Westinghouse

Photo-Electric Smoke Indicator and Recorder

INSTRUCTION BOOK

Westinghouse Electric & Manufacturing Company

East Pittsburgh Works East Pittsburgh, Pa.

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I. B. 5473-A

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Photo-Electric Smoke Indicator and Recorder

GENERAL

The photo-electric smoke indicator and recorder is a reliable and accurate instrument that gives to the operator a continuous indication of the conditions of combustion in the form of smoke density, and makes a record of these indications.

It is an accepted fact that smoke results from improper combustion, and this can almost always be remedied. Therefore, the density of smoke leaving the stack should be continually indicated to the operator. Methods of smoke determination in the past have depended upon the fallible human eye for judging the density. Such means of judging are inaccurate even during the day as weather conditions vary, and altogether ineffective at night. Thus the photo-electric smoke indicator and recorder, is a new instrument to promote increased combustion efficiency.

In obtaining combustion efficiency, the smoke indicator and recorder will also prove helpful in combination with the CO_2 meter. If the operator is required to maintain a maximum percentage of CO_2, he will obviously be crowding very close to the point at which smoke will occur due to a deficiency of air. Therefore, it is desirable to give the operator an instrument which he can use with the CO_2 meter in such a way as to obtain a maximum of CO_2 and at the same time a minimum of smoke.

When smoke occurs, it is generally an indication of serious losses, not because of the soot, but on account of the unburned, invisible, combustible gases which are distilled from the coal and not burned when insufficient air is present.

GENERAL DESCRIPTION

A beam of light projected through the smoke onto the photo-electric tube varies in intensity with the density of the smoke. Variations in the light striking the tube cause like variations in the current flowing through the tube. This current when amplified is measured by indicating or recording instruments calibrated in degrees of smoke density as read on a Ringelman Chart.

If so desired, a light or alarm bell can be operated.

DETAILED DESCRIPTION

Construction:

The device consists of two main parts: first, the light-source unit, and the photo-electric amplifier and control unit, mounted on opposite sides of the stack or breeching; second, the indicating or recording instruments, as well as the bell alarm or indicating lamp, located in the boiler room or any other convenient location.

The light-source unit consists essentially of a low-wattage incandescent lamp, a condensing lens for collecting the light rays into a parallel beam which is projected through the stack, and adjustments for properly focusing this beam of light.

The photo-electric amplifier and control unit contains the photo-electric tube on which, through a condensing lens, the beam of light sent out from the light-source unit is focused. It, also, contains the necessary transformer and control to properly adjust and operate the amplifier.

A cast iron box makes the units weatherproof, and they can be mounted either indoors or outdoors.

The method of mounting the apparatus on the stack is shown in Fig. 1. The

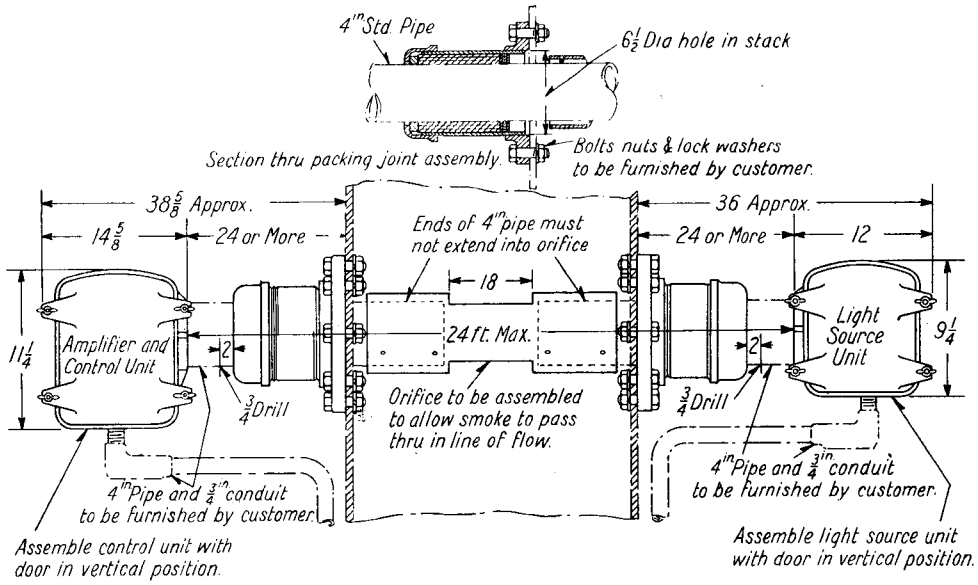


FIG. 1—SCHEMATIC STACK MOUNTING DIAGRAM OF THE PHOTO-ELECTRIC INDICATOR AND RECORDER

pipes pass through the walls of the smokestack in semi-flexible packing joints. This is necessary because it has been found that at high ratings, particularly in large stacks, the walls of the stack or breeching warp considerably due to the high flue-gas temperature. The pipes on which the units are mounted are joined inside the stack by a spacer in which is the smoke orifice. The spacer forms a rigid connection between the pipes, thus assuring maintenance of alignment, but at the same time permitting the flow of smoke through the light beam which traverses the pipes and spacer. By using an orifice of a given length which allows a definite portion of the smoke to cross the beam of light, the total diameter of the stack has no influence on the calibration of the device.

All stack-mounting details (smoke orifice, packing joints, pipe flanges, etc.), with the exception of the 4-inch pipe, are supplied with the units. The user cuts two openings through the stack or breeching on opposite sides and supplies two pieces of standard 4-inch pipe cut to proper lengths depending upon the width of the stack, and then makes the assembly as shown in Fig. 1.

Fogging of the lenses is prevented by a small hole in the 4-inch pipe which allows fresh air to be drawn into the stack ahead of the lenses. **It should be noted however that the smoke indicator must be located in the stack or breeching where the pressure is less inside the stack than that outside.** Inside pressure may in some locations in the stack or breeching be greater than that outside when forced draft is used.

Indicating and Recording Instruments:

The graphic recording instrument is a standard type R recording instrument, calibrated directly in degrees of smoke density. It is equipped with 3 contacts of 20 watts capacity which can be set to close at any desired value of smoke density. These may be set to have a green light burning to indicate clear, an amber light burning to indicate medium, and a red light and alarm bell to indicate dense smoke conditions. If a record is not desired, relays can be used to trip the control circuit of the lights and the alarm bell. If the recording instrument is located in the boiler room, no indicating instrument is required. If, however, it is located in the engineer's office, an indicating instrument should be mounted in the boiler room for the fireman.

