April 17, 1951 R. L. WILSON 2,549,653

CONTROL APPARATUS FOR STEAM LOCOMOTIVES

Filed July 13, 1946 4 Sheets-Sheet 1

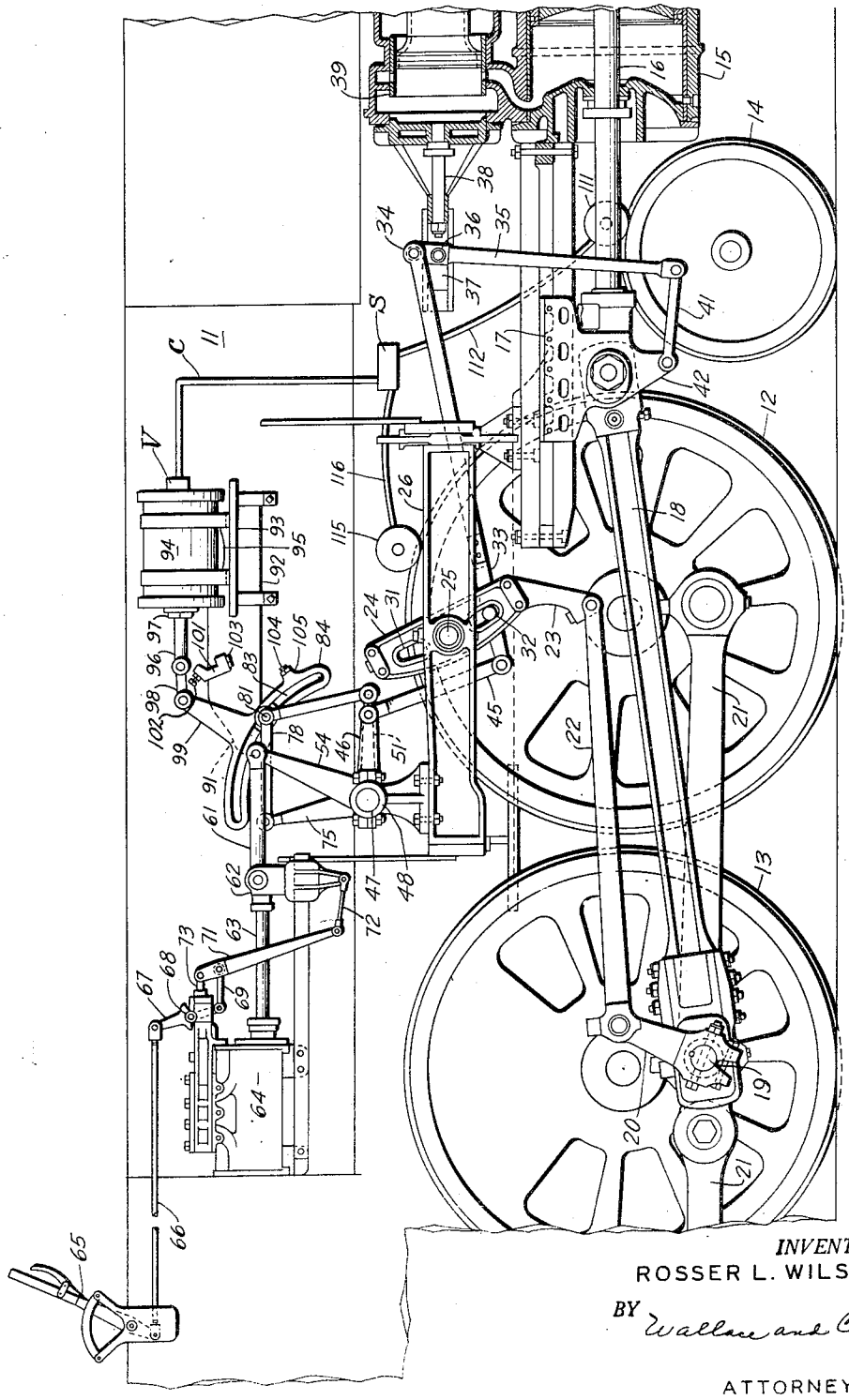


FIG. 1

INVENTOR.
ROSSER L. WILSON
BY Wallace and Cannon
ATTORNEYS

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CONTROL APPARATUS FOR STEAM LOCOMOTIVES

