ELECTRO MAGNETS
AS
APPLIED TO MOTOR CONTROL
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INTRODUCTION.

This thesis is intended to cover the operation of electro-magnets as applied to motor control. No attempt has been made to enter into the theoretical explanation of the principles involved; this in itself would constitute a thesis of unusual length.

The first chapter, a classification of electro-magnets, consists of a brief outline of electromagnetic switches, with such explanation of construction and operation as will familiarize the reader with the various types of switches considered in the following chapters.

The succeeding chapters constitute a discussion of standard and special types of controlling equipment.

The rapid development of electro-magnetic switches during the past century has been unusually surprising. The effect which an electric current, flowing in a wire, can exercise upon a compass
needle, was discovered by Oersted in 1820. Research
work by Arago, Ampere and Davy quickly followed. In
the latter part of 1820 Arago announced that a copper
wire carrying a current would attract iron filings. But it was not until 1825 that the electro-magnet
was discovered. At that time William Sturgen construc-
ted several electromagnets, showing in his experiments
that the poles of the magnet could be reversed by
winding the wire about the iron in the opposite di-
rection. His first publicly exhibited electromag-
net weighed about seven ounces and was able to lift
a load of nine pounds.
CLASSIFICATION

In ordinary practice it has been found convenient to classify solenoid switches in three general groups. (1) Plunger type electro magnet without fixed core and a movable armature. (2) Plunger type electro magnet with a fixed core and a movable armature. (3) Clapper type magnetic switches.

The essential parts of electro magnetic switches are the contacts, blowouts, magnet coil and the frame.

The type of contact depends on the duty which the switch must perform. Carbon as a general rule is used only on auxiliary contacts which are not subject to severe and constant duty. Solid copper is now used on contacts which carry and rupture normal values of current up to about one thousand amperes. This type of contact should
close with a rolling motion to prevent the first rush of current from welding them, or pitting the final carrying surfaces. For higher current values it is common practice to use laminated copper brushes in addition to the solid ones, making and breaking the current on the solid contacts, otherwise the laminations would soon be welded together.

The blow-out coil is a very essential part of the larger switches since it is necessary that the arc be broken as soon as possible to prevent burning of the contacts. The coil is connected in series with the circuit through the contacts, the current passing in such a direction that the magnetic field set up due to the sudden decrease in current tends to blow the arc away from the switch.

The magnet coil must be so designed that when energized, it will positively and instantly close the contacts on a range of voltage from twenty percent below to fifteen percent above normal. The insulation of the coil must stand the required high voltage test as well as any traces of moisture and acids, or a considerable rise in temperature.
In the context of the article titled "The Influence of Climate Change on Marine Ecosystems," it discusses the pressing issue of warming ocean temperatures and its impact on marine biodiversity. The authors emphasize the need for immediate action to mitigate the effects of climate change on the ocean environment. They argue that continued research is essential to understand the complex interactions between climate change and marine ecosystems. The article calls for international cooperation to share knowledge and resources in addressing this global challenge.
The frame of the switch must in the first place be designed with mechanical strength such that it will stand up under very severe use. It must be of such design that the iron will not be over-saturated when the coil is energized and in the case of alternating current switches, it should be of a laminated structure. When the coil is de-energized, the magnetism must break down instantly to permit the switch to open at once.

Plunger Type Electro Magnet Without Fixed Core and a Movable Armature.

This form of electro magnet is not used to a very great extent. One of the most interesting applications is its use in the manufacture of circular loom for cleaning the inside of the final product. The coil of the magnet is placed around the loom with the plunger inside and is of such strength as will hold the plunger within its magnetic field when the loom is drawn through it; the plunger acting as the cleaning tool.
Plunger Type Electro-Magnet With Fixed Core and a Movable Armature.

Brake Magnets.

The D.C. brake magnet, one of the simplest forms of the plunger type electro magnet, is shown in detail in figure (1). From this sketch is can readily be seen that the coil is well surrounded by a solid soft iron frame which affords a very efficient return path for the flux and a protection from external injury. The design of the frame and coil depend upon the load, length of travel, duration of excitation, and the interval between excitations.

The cross section of the plug and plunger

depends upon the magnetic flux required to produce the pre-determined pull. In case a short stroke is
required, a plug and plunger with flat sealing surfaces is preferable. However, if the stroke is of considerable length, it has been found necessary to make the sealing ends of the core and plunger conical. The reason for this may be explained by reference to figures 2, 3 and 4.

At the beginning of the stroke the forces tending to close the switch are represented by $F$ and $F_1$, figure 3, the resultant being $R$. As the plunger nears the plug the forces $F$ and $F_1$ pull in a direction nearing $90^\circ$ to the resultant $R$, as shown in figure 4. The resultant force $R$ therefore keeps getting smaller. The result is that we have a strong pull at the commencement and a weaker pull at the sealing point. This prevents the switch from jumping in with a hammer blow as would be the case with the flat surface plunger.

The alternating current brake magnet, figure 5, is essentially the same as the D.C. brake, except that the plunger and frame are made up of laminations, to cut down hysteresis and eddy current losses.
THIRD SIZE BRAKE SOLENOID
Overloads.

A simple modification of the brake magnet is found in the overload. This magnet is designed for continuous duty, its coil or coils carrying full load current at all times. The ampere turns are calculated to produce a flux of such strength as will permit the plunger to remain in the unsealed position on normal load current of the motor, but in case of an overload, the plunger will come into sealed position at the same time opening an auxiliary contact which in turn opens the main line switch.

Overloads may be grouped into four classes: (1) Overloads with series coils. (2) Compound overloads. (3) Overloads with an inverse time element. (4) Overloads with an inverse time element with instantaneous trip on excessive overload.

The series coil overload consists of a single coil connected in series with the armature and acts instantaneously on an overload. When the equipment trips thus opening the main line switch, the coil of the overload is de-energized and the
Fig. 8.
Compound Overload.
Fig. 7.

Inverse Time Element Overload.
plunger drops into the unsealed position.

The compound overload, figure 6, is made up of two coils, one in series with the armature circuits, and the other across the line ahead of the main switch. In case of an overload both coils act to draw the plunger into sealed position, thus opening the main line switch. In this case however, the plunger does not drop into normal position because the shunt coil remains energized until the shunt circuit is opened by the operator, usually at some remote point by means of a snap switch.

An overload with an inverse time element shown in figure 7 is a series overload, the instantaneous operation of which, is checked by means of a dash pot. This relay will not operate on momentary overloads or line surges. The heavier the overload the quicker the operation. The action of the relay can be made instantaneous on excessive overloads by addition of a calibrated valved in the piston of the dash pot.

Clapper Type Magnetic Switch.

The clapper type magnetic switch is essentially a horse shoe magnet with a coil on one leg, the armature being hinged in such a position that
Fig. 8.

Clepper-Switch with Normally open contacts.
it completes the magnetic circuit when the switch is closed. There are many modifications of this type of switch, several of the more important forms are shown in figures 8 to 11 inclusive.

