Sept. 2, 1952 R. L. JAESCHKE 2,609,181

HOIST CONTROL

Filed June 1, 1948 2 SHEETS—SHEET 1

FIG. 1.

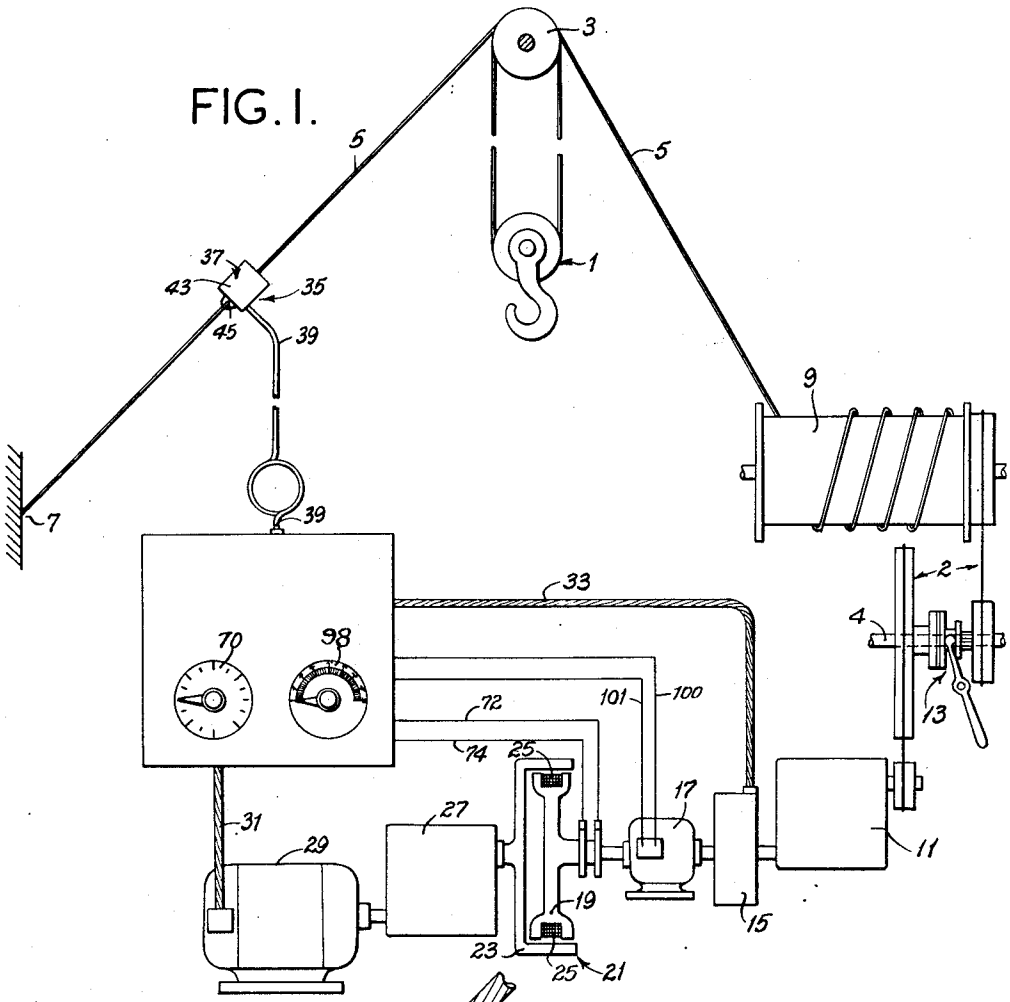
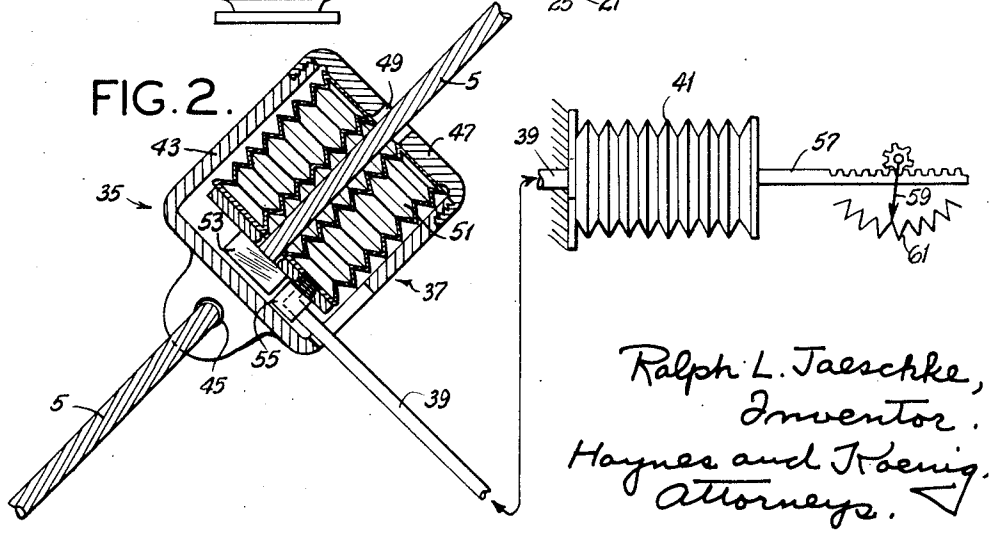


