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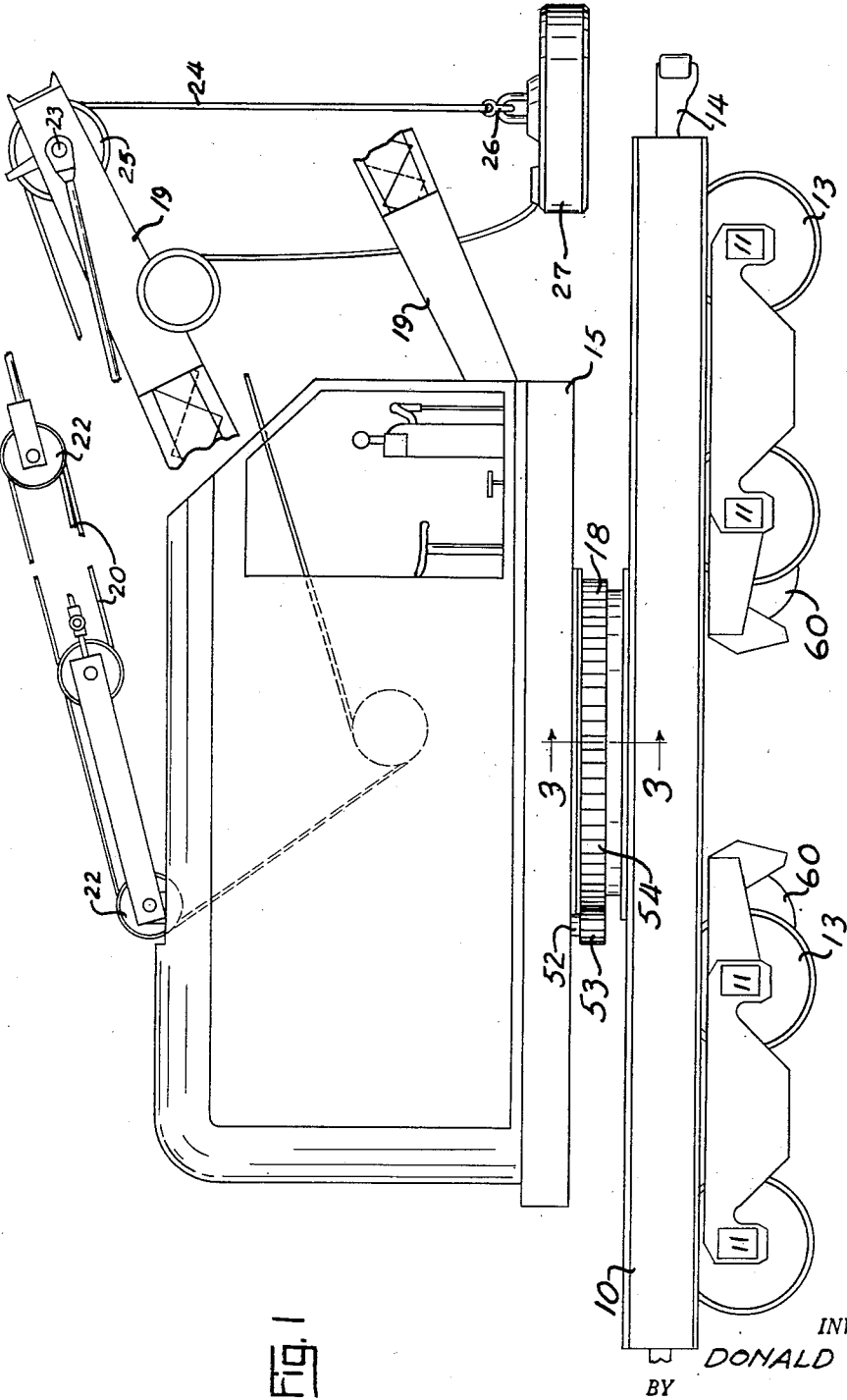
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ELECTRIC MOTOR DRIVEN MATERIAL HANDLING SYSTEM

Filed Dec. 22, 1945

4 Sheets-Sheet 1



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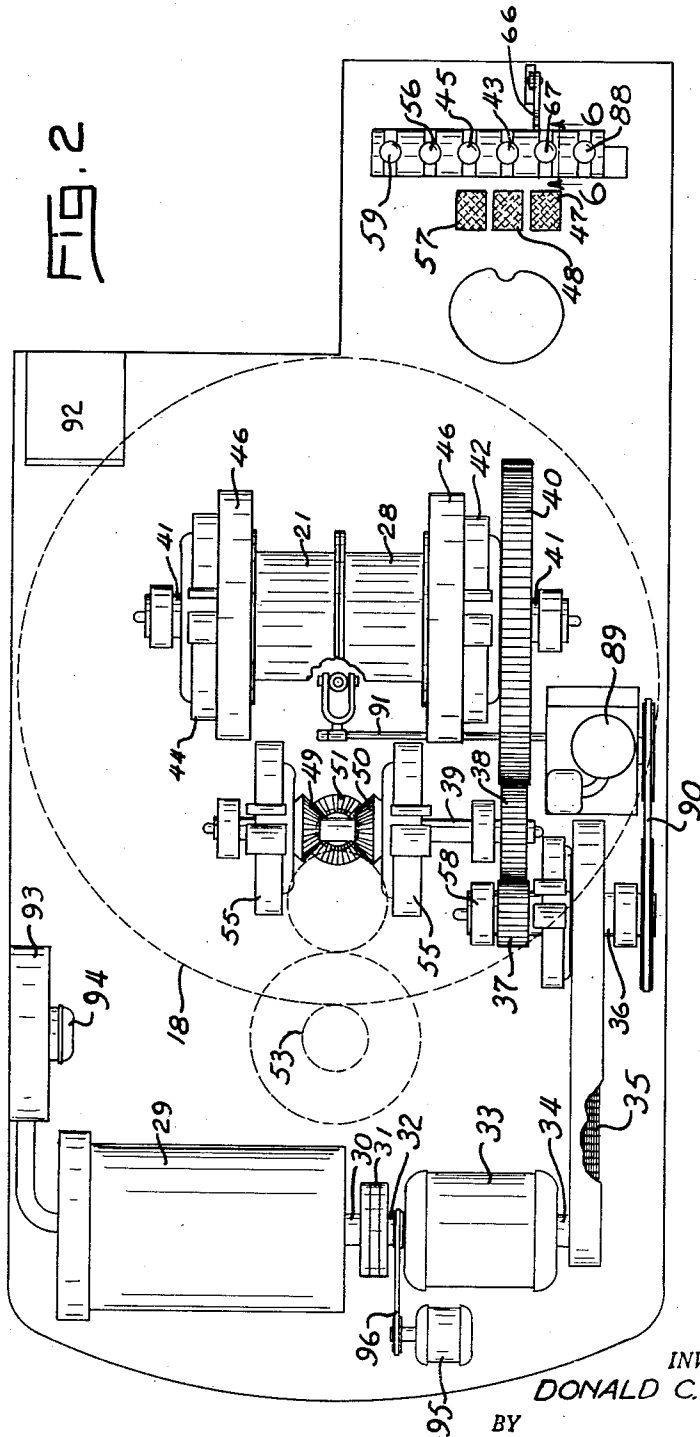
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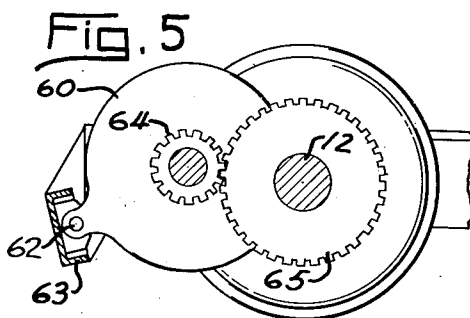
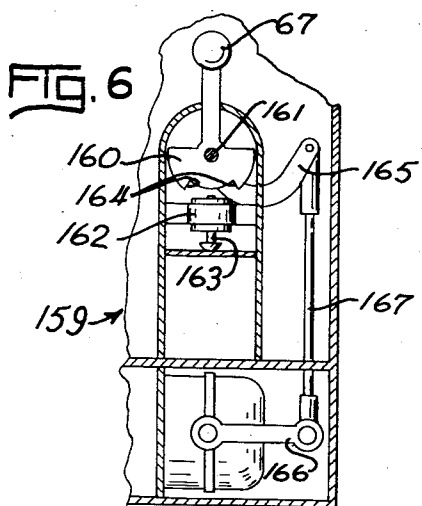
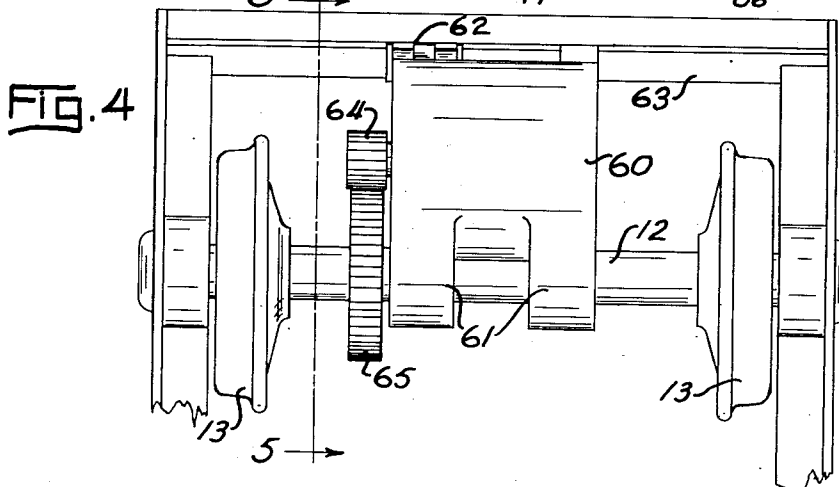
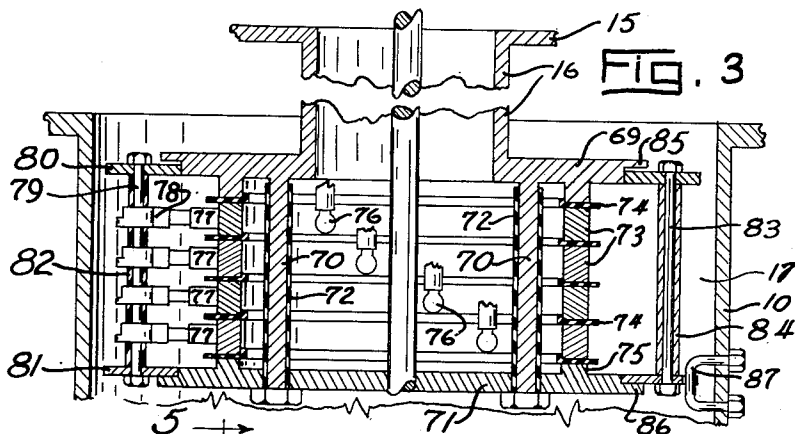
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4 Sheets-Sheet 3



