

A SYSTEM OF  
AUTOMATIC TRAIN CONTROL

BY  
C. W. MORGAN

ARMOUR INSTITUTE OF TECHNOLOGY

1911

625.2  
M 82



**Illinois Institute  
of Technology  
Libraries**

control







A SYSTEM OF AUTOMATIC TRAIN CONTROL

A THESIS

PRESENTED BY

CHARLES WOODWARD MORGAN

TO THE

PRESIDENT AND FACULTY

OF

ARMOUR INSTITUTE OF TECHNOLOGY

FOR THE DEGREE OF

MECHANICAL ENGINEER

HAVING FULFILLED THE REQUIRED CONDITIONS

PREPARATORY TO MAKING SUCH PRESENTATION

MAY 25, 1911

ILLINOIS INSTITUTE OF TECHNOLOGY  
PAUL V. GALVIN LIBRARY  
35 WEST 33RD STREET  
CHICAGO, IL 60616

*O.K.*  
*W. F. Lehard 5/11/17*  
*H. M. Raymond*  
*P. C. Monin*

*Charles Woodward Morgan.*





## A SYSTEM of AUTOMATIC TRAIN CONTROL.

The purpose of this thesis, is to present in as brief a manner as possible, consistent with clearness, the principles of a system of "automatic train control" and a general description of the apparatus used in connection with it.

The expression "automatic train control", as herein used, is understood to mean, a block signal system in combination with appliances which work in accordance with the signals, and afford complete automatic protection against;- errors in the despatching system, errors of the enginemen, and failures of the signals to operate properly. Summarily, it guards against all errors human or inanimate and permits trains to move only when it is safe for them to do so.

The principles of the system only as redesigned for commercial use will be dealt with. These reconstructed plans are the result of about twenty years experiment and practical application by the inventor, Benton C. Rowell of this city.

Up to the present time there have been seven installations of this system, as a whole or in part, six of which, were for practical use, and the seventh and last.



for test purposes by the United States Government.

The first of these installations was made on the "Boston, Revere Beach and Lynn Railroad" in 1891; the second, on the "Intramural Railway" at the "World's Columbian Exposition" in 1893; the third, on the "Chicago and South Side Rapid Transit Railroad" in 1893 and 1894; the fourth, on the "Metropolitan West Side Elevated Railroad" of Chicago, in 1894 and 1895; the fifth, at Hawley, Ill. at the crossing of the "St. Louis, Peoria and Northern" with the "Peoria, Decatur and Evansville"; the sixth on the "Chicago, Milwaukee and St. Paul" between Pacific Junction and Edgebrook in 1902; and the seventh, on the "Chicago, Burlington and Quincy Railroad" near Aurora, Ill. for the purpose of the government test, in 1908.

Any of the above installations for practical use, which have been taken out of service, were removed not because they were in any manner defective, but because traffic requirements for which they were not originally designed made them objectionable.

This system embraces single and double track blocking, applicable to either steam or electrically driven railroads, the two kinds of signals being the "two board two position" signals and the "upper quadrant" or "three position" signals. Both of these signal systems are combined with apparatus for automatically stopping moving trains, which is termed the "safety stop", and the latter



is of such design that it may be applied to either of the above systems of block signals already installed on any railroad.

On Plate 1, are shown both types of signals, Figure 1, being the first mentioned type, and Figure 2, the "upper quadrant" signal. To understand the significance of these signals, call the distance from one signal to the next on a railroad, a "block". The upper board shown in Figure 1, known as the "home" board (usually colored red), if standing horizontal when approached, indicates that the block about to be entered, already contains a train and must not be entered until the preceding train is beyond or under the protection of the next signal in advance. When the first train is under the protection of the next signal in advance, this home board assumes the position A, 60 degrees below the horizontal, which is the "proceed" or "clear" position, but the lower board termed the "distant" signal (usually green), does not fall to the "clear" position B, until the first train passes the second signal in advance. With the home signal in the clear position and the distant signal in the horizontal or cautionary position, the engineer is supposed to reduce speed when entering the block. In this system of train control, failure to obey the distant signal, automatically stops the train. In the upper quadrant system of signals, the position A, Figure 2





signifies "Danger!" or "Stop!", B, "Proceed with caution" and C, "Clear".

The automatic stop referred to, consists of a tripping device on the track located near the signal, which is designed to engage with a machine fixed to the rear tender truck of a locomotive, the function of the machine being to open the train pipe and thus apply the brakes. On electrically operated railroads, the same type of engine machine is used.

The power to operate the signals and the tripping device or "track instrument" (which may be installed singly or in duplicate), is obtained from what is termed the "power storage machine" (briefly, the "power machine") located beneath the signal pole and enclosed in a suitable weather-proof housing.

Plate 2, is the installation plan with track instruments installed in duplicate. On this plan are shown the power machine A, the two track instruments B, B, and the intermediate connections between them and the power machine. The intermediate connections consist of three sprocket-wheel cases joined together by piping, the center one containing two sprockets keyed to the same shaft and the ones at the track instruments containing one, each. These sprockets are of such size, and are so connected by sprocket chains and steel wires, that 45 degrees rotation of the central sprocket shaft, rotates





either of the outer ones through 90 degrees. The rotation of these, serves to raise one track instrument and lower the other. These track instruments will be described in detail later on.

Plate 3, is the plan of installation of the apparatus when one track instrument is used. This plan shows the track instrument and its operating machine, with the intermediate connections, piping and sprocket case mentioned in the other plan. Only the location of the signal is shown, as either the power machine on Plate 2, or any signal operating mechanism already installed may be used as a means of moving the track instrument.

Plate 4, shows the engine machine A', and the track instrument B. Although this drawing is not of the remodeled apparatus, it clearly illustrates how the engine machine engages with the track instrument when the latter is in the raised position. To release the air from the train pipe connected to the engine machine and thus apply the brakes, the track instrument raises the plates shown projecting below A'.

Both types of signals already mentioned, may be used with either of the above plans.

Before giving a detailed description of the different mechanisms used, a brief outline of the operation of the apparatus as a whole, will be presented. Whenever the power machine is used, power for the operation of



the signals and track instruments, is derived from coiled springs within the machine. On steam roads, these springs are wound by means of a treadle bar and a lever rigidly joined thereto. The depression and rise of this treadle bar by the wheels of a passing train, serves to produce a "pumping" action on the winding lever which, through a rack, gear and ratchet arrangement winds the springs. On electrically operated railroads, direct current motors controlled by the machine itself, replace this method of winding. Plate 2, plainly shows the treadle bar and winding lever.

In the power machine is a system of electro-magnets controlled by electric circuits in the rails, which govern the operation of the machine.

With track instruments installed in duplicate as on Plate 2, the operation of the apparatus is as follows.

On a single track railroad, the signals are normally in the "danger" position, and one track instrument is raised while the other is depressed. When within about half a mile from the signal under consideration, with a clear track ahead, the track instrument nearest the approaching train, assumes the depressed position, the other the raised position and the signals assume the "clear" position. When the engine has passed over the depressed track instrument, the two reverse the signals simultaneously returning to their normal danger position,



This of course, permits the train to pass without being stopped.

When using one track instrument, the operation of the system is quite different from that described. Normally this instrument is in the raised position, and the operation of the apparatus is the same externally, regardless of the normal position of the signals. If the signals are at danger when approached, the track instrument does not depress, with the consequent result that a train will be stopped by a disobedience of the signals. With the signals at the clear position upon approach, they will move to the danger position when the train passes over a pair of insulated rail joints a few feet distant from the track instrument. The track instrument immediately depresses, allowing the train to pass and then resumes its normal position. When approaching signals that indicate "Proceed with caution", the track instrument does not begin to lower until the locomotive passes over a pair of insulated joints closer to it than the first pair mentioned. Hence the distance the train has to travel while the track instrument is lowering, is materially lessened and only a train traveling at a reduced speed will avoid being brought to a stop by the engine machine engaging with the track instrument.

Having a general idea of the operation of the apparatus as a whole, the mechanism of each piece will now





be described in detail. There are four types of power machines but since all are a modification of the most complex only this particular machine will be described. Primarily this machine is used to operate, home and distant signals on a single track railroad, and also the track instruments. The functions of this machine are to operate the signals selectively, that is, when a train is traveling in one direction on a single track railroad, opposed signals must remain in the danger position, and the track instruments must work in accordance with the signals in operation. This machine contains three separate power units, all of which operate on the same principles. One of these units is used to operate the home signal, a second the distant signal and the third the selecting mechanism. The diagram on Plate 5, illustrates the principles of one of these units. On the actual machine, parts of the different units having the same functions, are of course not exactly alike in mechanical construction as desirable locations, requisite sizes of parts etc. materially modify them. Referring to Plate 5 C is the armature of the electro-magnet A, and is held away from the latter when deenergized, by the spring X. In the position shown, the end of the armature is designed to engage the lug 3, on the "lock" wheel B. This wheel B keyed to the shaft M, has a tendency to rotate in the direction indicated by the arrow, due to the torque





produced by a spiral spring. F1, and F2, are eccentrics fixed to the shaft M, and are connected to the dogs D1, and D2 by eccentric rods. These dogs alternately arrest the rotary motion of the lipped discs F1 and F2, keyed to the shaft O. This shaft is made to rotate by means of spiral springs contained within and fastened to the cylinder G, and the shaft O. To wind these springs the cylinder is rotated and held in position by means of a pawl and ratchet mechanism not indicated. As the rotation of this cylinder is primarily derived from the depression of the treadle bar on the track, by the wheels of a passing train, it is evident that with the arrangement just described, the power machine can be expending energy by rotating the shaft O (which serves to operate the signals and track instruments) and at the same time be storing energy.

The lock wheel B as previously mentioned, derives its energy from a coiled spring. This spring is contained within a small cylinder running loosely on the shaft M, and connected to the main cylinder shaft O, by sprocket wheels and chain. As in the case of the cylinder G, the spring is attached to both the cylinder and shaft, and when first assembled is given an initial torque. Hence it will be readily understood that each time the wheel B is released and turns through half a revolution, the energy thus expended is resupplied by the subsequent rota-



tion of the shaft O.

The action of the unit is as follows:- The magnet A being energized, the armature moves to the position 2, thus releasing the wheel B and allowing it to rotate until it is arrested by the lug 4, near the periphery of the wheel, striking the end of the armature. This half revolution of the wheel B, reverses dogs D1 and D2, thereby permitting discs F1 and F2, and shaft O to rotate through half a revolution. The rotation of this shaft transmits the desired motion to the mechanism to be operated. Demagnetization of A, repeats the operation and brings the parts shown back to their original positions.

Plates 6,7,8 and 9 are four elevations of the actual power machine, drawn half size. Referring to Plate 7, a "Rack End Elevation" of the machine, A is a shaft which receives a reciprocating motion by a crank and link connection not shown, from the winding lever already mentioned. This reciprocating motion of the shaft, imparts a reciprocating motion to the rack B through the arm C. The gear in mesh with B, runs free on the shaft D known as the main winding shaft. This gear by a pawl and ratchet mechanism, imparts an intermittent rotation of the shaft D similar to the stem wind of a watch. The main winding shaft is gear connected to the three power spring cylinders.

Plate 6, the "Front Elevation" of the machine, shows



plainly these three cylinders, E being the home signal cylinder, F the distant signal cylinder and G, that of the selecting mechanism. E is the largest of these as it is required to furnish power for the operation of both the home signal and track instruments, while G is the smallest since its function is merely to supply power to the selecting mechanism, which operates infrequently.

In order to prevent these cylinders from rotating in the wrong direction, their direction of rotation is restricted by a ratchet wheel connected to both driving gear and cylinder.

Overwinding of the power springs is prevented by providing a governor for each unit. The operation of the distant signal cylinder governor and that of the selector may be readily understood by referring to Plate 8, a "Rear Elevation" of the power machine. As the cylinders of both the distant signal and selector, require fewer turns to wind them up than the home signal cylinder, they will both be wound before the latter. The gear H on the main winding shaft winds the distant signal cylinder. This gear runs freely on the shaft and is only fixed to it when the clutch I is engaged as shown. This clutch is held in position by the spring J and is feather-keyed on the shaft. The parts K are all solid with the gear. The gear L which is meshed with that fixed to the distant signal cylinder, is prevented from any lateral motion





by a hub and babbitt ring and has running within it, a hollow shaft engaging at one end a screw M. When the distant signal cylinder is being wound, this gear rotates until the hollow shaft has been screwed to the right a certain distance dependent upon the pitch of the screw and number of turns of the gear. The bead N on the shaft O engages one end of the lever P and by so doing, the yoke Q is brought to the left in contact with cams on the gear H. These cams then become a fulcrum, the forked lever R being moved to the right which disengages the clutch against the compression of the spring. To throw the clutch in, the gear S, meshing with a gear on the distant signal cylinder shaft, moves the hollow shaft to the left, by rotating the screw within the hollow shaft. The governor on the selector cylinder is similar to this one.

Since the home signal cylinder is the last of the three to be wound, its governor prevents further winding by throwing in a dog T shown on Plate 7, thereby holding the rack in the raised position corresponding to a depressed position of the treadle bar on the track. This governor consists of a hollow shaft and lever arrangement just described, together with the spring shaft and latch shown at U on Plate 8.

The electro-magnet lock apparatus is easily seen in the rear elevation of the power machine. The lock





at V, is that of the home signal, the one at W releases the distant signal and the double lock X is for the selector. The distant signal eccentrics and disc dogs are respectively at Y and Z (rear and rack end elevations), those of the home signal at Y' and Z' (crank end elevation) and those of the selector at Y'' and Z'' (crank end and rear elevations).

The signal selecting mechanism or selector, is the most puzzling part of the entire power machine. The functions of this apparatus are as previously mentioned, to select the proper signals to be operated and to operate the track instruments in accordance with these signals. It consists essentially of five units, two of which are for operating the home signals two for the distant signals and one (compounded with those of the home signals), for reversing the track instruments. The diagram on Plate 10, is of one of these units; more specifically, it illustrates one of the home signal units shown on Plate 6, at 2, connected to a semaphore board. The bar A, Plate 10, known as the power bar, receives its motion by arm and link connection from the home signal spring cylinder shaft. This power bar A and the signal bar B, are guided so that they are held close together and may slide vertically. The bar A can impart motion to the bar B when the spring dogs D are permitted to engage with the notch in B. As shown, a vertical down-



ward movement of A imparts none to B and hence none to the signal as the spring dogs are held out of engagement with B by the lip L on the plate C engaging with small lugs on the dogs extending out from the bars. This plate C suitably guided, moves horizontally across the bars and is actuated primarily from the selector cylinder shaft turning through half a revolution. With a change of signals, the plate C will be moved in the direction indicated by the arrow thereby allowing the dogs D to engage with the notch in B. As will be readily seen, a downward movement of A will then cause a downward movement of B and a consequent clearing of the signal. On the cross section, Plate 10, the dotted portion shows the dog release plate for disengaging the dogs in the bars that operate the home signal for the opposite direction to that indicated. It is evident that with this arrangement, only one set of dogs can be in engagement at one time and hence only one home signal can be operative. The track instrument operating bar or shoe, is compounded with the power bar A and its mate for operating the home signal for the opposite direction, by having two sets of dogs in it, one set designed to engage a notch in one of the power bars, and the other set for engagement with another notch in the other power bar. These dogs are held out of engagement by the edges of the same plates which make the signal bar dogs inoperative.



On the actual power machine selector, shown at the center of Plate 6, one of the power bars moves upward to clear a home signal while the other moves downward to perform a similar operation. The object of this, is only to give the desired motion to the track instruments, for on the distant signal portion of the selector there is but a single power bar which by a downward movement may clear one of the two distant signals. Referring to the front elevation, the power bars of the home signals and track instruments are at 2 and 3, while that of the distant signals is at 4.

In the position shown on the drawing, both home and distant signals for each direction are in the normal danger position. To illustrate the operation of the whole selector, suppose that the track upon which this particular machine is located, runs east and west and that the power bar for the operation of the east bound home signal is the one in front at 2, while that for the west bound home signal is the one behind in the lower position at 3. It is evident that the west bound signals are in operation for the west bound power bar dogs are engaged while the east bound are disengaged. Now as a west bound train with a clear track ahead, approaches this signal, the power bars reverse but only the west bound home signal goes to clear. As to the track instruments, the first to be met by a west bound train is in





the depressed position and the other in the raised position. The dogs which operate the track instrument shoe or bar are disengaged and do not engage the west bound power bar until the latter has reached the limit of its upward stroke. The dogs for engagement with the east bound power bar are of course, held out of engagement by the dog plate, previously referred to. The west bound distant signal goes to clear immediately after the home by the action of the distant signal power bar moving the proper signal bar. When the train has passed over the first track instrument, the signals which have cleared return again to their normal danger position and the track instruments reverse for now the dogs in the track instrument shoe of the selector are in engagement with the west bound home signal power bar.

