Feb. 24, 1970 F. E. OSLAKOVIC ET AL 3,497,055

TRAM CONTROL SYSTEM

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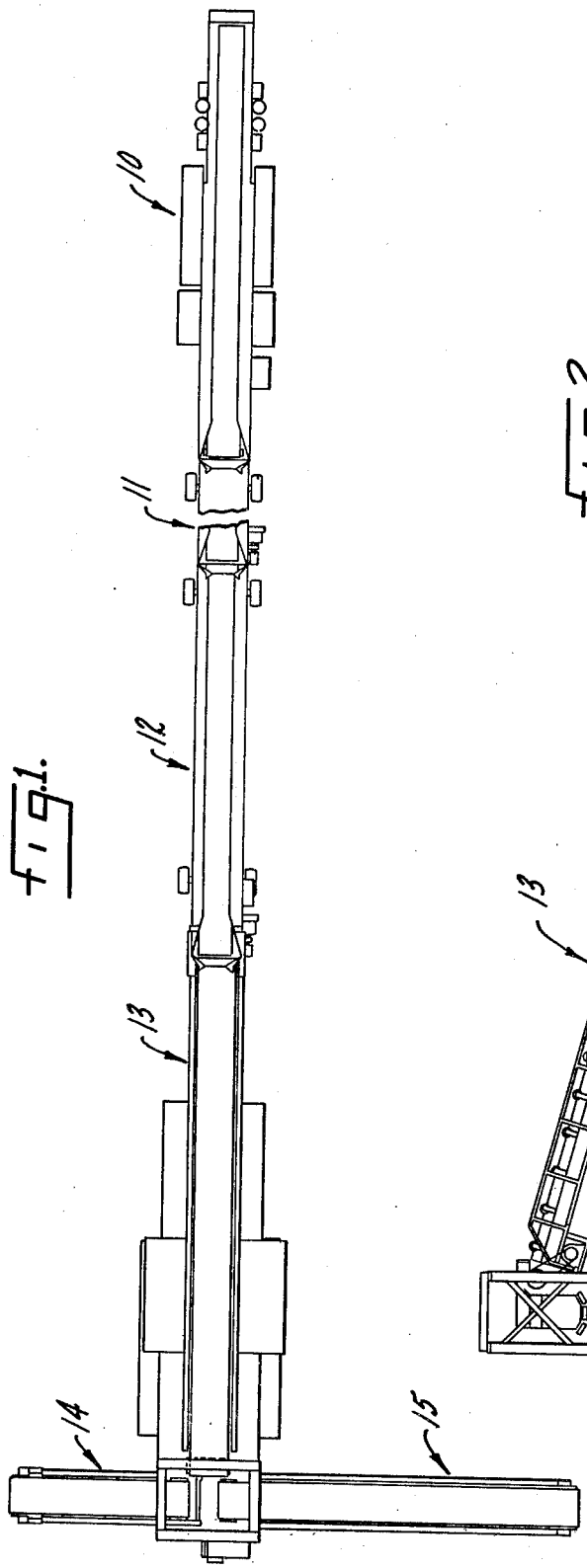


Fig. 1.

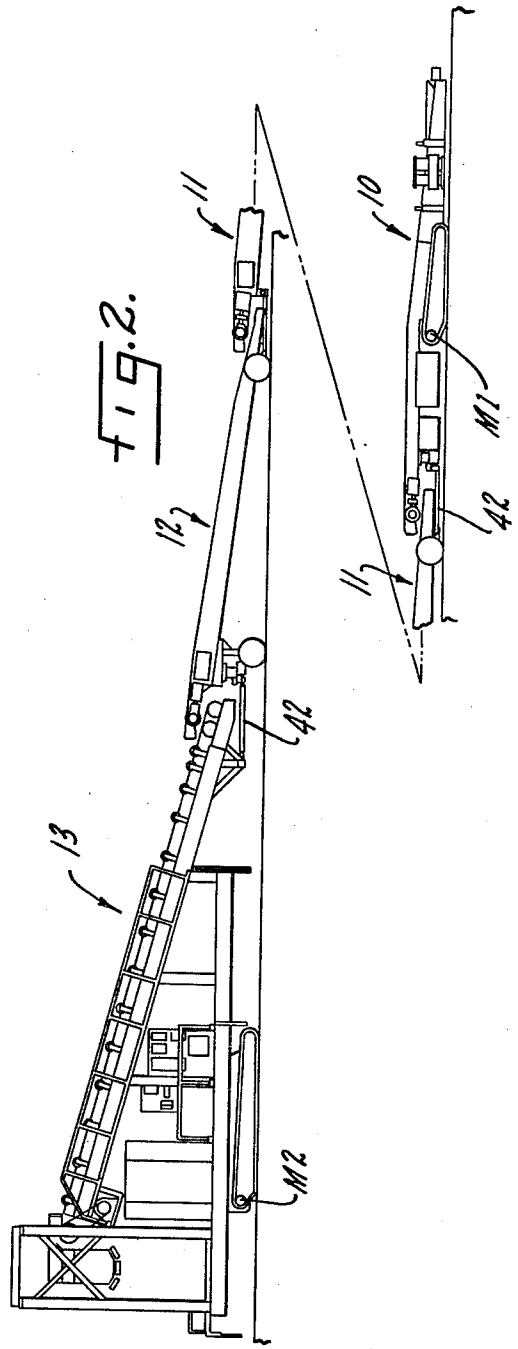


Fig. 2.

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TRAM CONTROL SYSTEM

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fig.3.

