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Vrabel et al.

[11] **3,905,012**

[45] **Sept. 9, 1975**

[54] **DYNAMIC RAILROAD FREIGHT CAR MONITORING SYSTEM**

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[22] Filed: **Aug. 2, 1974**

[21] Appl. No.: **494,098**

[52] **U.S. Cl.** ..... **340/48**; 246/167 D

[51] **Int. Cl.**[2] **B61L 15/00**

[58] **Field of Search** ..... 340/48, 150, 409, 224, 340/182, 171 R, 171 A; 246/30, 167 D, 168; 105/61; 343/228

[56] **References Cited**

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2,961,640	11/1960	Von Behren	340/48
3,273,145	9/1966	Joy et al.	246/167 D

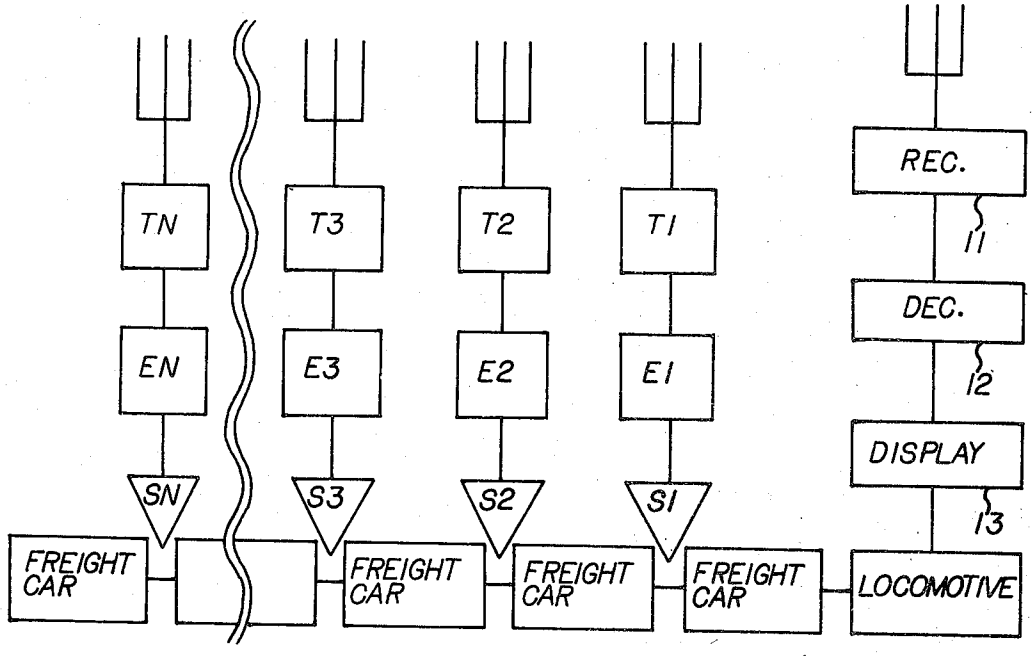
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[57] **ABSTRACT**

Disclosed herein is a monitoring system that provides an engineer of a freight train with a real time picture of the coupling extensions of selected cars distributed throughout the entire length of his train. Located between each selected pair of cars is a sensor that detects whether a Buff (compressed) or a Draft (stretched) condition exists at the coupling. Individual encoders associated with each of the sensors respond thereto by providing one of two uniquely coded outputs representing, respectively, either a Draft or Buff condition as detected by the sensor. The outputs of the encoders are relayed by individual transmitters to a receiver located at a control station. Coupled to the receiver is a decoder that decodes the incoming signals and energizes a display that furnishes the engineer with a dynamic indication of the coupling condition existing at each of the selected points along the train.