In order to prevent a train from shaking the electric locks and thereby produce a false operation of the signals, a mechanical locking device is provided on each one. The principle of the mechanical lock may be briefly described as follows. The soft iron armature proper, is held against the pivoted portion or non-magnetic part by springs and in this relative position of the two, motion of the armature is made impossible by mechanical means. In order to move the armature as a whole, it is necessary to pull the armature plate up against the magnets, which action releases the mechanical lock and allows the pivot-





ed member to move.

As the blow due to the inertia of a rotating lock wheel, is considerable, the armature on each lock is prevented from receiving the force of this blow by a mechanical bumper designed to engage with a lug on the wheel, a fraction of an inch before the latter has completed a half revolution. The operation of the rest of the machine, draws this bumper out of engagement with the lug and permits the wheel to come to rest on the armature of the lock. The bumper for the home signal lock wheel may be seen at 6 on the rear elevation.

As the distant signal always clears after the home signal, a mechanical device is inserted between the home and distant signal locks, to insure such operation.

To operate an upper quadrant system of signals with the power storage machine just described, auxiliary bars are introduced between the ends of the lazy levers directly underneath the roof of the housing and the steel rods attached to the signals, one set of bars being inserted for each pair of lazy levers. One of these sets is shown (full size) on Plate 11. Bar 1, is connected to a home signal lazy lever and 2, to the accompanying distant signal lazy lever, while 3 is the bar attached to the upper quadrant signal board. As the significance of the three positions of this type of signal has been explained on Pages 3 and 4, it will be evident that the



requirements of these bars are as follows. An upward movement of the bar 1, in connection with the home signal mechanism, must raise the board to the 45 degree position and the following upward motion of the bar 2, must throw the signal into the vertical or clear position. Either mechanism operating first after the signal is in this position, must return the board to the cautionary position and the operation of the remaining mechanism must lower the signal to its normal danger position. To explain the operation of these bars as illustrated in the drawing, suppose that there is a clear track ahead where this signal is located. When within half a mile of the signal, the home signal mechanism operates thereby raising the bar 1, to its upper position and this bar in raising, lifts the bar 3 thus moving the signal to an angle of 45 degrees. The operation of the distant signal mechanism which immediately follows that of the home, raises the bar 2 to its upper position. The first quarter inch of upward motion of the bar 2, allows the dog 8 to engage in the notch 9, and the remaining two inches of upward motion, carries the bar 3 to its uppermost position. This of course, throws the signal to the vertical or clear position. Ordinarily, the bar 1, is the first to be lowered by the home mechanism. Such a motion downward, of the bar 1, disengages the dog 8 from the notch 9 by means of cam plates 4 riveted to bar 1, thus



allowing the bar 3 to fall until engaging the shoulder on 2 in its uppermost position. This action lowers the signal through 45 degrees and the remaining downward movement of 2, returns the signal to normal.

To illustrate another condition which this type of signal must satisfy, consider that upon approaching a signal, the track is clear for both home and distant signals and that the signal has been raised to the clear position. Now suppose that a moment or two after the board has assumed the clear position, a train backs into the distant signal zone. Such an occurrence must at once lower the signal to caution. In this case the distant signal bar 2, would be the first to be lowered, and the motion of this bar downward would permit 3 to fall until arrested by shoulder 15 of bar 1. The last quarter inch of downward motion of 2 throws out dog 8, from engagement with 9 by bell crank 12 coming in contact with plate 16a fixed underneath the roof of the housing of the power machine. Should the train under consideration, back until it is within the home signal zone, the resulting downward movement of the bar 1, will return the signal to its normal position. This action will occur anyway, as soon as the forwardly moving train passes by the signal.

The track instrument operating machine referred to on Pages 5 and 7, in connection with the plan in which but one track instrument is used, is shown in section on





Plate 12. This machine may be used with the power storage machine described, or with any signal operating mechanism already installed. When operated by the power machine, the track instrument portion of the selector is eliminated and this machine is so connected to the power machine that its operating arm to be mentioned later, is compelled to move in accordance with the home signal cylinder shaft. The lowering of the track instrument, is effected by this machine "cocking and firing".

Referring to Plate 12, the operation of this machine is as follows. Suppose that the signals being operated are normally in the danger position, and that a train has cleared the signals where this machine is located. The action of clearing the signals, turns the shaft 2 in a clockwise direction which moves the arm 3 from left to right. As this arm straddles the shaft 4 and presses against the collar 7 at its end, the movement of this arm compresses spring 9, thereby "cocking" the machine. The spring 9 is held in the compressed position by the energizing of magnets 24 and 32, the armatures of which are linked to the levers 17 and 25 respectively, furnishing a leverage of twelve to one at the shoulders 19 and 27. When the train is within a few feet of the track instrument, the lever 3 returns to its original position, the signals move to danger and the magnet 24 becomes deenergized, thereby allowing the shaft 4 to snap to the right





or "fire". This serves to rotate sprocket 12 and the sprocket on the track instrument shaft, the latter action serving to depress the track instrument. After the train has proceeded a few feet beyond the depressed track instrument, the latter assumes its normal position by the deenergizing of magnet 32 and the action of a counter-weight connected with the track instrument shaft. Speed control, previously mentioned, is obtained by holding magnet 24 until the train has approached closer to the track instrument than in the illustration just given.

The track instrument is shown on Plates 2,3 and 4, and consists essentially of two manganese steel bars pivoted at their ends to an angle and riveted together at the center. These bars are raised by rotating a shaft to which is keyed an arm. As will be seen, one of these bars has a slot in it in which there fits a roll pivoted on the crank. When these bars are in the raised position, the slope at the top of the two is about one in thirty. They are made depressable when in the raised position by a spring bearing of the crank. A pressure of about three hundred pounds is required to lower them and they are made depressable so that anything on the moving train other than the engine machine, will not injure them. The engine machine has, to guard it from obstacles on the right of way, what is known as a "scraper", (see D', on Plate 4) which is nothing more than a steel angle bar set



crosswise to the track, so low down that it always depresses the track instrument before the latter comes in contact with the engine machine.

The engine machine on Plate 13, operates in the following manner. Members 2 and 1 are known respectively as the "locking" and "plunger" plates, and are arranged to slide vertically in guides in the main frame. The thinner of the two, acts as a lock on the other, being held down in the position shown by two springs. It will be seen that this locking plate projects below the plunger plate a short distance (actually about  $3/8$  of an inch). This plate being lower than the main plunger plate, it is always first to come in contact with the track instrument and the raising of it by the latter, serves to unlock the other. This action is accomplished by releasing two dogs which rest on the plunger plate and engage lugs on the side of the frame. These dogs have projections which extend into holes in the locking plate. The contact surface of the sides of these holes with the projections on the dogs, are of such form that the raising of the locking plate, throws them out of engagement with the aforementioned lugs. When the main plunger plate has been released, it rises, which action permits the peculiarly shaped lever to fall from the pressure of the air on the poppet valve and that of the heavy spring on the stem of the latter. This spring can only expand



about a quarter of an inch, being limited by the collar rigidly connected to it. When the poppet valve has been opened, air will escape from the train pipe reducing the pressure in the system until it balances the weight of the plunger plate and the pressure of the lock plate springs. To lock the valve, the engineer is obliged to raise the plunger underneath the valve stem with a hand lever, until the heavy spring is sufficiently compressed to permit the locking dogs to engage the lugs on the frame of the machine. The locking of the engine machine is purposely made difficult, so that when an engine machine has been opened by a track instrument, the train is compelled to come to a full stop before proceeding further.

Some points should be emphasized in connection with the self checking schemes for absolute safety which have been applied throughout the work. As electrical devices are usually the most faulty in their operation, special attention has been paid to them wherever used. It will be noted that on the power machine and the single track instrument operating machine, all electro-magnets are prevented from faulty operation, by mechanical locking devices operative on the side of safety. The power machine mechanisms have been made self checking in various ways. Should the power springs run down, a device is used to hold the signals in the danger position. If





owing to any cause, the signals stick in the clear position, a train is brought to a stop by a raised track instrument. A breakage of the connections between the track instruments is provided for by counterweights connected to the latter which serve to raise the one depressed, into the tripping position.

All parts of the machine are properly designed and are of suitable material to withstand the stresses and wear to which they are subjected.

In the practical installation, the weather-proof housing of the power machine is so designed that air may circulate freely through it, and thereby prevent an undesirable collection of moisture. The sprocket cases and single track instrument operating machine are filled with oil, for the purpose of lubrication and the elimination of the difficulty just mentioned. The track instrument is flexible so as to protect it from breakage, and the engine machine is protected from this same danger by suitable means. From a careful study of the latter machine, it will be noted that it is in all ways, designed on the side of absolute safety. Any part in the machine may break and such an accident will always apply the brakes, bring the train to a stop and thus warn the engineer that something is out of order. The object of using two vertically guided plates instead of a bell crank or other device, was to prevent any object other than the track





instrument from operating the machine.

As the mechanical apparatus connected with this system, has been described, a description of the electrical apparatus will now be presented together with the principles of operation of the track circuits and signal circuits.

On steam railroads, there are three types of relays used, the ordinary track relay, the "reversing" relay and the "unset" relay. All of these depend upon electro-magnets for their operation. The first mentioned type consists merely of an electro-magnet, the armature of which is arranged to make or break contacts. By way of definition, it may be said that points closed when the relay is energized are known simply as "contacts", while those closed by the deenergizing of the relay are termed "back-points". The second type of relay is especially designed for use with single track circuits and is a combination of two track relays and two special contacts which are closed by deenergizing the relays in the proper order. Deenergizing the relays in the reverse order fails to close these contacts. Like the reversing relay the unset relay is used only in connection with single track work, its function being, to break the signal circuits of opposed trains to the first one entering a single track section between two sidings.

Plate 14, shows diagrammatically, a reversing relay.



From a study of the construction of this relay, it will be seen that if the magnet E is deenergized first and is followed by magnet A, the contact XX will be closed, but when these magnets become deenergized in the reverse order, this break is not closed.

The action of the unset relay can best be understood from the following description of the single track wiring plan shown on Plate 15. At first sight this plan appears exceedingly complex but when the principles of it are once understood, it becomes simple. In nearly all systems of block signals, electric current is kept continually flowing through the rails when unoccupied by trains. On Plate 15, the squares k,k, etc. represent insulated joints which divide up the single track between the two sidings into blocks. Signals are shown at 1,2,3,4, and 5, there being home and distant signals for each direction. The circuits consist essentially of two parts namely, the track circuits and the signal operating circuits. To every insulated block, there is a relay operated by its own battery. This relay may be an ordinary track relay or one unit of a reversing relay. It is apparent from a study of any one of these sections, that the presence of a train on that section, will serve to short circuit the battery wired into it and thereby deenergize the relay of that section. Deenergizing this relay, will of course, break any contacts and make any



back points which may be on it. The signal circuits are used indirectly, only to operate the electric locks in the power machine and are entirely distinct from the track circuits. Relays from 1 to 9 inclusive, are reversing relays, even numbered ones being used to complete or close the signal circuits of east bound trains by deenergizing them in the proper order and odd numbered ones, of west bound trains in a similar manner. By referring to Plate 14, it will be noted that for practical convenience in wiring this type of relay, the wires of the magnet having its armature at the "B" end are brought out of the "O" end and vice versa. The relays 1a to 8a inclusive are ordinary track relays, while 10 and 11 are unset relays, one for each direction. M1, M2 etc. are ordinary relays introduced to economize in current for the operation of the electric locks. B', B'', and B''' are switch circuit breakers, points 1 to 5 being closed with the switch set on the main line, and 6, 7 and 8, closed with the switch set on the siding.

The fundamental principles of a home and distant signal circuit can be gained from a diagram on Plate 16. This represents just the circuits of the home and distant signals at A, west bound. M1 and M2 are the home and distant signal magnets of the respective power machine locks. c, c, etc. are contacts on relays, one pair for each insulated block and xx are the special contacts on





one of the reversing relays. To illustrate the operation of these circuits, suppose a west bound train crosses from section 1 into section 2, which is a point about half a mile from the signal. Such action closes the contacts xx, and if the track is clear ahead up to and including section 9, the circuit m, m, etc. is completed, thus energizing M1. This sends the home signal, which normally stands at danger, to the clear position and closes the circuit breaker R, attached to the home signal. Should the track be clear up to and including section 13, the distant signal circuit n, n, etc. will be completed, thereby energizing M2 and clearing the distant signal. As soon as the train has crossed into section 3, which is a short section at the signal, the contact c' is broken. This breaks the signal circuits, deenergizes the electric locks in the power machine, returns the signals to their normal position and reverses the track instruments. The train is now protected from following trains, by holding the signal circuits of A open, with the contacts c, c, etc. until it has passed beyond section 12. Of course in the actual wiring plan, there are various modifications of the above scheme but the main principles are the same.

Referring again to Plate 15, assume that there is a clear track between the sidings A and B, and that a train is going to enter this section from the east. This train first breaks the signal circuits of east bound trains at-





tempting to enter the section under consideration. The breaking of opposed circuits is as previously mentioned, the function of the unset relays. When the train has crossed from section a into section b, both ends of reversing relay 1 have been deenergized in the proper order to close the special contacts in it. Starting at binding post 0 of relay 1, current flows through the wire 1, 1, etc., through the side track switch circuit breaker to binding post 3 of unset relay 11. From this point, it passes around the electro-magnet A (shown at the top, Fig. 1 ), and out of 4, into 7 of relay 10 and out of 1 to battery C'. It then flows back by wire 2, 2, etc. through the various reversing relays to B of relay 1, and crosses special contacts XX to 0. This circuit energizes magnet A of relay 11, thus "unsetting" this relay by attracting the armature of A against the compression of the spring tending to hold it in the position shown. This also permits the armature of B to assume the deenergized position, under the compression of its spring. In actual practice, these relays are mounted in an upright position and their armatures are so counter-weighted that gravity is used to move them in place of springs.

The shifting of these armatures, serves to break the contacts between 3 and 4, and 7 and 1 of this relay, and to make those between 6 and 2, and 4 and 5. As the east bound battery circuit or signal circuit of signal 4,



passes through contacts between 1 and 7 of relay 11, and as there is now a break between these two points, the desired object is attained. Since the contacts between 3 and 4 are also broken, magnet A is no longer energized, but in its place the west bound signals of signal 1 are put in operation by the completion of the following circuit. Current flows by wire 1, 1, etc. from 0 of relay 1 through the switch circuit breaker, then by wire 3, 3 etc. through the west home signal relay M3, to binding post 5 of relay 11, then out of 4 (as the contacts between 5 and 4 are now closed). It now flows into 7 and out of 1 of relay 10, to battery C', then back through the various reversing relays and the contacts XX to the starting point 0 of relay 1. If the selector in the power machine is already set for west bound trains, the west bound home signal moves at once to the clear position, being immediately followed by the west bound distant signal. If on the contrary, the selector was last operated by an east bound train, the energizing of M3 serves primarily to energize the selector lock. As this releases the selector mechanism, the dog plates in the selector are shifted, and a double-throw circuit-breaker moving in accordance with the selector mechanism is rotated through half a revolution. The latter, by means of local circuits, energizes the locks of west bound signals and sends those signals to the clear position.



It will be noted by a study of the wiring diagrams of the reversing relays, that the home signal circuit in this particular case, overlaps to the center of the section instead of just one insulated block beyond signal 2, as is the usual case. The distant signal circuit is, as previously mentioned, merely an extension of the home signal circuit up to relay 3a. This extension 5, 5, etc. attaches to wire 3 at relay M3, passes through a circuit breaker b1, attached to the home signal and closed when that signal clears, passes through M4 and then along a pole wire to contacts 4-4 of relay 3a. From there, it passes back through all the relays between the end of the home signal circuit and the relay 3a, attaching to wire 3 near binding post 5 of relay 11. When the train crosses into the short track section c, the relay 1a of this section is dropped. This breaks the battery of section d, as the battery is wired through contacts on 1a. Breaking this battery, causes the unit in reversing relay 2 wired into section d, to be deenergized. As the west bound signal circuits of signal 1, pass through this particular unit, they are broken and the west bound signals of signal 1 return to their normal position.