Figures 8 and 17 show clapper switches with one normally opened contact. This type of switch is also made with two or more contacts, each style as a usual thing being held open by gravity and magnetically closed.

A switch with normally closed contacts is shown in figure 9. This switch is held closed by springs or gravity. The spring is used in case a quick and positive operation is required.

A combination of the open and closed types is shown in figure 10 and is used to control and operate many combinations of control circuits.

Figure 11 shows a very interesting modification of the clapper switch and is known as the D.C. magnetic lock-out switch. This switch consists of two coils in series, one coil acting to close the switch and the other tending to open or lock it out. The closing coil "C" has more turns than
the lock out coil "L". The closing coil has a complete iron circuit for the flux whereas the lock-out has not. The cross section of the iron circuit of the closing coil is of such size that it will be over-saturated by the inrush starting current.

The lock-out coil is of such design that its pull will be stronger than that of the closing coil on the inrush current and the switch is held open. As the current drops to normal the pull exerted by the closing coil remains about constant whereas the lock-out coil's pull weakens and at some pre-determined value the switch will close.

The A.C. clapper switch, figure 12, is almost invariably required to be double pole. In case of a three-wire three-phase circuit, the two-pole switch is sufficient to open the entire circuit. As to a four-wire two-phase, one-line of each phase is opened or else two switches are used.

Three-Phase Relays.

The three-phase relay, figure 13, is used with a slip ring motor in order to cut out
Fig. 12.

A. C. Clapper-Switch.
the several steps of starting resistance. These relays are shorted out after a few seconds of operation and are therefore designed for very intermittent duty and are correspondingly light and sensitive. Three-phase relays are manufactured with three separate coils and are so connected that they form the star point of the resistance in the secondary circuit of the motor. These relays are short circuited when corresponding resistance steps are cut out of the circuit by the succeeding clapper switches. Due to the fact that the relay forms the star point of the resistance, the potential difference between any two points of the relay is very small, therefore, the insulation between coils is very slight.

To prevent this relay from pumping on low frequencies, the three equal coils are connected in the three phases of the secondary circuit with one end of each connected together. With this connection the total pull exerted will be constant regardless of the frequency if the current is balanced and constant. It is very important that the relay
does not pump up and down with a change in frequency because the frequency in the secondary changes from that of the primary frequency at stand-still to as low as one or two cycles at normal speed, depending on the percent slip.

Some relays do not have the three coils connected to form the star point of the starting resistance in which case the coils are heavily insulated. Relays of this type when connected between the resistance and the slip rings of the motor are known as jam relays. The jam relay is used to re-insert resistance in the rotor circuit of the motor when a certain maximum torque is reached, so that if the motor is stalled by encountering an excessive load, the torque will be automatically increased up to the maximum which the machine can operate. This avoids stalling the motor with the resistance short circuited, which would result in opening the circuit breaker.

Vibrating Relay.

The vibrating relay, figure 14, is a spring opened single-pole clapper switch of very
Fig. 14.

Vibrating Relay.
light and sensitive construction, used to automatically accelerate the motor by varying the shunt field current. The operation of this relay may be explained by reference to figure 15.

The shunt field of the motor is connected through the clapper switch contacts which are shunted by a variable resistance. The relay coil is wound in two separate series sections, each in the same direction and carry the armature current. When the main line switch closes (not shown in the diagram) the inrush current closes the relay, cutting out the resistance R, thereby increasing the shunt field current which reduces the inrush current. As the motor speeds up and the inrush current drops to
a pre-determined setting, the relay will open, reinserting the resistance in the shunt circuit. This causes an increase in speed with the second inrush of current of somewhat lower value than the first. The relay will repeat, through this sequence of operations until the motor has attained full speed.

![Diagram of a relay system](image)

*Fig. 16*

It can readily be seen that the vibrating relay when used in connection with one or more armature accelerating switches, affords a very effective means of producing a smooth acceleration. When the last accelerating switch closes, it shorts out one section of the coil. Now in case the motor is overloaded to about 150 percent, the current through
the coil L will be sufficient to close the relay and slow up the motor.

By winding the two coils of this relay differentially and connecting one in series with the armature and the other across the line, as shown in figure 16, the relay can be used as a protection from overhauling loads. Under normal operation of the motor, this switch is held closed by the current through the series coil. In case of an overhauling load the motor will act as a generator, the reversal of current will drop the relay, reinserting resistance in the field circuit, thus lowering the generated voltage preventing the motor from pumping back into the line.

D.C. Series Relay.

A D.C. series relay shown in the lower part of figure 17, is a small clapper type, normally closed switch, held in position by an adjustable spring. The stationary contact of the switch is also adjustable to permit the changing of the magnetic gap.

In operation, this switch will be opened by an inrush of current, thus breaking the control
Fig. 17.
circuit of the next accelerating switch. As the current decreases in value, the relay will close. The opening and closing point of this relay being determined by the length of the air gap and spring tension.

In the manufacture of motor controlling equipment, combination of the foregoing electro magnets are assembled on panels, forming a self starting apparatus.

**Plunger Type with Self Starters.**

Plunger type self starters are of two general classes, the gravity or dash-down type and the dash-up type. These starters are always made with conical ceiling ends to the plunger and core. The otherwise rapid operation of this equipment is checked by means of a dash pot which may either be an air or oil dash. The oil dash is used where the apparatus is subject to great changes in external temperatures. The oil is one the viscosity of which does not vary with ordinary changes of temperatures.

**Potential Type Self Starters.**

The potential self starter is an A.C.
equipment in which the motor is started from the
low taps of a transformer, being thrown directly
across the line after the motor has attained about
fifty percent full speed. This operation is accom-
plished by means of a timed relay and several clapper
switches depending upon the size of the motor
and number of transformer taps.

Primary and Secondary Resistance Self
Starters.

The primary resistance self starter is
used to cut out one or more steps of resistance in
the primary circuit of a squirrel cage induction
motor. This action is produced by means of a timed
relay and two or more clapper switches.

The secondary resistance self starter is si-
milar to the primary starter. The circuits in
this case being controlled by a timed dash pot and
two or more clapper switches, or three-phase re-
lays.

D.C. Clapper Type Self Starter.

A D. C. Clapper type self starter is one
in which the acceleration is controlled by a combina-
tion of D.C. Clapper switch and series relays;
clapper and lock-out switches; and clapper and timed limit relays.
PUMP STARTERS.

The constantly increasing demand for pumping machinery has led to the development of various types of equipment.

For installations where the requirements are limited to starting the apparatus at a predetermined time the hand starter is usually entirely satisfactory. But for most installations the requirements on the demand of the pump are such that the starting and stopping time are not known in advance, such as in the case of a fire pump connected to a sprinkler system.

The advantages of the solenoid operated starters are that a float switch in connection with a gravity system afford a means of maintaining fixed limits in water level in reservoir; or by means of a pressure gauge, the pressure of a compressor or vacuum system can be held between fixed limits; the saving in operating cost, because the motor is operated only when needed.
In some installations such as mine pumps, it is essential that the controller automatically re-start the motor after a voltage failure and subsequent restoration of the supply.

