Westinghouse Switchboards

Installation

Operation Maintenance

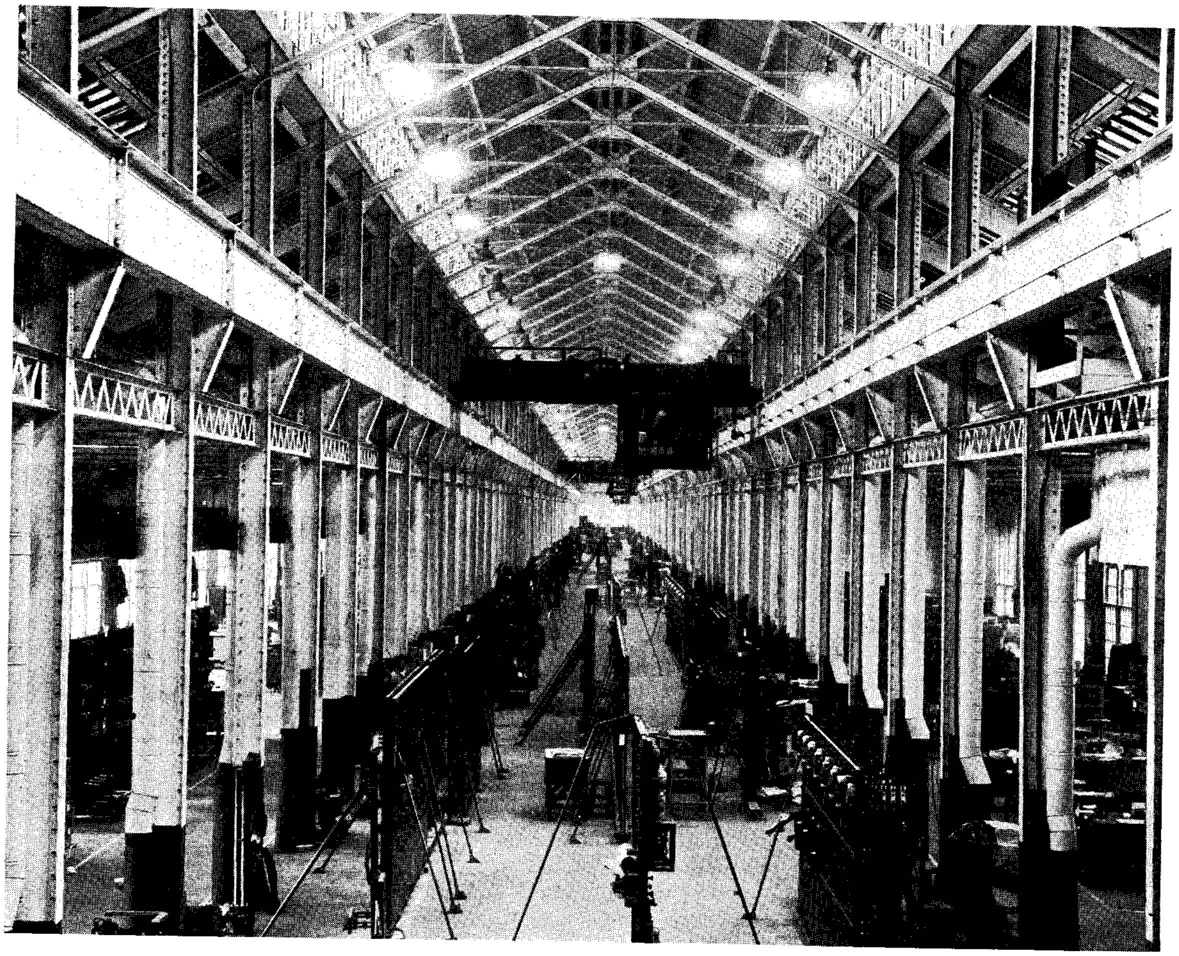
INSTRUCTION BOOK

Released Jan. 1, 1928

Westinghouse Electric & Manufacturing Company

East Pittsburgh Works East Pittsburgh, Pa.

I. B. 5201-C



The above photograph shows part of the space used at our East Pittsburgh Works for manufacturing Westinghouse Switchboards.

INDEX

Foreword

Many years in designing and manufacturing switching equipment have brought about organized experience from which the highest results are obtainable and have enabled Westinghouse engineers to put out unexcelled switching products—equipment which will yield the utmost in successful performance and satisfaction to the purchaser.

No matter what the excellence of the equipment may be, unless it is first properly installed and then given proper care after installation, operating results will very probably be disappointing.

Because it is of mutual interest and advantage to the manufacturer and the purchaser that satisfactory operation should initially and permanently result, we urgently request you to carry out the instructions herein respecting the installation, operation, and maintenance of switching equipment.

If further information or more precise instructions are desired concerning any particular phase of the subject covered in this book, it will be our pleasure to furnish it.

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CHECKING RECEIPT OF APPARATUS

Upon receipt of a shipment of Westinghouse Switching Equipment the numbers on all packages should be checked against the box numbers on shipping notices. Copies of the shipping notices are usually mailed to the consignee and an additional copy is packed in one of the boxes. This box may be easily identified (See Fig. 2) as orange colored stickers are pasted on the outside with the words **"This Case Contains Packing Lists"**. This box also contains the latest drawings, diagrams and instruction books. We especially urge that it be opened immediately upon receipt of shipment and the drawings and instruction data placed in the hands of the man responsible for the erection of the equipment.

The additional copy of the packing list which is placed in the case marked **"This Case Contains Packing List"** is an original copy and the box numbers are marked on it in pencil. It may, however, be used just as safely as the typed copy of the packing list which will be received later by mail.

UNPACKING

Time and expense will be saved in the erection of switching equipment if care is used when unpacking. The use of heavy sledges or crowbars and the complete demolishing of crates and boxes, will frequently result in broken apparatus, which obviously requires considerable time to replace. Nail pullers should be used for opening all crates or boxes.

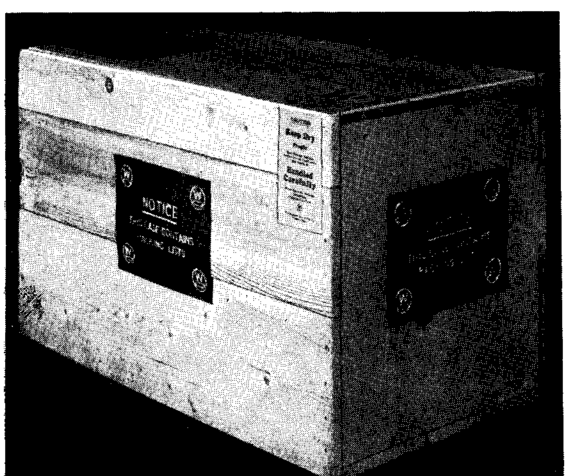


Fig. 2—Packing Box—in one box of each Westinghouse shipment of Switching Equipment is packed all drawings, packing lists and instruction books. The box containing this data is marked, NOTICE "This case contains packing lists".

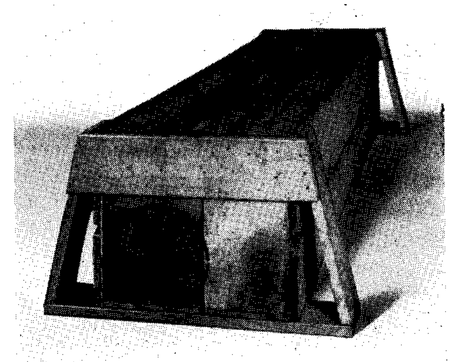


Fig. 3—Switchboard Panels will usually be received packed in a crate as shown. Note the wing braces which are used to insure that the panels will ride on edge.

You will frequently find special instructions pasted on the outside of the packages. These instructions should be carefully followed in order to avoid damaging the apparatus and to facilitate the unpacking.

Westinghouse multi-slab switchboard panels are comparatively easy to install because they are usually shipped in crates as a panel unit, completely wired and assembled on a frame.

When unpacking, set the crate on edge as shown in Fig. 3, resting one side of the crate on blocks as shown. Wing bracing is placed on the crate in order that the panel will ride on edge during transit. This wing bracing should be removed, then the boards of the crate, until it is possible to remove the panels from the crate as shown in Fig. 6.

As will be noted in Fig. 6 the panel is shown ready to remove from the case with the rear of panel up. The rear of the panel may be easily determined by breaking the paper before starting to unpack. **Opening the panel crate with the rear up, safeguards the apparatus on the front during the unpacking**

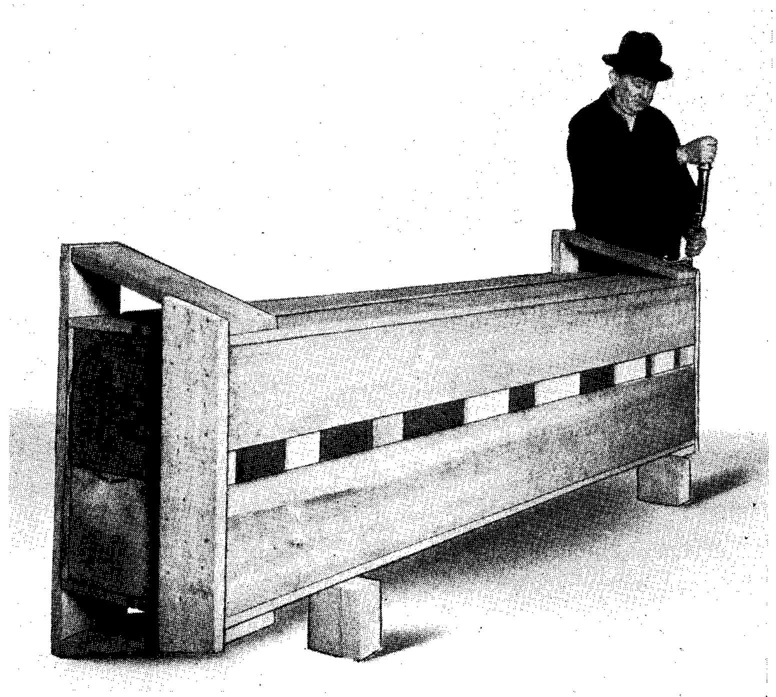


Fig. 4—When unpacking, the crate should be turned on edge as shown. Blocks should be placed under the crate to hold it in position.

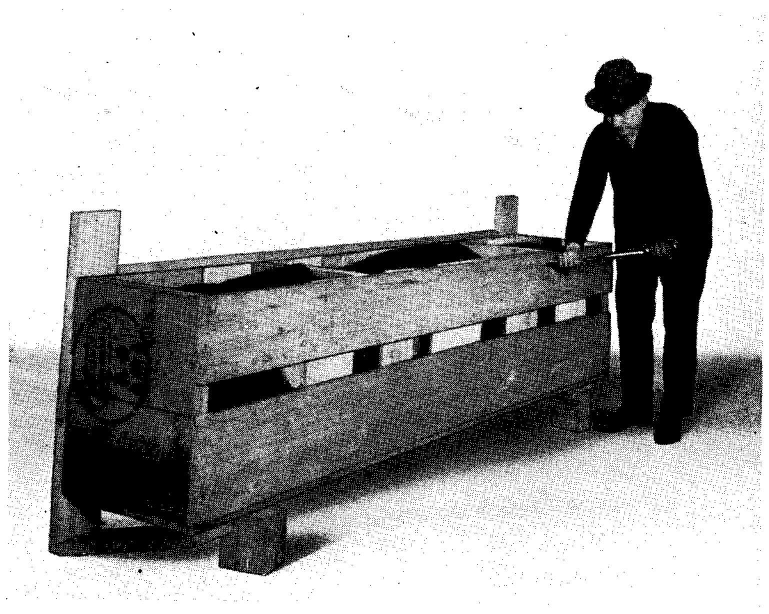


Fig. 5—After the wing bracing has been removed additional boards should be removed with a nail-puller as shown.

and handling. Removing the panel from the crate in this position also makes it easier to handle and place at the desired position at point of erection.

When panels are shipped with instruments mounted thereon, each individual instrument is protected by wrapping paper. We recommend that this paper be left on each instrument until all erection work around the switchboard has been completed.

When meters and relays are received apart from the panels they are each packed in a small box, and a number of these small boxes are placed in a large shipping case. The instruments should not be removed from the smaller boxes until practically all construction work around the switchboard has been completed.

All switchgear should be protected during construction work. Covering with tarpalins is very frequently necessary.

The box with the orange stickers marked "This Case Contains Packing List" also contains the instructions, drawings and other information on your order and extreme care should be used to see that they are placed in the hands of the man responsible for the erection of the equipment. This box should be opened at your earliest convenience as otherwise the instructions and drawings may be lost or mislaid.

Boxes and crates, when unpacked, may frequently be used as bins, or the lumber in them used for making bins as described under "Storing Switching Equipment".

When unpacking, the excelsior should not be destroyed until all of the material on the packing list has been accounted for, otherwise some small piece of equipment may be lost.

Brackets, castings, and other details are frequently marked with a "Westinghouse Identification Tag". This tag should not be removed from the different pieces of apparatus until they have been completely installed.

STORING

Trouble and delay may be avoided by having good storage facilities arranged so that the apparatus will be accessible only to authorized persons.

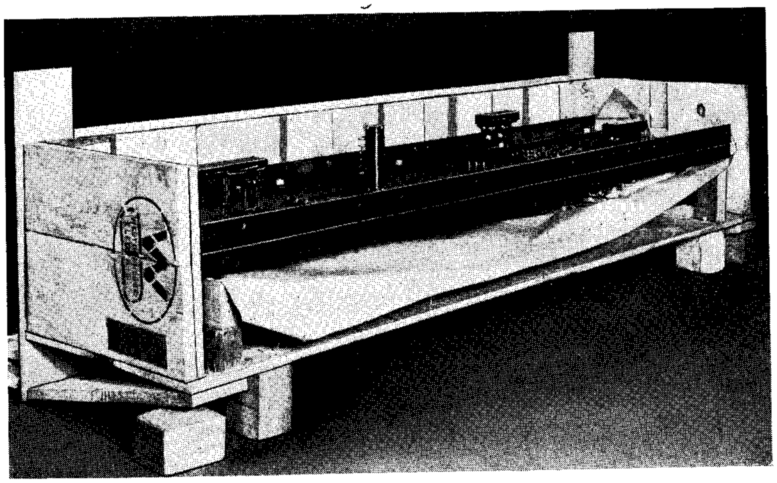


Fig. 6—In this figure sufficient boards have been removed to permit handling the panel. Note particularly that the rear of the panel is upward. Unpacking the panel with the rear upward permits removal without breaking or marring the face of the panel.

All switching equipment should be placed in dry and reasonably warm storage until ready to use.

Crated apparatus should be inspected to make sure that the contents have not been damaged during transit. This inspection can often be done without uncrating, especially if the apparatus is not to be erected immediately, for it can be stored much better when crated. You will also find that the removal of the wing bracing on the switchboard crates will permit more compact storing and save considerable space. These extension feet are placed on the crate only to assure that the panel will ride on edge while in transit.

After inspection, the location of the different crates, should be marked on the packing list indicating the boxes and other material in your storeroom, so that the apparatus may be located easily when needed.

Boxes or other packages should be unpacked and the contents identified and placed in numbered bins or boxes. These bin numbers should be placed on the shipping notice to indicate the bin in which the different pieces or parts have been placed, so that they may be easily located when needed.

Details such as bolts, nuts, small brackets, etc., are usually placed in cloth bags with a tag attached on which is indicated the contents. This makes it unnecessary to remove the contents of these bags until ready to assemble.

In order to eliminate the possibility of dust and dirt getting into relays, the covers of which are frequently removed for setting or adjustment, if such instruments are placed on the panel during the construction period they should be carefully protected by wrapping with paper.

Where a considerable amount of switching equipment is involved the shipping notice may be found bulky and rather difficult to handle. For such installations a card, form similar to Fig. 7 may be used to better advantage. Obviously it will be necessary to use the shipping report when making the card file. A file of cards similar to Fig. 7, however, provides a quick and ready reference as to the location of the apparatus especially when filed in numerica order under the Westinghouse drawing number which, as will be noted, is listed at the top. Cards, when filled out, will indicate the drawing number, item number of the drawing, description, shipping report number, location of bin number, number of pieces and when drawn from the storeroom, each card should bear the signature of the party making the withdrawal.

Lightning arresters for direct-current service are shipped completely assembled except for the oil and electrolyte, which are packed in separate containers. Autovalve type lightning arresters for alternating-current service up to and including the 37,000 volt size, are shipped complete, except that the gap sheds are removed to facilitate packing. Instruction Book 5299 should be consulted before erecting these lightning arresters.

DRAWING NUMBER ....

ITEM NUMBER ....

DESCRIPTION ....

SHIPPING REPORT NO. ....

LOCATION ....

BIN NUMBER ....

NUMBER OF PIECES ....

DRAWN OUT BY ....

DATE ....

Fig. 7—Recommended Card Form to be used by the Storekeeper so that withdrawal of equipment may be checked.

The main parts of large oil circuit-breakers, such as types G and O that are removed for shipping purposes are plainly marked with the serial number of the circuit-breaker and the sub number of the part. The serial number indicates to what breaker the part belongs and the sub number shows the location on the breaker.

The smaller oil circuit-breakers may have different pieces and parts which are separately tagged indicating the name of the part and style number or order number of the breaker to which the part belongs.

An instruction book accompanying each breaker indicates the method of assembly and proper adjustment.

As a general reference to detail switchboard parts, refer to Part Catalogue 6131, which is included with each switchboard shipment. The different brackets, etc., may quite frequently be identified from this part catalogue

LOCATION AND ARRANGEMENT

Arrangement of apparatus in the station should be such that in case of damage requiring repair or replacement of any piece, the necessary work may be done with the least possible danger of the workmen coming in contact with any live parts.

Care should be used to see that requirements of the "National Electric Safety Code" are met as well as any existing local rules.

Switchboards should not be located where open windows or ventilators will permit a high wind to carry the arc from carbon circuit-breakers to ground or allow driving rain to reach the apparatus. Switching equipment should also be isolated as far as possible from corroding fumes, abrasive or gritty dust, damp places excessive vibration, steam, excessive oil vapor, etc., which may later interfere with the successful operation of the equipment.

Where switching equipment will be subjected to any abnormal conditions, considerable trouble may later be avoided by advising us in advance just what these conditions are.

We especially urge, as a matter of safety to the operator, that an approved rubber or other insulating mat be provided both in the front and in the rear of the switchboard.

Rheostat and resistances should be located as to permit good ventilation and so that they do not transmit heat to each other.

that the operator cannot inadvertently touch such live parts without standing upon the mats, floors or platforms.

Parts exceeding 750 volts on the front of the board where within 6 feet of the floor shall be enclosed or otherwise guarded. Exposed live parts exceeding 750 volts shall be elevated

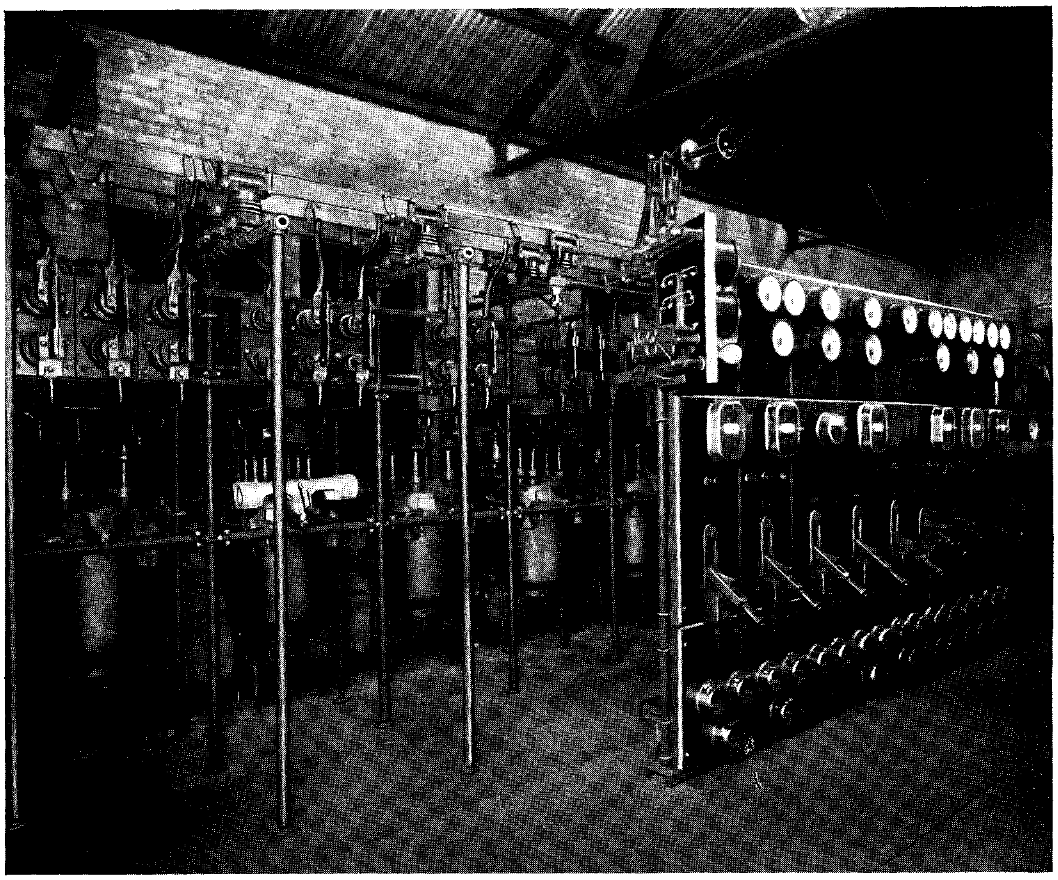


Fig. 8—Installation of Typical Westinghouse Switchboard and Pipe Frame Structure Showing Type B-20 Oil Circuit-Breaker

Note the tank lifting device shown on the top of the tank on the second breaker from the left.

or if of more than 1500 volts, they shall not be installed on the front of the board. Dead front panels and remote control are recommended where isolation by elevation is impracticable or undesirable.

The following rules from the Electric Power Club explain how live and current carrying parts should be guarded on the front and rear of switchboards:

All switchboards operating at more than 300 volts to ground and located near passageways shall be separated from these by rails, barriers or enclosures.

Where parts of more than 300 and not more than 750 volts on the front of the board are not guarded or isolated by elevation, insulating mats, floors or platforms shall be so arranged

All parts exceeding 300 volts to ground on the rear of the switchboard shall be suitably guarded or enclosed to prevent accidental contact by the operator if such parts are not isolated by elevation or if working space is not provided.

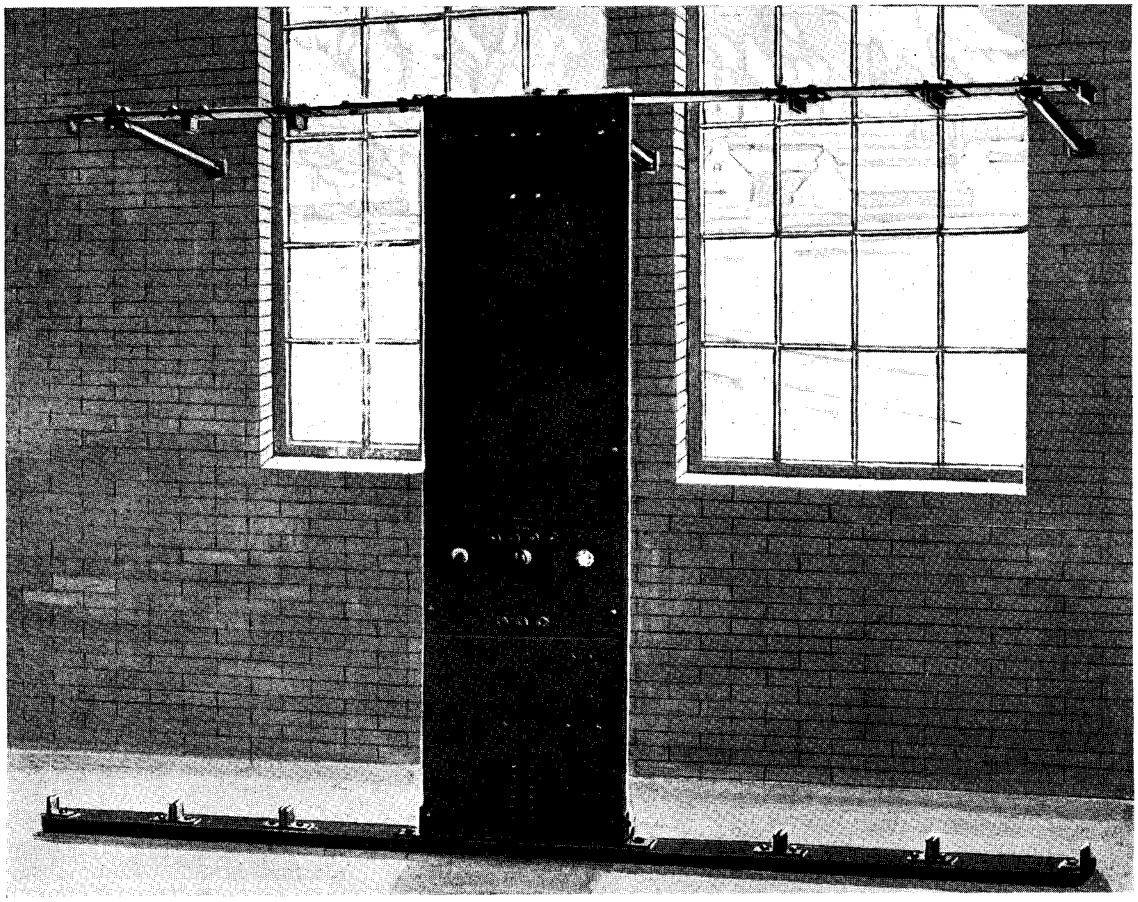


Fig. 9—Correct Method of Assembling and Aligning Switchboard Panels. Note that the middle panel has been first placed in position.

Isolation by Elevation—Normally exposed live or current carrying parts exceeding 300 volts shall be elevated above the floor level at least the following distances:—

Voltage of Part	Elevation in Feet
301 to 750	7
751 to 2500	7.5
2501 to 7500	8
7501 to 30000	9
30001 to 70000	10
70001 to 100000	12
More than 100000	14

Working Space About Switchboards—Working space shall, where practicable, be provided and maintained about exposed live equipment which requires adjustment and examination during operation and which is not isolated by elevation. Working space shall not be used as passageways and shall be made inaccessible to unauthorized persons. It shall provide at least 6.5 feet head room where practicable.

ASSEMBLY OF SWITCHBOARD PANELS, FRAMES, ETC.

General—Westinghouse switchboards are erected on true and level sole plates in our factory. The wiring is completed on the rear of panels so that the minimum amount of work is necessary in the field when erecting the panels.

Whenever possible channel iron bases are used for switchboards, For Railway switchboards and other grounded system it is usually necessary to insulate the switchboard frame from ground. In such cases the channel iron base is omitted and a wooden sill must be supplied by the purchaser. See pages 43 and 44 for full description.

When shipping, the panels are packed as panel units on their frames. This method and arrangement of shipping permits erection work to be performed quicker and at much less expense than if the panels were removed from the frames and shipped as slab units.

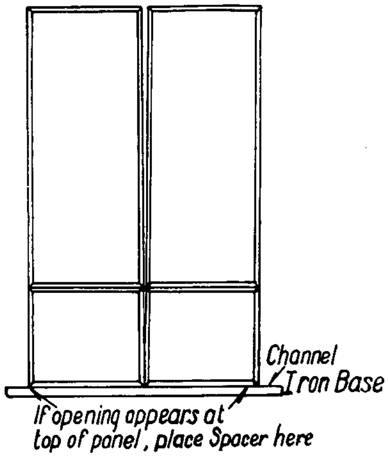


Fig. 10

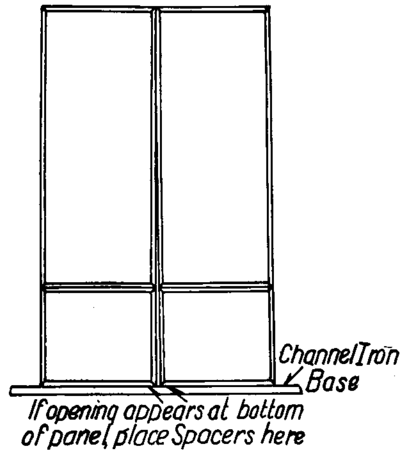


Fig. 11

Method of Aligning Panels

Conditions permitting, Westinghouse switchboards are at times, shipped two or more panels in a single box.

Our constant aim in design and assembly work is to do more and more of the work in our factory which has previously been done in the field. This obviously insures a quality product, entire satisfaction on the customer's part and a considerable reduction in cost of installation in the field because of the reduction in installation, labor and time.

Wall Braces—Provision should be made for fastening the panel wall braces securely to the wall. Either expansion sleeve or through bolts are used for this purpose, the construction of the wall, weight and size of panels determine the choice.

Placement and Alignment—When the panels are placed in position they should be bolted immediately to the corner angles supplied with the channel iron base.

The best results in aligning will be obtained by first placing the middle panel in position and assembling toward each end. (See Fig. 9.) It will be found that the panels will fit more snugly and drifting and shimming will be reduced to the minimum. A temporary arrangement of wall braces may be used until at least part of the panels are plumbed and lined up, then top irons, when supplied, and permanent wall braces should be placed in position.

ANGLE AND CHANNEL IRON FRAMES

When erecting switchboard panels of angle or channel iron frame construction, the channel iron base which is usually supplied with all Westinghouse switchboards should first be placed at the desired location on the floor, leveled and bolted down, then grouted in. Extreme care should be used when placing this channel iron to see that it is properly trued and leveled as otherwise trouble may result when lining up the switchboard panels. There are two holes drilled in the channel iron base at the rear of each panel. One of these holes is intended for the holding down bolt, the other for pouring in the grout.

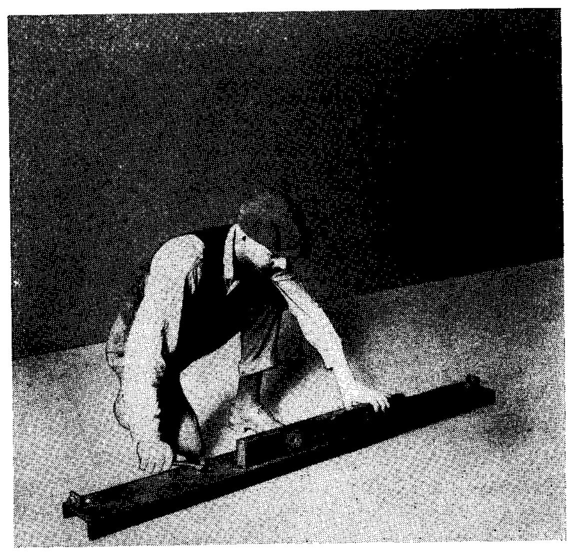


Fig. 12—Channel Iron Base should be properly leveled and securely bolted before grouting.

After the channel has been trued, leveled and bolted down securely as shown in Fig. 12, the ends of the channel should be plugged with a mixture of fairly dry mortar, then dammed with boards or bricks as shown in Fig. 13. A

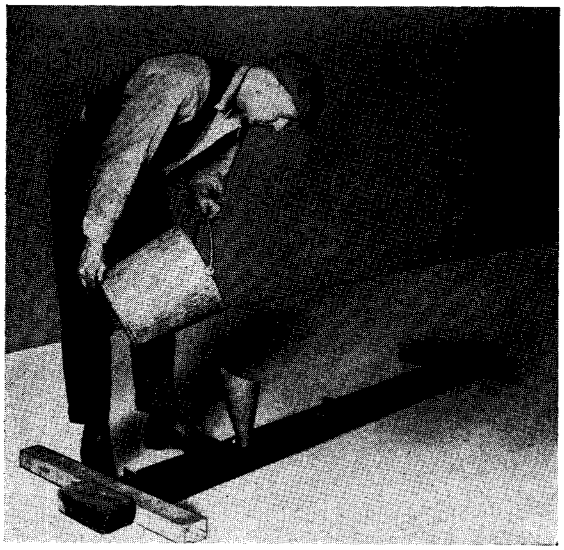


Fig. 13—After the base has been properly leveled and bolted down the ends of the channel should be closed as shown and then grouted in by pouring the grout through the large holes provided in the channel for this purpose. Note particularly that the corner angles should not be removed from the Channel Iron Base until the grouting has set.

grouting mixture of one part cement and one part sand should be mixed with enough water so that it will flow smoothly, then poured into the grout holes at the rear of each panel until the grout is plainly visible through the hole. Funnels of heavy paper may be inserted in these holes, and grout poured into the channel through the funnels until it is slightly above the surface of the channel iron. This provides for the settlement of the grout. When the grout tends to harden, the funnels should be pulled out and the top smoothed off with a putty knife or a straight-edge.

It is generally found advisable after the channel iron has been grouted in to go over its surface lightly with a rough file thus removing all high spots, dinges, concrete and other matter which may interfere with the proper alignment of panels.

If, while erecting, it is found that spaces appear between edges of adjacent panels either at the top or bottom, the panels should be raised and spacers inserted at such points between the bottom edge of panel and channel iron as to eliminate the openings and properly align all panels as shown in Figs. 10 and 11. Shims and spacers are sent with each switchboard for use in case they may be needed during the erection of the panels. These shims and spacers are placed in the box that contains the drawings and other instructions.

PIPE FRAME PANEL CONSTRUCTION

Westinghouse pipe frame switchboard panels are usually shipped completely assembled on pipe frame. This method of shipment permits us to complete the small wiring on the rear of the panels in the factory thus reducing the installation time in the field. The following instructions should be followed when assembling pipe frame panels:

When erecting, place the middle panel of the switchboard in position first (see Fig. 9) thus permitting any slight plus tolerance, in the panels to be distributed toward each end.

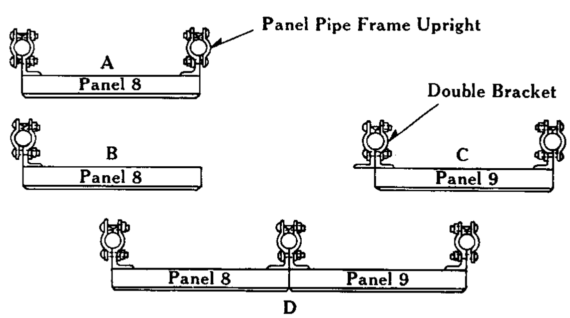
1—Set the middle panel, say panel 8, in position first as shown in View A, Fig. 14.

2—Remove one complete upright from panel 8, as shown in View B.

3—Remove the adjacent panel (9) from the crate and change one upright (in this case the left hand) making double brackets by using material taken from the upright removed from panel 8 and the [3/8x3] carriage bolts which are furnished separately (View C).

4—Move panel 9 shown in View C against the erected panel 8 bolting together as shown in View D.

This operation should be continued progressively on either side of the erected panels until all panels have been placed.



Top View

Fig. 14—Method of Erecting Pipe Frame Switchboards

STEEL PANELS

One of the most important advances in switchboard practice in recent years is the adoption of steel as a standard material for Westinghouse Switchboards.

Compared with slate, steel switchboards are:

Lower in cost, including first cost, erection expense and maintenance charges.

Lighter in weight, so that the transportation charges are lower, and the erection less difficult.

Easier to erect because the framework and panels are self-contained, and all wiring is completed.

More easily maintained because scratches and oil stains are less noticeable.

No breakage such as that encountered with slate panels.

Neater in appearance.

The Westinghouse C shaped steel switchboard panels do not require instructions for erecting. Quoting from one of our customers: "It is difficult to make a poor job of erecting Westinghouse steel panels due to their extremely light weight and uniformity in size".

There is rarely, if ever, any delay during the erection of Westinghouse steel panels due to breakage or rough handling. These panels are made from (1/8) **cold rolled stretcher leveled, steel** and are given a number of coats of enamel finish which has been especially developed by the Westinghouse Company for this work. This finish is comparatively hard but still retains sufficient elasticity to prevent its shaling off in case of rough handling.

The last finish placed on the panel is similar to that used on our regular slate panels which permits rubbing down with the ordinary machine oil without any deteriorating effects on the base finish. If oil is applied and it is desired at any time to remove it, especially if it ever is desired to respray, this can be done by using a rag soaked in benzine. Figs. 15 and 16 show an installation of Westinghouse C shaped **stretcher leveled cold rolled steel** panels

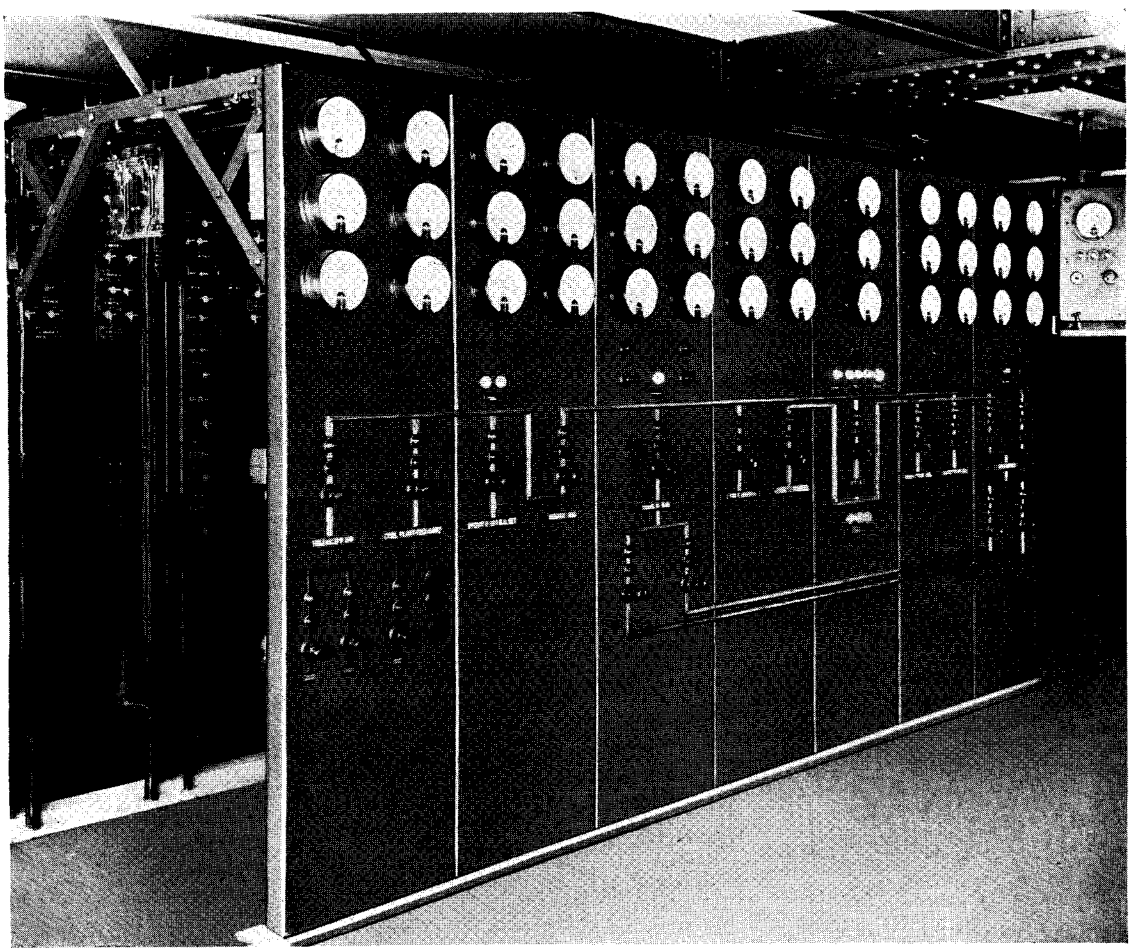


Fig. 15—Typical Westinghouse Steel Panel Switchboard Installed. Note the uniformity of the panels.

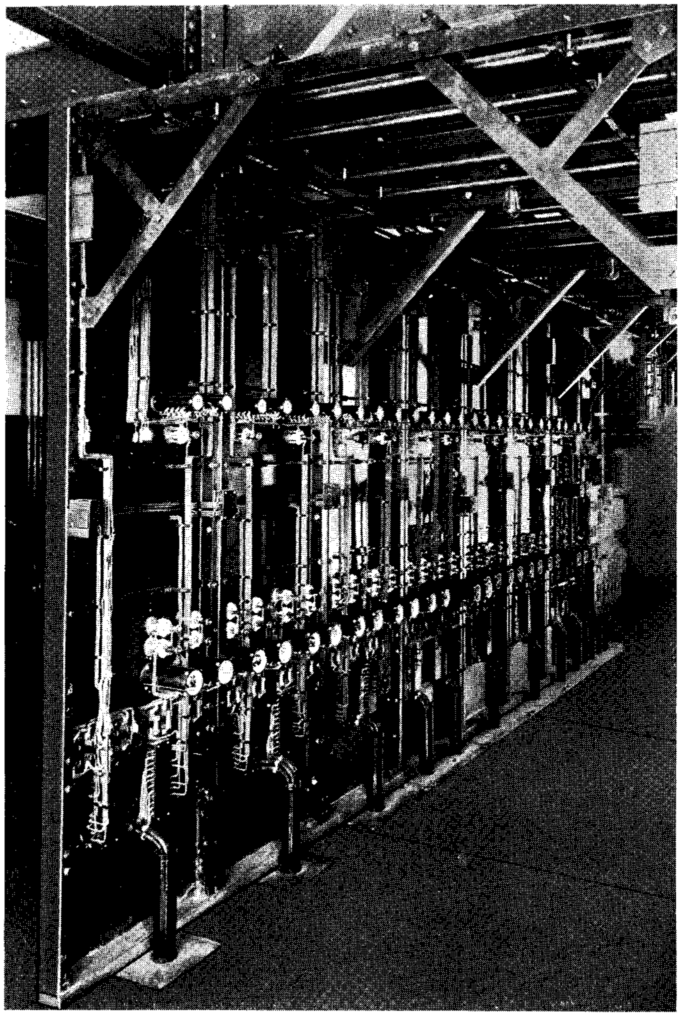


Fig. 16—Rear View of the Westinghouse Steel Panel Switchboard as shown in Fig. 15.