If another train follows the first, it will get its west home signal as soon as the first train has passed beyond insulated section j, and its distant signal after the first train has passed beyond insulated section m.





To explain the method of speed control, suppose that when the second train approached signal 1 from the east, the home signal cleared but the distant signal remained in the cautionary position. This indication is an order to proceed at a reduced speed. Further suppose that the engineer disregarded this signal and proceeded at full speed into section c. Such a procedure would bring the train to a stop by engagement with the second track instrument L' in the following manner. 41 is a circuit breaker on the distant signal and is closed when that signal is at danger. It will be seen by carefully noting the wiring at signal 1, that this circuit breaker when closed, patches the break of the battery of section d, produced by deenergizing relay 1a. With this battery patched by circuit breaker 41, the unit in reversing relay 2, wired into section d, is not deenergized. Hence the signals do not go to danger nor do the track instruments L and L' reverse. Only when the train passes into section d, are they put in operation, and as the distance from the end of section c to L' is very short, track instrument L' is not depressed soon enough to allow the train to pass. This scheme of speed control is employed at every signal.

Considering again just one west bound train after it has passed signal 1. As it approaches signal 2, it obtains its signals in a manner similar to that described





and continues west. After passing section j, the unset relays are set by the completion of the following circuit. Starting from battery C' at unset relay 10, current flows by wire 2, 2, etc. through reversing relays 4, 3, and 2 to B of reversing relay 1, and out of binding post 1 of this relay. (See wiring diagram of relay 1.) It then flows by wire 4 to 6 of relay 11, around the coils of magnet B of this relay, out of 2, into 7 of relay 10 and out of 1 to battery C'. The energizing of magnet B, restores relay 11 to its original position and the train is now under the protection of relays 5, 6, 7 and 8.

As the distance from signal 4 to the siding, is usually short, the west home signal circuit of signal 3, is wired through the switch circuit breaker so that absolute prevention of derailment at the switch is assured.

The wiring at the passing track is quite complex, hence only the ends accomplished by it, will be mentioned. The west bound train will obtain clear signals at signal 4 if the switches be set on the main line and the track be clear for entrance into the next section. Either switch set wrong or a train standing or moving on either the side track or the main line in such a manner as to be in danger of collision with the west bound train, will hold the signals at signal 4 in the danger position. If on approaching signal 4, there be a train standing on the side track and the switches be set on the main line, the



west bound train may proceed at full speed, provided that the section beyond the siding is safe. Reversing the condition by putting the waiting train on the main line and setting the switches for the siding, the approaching train will clear the home signal only, as the distant signal will remain in the cautionary position. This is to prevent the train from jumping the switch by proceeding at full speed. A train standing on the siding, may obtain its signals for exit from the siding, if the switch be properly set and the track be clear ahead.

An east bound train is controlled by circuits similar to those just explained.

There are three plans of double track wiring, one in which the signals stand normally at danger and two in which the signals are normally in the clear position. These three plans are all simple and since the fundamental principles of them are, with slight exceptions, embodied in the foregoing description of single track circuits, a detailed description of them has been considered unnecessary. The signal circuits are practically the same in principle of operation, as those for single track work, but ordinary track relays are used in place of reversing relays.

The extent of a home signal circuit is determined in the following manner. The battery of one insulated section, is wired through the relay of the adjoining



section beyond, and this process is continued up to the end of the first insulated section beyond the next signal in advance of the one under consideration. From this, it is evident that a train will hold a home signal circuit open, until it has all passed out of the last mentioned insulated section, and then all of the relays in this zone will recover in the reverse order in which they were deenergized. In order to obtain speed control, a slight deviation from this principle, is made by wiring the relay of one section through that of the next section to it. The distant signal circuit is merely an extension of the home signal circuit and requires no special comment.

In the normal danger plan, the home signal circuit is a short one at the signal and is put in operation for clearing a signal by closing back points on one of the track relays. This signal circuit though short, controls the track the desired distance by the previously mentioned interwiring of track batteries and relays.

In one of the normal clear plans, the home signal circuit is wired through the various track relays, while on the other plan, it is a short one at the signal.

The circuits of the operating machine for one track instrument are not included, as they are somewhat complex. Suffice it to say that they are local circuits adapted to be used in combination with any block signal system already in operation.





On electrically operated roads, alternating current is used in place of direct current, for the operation of the track relays and power storage machine locks. Insulated rail joints are used together with reactance bonds so that the rails may be utilized for the return of the direct propulsion current to the power house.

The power machine locks are especially designed for alternating current. The magnet cores are composed of two parts, each U-shaped, one fixed and the other adapted to move longitudinally within the extensions of the coils surrounding its mate. When the lock is energized, these cores form practically a closed magnetic circuit, with the result that the current consumption is small.

There are two types of relays which may be used, one of which is similar in principle of operation, to the electric lock just described, and the other in which the relay is composed of a two-phase induction motor with the shaft of the latter adapted to make and break contacts as in any relay. One phase is continually energized from the line while the other (of low voltage and current consumption) is energized from the track. Short circuiting the latter phase serves to "deenergize" the relay. Either of these types are made "reversing", and since the extent of an alternating current circuit may be of great length and still operate successfully, two sets of special contacts are put on these relays, one being used for closing



the signal circuit for a car traveling in one direction and the other for closing that for a car traveling in the opposite direction.

Alternating current is supplied to the track and signal circuits, through transformers.

The principles of the signal circuits and track circuits are the same as those on steam roads.

In conclusion, permit the writer to quote from the "Second Annual Report of the Block Signal and Train Control Board to the Interstate Commerce Commission".

"As regards the system taken as a whole, the board concludes that if the faults herein mentioned were remedied, and it sees no reason why they should not be substantially overcome, and if the apparatus were well inspected and maintained, the system would be safe and reliable and its use would tend materially to promote safety of operation on a railroad using it. As to its economy, there are not sufficient data from which to form a conclusion of any real value."

The faults herein referred to, though slight, have been remedied with great care and valuable additions to the system have been made since the test by the United States Government. The system, when adopted, whether well inspected and maintained or not, will always be safe, and will be reliable so long as it receives the attention which all mechanical and electrical devices require to



keep them in proper working order. As to its economy, especially on steam roads, it is far more economical to operate than the ordinary block signal system and when all of the advantages afforded by this system over those of a block signal system are considered, it becomes invaluable. The designer of this system for safeguarding the movements of trains, has entirely eliminated the human equation and has considered the block signal merely a convenience of secondary importance.

When such a system becomes the standard means of protection against railroad collisions, it will bring to an end, the appalling records of dead and injured, who annually meet their fate in such horrible disasters.

Will not the accomplishment of this single end alone, be sufficient recompense to the designer for twenty odd years of labor in behalf of humanity?



INDEX





INDEX.

	Page
Automatic train control, Definition of-----	1.
Alternating current power machine locks-----	36.
Comments on mechanical devices-----	24-25.
Conclusion-----	37-38.
Double track circuits-----	34.
Engine machine-----	5,22-23.
Installations of Rowell-Potter System-----	1-2.
Installation using two track instruments-----	4-5.
Installation using one track instrument-----	5.
Operating machine for one track instrument----	19-21.
Circuits of-----	35.
Purpose of thesis-----	1.
Power storage machine-----	4,8-17.
Principle of operation of system	
using two track instruments-----	6-7.
using one track instrument-----	7.
Principles of signal circuits-----	27-28.
Relays,	
Alternating current-----	36.



Index (Continued)

Page

Relays, (Continued)

Direct current reversing,-----	25-26,27.
,, ,, track-----	25.
,, ,, unset-----	25,26.

Signals,

Upper quadrant-----	2,3.
Two board two position-----	2,3.
Safety stop-----	2-3,4.
System as a whole, Outline of operation of----	5-7.
Self checking devices on power machine-----	23-24.
Single track circuits-----	26-34.
Speed control-----	32.
Types of signals used-----	2.
Track instrument-----	4,21,22.
Upper quadrant bars-----	17-19.



REFERENCES





REFERENCES.

"The Rowell-Potter Safety Stop"

Second Annual Report of the Block Signal and Train Control Board, to the Interstate Commerce Commission. Nov. 22, 1909. Appendix A.

"Report of W.L.Tarbet, Consulting Engineer."

Annual Report of the Railroad and Warehouse Commission of Illinois. 1898. Page XXI.

Annual Report of the Railroad and Warehouse Commission of Illinois. 1899. Pages XLIX. to IX.

Proceedings of the Eleventh Annual Convention of the National Association of Railway Commissioners. Denver, Colorado. Aug. 1899.

Proceedings of the Twelfth Annual Convention of the National Association of Railway Commissioners. Milwaukee, Wis. May 28-29, 1900. Pages 165,166.

Proceedings of the Eighteenth Annual Convention of the National Association of Railway Commissioners. Washington, D.C. April 2-5, 1906. Pages 68,71.

"Are Present Methods of Train Protection Adequate?"

by C.E.Davis, M.W.S.E.

Journal of the Western Society of Engineers.

April, 1900. Paper presented March 7, 1900.

Written Discussions by Chas. Henry Davis and

MEMORANDUM

TO: THE PRESIDENT

DATE: [Illegible]

SUBJECT: [Illegible]

[The remainder of the memorandum text is illegible due to extreme blurriness.]

Benton C.Rowell.

"Recent Development of Block and Interlocking Signal System." by W.H.Elliott.

Railway and Locomotive Engineering. Jan. 1903.

Page 31.

"Disregarding Signals."

Railway and Locomotive Engineering. March, 1903.

Page 124.

"The Rowell-Potter Safety Stop on the C.M. and ST.P. R.R.!"

Railway and Engineering Review. March 15, 1902.

Pages 199-202.

"Automatic Train Stops." by H.E.Bailey.

Railway and Engineering Review. April 6, 1907.

Page 299.

"Train Operation and the Human Equation." by H.E.Bailey.

Railway and Engineering Review. Feb. 19, 1910.

Page 164. June 11, 1910. Page 551.

"Editorial."

Railway Age. April 10, 1903. Page 698.





Fig. 1.

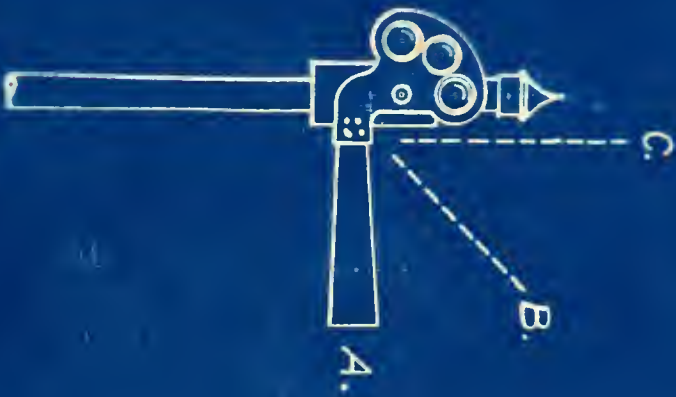


Fig. 2.