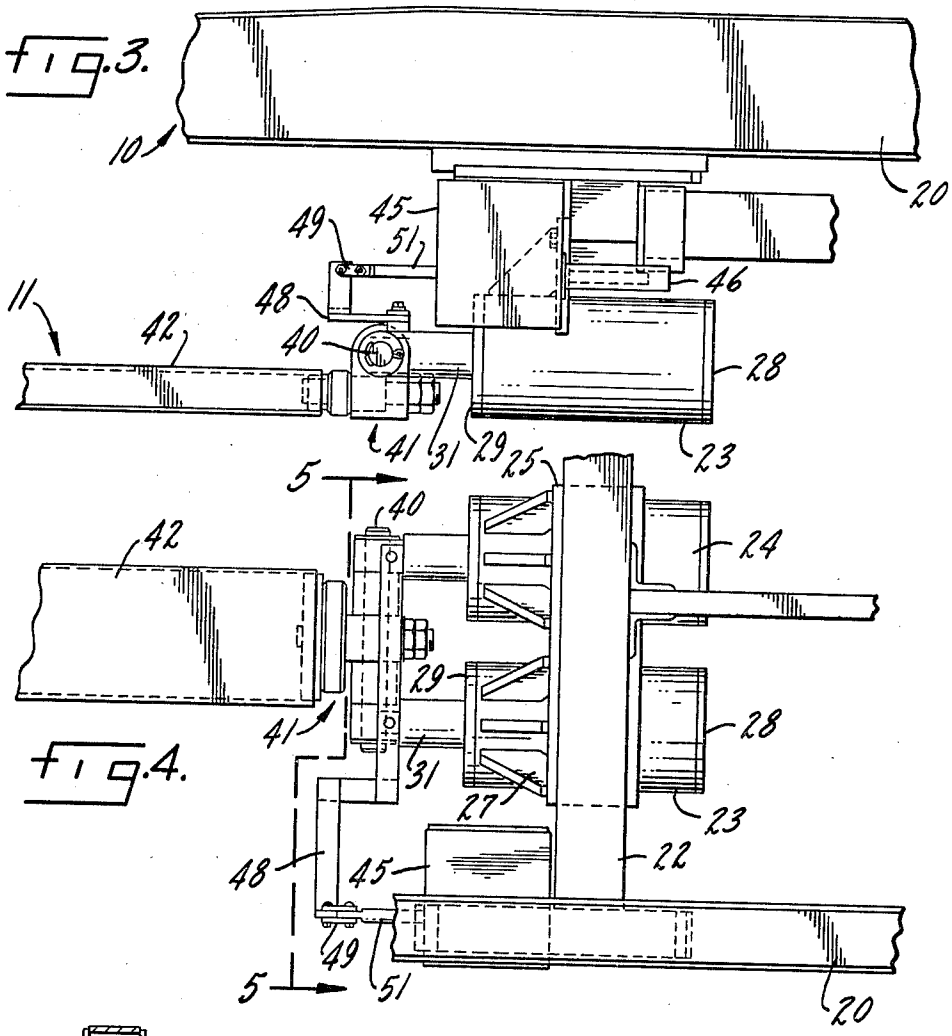


fig.4.

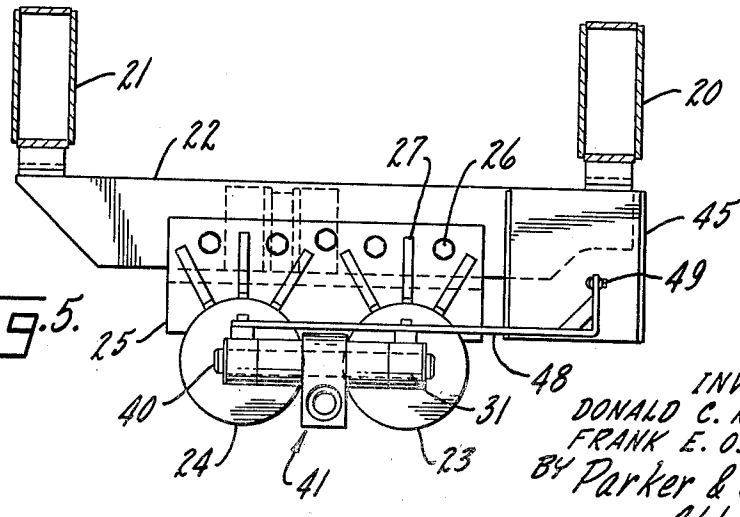


fig.5.

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TRAM CONTROL SYSTEM

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Fig. 6.