10 Claims, 5 Drawing Figures



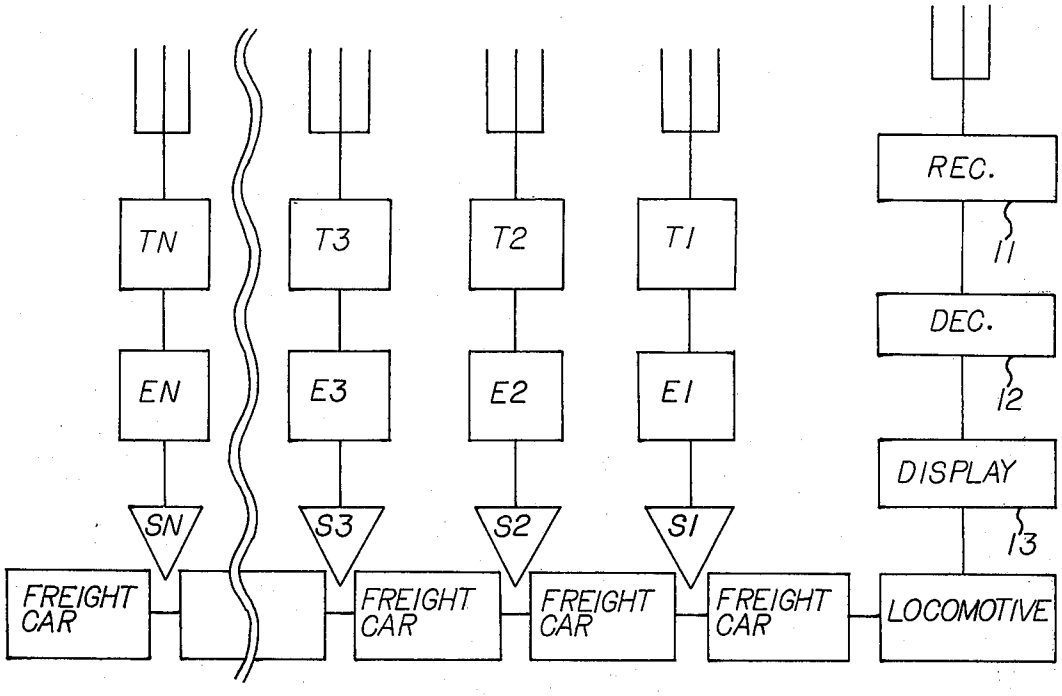

TN
T3
T2
T1
REC.
EN
E3
E2
E1
11
DEC.
12
DISPLAY
SN
S3
S2
S1
13
FREIGHT CAR
FREIGHT CAR
FREIGHT CAR
FREIGHT CAR
LOCOMOTIVE

