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W. HARNISCHFEGER ET AL

2,529,804

REMOTE HOIST CONTROL

Filed April 27, 1946

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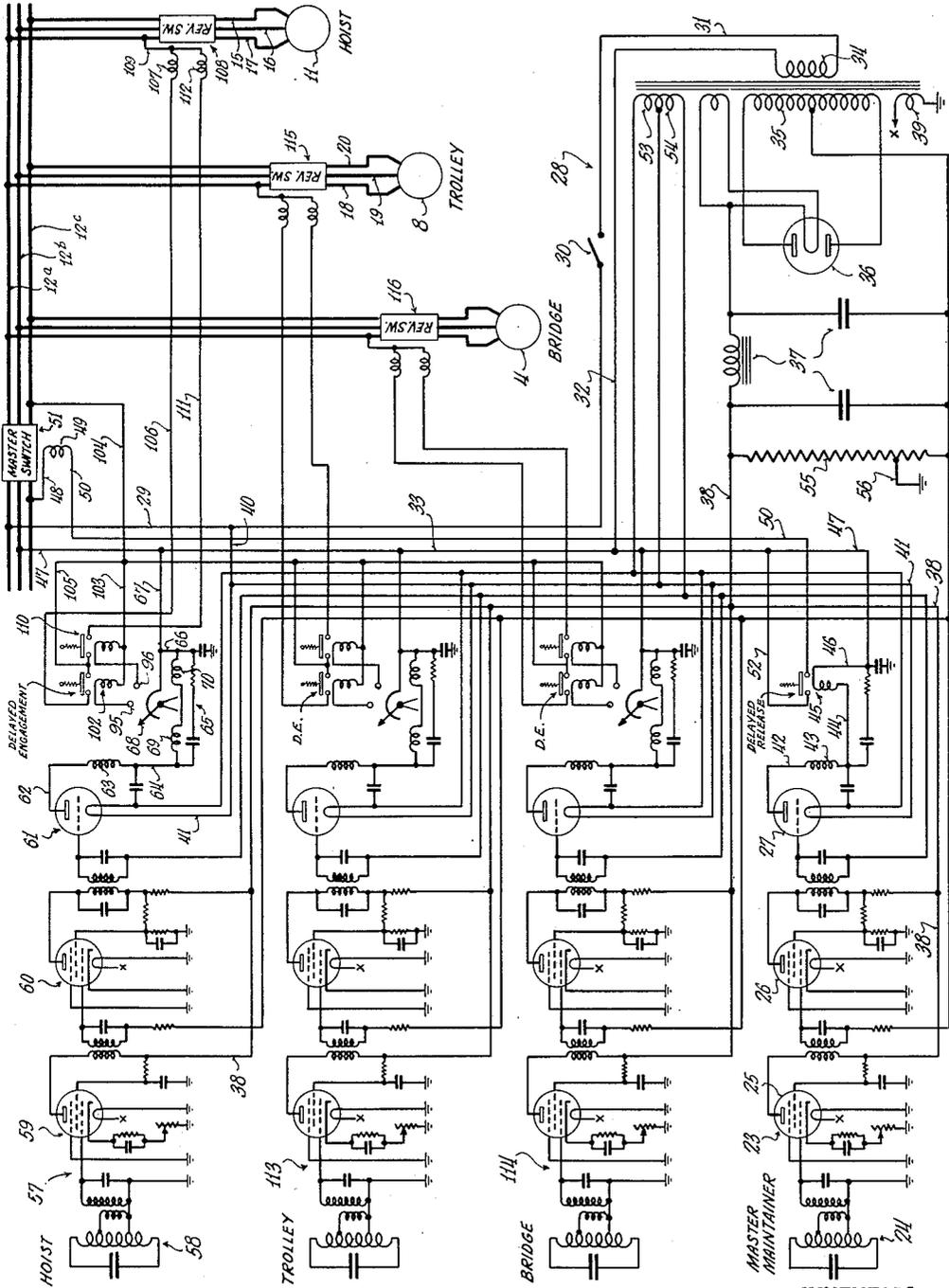


Fig. 1

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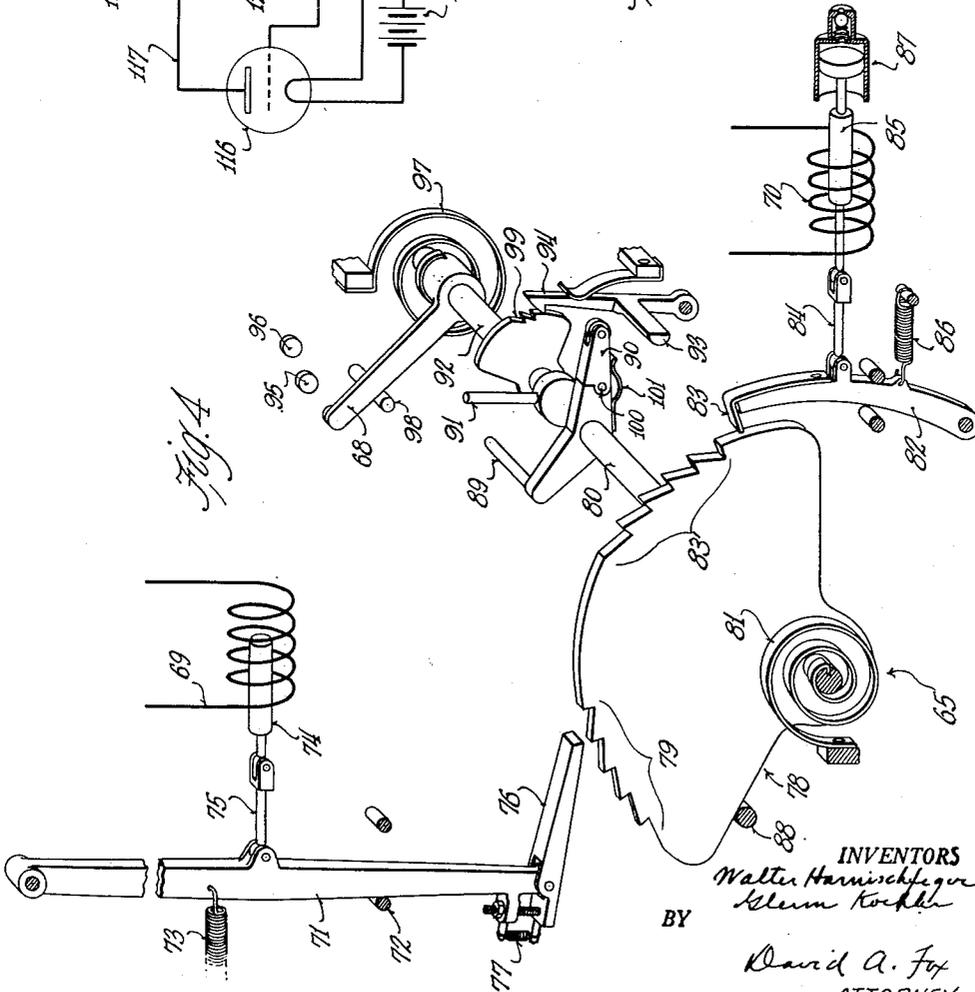
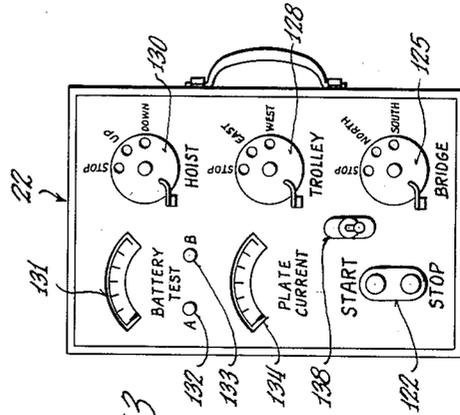
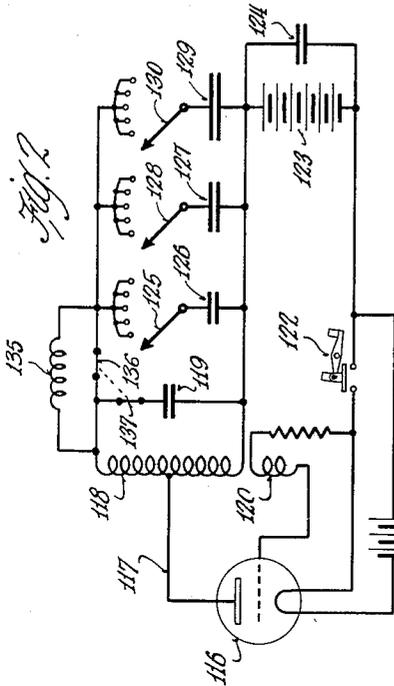
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4 Sheets-Sheet 2



