Instructions for

TELECHRON AUTOMATIC MASTER CONTROL CLOCK

TYPE E

Bulletin M-17

WARREN TELECHRON COMPANY
Ashland, Mass., U. S. A.

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Read these instructions carefully before attempting to unpack or to assemble the various parts.

Unpacking:

Do not unpack the master clock equipment until it is required for installation.

Use care in unpacking so as not to break the glass or to injure the movement. Do not allow any packing material to get into the movement. After unpacking, carefully wipe the glass cylinders and the various parts of the case to remove all dust and other foreign material.

The following articles are packed as indicated, and care should be taken to properly unpack and to account for each part.

Large glass cylinder

Small glass cylinder

Cast aluminum top, mid-ring, and base with magnetic regulator.
Rubber gaskets - four.
Multiple conductor cable.

Enclosing tube for cable
Pendulum
Tie rods (3 long and 3 short) and nuts (9).

Regulator movement
Envelope marked "Regulating Weights"
Envelope marked "Reserve Weights"

Time Error Indicator. (Unless being supplied with special panel assembly).

Location

Place the Automatic Regulator in a location which is firm and free from vibration and which is not subject to rapid or large fluctuations in temperature. Such a location should preferably be as much out of the way as possible, particularly as it is necessary to observe the Automatic Regulator only once a day when checking the timekeeping. If vibration is excessive, use a stone or concrete block, weighing at least five-hundred pounds, as a base and place a thick felt or natural cork pad between it and the floor.

Assembly of Case of Automatic Regulator

Remove the cable bushing binding ring from the underside of the cast aluminum base. Pull the terminal equipped end of the cable up through the

large hole in the base until the rubber plug seats properly. Replace the binding ring and fasten securely so that a tight seal is made.

The large knob at the top right-hand side of the base is used to regulate the swing of the pendulum. When first setting up the regulator, this knob should be in its mid-position to allow an ample range of adjustment in both directions. To set the knob to its mid-position, turn it to the right as far as possible, without using force, and then turn it twenty-turns to the left or in the F direction.

Pass the enclosing tube over the upper section of the cable and into the socket in the base, twisting it firmly into place.

Screw the long tie rods into the top of the base until the last thread just shows. Screw the lock nuts on the ends of the rods inside the base and securely tighten.

Level the base, checking with a spirit level, by means of the three adjustable legs and lock the latter in position with the clamp nuts.

Lay one of the rubber gaskets in the groove in the base. Carefully lower the long glass cylinder into place and adjust it, in regard to top and front, in accordance with the markings on the glass. Holding a rubber gasket in the under groove of the mid-ring, place it in position on top of the long glass cylinder with the tie rods projecting through their proper holes and with the cable leading through the inner hole into which the metal tube will slide. Place the coupling nuts on the tie rods and complete the assembly of the lower part of the case, making sure that both the tie rods and the glass cylinder are perpendicular to the base. Utilizing a spirit level, tighten the coupling nuts so that the mid-ring will be level and parallel to the base.

Assemble the movement on the mid-ring inserting the two posts into the proper holes. The motors and terminal block should be at the back and directly over the connection cable. Screw nuts onto the supporting posts and securely tighten.

Connect the cable according to the attached wiring diagram 1-W-232.

Hook the pendulum on the suspension strip so that the pointer on the pendulum bob is toward the front. Caution: The suspension strip is only .002 inches thick and great care must be taken to avoid binding, twisting or kinking. If the suspension spring is damaged, the timekeeping qualities of the pendulum will be seriously affected.

If the lower part of the case has been properly leveled, the tip of the pointer at the bottom of the pendulum should be directly over the zero mark on the scale. The tip should project about 1/16" over the nearest edge and should be above the scale by not more than 1/16".

Place the contents of the envelope marked "Regulating Weights" on the pan fastened to the pendulum rod. Do not allow any of the weights to lie on edge. Save the envelope containing "Reserve Weights". Each weight is marked with a numeral which designates the number of seconds per day (24 hours) which that particular weight will cause the pendulum to change its rate.

Starting the Master Regulator

Having removed all fastenings from the movement, energize lines 1 and 2 from a continuously energized source of the alternating current to be measured and of the voltage and frequency marked on the nameplate. This will cause the main driving motor (3) to rotate continuously and the double-field correcting motor (25) to operate at intervals. The pendulum will not start itself from rest and must be swung slightly by hand. The correcting motor may operate almost without interruption for a minute or two until the cams and pendulum pull into step with each other.