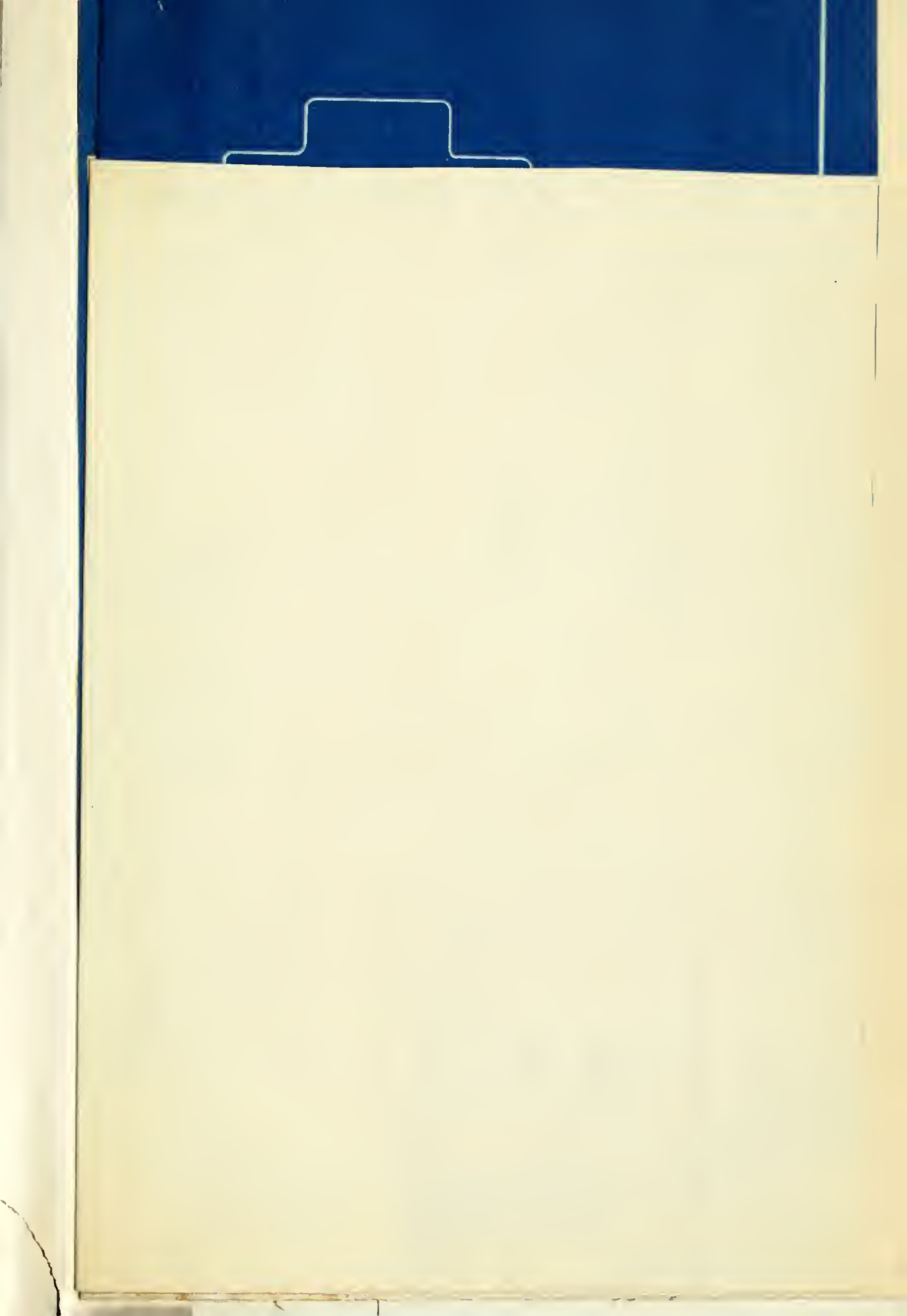






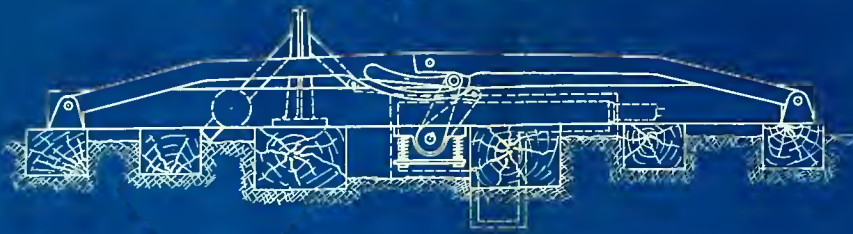






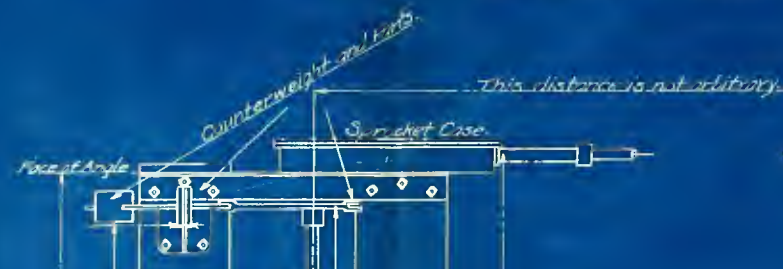




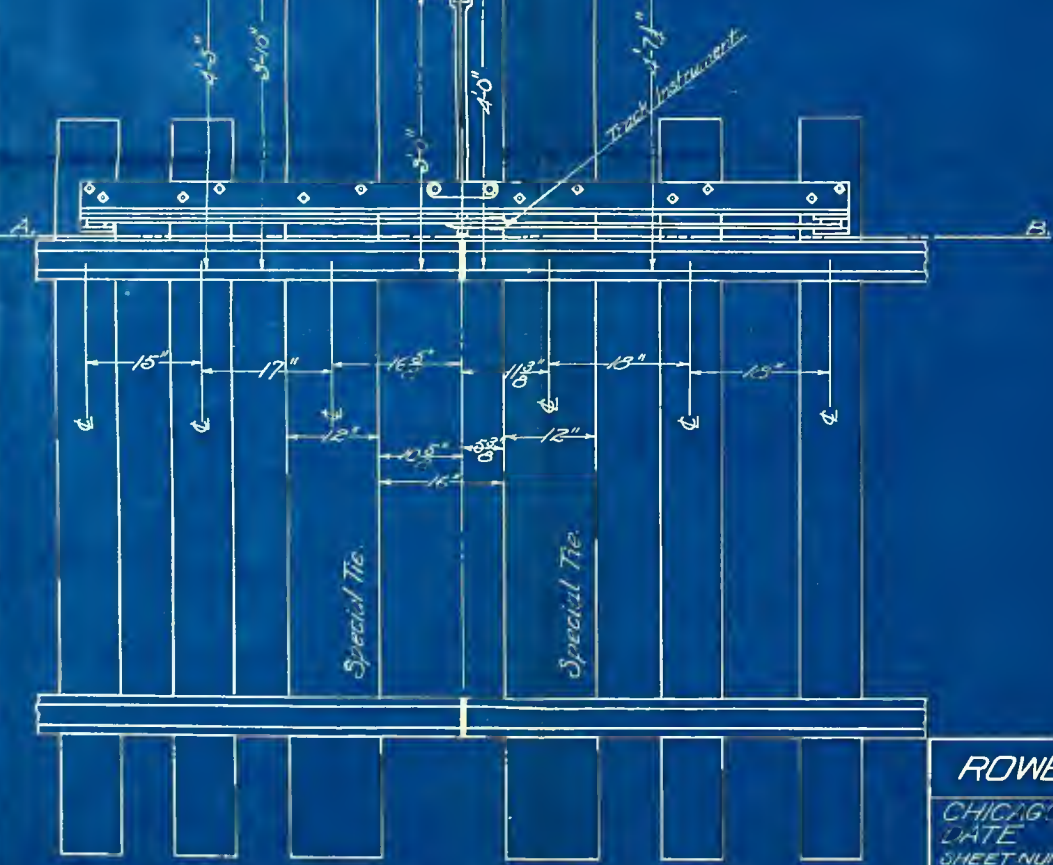


SIDE ELEVATION THROUGH *AE*.

Base of Signal.



Track Instrument Machine.



**ROWELL-POTTER SAFETY STOP CO.**

CHICAGO ILLINOIS  
 DATE OCT. 12, 1910.  
 SHEET NUMBER  
 DRAWER  
 SECTION  
 NOTES

RELATIVE LOCATION OF TRACK INSTRUMENT AND OPERATING MECHANISM AS APPLIED TO STANDARD BLOCK SIGNALS.  
 SCALE 1"=1'-0"  
 DRAWN BY G. T. [Signature]  
 TRACED BY G. T. [Signature]  
 APPROVED BY B. L. [Signature]





FRONT  
ER TRUCK







**ROWELL-POTTER SAFETY STOP CO.**

CHICAGO, ILL.

SHEET 6  
SCALE - 1/4" = 1"

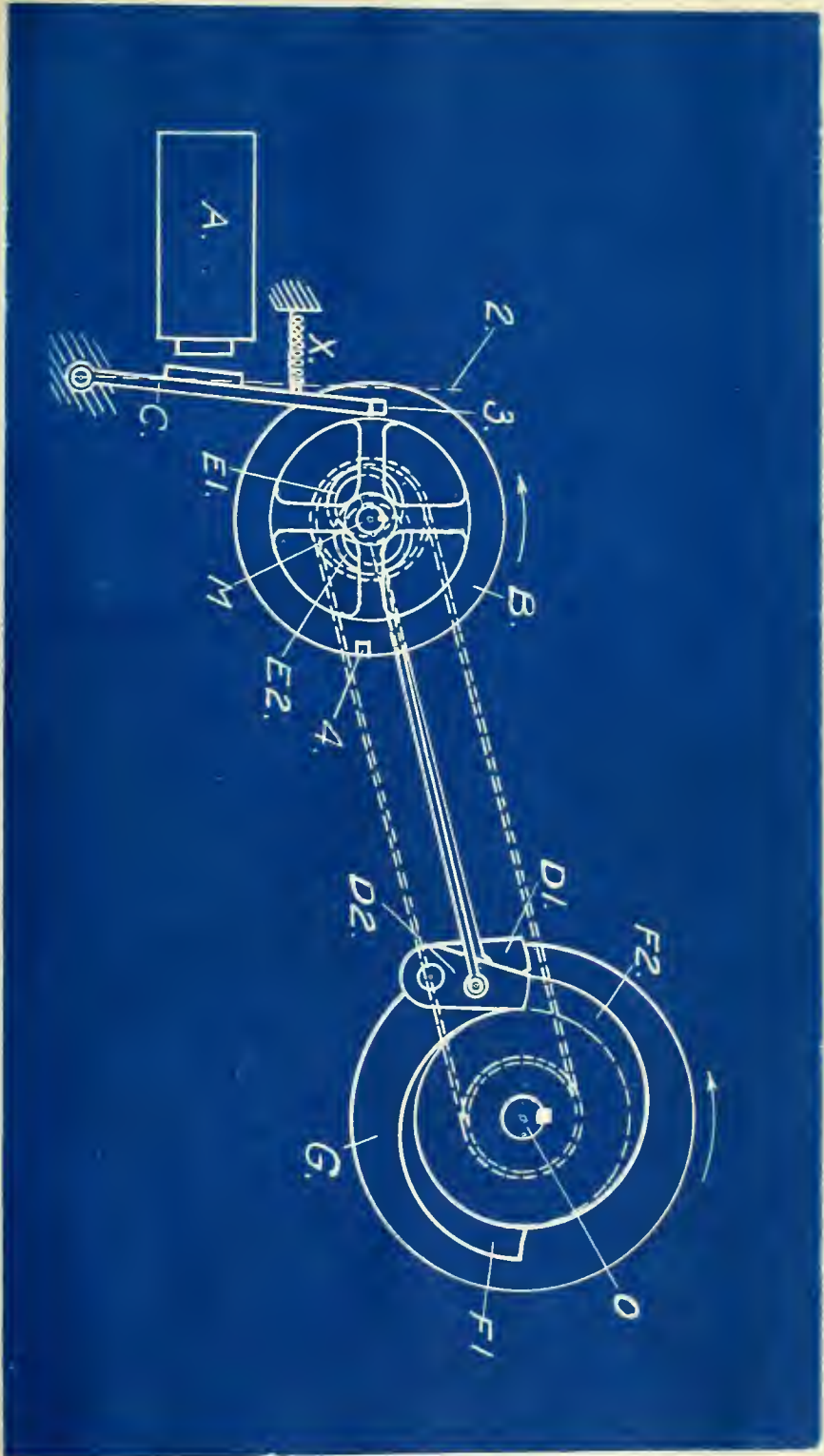
May 6, 1909.

