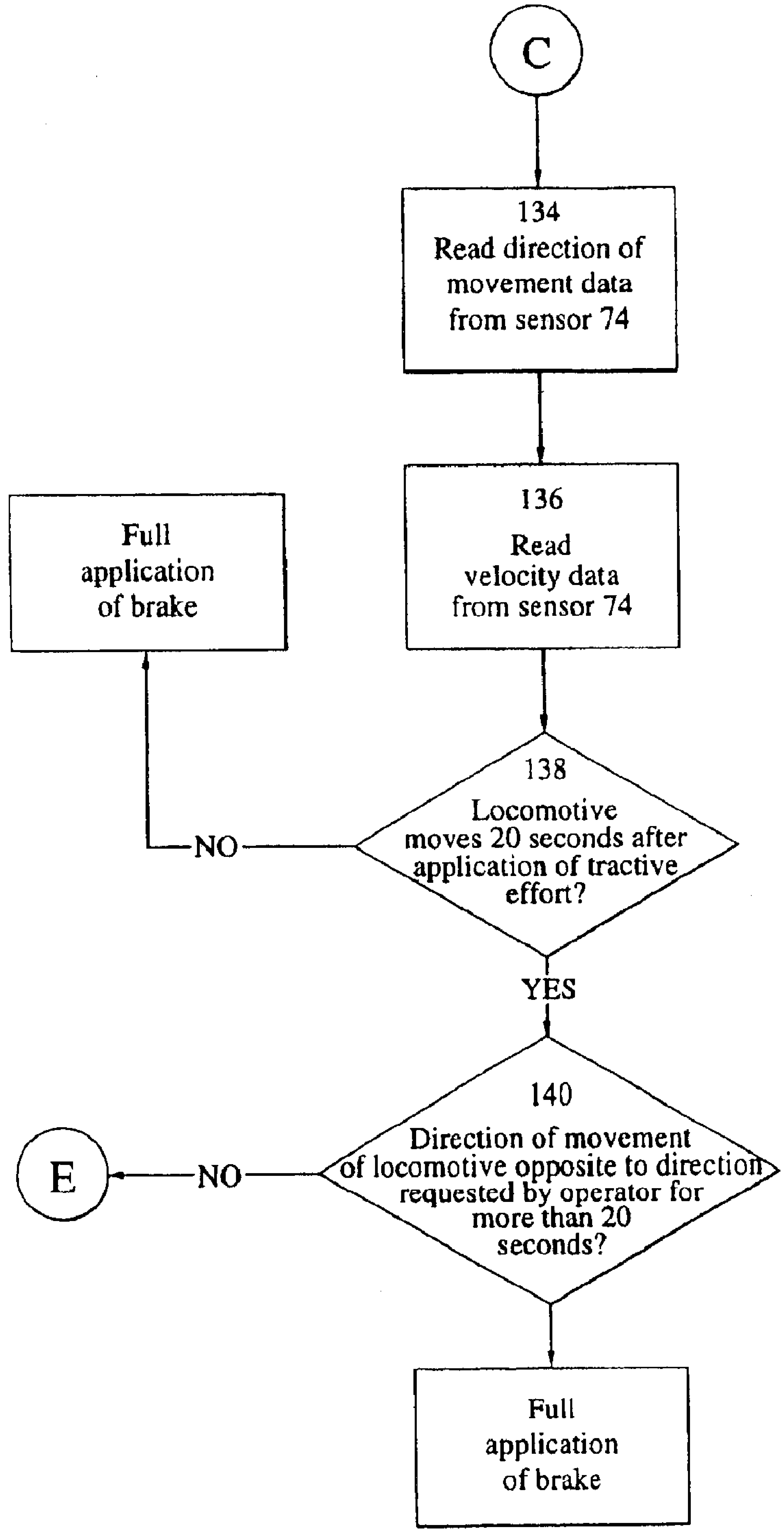

C
134
Read direction of movement data from sensor 74
136
Read velocity data from sensor 74
Full application of brake
138
Locomotive moves 20 seconds after application of tractive effort?
NO
YES
140
Direction of movement of locomotive opposite to direction requested by operator for more than 20 seconds?
NO
E
Full application of brake

Fig.14d

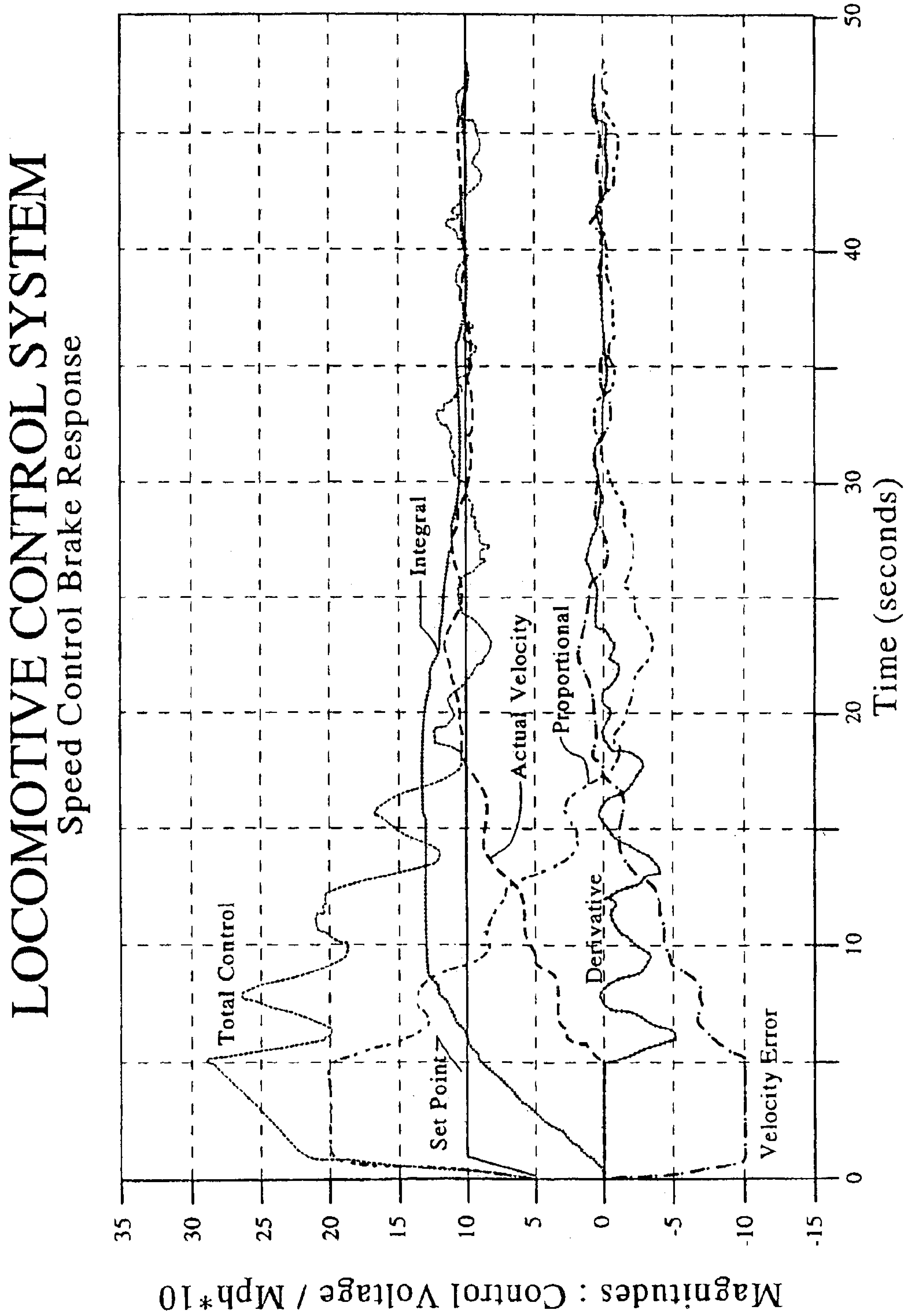

LOCOMOTIVE CONTROL SYSTEM
Speed Control Brake Response
Total Control
Set Point
Integral
Actual Velocity
Proportional
Derivative
Velocity Error
Magnitudes : Control Voltage / Mph*10
35
30
25
20
15
10
5
0
-5
-10
-15
0
10
20
30
40
50
Time (seconds)