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4 Sheets-Sheet 3

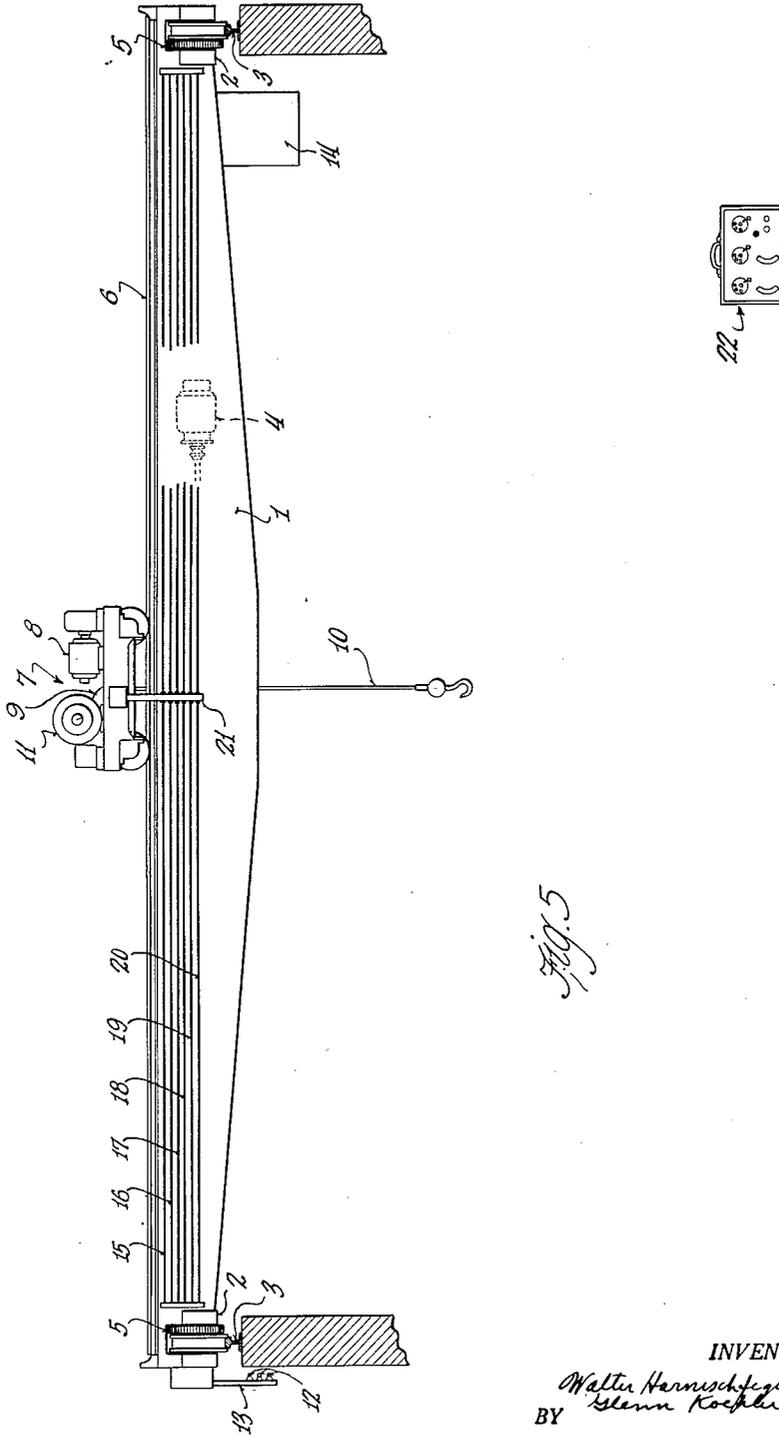


FIG. 5

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Fig. 7

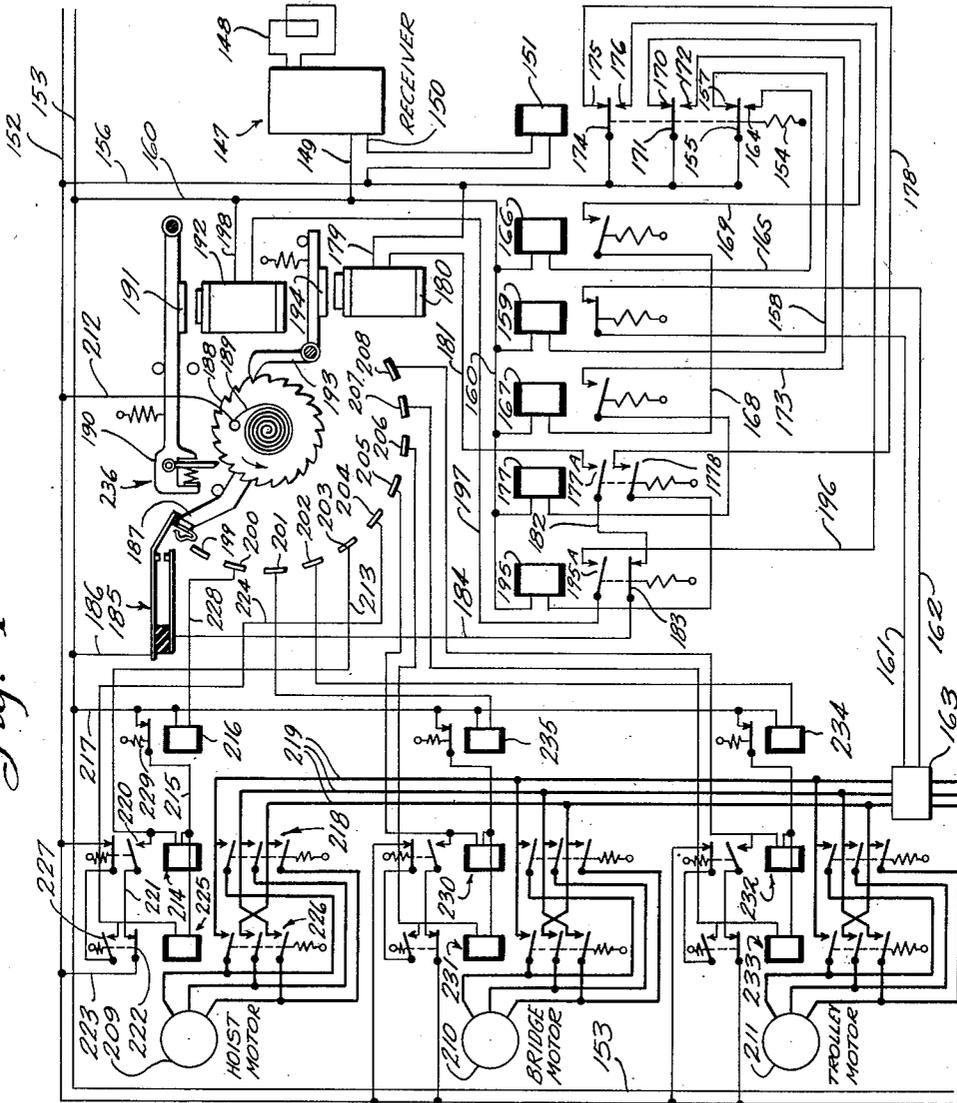
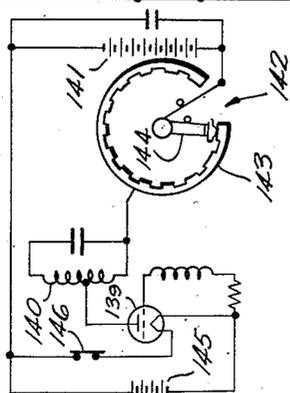


Fig. 6



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REMOTE HOIST CONTROL

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6 Claims. (Cl. 250—2)

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This invention relates to cranes, hoists and lifting devices adapted to be controlled from a distance and resides more specifically in an electrically driven hoist adapted to be raised, lowered or stopped through radiated impulses emitted by a portable control transmitter which may be carried to and operated at a point where a lift is to be made or at any other location in the vicinity of the hoist.

Many power driven hoists particularly that form thereof known as traveling overhead cranes are employed in locations where large and irregular periods of idleness occur. In such instances it is uneconomical to maintain an operator in constant attendance and it is also inconvenient for a temporary operator to have to climb to the operator's cab each time it is necessary to use the crane. To avoid this difficulty efforts have been made to employ pendant mechanical or electrical control cords through which the crane may be operated and controlled by a person situated on the floor who requires the services of the crane. For certain limited applications the pendant cord control is quite serviceable, but where large obstructions either temporary or permanent exist within the area served by the crane it is dangerous to depend upon pendant cord control. Also, with pendant cord control rates of traversing of the trolley and bridge must be kept below that of a walk in order to permit the person operating the crane to keep up with pendant cord.

In accordance with this invention means are provided by which an overhead crane may be controlled from any point on the floor by a control box or transmitter having no physical connection whatever with the traveling parts of the crane. In this way the dangers introduced by pendant cord control are avoided, efficient speeds are rendered feasible and the temporary operator need not climb to the control cab of the crane in order to put the same in use.

This invention is herein described by reference to the accompanying drawings forming a part hereof and in which there is set forth by way of illustration and not of limitation one form in which the apparatus of this invention may be constructed.

In the drawings:

Fig. 1 is a circuit diagram of the receiving, control and power circuits for the three motors giving motion to the bridge, trolley and hoist of an overhead crane;

Fig. 2 is a circuit diagram of a transmitting

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control circuit adapted to activate the receiving control circuit of Fig. 1;