*L. H. Hopkins*

APPROVED *R. S. R.*

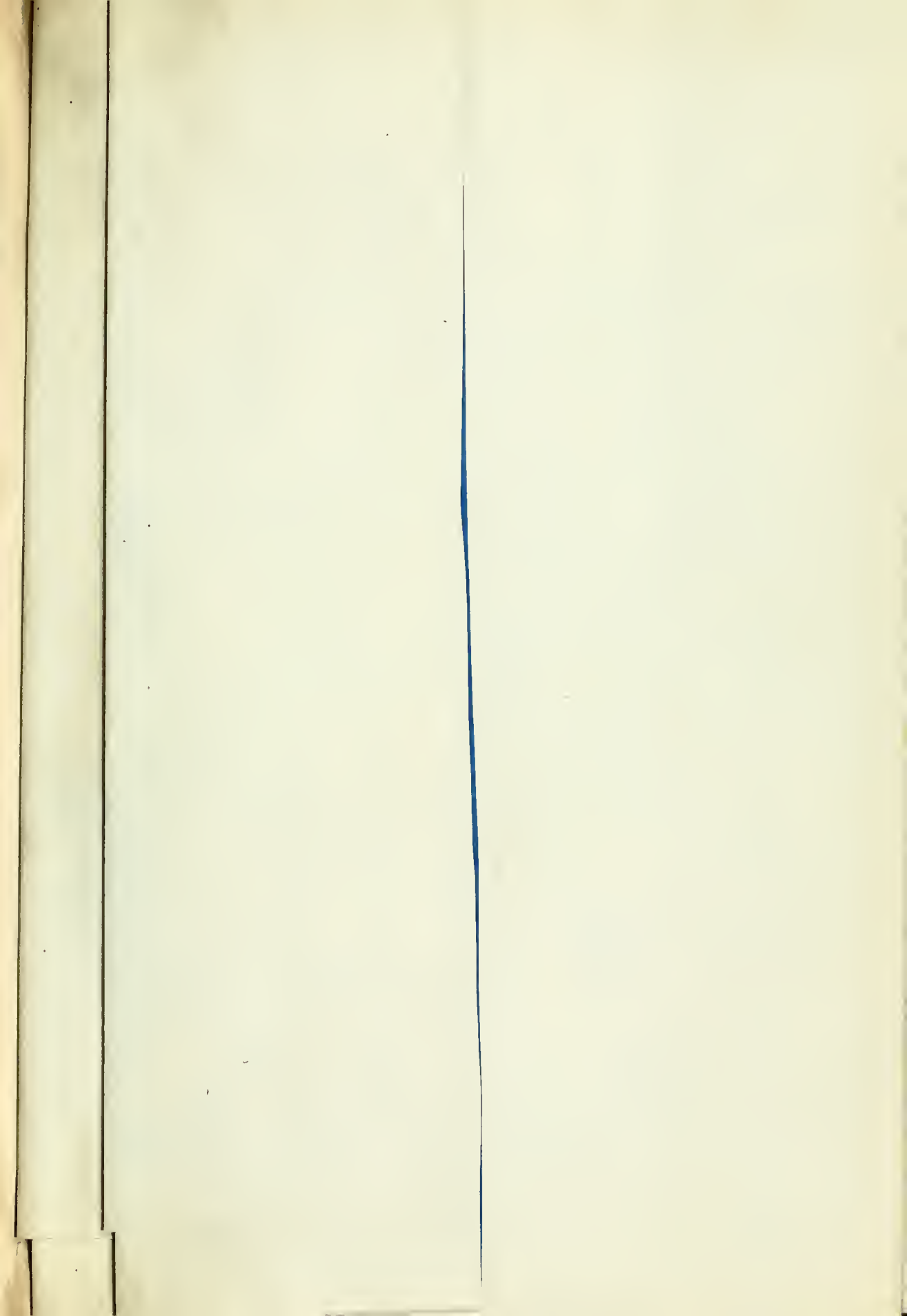






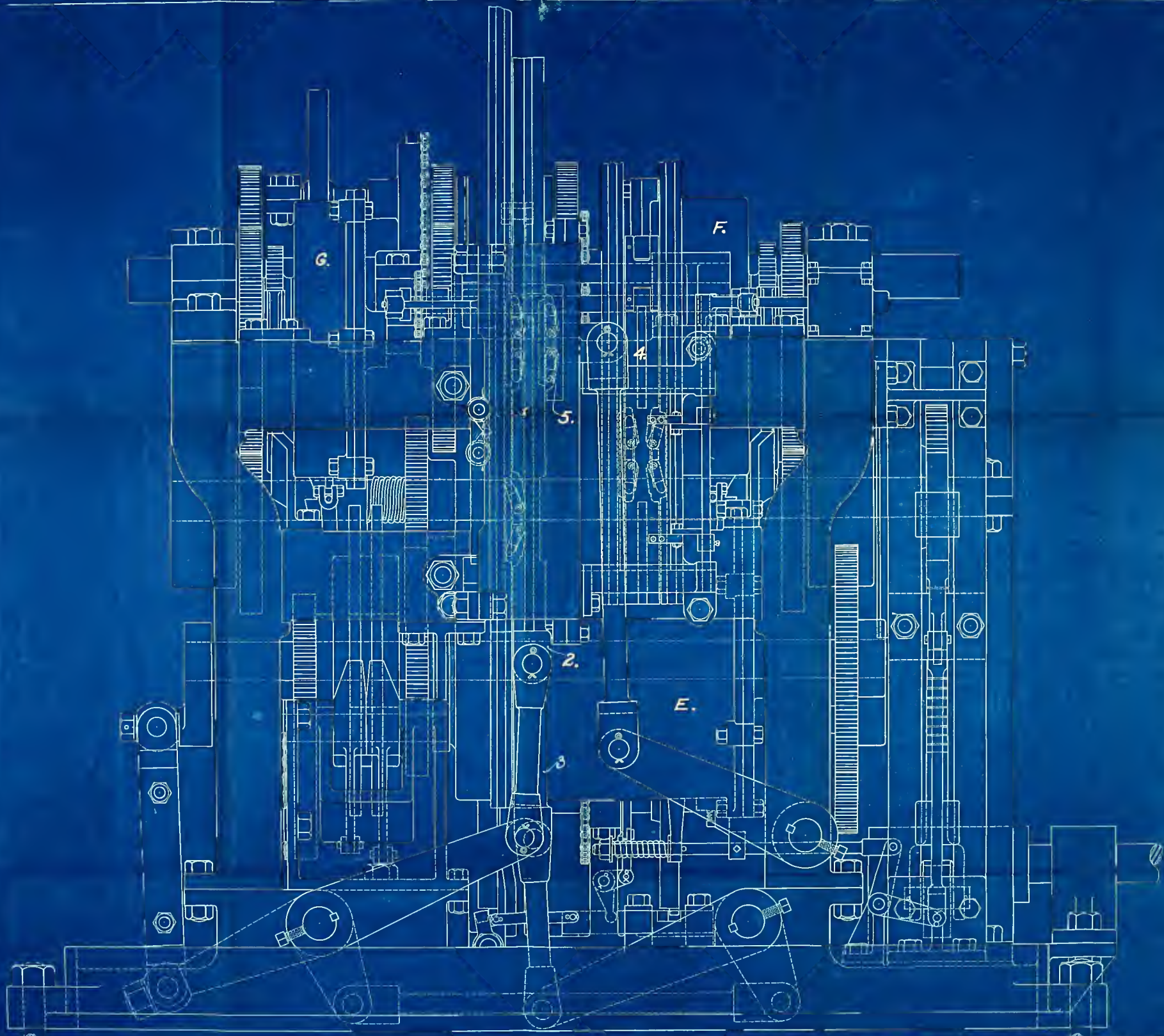












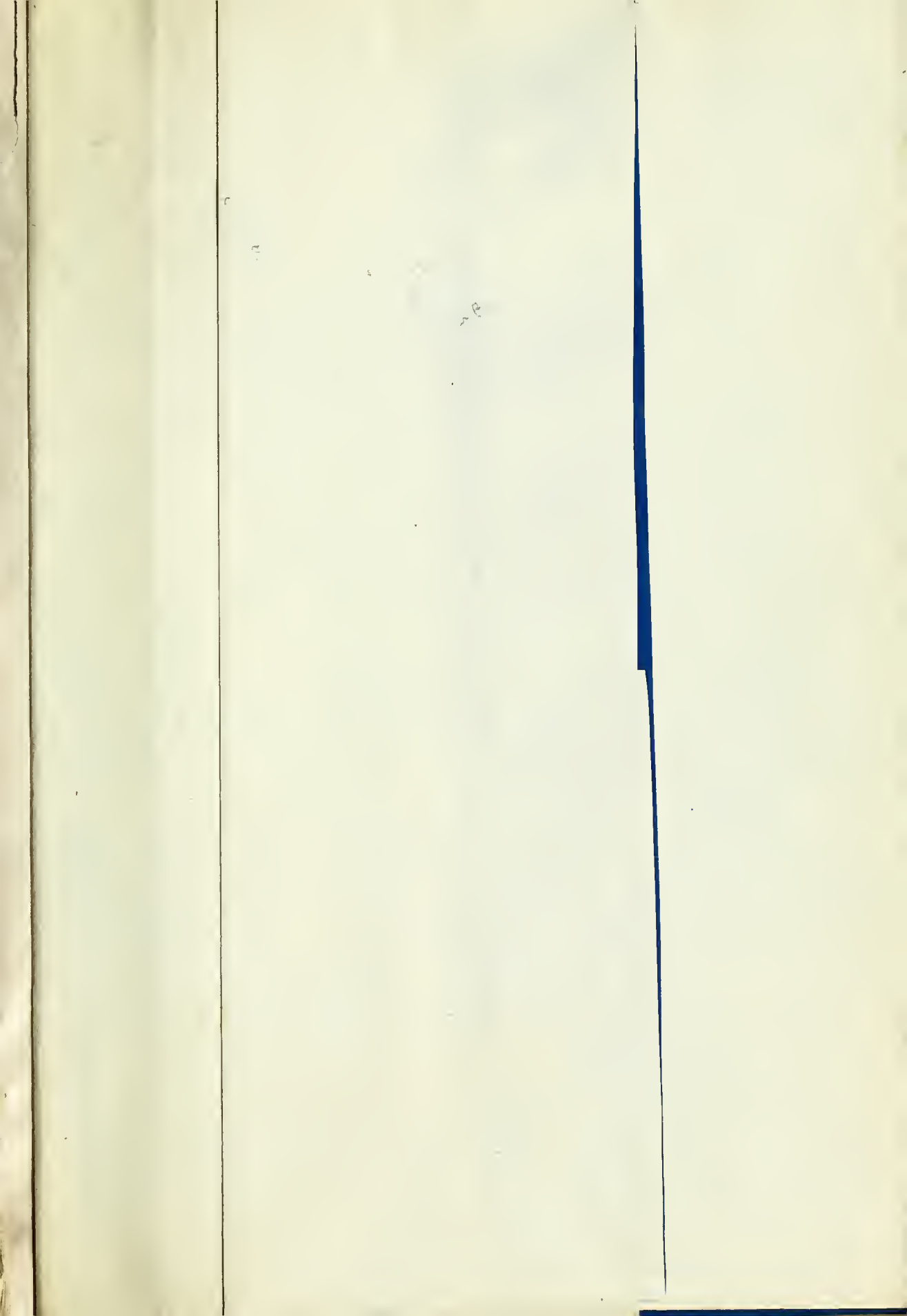
ROWELL-POTTER SAFETY STOP CO.

CHICAGO ILLINOIS.  
DATE MAY 1, 1909.  
DRAWN BY R. Hopkins  
SECTION  
NOTES-

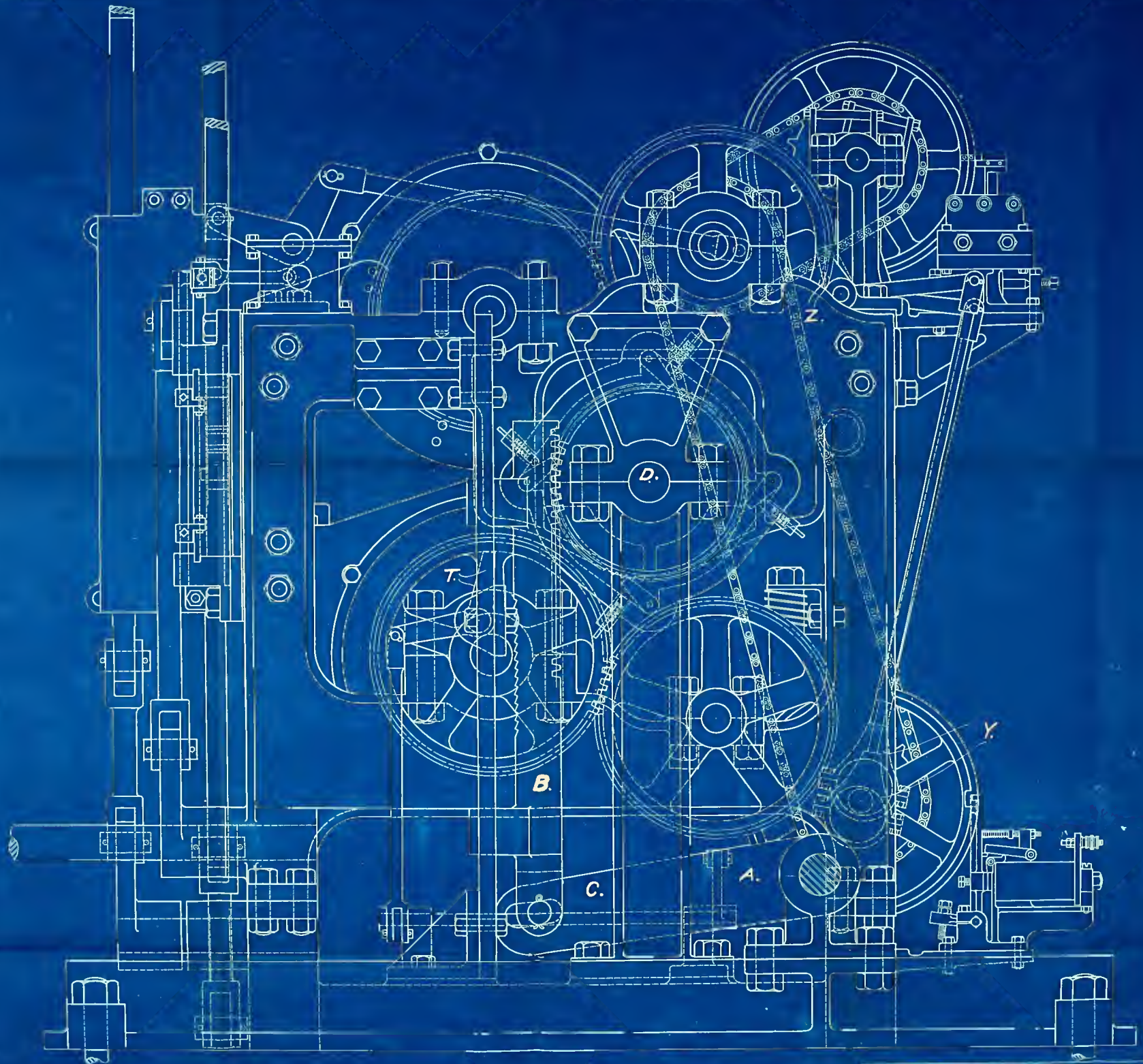
ASSEMBLY, FRONT ELEV.  
MACHINE D.  
SCALE 8 IN. = ONE FT.  
DRAWN BY R. Hopkins  
TRACED BY B. L. Rowell  
APPROVED BY B. L. Rowell











ROWELL-POTTER SAFETY STOP CO.

CHICAGO

ILLINOIS

DATE

MAY 1, 1909.

SHEET NUMBER

DRAWER

SECTION

NOTES:-

ASSEMBLY-FRONT ELEV.

MACHINE U

SCALE 5 IN = 1 FT.

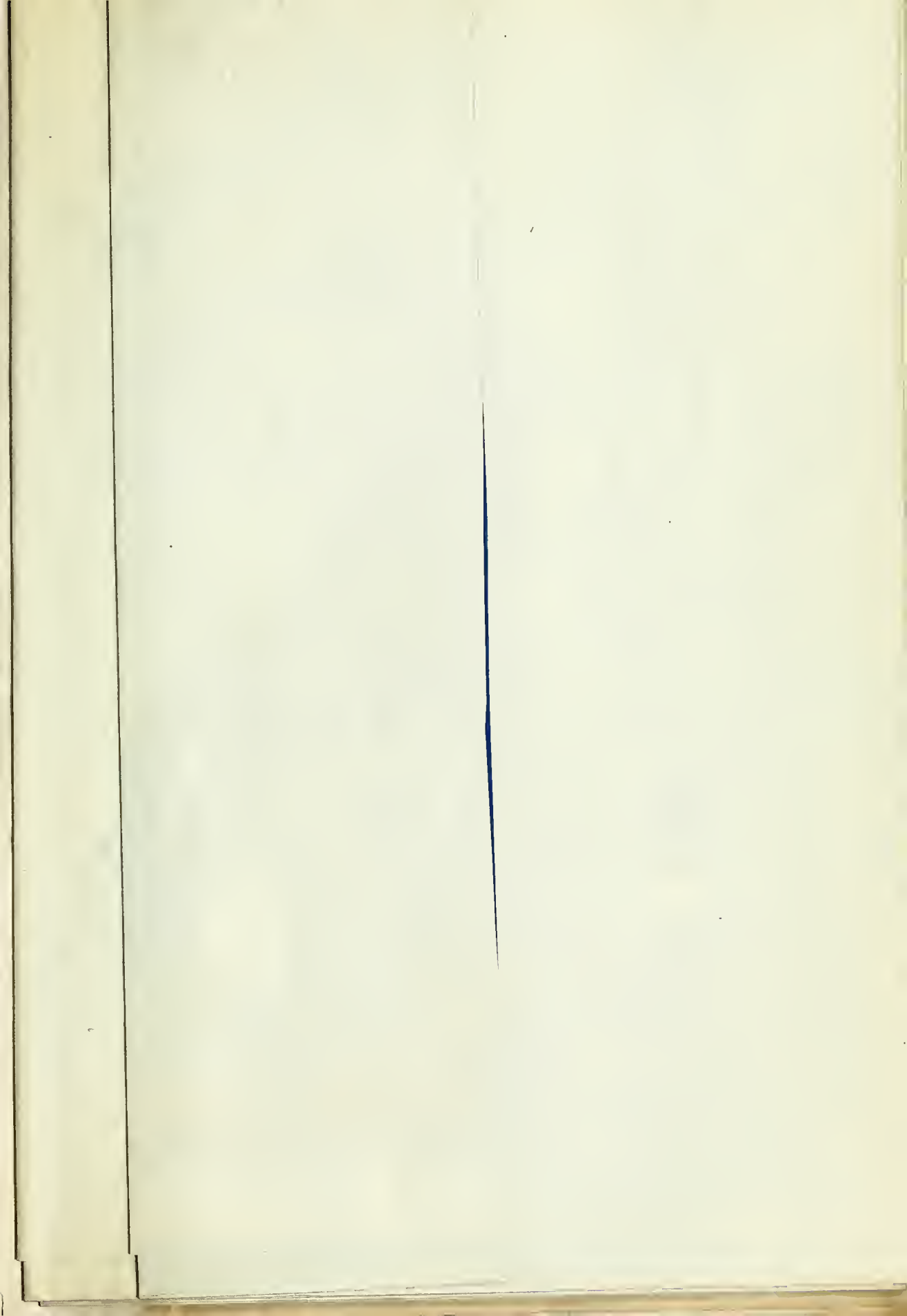
DESIGNED BY A. H. HARRIS

TRACED BY G. W. HARRIS

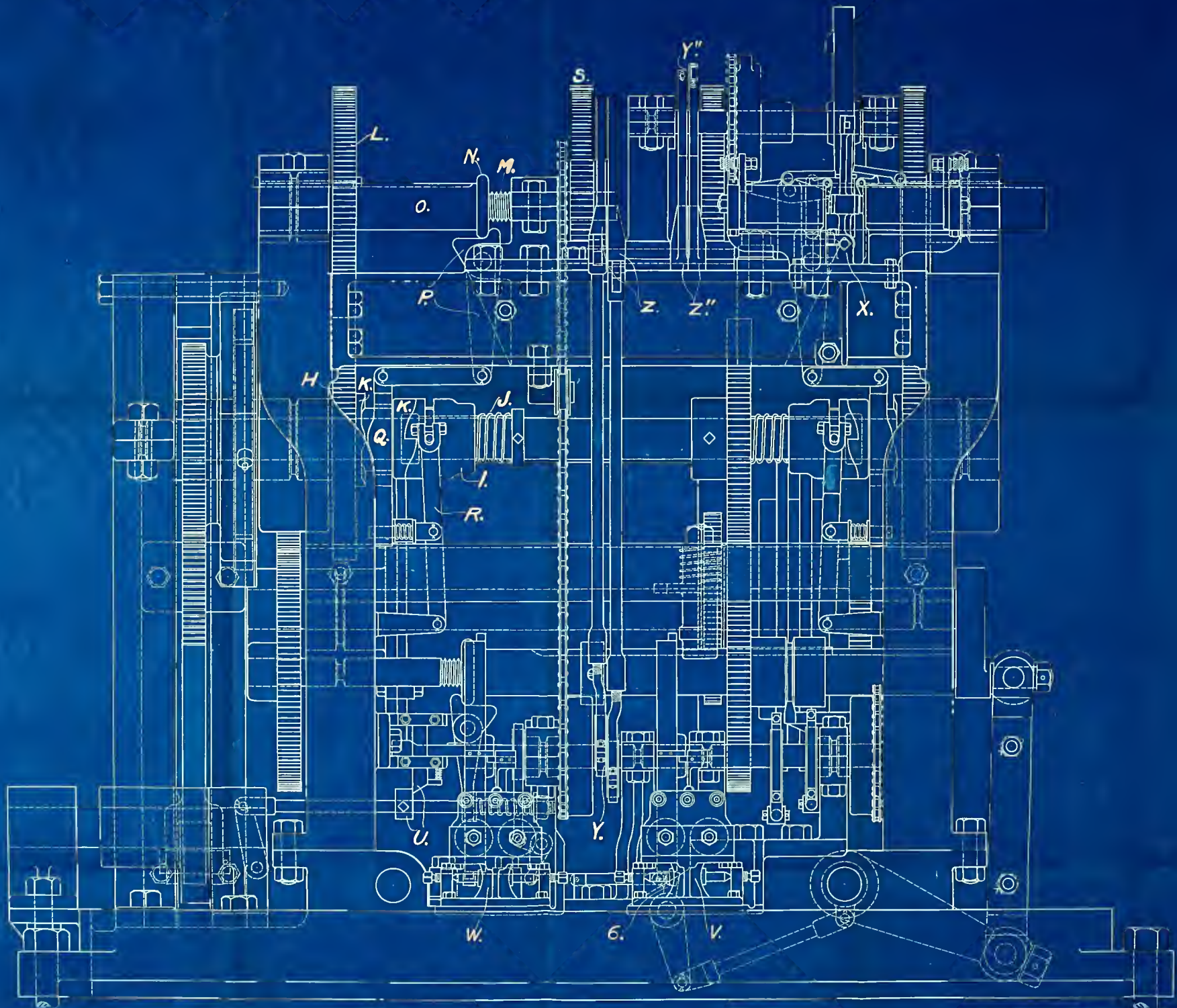
APPROVED BY J. W. ROWELL











ROWELL-POTTER SAFETY STOP CO.