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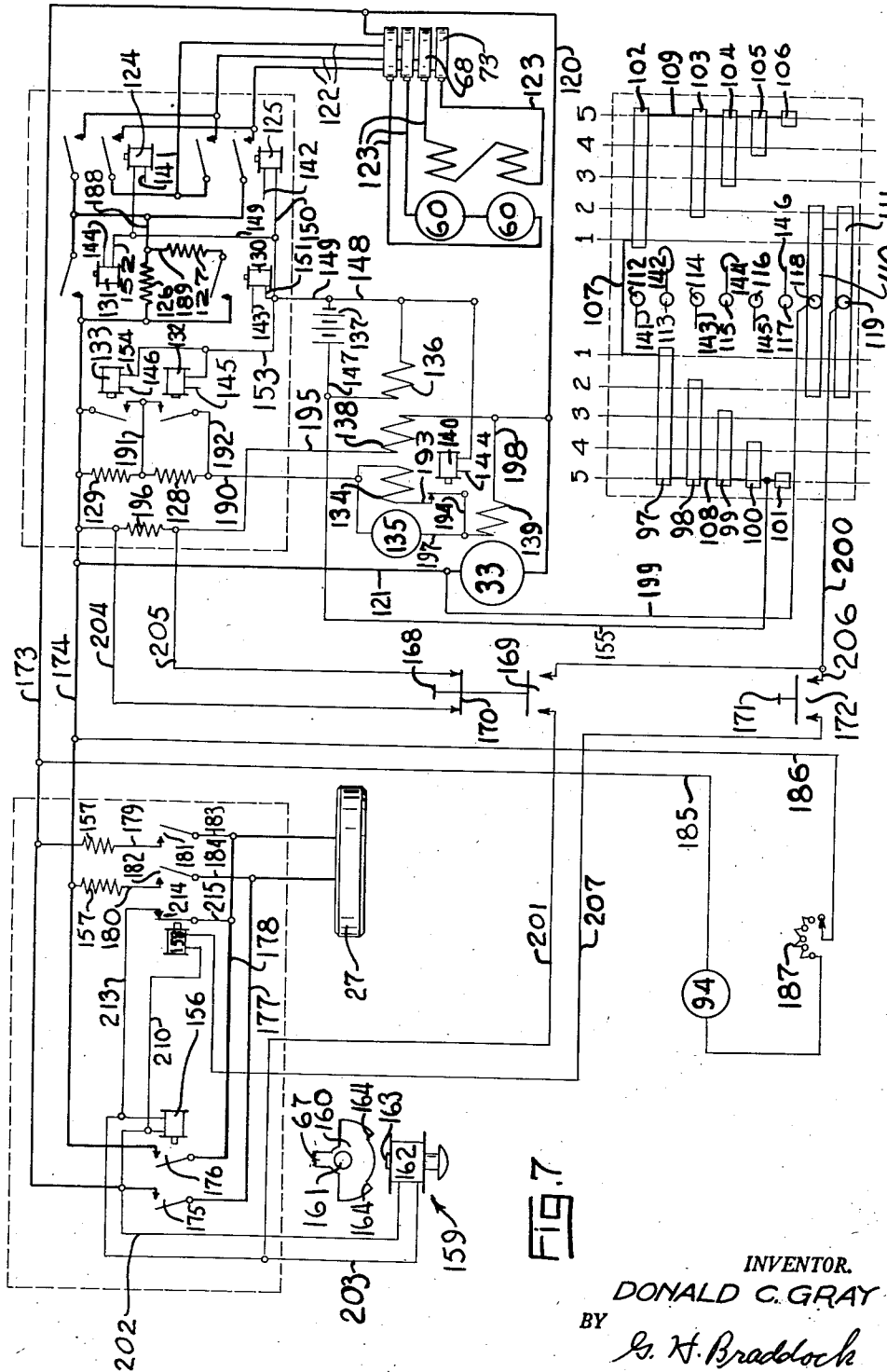
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UNITED STATES PATENT OFFICE

2,567,883

ELECTRIC MOTOR DRIVEN MATERIAL
HANDLING SYSTEM

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Application December 22, 1945, Serial No. 636,791

13 Claims. (Cl. 171-312)

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This invention relates to a material handling machine of the general type ordinarily known as cranes or locomotive cranes. As illustrated and described herein, the principles of the invention are applied to a locomotive crane. However, various features of the invention are applicable to other material handling machines and apparatuses of the general nature of cranes and locomotive cranes.

A locomotive or crawler or other type crane used for handling materials ordinarily consists of a crane unit comprising a car having a boom and an electro-magnet and/or bucket or dipper or hook and operating mechanism for the boom and electro-magnet and/or bucket or dipper or hook mounted upon a revoluble platform on the car of the crane, the operating mechanism also being adapted to cause the platform to be revolved so that the boom with electro-magnet and/or bucket or dipper or hook can be swung from side to side of the crane in the operations of removing material from any location about the crane and adjacent thereto. The power plant of the crane frequently is carried by the revoluble platform, and in such case the entire operating mechanism is mounted for relative rotation upon the frame of the car of the crane. In addition to driving the operating mechanism of a crane for its boom, electro-magnet and/or bucket or dipper or hook, and for revolving its platform upon the frame of its car, the crane's power plant when upon its revoluble platform sometimes has been connected up to propel the crane unit mechanically and sometimes has been connected up to propel the crane unit electrically along a railroad or other track or surface.

Electro-magnets when employed on cranes for the purpose of transporting or conveying ferrous materials from place to place are suspended from lifting lines which travel upon and relative to booms of the cranes. The electro-magnets are brought into contact with, or dropped upon, the ferrous materials. These adhere to the electro-magnets when they are energized and released when the electro-magnets are deenergized. The operating mechanisms of the cranes are employed to cause the electro-magnets, when energized to attract ferrous materials, to be conveyed from one place to another, and when the ferrous materials upon the electro-magnets have reached the locations where they are to be deposited, the electro-magnets are deenergized, by removal of the supply of current to said electro-magnets, thus to cause the ferrous materials to be released.

