

BULLETIN 492A
SUPERSEDES BULLETIN 492

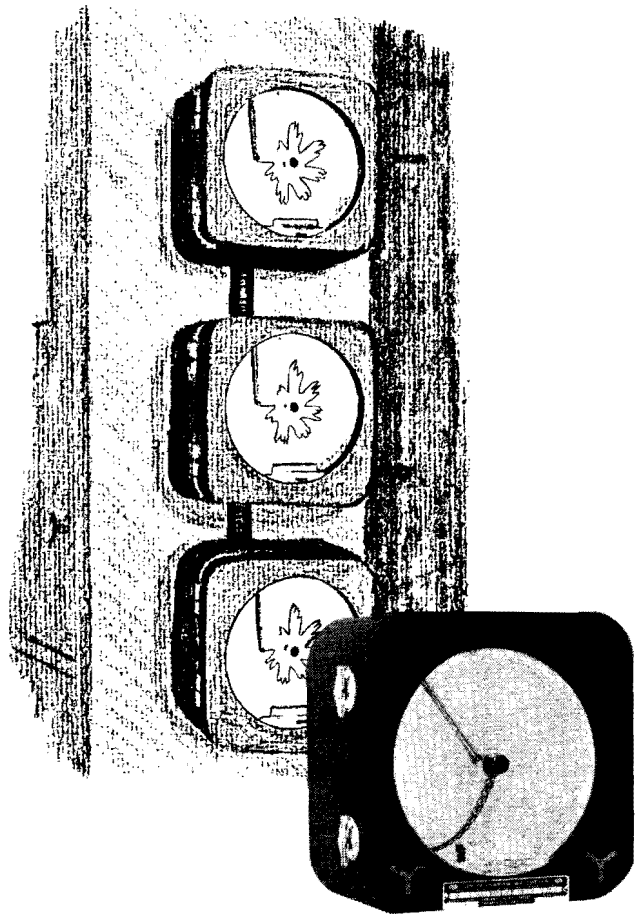
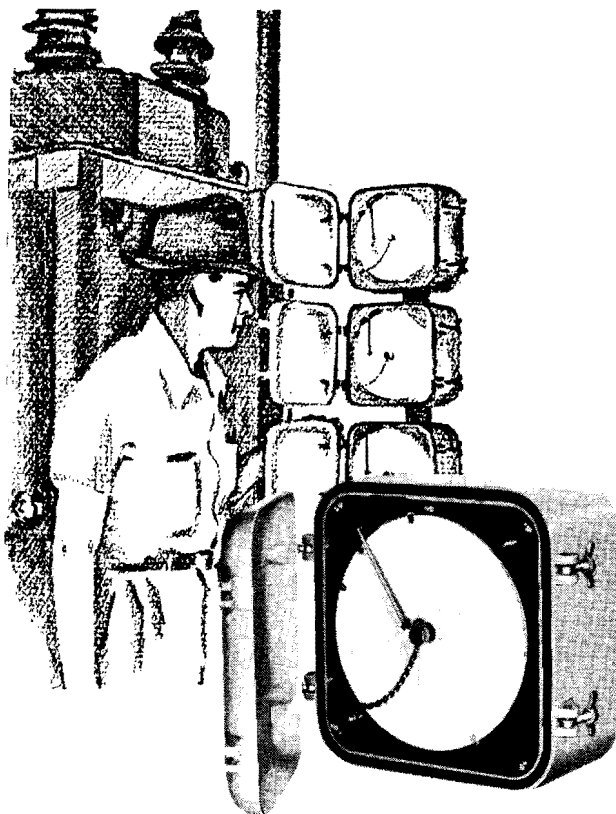
INTRODUCTION

This bulletin provides a brief description of operation, testing, adjustments and service of Lincoln graphic demand meters.

A similar bulletin (Bulletin 491) is available for Lincoln indicating meters.

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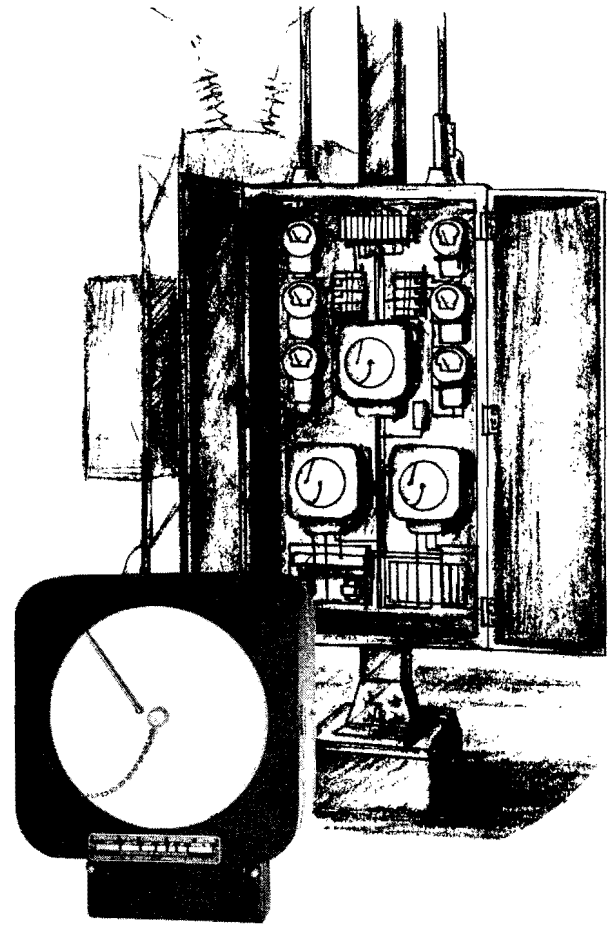
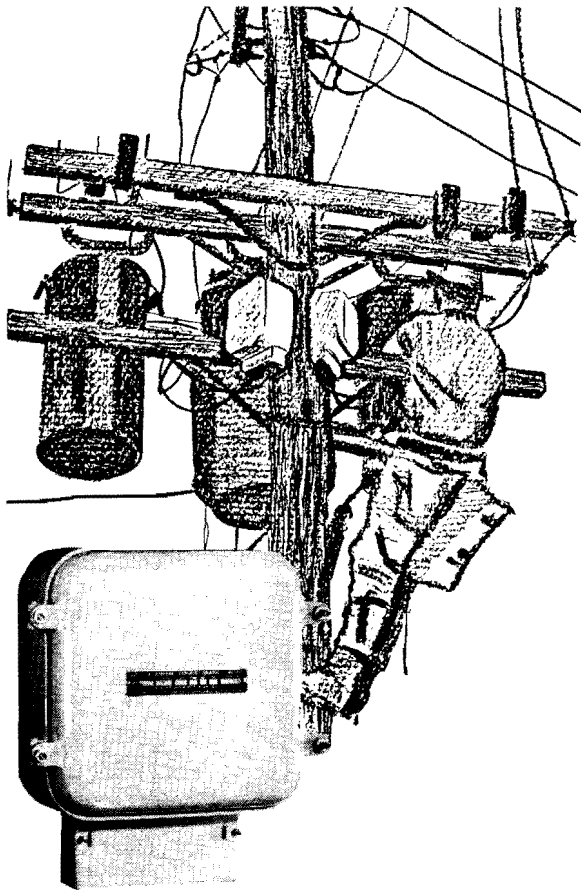
System

Lincoln graphic meters, available for chart recordings of 2, 8, 16 or 32 days operation, provide an accurate, reliable and economical means of measuring demand whenever a record of time and duration, as well as the magnitude of the electrical quantity is required.