Fig. 3 is a front view in elevation of the transmitting control circuit housing;

Fig. 4 is a diagrammatic perspective view of the parts of one of the selector switch units which perform circuit selecting operations in response to received control pulses;

Fig. 5 is an end view in elevation of a remotely controllable crane with which the circuits and parts of the foregoing figures may be employed.

Fig. 6 is a circuit diagram of a control transmitter adapted for control of a slightly different form of apparatus of this invention; and

Fig. 7 is a circuit diagram of a control receiver adapted to be actuated by the control transmitter of Fig. 6.

The form of the apparatus of this invention illustrated in the drawings comprises, as shown in Fig. 5, a bridge or girder 1 mouted on end trucks 2, arranged to travel on overhead runways 3. An electric driving motor or bridge motor 4 is mounted on the bridge 1 as shown and connected by transmission shafting, not shown, and gearing 5 with the wheels of the end trucks 2 so as to propel the bridge in known manner. Secured to the upper faces of the bridge 1 are trolley tracks 6, only one of which is shown, which support a trolley 7 in rolling engagement therewith. Trolley 7 is furnished with an electric trolley driving motor 8 connected by gearing, not shown, with wheels of the trolley so as to propel the same upon the tracks 6 in known fashion. Also mounted on the trolley 7 is the usual hoisting drum 9 from which hoisting line 10 extends downwardly as shown. Drum 9 is arranged to be driven through gearing, not shown, by an electric hoist motor 11. Each of the motors 4, 8 and 11 are provided with brakes not shown which are automatically released upon admission of electric power to the motors and automatically applied upon discontinuance of electric power admission in accordance with well established practice.

For supply of electric power (in this case three phase alternating current) main trolley rails 12 and collector shoes 13 are provided at the left end of the bridge 1. Power mains not shown extend from the shoes 13 to a control receiving unit 14 (to be described in greater detail) mounted near the right hand end of the bridge 1 from whence power is distributed to motor 4 by leads not shown and to motor 8 by trolley wires 15, 16 and 17 and to motor 11 by trolley wires 18, 19 and 20 and by appropriate connections between

the respective motors, not shown, and the collector shoe assembly 21.

To complete the apparatus a portable control transmitting unit 22 (to be described in greater detail) is provided which is capable of radiating pulses to be received by control receiving unit 14 which will cause the starting, stopping and reversing of the several motors 4, 8 and 11. From this it may be seen that an operator may command the operations of the crane through manipulation of the control transmitting unit 22 from any convenient location within the vicinity of the area served by the crane with all of the advantages previously described.