In order to start some motors which have a very large starting load it is necessary to use an unloader solenoid in connection with the starter, which removes the load during starting.

Sewage Elevation Controller.

A very interesting panel for controlling pumps in connection with a sewage system, is shown in diagram 18. This panel is designed to operate four pumps in connection with a sewage disposal plant. A photograph of the panel is being shown in figure 19. The number of pumps required for service depend upon the head of sewage in a large reservoir. The object of the panel is to automatically start and stop one or more of the pumps as the case may require.

The essential parts of this equipment are, four identical motor control panels, 1-3-4-5, a
Fig. 19.
Sewage Pumping Station Panel
general control and meter panel 2, and a five point float switch. The motor control panels are potential self starters. Each pannel is equipped with a dash-pot relay and two clapper switches. The general control has two wattmeters, a knife switch, clapper switch and plug board. The plug board is used for connecting the motors in such a manner that they can be operated in any desired sequence.

For convenience consider that the flow of sewage has been light and the tanks almost empty and pumps not operating. As the sewage rises in the tanks the first contacts 1 and L of the float switch close completing the circuits for the clapper switch T. T then closes connecting the low voltage tap of the transformer to the buss bar. As the sewage continues to rise the second contacts 2 and L of the float switch close, energizing the clapper switch S, and the dash-pot relay. The clapper switch closes starting the motor on low voltage. As the timed relay closes, it opens the circuit of switch S, dropping it out and instantly closing the circuit of S2, placing the motor direct across the line, If
to Time Frame: The recent events have brought a new perspective to the issue.

Long secret: The recent events have brought a new perspective to the issue.

The recent events have brought a new perspective to the issue.
the pump started has not sufficient capacity to handle the incoming sewage, the other motors will be started as their control circuits are closed through the contacts of the float switch.

As the sewage recedes the pumps will be cut out, by operation of the float switch, in the reverse order to which they were started.

Compressor Pump Starter.

A thermostat control panel for a small automatic refrigerator plant is shown in diagram 20. The essential parts of the equipment are two A.C. SW., timed relay, two overloads, high pressure cut-out, thermostat, and the usual knife switches, fuses and gauges.

The apparatus is for operating a two-phase four-wire induction motor, connected to an ammonia compressor. When the temperature of the refrigerator becomes warm, the thermostat closes the contacts H and O, energizing relay R, which closes energizing relay D. The relay D in closing places a short across the two overload coils then closes the circuit of the main line switch M. This opera-
The subject matter of the text is unclear due to the quality and orientation of the image.
Fig. 20.

A. C. Thermostat Control Panel.
tion throws the motor across the line and also opens the circuit of the timed relay D, which starts to descend to its original position. As D descends, it closes the contact for the switch 1 R, which shorts out the resistance in the rotor circuit; it next removes the short from the two overload coils. The motor then operates at full speed. As the refrigerator cools off, the thermostat closes the contacts O and C, short-circuiting the coil of relay R which opens the contact circuit and shuts down the motor.

A photograph of a three-phase thermostat control panel is shown in figure 21.

Potential Pump Starter.

A potential starter for pumping equipment as may be used for small installations, is shown in diagram 22. The motor here shown is two-phase, four wire, but by making changes as noted on the diagram, a two-phase, three-wire, or a three-phase induction motor may be used. The control equipment is made up of three magnetic switches, one timed relay; two inverse time element relays and one po-
Thermostat Panel

Fig. 21.
Fig. 22.

A. C. Potential Starter.
This potential starter is controlled by connecting the control lines C, K, and LX to the corresponding lines of any of the three wire starting stations shown in diagram 23. When the starting connection is made, the switches S₁ and S₂, and the timed relay D are energized. The switches close and the motor is connected to the low voltage taps of the transformer. As the timed relay nears the end of its stroke the circuit of the switch S₂ is opened and the circuit of S₃ closes. On closing the switch, S₃ opens the circuit of S₂ and connects the motor across the line. This leaves the motor operating at normal speed with the timed limit over-load protection and may be stopped in the usual manner. The switches S₂ and S₃ are mechanically interlocked so that they cannot be closed, at the same time short-circuiting a part of the transformer.

Secondary Resistance Starter.

A Secondary resistance type self starter as may be used in connection with small pumps, is shown in diagram 24. This equipment is for a three-phase wound rotor induction motor and consists of
Fig. 33.

Starting Stations.
Fig. 24.

A. C. Secondary Resistance Starter.
one main clapper switch, one gravity type timed accelerator, two inverse time element overloads. When the power is thrown onto this apparatus, by closing the knife switch the timed accelerator is brought to its upper-most position opening its own control circuit. This operation de-energizes the accelerator but it is held in position mechanically. It also closes the pick-up circuit for the main switch, thus preventing the motor from being thrown across the line with its secondary resistance short-circuited. To start the equipment, the start button is depressed, closing the main switch. The main switch on closing, starts the motor and also trips the latch of the accelerator. The accelerator descends cutting out the resistance. In case the motor is shut down either by pushing the stop button or by an overload, the main switch will open and the accelerator will again come to its uppermost position.

In case this equipment is being used on a vacuum system of known demand and where it is not necessary to run the motor at full speed, an attachment may be added to the accelerator by means of which
its descent may be stopped at any position. This attachment may be made so that the final position is set either mechanically at the starter or electrically from a remote point.

D.C. Pump Starter.

Figure 25 shows a wiring diagram for a lockout self starter with either two or three wire control as used for driving pumping machinery. This equipment consists of: one main switch, and four magnetic lockout switches. The control wires L-C-K may be connected to any of the controlling devices shown in figure 23. The apparatus is started by closing the contact of the start switch. This energizes the main switch coil closing it, which starts the motor with all the resistance in the circuit, and also cuts in a protecting resistance. The motor is brought up to speed by the action of the four magnetic lockout switches. The last lockout switch is equipped with a shunt coil which holds the switch closed through all variations of load.
Fig. 25.

B.C. Pump Controller.
ELECTRIC SHOVEL CONTROL.

The first electrically operated shovel used direct current motors but on account of the necessity of transmitting the power, to the shovels, usually over long distances, most of the shovels are now equipped with alternating current motors.

The ordinary electric shovel is equipped with three motors, one each for hoisting, thrust and swing. On the large type of shovel it has been found that the automatic control, although consuming more power, will handle more ground in a given time than will a non-automatic. However on the smaller type of machine the drum type control is used on the swing and thrust, the hoist usually being automatic.

The hoist control equipment is shown diagrammatically in figure 26. The hoist motor is usually a wound rotor induction motor. The control
Fig. 26.

A. C. Shovel Hoist Controller.
panel is not equipped for reversing the motor because there is always sufficient load to overhaul the motor when brakes are released. The essential parts of the hoist panel are: circuit breaker equipped with series overloads; main line switch, five accelerating switches, four accelerating three-phase relays; four jam relays and one drum master controller.