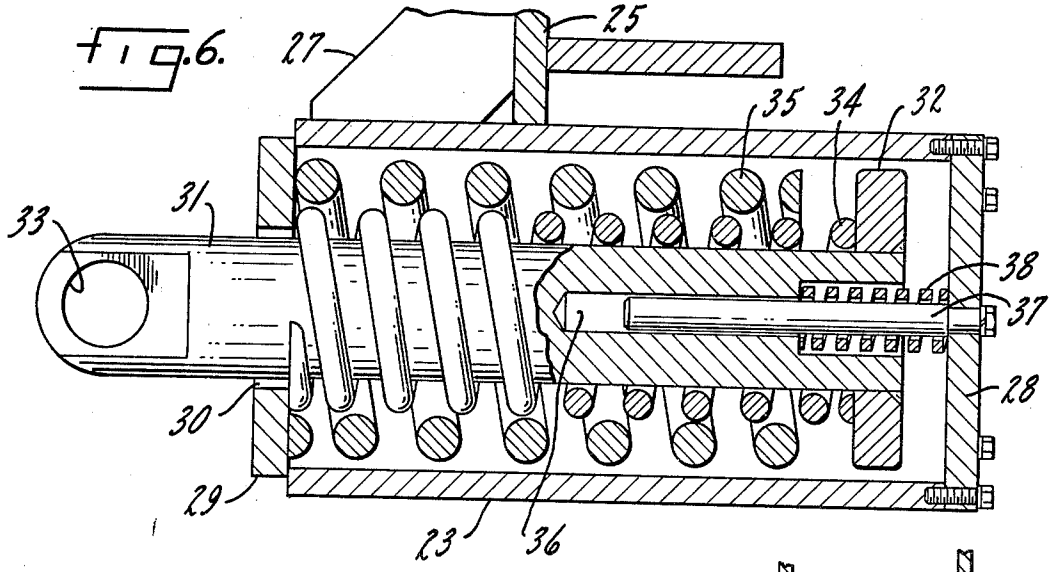



Fig. 8.

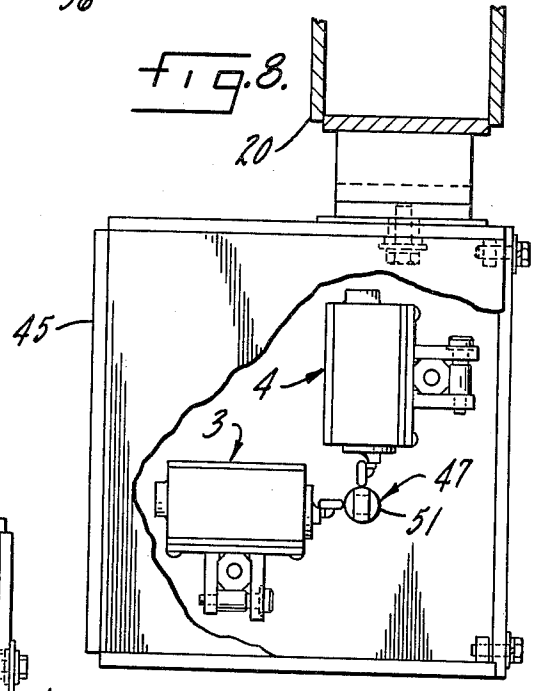
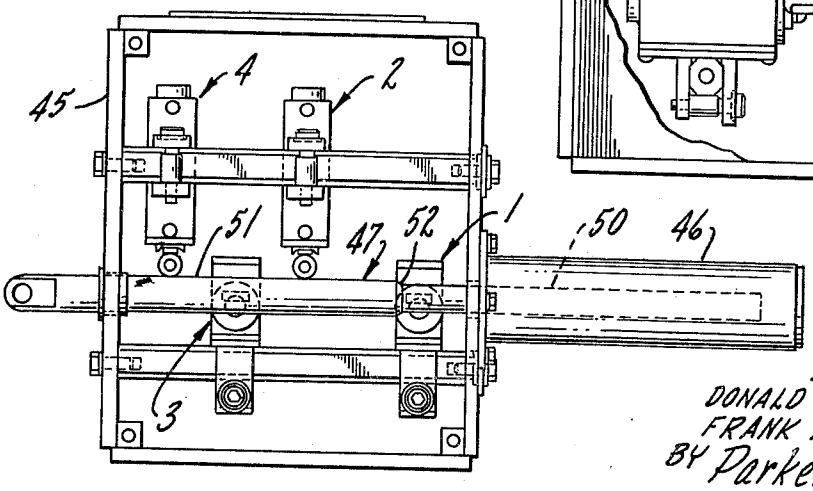



Fig. 7.

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TRAM CONTROL SYSTEM

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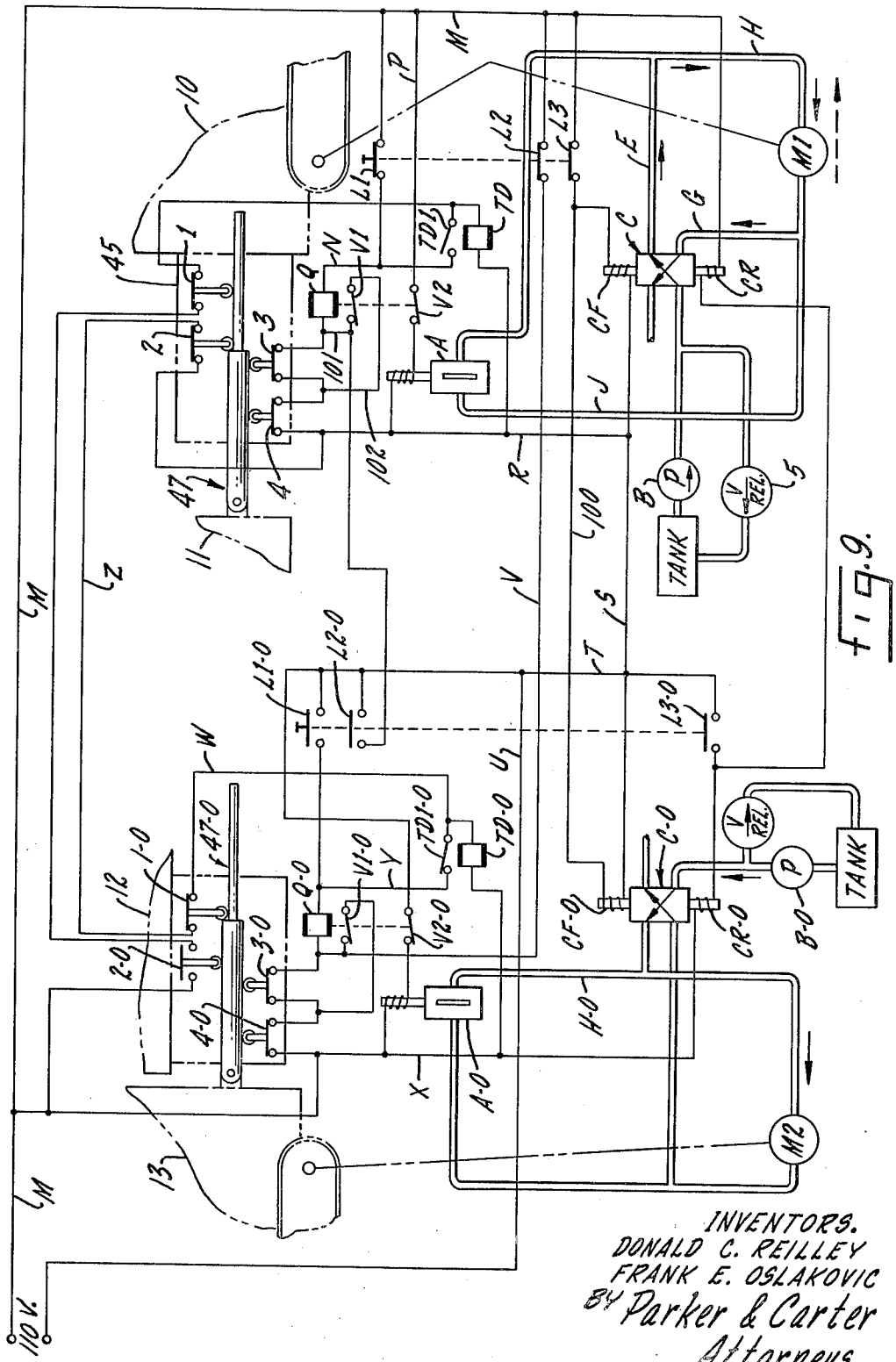