Customarily, the prime mover of a locomotive

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or other crane is, for purposes of convenience and efficiency in carrying on the various functions of the crane, a diesel or other internal combustion or other type engine adapted to be driven at variable speeds controlled in some suitable and convenient manner by the operator at his will. That is, a usual arrangement is to have the speed of the prime mover or engine of a crane controllable by the operator and the mechanisms for accomplishing various operations of the crane, such as swinging, lifting, etc., releasably clutchable to a driven shaft of said prime mover or engine. In commercial installations, the prime movers or engines of cranes are constructed to be capable of operation throughout a range of widely varying speeds.

A source of current for an electro-magnet employed in connection with a locomotive or other crane, to the purpose hereinbefore mentioned, heretofore has been a direct current generator driven from the prime mover of the crane through the instrumentality of a flexible chain, belting or gearing. Such a generator has been of the constant voltage, constant speed, self-excited type. It is adapted to deliver proper voltage characteristics only while the prime mover operates at substantially constant speed, or varies within but relatively small limits. With variations of the speed of the prime mover, the voltage of a constant voltage, constant speed generator will vary to extent at least as great as the prime mover speed, and, in some instances, will vary as much as the square of the prime mover speed. In instances when a constant voltage, constant speed generator is operated by a prime mover at higher than the rated speed of the generator, the voltage of course will be higher than normal with tendency toward overheating of an electro-magnet employed, and, obviously, lower than normal voltage will cause a serious reduction in the lifting capacity of the electro-magnet inasmuch as the lifting capacity varies as the square of the applied voltage.

An improved manner of accomplishing energization of an electro-magnet employed in connection with a locomotive or other crane is illustrated and described in my Patent No. 2,370,856, granted March 6, 1945. Stated briefly, the patent mentioned discloses a special generator system driven by the prime mover or internal combustion engine of the crane having a field controlled by means of a separate exciter also driven from said prime mover or internal combustion engine. The generator and exciter are supported upon the rotatable platform of the crane, as is a desirable arrangement. However, in any instance where

the type of special generator system of my Patent No. 2,370,856 is employed in connection with a crane also employing an electrical drive for the crane, as is employed in the patent to Ljungkull, No. 2,083,460, granted June 8, 1937, said special generator system constitutes an entity which is independent of and separate from the travel generator of the crane, and the same thing is true of the constant voltage, constant speed, self-excited type of direct current generator, hereinbefore mentioned, when employed to provide a source of current for an electro-magnet of a locomotive or other crane.

Stated broadly, heretofore the source of current for electro-magnets of locomotive or other cranes has been supplied by generators or generator systems independent of and separate from travel generators. It is possible, of course, for an operator of a locomotive or other crane to make manual adjustments of the generator field rheostat of the travel generator of the crane in attempt to maintain constant voltage throughout the various prime mover speeds, but this is completely impractical. Attempts at manual adjustments would result in complications and slowing down of crane operations.

It is desirable that a locomotive or other crane include a single prime mover and a single generator driven by the prime mover suitable to the purpose of supplying power to a travel motor and an electro-magnet of the crane, as well as to the purpose of supplying power to auxiliary motors when employed, thus to reduce the cost of equipment of the crane and the complexity of the equipment and to provide greater simplicity and space around the machinery, and the broad object of the present invention is to provide such a crane.

The characteristics which a generator for supplying power to an electric motor for propelling a crane is required to have are considerably different from the characteristics a generator for supplying power to a lifting magnet for a crane must possess. Due to the limited size of diesel and other internal combustion engines, both from the standpoint of cost and space, for use as prime movers of cranes, it is necessary, in order to get high current from the travel generator of a crane to provide high tractive effort, that there be low voltage, thus to avoid overloading of the prime mover. The output from a travel generator is dependent upon the horsepower from the prime mover. Therefore, in order to get a wide range of tractive effort and speed on a travel motor or motors, the characteristics of a travel generator must be such that at high current the voltage is low and at low current the voltage is high, and at no time can the product of voltage times amperes exceed the permissible output of the prime mover. On the other hand, the pick-up power of a lifting magnet varies as the square of the voltage. In order to obtain proper magnet operation, the value of the normally applied voltage cannot be too high, lest the magnet become overheated and destroyed, and cannot be below the magnets rating, lest the magnet power be insufficient for its intended purposes. In practical operation of cranes, generators heretofore employed have been unsuitable to use for applying power for both travel motors and lifting magnets under usual conditions of crane use.

A further object of the invention is to provide a locomotive or other crane of the character as stated which will include a single generator system having capacity to care for both travel and

magnet lift under all operative conditions as met in practical use of the locomotive or other crane, and also desirably having capacity additionally to supply power for an auxiliary motor or motors, such, for example, as a motor for a fan of a heating apparatus for the crane.

A further object is to provide a material handling machine of the nature of a locomotive or other crane which will include a prime mover and a generator driven by the prime mover suitable to the purposes of supplying power to a travel motor and to an electromagnet of the crane and which generator will be operative at substantially constant voltage throughout a range of low current values, thus to be capable of supplying suitable current for efficient magnet operation and at the same time include capacity for flow of sufficient current to said travel motor adapted to obtain relatively low drawbar pull and travel speed when it may be desirable that the crane be transported at low speed while a load is suspended from its electro-magnet, and will be capable of being operative at variable voltages throughout a range of higher current values, thus to include capacity for flow of additional current to said travel motor adapted to obtain comparatively higher drawbar pull or travel speed when it may be desirable that the crane be transported at higher speeds while its electro-magnet has no load.

A further object is to provide a material handling machine of the nature of a locomotive or other crane designed and constructed with the end in view of rendering the material handling machine an improvement in many respects and from various aspects over material handling machines and apparatuses heretofore known for accomplishing the same general purposes.

A further object is to provide a material handling machine of the nature of a locomotive or other crane wherein will be incorporated various desirable and improved features and characteristics of construction which will be novel both as individual entities of said material handling machine and in combination with each other.

And a further object is to provide a material handling machine incorporating features and characteristics of construction as herein illustrated and described.

With the above objects in view, as well as others which will appear as the specification proceeds, the invention comprises the construction, arrangement and combination of parts as now to be fully described and as hereinafter to be specifically claimed, it being understood that the disclosure herein is merely illustrative and intended in no way in a limiting sense, changes in details of construction and arrangement of parts being permissible so long as within the spirit of the invention and the scope of the claims which follow.

In the accompanying drawings forming a part of this specification,

Fig. 1 is a side elevational view of a material handling machine made according to the invention, parts being broken away;

Fig. 2 is an enlarged top plan view of the machine, parts being omitted;

Fig. 3 is a detail sectional view, taken substantially on line 3—3 in Fig. 1;

Fig. 4 is a fragmentary enlarged top plan view of the machine;

Fig. 5 is a detail sectional view, taken on line 5—5 in Fig. 4;

Fig. 6 is a detail sectional view, taken substantially on line 6—6 in Fig. 2; and

Fig. 7 is a diagrammatic view of an electric wiring system of the machine.

With respect to the drawings and the numerals of reference thereon, the locomotive crane disclosed includes a car body or truck consisting of a frame 10 having bearings 11 for front and rear axles 12 rigidly supporting travel wheels 13. As shown, there are two front and two rear axles 12 each supporting oppositely disposed traveling wheels 13. Coupling members 14 upon the car body or truck frame 10 are for the purpose of coupling the locomotive crane with a different vehicle or car, which in some instances may be propelled by the locomotive crane, and in some instances may propel said locomotive crane.

The car body or truck frame 10 supports a platform or deck 15 which is rotatable on said car body or truck frame. As shown, the platform or deck 15 includes a vertical, hollow, downwardly extending entity 16 which extends into a hollow portion 17 of the car body or truck frame.

A circumferential portion of the platform or deck 15 includes conveniently mounted rollers spaced about said platform or deck and concentric with the vertical, hollow entity 16, said rollers being supported upon and rideable upon or over a bull gear 18, which also is concentric with said vertical, hollow entity 16 and is fixedly attached to the car body or truck frame 10 in any suitable and convenient manner.

A boom of the crane, upon the rotatable platform or deck 15, is designated 19. The boom may be of usual or preferred construction. Said boom 19 is suitably and conveniently pivoted upon a part of the platform or deck 15. A mast (not shown) of usual or preferred construction also may be arranged upon the rotatable platform or deck. A cable 20 is for the purpose of accomplishing hoisting or raising and lowering operations of the boom 19. A drum 21 for actuating the cable 20 is mounted upon the rotatable platform or deck. As shown, the cable 20 has one of its end portions wrapped about the drum 21, and said cable 20 extends over pulleys 22 supported in ordinary or preferred manner. The end portion of the cable 20 opposite the drum 21 is assembled with the boom 19 in ordinary or preferred manner, as denoted generally at 23. When the drum 21 is rotated in direction to wind the cable 20 thereon, the boom is hoisted or raised, and when said drum 21 is rotated, or allowed to rotate, in opposite direction said boom is lowered by gravity.