FIG. 1

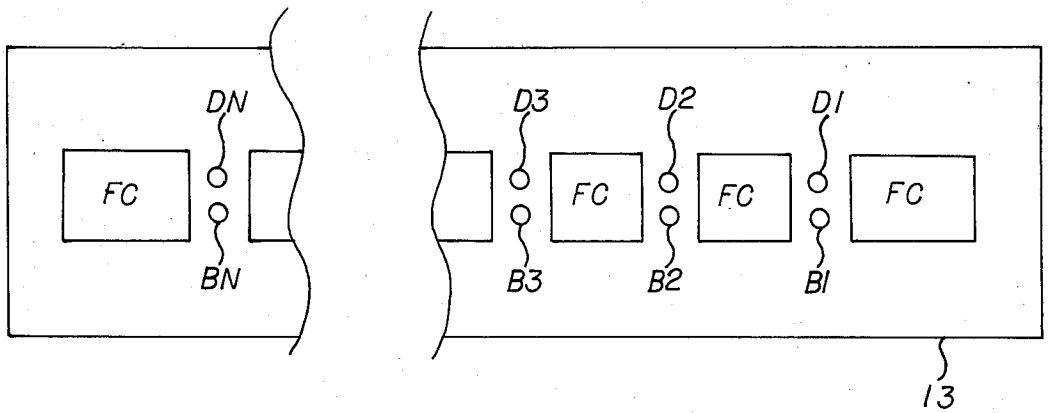

DN
D3
D2
D1
FC
FC
FC
FC
BN
B3
B2
B1
13

FIG. 2

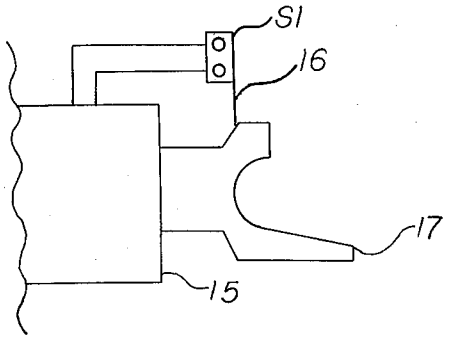

S1
16
17
15

FIG. 3

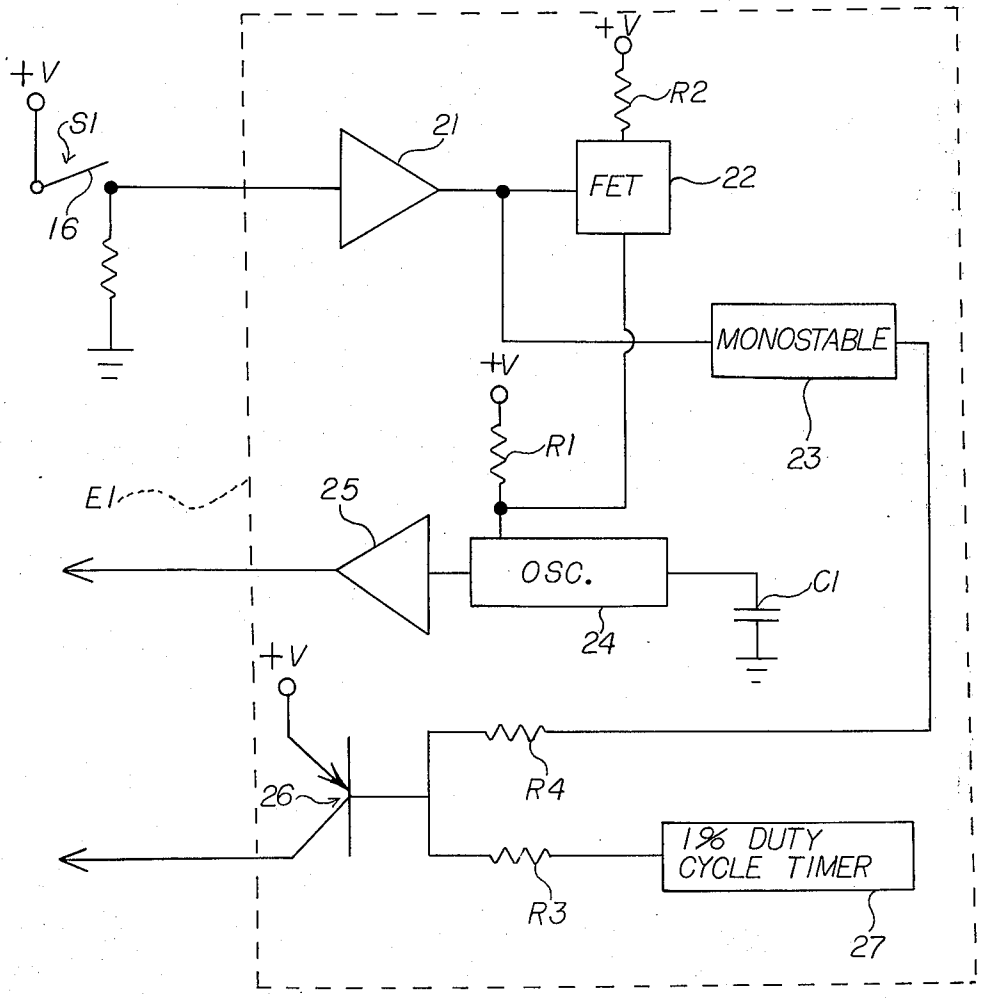

+V
S1
16
21
+V
R2
FET
22
MONOSTABLE
23
+V
R1
E1
25
OSC.
24
C1
+V
26
R4
R3
1% DUTY CYCLE TIMER
27

FIG. 4

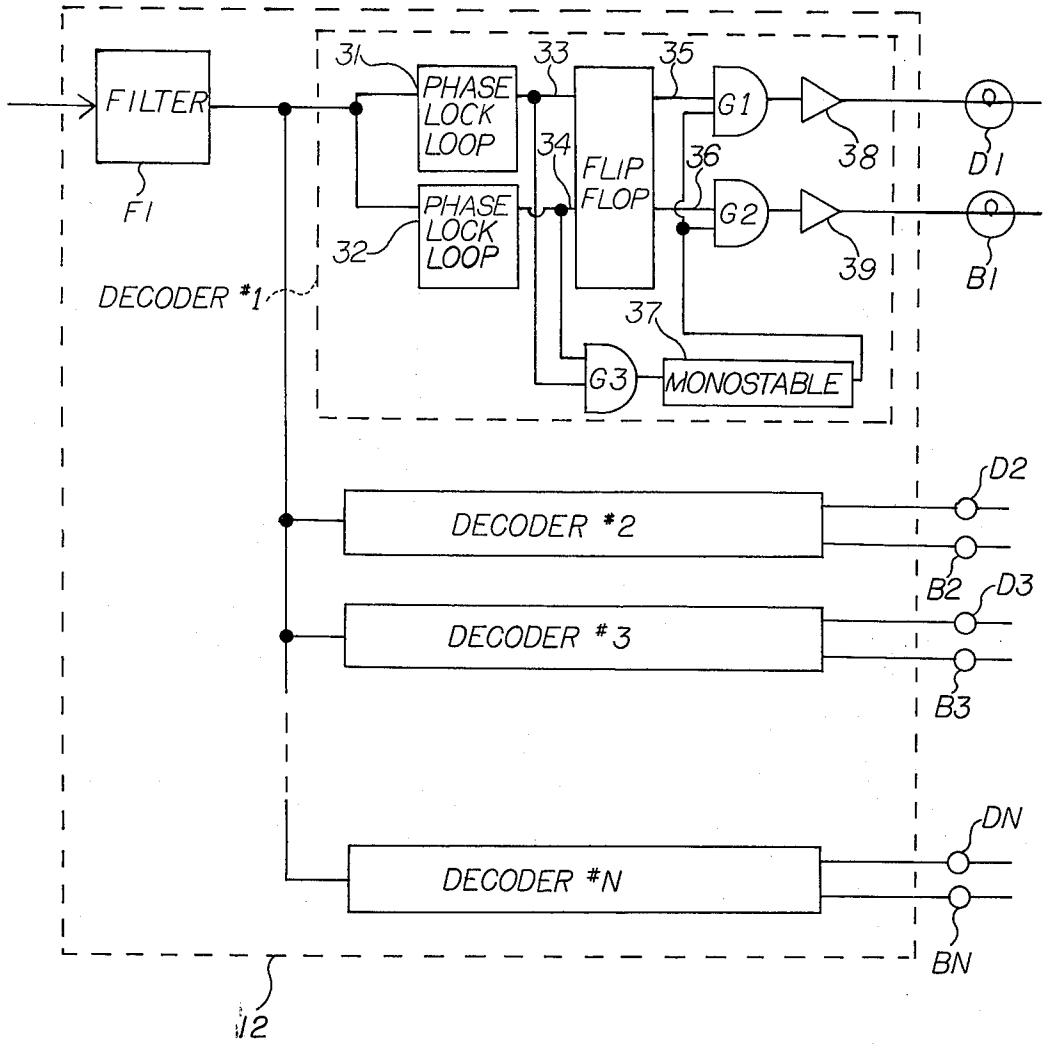

FILTER
F1
DECODER #1
31
PHASE LOCK LOOP
32
PHASE LOCK LOOP
33
34
FLIP FLOP
35
36
G1
G2
G3
38
39
37
MONOSTABLE
D1
B1
DECODER #2
DECODER #3
DECODER #N
D2
B2
D3
B3
DN
BN
12

FIG. 5

DYNAMIC RAILROAD FREIGHT CAR MONITORING SYSTEM

BACKGROUND OF THE INVENTION

This invention relates generally to a radio transmission system for dynamically indicating the coupling forces occurring between pairs of objects which are capable of undergoing relative movement and, more particularly, to such a system for monitoring the slack or looseness in the couplings of railroad freight cars.