Available in both self-contained and transformer-rated capacities, Lincoln graphic meters are furnished in switchboard, socket, bottom-connected and portable construction.

Complete information concerning all sides of the power triangle can be obtained from measurements recorded by Lincoln graphic demand instruments, kw (Type CCW), kva (Type CCVA) and kvar (Type CCVAR).

Lincoln graphic ammeters (Type CCA) are used whenever a record of ampere loading is required. Typical installations include feeders and distribution transformers.

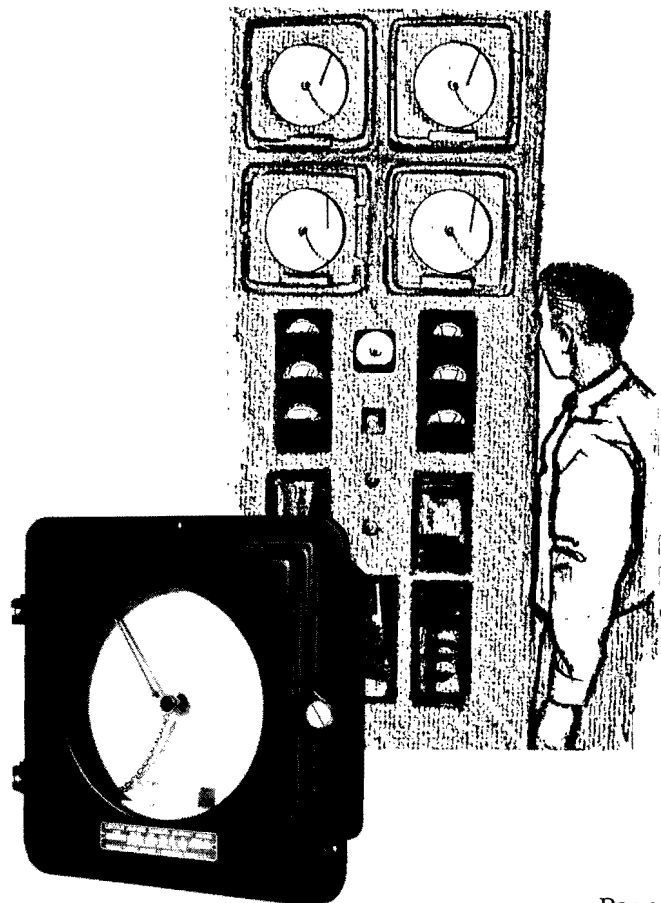


Applications

Lincoln graphic voltmeters (Type CCV) record "steady state" voltage conditions. The thermal principle of operation serves to average any surge or instantaneous peak voltage conditions. The resulting integrated record best serves the utility engineer.

The chart timing mechanism, offered as synchronous motor-drive, synchronous motor-drive with self-wound clock-driven carryover, or hand-wound clock-drive, drives the chart to show the time at which the demand occurs and is entirely independent of the measuring element.

Lincoln graphic "circular charts" (giving the Lincoln graphic meter its "CC" designation) are permanent, legible records of system conditions. They offer a simple, inexpensive means of storing valuable system information. It is possible to obtain an entire month of valuable information on a single 8 inch chart.



General Principles

The principle on which the thermal meter operates is the conversion of electrical energy into heat. The heat developed in an electrical circuit of given resistance is proportional to the square of the current.

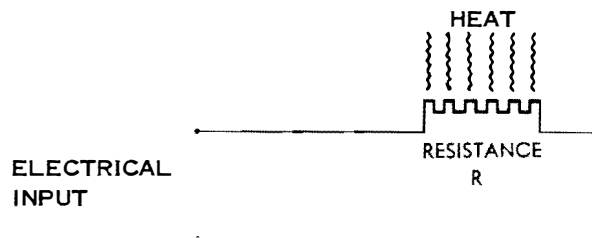


FIGURE 1.

By fusing together two metal strips with different temperature coefficients of expansion, a bimetal is formed. These metals will expand at different rates when heat is applied, and since they are attached to one another, the strip will bend.

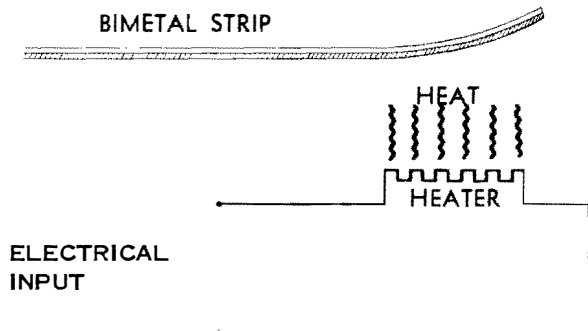
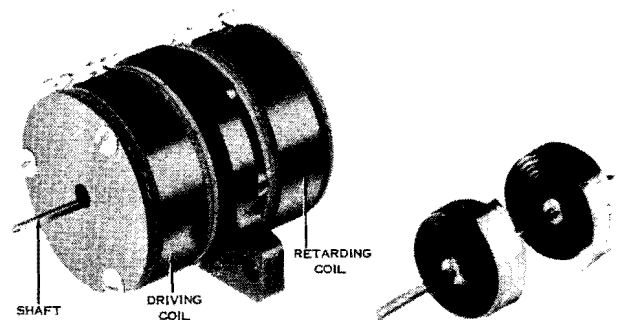


FIGURE 2.

When a bimetal is wound into a coil with the outer end fixed, the inner end can be fastened to a shaft which will rotate with the heating of the bimetal. A pointer, or pen in the case of a graphic instrument, can be fitted to the end of the shaft to produce a deflection.

Two matched bimetal coils, each of which constitutes a thermometer, are connected to a

common shaft in opposing directions. The outer ends of these coils are fixed in relation to each other and to the meter frame. The shaft, supported on pivot bearings, carries the pen. As long as the temperature of the two coils is the same, no motion of the pen results. Thus, even though ambient temperature may change, the counter forces of the bimetal coils cancel each other. When, however, the temperature of one coil is different than that of the other, there results a deflection proportional to the temperature difference between the coils.