Circuits:

The wiring diagram of the smoke indicator is shown in Fig. 2 with wiring to be installed by the customer shown in heavy lines. The apparatus operates from 110 volts, 25 to 60 cycles; no other source of energy is required. If operation from D-C. is necessary, a small rotary converter is used.

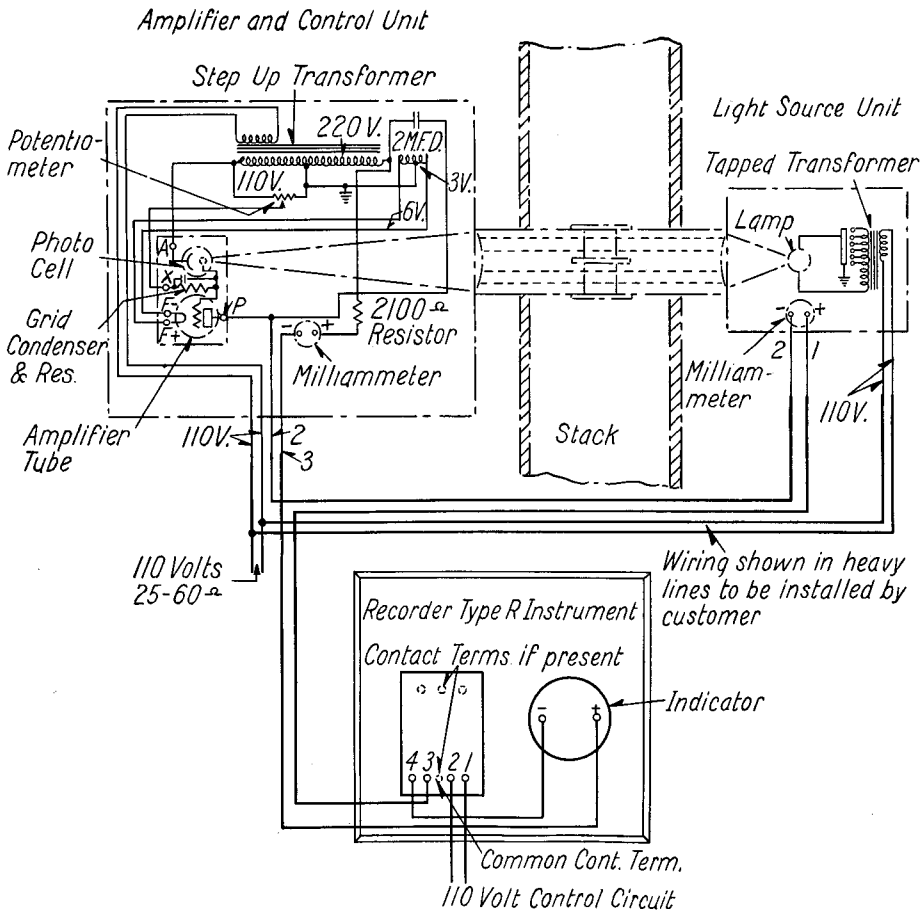


FIG. 2—WIRING DIAGRAM OF SMOKE INDICATOR AND RECORDER. HEAVY LINES INDICATE CUSTOMER'S WIRING.

PRINCIPLE OF OPERATION

When connections have been made per Fig. 2 and adjustments (Page 4) on that subject, the operation of the circuit may be explained by referring to Fig. 2. If the photo tube is dark, the grid of the amplifier tube will be at a negative potential with respect to the filament as determined by the setting of the initial current adjuster. If the photo tube is now considered to be illuminated, it will pass current which will be proportional to the amount of light falling on the photo tube. This current will flow from the photo tube through a section of the transformer and initial current adjuster, thence through the grid resistor and back to the photo tube from which it started. As a result of the current flowing through the grid resistor in the direction pointed out above, a voltage drop tending to add to the negative bias on the grid will occur. If the illumination on the photo tube is sufficient, the increase in negative bias on the grid of the amplifier tube will be large enough to cause the current flowing in the plate circuit of the amplifier tube to fall from 5 milliamperes to 1 milliampere. Now, if the light is gradually cut off, as by smoke, the increase in negative bias is lost and the current rises toward the value which existed when no light was allowed to fall on the photo tube.

Voltage Compensation:

The circuit of the smoke indicator is such that it automatically compensates for variations of as much as plus or minus 5% in line voltage at #3 smoke. It does not compensate completely at other smoke densities but the error is not great. Since the light emitted by the lamp in the light source unit varies as the fourth power of the voltage, it has been necessary to devise a circuit which will automatically off-set such variations. This has been accomplished in a very simple manner, in that the circuit used has the inherent characteristic of compensating for variations in supply voltage without the addition of complicated voltage regulating devices. The extent to which compensation is effected is shown in Fig. 3.

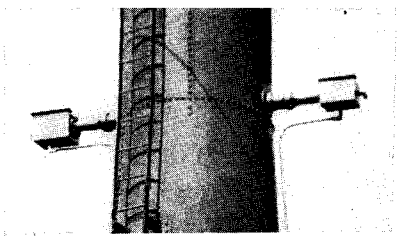


FIG. 3—INSTALLATION OF SMOKE INDICATOR AND RECORDER.

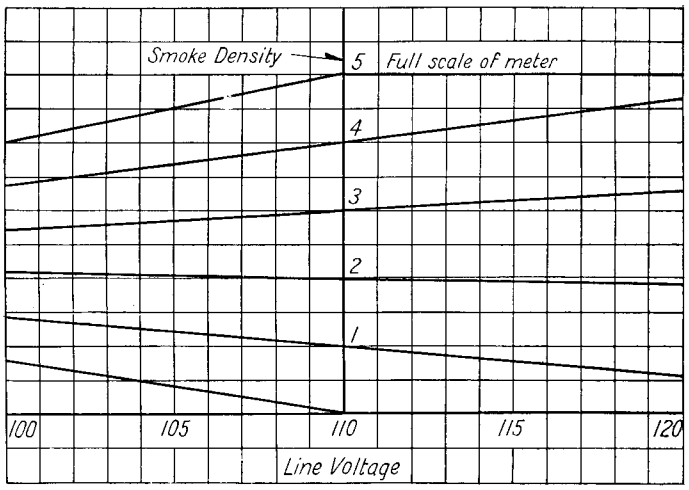


FIG. 4—VOLTAGE COMPENSATION CURVES. FOR NORMAL LINE VOLTAGES OTHER THAN 110 VOLTS SUFFICIENT ACCURACY MAY BE HAD BY ASSUMING THE EXISTING NORMAL VOLTAGE TO BE AT POINT MARKED 110 VOLTS ON CURVE. IF 115 VOLTS IS THE NORMAL LINE VOLTAGE, THE SCALE WILL THEN BE 105, 110, 115, 120, AND 125 FROM LEFT TO RIGHT.