Fig. 15 a

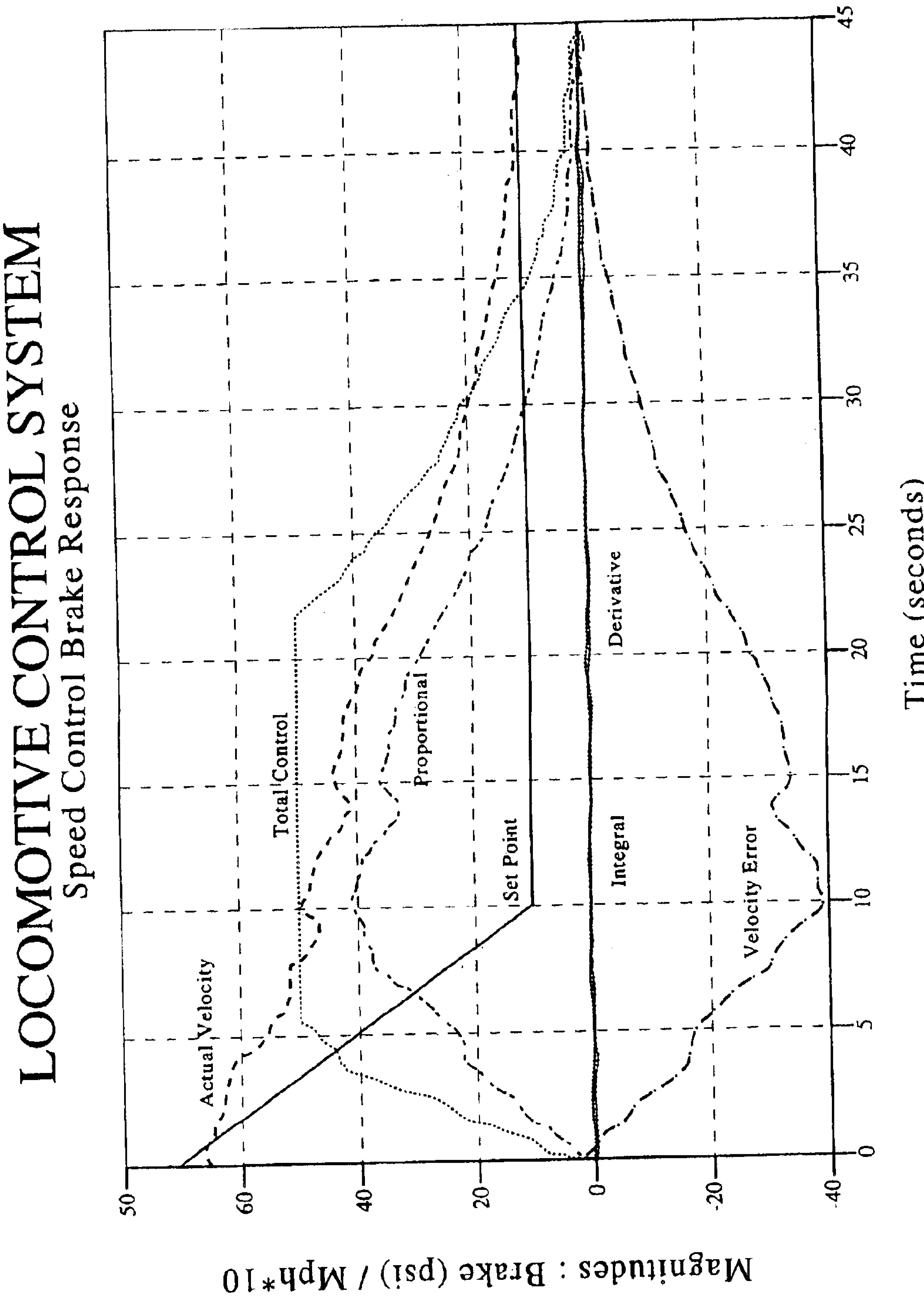

LOCOMOTIVE CONTROL SYSTEM
Speed Control Brake Response
Actual Velocity
Total Control
Proportional
Set Point
Derivative
Integral
Velocity Error
Magnitudes : Brake (psi) / Mph*10
Time (seconds)
50
60
40
20
0
-20
-40
0
5
10
15
20
25
30
35
40
45

Fig.15b

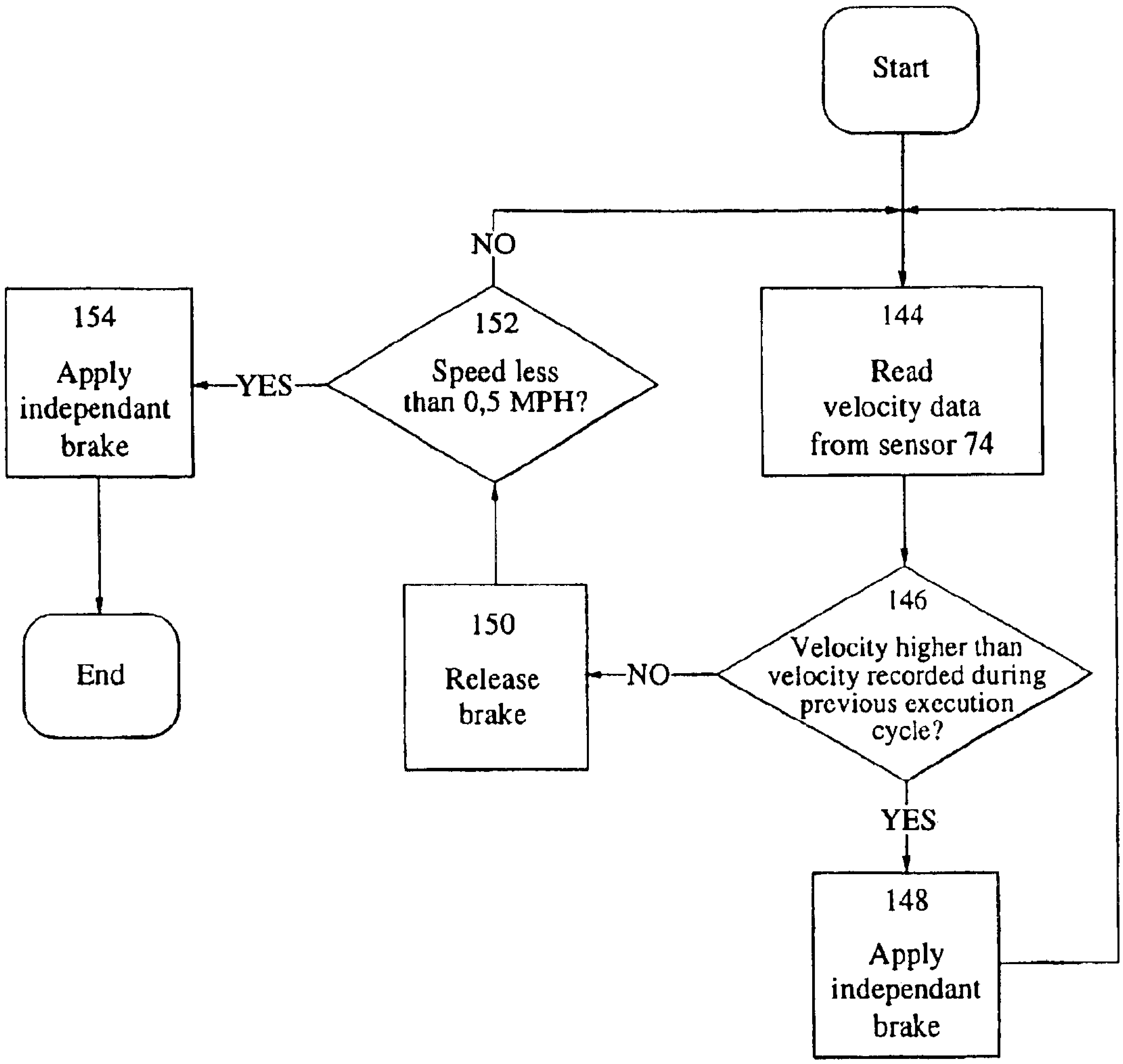
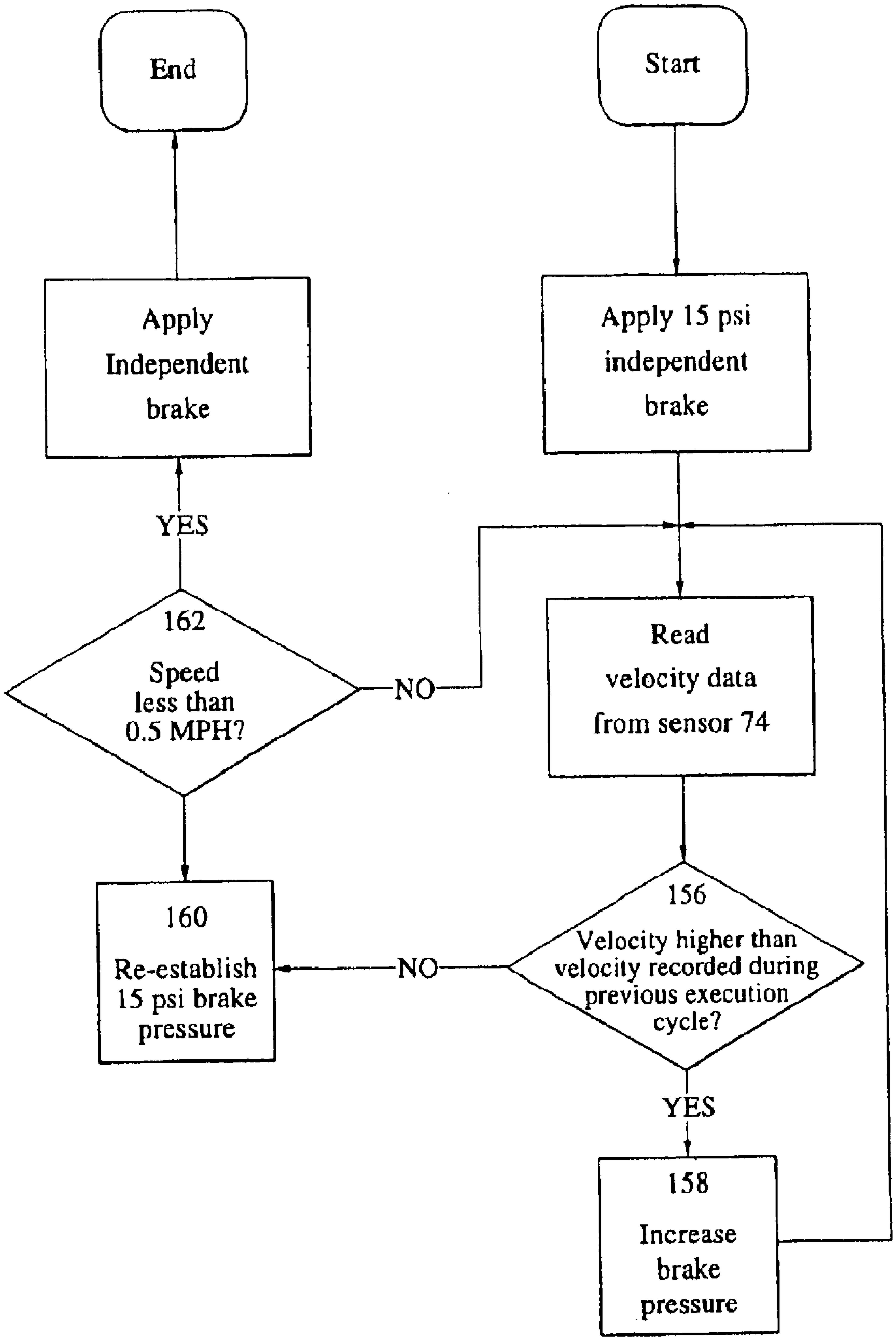

Start
144
Read velocity data from sensor 74
146
Velocity higher than velocity recorded during previous execution cycle?
YES
148
Apply independant brake
NO
150
Release brake
152
Speed less than 0,5 MPH?
NO
YES
154
Apply independant brake
End