BIMETAL COILS ON SHAFT

FIGURE 3.

Each of the two bimetal coils is contained in a separate enclosure, and one or both may be heated electrically to produce this temperature difference.

The general principle of operation of the thermal demand meter may be explained by reference to Figures 1-4.

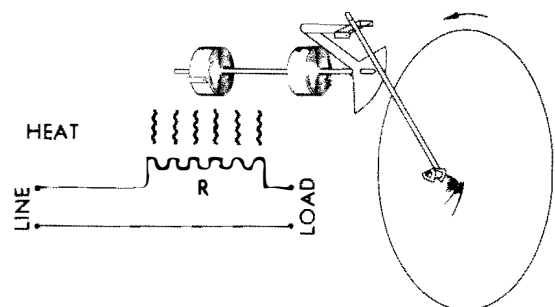


FIGURE 4.

Of Operation

When current is passed through a Lincoln ammeter, for example, heat proportional to I^2R is developed in one enclosure which raises the temperature above that of the other enclosure. The bimetal coils, responding to this difference in temperature, produce a deflection proportional to the electrical quantity being measured. Since Lincoln meters have an inherent thermally lagged response, a certain length of time is required for the heater to raise the temperature of its enclosure and the bimetal coil to the ultimate temperature. Thus, the pen approaches the ultimate indication slowly.

In all Lincoln instruments, deflection is caused by a temperature difference between two bimetal coils. For the circuitry of the other typical Lincoln meters, consult the wiring diagrams contained on page 14 of this bulletin.

The "Time Interval", as it is customarily defined, is the amount of time required to record 90% of the CHANGE in load.

Figure 5 shows a typical response curve of the Lincoln thermal meter for a steady load

condition. It can be seen from this curve that approximately 90% of the change in load is recorded on the meter in the first time interval. In the following interval, it responds to 90% of the difference between the reading at the beginning of the interval and the load level or 99% of the change. In the third interval, the meter reads 99.9% of the change. This averaging continues until there is another change in the load.

The time interval is set in a Lincoln meter by the thermal design of the enclosure in which the bimetal is placed. Unless otherwise marked on the nameplate, the time interval of a Lincoln demand meter, with the exception of all Lincoln voltmeters, is 15 minutes. Voltmeters have a time interval of approximately 10 minutes.

STANDARD LINCOLN TIME INTERVALS

Amperes (CCA) 15 Minutes.

Volts (CCV) 10 Minutes.

Power: KW (CCW), KVA (CCVA) and KVAR (CCVAR) 15 Minutes.

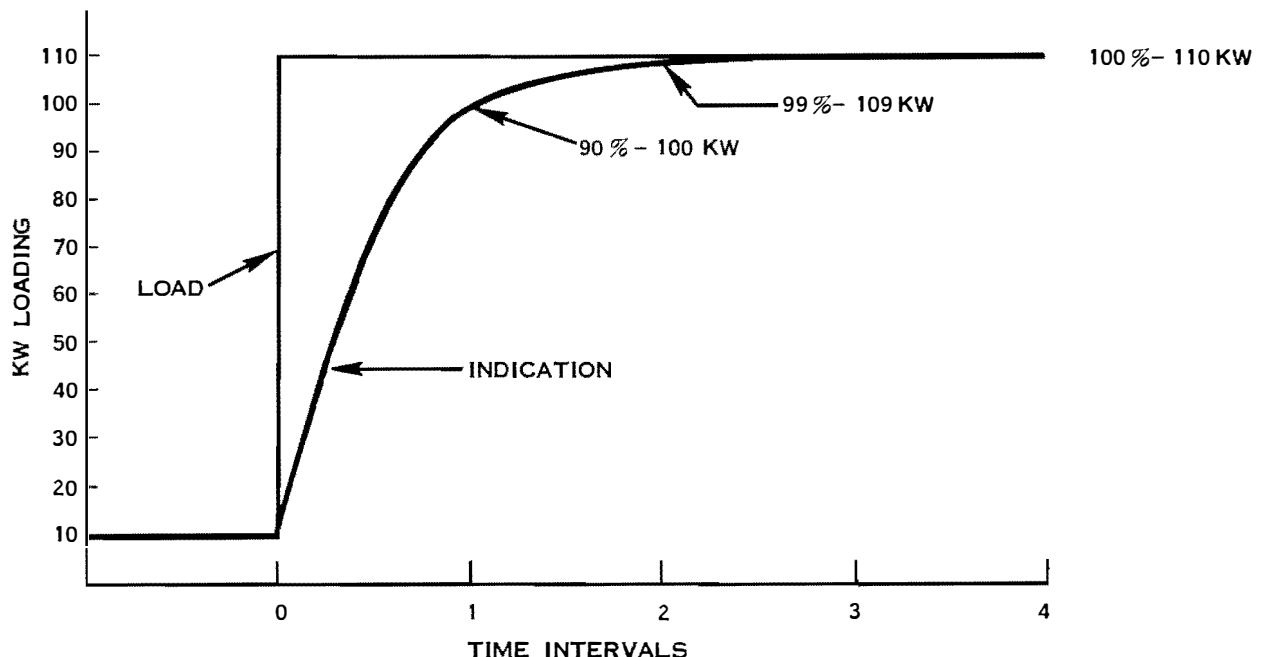


FIGURE 5. TYPICAL THERMAL RESPONSE CURVE (STEADY LOAD).

Testing

GENERAL

One of the important characteristics of the Lincoln demand meter is its inherent time lag. Three intervals are required for the meter to record 99.9% of test load.

The testing time of three intervals indicates that the most economical method of testing Lincoln meters is to test a group in series. The larger the group, the lower will be the cost per meter. Therefore, it is recommended that thermal meters be gang tested in the meter shop instead of individually tested in service.

Before the actual testing and adjustment procedures, the meters to be tested should be warmed on potential for at least 3 hours, or in the case of Lincoln ammeters left at room temperature for at least 3 hours. This precaution insures that any variations in ambient temperature conditions between the meter coils are adequately compensated for prior to testing and adjustments.

Polyphase Lincoln Types CCVAR, CCVA, and the special CCW/CCVAR meters can be tested as kw demand meters with a singlephase load applied and the switch on the 100% pf position. Singlephase CCVAR meters must be tested with a var load applied unless the meter is one of the newer types with a toggle switch for kw measurement.

GROUP TESTING

A test rack should be used which provides for the convenient connection of a group of current coils in series and potential coils in parallel. The circuit diagram for a relatively inexpensive and very convenient form of such a test rack is shown in Figure 7. It permits group testing of quantities of meters from 2 or 3 up to as many as 50 meters in series, and can be adjusted to the required meter capacity.

The arrangement shown in Figure 7 permits ready adjustment of load with small losses and also permits elimination of the phase angle between the loading transformer secondary current and the potential applied to the meters.