CONTROL DESKS

Steel Control Desks—Like steel upright panels, steel control desks are more durable, cheaper to install and are also provided with the special Westinghouse flexible finish which has been giving so much satisfaction on the upright panels.

There are very few, if any instructions necessary on Westinghouse steel control desks as they are completely assembled and usually wired in the factory before shipment to customer. See Fig. 18.

Slate Control Desks—Slate control desks are often shipped in sections not over 11 feet ong, but due to their shape, size or some special conditions, it may be necessary to ship them unassembled. Fig. 17 shows the end section of a typical Westinghouse control desk and in the following instructions are recommended progressive steps in erection.

End sections four inches wide are usually supplied with all slate control desks. When new sections are added this four-inch end section may be readily moved out and the new section quickly installed.

1—Locate the channels A and AA, leveling and grouting them in as shown in Figs. 12 and 13.

2—Adjust the tie bolts B between channels following very accurately the dimensions as given on the drawings. This should be done during the lining-up period and before the channels are grouted in.

3—After grouting in, erect the front vertical support B.

4—Erect the rear vertical support D.
5—Adjust panel bracket E on front and rear support.
6—Erect support F.
7—Adjust pipe bracket G.
8—Erect angle and horizontal bracing in front, when supplied.
9—Erect front vertical sections H beginning with the middle panel and working both ways.
10—Insert fibre washers between all panels and brackets.
11—Erect the bench slabs I beginning with the middle section and working both ways.
12—Erect the horizontal bench slabs J (when supplied) beginning with middle panel and working both ways.
13—Erect and adjust channel iron base K for meter sections according to your drawing.
14—Erect panel supports L for top instrument sections.
15—Adjust panel bracket M on instrument section support.
16—Erect instrument panels N beginning with the middle section and working both ways.
17—Erect top irons O.
18—The control desk should then be wired, panel boards mounted and bus wiring installed for which brackets have been provided.

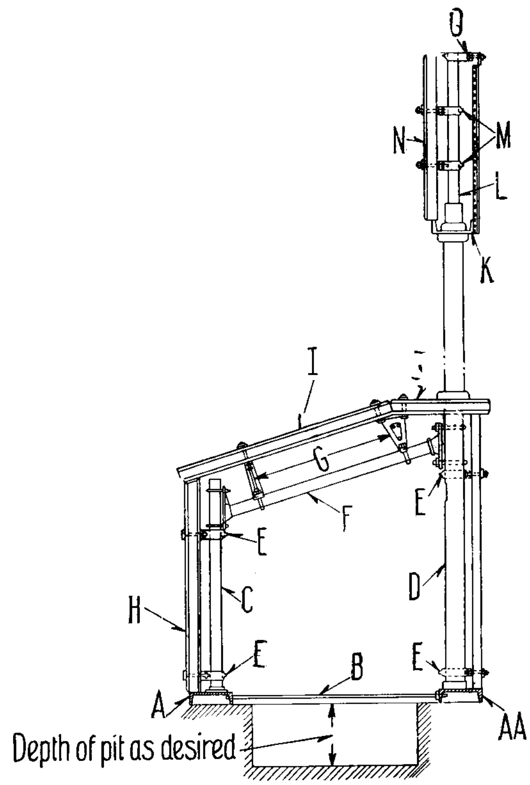


Fig. 17—Control Desk

19—Erect sheet iron or grill work on rear of desk (when supplied).
20—The ends of the desk may then be placed in position and the job completed.

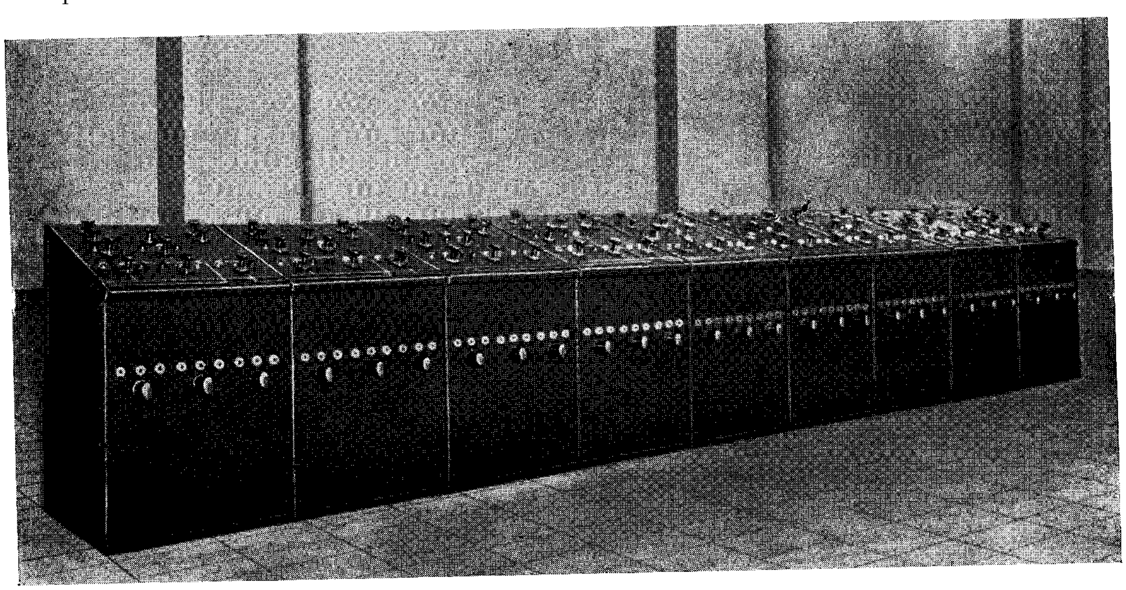


Fig. 18—Typical Westinghouse All Steel Control Desk

NOTE—Steel desks are more rugged and much more quickly and easily installed in the field than those of other construction.

We particularly recommend that a platform or pit be arranged underneath the control desk bench section for convenience in wiring, inspection and making repairs.

Practically all brackets used in control desk construction are of the unthreaded clamp type and are therefore very easily adjusted.

The construction of the different types of slate control desks varies somewhat, but in general the method of procedure in erecting them is similar to that shown in Fig. 17.

INSTRUMENTS AND RELAYS

General—Westinghouse Supply Catalogue lists a complete line of switchboard and portable instruments. This assortment represents the result of many years of careful study of the requirements of the electrical industry. Each type of instrument is designed on the principle best suited to the nature of its application. In all cases the important characteristics of readability. ruggedness, and ease of maintenance and repair have been given careful consideration.

Accuracy—In actual operation the errors in an electrical instrument are of two kinds, constant and variable. Constant errors are due to "parallax", width of scale divisions, friction, etc. Variable errors are due to incorrect calibration or to effects which change the constants of the instrument, and are proportional to the reading of the instrument. For simplicity however, the accuracy of electrical instruments is stated in A.I.E.E. Standardization Rules as a percentage of full scale capacity at all points of the scale. The probable ratio of constant error to variable error will therefore, increase to a certain extent as the load decreases.

Electrical instruments are necessarily delicate and always require care in handling. They must be correctly installed if accurate results are to be obtained. It is therefore obvious that accuracy in service is largely under control of the user.

The following table gives an indication of the accuracy which can be expected from various types of portable and switchboard instruments when they are properly applied, checked and recalibrated at periodic intervals. Error is given in percentage of full scale capacity.

Type	Instrument	
G	Shunts	½%
LX	Voltmeter and Ammeter	1 %
LY	Instruments	1 %
PC	Power Factor Meter	1 %
PC	Wattmeter and Voltmeter	¼%
PC	Iron Loss Voltmeter & Ammeter	½%
PD	Frequency Meter	½%
PL	Laboratory Instrument	1/5%
PL	Ammeter	½%
PL	Voltmeter	¼%
PM	Ammeter and Voltmeter	½%
PX-2	Ammeter and Voltmeter	1 %
PX-3	Ammeter and Voltmeter	½%
PX-4	Ammeter and Voltmeter	½%
PY-4	Instruments	½%
R	Ammeter, D-C. Wattmeter & Power Factor Meter	2%
R	Voltmeter, A-C. Wattmeter, Frequency Meter & Totalizing Wattmeter	1 %
SI	Power Factor & Reactive Meter	2 %
SX	Voltmeter and Ammeter	1 %
SY	Instruments	1 %

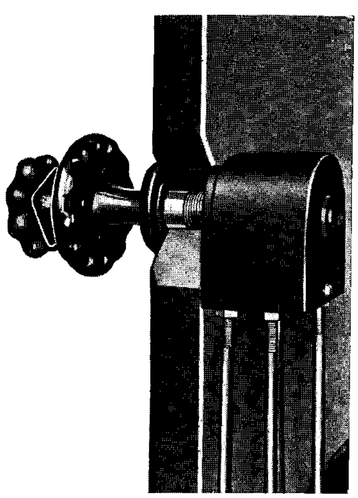


Fig. 19—Rheostat Hand Wheel Mechanism with Cover On

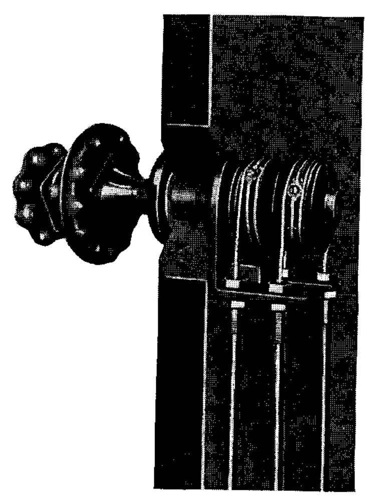
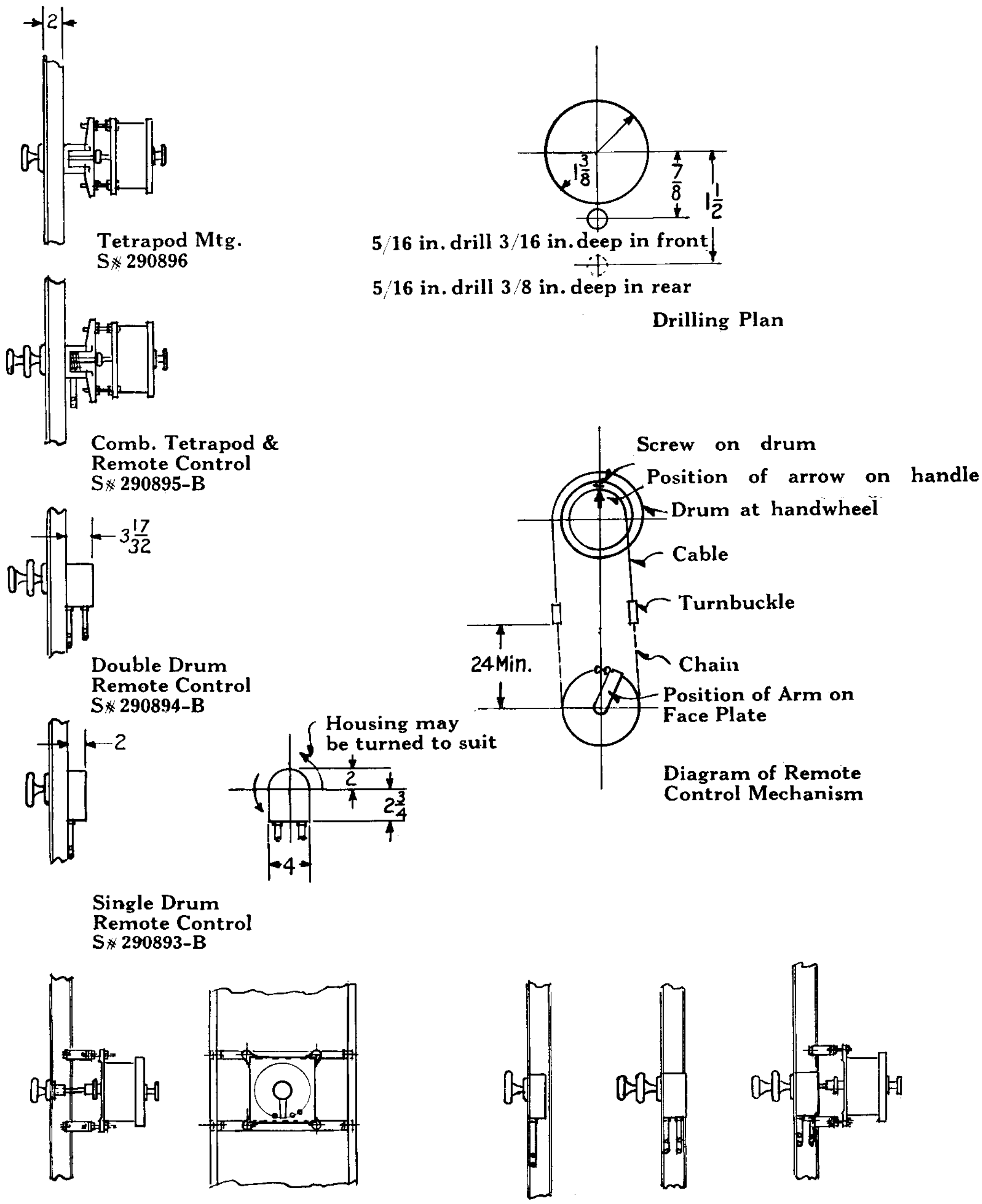


Fig. 20—Rheostat Hand Wheel Mechanism with Cover Removed



RHEOSTAT AND REMOTE CONTROL MOUNTING ON WESTINGHOUSE STEEL SWITCHBOARD PANEL

Fig. 21—Different Location of Rheostats and Mountings

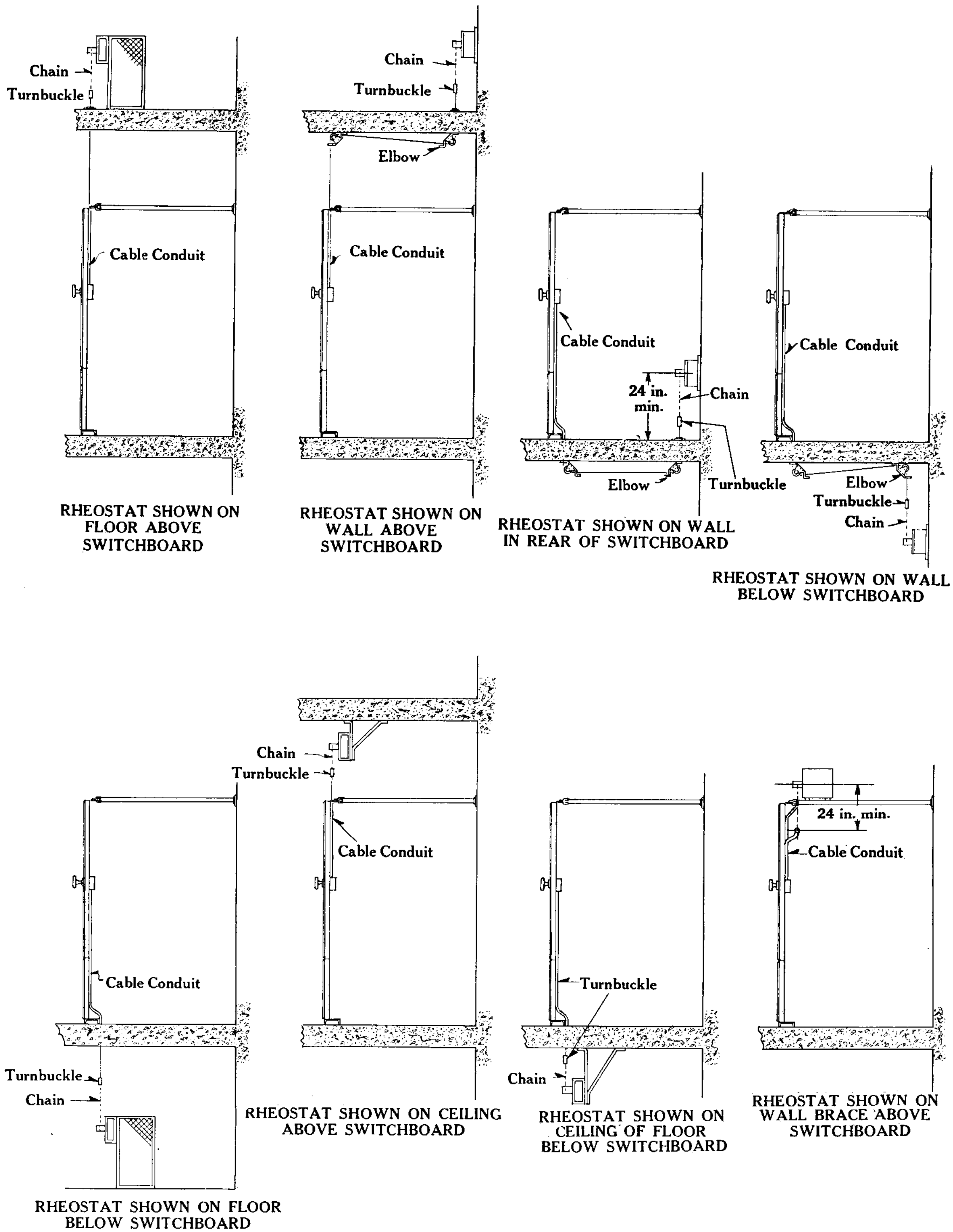


Fig. 22—Typical Methods of Mounting Rheostats Apart from Panels

Westinghouse instruments are usually provided with cork or felt gaskets, thus making them practically dustproof. It is desirable, however, to protect them from gritty, abrasive dust; This is particularly essential with relays where covers are removed for adjustment in the field. It is usually a good plan to wrap heavy paper around the instruments if they are mounted on the switchboard while concrete and other construction work is going on. If the instruments are shipped separately from the panels, perhaps it would be best to wait until the construction work has been completed before removing the instruments from their individual boxes and placing them on the board.

Although Westinghouse switchboard instruments are of very rugged construction, naturally their accuracy depends somewhat on the handling they receive. Some instruments require accurate leveling and adjustment when being installed, others may require different treatment. We, therefore, recommend that all instructions which are sent with the instruments be carefully read before mounting.

The energy required to operate coils of a-c. instruments is given under the heading of "Transformers".

RHEOSTAT MOUNTINGS, LOCATIONS, ETC.

Handwheel Mechanism—Handwheel mechanisms are usually shipped separate from the panels. They are easily assembled, however, and when installed should appear as shown in Figs. 19 and 20. The steel cable should be run through ⅛ inch pipe, the supports of which are included on the base of the mechanism. Idler elbows may be used if desired to guide the cable along the floors, walls or ceilings as shown in the different figures of proposed arrangements.

Figs. 21 and 22 indicate proposed arrangement of rheostats when mounted in different positions and locations.

Cable Adjustment and Installations—Open the cable strands at the middle point of cable and fasten to the drum with screws and washers which are provided. Arrange drum, handwheel, sprocket, turnbuckles, chain and cable in relative positions as shown in Fig. 21. Tighten the turnbuckles to take up slack with the pointer on the handwheel vertical, the rheostat resistance to be all out, then turn the handwheel to the right until other extreme position of the rheostat is obtained, then finally check to assure that the pointer is in the correct position on the dial plate.

Cable Conduits—Cable conduit may be run from the cable drum housing at the panel to a point not less than 24 inches from the sprocket at rheostat. The conduit should be ⅛ inch with smooth inside surfaces and all ends reamed to prevent abrasion of cable. The conduit may be bent for small angles on a radius not less than six inches. For 90 degree bends use the roller elbows.

Enclosing the flexible cable in pipe eliminates danger of short circuits due to a broken cable falling against live connections.

Lost motion in the rheostat handwheel operating cable is eliminated by adjusting the turnbuckles.

Housings—The rear position of the handwheel mechanism housing mounted on the panel and shown in Fig. 21 may be swung to any desired angle merely by drilling new pin holes in the rear of the panel to suit the new position.

Face Plates and Resistors—Face plates and resistors are usually assembled together on an angle or strap iron frame and protected by a covering of grill work. The rheostats are readily mounted on frame work, walls, ceiling or floor as indicated in Fig. 22. Supports, when required, are to be supplied by the purchaser.

Rheostats should be given a careful inspection before putting in operation to insure that the stationary and sliding contacts are clean and that good contact is being made.

CARBON CIRCUIT-BREAKERS

Westinghouse carbon circuit-breakers are carefully tested and adjusted in the factory. They will carry their rated current with a maximum temperature rise not exceeding 30 degrees centigrade above the temperature of the surrounding air if the copper contacts are kept reasonably clean and free from oxide.

Before putting carbon circuit-breakers in operation:

1—See that the brush contact surfaces are clean.

2—See that the brush has proper contact pressure.

3—Read the instructions which accompany the breaker.

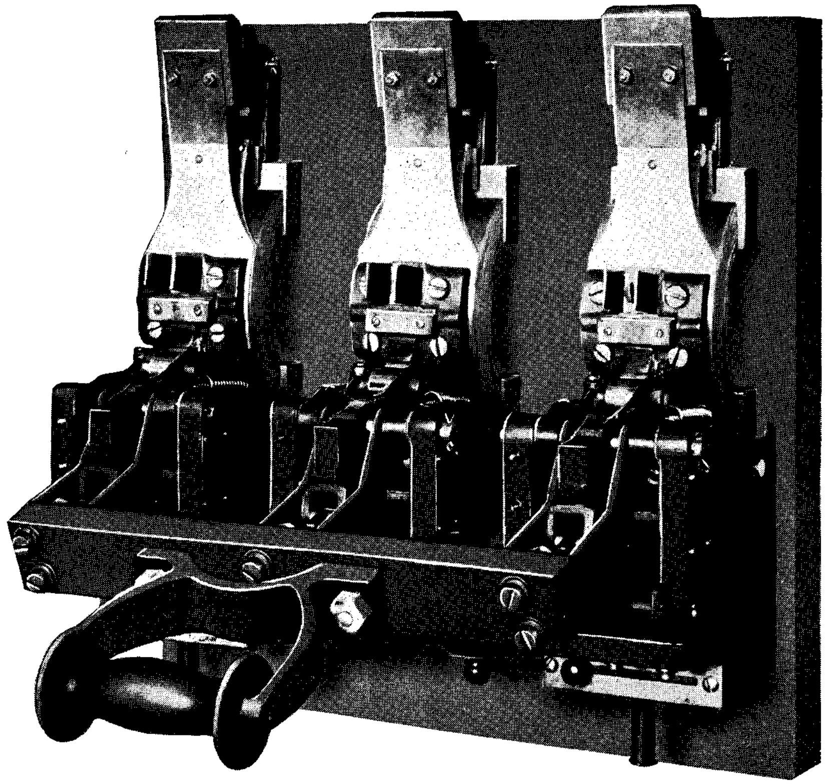


Fig. 23—Type CL Breaker Non-Closable-on-Overload

The contact surfaces may be kept bright by cleaning with very fine sand paper.

In order to ascertain whether or not the brush is making good contact, first, close the breaker, then hold a flashlight on one side of the brush contact and look through from the other. If light is evident between the brush and the stationary contact the contact should be adjusted in accord with instructions given in the instruction book, which is sent with the breaker.

If any trouble should later be encountered due to excessive heating of the breaker, we recommend that you check:

1—To see that the contact nuts on the studs are tight.

2—See that all clamping bolts on the copper connections are tight and contact surface clean.

3—Inspect the contact of the brush by feeler gauge and the flash light method.

4—Examine the surface of the main contacts to see that they are perfectly clean and free from oxidation.

5—Check the soldered joints of the cable. It happens occasionally that heat which has developed has melted the solder in the terminal causing part of it to run out of the joint.

Any carbon circuit-breaker, if allowed to stand closed, will heat up due to oxidation. It should be opened occasionally to keep its contact surfaces clean by the wiping action of brush on contact block.

When installing a switchboard on which there are carbon circuit-breakers it is well to see that the arcing contacts of the breaker are at least two feet from uninsulated metal beams or other grounded parts. Asbestos lumber for insulating such grounded parts may often be used to advantage.

For complete information on the installation and maintenance of carbon circuit-breakers please refer to the instructions which are shipped with the breakers.

OIL CIRCUIT-BREAKERS

Oil circuit-breakers are carefully adjusted, inspected and tested at the factory and therefore need no readjusting when received unless they have been disarranged.

A thorough examination should be made to see that no damage has occurred in shipment, storage or unpacking.

The following instructions apply in common to all oil circuit-breakers:

1—The blocking which is usually supplied with oil circuit-breakers should be carefully removed.

2—The contact alignment must not be disturbed in making the external connections. This point may be carefully checked if the tanks are removed while making these connections.

3—The toggle mechanisms are not adjusted alike on the different oil circuit-breakers. Breakers, that latch in the closed position, must make good contact before the toggle stop engages and the toggle adjustment must be such as to permit the breaker to trip freely as soon as the trigger is released. Other breakers must make proper contact when closed to the toggle stop.

4—Do not change the toggle stop unless its adjustment has plainly been disturbed. If re-adjustment is necessary the instruction book must be consulted.

5—Solenoid operated breakers are adjusted so that the electro-magnet cores stop the lever travel. The auxiliary switch, core and toggle stop must operate in the correct sequence.

6—All parts of the apparatus should be kept as clean as possible.

7—Periodic inspection should be made at intervals depending on the nature of the service both to check mechanical adjustments and to insure renewal of arcing contacts before they are burned away sufficiently to cause arcing on the main contacts.

8—The oil should be kept at the proper level in the tank and filtered when necessary. See Pages 106-108.

9—**The frames of all oil circuit-breakers should be grounded in order to safeguard the lives of persons working around them.**

It is generally necessary to insulate the leads of oil circuit-breakers after erection because it affords a certain amount of protection of the lead against breakdown, especially if a bubble of hot gas should reach the exposed parts which might cause a short circuit or grounding.

Insulation protects the operator from accidental contact with leads when working around the breaker.

It may protect against breakdown where clearances are close.

It gives considerable protection to the conductors against failure due to unusual voltage disturbances on the system.

Oil circuit-breakers should be easily accessible so as not to place a hardship on the inspector in performing his duty. In making these inspections it should be impossible for him to accidentally come in contact with live parts of adjacent sections or disconnecting switches used in isolating the breakers.

With remote control manually-operated oil circuit-breakers where the total length of rod may exceed 50 feet. The weight of the rod and the friction in the standard mechanisms may offer so much resistance to the proper

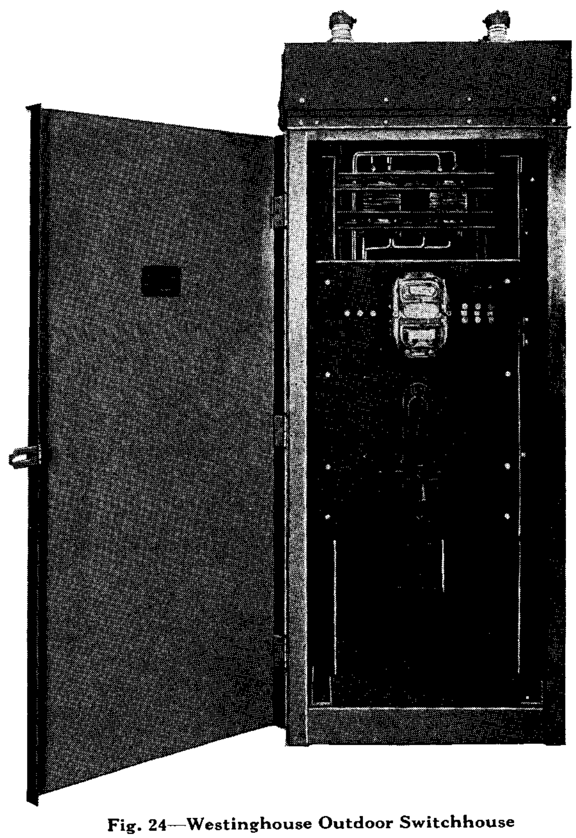


Fig. 24—Westinghouse Outdoor Switchhouse

operation that special operating devices may be needed. Wherever possible, all rods should be in tension while the circuit-breakers are being closed and all vertical rods should be so arranged that their weights are counterbalanced.

See that the operating mechanism and the moving parts of the breaker are clean and properly lubricated before operating. Also be sure that the tanks are free from dust and moisture before putting in the oil. Westinghouse grade C oil is an all year round oil, which saves the trouble of changing oil to meet the various temperatures. See page 106 for oil data.

Mufflers—Mufflers are applied to oil circuit-breakers to permit the release of the pressure generated within the circuit-breakers while interrupting electric current and to prevent the oil contained in the circuit-breaker from being carried out with the vapor and gas. The vaporized oil, when mixed with oxygen, may be highly inflammable or even explosive. The temperature of the vapor as it comes out of the muffler will be sufficiently low so that there is no danger of self ignition. There are often present in switch structures auxiliary switches which may provide the spark necessary to ignite this vapor if the vapor is free in the structure. It is, therefore, advisable to connect the mufflers together and to lead this manifold out of the structure.

Fig. 25—Installation of Westinghouse Switchboard with Pipe Frame Structure in the Rear.

Breakers of the smaller types which are not furnished with mufflers are sometimes mounted in cell structures. In some cases such as automatic reclosing feeder breaker installations, the location of the auxiliaries, such as control relays, should be given consideration, for here again, there are possibilities that arcing from these devices may ignite any accumulated vapors.

LIGHTNING ARRESTERS

Westinghouse Autovalve lightning arresters are shipped in practically complete assembled form. This minimizes erection time in the field and insures operation when finally installed.

Lightning arresters of the Autovalve type should receive reasonably careful handling and when stored should be protected from mechanical breakage.

Further information on the handling, installation and operation of Westinghouse Autovalve lightning arresters may be obtained from Instruction Book 5299.

BARRIERS

When slate, marble or other insulating barriers are used between carbon circuit-breakers, the blades of knife switches, etc., on the switchboards, they are usually fitted in their positions at the factory. The larger barriers, however, are usually removed from the panel for shipment and are identified by a tag or lettering with the position at which they were assembled. This insures the barrier being replaced in the position from which it was removed.

NAMEPLATES AND CARD HOLDERS

Westinghouse switchboards are provided with identification nameplates on the rear of each panel. In case it is desired to refer to any panel, the identification on the rear should be used. The Westinghouse switchboard name plate which is fastened on the front of each job is also engraved with the order number and date on which the job has been built.

Westinghouse card holders are so designed as to prevent entrance of dirt and dust and if pyraline or other transparent material is inserted between the inside of the holder and the front of card, it will insure a clean, readable card at all times.

KNIFE SWITCHES

The current carrying parts of Westinghouse Knife Switches consist of a high grade of drawn copper of guaranteed conductivity. The sectional areas and contact faces on all sliding and stationary parts have been calculated in accordance with the best practices and a liberal allowance has been made for overloads.

All of the switches listed conform to the requirements of the National Electric Code and are included in the list of approved devices issued by the National Board of Fire Underwriters.

The current carrying parts adjacent to the contact will carry their full rated current continuously with a maximum temperature rise of 30 degrees Centigrade based on a room temperature of 25 degrees Centigrade. Switches of 1000 ampere capacity and below have the same rating for either a-c. or d-c. on the 30 degree rise basis. Switches of 1200 ampere capacity d-c. and larger have lower a-c. ratings.

The contacts of all knife switches mounted on switchboard panels are always "ground in" before leaving the factory. However, it is usually well to inspect the switches before putting them into operation to insure that they have not become bent or distorted when re-

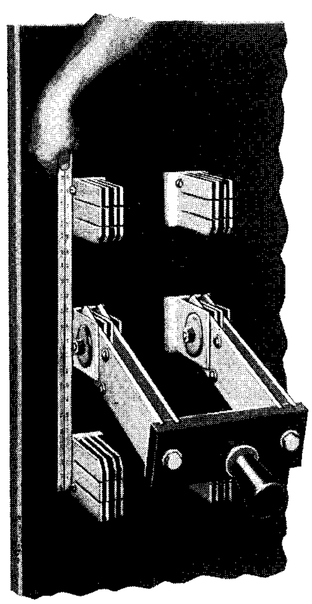


Fig. 26—When mounting new switches or remounting old ones we recommend that, the outside blades of the hinge and break jaw first be checked to see that they are in line. A steel scale may be used for this purpose when the switch is dead.

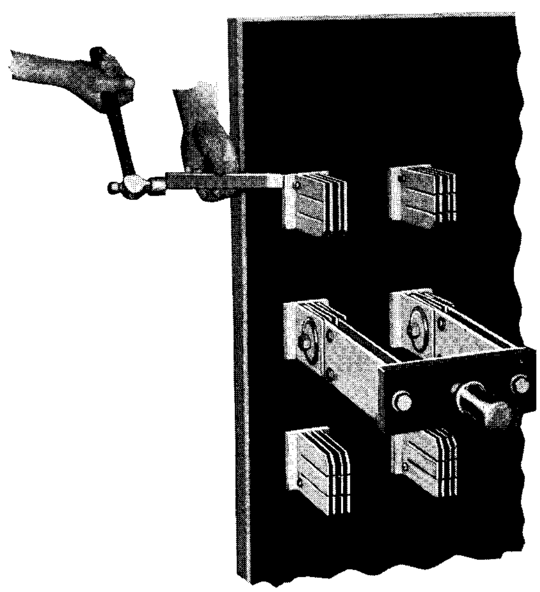


Fig. 27—If the blades of the hinge and break jaws are not in the same plane they should be bumped into the proper position by using a fibre bar and a steel hammer as shown.

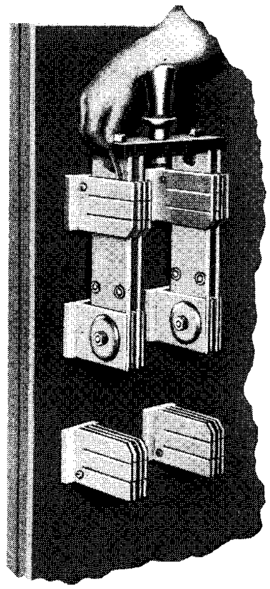


Fig. 28—In order to check the contact between blades and jaw, a one and one-half thousandth feeler is used.

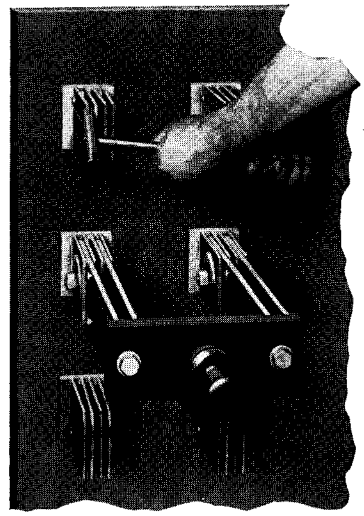


Fig. 29—If the jaw blades are not parallel, they should be twisted into position as shown.

moving the switchboard panels from the packing case.

In order to maintain their efficiency, frequent operations of the switch is recommended as the contact surface oxidizes quickly when the switch is not operated. Occasionally it may be necessary to recontact switches which have been in operation for a long period or perhaps due to some accident the jaws of knife switches may be forced out of alignment. The methods used are shown in Figs. 25 to 31.

Fig. 26 shows the first operation when recontacting switches, that is, to see that the outside of hinge and jaw blades are in the same plane. A steel scale may ordinarily be used for this purpose when the switch is dead.

Fig. 27—In case the jaw or hinge blades are out of line they may be tapped with a machinist hammer using a fibre block against the switch so that the copper will not be marred.

Fig. 28—Checking the switch contact with a 1½ thousandth-inch feeler.

Fig. 29—If the jaw blades are not parallel they should be twisted into position using the twisting tool as shown.

Fig. 30—If there is an outward bow in the jaws the blade of the switch is pulled out as far as possible and the jaws straightened by striking lightly with a rawhide mallet.

Fig. 31—If there is any inward bow in the jaws it is straightened by inserting a round pin between jaws, then squeezing the ends of jaws together with a pair of gas pliers with protected ends so that copper jaws will not be marred.

In case it is desired to "grind in" the contact of the switch, vaseline mixed with pumice or scouring powder should be applied to the blade and jaw, then the switch should be operated a sufficient number of times to grind in the contact. This grinding mixture should be entirely removed before putting the switch into operation. **Do not use emery dust or other hard abrasives** as the switch copper will start cutting between contacts and the contact will be destroyed.

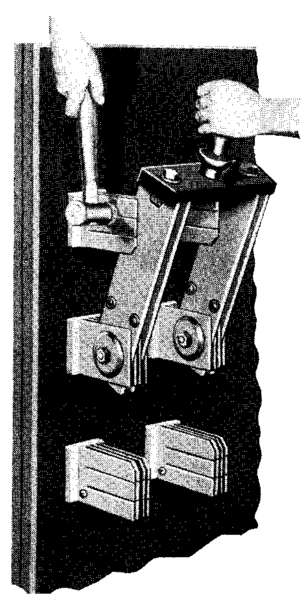


Fig. 30—If there is an outward bow in the jaw, the blade of the switch is pulled out as far as possible and the jaw straightened by striking lightly with a rawhide mallet.

Plain break knife switches are ordinarily not intended for opening a loaded circuit. Therefore, it is well to see that the breaker or starting device in series with the knife switch is opened first.

Knife switches with quick-break attachments can be used for opening circuits under load up to their normal current rating.

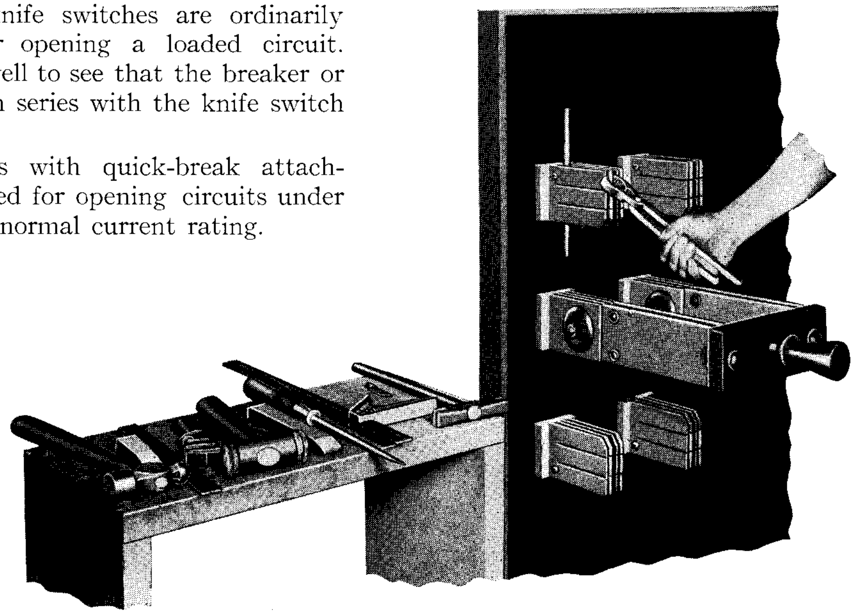


Fig. 31—If there is an inward bow in the jaws, it can be straightened by inserting a round pin between the jaws and squeezing the ends of the jaws together with a pair of pliers with protected fibre ends. Note the tools used in the different operations.

LAMINATED STUDS

Switches—Before placing copper straps in slots of laminated switches be sure the copper straps and slots are clean, smooth and the slots parallel.

If the copper strap connections have become bent or distorted in any way, they should be flatened carefully before inserting in the slots of laminated stud switches.

DISCONNECTING SWITCHES

Operation—Disconnecting switches are usually installed to isolate the higher voltage circuits after the oil circuit-breakers of those circuits have been opened. They are not designed to be opened under load and therefore extreme care should be used to guard against this possibility. Unless there is some form of interlock between the disconnecting switch and oil circuit-breaker it is often desirable to place warning signs in prominent positions which will tend to cause the operators to use extreme care before operating them.

Installation—Disconnecting switches should be located at such a height or be guarded so that it will not be possible for any person to accidentally come in contact with them. The arrangement should, however, allow for easy manipulation without requiring operating poles of excessive length.

Locate disconnecting switches so that gravity will tend to open them.

Arrangement of connections to disconnecting switches should be such that any breakage of these connections will not cause short circuits or grounds.

All disconnecting switch jaw and blades are carefully lined up on their bases at our factory. If, however, the disconnecting switch is finally bolted to an uneven wall or surface the base may deflect causing misalignment of the jaws and blades. Washers or spacers are frequently necessary on uneven surfaces under the mounting bolts, in order to obtain proper alignment.

HOOK STICKS

Before using hook sticks inspect carefully to see that they are perfectly clean. It is a good plan to provide a place to keep hook sticks, fuse tongs, etc., so that they will not accumulate conductive dust and dirt.

Rubber gloves should be worn when using hook sticks.