Of importance to railroad companies and others is decreasing or eliminating damage to goods shipped by rail. Intrinsically associated with the physical design and use of most freight cars in use today is an amount of large dynamic forces in the form of physical shocks. It is not unusual for shock forces in excess of 1,000,000 pounds to be recorded on freight cars in normal use. These forces occur due to a necessary amount of slack, or looseness, in the couplings presently used. The presence of slack is required to start a stationary train because of the large impulse force needed. The force which a locomotive or locomotive consist can apply to its load is limited by its power, its mass, the coefficient of friction between its wheels and the rails and the tensile strength of the coupling. For an engineer to start a long stretched (all slack between cars taken up) train he must first reverse and compress the train one car at a time and then move forward accelerating one car at a time until the entire train is moving. He can then pull the train as a unit, accelerating slowly. While the engineer can start a stretched train, it subjects the couplings to large forces and possible breaks.

However, this necessary slack poses many problems. If we consider the previously mentioned compressed stationary train, and the engineer starts to accelerate the locomotive, each car is jerked from a stationary position to a moving one, and once started, accelerates with the train. As the cars are sequentially started and gain speed, each succeeding car is jerked harder. Consequently, the cars at the tail of the train can receive an immense force, based on what rate the engine has been accelerating, and the velocity it has achieved, because in one instant the car is accelerated from zero to the velocity of the locomotive.

In addition, as the train moves over uneven terrain, the cars can move independently from the engine due to the slack which decouples the engine force from the car. This can result in floating cars, cars rolling down hill independently; slapping cars; and shock waves propagating along the train. This is by no means a small consideration, as freight trains can routinely extend for up to two miles with a distributed slack on the order of 50 feet. On a train of this size the engineer has no idea of the amount of magnitude of terrain induced slack action occurring in the train as he can only feel the shocks acting on his locomotive. These shocks can be sufficient to break the forged couplings.

Prior to this time the effort devoted to this problem has been limited to monitoring and recording the coupling extensions of selected cars on specially instrumented trains and the resultant data analyzed by technical personnel at a later date. Such techniques do not, of course, provide this information to the engineer on a real time basis. At present, aside from shocks to the head locomotive, the only indications the engineer receives are reports on the slack action in the caboose from the conductor. Similarly, limited information would be obtained by a Doppler system for monitoring total train length in a manner disclosed in U.S. Pat. No. 3,273,145. Information from either of these sources, however, provides no insight into shock forces occurring at specific points within the train.

The object of this invention, therefore, is to provide a monitoring system that will help an engineer eliminate or reduce slack action shock, and consequently freight damage.

SUMMARY OF THE INVENTION

This invention provides an engineer of a freight train with a real time picture of the coupling extensions of selected cars distributed throughout the entire length of his train. Located between each selected pair of cars is a sensor that detects whether a Buff (compressed) or a Draft (stretched) condition exists at the coupling. Individual encoders associated with each of the sensors respond thereto by providing one of two uniquely coded outputs representing, respectively, either of Draft or Buff condition as detected by the sensor. The outputs of the encoders are relayed by individual transmitters to a receiver located at a control station. Coupled to the receiver is a decoder that decodes the incoming signals and energizes a display that furnishes the engineer with a dynamic indication of the coupling condition existing at each of the selected points along the train. The engineer then can modify this train handling techniques and receive an instantaneous picture of the effect thereof on the stability of the train. Use of the system will ultimately equip the engineer with better train handling techniques in his attempts to minimize unwanted display changes which are indicative of slack action between cars of the train.

In a featured embodiment of the invention, each of the individual transmitters is operated on a limited duty cycle such that the encoders provide their output signals asynchronously but at least once during a given operating time cycle. In response to the failure of the receiver to receive a signal from a given transmitter during a given time period of, for example, twice the operating time cycle, the decoder provides an output indicating this trouble condition thereby alerting the engineer that no signal is being received.