Fig. 9.

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TRAM CONTROL SYSTEM

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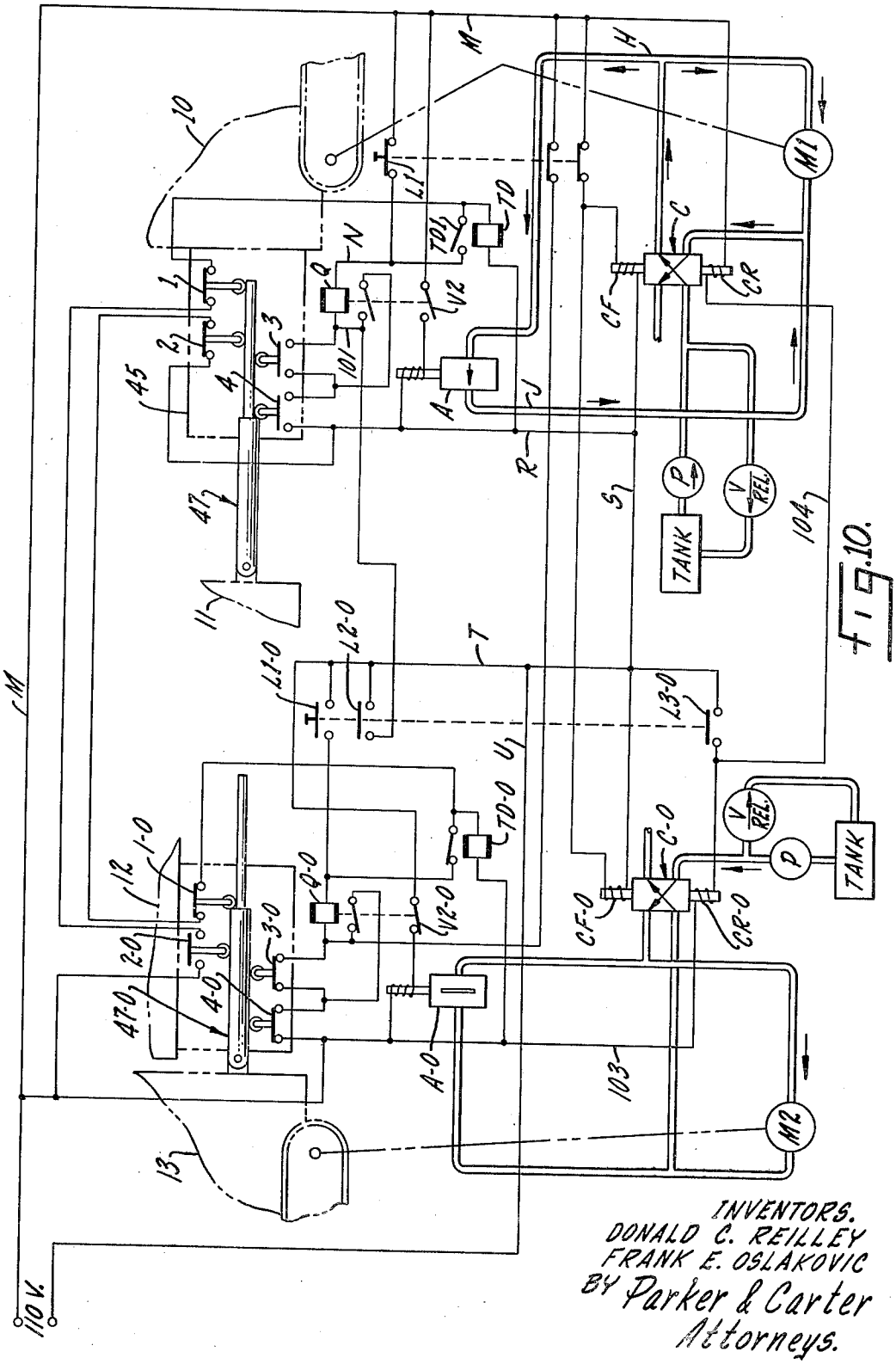


FIG. 10.

