(12) UK Patent Application (19) GB (11) 2 085 191 A

(21) Application No **8119959**
(22) Date of filing **29 Jun 1981**
(30) Priority data
(31) **5003/80**
(32) **8 Oct 1980**
(33) **Austria (AT)**
(43) Application published
21 Apr 1982
(51) **INT CL³**
B60T 8/10
E01B 27/16
(52) Domestic classification
G3N 286C K
E1G 406 444 GC
F2F BB
(56) Documents cited
GB 1246053
(58) Field of search
F2F
G3N
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(54) **A railway track tamping machine**

(57) A tamping machine which advances intermittenly has electronic controls responsive to slip and including a vehicle speed sensor 24 and a wheel speed sensor 21. The vehicle advance is controlled through a drive control unit 31 and a brake control unit 30 to prevent wheel slip and locking during the step by step advance movement.

Fig. 2

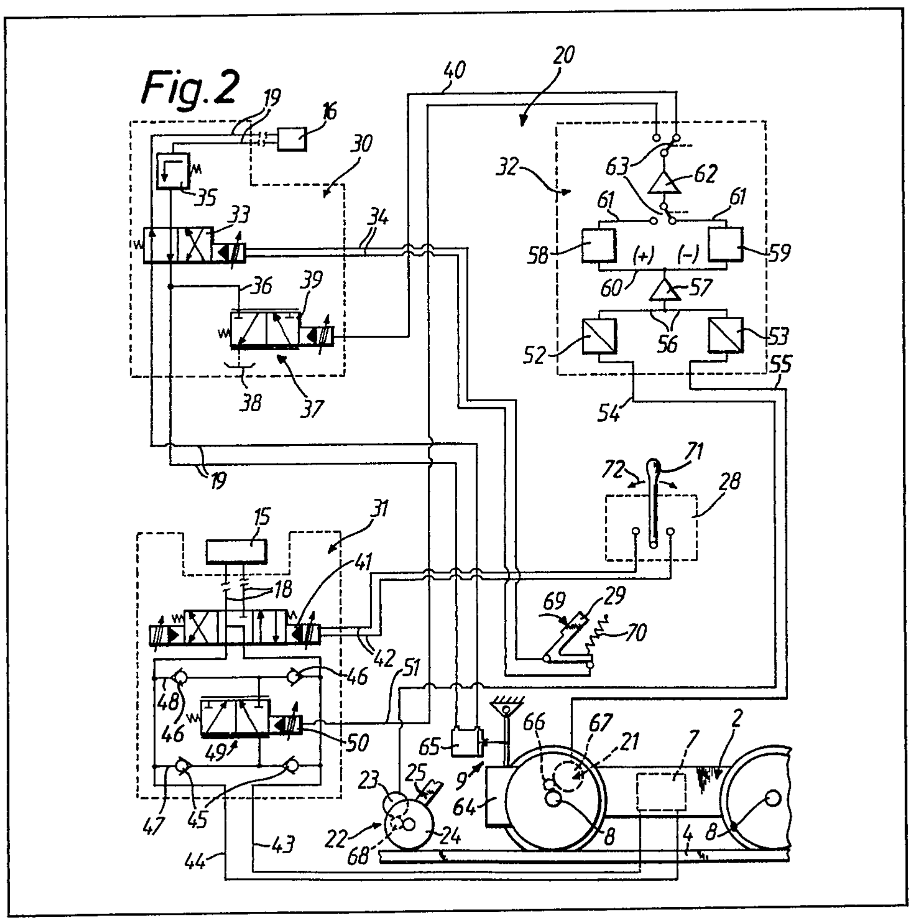

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Fig.1

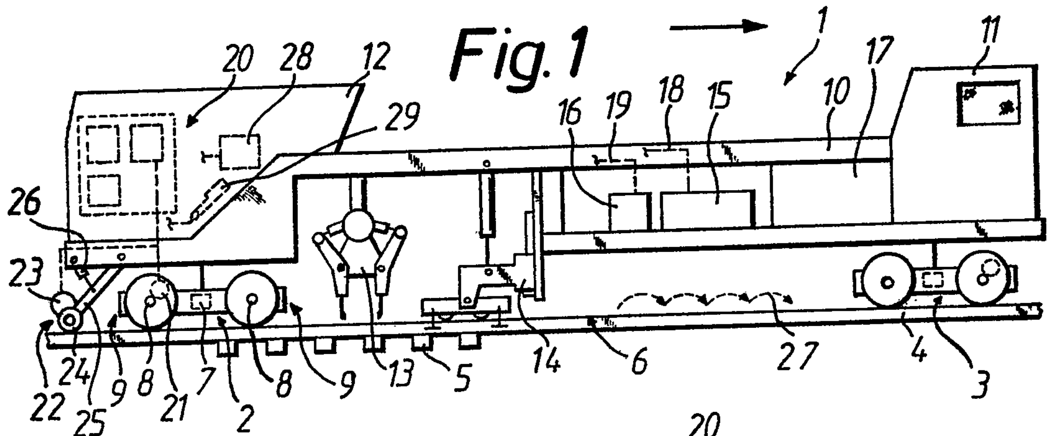


Fig.2

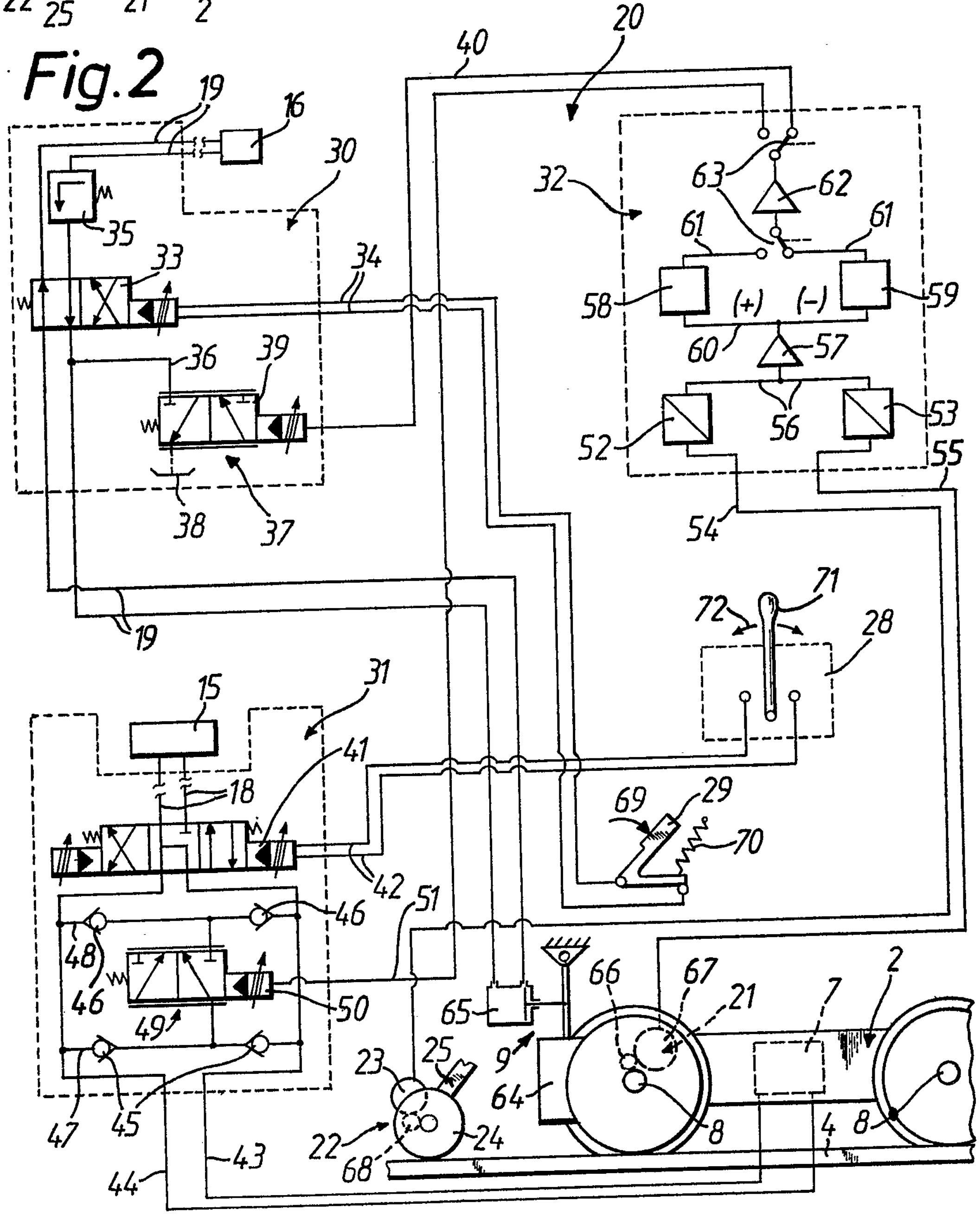
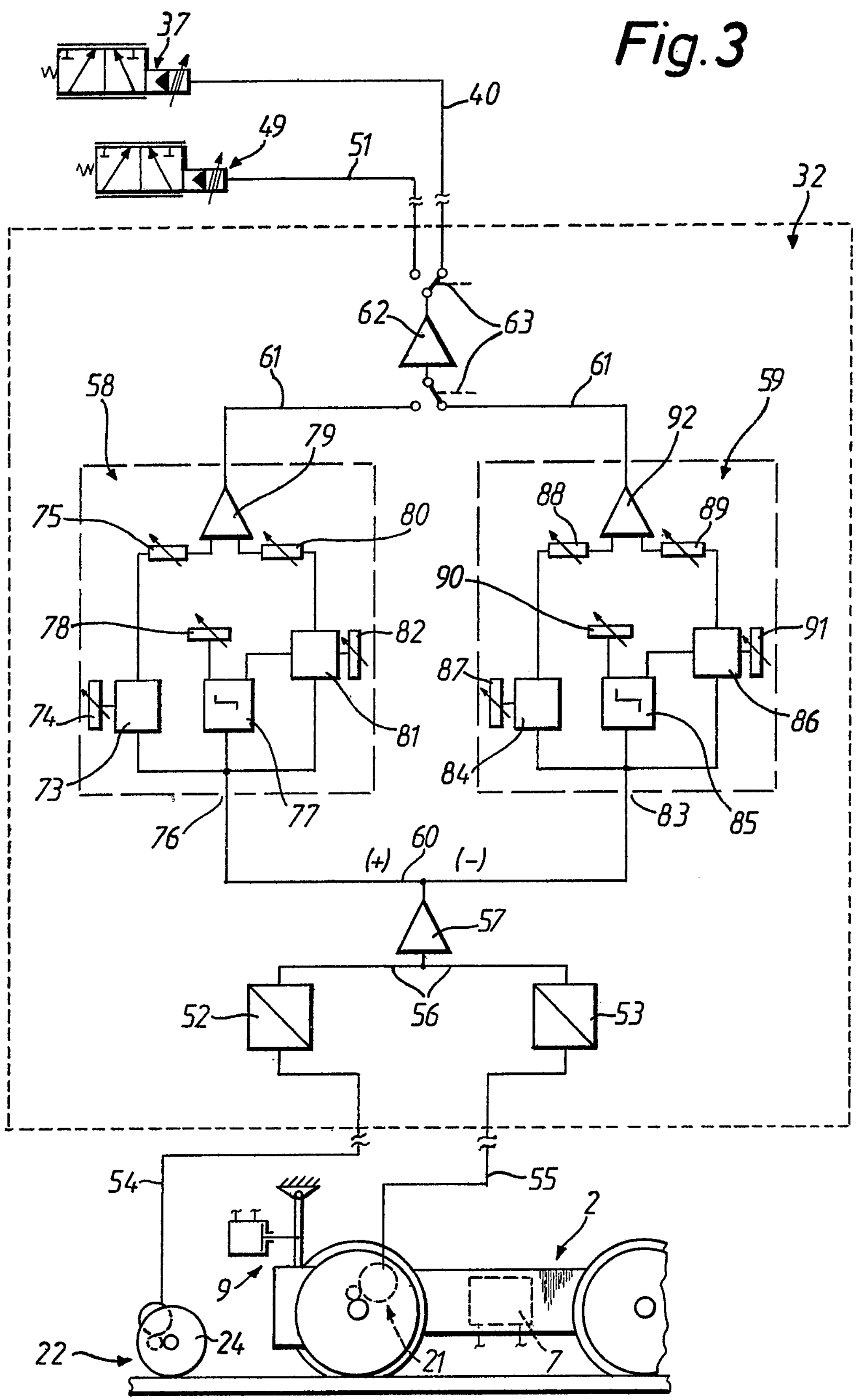