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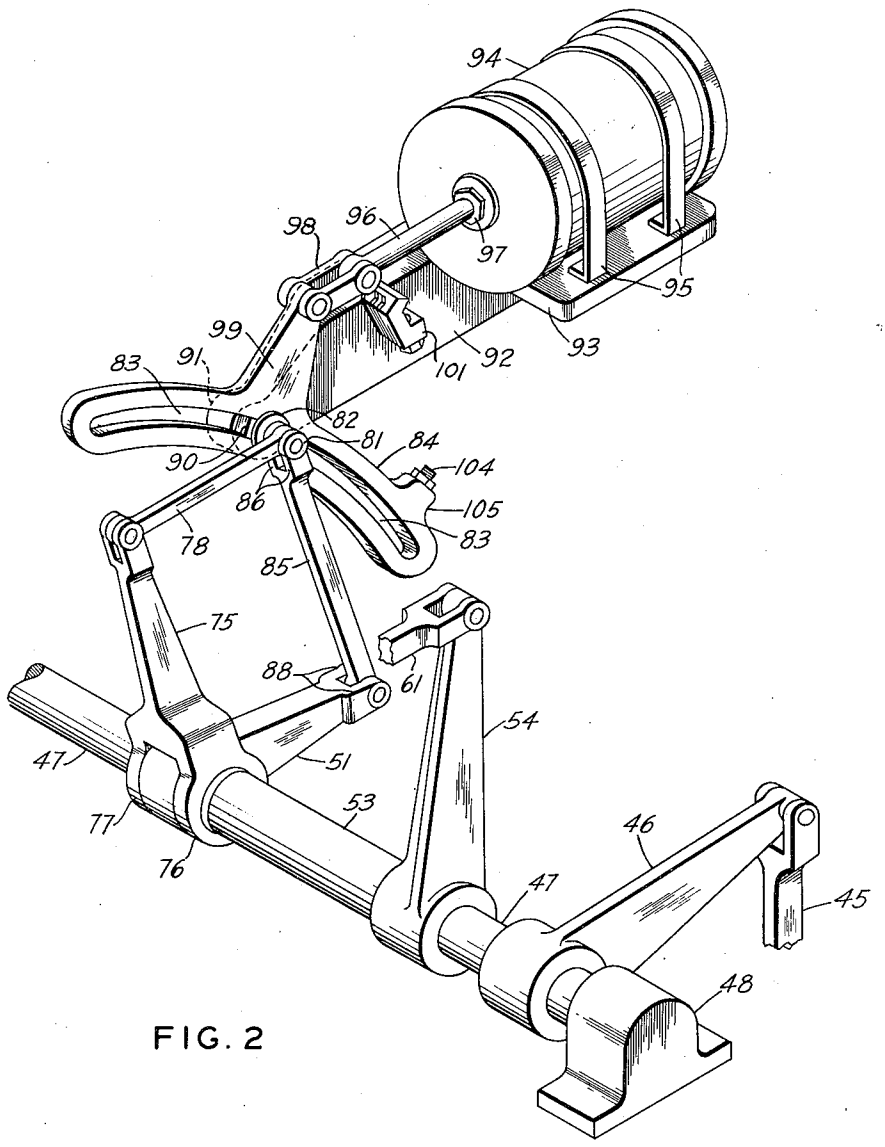


FIG. 2

INVENTOR.
ROSSER L. WILSON
BY Wallace and Cannon

ATTORNEYS

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CONTROL APPARATUS FOR STEAM LOCOMOTIVES