In hoisting, the motor can be brought up to full speed automatically by placing the master in the high speed position, 6. With the master in this position, the main and first accelerating switches close. The inrush of current energizes the first accelerating relay R2 which opens and remains open until the current drops to a pre-determined value, permitting the relay to close and energize the second accelerating switch 3R. The operation continues through the remaining relays until the motor is at full speed. If the operator wishes to run the motor at any intermediate speed he can do so by placing the master on one of the intermediate points. There are six different speeds to select from.
For convenience, suppose the dipper is hoisting through soft ground and suddenly encounters an excessive heavy obstruction, tending to stall the motor. For just such emergencies this controller is equipped with four jamming relays: $j_1$, $j_2$, $j_3$, $j_4$. Each relay is set to open and close at different current values. If the obstruction is light, the jam relay $j_1$ with low calibrations will open, cutting out the last accelerating switch 6R, thereby reinserting resistance in the rotor circuit, and automatically increasing the torque up to the maximum which the machine can stand. This prevents stalling the motor with the resistance short circuited, which would result in opening the circuit breaker and loss of power. Had the obstruction been very heavy, more of the jam relays would have operated. If it would be possible for the motor to hoist through the obstruction at a low speed depending on the number of jam relays that operated, the hoist motor would continue at low speed until past the obstruction. It would then be automatically accelerated to full speed. In case the dipper strikes
a load sufficient to stall the motion instantly, the hoist motor which is operating at a high speed could not be stopped at once without some injury to the moving parts. The momentum of the motor in this case is absorbed in a friction clutch.

The swing motion is controlled by a full reverse automatic selfstarting equipment shown diagrammatically in figure 27. The panel is equipped with: circuit breaker with series overloads, two reversing main switches, four accelerating switches, four accelerating relays and one master controller. The operation of this panel is the same as that of the hoist except that the motor has reversing switches and there are no jam relays. The accelerating relays on this panel are very essential because the inertia of the boom is very high and if the acceleration was too fast the shovel would be lifted off the track. In the case of a drag line where the boom is very long, the adjustment of the accelerating relays is of still greater importance.

The thrust motion of the shovel is controlled essentially the same as the swing except that sufficient permanent resistance is left in the secon-
Fig. 27.

A. C. Shovel Swing Controller.
dary circuit so that the speed torque curve is nearly a straight line when the controller is in the maximum to have the bucket follow the curvature of the bottom of the pit without danger of wrecking the machine by exerting undue stresses on the thrust and hoist motor.

A photograph of the hoist and swing panels are shown in figure 28.
- used to have enough houses and could be distributed evenly.

And in an effort to make more use of the resources available, a group of engineers and architects have begun to develop a new building technique that is expected to revolutionize the way we build and live in the future. According to the engineers, this new technique will enable us to construct entire cities of millions of buildings at once.

These plans have faced a lot of opposition, especially from those who are concerned about the environmental impact of such a huge project. However, the engineers believe that this will be a step forward in sustainable urban development.
Fig. 28.

HOIST AND SWING CONTROLLERS
PRINTING PRESS CONTROL.

Many experiments on the drive and control of large printing presses made by the leading printers of this country, during the past year, has resulted in the unanimous selection of an automatic two-motor control system.

Such a system must meet the following requirements: (1) Slow and uniform threading in speed, (2) Smooth acceleration and deceleration. (3) Must quickly slow down and again accelerate. (4) Be able to operate continuously at various speeds to accommodate different grades of paper. (5) Shut down the press from various points about the equipment. (6) Control should be simple and substantial. (7) Must be possible to quickly stop the press without imposing too great a stress on the paper.

When the press is started it is run at a very slow speed to enable the operator to feed the paper over the various rolls and avoid tearing the paper.
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After the paper has been adjusted through the entire press, it is permissible to run the apparatus at a very high rate of speed. Due to tearing of the paper, uneven supply of ink, etc., the press usually operates on slow speed about ten or twenty percent of the time. It is much more efficient to use a small slow speed motor for this purpose than to operate a large high speed motor at a slow rate of speed. Therefore, two motors are used on most of the large presses.

Semi-Automatic Control.

A wiring diagram for a semi-automatic A.C. control system is shown in figure 29. The essential parts of this equipment are two main magnetic switches, one controlling the large and the other the small motor; hand operated secondary resistance regulator; two series overloads in the large motor circuit; three protecting fuses in the slow speed motor circuit; one small clapper switch controlling the brake solenoid and a two-pole knife switch.

The two-pole knife switch has two functions to perform; when thrown down it releases the brakes
of the press and also opens the control circuit, permitting the operator to turn the press by hand and at the same time making it impossible to start the motor. When thrown in the up position, the control circuits are closed.

The start switch on the panel is a normally opened push button and may be connected in parallel with any number of starting switches about the printing press. The stop button is a normally closed push button switch and is connected in series with the run and safety buttons which will remain in either the closed or open position. These two buttons may be connected in series with any number of similar sets of buttons.

At several points on the press, switches installed are in series with the large motor control switch and are held in the closed position by the paper. In case the paper breaks, the switch opens, shutting down the press.

To start the press the handle of the secondary resistance starter must be in its extreme starting position in order that the control circuit of the
small motor will be closed through its auxiliary contacts. If all the run and safety stop switches are closed and in the running position, the small motor can be started by closing one of the start buttons. This small motor is a three-phase squirrel cage induction motor.

The press can be run at a high rate of speed by revolving the regulator by hand to the next auxiliary contact, closing the circuit for the large motor switch, which on closing, opens the switch for the small motor. From this point the speed is controlled by the hand regulator. The large motor is a wound rotor three-phase, induction motor, the regulator varying the resistance in the rotor or secondary circuit.

The apparatus may be stopped by an overload, tripping the overload relay; a brake in the paper opening the paper brake switch, or by pushing the safety or stop buttons. A photograph of a duplex semi-automatic printing press controller is shown in figure 30.
Fig. 30.

A.C. Semi - AUTOMATIC FOUR MOTOR PRINTING PRESS CONTROLLER
Full Automatic.

An A.C. full automatic printing press controlling equipment is shown in diagram 31. In addition to the semi automatic apparatus, this panel consists of: normally open "on" and "off" switches, normally closed stop and safety switches, motor operated speed regulator.

The operating features are the same as those of the semi-automatic except that the secondary circuit of the large motor is motor operated. The equipment is started by pressing the "on" button, energizing the "on" switch, the small motor switch and the brake relay, also the pilot or rheostat motor. The pilot motor will continue to operate as long as the "on" switch is energized. Its operation will be stopped if the "on" button is released before the press is at full speed, and the press motor will continue to operate at that speed. As this motor operates, it will shut down the small motor and start the large one, as in the case of a semi-automatic. The pilot motor is automatically stopped at both ends of its travel.
If the press is running at high speed, it can be slowed down by holding in the off button until the speed has been reduced to that desired.