Fig.3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SPECIFICATION

A travelling railway track maintenance machine advancing step by step and comprising on-track undercarriage

This invention relates to a travelling track maintenance machine comprising on-track undercarriages and advancing in steps, more particularly a track tamping machine for carrying out track maintenance work at relatively short intervals from one sleeper to the next, comprising a measuring wheel which rolls along the rail and a control system connected to a working brake installation and at least one propulsion drive.

A particular problem of track maintenance machines of the type in question which operate in steps is that they have to be continually started and stopped for each working cycle. However, any increase in the performance of the machines requires rapid acceleration by a powerful driving moment acting on the drive wheels. Unfortunately, on account of the relatively short distance travelled - which is governed by a sleeper interval of about 50 to 60 cm - braking has to be commenced after brief acceleration to bring the machine to a stop at the right time. Now, track maintenance machines of the type in question are actually equipped with their own working brake installation to supply the immense braking power required for this purpose. However, if the track being treated is wet or covered with oil or rust, all the wheels tend to lock and slide on braking whilst the drive wheels tend to slip on acceleration. Accordingly, very different conditions often prevail, for example also where the track slopes upwards or downwards, giving rise to different coefficients of friction between the rail and the drive wheel. As a result, the drive wheel slips both on acceleration and on braking, in other words the drive wheels slip on acceleration whilst the other wheels lock or slide on braking. A tamping machine takes about 5 seconds for example to complete a working cycle and has to be started and stopped more than 700 times per hour to that end. Apart from a reduction in performance, this continual starting and stopping also causes very unfavourable uneven wear of the drive wheel and rail through wheel spin and locking. In addition, the often different braking distance makes it difficult to centre the working units accurately over the area to be treated.

Now, it is already known from German Patent No. 1,049,412 that uniform advance can be obtained by arranging two independent grippers each associated with one of the two rails on travelling track maintenance machines. These grippers are designed to be alternately clamped fast to the rail and to be variable in their distance from the machine longitudinally of the track by the admission of pressure through a hydraulic cylinder. Although, as a result of this, a track maintenance machine of the type in question is no longer so heavily dependent upon the existing friction conditions, thereby avoiding possible slip between wheel and rail, limits are imposed on this machine construction in practice because the grippers cannot be fully applied to the rail at all points thereof, for example in the vicinity of a joint between rails on account of the fish plates used there or in the region of weld beads and the like. In addition, this solution involves fairly heavy outlay, particularly in the case of relatively large and heavy track maintenance machines. This construction is also unsuitable for a relatively small, step-by-step advance, for example for track tamping machines, from sleeper to sleeper. The machine in question has also proved unsuccessful in practice.

U.K. Patent Spec. 1347013 describes a track tamping machine of the type mentioned at the beginning in which the disadvantages caused by the different friction and braking conditions between wheel and rail as prevail during the step-by-step advance from sleeper to sleeper (in regard to the centring of the working unit) are eliminated by an automatic advance control system. This system comprises a measuring wheel designed to roll along the rail for measuring distance in conjunction with determination of the actual position of the individual sleepers. The measuring wheel, which is in the form of a pulse generator, is associated with a control unit in the form of a pulsor, the pulses corresponding to the distance travelled by the tamping machine along the track being transmitted to a control block. The pulse generator is connected to a pulse counter in the control block which comprises two preselectable count levels. When the tamping machine advances to the next sleeper below which the bedding ballast is to be tamped, the pulsor sets the pulsor to zero in the presence of a rail fastening. After the machine has advanced further, i.e. when the pulse generator reaches a number of pulses preselected in the control block, the braking operation is automatically initiated. After a second number of pulses preselected in the control block has been reached, lowering of the tamping units is initiated. In the case of a relatively long braking distance caused for example for wheel slip, the preselectable count level is altered accordingly by the machine operator. By means of this system, a track tamping machine can be centred much more accurately over the sleepers beneath which the bedding ballast is to be tamped, even where the sleeper intervals are relatively different and where the levels of slip between the drive wheel and the rail are different and affect the length of the braking distance. However, this automatic advance control system also involves additional outlay and for this reason is intended solely for high-performance machines. Although track tamping machines of this type equipped with a hydraulic propulsion drive and with a hydraulic working brake installation have successfully used this system in practice, the uneven slip-included wear of drive wheel and rail cannot always be avoided.