INSTALLATION

Stack Mounting:

The first step in installing the smoke indicator is to decide on the proper location for the two units as a space as shown in Fig. 1 must be available on each side of the smoke flue at the point where it is desired to mount the smoke indicator. It must be possible to mount the packing joints on opposite sides of the flue so that they are in alignment with each other. It must also be possible to insert through the packing joint on one side of the flue a piece of pipe at least 4 ft. longer than the flue is thick at this point. The units have thus far been constructed to operate horizontally or nearly so. The photo electric amplifier and control unit should not be subjected to temperatures greater than 110° F.

Reference to Fig. 1 will enable the customer to understand readily how installation is to be effected. The packing joints are first fastened securely to opposite sides of the smoke flue. The two pieces of 4 inch pipe which are to be furnished by the customer and cut to the proper length, threaded and the proper holes drilled as shown in Fig. 1 should now be inserted in the ends of the framework supplied and fastened securely by means of the set screws when the ends of the two pipes are 18 inches apart. Now check whether or not the two pipes are in absolute alignment. They must be aligned properly in order that there shall be no obstruction to the passage of the beam of light from the light source unit. The next step is to fasten in place on the 4 inch pipes the loose rings which are equipped with set screws. These rings should be just far enough apart so that when the assembly is placed through the packing joints the rings will be inside the joints and not inside the walls of the flue. The complete assembly may now be placed through the flue by inserting it through the packing joints. The assembly should slip through the packing joint freely and when in position should not bind as this may cause the assembly to be twisted or thrown out of position if the flue warps due to changes of flue gas temperature. Now carefully place in position the asbestos packing which is supplied. **This packing should not be forced in as the joint is intended to be somewhat flexible.** The remaining two rings are now to be placed in front of the asbestos packing and the 6 inch pipe caps placed in position and screwed down firmly.

The two units may now be screwed on the extending ends of the 4 inch pipes and connected as shown in Fig. 2. The units may be mounted any distance apart up to 24 ft. and sufficient light will be obtained to operate the amplifier and control unit properly. If it is essential that the spacing should be from 25 to 35 ft., a distance this great may be used provided the photo tube sensitivity

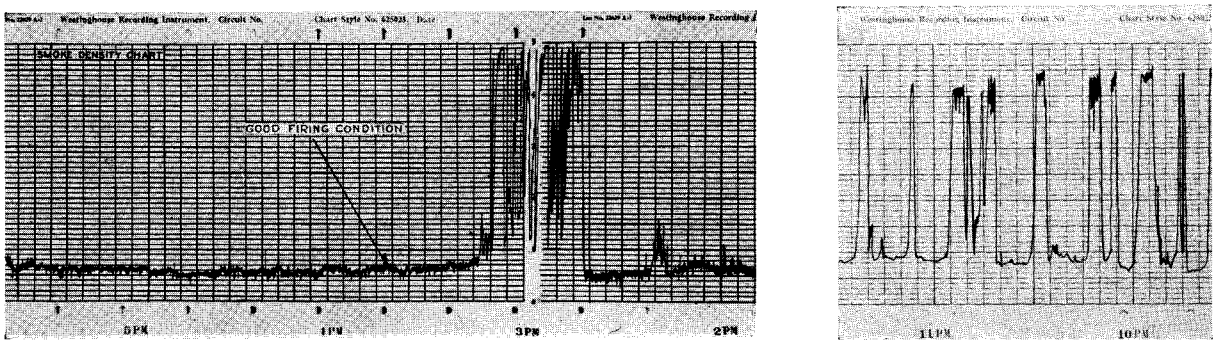


FIG. 4—SECTIONS OF SMOKE RECORDER CHARTS. LEFT CHART SHOWS IRREGULAR COAL FEED AT 2:20 P.M. CAUSED BY VIBRATIONS IN BUILDING, AND 3:00 P.M. BLOWING SOOT. RIGHT CHART SHOWS IRREGULAR OPERATION

is great enough. This will require more frequent replacement of the tube and special selection of replacement tubes. It should be borne in mind, however, that the closer the units are placed together, the easier will be the adjustments and the easier it will be to keep the light beam properly focused on the lens of the amplifier and control unit.

It is essential for constancy of calibration that the mounting of the apparatus be done carefully.

If the stack or breeching is less than 60 inches in width at the point of installation, a different assembly must be used. The smoke orifice as supplied is then not used and it is only necessary to cut an 18 inch long smoke orifice in a piece of standard 4 inch pipe cut to the proper length to extend all the way through the stack. Then assemble the same as above but with the special smoke orifice and mounting instead of the standard smoke orifice.

Wiring should be then made as shown in Figure 2 with the proper number of instruments in series between 1 and 3 such as recording and indicating instruments and relays.

Mounting Photo Cell and Amplifier Tube:

To mount the photo tube and amplifier tube, remove the nickel plated screws which hold the ring on each socket. Loosen the three cupped set screws whose heads extend at the side of each ring. Now place the base of the photo tube or amplifier tube, as the case may be, in the ring and tighten up the set screws when the bottom of the Micarta base on the tube extends about $\frac{1}{8}$ inch below the surface of the ring which is next to the cork when assembled. The tube must also be in a position in the ring which will permit the replacement of the nickel plated clamping screws when the prongs of the amplifier tube or photo tube have been inserted in the socket. When the ring has been properly fastened onto the base of both the amplifier tube and photo tube, insert the tubes in their sockets. Place the photo tube in the socket nearest the rear of the photo-electric cell amplifier unit first. The window must face toward the lens. Now, replace the clamping screws and screw firmly but **do not force the screws** as this will result in breaking loose the hold which the set screws have on the base of the tube. The amplifier tube should now be placed in its socket and screwed down in a manner similar to that used in mounting the photo tube.

The lamp should then be mounted in the light source unit and clamped solidly in position with the screw provided for that purpose.