In the diagram, potential to the meter is taken from phase AB. The primary of the loading transformer is connected to a variac. Moving the variable tap of this variac changes the magnitude of the voltage applied to the primary, providing a complete range of adjustment of load.

The loading transformer should be so designed that the secondary supplies 1 volt per meter for the maximum number of meters that will be connected in series at any one time. This voltage is sufficient for either singlephase or polyphase meters. The transformer should, of course, be of sufficient capacity to handle the maximum ampere load of the largest capacity meters that are to be tested.

When the loading variac is connected directly across phase AB, the phase angle between the load applied to the meters and the applied potential will vary with the quantity and capacity of the meters under test. Therefore, another variac indicated as the "phase variac" is connected across phase AC. One end of the loading variac is connected to the moving contact of the phasing variac, this moving contact being designated as A'. The loading transformer primary is A'B and the potentials to the meters AB. By moving A', the secondary loading current can be brought into phase with the meter potential, regardless of the impedance in the load circuit.

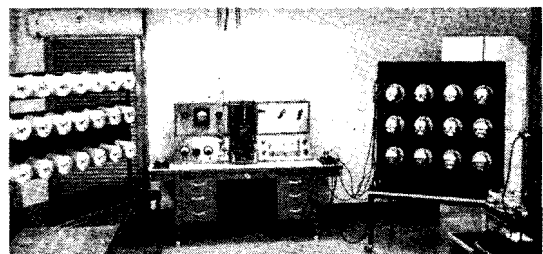


FIGURE 6. TYPICAL TEST RACK.

Procedures

The switch "P. F." is unnecessary for testing thermal meters since the meters are inherently within good accuracy limits and no adjustment for power factor is provided. The switch, however, permits selecting potential BC which is 60° displaced from the load current for 50% power factor loading.

The double-pole, double-throw phasing switch is very convenient in determining unity power factor in the test circuit. The current through the wattmeter is connected in series with the meters under test. The potential for the wattmeter can be transferred to potential CD which is 90° displaced with respect to phase AB. Therefore, when point A' is moved along the variac across phase AC until the wattmeter reads zero when its potential is across CD, it is known that the load is exactly 90° out of phase with CD and, therefore, in phase with the potential AB applied to the meters under test. When this power factor condition has been established, the switch is then thrown over to connect the wattmeter to the same potential that is applied to the meters under test, and the wattmeter then serves as the indicator for the load applied to the meters. The loading variac can be used to vary the load over wide ranges without disturbing the established phase angle of the test circuit.

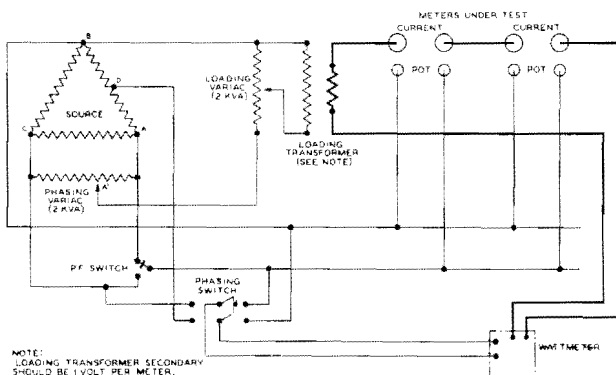


FIGURE 7. CIRCUIT DIAGRAM OF LINCOLN THERMAL METER TEST RACK.

In Figure 7, an instantaneous wattmeter is used as a standard to indicate the load on the demand meters. In this case, means must be provided for holding the load steady. A given load, preferably not less than $3/4$ full scale value of the meters under test, should be applied for not less than 60 minutes or four time intervals. At the end of this time, the indication of the demand meters should coincide with the load being held on the wattmeter.

If the load does not vary too greatly, say, not over 10% plus or minus, it is not necessary to control the load during the first 30 minutes, but the load should be controlled carefully for a final period of not less than 15 minutes. Because the Lincoln meters will indicate 90% of any change in load in 15 minutes, it can readily be seen that an approximate load, except during the final 15 minutes, will give a sufficiently accurate indication.

TESTS IN SERVICE

When it is necessary to test a thermal demand meter in service, the following methods are suggested.

1. A specially calibrated Lincoln demand meter of the same capacity as the meter to be tested may be placed in series with the service meter and allowed to remain long enough to get a comparison of the maximum demand readings of the two meters.
2. Tests of ammeters and power meters may be made with an indicating wattmeter and controlled phantom load or resistance load, holding the load carefully during the last 15 minutes of a 60 minute period.
3. This test may also be made by using a rotating standard in place of the indicating wattmeter if readings are taken at frequent intervals.

Adjustment Procedures

GENERAL

Two adjustments are provided on all Lincoln meters: the zero adjustment procedure and the deflection (or full load) adjustment. The zero adjustment procedure differs on Lincoln voltmeters as a result of the suppressed zero scale peculiar to these meters. Consequently, adjustments for voltmeters will be explained separately. The inherent power factor characteristics of the Lincoln design are such that no adjustment is required. The location and operation of adjustments are the same for all Lincoln graphic meters (Figures 8 and 9).

Load checks need be made at only one point. The check should be made above $3/4$ scale since calibration at zero and $3/4$ scale or higher is necessary to insure accuracy at all intermediate points. Adjustments at points lower than $3/4$ scale may introduce excessive errors at full scale, since the full load adjustment spring has an effect proportional to the scale point (that is, no effect at zero and maximum effect at full scale).

No adjustment has been provided for balance between the elements in three-wire and four-wire meters. All meters are carefully checked for balance at the factory, and the design is such that the balance is not subject to change.

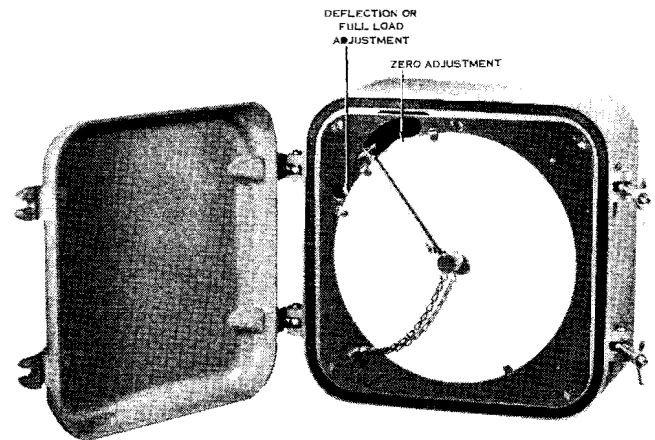


FIGURE 9.

ZERO CHECK & ADJUSTMENT

Zero should be checked only when the meters have been in the test room and warmed on uninterrupted potential, with the current circuit open, for at least 3 hours. Under this condition, the reading of the pen should be zero; that is, on the zero line. If any adjustment is needed, the finger operated wheel, as shown in Figure 8, is rotated.