German Offenlegungsschrift No. 1,906,513 describes a so-called anti-slip system for traction vehicles that advance continuously, for example locomotives, which prevents the drive wheels from slipping over the relatively long acceleration paths required by vehicles of this type. In this anti-slip system for railway traction vehicles which consists solely of mechanical and electrical elements, means are provided for determining the speed of (continuous) travel (translation speed) of the locomotive and for determining a so-called slip speed (speed in the event of wheel slip) formed from the difference between the peripheral speed of the drive wheels and the speed of travel of the machine, along with means for initiating anti-slip measures in dependence upon this slip speed. These means further comprise a slip-limiting unit which is formed by a so-called dead-zone element provided with a resistance chain and a limiting calculator and which is connected to a static converter control unit and a control valve of the brake system. Now, if the drive wheels slip on acceleration of the locomotive, the measured-value difference determined with respect to the actual translation speed measured by a measuring wheel is compared with the value of the dead-zone element. The resulting difference in the measured values acts through the static converter control block on the drive moment of the engine. The construction of the dead-zone element is such that no measuring signal is relayed within a certain range dependent upon an auxiliary voltage. The auxiliary voltage is determined by the limiting calculator in dependence upon the translation speed, the motor current and a value selectable by the driver. This produces a delay in the anti-slip measures - dependent upon the condition of the rail and the translation speed - in order to obtain a higher adhesion coefficient in the event of minimal slip. However, this anti-slip system is adapted solely to the properties of continuously travelling railway traction vehicles which require powerful forces for pushing and pulling trains and very along acceleration paths. Although this system is able to prevent the drive wheels from spinning, it is unable to prevent the wheels from locking on braking so that it cannot be used in track maintenance machines advancing in steps.

Now, the object of the present invention is to provide a track maintenance machine of the type described at the beginning in particular of the type which advances step-by-step from sleeper to sleeper, by which the above-mentioned disadvantages can be lessened or avoided, even where different conditions prevail along the track, and the stepwise advances kept exactly the same.

In the track maintenance machine described at the beginning, this object is achieved in that, to prevent the drive wheels from slipping on start-up and from locking (sliding) on braking, the control system is fully electronic and comprises an arrangement which - for permanently maintaining the nominal required values for the drive and braking moments and for reducing the traction and braking forces - comprises signalling and regulating elements designed to be activated in dependence upon any drive or brake slip present and is connected to a unit for measuring the speed of travel, more particularly to a measuring wheel designed to roll along the rail, and to a unit for measuring the peripheral speed of the wheels.

In this way, the invention provides in a surprisingly simple manner a track maintenance machine which, irrespective of the particular working conditions prevailing along the track and irrespective of the conditions along the track at any given time whether attributable to soiling or even to positional inaccuracies - always ensures automatic utilisation of the greatest possible adhesion between drive wheel and rail - largely in the absence of slip - both during acceleration and on braking. Accordingly, a track maintenance machine constructed in accordance with the invention reliably and virtually automatically prevents slipping and locking, so that wheels and rails are effectively protected against excessive and uneven wear. The variations in the condition of rails which are frequently encountered in track maintenance work and the accompanying problem of different coefficients of friction over relatively short distances is solved particularly simply and effectively by the electronic system according to the invention. By virtue of the direct association of the measured slip value determined by the electronic system with the control elements of the working brake installation and the propulsion drive, the very short acceleration and braking distance in a step-by-step advance from sleeper to sleeper is maintained without delay and free from any slip. The continuous regulation of the drive moment and braking pressure in proportion with the measured slip value determined provides for the utilisation of maximal adhesion in accordance with the particular condition of the rail and hence for maximal performance of the track maintenance machine. It is thus possible reliably to avoid uneven wear of the drive wheel and, in particular, the rails despite the continuous variation in the condition of the rails caused by the extremely high frequency of stops and starts made in particular by a step-by-step track maintenance machine of the type in question. Through the continuous comparison of the speed of advance as measured by the measuring wheel with the peripheral speed of the drive wheel, the slip value is re-determined for each working cycle both during acceleration and on braking to obtain a maximal setting for the next step forward so that there is virtually no longer any slip during acceleration and braking of the machine.

One particularly practical and advantageous embodiment of the invention is characterised in that the arrangement comprising the signalling and regulating elements is connected at its input through lines to a generator associated with the two units for measuring the speed of travel and the peripheral speed of the wheels and, at its output, is connected through lines to a hydraulic propulsion-drive control block and to a brake-pressure control block of the hydraulic working brake installation of the control system. The combination of the control system with a hydraulic propulsion-drive control block and a brake-pressure control block of a hydraulic brake installation provides for particularly rapid and delay-free adaptation to the particular condition of the rails or track, in addition to which the advantages hitherto afforded by the hydraulic design in track maintenance machines, for example on the one hand safe and rapid working and on the other hand robust working, can be retained. These advantages are strengthened by the fact that constant comparison of the actual speed of travel with the corresponding peripheral speed of the wheels is almost always carried out by means of low-inertia elements in the form of pulse or analog signals.

According to another aspect of the invention, the arrangement is designed for comparative measurement and to release a slip measurement signal corresponding to the difference between the two input signals, its output being associated with a regulating element of the two control blocks connected by lines to the working brake installation and to the propulsion drive, the regulating elements being formed by electrohydraulic proportional valves. An arrangement such at this provides in particular for immediate response, even in the event of minimal differences, so that the propulsion drive and the working brake installation may be activated particularly effectively and exactly in accordance with the particular working conditions.

In one advantageous embodiment of the invention, the arrangement consists of two frequency/voltage converters and of a differential circuit designed to release a positive drive slip measurement signal or negative brake slip measurement signal. These measures provide above all for substantially delay-free influencing of the regulating elements so that the slip of the drive wheel which is still present for measuring the difference in speed between the drive wheel and the measuring wheel lies - as shown by experience - in a range which can no longer be determined of one revolution of only about 1 to 2°. The independent regulation of the individual on-track undercarriages reliably precludes any danger of slipping even over short distances (less than the distance between the on-track undercarriages) involving different rail conditions.