INSTRUMENT SWITCHES—TYPE RS

Operation—All type RS instrument switches may have removable keys or handles. These keys are labeled and so constructed mechani-

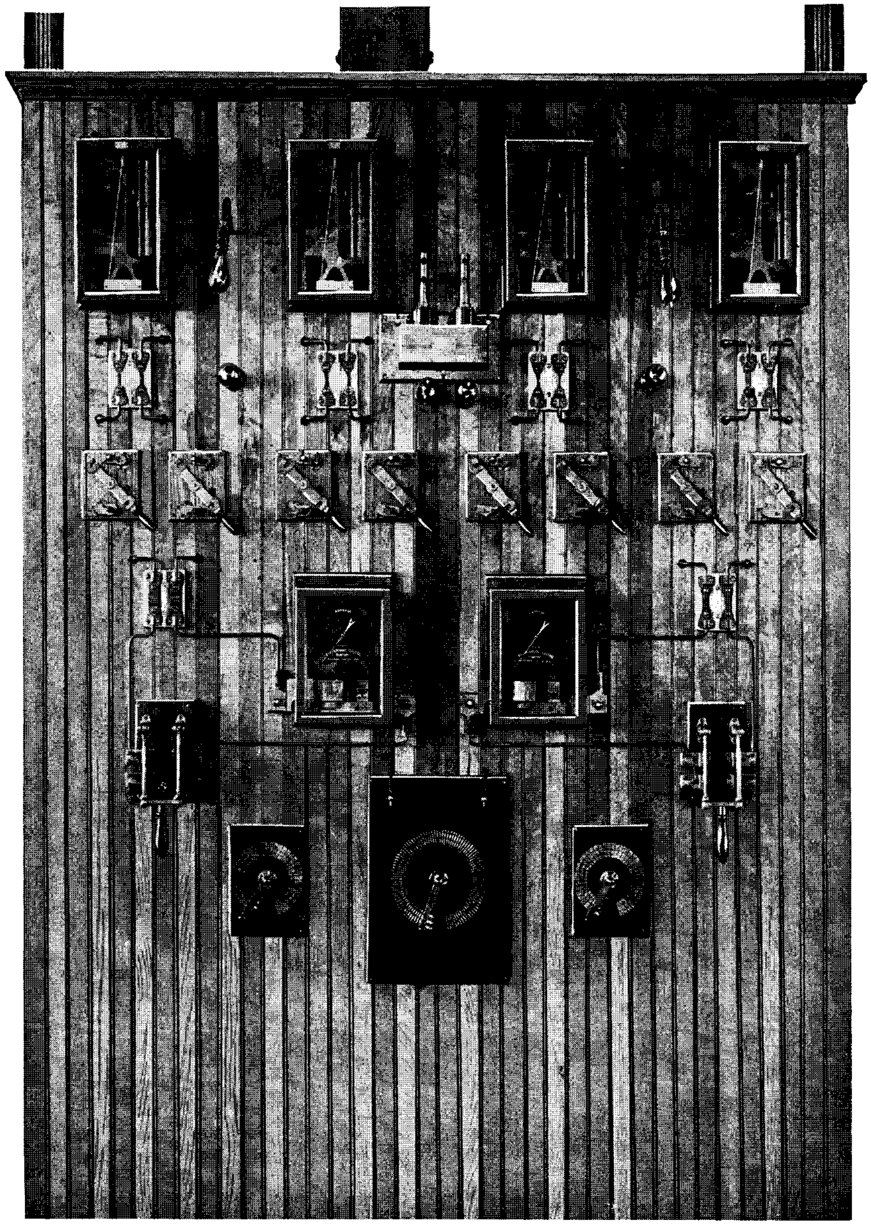


Fig. 32—Type of Westinghouse Switchboard built in 1889.

cally that they cannot be inserted in the wrong switch.

Ammeter Switches—With one ammeter switch and two or more current transformers on a polyphase circuit the ammeter can be connected so as to read the current in any phase.

The segments on the drum and the contact fingers on the housings are so arranged that the current transformer secondary circuits are never open.

There are two forms of ammeter switches, the two phase and three phase switches make the neutral connection in the switch, while the three circuit and four circuit switches keep the several circuits entirely independent. See Fig. 33.

Thermo Couple Switches—With one switch per generator the potentiometer or temperature indicator can be connected so as to read the temperature in any couple on any machine. See Fig. 34.

Voltmeter Switches—With one voltmeter switch for each polyphase circuit or set of voltage transformers, one voltmeter can be connected so as to read the voltages on all phases of any circuit. See Fig. 35. One key is required for each voltmeter and its group of switches. Where more than one group of voltmeter and switches is furnished, each

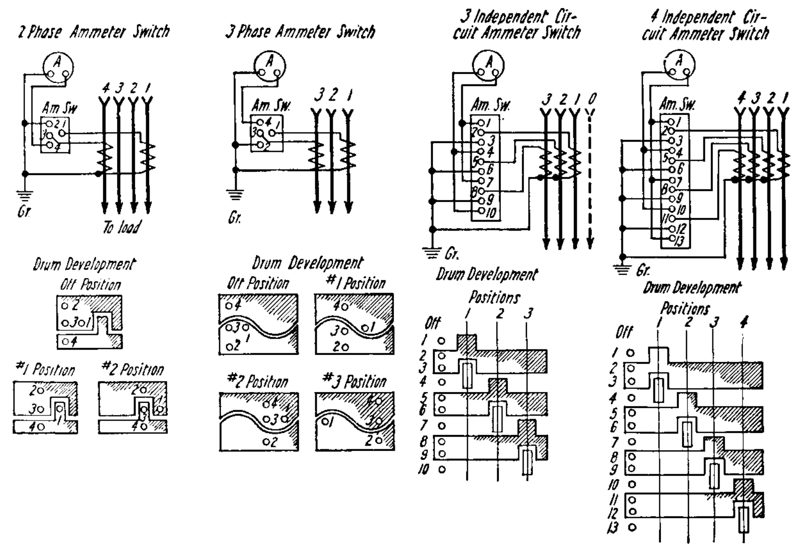


Fig. 33—Two and Three-Phase and Three and Four-Circuit Ammeter Switches

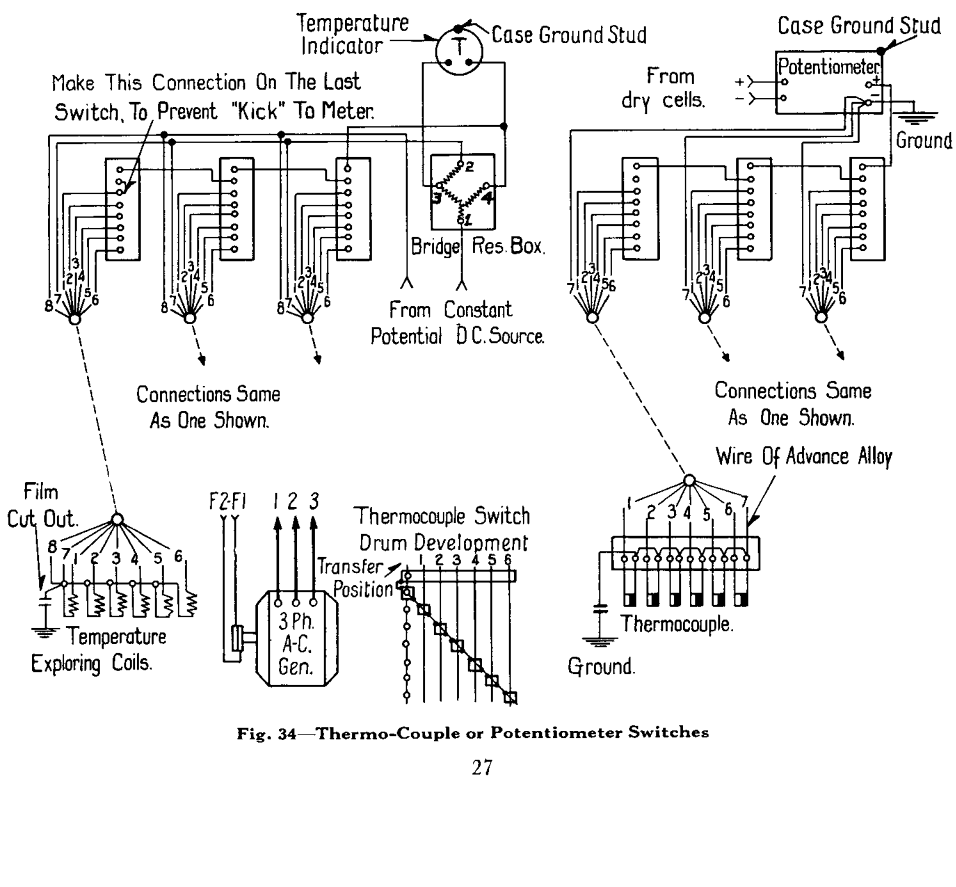


Fig. 34—Thermo-Couple or Potentiometer Switches

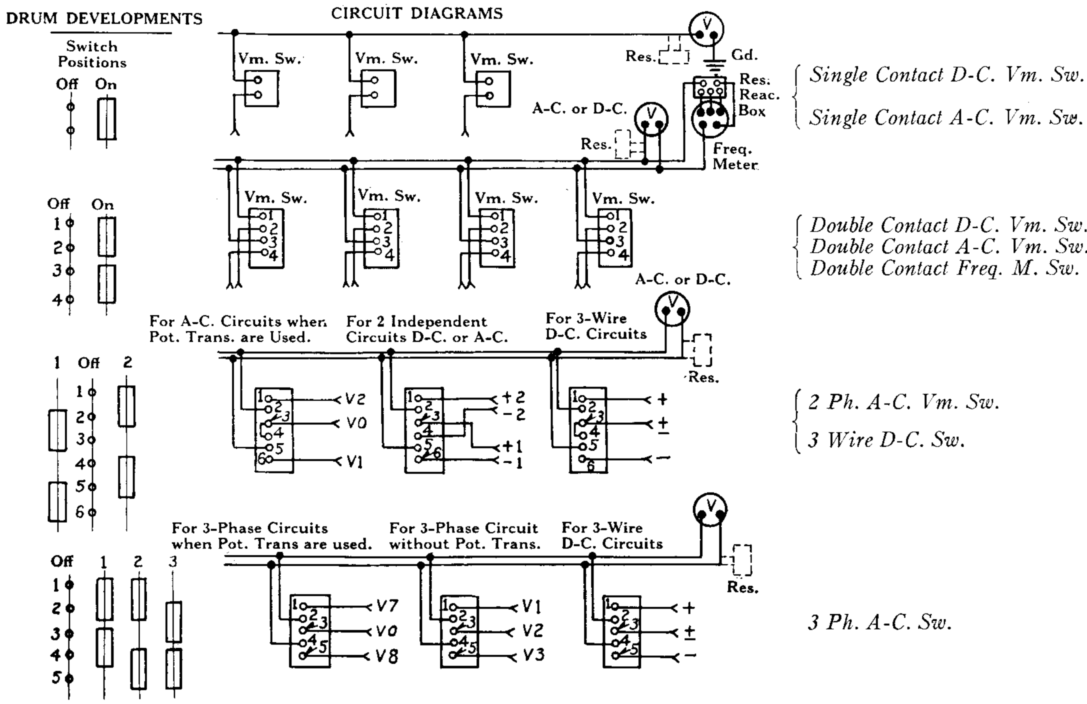


Fig. 35—A-C. and D-C. Voltmeter and Frequency Meter Switches

group is supplied with a different key arrangement.

Multi circuit voltmeter switches are arranged to connect the meter to any one of a number of circuits as per Figs. 36, 37 and 38.

Frequency Meter Switch—With one frequency meter the necessary potential transformers and one switch for each bus system, the frequency can be read on any bus system. Fig. 35. One key is required for each frequency meter.

Wattmeter and Power Factor Meter Switches—With one instrument, one switch with proper labeling and key arrangement for each circuit and the necessary instrument transformers, readings can be taken on any circuit. See Figs. 40 and 42. One key is supplied with each instrument.

Synchronizing Switch for Synchronizing Between Machine and Bus—With one synchronoscope equipment, one switch for each generator on a single bus system, and two

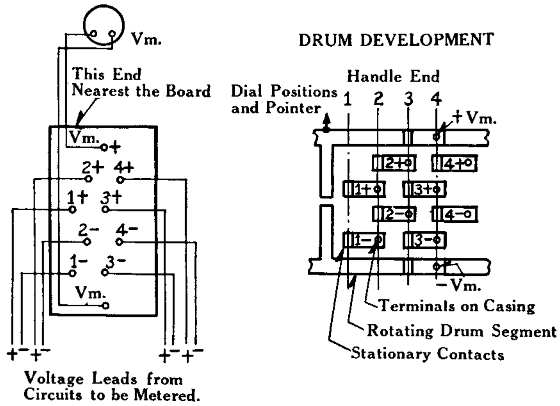


Fig. 36—Type RS Multi-Circuit Voltmeter Switch. Four-Circuit, Double-Pole

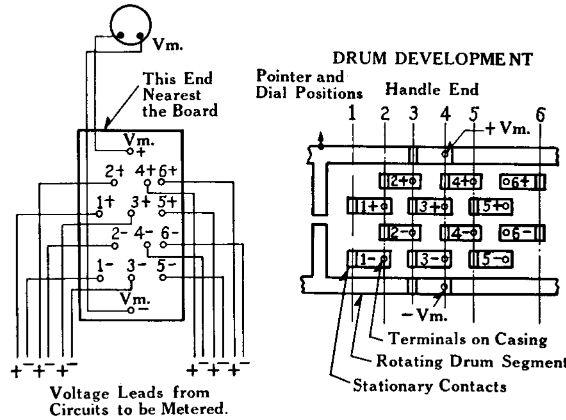


Fig. 37—Type RS Multi-Circuit Voltmeter Switch. Six-Circuit, Double-Pole

switches for each generator on a double bus system and the necessary potential transformers, a synchronizing indication between the bus and any incoming machine is obtained. See Fig. 41. One key is required.

Synchronizing Switch for Synchronizing Between Machines—With one synchronoscope equipment, one switch for each machine and the necessary potential transformers, a synchronizing indication is obtained between any two machines. See Fig. 39. One **Running Key** and one **Incoming Key** are supplied. The Running Key is to be placed in the synchronizing switch of one of the running machines and can be turned in the running position only. The Incoming Key is to be placed in the synchronizing switch of the machine being brought in and can be turned in the incoming position only. Each switch has a running and an incoming position

Synchronizing Switches—Synchronizing switches are supplied with and without interlock contacts for the closing circuits of electrically operated oil circuit-breakers.

Construction—Ruggedness and compactness are salient features of the type RS instrument switches. Movable contact members securely mounted on a micarta drum engage with

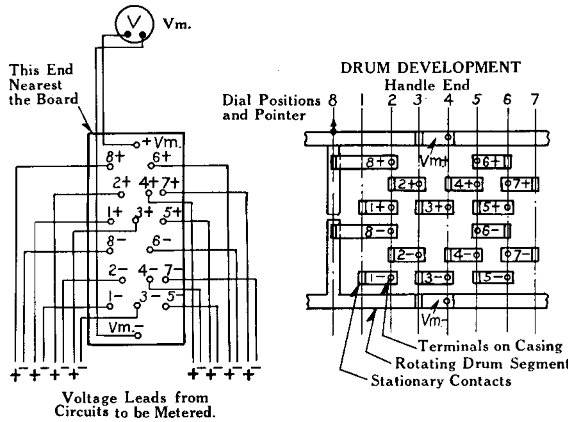


Fig. 38—**Type RS Multi-Circuit Voltmeter Switch. Eight-Circuit, Double Pole.**

stamped contact fingers as the drum is rotated to the right or left. The switching element is housed in a substantial micarta tube. A segment of the housing is easily removed for inspection and adjustment.

Before placing into operation the top segment of housing should be removed and the interior inspected to see that no packing or other material has fallen inside of the case. Before replacing the cover a casual inspection will show whether all fingers are making contact.

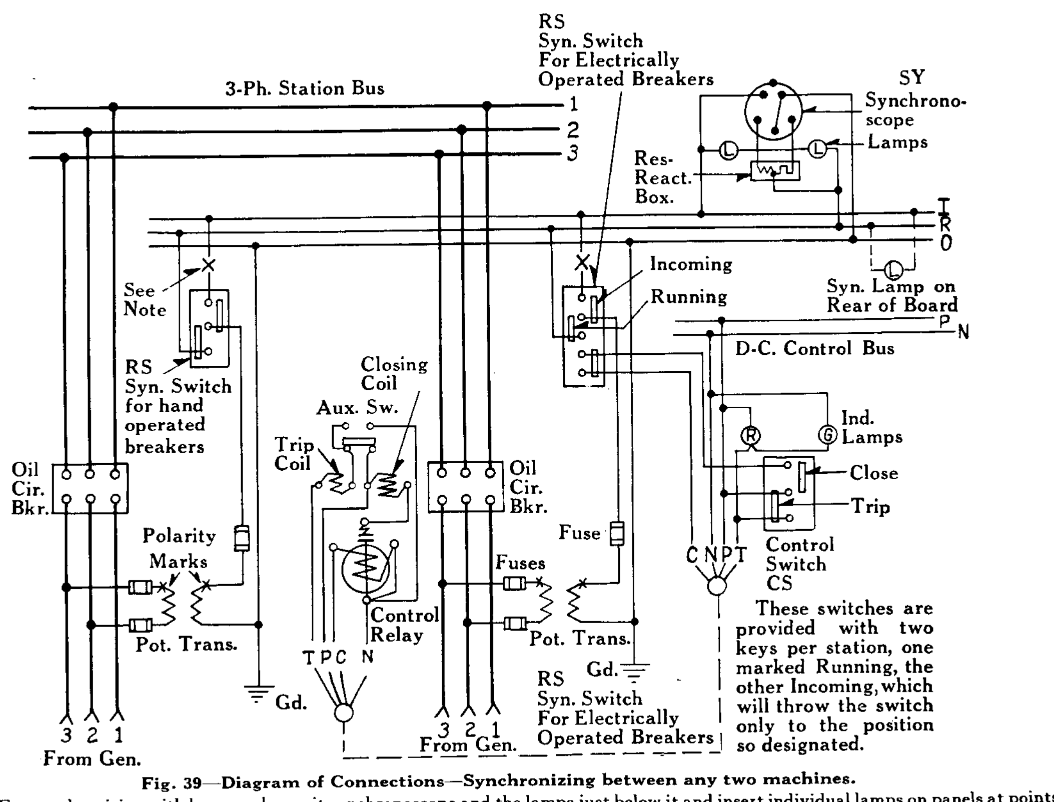


Fig. 39—**Diagram of Connections**—**Synchronizing between any two machines.**

Note—For synchronizing with lamps only, omit synchronoscope and the lamps just below it and insert individual lamps on panels at points marked X and add one lamp on rear of board as shown by dotted lines.

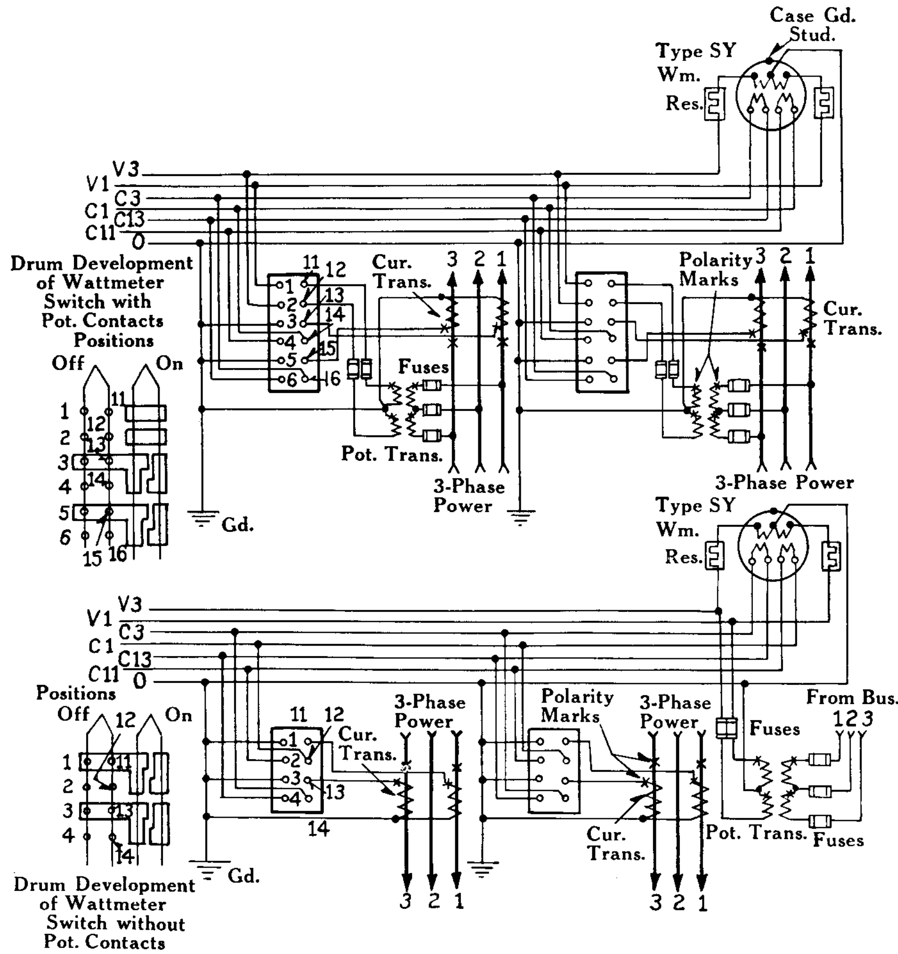


Fig. 40—Connections of Wattmeter Switches

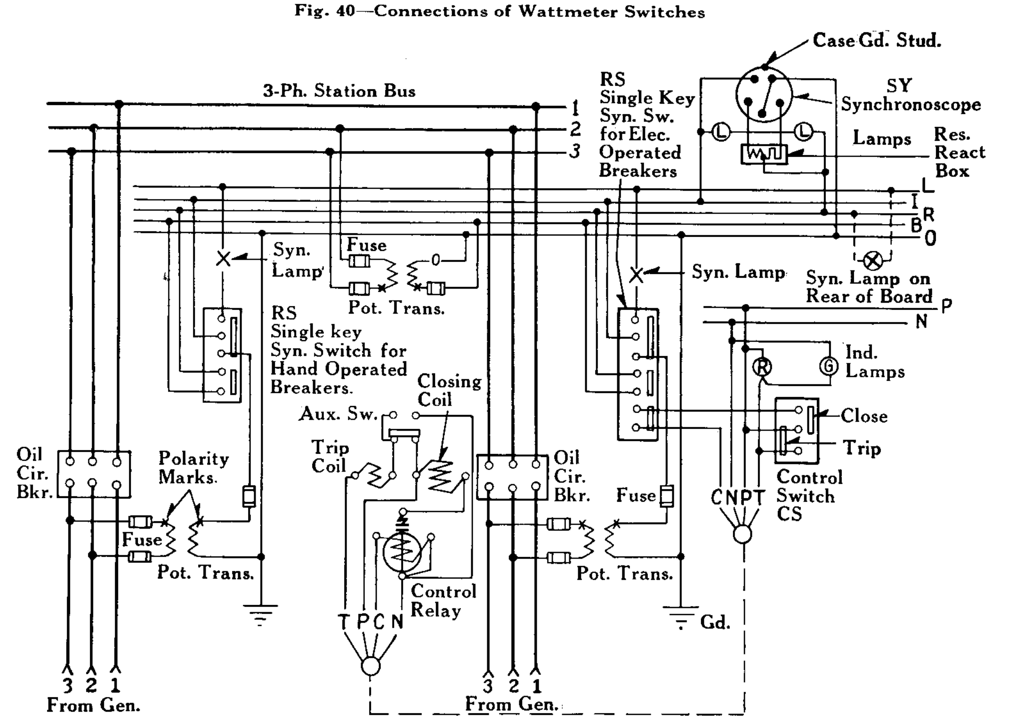


Fig. 41—Diagram of Connections—Synchronizing Between Bus and Any Machine

Note—For synchronizing with lamps only, omit synchronoscope and the lamps just below it and insert individual lamps on panels at points marked X, and add one lamp on rear of board as shown by dotted lines.

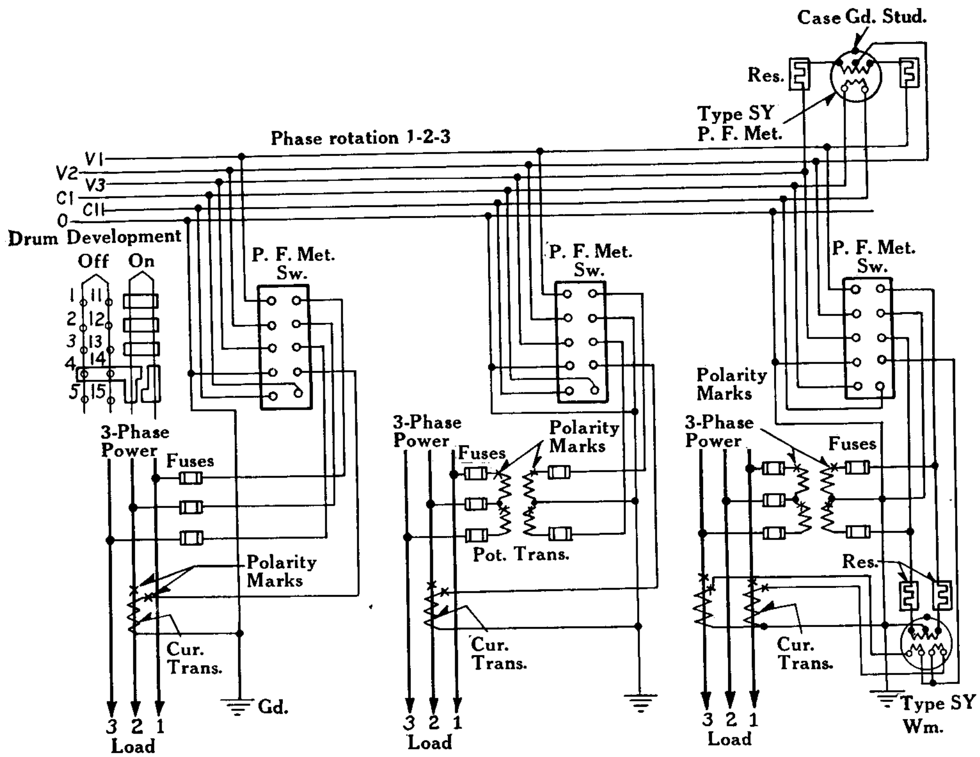


Fig. 42—Connections for Power Factor Meter Switches

CONTROL SWITCHES—TYPE CS

The construction of this switch is very simple, consisting of movable contact members mounted on a square insulated shaft which engages with stationary spring contact fingers as the shaft is rotated to the right or left. See Figs. 43 and 44.

The switching element is housed in a substantial micarta tube which provides a simple, rigid, insulating structure. A segment of the housing is easily removed for inspection and adjustment.

Before placing in operation the top segment of the housing should be removed and the interior inspected to see that no packing or other material has fallen inside of the case. Before replacing the housing, a casual inspection will show whether all fingers are making contact.

All control switches for circuit-breakers are provided with a mechanical indicating device which shows the last manual operation of the control switch. When the handle is released, the switch automatically returns to the neutral (central) position.

Most type CS switches for the control of solenoid-operated breakers embody a signal lamp cutout. After tripping the breaker, the

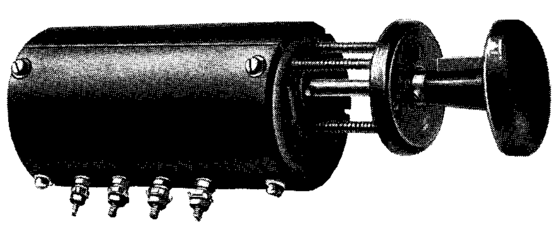


Fig. 43—Type CS Control Switch. Note the heavy housing and three points of support.

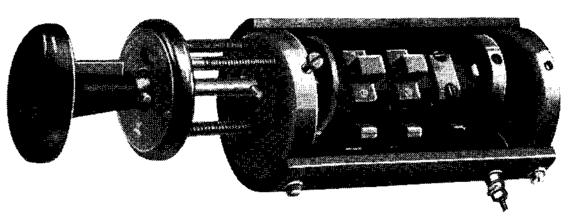


Fig. 44—Type CS Control Switch with Cover Removed. Note the rugged contact members.

handle on the control switch may be pulled out while in the tripped position, thus latching it into place and at the same time opening both the trip circuit and indicating lamp circuit. This feature not only reduces the load on the control battery, but also differentiates between breakers opened manually and those opened automatically, as the only green lamps lighted on the switchboard will be those which indicate automatic operation and thus require the attention of the operator.

with the cases of the relays, instruments, or meters to which they are connected.

Types and Rating—There are two general classes of instrument transformers, dry and oil insulated. Dry type voltage transformers are listed for primary voltages up to the 13 200 volt class and the oil insulated type up to the 66 000 volt class. Current transformers are listed for primary currents up to 10,000 amperes. For voltage classes up to 23,000 volts the dry type of current transformer is used and for the

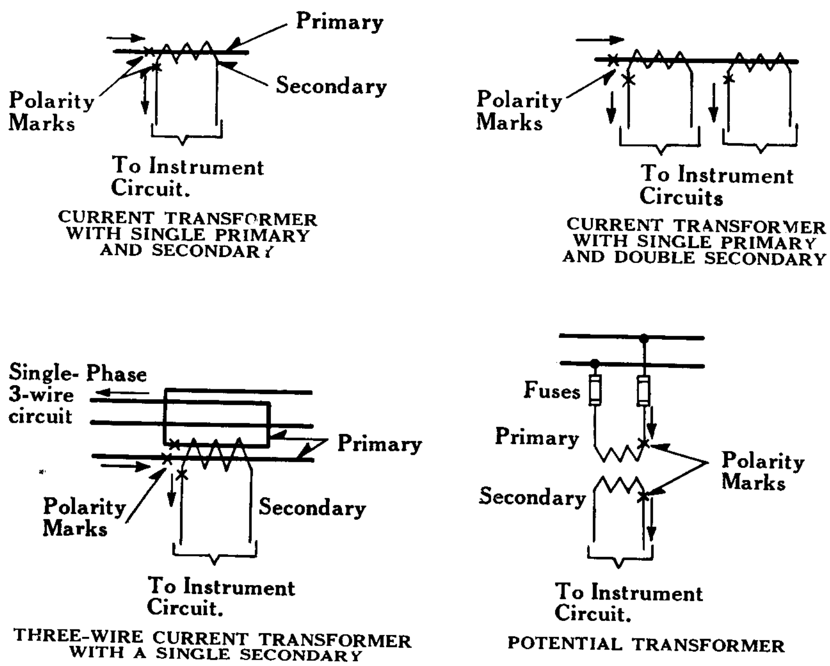


Fig. 45—Symbols for Current and Potential Transformers

Note—Small arrows indicate relative instantaneous direction of current in the primary and secondary leads.

INSTRUMENT TRANSFORMERS

Instrument transformers are used for two reasons; first, to protect station operators from contact with high voltage circuits and second to permit the use of instruments with a reasonable amount of insulation and a reasonable current carrying capacity. The function of instrument transformers is to deliver to the instrument a current or voltage which shall be always proportional to the primary current or voltage and which shall not exceed a safe potential above ground. Generally, the secondary of a voltage transformer is designed for about 115 volts and the secondary of a current transformer for five amperes and both the secondary circuits should be grounded together higher voltages the oil insulated type.

The demand for transformers of higher ratings than those given is so small that they are not listed although they are frequently built on special orders. Reference may be made to the Westinghouse Catalog of Electrical Supplies for standard type and ratings of transformers.

Oil—Oil is used in oil insulated instrument transformers chiefly for its insulating properties. It is extremely important, therefore, that it be of the proper quality and that it be kept free from dirt and moisture.

Polarity Marking—In connecting instrument transformers to wattmeters, watthour meters, power factor meters, etc., it is necessary to know the relative instantaneous direction of current in the leads. For this reason, one primary and one secondary lead of each Westinghouse instrument transformer are marked with a white polarity marker. The arrows in Fig. 45 show the relative instantaneous direction of current in the corresponding white terminals. The marking of polarity on transformer leads is carefully checked by a polarity test.

When making connections in the field, extreme care should be used to see that the high voltage leads are connected to the line as a dangerous voltage will be produced if the primary and secondary windings are interchanged.

Grounding of Secondaries—All instrument transformers should be grounded on the secondary side as an extra precaution against danger from the high voltage in case the insulation should be punctured by lightning or other abnormal stresses. In polyphase groups any point of the secondary may be grounded but it is preferable to use a neutral point or a common wire between two transformers. The diagram provided with the switchboards should be used to determine the point which should be grounded.

Insulation—The insulation of 'nstrument transformers protects the meters and control apparatus as well as the power station operators from high voltage circuits. It is highly important therefore that it be able to withstand the strains of service. For this reason the insulation of Westinghouse transformers is designed with special care. Dry type transformer coils are impregnated w:th a compound impervious to moisture. Coils for oil insulated transformers are dipped in varnish or impregnated to seal them against moisture.

Insulation Test—The insulation test conforms to the standardization rules of the A. I.-E. E.

VOLTAGE TRANSFORMERS

Voltage transformers are used with voltmeters wattmeters, watthour meters, power factor meters, frequency meters, synchronoscopes and synchronizing apparatus, protective and regulating relays , and the no-voltage and overvoltage trip coils of automatic circuit-breakers. One transformer can be used for a number of instruments at the same time, if the total current taken by the instruments does not exceed that for which the transformer is designed and compensated. See pages 34 and 35 for Energy Required to Operate Coils of A-C. Instruments". Voltage transformers have a rated capacity of 200 volt amperes but are usually compensated to give correct ratio at 40 volt amperes, as this is the average load demanded of a voltage transformer. Special

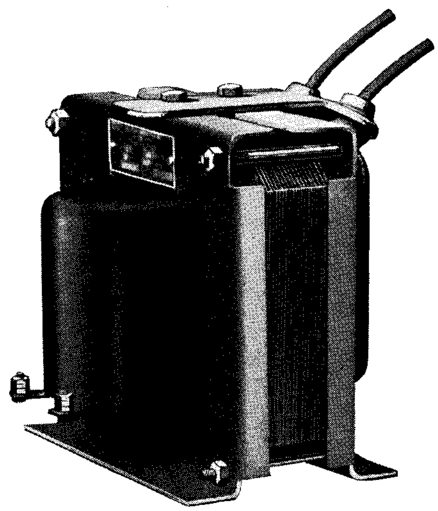


Fig. 46—Dry Type Voltage Transformer

transformers may be compensated for correct ratio at any specified load up to the full capacity of 200 volt amperes.

The standard voltage is 115 volts (normal) to suit standard instruments. Instrument transformers with special secondary voltages are made when necessary.

Principle of Operation—The voltage transformer is in principle an ordinary constant potential transformer especially designed for close regulation so that the secondary voltage under any condition will be as nearly as possible a fixed percentage of the primary voltage. The secondary voltage can never be exactly proportional to the primary voltage or exactly opposite in phase to the primary voltage on account of the losses :n the transformer and the magnetic leakage between coils. There are two classes of errors inherent in voltage transformers, ratio error and phase angle error. The part of these errors due to the exciting current is constant for any particu!ar voltage. In Westinghouse transformers it is reduced to the minimum by choosing the best quality of iron and working it at a low magnetic density. The part of the errors due to the load current varies directly with the load and is minimized by making the resistance and reactance of the windings very low.

CURRENT TRANSFORMERS

The current transformer is a special development of the transformer principle. The object is to maintain a constant ratio between the current in the primary and secondary windings, instead of a constant ratio between voltages which is the usual requirement.

Uses—Current transformers are used with ammeters, wattmeters, power factor meters, watthour meters, compensators, protective and regulating relays and the trip coils of circuit-breakers.

One current transformer can be used to operate several instruments provided the combined burden does not exceed that for which the transformer is designed and compensated.

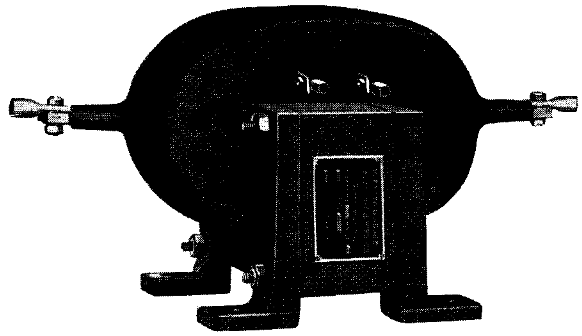


Fig. 47—Type KA Switchboard Current Transformer. (Dry Type)

Energy Required to Operate Coils for A-C. Instruments
Burden on Current Transformers at 5 Amperes*

INSTRUMENT AND TYPE	25 Cycle				60 Cycle			
	Volt Amperes	Watts	Reaction Component	Power Factor	Volt Amperes	Watts	Reaction Component	Power Factor
				%				%
Ammeter SM-SR-TM-GM-JM	6.3	6.0	1.9	95	3.1	3.0	0.8	97
Ammeter—PM-PR	4.5	4.0	2.0	89	4.5	4.0	2.0	89
Ammeter—TK	8.0	5.0	6.2	63	8.0	5.0	6.2	63
Ammeter—SY-DY	2.4	2.4	0.0	100	2.45	2.4	0.5	99
Ammeter-Recording—U	16.0	5.0	15.0	31	16.0	5.0	15.0	31
Ammeter-Recording—M-R	10.0	6.0	8.0	60	10.0	6.0	8.0	60
Wattmeter—SM-TM-GM-JM	4.0	4.0	0.0	100	4.0	4.0	0.0	100
Wattmeter—PC	2.0	2.0	0.0	100	2.0	2.0	0.0	100
Wattmeter—SY-DY	2.6	2.6	0.0	100	2.7	2.6	0.7	98
Wattmeter-Recording—M-R	3.5	3.5	0.0	100	3.5	3.5	0.0	100
Watthour Meter—C	1.88	0.7	1.74	37	1.88	0.7	1.74	37
Watthour Meter—OA	1.2	0.7	0.98	58	1.2	0.7	0.98	58
Power Factor Meter / Reactive Factor Meter } SI-TI	1.5	1.5	0.0	100	1.5	1.5	0.0	100
Power Factor / Reactive Factor Meter } SY-DY	2.6	2.6	0.0	100	2.7	2.6	0.7	98
Power Factor Meter / Reactive Factor Meter } PC	2.0	2.0	0.0	100	2.0	2.0	0.0	100
Power Factor Meter Recording / Reactive Factor Meter-Recording } M-R	3.5	3.5	0.0	100	3.5	3.5	0.0	100
Relay—CO	16.0	9.6	12.8	60	17.0	8.5	14.7	50
Relay—CR	18.0	11.0	14.3	61	17.0	10.0	13.8	59
Relay (Non-Directional)—CZ	5.0	3.0	4.0	60	5.0	2.5	4.3	50
Relay (Directional)—CZ	7.0	4.3	5.5	62	7.0	4.2	5.6	60
Trip Coil (Light Pull) S-No. 62072	18.8	....	....	....	42.5	....	....	....
Triple Coil (Heavy Pull) S-No. 224185	32.0	....	....	....	65.0	8.5	64.0	13
Direct Trip attachment and Trip Coil—S-No. 209741	50.0	....	....	....	120.00	12.4	119.6	10
Type BT Relay (normal position)—S-No. 252725	19.9	7.0	18.6	35	28.0	7.5	27.0	27
Type BT Relay (tripping position)—S-No. 252725	80.0	22.5	77.0	28	145.0	32.0	142.0	22

*Values given are for a single element. Polyphase instruments usually have two elements connected to separate instrument transformers. The volt-amperes are given for 5 amperes in the current elements and normal voltage on the voltage elements

Energy Required to Operate Coils for A-C. Instruments—Continued

Burden on Voltage Transformers at 110 Volts*

INSTRUMENT AND TYPE	25 Cycle				60 Cycle				REMARKS
	Volt Amperes	Watts	Reaction Component	Power Factor	Volt Amperes	Watts	Reaction Component	Power Factor	
				%				%	
Voltmeter SM-TM-TK—GM-JM	9.0	8.0	4.1	89	9.0	8.0	4.1	89	External Resistance Used.
Voltmeter—PC	5.0	5.0	0.0	100	5.0	5.0	0.0	100	
Voltmeter—SY-DY	10.2	10.2	0.0	100	10.2	10.2	0.0	100	External Resistance Used.
Voltmeter (Recording)—U	26.0	23.0	12.2	89	26.0	23.0	12.2	89	External Resistance Used.
Voltmeter (Recording)—M-R.	12.7	12.7	0.0	100	12.7	12.7	0.0	100	External Resistance Used.
Wattmeter—SM-TM-GM-JM	6.3	5.5	3.1	87	6.3	5.5	3.1	87	External Reactance Used.
Wattmeter—PC	5.0	5.0	0.0	100	5.0	5.0	0.0	100	
Wattmeter-(Single Phase) SY-DY	10.6	10.6	0.0	100	10.6	10.6	0.0	100	External Resistance Used.
Wattmeter-(Polychase) SY-DY	8.5	8.5	0.0	100	8.5	8.5	0.0	100	
Wattmeter-Recording—M-R.	9.8	9.8	0.0	100	9.8	9.8	0.0	100	External Resistance Used.
Watthour Meter—C	10.4	1.5	10.3	14.4	10.4	1.5	10.3	14.4	
Watthour Meter—OA	10.2	1.3	10.1	12.8	10.2	1.3	10.1	12.8	
Power Factor Meter—SI-TI	11.0	10.0	9.95	91.0	11.0	10.0	9.95	91.0	External Resistance Used.
Reactive Factor Meter—SI-TI	11.0	10.0	9.95	91.0	11.0	10.0	9.95	91.0	External Resistance Used.
Power Factor Meter Single Phase—SY-DY	17.0	13.3	10.6	78.0	17.0	13.3	10.6	78.0	
Reactive Factor Meter-Single Phase—SY-DY	17.0	13.3	10.6	78.0	17.0	13.3	10.6	78.0	
Power Factor Meter (Polyphase 50-100-50)—SY-DY	11.2	11.2	0.0	100	11.2	11.2	0.0	100	
Reactive Factor Meter (Polyphase 50-100-50)—SY-DY	11.2	11.2	0.0	100	11.2	11.2	0.0	100	
Power Factor Meter (Polyphase 20-100-90)—SY-DY	9.67	9.02	3.4	93	9.67	9.02	3.4	93	External Resistance Used.
Reactive Factor Meter (Polyphase 20-100-90) SY-DY	9.67	9.02	3.4	93	9.67	9.02	3.4	93	External Resistance Used.
Power Factor Meter PC	8.0	6.0	5.3	75	8.0	6.0	5.3	75	
Reactive Factor Meter PC	8.0	6.0	5.3	75	8.0	6.0	5.3	75	
Power Factor Meter Recording R-M	11.0	10.0	9.95	91	11.0	10.0	9.95	91	
Reactive Factor Meter-Recording—R-M	11.0	10.0	9.95	91	11.0	10.0	9.95	91	
Frequency Meter SD-TD-PD	20.0	15.0	13.2	75	20.0	15.0	13.2	75	External Resistance Used.
Frequency Meter SY-DY	15.0	12.8	7.8	85	15.0	12.8	7.8	85	External Resistance Used.
Frequency Meter M-R	25.0	21.3	12.9	85	26.0	22.0	13.9	85	External Resistance Used.
Graphic Control Circuit M-R	63.8	58.5	25.3	92	55.0	51.0	20.5	93	
Synchronoscope SI-TI	11.0	10.0	9.95	91	11.0	10.0	9.95	91	External Reactance Used.
Relay CR	10.6	1.6	10.5	17	25.0	2.75	24.8	86	
Relay (non-directional) CZ	17.5	16.0	7.1	91.5	16.5	14.2	7.8	86	
Relay (Directional) CZ	22.3	19.1	11.5	86.0	32.0	18.2	26.4	57	
Relay Volt. Reg.	50.0	40.0	30.0	80.0	50.0	40.0	30.0	80	External Resistance Used.
LV Coil (110V) S-No. 148908	......	......	......	......	27.5	8.4	26.2	31	

*Values given are for a single element. Polyphase instruments usually have two elements connected to separate instrument transformers. The volt-amperes are given for 5 amperes in the current elements and normal voltage on the voltage elements.