Setting and Initial Regulation

After starting the Master Regulator, let it run for one or two hours to allow the pendulum to attain its normal swing. Set the hands on the dial to the correct time as obtained from the government time signals. The minute and hour hands may be set by manually turning the minute hand. Adjustments of a few minutes and any number of seconds may be accomplished by rotating the large gear behind the dial in a clockwise direction from the front. Caution: Do not set the hands backward and do not move the seconds hand except by turning the large gear.

At the end of 24 hours, check the time against the observatory time signals and continue this daily check for several days. If, at the end of this period, the daily error in rate is not more than 2 or 3 seconds, the short glass cylinder and metal top can be mounted in place (insert rubber gaskets at top and bottom of glass) and held in position by the short tie rods, evenly tightened. Additional regulation of the pendulum can be accomplished by means of the large knob on the right hand side of the base. One turn of this screw will change the pendulum rate approximately a half second per day, although this value will vary with different positions of the regulating mechanism.

If the error in rate is greater than 2 or 3 seconds a day, the pendulum should be regulated to within this limit by adding or removing weights from the pan. The Master Regulator, when tested at the factory, kept accurate time when the weights in the envelope marked "Regulating Weights" were upon the pendulum pan. As mounted in its new location, the clock may require a change in the weights in order to maintain accurate time but this can only be determined after it has been in operation for several days. If the Master Regulator shows by its record that it is LOSING, weights (of the average number of seconds which the clock is losing in twenty-four hours) should be ADDED to the pendulum pan. If the Master Clock is GAINING, weights (of the same value as the average number of seconds per day that the clock is gaining in twenty-four hours) should be REMOVED from the pendulum pan. The best method of changing a weight is by handling it with a pair of tweezers, moving the latter back and forth in time with the pendulum. In this manner, the period of swing of the pendulum will not be disturbed. When the rate is approximately correct, the top should be fastened on and additional regulation accomplished by the regulating screw.

Daily Regulation

Once each day, preferably at NOON, Eastern Standard Time, the time of the hands should be checked against the government time signals and a record kept of the time error and rate. Errors in rate should be corrected by turning the regulating screw in the base - clockwise to cause the pendulum to lose time and counter-clockwise to gain time. It is not recommended that regulation be attempted more often than every three or four days although the rate should be

noted every day. It should be borne in mind that, although the Master Regulator contains no escapement in the ordinary sense of the word, the hands read pendulum time unless the current has been interrupted or a frequency error of 1/2 cycle or greater (60 cycle basis) has continued for an appreciable period of time.

Radio Time Signals

Radio time signals are broadcast at noon and at 10:00 P.M. Eastern Standard Time, each day by the U. S. Naval Observatory at Washington, D. C. These signals, in the form of quarter second impulses, commence at five minutes before the hour and are sent in the following sequence, expressed in minutes and seconds. The one second dash at the end of the 10 second interval in the 59th minute is the signal for the hour.

55:00 - 55:28	55:30 - 55:50	55:52 - 55:55
56:00 - 56:28	56:30 - 56:51	56:53 - 56:55
57:00 - 57:28	57:30 - 57:52	57:54 - 57:55
58:00 - 58:28	58:30 - 58:53	58:55
59:00 - 59:28	59:30 - 59:50	60:00 (1 sec.)

If the naval radio time signals are not available, they may be obtained by telephone or telegraph from a reputable astronomical observatory or from either of the national telegraph companies at NOON, Eastern Standard Time.

Time Error Indicator

Mount the time error indicator in a conspicuous place where it can be clearly and frequently observed. Connect the leads numbered 1, 3, 4 and 5 to the Master Regulator leads numbered 1, 3, 4 and 5 respectively. Clockwise rotation means fast time or high average frequency. If the large hand goes counter-clockwise when the frequency is high, reverse leads 3 and 5. The scale is divided into tenths and hundredths of a second. One full revolution of the large hand represents one second of time error. The small hands read the units and tens of seconds, and should be read like the hands on a watthour meter scale.

Auxiliary Devices

There are six other leads in the cable to the Master Regulator, of which leads No. 6 and 7 are for use in the automatic regulation of frequency, as shown in wiring diagram #1-W-232. Leads No. 8 and 9 are connected to the minute contact mechanism. These connections are to be used when a Telechron Recording Master Clock is installed in connection with the Type E Master Clock. The contact mechanism should be connected to the Recording Master Clock as shown in blueprints enclosed with the latter. It is sometimes advantageous to connect a single-stroke bell, operated by a low powered relay in the contact circuit, so that the clock time may be checked over the telephone.