If at any time the safety button is pushed it will be impossible to speed up the motor but it can be slowed down or stopped. In case the motor is stopped it cannot be started until the safety switch is open.
ELEVATOR CONTROL.

The development of electric motors on control equipment particularly suited to the work of operating passenger and freight elevators, has resulted in a most satisfactory system of operation. The controlling equipment of passenger elevators is subject to very severe operation, due to the great number of times which the motor must be stopped and started and often times suddenly reversed to permit the car to make an even landing. Due to the quickness of operation required to give good service, the full magnetic equipment provides the best control system. On the other hand, for freight service, where the speed is slow and operation infrequent, it seldom pays to install an expensive electric control, the mechanical or semi automatic equipment being most satisfactory.

In designing any system of elevator control the primary consideration is safety and is often
THE DEPARTMENTS

The departments are administered and managed by the University's Office of the President, with the support of the university's executive team. Each department is responsible for the implementation of university policies and procedures, and for ensuring the effective operation of its facilities and resources. The departments are organized into several categories, including academic, administrative, and support services. Each department has a designated budget and is accountable for the efficient use of resources to support the university's mission.

The academic departments are responsible for the delivery of educational programs and services, while the administrative departments provide support services such as finance, human resources, and information technology. The support services departments include facilities management, security, and healthcare services.

The university's strategic plan outlines the goals and priorities for each department, and the department heads are held accountable for achieving those objectives. Regular meetings and reviews are conducted to assess department performance and to identify areas for improvement.

The university's leadership team is responsible for overseeing the operations of the departments and ensuring that the university's mission is realized. The department heads are expected to collaborate with other departments and stakeholders to address common issues and to ensure the smooth operation of the university.
times overlooked in an attempt to give service, the real problem of the passenger elevator. For the greater part the control equipment is called upon to perform the following functions: First: to accelerate the motor automatically under all conditions of load by cutting out starting resistance by means of series relay or dash pot control. Second: to control the speed by cutting resistance in or out of the shunt field circuit in D.C. equipment. Third: to bring the elevator to a quick smooth and accurate stop at all landings, regardless of load. With a mechanical brake it is not possible to obtain a smooth accurate stop, due to the fact that the elevator will coast farther with a heavy than a light load... The energy stored in a moving mass is proportional to the square of the velocity. The mechanical brake is capable of absorbing this energy in direct proportion to the velocity, while the dynamic brake will dissipate energy proportional to the square of the velocity. A combination of these two brakes gives the best results. Fourth: to disconnect the equipment from the line in A.C. system, when operator has lever at the off
position. In D.C. apparatus, the shunt field of the motor is partially excited when the motor is at rest. This arrangement gives a quicker start than is the case when the field circuit is open, and results in a saving of both time and energy.

Semi Automatic Control.

Referring to figure 32, a wiring diagram of an A.C. semi-automatic freight elevator control, this equipment controls a squirrel cage motor and consists of two essential parts, a reversing drum and the main switch. The drum is located at the motor and is operated by cables from the elevator. In the rotation of the drum the contacts for the main line current are closed before the control circuit of the main line switch. This prevents the making or breaking of the current on the contacts of the drum. The contacts of the main switch are equipped with blow-out coils. The control circuit for the switch passes through the limit and slack cable switches.

The limit switches, usually consist of a final up and down switch, which stop the car at the top
Fig. 82.

A. C. Semi-automatic Elevator Controller.
and bottom if the operator fails to bring the equipment to a stop. When the car opens, the up limit, it is impossible to move the car in the up direction but it can operate in the downward direction. In addition to the two limit switches it is customary to add two over-travel limits so that in case of failure of the stop limit switch, the car will be stopped before any damage can be done to the machinery. If the car does over-travel, it is impossible to move the elevator in either direction. After the trouble has been located the car can be moved by either short circuiting the limit switch or by closing the line switch by hand. The floor limit switches may be hatch switches or they may be traveling cam limit switches geared directly to the hoisting drum.

The slack cable switch is a safety switch which is balanced between spring and the cable tensions, in such a manner that if one or more of the cables become slack the switch will be opened, making it impossible to operate the car.

In most elevator installations door switches
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are used to prevent operation of the car with doors open.

**Full Automatic.**

Figure 33 is a wiring diagram of a full automatic elevator controller as may be used for light passenger service or dumb waiters.

This equipment is for a two phase, four wire squirrel cage induction motor. The essential parts of the equipment are: three magnetic switches; floor stop device; push buttons in the car and at landings; slack cable switch; door switch, over travel switches and a solenoid operated brake.

For convenience, consider the car to be at the third floor as indicated by the floor stop device. This floor stop device is geared directly to the hoisting drum. The four relays are spaced to correspond to the distance between floors. To start the elevator from the car or any landing the button corresponding to the floor, to which we wish the car to stop, is pushed; for instance number one. In this case the relay number one of the floor stop device would drop making contact for the down and
Fig. 32A.

D. C. Semi-Automatic Elevator Controller.
The motor is then thrown across the line and the elevator starts down. When at the first landing the relay number one will be opened by the insulated contact between the up and down ribbons of the floor stop device. The switch will then open and the car stop.

Now consider that we are on the first floor and push button number four, starting the car up. If we wish to stop the car at some intermediate point, we can do so by pressing the emergency stop button which energizes the emergency stop coil of the floor stop device. This operation will trip out the relay and stop the car. The car could then be started for the desired floor.

If the car is in operation and any button, other than the emergency button, is pushed, the relay will not operate because the control circuit for the first relay operated is made through the normally closed auxiliary contacts of the up and down switch. The control circuit of the relay is made through a resistance H.K., the object being to prevent the closing of two relays at one time.
The resistance H.K. is of such value that the voltage will be too low to operate two coils at once. This resistance H.K. is also large enough to prevent operation of any relay when the line voltage is below seventy-three percent normal.

Figure 32-A represents a D.C. semi-automatic elevator controller. A photograph of an installation is shown in figure 32-B. The control equipment consists of: one clapper switch, one solenoid operated accelerator, and a reversing drum. This drum is operated from the car by cable, as shown in the photograph. The main line circuits are closed first, then the clapper switch circuit, eliminating arcing on the drum contacts. The motor then starts as a compound motor and is accelerated by the accelerator which, on reaching its last step, cuts out the series field.

A.D.C. full automatic elevator controlling equipment is shown in figure 32-C. This apparatus consists of: one main clapper switch, two clapper reversing switches, one lock-out switch, service switch, two field switches, one timed
Elevator controller installation

Fig. 32B.
accelerator, five accelerating switches, two vibrating relays, one double coil overload machine limit switch, car switch, and the ordinary slack cable, hatchway and safety switches.