The power and control receiving circuits of the crane and the control receiving unit 14 are shown in greater detail in Fig. 1 where the bridge, trolley and hoist motors 4, 8 and 11 respectively are diagrammatically indicated. Within the control receiving unit 14 is situated a master maintainer receiver 23 so designated on the drawing. The receiver 23 is made up of a tuned loop antenna unit 24, a first stage of tuned radio frequency amplification 25, a second stage of tuned radio frequency amplification 26 and a hot cathode gaseous discharge tube and associated circuit 27.

To provide power for the operation of the receiver 23, a power pack unit 28 having a transformer primary winding 34 is arranged to be supplied with current through lead 29 joined with main 12a, switch 30, lead 31, lead 32 and lead 33 joined with main 12b. Plate current for the amplifiers 25 and 26 is furnished by secondary winding 35 joined through rectifier 36 and filter elements 37 to ground and plate current supply lead 38 as shown. Current for supply of the cathode heaters of amplifiers 25 and 26 is supplied by secondary winding 39 as indicated. For heating of the filament of tube 27, secondary winding 53 is connected as shown, while bias for the grid of tube 27 is created by secondary winding 54. Bias for the grids of amplifiers 25 and 26 is provided for through grounding of voltage divider resistor 55 shown at 56.

The output of amplifier 26 is applied to the grid of gas discharge tube 27 and when of sufficient intensity causes the tube 27 to break down and become conducting completing a circuit from main 12a through leads 29, 40, 41, tube 27, lead 42, choke 43 and lead 44 to the coil of sensitive relay 45 and thence through leads 46 and 47 back to main 12b. Relay 45 is of the normally-open, delayed-release type being capable of remaining closed for about one second after excitation ceases. Upon closure of relay 45 a circuit is established extending from main 12c, through lead 48, coil 49 of magnetic contactor master switch 51, lead 50, contacts of relay 45, lead 52 and thence through lead 47 back to main 12b. This causes the closure of master switch 51 and prepares the system for response to commands issued to it.

From the foregoing it will be understood that unless a nearly completely uninterrupted signal of sufficient strength is continuously received by the receiver 23 master switch 51 will not be closed and none of the motors 4, 8 or 11, supplied therethrough, can be operated. Receiver 23 is tuned to a specific frequency, for example, 410 kc. or other suitable frequency and is responsive to no other. Provision for its nearly steady excitation when needed by a signal of this frequency is made through means contained within the control transmitting unit 22, to be more fully described hereinafter.

For reception of commands directed to the hoist motor 11 another receiver generally designated 57 is also mounted in the control receiving unit 14. The receiver 57 in manner analogous to receiver 23 is provided as shown with a tuned loop antenna unit 58, tuned radio frequency amplifier units 59 and 60 and a hot cathode gaseous discharge tube 61 and associated circuit elements. These parts are supplied with power from the power pack 28 by connecting leads 38, 41 and 47 as previously described in the case of receiver 23.

The output of gaseous discharge tube 61 is confined to a circuit starting with main 12a and passing through leads 40 and 41 to the filament of tube 61. From thence the circuit passes to the plate of tube 61 and then through lead 62, choke 63, lead 64, the two windings 69 and 70 of step-by-step unit 65, leads 66 and 67 and then through lead 47 back to main 12b.

Receiver 57 is tuned to a specific frequency different from that of receiver 23, for example, 350 kc. or other suitable frequency and is responsive to no other. Provision for excitation of receiver 57 in pulses of controlled frequency, spacing, duration and number is made through means contained within the control transmitting unit 22, to be more fully described hereinafter.

Pulses delivered through the two windings 69 and 70 of step-by-step unit 65, cause the sweep contact 68 thereof to be shifted to one or another of the three possible positions thereof as more fully indicated in Fig. 4. As there shown the unit 65 comprises a pivotally mounted pawl support 71, normally held in the position shown, against the stop 72 by a spring 73. Attached to the support 71 intermediate the ends thereof by means of an armature link 75 is an armature 74 positioned to be drawn into coil 69 upon excitation thereof. At the lower end of support 71 a pawl 76 is pivotally attached and normally held in the position shown by a spring 77.

Located so as to be engaged by the pawl 76 upon its actuation by coil 69 and armature 74 is that part of the toothed periphery of a ratchet segment 78 which is designated 79 and which constitutes the driving ratchet of unit 65. Ratchet segment 78 is secured to a rotatable shaft 80 normally held in and urged to return to the position shown by means of a spiral return spring 81.

For temporary retention of segment 78 and shaft 80 in any position to which it may be advanced by the action of pawl 76 a pivotally mounted locking pawl 82 having a spring retaining finger 83 is provided and mounted as shown to engage that part of the toothed periphery of segment 78 constituting the temporary retaining ratchet designated 83'. Attached to the locking pawl 82 by an armature link 84 is an armature 85 positioned within coil 70 so as to be drawn to the left when the latter is excited. To restrain immediate return of armature 85 and associated parts under the influence of spring 86 when excitation of coil 70 is terminated, pneumatic dash pot 87 is attached to the armature 85. Dash pot 87 is provided with sufficient ventage or leakage between the piston and cylinder wall thereof so that after an elapse of about 2 seconds following termination of excitation of coil 70, spring 86 will have taken charge to an extent necessary to cause disengagement of finger 83 from ratchet 83'.

By reason of the structure of step-by-step unit 65 so far described upon simultaneous excitation

of windings 69 and 70 in pulses of sufficient intensity and spaced from one another by intervals less than 2 seconds but more than the brief interval required for return movement of pawl 76, segment 78 and associated shaft 80 are advanced clockwise in discrete steps against the action of spring 81. As soon as properly spaced pulses cease for a longer interval than 2 seconds segment 78 and shaft 80 are released to return to normal position against the stop 88. The interval of 2 seconds is given by way of example only and may be made longer or shorter as desired depending upon conditions to be fulfilled.

Secured to the end of shaft 80 opposite the segment 78 is an arm carrying an advancing pin 89 and an arm carrying a clearing lever 90. Advancing pin 89 is so located axially with respect to radial follower pin 91 as to come into contact therewith and to rotate the same and the independent sweep support shaft 92 upon which it is mounted whenever shaft 80 is sufficiently rotated. In like fashion clearing lever 90 is so positioned as to come into contact with and displace cam finger 93 and final holding pawl 94 to which the cam finger 93 is secured.

The sweep supporting shaft 92 is separate from the shaft 80 and rotatably mounted so as to carry the sweep contact arm 68 through an arc bringing the same into engagement with stationary step-by-step contacts 95 and 96. A spiral spring 97 secured to the shaft 92 operates to return the shaft 92 and arm 68 to and hold them against the stop 98. Also secured to the shaft 92 is a holding segment having a toothed ratchet portion 99 positioned to be engaged by the tip of holding pawl 94, the two notches thereon corresponding to the two angular positions in which sweep contact 68 is in contact with the stationary contacts 95 and 96.