Fig.16a



End
Start
Apply Independent brake
Apply 15 psi independent brake
YES
162
Speed less than 0.5 MPH?
NO
Read velocity data from sensor 74
156
Velocity higher than velocity recorded during previous execution cycle?
NO
160
Re-establish 15 psi brake pressure
YES
158
Increase brake pressure

Fig.16b

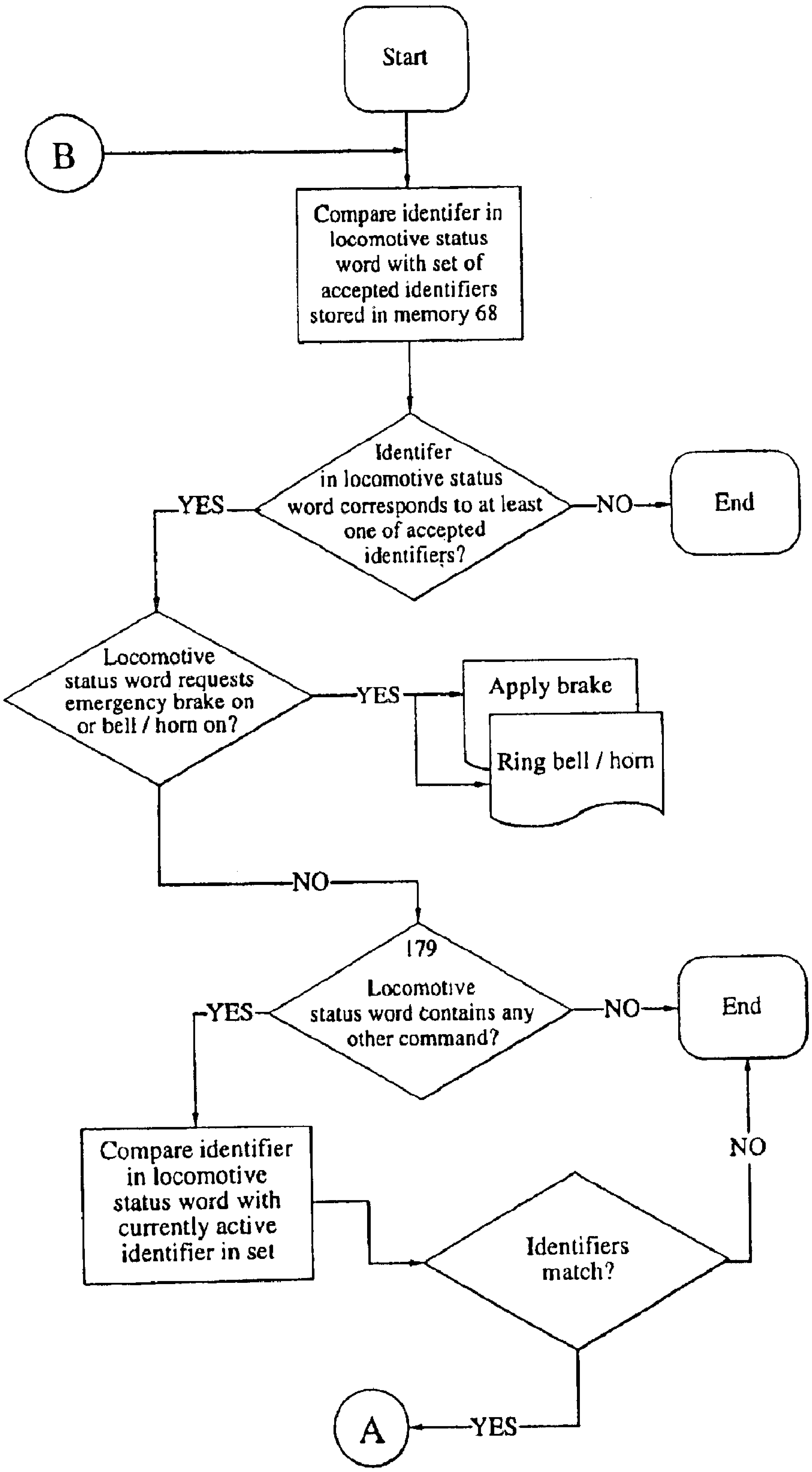

Start
B
Compare identifer in locomotive status word with set of accepted identifiers stored in memory 68
Identifer in locomotive status word corresponds to at least one of accepted identifiers?
YES
NO
End
Locomotive status word requests emergency brake on or bell / horn on?
YES
Apply brake
Ring bell / horn
NO
179
Locomotive status word contains any other command?
YES
NO
End
Compare identifier in locomotive status word with currently active identifier in set
NO
Identifiers match?
YES
A

Fig. 17a

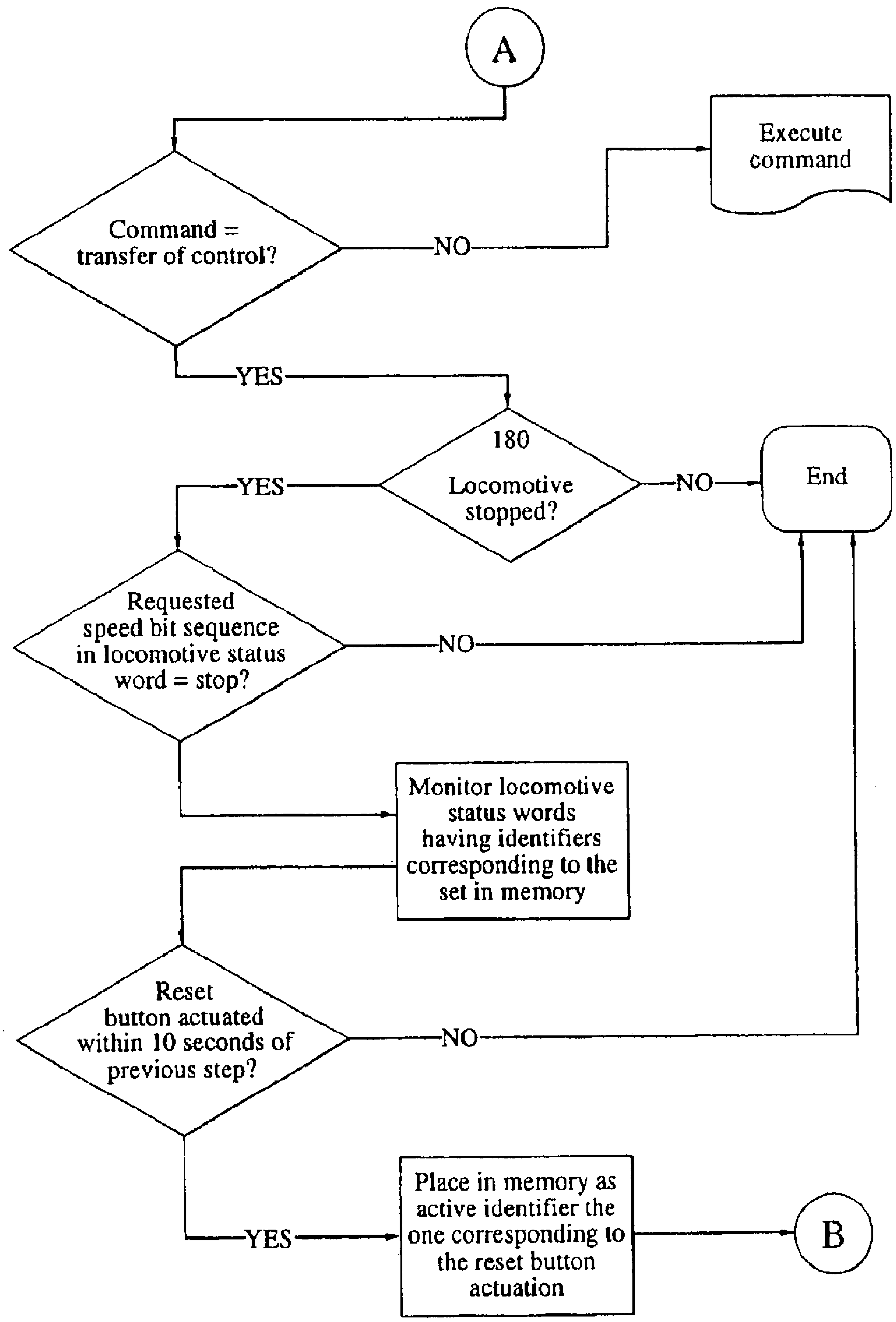

A
Command = transfer of control?
NO
Execute command
YES
180
Locomotive stopped?
NO
End
YES
Requested speed bit sequence in locomotive status word = stop?
NO
Monitor locomotive status words having identifiers corresponding to the set in memory
Reset button actuated within 10 seconds of previous step?
NO
YES
Place in memory as active identifier the one corresponding to the reset button actuation
B