This apparatus is designed for operating a high speed freight elevator. To start the equipment the service switch located in the car is closed. This switch is nothing more than an additional safety device. On closing the service switch, the shunt field circuit is completed through the external resistance V-Vj. By replacing the car switch in the first running position the main and direction switches close, the dynamic brake is also released. These switches on closing, energize the timed accelerator which closes the contacts of the five accelerating switches. These accelerating switches on closing cut out the armature resistance. This equipment is designed for accelerating the car at two different rates of speed depending upon the load to be carried. For this particular installation the car was required to lift a heavy load for about one half the operat-
ing time; during the remaining period lighter loads were carried. It was therefore necessary to have two accelerating rates in order to operate at a high efficiency. These two accelerating rates are obtained by dividing the starting resistance into two separate parts, accelerating at a high rate of speed on about one half the total resistance. The knife switch K is used to interconnect the resistance on placing the car switch in the second position, the final speed is obtained by operation of the two vibrating relays.

In high speed elevator operation it has been found necessary to have a smooth deceleration. In this equipment the timed acceleration is designed to have its operation retarded in both directions by a double dash pot. On stopping the car the dynamic brake is set directly across the armature but as the timed relay opens, it re-inserts the armature resistance, which now acts as a decelerating resistance, giving a very smooth stop.
SUBMARINE CONTROLLING EQUIPMENT.

The control panel for the chain munition conveyor is shown in diagram 33A. The equipment consists of two main switches, one magnetic single coil overload, one hand operated starting box and speed regulator, one hand operated reversing switch and a remote push button for stopping the apparatus.

The object of the panel is to carry the munition from the magazine to the place of discharge by means of a specially designed chain conveyor. The direction of rotation is controlled from the panel by the hand reversing switch. In order to start the motor the starting lever must be in the neutral position. The lever must be in this position in order that the interlocking resistance A.B. will not be connected in series with the main switch coils, permitting them to be connected across the line on full voltage. A.B. has enough resistance to prevent the switch from closing when in series with it, but if the switch is closed, the insertion of the re-
Fig. 39A.
Submarine Ammunition Conveyor.
sistance will not trip the switch. By turning the starting handle to the start position, the two main switches close, operating the motor with all the resistance in the armature and field circuits. The resistance of the armature circuit is cut out as with the ordinary starting box and the speed may be regulated in a similar way.

The motor may be stopped by the hand operated lever or by the remote stop button. The remote control buttons may be equipped with a catch for locking, them in the open position in case something goes wrong with the apparatus.

There are various methods of submerging and raising the submarine, the controlling panels of one of the American Submarines is shown in figure 34. The panel consists of two magnetic reversing switches equipped with single normally open and closed contacts, one double coil overload and one remote switch. This remote control switch is a three-point switch, the other two positions depending on whether the boat is to be submerged or not.
Fig. 34.
Submarine Submerging Controller.
To start the motor the snap switch is closed, energizing the corresponding coil of the main switch, closing it, allowing the line current to pass through the motor and the normally closed contact of the other main switch back to the line. When the main switch closed it opened the auxiliary contact, which is connected in series with the other switch coil, thus insuring against closing both switches at the same time. In case of an overload, the current through the series coil of the overload will cause its plunger to raise, tripping its auxiliary contact, shutting down the motor. After the plunger has operated in this manner, the shunt coil of the overload is sufficient to hold it open. If it were not for this shunt coil, the main switch would telegraph.

To shut down the motor, the snap switch is opened, the main line switch trips and a short is placed across the armature of the motor through the normally closed contact of the second main switch. The short across the motor causes it to stop quickly
due to its dynamic breaking effect. The usual dynamic brake is eliminated in this case because of lack of space on a submarine, a compact equipment being essential. This same equipment is used to raise and lower the periscope.

The main propelling equipment consists of two separate motor driven propellers. The control apparatus for this equipment is one of the most interesting electrical features of submarine control, as shown in figure 34A.

In general, the panel may be controlled from three different places, at the panel by hand operation, in the engine room and at the central cruising station. These three starting stations are mechanically interlocked by a lever which must be inserted in its proper position at the starting station to be operated. This lever is so designed that it cannot be removed unless the starting station masters are all in the off-position. The hand operation is used at the panel in case of emergency, such as burning out of coils or the failure of the auxiliary power. The motors are driven from the main batteries.
The equipment consists of four main switches, two for forward and two for reverse, four accelerating relays, one field switch having two normally open contacts and one normally closed, one double coil overload and one relay. The switches of this panel are of very heavy construction, balanced with heavy weights to assure quick and positive action. These weights are installed to hold the switches open, if not in use, when the boat is rocking on a heavy sea.

The operation of the propelling starting equipment is similar to other panels except that the acceleration depends upon the operator. The direction of rotation and the acceleration are controlled from an ordinary master. When the master is in the off position and all switches open, the field switch on opening, closes its down contacts which shorts the field through the discharge resistance. This is necessary to prevent the high voltage kick of the field current, caused by the sudden breaking of the field, from breaking down the insulation of the circuit.
The diagram for the magnetic lockout starter for submarine signal work is shown in diagram 35.

The object of this equipment is to obtain A.C. current for wireless, all other voltages are D.C.

The equipment consists of one main switch, two lockout switches, one double coil overload, one field relay, and two field rheostats, one in the field for speed variation and the other in the field of the generator for voltage regulation.

This apparatus is controlled from an ordinary single pole knife switch, which when closed, energizes the main switch. When the main switch closes, the line to the motor is completed, and the fields of the generator and motor are closed. The inrush of current through the motor energizes the two coils of lockout switch 2 R, which will close when the current drops to given value causing the current to flow through the two coils of the lockout 3 R. 3 R closes as soon as the current decreases to its setting value. The motor is then directly across the line.

The equipment for controlling the ballast, cen-
Fig. 35.
Submarine Signal Controller.
trifugal pump apparatus is shown in figure 36. The essential parts of the equipment are: hand operated drum, hand operated field regulator, one overload, one magnetic switch and one hand operated locking lever. This equipment is enclosed in a water-tight compartment.

To start the pump, the locking lever is placed in the running position. This will energize the main switch coil and close it. Now by moving the drum to the first position, the motor will start with all the resistance in the circuit. By moving through the next three steps the resistance will be cut out of the armature circuit. The speed of the motor is then regulated by adjusting the field rheostat. In case of an overload or voltage failure, the motor will be shut down by the opening of the main switch. In an ordinary shut-down, the drum is moved to the off position and the main switch will remain closed. The pump can be operated in the reverse direction by reversing the drum.

Figure 37 is a diagram for controlling the operation of the circulating water pump used for
Fig. 36.
Submarine Ballast Controller.
Fig. 37.
Circulating Water Pump Controller.
cooling the engine. This equipment consists of: one master drum, series overload, and one main switch.

To start the equipment the master is placed in the first position, this closes the main switch and starts the motor with all the resistance in the circuit. The movement of the master to the second position cuts out the first step of resistance and also opens the pick-up circuit, for the main switch coil and cuts in a protecting resistance in series with the coil of the main switch. The motor may then be speeded up to full speed by rotation of the master. The motor is shut down by bringing the master to the neutral position. If shut down by action of the overload, it is necessary to bring the master back to the first position before the motor can be started again.
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COAL HANDLING CONTROL EQUIPMENT.