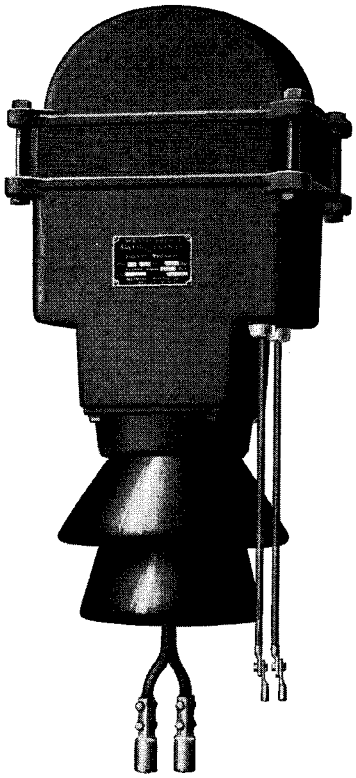


Fig. 48—Type MA Outdoor Current Transformer. (Dry Type)

Principle of Operation—The ordinary voltage transformer or distribution transformer is connected across the line and the magnetic flux in the core depends upon the primary voltage. For a given voltage the flux is therefore fixed while the current in the winding rises and falls as the load of the secondary winding changes.

The current transformer is connected directly in series with the line. For a fixed number of instruments in the secondary (which is the usual condition) a rise or fall in the line current requires a corresponding rise or fall in the secondary voltage to force the secondary current through the impedance of the meter load. The magnetic flux in the iron which supplies this voltage, thus follows the rise and fall of the primary or line current.

In any transformer the primary ampere turns may be considered as made up of two parts, one small element which supplies the magnetizing and core loss current and another element which supplies the "working current". The working current" ampere turns are always exactly equal to the secondary ampere turns.

Secondary Circuit of Current Transformers—Under no consideration should the secondary circuit of a current transformer be opened while the primary circuit is carrying current. First short circuit the secondary winding before opening the circuit which may run to meters, relays, etc. If this is not done there will be a very high voltage developed in the secondary winding which may endanger the life of the workman or cause a breakdown of the transformer insulation.

Testing Secondary Circuits of Current Transformers—It is advisable to test the secondary circuits of all current transformers before energizing the primary. This assures against any open circuit in the wiring, instrument switches, meters, relays or in the transformer secondary. As the voltage of such circuits should be low, dry batteries and bells or a flashlight circuit should be used for such testing.

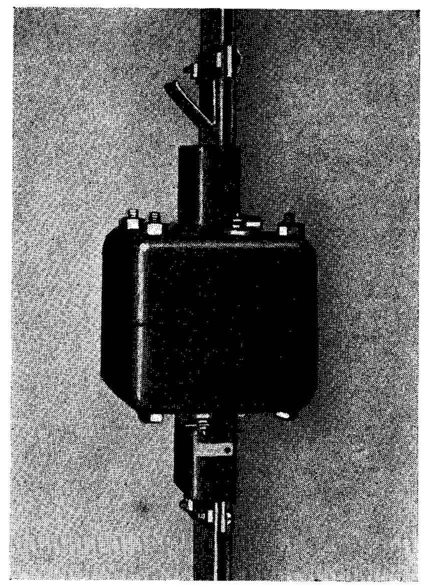


Fig. 49—Spring Support for Through Type Current Transformer. The upper spring is pushed down into place after the transformer has been permanently located.

TERMINAL BLOCKS

Terminal blocks mounted on angle, channel, pipe frames or steel panels are fully assembled and completely wired, ready to connect to the cables or wires leaving the switchboard when installed in the field. The lettering at each terminal point corresponds to the lettering on the switchboard diagram. The block is made of moldarta, thus assuring ruggedness. Marking strips are provided, also cover when requested. See Fig. 50.

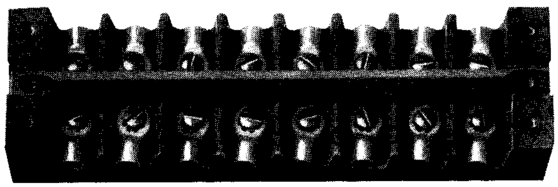


Fig. 50—Terminal Block with Self Locking Terminal Clamps. Note the two-face marking strip.

TESTING TERMINALS

When specified, testing terminals as shown in Fig. 52 are mounted on the front or rear of switchboard panels. Extreme care should be used when testing current circuits to see that the circuit for testing has been completed to the testing meter before removing the links on the testing terminals. **If the circuit is not completed at all times there will be a very high voltage developed in the secondary winding of the current transformer which may cause a breakdown in the transformer insulation and also endanger the life of the operator.**

RESISTORS FOR METERS AND OTHER APPARATUS

Provision is usually made for mounting small meter resistors directly on the rear of switchboard panels by means of expansion screws or self tapping screws. This cannot be done in all cases, because it will cause a crowded condition on the rear of the panels. For such conditions the resistors are mounted on brackets fastened to the rear of panels as shown in Figs 51 and 53. When mounting see that the resistor bears the same serial number as the meter with which it is to connect.

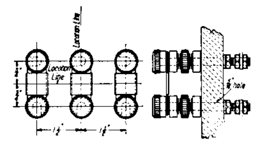


Fig. 52—Testing Terminals

CONDENSER SECTION FOR REGULATORS

Regular condenser sections are shipped assembled in one or more groups and will always be received ready to mount on brackets as indicated on the switchboard drawings.

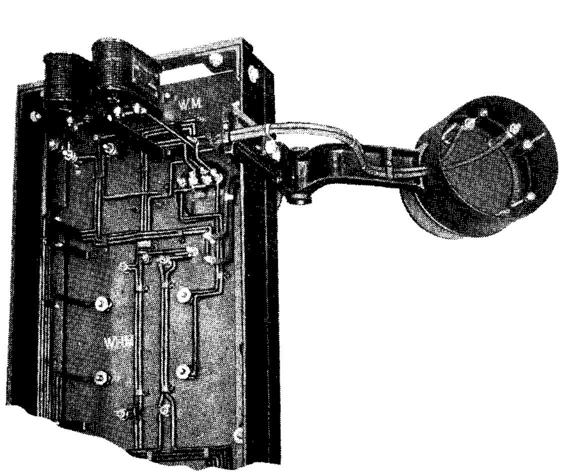
AMMETER SHUNTS

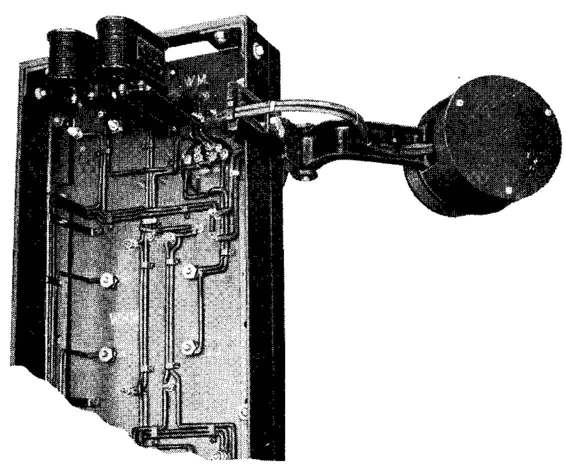
Ammeter shunts are shipped mounted directly on the switchboard panels except when for shipping purposes it is not deemed advisable to do so. Care should be taken to avoid buckling or damaging the leaves of the manganin as this may effect the calibration of the shunt.

SMALL WIRING ON REAR OF VERTICAL PANELS AND CONTROL DESKS

General—Small wiring on the rear of switchboard panels and control desks may be done in various ways. The method used depends largely on the number of wires involved and the amount of space available on the rear of the panels.

Flat Panel Wiring—Flat Panel, L Bracket and Channel Type of Wiring are used as standard on Westinghouse switchboards. The **flat panel wiring** method is one of the most common arrangements for fastening wires to the rear of a switchboard panel and is used frequently.





Method of supporting resistors on L brackets on the rear of switchboard panels. Note the method of running wires to the swinging bracket. Flexible cable is used.

Fig. 51—Lid of Protective Cover on Swinging Bracket Removed

Fig. 53—Lid of Protective Cover on Swinging Bracket in Place.

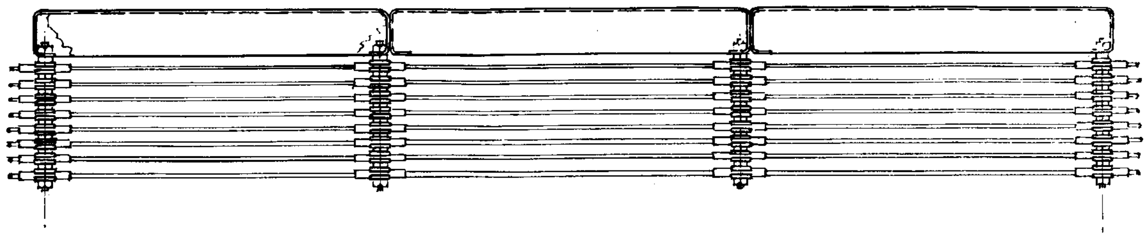


Fig. 58—Plan View of Instrument and Control Bus Mounted on Stretcher Level Steel Panel.

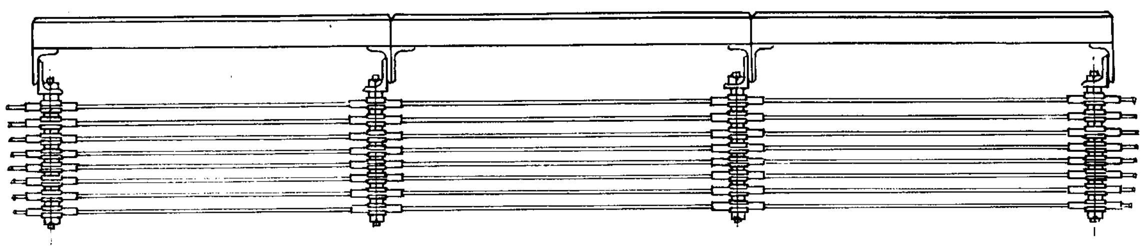


Fig. 59—Plan View of Instrument and Control Bus Mounted on Slate Panel with Angle Iron Frame.

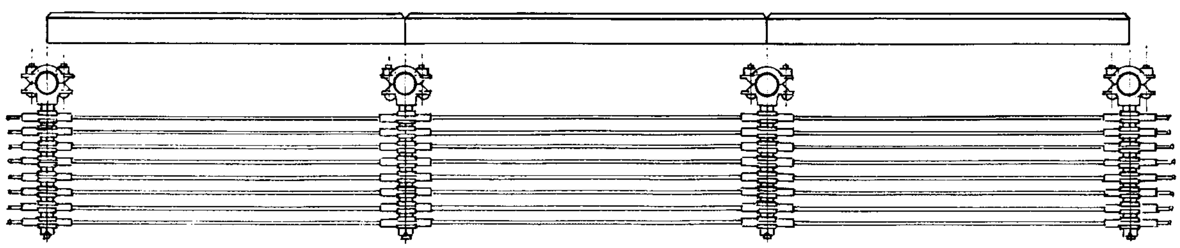


Fig. 60—Plan View of Instrument and Control Bus Mounted on Slate Panel with Pipe Frame.

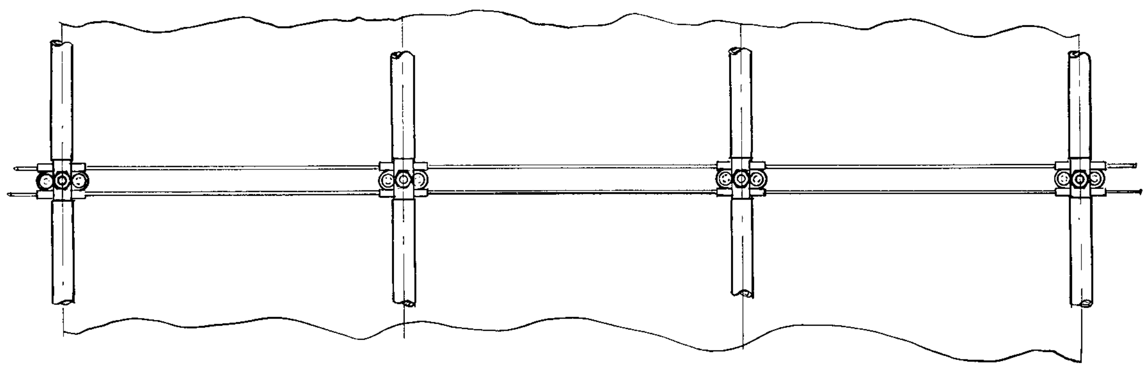


Fig. 61—Elevation of Bus Mounted on Rear of Panel with Pipe Frame. If it is desired to insulate the brass tube, cambic or other insulating tape may de used. The use of "medical adhesive tape", for this purpose has found considerable favor. Tape the width depending on the number of layers desired, is folded lengthwise around each tube after the connections have been made. The insulation is occasionally painted black.

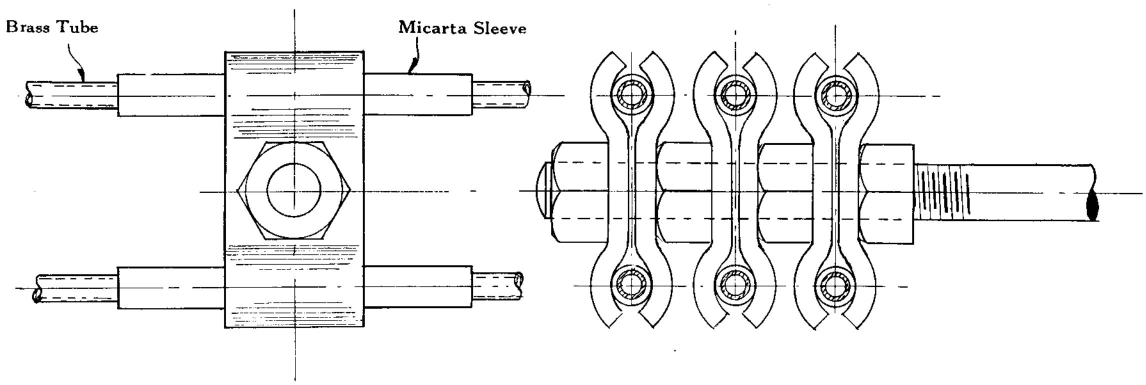


Fig. 62—**Detail of Bus Tube Support. Micarta Sleeve should be slipped over Brass Tube Bus at supporting points between panels.**

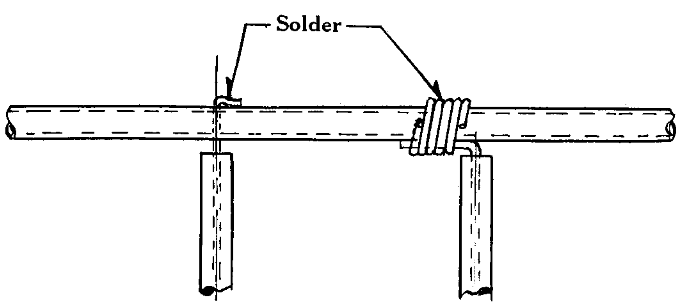


Fig. 63—**Method of Tapping Small Wires to Tube Bus.**

NOTE—Holes may be drilled through the tube, wire run through the hole, clinched and soldered or the wires may be fastened to the tube by bending wire parallel with tube, then wrapping with fine wire and soldering.

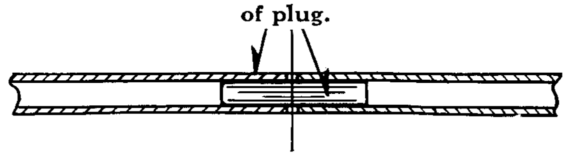


Fig. 64—**Method of Splicing Bus When Long Runs are required.**

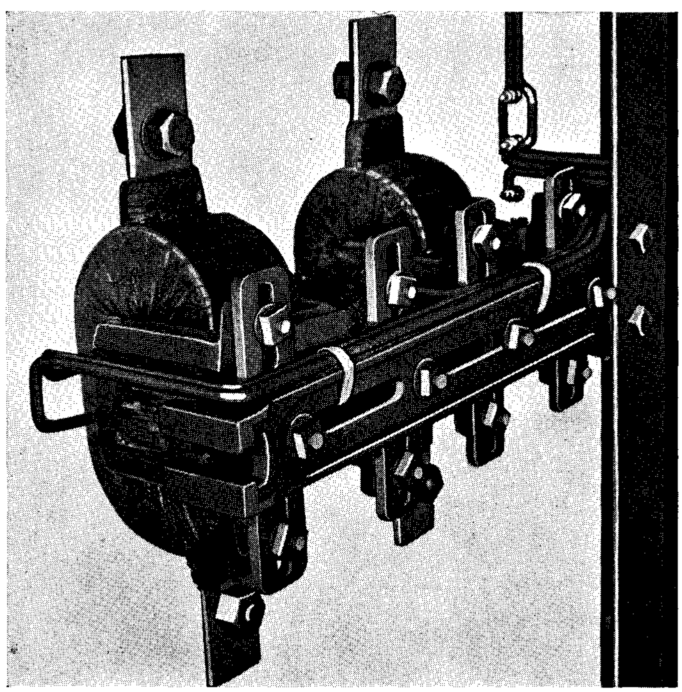


Fig. 65—**Method of Wiring between Panel and Instrument Transformers**

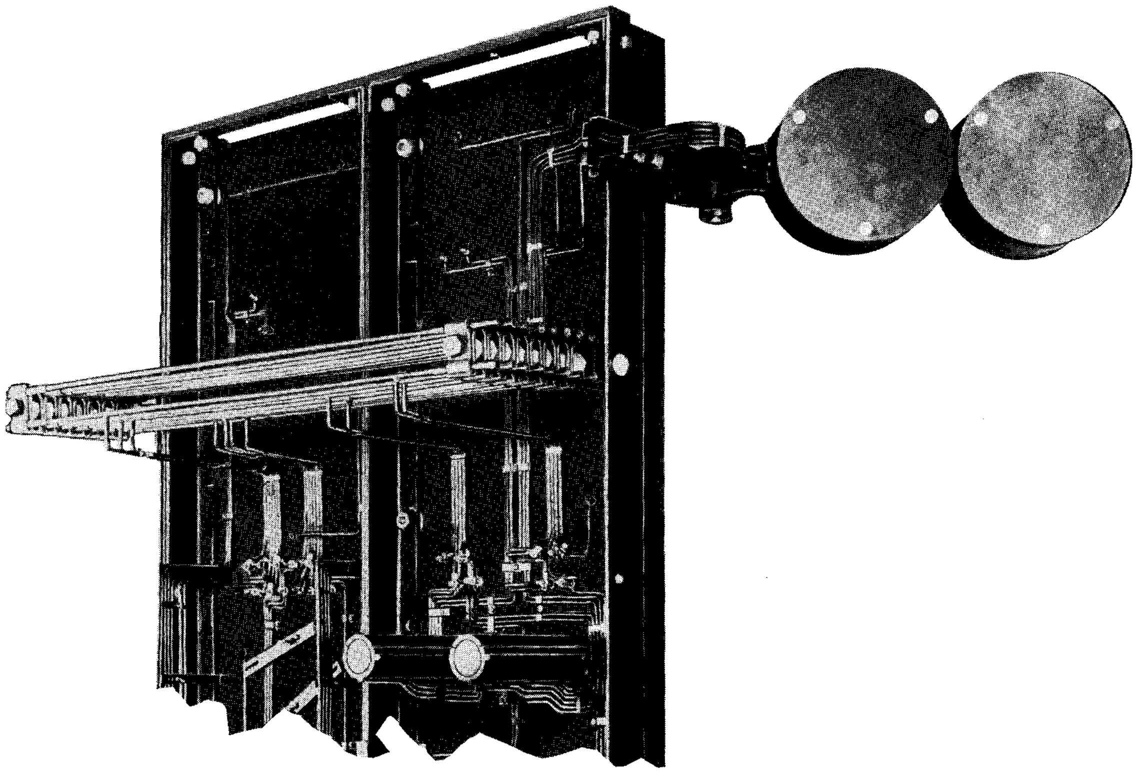


Fig. 66—Instrument Bus across rear of Panels. Brass tubing is used. Note also the neat protective covers on the Swinging Brackets.

Ammeter Shunt Leads—Wires for connecting d-c. ammeters to shunts are placed on the rear of each panel at the factory. This wire is known to have the proper resistance to insure proper operation of the instruments and should not be replaced by other connections.

In cases where long calibrated leads are supplied for connecting to shunts mounted apart from the switchboard the surplus leads should if possible be neatly rolled and supported apart from the panels.

Resistors for Meters—All meter resistors should be connected in the circuit, using extreme care to locate them on the side of the line exactly as indicated in the switchboard diagram. The position of the resistance with respect to ground potential is often vital and has been considered in the preparation of the diagram.

Grounding Transformer Leads—Do not fail to ground one secondary lead of each current and voltage transformer taking care, however, that no short circuit of the small wiring results from grounding different phases of potential and current transformers that are connected together at some other point. The diagram accompanying each switchboard indicates the proper place to make the ground. Never fuse the ground or secondary lead of a voltage transformer, or the secondary lead of a current transformer as the blowing of the fuse may lead to serious consequences.

GROUNDING OF SWITCHBOARD FRAME, ASSOCIATED STRUCTURE, INSTRUMENT CASES, ETC.

The established regulations for all a-c. switchboards, regardless of service voltage, demand that instrument cases, frames and associated structures be grounded.

For all d-c. boards having one side connected directly to ground for example, the railway type of switchboard, should have instrument cases, frames, and associated structures insulated from ground. In general other d-c. boards should have instrument cases, frames and structures grounded.

In mixed boards, for example, a board having both a-c. and railway panels, a literal interpretation of the safety code requires that the a-c.

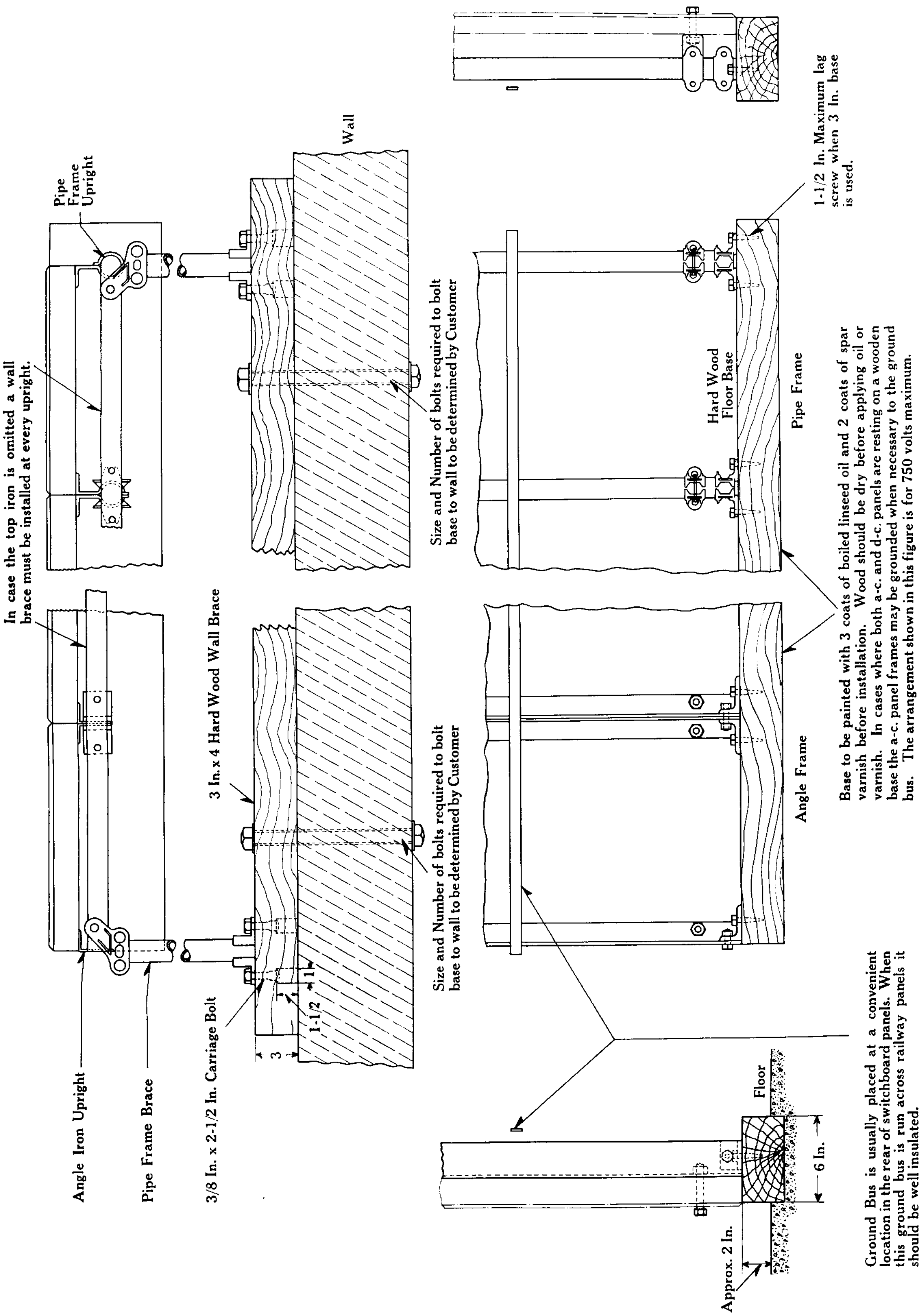


Fig. 68—Method of Insulating Switchboard Frames.

panel frames and associated structure be grounded and d-c. panel frames and associated structure be insulated. It will, however, often be preferable to insulate the entire panel framing of a mixed board even though the associated a-c. structure is grounded. Such cases, however, should always be checked to insure that the arrangement selected is in accordance with local requirements.

When panel frames are insulated, instrument cases must not be grounded, when panel frames are grounded instrument cases must be grounded.

Insulating Bases—Unless otherwise specified in the contract the hardwood bases for insulating railway panels are supplied by the customer. The floor base should be about 3″ x 6″. The support for the wall braces should be about 3″ x 4″. Care should be used to see that the lag screws holding the toe clips to the wooden base do not extend through. Proper clearance should be maintained at this point in line with insulation for switchboards on Page 61 Be sure that a good ground connection exists between brackets, frame uprights, mounting brackets and the ground base when the frame is grounded. See Fig. 68.

MINIATURE BUS

A miniature bus on the front of a switchboard or control desk is a convenience for the operator. It represents a single line diagram of the main connections and when supplied with miniature disconnecting switches it is possible for the operator to arrange the switches so as to show the connections of the plant at all times. Westinghouse miniature bus is free from mounting bolt heads thus presenting a smooth, flush surface. It is supplied in different finishes to represent the different voltages on the system.

The miniature disconnecting switches are real miniatures of the large switches and are very easily manipulated. The bus is mounted on the panels in our factory and is lined up very carefully. It will not ordinarily require any further adjustment if the panels are erected in the field on perfectly level and true bases as they were in our factory. The end of the bus on each panel is terminated at the edge of the bevel so that there will be no danger of bending or marring the end of the bus during the unpacking and erection period. In order that the bus will furnish a continuous line across the bevels after the panels are erected, **jumper** pieces are furnished which may easily be slipped over the busses at the intersection of the panels. See Fig. 67.

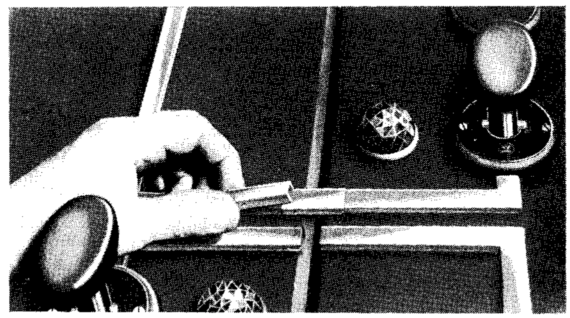


Fig. 67—Miniature Bus is run only to the edge of the Bevels on Westinghouse Switchboard Panels. In order to provide a continuous line, jumpers are supplied which are slipped into place after the job is erected.

RENEWAL PARTS

It is desirable to have renewal parts on hand thus minimizing shut-down periods in case of accidents and the possibility of interruption of service to customers. Renewal parts lists will gladly be furnished upon request.

Renewal parts when received should be identified and stored in such a manner that they may be obtained easily and quickly when required.

WIRING DIAGRAM SYMBOLS, CONNECTIONS, ETC.

Wiring diagram symbols, typical circuit-breaker control, switch and meter connections are shown in the following Figures. These typical connections, however, in no way supersede the switchboard diagram which accompanies each switchboard.

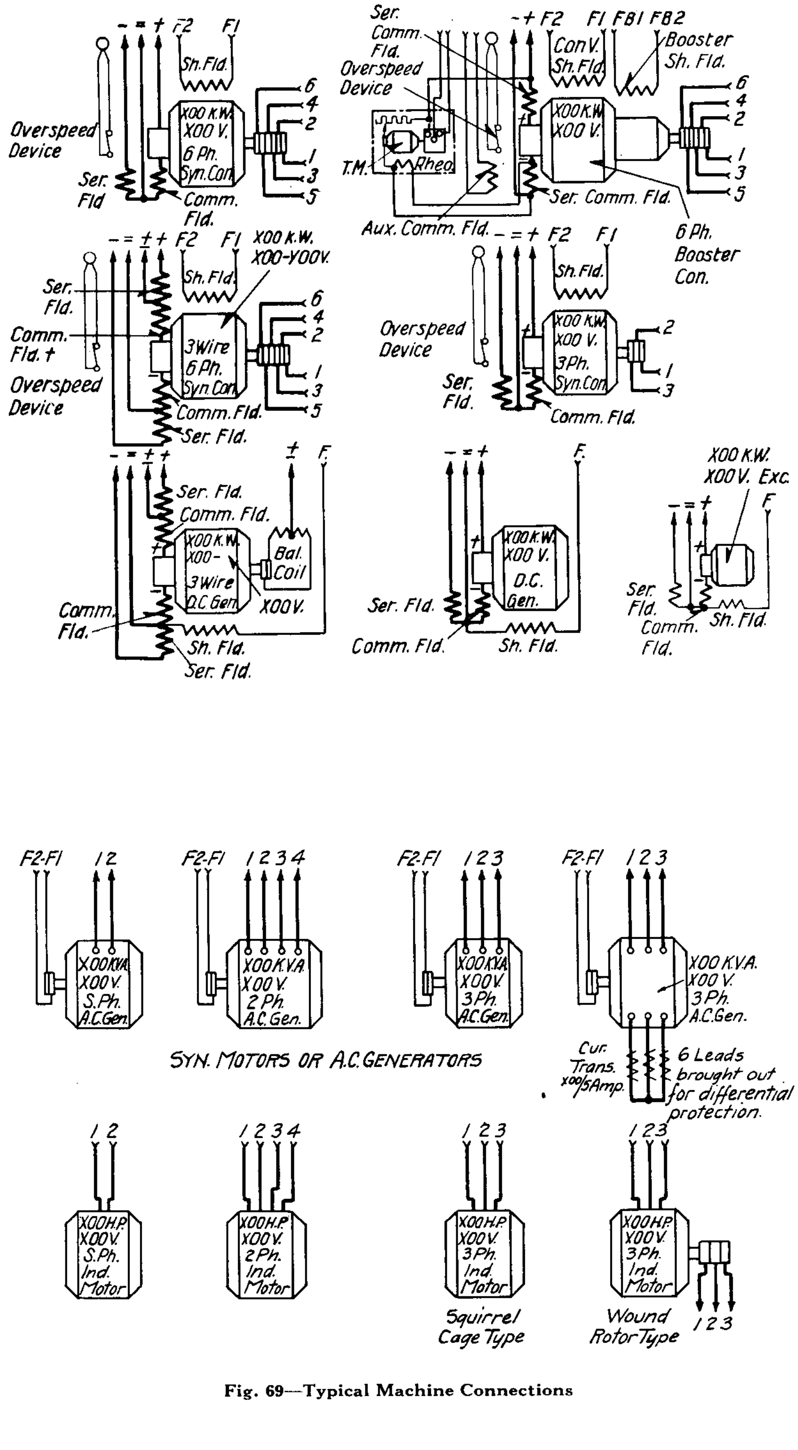
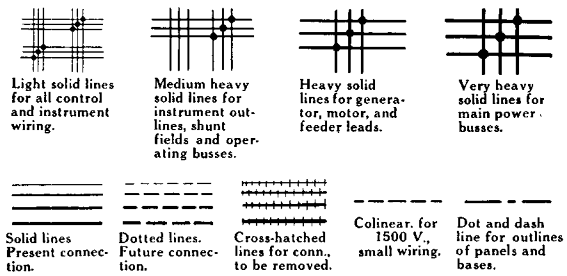


Fig. 69—Typical Machine Connections



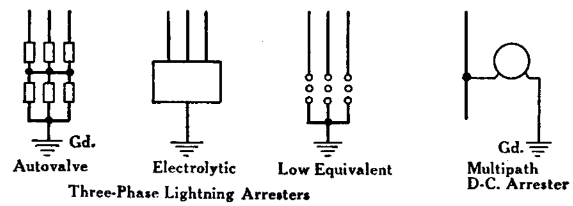


Fig. 71

Fig. 70—Standard Lines for Switchboard Connections.

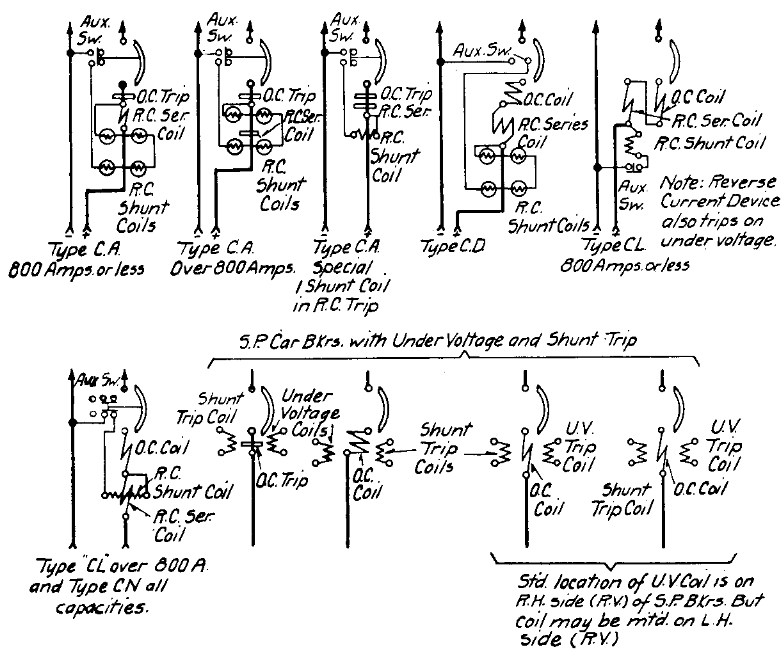


Fig. 72—Typical Carbon Circuit-Breaker Symbols

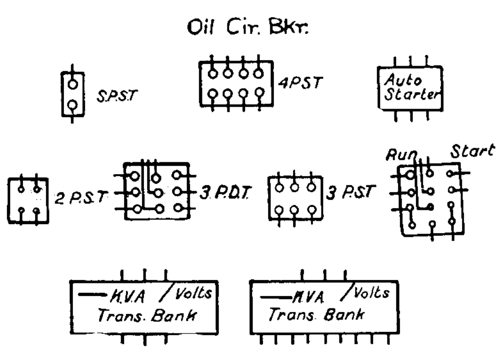


Fig. 73—Typical Oil Circuit-Breaker and Power Transformer Symbols

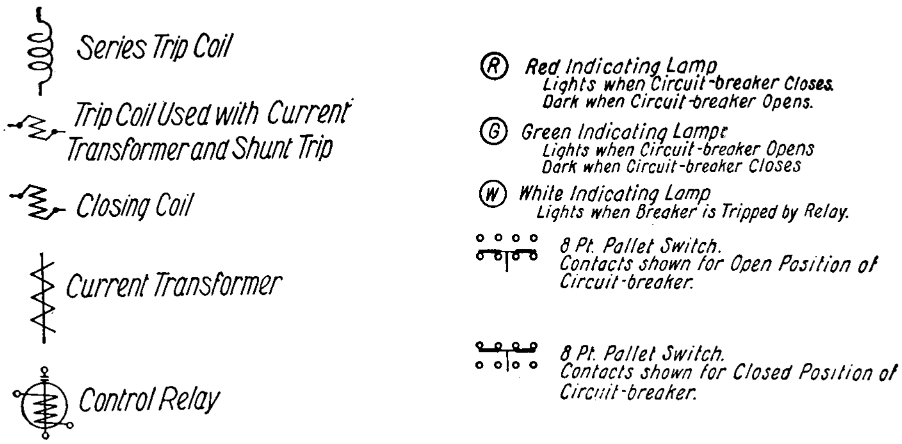
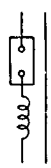


Fig. 74

SINGLE-THROW BREAKERS

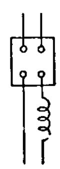
SERIES TRIP

Single-Phase Circuits



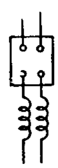
Single-Pole Single-Phase One Trip Coil

Fig. 75



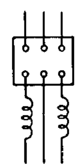
Two-Pole Single-Phase Two-Wire One Trip Coil

Fig. 76



Two-Pole Single-Phase Two Trip Coils

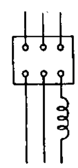
Fig. 77



Three-Pole Single-Phase Three-Wire Two Trip Coils

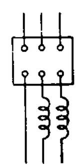
Fig. 78

Three-Phase Circuits



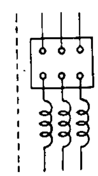
Three-Pole Three-Phase Balanced Load One Trip Coil

Fig. 79



Three-Pole Three-Phase Two Trip Coils

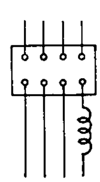
Fig. 80



Three-Pole Three-Phase Three or Four-Wire Three Trip Coils

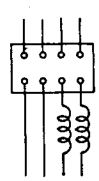
Fig. 81

Two-Phase Circuits



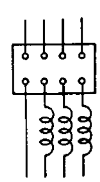
Four-Pole Two-Phase Balanced Load One Trip Coil

Fig. 82



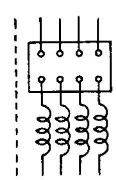
Four-Pole Two-Phase Two Trip Coils

Fig. 83



Four-Pole Two-Phase Four-Wire Three Trip Coils

Fig. 84

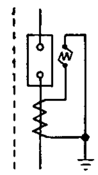


Four-Pole Two-Phase Five-Wire Four Trip Coils

Fig. 85

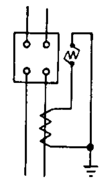
CURRENT-TRANSFORMER TRIP WITHOUT RELAYS

Single-Phase Circuits



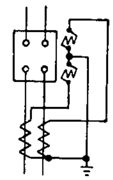
Single-Pole Single-Phase One Trans. One. Trip Coil

Fig. 86



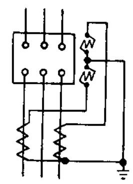
Two-Pole Single-Phase One Trans. One Trip Coil

Fig. 87



Two-Pole Single-Phase Grounded Neutral Two Trans. Two Trip Coils

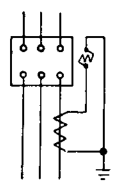
Fig. 88



Three-Pole Single-Phase Three-Wire Two Trans. Two Trip Coils

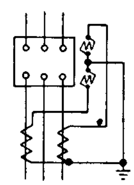
Fig. 89

Three-Phase Circuits



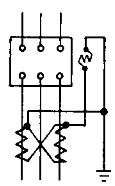
Three-Pole Three-Phase Balanced Load One Trans. One Trip Coil

Fig. 90



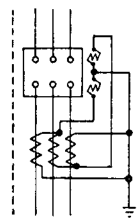
Three-Pole Three-Phase Two Trans. Two Trip Coils

Fig. 91



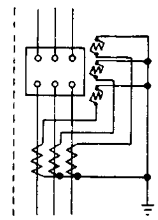
Three-Pole Three-Phase Two Trans. One Trip Coil

Fig. 92



Three-Pole Three-Phase Three Trans. Z-Connected Two Trip Coils

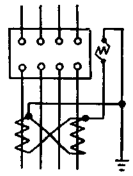
Fig. 93



Three-Pole Three-Phase Three Trans. Y-Connected Three Trip Coils

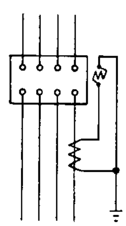
Fig. 94

Two-Phase Circuits



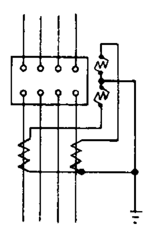
Four-Pole Two-Phase Balanced Load Two Trans. One Trip Coil

Fig. 95



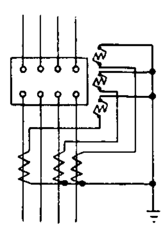
Four-Pole Two-Phase Balanced Load One Trans. One Trip Coil

Fig. 96



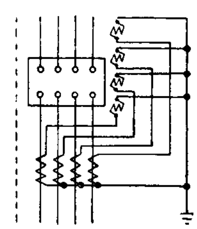
Four-Pole Two-Phase Two Trans. Two Trip Coils

Fig. 97



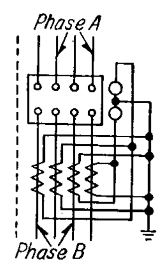
Four-Pole Two-Phase Inter-connected Three Trans. Three Trip Coils

Fig. 98



Four-Pole Two-Phase Four or Five-Wire Four Trans. Four Trip Coils

Fig. 99

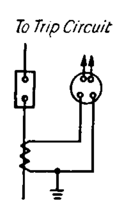


Four-Pole Two-Phase Four or Five-Wire Four Trans. Two Trip Coils

Fig. 100

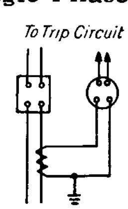
CURRENT-TRANSFORMER TRIP WITH RELAYS

Single-Phase Circuits



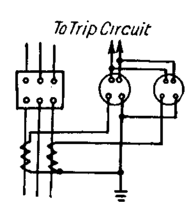
Single-Pole Single-Phase One Trans. One Relay.