Filed July 13, 1946 4 Sheets-Sheet 3

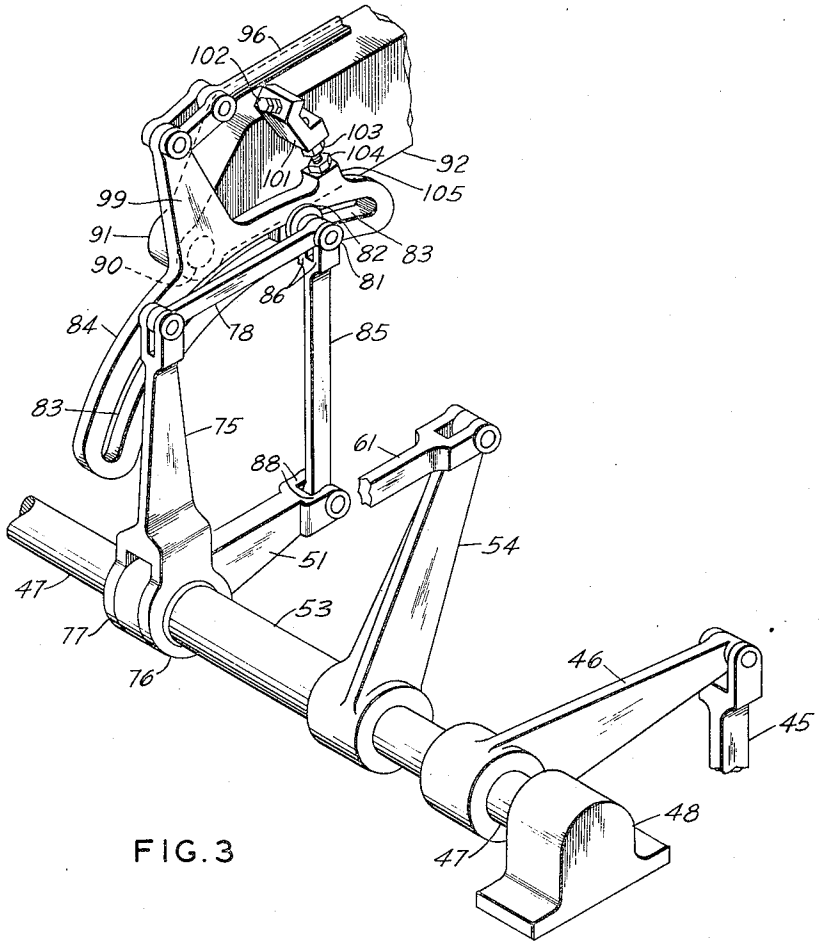


FIG. 3

INVENTOR.
ROSSER L. WILSON
BY Wallace and Cannon

ATTORNEYS

April 17, 1951 R. L. WILSON 2,549,653

CONTROL APPARATUS FOR STEAM LOCOMOTIVES

Filed July 13, 1946 4 Sheets-Sheet 4

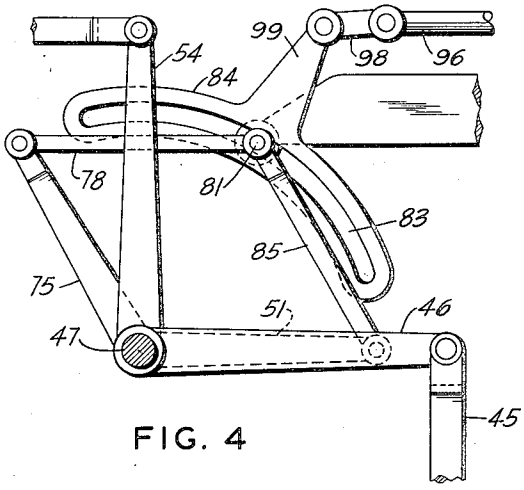


FIG. 4

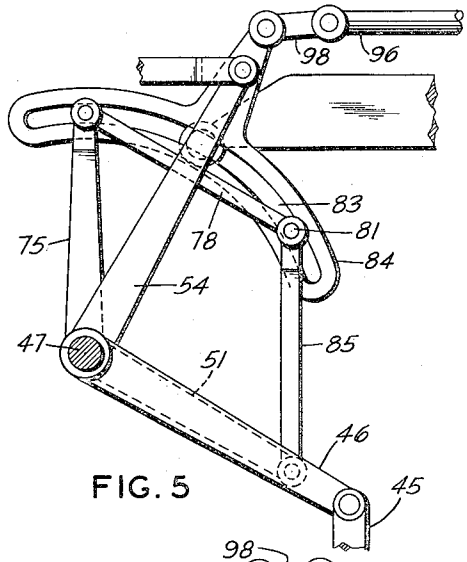


FIG. 5

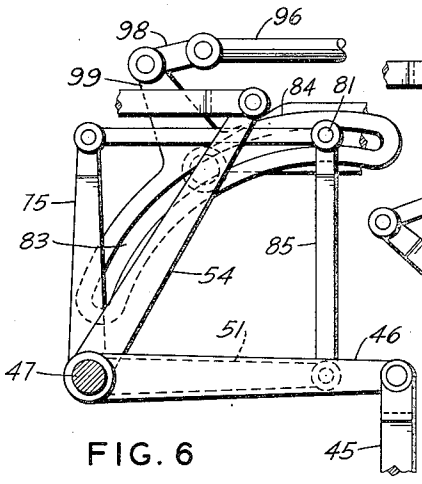


FIG. 6

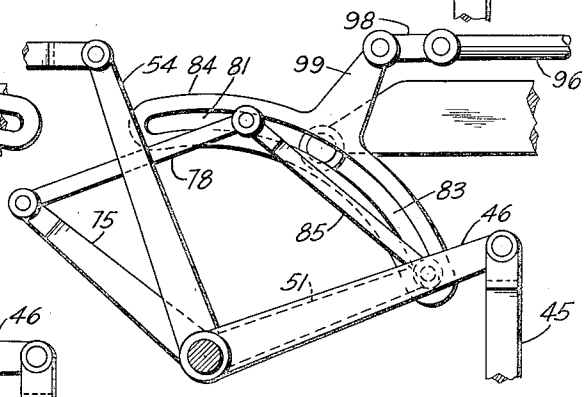


FIG. 7

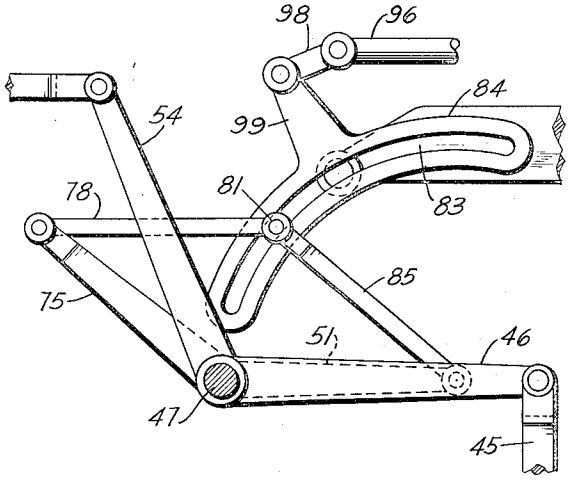


FIG. 8

INVENTOR.
ROSSER L. WILSON
BY Wallace and Cannon
ATTORNEYS

Patented Apr. 17, 1951 2,549,653

UNITED STATES PATENT OFFICE

2,549,653

CONTROL APPARATUS FOR STEAM LOCOMOTIVES

Rosser L. Wilson, Mahwah, N. J., assignor to American Brake Shoe Company, Wilmington, Del., a corporation of Delaware

Application July 13, 1946, Serial No. 683,397

6 Claims. (Cl. 105—48)

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This invention relates to a control apparatus and particularly to an apparatus for controlling the relative speed of rotation of a given mechanical element with respect to that of another rotating part to maintain a desired speed ratio. More specifically, my invention relates to an apparatus for automatically controlling or limiting the power supplied to a power driven element so as to avoid excessive speed and uneconomical operation thereof.

A specific application of my invention has to do with the control of the valve mechanism of a steam driven railway locomotive and the invention will be described in connection with such a locomotive, although it will be understood that the invention is by no means limited to such an application.

When a steam driven railway locomotive is being started under heavy load, great skill and care are required to control the steam supply to the driving cylinders so as to get the load moving without slipping the drive wheels. With the greatest of skill and the best of care it frequently happens that an excessive amount of steam is turned on and the torque applied to the drivers overcomes the adhesion between the drivers and the rails which support them. When this occurs, the drivers are rotated at an excessive speed, losing much of their tractive effort, burning and sometimes actually melting the surfaces of the rails, and wasting power. The use of sand and the like to increase adhesion is of some benefit but does not entirely prevent such operation. Under such conditions it is necessary for the operator to shut off or at least materially reduce the steam supply until traction can be regained. In starting a heavy load up grade, particular difficulty in this respect is commonly encountered.

Therefore, it is an object of my invention to control and limit, by automatic means, the power imparted to a rotating element, such as a locomotive driving wheel, so that such element cannot be operated at an excessive rate of speed.