DESCRIPTION OF THE DRAWINGS

These and other objects and features of the present invention will become more apparent upon a perusal of the following description taken in conjunction with the accompanying drawings wherein:

FIG. 1 is a schematic block diagram illustrating the invention;

FIG. 2 is a schematic diagram illustrating the display indicator shown in FIG. 1;

FIG. 3 is a schematic illustration of one of the switches mounted on a coupling between each pair of freight cars shown in FIG. 1;

FIG. 4 is a schematic block diagram of one of the encoders shown in FIG. 1; and

FIG. 5 is a schematic block diagram of the decoder shown in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Schematically shown in FIG. 1 is a railway train including a locomotive and a plurality of freight cars. Mounted between selected pairs of freight cars distrib-

uted along the length of the train and responsive to the slack condition therebetween are switches S1, S2, S3 . . . SN. Each of the switches S1–SN activates an individual encoder E1, E2, E3 . . . EN which in turn controls an individual ratio transmitter T1, T2, T3 . . . TN. Mounted in the locomotive is a radio receiver 11 that receives signals transmitted by all of the transmitters T1–TN. The output of the receiver 11 is fed to a decoder 12 that in turn operates a display indicator unit 13 that is monitored by the engineer controlling the locomotive.

Referring now to FIG. 2 there is shown schematically the display unit 13 of FIG. 1. A plurality of blocks FC represent the freight cars illustrated in FIG. 1. Disposed between each pair of blocks FC are a pair of signal lights D1, B1; D2, B2; D3, B3; . . . DN, BN. As described hereinafter, the decoder 12 energizes one of the signal lights D1–DN in response to a signal indicating a Draft condition between the freight cars represented by the blocks FC straddling the energized light and energizes one of the lights B1–BN in response to a signal indicating a Buff condition therebetween. Thus, an engineer controlling the locomotive is provided with a dynamic display indicating at any time whether a Buff or Draft condition exists between selected pairs of freight cars distributed along his train.

FIG. 3 schematically illustrates the switch S1 of FIG. 1 mounted on a stationary journal 15 of a freight car. The switch S1 is mounted on the journal box 15 such that its switch arm 16 is responsive to the slack condition existing at a coupling 17. The position of the switch is adjusted so that the coupling 17 barely activates the switch arm 16 when in a gentle Buff condition (no compression of the Draft gear). Any further compression of the coupling 17 signals a Buff state, and any extension past this point signals a Draft condition as explained in greater detail below. It will be appreciated that the other switches S2–SN are similarly mounted on the couplings between their respective freight cars.

The circuit details of the encoder E1 of FIG. 1 are illustrated in FIG. 4. A positive voltage is supplied by the switch S1 to a buffer 21 the output of which is received by both an FET (field effect transistor) 22 and by an either edge triggerable monostable 23. Other electrodes of the FET are connected to a positive voltage source by, respectively, resistors R1 and R2. These resistors combine with a capacitor C1 to establish the frequency output of an oscillator 24 which output is supplied by a buffer 25 to the modulation input of the transmitter T1 shown in FIG. 1. A base electrode of a power transistor 26 receives the complement output of a 1% duty cycle timer 27 through a resistor R3 and the complement output of the monostable 23 through a resistor R4. A positive voltage is applied to the emitter electrode of the transistor 26 while its collector electrode is connected to the power connection of the transmitter T1 of FIG. 1. Except for differences in the frequencies of the oscillator 24 and the timer 27, the encoder E1 is identical to the other encoders E2–EN shown in FIG. 1.