Fig. 101



Two-Pole. Single-Phase One Trans. One Relay.

Fig. 102

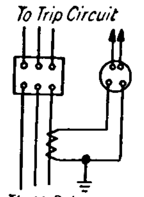


Three-Pole. Single-Phase Three-Wire. Two Trans. Two Relays

Fig. 103

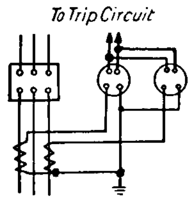
OIL CIRCUIT-BREAKERS

Three-Phase Circuits



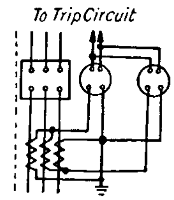
Three-Pole
Three-Phase
Balanced Load
One Trans. One Relay

Fig. 104



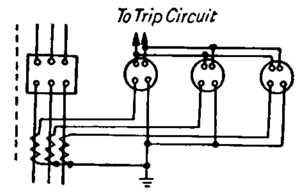
Three-Pole Three-Phase
Two Trans. Two Relays

Fig. 105



Three-Pole Three-Phase
Three-Wire or Four-Wire
Z Connected Ground System
Three Trans. Two Relays

Fig. 106

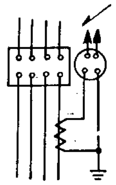


Three-Pole Three-Phase
Three-Wire or Four-Wire
Y-Connected
Three Trans. Three Relays

Fig. 107

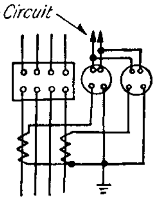
Two-Phase Circuits

To Trip Circuit



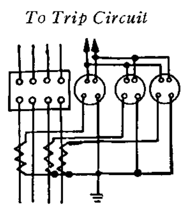
Four-Pole
Two-Phase
Balanced Load
One Transformer
One Relay

Fig. 108



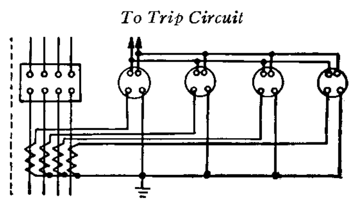
Four-Pole
Two-Phase
Two Transformers
Two Relays

Fig. 109



Four-Pole.
Two-Phase.
Inter-connected
Three Transformers,
Three Relays

Fig. 110



Four-Pole Two-Phase
Four or Five-Wire
Four Trans. Four Relays

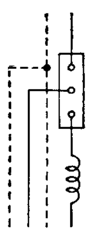
Fig. 111

DOUBLE-THROW BREAKERS

SERIES TRIP

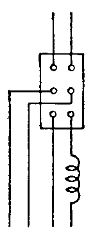
Single-Phase Circuits

Automatic Both Breaker Positions | **Automatic One Breaker Position only**



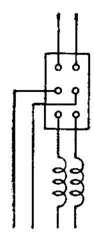
Single-Pole
Single-Phase
One Trip Coil

Fig. 112



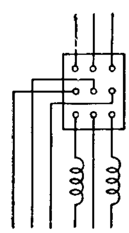
Two Pole
Single-Phase
One Trip Coil

Fig. 113



Two Pole
Single-Phase
Two Trip Coils

Fig. 114

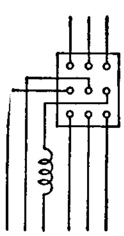


Three-Pole
Three-Phase
Three-Wire
Two Trip Coils

Fig. 115

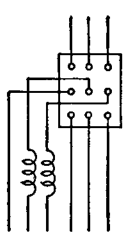
Three-Phase Circuits

Automatic Both Breaker Positions | **Automatic One Breaker Position Only**



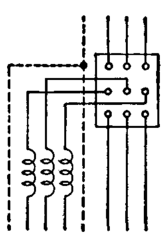
Three-Pole
Three-Phase
Balanced Load
One Trip Coil

Fig. 116



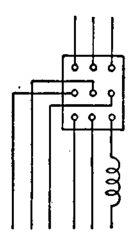
Three-Pole
Three-Phase
Two Trip Coils

Fig. 117



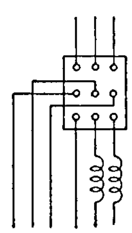
Three-Pole.
Three-Phase.
Three or Four-Wire
Three Trip Coils

Fig. 118



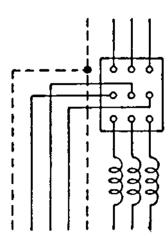
Three-Pole
Three-Phase
Balanced Load
One Trip Coil

Fig. 119



Three-Pole
Three-Phase
Two Trip Coils

Fig. 120



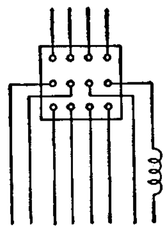
Three-Pole
Three-Phase
Three or Four-Wire
Three Trip Coils

Fig. 121

OIL CIRCUIT-BREAKERS

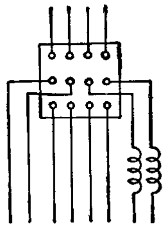
Two-Phase Circuits

Automatic Both Breaker Positions



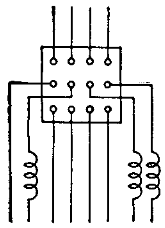
Four-Pole
Two-Phase
Balanced Load
One Trip Coil

Fig. 122



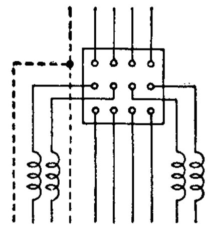
Four-Pole
Two-Phase
Two Trip Coil

Fig. 123



Four-Pole
Two-Phase
Four-Wire
Three Trip Coils

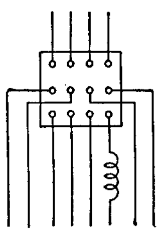
Fig. 124



Four-Pole
Two-Phase
Four or Five-Wire
Four Trip Coils

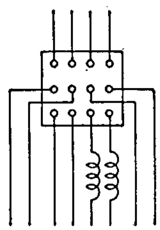
Fig. 125

Automatic One Breaker Position Only



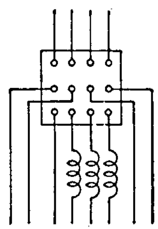
Four-Pole
Two-Phase
Balanced Load
One Trip Coil

Fig. 126



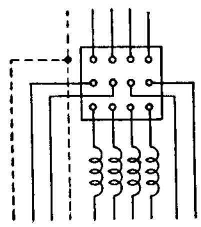
Four-Pole
Two-Phase
Two Trip Coils

Fig. 127



Four-Pole
Two-Phase
Four-Wire
Three Trip Coils

Fig. 128



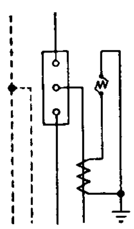
Four-Pole
Two-Phase
Four or Five-Wire
Four Trip Coils

Fig. 129

CURRENT-TRANSFORMER-TRIP WITHOUT RELAYS

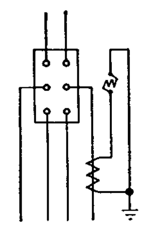
Single-Phase Circuits

Automatic Both Breaker Positions



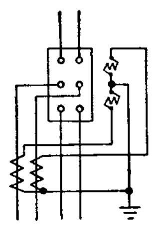
Single-Pole
Single-Phase
One Trans.
One Trip Coil

Fig. 130



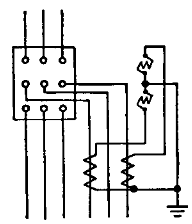
Two-Pole
Single-Phase
One Trans.
One Trip Coil

Fig. 131



Two-Pole
Single-Phase
Grounded Neutral
Two Trans.
Two Trip Coils

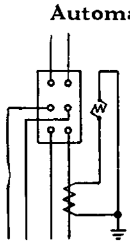
Fig. 132



Three-Pole
Single-Phase
Three Wire
Two Trans.
Two Trip Coils

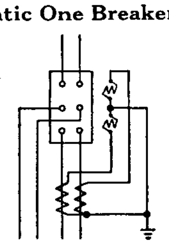
Fig. 133

Automatic One Breaker Position Only



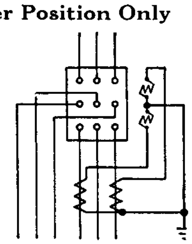
Two-Pole
Single-Phase
One Trans
One Trip Coil

Fig. 134



Two-Pole
Single-Phase
Two Trans
Two Trip Coils

Fig. 135



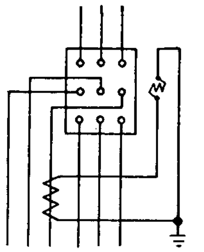
Three-Pole
Single-Phase
Three-Wire
Two Trans
Two Trip Coils

Fig. 136

OIL CIRCUIT-BREAKERS

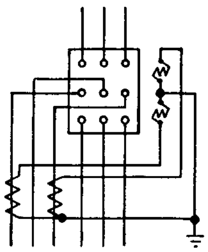
Three-Phase Circuits

Automatic Both Breaker Positions



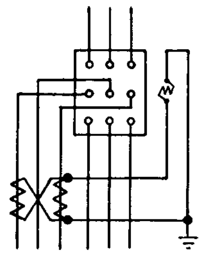
Three-Pole
Three-Phase
Balanced Load
One Transformer
One Trip Coil

Fig. 137



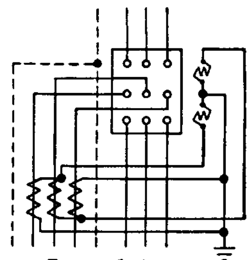
Three-Pole
Three-Phase
Two Transformers
Two Trip Coils

Fig. 138



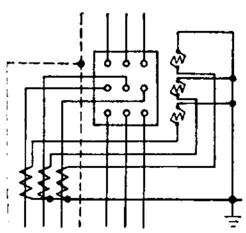
Three-Pole
Three-Phase
Two Transformers
One Trip Coil

Fig. 139



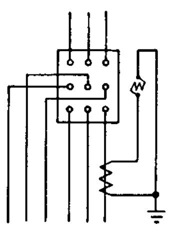
Three-Pole
Three-Phase
Three or Four-Wire
Z-Connected
Three Transformers
Two Trip Coils

Fig. 140



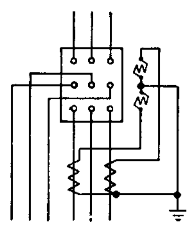
Three-Pole
Three-Phase
Three or Four-Wire
Y-Connected
Three Transformers
Three Trip Coils

Fig. 141



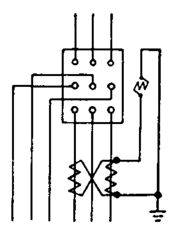
Three-Pole
Three-Phase
Balanced Load
One Trans.
One Trip Coil

Fig. 142



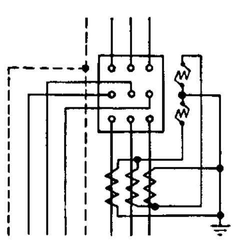
Three-Pole
Three-Phase
Two Trans
Two Trip Coils

Fig. 143



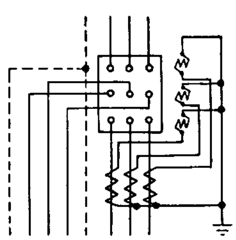
Three-Pole
Three-Phase
Two Trans
One Trip Coil

Fig. 144



Three-Pole
Three-Phase
Three or Four-Wire
Z-Connected
Three Trans
Two Trip Coils

Fig. 145

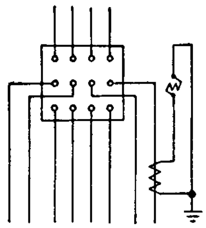


Three-Pole
Three-Phase
Three or Four-Wire
Three Trans
Three Trip Coils
Y-Y Connected

Fig. 146

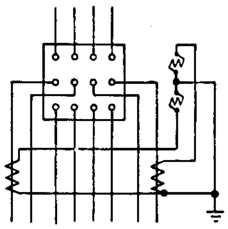
Two-Phase Circuits

Automatic Both Breaker Positions



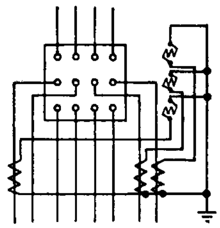
Four-Pole
Two-Phase
Balanced Load
One Transformer
One Trip Coil

Fig. 147



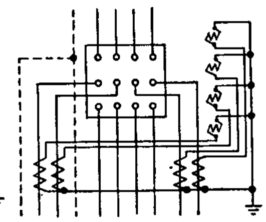
Four-Pole
Two-Phase
Two Transformers
Two Trip Coils

Fig. 148



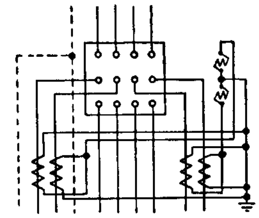
Four-Pole
Two-Phase
Inter-connected
Three Transformers
Three Trip Coils

Fig. 149



Four-Pole
Two-Phase
Four or Five-Wire
Four Trans
Four Trip Coils

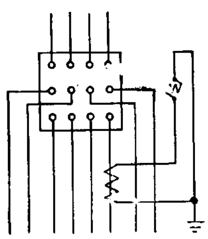
Fig. 150



Four-Pole
Two-Phase
Four or Five-Wire
Four Trans
Two Trip Coils

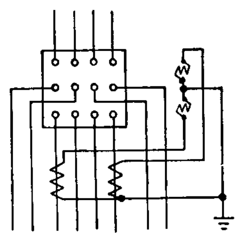
Fig. 151

Automatic One Breaker Position Only



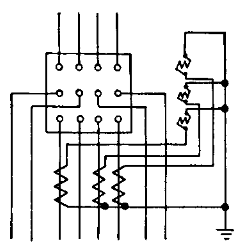
Four-Pole
Two-Phase
Balanced Load
One Trans
One Trip Coil

Fig. 152



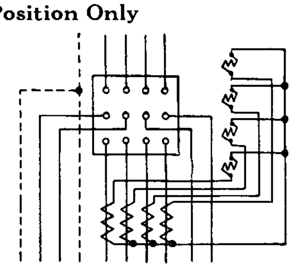
Four-Pole
Two-Phase
Two Trans
Two Trip Coils

Fig. 153



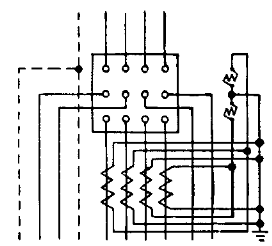
Four-Pole
Two-Phase
Inter-connected
Three Transformers
Three Trip Coils

Fig. 154



Four-Pole
Two-Phase
Four or Five-Wire
Inter-connected
Four Transformers
Four Trip Coils

Fig. 155

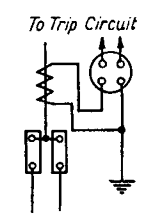


Four-Pole
Two-Phase
Four or Five-Wire
Inter-connected
Four Transformers
Vector Parrallel
Two Trip Coils

Fig. 156

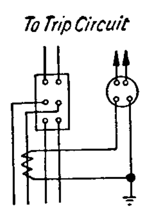
Single-Phase Circuits

Automatic Both Breaker Positions



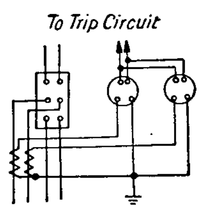
Single-Pole
Single-Phase
One Transformer
One Relay

Fig. 157



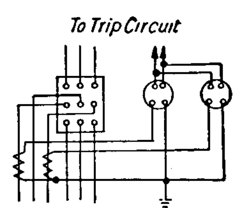
Two-Pole
Single-Phase
One Transformer
One Relay

Fig. 158



Two-Pole
Single-Phase.
Two Transformers
Two Relays

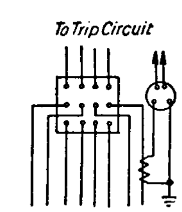
Fig. 159



Three-Pole Single-Phase
Three-Wire
Two Transformers
Two Relays

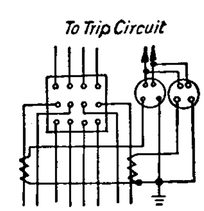
Fig. 160

Two-Phase Circuits



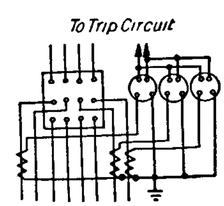
Four-Pole Two-Phase
Balanced Load.
One Transformer One Relay

Fig. 161



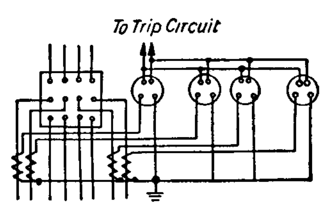
Four-Pole. Two-Phase
Two Transformers. Two Relays.

Fig. 162



Four-Pole Two-Phase
Three Transformers Three Relays

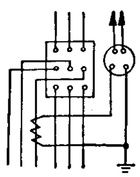
Fig. 163



Four-Pole. Two-Phase
Four or Five-Wire
Four Transformers
Four Relays

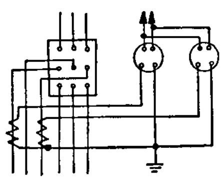
Fig. 164

Three-Phase Circuits



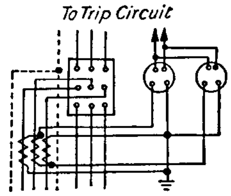
Three-Pole Three-Phase
Balanced Load
One Transformer
One Relay

Fig. 165



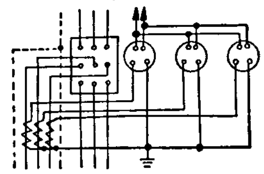
Three-Pole Three-Phase
Two Transformers
Two Relays

Fig. 166



Three-Pole Three-Phase
Three or Four-Wire,
Grounded Systems
Three Transformers Two Relays
Z-Connected

Fig. 167



Three-Pole Three-Phase
Three or Four-Wire
Three Transformers Three Relays
Y-Connected

Fig. 168

Oil Circuit-Breaker Wiring Diagrams—Control Schemes

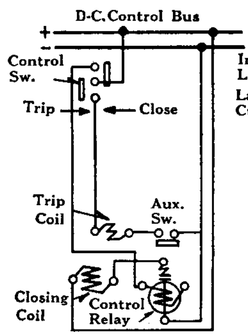


Fig. 169

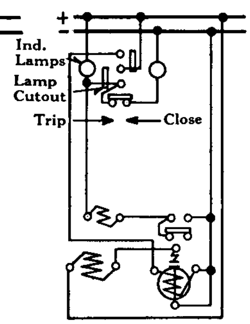


Fig. 170

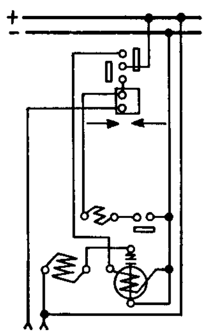


Fig. 171

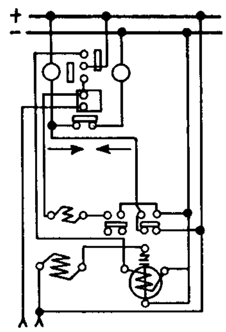


Fig. 172

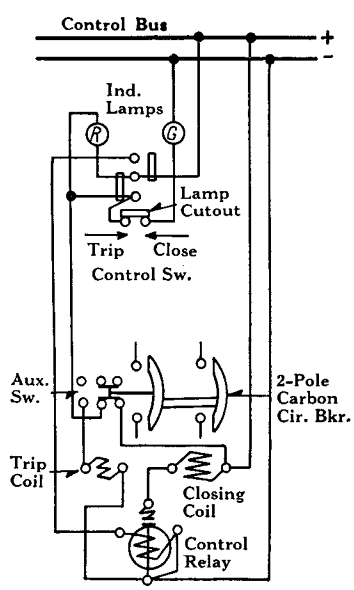


Fig. 173—Diagram of Connections. Control Scheme for Type CL Carbon Circuit-Breakers.

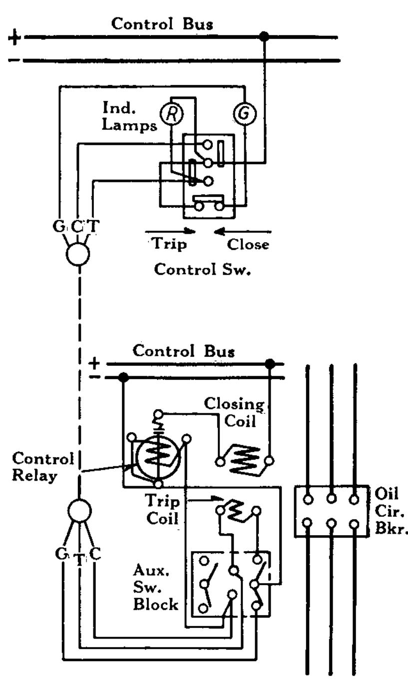


Fig. 174—Diagram of Connections. Control Scheme of Type F-22 Oil Circuit-Breakers.

Note—Auxiliary Switches shown for the open position of the Breaker. Relay Contacts are shown in the de-energized position of the Relay.

Diagram of Connections—Shunt Trip and Undervoltage Trip Circuits

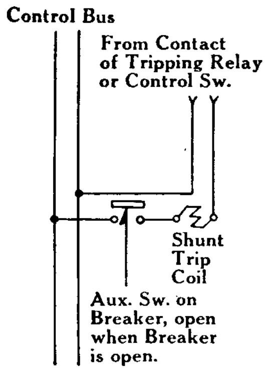


Fig. 175
Connections for Shunt Trip Coil

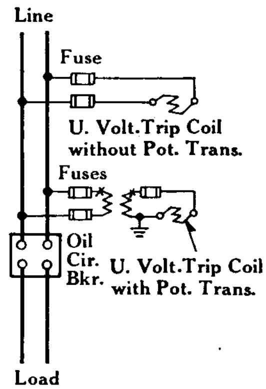


Fig. 176
Connections for Self-Re-setting Type of Under-Voltage Device

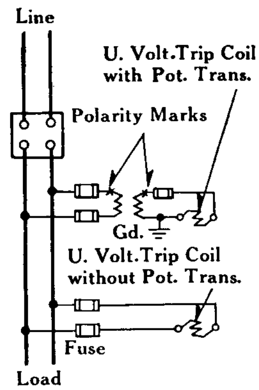


Fig. 177
Connections for Hand-Re-setting Type of Under-Voltage Device

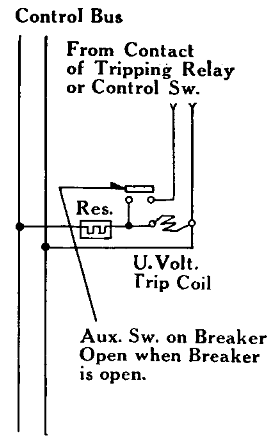


Fig. 178
Connections for Under-Voltage Trip Coil and Resistance used with a Circuit-Closing Tripping Device

Notes—Energizing trip free relay operating coil closes the relay contacts. Energizing the relay release coil opens the relay contacts which remain open until the relay operating circuit is de-energized and again energized. Auxiliary switches are shown for the open position of the breaker. Relay contacts are shown for the de-energized position of the relay.

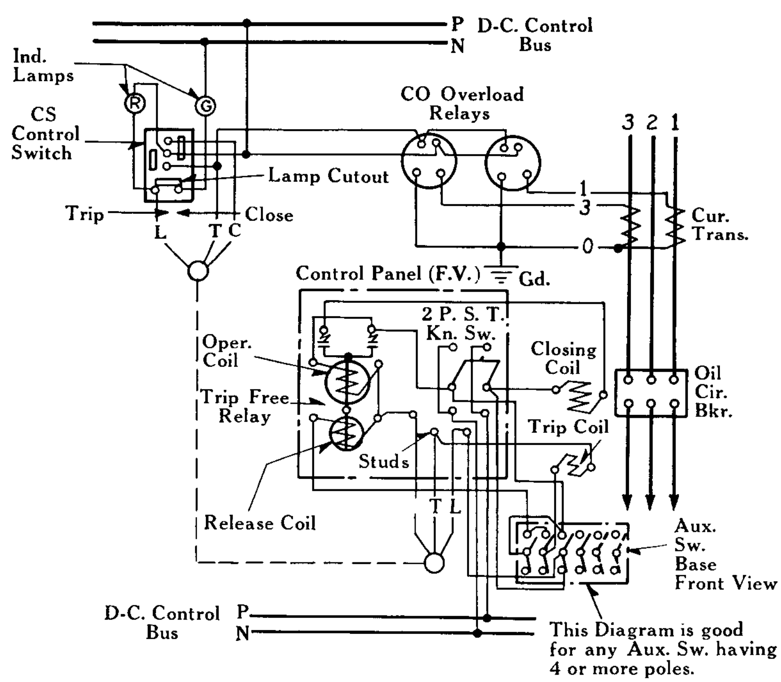


Fig. 179—Oil Circuit-Breaker Panel Control Scheme Using a Trip Free Relay Control Panel and Separately Mounted Knife Type Auxiliary Switch.

NOTES—Energizing trip free relay operating coil closes the relay contacts. Energizing the relay release coil opens the relay contacts which remain open until the relay operating circuit is de-energized and again energized. Auxiliary switches are shown for the open position of the breaker. Relay contacts are shown in the de-energized position of the relay.

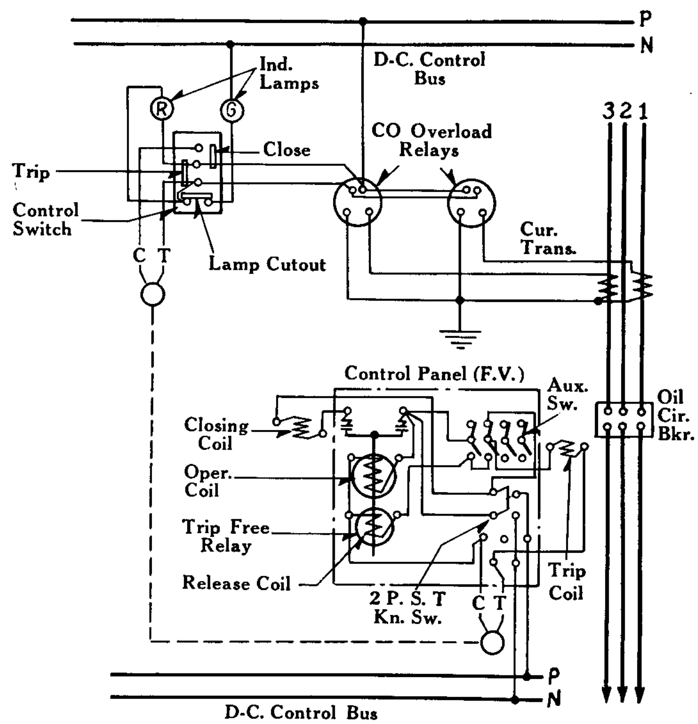


Fig. 180—Oil Circuit-Breaker Panel Control Scheme Using a Trip Free Relay Control Panel with Knife Type Auxiliary Switch Mounted on the Control Panel.

NOTES—Energizing the trip free relay operating coil closes the relay contacts. Energizing the relay release coil opens the relay contacts which remain open until the relay operating circuit is de-energized and again energized. Auxiliary switches are shown for the open position of the breaker. Relay contacts are shown for the de-energized position of the relay.

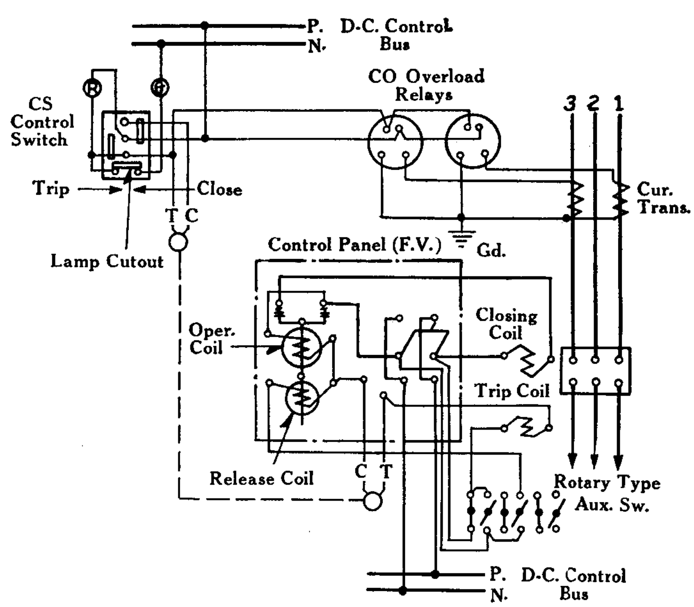


Fig. 181—Oil Circuit-Breaker Panel Control Scheme Using a Trip Free Relay Control Panel with Separately Mounted Rotary Type Auxiliary Switch.

NOTES—To close the breaker the "C" wire is energized which closes the closing contactor thus energizing the closing coil of the breaker. The cut off relay is energized through the breaker auxiliary switch in the closed position. Thus de-energizing the closing contactor which remains de-energized until the "C" wire is de-energized and again energized. Auxiliary switches are shown for the open position of the breaker. Contactors are shown in the de-energized position.

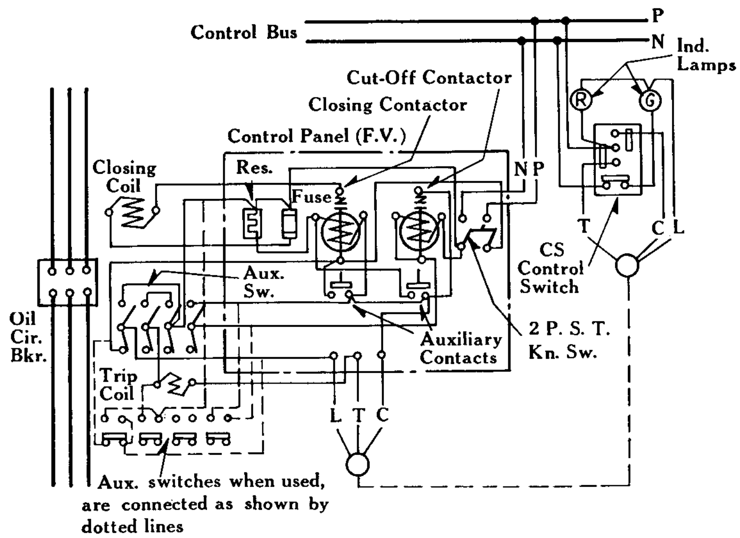


Fig. 182—Oil Circuit-Breaker Panel Control Scheme Using a Trip Free Relay Control Panel Consisting of the Contactors Equipped with Auxiliary Contacts. The Breaker Auxiliary Switches Are Mounted Apart from the Control Panel.

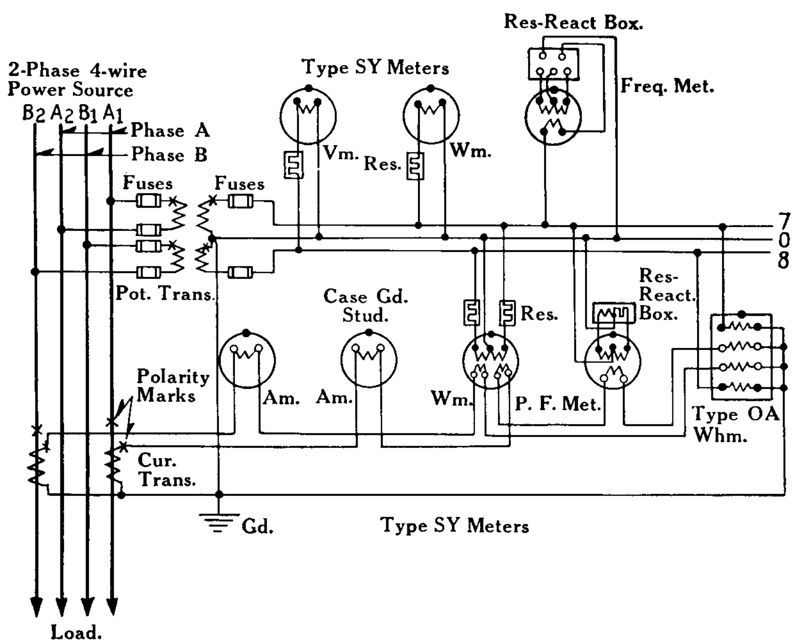


Fig. 183—Metering Equipment on 2-Phase, 4-Wire Circuit—Diagram of Connections

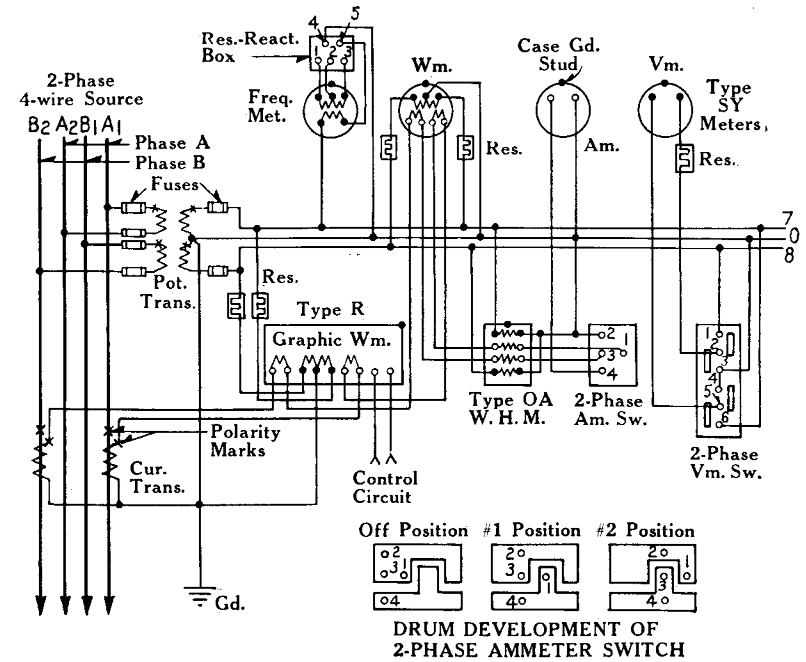


Fig. 184—Metering Equipment on Two-Phase Four-Wire Circuit—Diagram of Connections

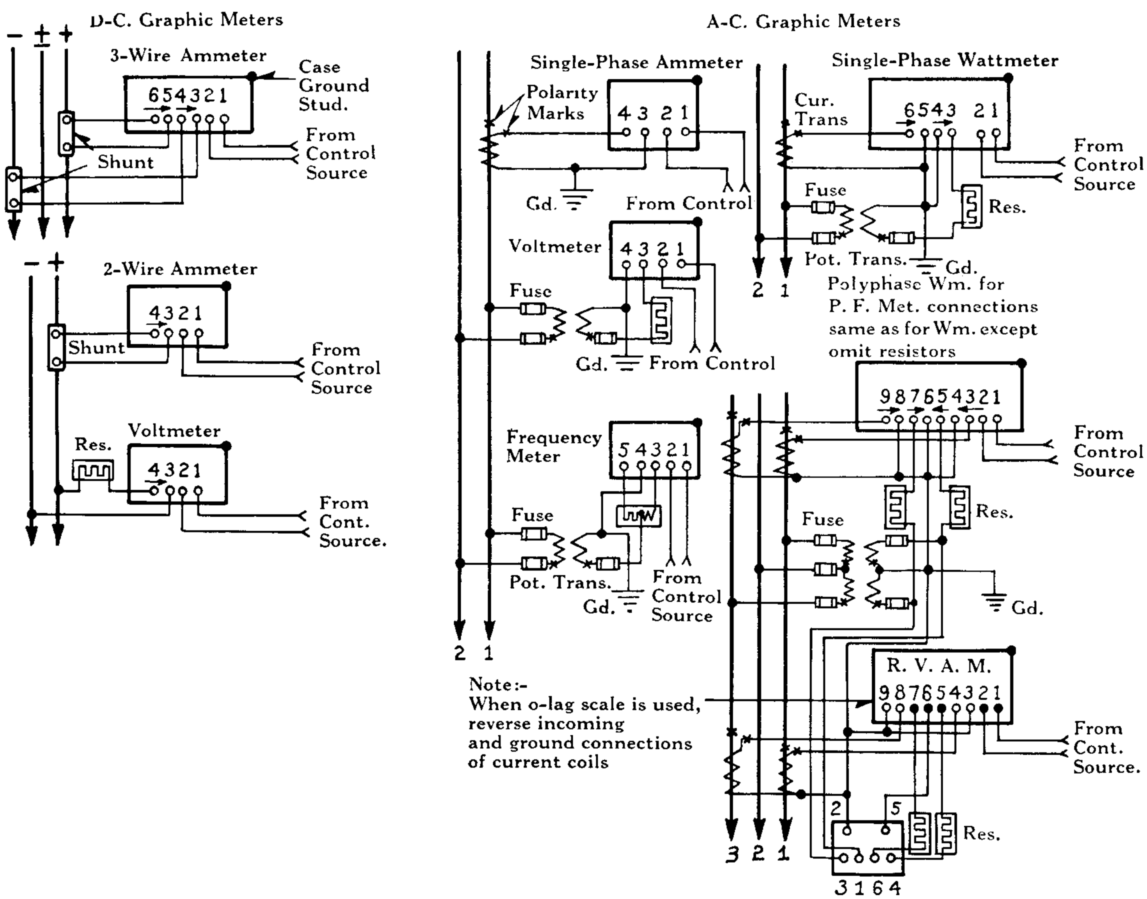


Fig. 185—Type R Graphic Meters—Rear View —Diagram Information

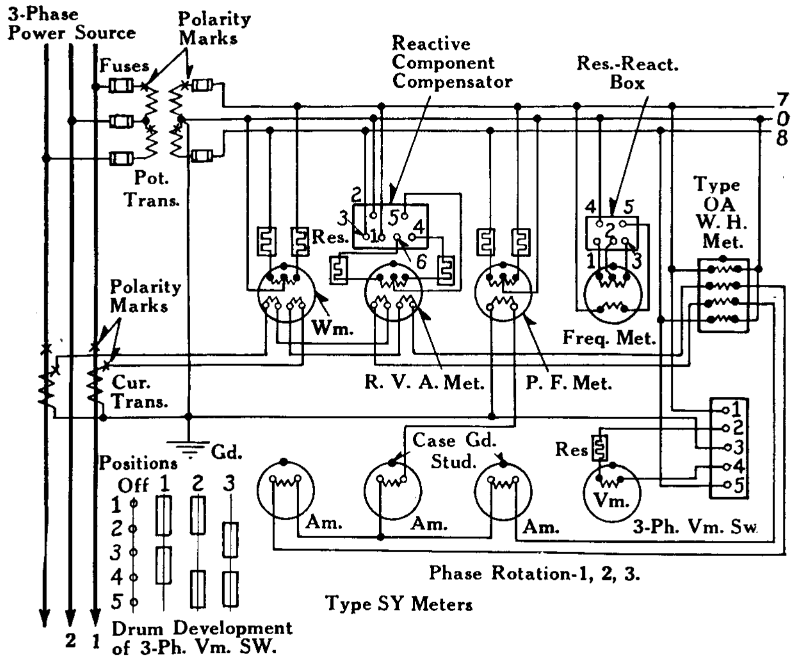


Fig. 186—Metering Equipment on Three-Phase, Three-Wire Circuit

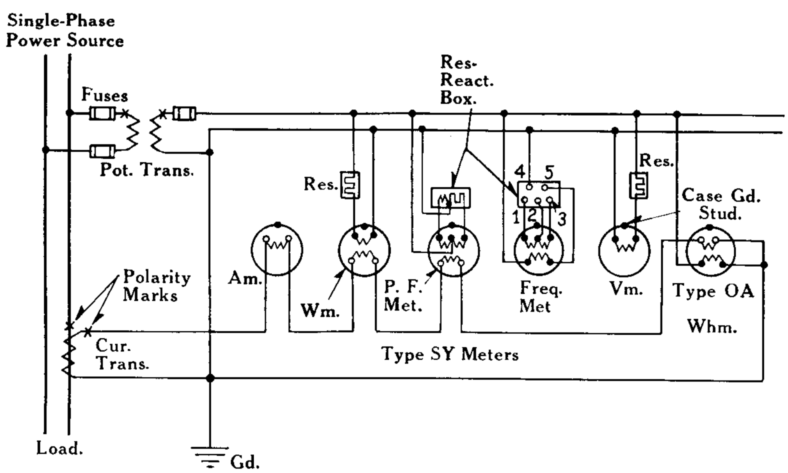


Fig. 187—Connections for Type OA and Type SY Meters on Single-Phase Two-Wire Circuits

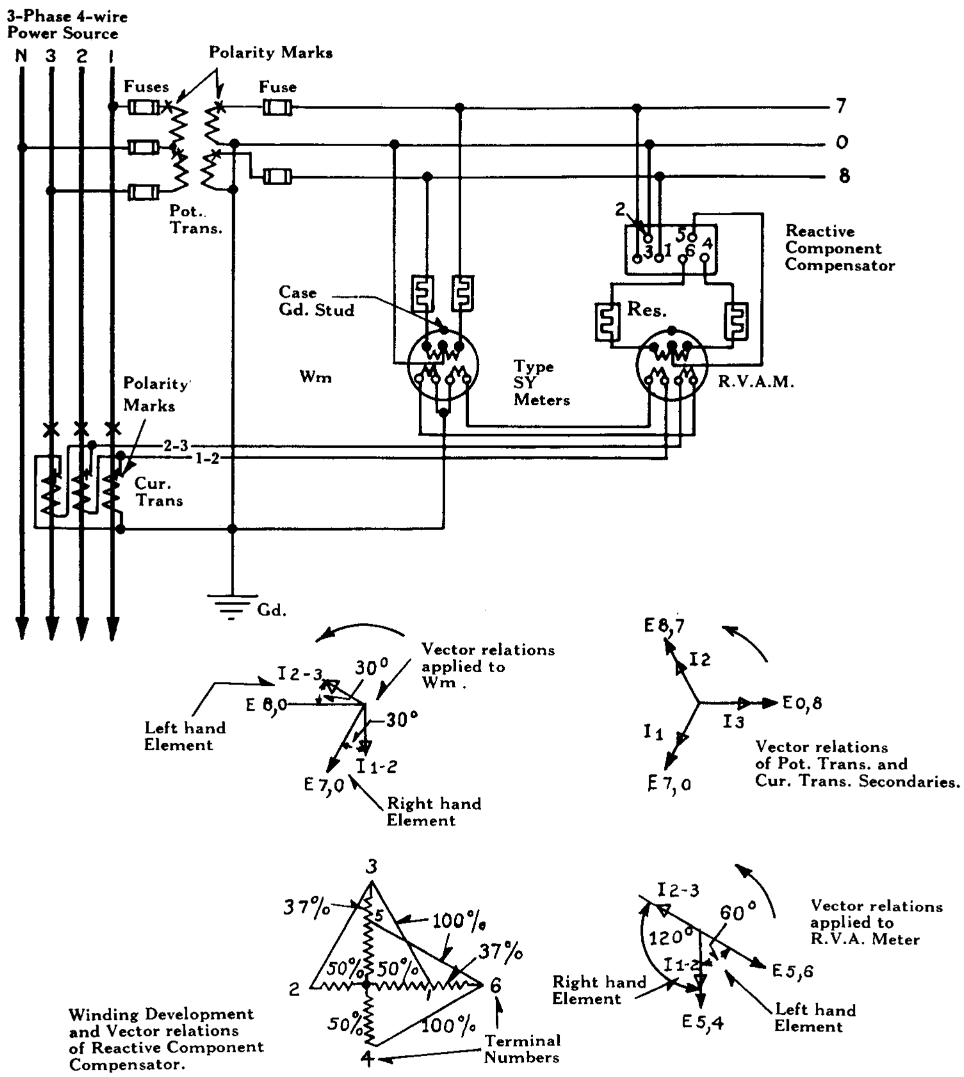


Fig. 188—Type SY Wattmeter and Reactive Volt-Ampere Meter on the Phase Four-Wire Circuits—Diagram of Connections.