Another advantageous embodiment of the invention is characterised in that, for dynamically influencing the positive drive slip measurement signal or negative brake slip measurement signal acting on the control elements, the arrangement comprises electronic regulating units of which each preferably consists of a proportional amplifier and an integral amplifier connected in parallel, of which the outputs are connected to a summation amplifier, a switching element and an integral regulator being associated with the integral amplifier. The regulating unit associated with the positive slip measurement signal provides for specific adaptation solely to the start-up phase in dependence upon various factors, a sudden forward movement in particular being avoided by the dynamic influence. Similarly, the reduction in the brake pressure can be specifically adapted by the second regulating unit to the braking operation. By virtue of the proportional component, the amplifier combination results in the regulating elements immediately being driven to full output so that slipping and locking of the drive wheels are prevented at the beginning of the acceleration and braking phases when the dead weight of the track maintenance machine and hence slipping of the wheels are at their greatest. The delay in the resetting of the regulating unit brought about by the integral component prevents the drive moment and the brake pressure from returning prematurely to the respective starting values.

According to another aspect of the invention, the integral amplifier associated with the negative brake slip measurement signal has a shorter switching time than the integral amplifier associated with the positive drive slip measurement signal. The particular object of this measure is to ensure that, when an only very weak measured slip signal is present at the input of a regulating unit, the switching element prevents the integral amplifier from responding. Brief switching-through of the proportional amplifier is sufficient for minimal slip because an increase in the performance of the machine is obtained through the immediate switch to the full drive moment or to the full brake pressure. In addition, this measure takes into account above all any sudden deceleration because the variation in the brake pressure at short intervals often gives rise to sudden deceleration (which is undesirable when it comes to start up) so that the effectiveness of the brakes can be maximally utilised.

In another embodiment of the invention, the slip measurement signal determined during braking and intended to act on the regulating element of the hydraulic working brake installation is stored in a memory of which the output is designed to be switched by the regulating element of the hydraulic propulsion drive after the actuation of a control lever which initiates the start-up operation. Storage of the slip measurement signal determined during braking and its additional use for regulating the regulating element acting on the propulsion-drive circuit eliminate the brief slip otherwise required for slip measurement during the start-up operation. Accordingly, the measured slip value determined during braking is substantially identical with the slip occurring during start-up.

Finally, according to another aspect of the invention, the fully electronic control system connected to the signalling and regulating arrangement is associated with each on-track undercarriage provided with a propulsion drive. This ensures that, for each on-track undercarriage, the hitherto known disadvantages of slipping on start-up are safely avoided. A control system of the type in question may of course be used in conjunction with a single-axled on-track undercarriage or even in a bogie or the like.

One example of embodiment of the invention is described in detail in the following with reference to the accompanying drawings, wherein:

Figure 1 is a side elevation of a track tamping machine advancing in steps for tamping the ballast below a sleeper.

Figure 2 is a diagrammatic circuit diagram of the control system of the track tamping machine shown in Figure 1 comprising the control and regulating system according to the invention which regulates the drive moment and the brake pressure.

Figure 3 is a detailed illustration of the electronic signalling and regulating unit of the control system shown in Figure 2.

The track tamping machine 1 shown in Figure 1, of which the working direction is indicated by an arrow, is designed to travel along a track 6 consisting of rails 4 and sleepers 5 by means of two on-track undercarriages 2, 3. The on-track undercarriage 2 consists of two drive axles 8 which are driven by a hydraulic propulsion drive 7 in the form of an oil engine and on which acts a hydraulic working brake installation 9. For each rail 4, a tamping unit 13 and a lifting and lining unit 14 are mounted for vertical displacement on a chassis 10 between operator's cabins 11 and 12. The propulsion drive 7 which acts on the drive axles 8 is supplied with oil under pressure from an oil pressure supply unit 15. Like the oil pressure supply unit 15, a brake pressure supply unit 16 for the hydraulic working brake installation 9 is connected to a diesel engine 17. Pressure lines 18 and 19 lead respectively from the oil pressure supply unit 15 and from the brake pressure supply unit 16 to an electronic control system 20. The control system 20 is connected by cables (shown in Figure 2) to an arrangement 21 for measuring the peripheral speed of the wheels, to an arrangement 22 for measuring the speed of travel and to the propulsion drive 7 and the working brake installation 9. A generator 23 belonging to the arrangement 22 for measuring the speed of travel is adapted to be driven by a rubber-coated measuring wheel 24 designed to roll along the rail 4. A suspension 25 pivotally connected to the chassis 10 and linked to the measuring wheel 24 is adapted to be vertically displaced by a lifting cylinder 26. The measuring wheel 24 which rolls along the railhead during the step-by-step advance of the machine (indicated by the arrows 27) does not have any flanges and is arranged immediately adjacent the on-track undercarriage 2 in order to avoid excessive deflection around curved sections of track. A control panel 28 is used for controlling the step-by-step advance of the track tamping machine 1, whilst a brake pedal 29 is used for controlling the working brake installation 9.

The control system 20 shown in detail in Figure 2 consists of a control block 30 for the brake pressure, a control block 31 for the propulsion drive and of a signalling and regulating unit 32 which are connected to one another by lines described in more detail in the following.

In the brake-pressure control block 30 shown at the top left-hand side of Figure 2, the pressure lines 19 coming from the brake-pressure supply unit 16 are associated with a two-way valve 33 controlling the working brake installation 9, lines 34 connecting the two-way valve 33 with the brake pedal 29 which acts as a switch. A pressure limiting valve 35 for limiting the oil pressure is provided in the pressure line 19 which serves as a feed line. A pressure line 36 connects the pressure line 19 serving as a feed line to a regulating element 37 and to an outlet 38 of the brake-pressure supply unit 16. The regulating element 37 is in the form of an electrohydraulic proportional valve 39 with a control range proportional to the input value arriving through a line 40. The pressure lines 19 are connected to the working brake installation 9.