A further object of my invention is to control valve mechanism automatically so as to reduce the flow of a motive fluid therethrough when the rotary speed of a member driven thereby becomes excessive, even though a manual control for such mechanism has been operated to permit such excessive speed.

A still further object of my invention is to combine manual and automatic control apparatus for valve mechanism, in steam locomotives and the like, in such a manner that such mechanism may be set manually to provide a desired maximum flow of steam, and the automatic control means will reduce or stop the flow, when required, to stop any substantial slipping of the locomotive drive wheels.

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Another object is to maintain substantial synchronism or equality of peripheral speed between locomotive drivewheels and non drivers, or between separately driven drivers or sets of drivers, and to utilize any substantial departure from such synchronism or equality to initiate the operation of control mechanism.

Still another object is to operate valve mechanism by automatic means which is controlled by the relative rotative speed between a driver and a non-driver, or between separately powered drivers.

Other and further objects of the present invention will be apparent from the following description and claims and are illustrated in the accompanying drawings which, by way of illustration, show preferred embodiment of the present invention and the principle thereof and what I now consider to be the best mode in which I have contemplated applying these principles. Other embodiments of the invention embodying the same or equivalent principles may be used and structural changes may be made as desired by those skilled in the art without departing from the present invention and the purview of the appended claims.

In the drawings:

Fig. 1 is an elevational view showing part of a locomotive embodying my invention;

Fig. 2 is a perspective view of the control mechanism of my invention;

Fig. 3 is another perspective view generally similar to Fig. 2, with certain parts omitted, and certain other parts in changed positions;

Fig. 4 is a fragmentary elevational view, showing certain elements of the control apparatus, a primary control member per se and certain operating elements for valve mechanism all being shown in an inoperative or neutral position; and

Figs. 5, 6, 7 and 8 are views of the mechanism shown in Fig. 4 in various other positions.

In Fig. 1 there are shown certain major operating parts of a well known type of railway locomotive, the particular locomotive illustrated being of the 4–6–2 (Pacific) type equipped with a standard valve gear of a type commonly and widely used.

The locomotive, as shown in Fig. 1, comprises a boiler structure 11, drivewheels, hereinafter referred to as drivers 12, 13, a pilot wheel 14, a steam cylinder 15, a piston rod 16, a cross head

17, a connecting rod 18, a crank pin 19 and an eccentric arm 20, as well known in the art. A parallel bar 21 connects the drivers, of which only two are shown, and a link 22 extends from the eccentric crank to the depending arm 23 of a reverse link 24.