In order to permit a single pulse series to produce either a net clockwise or counter-clockwise shifting of sweep contacts 68, advancing pin 89 and follower pin 91 are so related angularly, when the apparatus is in normal position, that 3 pulses or advancing steps of segment 78 are necessary to bring them into engagement with one another. Also clearing lever 90 and cam finger 93 are so related angularly that engagement thereof and release of holding segment 99 only takes place during movement of segment 78 from the second to the third step from the normal or starting position thereof. By reason of this a pulse series of less than 3 pulses will cause no change to take place in the position of sweep contact 68. A pulse series of 3 pulses will not move sweep contact if in the position shown in Fig. 4 or will cause it to be returned thereto from either of its other two possible positions. A pulse series of 4 pulses will cause return of sweep contact 68 from any position occupied by it to normal position and will then move it into contact with stationary contact 95. In doing so clearing lever 90 passes beyond cam finger 93 and to avoid release of holding pawl 94 during return movement, clearing lever 90 is pivotally attached to the clearing arm at 100 so as to be free to lag by displacement of spring 101 during return movement without displacement of cam finger 93 and holding pawl 94. In similar fashion a pulse series of 5 pulses will carry the sweep contact 68 to and leave it in engagement with stationary contact 96 regardless of the position occupied at the start of the pulse series.

While a pulse series of more or less than 3

pulses may be employed as a clearing or preliminary pulse series by simply varying the number of notches or steps in the segment 78 and appropriately relating the angular positions of the other parts a three pulse clearing series is preferred. The reason for this preference is that the apparatus will ignore a spurious radiation having two accidental peaks spaced in a manner corresponding to the delay interval necessary and will stop safe in the rather improbable case of 3 such peaks being properly spaced. The apparatus will only be dangerously responsive to the very improbable coincidence of 4 or more such peaks occurring in properly spaced intervals. To provide a greater number of preliminary clearing steps is to introduce an undue lag in the response of the apparatus. To provide a smaller number is to unduly increase the possibility of response to spurious radiations.

Stationary contacts 95 and 96 are employed as means by which selection is made of either forward or reverse driving of the hoist motor 11. To this end contact 95 will complete a circuit from main 12b, through lead 47, lead 67, sweep contact 68, contact 95, coil of relay 102, lead 103, and lead 104 back to main 12c. Relay 102 is of the normally-open, delayed-engagement type so that it will not respond to contacts made between contact 95 and sweep contact 68 when the latter is merely passing to and from a position of engagement with contact 96. However, when contacts 68 and 95 remain in engagement for an appreciable interval relay 102 closes and completes a circuit from main 12c through lead 104, lead 105, the contacts of relay 102, lead 106 to coil 107 of switch 108 and then through lead 109 back to power main 12a. This causes switch 108 to close for forward driving of hoist motor 11 to cause a lifting motion of hoisting line 10. In similar fashion engagement of contacts 68 and 96 causes closure of relay 110 and through lead 111 the energization of coil 112 of switch 108 to cause it to close for reverse or lowering driving of the hoist motor 11.

When sweep contact 68 engages neither of the contacts 95 or 96 neither of the coils 107 or 112 is energized and switch 108 remains open so that motor 11 is stopped.

For control of the trolley motor 8 and the bridge motor 4 control receiving unit 14 also contains receivers 113 and 114 identical in make up with receiver 57 with the exception that receivers 113 and 114 are tuned to respond, each to its own individual frequency. For example, receiver 113 may be tuned to respond to a frequency of 370 kc. and receiver 114 to a frequency of 390 kc. By reason of the identity of circuits and of parts in the receivers 57, 113 and 114 detailed description of the latter two is unnecessary and separate designating numerals for the parts thereof have therefor been omitted to avoid unnecessary confusion. It is sufficient to point out that reversing switch 115 under control of receiver 113 causes the stopping, starting and reversing of trolley motor 8 while reversing switch 116 in like manner responds to receiver 114 to control bridge motor 4.

For excitation of receivers 23, 57, 113 and 114 control transmitting unit 22 previously referred to is provided. The unit 22 as appears more clearly in Figs. 2 and 3 is made up of a three element vacuum tube 116 capable of driving an oscillating circuit with an output of limited wattage. The plate of tube 116 is connected by lead 117 with the mid point of a loop antenna 118

which forms with capacitor 119 an oscillating circuit tuned to the frequency of the master main-
tainer receiver 23. Inductively related to the
loop 118 is coil 120 connected to the grid of tube
116 so as to maintain oscillation. Battery 121
connected in circuit with the filament of tube
for heating the same is controlled by a switch or
start-stop button 122. For supply of plate cur-
rent battery 123 shunted by condenser 124 is
provided and connected as shown. Upon closure
of start button 122 which is self maintaining in
either open or closed position antenna 118 be-
gins to emit a steady radiation at its tuned fre-
quency, given for example as 410 kc. If at the
same time switch 30 in the control receiving unit
14 is closed, master switch 51 promptly closes
placing the crane in readiness for use.

Connected as shown in Fig. 2 so as to augment
the capacity of capacitor 119 upon closure of dial
switch 125 is a supplementary capacitor 126 of
such capacity as to alter the frequency of oscil-
lation in antenna 118 to that of receiver 114, for
example, from 410 kc. to 390 kc. Dial switch
125 is of conventional construction and therefor
shown diagrammatically only, being of the type
which makes contact on return movement only,
which return movement is accomplished at a
regulated rate. By reason of this a series of
pulses of 390 kc. frequency is interposed in the
steady emission of 410 kc. frequency each time
dial switch 125 is actuated. Dial switch 125 is
so adjusted as to its return rate that the duration
of each of the 390 kc. pulses is less than the in-
terval during which relay 45 will maintain itself
in closed position. By reason of this master
switch 51 is not disturbed by any regular mani-
pulation of dial switch 125.

In like manner capacitor 127 is arranged to
augment the capacity of capacitor 119 upon ac-
tuation of dial switch 128 to such an extent as
to alter the transmitter frequency to that of re-
ceiver 113 while capacitor 129 will accomplish a
similar function upon actuation of dial switch
130 so as to alter the transmitter frequency to
that of receiver 57.

For convenience there may be housed in the
unit 22 a meter 131 for indicating the condition
of batteries 121 and 123 upon closure of buttons
132 or 133 through connections not shown. A
meter 134 may also be provided for indicating
plate current connected in circuit in well known
manner not shown.

It may be observed that the relationship be-
tween transmitting unit 22 and receiving unit
14 is such that a command issued to the crane
can remain under execution only so long as the
transmitting unit 22 is properly functioning. If
unit 22 fails from any cause receiver 23 is no
longer excited and master switch 51 drops open.
In this way it is impossible for the crane to run
away beyond the control of the transmitting
unit 22.