In the propulsion-drive control block 31 shown at the bottom left-hand side of Figure 2, the pressure lines 18 coming from the oil-pressure supply unit 15 are associated with a three-way valve 41 which controls the propulsion drive 7. The three-way valve 41 is designed to be controlled through lines 42 into an end position in which the propulsion drive 7 is drivable in both directions, an intermediate position being provided for the stoppage of the propulsion drive 7. A pressure-supply line 43 and a pressure-discharge line 44 lead from the three-way valve 41 to the propulsion drive 7, both lines 43, 44 being connected to one another at their ends by lines 47, 48 each incorporating a non-return valve 45, 46. Whereas the non-return valves 45 of the line 47 block the connection of the two lines 43, 44 the connection established by the non-return valves 46 in the second line 48 remains open in both directions. The two lines 47 and 48 are connected to one another between the non-return valves 45, 46 by a regulating element 49. The regulating element 49, which is in the form of an electrohydraulic proportional valve 50, comprises a servomotor for continuously transforming continuously variable electrical signals passing through a line 51 into hydraulic energy through a change in the cross-section of the line.

The arrangement 32 shown at the top right-hand side of Figure 2 consists at its input end of two frequency/voltage converters 52, 53 which are connected by lines 54, 55 to the unit 22 for measuring the speed of travel and to the unit 21 for measuring the peripheral speed of the wheels. Two regulating units 58, 59 respectively associated with a positive and negative slip measurement signal of a differential circuit 57 connected to the outputs of the frequency/voltage converters 52, 53 by lines 56 are associated with the differential circuit 57 through lines 60. Two reversing switches 63 connected to the input and output of a power amplifier 62 are connected by lines 61 to the regulating units 58, 59. The lines 40 and 51 respectively leading to the brake-pressure control block 30 and to the propulsion-drive control block 31 are connected to the reversing switch 63 at the output end.

The rear on-track undercarriage 2 carrying the propulsion drive 7 and the unit 22 for measurement the speed of travel are both diagrammatically illustrated in Figure 2 to enable the mode of operation of the control system 20 to be more clearly understood. The unit 21 for measuring the peripheral speed of the wheels consists of a generator 67 which is driven by the drive axle 8 of the on-track undercarriage 2 via a gear wheel 66. The generator 23 of the device 22 for measuring the speed of travel is driven - again via a gear wheel 68 - by the measuring wheel 24 which rolls along the rail 4. The working brake installation 9 of the on-track undercarriage 2 consists of a double-acting brake cylinder 65 which presses a brake block 64 against the drive wheel of the drive axle 8. The brake pedal 29 which controls the working brake installation 9 is in the form of a switch and, to initiate braking, is depressed in the direction indicated by an arrow 69 against the action of a helical spring 70. The control panel 28 which controls the propulsion drive 7 by turning a control lever 71 in one of the directions indicated by an arrow 72 is associated through the lines 42 with the three-way valve 41 of the propulsion-drive control block 31.

Whereas, at its input end, the arrangement 32 is respectively connected by the lines 54 and 55 to the generator 23 driven by the measuring wheel 24 and to the generator 67 driven by the drive axle 8, the outputs are respectively connected by lines 40 and 51 to the regulating element 37 of the brake-pressure control block 30 and to the regulating element 49 of the propulsion-drive control block 31. The brake pedal 29 and the working brake installation 9 are respectively associated through the lines 34 and the pressure lines 19 with the brake-pressure control block 30 which, on the other hand, is connected by the line 40 to the arrangement 32. Similarly to the brake-pressure control block 30, the propulsion-drive control block 31 is connected to the control panel 28 by the lines 42 and to the propulsion drive 7 by the lines 43, 44. It is also connected to the arrangment 32 by the line 51.

The control and regulating system described in particular with reference to Figure 2 operates as follows:

For starting and stopping the machine during its step-by-step advance in the working direction indicated by the large arrow in Figure 1, the machine operator turns the control lever 71 connected to the propulsion-drive control block 31 and depresses the brake pedal 29 connected to the brake-pressure control block 30. As a result, the two-way valve 33 and three-way valve 41 are shifted in such a way that the propulsion drive 7 is set in motion and the brake cylinder 65 presses the brake block 64 onto the drive wheel. When the control lever 71 is turned into the central position shown in Figure 2, the propulsion drive 7 remains in its rest position. After the foot of the machine operator has been lifted, the helical spring 70 immediately returns the brake pedal 29 into a position in which the circuit formed by the lines 42 is broken and the brake cylinder is activated in the opposite direction.

Providing the rails are in good condition, the driveless measuring wheel 24 of the unit 22 for measuring the speed of travel and the drive wheels of the drive axle 8 roll along the rail 4 at the same peripheral speed. As a result, the two generators 23 and 67 driven on the one hand by the measuring wheel 24 and on the other hand by the drive wheel of the drive axle 8 generate an equal number of pulses. Accordingly, the actual speed of travel is continuously compared with the corresponding revolutions of the drive wheels by the generators 23, 67 - acting as low-inertia transmitters - in the form of pulse signals (it is of course also possible to use analog signals). However, if the rails are wet or covered with oil or rust, all the braked wheels tend to lock on deceleration whilst the drive wheels tend to slip on acceleration. Accordingly, slipping and locking are automatically prevented by means of the track tamping machine 1 constructed in accordance with the invention, so that the wheels and rails are effectively protected against excessive and uneven wear. When the two generators 23, 26 stop releasing the same number of pulses, a relative movement occurs between the track tamping machine 1 and the rail 4, in other words the drive wheels slip on acceleration and thus have a higher peripheral speed than the measuring wheel 24 rolling along the rail 4 or, on braking, the speed of travel of the track tamping machine is greater than the peripheral speed of the wheels locked by the brake.