CALIBRATION

When the units have been mounted and the wiring completed as per Fig. 2, the adjustments may be properly made as follows:

Adjust the smoke indicator as specified below and allow to operate several days (three or four) and then make the final calibration in a similar manner. This allows the circuit to become stabilized. Follow the same procedure when installing new tubes.

Completely darken the photo-electric tube by removing the voltage adjusting plug in the light source unit and turn the initial current adjuster which is at the right front of the unit until a reading of 5 milliamperes (5 smoke density) is obtained on the meter. **Do not allow stray light such as sunlight to fall on the cell.**

When the amplifier and control unit has been adjusted as directed above, place the voltage adjusting plug in the position of minimum lamp voltage. It is desirable that for the next adjustment no smoke shall be passing up the flue. If it is possible to obtain this condition, then focus the lamp by means of the two focusing adjustments until the minimum reading is obtained on the meter. One of these allows adjustments vertically and is controlled by the large knurled nut on the back side of the lamp support. The other allows adjustment in all directions in the horizontal plane and is controlled by the large knurled nut directly beneath the lamp.

In focusing the lamp, both adjustments should be loosened and the lamp shifted about till the light beam falls on the lens of the amplifier and control unit as told by watching the meter. When a response is obtained on the meter, tighten temporarily the horizontal adjustment and change the other until the maximum possible response is obtained. Now tighten securely the vertical adjusting nut, loosen the other and proceed to further increase the response (lower the current reading) by altering both the distance of the lamp from the lens and the lateral position of the lamp until the best focus is obtained. It will also be found best to firmly secure the lamp with the plane of the lamp filament at 45° to the face of the lens.

If the illumination is found to be insufficient to reduce the current from 5 to 1 milliampere (5 to 0 density) increase the voltage on the lamp until the meter reading goes below 1 milliampere. **Make sure that the plug is screwed in tightly.** When the voltage tap has been selected which will give just slightly less than 1 milliampere, move one of the focusing adjustments slightly until the meter reads exactly 0 density. **Make sure to tighten the adjustments securely.** The smoke indicator should now be in adjustment.

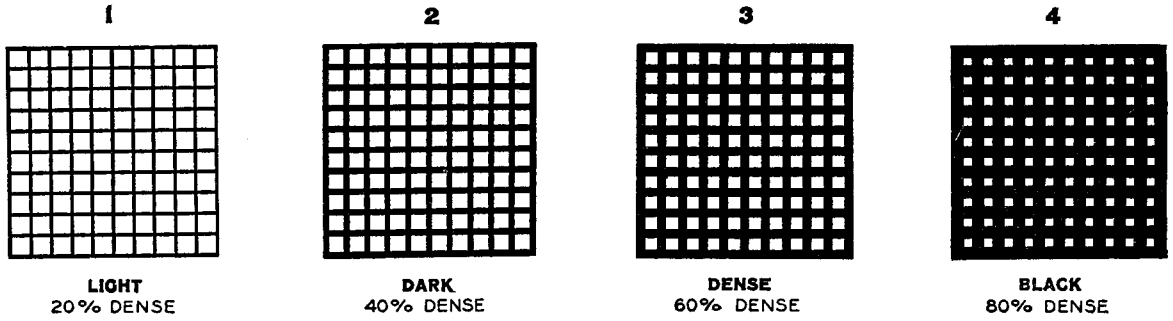


FIG. 5—RINGELMANN CHART REDUCED—IN THE ORIGINAL THE CHARTS ARE TWO INCHES SQUARE. (TO USE THIS A FULL-SIZED CHART IS SET UP DIRECTLY IN LINE BETWEEN THE OBSERVER AND THE STACK AT A DISTANCE OF ABOUT FIFTY FEET FROM THE OBSERVER, SO AS TO CAUSE THE LINES TO MERGE).

In case that it is impossible to make adjustments without smoke in the flue, proceed exactly as has been explained above except that the focusing must be done in such a manner that the current is adjusted to the proper value corresponding to the smoke density existing in the flue as estimated from a Ringelmann Chart (Fig. 4). The proper current values for certain smoke densities are given below in tabular form;

Smoke Density	Current-Milliamperes
0	1.0
1	1.8
2	2.6
3	3.4
4	4.2
5	5.0

It will be found that when adjusting the smoke indicator with smoke passing through the flue, it will be more difficult to obtain a definite calibration than with no smoke because smoke passes through the flue in puffs causing a considerable variation of the current reading. This fact makes it necessary to take for the current reading a value which is the mean of the variation. A smoke indicator adjusted in this manner should be very accurately calibrated, however, particularly if the adjustments are made at the lowest smoke density possible to obtain.

After a little experience is had on a given installation, it will be found possible to accurately adjust the apparatus with smoke in the stack without attempting to read the smoke density. This is made possible by the fact that a given boiler has a minimum possible smoke density which is emitted most of the time when the boiler is properly fired.

It should be understood, with regard to the life of the lamp, that the lamp voltage should be as low as possible.

TESTS

If after making connections as under Circuits on page 4 difficulty is encountered in making the smoke indicator operate properly either when the device is first installed or after a period of operation, the trouble may be located as follows:

A. **If the light source fails to light** when power is turned on,

(1) Examine lamp to see that it is not damaged.

(2) Make sure that all supply circuits are properly connected.

(3) Make sure that the voltage adjusting plug on the terminal board is screwed in tightly.

(4) If the above three points are checked and fail to produce results, the transformer must be at fault.

B. **If no current reading can be obtained in the meter** for any setting of the initial current adjuster when the photo tube is dark,

(1) Make certain that a power supply of 110 volts 25-60 cycles is applied to leads marked 110 V.

(2) The amplifier tube may be damaged. Note if filament lights. If not, replace with a new one.

C. **If no control is exerted by initial current adjuster when all light is cut out and adjustments made per page 4.** (That is, if the current rises to more than full scale and cannot be reduced by the initial current adjuster.)

(1) The grid resistor may be open circuited.

(2) The grid condenser may be open circuited.

(3) If, immediately or after a period of 5 or 10 minutes operation, the current cannot be controlled by the initial current adjuster, the amplifier tube may be at fault although the tubes are given a rigid inspection and test before leaving the factory.

D. If after adjustments have been made per page 4, **no change in current readings is obtained when the light is turned on,**

(1) The photo-electric tube may have lost its sensitivity due to long usage or rough treatment.

(2) The grid resistor may be shorted or may have been damaged so that its resistance is very low.

E. **Too great sensitivity is shown by the device** when the light is turned on as shown by a tendency of the current reading to drop to or near 0 meter reading with an ordinary amount of light in the cell.