Referring now to FIG. 5 there is shown a schematic block diagram illustrating the decoder 12. A filter F1 receives the output of the receiver 11 and supplies an output to each of a plurality of individual decoders Nos. 1, 2, 3 . . . N. The input to the decoder No. 1 is applied to both of a pair of phase lock loop tone detectors 31 and 32 each tuned to one of the possible frequency outputs of the oscillator 24 as described hereinafter. Inputs 33 and 34 of a flip-flop receive, respectively, the outputs of the phase lock loops 31 and 32. Outputs 35 and 36 of the flip-flop are applied, respectively, to a pair of gates G1 and G2. Also receiving outputs from both of the phase lock loops 31 and 32 is a gate G3 that triggers a monostable 37 the output of which is applied to both of the Gates G1 and G2. An output signal from the Gate G1 is applied through a buffer 38 to energize the signal light D1 while an output from the Gate G2 is applied through a buffer 39 to energize the signal light B1. All of the other decoders Nos. 2, 3 . . . N are identical to the decoder No. 1 except that their phase lock loops are tuned, respectively, to the output frequencies of the encoders E2, E3 . . . EN with which they are associated.

Operation of the system shown in FIG. 1 is as follows. With the switches S1–SN in quiescent states, each transmitter T1–TN broadcasts one of two tones assigned to it on an asynchronous duty cycle, one tone for Buff and another for Draft. The depicted system utilizes 2N different tones, therefore, each of which defines a specific coupling and its condition. In addition when any switch changes state, the associated transmitter immediately transmits the tone associated with the new condition of the coupling.

The radio receiver 11 receives all transmissions while the decoder 12 decodes the tones and updates the display memory accordingly. If neither of the two tones assigned to a station are received for a time consistent with two tone cycles, both indicator lights D1–DN or B1–BN for that coupling are turned off to indicate trouble or the loss of contact. The next valid reception will restore the correct indicating light. Two tone cycles are used because, in normal operation, chance simultaneous transmissions may cause interference and the loss of one or both signals. However, two sequential losses are unlikely since the tone cycle times are staggered in length. The transmitters T1–TN are on 1% duty cycles to conserve power, but all changes in couplings are displayed immediately.

The outputs of the transmitters T1–TN center of the response of the encoders E1–EN to proper operation of the switches S1–SN. This response will be described in connection with encoder E1 of FIG. 4. The state of the switch S1 generates a logic level through the buffer 21, and controls the FET switch 22. The condition of the FET 22 determines the frequency of the oscillator 24 by choosing a time constant of R1C1 (FET 22 off) or

$$\frac{R1R2C1}{R1 + R2}$$

(FET 22 on). The output of the oscillator 24 is buffered by the buffer 25 and fed to the modulator (not shown) of the RF transmitter T1 which is powered by the transistor 26. The transistor 26 is activated either by the 1% Duty Cycle Timer 27 through the resistor R3 at regular intervals or by the Either Edge Triggerable monostable 23. Signals from the monostable 23 will activate the transistor 26 through the resistor R4 for short periods whenever the switch S1 changes state. The operations of the other transmitting stations T2–TN are identical with the exception of the frequencies of their oscillators and 1% duty cycle timers.

The transmitted modulated carriers from all transmitters T1–TN are received by the receiver 11 and sent through a Band Pass filter F1 (FIG. 5). The filter F1 removes all spurious frequencies out of the narrow band containing the 2N tones, and sends the remaining signals to the phase locked loops in each of the decoders Nos. 1–N. Each phase locked loop is tuned to one of the 2N frequencies of interest. For simplicity of explanation, only one section of the decoder 13 is described, that of decoder No. 1; the other decoders Nos. 2–N being identical with the exception of the phase lock loop frequencies.

Upon reception of a tone burst, the two phase lock loop tone detectors 31 and 32 (FIG. 5) examine the frequency and accept it or reject it. If accepted by phase lock loop 31, it is the signal from transmitter T1 of a Buff condition. If accepted by phase lock loop 32, it is the signal from transmitter T1 of a Draft condition. The two signals cannot be received simultaneously. A detection by phase lock loop 31 resets the flip-flop and triggers the monostable 37 through the gate G3. The outputs of the flip-flop and the monostable 37 then enable the gate G2 and illuminate the light B1, indicating a Buff condition at the station represented by the transmitter T1. The light B1 will stay lit either until phase lock loop 32 detects its frequency and sets the flip-flop while retriggering the monostable 37 through the gate G3, at which time the light D1 is illuminated through the gate G1; or until the monostable 37 times out and disables both of the gates G1 and G2. This would occur if neither of the phase lock loops 31 and 32 detects its frequency for a time greater than two times the period of the duty cycle timer 27 of the encoder E1 (FIG. 4). It will be obvious that the other decoders Nos. 2–N operate similarly to illuminate the appropriate lights B2–BN or D2–DN in response to the signals from the transmitters T2–TN.