DEFLECTION ADJUSTMENT

Before making the deflection or full load adjustment, a minimum of $3/4$ scale load should be applied for at least 4 time intervals. The deflection adjustment or full load adjustment consists of a drum and chain connected to a helical spring. The spring exerts a retarding force on the pen assembly. By turning the slotted drum head with a screw driver, the spring torque pull on the pen assembly can either be increased or decreased. If the reading of the meter is low, decrease the tension on the spring, and if the reading is high, increase the tension.

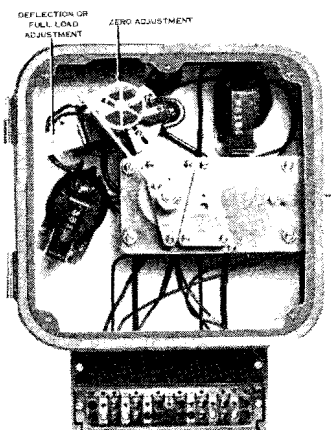


FIGURE 8.

VOLTMETER ADJUSTMENT

All Lincoln voltmeters have a suppressed zero. To calibrate the meters, two adjustments are required: on-scale-zero and the deflection or full scale adjustment. The on-scale-zero of the suppressed zero scale is the voltage at which the deflection spring has no torque.

The zero adjustment is made with on-scale-zero voltage applied to the meter. For Lincoln graphic meters, zero adjustment is made at 95 volts and 190 volts for 120 and 240 volt meters respectively. Since the true zero is suppressed, it will require about 30 minutes, or threetime intervals, for the meter to indicate the on-zero reading. After the on-scale-zero test, apply full scale voltage for at least 35

minutes. If necessary, adjust meter reading to full scale by means of full scale adjustment.

After the deflection adjustment, repeat the zero adjustment test and readjust if necessary. If readjustment of zero is required, then full scale must be rechecked.

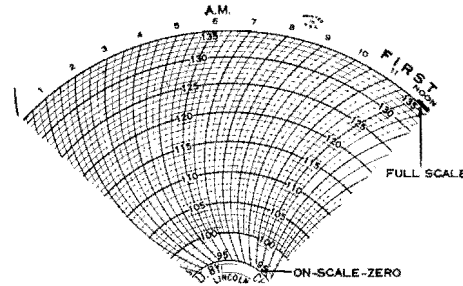


FIGURE 10.

Installation Instructions

Lincoln thermal demand meters are shipped completely assembled, adjusted and tested, ready for service. Meters should be installed in a place easily accessible for reading and where there is not excessive vibration.

Graphic type thermal meters are larger than service type watthour meters and require more space for mounting. Terminal chambers, however, are such that standard watthour meter trims, boxes or test blocks can be used with Lincoln graphic meters.

Lincoln ammeters are connected in service by connecting their current coils in series with current coils of other instruments in the circuit.

Lincoln voltmeters are connected in service by connecting their potential coils in parallel with the potential coils of other instruments in the circuit.

Lincoln kw, kva and kvar demand meters are installed with their current coils in series with the corresponding current coils of other instruments and their corresponding potential coils in parallel. Proper phase sequence on wiring diagram must be observed on polyphase kva and kvar meters.

In all cases, except when 5 ampere watthour meters are involved, the Lincoln power demand meters may be connected either on the line or the load side of the watthour meter, as the watts loss in the potential coils of any Lincoln demand meter is less than the watts required to start a watthour meter of over 5 ampere capacity. All 5 ampere Lincoln power demand meters are for use with transformers and are equipped with separate potential terminals. Because the potentials of these meters can be carried to a point ahead of the watthour meter, the demand meter can be mounted on the load side of the watthour meter. All meters can be supplied with independent potentials, if so specified.

CHART DRIVES

Lincoln graphic meters are available with three different types of chart drives.

1. Synchronous motor-drive.
2. Synchronous motor-drive with clock carryover.
3. Hand wound clock-drive, 15 day clock movement.

The last two types of drives entail clock movements and should be sent to the factory or taken to a watchmaker for repair or adjustment.

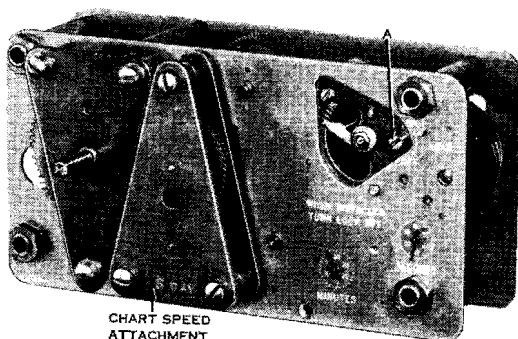


FIGURE 11.

SYNCHRONOUS CARRYOVER

With the synchronous carryover feature, the chart is normally driven by a synchronous motor. In the case of a power outage, however, the drive is automatically transferred to a spring movement. A fully wound mainspring in the clock is capable of driving the train for 14 hours. When power is restored, the drive automatically transfers to the synchronous motor. These transfers are accomplished by means of a bi-metallic blocking device which is heated when the synchronous motor is energized. This blocks the movement of the escapement in the clock. Conversely, when the device cools due to the loss of voltage, it quickly releases the escapement and allows the clock to function.

Upon power resumption, the synchronous motor rewinds the mainspring, requiring about 54 hours for a completely unwound mainspring.

In order to prevent the spring movement from running during storage and shipment, a manually operated lock is provided to block the operation of the escapement. This lock is operated by means of a slotted shaft, "A" (Figure 11) located at the position marked "LOCK" on the front of the train. The meter is shipped from the factory with the lock in the "ON" position. When the meter is installed and energized, the lock must be returned to the "OFF" position so that the thermal blocking device will be free to operate.

SYNCHRONOUS MOTOR

The porous type bronze sleeve bearings of this motor are vacuum-impregnated with a special silicon compound which provides adequate lubrication over wide ranges of temperature and climatic conditions.

Field lubrication is considered unnecessary, even after years of operation. If inspection is desired, the most effective means is to supply reduced voltage to the motor and test for synchronous speed. If the motor synchronizes under load at 75% rated voltage, no further check is needed. The Type H motor operates at a synchronous speed of 450 rpm. Markings are provided on the motor for a stroboscope check of synchronous operation.

CHART SPEED CHANGES

Lincoln graphic meters may be equipped for chart speeds of 2, 8, 16, or 32 days. As indicated by Figure 11, conversion from one chart speed to another is accomplished by changing the chart drive speed changing attachment. By simply removing three screws, the existing gear assembly can be removed and the appropriate gear assembly easily inserted in its place. No other adjustments are required.

It is also possible to replace a synchronous drive mechanism with a synchronous carryover type by disconnecting motor leads and removing four mounting screws (Figure 11).