(1) Grid resistor may be too high in resistance.

F. If after the smoke indicator has been in service for some time, a change in indication for a given smoke density occurs:

(1) Clean lens on both units. (The indication may not return exactly to the correct value due to slight shifting of the lens in replacing them. This will not usually be greater than plus or minus ¼ degree of smoke density). If cleaning of lenses is necessary oftener than once in two weeks, either an outward draft is sometimes produced or the unit is located where the atmosphere is unusually dirty.

(2) If, as noted in (1) the reading is not returned to approximately the correct value by cleaning the lens, readjust the apparatus per page 6 on calibration.

(3) If the apparatus continues to get out of adjustment at very frequent intervals (the average interval between adjustments is two weeks) the difficulty should be traced as follows:

(a) Check alignment of units and rigidity of mounting. See page 5 under Installation.

(b) Note section A, B, C, D and E above.

(c) If it is found impossible to make the smoke indicator work, it should be returned to the factory for repairs since in most cases our factory is better fitted to repair such apparatus than the customer. If the photo-electric cell amplifier unit is found to be at fault, it may be removed by taking out the four screws holding it to the steel sub-base and loosening the wiring from the five binding posts at the side of the unit. It may then be returned to the factory for repair and a new one put in its place.

MAINTENANCE

The smoke indicator when once in adjustment requires very little attention other than infrequent inspections and such readjustments as may be occasioned by small changes in some of the devices or by replacement of parts in line with the schedule given below. The parts most likely to require replacement are listed below with the recommended useful life. The figures given are intended to be far enough inside the actual life of the device so that if the parts are replaced as recommended, the smoke indicator will not give false operation for any but extraordinary conditions.

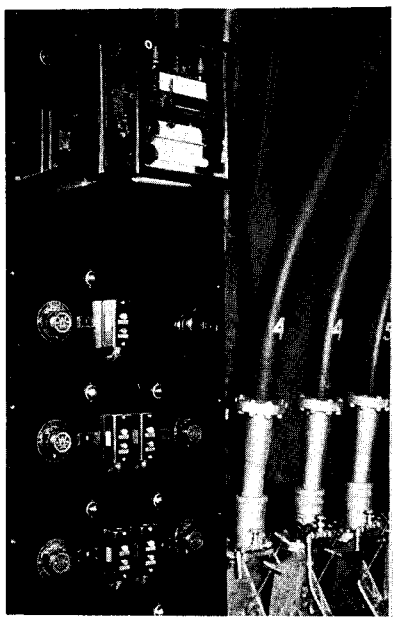


FIG. 6—INSTRUMENT PANEL IN BOILER ROOM.

The question commonly asked is "How will we know when the apparatus is in need of readjustment?" This is easily seen on the chart since, as has been explained under "Adjustments", each boiler has a minimum possible smoke density which exists most of the time under proper firing conditions. If this minimum reading on the instruments rises above that known to be usual for that boiler, then adjustment is necessary.

A. The **small incandescent lamp** in the light source unit is run at low voltage in order to obtain long life but **should be replaced once each six months for safety.**

B. The **amplifier tube** has a very long life but **should be replaced once each year** if the smoke indicator is in use 24 hours a day. If the smoke indicator is not in constant use, the tube **should be replaced after a period of operation which is equivalent to one year of continuous operation or after 9000 hours of actual operation.**

C. The photo-electric tubes are factory aged and sorted. Usually they will not fail suddenly like an incandescent lamp but will show a gradually declining sensitivity for a given amount of light impinging on them. For this reason it is better that the customer decide for himself when replacement is desirable. The average life is one year or longer. Replacement will be necessary when it is no longer possible to obtain sufficient light by adjustment of the light source voltage and focus to cause the current to fall from 5 to 1 milliampere (5 to 0 density) when no smoke is present in the flue.

D. The grid resistor is subject to the same type of life characteristic as the photo cell and hence should be replaced only when operation indicates a big change in resistance which causes the normal light current to become lower for a given smoke density. Their average life is in excess of one year.

The lens should be inspected and cleaned periodically. The period of time between cleanings will depend almost entirely on the location of the smoke indicator. That is to say, if the smoke indicator is placed in an extremely dusty and dirty location, it will be necessary to clean the lens very frequently. It will also be found to be necessary to clean them more frequently in smoky and foggy weather such as is experienced in winter than in clear summer weather. The average time between lens cleanings is about two weeks.

The lens is removed by loosening the three screws holding it in place and giving the lens a partial turn after which it can be removed with its mounting.

The whole smoke indicator and its adjustment should, of course, be inspected at periodic intervals to make sure that the device is properly adjusted and in good working condition. The exact period of time between inspections can best be determined by the customer, but as a guide it is recommended that the apparatus be checked once every two weeks.

AUXILIARY APPARATUS

Type R recording instrument, calibrated in smoke density, with three 20 watt adjustable alarm contacts, S# 682993.

Type R recording instrument, calibrated in smoke density and with one 200 watt adjustable contact, S# 630634.

Type SX indicating instrument calibrated in smoke density, S# 682994.

Relay, Type TV, capacity 1 amp. 110 volts, non-inductive load; for use when operating alarms when recording instruments are not used, S# 530466.

Rotary converter for operation on 110 volts DC, S# 578136.

RENEWAL PARTS

The list of parts shown on the following page is made up for your convenience in ordering renewal parts. To order a renewal part, give the style number of unit and name and style number of the part desired. Due to the necessity of avoiding interruption in service, it is well to carry a number of renewal parts on hand. Carrying such a stock will also avoid a delay in shipment at a time when parts are most needed.