Fig. 17b

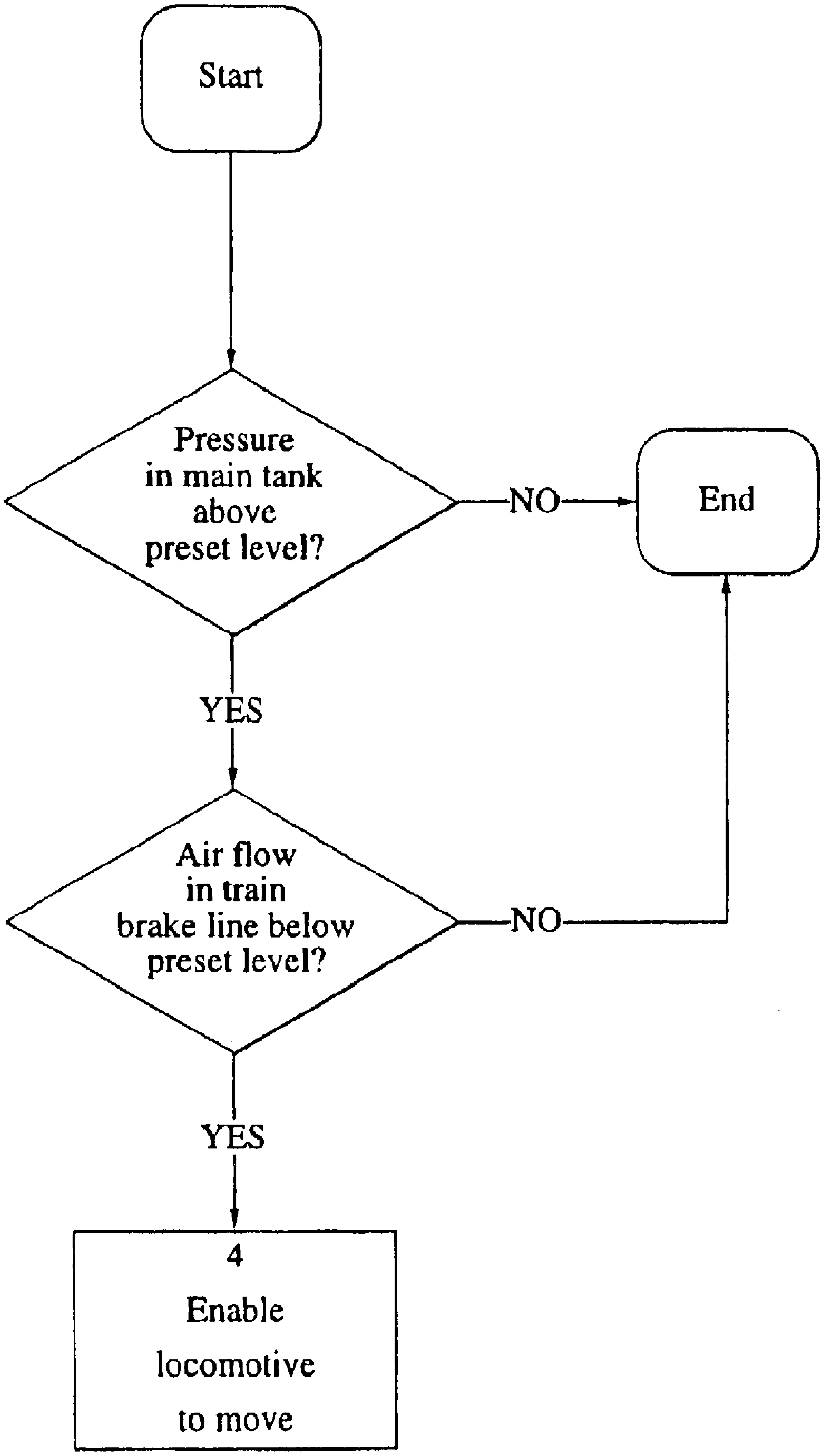

Start
Pressure in main tank above preset level?
NO
End
YES
Air flow in train brake line below preset level?
NO
YES
4
Enable locomotive to move

Fig.18

REMOTE CONTROL SYSTEM FOR A LOCOMOTIVE

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

FIELD OF THE INVENTION

The present invention relates to an electronic system for remotely controlling a locomotive. The system is particularly suitable for use in switching yard assignments.

BACKGROUND OF THE INVENTION

Economic constraints have led railway companies to develop portable units allowing a ground based operator to remotely control a locomotive in a switching yard. The unit is essentially a transmitter communicating with a slave controller on the locomotive by way of a radio link. Typically, the operator carries this unit and can perform duties such as coupling and uncoupling cars while remaining in control of the locomotive movement at all times. This allows for placing the point of control at the point of movement thereby potentially enhancing safety, accuracy and efficiency.

Remote locomotive controllers currently used in the industry are relatively simple devices that enable the operator to manually regulate the throttle and brake in order to accelerate, decelerate and/or maintain a desired speed. The operator is required to judge the speed of the locomotive and modulate the throttle and/or brake levers to control the movement of the locomotive. Therefore, the operator must posses a good understanding of the track dynamics, the braking characteristics of the train, etc. in order to remotely operate the locomotive in a safe manner.

OBJECT AND STATEMENT OF THE INVENTION

An object of the invention is to provide a remote control system allowing the operator to command a desired speed and responding by appropriately controlling the throttle or brake to achieve and maintain that speed.

Another object of the invention is to provide a remote locomotive control system allowing for control of the locomotive from one of two different transmitters.

Yet another object of the invention is to provide a remote locomotive control system having the ability to perform a number of safety verifications in order to automatically default the locomotive to a safe state should a malfunction be detected.

SUMMARY OF THE INVENTION

As embodied and broadly described herein the invention provides a locomotive remote control system. The system has

a transmitter capable of generating a binary coded radio frequency signal representing commands to be executed by the locomotive and

a slave controller for mounting on-board the locomotive. The slave controller has

a) a receiver for sensing the radio frequency signal;

b) a processor for receiving the radio frequency signal; and

c) a velocity sensor for generating data representing velocity of the locomotive. The processor responds to the velocity sensor and to the RF signal to actuate either one of a brake of a locomotive or a tractive power of the locomotive in order to attempt maintaining a requested speed.

As embodied and broadly described herein the invention also provides a locomotive control system which has

a) a transmitter for generating a binary coded RF signal; and

b) a slave controller mounted on-board the locomotive for receiving that signal, the slave controller selectively accepting commands from a first transmitter or from a second transmitter.

As embodied and broadly described herein the invention further provides a remote control system for a locomotive which has

a) a transmitter for generating an RF binary coded signal; and

b) a slave controller mounted on-board the locomotive. The slave controller includes

a first sensor responsive to pressure of compressed air in a main tank of the locomotive; and

a second sensor responsive to flow of compressed air in a pneumatic brake line. The slave controller responds to output of the sensors to enable application of tractive power to the locomotive only when a pressure in the main tank is above a predetermined level and a flow of air in the brake line is below a predetermined level.

DESCRIPTION OF THE DRAWINGS

FIG. **1** is a top plan view of the portable transmitter of the remote locomotive control system in accordance with the invention;

FIGS. **2** and **4** are side elevational views of the portable transmitter;

FIG. **3** is a front elevational view of the portable transmitter;

FIG. **5** is a functional block diagram of the portable transmitter;

FIG. **6** is a diagram of the signal transmission protocol between the portable transmitter and a slave controller mounted on-board the locomotive;

FIG. **7** is a functional block diagram of the slave controller mounted on-board the locomotive;

FIG. **8** is a diagram illustrating the temporal relationship between the signal transmission and the operation of the receiver of the slave controller;

FIG. **9** is a diagram illustrating the temporal relationship between signal transmission from two portable transmitters and the operation of the receiver of the slave controller;

FIG. **10** is a detailed functional block diagram of the slave controller mounted on-board the locomotive;

FIG. **11** is a side elevational view of a velocity sensor for generating a pulse signal whose frequency is correlated to the speed of the locomotive;

FIG. **12** is a side elevational view of the velocity sensor shown in FIG. **11**;

FIG. **13** illustrates the pulse output of the velocity sensor shown in FIGS. **11** and **12**;

FIGS. **14**a to **14**d are a flow charts of the logic implemented to control the speed of the locomotive;

FIGS. **15**a and **15**b are diagrams illustrating the variation with respect to time of the velocity of the locomotive and of variables used to calculate a throttle or brake correction signal;

FIG. 16a is a flow chart illustrating the logic for controlling the speed of the locomotive in a COAST speed setting;

FIG. 16b is a flow chart illustrating the logic for controlling the speed in COAST WITH BRAKE setting;

FIGS. 17a and 17b are flow charts of the logic for transferring the command authority from one remote control transmitter to another; and

FIG. 18 is a flow chart of the safety diagnostic routine performed on the braking system of the locomotive.

DESCRIPTION OF PREFERRED EMBODIMENTS

With reference to the annexed drawings, the locomotive control system in accordance with the invention includes a portable transmitter **10** which generates a digitally encoded radio frequency (RF) signal to convey commands to a slave controller mounted on-board the locomotive. The slave controller decodes the transmission and operates various actuators on the locomotive to carry into effect the commands remotely issued by the operator.

FIGS. **1** to **4** illustrate the physical layout of the portable transmitter **10**. The unit comprises a housing **12** enclosing the electronic circuitry and a battery supplying electric power to operate the system. A plurality of manually operable levers and switches projecting outside the housing **12** are provided to dial-in locomotive speed, brake and horn settings, among others. The various controls on the portable transmitter are defined in the following table:

REFERENCE NUMERAL	FUNCTION	TYPE OF ACTUATOR
14	Locomotive Speed Control	Multi-Position Lever
16	Locomotive Over-ride Brake Control	Multi-Position Lever
18	Reset	Push-Button
20	Direction (Forward/Reverse/ Neutral)	Multi-Position Switch
22	Ring Bell/Horn	Toggle Switch
24	Train Brake Control	Toggle Switch
26	Power on/Lights Dim/Bright	Multi-Position Switch
28	Status Request	Push-Button
30	Time Extend	Push-Button
32	Relinquish Control to Companion Portable Transmitter	Push-Button

A detailed description of the various functions summarized in the above table is provided later in this specification.

On the top surface of the housing **12** is provided a display panel **34** that visually echoes the control settings of the portable transmitter **10**. The display panel **34** includes an array of individual light sources **36**, such as light emitting diodes (LED), corresponding to the various operative conditions of the locomotive that can be selected by the operator. Hence, a simple visual observation of the active LED's **36** allows the operator to determine the current position of the controls.

FIG. **5** provides a functional diagram of the portable transmitter **10**. The various manually operable switches and levers briefly described above are constituted by electric contacts whose state of conduction is altered when the an opened condition. The multi-position levers **14** and **16**, and the multi-position switches **20** and **26**, have a set of electric contact pairs, only a single pair being closed at each position of the lever or switch. By reading the conduction state of the individual electric contact pairs, the commands issued by the operator can be determined.

An encoder **38** scans at short intervals the state of conduction of each pair of contacts. The scan results allow the encoder to assemble a binary locomotive status word that represent the requested operative state of the locomotive being controlled. The following table provides the number of bits in the locomotive status word required for each function:

NUMBER OF BITS IN LOCOMOTIVE STATUS WORD	FUNCTION
3	Locomotive Speed Control
3	Locomotive Brake Control
1	Reset
2	Direction (Forward/Reverse/ Neutral)
2	Ring Bell/Horn
3	Train Brake Control
1	Lights Dim/Bright
1	Status Request
1	Time Extend
1	Relinquish Control to Companion Portable Transmitter

The locomotive status word also contains an identifier segment that uniquely represents the transmitter designated to control the locomotive. The purpose of this feature is to ensure that the locomotive will only accept the commands issued by the transmitter generating the proper identifier.