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United States Patent Office 3,497,055
Patented Feb. 24, 1970



3,497,055

# TRAM CONTROL SYSTEM

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Int. Cl. B65g 37/00, 47/31
U.S. Cl. 198—92 15 Claims

## ABSTRACT OF THE DISCLOSURE

A train system having a self-propelled unit at each end coupled to intermediate units, each end unit being capable of towing the intermediate units, but not the other end unit, irrespective of the direction of movement. An electro-hydraulic system ensures that the lead unit reaches high speed first, and thereafter slows down and then speeds up if the lead unit advances relative to the trailing unit. The system also ensures that the trailing unit slow down and then speed up if it advances relative to the lead unit. By suitable regulation of the switches in the electro-hydraulic circuit a predetermined draw bar tension between the units is not exceeded so that the lead unit never tows the trailing unit, and the trailing unit never pushes the intermediate unit.

This invention relates to a method and system for controlling the tramming movement of a multi-unit train consisting of at least two end units, one of which leads and the other of which trails, and an intermediate unit. It is specifically directed to causing the vanguard or lead unit to tow the intermediate unit irrespective of the direction of movement of the train. The invention is further concerned with means for causing the lead unit to move at different rates of speed and the trailing unit to move at a suitably reflected rate of speed.

Accordingly, a primary object of the invention is to provide a method of causing the lead unit in a multi-unit train to tow the intermediate unit or units, but not the trailing unit, irrespective of the direction of movement of the train.

Another object is to provide a method of maintaining the drawbar tension between the units of a multi-unit train within predetermined limits.

Yet another object is to provide apparatus for accomplishing the above objects.

Other objects and advantages of the invention will become apparent from reading the following description:

The invention is illustrated more or less diagrammatically in the accompanying figures wherein:

FIGURE 1 is a partly diagrammatic top plan view of a multi-unit train embodying the invention;

FIGURE 2 is a side elevation of the multi-unit train of FIGURE 1;

FIGURE 3 is a side view, to an enlarged scale, of the coupling mechanism between adjacent units;

FIGURE 4 is a top view of the coupling mechanism of FIGURE 3;

FIGURE 5 is a view taken substantially along the line 5—5 of FIGURE 4;

FIGURE 6 is a sectional view of the spring mechanism associated with each coupling means;

FIGURE 7 is a top plan view of the cam box with the cover removed;

FIGURE 8 is an end view of the cam box of FIGURE 7 with a portion of one end removed;

FIGURE 9 is a schematic diagram of the electro-mechanical system for controlling the tramming movement of the inby and outby units showing the units in a condition of maximum speed; and



FIGURE 10 is a schematic diagram of the system of FIGURE 9 in a condition in which the inby unit is moving at low speed and the outby unit is moving at high speed.

Like reference numerals will be used to refer to like parts from figure to figure.

Although it is contemplated that the invention may, with appropriate modification, be applied to any multi-tram system in which the leading one of two end units is required to tow the intermediate unit, the invention will be described as applied to a coal mining system. In the illustrated system an inby tram unit is connected by coupling means to an intermediate unit or units which in turn are coupled to an outby unit. The inby unit is positioned to receive coal from a borer and convey the mined coal, usually by means of a belt conveyor, to a trailing intermediate conveyor unit. Each conveyor unit discharges onto a trailing conveyor unit, the last conveyor unit discharging onto the outby unit which in turn discharges the coal into a storage pile or removal system.

For further description of a typical mining system to which the invention may be applied reference is made to copending applications Ser. Nos. 655,413 and 655,426, assigned to the assignee of this application.

An inby conveyor unit is indicated generally at **10** in FIGURES 1 and 2. The inby unit discharges coal onto an intermediate conveying unit **11** which in turn discharges onto any suitable number of similar trailing units, the last of which is indicated at **12**. Conveyor unit **12** discharges onto outby unit **13** which is equipped with a short conveyor **14** for discharge onto a truck or other removal means, and a long conveyor **15** for discharge into a storage pile.

The source of power, which may for example be a hydraulic motor, is indicated at M1 on inby unit **10** and a similar source of power is indicated at M2 on outby unit **13**. It will be understood that when the train moves to the right, as viewed in FIGURES 1 and 2, it is necessary for the inby unit **10** to tow the intermediate units **11, 12** which, for purposes of illustration, will be assumed to have no self-contained power system, and outby unit **13** must be self-propelling. When the train moves in the reverse direction, that is to the left as viewed in FIGURES 1 and 2, outby unit **13** which then becomes the lead unit is required to tow the intermediate units **11** and **12**, and inby unit **10**, which then becomes the trailing unit, must be self-propelled.

A typical coupling mechanism for coupling one unit to an adjacent unit is indicated in FIGURES 3–6.

The frame of inby unit **10** is indicated at **20, 21** and **22**. Means for providing relative movement between adjacent units, in this instance a pair of spring assemblies are indicated at **23** and **24**, the housings of the spring assemblies being connected to cross frame member **22** by a plate **25** and bolts **26**. Reinforcing struts are indicated at **27**.

Housing assembly **23** includes end plates **28, 29**. An aperture **30** in end plate **29** receives a connecting rod **31** which terminates, at one end, in a flange **32** and at the other end in an aperture **33**. A relatively light spring is indicated at **34** and a heavier spring at **35**. Connecting rod **31** has an axial bore **36** which receives a guidepin **37**. A relatively light spring is indicated at **38**.