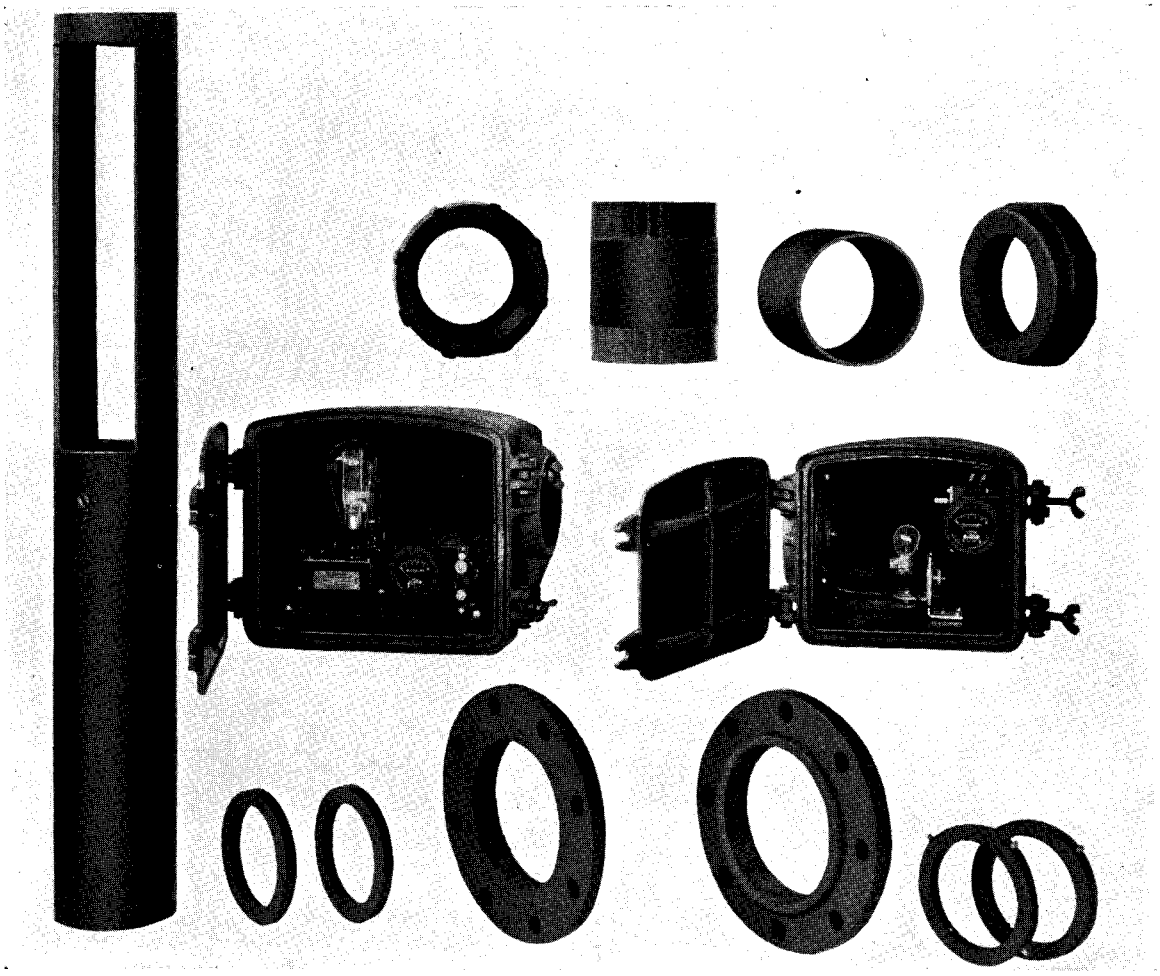


FIG. 7—EXPLODED VIEW OF PHOTO-ELECTRIC SMOKE INDICATOR AND RECORDER APPARATUS COMPLETE. AT THE LEFT IS SHOWN THE SMOKE ORIFICE. AT LEFT CENTER THE AMPLIFIER AND CONTROL UNIT. AT RIGHT CENTER THE LIGHT SOURCE UNIT.

RECOMMENDED STOCK OF RENEWAL PARTS

Photo Electric Amplifier and Control Unit

Units in use up to and including		2	5	15	
Name of Part	**No. Per Unit**	**Recommended For Stock**			**Style No.**
Transformer	1	0	1	1	700634
Milliammeter	1	0	0	1	422592
Condenser	1	0	1	2	552844
Resistor	1	0	0	1	376364
*Photo Tube Amplifier Unit, Type B	1	0	0	0	684371
Wing Nut for Case and Cover Bolt	4	1	2	4	197940
Glass lens	1	0	1	1	713668
Photo Cell	1	1	1	2	700659
Amplifier Tube	1	1	1	2	593428

Light Source Unit

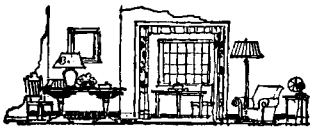
Lamp, 21 C.P. 6-8 Volts S.C.	1	1	1	2	596784
Transformer	1	0	1	1	594242
Milliameter	1	0	0	1	422592
Wing Nut for Case and Cover Bolt	4	1	2	4	197940
Glass lens	1	0	1	1	713669

*See I. B. 5458 for tubes and parts for this unit.

MEMORANDUM

(Use Ink)

Westinghouse Products

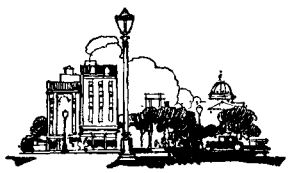


Homes—Farms

Air Heaters
Auto Engine Heaters
Automatic Irons
Automatic Percolators
Automatic Ranges
Cozy Glow Heaters
Curling Irons
Fans
Hot Plates
Light and Power Plants
Lighting Equipment
Mazda Lamps
Motors for
  Buffers and Grinders
  Ice Cream Freezers
  Ironers and Washers
  Refrigerators
  Sewing Machines
  Vacuum Cleaners
Newel Posts
Panelboards
Rectigon Chargers for Automobile and Radio Batteries
Rectox Trickle Charger
Refrigerators, Electrical
Safety Switches
Sollaire Luminaires
Sol-Lux Luminaires
Solar Glow Heaters
Table Stoves
Tumbler Water Heaters
Turnover Toasters
Vacuum Cleaners
Wall-Type Heaters
Waffle Irons
Warming Pads
Water Heaters

Buildings

Arc Welding Equip.
Circuit-Breakers
Elevators and Control
Glue and Solder Pots
Instruments and Relays
Kitchen Equipment
  Bake Ovens,
  Hot Plates Ranges
Lighting Equipment
  Brackets, Newels and Lanterns
  Reflectors & Lamps
  Sol-Lux Luminaires
Lightning Arresters
Micarta Trays
Meters
Meter Service Switches
Motor Generators
Motors and Control for:
  Coal and Ash-Handling Equipment
  Compressors
  Elevators
  Fans and Blowers
  Laundry Equipment
  Refrigerating Equip.
  Vacuum Cleaners
  Water & Sump Pumps
Panelboards
SynchronousConverters
Safety Switches
Solar Glow Heaters
Stokers
Switchgear
Transformers