Information

CHANGING CHARTS

The chart can be set to show correct time more accurately if the pen is used as the indicator rather than the time indicator on the platen. Settings should be made toward the outer edge of the chart where the chart is more easily read. The time indicator, a chart tab on the platen immediately below the full load adjustment hole, however, provides a quick and effective method of aligning the chart. When using this method, align the heavy time line with the arrow on the time indicator.

In setting the time of the chart, it is important that the backlash of the gears be taken up completely. This is accomplished by turning the chart holder nut clockwise. This precaution assures more accurate time setting. In setting the chart, the following steps are required:

1. Place chart on meter and replace chart holder nut.
2. Check time setting of chart by use of pen or time indicator. Adjust until pen indicates correct time.
3. Take up backlash as described above.
4. Swing pen from inside to outside of chart. If necessary, readjust for backlash and again check time setting.

CHART CONSTANTS

The chart constant (K) is a multiplier applied to the actual chart reading in order to convert it to the primary load measured by the meter. The chart constant may be something other than $K = 1$ for several different reasons. An easily read chart, such as 1 kw, may be specified for all capacities, or a direct reading

chart may not be available for certain special capacities. Where instrument transformers are used, the actual chart reading must also be multiplied by potential and current transformer ratios. The chart K is determined as the ratio of full scale meter capacity to full scale of the chart or

$$\text{Chart K} = \frac{\text{Full Scale of Meter}}{\text{Full Scale of Chart}}$$

Example: If a 6 ampere full scale chart is used on a meter rated at 3 amperes,

$$\text{Chart K} = 3/6 = 1/2;$$

therefore, all chart readings must be multiplied by $1/2$ in order to obtain the correct current value measured by the meter. If 200:5 current transformers are being used, for example, the chart reading would also have to be multiplied by the CTR = $\frac{200}{5} = 40$. Thus, a chart reading of 2.5 amperes would be multiplied to primary amperes by

$$\text{Primary Amperes} = \text{Chart Amperes} \times K \times \text{CTR}$$

$$\text{Primary Amperes} = 2.5 \times 1/2 \times 40 = 50 \text{ Amps.}$$

CHART SUGGESTIONS

1. Store charts in air-conditioned, dry places, not at outside locations.
2. Do not over-fill the pen nib. One drop lasts 32 days.
3. Replace a dirty pen nib with a clean one. Dirty nibs can be cleaned or replaced at a very low cost.
4. To insure positive pen contact with the graphic chart, the meter should be vertical or tilted slightly backwards ($1^\circ - 3^\circ$).

Zero Conversions

Sometimes it is necessary to convert the zero position of a graphic meter. In the case of inside to outside zero or vice versa, time resolution is usually the deciding factor. Time is much easier to read in the outer half of the chart. Conversion to or from raised zero is generally dependent on the possibility of reversed power flow or leading power factor conditions.

In any case, the zero position of the pen on most Lincoln graphic meters can be converted from the original position to any of three other positions. Chart zero positions are inside, outside, center or 1/3 raised zero. The following procedures outline the necessary steps.

ACTUATING UNIT

When changing counterweight assemblies in connection with zero conversions, it is necessary to remove the actuating unit. The following steps outline the recommended procedure (Figures 12, 13 and 14).

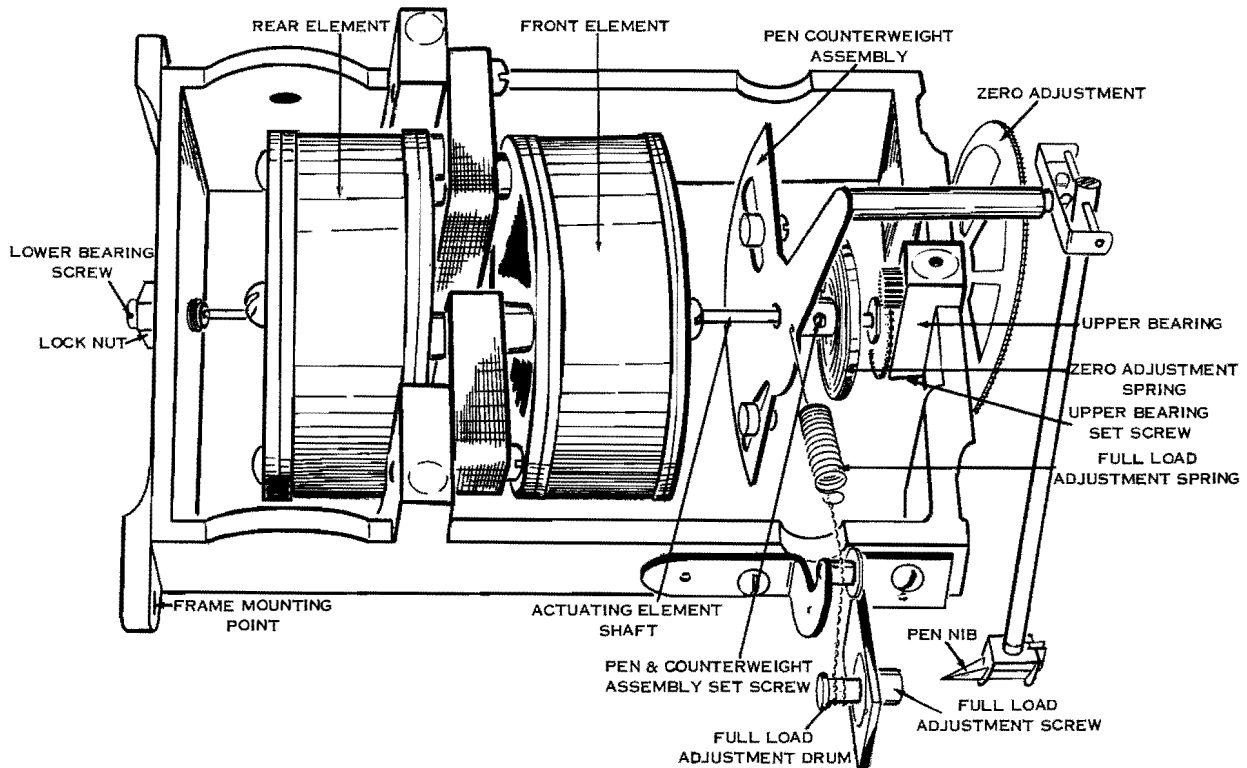


FIGURE 12.

I. Removal

1. Take out the frame mounting screws and carefully lift frame from base.
2. Unsolder all electrical connections and the zero spring connection.
3. Unhook full load spring and loosen set screw on pointer hub.
4. Loosen lower bearing nut and back off the bearing until actuating element is freed from pivot.
5. Remove element mounting screws and lift out actuating unit.
- *6. Remove pen counterweight assembly from end of shaft.