The left end of connecting rod **31** is connected by a pin **40** to a universal connector indicated generally at **41**. The universal connector is in turn connected to a drawbar **42** which is integral with the conveyor unit **11**.

A cam box is indicated at **45**. The cam box includes a horizontally extending projection or sleeve **46** which accommodates a cam rod **47**. The left end of rod **47** is connected by suitable linkage **48** and a motion permitting connector **49** to the connection rods **31**.

Cam rod **47** includes a first portion having a small diameter **50**, and a second portion having a larger diameter **51**, the two portions being separated by shoulder **52**. Four switches are indicated at **1**, **2**, **3** and **4**. As best shown in FIGURE 8, the switches are oriented at 90 degrees with respect to one another but it will be understood that within the scope of the invention they could all be in line.

Referring now to FIGURES 9 and 10, it will be noted that hydraulic motor **M1**, which powers inby unit **10**, is incorporated in a hydraulic circuit which includes a pump B, a relief valve **5**, a direction control valve C and a solenoid operated flow control valve A.

Valve C, which is also solenoid operated and includes a forward direction coil CF and a reverse direction coil CR, is a three-position valve. When neither the forward coil CF or reverse coil CR is energized the valve is in neutral, and flow is circulated back to tank. If forward coil is energized, the output from pump B passes into line E. If flow control valve A is in the illustrated blocking position the entire pump output goes through **M1** and inby unit **10** moves in a forward direction at high speed. If the reverse coil CR is energized, the output from pump B passes into line G. If flow control valve A is in the blocking position the entire pump output goes through **M1** in the direction of the dotted arrow beneath it, and inby unit **10** moves in a reverse direction at high speed as will be described in detail hereinafter.

If flow control valve A is in a non-blocking position and forward coil CF is energized, a portion of the pump output is diverted through lines H and J back to tank, and inby tram unit **10** is propelled at a lower speed. The speed of inby tram unit **10** is directly proportional to the volume flow through the motor **M1**.

It will thus be seen that the key to high speed or low speed movement of inby unit **10** is whether flow control valve A is energized or de-energized.

It should be understood that for purposes of convenience only a single pump and a single flow control valve have been illustrated. A greater or lesser number may be used, as desired.

Referring now to the electrical portion of the diagram, a run button is indicated at **L1**. When **L1** is depressed contacts **A2** and **L3** are also closed.

Closure of contact **L1** completes a circuit composed of lines M, N, relay coil Q, switches **3** and **4**, and lines R, S, T and U.

Energization of coil Q closes relays **V1** and **V2**. Closure of **V2** completes a circuit through the coil of flow control valve A comprising lines M, P, coil A, lines R, S, T and U which thereby blocks fluid flow therepast and directs the entire pump output through the motor **M1**. As a result inby unit **10** moves forward at high speed.

It should be understood that the instant before contact **L1** was depressed, switches **1**, **3** and **4** were closed and switch **2** was open. This condition is shown in FIGURES 7 and 8.

As inby unit **10** trams forward cam box **45**, which is bolted to unit **10**, pulls switches **1** and **2** to the right with respect to rod **47** which remains stationary for the time being. The initial increment of movement causes switch **2** to close. Switch **2** is a make-ready switch which, when closed, energizes a circuit which includes lines U, T, S, R, switch **2**, line Z, switch **1–0**, line W, the coil of **TD–0**, and lines X and M.

It will be noted that the hydraulic and electrical circuits for the inby and outby tram units are substantially identical. Accordingly, components in the outby tram unit circuits which correspond to a similar component in the inby tram unit circuits will be identified by the same letter or number and the suffix "**–0**."

Energization of the time delay coil **TD–0** causes contact **TD1–0** to close after a suitable time period, such as a second. Closure of switch **TD1–0** completes the circuit which includes coil **Q–0**, switches **3–0** and **4–0**, and line M. However, due to transient conditions this last mentioned circuit is not relied on to maintain **Q–0** energized. Rather, a circuit comprising switch **TD1–0** line Y, coil **Q–0**, and line V, switch **L2** and line M is maintained. Energization of coil **Q–0** causes contacts **V1–0** and **V2–0** to close, thereby energizing flow control valve **A–0** by completion of a circuit which includes line M, coil **A–0**, switch **V2–0**, and lines T and U. As a result motor **M2** will cause outby tram unit **13** to move forward at a high rate of speed since it will be noted that when the coil of **A–0** is energized and the valve is placed in a blocking condition, the entire output of pump **B–0** will pass through **M2** in the direction of the solid arrow and outby tram unit **13** will move in a forward direction at high speed.



It should be noted that contact **L3** is a direction control switch. That is, when the tram button **L1** is depressed switch **L3** closes to establish a circuit through line M, switch **L3**, line **100**, coils CF and **CF–0**, and lines S, T and U. As a consequence both the inby and outby tram units will move in a forward direction since the energization of the "**–F–**" coil in each of valves C and **C–0** causes hydraulic fluid in each hydraulic circuit to drive its respective motor in a direction which results in forward movement of both the inby and outby tram. Although both tram units started to move in a forward direction at the same instant because valves C and **C–0** were simultaneously actuated, it should be remembered that outby tram unit **13** reached high speed condition last because of the delay derived from time delay switch **TD1–0**.

It should further be noted that depression of tram button **L1** effectively bypassed or knocked out coil TD. This is necessary because no time delay should occur in the inby tram unit circuit when the inby tram unit is started in a forward direction.

It will also be noted that closure of contact **L2** effectively cuts out switches **4–0** and **3–0** for a purpose which will be explained hereinafter.