Leads No. 10 and 11 are available for operating the synchronizing magnet, which attachment may be ordered at any time and readily fastened to the movement. In addition to the magnet, an external impulse generator is required which will operate from a frequency standard whenever this service is available.

Power Interruptions

If the power supply to the Master Regulator is interrupted for any reason, the movement will stop but the pendulum will continue to swing for an hour or two. When the power is restored, the movement will start and will pull into phase

if the pendulum is still swinging. If the pendulum has stopped swinging, it will have to be started by hand. A light, rhythmic pressure with the finger tips against the side of the metal top of the case will start the pendulum without disturbing the position of the case. The clock hands will lose time during an interruption and if it is desirable to reset them, the metal top must be removed. If the regulator is in a secluded place and is not used for time-of-day purposes, it will not be necessary to reset the hands as this would in no way affect the operation of the device. When the Master Regulator is again in service, the time error indicator will be in error by the amount of the difference in phase between the pendulum and the cams when the power was restored or a maximum of one second plus or minus.

Principles of Operation

The Telechron Master Regulator is a precision instrument for comparing the swing of a pendulum with the rotation of a synchronous motor. As an accurate pendulum is conceded to be the most precise standard for the measurement of frequency, the basis of this mechanism is a properly designed pendulum beating seconds or making a full swing in two seconds. The mechanism used in conjunction with the pendulum will detect errors as small as 1/400th of a second, which amount will be produced by a frequency error of 1/15th of a cycle (60 cycle basis) in two seconds, 1/30th of a cycle in four seconds, etc.

The pendulum is of the type commonly known as a free pendulum because it has no escapement to unlock nor any work to do. There is no mainspring nor clock mechanism of the usual type. The pendulum receives a slight impulse every two seconds which maintains its motion. This slight impulse is always of the same magnitude and is always applied at the same point in the pendulum cycle, which point has been selected so that it will have the least possible effect on the period of the pendulum. As a result, the pendulum is an excellent timekeeper.

Referring to the accompanying drawing, 4-SK-X158, the pendulum (1) is suspended from the suspension strip (2), and, as previously stated, swings one complete cycle back and forth in exactly two seconds. The Telechron synchronous motor (3) drives the cam shaft (4) at a speed of one revolution in two seconds, provided the frequency is correct. This drive is accomplished through an epicyclic gear train consisting of gears (5), (6), (7), (8) and (9) and a sun gear (10) which is normally stationary. The sun gear is under the control of the correcting motor (25), the operation of which will be described later.

The front cam (11) on the cam shaft (4) operates the gravity lever, pivoted at (12), which, when released by the cam, rests for an instant against the pendulum rod and imparts enough energy to the rod to keep the pendulum going.

While the wire (31) is resting against the pendulum, it is entirely free of the cam (11) and consequently moves with the pendulum which is swinging to the left. During this brief instant while its motion is controlled by the pendulum, the point (13) on the gravity lever drops through a small arc until it meets the surface of lever (14). During this same brief instant, lever (14), which follows cam (15), is swinging quite rapidly to the right and its position and speed are dependent on the system time and frequency. The working edge of lever (14) is saw-toothed, and ground so that the tips of the teeth are all on the same radius.

Assuming that the frequency is absolutely correct and that the pendulum and synchronous motor are exactly in phase, the descending point (13) will strike the swinging lever (14) in the very middle of the toothed surface. Because of this toothed surface, the lever (14) will be prevented from further

swinging and will not continue to follow cam (15) until cam (11) raises the gravity lever pivoted at (12) and thus releases it. As long as the frequency is correct, this cycle will be repeated and every two seconds the point (13) will catch the middle tooth on the lever (14).

Assume that a sudden change in the frequency occurs so that the frequency will be high for two seconds, will then restore itself and will continue at the correct value for an indefinite time. It is at once obvious that, after the two second interval and at the time of impact, lever (14) will be farther to the right since it has gained on the dropping point (13) which at this moment is controlled by the pendulum.

If it were not for the correcting mechanism, lever (14) would continue to be ahead of the dropping point (13) even though the frequency has restored itself and continues to be correct. In other words, there has been a phase shift between the cams and the pendulum and this must be removed before the device is prepared to detect any new frequency errors which may occur.

To overcome this phase difference, there is an intermittent contact arrangement, consisting of the two fixed contacts (18) and (19), the two operating steps (20) and (21), the lever (22) and the cam (23) which last is the third and rearmost cam on the main cam shaft.