CHICAGO	ILLINOIS.	ASSEMBLY; REAR ELEV.
DATE	MAY 1, 1909.	MACHINE D.
SHEET NUMBER		SCALE 6 IN. = 1 FT.
DRAWER		DRAWN BY R. Hopkins
SECTION		TRADED BY G. F. Morgan
NOTES:-		APPROVED BY R. C. Kimball

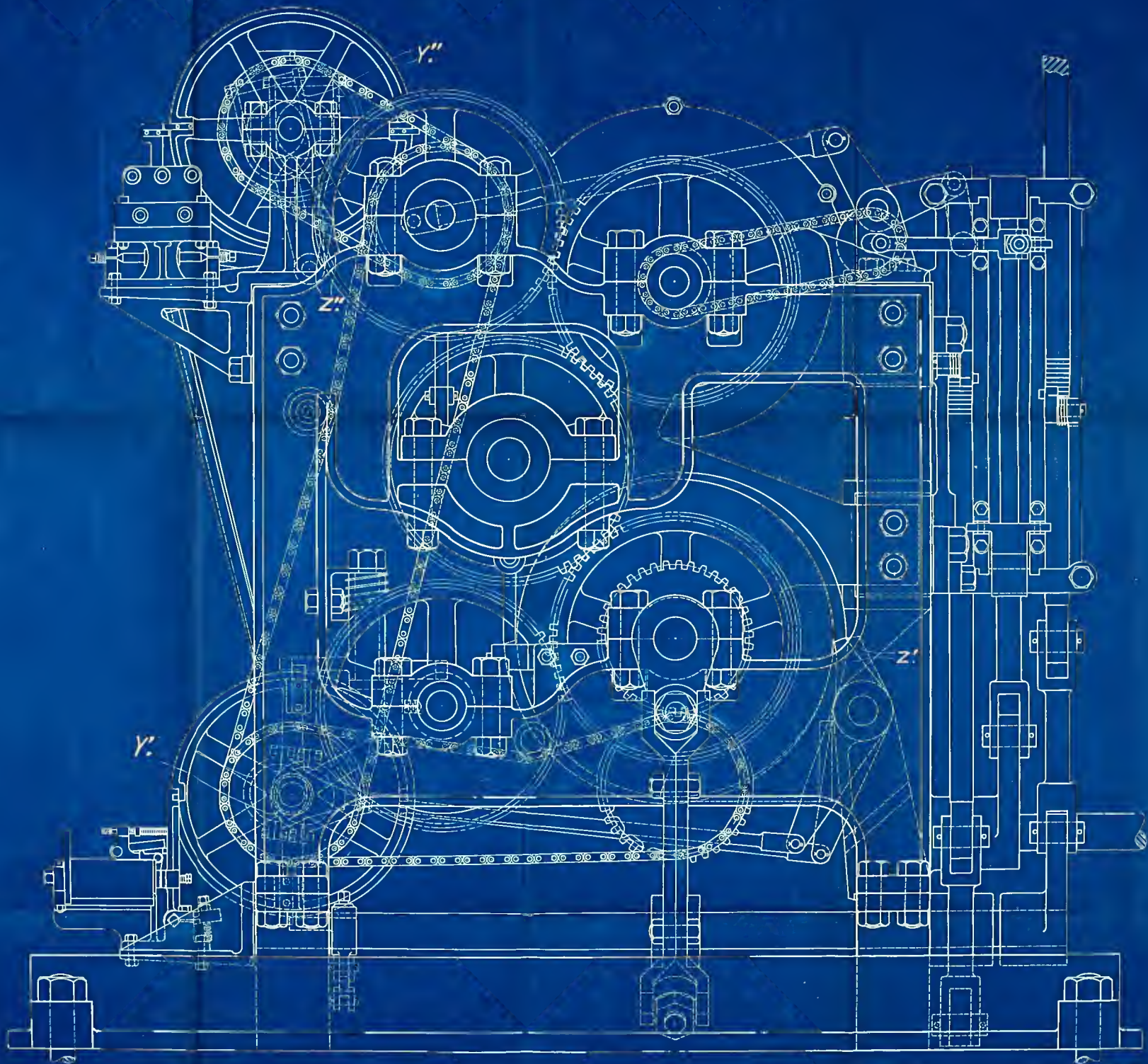












ROWELL-POTTER SAFETY STOP CO.

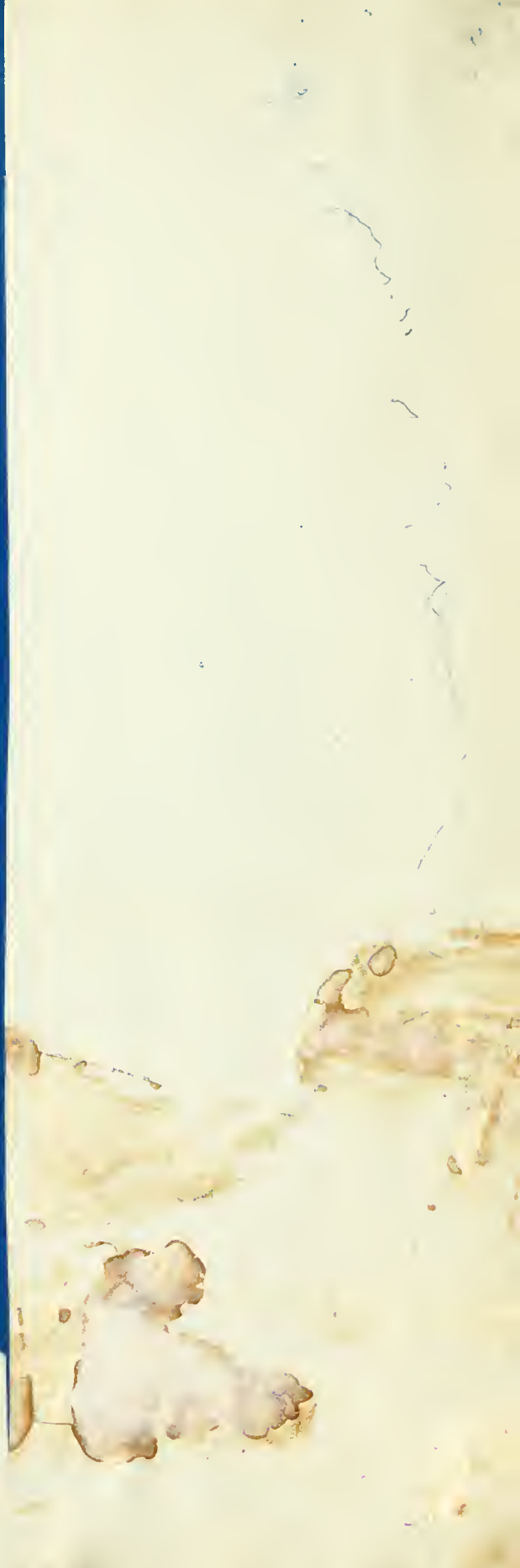
CHICAGO	ILLINOIS.	ASSEMBLY, CRANK END ELEV.
DATE	MAY 1, 1909.	MACHINE D.
SHEET NUMBER	SCALE	6 IN. = 1 FT.
DRAWER	DRAWN BY	R.H. [Signature]
SECTION	TRACED BY	E.H. [Signature]
NOTES--	APPROVED BY	A.G. [Signature]





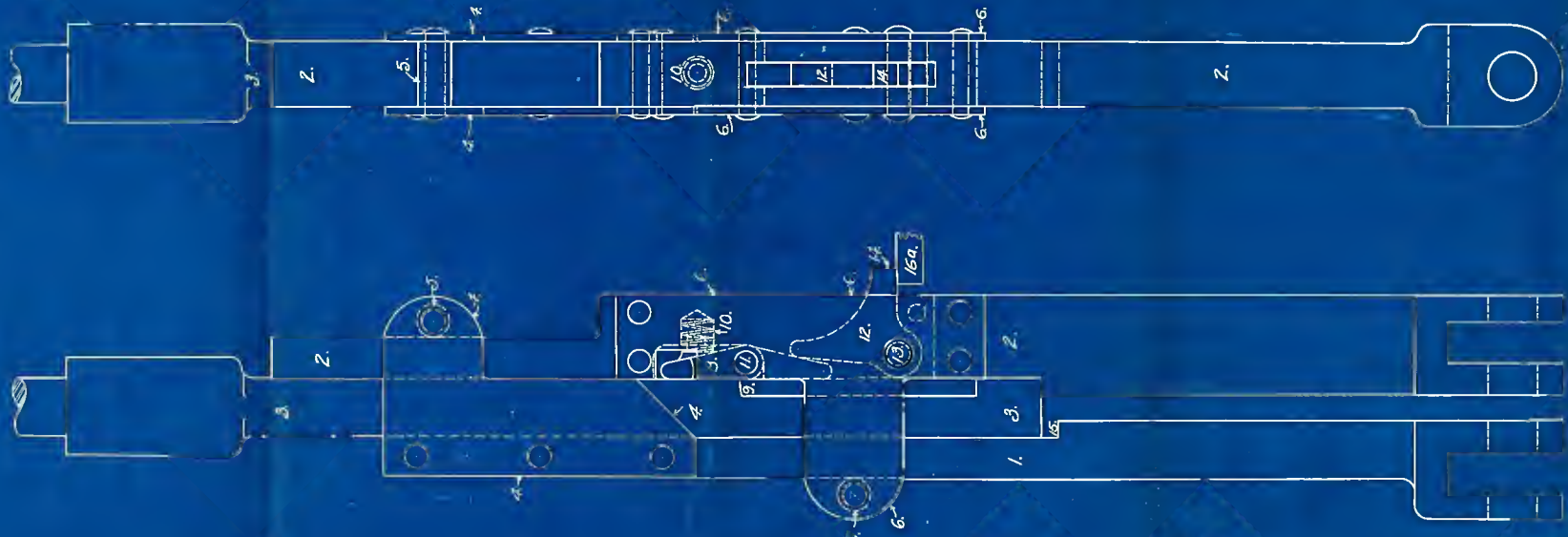








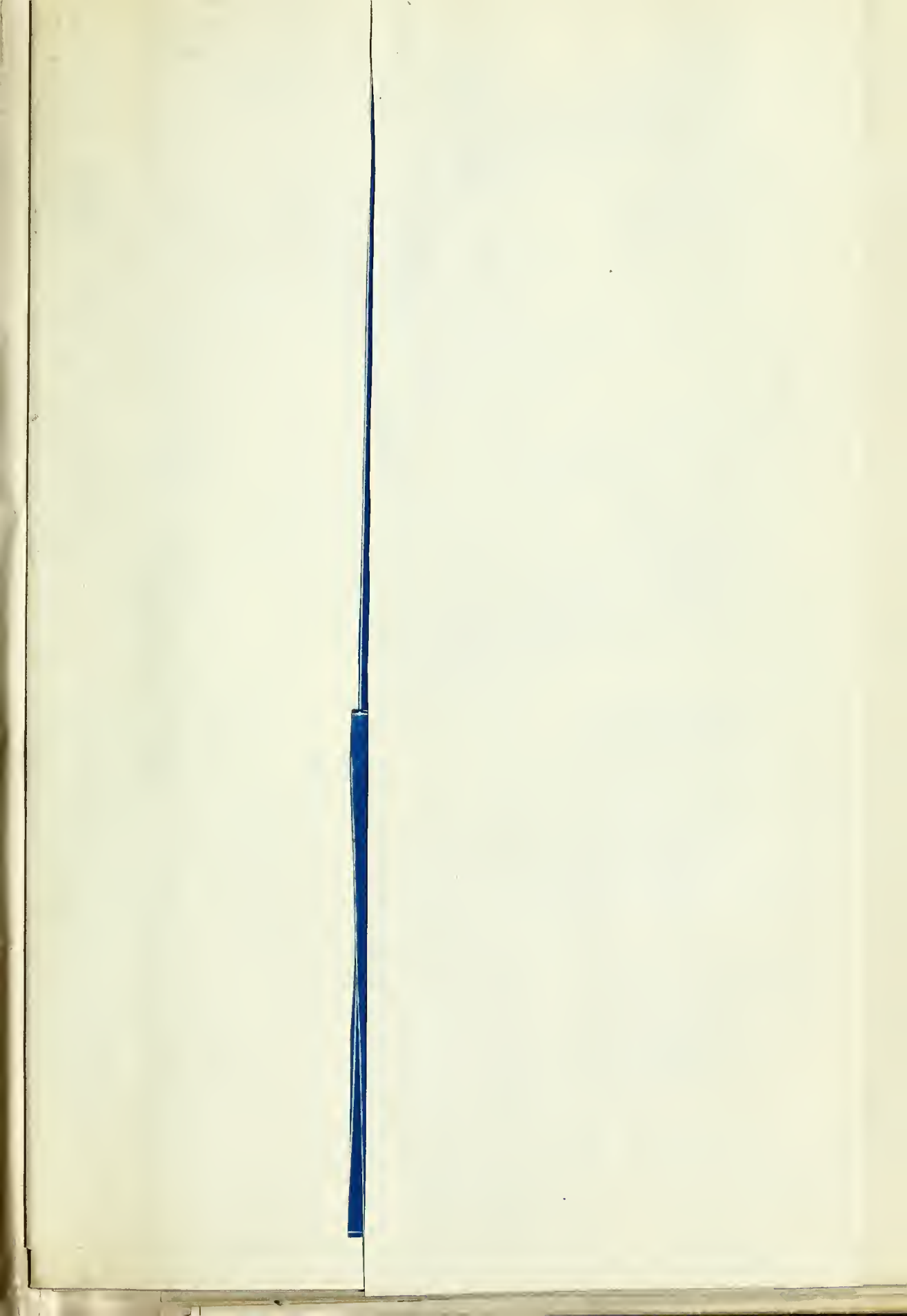




**ROWELL-POTTER SAFETY STOP CO.**

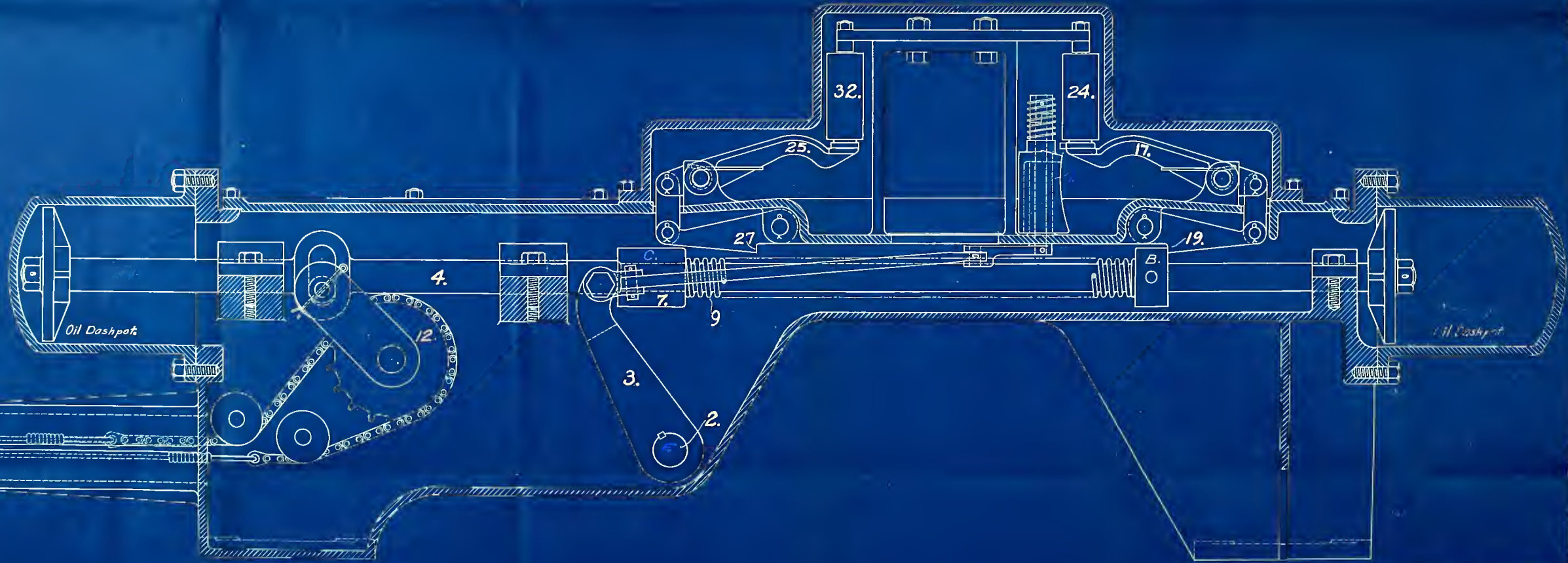
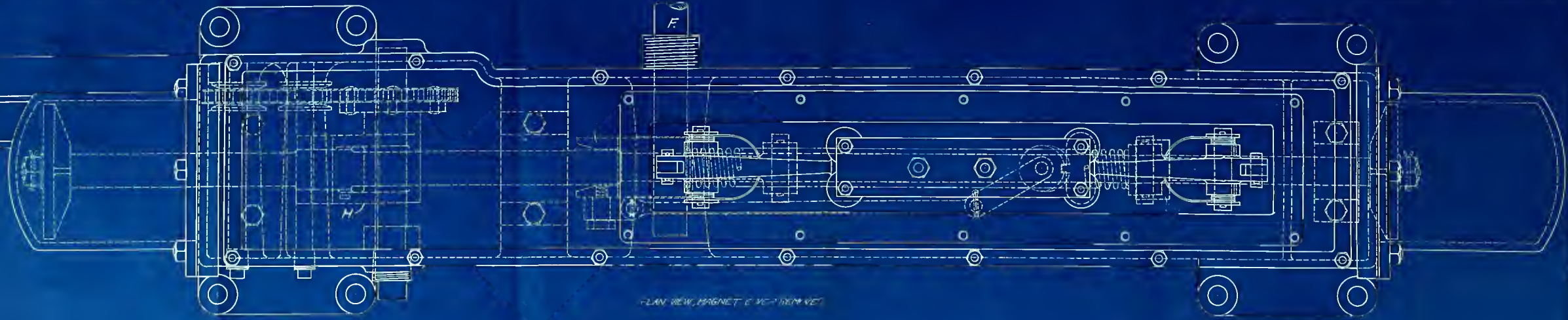
CHICAGO	ILLINOIS	UPPER QUAD. SEMAPHORE
DATE	FEB 1, 1910.	BAR ASSEMBLY. (Single Track)
SHEET NUMBER		SCALE FULL SIZE.
DRAWN BY		DRAWN BY <i>J. H. Thompson</i>
SECTION		TRACED BY <i>L. B. Thompson</i>
NOTES-		APPROVED BY _____