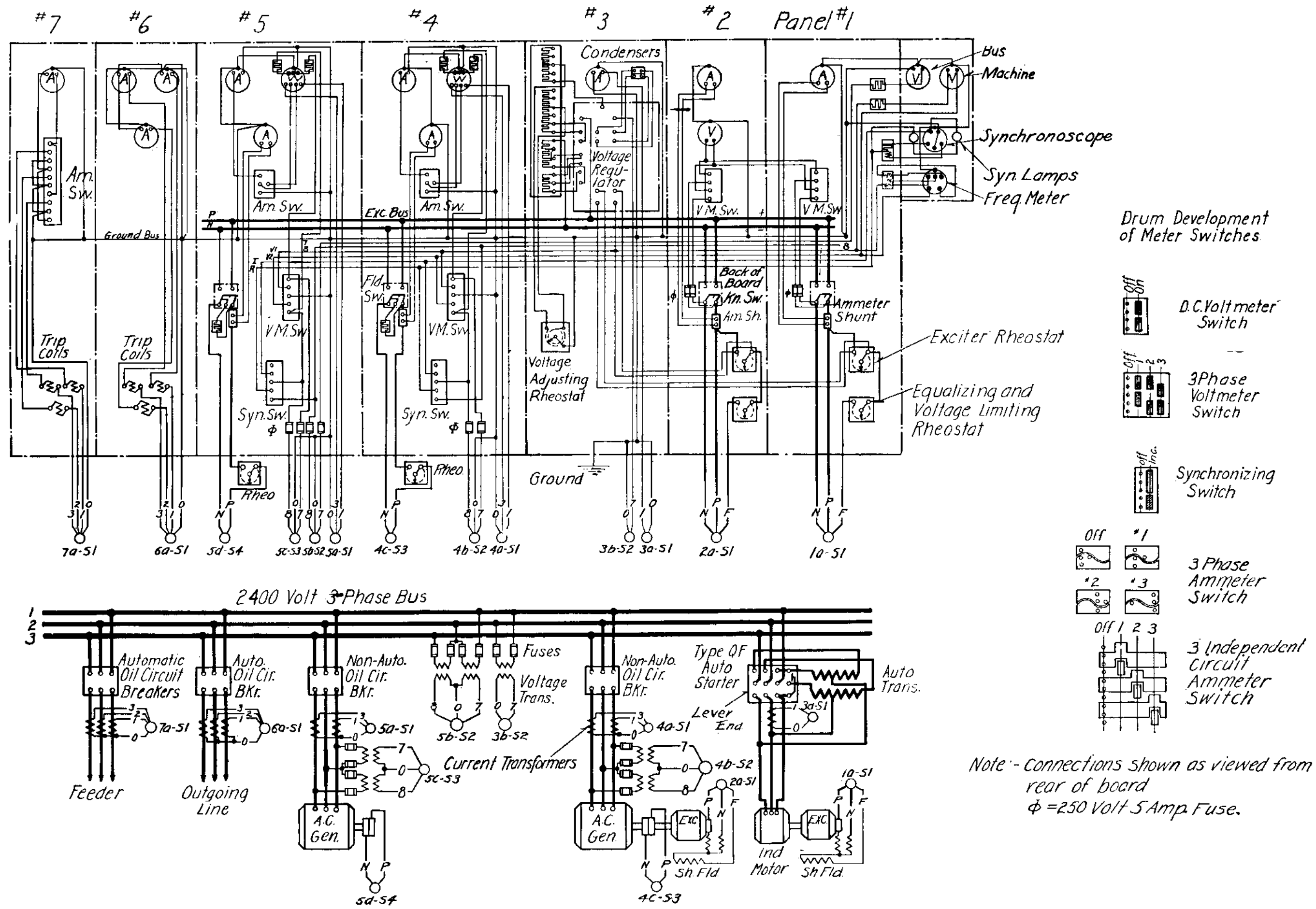


Fig. 189—Typical Wiring Diagram of a 7-Panel Switchboard

SWITCHBOARD DIAGRAMS

Switchboard diagrams are prepared showing the connections on the panels as viewed from the rear.

On Westinghouse diagrams, the bus bars are always shown by the heaviest weight of line, main connections by medium weight and the small wiring connections by light lines as shown in Fig. 70.

Insofar as practicable the lines on all switchboard diagrams are grouped to correspond with the arrangement that is to be used in wiring the panels. The diagrams are not to scale but may be used to determine the order of conduit arrangement.

In all cases, it is desirable to refer to the detail diagrams and instruction books sent with transformers, synchronous converters, generators, motors and other apparatus before completing their connections.

INSULATING DISTANCES FOR SWITCHBOARDS

The following tables of insulating clearances apply particularly to Westinghouse switchboards. It will be noted that tables for striking and creeping distances are given for systems where the capacity does not exceed 150 kv-a. and another above 150 kv-a. All secondary connections from instrument transformers are classed as less than 150 kv-a. capacity. The following applies to connections and bare parts mounted on Power Switchboards but do not apply to individual pieces of apparatus.

INSULATION DATA

MINIMUM CLEARANCE IN INCHES BETWEEN LIVE PARTS OR BARE CONDITIONS

Indoor Application on Switchboard Circuits Connected to Systems up to 150 Kv-a. Capacity or Wiring Connected to the Secondary of Instrument Transformers

Creeping Distance — When Mounted on Same Surface of Insulating Panels as Shown in Fig. 190-A Only.		Voltage Class — For Intermediate Voltages, it is Advisable to Use the Distances Given for the Next Higher Voltage Class	Striking Distances — When Rigidly Supported and Clear of Surfaces.	
Between Parts of Opposite Polarity	Between Live Parts and Ground		Between Parts of Opposite Polarity	Between Live Parts and Ground
3/8	1/4	Up to 50	1/4	1/8
1/2	3/8	125	3/8	1/4
5/8	1/2	250	3/8	1/4
1	3/4	600	1/2	3/8
1 1/4	1 1/4	750	3/4	3/4
1 3/4	1 3/4	1500	1 1/4	1 1/4
2 1/2	2 1/2	2500	2	2
3	3	3500	2 1/2	2 1/2

When one side of a circuit is permanently grounded, the clearance class for parts of opposite polarity should be used.

For voltages above 3500 all live parts should be supported on insulating pillars.

Clearances in table above do not apply within the proximity of an electric arc. Where arcs are likely to occur, non-combustible barriers should be used above 250 V., D-C. or 500 V., A-C. Where conditions are similar to Fig. 190-B greater spacings are required. For Fig. 190-C smaller spacing may be used.

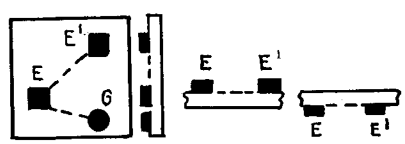
E and E' = Parts of opposite polarity.
G = Ground.
(. . . . . .) Creeping distances over surface.

Voltage Limits for Panel Material:

Slate up to 750 V.

Marble up to 2500 V.

Micarta and Ebony Asbestos up to 3500 V.



Vertical — Horizontal

A B C

Methods of Mounting

Fig. 190

INSULATION DATA—Continued

Indoor Application on Switchboard Circuits Connected to Systems above 150 Kv-a. capacity

Creeping Distances — When Mounted on Same Surface of Insulating Panels as Shown in Fig. 190-A Only.		Voltage Class — For Intermediate Voltages, it is Advisable to Use the Distances Given for the Next Higher Voltage Class	Striking Distances — When Rigidly Supported and Clear of Surface	
Between Parts of Opposite Polarity	Between Live Parts and Ground		Between Parts of Opposite Polarity	Between Live Parts and Ground
1	1/2	125	1/2	3/8
1 1/4	5/8	250	3/4	3/8
2	1	600	1	1/2
2 1/8	1 1/4	750	1 1/4	3/4
2 1/2	1 3/4	1500	1 3/4	1 1/4
3	2 1/2	2500	2 1/2	2
3 1/2	3	3500	3	2 1/2

When one side of a circuit is permanently grounded, the clearance class for points of opposite polarity should be used.

MINIMUM CLEARANCES IN INCHES BETWEEN LIVE PARTS OR BARE CONDUCTORS IN AIR

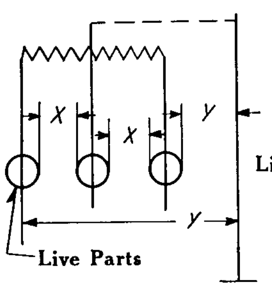
For Rigid Conductors Only when Supported Clear of Surface.
For Flexible Conductors Increase Clearances Given by Twice the Maximum Sag.
Smaller Spacings may be Used for Standard Apparatus When All Parts are Shaped to Minimize Electrostatic Stresses.

Indoors		Voltage Class	Outdoors	
(See Figs. 191 to 193) Phase to Phase X	To Ground Y	For Intermediate Voltages, it is Advisable to Use the Distances Given for the Next higher Voltage Class	(See Figs. 191 to 193) Phase to Phase X	To Ground Y
		Up to 3500	6	6
3 1/2	2 1/2	4500	6	6
4	3 1/4	7500	6	6
7	5 1/2	15000	12	9
11	8 1/2	25000	17	13
16	12	37000	24	18
21	16	50000	32	23
30	23	73000	44	32
36	28	88000	52	38
45	34	110000	64	47
54	41	132000	77	56
63	47	154000	89	65
76	57	187000	106	78
89	67	220000	124	90

Voltage classes up to 73000 inc. are maximum allowable.

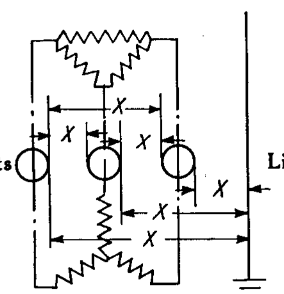
Voltage classes above 73000 are nominal and a variation of + or — 5% may be allowed, without changing the values given.

For voltages 187,000 and above, corona shields should be used.



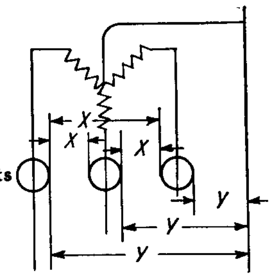
Single Ph. or Quarter Ph. with Neutral Grounded or Ungrounded.

Fig. 191



Three Ph. Delta or Star Connected Ungrounded.

Fig. 192



Three-Phase Star Connected Grounded Neutral

Fig. 193

CONDUIT

Bending Conduit—If a comparatively small amount of conduit is involved the "hickey" or the "peg" method may be used for bending. Fig. 194 illustrates the use of these different types of conduit benders. If there is an appreciable amount involved it may be best to have an approved conduit bender on the job. The type of bender to use depends largely on the size and amount to be bent.

The "hickey" is made up of a piece of 1¼ inch pipe about four feet long with a pipe tee screwed on one end. The conduit to be bent is laid on the floor and the tee slid to the point of bending and slightly pulled and then readjusted, this pulling and readjusting should be continued until the conduit has been bent to the desired angle. Extreme care should be exercised, however, to see that readjustments are made long and often to prevent the conduit from buckling.

The "peg" consists of two pieces of pipe or pegs sunk into a two-inch plank or platform approximately three inches apart. The conduit to be bent should then be placed between the two upright pegs and one end of conduit pulled slightly then readjusted and pulled

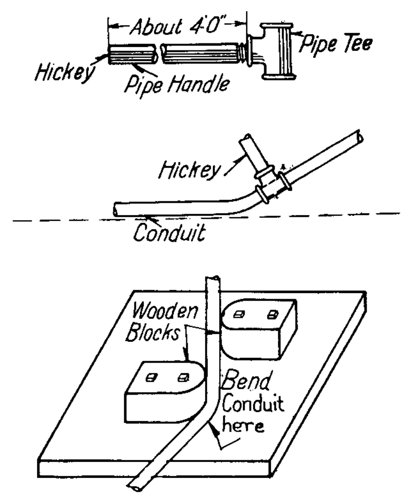


Fig. 194—Conduit Bender

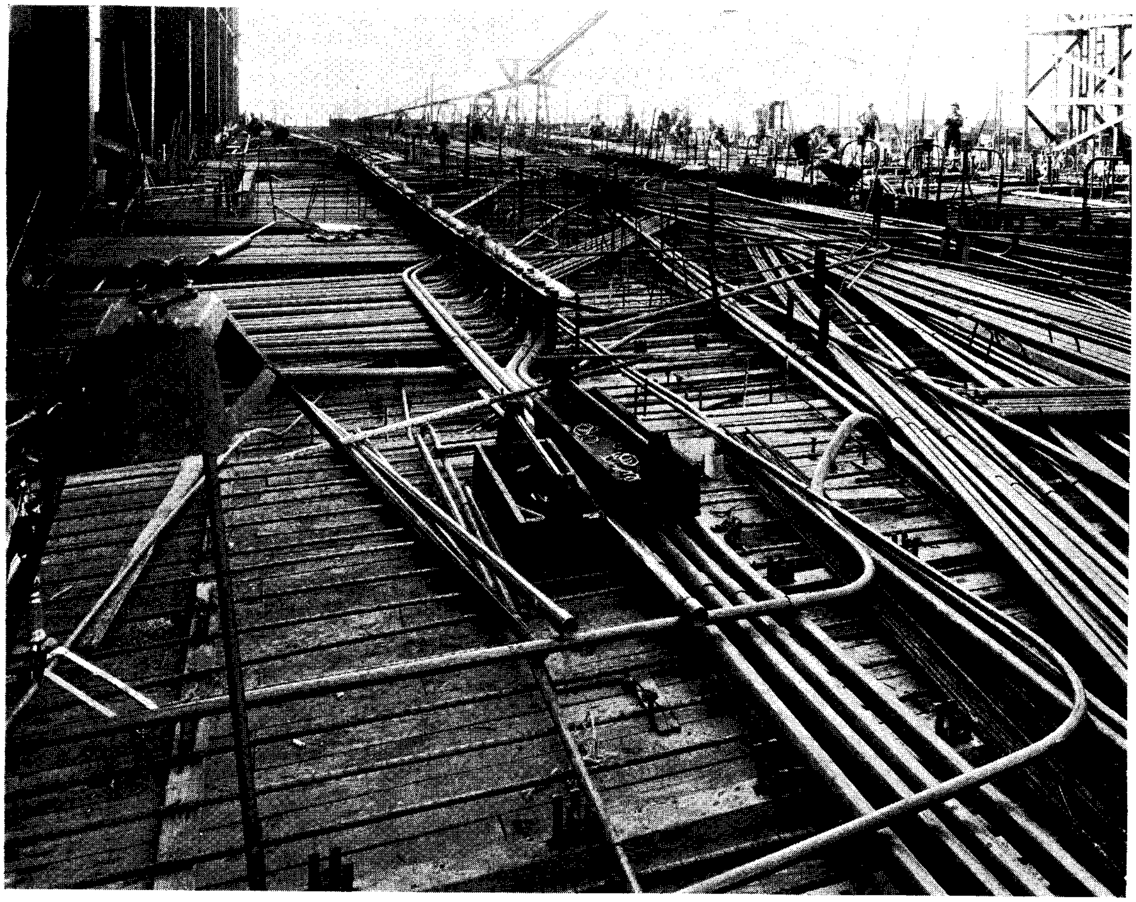


Fig. 195—An installation of conduit just before pouring concrete floor. Note particularly the template method of holding conduits in position.

again. This readjusting and pulling should be continued until the conduit is bent at the desired angle. Two blocks may also be securely bolted to a plank or platform as shown in the figure. If conduit is not constantly readjusted when bending it will flatten on curvature and be unsatisfactory.

Conduit elbows are recommended for all conduit which is too large to be bent satisfactorily in the field.

Installing Conduit—The ends of all conduit should be reamed before joining together. It is recommended that bushings be used at all pull box outlets. Conduit fittings may often be used when terminating at motors, electrically operated oil circuit-breaker, etc.

All conduit ends should be plugged with wooden plugs to prevent entrance of foreign matter. These plugs should be removed only when ready to pull cable through. The conduit should also be cleaned out by drawing a rag through it before pulling cables.

The National Electric Code states that all elbows or bends must be so made that the conduit will not be injured. The radius of the curve of the inner edge of any elbow must not be less than seven times the diameter of the conduit to be bent and must have not more than the equivalent of four quarter bends from outlet to outlet, the bends at outlets not being counted. Pull boxes should be used instead of bends in conduit when the heavier cables are involved.

When laying conduit in concrete, care should be taken to see that all joints are water tight. It is recommended that either a pipe compound or white lead be used on the threads before joining together.

On account of the strain imposed on conduit when pulling cable through, it should be rigidly supported.

Care should be exercised to see that a sufficient number of conduits of the proper sizes have been provided before pouring concrete.

Fig. 195 shows an installation of conduit just before pouring the floor. Note the templates used for holding the conduit in place.

Where iron conduit is used it is essential to run all wires of a single-phase or polyphase circuit in the same conduit. If this is impossible the use of tile or fibre conduit is recommended.

Cable or conductor supports must be so designed so that there will be no loop of magnetic material around one conductor which does not loop around all conductors of a single or polyphase circuit. Otherwise there will be considerable heating of the magnetic material.

It is essential to ground iron conduits carrying primary or secondary cables.

It is recommended that the diameter of conduit be at least 30 percent larger than the outside diameter of the cable to be pulled through.

Pulling Cable Through Conduit—For pulling wire and cable through conduit, a flexible steel ribbon, commonly called a "fish wire" or "snake", is first run through the conduit. If the cable to be pulled is not too heavy it may be attached to the "fish wire" and pulled through the conduit. When long runs of heavy control wire or cable are to be pulled through conduit, the "fish wire" should be followed by a heavier wire or light rope. The cable should then be securely fastened to this wire or rope and the junction taped to prevent the end of the cable from catching in the conduit. Talc or soapstone dust on the cable will allow it to be pulled through and around bends in the conduit more easily.

Interior Conduit—Where single conductor, single braid, solid wires only are used, four No. 14 wires may be installed in a ½ inch conduit and up to seven No. 14 wires in a ¾ inch conduit. Three No. 12 wires may be installed in a ½ inch conduit. Four No. 10 wires or three No. 8 wires may be installed in a ¾ inch conduit.

Sizes of conduit given in the following table are standard electrical trade sizes.

Size of Conduit for the Installation of Wires or Cables

This table applies to complete conduit systems and not to short sections of conduit used for the protection of exposed wiring from mechanical injury

Two-Wire or Three-Wire Systems

Size of Conductor B & S Gage	—Number of Conductors in One Conduit— 1	2	3	4	5	6	7	8	9
	—Minimum Size of Conduit in Inches—								
14	½	½	½	¾	¾	1	1	1	1
12	½	½	¾	¾	¾	1	1	1	1¼
10	½	¾	¾	1	1	1	1¼	1¼	1¼
8	½	¾	1	1	1	1¼	1¼	1¼	1¼
6	½	1	1¼	1¼	1½	1½	2	2	2
5	¾	1¼	1¼	1¼	1½	2	2	2	2
4	¾	1¼	1¼	1½	2	2	2	2	2½
3	¾	1¼	1¼	1½	2	2	2	2½	2½
2	¾	1¼	1½	1½	2	2	2½	2½	2½
1	¾	1½	1½	2	2	2½	2½	3	3
0	1	1½	2	2	2½	2½	3	3	3
00	1	2	2	2½	2½	3	3	3	3½
000	1	2	2	2½	3	3	3	3½	3½
0000	1¼	2	2½	2½	3	3	3½	3½	4
200000 C.M.	1¼	2	2½	2½	3	3	3½	3½	4
225000	1¼	2½	2½	3	3	3½			
250000	1¼	2½	2½	3	3	3½			
300000	1¼	2½	3	3	3½	3½			
350000	1¼	2½	3	3½	3½	4			
400000	1¼	3	3	3½	4	4			
450000	1½	3	3	3½	4	4½			
500000	1½	3	3	3½	4	4½			
550000	1½	3	3½	4	4½	5			
600000	2	3	3½	4	4½	5			
650000	2	3½	3½	4					
700000	2	3½	3½	4½					
750000	2	3½	3½	4½					
800000	2	3½	4	4½					
850000	2	3½	4	4½					
900000	2	3½	4	4½					
950000	2	4	4	5					
1 000000	2	4	4	5					
1 100000	2½	4	4½	6					
1 200000	2½	4½	4½	6					
1 250000	2½	4½	4½	6					
1 300000	2½	4½	5	6					
1 400000	2½	4½	5	6					
1 500000	2½	4½	5	6					
1 600000	2½	5	5	6					
1 700000	3	5	5	6					
1 750000	3	5	5	6					
1 800000	3	5	6	6					
1 900000	3	5	6						
2 000000	3	5	6						

Note—The above is from Table I, Article 5, N. E. C. 1925 and applies to conduit wire with N. E. C. insulation.

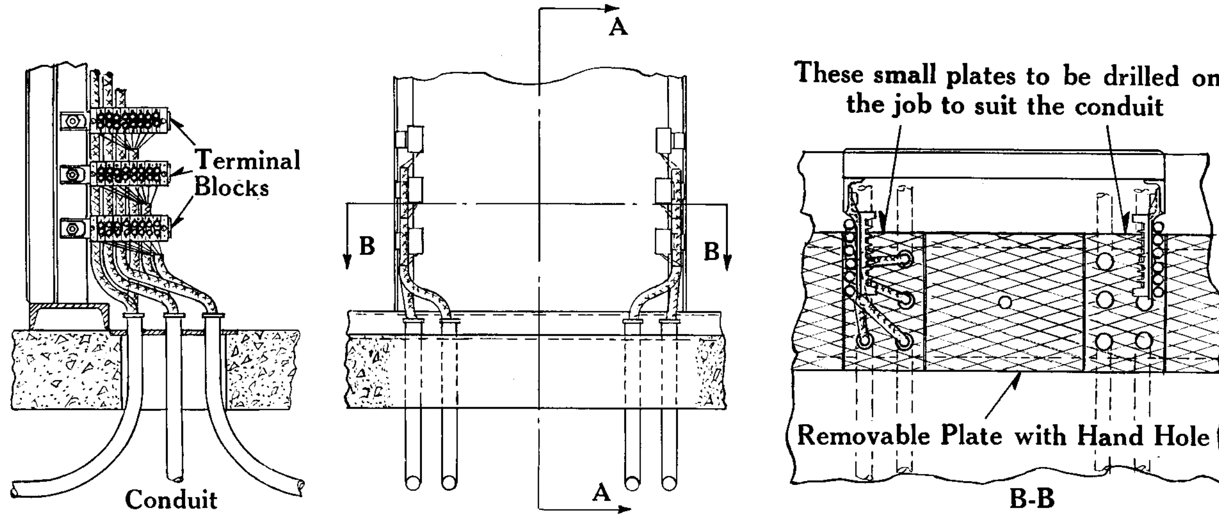


Fig. 196—Terminating conduits at rear of switchboard panels. This arrangement shows the conduits extending through the floor and supported in place by stationary iron plates. (Angle iron frame Switchboard shown).

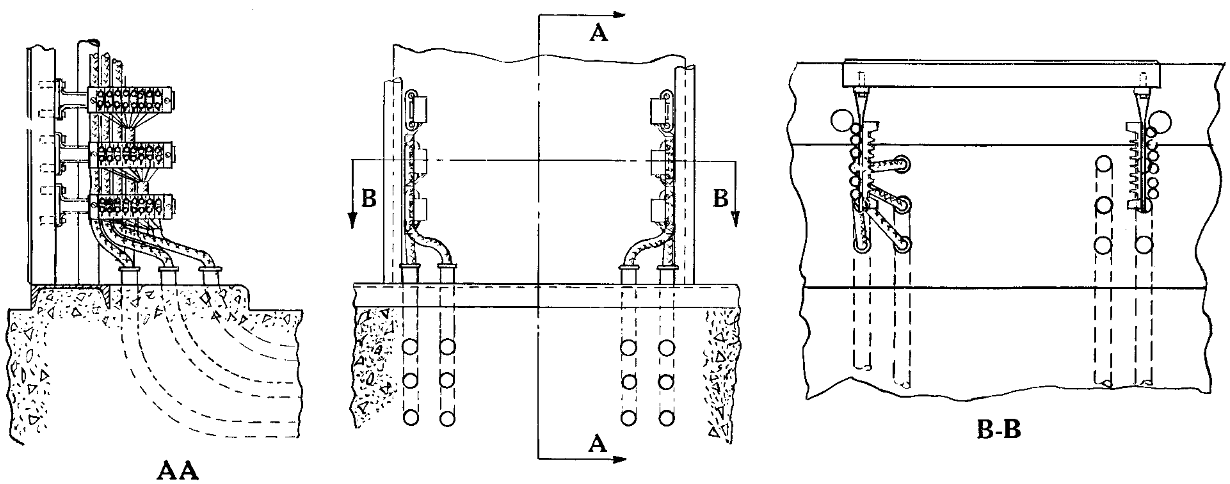


Fig. 197—In this arrangement all conduits are laid in concrete. Note particularly the method of mounting terminal boards in order that the maximum accessible space on the rear will be obtained. (Pipe frame switchboard shown).

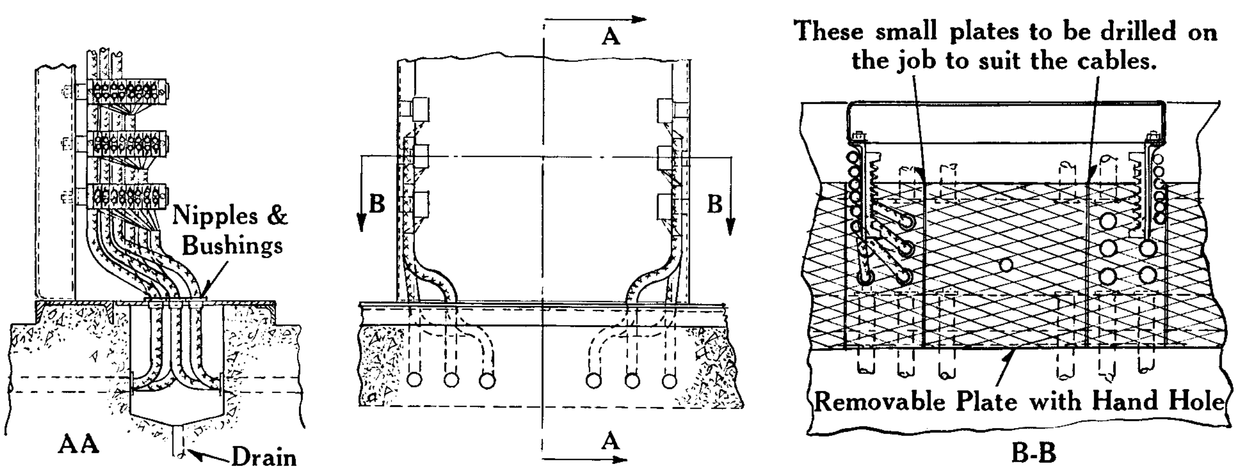


Fig. 198—This arrangement shows conduits terminating in a trench. This is an excellent scheme especially when there are a number of cables and conduits involved. (Steel panel switchboard shown).

Terminating Conduits at Rear of Switchboard Panels—In Figs. 196, 197 and 198 are shown typical arrangements for terminating incoming instrument and control cable with conduits near the bottom of the switchboard panel. It will be particularly noticed in the different figures shown that the Westinghouse terminal block is mounted perpendicular to the plane of the rear of panel. This method of mounting terminal blocks permits easy access to rear of panel and makes a clean cut job when installed in the field. Fig. 196 shows the conduit coming up through an opening in the floor, this opening extending entirely along the rear of the switchboard. If the bending of the conduit is started from the switchboard end the stationary plates can be drilled in a more uniform manner thus insuring a neater looking job when completed. A hole in the middle plate permits easy removal when necessary. While this Fig. 196 shows an angle iron frame panel the scheme may be used for any type of panel frame construction.

Fig. 197 shows the conduits laid in the concrete floor and terminating at the switchboard in the same manner as shown in Fig. 196. This terminal board also extends out in a plane perpendicular to the rear of the panel.

Fig. 198 shows conduit terminating in a trench which extends the entire length in the rear of the switchboard. The trench is of a depth to suit requirements and is provided with a drain. A curb is arranged around the trench to prevent debris from getting into it. With this arrangement cables may be crossed in the trench instead of on the rear of panels, thus making a very finished and neat arrangement. The stationary plates in this case may all be drilled in advance, as the conduit terminates in the trench. Bushings are placed in the hole of the stationary plate before cables are pulled through. Fig. 198 makes an excellent arrangement, especially where a number of conduits are involved.

It is often convenient to run instrument or control wiring from the top of panel to the structure located directly in rear. In this case, iron conduit may be used, supported at proper intervals along pipe wall braces.

PIPE STRUCTURES

Structures should be so made that when assembled there will be no chance for any movement due to the operation of oil circuit-breakers. Such movement may transfer stresses to the various copper connections, bus bars, etc., and may disarrange adjustments between the operating handle on the panel and the breaker.

Structure location with reference to the panels on which the operating handles of circuit-breakers are located should be such that the length of the operating rods and the number of bell cranks and unsupported pipes will be a minimum.

In heavy capacity structures care must be taken to insure that the pipe frame forming the supporting structures does not form a complete magnetic circuit around heavy current carrying conductors.

It is necessary to make an effective ground when grounding structures and the ground wire should not be run where it is liable to mechanical injury, as it is highly important that the ground connections should remain intact at all times.

All metal works should receive suitable protective painting from time to time.

Plugs—Pipe plug ends accompany all pipe structures. They may be inserted easily in the ends of pipes, thereby improving the general appearance of the structure as indicated in Fig. 199. These plugs also prevent the collection of moisture in pipes which are located in outdoor structures.

Pipe Cap—This cap fits loosely in the end of the pipe. A few blows on the face of the cap with a machinist's hammer will spread the prongs of the cap on the inside of the pipe and hold it securely.

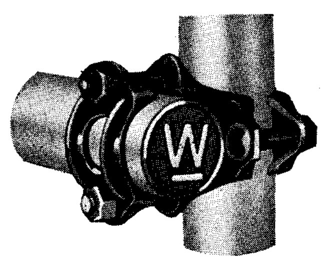


Fig. 199—Westinghouse Pipe End Driven in End of Pipe

PIPE FITTINGS

Part Catalogue 6131 describes the most complete line of structural pipe fittings ever submitted to the trade. These Westinghouse structural pipe fittings employ yokes and carriage bolts for clamping rather than the old U bolt. Both yoke and fittings are made of the best grade of malleable iron. They are light in weight, compact and neat in appearance and are stronger than the carriage bolt used for clamping. This may be demonstrated easily by twisting off the nuts with a large wrench without damaging the malleable iron fitting.

The carriage bolts which have a square shank under the head fit into a square hole in the fitting. Since the bolt cannot turn in the fitting, assembly is readily accomplished through use of a single wrench.

The fittings are furnished with either a baked black gloss finish for indoor use or are galvanized for outdoor use.

The form of the yoke and other unit parts is such that a considerable area of contact with the pipe is secured. As the fittings are bolted up they yield slightly due to the malleable characteristics of the metal until they fit the pipe perfectly.

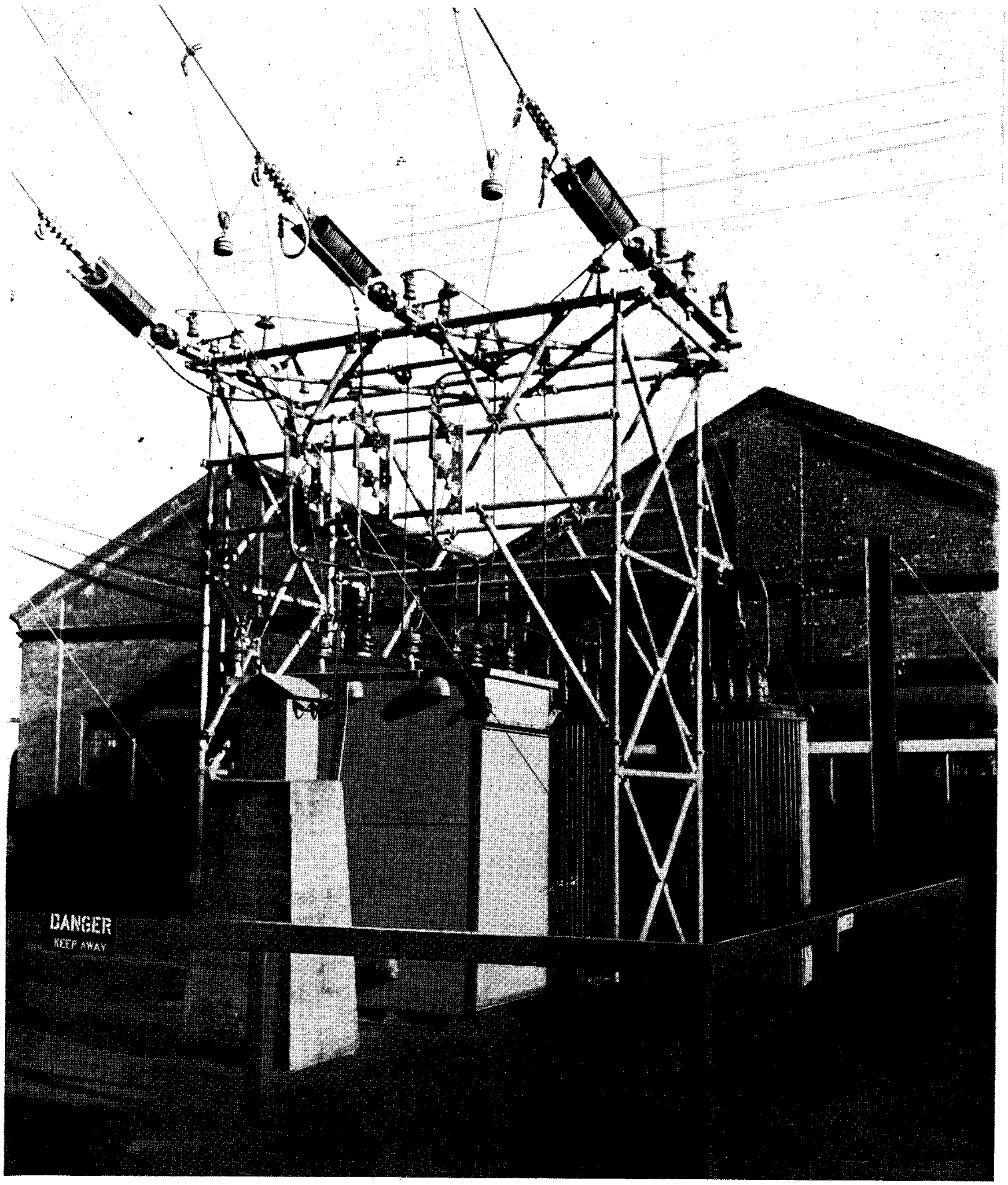


Fig. 200—Typical outdoor pipe structure using Westinghouse pipe fittings.

While designed primarily for electrical installations they are by no means so restricted in their application. They will be found economical and convenient for the construction of racks, railings, bench or table frames, playground structures, dairy stable stanchions, tennis court and golf course barriers, poultry yard fences and a variety of other uses.

The Westinghouse structural pipe fittings assure:

1—Strength
2—Economy
3—Interchangeability
4—Appearance
5—Adaptability.

Common wrought iron or steel pipe has long been recognized as a convenient material for structural work, particularly in connection with electrical switching installations both indoor and outdoor. Pipe is light for its strength, has a symmetrical cross section, thus resists bending equally well in any direction and can be cut easily and rapidly with inexpensive tools by inexperienced men.

Due to the shape of pipe, it has low wind resistance for its strength, is available in a well graded series of sizes and can be obtained anywhere in convenient lengths, either black or galvanized. Fig. 201 shows an isometric or perspective sketch of a pipe structure with item numbers at each pipe fitting joint. When designing pipe structures similar sketches will aid in determining the number and style of fitting required.

If you have not received a copy of the Westinghouse Part Catalogue 6131. It will be sent promptly upon request.

Bill of Material Required for 1¼″ Pipe Structure Diagram.