The reverse link 24 is pivoted on a pin 25 mounted in a rigid frame member 26 which extends longitudinally of and is secured to the side framework of the locomotive. The reverse link is provided with a curved slot 31 which is adapted to slidably receive a pin 32 carried by a radius rod 33. The forward end of radius rod 33 is pivoted, as indicated at 34, to the upper end of a combination lever 35. Combination lever 35 is pivoted near its upper end as shown at 36, to a sliding block 37 secured to a valve stem 38. Valve stem 38 operates a slide valve mechanism 39. The lower end of the combination lever 35 is pivotally attached to the forward end of a link 41. The rear end of link 41 is pivotally secured to an arm 42 which forms an integral part of the cross head 17. By the means just described, the combination lever 35 is moved in a manner well known in the art to actuate the main slide valve mechanism 39 which controls the flow of steam alternately to the front and rear intake ports of the main drive cylinder 15.

The extent to which the valve 39 is moved, as well as its direction of movement at a given instant, is controlled by the position of the pin 32 in the slot 31 of the reverse link 10. Thus when the pin 32 occupies a position at the bottom of slot 31, as shown in Fig. 1, the valve 39 is positioned to admit steam to the respective ends of cylinder 15 in proper timed relation so as to drive the locomotive forward. If pin 32 is at the upper end of the slot 31, the valve will be operated to drive the locomotive in reverse. In a position at or near the middle of the slot, the valve mechanism is neutral and passage of steam to cylinder 15 is restricted.

The rear end of the radius rod 33 is pivotally connected to the lower end of a link 45. The upper end of link 45 is pivotally connected to the forward end of an arm 46 which is keyed or otherwise secured against relative rotation on a shaft 47. The shaft 47 is suitably mounted for rocking movement in a pair of bearings appropriately mounted on the locomotive framework, one such bearing being shown at 48, and secured in any appropriate manner to the frame member 26, previously mentioned.

Another arm 51 is keyed or otherwise rigidly secured to shaft 47 at a point inwardly spaced from said arm 46. Hence the arms 46 and 51 and shaft 47 are all fixed with respect to each other so as to rotate together, this construction being best shown in Figs. 2 and 3.

Mounted on and surrounding the shaft 47 between the two arms 46 and 51 is a sleeve 53. At its outer end this sleeve carries an upwardly projecting arm 54 which is welded or otherwise rigidly secured to said sleeve. This arm or lever 54 is the reverse shaft lever, a main control lever well known in the prior art, and is the lever through which the other valve mechanism just described is normally controlled. The upper end of arm 54 is pivotally connected to the forward end of a link 61, the rear end of such link being pivotally connected to a slide 62 attached to the piston rod 63 of a control piston and cylinder assembly 64. The assembly 64, which is also well known in the prior art, is controlled by a manual lever 65 through a link 66, a lever 67 pivoted at 68, a link 69, lever 71 connected at its lower end to the slide 62 by a link 72 and the pilot valve stem 73 connected to the upper end of lever 71. When the manual lever 65 is moved, the valve stem 73 is operated to allow compressed air or steam to move the piston rod 63 and thus to move the arm 54.

In the valve control mechanism illustrated, which is of a general type that is well known in the prior art, the arm 54 has in the past been directly connected to the arm 46 so that they move together when the control assembly 64 causes piston rod 63 to move. Through the link 45, in the prior art structure, the radiu rod 33 is raised or lowered to move the pin 32 in the slot 31, thus operating the valve 39 to feed steam into the cylinder 15 and to drive the locomotive forward or backwards depending upon the setting of pin 32. In the present instance this direct connection between arm 54 and arm 46 is replaced by a parallelogram linkage arrangement which is subject to automatic control by mechanism which becomes operative when and in case the drive wheels 12 and 13 begin to slip with respect to the rails on which they ride.

The linkage through which arm 54 is connected to arm 46 is as follows: To the inner end of sleeve 53, to which arm 54 is rigidly secured, there is secured another arm 75. As shown, arm 75 has a bifurcated hub portion which straddles the arm 51, one branch 76 being welded or otherwise rigidly secured to the sleeve 53 and the other branch 77 being mounted for free rotation on the shaft 47. The upper end of arm 75 is pivotally connected to a link 78 which extends forwardly, its forward end being mounted on a pin or stud 81 which projects from a slide block 82 mounted in the arcuate slot 83 of an arcuate or curved control member 84. Another link 85 has a bifurcated upper end portion 86 which straddles the end of link 78 and pivots on the same pin 81. The lower end of link 85 is pivotally connected to the forward bifurcated end 88 of the arm 51 previously mentioned.