Just after point (13) has caught a tooth of lever (14) and before cam (11) has raised the gravity lever pivoted at (12), cam (23) allows lever (22) to suddenly drop. Lever (22) carries with it the two operating steps (20) and (21) which descend on the projecting tip of lever (14). If point (13) has caught the mid-tooth of lever (14), the projecting arm will pass through the gap in the descending operating steps. If, however, there is a phase error caused by <u>high</u> frequency, the lever (14) will be standing in a position somewhat to the right of vertical and the step (21) will fall on the projecting tip of the lever (14).

Such a condition will cause contact (19) to touch contact (17) which will complete the circuit to coil (24) of the Telechron reversing motor (25) which will drive the gears (26) in a clockwise direction. However, the duration of this contact is quite short because cam (23), which has a gradually increasing radius, slowly raises lever (22) until the step (21) is free from the tip of lever (14). In fact, the duration of this contact is proportional to the phase error because the lever (22) rises slowly while the operating steps have a rapid increase in height from the center toward the ends.

The clockwise rotation of the gears (26) will rotate the sun gear (10) in a counter-clockwise direction and, because of the difference in the numbers of teeth on gears (7) and (9) will subtract from the normal clockwise rotation of the main cam shaft. Thus, the cam shaft will be restored to its proper phase relation with the pendulum, as the gear train and operating steps are designed so that the phase correction is approximately equal to the phase error.

If the frequency is low instead of high, the lever (14) is caught before it has reached the vertical position. Operating step (20) then descends on the projecting tip of lever (14) causing contact (18) to touch contact (16) which energizes coil (27) of the Telechron reversing motor and increases the normal clockwise rotation of the main cam shaft enough to restore the phase relation.

From this, it is evident that since the main cam shaft is kept in phase with the pendulum it is only necessary to gear clock hands to this shaft to cause them to read pendulum time. This is actually done and the hands on dial (28) are for the purpose of checking the pendulum rate against the observatory time signals.

The movement of these hands, in the course of any period, is the algebraic sum of the rotations of the shaft of the main driving motor (3) and the reversing motor (25). In other words, the motion of the Telechron reversing motor (25) is the difference between pendulum time and frequency time, or it represents the system time error. This error can be indicated by a hand coupled to the shaft of this motor. However, it is usually desirable to have the system time error indicated at some point remote from the Regulator so that an electrical coupling is used. The transmitter of this electrical coupling consists of the free rolling brushes (29) and the commutator buttons (30). The receiver is located in and geared to the hands of the Time Error Indicator which is supplied with the Telechron Master Regulator and which may be placed at the most desirable point.

Use of Time Error Indicator

The Time Error Indicator is primarily of value for the manual control of frequency. Its great precision and its quick response to small frequency errors make it an unusually fine instrument for this purpose. However, its extraordinary value for obtaining a quick check on the calibration of an indicating or recording frequency meter should not be overlooked. In one minute the average frequency during this minute can be determined with an accuracy greater than 1/100th of a cycle as each 1/100th second of time error accumulated during the minute represents 1/100th cycle error in the frequency (60 cycle basis). It is only necessary to select a minute when the instantaneous frequency happens to be fairly uniform to make the average frequency a fair measure of the actual frequency. Different observers have been able to consistently check their own and each others results to 1/100th cycle in checking a two cycle, full scale, frequency meter.

Care and Maintenance

If the correcting motor hunts back and forth, unscrew contacts (16) and (17) slightly. If the correcting motor is apparently sluggish, the contacts should be screwed in. The minimum length of contact on either step should cause the rolling brushes to travel over one or two buttons on the commutator.

The movement should be carefully oiled every year. Oil all bearings with a very small amount of watch oil or Sangamoil M. Wipe the surfaces of the cams with a thin film of white vaseline. Brush out the commutator buttons and clean the surface with crocus cloth. Do not oil the commutator.

The units of the operating motors should be replaced by new ones every year. The contact points (18) and (19) should be examined annually and if badly burned, should be replaced. A complete assembly consisting of the contact points, spring sheet, and operating steps can be ordered and readily substituted for the old one.

Adjustments

If the movement is received from the factory in good condition, it is unwise to change any of the existing adjustments. In case the movement is damaged so that it becomes necessary to readjust the various parts, the following information is given.