A Coal tower operating equipment is shown in diagram 38. The object of this apparatus is to control the hoist, and rack of a large coal bridge as used for unloading coal boats.

The equipment consists of three separate panels. First the hoist, controlling the hoist, closing and opening of the bucket. Second, the rack controlling the movement of the carriage up and down its track. Third an accessory panel controlling a small motor generator set for operating the brakes and clutch.

The hoist controller consists of: one main switch, two reversing switches, five accelerating switches, four three-phase relays, one circuit breaker equipped with overloads and a no-voltage release, hand operated master and a normally closed push button.

To lower the bucket the master is placed in the
first position energizing the main and lowering switches. The next four steps of the master, will bring the motor to full speed by operation of the four series relays. The bucket may be opened anywhere during its descent by closing the hand lever which energizes the brake and clutch coils which control the opening and closing of the bucket. To hoist the bucket the master is placed in the first position with the hand lever closed starting the bucket up with both the brake and clutch energized. the motor can be brought up to speed in the usual manner. After the master has passed the first hoisting position, the control circuit for the clutch is opened and cannot be closed in order that the bucket will remain in the locked position. In case something happens to the equipment during operation, the push button near the master may be opened, which will open the no-voltage release, and shut down the apparatus.

The rack controlling equipment consists of: one main switch, two reversing switches, three accelerating switches, three accelerating relays,
one master, a circuit breaker equipped with a no-voltage release, and a normally closed push button. The operation of this equipment is controlled by the operation of the master and the series relays. In case of an emergency, the circuit breaker can be tripped by bushing the emergency push button.
BLAST FURNACE CONTROL.

A.C. Skip Hoist.

Figure 39 is a wiring diagram of an A.C. full automatic skip hoist as used on a charging machine of a blast furnace. The charging machine consists of two tram cars which operate by cable and so connected that one car discharges into the furnace while the other is loading. The object of the control panel is to operate these cars automatically.

This panel consists of two main magnetic switches U and D; two accelerating relays 2R and 3R; two three-phase relays and a timed relay. The main switches are used to control the direction of rotation and are mechanically and electrically interlocked, making it impossible to close both at once.

The equipment is started by pushing either the up or down button which in turn closes the up or down main switch. In case the car is at the bottom and the down button pushed the apparatus
Fig. 39.

A. C. Skip Hoist Controller.
will not start due to the fact that the car is holding open the final down limit switch. The main switch being closed, the first accelerating relay is energized and held in the open position, thus cutting in the maximum starting resistance. As the motor speeds up, the current drops and at a predetermined value the relay closes, energizing the first accelerating switch 2R which shorts out the first portion of starting resistance and energized the second relay. The relay now opens and remains open until the current drops to the setting of the relay, at which time the second accelerating switch closes, cutting out the last step of resistance and throws a short across the slip rings of the motor. The motor then operates at full speed.

For convenience, suppose that the car was at the bottom and started up with a load. As the car nears the top it opens the slow down switch, thus opening the two accelerating switches on the panel and the motor slows down. The car finally hits the up limit and the down start. This stops the motor and energizes the timed relay R. This oil dash relay is adjusted so that the car has time to unload
before it closes the contact of the down switch.
The unloading is accomplished by passing the car over the top of the inclined track. The car at the bottom opens a hopper and continues to load until the car starts up and closes the hopper. When the contact of the down switch closes, the motor reverses and the equipment starts in the opposite direction.

This panel is also equipped with several safety switches which may be opened at any time. An emergency start button is installed for testing out the control circuits from the panel.
MILL CONTROL.

A. C. Steel Mill.

An A.C. full reverse Kraemer system speed controller for operating a large sheet steel mill is shown in diagram 40. This installation is for a 6600 volt, 3 phase, 2000 horse power wound rotor induction motor. The main object of the equipment is to keep the motor at a constant speed regardless of load. A constant speed is essential to prevent the sheets from varying in thickness. In addition to the usual switch control equipment this apparatus has a Kraemer motor mounted on the shaft of the induction motor. This Kraemer motor is a shunt D.C. motor. A rotary converter is also used with this equipment. The D.C. side of the converter is connected across the armature of the Kraemer motor and the A.C. side is connected through the controlling equipment to the slip rings of the induction motor.

The controlling equipment of this installation
consists of three separate panels, one consisting of two solenoid operated oil switches used for reversing the direction of rotation of the induction motor. Panel A is equipped with accelerating switches and relays for cutting out the resistance, two field switches, one for the Kraemer motor and the other for the rotary converter, four small clapper relays for cutting in the accelerating switches; and one A.C. switch. The object of this A.C. switch is to form an electric interlock between the A.C. and D.C. voltages, thus making sure that all switches will open in case either source of supply fails. Panel H consists of: three clapper relays, three D.C. clapper switches, and one drum type master controller.

In starting the equipment the master is placed in the first position which closes the relay for the forward main switch, also the three switches C1, C2, C3; E1 and E2 are also closed. All these switches on closing, connect the slip ring of the induction motor to the total resistance. The motor then starts with all the resistance in the circuit.
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the Kraemer motor running idle. The induction motor may now be run up to full speed by bringing the master to the fourth position. The last three accelerating steps are then brought in by their accelerating relays which are independent of the master. By moving the master to the fifth position, relays $8P_1$ and $8R_2$ close. The two switches on closing, place a short across the slip rings of the induction motor and at the same time opens the circuit of the accelerating switches, allowing them to open. At this point, the induction motor is operating at full speed and the Kraemer motor is running idle and the rotary converter is standing still. By moving the master to the sixth position the short is removed from the induction motor by opening $8R$ and $8R_2$, $C_1$, $C_2$ and $C_3$, $E_1$ and $E_2$; the slip rings are immediately connected to the A.C. side of rotary converter by the closing of switches $A_1$, $A_2$, $A_3$, $D_1$, $D_2$, $D_3$, and the two field switches $F_1$ and $F_2$. This energizes the field of the rotary converter and Kraemer motor. The rotary will then
be brought up to speed by the two sources of power. Now by adjusting the field current of the Kraemer motor and the rotary converter the equipment may be operated at the desired speed, and it will continue to run at a constant speed.

In case of an ordinary shut down, the master may be brought to the off position, or by pressing the stop button. In case of an emergency when it is desired to stop immediately, the stop button and the plug in switch may be closed. The action of the entire equipment will then bring the motor almost instantly to a stand-still.

This apparatus may be run in the reverse direction on slow speed only, it being impossible to cut out more than the first step of resistance.
MISCELLANEOUS

Transfer Panel.

Diagram 4] shows a scheme of connections for transferring an A.C. motor from the A.C. power line, in case of failure, to a motor generator set operated from storage batteries.

The essential parts of the equipment are:

- two clapper switches with A.C. coils,
- two clapper switches with D.C. coils,
- one D.C. self starter,
- one phase failure relay.

To start the equipment with the A.C. line, the left hand single pole switch and phase failure relay are closed, the two switches with A.C. coils close throwing the motor direct across the line.