FIG. 2.



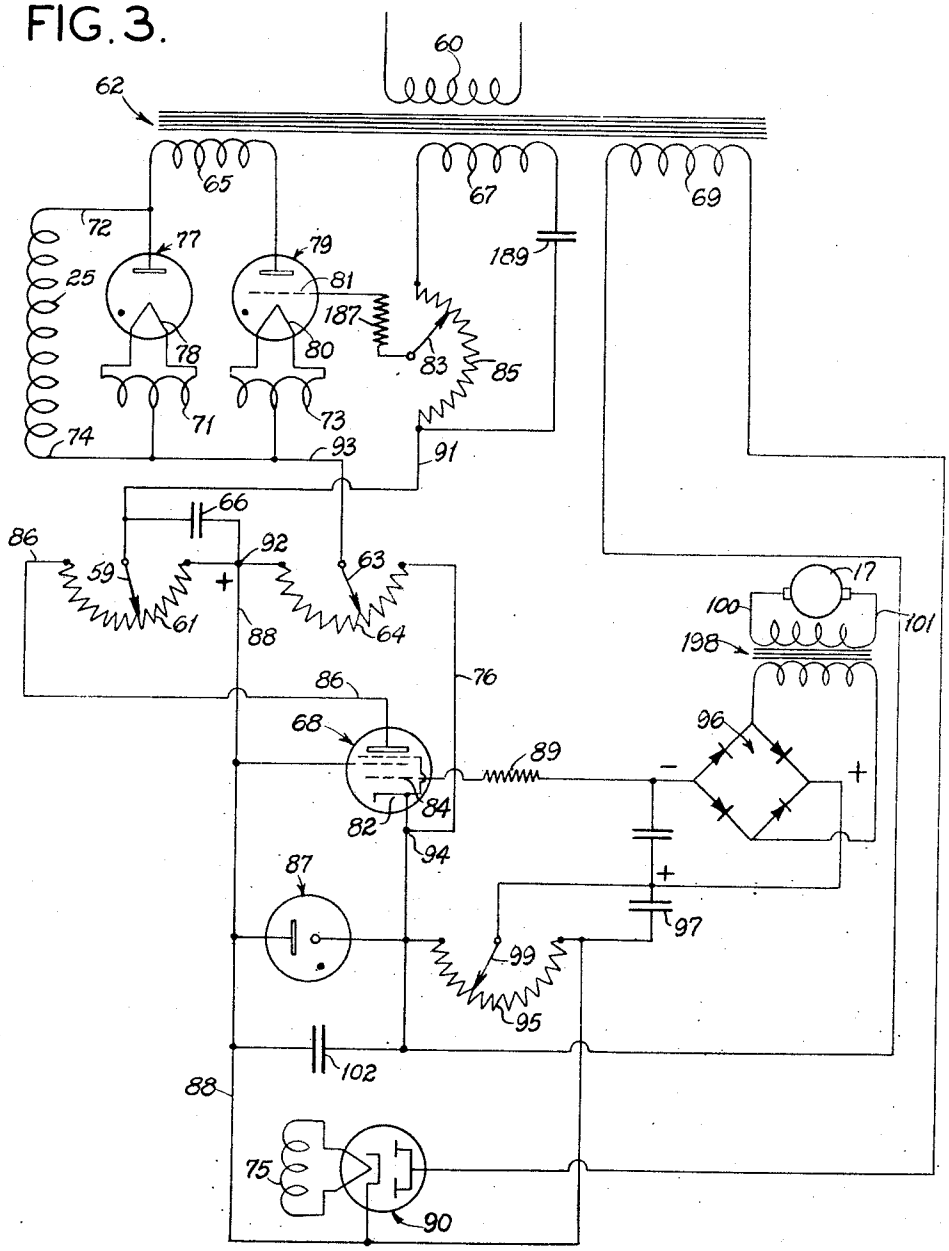
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FIG. 3.