A cable 24 extends over a sheave 25 upon the outer end of the boom 19 and supports a hoisting hook 26. In turn, the hoisting hook 26 supports an electromagnet 27. A drum 28 for actuating the cable 24 also is mounted upon the rotatable platform or deck 15.

Said rotatable platform or deck 15 suitably and conveniently supports a power plant or prime mover, which is, as disclosed, constituted as an internal combustion engine 29 of the diesel type. The internal combustion engine 29 includes a driven shaft 30 which is conveniently and desirably flexibly connected, as represented generally at 31, to the driving shaft 32 of the generator 33. The generator 33 also is suitably supported upon the revolvable platform or deck 15, and said internal combustion engine 29 and said generator 33 of course are rigidly secured to said platform or deck. The generator 33 desirably is of that type designed for drooping

characteristics of the generator volt-ampere curve and wherein the voltage is high for low current and low for high current. As disclosed, the generator 33 includes a driven shaft 34, arranged opposite the internal combustion engine 29, which fixedly supports a sprocket wheel. A sprocket chain 35 rides over the sprocket wheel upon said driven shaft 34 and also rides over a sprocket wheel fixed upon a horizontal shaft 36 suitably and conveniently mounted upon the platform or deck 15. The horizontal shaft 36 releasably carries a small gear 37 which meshes with a larger gear 38 fixed upon a horizontal shaft 39 suitably and conveniently mounted upon the platform or deck 15. The gear 38 meshes with a gear 40 fixed upon a horizontal shaft 41 at the side of the horizontal shaft 39 opposite the horizontal shaft 36. Said horizontal shaft 41 also is suitably mounted upon the rotatable platform or deck 15. It will be seen that when the horizontal shaft 39 is driven by the internal combustion engine 29, through the instrumentality of the sprocket chain 35, the horizontal shaft 36 and the gears 37 and 38, the horizontal shaft 41 will be driven through the instrumentality of said gear 38 and the gear 40.

The drums 21 and 28 are carried by the horizontal shaft 41 and are normally loose on said mentioned horizontal shaft. Said drums 21 and 28 are adapted to be rotated, independently of each other, with said horizontal shaft 41. A clutch, denoted generally at 42, is for the purpose of clutching the drum 28 to the horizontal shaft 41, and a clutch lever 43 is for actuating said clutch 42 to operative and inoperative positions. A clutch, denoted generally at 44, is for the purpose of clutching the drum 21 to said shaft 41, and a clutch lever 45 is for actuating said clutch 44 to operative and inoperative positions. In the disclosure as made, the clutches 42 and 44 are of air actuated type and are operated in well known manner requiring no further description herein.

Each of the drums 21 and 28 is as disclosed provided with a brake 46. The brakes 46, 46 may be of well known construction. Numeral 47 indicates a braking pedal for operating the brake 46 associated with the drum 21, and 48 designates a braking pedal for operating the brake 46 associated with the drum 28.

The horizontal shaft 39 conveniently supports oppositely disposed bevel gears, represented 49 and 50, respectively, each normally loose on said horizontal shaft 39. The bevel gears 49 and 50 mesh with a bevel gear 51 fixed upon a vertical shaft which drives a vertical shaft 52 suitably mounted in bearings fixed upon the rotatable platform or deck 15. Said vertical shaft 52 fixedly carries a pinion 53 which meshes with the teeth 54 of the bull gear 18. The bevel gears 49 and 50 mesh with portions of the bevel gear 51 at opposite sides of its vertical shaft, and clutches 55, 55 are for separately clutching said bevel gears 49 and 50 to said horizontal shaft 39. A single clutch lever 56 is for actuating each of the clutches 55, the arrangement being such that both clutches 55, 55 may be inoperative, or either one, but not both, operative to clutch one or the other of the bevel gears 49, 50 to the horizontal shaft 39. Evidently, when the bevel gear 49 is clutched to the horizontal shaft 39 and said horizontal shaft is rotated, the bevel gear 51, with the vertical shaft 52 and the pinion 53, will be rotated in one direction, and when the bevel gear 50 is clutched to said hori-

zontal shaft 39 and the horizontal shaft is rotated, said bevel gear 51, with the vertical shaft 52 and the pinion 53, will be rotated in opposite direction. Rotation of the pinion 53 in either direction obviously will cause the platform or deck 15 to be rotated about its vertical axis in direction to correspond, by reason of the engagement of said pinion 53 with the teeth 54 of the bull gear 18. The specific arrangement selectively for clutching the bevel gears 49 and 50 to the horizontal shaft 39 is well known and requires no fuller description herein. In the disclosure as made, the clutches 55, 55 are of air actuated type.

A brake for the horizontal shaft 39, and hence for the rotatable platform or deck 15, may be of any suitable construction, and said brake may be actuated by means of a braking pedal 57, similar to the braking pedals 47 and 48. A brake such as mentioned for said horizontal shaft 39 is ordinary equipment of machines of the present general character, and, therefore, requires no further description herein.

The clutches 42 and 44 may be inoperative when the brakes 46, 46 are applied to the drums 28 and 21. In addition, any suitable type of means well known in the present art may be included for disconnecting the horizontal shaft 41 from driving connection when a brake is applied to either drum 21 or 28. Also, a suitable type of well known means will be included for disconnecting the horizontal shaft 39 from driving connection when the brake for said horizontal shaft 39 is applied.

A clutch for connecting the small gear 37 to and disconnecting said small gear from the horizontal shaft 36 is denoted 58. As disclosed, the clutch 58 is of air actuated type. A clutch lever for actuating the clutch 58 is represented 59.

It will be evident from the description thus far given, that the clutch 58 can be manipulated to disconnect the small gear 37 from the horizontal shaft 36 so that said small gear 37 and all of the parts driven thereby will be stationary. When the clutch 58 connects the small gear 37 to the horizontal shaft 36, said small gear 37 will be driven to rotate the larger gear 38 and the horizontal shaft 39 upon which said larger gear 38 is fixed when the internal combustion engine 29 is operative. When said horizontal shaft 39 is rotating, the drums 21 and 28 and the vertical shaft 52 can each be stationary or in motion, all independently of each other, and said vertical shaft 52 can be rotated in either direction, necessary or preferred at some particular time. And all of the brakes and clutches are capable of independent actuation, the operating parts being adapted satisfactorily to accomplish all of the working operations in the machine except those necessary to propel said machine.

The locomotive crane is adapted to be propelled by electric motive power, the machine including a pair of electric motors, each designated 60, as shown, although a single electric motor, or more than two electric motors, could be employed. The electric motors 60, 60 are adapted to be actuated or driven in either direction by the generator 33. Each electric motor 60 is conveniently and flexibly attached to the underside of the car body or frame 10 at location adjacent an axle 12 to be driven. As shown, an interior end portion of each electric motor 60 is rotatably mounted, as at 61, upon an outermost axle 12, and an exterior end portion of each electric motor is pivotally sup-

ported, as at 62, upon a transverse bar 63 at an end of and extending from side to side of the car body or frame 10. The construction and arrangement will be such that the electric motors 60, 60 are resiliently connected with the transverse bars 63, 63. The shaft of each electric motor 60 fixedly carries a pinion 64 which meshes with a gear 65 fixed upon the axle 12 which supports the corresponding electric motor.

The electric motors 60, 60 are of the reversing type, and a controller or master switch 66 for said electric motors is suitably and conveniently mounted upon the revolvable platform or deck 15. The controller or master switch 66 may be of any construction suiting it to its purposes. It includes a control lever 67 adapted to be manipulated to selected positions to close various different circuits for the electric motors 60, 60 adapted to cause said motors to be driven at predetermined and preferred speed in either direction. A series of lead wires, including a sufficient number suitable to the purpose, extend between the generator 33 and the controller or master switch 66. The connection of said mentioned lead wires between said generator 33 and said controller or master switch 66 can be made in ordinary manner, both said generator and controller or master switch being carried by the platform or deck 15 and movable therewith, and being supported in stationary relation to each other.