When arm 54 is rocked by the control piston rod 63 through link 61, the sleeve 53 and arm 75 are rotated, the bifurcated hub 76, 77 of this arm serving to position the sleeve 53 and its two arms lengthwise with respect to shaft 47. Movement of arm 75 causes link 78 to move the pin 81 and the slide block 82 in the arcuate slot 83, assuming that the curved member 84 is held stationary, and this causes the link 85 to rock arm 51. Since arms 51 and 46 are both keyed to shaft 47, arm 46 is thereby moved to operate the radius rod 33 and thus to control the main valve mechanism 32, 35, 39 in the usual manner. Motion is thus transferred from arm 54 through sleeve 53, through the parallelogram arrangement mentioned above to shaft 47, and thence to arm 46.

The curved control member 84 is pivotally mounted as indicated at 90 by a stud which projects from its rear face (not shown) into a bearing opening formed in a boss portion 91 of a rigid frame member 92. The member 92 extends forwardly of the locomotive and has formed thereon, or rigidly attached thereto at its forward end a bracket 93 to which a control cylinder 94 is firmly secured as by tension straps 95. The cylinder 94 contains a sliding piston, not shown, on the end of a piston rod 96 which is slidably mounted in the usual packing box 97 of the cylinder head. Piston rod 96 is se-

cured at its rear end to a pair of links 98 pivotally attached to an upstanding arm 99 of the member 84. The cylinder 94 is preferably supplied with compressed air from a suitable supply source through valve mechanism, not shown, and by this means the curved member 84 may be rocked about its pivot 90, from the position, Figs. 1 and 2, counterclockwise as seen in the drawings to the position shown in Fig. 3.

A stop member 101 is secured to frame member 92 and is provided on its upper rear corner with an adjustable stud 102 adapted to limit clockwise movement of the arm 99, as seen in Figs. 1, 2 and 3. Hence the stop is effective to limit rotation of the curved member 84 in this direction. The lower end of stop member 101 is provided with another adjustable stud 103 adapted to contact a projecting stud 104 mounted in a boss or projection 105 on the upper edge and forward end of the curved control member 84. The latter elements limit movement of the curved or arcuate control member 84 in the other direction, as best shown in Fig. 3.

As shown in Fig. 1, a friction wheel 111 is suitably mounted in a support, not shown, for frictional driving contact with the pilot wheel 14 of the locomotive, so that wheel 111 will rotate as the wheel 14 turns. The wheel 111 is resiliently mounted so as to insure driving contact between this friction wheel and the pilot wheel 14, so that the drive will be constant and reliable, regardless of vertical vibrational movement of the wheel 14. If desired, means not shown may be provided for separating friction wheel 111 from driving relation with wheel 14 when the locomotive is running at sustained speed.

A flexible shaft 112 leads from the friction wheel 111 to a commutator mechanism enclosed in a switch box S and hereinafter referred to broadly as being comprised by the box S. Another friction wheel 115 similar to the wheel 111 is supported to contact and be driven by one of the drive wheels, for example the drive wheel 12. This wheel may be mounted in the same manner as wheel 11. A flexible shaft 116 leads from this friction wheel 115 to the electrical control or commutator mechanism represented by the switch box S.

The electrical control mechanism S is not shown in detail herein but is preferably similar to or identical with that described in my prior Patent No. 2,232,752, patented February 25, 1941. As described in said patent, the commutator mechanism includes means for comparing the speed of two revolving shafts and for forming impulses, for example electrical impulses, when the difference in speed between the two shafts reaches an objectionable magnitude. It involves the use of relatively slow-to-release electrically operated relays which activate certain electrical circuits when certain speed differentials are reached, the activated circuits being then utilized to perform control functions, as by energizing the field windings of a control motor which is employed to move a mechanical member. In the patent referred to, such mechanism is employed to detect differences in rotating speeds as of the wheels of railway equipment, and to make suitable adjustments, as by applying sand to certain wheels to equalize their effectiveness in braking. In the present case, similar mechanism is used to open a valve, not shown in detail but indicated at V, Fig. 1, a suitable circut from the switch-box S to the valve V being indicated at C.

The operation of the mechanism just described is as follows: Assuming that the arcuate member 84 is in the position shown in Figs. 1 and 2, the manual lever 65 is first moved to activate the control cylinder 64 and move the piston rod 63, thus putting in action the main valve mechanism 31, 32, 33, 38, 39. Power is thus applied to the drive wheels as 12 and 13 which begin to rotate. As long as slippage between these wheels and the rail (not shown) is negligible, their comparative peripheral speed is substantially constant to that of the non-driven pilot wheel 14. Minor differences amounting to a small percentage of slippage of the drivers do not affect the operation. Under these conditions the friction wheels 111 and 115 are driven at or nearly at the same speeds and the electrical control mechanism indicated at the switch box S, and described in detail in my aforesaid Patent No. 2,232,752, performs no control function.