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2,609,181

HOIST CONTROL

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6 Claims. (Cl. 254—172)

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This invention relates to a hoist control, and more particularly to a hoist control for oil well drilling equipment and the like.

Among the several objects of the invention is the provision of a hoist control which effectively and automatically controls the tension in a hoist cable as well as the pay-out rate of the cable; the provision of a hoist control for drilling equipment which cooperatively and simultaneously control the drill load and rate of drill descent substantially to increase the life of the drill bit and to decrease the drilling time; the provision of a hoist control of the type referred to which may be manually adjusted accurately to control the cable tension and the rate of cable paying out to any desired predetermined values; and the provision of a hoist control which is efficient and dependable in operation and strong in construction. Other objects will be in part apparent and in part pointed out hereinafter.

The invention accordingly comprises the elements and combinations of elements, features of construction, and arrangements of parts which will be exemplified in the structures hereinafter described, the scope of which will be indicated in the following claims.

In the accompanying drawings, in which one of various possible embodiments of the invention is illustrated,

Fig. 1 is a diagrammatic view of the hoist control of the present invention associated with a drilling rig and hoist drum assembly;

Fig. 2 is an enlarged diagrammatic sectional view of a tension-sensitive pick-up and an associated potentiometer control; and,

Fig. 3 is an electrical circuit diagram of the hoist control.

Similar reference characters indicate corresponding parts throughout the several views of the drawings.

In drilling oil wells it is necessary to penetrate many geologically different earth strata. Frequently subterranean caverns are unexpectedly encountered. The passage of the drill bit from one stratum to another of different composition may in some instances cause damage to the drill bit or at other times permit too great a rate of drill descent. For example, if the drill bit breaks through the roof of an underground cavern, it may be broken due to the resultant rapid speed increase caused by its acceleration and the sudden impact when a solid stratum is again encountered.

I have found that, by maintaining a substantially constant tension in the hoist cable used to support such a drill bit and maintaining the

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paying-out rate of such a cable below a predetermined value, the drill load and the rate of descent of the drill can be maintained at such values that the life of the expensive drill bits can be greatly extended and the time of drilling be substantially reduced with a commensurate economy in material and labor costs.