Mount the movement in the case, hang the pendulum in place, and adjust the leveling screws in the base as previously described. With the pendulum stationary and hanging free and vertical, rotate the main cam shaft until the gravity lever pivoted at (12) is entirely free of the cam (11) and the bent wire (31) rests against the pendulum rod. Advance screw (36) until it just barely touches the wire (31) and then back it off exactly 1/2 turn. Then hold the pendulum to the left enough to permit the wire (31) to swing against the end of the screw (36). In this position, the tip (13) should reach well into the teeth on the edge of lever (14) but should not quite "bottom". That is, the tip should reach into the teeth about three-quarters of the depth of a tooth. To secure this adjustment, bend the wire rod (31), that kicks the pendulum rod, to the right or left as required. Grip the wire as far up as possible and rigidly hold this part while bending the lower part so that no strain will be transmitted to the other parts of the gravity lever.

Turn the main cam shaft slowly in a clockwise direction by hand while the pendulum is hanging free, vertical and stationary until lever (14) has gone to the extreme left of its travel and moves toward the right. Just as the lever (14) completes its travel to the right, the end of lever (22) should be resting a slight amount below the high point of cam (23) on the ascending side but it must on no account be on the descending side. Cam (23) is fixed but cam (15) may be moved by loosening the set screws to secure this adjustment.

Rotate the main cam shaft slowly in a clockwise direction as before but hold the pendulum to the left of the vertical. The tip (13) of the lever pivoted at (12) should drop low enough to engage the teeth of the lever (14) just as or slightly before the latter reaches its extreme left hand position. As cam (15) has already been located with reference to cam (23) it is necessary to move cam (11) to make this adjustment.

The lever (14) is provided with an overbalancing screw (32) so that its tendency to swing to the right can be made sufficient for operation but not enough to cause a strain on the point (13) which must arrest the swing. The projecting tip of lever (14) should pass through the gap between the descending operation steps (20) and (21) when the tip (13) catches some one of the teeth on lever (14). This tooth need not be exact middle tooth. If the projecting tip always strikes one of the other operating steps, it should be bent very slightly so that it will pass through the gap.

The gravity lever pivoted at (12) is supplied with adjustable counterweights (33) by means of which the amplitude of the pendulum swing can be controlled. The lower end of the pendulum bob should swing through a total arc of about two inches. To increase the length of the arc, the counterweights should be screwed nearer to the pivot and vice-versa. After adjusting the counterweights, be sure to lock them securely against each other.

The brush holder (34) contains a carbon brush and spring. The brush pressure should be as light as possible and yet keep the rolling brushes (29) in contact with commutator buttons (30).

The long spring (35) is simply an electrical connection and should not be adjusted for spring tension.

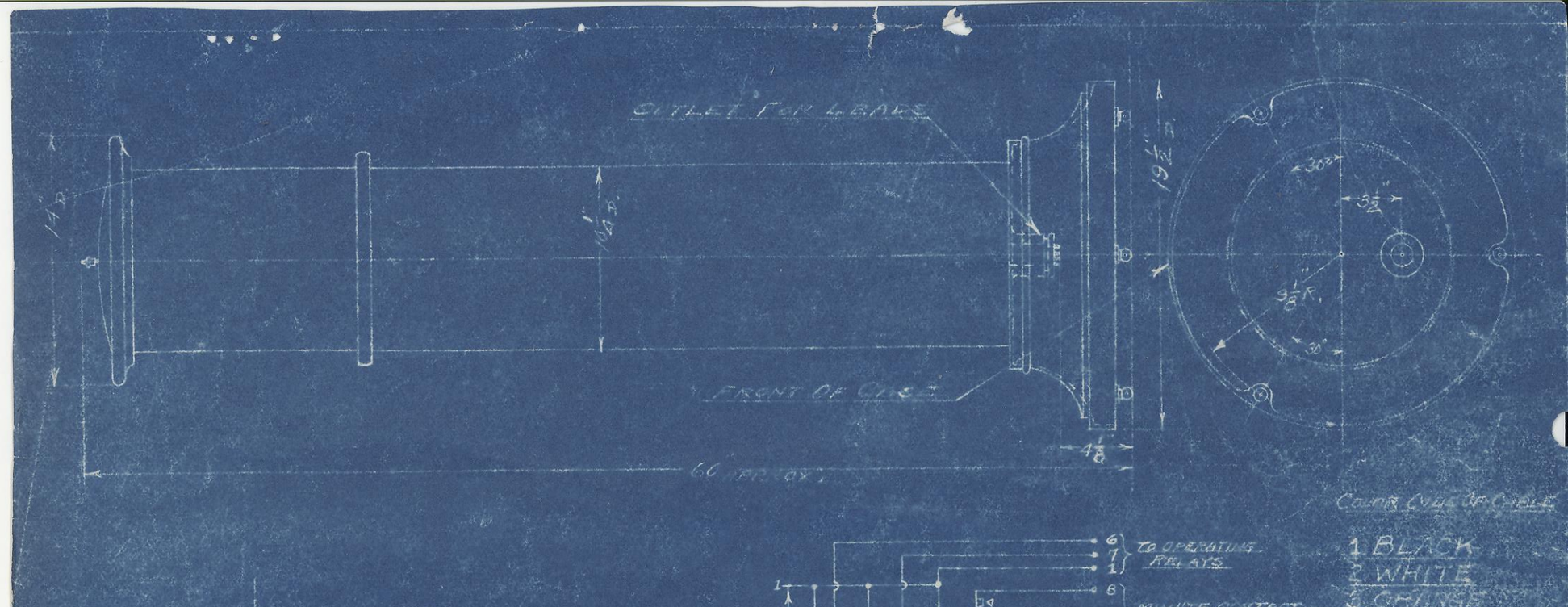
The pinion (5) of the main driving motor (3) rotates counter-clockwise from the front.