Item	Description and Material	Req.
1	Flange Clamp M. I.	8
2	Wall Brace M.I.	4
3	Tee Assembly M.I.	4
4	Tee Assembly M.I.	25
5	4 Way Assembly M.I.	1
6	5 Way Assembly M.I.	1
7	Side Outlet Tee M.I.	5
8	Cross M.I.	9

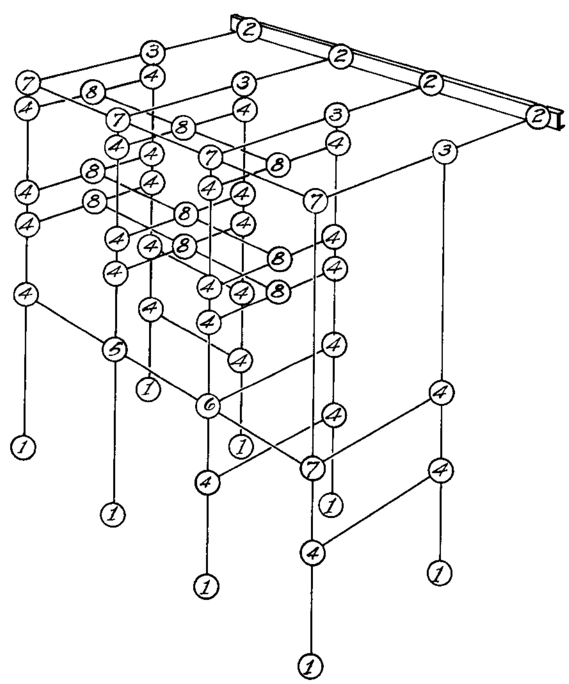


Fig. 201—An isometric or perspective one line diagram (in addition to the mechanical drawing) frequently aids in checking the fittings required for a pipe frame structure. As will be noted ballooned item numbers are drawn in at the different points where fittings are used from which a Bill of Material may be made when desired.

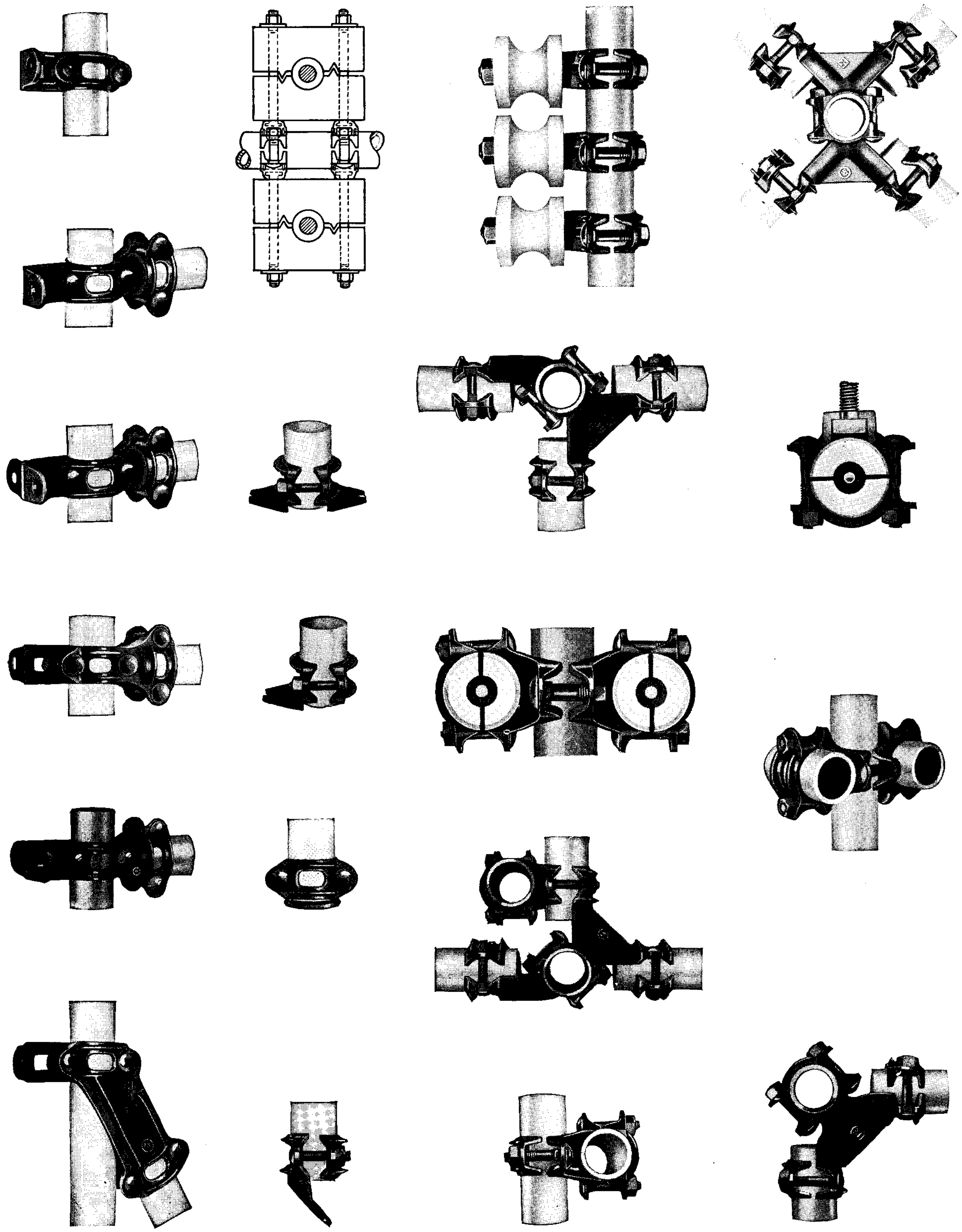


Fig. 202—Typical Westinghouse threadless pipe fittings, cable rack fittings, etc. A complete line of these fittings with style numbers will be found in the Westinghouse Catalogue of Electrical Supplies.

CONCRETE CELL STRUCTURES

General—Concrete has been adopted quite generally as the best material for making cell structures. It is easily formed to fit the apparatus, allows for readily setting of anchor bolts for supports and when completed gives a very neat and clean appearance. The following instructions are based on a typical Westinghouse structure, they may, however, be followed generally in building any type of concrete cell structure.

Proportions—Owing to the strength, narrow cross sections and smooth finish required, a concrete mixture consisting of one part cement, two parts fine aggregate and three parts coarse aggregate is best suited for this work. If the **"water-ratio"**—can be carefully controlled——a mixture of **one, two, four** may be used, especially in the main thick wall. It is generally recognized that the strength of concrete varies in proportion to the amount of **water** used in the mix. This is very well outlined by the Portland Cement Association in their booklet entitled **"Concrete Data for Engineers and Architects"** also **"Design and Control of Concrete Mixtures".**

Cement—The cement used should be a standard brand of Portland cement and should meet the current standard requirements of the American Society for Testing Materials, Serial Designation C-921 which may be obtained from the Portland Cement Association on request.

Storage—Cement should be stored in sheds or other rain proof space, the floor of which is high enough above the ground to allow free circulation of air underneath. Cement in sacks should be stacked so as to leave a free air-space at all points between the sacks and the outside walls of the shed as moisture will effect the quality of Portland cement. Reasonable care should be taken to have the storage house as dry as possible.

Fine Aggregate—The fine aggregate used should be natural sand or screenings from hard, tough, durable, crushed rock or gravel, consisting of quartzite grains and graded from fine to coarse. When dry it should pass a screen having four meshes per lineal inch, although not more than 25 percent should pass a sieve having 50 meshes per lineal inch and not more than five percent should pass a sieve having 100 meshes per lineal inch. It should not contain vegetable or other deleterious matter and not more than seven percent of clay or loam by volume.

Routine field tests for clay loam and organic impurities should be made on all fine aggregate as delivered. If there is more than seven percent of clay or loam by volume in one hour's settlement after shaking in an excess of water, the material represented by the sample should be rejected. Natural sand shall be rejected which shows a color darker than the standard color when tested in accordance with the "Tentative Method of Test for Organic Impurities in Sands" for concrete of the American Society for Testing Materials (Serial Designation C 40-21 TA) a copy of which may be obtained on request from the Portland Cement Association.

Water—Water for concrete shall be clean and free from oil, alkali, organic matter or other deleterious substance and only enough water shall be used to obtain a plastic consistency such that the concrete can be worked into the forms without separation of the ingredients. **An excess quantity of water should be avoided as it seriously reduces the strength of the concrete. See bulletin of the Portland Cement Association on "Concrete Data for Engineers and Architects".**

Coarse Aggregate—The coarse aggregate should consist of clean, hard, durable, crushed stone or gravel free from vegetable matter.

The size of the aggregate for the main and transverse barrier walls should be such that it will pass through a one-inch round opening and should be one-half inch in diameter and larger. Not more than five percent should pass through a screen having four meshes per lineal inch.

For the bus barrier shelves smaller aggregate is desirable and should pass through a screen having one-half inch round opening.

Retempering concrete, that is remixing partially set concrete, should not be allowed.

Concrete should not be allowed to stand more than 45 minutes after mixing before placing it into the forms. Any concrete that has gained its initial set before being placed into the forms should be rejected.

Placing—Care should be taken in placing the concrete to see that it is thoroughly worked in around the reinforcing steel and thoroughly worked and spaded along the faces to prevent formation of stone pockets. Tapping the form lightly with a wooden mallet while the concrete is being placed also helps to prevent stone pockets.

Reinforcement—The choice of reinforcing rods may vary slightly, however, very good results should be obtained in the main-through longitudinal barrier wall by using ⅝ inch bars spaced 12 inches between centers vertically and ½ inch bars, nine inches center to center horizontally.

magnetic circuit around conductors carrying heavy current. This can, in general, be prevented, but in some cases the use of non-magnetic reinforcing material will probably be advisable.

All horizontal reinforcing rods in transverse barrier walls should be securely wired or other-

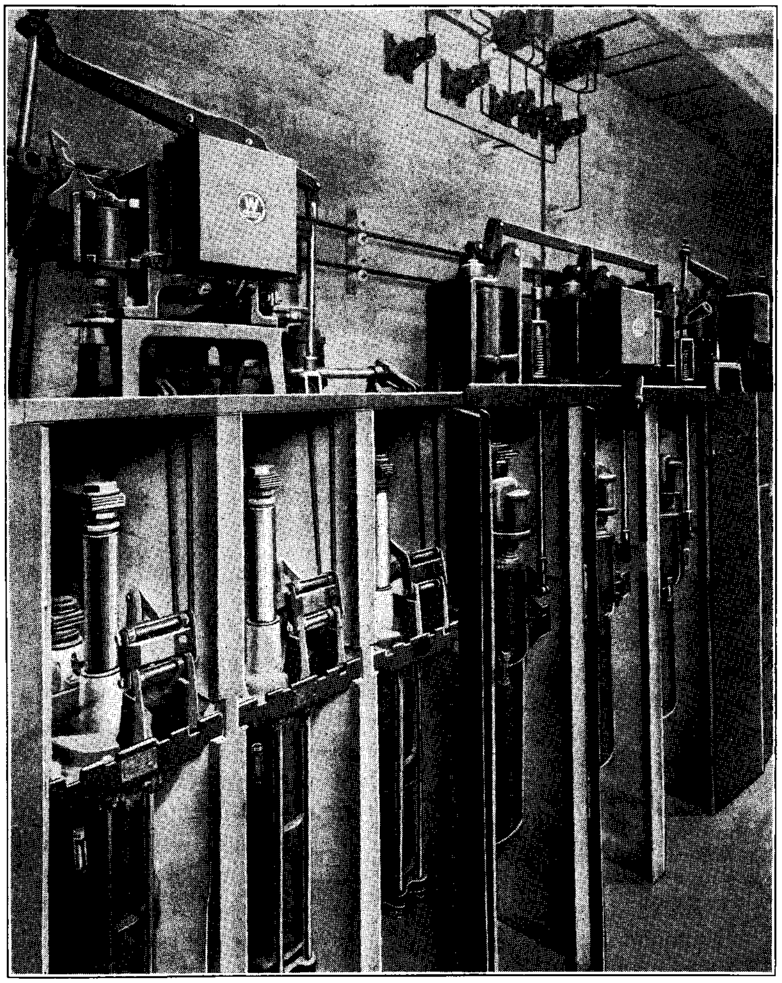


Fig. 203—Installation showing Type E-16 Oil Circuit-Breakers.

For the transverse barrier walls use ⅜ inch bars spaced eight inches between centers vertically, 10 to 12 inches center to center horizontally. These horizontally spaced bars should be tied to the main-through wall reinforcement. Reinforcement is desirable for the bus barrier shelves which will be precast. Expanded metal or mesh fabric may be used for this purpose. All reinforcing bars should be of the square twisted type.

Extreme care should be taken to avoid having the reinforcing material form a closed

wise tied to the reinforcing bars in the main-through barrier wall. Ordinarily No. 14 soft iron baling wire will be satisfactory for this purpose.

Forms—Forms should be built of ⅞ inch dressed and matched lumber made up in box form and thoroughly braced. Care should be taken in designing the box forms so they may be removed and set up again without wrecking. For the first pour, vertical box forms for main and transverse barrier walls should be built in one section to the height of oil circuit-breaker transverse barrier walls so as to permit spading and tamping of the concrete on the faces of the forms and the working of the concrete around the reinforcing steel. The inner corners of all box forms should be rounded to a radius of two inches (Fig. 204) both to improve the cleanliness and appearance of the structure and to make the forms easier to remove. Beveling outside edges of the barrier walls eliminates chipped and broken corners. This beveling may be done by nailing small angle strips in the corners of the forms.

In order to prevent forms from sticking to the concrete during removal, they should be given a brush coat of paraffine oil before placing in position. Paraffine oil may be obtained by dissolving commercial paraffine wax in kerosene or gasoline until the solution has a consistency like that of heavy paint. One or two coats of this mixture on the forms will have a waxlike finish after the kerosene or gasoline in the solution had evaporated from the surface of the form. The forms should be refinished each time they are used.

Mixtures of soft soap may also be used for this purpose.

Expansion Joints—When the structure is enclosed in a heated building with little variation of temperature, expansion joints are unnecessary. However, in an isolated station with no heat in the winter, expansion joints should be provided if the structure exceeds 50 feet in length. They should be made at a through transverse barrier wall. The best method of making these joints is to bevel a 4″ x 4″ timber into the form of a key and set this vertically in the center of the main longitudinal barrier wall. Six thicknesses of tarred felt should then be placed over these keys and across the entire joint so that when the keys are removed to pour the next section, the tarred felt will remain, completely separating the concrete in the two sections. All expansion joints should be carried through the foundation and no reinforcing steel should be allowed to extend across an expansion joint.

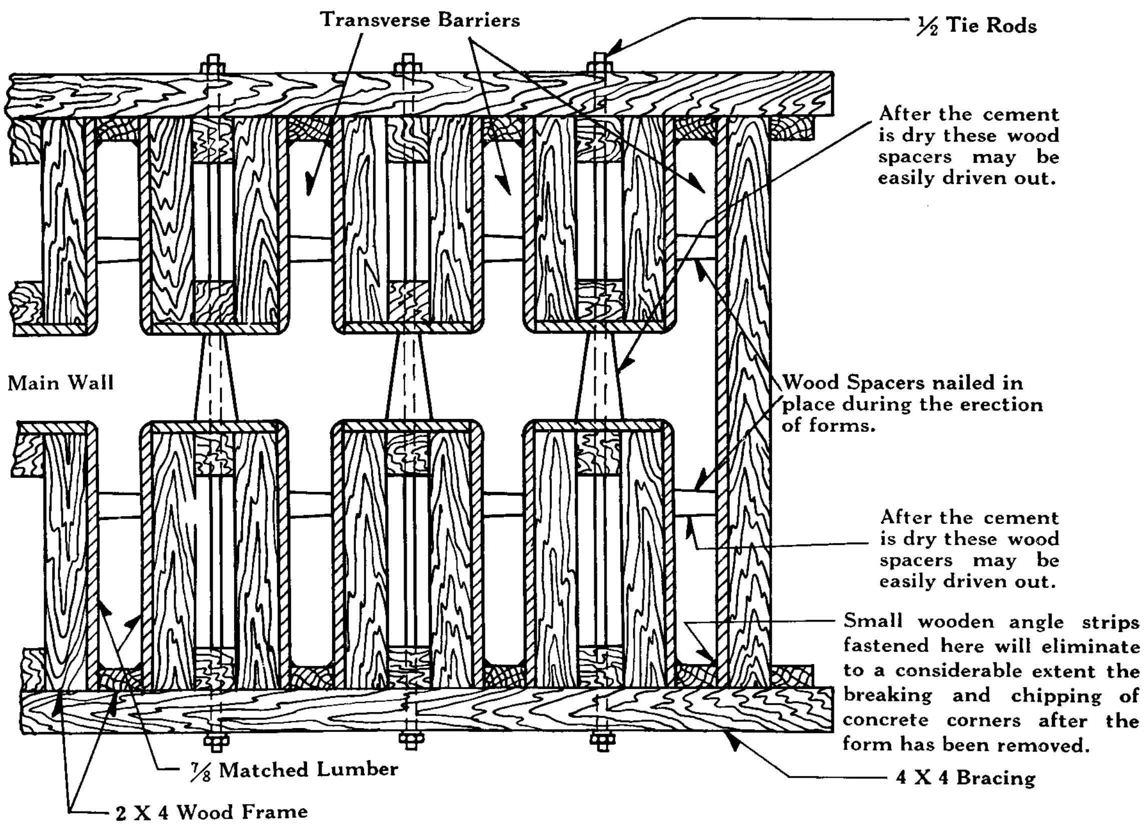


Fig. 204—Section AA showing forms for cells. Note particularly the rounded corners which improve appearance and make forms easier to remove.

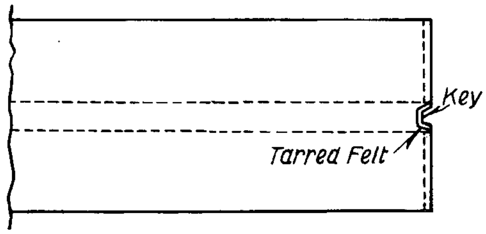


Fig. 205—Plan Showing Expansion Joint in Main Longitudinal Barrier Wall

Foundation and Floor—Before laying the floors, lay out the lines for the foundation on the ground and excavate until a firm footing is secured. Erect a temporary lumber framework to support the tops of the vertical reinforcing rods and after placing them, pour the concrete in the foundation and that part of the floor within the rectangle covered by the cell structure, being careful not to forget any expansion joints that may be necessary. These must come directly on a vertical plane with the expansion joints to be placed in the structure above and should extend through the entire cross section of foundation and floor.

When located on the structure should be anchored by drilling holes at least twice the greatest diameter of the vertical reinforcing rods, three to four inches deep and anchor the vertical reinforcing rods in these holes by using a thin mortar composed of one part Portland cement and one part fine sand to fill in around the rods. A framework as described above will be necessary to hold the rods in position until this mortar is set.

Setting Up Forms—After the foundation and floor are set, securely wire all horizontal reinforcing steel to the vertical steel, tying the oil switch barrier wall and other transverse barrier wall steel to that in the main-through barrier wall. After this is done, the framework holding the top of the vertical rods may be removed. Next, lay out the exact lines of the vertical barrier walls with chalk lines or straight edges on the floor section completed and then place the box forms to these lines. First plumb and level them into position, then tie them there by means of longitudinal bracing and tie rods. Wooden form-spacers approximately 2″ x 2″ slightly tapered and bored with a ¾-inch hole in the center to allow the passage of a tie rod should be used to hold the forms apart and should be knocked out after the forms are stripped. The 4″ x 4″ horizontal bracing should be placed at such points on the structure as to prevent bulging when the concrete has been poured.

Anchor Bolts—Before placing the forms in position, holes for locating anchor bolts or inserts should be laid out and drilled. The anchor bolts or inserts should also be firmly attached to the forms, before placing in position. It is a very good idea to make the holes in the forms perhaps ⅛ of an inch larger than the bolts in order to permit easy removal of the forms, after the concrete has set. These bolts should be threaded long enough to allow for a nut and washer on the inside of the form. A thin metal template (with the same drilling as the apparatus which is to be supported on the anchor bolts) placed on the outside of the form in place of the washer, as shown in Fig.

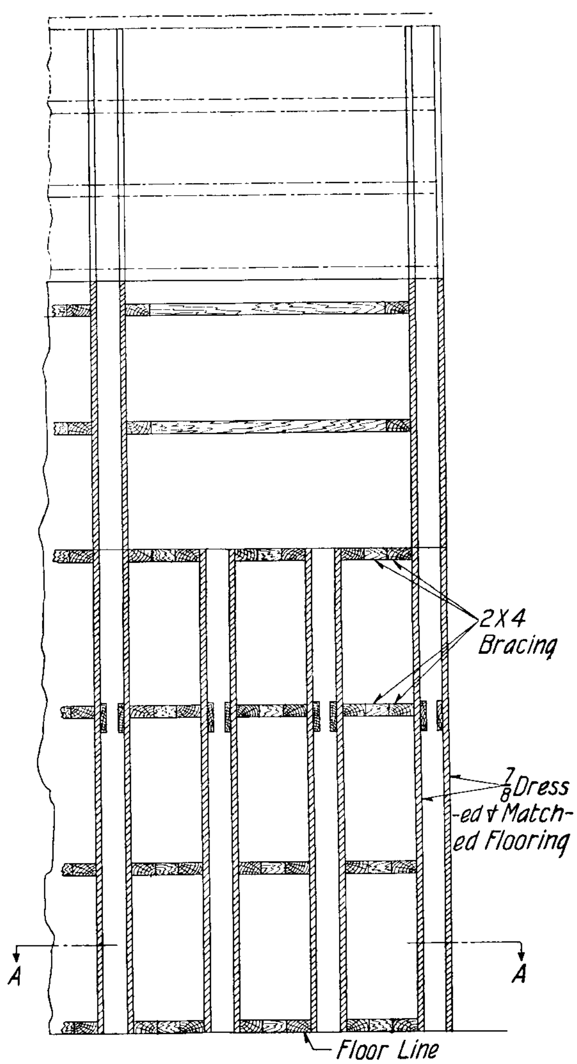


Fig. 206—Section Showing Forms, for First Cell with External Bracing and Tie Bars Removed

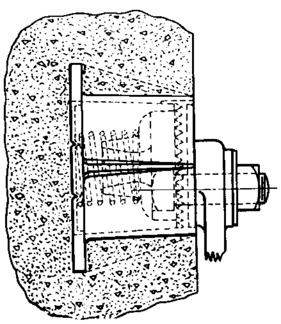


Fig. 207

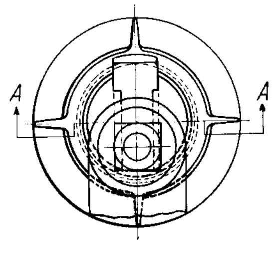


Fig. 203

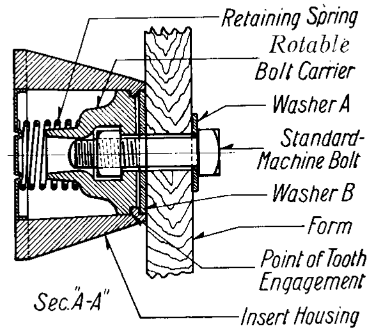


Fig. 209

Concrete Adjustable Insert. This Insert is Adjustable in Any Direction in a 5/8" Radius.

212, helps to line up the bolts. Particularly note that the washer on the inside of the form, as shown in this figure, prevents any concrete from filling in the hole around the bolt, thereby, allowing the easy removal of the form when the outside nuts, templates or washers are removed. It is also a good plan to have a certain number of hardened die nuts at hand so that after stripping the forms the die nuts may be run over all protruding studs so as to eliminate all danger of crossed threads when mounting the apparatus. Usually anchor bolts less than 3/8 of an inch in diameter are fastened in the concrete wall by the use of expansion sleeves.

Adjustable Insert—Unless extreme care is used in placing anchor bolts in concrete they will not fit the mounting bolt holes of the apparatus. As a result it is either necessary to file the holes to fit the bolts or the threads of the bolts are damaged in an endeavor to hammer them to the desired position.

To entirely eliminate this trouble the Westinghouse Company has designed an insert which permits moving the apparatus holding bolt to any desired position in a 5/8-inch radius.

The use of the new Westinghouse Adjustable Insert will save both time and money on any job.

Numerous tests in concrete have proven that the holding power of this insert is as great as the strength of the bolt.

The simple construction of this insert is shown in Fig. 209.

The **housing** has been designed so as to obtain the maximum holding power in concrete.

The **rotatable bolt carrier** may be rotated to any desired position. A slot which is provided in the top permits any bolt adjustment within a 5/8-inch radius when embedded in concrete.

The **retaining spring** holds the rotatable bolt carrier in position while securing to the concrete form or fastening the apparatus to the insert imbedded in the concrete. As will be noted in Fig. 209 the housing and the rotatable bolt carrier are both provided with teeth which prevent any change in position while in engagement.

Washer B is also slotted, making it possible to fasten apparatus with even the smallest base or foot to the insert.

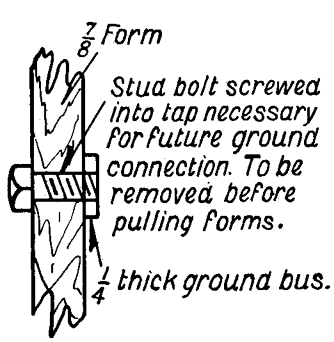


Fig. 210—Method of Fastening Ground Bus to Forms

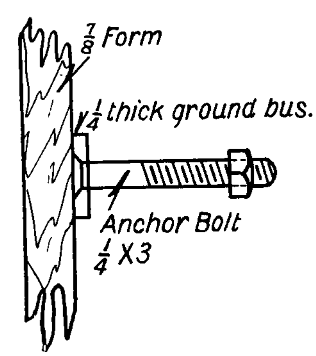


Fig. 211—Method of Anchoring Ground Bus Into Concrete

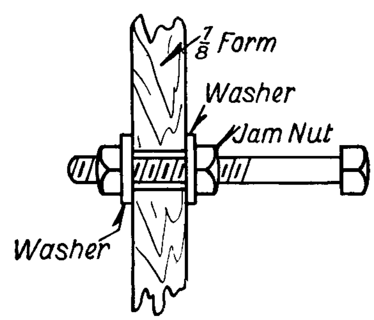


Fig. 212—Method of Setting Anchor Bolts with Jam Nuts Inside Form to Hold Bolt in Place

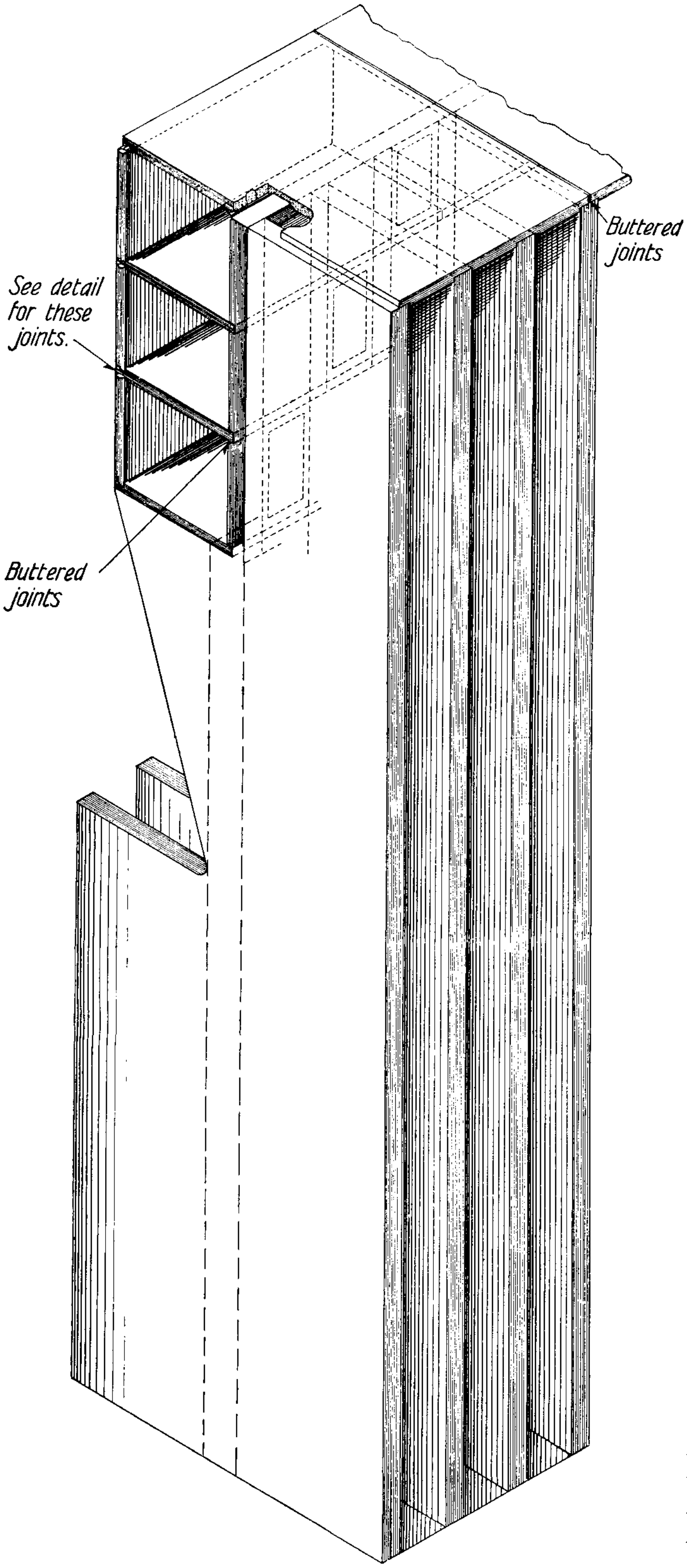


Fig. 213—Isometric of a Completed Single Concrete Cell Structure.

Fig. 209 shows the insert fastened to the concrete form with the nut in the rotatable bolt carrier. We recommend this method of securing to forms due to the fact that the threads of a bolt are very often damaged when the stud protrudes through the nut on the outside of the form. After the form has been removed, this nut may be removed from the insert and the head of the bolt placed in the rotatable bolt carrier with the stud protruding outward for supporting apparatus.

These inserts are now available for either 3/8 or 1/2 inch machine bolts.

Ground Bus Bar—The ground bus bar should be drilled and tapped for ground connections before being placed in the form. It should be provided with anchor bolts two or three inches in length spaced 18 inches between centers with flat screw heads (Fig. 211). The best method of fastening the ground bus to the forms is by machine screws which pass tapped holes already provided for future ground connection (Fig. 210). It is very important that the face of this bus bar be drawn tight against the form at all points to prevent the concrete from getting between the bar and the forms and to make the face of the bus exactly flush with the face of the concrete when the form is removed.

Bus Compartments—In order that time may be saved in building the complete structure, the bus compartment slabs which are precast should be moulded before or at the same time that the main structure is placed. The bus compartments may also be poured in places, the method selected depending largely on the skill of those doing the work.

The bus compartment slabs should also be reinforced using expanded metal or mesh fabric approximately 25 pounds to 100 square feet. Heavier mesh may be desirable on very long spans.

Fig. 213 shows the completed structure. Fig. 214 shows in detail the method which should be used for holding the slabs in place.

As will be noted in Fig. 213, slots should be provided in the top part of the main wall for supporting precast bus barrier shelves. These slots should be made larger than the width of the shelves so as to take care of any variations. When placing the shelves in position, all points that are to be mortared should be well moistened and particular care should be used to see that the slabs are temporarily supported while being placed.

The vertical precast slab for the bus compartment is shown in Fig. 215 and as will be noted is placed so that all joints are broken.

As will be noted in Fig. 214, the front slabs are securely held in place by ramming the joints with dry mortar. Particular care should be used to see that all joints are well moistened before buttering and ramming. Doors are not shown in Fig. 215 but may be added, if desired, by shortening the front slabs.

Obviously inserts or embedded bolts for fastening bus bar supports in these compartments should be placed before precasting the bus barriers.

Fig. 216 shows the concrete structure complete with apparatus mounted thereon.

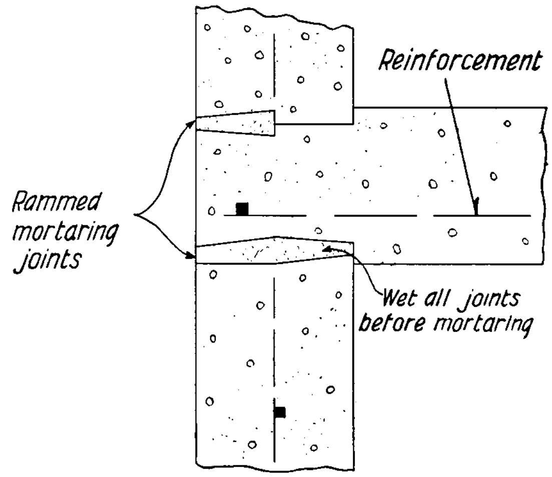


Fig. 214—Method of Constructing Bus Cell Compartment.

Finishing—If the temperature is 70 degrees Fahrenheit or higher, forms may be removed after the concrete has been allowed to set three days but care must be taken not to damage the green concrete by hammering on the forms or prying against the concrete.

After the removal of the forms and form-spacers, the surface should be rubbed down with a carborundum or similar stone until all form marks are removed. The holes where form spacers were removed and any stone pockets should be filled with fresh mortar composed of one part Portland cement to two parts fine aggregate, so as to produce an even unbroken surface.

The final finish may then be given by brushing the surface with a mixture of one part

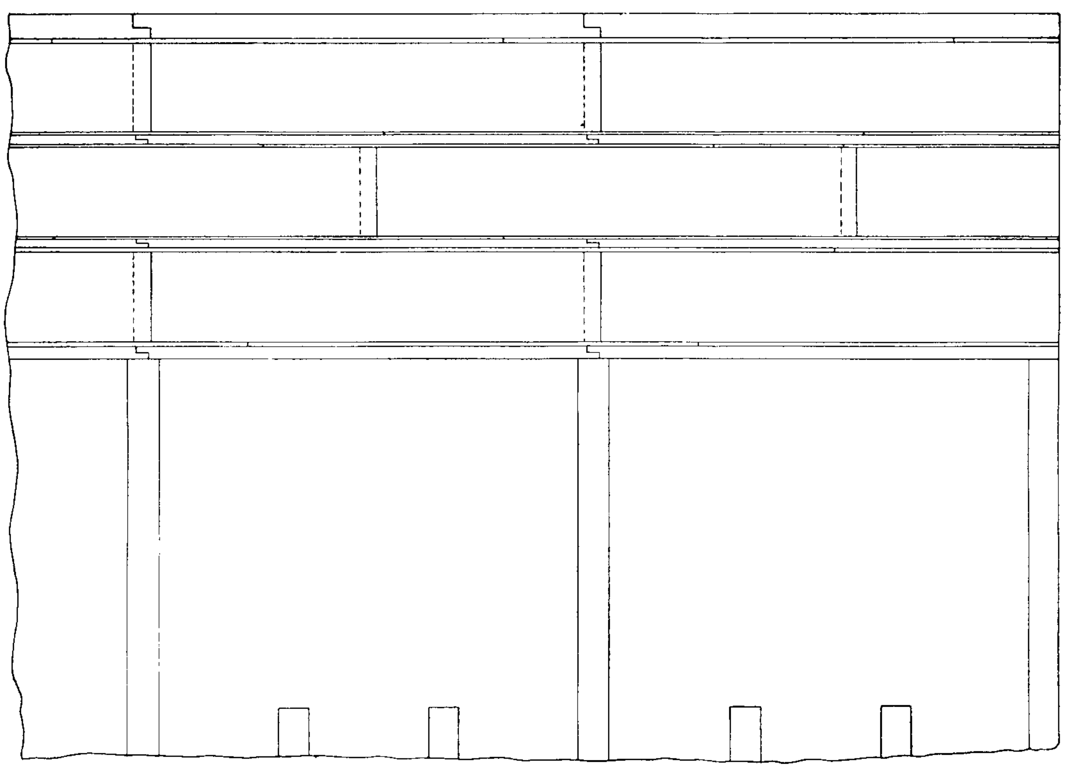


Fig. 215—Precast slabs for bus compartment. Note that all joints are broken.

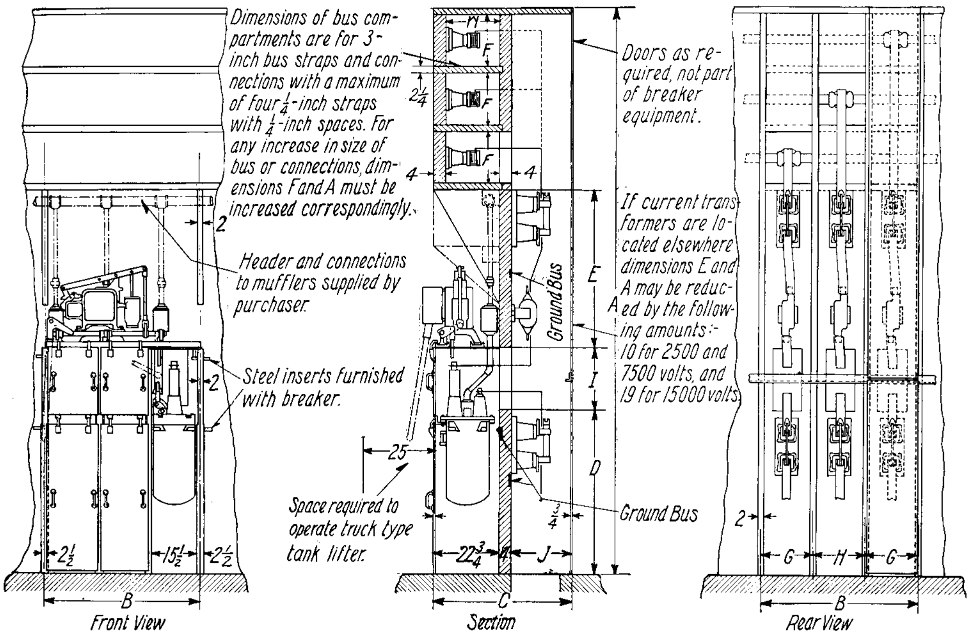


Fig. 216—Complete Concrete Structure with Apparatus Installed.

Portland cement to one part fine sand. This sand should pass a screen having 16 meshes per lineal inch.

The mortar for brush coating should be mixed to the consistency of thick pea soup and should be stirred constantly to prevent the sand from settling to the bottom. It should be applied with a fine bristle white-wash brush.

If a brush coat of white Portland cement and white sand is used for the final brush coat for the exterior walls or the interior of the cells, a permanent white surface is secured, which not only adds to the finish of the structure but also greatly reduces the light required in working in and around the structure.

The white cement should not be applied until 48 hours after the surface has been rubbed up.

Curing—After the forms are removed, the concrete rubbed up and the white cement applied, if desired (waiting 24 hours after applying brush coat), the entire structure should be well sprinkled with water twice a day for seven days to prevent the rapid drying out of the concrete.

Approximately two to three weeks should elapse between the pouring of the concrete and the placing of the switching equipment on the structure.

A bulletin issued by the Portland Cement Association under the subject of "Concrete Data for Engineers and Architects" gives very complete and practical instructions on the best methods for mixing concrete.

If, for any reason, the instructions given herein for concrete cell structures are not sufficient to meet your requirements, we will be glad to furnish you further information promptly upon request, or if desirable, you may refer to the nearest district office of the Portland Cement Association who will be glad to give you any additional information you may require.

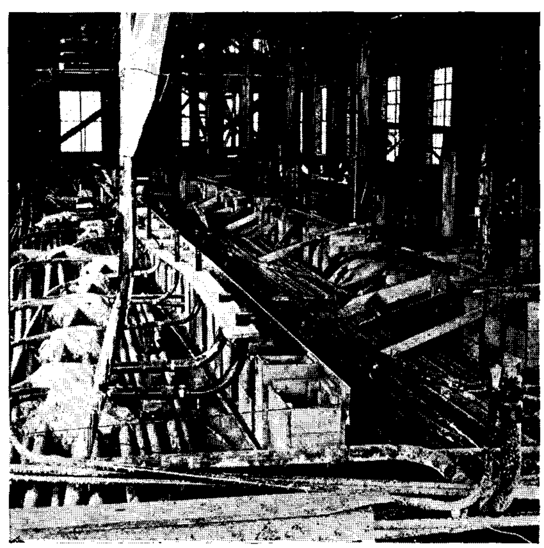
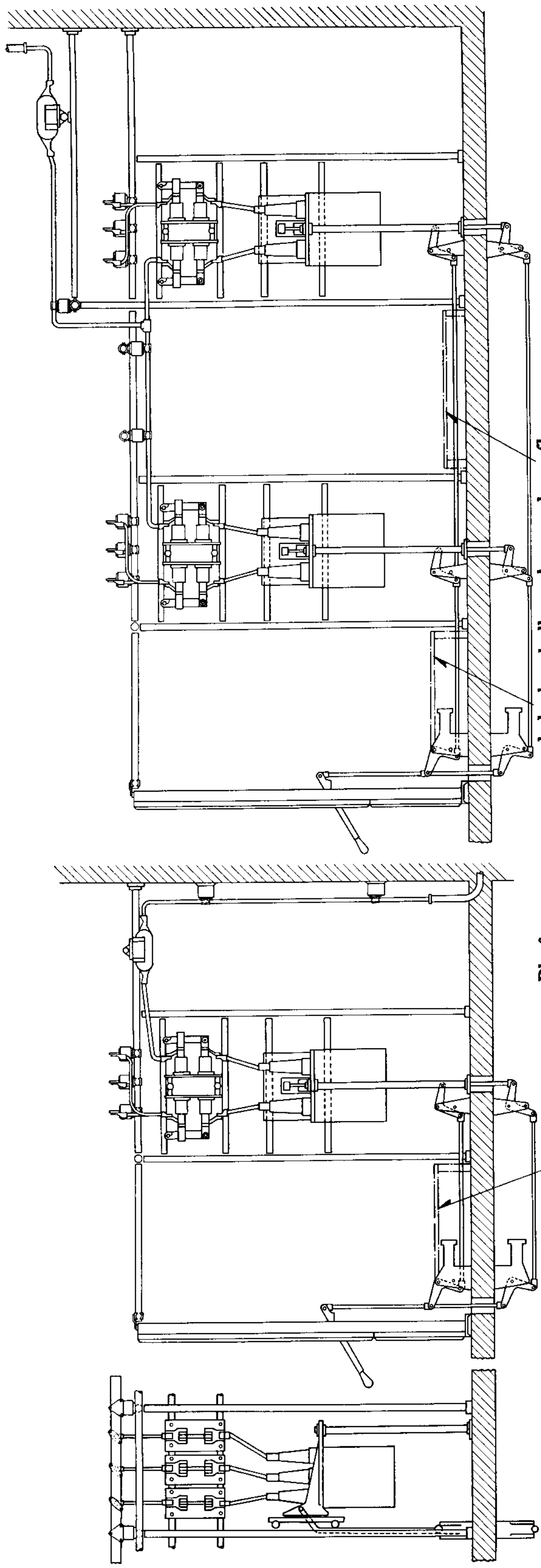


Fig. 217—View Showing the Supporting of Conduits Before Pouring Floor.