Assuming now that the drive wheels begin to slip and lose traction, their peripheral speed quickly becomes much greater than that of the pilot wheel. As a result, friction wheel 115 is driven more rapidly than friction wheel 111 and the commutator mechanism indicated at S energizes circuit C to open valve V and admit compressed air or other motive fluid into the cylinder 94. This drives piston rod 96 rearwardly and rocks the arcuate member 84 counterclockwise, as seen in the drawings, to the position shown in Fig. 3. As soon as the condition has been corrected, the piston rod 95 is restored to its forward position, by operating the valve mechanism V to release the air which drove the piston rearwardly, a suitable means being provided for returning the member 84 to its normal neutral position. The return means may be of any desired character, such as a spring, or a valve mechanism to admit air or other fluid to the other end of the cylinder 94. This means is not illustrated or described as it is believed to be obvious to those skilled in the art.

The operation of the entire apparatus which constitutes the present invention may now be more fully understood by reference to Figs. 4 to 8, inclusive, of the drawings. In Fig. 4 a condition is represented where both the valve mechanism and the arcuate control member 84 are in their neutral positions. This represents the normal stop position when the locomotive is not moving. Under the conditions shown in Fig. 4 no steam is flowing into the drive cylinder 15.

When the lever arm 54 is moved to a forward position, as by means of control lever 65, control cylinder 64, and piston rod 63, the arm 75 likewise moves forward, sliding pin 81 and slide block 82 forwardly in the arcuate slot 83 of the control member 84. Again assuming that the curved control member 84 is retained in its neutral position, the pin 81 and block 82 sliding forward in curved slot 83 force link 85 downwardly. This movement forces arm 51 downwardly and arm 46, which is keyed to the same shaft 47, is carried downwardly to move the pin 32 toward the bottom of the slot 31. This operates the main valve 39 so as to drive the locomotive forwardly.

As long as there is no substantial slippage of the drivers 12 and 13 with respect to the rail, the control member 84 remains in the neutral position shown in Figs. 4 and 5. However, when the driving force applied to the drivers exceeds

their adhesion to the rail, they begin to slip and the friction wheel 115 is driven faster than friction wheel 111, as explained above. Thereupon the commutator mechanism at S is activated to operate the valve mechanism V and admit an operating fluid, such as compressed air, into cylinder 94 to rock the control member 84 rearwardly into its control position as shown in Fig. 6. When this occurs, the parallelogram linkage 78 and 85 is operated to raise arms 51 and 46 to neutral position even though arms 54 and 75 are retained in the same forward positions as they were in Fig. 5. The result is that operation of the control member 84 shifts the radius rod 33 to or toward neutral position with respect to the reverse link 24, Fig. 1, even though the engineer has not moved the lever 85. The valve mechanism 39 therefore reduces the supply of steam to main cylinder 15 and the drivers 12 and 13 are permitted to resume normal rolling contact with the rail. As soon as this is accomplished, the commutator mechanism S ceases to function and the control member 84 is automatically restored to its normal neutral position by suitable means as mentioned above.

It should be particularly noted that the adjustable stops 103, 104, which limit the movement of the control member 84 to control position, may be set so as to permit movement of the radius rod 33 to a position other than neutral with respect to reverse link 24, if desired. By suitable adjustment a condition may be established whereby the main cylinder is still supplied with a limited flow of steam after the control member 84 has shifted to its control position. Likewise stop 102 may be adjusted to stop movement of member 84 toward neutral at some point other than exact neutral.

Fig. 7 represents a condition where the controls are set for normal reverse operation. The arm 54 has been drawn to the rear of its normal neutral position as will be seen by comparing this figure with Fig. 4. Arm 75 likewise has moved rearwardly, pin 81 has slid counterclockwise with respect to control member 84, as seen in this figure, and arms 51 and 46 have been raised to lift the radius rod 33 toward the top of the reverse link 24. These operations position the main valve mechanism 39 to drive the locomotive in reverse. The control member 84 is in its normal neutral position or as near such position as adjustment of stop 102 permits.

Fig. 8 represents a condition where the drive wheels have slipped and attained an excessive rate of speed in reverse operation, causing the control member 84 to move to its control position, thus moving arm 46 and its connections including radius rod 33 to their neutral positions. This operation is initiated by the difference in speed between friction wheel 111 and friction wheel 115 and is identical with the operation described above which results when the drivers slip in forward movement. In other words, slipping of the drivers in either direction is effective to shift the control member 84 from its neutral position, Figs. 1, 2, 4, 5 and 7, to its control position, Figs. 3, 6 and 8.

It will be understood that the term "neutral position" refers to the limiting position toward neutral where the member 84 or the operating members 45, 33 and associated parts are moved when the commutator mechanism is activated. The direction of motion of the locomotive makes no difference in this respect, commutator mechanism S being operative alike in either direction.

As described in my aforesaid patent, No. 2,232,752, the differential between rotary speeds is the controlling factor which is utilized to provide a desired controlling impulse.