The digital input signals coming from the lines 54 and 55 to the arrangement 32 are converted into analog voltages in the two frequency/voltage converters 52, 53. In the differential circuit 57, the difference between the two input voltages is formed and equalised in such a way that, where the required rotational speed and the actual rotational speed are the same (no slip), the difference becomes zero. Depending on whether the actual rotational speed measured by the measuring wheel 24 is faster (slipping of the wheels) or slower (locking or sliding of the wheels along the rail), a positive or negative differential voltage appears at the output of the differential circuit 57. Accordingly, given a slip-free coupling between the wheel and the track, the reference value and the comparison values are the same, with the result that there is no differential voltage and no slip measurement signal. In the event of slipping between wheel and rail, a slip measurement signal is generated, its size corresponding to the magnitude and type of slip: drive slip, wheel slip corresponds to a positive slip measurement signal whereas brake slip (locking or sliding) corresponds to a negative slip measurement signal. The differential voltage or rather the slip measurement signal is dynamically influenced by the regulating unit 58 or 59. The nature of this influence and also the exact structure of the regulating unit 58, 59 will be explained in more detail in the description of Figure 3. The two reversing switches 63 preceding and following a power amplifier 62 are switched according to the position of the brake pedal 29 and the control lever 71. The positions of the control lever 71 and brake pedal 29 illustrated in Figure 2 represent activation of the working brake installation 9. The dynamically influenced slip measurement signal is amplified by the power amplifier 62 and passes through the corresponding position of the reversing switch 63 via the line 40 to the regulating element 37 of the brake-pressure control block 30.

The circuit connecting the pipes 34 which is completed by operation of the brake pedal 29 in the direction indicated by the arrow 69 shifts the two-way valve 33 into the position illustrated in Figure 2 against the effect of a helical spring. As a result, pressure is admitted to the brake cylinder 65 which causes the brake block 64 pivotally mounted on the chassis 10 to be pressed against the wheel. The electrohydraulic proportional valve 39 which acts as a regulating element 37 is shifted from its starting position proportionally to the magnitude of the slip measurement signal, the throughflow cross-section of the initially blocked pressure line 36 increasing with increasing displacement of the valve. The pressure oil flowing off through the regulating element 37 is returned through the outlet 38 to the brake-pressure supply unit 16. The displacement of the electrohydraulic proportional valve 39 results in a drop in pressure which leads to a lower contact pressure of the brake block 64 through the brake cylinder 65 so that there is no danger of the braked wheels locking. When the machine operator lifts his foot off the brake pedal 29, the circuit controlling the two-way valve 33 is broken and the valve is shifted into the other position through the action of a return spring. The resulting reversal in the direction of flow of the pressure oil causes the brake block 64 to be lifted off the wheels of the on-track undercarriage 2.

To initiate the start-up phase, the machine operator turns the control lever 71 so that the circuit with one of the two lines 42 is completed through the control lever 71. As a result, the electromagnets of the three-way valve 41 are energised, moving the valve into one of its two end positions. The path thus released for the pressure oil to flow from the oil-pressure supply unit 15 through one of the two pressure lines 18 to the line 43 and back to the propulsion drive 7 through the line 44 and the pressure line 18 causes the propulsion drive 7 to rotate in the required direction. The hydraulic pressure in the propulsion-drive circuit is normally selected in such a way that, providing the wheel and the track are in very good condition, the drive wheels do not slip. Drive slip is caused by a tractive force which is too great for the actual condition of the track. In the event of slip, an electrical differential voltage proportional to the degree of slip is again generated by the differential circuit 57 of the arrangement 32, again being associated - after dynamic influence by the regulating unit 58 - with the regulating element 49 of the propulsion-drive control block 31 through the line 51. This signal acts on the propulsion-drive circuit through the electrohydraulic proportional valve 50 in the form of a regulating element 49 in such a way that the torque of the drive axles 8 is reduced to the necessary extent. To achieve this reduction, the cross-section of the line connecting the two lines 48, 47 to one another is increased according to the size of the slip measurement signal by displacement of the electrohydraulic proportional valve 50. Owing to this short-circuited connection from the pressure-carrying line 43 via the non-return valve 46 and the regulating element 49 to the non-return valve 45 to the pressure-discharging line 44 there is a drop in pressure which reduces the drive moment generated by the propulsion drive 7. Since the automatic operation involved is an adjustment, the preset required values for the driving and braking moments remain permanently intact.

The positive slip measurement signal formed by the differential circuit 57 in the arrangement 32 shown in detail in Figure 3 is associated with the regulating unit 58. The positive differential voltage or rather the slip measurement signal is delivered to a proportional amplifier 73 by which it is highly amplified through a gain control 74 so that, even in the event of minimal slip (i.e. no visible traces left), a powerful output voltage is available for activating the regulating element 49 of the propulsion-drive control block 31. The magnitude of this regulating voltage may be adjusted by a regulating element 75. At the same time, the positive differential voltage present at the input 76 is also delivered to an integral amplifier 77. The switching point adjustable by a switching element 78 enables the integral amplifier 77 to be switched off in the event of very weak differential signals. However, if the preset switching point is exceeded, the integral amplifier 77 is briefly switched through (for about 20 milliseconds) to the output of a summation amplifier 79, depending on the value set by a regulating element 80. An integral regulator 81 with a timing adjustment 82 is connected to the output of the integral amplifier 77.