II. Installation

- *1. Attach counterweight assembly to shaft.
 2. Insert element and attach to frame by insertion and tightening of element mounting screws.
- * Steps can be eliminated if meter has three zero position holes.

3. Engage shaft in upper and lower bearings.
4. Refer to Figure 13 and internally center the bimetal coils. To do this, loosen upper bearing set screw and back off lower bearing until upper bearing and shaft fall as far as internal bimetal clearance will allow. With the shaft in both bearings, advance lower bearing half the available internal travel.
5. Tighten upper bearing set screw and back off lower bearing set screw for proper end-shake. Tighten lock nut.
6. Rehook full load spring to proper hole in counterweight assembly and rotate counterweight assembly on shaft until points A, B and C, as shown in Figure 14, are in line. Tentatively tighten set screw until Step 9.
7. Resolder electrical leads and zero spring connection at nearest point on the zero adjustment wheel, such that after soldering there is a no-tension condition. This can be achieved by a slight adjustment of the zero adjustment wheel, prior to soldering.
8. Replace actuating unit in base.
9. Loosen counterweight set screw and adjust pen until it touches the chart. Then tilt the meter forward between 3 and 7 degrees. If counterweight is not back too far on the shaft, the pen should leave the chart. Adjust until this condition is met and then retighten set screw.

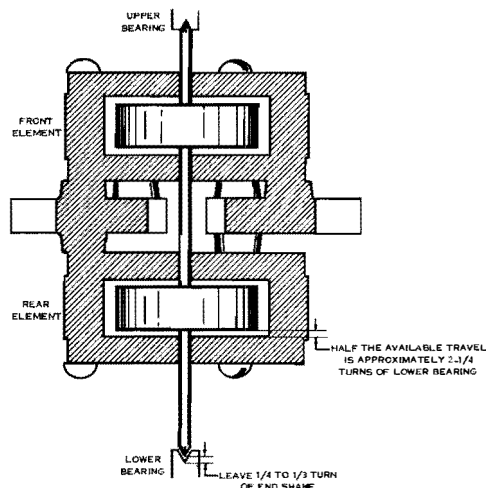


FIGURE 13.

TYPES CCW, CCVAR & CCVA

When the desired zero position is available, the zero change is accomplished by moving the full load spring to the desired zero hole and aligning the counterweight assembly as shown in Figure 14. Care should be taken that the front to back position of the counterweight on the shaft is maintained.

If the counterweight assembly supplied does not have the desired zero position hole, a new one must be ordered from the factory. The removal and installation procedure outlined on Page 12 should be followed in the replacement of the counterweight assembly.

In the case of inside to outside zero or vice versa, the secondary potential leads to the heater elements must be reversed for proper operation of polyphase CCVAR and CCVA meters. The primary leads may be reversed on CCW and singlephase CCVAR meters.

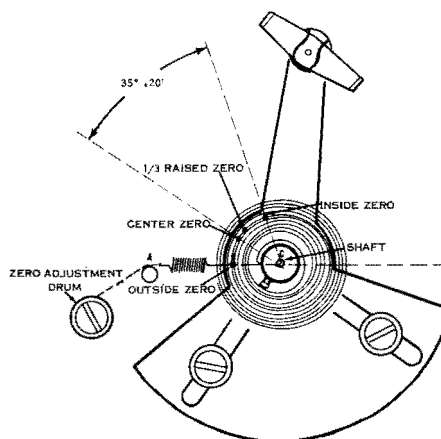


FIGURE 14. WITH THE PEN ON THE DESIRED CHART ZERO POINT, THE SHAFT, ZERO HOLE AND FULL LOAD SPRING SHOULD BE IN A STRAIGHT LINE.

TYPE CCA

Only the inside and outside zero holes are required with these meters. In order to change from inside to outside zero it is necessary to replace the actuating unit of the meter, per the steps outlined on Page 12, with a unit suitable for outside zero operation. Conversions from outside to inside zero are accomplished in the same manner.

TYPE CCV

Zero conversions on Lincoln graphic voltmeters are not advised. Operation within the chart voltage limits is obtained without the need for zero conversions.

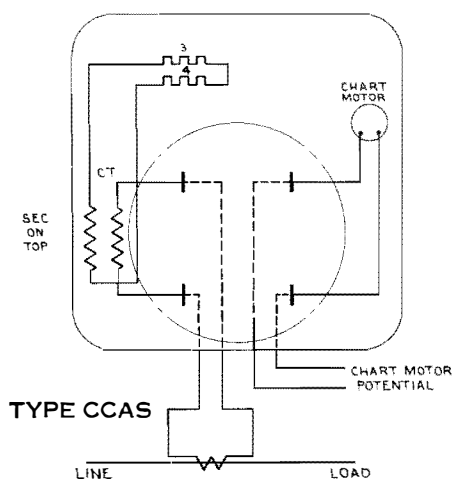
CAUTION:

Meters having an actuating unit which is not physically symmetrical should not be used as 1/2 raised zero meters. Actuating units which are not physically symmetrical will perform differently on forward and reverse operation. If a physical dissymmetry between the front and rear elements is noticed, the factory should be

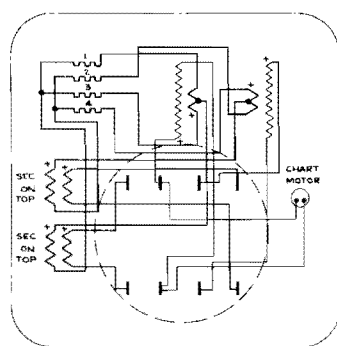
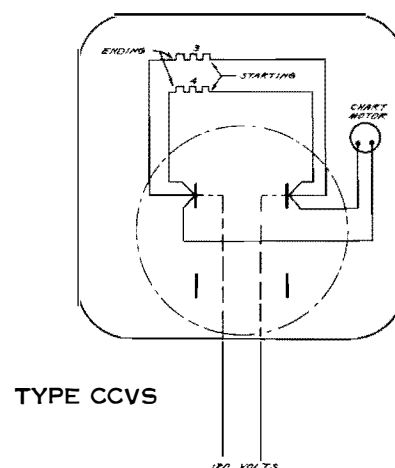
consulted regarding conversion to 1/2 raised zero operation.

Ink

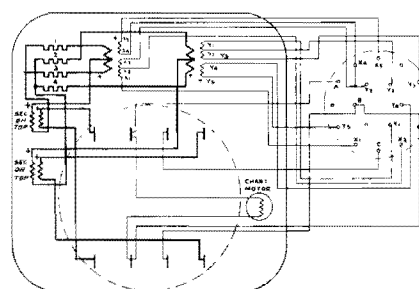
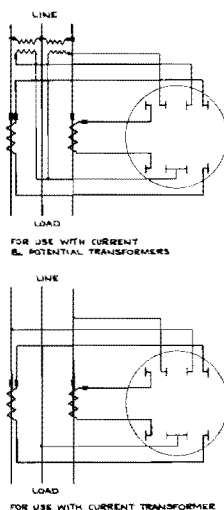
One drop of the special slow-drying ink used in the graphic meter pen assures an adequate supply for a 32 day record over a temperature range from -20°F. to a maximum summer condition. For operation below -20°, undiluted methyl, ethyl, or propyl alcohol should be added to the ink to insure proper flow. The mixture should be in the following proportion: Ink=90%, Alcohol=10%. Sangamo also supplies two types of pen nibs; one for low temperature conditions and one for normal and high temperature conditions.