While I have described the friction wheel 111 as being applied to a non-driven wheel, such as a pilot wheel, it might be applied to a drive wheel of another set of drivers, as for example in locomotives of the mallet type. In such case, a separate control member 84, with associated mechanism, would be provided for the valve gearing of each set of drivers and their drive cylinder, so that either set of drivers might be controlled whenever it is driven at an excessive rate of speed with respect to the other. By this means greater uniformity is achieved in applying driving power to the various sets of drivers. Uniform application of power obviously results in maximum performance and maximum economy of power, as well as preventing injury of the character mentioned hereinabove, to wheels and rails.

It will also be evident that the invention is not necessarily limited to locomotives, or to reciprocating engines, or to valve mechanism of the type described hereinabove. Obviously the control mechanism might be applied to various types of motors and to various types of valve mechanism, although the above described application to reciprocating steam locomotives is considered an important one.

It will be understood also that the control mechanism could be interposed between the throttle lever in the locomotive cab and the throttle valve in the steam dome, the supply of steam in this case being directly controlled in response to slipping of the locomotive drivers. The invention is applicable also to the control of the poppets of a poppet valve locomotive. Both of these are considerably different from the arrangement shown in Fig. 1, but the same parallelogram mechanism, controlled in response to the slipping of the drivers, is utilized.

The parallelogram mechanism itself is useful without the control cylinder 94 and the electrical control mechanism which operates it by controlling valve V. It is thus independent of the origin of the control and obviously could be used with other control means than those described. It might, for example, be manually controlled for some purposes. The arcuate sector and the parallelogram arrangement thus constitutes an important part of my invention, aside from its specific application to any particular machine and independent of the particular means or manner by which the control sector is moved.

Hence, while I have illustrated and described the preferred embodiments of my invention, it is to be understood that these are capable of variation and modification and I therefore do not wish to be limited to the precise details set forth, but desire to avail myself of such changes and alterations as fall within the purview of the following claims.

I claim:

1. In combination, a locomotive drive wheel, another wheel operating independently of said drive wheel, a cylinder for driving said drive wheel, valve mechanism for controlling the supply of power to said cylinder, a manually operated control for said mechanism, linkage including a flexible connection interposed between said control and said mechanism, a movable arcuate control member for said flexible connection, speed comparing means associated with said drive wheel and operable to compare the peripheral

speeds of said wheels, and power means controlled by said speed comparing means, for shifting said arcuate member to alter the position of said flexible connection when the peripheral speed of said drive wheel objectionably exceeds the peripheral speed of said other wheel.

2. In a control linkage, the combination of a power control member, means including a parallelogram linkage having one free corner connection, for controlling the movement of said member, and a slotted device for variably positioning said free corner connection and operable to shift said connection and alter the effective operation of said linkage in response to a control impulse.

3. In a power control mechanism, a primary control arm and a secondary control arm mounted on a common shaft, at least one of said arms being freely mounted on said shaft, a link pivoted to said first arm, another link pivoted to said second arm, the other ends of said links being pivoted together and a control device for varying and controlling the position of said last named pivotal connection, to alter the relation between said arms.

4. In a control mechanism, a primary control arm, a secondary control arm, two links in series connecting said arms to form with said arms an approximate parallelogram arrangement with the connection between said links being relatively unconstrained, and means for partially constraining said connection to control the relative position of said arms, said means being effective in movement to or from another position to shift said connection to alter the effect of said secondary arm without a corresponding change in the position of said primary arm.

5. In a control mechanism of the character described, a pair of control arms relatively movable with respect to each other and mounted for movement about a common center, a pair of links in series connecting the free ends of said arms to form a quadrilateral arrangement, having the connection between said links relatively unconstrained, and control means for constraining the movement of said connection in certain respects, such means being movable to vary the constraining effect and to thereby alter the relation between said arms.

6. In a locomotive power control apparatus, a locomotive drive wheel, another wheel operating independently of said drive wheel, piston and cylinder means for driving said drive wheel, valve mechanism in power increasing and power reducing directions for controlling the supply of power to said piston and cylinder means, a manually operated control element for said valve mechanism, means actuated by said manually operated control element for governing said valve mechanism and including a linkage having a flexible connection, said flexible connection having a normal relation in which said manual control element is effective through said linkage to operate said valve mechanism, and said flexible connection being shiftable from said normal relation to an actuated relation to operate said valve mechanism in a power reducing direction while said manual element remains in any predetermined set position, speed comparing means associated with said wheels and operable to compare the peripheral speeds of said wheels, and power means controlled by said speed comparing means and operable normally to maintain said flexible connection in said normal relation and operable to actuate said flexible connection to said actuated relation when the peripheral speed of said drive wheel objectionably exceeds the peripheral speed of said other wheel.

ROSSER L. WILSON.

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