The slip measurement signal or rather the differential voltage is dynamically influenced by the regulating unit 58 shown in Figure 3 in the following manner:

On the arrival of a differential voltage at the input 76, the high gain of the proportional amplifier 73 immediately saturates the summation amplifier 79, in other words the regulating element 49 of the propulsion-drive control block 31 is driven to full output. The degree of reduction in the drive moment brought about by the regulating element 49 being driven to full output may be adjusted as required. An approximately 20% reduction in the drive moment for rails in normal condition causes no further slipping of the drive wheels - even if the rails are in poor condition - through driving of the control element 49 to full output. Through the reduced drive moment, the rotational speed of the drive axles 8 is equal to that of the measuring wheel 24. As a result, a slip measurement signal is no longer present at the input 76 and the proportional amplifier 73 is inactivated. Since the proportional factor results in the control element 49 being driven to full output, positive summation of the integral factor can no longer have any influence. The control element 49 designed to be activated by the summation amplifier 79 through the power amplifier 62 is driven to full output and immediately returns the input difference to zero through equality of the rotational speeds. At the same time, the proportional factor at the summation amplifier 79 also falls to zero. However, the control signal coming from the integral regulator 81 remains fully stored for the timebeing and can only fall back to zero in the form of an adjusted time ramp (of the order of 500 milliseconds). This time ramp is transmitted to the regulating element 49 and enables the track tamping machine 1 to accelerate smoothly. If the drive wheels begin to slip again, the operation described above is repeated by driving the regulating element 49 to more or less full output. The position of the time ramp may be adjusted in dependence upon various parameters, such as required output, the condition of the rails, etc.

As can be seen more clearly from Figure 3, the regulating unit 59 associated with the negative differential voltage consists of an input 83, a proportional amplifier 84, an integral amplifier 85, an integral regulator 86 and a gain regulator 87, regulating elements 88, 89, a switching element 90, a timing regulator 91 and a summation amplifier 92. The regulating unit 59 has the same structure as the regulating unit 58. Through the negative differential voltage, the regulating unit 58 is inactivated and the regulating unit 59 activated. The process by which the dynamic influence is exerted is then completed in exactly the same way as described with reference to the regulating unit 58, but on this occasion through the proportional amplifier 84, the integral amplifier 85, the summation amplifier 92 and the regulating element 37 of the brake-pressure control block 30. However, the various set values of the switching and regulating elements 87,88,89, 90 and 91 may be differently adjusted in accordance with the conditions prevailing on braking. For example, the falling time ramp need only be set in the range from about 50 to about 100 milliseconds to enable the prescribed regulating and control operation to be repeated at shorter intervals in the event of the wheels locking. As a result, the effectiveness of the brakes is also maximally utilised. According to the invention, the slip measurement signal may also be dynamically influenced in dependence upon various parameters using various regulators or even various combinations. For example, a differential amplifier may be used in addition to the proportional and integral amplifiers.

CLAIMS

1. A travelling track maintenance machine comprising on-track undercarriages and advancing in steps, more particularly a track tamping machine for carrying out track maintenance work at relatively short intervals from one sleeper to the next, comprising a measuring wheel which rolls along the rail and a control system connected to a working brake installation and at least one propulsion drive, characterised in that, to prevent the drive wheels from slipping on start-up and from locking (sliding) on braking, the control system is fully electronic and comprises an arrangement which - for permanently maintaining the nominal required values for the drive and braking moments and for reducing the traction and braking forces - comprises signalling and regulating elements designed to be activated in dependence upon any drive or brake slip present and is connected to a unit for measuring the speed of travel, more particularly to a measuring wheel designed to roll along the rail and to a unit for measuring the peripheral speed of the wheels.

2. A track maintenance machine as claimed in Claim 1, characterised in that the arrangement comprising the signalling and regulating elements is connected at its input through lines to a generator associated with the two units for measuring the speed of travel and the peripheral speed of the wheels and, at its output, is connected through lines to a hydraulic propulsion-drive control block and to a brake-pressure control block of the hydraulic working brake installation of the control system.

3. A track maintenance machine as claimed in Claim 1 and 2, characterised in that the arrangement is designed for comparative measurement and to release a slip measurement signal corresponding to the difference between the two input signals, its output being associated with a regulating element of the two control blocks connected by lines to the working brake installation and to the propulsion drive, the regulating elements being formed by electrohydraulic proportional valves.

4. A track maintenance machine as claimed in Claim 3, characterised in that the arrangement consists of two frequency/voltage converters and of a differential circuit designed to release a positive drive slip measurement signal or negative brake slip measurement signal.

5. A track maintenance machine as claimed in Claim 3 and 4, characterised in that, for dynamically influencing the positive drive slip measurement signal or negative brake slip measurement signal acting on the control elements, the arrangement comprises electronic regulating units each of which preferably consists of a proportional amplifier and an integral amplifier connected in parallel, of which the outputs are connected to a summation amplifier, a switching element and an integral regulator being associated with the integral amplifier.

6. A track maintenance machine as claimed in Claim 5, characterised in that the integral amplifier associated with the negative brake slip measurement signal has a shorter switching time than the integral amplifier associated with the positive drive slip measurement signal.

7. A track maintenance machine as claimed in any of Claims 1 to 6, characterised in that the slip measurement signal determined during braking and intended to act on the regulating element of the hydraulic working brake installation is stored in a memory of which the output is designed to be switched by the regulating element of the hydraulic propulsion drive after the actuation of a control lever which initiates the start-up operation.

8. A track maintenance machine as claimed in any of Claims 1 to 7, characterised in that the fully electronic control system connected to the signalling and regulating arrangement is associated with each on-track undercarriage provided with a propulsion drive.

9. A railway track maintenance machine substantially as herein described with reference to the accompanying drawings.

Printed for Her Majesty's Stationery Office, by Croydon Printing Company Limited, Croydon, Surrey, 1982.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.