Most preferably, the encoder **38** includes a microprocessor programmed to intelligently assemble the locomotive status word. The microprocessor continuously scans the electric contacts of the transmitter controls and records their state of conduction. On the basis of the identity of the closed contacts, the program will produce the function component of the locomotive status word which is the string of bits that uniquely represents the functions to be performed by the locomotive. The program then appends to the function component the locomotive identifier component and preferably a data security code enabling the receiver on-board the locomotive to check for transmission errors.

In a different form of construction, the encoder may be constituted by an array of hardwired logic gates that generate the locomotive status word upon actuation of the controls.

A transmitter **40** receives the locomotive status word and generates an RF signal for transmission of the coded sequence by frequency shift keying. In essence, the frequency of a carrier is shifted to a first value to signal a logical 1 and to a second value to signal a logical 0. The transmission protocol is best shown in FIG. **6**. Each transmission begins with a burst of the carrier frequency **42** for a duration of eight (8) bits (the actual time frame is established on the basis of the transmission baud rate allowed by the equipment). Each bit of the data stream is then sent by shifting the frequency to the first or the second value depending on the value of the bit, during a predetermined time slot **44**.

The transmitter **40** sends out the locomotive status word in repetition at a fixed rate selected in the range from two (2) to five (5) times per second. By providing the transmitter with a unique repetition rate, the likelihood of transmission errors is reduced when several portable transmitters in close proximity broadcast control signals to individual locomotives, as described below.

FIG. **7** provides a diagrammatic representation of the slave controller mounted on board the locomotive. The slave controller identified comprehensively by the reference numeral **46** has three main components, namely a receiver unit **48**, a processing unit **50** and a driver unit **52**. More particularly, the receiver unit **48** senses the locomotive status word sent out from the portable transmitter **10**, decodes the transmission and supplies the resulting binary sequence to the processing unit **50**. To achieve a reliable communication link, the receiver **48** is synchronized with the transmitter **40** at three different levels. First, the receiver circuitry defines a signal acceptance window that opens itself at the rate at which the locomotive status word is sent out by the respective controlling transmitter **40**. Second, the receiver **48** will observe the frequency value of the transmission in order to decode the binary sequence at intervals precisely corresponding to the time slots **44**. Third, the acceptance window opens in phase with the signal transmission.

The first two levels of synchronization are established through hardware design, by setting the transmitter **40** and the receiver **48** to the same period of transmission/reception. On the other hand, the phasing of the receiver to the incoming locomotive status word transmission is effected through observation of the burst of carrier frequency **42** that begins each transmission cycle. The diagram in FIG. **8** graphically illustrates the relationship between the signal transmission and the signal reception. The time line **54** shows the successive transmission of the locomotive status word as a series of blocks **56**. The activity of the receiver **48** is shown on the time line **58**. The hatched areas correspond to the time intervals during which the receiver is not listening. At time t=**0** the first locomotive status word is sent out by the transmitter **40**. The burst of the carrier frequency **42** is sensed by the receiver **48** which then activates the sequence of opening and closing of the signal acceptance window which is fully synchronized (in period and phase) with the signal transmission.

This characteristic is particularly advantageous when several transmitters broadcast simultaneously control signals to different locomotives in close proximity to one another. By setting each transmitter (and the companion receiver) at a unique transmission/reception period, secure communication links can be maintained even when all the transmitters use the same carrier frequency. FIG. **9** illustrates this feature. Time line **60** shows the transmission pattern of a first portable transmitter. The time line **62** depicts the window of acceptance of the companion receiver. The numeral **64** identifies the transmission pattern of a second portable transmitter. Assuming that both portable transmitters are actuated exactly at t=0, the signal received during the first opening of the window of acceptance will be corrupted since two locomotive status word transmissions are concurrent in time. However, the third and the seventh locomotive status word transmissions from the first portable transmitter will be clearly received since there is no overlap with the locomotive status words sent out by the second portable transmitter. Hence the purpose of providing each transmitter with a unique signal repetition rate reduces the likelihood of transmission conflicts.

It should be noted that the receiver **48** can, and probably will, correctly receive from time to time a locomotive status word from an unrelated transmitter. This status word will be rejected, however, because the transmitter identifier will not match the value stored in the memory of the slave controller.

The transmitter/receiver gear of the remote locomotive control system has been described above in terms of function of the principal parts of the system and their interaction. The components and interconnections of the electric network necessary to carry into effect the desired functions are not being specified because such details are well within the reach of a man skilled in the art.

FIG. **10** provides a functional diagram of the processing unit **50**. A central processing unit (CPU) **66** communicates with a memory through a bus **70**. A reserved portion memory **68** contains the programm that directs the CPU **66** to control the locomotive depending on the several inputs that will be discussed later. The memory also contains a section allowing temporary storage of data used by the CPU when handling hardware events.

The current locomotive status and the commands issued from the remote transmitter are directed to the CPU through an interface **72** communicating with the bus **70**. The interface **72** receives input signals from the following sources:

a) A speed direction sensor **74** providing locomotive velocity and direction of movement data;

b) A speed sensor **76** providing solely locomotive velocity data. The speed sensor **76** provides the CPU **66** with redundant velocity data allowing the CPU **66** to detect a possible failure of the main speed sensor **74**.

c) A pressure sensor **78** observing the air pressure in the locomotive brake system;

d) A pressure sensor **79** observing the air pressure in the main reservoir;

e) A pressure sensor **80** observing the air pressure in the train brake system;

f) A sensor **82** observing the flow rate of air in the brake system of the train; and

g) The decoded locomotive status word generated by the receiver **48**.

The structure of the speed/direction sensor **74** is illustrated in FIGS. **11** and **12**. The sensor includes a disk **84** mounted to an axle **86** of the locomotive. When the locomotive is moving the disk **84** turns at the same angular speed as the axle **86**. The disk **84** is provided with a layer of reflective coating **85** deposited to form on the periphery of the disk equidistant and alternating reflective zones **87** and substantially non-reflective zones **89**. A pair of opto-electric sensors **92** and **94** are mounted in a spaced apart relationship adjacent the periphery of the disk **84**. The sensor **92** comprises an emitter **92**a generating a light beam perpendicular to the plane of the disk **84**, and a receiver **92**b producing an electrical signal when sensing the reflection of the light beam on the reflective zones **87**. However, when a substantially non-reflective surface **89** registers with the sensor **92**, the output of the receiver is null or very low. The structure and operation of the opto-electric sensor **94** is identical to the sensor **92**. Thus, the sensor **94** comprises an emitter **94**a and a receiver **94**b.

The spacing between the opto-electric sensors **92** and **94** is such that they generate output pulses due to the periodic change in reflectivity of the disk surface, occurring at different instants in time. As best shown in FIG. **10**, and assuming that the disk **84** rotates in the counter clockwise direction, when the sensor **92** switches on as a result of a reflective zone **87** registering with the emitter **92**a and the receiver **92**b, the sensor **94** is still in a stable on condition and can be caused to switch off only by further rotating the disk **84**.

Preferably, the disk **84** and the sensors **92** and **94** are mounted in a hermetically sealed housing to protect the assembly against contamination by water or dirt.

FIG. **13** illustrates the signal waveforms produced by the opto-electric sensors **92** and **94**. Both outputs are pulse trains having the same frequency but out of phase by an angle α which depends upon the spacing of the sensors **92** and **94**. When the locomotive moves forward the disk **84** rotates in a given direction, say clockwise. In this case, the pulse train from sensor **94** leads the pulse train from sensor **92** by angle α. When the locomotive is in reverse, then the output of sensor **92** leads the output of sensor **94** by angle α (this possibility is not shown in FIG. **13**). The processing unit **50** observes the occurrence of the leading pulse edges from the sensors **92** and **94** with relation to time to determine the identity of the leading signal, which allows derivation of the direction of movement of the locomotive.

Velocity data is derived by measuring the rate of fluctuation of the signal from any one of sensors **92** and **94**. It has been found practical to determine the velocity at low locomotive speeds by measuring the period of the signal. However, at higher speeds the frequency of the signal is being measured since the period shortens which may introduce non-negligible measurement errors.

The speed sensor **76** is similar to sensor **74** described above with two exceptions. First, a single opto-electric sensor may be used since all that is required is velocity data. Second, the speed sensor **76** is mounted to a different axle of the locomotive.

The pressure sensors **78** and **79** are switches mounted to the main reservoir and to the pneumatic line that supplies working fluid to the locomotive independent braking mechanism, and produce an electric signal in response to pressure. These sensors merely indicate the presence of pressure, not its magnitude. In essence, each sensor produces an output when the air pressure exceeds a preset level, indicating whether the reserve of compressed air is sufficient for reliable braking. Unlike the sensors **78** and **79**, the pressure sensor **80** is a transducer that generates a signal indicative of presence and magnitude of pressure in the train brake air line.

The airflow sensor **82** observes the volume of air circulating in the pneumatic lines of the train brake system. The results of this measurement along with the output of pressure sensor **78** provide an indication of the state of charge of the pneumatic network. It is considered normal for a long pneumatic path to experience some air leaks due primarily to imperfect unions in pipe couplings between cars of the train. However, when a considerable volume of air leaks, the airflow sensor **82** enables the processing unit to sense such condition and to implement corrective measures, as will be discussed later.

The interface **72** receives the signals produced by the sensors **74**, **76**, **78**, **79**, **80**, and **82** and digitizes them where required so they can be directly processed by the CPU **66**. The locomotive status word issued by the receiver **48** requires no conversion since it is already in the proper binary format.

The binary signals generated by the CPU **66** that control the various functions of the locomotive are supplied through the bus **70** and the interface **72**. The following control signals are being issued:

a) A signal **98** to set the lights of the locomotive to off/low intensity/high intensity. The signal is constituted by one (1) bit, each operative condition of the locomotive lights being represented by a different bit state;

b) A two (2) bit signal **100** to operate the bell or the horn of the locomotive;

c) A five (5) bit signal **102** for traction control. Four bits are used to communicate the throttle settings (only eight (8) settings are possible) and one bit for the power contacts of the electric traction motors;

d) An eight (8) bit signal **104** for train brake control. The number of bits used allows 256 possible brake settings; and

e) A seven (7) bit signal **106** for independent brake control. The number of bits used allows 128 possible brake settings.