Referring now to Fig. 1, there is indicated at numeral 1 a pulley block adapted to support any desired load, such as, for example, a drill pipe and a drill bit for oil well drilling. Block 1, an anchor pulley block 3 and a suspension cable 5 are organized to form a tackle, one end of the cable of which is wound on a hoist drum 9 and the other end of which is held stationary, as indicated at numeral 7. Drum 9 is coupled to a speed reducer 11 through a transmission 2 including a mechanical clutch 13. The speed reducer 11 is in turn connected through an electrically actuated mechanical brake 15 and a governor generator 17 to a field member 19 of an eddy-current electromagnetic slip-clutch unit 21 such as described, for example, in U. S. Patents Re. 20,225, dated December 29, 1936, and 2,106,542, dated January 25, 1938. As these patents show, such units which may be designated as brakes or slip couplings, have a field member and an inductor wherein currents are induced when the field member is excited. These currents produce reactive fields which effect the variable coupling. Clutch unit 21 includes an inductor member 23 for a field coil 25 carried on the periphery of field member 19. Parts 19, 23 and 25 are shown in diagrammatic section and are actually circular in form. The member 23 is driven through a second speed reducer 27 by means of a prime mover motor 29. Reducer 27 increases the effective torque of motor 29 on inductor member 23. Reducer 11 increases the effective torque of member 19 on drum 9. Electrical power is supplied to motor 29 and the mechanical brake 15 by cabled wires 31 and 33, respectively. Clutch 13 is closed when lowering operations are to occur. It is opened when lifting operations are to occur. Power for lifting is then applied to shaft 4 from another prime mover and transmission (not shown).

A tension-sensing unit 35, including a tension-sensitive pick-up 37, a length of tubing 39 and an expansible receiver 41, is associated with the tackle at any convenient point, such as in the so-called "dead" portion of cable 5 as shown in Fig. 1. Pick-up 37 (shown diagrammatically in Fig. 2) comprises a cylindrical cup 43 with a hole 45 connected to one portion of cable 5 and a cap 47 having an aperture 49 adapted to receive the other portion of cable 5. Pick-up 37 also in-

cludes an interior fluid-filled expansible annular chamber 51 which separates the one portion of cable 5 carrying a head 53 from the other portion of cable 5 carrying the cup 43 and cap 47. Flexible tubing 39 is connected to the chamber 51 through an adapter 55. Chamber 51 and receiver 41 are interconnected by the tubing 39, which communicates fluid pressure variations in the pick-up 37 to the receiver 41. An extension arm 57, which is responsive to these pressure changes, is coupled to an arm 59 of a potentiometer 61. Fig. 2 is diagrammatic of various devices that can be used for the purpose but it is to be understood that various suitable mechanical equivalents are available.

Referring now to Fig. 3 there is indicated at numeral 62 a transformer having a primary winding 60 (energized from any convenient A. C. source) and several secondary windings 65, 67, 69, 71, 73 and 75. The winding 65 is connected to the anodes of two gas-filled rectifier tubes 77 and 79. The cathodes 78 and 80 of these tubes are heated by the center-tapped transformer windings 71 and 73, respectively. The electromagnetic slip-clutch field winding 25 is connected by wires 72 and 74 between the anode of tube 77 to the common center-tap connections of windings 71 and 73. Tube 79 contains a cathode 80 and a control grid 81 which is connected to an arm 83 of a sensitivity potentiometer 85 through a grid-blocking resistor 187. Potentiometer 85 is included in a phase-shifter network comprising windings 67 and a condenser 189. A D. C. grid bias potential is impressed through wires 91 and 93 between the cathodes of tubes 77 and 79 and the grid 81 of tube 79. This D. C. grid bias potential for the grid 81 is delivered to wires 91 and 93 from the potentiometer arms 59 and 63. Arm 50 is on potentiometer 61 above mentioned. Arm 63 is on a potentiometer 64. The potentiometers are connected in an electrical network including an electronic tube 68 and a condenser 66 which serves to by-pass potentiometer 61. The electronic tube 68 is preferably of the vacuum pentode type, including a control grid 84. One side of potentiometer 61 is connected to the anode of tube 68 through a wire 86 while a cathode 82 of tube 68 is connected through a wire 76 to one side of potentiometer 64. The remaining connections of potentiometers 61 and 64 are connected through a wire 88 to the cathode of a rectifier tube 90. A filtered and regulated D. C. potential is impressed upon this network between points 92 (of positive polarity) and point 94 (of negative polarity). This D. C. potential is produced by a half-wave rectifier circuit including the transformer winding 69, the rectifier tube 90, a filter condenser 102, and a voltage regulator tube 87. The cathode of rectifier tube 90 is indirectly heated by the transformer winding 75.