City Improvements

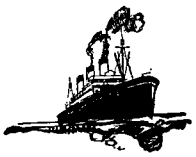
Airport Floodlights
Automatic Substations
Constant Current Regulators
Control Apparatus
Elec. Railway Equip.
Lighting Units
Mazda Lamps
Ornamental Standards
Parkway Cables
Street Brackets
Streethoods

Offices and Stores

Air Heaters
Bread-baking Oven
Elevators and Control
Fans, Desk and Exhaust
Fuses
Lighting Equipment
Mazda Lamps
Meters
Micarta Desk Tops
Motors for
  Adding Machines
  Addressing Machines
Motors for
  Coffee and Meat Grinders, etc.
  Dictaphones
  Envelope Sealers
  Fans and Blowers
  Pumps
  Refrigerating Machines
Panelboards
Safety Switches
Switches
Tumbler Water Heaters

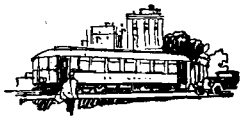
Aviation

Approach, Boundary, Hangar, and Obstruction Lights
Arc Welding Equip.
Floodlight Projectors
Motor Generators
Reflectors
Transformers
Mazda Lamps
Micarta
  Cabin-lining Plate
  Fairleads
  Hinge Bearings
  Propellers
  Pulleys
  Tailwheels



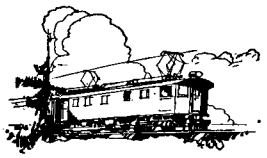
Ships

Circuit-Breakers
Condensing Equipment
Deck Winch Motors
Elec.Heating Appar.
Eng. Room Auxiliaries
Fans and Blowers
Fuses
Generating Equipment
Instruments
Light and Power Plants
Lighting Equipment
Micarta Trays
Motors and Controllers
Ovens, Ranges and Galley Equipment
Panelboards
Propulsion Equipment
  Diesel-Electric
  Geared Turbine
  Turbine Electric
Safety Switches
Switchgear



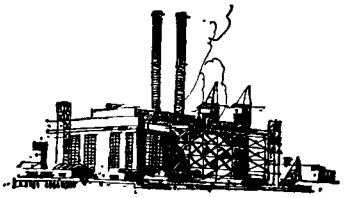
Electric Railways

Arc Welding Equip.
Automatic Substations
Babbitt, Solder & Pots
Baking Ovens
Circuit-Breakers
Elec. Trolley Coaches
Fans
Gas Electric Coaches
Gears and Pinions
Generators
Insulating Material
Insulators
Lighting Fixtures
Lightning Arresters
Line Material
Manual Substations
Mazda Lamps
Meters
Motors and Control
Panelboards
Portable Substations
Relays
Signal Equipment
Supervisory Control
Switchgear
Synchronous Convert's
Transformers
Trolley Poles



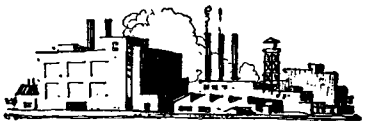
Railroads

ArcWelding Equipment
Automatic Substations
Babbitt, Solder & Pots
Baking Ovens
BatteryChargingEquip.
Cars—Multiple-Unit. Gas-Elec., Oil-Elec.
Circuit-Breakers
Control Apparatus
Elec.HeatingApparatus
Fans
Gears and Pinions
Generators
Headlight Equipment
Instruments
Insulating Materials
Insulators
Lighting Equipment
Lightning Arresters
Line Material
Locomotives—Electric Gas-Elec., Oil-Elec.
Manual Substations
Mazda Lamps
Micarta Gears
Motors and Control
Outdoor Substations
Panelboards
Power House Apparatus
Safety Switches
Signal Equipment
Stokers
Supervisory Control
Switchgear
Transformers
Yard Lighting Equip.



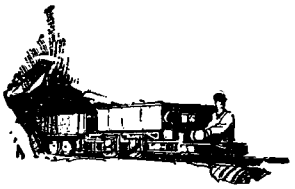
Electric Service Companies

Automatic Switching Equipment
Circuit-breakers
Condensers
Cutouts
Fans
Frequency-converters
Fuses
Generators
Instruments & Meters
Insulating Material
Insulators
Line Material
Lighting Equipment
Lightning Arresters
Micarta
Motors and Control
Motor Generators
Network Protectors
Network Transformers
Oil Testing and Purifying Equipment
Outdoor Substations
Panelboards
Porcelain Insulators
Relays
Safety Switches
Steam Turbines
Stokers
Supervisory Control
Switchgear
SynchronousConden'rs
SynchronousConv'ters
Transformers
Turbine Generators
Voltage Regulators



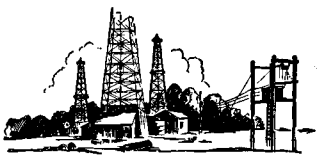
Mills and Factories

Arc Welding Equip.
Automatic Starters and Controllers
Babbitt & Babbitt Pots
Capacitors
Circuit-Breakers
Condensers
Fans, Desk and Exhaust
Furnaces and Ovens
Fuses
Generating Equipment
Insulating Materials
Knife Switches
Larry Car Equipment
Lighting Equipment
Lightning Arresters
Locomotives—Electric Gas-Elec., Oil-Elec.
Mazda Lamps
Meters and Relays
Micarta Gears
Motors and Controllers
Panelboards
PipeFittings(Struct'al)
Power House Apparatus
Safety Switches
Solder & Glue Pots
Space Heaters
Stokers
Switchgear
Transformers
Turbines



Mines

Arc Welding Equip.
Auto. Feeder Equip.
Automatic Starters and Controllers
Automatic Substations
BatteryChargingEquip.
Circuit-Breakers
Clamps
Elec.HeatingApparatus
Fans
Gears and Pinions
Headlights
Insulating Materials
Insulators
Larry Car Equipment
Lightning Arresters
Line Material
Locomotives
Manual Substations
Mazda Lamps
Meters & Instruments
Micarta
Motor Generators
Motors for Hoists, Pumps, Tipples, and Breakers
Panelboards
Portable Substations
Relays
Safety Switches
Switchgear
Synchronous Conv'ters
Transformers
Ventilating Outfits



Oil Fields

Arc Welding Equip.
Change House Heaters
Floodlight Projectors
Gear Units
Insulators
Mazda Lamps
Motors and Control
Panelboards
Reflectors
Rig Lighters
Safety Switches
Small Light Plants
Transformers
Vapor Proof Fixtures

Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

WESTINGHOUSE SALES OFFICES

ABILENE, KAN., 300 Cedar St. N.
ABILENE, TEX., 774 Butternut St.
AKRON, OHIO, 7 S. Main St.
ALBANY, N. Y., 90 State St.
*ATLANTA, GA., 426 Marietta St.
BAKERSFIELD, CALIF., 2224 San Emedio St.
BALTIMORE, MD., 39 W. Lexington St.
BEAUMONT, TEX., 1245 Threadneedle Ave.
BIRMINGHAM, ALA., 2030 Second Ave.
BLUEFIELD, W. VA., 525 Bland St.
*BOSTON, MASS., 10 High St.
*BRIDGEPORT, CONN., Bruce Ave. and Seymour St.
*BUFFALO, N. Y., 814 Ellicott Square
BURLINGTON, IOWA, 320 N. Third St.
*BUTTE, MONT., 52 E. Broadway
CANTON, OHIO, 120 Tuscarawas St.
CEDAR RAPIDS, IOWA, 1400 Second Ave.
CHARLESTON W. VA., 101 Capitol St.
*CHARLOTTE, N. C., 210 E. Sixth St.
CHATTANOOGA, TENN., 536-540 Market St.
*CHICAGO, ILL., 20 N. Wacker Drive
*CINCINNATI, OHIO, 207 W. Third St.
*CLEVELAND, OHIO, 2209 Ashland Rd. S. E.
COLUMBUS, OHIO, 209 S. Third St.
*DALLAS, TEX., 108-116 S. Akard St.
DAVENPORT, IOWA, 206 Second St.
DAYTON, OHIO, 30 Main St. N.
*DENVER, COLO., 910 15th St.
DES MOINES, IOWA, 604 Locust St.
*DETROIT, MICH., 5757 Trumbull Ave.
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*EL PASO, TEX., Oregon and Mills St.
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ERIE, PA., State and Tenth St.
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FORT WORTH, TEX., 2426 Tierney Rd.
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*HUNTINGTON, W. VA., 209 Ninth St.
*INDIANAPOLIS, IND., 20 N. Meridian St.
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JACKSON, MISS., 519 Hemlock St.
JACKSONVILLE, FLA., 719 W. Forsyth St.
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*NEW ORLEANS, LA., 333 St. Charles St.
*NEW YORK, N. Y., 150 Broadway
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*OKLAHOMA CITY, OKLA., 128-32 W. Grand Ave.
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*PHILADELPHIA, PA., 3001 Walnut St.
*PHOENIX, ARIZ., 11 W. Jefferson St.
PINE BLUFF, ARK., 1711 Linden St.
*PITTSBURGH, PA., 310 Grant St.
PORTLAND, ME., 61 Woodford St.
*PORTLAND, ORE., 83 Sixth St.
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QUINCY, ILL., 506 Maine St.
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*SALT LAKE CITY, UTAH, 10 W. First South St
SAN ANTONIO, TEX., Main and Commerce St.
SAN DIEGO, CALIF., 863 Sixth St.
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*SEATTLE, WASH., 603 Stewart St.
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SPRINGFIELD, MASS., 395 Liberty St.
*ST. LOUIS, MO., 411 Seventh St. N.
SYRACUSE, N. Y., 108 W. Jefferson St.
TACOMA, WASH., 1021 Pacific Ave.
*TAMPA, FLA., 417 Ellamae Ave.
TERRE HAUTE, IND., 701 Wabash Ave.
TEXARKANA, ARK., 503 E. Sixth St.
TOLEDO, OHIO, 416-424 Madison Ave.
*TULSA, OKLA., 602 S. Main St.
*UTICA, N. Y., 258 Genesee St.
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WATERLOO, IOWA, 305 W. Fourth St.
WICHITA, KAN., 309 N. Rock Island St.
WILKES-BARRE, PA., 267 Pennsylvania Ave. N
WILMINGTON, CALIF., 305½ Avalon Blvd
WORCESTER, MASS., 54 Commercial St.
YOUNGSTOWN, OHIO, 16 Central Square
The HAWAIIAN ELECTRIC CO., Ltd., Honolulu, T. H.—Agent

*Warehouse located in this city.

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WORCESTER, MASS., Wetmore-Savage Electric Supply Co.
YORK, PA., Westinghouse Elec. Sup. Co. of Pa
YOUNGSTOWN, O., The Moock Elec. Sup. Co

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BOSTON, MASS., 12 Farnsworth St.
BRIDGEPORT, CONN., Bruce Ave. and Seymour St.
BROOKLYN, N. Y., 160 Seventh St.
BUFFALO, N. Y., 141-157 Milton St.
CHARLOTTE, N. C., 210 E. Sixth St.
CHICAGO, ILL., 2201 W. Pershing Road
CINCINNATI, OHIO, 207 W. Third St.
CLEVELAND, OHIO, 2209 Ashland Rd. S. E
DENVER, COLO., 2640 Market St.
DETROIT, MICH., 5757 Trumbull Ave.
FAIRMONT, W. VA., 602 Cleveland Ave.
HOUSTON, TEX., 2311-19 Commerce St.
HUNTINGTON, W. VA., 209 Ninth St.
INDIANAPOLIS, IND., 547 W. Merrill St.
JOHNSTOWN, PA., 47 Messenger St.
KANSAS CITY, MO., 2124 Wyandotte St.
LOS ANGELES, CALIF., 420 S. San Pedro St.
MILWAUKEE, WIS., 37 Erie St.
MINNEAPOLIS, MINN., 2303 Kennedy St. N.E.
NEW YORK, N. Y., 460 West 34th St.
PHILADELPHIA, PA., 3001 Walnut St
PITTSBURGH, PA., 6905 Susquehanna St.
PROVIDENCE, R. I., 393 Harris Ave.
SALT LAKE CITY, UTAH, 346-A Pierpont Ave
SAN FRANCISCO, CALIF., 1466 Powell Street, Emeryville, Calif.
SEATTLE, WASH., 3451 East Marginal Way
SPRINGFIELD, MASS., 395 Liberty St.
ST. LOUIS, MO., 717 S. Twelfth St.
TOLEDO, OHIO, 203-205 First St.
UTICA, N. Y., 113 N. Genesee St.
WILKES-BARRE, PA., 267 N. Pennsylvania Ave.

WESTINGHOUSE ELECTRIC INTERNATIONAL CO.
150 BROADWAY, NEW YORK, U. S. A.

CANADIAN WESTINGHOUSE CO., Limited
HAMILTON, ONTARIO

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