As will be apparent, the electric motors 60, 60 being fixed upon the car frame 10, and the controller or master switch 66 being fixed upon the revolvable platform or deck 15 in spaced relation to the vertical axis thereof and movable with said platform or deck, an arrangement of conducting connections between said controller or master switch 66 and electric motors 60, 60 which has no loose and dangling lead wires is desirable, although it is to be understood that the lead wires between the controller or master switch and the electric motors could be continuous in appropriate manner, sufficient slack in the connections of course being permitted to allow for the revolving movements of the platform or deck 15. Numeral 68 denotes a contact element assembly for making connections between the controller or master switch 66 and the electric motors 60, 60. Said contact element assembly 68, or equivalent, making provision for neat, practical and vastly more satisfactory conducting connections, is greatly to be preferred.

The contact element assembly 68 is very clearly disclosed in Fig. 3, of the drawings. As there shown, an annular, horizontal extension 69 of the vertical, hollow entity 16 integrally supports downwardly extending, vertical bolt members 70, 70 which in turn support a circular, horizontal plate 71. Tubular insulation upon the bolt members 70, 70 is denoted 72.

A series of contact rings 73 are arranged in overlying relation to each other between the horizontal extension 69 and the horizontal plate 71 and rigidly supported by said extension and plate in spaced, surrounding relation to the bolt members 70, 70. A series of separator insulating discs 74 are arranged between each pair of adjacent contact rings 73 and between the uppermost and lowermost contact rings and said extension 69 and plate 71. Annular spacers of the extension 69 and the plate 71 are denoted 75.

A series of connector rods 76, including a connector rod 76 for each contact ring, extend in spaced relation to each other through the vertical, hollow entity 16 and the annular, hollow ex-

tension 69, as well as through a greater or less number of the contact rings 73 and insulating discs 74. Each connector rod 76 is secured to a corresponding contact ring 73 and is in spaced or insulated relation to all contact rings except the one to which connected. The upper end of each connector rod 76 is separately attached to a lead wire from the controller or master switch 66.

The contact element assembly 68 also includes spaced apart contact brushes 77, one in engagement with each contact ring 73. Said contact brushes 77 can be of any ordinary or preferred construction. As shown, each contact brush 77 is carried by a holder 78 therefor, and said holders 78 are suitably fixed in spaced relation to each other upon a vertical pipe 79 itself suitably supported by the car body or frame 10. More explicitly, the upper and lower ends of the vertical pipe 79 are supported in upper and lower annular elements, represented 80 and 81, respectively, and tubular insulation 82 upon said vertical pipe 79 retains the holders 78 and one side of the annular elements 80 and 81 in fixed, spaced apart relation. Said annular elements 80 and 81 are retained in fixed, spaced apart relation at their opposite side by a headed and nutted bolt 83 and a tubular spacer 84 upon said bolt and between the annular elements 80 and 81. The inner margin of the upper annular element 80 engages the outer margin of the annular, horizontal extension 69 beneath an annular flange 85 upon said annular, horizontal extension 69, the inner margin of the lower annular element 81 engages the outer margin of the circular, horizontal plate 71 above an annular flange 86 upon said circular, horizontal plate, and the circular, horizontal plate is anchored to the car body or frame as denoted at 87. The brush holders 78 support lead wires which are appropriately connected to the electric motors 60, 60. Said brush holders and electric motors obviously having stationary or fixed relation with respect to each other, the connections for both ends of the lead wires between the brush holders and the electric motors can be ordinary binding post connections.

It will be seen that the parts of the contact element assembly 68 which move relative to each other in practice are a unitary structure including the contact rings 73 which are rotatable relative to the contact brushes 77, and said contact brushes 77 ride said contact rings 73 as these rotate, continuously to provide conducting capacity for electrical current between each of the lead wires to the contact element assembly 68 and the corresponding lead wires from said contact element assembly.

A brake of any suitable construction for the traveling wheels 13 may be employed, and the locomotive crane may include a braking lever 88 for such a brake; or the locomotive crane may incorporate a usual or preferred type of air brake adapted to be actuated by air pressure provided by an air compressor such as denoted at 89. The air compressor 89 may be of any construction suitable to its purpose. As shown, it is operated through the instrumentality of a belt 90 which is driven from the horizontal shaft 36. Braking mechanism for operating the travel brake of the machine is represented generally at 91.

A magnetic controller box upon the rotatable platform or deck 15 is indicated 92, and a heating apparatus, also upon said platform or deck, is designated 93. An auxiliary electric motor 94 is for driving a fan (not shown) of the heating

apparatus 93. The auxiliary electric motor 94 is supported upon said heating apparatus 93.

A small generator 95, of special design and for a purpose to be made plain, is mounted upon the rotatable platform or deck 15. Said small generator 95 is adapted to be driven, as by the belt 96, from the driving shaft 32 of the generator 33.

The prime mover or internal combustion engine 29 is adapted to cause or be capable of causing mechanism for accomplishing ordinary operations of the locomotive crane to be actuated, and said prime mover or internal combustion engine additionally is adapted to cause or be capable of causing the small generator 95 and the generator 33 to be driven. The generating system of the machine is adapted to cause or be capable of causing the travel electric motors 60, 60, the electromagnet 27 and the auxiliary electric motor 94 to be energized.

The controller or master switch 66 is a reversing type drum master switch. It includes a plurality of conducting segments 97, 98, 99, 100 and 101, and a plurality of conducting segments 102, 103, 104, 105 and 106. A conductor between the conducting segments 97 and 102 is denoted 107, conductors between the conducting segments 97, 98, 99, 100 and 101 are indicated 108, and conductors between the conducting segments 102, 103, 104, 105 and 106 are denoted 109. The controller or master switch 66 additionally includes conducting segments 110 and 111, and also includes a plurality of fingers 112, 113, 114, 115, 116, 117, 118 and 119.

The generator 33 is adapted to be connected through conductors 120 and 121 and 122 and 123, by means of reversing contactors 124 and 125, through the slip rings 73 and control brushes 77 to the electric motors 60, 60. Closing of the contactor 124 is adapted to cause the electric motors 60, 60 to be energized for rotation in direction to drive the locomotive crane in one direction, and closing of the contactor 125 is adapted to cause said electric motors to be energized for rotation in direction to drive said locomotive crane in opposite direction.

Resistors, denoted 126 and 127, respectively, are adapted to be connected in circuits for the electric motors 60, 60. A contactor 130 is for connecting the resistor 127 in parallel with the resistor 126, and a contactor 131 is for short circuiting the resistors 126 and 127.

Resistors 128 and 129 are adapted to be connected in the circuit for a generator shunt field 139. A contactor 132 is for short circuiting the resistor 128 and a contactor 133 is for short circuiting the resistor 129.

In the illustrated embodiment of the invention, the small generator 95 is a regulator which may include three or more fields, but in instances where preferred the small generator or regulator may take other forms and yet perform the functions as hereinafter described. One field 134 of the generator or regulator 95 is a shunt field responsive to the voltage generated by an armature 135. Operation of a contactor 140 opens this field to make the generator inoperative. A second shunt field 136 of said generator or regulator 95 is excited from a reference source which in the present disclosure is a constant potential battery 137. A third shunt field 138 of the generator or regulator 95 is connected across the terminals of the generator 33 and is the control field of said generator 33. The fields 136 and 138 are differential with respect to their magnetic fluxes so that should the

field 138 become higher than the field 136 a voltage will be generated in the armature 135 of such direction as to reduce the current flowing in the main generator field and thus reduce the voltage generated by the generator 33. Should the effect of the field 138 become less than the effect of the field 136, a voltage will be generated in the armature 135 of such direction as to increase the current in the main generator field and thus increase the voltage generated by the generator 33. The shunt field 134 amplifies the effect of the two fields 136 and 138 and thus is provision for slight differences between fields 138 and 136 producing great changes in voltage generated in the armature 135. The design of the small generator or regulator 95 is such that the voltage of generator 33 can be maintained at a constant value.

A conductor 141 extends between the reversing contactor 124 and the finger 112. A conductor 142 extends between the reversing contactor 125 and the finger 113. A conductor 143 extends between the contactor 130 and the finger 114. A conductor 144 extends between the contactors 131 and 140 and the finger 115. A conductor 145 extends between the contactor 132 and the finger 116. A conductor 146 extends between the contactor 133 and the finger 117.

The field 136 is connected to the battery 137 by conductors 147 and 148. A conductor 149 extends between the contactor 124 and the battery 137. A conductor 150 extends between the contactor 125 and the conductor 149. Conductors 151 and 152 extend between the contactors 130 and 131 and said conductor 149. Conductors 153 and 154 extend between the contactors 132 and 133 and the conductor 149. A conductor 155 extends between the conductors 108 and the conductor 147.

A magnet controller of the machine includes a line contactor 156 for connecting the electromagnet 27 to the leads of the generator 33, a line resistor 157 and a drop contactor 158.