The grid 84 of the electronic tube 68 is biased by an electrical network including a grid-blocking resistor 89, a bridge rectifier 96, a transformer 198, the governor generator 17, a potentiometer 95 having an arm 99 and a by-pass condenser 97. The electrical output of the generator 17, which is mounted on or coupled to the field member 19, has its electrical output connected to transformer 198 through the wires 100 and 101.

It is to be understood that the generator 17 may be a D. C. or an A. C. type generator and that in the former case the bridge rectifier 96 and transformer 198 may be eliminated.

Operation is as follows:

When a drill pipe and a drill bit are supported by block 1 and drilling operations are in progress, tension-sensing unit 35 will have a stress applied to pick-up 37 dependent both upon the difference between the weight of the drilling equipment suspended from block 1 and the reaction resistance of the earth stratum through which a well is being bored. This stress, a function of the tension in the cable, will cause a certain fluid pressure to be applied through tubing 39 to the receiver 41, which positions potentiometer arm 59 in response to this pressure. The position of this automatically responsive arm 59 and the position of manually adjustable arm 63 influence the electrical characteristics of the electrical network of which they are a part to impress a potential between the grid 81 and the cathode 80 of tube 79. The potential difference between the cathode 80 and grid 81 determines the conduction period of tube 79 and thus controls the current flow through field coil 25. Tube 77 serves as a discharge path for coil 25 during non-conduction of tube 79. The action of tube 77, therefore, smooths the current flow characteristics through coil 25. The phase-shifter network impresses an A. C. rider wave upon the D. C. bias level supplied through wires 91 and 93. Both the phase and amplitude characteristics of this rider wave may be varied by movement of arm 83, which controls the firing sensitivity of tube 79.

When the grid 84 of tube 68 is at saturation bias level, any movement of arm 63 or 59 will vary the D. C. grid bias of tube 79 which will affect its conduction time. For example, if the drill bit encounters an earth stratum more resistant to drilling, the tension in cable 5 decreases and the sensing unit 35 causes arm 59 to be moved clockwise (Fig. 3). This action causes a decrease in D. C. bias (grid 81 becomes more positive in relation to cathode 80) and an increase in current flow through coil 25. This increased current increases the electromagnetic coupling (decreases slip) between members 23 and 19, thereby causing increased "braking action" on hoist drum 9. This action tends to hold back the drill bit and increase the tension in cable 5, thus returning potentiometer arm 59 counterclockwise to its original position. By manually adjusting the potentiometer arm 63 to any predetermined value of tension indicated on a calibrated scale 98, any desired substantially constant drill load or cable tension may be maintained. The action of the hoist control is the reverse of that described above if the drill bit encounters a less resistant earth stratum, the brake action on hoist drum 9 decreasing until the tension in cable 5 is decreased to the predetermined value as manually set by potentiometer arm 63.

Maintenance of the substantially constant tension of cable 5 will greatly increase the life of a drill bit and decrease drilling time by permitting an optimum drilling rate according to strata densities. However, it is frequently desirable to prevent the drilling rate (as determined by the paying-out rate of cable 5 from drum 9) from exceeding a predetermined value. To accomplish this purpose a second electrical network including governor generator 17 and the grid 84 of tube 68 is supplied.

Governor 17 has an electrical output potential directly responsive to the rotational speed of drum 9. This potential may be D. C. if a commutator is used. Or it may be A. C. (as in the present example), which is transformed by means of the transformer 198 and bridge rectifier 96 (as shown in Fig. 3) into a D. C. potential

responsive to the rotational speed of drum 9, which is proportional to the speed of member 19. This D. C. potential is impressed between the grid 84 and the cathode 82 of tube 68 through the potentiometer 95. Potentiometer 95 is connected across the constant potential D. C. output of the voltage regulator tube 87 in such a manner that the polarity of the potential across potentiometer 95 is in bucking opposition to that of bridge rectifier 96. The net potential as determined by the position of arm 99 and the output of bridge 96, is such that the potential of grid 84 in relation to the cathode 82 is normally maintained positive, or at, or near, a saturation bias level.