The interface **72** will convert at least some of the signals **98**, **100**, **102**, **104**, and **106** from the binary form to a different form that the devices at which the signals are directed can handle. This is described in more detail below.

The actuators for the lights and bell/horn are merely switches such as relays or solid state devices that energize or de-energize the desired circuit. The interface **72,** in response to the CPU **66** instruction to set the lights/bell/horn in the desired operative position, will generate an electric signal that is amplified by the driver unit **52** and then directed to the respective relay or solid state switch.

With regard to the traction control it should be noted that most locomotive manufacturers will install on the diesel/electric engine as original equipment a series of actuators that control the fuel injection, power contracts and brakes among others, hence the tractive power that the locomotive develops. This feature permits coupling several locomotives under control of one driver. By electrically and pneumatically interconnecting the actuators of all the locomotives, the throttle commands the driver issues in the cab of the mother engine are duplicated in all the slave locomotives. The locomotive remote control system in accordance with the invention makes use of the existing throttle/brake actuators in order to control power. The interface **72** converts the binary throttle settings issued by the CPU **66** to the standard signal protocol established by the industry for controlling throttle/brake actuators. This feature is particularly advantageous because the locomotive remote control system does not require the installation of any throttle/brake actuators. As in the case of the lights and bell/horn signals **98** and **100**, respectively, the traction control signal **102** incoming from the interface **72** is amplified in the driver unit **52** before being directed to the throttle/brake actuators.

The train brake control signal **104** issued by the interface **72** is an eight (8) bit binary sequence applied to a valve mounted in the train brake circuit to modulate the air pressure in the train line that controls the braking mechanism. The working fluid is supplied from a main reservoir whose integrity is monitored by the pressure sensor **79** described above. The independent locomotive brake is controlled in the same fashion with binary signal **106**.

The operation of the locomotive control system will now be described with more detail.

SPEED CONTROL TASK

The flowchart of the speed control logic is shown in FIGS. **14**a to **14**d. The program execution begins by reading the velocity data generated from sensors **74** and **76** that are mounted at different axles of the locomotive. The data gathered from each sensor is stored in the memory **68** and then compared at step **124**. If both sensors are functioning properly they should generate identical or nearly identical velocity values. In the event a significant difference is noted the CPU **66** concludes that a malfunction exists and issues a command (step **126**) to fully apply the independent brake in order to bring the locomotive to a complete stop.

Assuming that no mismatch between the readings of sensors **74** and **76** is detected, the CPU **66** will compare the observed locomotive speed with the speed requested by the operator. The later variable is represented by a string of three (3) bits in the locomotive status word (the flowchart of FIGS. **14**a to **14**d assumes that the locomotive status word has been correctly received, has the proper identifier and has been stored in the memory **68**). The operator can select on the portable transmitter **10** eight possible speed settings, each setting being represented by a different binary sequence. The speed settings are as follows:

1) STOP
2) COAST WITH BRAKE
3) COAST
4) COUPLE (1 MILE PER HOUR (MPH))
5) 4 MPH
6) 7 MPH
7) 10 MPH
8) 15 MPH

If any one of settings 4 to 8 have been selected, which require the locomotive to positively maintain a certain speed, the CPU **66** will effect a certain number of comparisons at steps **128** and **130** to determine if there is a variation between the actual speed and the selected speed along with the sign of the variation, i.e. whether the locomotive is overspeeding or moving too slowly. More particularly, if at step **128** the CPU **66** determines that the observed speed is in line with the desired speed no corrective measure is taken and the program execution initiates a new cycle. On the other hand, if the actual speed differs from the setting, the conditional test **130** is applied to determine the sign of the difference. Under a negative sign, i.e. the locomotive is moving too slowly, the program execution branches to processing thread A (shown in FIG. **14**b). In this program segment the CPU **66** will determine at step **132** the velocity error by subtracting the actual velocity from the set point contained in the locomotive status word. A proportional plus derivative plus integral algorithm is then applied for calculating throttle setting intended for reducing the velocity error to zero. Essentially the CPU **66** will calculate the sum of the integral of the velocity error signal (calculated in step **145**), of the derivative of the velocity error signal (calculated in step **147**), and of a proportional factor (calculated in step **143**). The latter is the velocity error signal multiplied by a predetermined constant. The result of this calculation provides a control signal that is used for modulating the throttle actuator of the locomotive through output signal **102** of the interface **72**.

FIG. **15**a is a diagram illustrating the variation of the current velocity signal, the set point, the velocity error, the velocity error integral, the velocity error derivative and velocity error proportional with respect to time.

With reference to FIG. **14**d, when the new throttle setting has been implemented the program execution continues to steps **134** and **136** when the current direction of movement and speed of the locomotive are determined from the reading of sensor **74**. In the event the CPU **66** observes a zero speed value for a time period of more than 20 seconds in spite of the fact that a tractive effort is being applied (step **138**), it declares a malfunction and fully applies the independent locomotive brake. Normally, when a tractive effort is applied it causes the locomotive to accelerate. The movement, however, may occur after a certain delay following the application of the tractive effort especially if the locomotive is pulling a heavy consist. Still, if after a certain time period no movement is observed, some sort of malfunction is probably present. One possibility is that both sensors **74** and **76** have failed and register zero speed even when the locomotive is rolling. This is highly unlikely but not impossible. When such condition is encountered the CPU **66** immobilizes the locomotive immediately upon determination that a fault is present.

The 20 seconds waiting period before application of the independent brake is implemented by verifying the velocity data from sensor **74** during a certain number of program execution cycles. For instance, the current velocity value is compared to the velocity value observed during the previous execution cycle that has been stored in the memory **68**. If a change is noted, i.e. the locomotive moves, then the step **138** is considered to have been successively passed. If, however, after 200 execution cycles that require about 20 seconds to be completed, no change with the previously observed velocity value is noted, the independent brake is fully applied.

Assuming that motion of the locomotive is detected at step **138**, the program proceeds to step **140** where the direction of movement of the locomotive read from the output of sensor **74** is compared to the direction of movement specified by the operator. This value is represented by a four (4) bit string in the locomotive status word. If the locomotive is moving rearwardly while the operator has specified a forward movement, the CPU **66** detects a condition known as “rollback”. Such condition may occur when the locomotive is starting to move upwardly on a grade while pulling a heavy consist. Under the effect of gravity the train may move backward for a certain distance until the traction system of the locomotive has been able to build-up the pulling force necessary to reverse the movement. During a rollback condition the electric current in the traction motors of the locomotive increase beyond safe levels. Hence it is desirable to limit the rollback in order to avoid damaging the hardware. The program is designed to tolerate a rollback condition for no longer than 20 seconds. If the condition persists beyond this time period the independent brake is fully applied. The 20 seconds delay is implemented by comparing the evolution of the results of the comparison step **140** with the results obtained during the previous execution cycle; if the results do not change for 200 program execution cycles that require about 20 seconds of running time on the CPU **66**, a fault is declared and the brake applied.

In the case where both tests **136** and **140** are successively passed, i.e. the locomotive is moving in the selected direction, the program execution returns to the beginning of the cycle as shown in FIG. **14**a.

Referring back to step **130**, if the conditional branch points toward processing thread B (see FIGS. **14**a and **14**c), which means that the locomotive is overspeeding, then the CPU **66** will calculate at step **142** the difference between the selected speed and the observed speed. The resulting error signal is then processed by using the proportional plus derivative plus integral algorithm described above to derive a new throttle setting. If by controlling the throttle (reducing the tractive effort developed by the engine) speed correction cannot be achieved, the brake is applied. The brake is modulated by using a proportional plus derivative plus integral algorithm, FIG. **15**b illustrates the brake response, along with the actual brake, error, proportional, derivative, and integral signals with relation to time. The calculated brake setting is issued as binary signal **106** (see FIG. **10**) that is directed to the braking mechanism on the locomotive.

The STOP, COAST WITH BRAKE and COAST settings will now be briefly described. The STOP setting, as the name implies, intends to bring and maintain the locomotive stationary. When the CPU **66** receives a locomotive status word containing a speed setting corresponding to STOP it immediately terminates the tractive effort and applies the independent locomotive brake at a controlled rate.

The program logic to implement the COAST and COAST WITH BRAKE services is illustrated as flowcharts in FIGS. **16**a and **16**b, respectively. When the multi-position lever **14** is set to the COAST setting the program reads the velocity data from sensor **74** at step **144** and then compares it at step **146** to the velocity value recorded during the previous program execution cycle. If the consist accelerates under the effect of gravity down a grade (no tractive effort is applied by the system in the COAST and COAST WITH BRAKE settings) the observed velocity will show an increase. The CPU **66** will then apply the independent locomotive brake to slow the consist at step **148**. The brake is modulated by using a proportional plus integral plus derivative (PID) algorithm. In the event that no velocity increase is observed the CPU **66** may set (depending upon the control signal resulting from the PID calculation) the independent brake to the release position at step **150** or keep the brake at the current setting.

The next step in the program execution is a test **152** which determines if the speed of the consist is below 0.5 MPH. In the affirmative the movement is stopped by full application of the independent brake at step **154**. If the speed of the consist exceeds or is equal to 0.5 MPH then the program returns to step **144**.

The COAST WITH BRAKE function, depicted in FIG. **16**b is very similar to the COAST service described above. The only difference is that a minimum independent brake pressure of 15 pounds per square inch (psi) is always maintained. At step **156** the acceleration of the consist is determined by comparison of the current velocity with a previous velocity value. If a positive acceleration is observed, such as when the consist moves down a grade, the brake pressure is increased at step **158** (the control is made by a PID algorithm). During the next program execution cycle the acceleration is determined again. If no positive acceleration is sensed the brake pressure is returned to 15 psi at step **160**. At step **162** the velocity of the consist is tested against the 0.5 MPH value. If the current speed is less than this limit a full independent brake application is effected in order to stop the consist, otherwise the program execution initiates a new cycle.