An interlock of said machine, denoted generally at 159, is interposed between the magnet controller and the controller or master switch 66. A cam 160 of the interlock 159, integral with the control lever 67 for the master switch 66, is rotatably supported, as at 161, in any suitable and convenient manner, upon the revoluble platform or deck 15, and a solenoid 162, also suitably and conveniently supported upon said revoluble platform or deck, has an armature 163 adapted to lie in the path of spaced apart limit surfaces 164, 164 of said cam 160 when said solenoid 162 is energized. A curved lever 165 is rigid with the control lever 67 to be swung upwardly and downwardly with swinging of said control lever 67 from side to side, a straight actuating lever 166 for the travel controller or master switch 66 is suitably and conveniently assembled with said travel controller or master switch, and a rigid link 167 is connected between the outer or free ends of the curved lever 165 and the straight actuating lever 166. The construction and arrangement are such that the control lever 67, and hence the actuating lever 166, can be swung through a substantially unlimited arc when the solenoid 162 is de-energized, but can be swung through only a limited arc when said solenoid 162 is energized. The arc through which said control lever 67 can be swung of course will be limited by engagement of one or the other of the limit surfaces 164, 164 with the armature 163 when the solenoid 162 is energized. The farther apart said

limit surfaces 164, 164, the greater the magnitude of the arc through which the control lever 67 can be swung when the solenoid 162 is energized, and vice versa, as will be obvious.

It should be remarked that interlocking could be accomplished in a manner different from that disclosed.

A pilot circuit button 168 is adapted manually to be actuated to cause a normally open switch 169 to be closed and a normally closed switch 170 to be opened, and a push button 171 is adapted manually to be actuated to cause a normally open switch 172 to be closed.

Conductors 173 and 174 extend from the conductors 120 and 121 to switches 175 and 176 controlled by the line contactor 156, and conductors 177 and 178 extend from said switches 175 and 176 to the electromagnet 27.

Conductors 179 and 180 including the line resistor 157 extend from the conductors 173 and 174 to switches 181 and 182 controlled by the drop contactor 158, and conductors 183 and 184 extend from said switches 181 and 182 to the conductors 178 and 177.

Conductors 185 and 186 extend from the conductors 173 and 174 to the auxiliary electric motor 94, and said conductor 186 includes a regulator 187 for said auxiliary electric motor.

The resistor 126 is included in a conductor 188 extending between switches controlled by the contactors 124, 125 and 130, 131, respectively, and the resistor 127 is included in a conductor 189 extending between the conductor 188 and the switch controlled by said contactor 130.

The resistors 128 and 129 are included in a conductor 190 extending between the conductor 174 and the field 139. A conductor 191 extends from a portion of the conductor 190 between said resistors 128 and 129 to a switch controlled by the contactor 133, and a conductor 192 extends from a portion of the conductor 190 between the resistor 128 and said field 134 to a switch controlled by the contactor 132. A conductor 193 extends from the field 134 to a switch controlled by the contactor 140, and a conductor 194 extends from said last mentioned switch to the field 139.

The field 138 is included in a conductor 195 extending between the conductor 174 and the conductor 120, and said conductor 195 includes a resistance 196. The armature 135 is included in a conductor 197 extending from the conductor 190 to the conductor 194, and a conductor 198 extends from the field 139 to the conductor 195.

A conductor 199 extends between the conducting segment 110 and the conductor 121, and a conductor 200 extends between the normally open switch 169 and the conducting segment 111.

A conductor 201 extends from said normally open switch 169 to the line contactor 156, a conductor 202 extends from said line contactor 156 to the solenoid 162, and a conductor 203 extends from said solenoid to the conductor 201.

A conductor 204 extends between the normally closed switch 170 and a portion of the conductor 195 between the resistance 196 and the conductor 174, and a conductor 205 extends between said normally closed switch 170 and a portion of said conductor 195 between the field 138 and said resistance 196.

A conductor 206 extends from the conductor 200 to the normally open switch 172, a conductor 207 extends from said normally open switch 172 to the drop contactor 158, a conductor 210 extends from said drop contactor 158 to the line

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contactor 156, a conductor 213 extends from the conductor 201 to a switch 214 controlled by the drop contactor 158, and a conductor 215 extends from said switch 214 to the conductor 178.

The invention herein disclosed presents a locomotive crane or other crane which includes a prime mover and a generator driven by the prime mover suitable to the purpose of supplying power to drive travel motors employed in connection with a crane and to the purpose of supplying power for energizing an electro-magnet of the crane, as well as to the purpose of supplying power to auxiliary equipment, such as the auxiliary electric motor 94, when employed in connection with a crane.

It will be apparent from Fig. 2 of the drawings that the internal combustion engine 29, the generator 33, the auxiliary electric motor 94, the small generator 95 and the mechanism of the crane for accomplishing hoisting, swinging, etc., are all upon the rotatable platform or deck 15.

The generator 33 is adapted to be operative at substantially constant voltage throughout a range of lower current values to be capable of supplying suitable current for efficient operation of the electro-magnet 27 and at the same time include capacity for flow of sufficient current to the electric motors 60, 60 adapted to obtain relatively low drawbar pull and travel speed of the crane when it is desirable that the crane be transported at low speed while a load is suspended from the electro-magnet 27, and said generator 33 is adapted to be capable of being operative at variable voltages throughout a range of higher currents to include capacity for flow of additional current to said electric motors 60, 60 adapted to obtain comparatively higher drawbar pull and travel speed when it may be desirable that the crane be transported at higher speeds while its electro-magnet has no load.

When the master switch 66 is in neutral position, as said master switch is disclosed in Fig. 7 of the drawings, the control lever 67 is in vertical position, as said control lever is disclosed in Figs. 2 and 6, both of the reversing contactors 124 and 125 are in open position, and all of the parts of the electrical system of the machine are situated as in said Fig. 7.

The construction and arrangement will be such that when the internal combustion engine 29 is operating at its governed speed, the generator 33 will be supplying a substantially constant voltage maintained by the small generator or regulator 95, and when the control lever 67 is moved to actuate contacts in the master switch 66, the excitation of the field of said generator 33 will be varied thus to vary the current through the travel electric motors 60, 60. The voltage output of the generator 33 is adapted to be maintained substantially constant over a limited current range of said generator 33.

When the master switch 66 is moved to the first position forward, the conducting segment 102 becomes engaged with the finger 112 and the contactor 124 becomes energized from the battery 137 to cause the switches controlled by said contactor 124 to become close. Current then flows from the generator 33 through the resistor 126, the fields of the travel motors 60, 60 by way of the collector rings 73 to the armature of said travel motors 60, 60 and back to said generator 33. The small generator or regulator 95 maintains constant voltage at the terminals of the generator 33 while current and voltage across the travel motors 60, 60 is a function of the dif-

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ference in voltage occasioned by the resistor 126. Stated otherwise, the difference in voltage at the terminals of the generator 33 and the voltage across the travel motors 60, 60 when the master switch 66 is moved to the first position forward is absorbed by the resistor 126.

When the master switch is moved to the second position forward, the conducting segment 103 becomes engaged with the finger 114 and the contactor 130 becomes energized to cause the switch controlled by said contactor 130 to become closed, thus to connect the resistor 127 in parallel with the resistor 126 and cause the total resistance in series with the armatures of the travel motors 60, 60 to become reduced. While the power transmitted to the travel motors 60, 60 is increased in response to movement of the master switch 66 to the second position forward, thus to cause greater drawbar pull or speed of operation of said travel motors, the voltage at the terminals of the generator 33 is maintained at constant value by the small generator or regulator 95. The difference in voltage at the terminals of said generator 33 and the voltage across said travel motors 60, 60 is absorbed by the resistors 126 and 127 acting in parallel.

When the master switch is moved to the third position forward, the conducting segment 104 becomes engaged with the finger 115 and the contactor 131 becomes energized to cause the switch controlled by said contactor 131 to become closed, thus to short circuit the resistors 126 and 127 and connect the travel motors 60, 60 directly to the generator 33. The auxiliary contactor 140 is energized upon energization of the contactor 131 to cause the field 134 of the small generator or regulator 95 to be opened thus to render said small generator or regulator inoperative. The current and voltage across the travel motors 60, 60 becomes that of the generator 33 upon opening of said field 134. Evidently, the power transmitted to the travel motors 60, 60 will be increased upon movement of the master switch 66 to the third position forward by reason of short circuiting of the resistors 126 and 127.