When a predetermined rate of paying out of the cable 5 is exceeded, then the increased output of generator 17 increases the potential output of bridge 96 past the point where its magnitude will exceed that of the opposing potential of potentiometer 95. This action will decrease the bias level of grid 84 so that it will be more negative in relation to cathode 82. This change in bias level decreases the conduction rate of tube 68 so that less current will be conducted through potentiometer 61 which serves as the plate load resistor of tube 68. The decreased current through potentiometer 61 decreases the D. C. grid bias upon tube 79, thus increasing its conduction time. That is, it makes the grid less negative in relation to cathode 80. This action increases the current flow through coil 25 and the braking action of the electromagnetic clutch 21 upon hoist drum 9. The paying-out rate of cable 5 is thus controlled and the rotational speed of drum 9 and governor 17 is proportionately reduced until the bias level of grid 84 returns to saturation level.

The desired paying-out rate of cable 5, which is not to be exceeded, may be selected within a range by manually positioning the arm 99 of potentiometer 95 to this predetermined value, as indicated on a calibrated scale 70.

The electrically actuated mechanical brake 15 is provided as a further safety feature and may be connected in the electrical circuit diagram of Fig. 3 in any conventional manner, so that if there is any failure in the current supplied to field coil 25, brake 15 will be immediately applied to prevent all rotation of the drum 9. Such a system is shown, for example, in U. S. Patent 2,512,017.

Although the tension-sensing unit 35 is shown including expansible chamber 51 and tubing 39 to energize receiver 41 and potentiometer arm 59, any other satisfactory tension-sensing device may be used. For example, a strain gage having a fine wire, the resistance of which is a function of strain upon a body supporting this wire, may be advantageously used in place of unit 35. It is to be understood that pick-up 37 may be placed in any convenient position in the tackle system which is responsive to cable tension in the tackle or drill load. For example, the pick-up may be interposed between the pulley block 3 and any structure, such as a derrick, which supports this pulley.

An advantage of the present invention is the completely continuous control that it effects of the load on the drill bit so that the bit is never overloaded. Discontinuously operating controls do not have such advantage but may allow bits to be overloaded for certain intervals.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results attained.

As many changes could be made in the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above describtion or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

I claim:

1. A hoist control for hoisting equipment having a hoist drum and a cable adapted to be payed out therefrom, comprising an electrically controlled induced-current brake having a field coil, a grid-controlled electronic tube having an anode and a cathode, a generator electrically connected to the grid of said tube and responsive to the rotational speed of said drum to produce a first potential for the grid of said tube, a source of electrical energy connected to said tube, a first potentiometer adapted to produce a second potential, a tension-sensing unit connected for response to the tension of said cable to produce a third potential, said sensing unit and said first potentiometer being series connected in voltage opposition across said anode and cathode to produce a composite potential, a grid-controlled rectifier tube having a cathode connected in a rectifier circuit for energizing the field coil of said brake, said composite potential being applied between said rectifier tube grid and cathode to control the energization of said field coil to maintain the rotational speed of said drum below a first predetermined value and to maintain the tension of said cable substantially constant at a second predetermined value.

2. A hoist control for hoisting equipment having a hoist drum and a cable adapted to be payed out therefrom, comprising an electrically controlled induced-current brake having a field coil, a grid-controlled electronic tube having an anode and a cathode, a generator electrically connected to the grid of said tube and connected for response to the rotational speed of said drum to produce a first potential for the grid of said tube, a source of electrical energy connected to said tube, a tension-sensitive pick-up connected for response to the tensioning of said cable, a first and second potentiometer connected in series opposition across said anode and cathode to produce a composite potential, said second potentiometer being actuated by said pick-ups, a grid-controlled rectifier tube having a cathode connected in a rectifier circuit for energizing the field coil of said brake, said composite potential being applied between said rectifier tube grid and cathode to control the energization of said coil to maintain the rotational speed of said drum below a first predetermined value and to maintain the tension of said cable substantially constant at a second predetermined value.