EXCHANGE OF COMMAND AUTHORITY BETWEEN REMOTE TRANSMITTERS

In some instances a single operator may effectively and safely control a consist that includes a limited number of cars remaining at all times well within the visual range of the operator. However, when the consist is long two operators may be required, each person being physically close to and monitoring one end of the train. The present invention provides a locomotive control system capable of receiving inputs from the selected one of two or more remote transmitters. In a two-operator arrangement, each person is provided with a portable transmitter **10** able to generate the complete range of locomotive control commands. In order to avoid confusion, however, the slave controller on-board the locomotive will accept at any point in time commands from a single designated transmitter. The only exception is a limited set of emergency and signalling commands that are available to both operators. The control function can be transferred from one transmitter to the other by following the logic depicted in the flowchart of FIGS. **17**a and **17**b.

Upon reception of a locomotive status word, the CPU will compare the identifier in the word to a list of two or more possible identifiers stored in the memory **68**. The list of acceptable identifiers contains the identifiers of all the remote transmitters permitted to assume control of the locomotive. If the identifier in the locomotive status word does not correspond to any one of the identifiers in the list, then the system rejects the word and takes no action. Otherwise, the system will determine what are the requested functions that the locomotive should perform. If the locomotive status word requests application of the emergency brake or sounding the bell or horn, then the system complies with the request. Otherwise (step **179**), if a new speed setting is requested for example, the system will comply only if the identifier in the locomotive status word matches a specific identifier in the list that designates the remote transmitter currently holding the command authority. If this step is verified, then the locomotive executes the command unless the command is a request to transfer command authority to another remote controller. The CPU **66** recognizes this request by checking the state of the bit reserved for this function in the locomotive status word. If the state of the bit is 1 (command transfer requested) the program execution continues at step **180** where the CPU **66** will perform a certain number of safety checks to determine if the command transfer can be made in a safe manner. More particularly, the CPU will determine if the locomotive is stopped and if the brake safety checks (to be described later) are verified. If the locomotive is moving or the brake safety checks fail, then no action is taken and the command remains with the portable transmitter currently in control. If this test is passed, then the CPU will monitor the reset bit of all the locomotive status words received that carry an identifier in the list stored in the memory **68** (the reset bit issued by the transmitter currently holding the controls is not considered). If within 10 seconds of the reception of the request to transfer control from the current transmitter the CPU observes a reset bit in the high position, which means that the operator of a remote transmitter in the pool of candidates able to acquire control has depressed the reset button, then the CPU **66** shifts in memory the identifier associated with the reset bit at high to the position of the current control holder. From now on the CPU **66** will accept commands (except the safety related functions of emergency brake and sounding the bell/horn) only from the new authority. The procedure of checking the reset bit is used for safety purposes in order to transfer the control of the locomotive only when the target remote controller has effectively acknowledged acceptance of the control.

If within the 10 seconds no reset bit is set to the high position, the CPU **66** will abort the transfer function and resume normal execution of the program.

BRAKE SAFETY CHECKS

FIG. **18** is a flow chart of a program segment used to identify the state of readiness of the braking system before authorizing movement of the locomotive. When a command is received to move the locomotive forward, the CPU **66** will check the pressure in the main tank that supplies compressed air to both the independent locomotive and to the train brake. If the pressure is below a preset level, the command to move the locomotive forward is aborted and no action is taken. A second verification step is required to allow movement of a locomotive which is a measurement of the flow rate of compressed air in the train brake line. The traction control signal **102** is issued only when the compressed air flow rate is below a predetermined level. As briefly discussed earlier, it is normal for a train brake line to exhibit a certain leakage due to imperfect couplings in unions between cars. However, when this leakage exceeds a predetermined level, either there is a major leak or the system is discharged and it is currently being pumped with air. In both cases the train should not be operated for obvious safety reasons.

The scope of the present invention is not limited by the description, examples and suggestive uses herein as modifications and refinements can be made without departing from the spirit of the invention. Thus, it is intended that the present invention covers the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

What is claimed is:

1. A remote control system in connection with a locomotive including a main tank with compressed air under pressure, a pneumatic brake line in which compressed air flows, and a member applying tractive power, said remote control system comprising:

a) a transmitter for generating an RF signal; and

b) a slave controller mounted on-board the locomotive, said slave controller having a first sensor responsive to the pressure of the compressed air in the main tank of the locomotive and a second sensor responsive to the flow of compressed air in the pneumatic brake line, said slave controller being responsive to outputs of said sensors to enable application of tractive power to the locomotive only when the pressure in the main tank is above a predetermined level and the flow of air in the pneumatic brake line is below a predetermined level.

2. A remote speed control system in connection with a locomotive that includes a main tank with compressed air, a pneumatic brake line in which compressed air flows, a throttle having a plurality of settings allowing tractive power regulation, and a brake system having a plurality of settings allowing braking power regulation, said speed control system comprising:

a transmitter generating an RF signal indicative of a desired speed of travel of the locomotive; and

a slave controller mounted on-board the locomotive, said slave controller having:

a) receiver means for sensing said RF signal and providing data relative to the desired speed of travel of the locomotive,

b) a first sensor responsive to the pressure of the compressed air in the main tank of the locomotive,

c) a second sensor responsive to the flow of compressed air in the pneumatic brake line of the locomotive, and

d) processor means for receiving said data relative to the desired speed of travel of the locomotive from said receiver means, said processor means responsive to said first sensor means, to said second sensor means, and to said data relative to the desired speed of travel for generating a throttle setting signal causing the throttle of the locomotive to acquire a selected setting *only* when the pressure of the compressed air in the main tank is above a predetermined level and the flow of compressed air in the pneumatic brake line is below a predetermined level.

[3. A remote speed control system in connection with a locomotive that includes a throttle having a plurality of settings allowing tractive power regulation and a brake system having a plurality of settings allowing braking power regulation, said speed control system comprising:

a transmitter generating an RF signal indicative of a desired speed of travel of the locomotive; and

a slave controller mounted on-board the locomotive, said slave controller having:

a) receiver means for sensing said RF signal and providing data relative to the desired speed of travel of the locomotive,

b) velocity sensor means for generating data representative of an actual speed of travel of the locomotive, and

c) processor means for receiving data relative to the desired speed of travel of the locomotive from said receiver means and generating a throttle setting signal causing the throttle of the locomotive to acquire a selected setting and a brake setting signal causing the brake system of the locomotive to acquire a selected setting, said processor means being responsive to said velocity sensor means and to said data relative to the desired speed of travel and generating one of said throttle setting signal and said brake setting signal correlated to a difference between the desired speed of travel and the actual speed of travel of the locomotive to change the actual speed of travel of the locomotive and diminish that difference.**]**

4. The invention as claimed in claim **[3]** *36*, wherein said processor means includes means for comparing said data relative to the desired speed of travel of the locomotive with said data representative of an actual speed of travel of the locomotive and generating an error signal correlated to the difference between the actual and desired speeds, said throttle setting signal being a linear combination of said error signal, its derivative, and its integral.

5. The invention as claimed in claim **[3]** *36*, wherein said processor means includes means for comparing said data relative to the desired speed of travel of the locomotive with said data representative of an actual speed of travel of the locomotive and generating an error signal correlated to the difference between the actual and desired speeds, said brake setting signal being a linear combination of said error signal, its derivative, and its integral.

6. The invention as claimed in claim **[3]** *36*, wherein said velocity sensor means includes a first velocity sensor generating a first signal representative of a speed of travel of the locomotive and a second velocity sensor generating a second signal representative of a speed of travel of the locomotive, said processor means being responsive to a discrepancy between said first and second speed of travel signals and issuing a brake setting signal causing the brake system of the locomotive to apply braking power.

7. The invention as claimed in claim **[3]** *36*, wherein said slave controller has means for generating data representative of a direction of travel of the locomotive.

[8. A remote coast control system in connection with a locomotive that includes a throttle having a plurality of settings allowing tractive power regulation and a brake system having a plurality of settings allowing braking power regulation, said coast control system comprising:

a transmitter generating an RF signal providing a coast command to the locomotive;

a slave controller mounted on-board the locomotive, said slave controller having:

a) receiver means for sensing said RF signal and providing said coast command,

b) means for generating data representative of a velocity variation of the locomotive with relation to time, and

c) processor means receiving said coast command from said receiver means and generating in response to said data representative of a velocity variation of the locomotive with relation to time one of (i) a brake setting signal causing the brake system of the locomotive to increase braking power when said velocity variation denotes a positive acceleration, and (ii) a brake setting signal causing the brake system of the locomotive to decrease braking power when said velocity variation denotes a negative acceleration, said processor means controlling the velocity of the locomotive without effecting any application of tractive power.]

[9. The invention as claimed in claim **8**, wherein said brake setting signal is a linear combination of an error signal representing a difference between an actual velocity of the locomotive and a velocity of the locomotive measured at a previous moment, its derivative, and its integral.]

[10. The invention as claimed in claim **9**, further comprising a velocity sensor measuring an actual speed of travel of the locomotive, said velocity sensor communicating actual speed of travel data to said processor means.]

[11. The invention as claimed in claim **8**, wherein said brake setting signal generated when said velocity variation denotes a negative acceleration represents a non-nil brake system setting, whereby braking power is applied to the locomotive at all times when said velocity variation denotes one of a positive and a negative acceleration.]

[12. A remote control system in connection with locomotive that includes a throttle allowing tractive power regulation and a brake system allowing braking power regulation, said remote control system comprising:

- a transmitter generating an RF signal providing a drive command that signals the locomotive to move in a first direction of travel;
- a slave controller mounted on-board the locomotive, said slave controller having:
  - a) receiver means for sensing said RF signal and providing data indicative of said drive command,
  - b) sensor means for generating data representative of a direction of travel of the locomotive, and
  - c) processor means receiving said data indicative of said drive command from said receiver means and generating a throttle signal causing application of tractive power to the locomotive, said processor means also receiving said data representative of a direction of travel of the locomotive from said sensor means and generating a brake signal causing application of the brakes when the locomotive moves in a direction other than said first direction of travel.]

[13. The invention as claimed in claim **12**, wherein said processor means generates said brake signal causing application of the brakes when the locomotive moves in a direction other than said first direction of travel after a predetermined amount of time has elapsed from the application of tractive power to the locomotive.]

[14. The invention as claimed in claim **12**, wherein said predetermined amount of time is about 20 seconds.]