At this time the right hand single pole switch is closed.

In case of outage of the A.C. power line, one or more lines failing or a phase reversal, the phase failure relay will open, tripping the A.C.
Fig. 41. Transfer Controller.
switches. The left hand switch, on opening, will close the coil of the D.C. self-starter through its auxiliary contact. This will start the motor. generator set and as soon as the self starter reaches the end of its travel the contacts for the two switches with D.C. coils will close, connecting the motor across the generator.

Machine Tool Control.

Diagram 42 shows the connections for a non-reversable machine tool controller. This equipment consists of: one main switch and one lockout switch. The apparatus is controlled from a two-button station, the stop button being normally closed and the start normally opened. By pushing the start button, the main switch closes connecting the motor to the line through the starting resistance. The maintenance contact also closes, so that the starting button can be released. The motor is then accelerated through the three lockout switches in the usual manner. The last lockout is equipped with a shunt coil in order that it will stay closed on a very
Fig. 42
Nonreversible Machine Tool Controller.
light load as may occur on making a light cut. When
the apparatus is shut down the main switch on open-
ing puts a short across the armature through the
dynamic break resistance.

Diagram 43 shows similar connections for a
full reverse tool controller. The only characteri-

stic difference being that the apparatus is equipped
with a field discharge resistance. The control is,
however, handled with a two-direction master.
LAUNDRY MACHINE CONTROL.

An A.C. controlling equipment for an electric driven washing machine is shown in figure 44. This apparatus is used for automatically reversing the direction of rotation of washing machine. The equipment consists of: one magnetic switch, one motor driven drum controller and one remote control switch.

The machine is started by pressing the start button which closes the circuit for the motor driving the drum. This motor will then revolve the drum, closing the circuit of the main motor. As the drum turns through about 170 degrees the main motor will continue to revolve in the direction started. For the next 10 degrees the motor will be shut off and through the following 170 degrees the main motor will operate in the reverse direction and will be stopped during the next 10 degrees. This operation of reversing the main motor forty times a minute will continue until shut down.
...
Fig. 44.

A. C. Washer Controller.
A similar equipment for D.C. control is shown in figure 45. The operation is the same as that of the A.C. controller.

The controller for operating the extractor or drying machine is shown in figure 46. This is an A.C. three-phase equipment consisting of: main clapper switch, one special overload, and one remote control button with indicating lamp. The object of this apparatus is to revolve a large perforated tank containing very wet clothes at a high rate of speed. Due to the heavy weight of clothes at the start, the inrush current to the high speed motor is five to seven times normal. Therefore, on starting this motor, by pushing the start button, it is necessary that the button be held in the closed position until the inrush current has dropped below the tripping point of the overload. The operator is notified when the current has reached normal value by the lighting of the indicating lamp. When the button is pushed on starting, the overload opens the maintaining circuit of the main switch, also, the lamp circuit.
D. C. Washer Controller.
As the current nears normal value, the overload closes, completing the lamp and maintaining circuits. The lamp will remain lighted until the motor is shut down.

The wiring diagram for a D.C. extractor panel is shown in figure 47.

Figure 48 shows a photograph of a large washing machine panel consisting of several washers and extractors.
Fig. 47.
D. C. Extractor Controller.
LAUNDRY CONTROL PANEL

Fig. 43.
Special Coke Handling Apparatus.

A wiring diagram of one section of the coke handling equipment of the New York gas plant is shown in figure 48A. This is an A.C. panel designed to operate seventeen motors of the coke conveying equipment including the crusher and screening apparatus.

In this installation the crusher is made up of two large cylinders, geared together, with surfaces provided with projecting knives. These knives are so constructed that they always remain at the same distance from each other when revolving. The action is similar to gears of the same size revolving out of mesh.

The motors of this conveying equipment are all squirrel cage induction motors of various sizes. The smaller motors are started by means of one clapper switch which throws them directly across the line. The larger motors are started with three or more clapper switches which connect them across the low voltage taps of the transformer on starting. All motors are protected by two time limited over-
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Fig. 48A
loads and fuses. They are all started and stopped by means of push buttons.

The crusher may be started and stopped independent of the rest of the equipment. Of the twelve conveyors, conveyor 6, 6A, 6B, 8 and 9 are operated independent of other apparatus. Conveyor 5 and 7A can only be started after either or both the screens have been started. Conveyor 4 may be started when 5 and 7A are operating.

Conveyor B3 and 11 are reversible. If B3 is started west it is possible to start conveyor 12 and at no other time can 12 be operated. After 12 is in operation, number 11 may be started west but cannot be started east. These three conveyors are shut down in the reverse order from which they were started. If these three conveyors are not in motion, 11 may be started east but not west.

After 11 has been started east, number 13 can be put in operation, and only at this time. With 13 in motion B3 can be started east. This set of conveyors is shut down in the reverse order to which they were started.
It might be interesting to know that this plant has a much larger equipment than the one just described.

A similar equipment for D.C. control is shown in figure 49.
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Ore Unloader.

A wiring diagram for a series relay operated beam ore hoist is shown in figure 50. This apparatus consists of: one main switch, six accelerating switches, one dynamic brake switch, three auxiliary switches, four clapper relays, five D.C. series relays, four limit switches and one transfer switch.

This equipment is started by placing the master in the hoising position, which closes the main switch and releases the dynamic brake. The motor then comes to full speed through the action of the five series relays and their corresponding clapper switches. In this installation there is no field speed control. In lowering, the master is placed in the lowering position and due to the heavy weight of the beam and bucket the motor acts as a dynamic brake.

Since the apparatus is not provided with field resistance, it has an external field discharge resistance which is inserted, when the main knife switch is open by means of its auxiliary contacts.
Heavy Duty Hoist Controller.

A heavy duty hoist controller as may be used in mines, is shown diagrammatically in figure 5]. The panel is made up of two reversing switches, two clapper type relays, two auxiliary clapper relays, used as limit switches, over-speed governor and one traveling nut limit switch. This nut switch consists of two parts, one part is geared directly to the tight cable drum, the other is geared to the loose cable drum. There are also two over-travel limit switches, one plug switch and a master controller. This master is directly connected to the liquid rheostat controller. The liquid rheostat is used to give/very smooth and long range of acceleration.

The apparatus is started by placing the controller in the running position and is accelerated by moving the master. As the master is moved forward, the water raises in the rheostat, cutting out the rotor resistance.

The equipment is automatically stopped by the limit switches. The plug switch has a long chain
Very trying facts concerning

A very trying fact concerning a man, who

The beard is not of the same nature as the other, and

their faces form letters. The form of the eyes, and the

are not similar. The eyes are also two or three times

writing, and that a part of the picture is necessary to the

There is no direct communication to the right ear.

the right hand is used in the place of the conversation.

The manner of the right hand is different.

The manner of the right hand is...
connected to it which hangs down the shaft which can be pulled at any time, removing the plug from its receptacle and shutting down the equipment.
May be false and/or have some unclear content that needs further explanation.