Now assume that the inby tram unit is moving in a forward direction faster than desired, that is, faster than the movement of the outby tram unit **13** Since cam box **45** is carried by inby tram unit **10**, relative displacement of the cam box **45** to the right with respect to rod **47** first causes switch **3** to open. No immediate change in speed takes place, however, because a circuit is maintained through coil Q which controls switch **V–2** and thereby flow control valve A, by a bypass circuit which includes coil Q, line **101**, switch **V–1**, line **102**, switch **4**, and lines R, S, T and U.

As inby tram unit **10** continues to draw away from the first conveyor unit **11** switch **4** opens. This condition is illustrated in FIGURE 10. Opening of switch **4** deenergizes coil Q which opens switch **V–2**. As a result the coil of flow control valve A is deenergized.

When flow control valve A is deenergized a portion of the output from the pump passes through the valve as illustrated in FIGURE 10, and accordingly the quantity of fluid passing through motor **M1** is decreased. The speed of inby tram unit **10** therefore drops. In this condition the springs **35** in the coupling assemblies, which had been compressed as the inby tram unit **10** pulled away from the trailing conveyor units, relax and conveyor unit **11** begins to catch up with inby tram unit **10**. In this connection it is important to note that the outby tram unit **13** does not push the units together. The closing movement occurs due to relaxation of springs **34** and **35**.

As conveyor unit **11** catches up with inby tram unit **10**, switch **4** is closed, but no immediate change in the speed occurs. Thereafter switch **3** closes which reestablishes the circuit comprised of line M, switch **L1**, coil Q, switches **3** and **4**, and lines R, S, T and U. As noted above, energization of coil Q closes switch **V2** which completes the earlier described circuit to the solenoid of flow con-

trol valve A. The coil Q holding circuit which includes line **101** is also reestablished. Energization of the solenoid moves the valve to a flow blocking position and high speed of inby tram unit **10** is reestablished.

Now assume that the outby tram unit **13** has been moving too fast; that is, it is creeping up on inby tram unit **10**. When this occurs switch **1–0** will open because rod **47–0** will move to the right at a faster speed than will switch **1–0**. Opening of switch **1–0** breaks the circuit through coil TD–**0** and contact TD–**0** opens. Opening this contact breaks the circuit through coil Q–**0** and accordingly switch **V2–0** is opened. This breaks the circuit through the solenoid of flow control valve A–**0** and consequently a portion of the hydraulic fluid is bypassed to tank and the speed of motor M2, and consequently outby tram **13**, is slowed.

Now assume outby tram unit **13** is moving too slow relative to inby tram unit **10**. Switch **1–0** closes. A circuit is thereby reestablished through TD–**0** which closes switch TD**1–0** thereby energizing coil Q–**0**. Flow control valve A–**0** is thereby energized, blockage of the hydraulic fluid in line H–**0** is restored, and motor M2 is caused to operate at high speed.

Now assume the system is stopped and is to be started in a reverse direction, that is to the left as viewed in FIGURES 1 and 2.

Refer to FIGURE 10. Outby unit tram button L**1–0** is depressed, and consequently contacts L**2–0** and L**3–0** are closed. Closure of L**3–0** establishes a circuit which includes M, **103**, CR–**0**, CR, **104**, L**3–0**, T and U. Direction control valves C–**0** and C are now in the proper position.

As switch L**1–0** closes, a circuit is established which includes line M, switches **4–0** and **3–0**, coil Q–**0**, switch L**1–0**, and lines T and U. Energization of coil Q–**0** closes switches **V1–0** and **V2–0** thereby completing a circuit through the coil of flow control valve A–**0** which comprises M, A–**0**, **V2–0**, T and U. Flow control valve A–**0** is thus placed in a blocking position and the entire pump output flows through motor M2, thereby causing outby tram unit **13** to move at a high speed in a reverse direction. Inby tram unit **10** will likewise move in a reverse direction, but at a lower speed because flow control valve A is in the partial flow condition illustrated in FIGURE 10 temporarily. As soon as the time delay derived from coil TD expires, flow control valve A will be placed in a fully blocked condition, as earlier described, and the inby unit will move in the reverse direction at high speed.

It will be understood that very shortly after outby tram unit **13** began to move in a reverse direction, switch **2–0** closed.

It will be understood that when the above described conditions of relative displacement between the inby and outby tram units occur as was discussed in connection with movement in a forward direction, the same operations will take place with the same results. In view of the identity of the circuitry a detailed description of the functioning of the circuits associated with each condition is not necessary to one skilled in the art.

Although a preferred embodiment of the invention has been illustrated and described it will be at once apparent to those skilled in the art that modifications may be made within the scope of the invention. Accordingly, it is intended that the scope of the invention be not limited by the foregoing illustrative description, but solely by the scope of the hereinafter appended claims when construed in light of the pertinent prior art.

What is claimed is:

**1.** In combination in a multi-unit train,

a first end unit,

a second end unit,

an intermediate unit or units disposed between the end units,



mechanical coupling means between each end unit and its adjacent unit, and

means for automatically coupling the intermediate unit to the lead end unit irrespective of the direction of movement of the train,

said automatic coupling means including an electro-hydraulic system having means for starting the first end unit, and thereby the intermediate unit, in a forward direction of movement in response to a starting signal at an initial speed, and

means for causing the second end unit to reach the initial speed of the first unit at a time subsequent to starting of the first end unit and the intermediate unit, and thereafter maintaining said second, trailing end unit at substantially the same initial speed.