[15. A remote drive control system in connection with a locomotive with rollback protection, the locomotive including a throttle allowing tractive power regulation and a brake system allowing braking power regulation, said remote drive control system comprising:

- a transmitter generating an RF signal providing a drive command that signals the locomotive to start moving in a first direction of travel;
- a slave controller mounted on-board the locomotive, said slave controller comprising:
  - a) receiver means for sensing said RF signal and providing data indicative of said drive command,
  - b) sensor means generating data representative of an actual direction of travel of the locomotive, and
  - c) processor means receiving said data indicative of said drive command from said receiver means and issuing a throttle signal causing application of tractive power to the locomotive, said processor means also receiving said data representative of an actual direction of travel of the locomotive from said sensor means and generating a brake signal causing application of the brakes when the locomotive moves in a direction other than said first direction of travel and a predetermined period of time has elapsed from the application of tractive power to the locomotive.]

[16. The invention as claimed in claim **15**, wherein said predetermined period of time is about 20 seconds.]

17. A remote speed control system in connection with a locomotive that includes a throttle having a plurality of settings allowing tractive power regulation and a brake system having a plurality of settings allowing braking power regulation, said speed control system comprising:

- *a transmitter generating an RF signal indicative of a desired speed of travel of the locomotive; and*
- *a slave controller mounted on-board the locomotive, said slave controller having:*
  - *a) receiver means for sensing said RF signal and providing data relative to the desired speed of travel of the locomotive,*
  - *b) velocity sensor means for generating data representative of an actual speed of travel of the locomotive,*
  - *c) a first sensor responsive to pressure of compressed air in a main tank of the locomotive,*
  - *d) a second sensor responsive to a flow of compressed air in a pneumatic brake line of the locomotive, and*
  - *e) processor means for receiving data relative to the desired speed of travel of the locomotive from said receiver means and generating a throttle setting signal causing the throttle of the locomotive to acquire a selected setting and a brake setting signal causing the brake system of the locomotive to acquire a selected setting, said processor means being responsive to said velocity sensor means and to said data relative to the desired speed of travel and generating one of said throttle setting signal and said brake setting signal correlated to a difference between the desired speed of travel and the actual speed of travel of the locomotive to change the actual speed of travel of the locomotive and diminish that difference; and*
- *wherein said slave controller is responsive to outputs of said first and second sensors to enable application of tractive power to the locomotive only when the pressure in the main tank is above a predetermined level and the flow of air in the pneumatic brake line is below a predetermined level.*

18. The remote speed control system as defined in claim 17, wherein said transmitter assembles a locomotive status word representing one or more requested operative states of the locomotive.

19. The remote speed control system as defined in claim 18, wherein said locomotive status word includes locomotive speed information.

20. The remote speed control system as defined in claim 18, wherein said locomotive status word includes locomotive brake information.

21. The remote speed control system as defined in claim 18, wherein said locomotive status word includes reset information.

22. The remote speed control system as defined in claim 18, wherein said locomotive status word includes direction of movement of the locomotive information.

23. The remote speed control system as defined in claim 18, wherein said locomotive status word includes locomotive bell/horn ring information.

24. The remote speed control system as defined in claim 18, wherein said locomotive status word includes locomotive lights control information.

25. The remote speed control system as defined in claim 18, wherein said locomotive status word includes information indicating intent to relinquish command authority to another transmitter.

26. The remote speed control system as defined in claim 18, wherein said transmitter appends to said locomotive status word transmitter identifier information.

27. The remote speed control system as defined in claim 18 wherein said transmitter repeatedly transmits information in said locomotive status word at a unique repetition rate with respect to other transmitters.

28. The remote speed control system as defined in claim 17, wherein said receiver means is synchronized with said transmitter.

29. The remote speed control system as defined in claim 17, wherein said processor means is capable of detecting a fault condition associated with said velocity sensor means, when the fault condition is detected said processor means generating the brake setting signal to cause the locomotive to stop.

30. A remote speed control system in connection with a locomotive that includes a throttle having a plurality of settings allowing tractive power regulation and a brake system having a plurality of settings allowing braking power regulation, said speed control system comprising:

a portable transmitter generating an RF signal indicative of a desired speed of travel of the locomotive; and

a slave controller mounted on-board the locomotive, said slave controller having:

a) receiver means for sensing said RF signal and providing data relative to the desired speed of travel of the locomotive,

b) velocity sensor means for generating data representative of an actual speed of travel of the locomotive and an airflow sensor responsive to a flow of compressed air in a pneumatic brake line of the locomotive, and

c) processor means for receiving data relative to the desired speed of travel of the locomotive from said receiver means and generating a throttle setting signal causing the throttle of the locomotive to acquire a selected setting and a brake setting signal causing the brake system of the locomotive to acquire a selected setting, said processor means being responsive to said velocity sensor means and to said data relative to the desired speed of travel and generating one of said throttle setting signal and said brake setting signal correlated to a difference between the desired speed of travel and the actual speed of travel of the locomotive to change the actual speed of travel of the locomotive and diminish that difference; and

wherein said processor means initiates a brake line check to enable application of tractive power by the locomotive only when the flow of air sensed by said airflow sensor is below a predetermined level.

31. The remote speed control system as defined in claim 17, wherein when processing means enables application of tractive power but the locomotive is not caused to move after a predetermined amount of time has elapsed from application of tractive power, said processing means causes application of the brake system.

32. The remote speed control system as defined in claim 17, wherein said processing means causes application of the brake system when a rollback condition exceeds a predetermined time period.

33. The remote speed control system as defined in claim 17, wherein said transmitter is operative to convey a coast command to said receiver means, said processing means being responsive to said coast command to preclude application of tractive power to the locomotive and control movement of the locomotive by regulating application of said brake system.

34. A remote speed control system as defined in claim 17, wherein said transmitter is operative to convey a coast with brake command to said receiver means, said processing means being responsive to said coast with brake command to preclude application of tractive power to the locomotive and cause said brake system to be continuously applied during movement of the locomotive.

35. The remote speed control system as defined in claim 17, wherein said transmitter includes a display panel displaying a current setting of one or more controls.

36. The remote speed control system as defined in claim 35, wherein said display panel displays locomotive speed control information.

37. The remote speed control system as defined in claim 36, wherein said locomotive speed control information includes at least one of a coast with brake indication, a stop indication, a coast indication and a couple indication.

38. The remote speed control system as defined in claim 35, wherein said display panel displays information on a direction of movement of the locomotive.

39. The remote speed control system as defined in claim 35, wherein said display panel displays brake information.

40. The remote speed control system as defined in claim 17, wherein said transmitter includes manually operable controls and wherein said manually operable controls include a multi position control element to control locomotive speed.

41. The remote speed control system as defined in claim 40, wherein said multi position control element includes a stop setting.

42. The remote speed control system as defined in claim 40, wherein said multi position control element includes a coast with brake setting.

43. The remote speed control system as defined in claim 40, wherein said multi position control element includes a coast setting.

44. The remote speed control system as defined in claim 40, wherein said multi position control element includes a couple setting.

45. The remote speed control system as defined in claim 40, wherein said multi position control element to control locomotive speed is mounted a sidewall of said transmitter.

46. The remote speed control system as defined in claim 40, wherein said manually operable controls include a multi position control element to control locomotive braking.

47. The remote speed control system as defined in claim 35, wherein said display panel is mounted on a top wall of said transmitter.

48. The remote speed control system as defined in claim 40, wherein said manually operable controls include a control element having a reset function.

49. The remote speed control system as defined in claim 40 wherein said manually operable controls include a multi position control element to control a direction of movement of the locomotive.

50. The remote speed control system as defined in claim 49, wherein said transmitter has a front wall, said multi position control element to control a direction of movement of the locomotive being mounted on said front wall.

51. The remote speed control system as defined in claim 40, wherein said manually operable controls include a control element to ring a bell/horn on the locomotive.

52. The remote speed control system as defined in claim 40, wherein said manually operable controls include a control element to control a train brake.

53. The remote speed control system as defined in claim 40, wherein said manually operable controls include a control element to control lights on the locomotive.

54. The remote speed control system as defined in claim 40, wherein said manually operable controls include a control element to perform a locomotive status request function.

55. The remote speed control system as defined in claim 40, wherein said manually operable controls include a control element to signal intent to relinquish control to a another transmitter.

56. The remote control system as defined in claim 1, wherein said member applying tractive power includes a throttle having a plurality of settings allowing tractive power regulation, said slave controller being responsive to said RF signal to generate a throttle setting signal causing the throttle of the locomotive to acquire a selected setting for imparting movement to the locomotive, when the pressure in said main tank is above said predetermined level and the flow of air in said pneumatic brake line is below said predetermined level.

57. The remote control system as defined in claim 56, wherein the locomotive has a brake system having a plurality of settings allowing braking power regulation, the RF signal conveying a desired speed of travel of the locomotive, said slave controller generating one of the throttle setting signal and a brake setting signal causing the brake system of the locomotive to acquire a selected setting such as to regulate the speed of the locomotive in accordance with the desired speed of travel.

58. The remote control system as defined in claim 1, wherein said slave controller is responsive to the RF signal to impart movement to the locomotive when the pressure in said main tank is above said predetermined level and the flow of air in said pneumatic brake line is below said predetermined level, wherein said transmitter is one of two or more transmitters, one of which holds command authority, the command authority being transferable between the two or more transmitters.

59. The remote control system as defined in claim 2, wherein said slave controller causes the brake system of the locomotive to acquire a selected setting such as to regulate the speed of the locomotive in accordance with the desired speed of travel.

60. The remote control system as defined in claim 2, wherein said transmitter is one of two or more transmitters, one of which holds command authority, the command authority being transferable between the two or more transmitters.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : RE 39,011 E
APPLICATION NO. : 10/374590
DATED : March 14, 2006
INVENTOR(S) : Folkert Horst et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Col. 1, before FIELD OF THE INVENTION, please add

--Notice: More than one reissue application has been filed for the reissue of Patent No. 5,511,749. The reissue applications are application number 10/374,590 (the present application) and 11/274,719, which is a continuation reissue of Patent No. 5,511, 749.--.

Col. 17, line 57, please replace “when processing” with --when said processing--.

Col. 18, line 47, please replace “mounted a sidewall” with --mounted on a sidewall--.

Signed and Sealed this

Fifth Day of September, 2006

Jon W. Dudas

JON W. DUDAS
Director of the United States Patent and Trademark Office