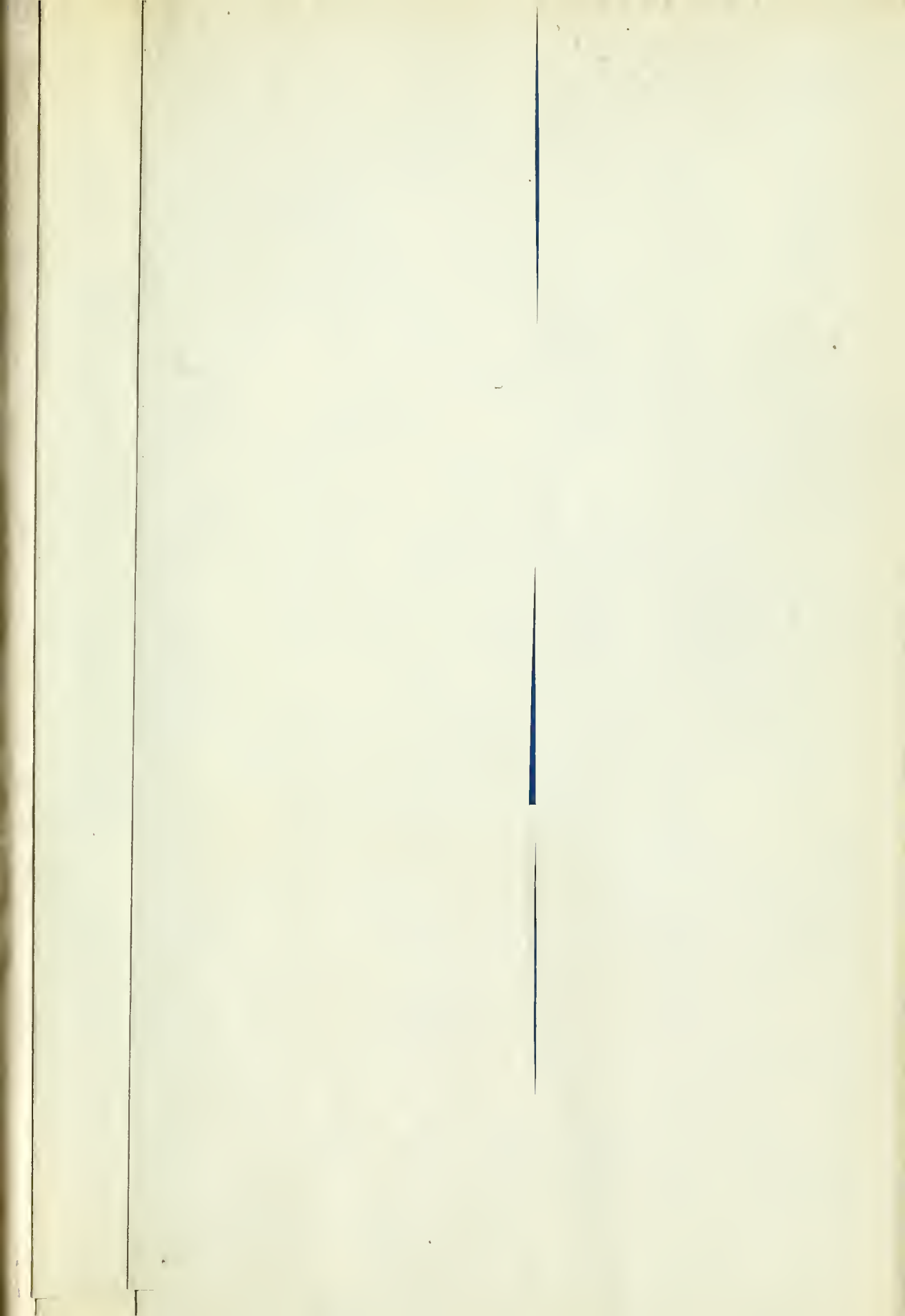


ROWELL-POTTER SAFETY STOP CO.  
 CHICAGO ILLINOIS  
 DATE OCT. 10, 1910.  
 SHEET NUMBER  
 DRAWER  
 SECTION  
 NOTES

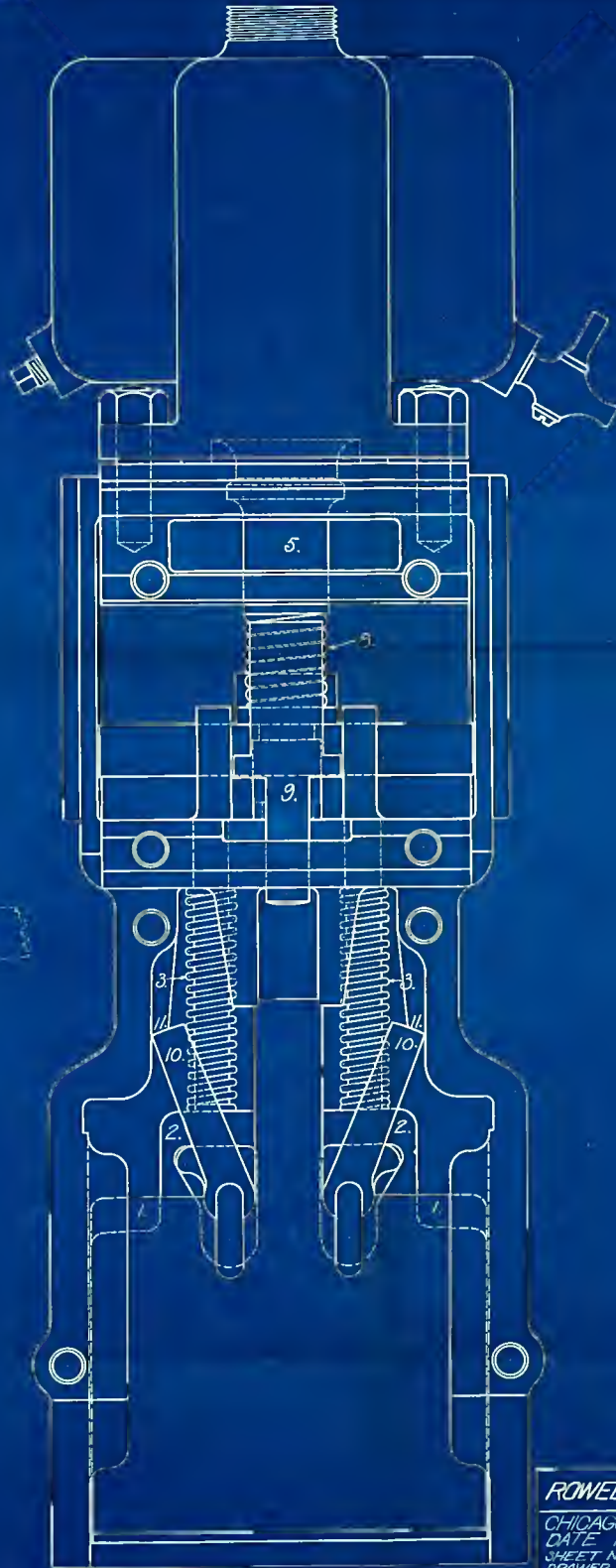
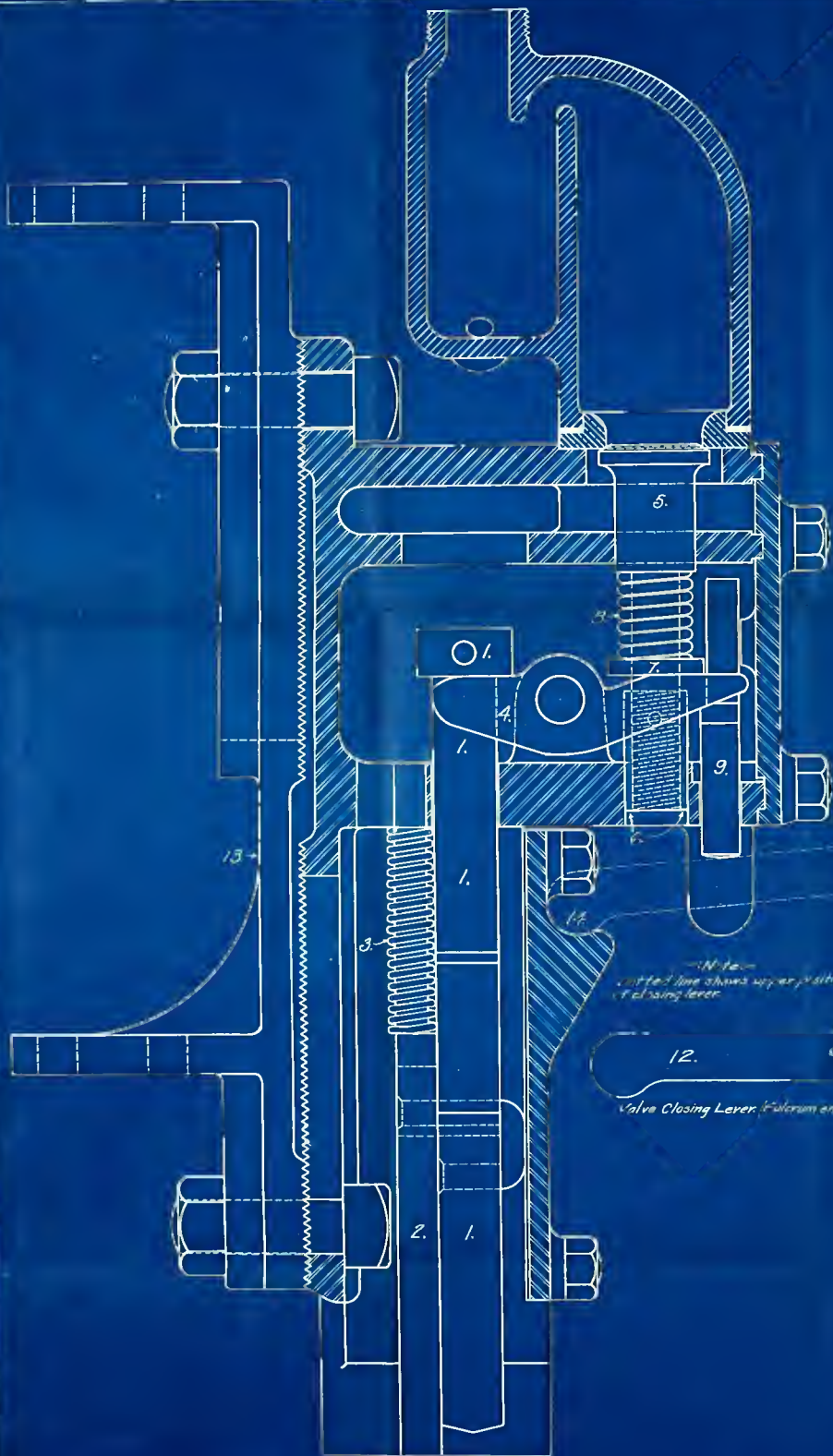
ASSEMBLY of  
 SINGLE T. MACHINE  
 SCALE 6" = 1'-0"  
 DRAWN BY  
 TRACED BY  
 APPROVED BY







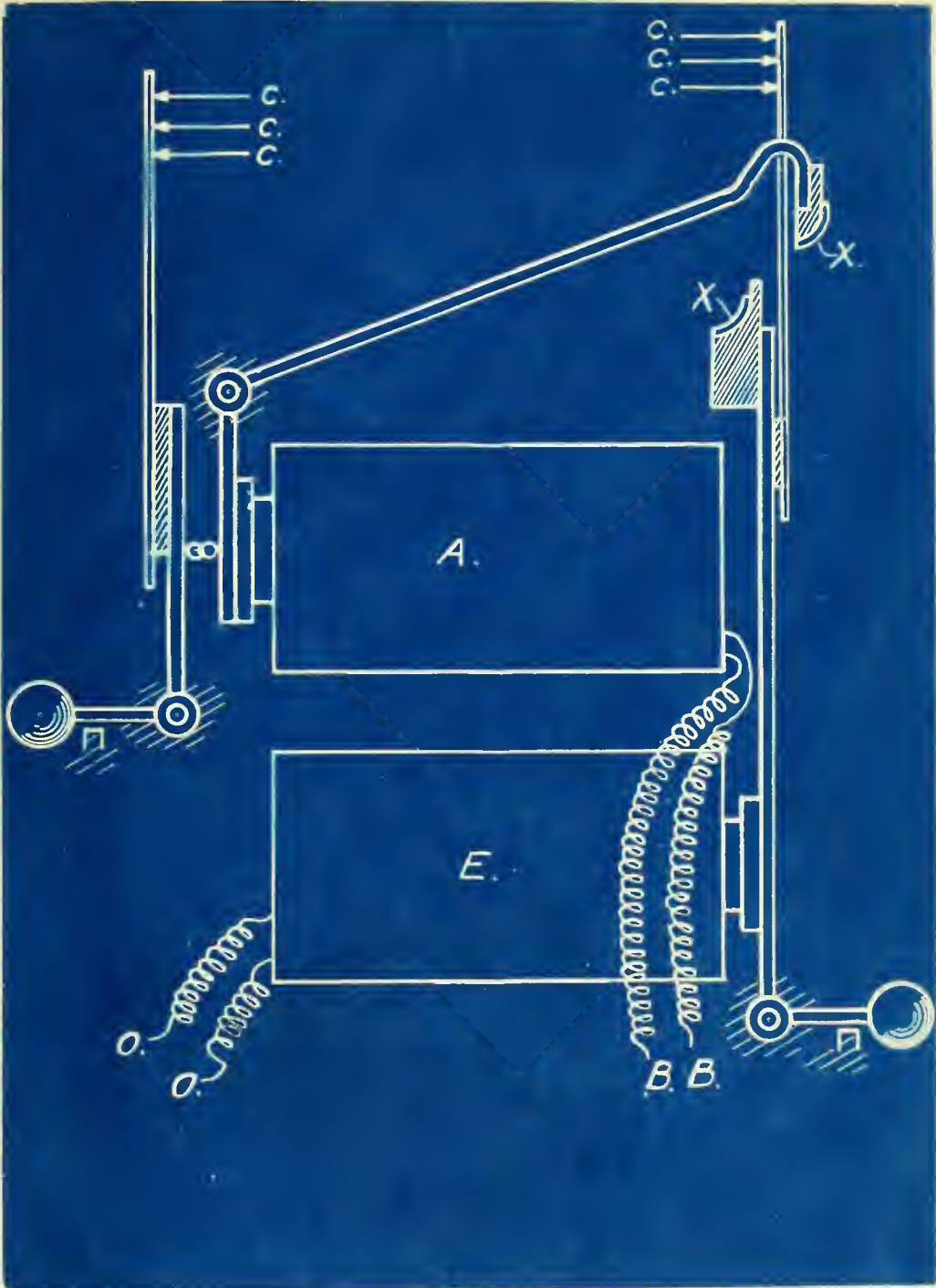




**ROWELL-POTTER SAFETY STOP CO.**  
 CHICAGO ILLINOIS ASSEMBLY of POP VALVE  
 DATE MARCH 25, 1910. ENGINE MACHINE.  
 SHEET NUMBER # 22 SCALE FULL SIZE  
 DRAWER # 3 DRAWN BY G. J. Marshall  
 SECTION # 17 TRACED BY G. J. Marshall  
 NOTES: APPROVED BY W. J. C.