In operation a person intending to use the
crane carries the unit 22 to the location where
supervision of the lift is most convenient. Switch
30 is assumed to be closed. The operator then
pushes the start button 122 and dials either
"north" or "south" on dial switch 125 to bring
the bridge 1 over the lift. Before, after or during
movement of the bridge the operator may dial
either "east" or "west" on the dial switch 128
to bring the trolley 7 to the desired position.
Upon arrival of the bridge 1 at the desired lo-
cation "stop" is dialed on switch 125 and upon
arrival of trolley 7 in the desired location "stop"

is dialed on the switch 130. Hoisting line 10
at any time either before, during or after these
motions may be manipulated as desired by simi-
lar dialing of switch 130. Lifting, traversing and
lowering of the load is accomplished in similar
fashion. At any time all functions of the crane
can be brought to a stop simultaneously by push-
ing the stop button of switch 122. Upon again
pushing the start button of switch 122 the crane
will resume the execution of any pre-existing
commands.

In order to permit the clearing of pre-existing
commands and to permit the placement of sus-
pended advance commands without activation of
receiver 23 inductance 135 and mechanically in-
terlocked switches 136 and 137 are provided and
connected as shown in Fig. 2. When the latter
switches are moved from the position shown to
a position where 136 and 137 are open, dial
switches 125, 128 and 130 may be actuated to
move the step-by-step units of their respective
receivers 114, 113 and 57 to and from any of their
three positions but without any of these com-
mands being executed. When the switches 136
and 137 are returned to the position shown in
Fig. 2 execution of any existing command will
then be brought about by reason of the activation
of receiver 23.

It is preferred that a single mechanical ac-
tuator for the interlocked switches 136 and 137
be provided as shown at 138 in Fig. 3.

While the apparatus as above described is em-
bodied in the familiar form of an overhead
traveling crane having three functions or move-
ments, it is evident that the apparatus may be
adapted to cranes or hoists having either more
or less than three functions. It also is feasible if
desired to employ step-by-step units having
more than three positions, controlled by ap-
propriate dial switches in the transmitting unit
22, by which more than one forward or reverse
driving speed may be selected.

In Figs. 6 and 7 is shown another form of the
apparatus of this invention in which the control
pulses are in the form of interruptions in the
otherwise continuously emitted radiation pro-
duced by the control transmitter. As shown in
Fig. 6 the control transmitter is made up of the
three element tube 139 connected as shown in an
oscillating circuit including an antenna 140 sup-
plied by the plate current source 141 through a
dial switch 142. The dial switch 142 as shown is
provided with an interrupted contact ring 143
over which the self-returning contact arm 144
may pass so as to cause interruptions in the plate
circuit thus producing interruptions in the emit-
ted radiation. In normal position the arm 144
remains in contact with the contact surface 143
as shown. Filament current is supplied from the
source 145 and is arranged to be interrupted by
the manual switch 146 when the apparatus is not
in use.

The signal emitted by the transmitter shown
in Fig. 6 is adapted to be received by a receiver
147 having an antenna 148. The receiver 147 may
be of well known form and so constructed as to
close the circuit between leads 149 and 150 so
long as a signal is being received from the trans-
mitter shown in Fig. 6 and in so doing to energize
the relay 151 with current supplied through con-
trol current supply leads 152 and 153. The relay
151 is of the rapidly operating type and is biased
by a spring 154 away from the position shown in
Fig. 7 but is held in the position there shown so
long as the transmitter 6 is emitting a signal.

Upon dialing of the switch 142 the several impulses in the form of signal interruptions which occur cause the relay 151 to move from the position shown in Fig. 7 to the position to which it is biased by the spring 154 and to return therefrom each time an interruption impulse occurs. In the position shown in Fig. 7 contact 155 of relay 151 being joined through lead 156 with control current supply lead 152 establishes a circuit through contact 157 and lead 158 with relay 159 and thence through lead 160 back to control current supply lead 153. The relay 159 is of the normally open, rapidly closing, delayed release type and it acts through its contacts and leads 161 and 162 to close and maintain the closure of main power switch 163. When a pulse occurs and contact 155 leaves contact 157 momentarily, relay 159 remains undisturbed because of its delay characteristics thus maintaining the closure of main power switch 163.

The dropping of contact 155 due to an impulse also causes it to momentarily engage contact 164 which through a lead 165 momentarily energizes relay 166 which is provided with a return connection through the lead 160. The relay 166 is also of the normally open, rapidly closing, delayed release type the amount of delay being sufficient to overlap at least two impulses caused by the contact arm 144 traveling at its normal rate. The closure of relay 166 is without immediate effect although a circuit from lead 160 through a relay 167, lead 168 and lead 169 is established in part up to a contact 170. Upon termination of the first impulse contact 171 engages contact 170 thus completing the circuit referred to by reason of connection of contact 171 with lead 156, the effect of which will be more fully described hereinafter.

During each impulse including the first the contact 171 also momentarily engages the contact 172 but on the first impulse contact 172 connected through lead 173 with contacts of relay 167 finds the relay 167 open and, therefore, performs no function. The relay 151 is provided with an additional set of contacts 174, 175 and 176 which likewise for reasons to be more fully explained hereinafter are idle during the first impulse.

At the end of the first impulse re-closure of contacts 155 and 157 recharges relay 159 to insure maintenance of closure of main power switch 163. Also at the end of the first impulse contact 155 leaves contact 164, but relay 166 being of the delayed release type remains closed temporarily. At the end of the first impulse also, contacts 171 and 170 close thus completing the circuit which supplies relay 167 which then closes. A single impulse such as this, however, does not operate to cause the execution of any control function which is felt by power elements of the circuit to be more fully described and if but a single impulse is received, relays 166 and 167 will again open.

If a succession of two impulses is transmitted and received, as soon as the second impulse interruption starts relay 166 still under retention is recharged but without effect since relay 167 is still under retention. The closure of contact 171 with contact 172, however, brings into play a new circuit since the contacts of relay 167 are now closed causing relay 177 which also is of the normally open, rapidly closed, delayed release type to become energized and to close contacts 177A and 177B. Closure of contact 177B is without immediate effect since it is joined by lead 178 with contact 175 which at the start of the impulse is open. The function of contact 177B, however, is

delayed, but briefly, since at the termination of the second impulse contact 175 is engaged by contact 174 with a result to be described hereinafter. The closure of contact 177A, however, may be of immediate effect since it is interposed in a circuit extending from supply lead 152 through leads 156 and 179 through a ratchet release magnet 180 and thence through lead 181, contact 177A, lead 182, contact 183, lead 184, clearing switch 185 and lead 186 back to supply lead 153.

Clearing switch 185 is a part of a stepper switch mechanism 236 having a pivotally mounted control arm 187 mounted on a shaft carrying ratchet wheel 188 and urged to the position shown in Fig. 7 by a return spring 189. The ratchet wheel 188 is positioned to be engaged by magnetically actuated advancing pawl 190 having an armature 191 arranged to be attracted by a magnet 192. The ratchet wheel 188 is also arranged to be retained against the returning action of spring 189 by a retaining pawl 193 having an armature 194 positioned to be attracted by the magnet 180 previously referred to. If the contact arm 187 is found in any position other than that shown in Fig. 7 at the moment of starting of the second impulse switch 185 will be in closed position and the closure of relay 177 will result in the energizing of magnet 180 and the lifting of the retaining pawl 193 from the ratchet wheel 188 thus permitting the spring 189 to cause return of the arm 187 to the position shown in Fig. 7. By reason of this any series of two pulses or the first two pulses of any series having a greater number of pulses than two will cause the arm 187 to return to the position shown in Fig. 7 regardless of where the same may be located.