When the master switch 66 is moved to the fourth position forward, the conducting segment 105 becomes engaged with the finger 116 and the contactor 132 becomes energized to cause the switch controlled by said contactor 132 to become closed, thus to short circuit the resistor 128. The reduction in the resistance of the field circuit 139 as a consequence to short circuiting the resistor 128 causes an increase in voltage and current across the travel motors 60, 60.

When the master switch 66 is moved to the fifth position forward, the conducting segment 106 becomes engaged with the finger 117 and the contactor 133 becomes energized to cause the switch controlled by said contactor 133 to become closed, thus to short circuit the resistor 129. The reduction in the resistance of the field circuit 139 as a consequence to short circuiting the resistor 129 causes an increase in voltage and current across the travel motors 60, 60.

It will be obvious that the description given with respect to the manner of operation of the travel motors 60, 60 upon forward advancement of the master switch 66 from position to position also applies with respect to the manner of operation of said travel motors upon rearward advancement of said master switch, except that

at the first position rearward the conducting segment 97 will become engaged with the finger 113, and the contactor 125 will become energized to close the switches controlled by said controlled by said contactor 125 thus to cause operation of the travel motors to be reversed, at the second position rearward the conducting segment 98 will become engaged with the finger 114, at the third position rearward the conducting segment 99 will become engaged with the finger 115, at the fourth position rearward the conducting segment 100 will become engaged with the finger 116, and at the fifth position rearward the conducting segment 101 will become engaged with the finger 117.

While in the illustrated embodiment of the invention, the generator includes in-built characteristics for obtaining the desired characteristics for the third, fourth and fifth positions forward and reverse of the master switch 66, these same characteristics could be provided by means of a regulator functioning after the fashion of the regulator 95.

The electro-magnet 27 can be energized only when the master switch 66 is in its neutral position or in its first or second positions forward or reverse. The circuit for the normally open switch 169 is through the conducting segments 110 and 111, and, therefore, can be established when, and only when, said master switch 66 is in one of the positions mentioned; viz., neutral position or first or second position forward or reverse. Obviously, the fingers 118 and 119 will be clear of the conducting segments 110 and 111 when the master switch 66 is in third, fourth and fifth positions forward and reverse. It will be apparent that said conducting segments 110 and 111 could be shorter to be clear of said fingers 118 and 119 when said master switch is in second position forward and reverse; or the conducting segments could be longer so as to engage the contact fingers 118 and 119 when the master switch is in third, or even fourth, position forward and reverse.

Depression of the pilot circuit button 168 to cause the normally open switch 169 to be closed will complete a circuit from the generator 33 through the conducting segments 110, 111 and said switch 169 to the line contactor 156. Energization of said line contactor 156 will cause the switches 175 and 176 to be closed thus to connect the electro-magnet to the conductors 173 and 174 supplied from said generator 33, which, in turn, has its voltage maintained at a constant value by the small generator or regulator 95, whether or not the travel motors 60, 60 are energized.

The normally closed switch 170 is opened in response to depressing movement of the pilot circuit button 168 which causes the normally open switch 169 to be closed, and with opening of said normally closed switch 170 the resistance 196 is inserted in the field 138 of the small generator or regulator 95 thus to cause increased voltage, or voltage greater than normal, to be maintained on the generator 33. Such increased voltage will be maintained on said generator 33 as long as the pilot circuit button 168 is retained in the closed position of the normally open switch 169. Upon release of the pilot circuit button 168, the normally closed switch 170 becomes closed and the circuit of the field 138 is returned to normal so that the voltage output of the generator 33 is immediately returned to its normal value by the small generator or regulator 95.

A holding circuit for the line contactor 156 is completed upon energization of said line contactor, said holding circuit being traced from the conductor 174 through the closed switch 176 and the conductors 178 and 215 to the closed switch 214, and thence through the conductor 213 to the line contactor 156. Thus, said line contactor 156 will remain closed after the switch 169 is opened. It will be evident that as long as the pilot circuit button 168 is held depressed to cause the normally closed switch 170 to be open, not only will the electro-magnet 27 be and remain energized, but also the voltage applied to said electro-magnet will be increased. Also it will be evident that the solenoid 162 of the interlock 159 will become energized simultaneously with energization of the line contactor 156 and will remain energized as long as said line contactor remains energized. A circuit for said solenoid 162 which is closed when the line contactor 156 is energized is traced from the conductor 174 through the switch 176, the conductors 178 and 215, the closed switch 214 and the conductors 213, 201 and 203 to said solenoid 162, and thence through the conductor 202 to the conductor 173. The adjacent end portion of the armature 163 is adapted to lie between and in the path of the limit surfaces 164, 164 of the cam 160 at all times while the solenoid 162 is energized, thus to limit the extent to which the control lever 67 can be swung. In the disclosure as made, the cam 160 is adapted to permit swinging movement of the control lever 67 between its position when the master switch 66 is at second position forward and its position when said master switch is at second position reverse. The limit surfaces 164, 164 of said cam 160 could, however, be spaced apart a shorter distance to limit swinging movement of the control lever 67 to capacity for travel between the position of said control lever when the master switch is at first position forward and the position of said control lever when said master switch is at first position reverse; or said limit surfaces 164, 164 could be spaced apart a longer distance to permit swinging movement of the control lever 67 between the third, or even the fourth, positions forward and reverse of the master switch.

Depression of the push button 171 to cause the normally open switch 172 to be closed will complete a circuit from the generator 33 through the conducting segments 110 and 111, said switch 172 and the drop contactor 158. Energization of said drop contactor 158 will cause the switches 181 and 182 to be closed and the switch 214 to be opened. Closing of the switches 181 and 182 will cause a reverse flow of current through the electro-magnet 27 and opening of the switch 214 will cause the line contactor 156 to be deenergized thus to cause the energizing circuit, including the switches 175 and 176, through said electro-magnet to be broken but an instant after reverse flow of current through the electro-magnet by way of the switches 181 and 182 is accomplished. Upon release of said push button 171 said normally open switch 172 will become opened, to break the circuit to the contactor 158. Thus the switches 181 and 182 in the reverse circuit for the electro-magnet 27 will become open.

It will be apparent that de-energization of the line contactor 156, by reason of opening of the switch 214 due to energization of the drop contactor 158 in response to closing of the normally open switch 172, also will cause the solenoid 162 to become de-energized thus to cause or permit

the armature 163 to be moved to position where it will be clear of the limit surfaces 164, 164 of the cam 160.

The generator system of the invention, including the generator 33 and the small generator or regulator 95, is equipped to be capable of supplying power suitable for operation of the electric motors 60, 60 and also to be capable of supplying power suitable for the electro-magnet 27. Said generator system is so constructed that it can function as a travel generator having characteristics making it possible that at high current the voltage will be low and at low current the voltage will be high, and the generator system also is so constructed that it can function as a lifting magnet generator having characteristics making it possible that the value of the normally applied voltage will be substantially constant.

It is considered that when auxiliary motors, such as the auxiliary electric motor 94, are to be operated from a locomotive crane generator system adapted to function after the manner of the generator system disclosed, said auxiliary motors may be operated under all conditions of voltage of said generator. Ordinarily, the generator 33, connected to the auxiliary electric motor 94 through the regulator 137, will operate at constant voltage. Should it be desirable to operate auxiliary electric motors, such as the auxiliary electric motor 94, while a generator such as the generator 33 is operating under variable conditions, the auxiliary electric motors employed can be of such design that they will be successfully operable within the variable voltage range encountered.

What is claimed is:

1. In combination, a prime mover, a generator driven thereby, an electric motor, an electro-magnet, output leads from said generator for feeding circuits for said motor and electro-magnet, a controller adapted to be advanced step by step from a neutral position to different operative positions to cause circuits for transmitting power of increasing value to said motor successively to be closed, a contactor for controlling a circuit to include said electro-magnet, a circuit for said contactor, a manually actuable switch for controlling said contactor circuit, and an interlock operable when the contactor is conditioned to cause said electro-magnet circuit to be closed to preclude actuation of the controller to any of said operative positions in advance of a selected operative position.

2. In combination, a prime mover, a generator driven thereby, an electric motor, an electro-magnet, output leads from said generator for feeding circuits for said motor and electro-magnet, a controller adapted to be advanced step by step from a neutral position to different operative positions to cause circuits for transmitting power of increasing value to said motor successively to be closed, a contactor for controlling a circuit to include said electro-magnet, a circuit for said contactor, a manually actuable switch for controlling said contactor circuit, an interlock operable when the contactor is conditioned to cause said electro-magnet circuit to be closed to preclude actuation of the controller to any of said operative positions in advance of a selected operative position, and means for rendering said contactor incapable of closing said electro-magnet circuit when said controller is situated at any of its operative positions in advance of said selected operative position.