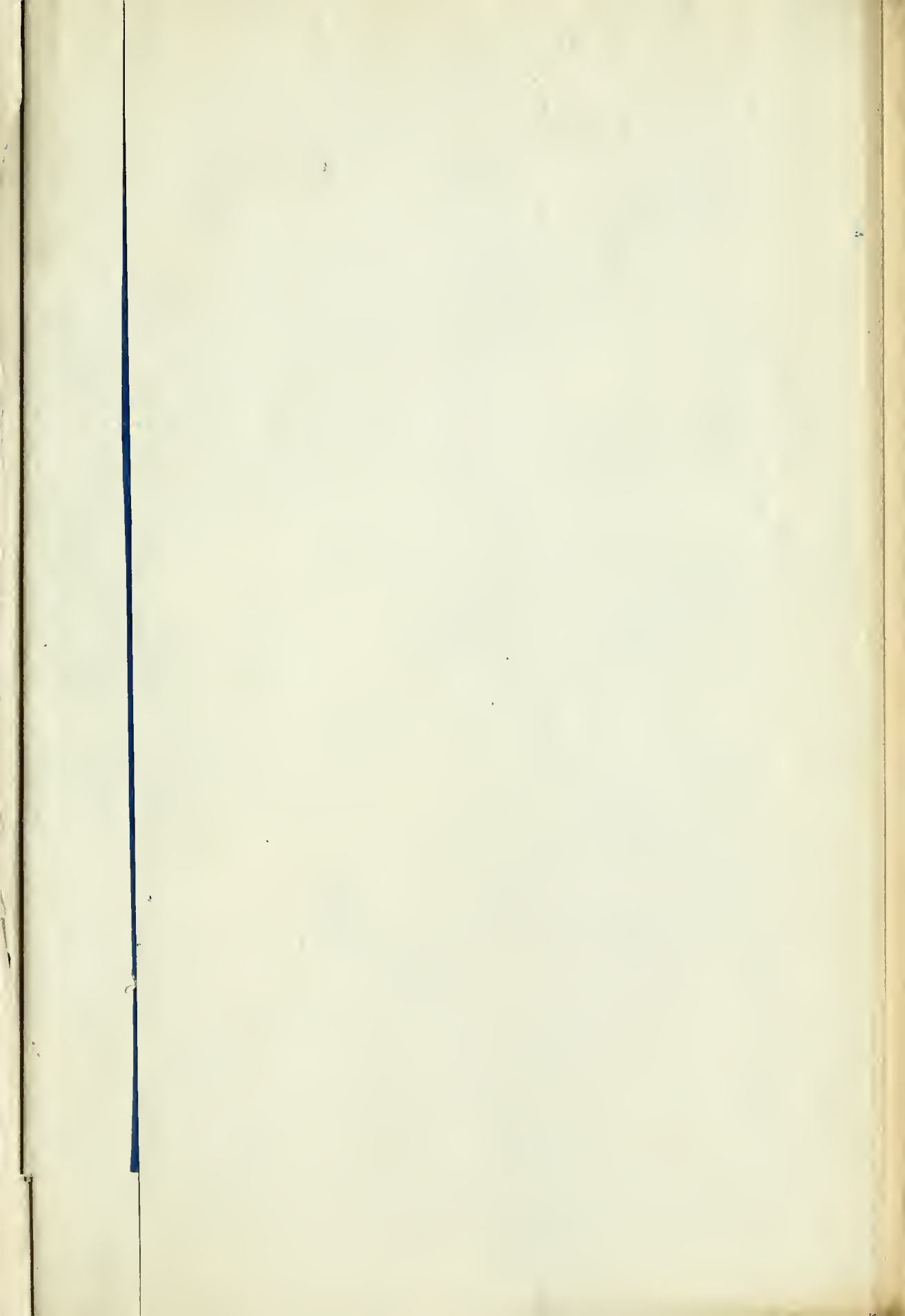












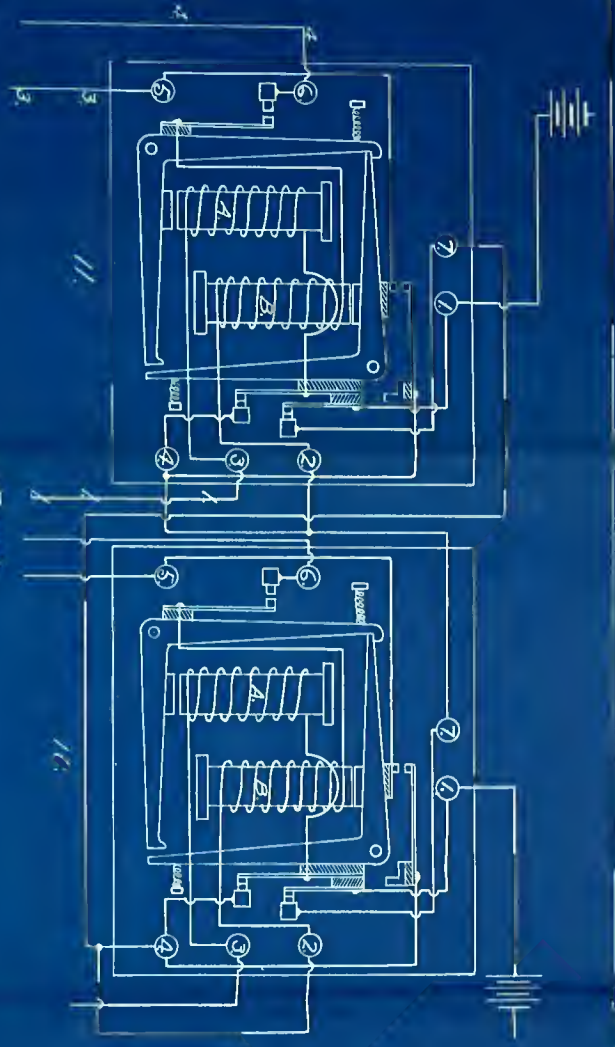


Figure 1

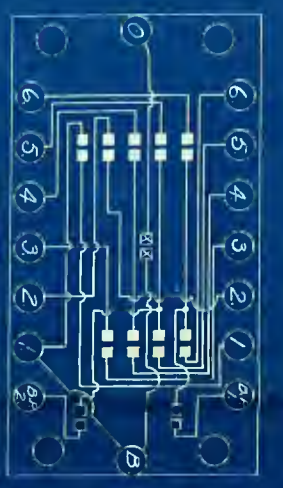


Figure 2



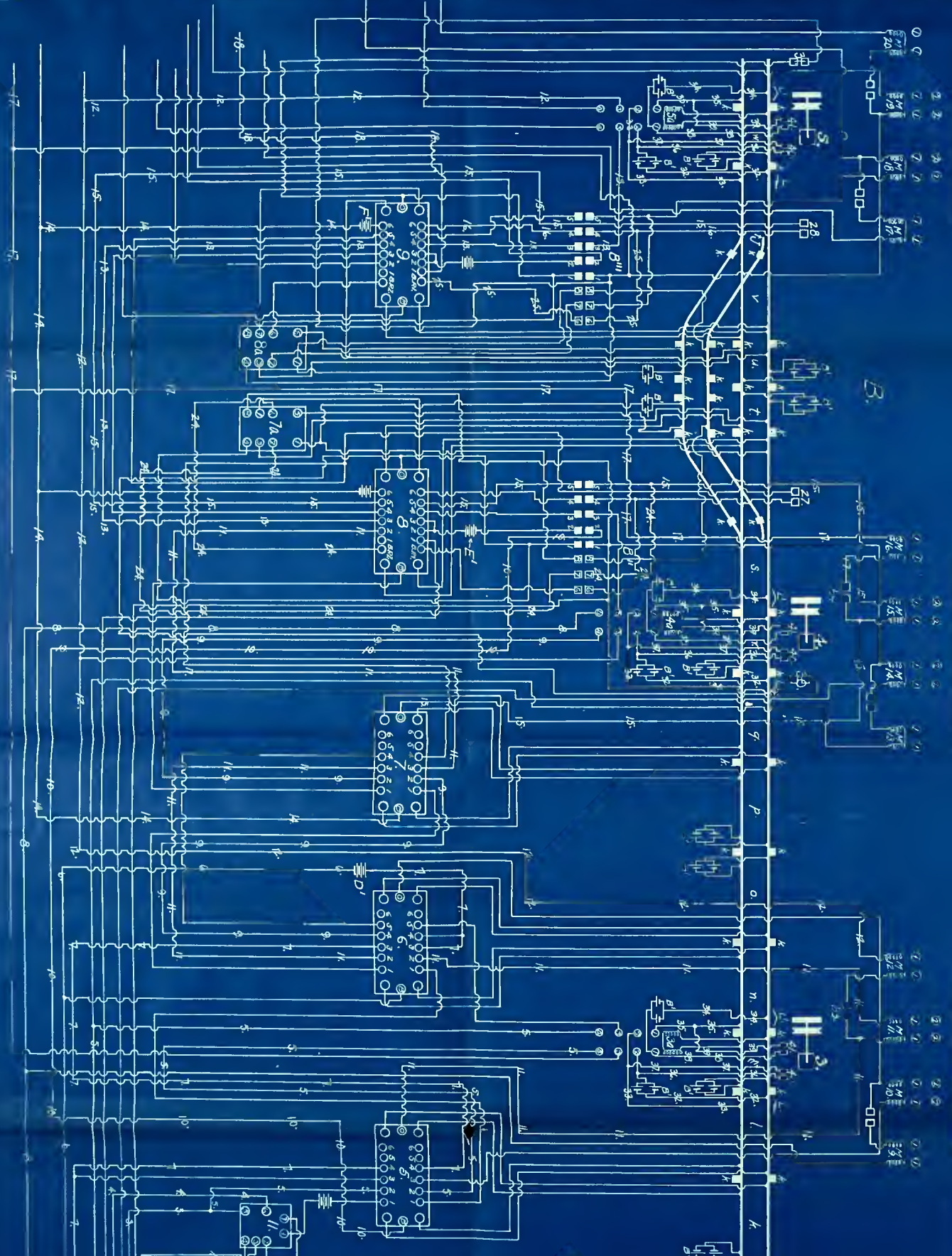
Figure 3



Figure 4



Figure 5





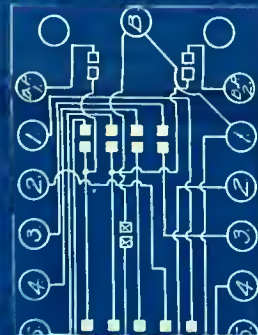


Figure 1  
Relay #1, 2, 3, 4

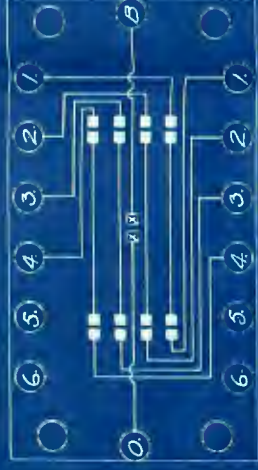


Figure 2  
Relay #5, 6, 7, 8, 9

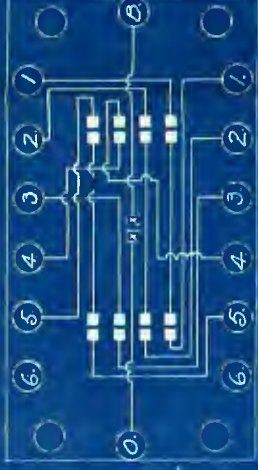
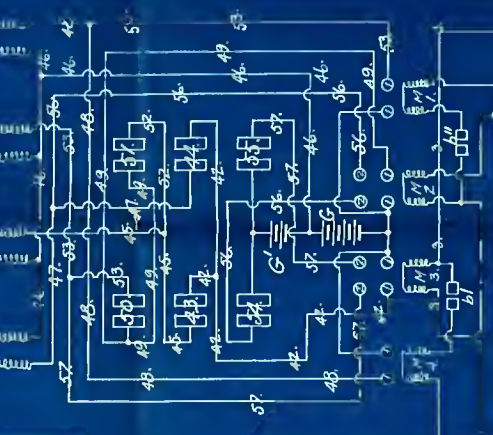


Figure 3  
Relay #10, 11, 12, 13, 14

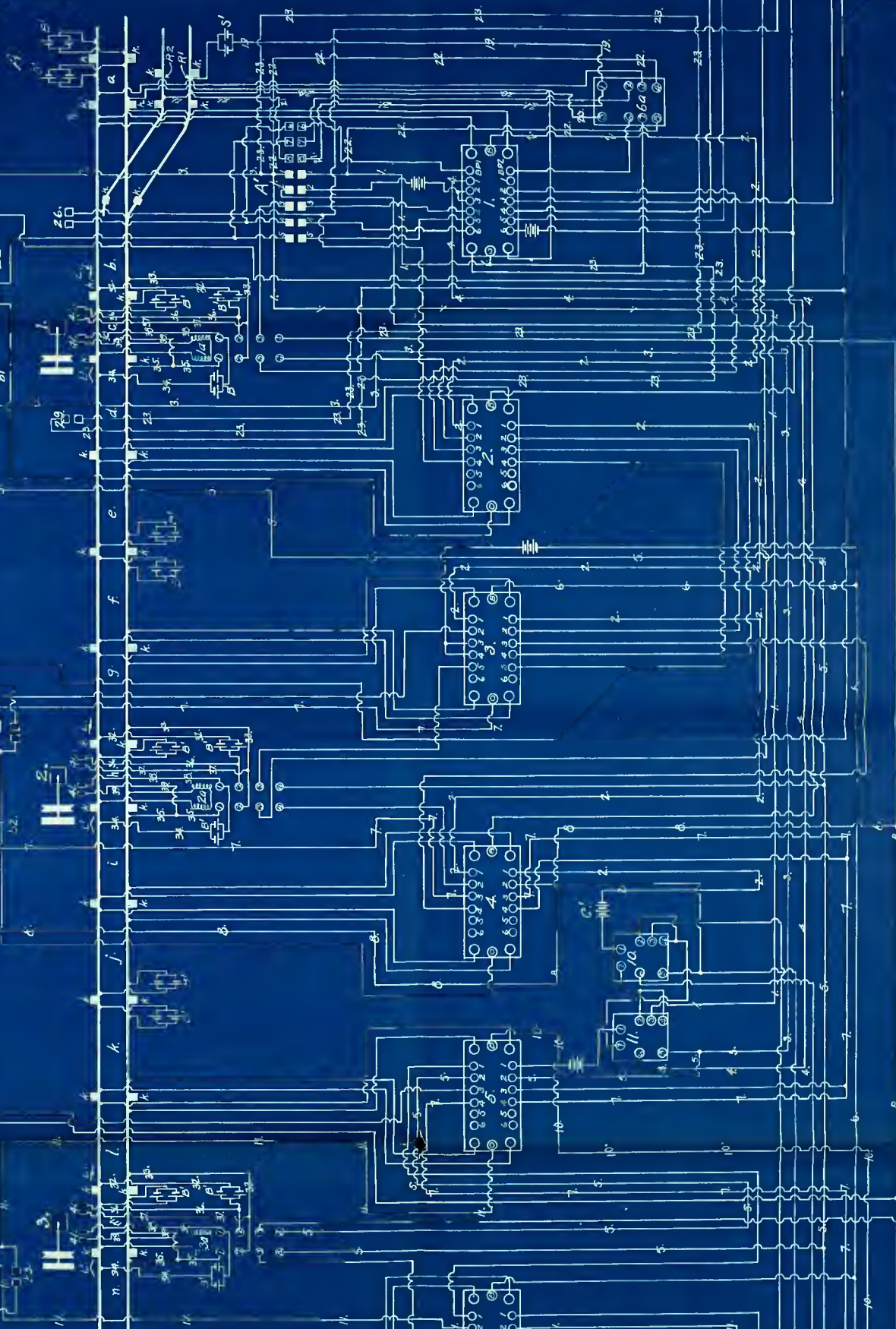
W.S.L. M.L. E.S.L. L.M.L.



Coil  
100-0-100  
150-0-150



Coil  
100-0-100  
150-0-150



ROWELL-POTTER SAFETY STOP CO.

CHICAGO ILLINOIS  
DATE JULY 5, 1910  
SHEET NUMBER 27  
DRAWN BY G. B. ...  
CHECKED BY G. B. ...  
NOTES - See by written description.

SINGLE TRACK  
WHIPPING PLAN  
NOT DRAWN TO SCALE  
L. J. ...  
SECTION ...  
NOTES - See by written description.