At the end of the second pulse interruption contact 155 engages contact 157 maintaining retention of relay 159 and continued closure of switch 163. The separation of contact 155 from contact 164 is without immediate effect because of the delayed release characteristics of relay 166. At the same time contact 171 re-engages contact 170 insuring retention of relay 167. The separation of contact 171 from contact 172 is without immediate effect because of the delayed release characteristics of relay 177. The engagement of contact 174 with contact 175 now sets up a circuit through lead 178, contact 177B and relay 195 normally biased to the position shown which will be called the open position which is of the quickly attracted, delayed release type. This closes contact 195A for a purpose to be hereinafter described and opens the contact 183 so as to permit the retaining pawl 193 to return to retaining position.

On commencement of a third interruption impulse relays 159, 167 and 195 maintain themselves temporarily while relays 166 and 177 are recharged so as to prolong the maintenance thereof. As a result all previously established circuits involving closure of the relays named are preserved and upon engagement of contact 174 with contact 176 a circuit is established for the first time through lead 196, contact 195A, lead 197, advancing magnet 192, lead 198 and lead 160 causing the advancing pawl 190 to move the arm 187 into contact with idle contact 199.

As the third interruption impulse comes to a close relays 159, 167 and 195 are recharged to prolong the maintenance thereof temporarily and relays 166 and 177 become self-maintained

temporarily thus preserving circuits previously set up through these relays.

If no further impulses occur, relays 166 and 177 at the end of their delay period will drop open causing relays 167 and 195 to follow at the end of their delay period. The arm 187 will thus be left in contact with the idle contact 199 where it will remain until a new pulse series of at least two pulses is applied to cause arm 187 to return to the position shown in Fig. 7.

In a pulse series of more than three pulses at the commencement of the fourth interruption pulse engagement of contact 174 with contact 176 causes the motor magnet 192 to advance the arm 187 to the segment 200. At the end of the fourth interruption pulse contact arm 187 remains in contact with segment 200 unless further pulses occur in the series. For each pulse in the series in excess of four the arm 187 is successively advanced to segments 201 to 208, respectively, depending upon the number of pulses in the series. At the termination of any pulse series having more than two pulses contact arm 187 is left in engagement with that segment last contacted in the manner described in connection with the termination of a three pulse series.

The segments 200 to 208 are connected as shown so as to control a hoist motor 209, a bridge motor 210 and a trolley motor 211 mounted as described in connection with previously described forms of the invention so as to actuate the three essential motions of an overhead traveling crane. In the case of hoist motor 209 a pulse series of seven pulses will bring the arm 187 into engagement with segment 203 and if the pulse series there terminates such engagement will be retained. In doing so a circuit is established through lead 212 extending from control current supply lead 152 through spring 189 and arm 187 to segment 203 and thence through lead 213 to reversing switch magnet 214 and thence through lead 215 and the contacts 229 of relay 216 to the lead 217 which joins with control current supply lead 153. Magnet 214 is of the delayed attraction type so that it will not respond to the passage of arm 187 across the segment 203 in moving to and from other segments but only responds when the arm 187 is allowed to dwell for a substantial interval in contact with segment 203. Upon sufficient energization of magnet 214 forward driving contacts 218 are closed, thus supplying current from the power mains 219 to the hoist motor 209 to cause the same to travel in the hoist direction. At the same time a maintaining contact 220 is closed by energization of the magnet 214 thus providing for maintenance of the magnet 214 even though the arm 187 is subsequently moved from engagement with segment 203. This maintaining circuit extends through lead 221 and normally closed contact 222 and lead 223 into connection with control current supply main 152. In entirely analogous fashion segment 204 is connected through lead 224 with magnet 225 arranged to close power contacts 226 to cause hoist motor 209 to travel in the lowering direction. Upon shifting of contact arm 187 from contact 203 to 204 the maintaining circuit of magnet 214 becomes broken by opening of contact 222. At the same time contact 227 closes to establish a maintaining circuit for magnet 225 which will cause it to remain energized even though the arm 187 is subsequently moved out of engagement with seg-

ment 204. To terminate the driving of hoist motor 209 when running it in either direction a pulse series of four pulses is required which will bring the arm 187 into engagement with segment 200. When this occurs current is directed through lead 223 to magnet 216 and thence through lead 217 back to the control current supply main 153. The magnet 216 is of the delayed attraction type so that a substantial dwell of the arm 187 in contact with the segment 200 is required to cause the magnet 216 to open the normally closed contact 229 upon which magnets 225 and 214 both depend for their energization. Thus a four pulse series will cause stoppage of the hoist motor 209 regardless of the direction in which it is traveling.

In an entirely analogous manner a pulse series of nine interruption pulses will through switch assembly 230 cause driving of bridge motor 210 in one direction while a pulse series of ten pulses will cause driving of the same in the opposite direction through operation of switch 231. In order to bring about stoppage of bridge motor 210 segment 201 and relay 235 are brought into play by a pulse series of five pulses. Similarly through pulse series of 11 or 12 pulses trolley motor 211 can be operated in either direction through the operation of switches 232 and 233. Stoppage of trolley travel is brought about by a pulse series of six pulses bringing into operation segment 202 and relay 234.

By reason of the arrangement above described an operator through actuation of the transmitter shown in Fig. 6 may dial so as to bring into play any one or more of the crane functions which may all proceed simultaneously and may at any time cause stoppage of any of such functions selectively or in the case of emergency may cause stoppage simultaneously of all functions by opening the manual switch 146. It is furthermore apparent that if for any reason the transmitter in Fig. 6 should fail relay 151 will move to the position opposite that shown in Fig. 7 thus causing main power switch 163 to open. Furthermore, the apparatus of this invention as set forth in Figs. 6 and 7 is relatively insensitive to accidental transients since it will not respond to cause any driving motion of any motor unless a pulse series of at least five pulses shall be impressed upon the receiver 147 and it is very unlikely that a transient will occur in such a way as to imitate such a five pulse series. Furthermore, in the form of apparatus described in connection with Figs. 6 and 7 but a single receiver 147 is required, the structure of which may be substantially as shown in the case of master maintainer receiver 23 shown in Fig. 1 although any other suitable form of receiver may be used for the purpose.

We claim:

1. In a remotely controllable power unit a transmitter adapted to transmit a continuous signal subject to manually selected series of pulse-interruptions of predetermined duration, spacing, and number of pulses; an electric driving motor for said power unit; power mains for supplying power thereto; switch means in said power mains for establishing and interrupting the supply of power to said motor; a receiver responsive to the signal transmitted by said transmitter; means connected to and activated by said receiver responsive to the continuous signal emitted by said transmitter adapted to cause closure of said switch means during persistence of said signal and to retain said switch

means closed thereafter for an interval not less than the duration of a pulse-interruption of said continuous signal; selector means adapted to occupy a plurality of selective positions, connected to said receiver and adapted to respond to a series of pulse-interruptions delivered therefrom to move to a predetermined selective position dependent upon the number of pulse-interruptions in said pulse series; and means in circuit with said motor adapted to alter the operating condition thereof and adapted to respond to the position assumed by said selector means to interpose a different operating condition upon said motor for each selective position assumed by said selector means.