3. A hoist control for hoisting equipment having a hoist drum and a cable adapted to be payed out therefrom, comprising an electrically controlled induced-current brake having, a field coil, a grid-controlled electronic tube having an anode and a cathode, a generator electrically connected to the grid of said tube and responsive to the rotational speed of said drum to produce a first potential for the grid of said tube, a source of electrical energy connected to said tube, a manually adjustable first potentiometer adapted to produce a second potential, a tension-sensing unit connected for response to the tension of said cable to produce a third potential, said sensing unit and said first potentiometer being series connected in voltage opposition across said anode and cathode to produce a composite po-

tential, a grid-controlled rectifier tube having a cathode connected in a rectifier circuit for energizing said field coil of the brake, said composite potential being applied between said rectifier tube grid and cathode to control the energization of said coil to maintain the rotational speed of said drum below a first predetermined value and to maintain the tension of said cable substantially constant at a second predetermined value as manually adjusted by said first potentiometer.

4. A hoist control for hoisting equipment having a hoist drum and a cable adapted to be payed out therefrom, comprising an electrically controlled induced-current brake having a field coil, a grid-controlled electronic tube having an anode and a cathode, a generator connected for response to the rotational speed of said drum, a manually adjustable first potentiometer connected in a circuit with the grid of said tube and with said generator to produce a first potential for the grid of said tube, a source of electrical energy connected to said tube, a tension-sensitive pick-up connected for response to tension in said cable, a second potentiometer actuated by said pick-up to produce a second electrical potential which is a function of said cable tension, a third manually adjustable potentiometer adapted to produce a third electrical potential, said second and third potentiometers being series connected in voltage opposition across said anode and cathode to produce a composite potential, a grid-controlled rectifier tube having a cathode connected in a rectifier circuit for energizing the field coil of said brake, said composite potential being applied between said rectifier tube grid and cathode to control the energization of said field coil to maintain the rotational speed of said drum below a first predetermined value as manually adjusted by said first potentiometer and to maintain the tension of said cable substantially constant at a second predetermined value as manually adjusted by said third potentiometer.

5. A hoist control for hoisting equipment having a hoist drum and a cable adapted to be payed out therefrom, comprising an electrically controlled induced-current brake having a field coil, a grid-controlled electronic tube having an anode and a cathode, a generator connected for response to the rotational speed of said drum, a manually adjustable first potentiometer connected in a circuit with the grid of said tube and with said generator to produce a first potential for the grid of said tube, a source of electrical energy connected to said tube and to a phase shifter network adapted to produce an A. C. potential, a tension-sensitive pick-up connected for response to tension in said cable, a second potentiometer actuated by said pick-up to produce a second electrical potential which is a function of said cable tension, a third manually adjustable potentiometer adapted to produce a third electrical potential, said second and third potentiometers being series connected in voltage opposition across said anode and cathode to produce a composite potential, a grid-controlled rectifier tube having a cathode connected in a rectifier circuit for energizing said brake, said composite potential combined with said A. C. potential being applied between said rectifier tube grid and cathode to control the energization of said field coil to maintain the rotational speed of said drum below a first predetermined value as manually adjusted by said first potentiometer and to maintain the tension of said cable substantially constant at a second predetermined value as manually adjusted by said third potentiometer.

6. A hoist control for hoisting equipment having a hoist drum and a cable adapted to be payed therefrom, comprising a variable electromagnetic brake for said hoist drum, a generator responsive to the rotational speed of said drum to produce an electrical output, a tension-sensitive pick-up connected for response to the tension in said cable, a source of electrical power, a first potentiometer connected to said power source and remotely controllable by said pick-up to produce a first potential, a second potentiometer connected to said generator and adapted to produce a second potential, and a third potentiometer connected in series opposition with said first potentiometer to produce a third potential, said brake being connected for response to the composite potential of said three potentiometers and said electrical output to maintain the rotational speed of said drum below a first predetermined value and the tension in said cable substantially constant at a second predetermined value, said second and third potentiometers being manually adjustable to vary the respective predetermined values of rotational speed and cable tension.

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