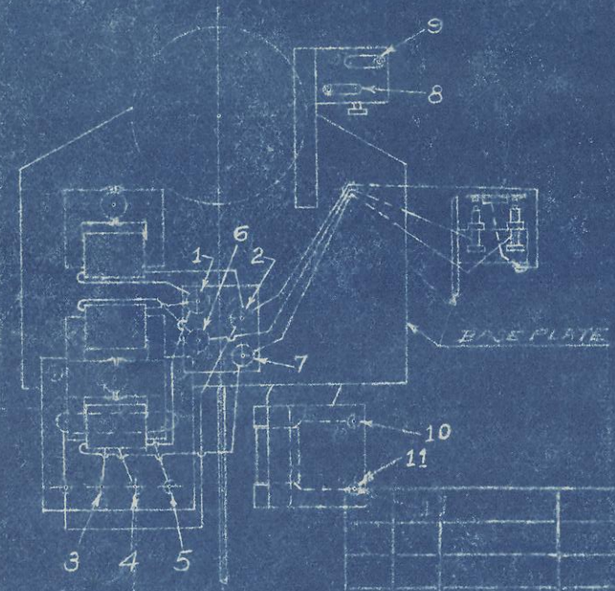
The pinions (26) of the reversible motor go clockwise from the front when the front coil (27) is energized. This coil is connected to the contact operated by the high frequency or right hand step (21).

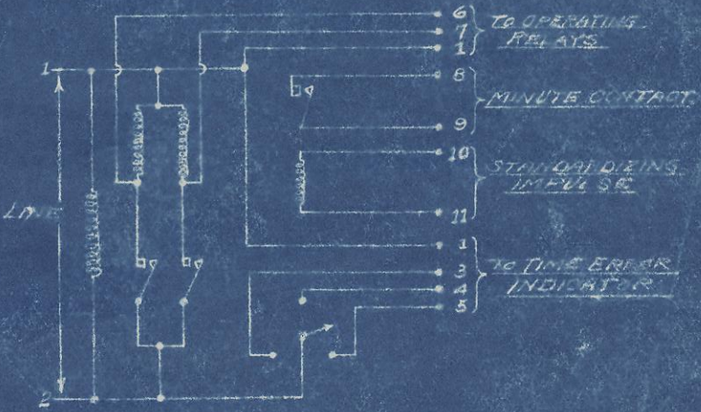
When replacing motor units, be sure that the word TOP, stamped on the shell of the unit, is in the uppermost position.

WARREN TELECHRON COMPANY
Ashland, Mass., U. S. A.

December, 1936







Color Code of Cable

1 BLACK
2 WHITE
3 ORANGE
4 GREEN
5 ORANGE & BLUE
6 RED & BLUE
7 BLUE
8 RED
9 RED BLUE & BLACK
10 BROWN
11 GREEN & BROWN

WARREN TELECHRON CO.
ASHLAND, MASS.

TELECHRON AUTOMATIC MASTER
CONTROL CLOCK

DRAWN	TRACED	CHECKED	SCALE	DATE
E.L.A.			½ & 3" = 1 FT	3-24-31

A 4-16-35 CHANGE COLOR CODE ALL
DATE REVISION

1-W-232

No. of Sheets
SHEET NO.