2. In a remotely controllable crane having a power unit for operation thereof a transmitter adapted to transmit a continuous signal subject to manually selected series of pulse-interruptions of predetermined duration, spacing, and number of pulses; an electric driving motor for said power unit; power mains for supplying power thereto; switch means in said power mains for establishing and interrupting the supply of power to said motor; a receiver responsive to the signal transmitted by said transmitter; means connected to and activated by said receiver when responding to the continuous signal emitted by said transmitter adapted to cause closure of said switch means during persistence of said signal and to retain said switch means closed thereafter for an interval not less than the duration of a pulse-interruption of said continuous signal; selector means adapted to occupy a plurality of selective positions, connected to said receiver and adapted to respond thereto upon occurrence of a series of pulse-interruptions to move to a predetermined selective position dependent upon the number of pulse-interruptions in said pulse series; and means in circuit with said motor adapted to alter the operating condition thereof and adapted to respond to the position assumed by said selector means to interpose a different operating condition upon said motor for each selective position assumed by said selector means.

3. In a remotely controllable crane having a power unit for operation thereof a transmitter adapted to transmit a continuous electromagnetically radiated signal subject to manually selected series of pulse-interruptions of predetermined duration, spacing, and number of pulses; electric driving motors for said power unit; power mains for supplying power to said motors; switch means in said power mains for establishing and interrupting the supply of power to said motors; a receiver responsive to the electromagnetically radiated signal transmitted by said transmitter; means connected and activated by said receiver when responding to the continuous signal emitted by said transmitter adapted to cause closure of said switch means during persistence of said signal and to retain said switch means closed thereafter for an interval not less than the duration of a pulse-interruption of said continuous signal; selector means adapted to occupy a plurality of selective positions connected to said receiver and adapted to respond thereto upon occurrence of a series of pulse-interruptions to move to a predetermined selective position dependent upon the number of pulse-interruptions in said pulse series; and means in circuit with said motors adapted to alter the operating conditions thereof and adapted to respond to the position assumed by said selector means to interpose different operating

conditions upon said motors for each selective position assumed by said selector means.

4. In a remotely controllable power unit a transmitter adapted to transmit a continuous signal subject to manually selected series of pulse-interruptions of predetermined duration, spacing, and number of pulses; a receiver responsive to the signal transmitted by said transmitter; a first receiver operated relay having three signal contacts closed only when said receiver is receiving and responding to a signal, and three pulse contacts closed only when said receiver is not receiving and responding to a signal; a second relay in circuit with one of said signal contacts and having a contact closed when said signal contact is closed said second relay being adapted to remain closed for an interval not less than the duration of a pulse interruption; a main power switch activated by said second relay contact adapted to close a power circuit to an operating unit as long as said second relay contact is closed; a third relay in circuit with one of said pulse contacts and having a contact which is closed when said pulse contact is closed said third relay being adapted to remain closed for an interval exceeding the spacing between pulse interruptions; a fourth relay in circuit with another of said signal contacts and with the contact of said third relay and having a contact which is closed when said signal contact is closed and said third relay is closed said fourth relay being adapted to remain closed for an interval not less than a pulse interruption; a fifth relay in circuit with the contact of said fourth relay and with another of said pulse contacts and having a clearing contact and an advancing contact both of which are closed when said fourth relay is closed and said pulse contacts are closed said fifth relay being adapted to remain closed for an interval exceeding the spacing between pulse interruptions; a sixth relay in circuit with the advancing contact of said fifth relay and with the third signal contact adapted to be excited when the latter are closed and having a clearing contact which is open when said sixth relay is excited and closed when it is not and an advancing contact which is closed when said sixth relay is excited and opened when it is not; a ratchet held spring returned selector switch having an advancing magnet, a retaining pawl adapted to engage the ratchet and a clearing magnet adapted to disengage said pawl from said ratchet to permit said selector switch to return to a home position; circuit connections adapted to complete a circuit through the third of said pulse contacts, the advancing contact of said sixth relay and the advancing magnet of said selector switch; circuit connections adapted to complete a circuit when said selector switch is in a position away from home position through the clearing contacts of said fifth and sixth relays and said clearing magnet; a plurality of control circuits adapted to be selectively completed by said selector switch; and an operating unit connected to be supplied with power through said main power switch and adapted to be controlled as to its operating condition by the selective action of said selector switch upon said control circuits.

5. In a remotely controllable power unit a transmitter adapted to transmit a continuous signal subject to manually selected series of interruption pulses of predetermined duration, spacing, and number of pulses; a receiver responsive to the signal transmitted by said transmitter; a receiver operated relay means; a main

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power switch activated by said relay means adapted to complete a power circuit to an operating unit as long as a signal is being transmitted and received; a selector switch having means for selectively completing a plurality of circuits, an advancing magnet, retaining means and a clearing magnet adapted to act upon said retaining means to cause said selector switch to return to a home position; circuit connections between said relay means and said selector switch magnets adapted to cause said selector switch to move to complete predetermined circuits in response to series of predetermined numbers of pulse interruptions; a plurality of control circuits adapted to be selectively completed by said selector switch; and an operating unit connected to be supplied with power through said main power switch and adapted to be controlled as to its operating condition by said control circuits completed by said selector switch.

6. In a remotely controllable hoist having an electric motor for driving the same, a main power control switch for said motor, an electro-magnetic radiation responsive receiver including switch operating means operative to close said main power control switch upon excitation, a second switch having a plurality of positions corresponding to driving conditions of said motor in circuit with said motor, a second receiver including switch operating means operative to alter the position of said second switch upon excitation by a predetermined pulse radiation,

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and a transmitter including means forming an oscillatable circuit containing an antenna, means for driving said oscillatable circuit to cause said antenna to emit a steady radiation capable of excitation of said first receiver, and means adapted to interrupt said steady radiation and to cause said antenna to emit control pulses of such pre-determined spacing and duration as to excite said second receiver.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,188,202	Perry et al.	June 20, 1916
1,597,416	Mirick	Aug. 24, 1926
1,635,779	Carter	July 12, 1927
1,760,479	Colman	May 27, 1930
1,805,167	Fitzgerald	May 12, 1931
2,052,708	Hammond	Sept. 1, 1936
2,325,829	Boswau	Aug. 3, 1943
2,388,595	Boyajian	Nov. 6, 1945
2,388,748	Kipetzky	Nov. 13, 1945
2,391,881	Clay	Jan. 1, 1946
2,393,892	De Ganahl	Jan. 29, 1946
2,396,091	De Bey	Mar. 5, 1946
2,397,088	Clay	Mar. 26, 1946
2,397,475	Dinga	Apr. 2, 1946