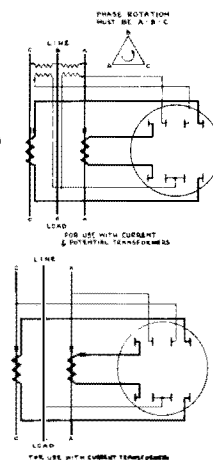
TYPICAL
SCHEMATIC
DIAGRAMS*



TYPE CCWS



TYPE CCVARS



*The very large number of internal and external connection diagrams associated with Lincoln graphic meters prohibits their inclusion in this bulletin. The diagram supplied with the meter should be consulted for detailed wiring information.

Burden Data

CURRENT CIRCUITS

| Type | Phase | Wire | Elements | Rated Amps. | Full Scale | R (ohms of highest phase) | X | Z | Volt-Amps. (at rated amperes) | Watts | P. F. |
|------|-------|------|----------|----------------|------------|------------------------------|------|------|----------------------------------|-------|-------|
| CCA | 1 | 2 | 1 | 3 | 3 amps | .485 | .077 | .491 | 4.42 | 4.36 | .99 |
| CCA | 1 | 2 | 1 | 5 | 5 amps | .175 | .028 | .177 | 4.42 | 4.36 | .99 |
| CCA | 1 | 2 | 1 | 6 | 6 amps | .121 | .019 | .123 | 4.42 | 4.36 | .99 |

With instantaneous ammeter, add .25 VA at 1.0 P. F.

| | | | | | (120 volt) | | | | | | |
|-----|---|---------|---|---|------------|------|------|------|------|------|-----|
| CCW | 1 | 2 | 1 | 5 | 0.75 kw | .103 | .040 | .110 | 2.76 | 2.58 | .93 |
| CCW | 3 | 3 or 4Δ | 2 | 5 | 1.50 kw | .076 | .031 | .082 | 2.05 | 1.90 | .93 |
| CCW | 3 | 4Y | 2 | 5 | 2.25 kw | .077 | .055 | .094 | 2.36 | 1.92 | .81 |
| CCW | 3 | 4Y | 3 | 5 | 2.25 kw | .072 | .028 | .077 | 1.92 | 1.79 | .93 |

For other full scale capacities: R, X and Z vary inversely as the square of the capacities. As an example, a 1.0 kw 1φ CCW would have $R = \frac{(.103)(.75)^2}{(1.0)^2} = .058$ ohm.

For computing burden, the capacity of a raised zero meter is the sum of the forward and backward capacity. CCVA and CCVAR meters have same current circuit burden as corresponding CCW.

POTENTIAL CIRCUITS

| Type | Phase | Wire | Elements | Maximum V. A. per Element | Watts per Element | Power Factor |
|-------|-------|--------|----------|------------------------------|----------------------|-----------------|
| CCV | 1 | 2 | 1 | 4.65 | 4.65 | 1.00 |
| CCVA | 3 | 3 | 2 | 3.62 | 1.71 | .47 |
| CCVA | 3 | 4Y | 2 | 4.43 | 2.05 | .46 |
| CCVA | 3 | 4Y | 3 | 1.40 | 1.15 | .83 |
| CCVAR | 1 | 2 | 1 | 4.10 | 2.79 | .68 lead |
| CCVAR | 3 | 3 | 2 | 3.76 | 3.76 | 1.00 |
| CCVAR | 3 | 4Y | 2 | 4.53 | 4.53 | 1.00 |
| CCVAR | 3 | 4Y | 3 | 1.30 | 1.10 | .85 |
| CCW | 1 | 2 or 3 | 1 | 3.55 | 2.70 | .76 |
| CCW | 3 | 3 or 4 | 2 | 2.62 | 1.60 | .61 |
| CCW | 3 | 4Y | 3 | 1.11 | 1.00 | .90 |

Above burdens do not include chart motor. Motor adds 4.26 VA, 2.34 watts, .55 P. F. to one phase.

STANDARD CHARTS FOR LINCOLN GRAPHIC METERS

TYPE CCA AMPERE DEMAND GRAPHIC METERS

| Range | Zero | 2-Day | 8-Day | 16-Day | 32-Day |
|----------|---------|--------|--------|---------|---------|
| 0-5 amp. | Inside | 825A2 | 885A2 | | 8325A2 |
| 0-5 amp. | Outside | | | 8165A2R | 8325A2R |
| 0-6 amp. | Inside | 826A1 | 886A1 | 8166A1 | 8326A1 |
| 0-6 amp. | Outside | 826A1R | 886A1R | | 8326A1R |

TYPE CCW WATT DEMAND GRAPHIC METERS

| Range | Zero | 2-Day | 8-Day | 16-Day | 32-Day |
|------------------|---------|--------|--------|---------|---------|
| 0-1 kw | Inside | 820W2 | 880W2 | 8160W2 | 8320W2 |
| 0-1.5 kw | Inside | 821W2 | 881W2 | 8161W2 | 8321W2 |
| 0-1.5 kw | Outside | 821W2R | 881W2R | 8161W2R | 8321W2R |
| 0-2.25 kw | Inside | 821W3 | 881W3 | 8161W3 | 8321W3 |
| 0-2.25 kw | Outside | 821W3R | 881W3R | 8161W3R | 8321W3R |
| 0.5-0-0.5 kw | Raised | | 880W2M | 8160W2M | |
| 0.5-0-1 kw | Raised | 821W2S | 881W2S | 8161W2S | 8321W2S |
| 1.125-0-1.125 kw | Raised | 821W3M | 881W3M | 8161W3M | |

TYPE CCV GRAPHIC VOLTMETER

| Range | Zero | 2-Day | 8-Day | 16-Day | 32-Day |
|--------------|--------|-------|-------|--------|--------|
| 95-135 volts | Inside | 821V1 | 881V1 | 8161V1 | 8321V1 |

BULLETIN CROSS-REFERENCE

| Meter Type | Description | Price List | Replacement Parts |
|------------|-------------|------------|-------------------|
| Ampere | 460A | 146 | 943 |
| Volt | 470A | 146 | 943 |
| Watts | 440 (3) | 144 | 943 |
| KVA | 440 (3) | 144 | 943 |
| KVAR | 440 (3) | 144 | 943 |



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