Obviously, many modifications and variations of the present invention are possible in light of the above teachings. For example, other embodiment possibilities include non-audio signaling on the railroad radio frequency and utilization of the present railroad radios; ultrasonic or RF carrier modulation on the rails; interrogation of the stations from a base transmitter associated with the receiver-display; carrier monitoring by the individual stations to avoid overlapping transmissions; and other telemetry techniques. Also various alternatives to the switch detector such as microwave phase radar, ultrasonic radar, string pulls, etc., are possible in addition to an indication of the relative forces experienced by the cars or couplings. An alternate display configuration might comprise a line of uniform lights representing the train with the locomotive being represented by the rightmost lights. The Buff-Draft information would be contained in the spacing between illuminated lights. A Buff condition could be displayed by two adjacent illuminated lights and a Draft condition by two illuminated lights separated by an extinguished light. It would of course be necessary to use 2N–1 lights on the display to accommodate N transmitting stations in order to display a completely stretched train, which could be represented by each alternate light being illuminated. Accordingly, a bunched train (all Buff) would be displayed by the illumination of the N+1 rightmost lights. A more advanced system using this concept might utilize string pulls to generate a Bufffloating-Draft signal to the engineer as well as shock or force magnitudes from strain or semiconductor gauges. Other car signals could also be monitored; i.e., bearing temperature, brake pipe pressure, door locks, wheel slip, etc. All these signals could be multiplexed over the existing radio link using standard serial digital data transmission techniques. Eventually a transmission scheme could be employed through the rails, through the brake pressure line, or through wires running the length of the train using automatic connectors between cars eliminating the need for high power radios. It is to be understood, therefore, that the invention can be practiced otherwise than as specifically described.

We claim:

1. Apparatus for dynamically monitoring the relative positions of railroad freight cars and comprising:
   - a plurality of individual sensors, each for detecting the extension on a coupling between a different pair of cars of a railroad train, said pairs of cars being distributed in locations along the length of the train;
   - a plurality of radio transmitters, one associated with each of said sensors and responsive thereto to produce an output signal indicative of the extension sensed thereby;
   - a plurality of encoders, one associated with and providing each of said transmitters with a uniquely coded output;
   - receiver means for receiving said output signals at a control station on the train;
   - decoder means for decoding the signals received by said receiver; and
   - indicator means for dynamically indicating the coupling extensions existing between said pairs of cars and sensed by said sensors.

2. Apparatus according to claim 1 wherein each of said encoders provides its associated transmitter with one output signal in response to the detection of a Draft condition by its sensor and a different output signal in response to the detection of a Buff condition thereby.

3. Apparatus according to claim 2 wherein each of said one and different output signals from each of said receivers possesses a unique tone frequency.

4. Apparatus according to claim 3 wherein said transmitters operate on a limited duty cycle such that said encoders provide either said one or said different signal asynchronously.

5. Apparatus according to claim 4 wherein the outputs of all said transmitters occur at least once during a given operating time cycle.

6. Apparatus according to claim 5 wherein said decoder comprises trouble means that provides said display means with a trouble indication in response to a failure to receive either said one or different output signal from any of said transmitters during a given time period.

7. Apparatus according to claim 6 wherein said given time period is at least twice said operating time cycle.

8. Apparatus according to claim 7 wherein said encoder immediately provides an appropriate signal to its associated transmitter in response to a change of extension condition detected by its associated sensor.

9. Apparatus according to claim 1 wherein said indicator means comprises a display including diagramatic representation of the cars of the train, and electrical signal lights positioned between the diagramatic cars representing the actual cars between which said sensors are disposed.

10. Apparatus according to claim 9 wherein said signal lights provide in response to said decoder a distinct indication representing either a Buff or Draft condition as detected by said sensors.

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