3. In combination, a prime mover, a generator

driven thereby, an electric motor, an electro-magnet, output leads from said generator for feeding circuits for said motor and electro-magnet, a controller adapted to be advanced step by step from a neutral position to different operative positions to cause circuits for transmitting power of increasing value to said motor successively to be closed, a contactor for controlling a circuit including said electro-magnet, a circuit for said contactor, a manually actuable switch for controlling said contactor circuit, and an interlock constituted as a solenoid in said contactor circuit and a stop element rigid with said controller operable when the contactor is conditioned to cause said electro-magnet circuit to be closed to preclude actuation of the controller to any of said operative positions in advance of a selected operative position.

4. In combination, a prime mover, a generator driven thereby, an electric motor, an electro-magnet, output leads from said generator for feeding circuits for said motor and electro-magnet, a controller adapted to be advanced step by step from a neutral position to different operative positions to cause circuits for transmitting power of increasing value to said motor successively to be closed, a contactor for controlling a circuit including said electro-magnet, a circuit for said contactor, a manually actuable switch for controlling said contactor circuit, an interlock constituted as a solenoid in said contactor circuit and a stop element rigid with said controller operable when the contactor is conditioned to cause said electro-magnet circuit to be closed to preclude actuation of the controller to any of said operative positions in advance of a selected operative position, and means for rendering said contactor incapable of closing said electro-magnet circuit when said controller is situated at any of its operative positions in advance of said selected operative position.

5. In combination, a prime mover, a generator driven thereby, an electric motor, an electro-magnet, output leads from said generator for feeding circuits for said motor and electro-magnet, a controller adapted to be advanced step by step from a neutral position to different operative positions to cause circuits for transmitting power of increasing value to said motor successively to be closed, a contactor for controlling a circuit including said electro-magnet, a circuit for said contactor, a manually actuable switch for controlling said contactor circuit, and a regulator operative in response to advancement of said controller to said different operative positions to maintain substantially constant voltage at the terminals of said generator.

6. In combination, a prime mover, a generator driven thereby, an electric motor, an electro-magnet, output leads from said generator for feeding circuits for said motor and electro-magnet, a controller adapted to be advanced step by step from a neutral position to different operative positions to cause separate circuits for said motor successively to be closed, devices for causing power of increasing value to be transmitted to said motor in response to successive closing of said separate circuits, a contactor for controlling a circuit independent of the separate motor circuits and including said electro-magnet, a circuit for said contactor, a manually actuable switch for controlling said contactor circuit, and a regulator operative in response to closing of said separate circuits to maintain substantially

constant voltage at the terminals of said generator.

7. In combination, a prime mover, a generator driven thereby, an electric motor, an electro-magnet, output leads from said generator for feeding circuits for said motor and electro-magnet, a controller adapted to be advanced step by step from a neutral position to different operative positions to cause circuits for transmitting power of increasing value to said motor successively to be closed, a contactor for controlling a circuit including said electro-magnet, a circuit for said contactor, a manually actuatable switch for controlling said contactor circuit, a regulator operative in response to advancement of said controller to said different operative positions to maintain substantially constant voltage at the terminals of said generator, and an interlock operable when the contactor is conditioned to cause said electro-magnet circuit to be closed to preclude actuation of the controller to any of said operative positions in advance of a selected operative position.

8. In combination, a prime mover, a generator driven thereby, an electric motor, an electro-magnet, output leads from said generator for feeding circuits for said motor and electro-magnet, a controller adapted to be advanced step by step from a neutral position to different operative positions to cause circuits for transmitting power of increasing value to said motor successively to be closed, a contactor for controlling a circuit including said electro-magnet, a circuit for said contactor, a manually actuatable switch for controlling said contactor circuit, a regulator operative in response to advancement of said controller to said different operative positions to maintain substantially constant voltage at the terminals of said generator, an interlock operable when the contactor is conditioned to cause said electro-magnet circuit to be closed to preclude actuation of the controller to any of said operative positions in advance of a selected operative position, and means for rendering said contactor incapable of closing said electro-magnet circuit when said controller is situated at any of its operative positions in advance of said selected operative position.

9. In combination, a prime mover, a generator driven thereby, an electric motor, an electro-magnet, output leads from said generator for feeding circuits for said motor and electro-magnet, a controller adapted to be advanced step by step from a neutral position to different operative positions to cause separate circuits for said motor successively to be closed, devices for causing power of increasing value to be transmitted to said motor in response to successive closing of said separate circuits, a contactor for controlling a circuit independent of the separate motor circuits and including said electro-magnet, a circuit for said contactor, a manually actuatable switch for controlling said contactor circuit, a regulator operative in response to closing of said separate circuits to maintain substantially constant voltage at the terminals of said generator, and an interlock operable when the contactor is conditioned to cause said electro-magnet circuit to be closed to preclude actuation of the controller to any of said operative positions in advance of a selected operative position.

10. In combination, a prime mover, a generator driven thereby, an electric motor, an electro-magnet, output leads from said generator for feeding circuits for said motor and electro-magnet, a

controller adapted to be advanced step by step from a neutral position to different operative positions to cause separate circuits for said motor successively to be closed, devices for causing power of increasing value to be transmitted to said motor in response to successive closing of said separate circuits, a contactor for controlling a circuit independent of the separate motor circuits and including said electro-magnet, a circuit for said contactor, a manually actuatable switch for controlling said contactor circuit, a regulator operative in response to closing of said separate circuits to maintain substantially constant voltage at the terminals of said generator, an interlock constituted as a solenoid in said contactor circuit and a stop element rigid with said controller operable when the contactor is conditioned to cause said electro-magnet circuit to be closed to preclude actuation of the controller to any of said operative positions in advance of a selected operative position, and means for rendering said contactor incapable of closing said electro-magnet circuit when said controller is situated at any of its operative positions in advance of said selected operative position.

11. In combination, a prime mover, a generator driven thereby, an electric motor, an electro-magnet, output leads from said generator for feeding circuits for said motor and electro-magnet, a controller adapted to be advanced step by step from a neutral position to different operative positions to cause separate circuits for said motor successively to be closed, devices for causing power of increasing value to be transmitted to said motor in response to successive closing of said separate circuits, a contactor for controlling a circuit independent of the separate motor circuits and including said electro-magnet, a circuit for said contactor, a manually actuatable switch for controlling said contactor circuit, a regulator operative in response to closing of said separate circuits to maintain substantially constant voltage at the terminals of said generator, and an interlock operable when the contactor is conditioned to cause said electro-magnet circuit to be closed to preclude actuation of the controller to any of said operative positions in advance of a selected operative position and when said contactor is conditioned to cause the electro-magnet circuit to be open to permit actuation of said controller to operative positions therefor in advance of said selected operative position.

12. In combination, a prime mover, a generator driven thereby, an electric motor, an electro-magnet, output leads from said generator for feeding circuits for said motor and electro-magnet, a controller adapted to be advanced step by step from a neutral position to different operative positions to cause separate circuits for said motor successively to be closed, devices for causing power of increasing value to be transmitted to said motor in response to successive closing of said separate circuits, a contactor for controlling a circuit independent of the separate motor circuits and including said electro-magnet, a circuit for said contactor, a manually actuatable switch for controlling said contactor circuit, a regulator operative in response to closing of said separate circuits to maintain substantially constant voltage at the terminals of said generator, an interlock constituted as a solenoid in said contactor circuit and a stop element rigid with said controller operable when the contactor is conditioned to cause said electro-magnet circuit to be closed to preclude actuation of the controller to any of

said operative positions in advance of a selected operative position and when said contactor is conditioned to cause the electro-magnet circuit to be open to permit actuation of said controller to operative positions therefor in advance of said selected operative position, and means for rendering said contactor incapable of closing said electro-magnet circuit when said controller is situated at any of its operative positions in advance of said selected operative position.

13. In combination, a prime mover, a generator driven thereby, an electric motor, an electro-magnet, output leads from said generator for feeding circuits for said motor and electro-magnet, a controller for a circuit to include said motor, a contactor for controlling a circuit to include said electro-magnet, a holding circuit for said contactor, a regulator for normally maintaining substantially constant voltage at the terminals of said generator, a first switch adapted to be initially actuated to cause said contactor holding circuit and said electro-magnet circuit to be closed and voltage of value greater than normally supplied by said generator to be impressed upon the electro-magnet circuit, said first switch being adapted to be later actuated to cause voltage as normally supplied by the generator to be impressed upon said electro-magnet circuit,

and a second switch adapted to be actuated to cause said contactor holding circuit and said electro-magnet circuit to be opened.

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