**2.** The combination of claim **1** further characterized in that

the mechanical coupling means includes means which permit relative movement between the end units and the intermediate unit,

said relative motion means having a limit of movement sufficient to enable either end unit to move in either direction a distance sufficient to set the towed intermediate unit in motion prior to imposition of a direct towing force on the trailing unit by the lead unit.

**3.** The combination of claim **2** further including

means for slowing the first end unit, in the event it advances too far relative to the second end unit, until the second end unit closes to a pre-determined position, and

means for thereafter reestablishing the initial speed of the first end unit.

**4.** The combination of claim **2** further including

means for slowing the second end unit in the event it advances too far relative to the first end unit, until the first end unit advances to a pre-determined position relative to the second end unit, and

means for thereafter reestablishing the initial speed of the second end unit.

**5.** The combination of claim **2** further characterized in that the automatic coupling means and electro-hydraulic system includes

first hydraulic motor means associated with the first end unit,

second hydraulic motor means associated with the second end unit,

a first electrical circuit associated with the first hydraulic motor means for enabling the first hydraulic motor means to be drivingly connected to the first end unit,

a second electrical circuit associated with the second hydraulic motor means for enabling the second hydraulic motor means to be drivingly connected to the second end unit,

said second electrical circuit means having time delay means associated therewith which is effective to delay operation of the second hydraulic motor means at the same initial speed as the first hydraulic motor means for a pre-determined delay period after connection of the first hydraulic motor means to the first end unit under that condition in which the first end unit is the lead unit.

**6.** The combination of claim **5** further characterized in that the first electrical circuit means has

time delay means associated therewith which is effective to delay operation of the first hydraulic motor means at the same initial speed as the second hydraulic motor means for a pre-determined delay period after connection of the second hydraulic motor means to the second end unit under that condition in which the second end unit is the lead unit.

**7.** The combination of claim **2** further characterized in that

the first end unit is a self-propelled conveyor unit adapted to receive cuttings,

the intermediate unit is a conveyor unit adapted to convey cuttings which have been received by the first end unit, and

the second end unit is a self-propelled discharge unit adapted to discharge cuttings conveyed to it by the intermediate unit.

**8.** The combination of claim **1** further characterized in that,

firstly, the mechanical coupling means between each unit includes relative motion means which are connected to and movable relative to plunger means,

said relative motion means being operatively connected to one unit and the plunger means to the other unit, and

secondly, in that the electro-hydraulic system includes cam means operatively associated with one unit and cam follower means operatively associated with the other units,

said cam means and cam follower means actuating switches in electrical circuits which control slow down and speed up conditions of the end units,

said cam means and cam follower means being constructed and arranged to move relative to one another proportionately to movement between the units as reflected by the relative motion means.

**9.** A multi-unit train having two end units connected for movement in the same direction, power tram means for each end unit, and control means for said power tram means effective to energize each of said power tram means independently to move both of said end units independently in the same direction without transmission of substantial tractive forces from either of said end units to the other, said control means including means sensing relative motion between the end units to energize either of the associated power tram means to maintain their relative positions.

**10.** A multi-unit train according to claim **9** in which an intermediate unit is connected between the end units, and the intermediate unit is moved by tractive force transmitted from a single one of said end units.

**11.** In combination with a multi-unit train having two end units and an intermediate unit,

means for automatically coupling the intermediate but not the trailing, unit to the lead end unit irrespective of the direction of movement of the train,

means for automatically slowing whichever one of the two end units is moving too fast relative to the other end unit irrespective of the direction of travel of the train, and

relative motion means connecting each end unit to its adjacent unit whereby the tension between adjacent units may vary between limits defined by the relative motion means and switch means associated with the automatic coupling means.

**12.** A multi-unit train having leading and trailing end units connected for movement in the same direction,

power tram means for both of said units,

control means for the trailing end unit tram means effective to energize the trailing end unit tram means to move the trailing end unit in response to leading movement of said leading end unit,

said end units being connected by means including coupling means enabling limited relative movement between the end units, and said control means is operable responsive to said relative movement for energizing the trailing end unit tram means to maintain the trailing end unit in a predetermined position with respect to the leading end unit while the latter is moving in a leading direction.



**13.** A multi-unit train having leading and trailing end units connected for movement in the same direction,

power tram means for both of said units,

control means for the trailing end unit tram means effective to energize the trailing end unit tram means to move the trailing end unit in response to leading movement of said leading end unit,

an intermediate unit connected between the end units, and

coupling means disposed between the trailing end unit and the intermediate unit, said coupling means enabling relative longitudinal movement between the trailing end unit and the intermediate unit, and said control means is operable responsive to said relative movement for energizing the trailing end unit tram means to maintain a predetermined position with respect to the intermediate unit while the latter is moving with the leading unit in a leading direction.

**14.** A multi-unit train according to claim **13** in which both leading and trailing end units are provided with power tram means, and said control means is operable responsive to relative movement at either of said coupling means for energizing either of said power tram means.

**15.** A multi-unit train having leading and trailing end units connected for movement in the same direction,

power tram means for both of said units,

control means for the trailing end unit tram means effective to energize the trailing end unit tram means to move the trailing end unit in response to leading movement of said leading end unit,

an intermediate unit connected between the end units, and

coupling means disposed respectively between each end unit and said intermediate unit, each coupling means enabling relative longitudinal movement between the intermediate unit and a corresponding one of said end units, and said control means is operable responsive to relative movement at one of said coupling means for energizing the trailing end unit tram means to maintain the trailing end unit in a predetermined position with respect to the leading end unit while the intermediate unit is moving with the leading end unit in a leading direction.

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RICHARD E. AEGERTER, Primary Examiner

U.S. Cl. X.R.

180—14