TYPICAL CIRCUIT-BREAKER AND BUS STRUCTURES

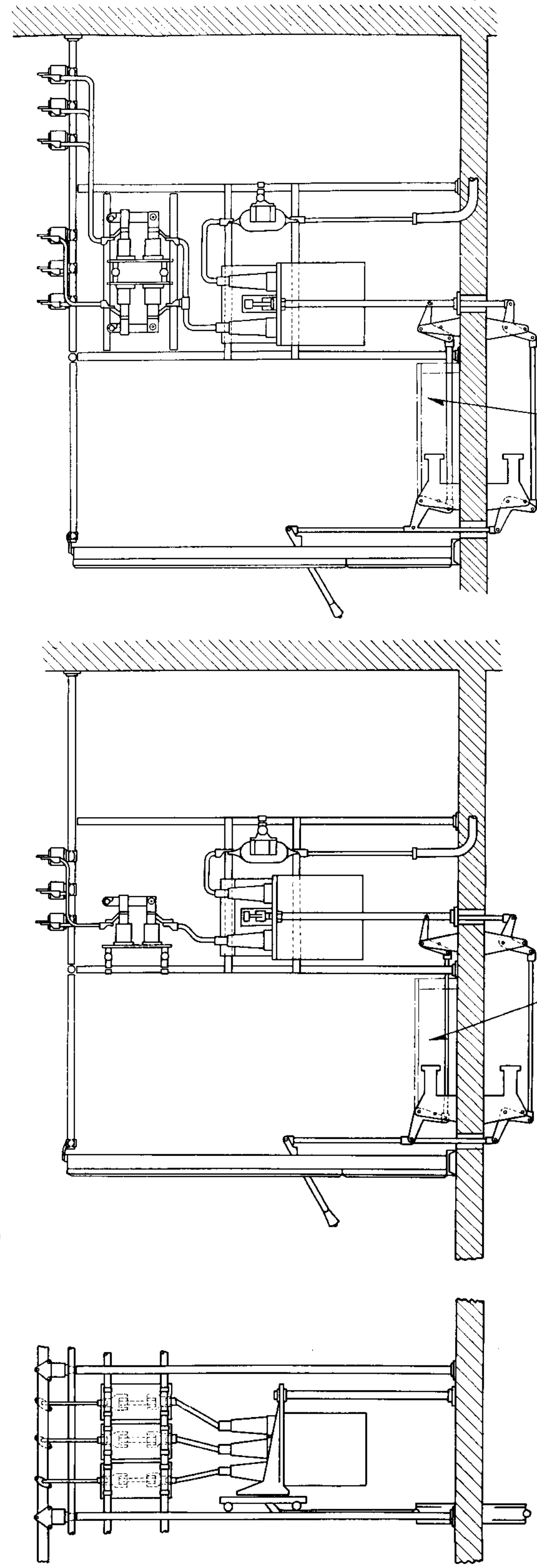


Platforms are recommended when bell cranks are above floor.

Shows a two breaker double bus structure with disconnecting switches on each side of breaker.

Shows a one breaker single bus structure with disconnecting switches on each side of breaker.

Fig. 218



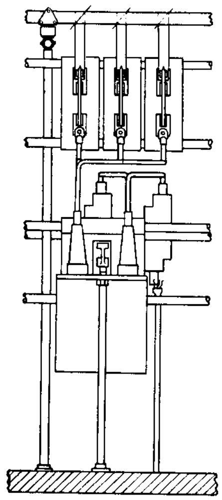
Shows a one breaker double bus structure with disconnecting switches on one side of breaker.

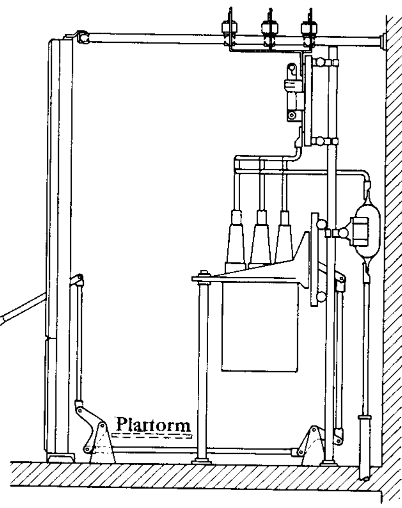
Platforms are recommended when bell cranks are above floor.

Shows a one breaker single bus structure with disconnecting switches on one side of breaker.

Fig. 219

Typical Circuit-Breaker and Bus Structures—Cont'd





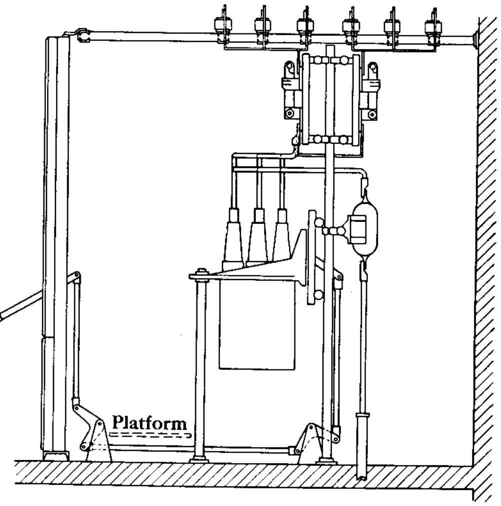
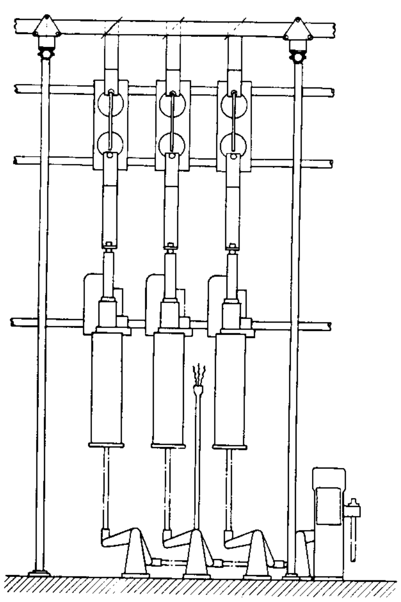
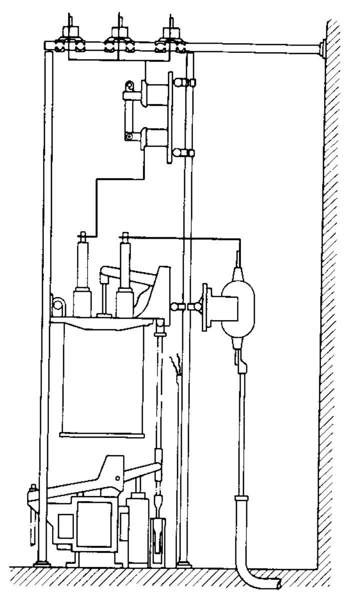


Fig. 220

Typical arrangement of a single bus system using a manual operated oil circuit-breaker with disconnecting switches between bus and breaker.

Typical arrangement of a double bus system showing a manual operated oil circuit-breaker with disconnecting switches between bus and breaker.





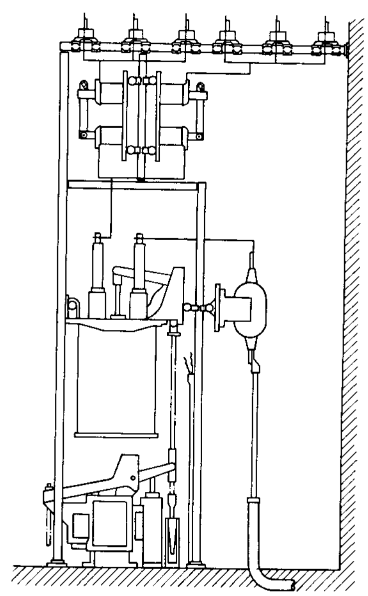


Fig. 221

Shows a one breaker (electrically operated) single bus system with disconnecting switches on one side of breaker

Shows a one breaker (electrically operated) double bus system with disconnecting switches on one side of breaker.

Typical Circuit-Breaker and Bus Structures—Cont'd

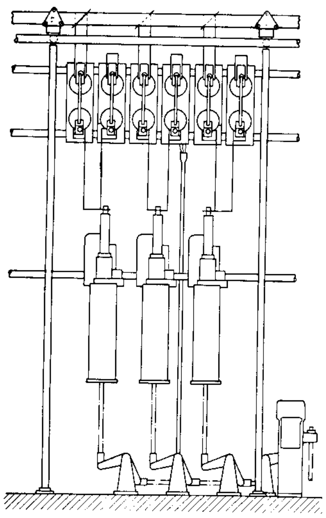
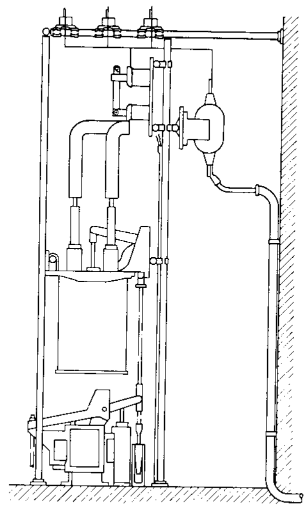
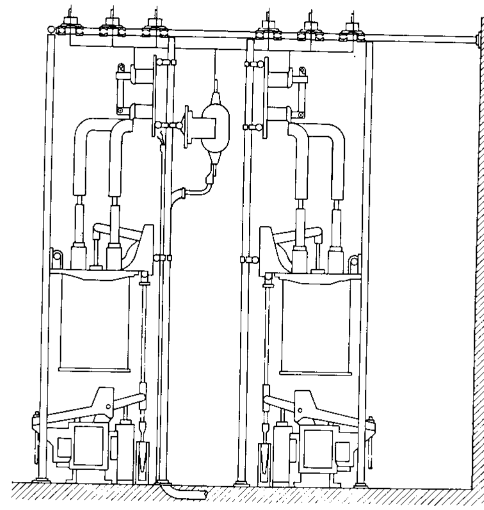


Fig. 222



Shows a typical pipe frame structure with one breaker and disconnecting switches on each side of the breaker.



Side view of typical pipe frame structure showing a double bus system with two breakers and disconnecting switches on each side of both breakers. Breakers are electrically operated.

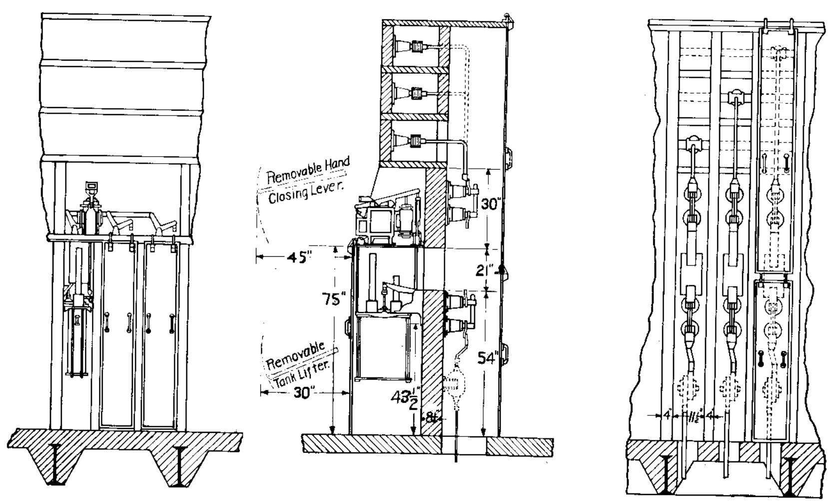


Fig. 223—Oil Circuit-Breaker and Bus Structure, Enclosed Construction, Cell Mounting, Arrangement—One-Breaker Single-Bus System

Typical Circuit-Breaker and Bus Structures—Cont'd

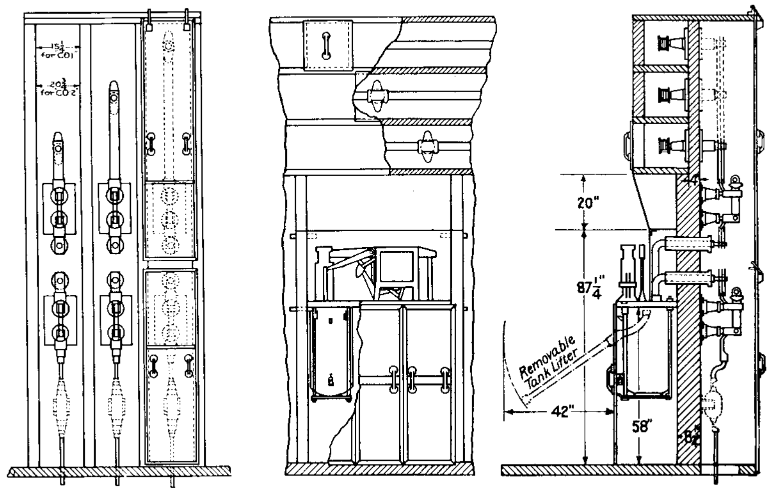


Fig. 224—Oil Circuit-Breaker and Bus Structure, Enclosed Construction, Cell Mounting, Arrangement—One-Breaker Single-Bus System

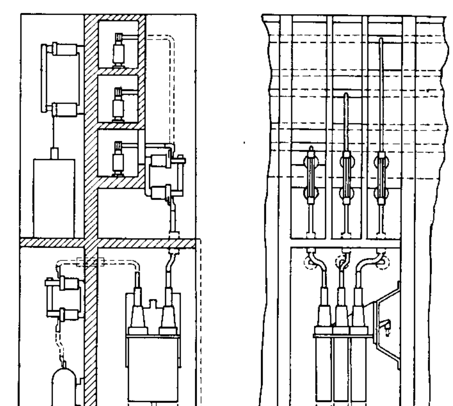


Fig. 225—Single-Bus Structure

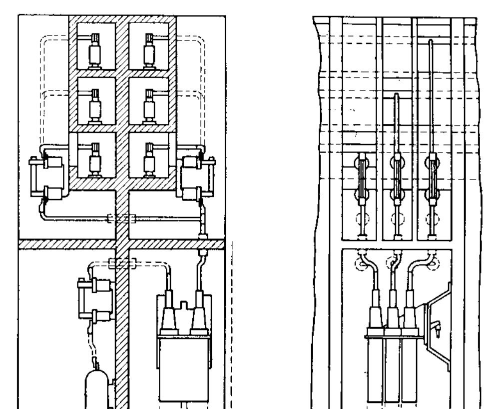


Fig. 226—Double-Bus Structure

Outdoor Sectional Type

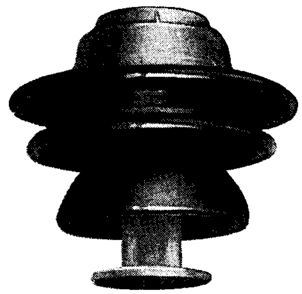


Fig. 227—Single Unit, Style Number 329628

BUS BAR SUPPORTS

Westinghouse bus bar and connection supports are available for all applications. Our bus bar supports are gauged, checked, tested and inspected very carefully before they leave our Works in order that no trouble will be experienced by our customers.

Types S indoor bus bar supports are a heavy duty type and are available for voltages up to and including 25,000. Standard insulator units are used with base and cap cemented to the insulator to give the strongest possible construction.

Type P indoor bus supports are adequate for most applications. They consist essentially of an insulator on which suitable bus and mounting fixtures are clamped. They are available for voltages up to and including 45000. The fittings are made of malleable iron or cast brass and have a high grade dull black baked finish.

Type R outdoor bus supports are made up of standard insulator units with cemented cups and pins. All insulator units are interchangeable with the insulator units which are used with the standard line of outdoor mounting switches and protective apparatus. This greatly reduces the number of spares to be carried in stock by the customer.

Pillar Type Insulator—These insulators are designed to be bolted together into columns containing as many units as are required to meet the conditions of service. See Figs. 227 and 228. Refer to Westinghouse Catalogue of Electrical Supplies for Details on Bus Supports.

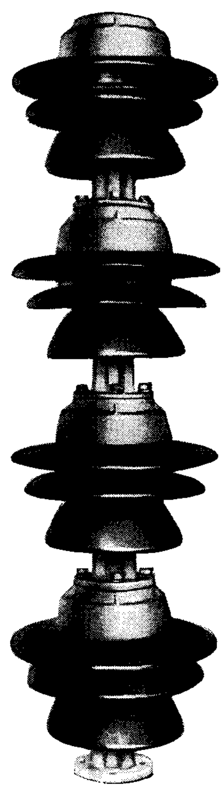


Fig. 228—A Four-Unit Column for 154,000-Volt Outdoor Service.

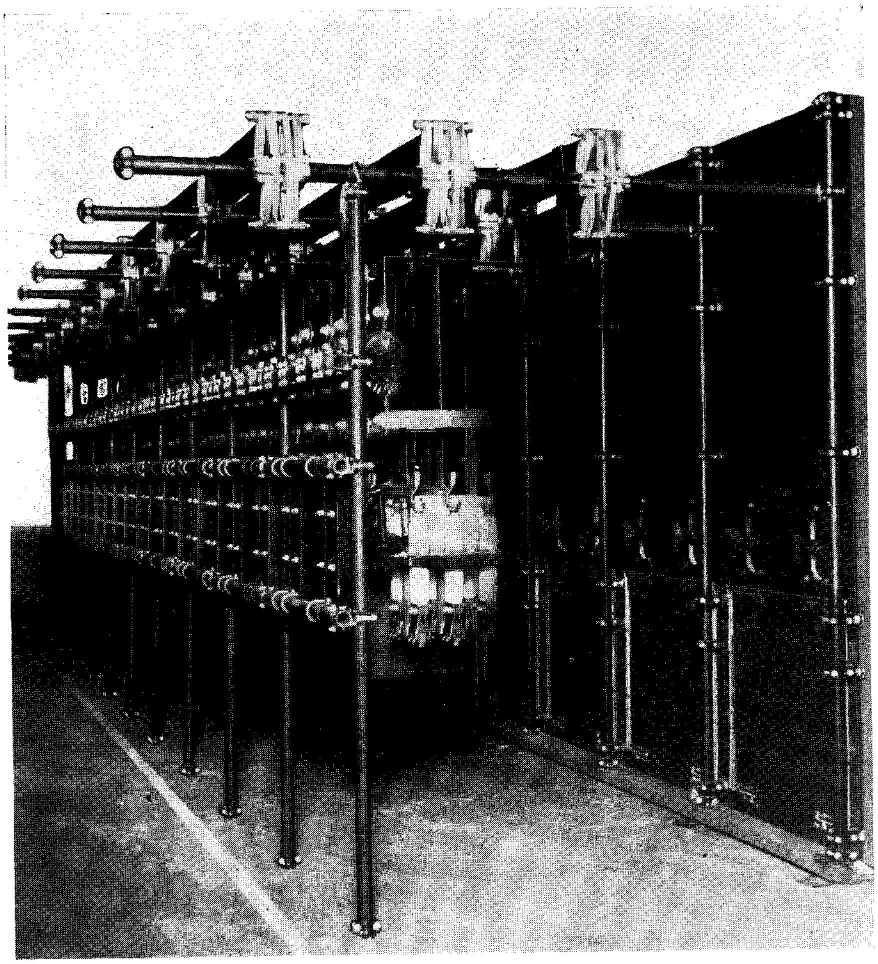


Fig. 229—Application of Modified Hollow Square Bus Supports.

MODIFIED HOLLOW SQUARE BUS BAR SUPPORT

4000 Volts Maximum A-C. or D-C.

Designed for heavy duty and a more even distribution of currents in all of the bus laminations, these supports are used for main bus bars or bus risers in a number of combinations as listed in the following table. Fig. 229 shows a typical example of hollow square bus construction.

The complete support consists of heat treated aluminum alloy clamps and an insulating tube of high grade micarta having a hard glossy finish.

The design is suitable for bars four inches wide only and will support a maximum total of 16 bars, 4″ x ¼″, spaced ¼ inch apart per phase.

For polyphase, 60 cycle systems, the recommended phase spacing is 18 inches, center to center of supports.

Number and Arrangement of Bus Bars	Style No. Complete Sup.
1 1	482629
11 11	482630
111 111	482631
1 1	482632
11 11	482633
111 111	482634
1 1 1 1	482635
11 11 11 11	482636
111 111 111 111	482637

WALL AND FLOOR TUBES—BUSHINGS

Figs. 230 to 235 with tables make it comparatively simple to order wall and floor bushings.

Porcelain Wall Tubes—Indoor Service

OUTLINE DIMENSIONS

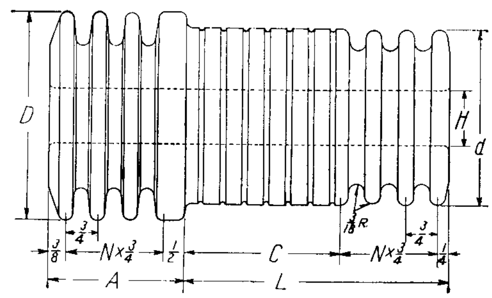


Fig. 230

DIMENSIONS, INCHES

	Nom. Volt. Rating	H	D	d	A	N*	Dimension C or Thickness of Wall for L Equal to 6	8	10	12	14	16	18	20	22
Insulator No......							9000	9001	9002	9003	9004	9005	....	....	....
	6600	1¼	4¾	4	3	3	3½	5½	7½	9½	11½	13½	....	....	....
Insulator No......							9010	9011	9012	9013	9014	9015	9016	....	....
	6600	1¼	4¾	4	3¾	4	2¾	4¾	6¾	8¾	10¾	12¾	14¾	....	....
Insulator No......							9020	9021	9022	9023	9024	9025	9026	....	....
	11000	1¼	4¾	4	4½	5	2	4	6	8	10	12	14	....	....
Insulator No......							....	9031	9032	9033	9034	9035	9036	9037	....
	15000	1¼	4¾	4	6	7	....	2½	4½	6½	8½	10½	12½	14½	....
Insulator No......							....	....	9042	9043	9044	9045	9046	9047	9048
	15000	1¼	4¾	4	7½	9	....	....	3	5	7	9	11	13	15
Insulator No......							9050	9051	9052	9053	9054	9055	....	....	....
	6600	2	5½	4¾	3	3	3½	5½	7½	9½	11½	13½	....	....	....
Insulator No......							9060	9061	9062	9063	9064	9065	9066	....	....
	6600	2	5½	4¾	3¾	4	2¾	4¾	6¾	8¾	10¾	12¾	14¾	....	....
Insulator No......							9070	9071	9072	9073	9074	9075	9076	....	....
	11000	2	5½	4¾	4¾	5	2	4	6	8	10	12	14	....	....
Insulator No......							....	9081	9082	9083	9084	9085	9086	9087	....
	15000	2	5½	4¾	6	7	....	2½	4½	6½	8½	10½	12½	14½	....
Insulator No......							....	....	9092	9093	9094	9095	9096	9097	9098
	15000	2	5½	4¾	7½	9	....	....	3	5	7	9	11	13	15
Insulator No.....							9500	9501	9502	9503	9504	9505	....	....	....
	6600	2½	6	5¼	3	3	3½	5½	7½	9½	11½	13½	....	....	....
Insulator No.....							9510	9511	9512	9513	9514	9515	9516	....	....
	6600	2½	6	5¼	3¾	4	2¾	4¾	6¾	8¾	10¾	12¾	14¾	....	....
Insulator No.....							9520	9521	9522	9523	9524	9525	9526	....	....
	11000	2½	6	5¼	4½	5	2	4	6	8	10	12	14	....	....
Insulator No......							....	9530	9531	9532	9533	9534	9535	9536	....
	15000	2½	6	5¼	6	7	....	2½	4½	6½	8½	10½	12½	14½	....
Insulator No......							....	....	9540	9541	9542	9543	9544	9545	9546
	15000	2½	6	5¼	7½	9	....	....	3	5	7	9	11	13	15

*Number of corrugations.

NOTE—Extension on both ends should be approximately the same for a given voltage.

Porcelain Wall Bushings

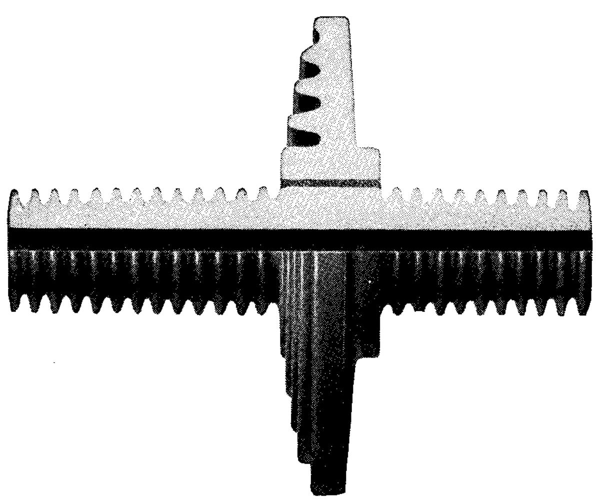


Fig. 231

Porcelain Wall Bushings—Cont'd

OUTLINE DIMENSIONS

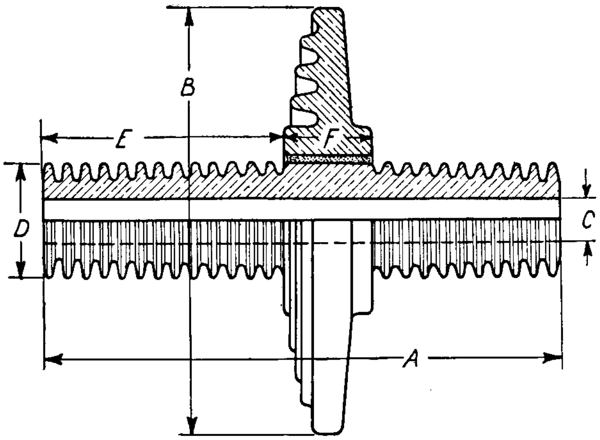


Fig. 232

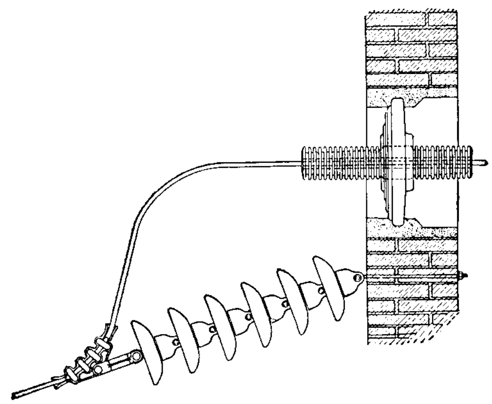


Fig. 233

Insulator No.	**911**	**922**	**933**	**944**
Trade voltage rating	25000	35000	45000	50000
Dry arc-over voltage	65000	85000	100000	120000
Leakage distance, inches	19	26½	33½	43
Diameter in inches (B)	14	14	18	18
Length in inches (A)	12	20	20$\frac{11}{16}$	24
Diameter hole, inches (C)	1¼	1¼	1½	1½
Diameter tube, inches (D)	3¾	3¾	4¾	4¾
Dimension E in inches	5⅛	9⅛	9¼	11¼
Dimension F in inches	2¾	2¾	4$\frac{7}{16}$	4$\frac{7}{16}$
Approximate net weight each in pounds	23	34	50	65
Approximate weight packed each in pounds	47	97	110	130

Porcelain Floor Tubes—Indoor Service

OUTLINE DIMENSIONS IN INCHES

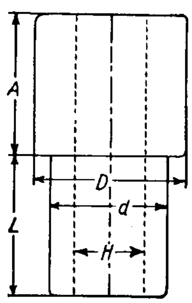


Fig. 234

Max. Voltage 4500

Dimensions, Inches				Insulator Numbers for L Equal to										
H	D	d	A	3	4	5	6	8	10	12	14	16	18	20
¾	2½	1¾	3	9100	9101	9102	9103	9104	9105	9106	9107	9108	....	....
1	2¾	2	3	9110	9111	9112	9113	9114	9115	9116	9117	9118	....	....
1¼	3	2¼	3	....	9120	9121	9122	9123	9124	9125	9126	9127	....	....
1½	3¼	2½	3	....	....	9130	9131	9132	9133	9134	9135	9136	9137	....
1¾	3½	2¾	3	....	....	....	9140	9141	9142	9143	9144	9145	9146	....
2	3¾	3	3	....	....	....	9150	9151	9152	9153	9154	9155	9156	....
2½	4½	3¾	3	....	....	....	9160	9161	9162	9163	9164	9165	9166	....
3	5	4¼	3	....	....	....	....	9170	9171	9172	9173	9174	9175	9176

Porcelain Tubes—Indoor Service

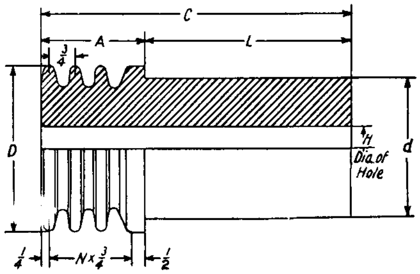


Fig. 235

Insulator No.	H	D	C	d	A	L	N*	Nom. Volt. Rating
9200	1¼	4¼	7	3	3	4	3	6600
9201	1¼	4¼	12½	3	4½	8	5	11000
9202	1¼	4¼	18	3	6	12	7	15000
9203	1¼	4¼	23½	3	7½	16	9	15000
9210	2	5	7	3¾	3	4	3	6600
9211	2	5	12½	3¾	4½	8	5	11000
9212	2	5	18	3¾	6	12	7	15000
9213	2	5	23½	3¾	7½	16	9	15000

(H through N: Dimensions, Inches)

*Number of corrugations.

In those cases when an abnormal amount of dust is in evidence the insulator should be corrugated on both ends.

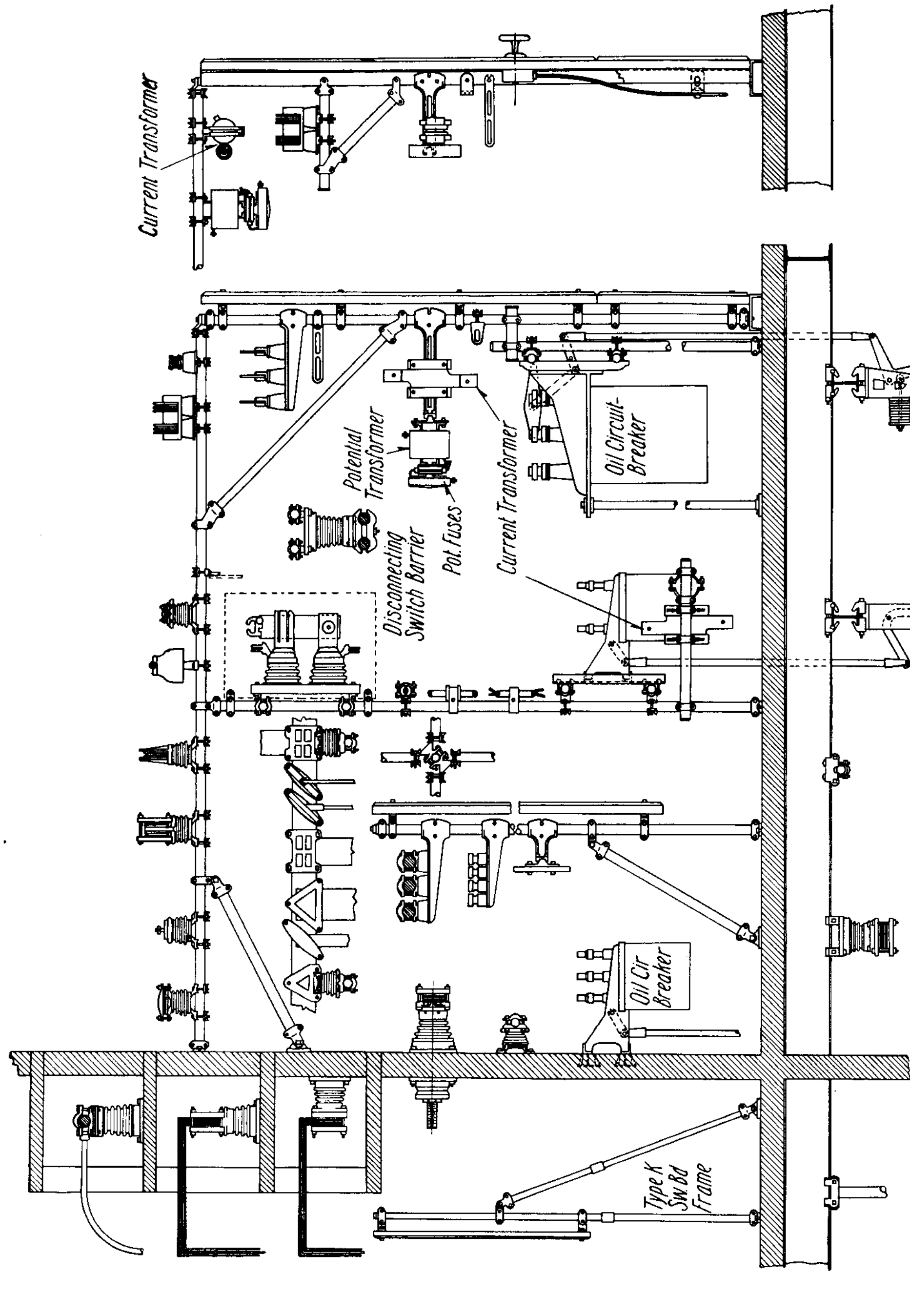


Fig. 237—Application of some switchboard detail accessories. For style number and other information refer to Westinghouse Catalogue of Electrical Supplies.

GRILLEWORK PANELS FOR SWITCHBOARD

Screening the rear of a switchboard prevents the access to the equipment by unauthorized persons. It also adds to the appearance of the installation. Screening of high-voltage live parts, such as oil circuit-breakers and their connections along aisles and runways, is also an added precaution to the safety of the operators. These two classes of screening are in line with the requirements of the National Electrical Safety Code and greatly enhance the value of the installation.

Grille panels of selected dimensions and weave have been standardized to expedite delivery. The panels are easily removable to give access to the equipment for cleaning, etc.

The door section is complete in itself forming a panel two feet eight inches wide. It is provided with lock and keys and may be inserted at any desired location in the grillework.

Mesh of Panels—Three different forms of mesh are available for panels enclosing switchboards: First, panels of No. 13 gauge expanded metal with 1″ x 2″ diamond mesh; second, No. 17 gauge flat ribbon ¼ inch wide with one inch square opening; and third, No. 16 gauge flat ribbon ½ inch wide with ½ inch square opening. The first gives fair appearance but practically no screening from view; the second gives good appearance with but little screening from view; and the third gives good appearance and good screening from view.

The panels for screening live parts, bus bars, etc., are of No 13 gauge expanded metal with

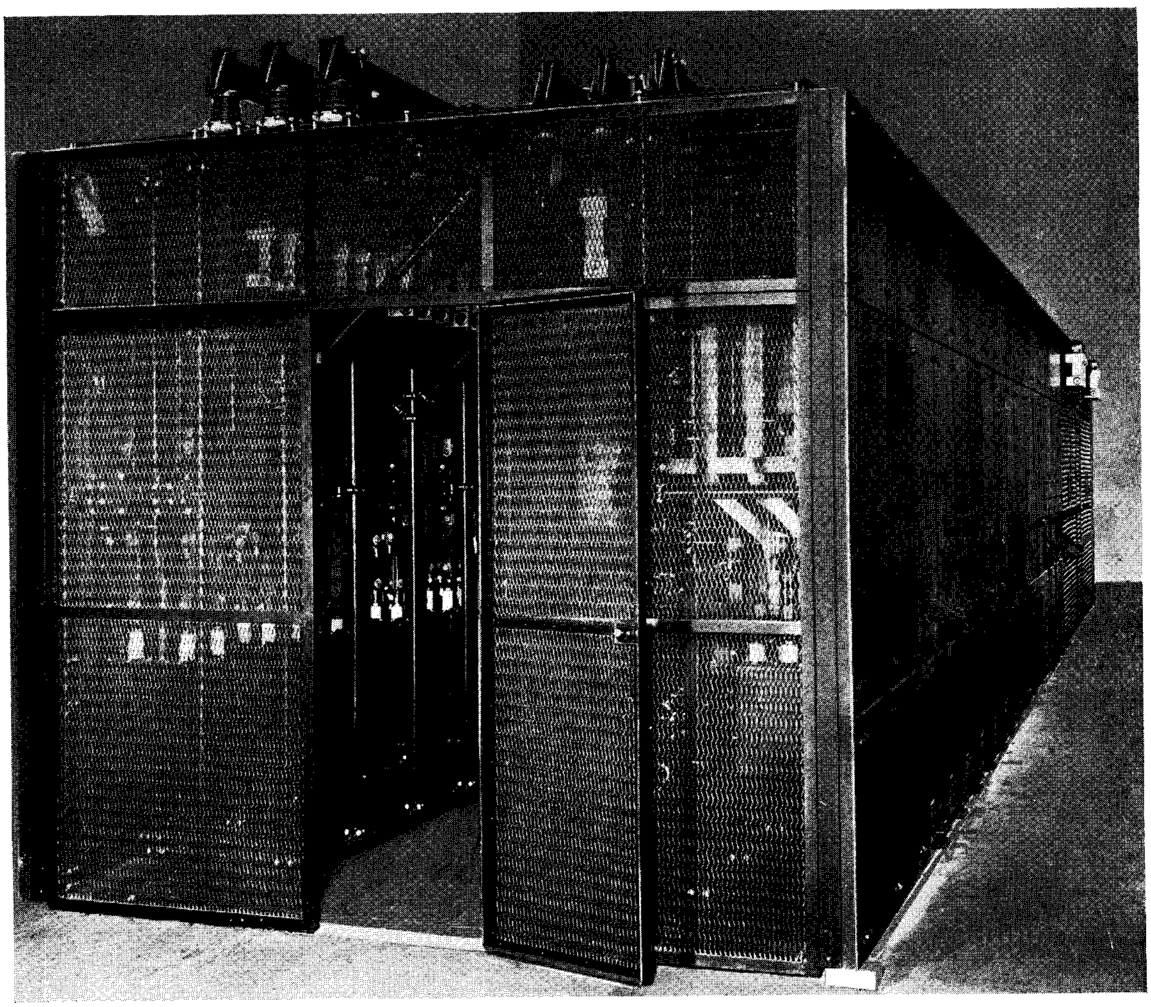


Fig. 238—Typical Grille Installation. Note grillework for future panels at end of structure.

1″ x 2″ diamond mesh. See Figs. 239, 240 and 241.

Frames for grille panels are of 1″ x 1″ x ⅛″ angle iron with holes punched in the side constituting the edge of the panel for bolting to adjacent panels or to supports.

Finish—Standard grille work as supplied is finished in dull black to match the standard finish of the board and other equipment.

Descriptions of Illustration—Fig. 242 shows the front of a switchboard for future equipment, the grille panel occupying the place of a future switchboard panel.

Standard Grillework Panels and Accessories

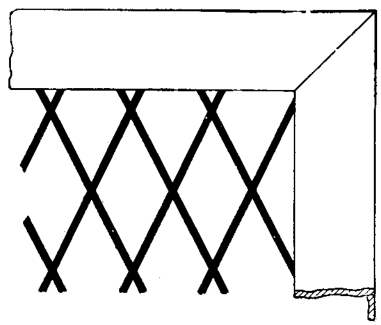


Fig. 239 shows 1 x 2 inch diamond mesh of No. 13 gauge expanded metal.

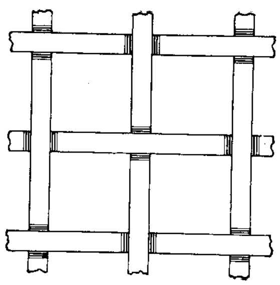


Fig. 240 shows 1-inch square mesh of No. 17 gauge flat wire, ¼-inch in width.

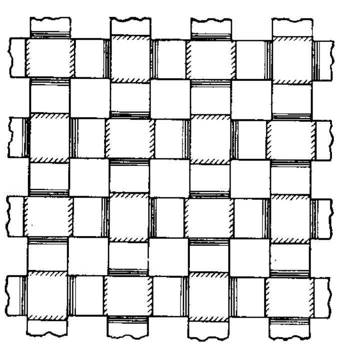


Fig. 241 shows 1-inch square mesh of No. 16 gauge flat wire, ½-inch in width.

Fig. 245 shows grillework at the end of the switchboard, running from switchboard to wall. The door section may be placed next to the switchboard without any intervening grille panel or next to the wall without any intervening grille panel.

Fig. 245 shows elevation of rear grillework enclosing a switchboard when the switchboard framework is self-supporting and independent of the wall support. It also shows a plan view of a complete switchboard enclosure, and screens for oil circuit-breakers.

Fig. 246 shows screens for breakers and bus bars.

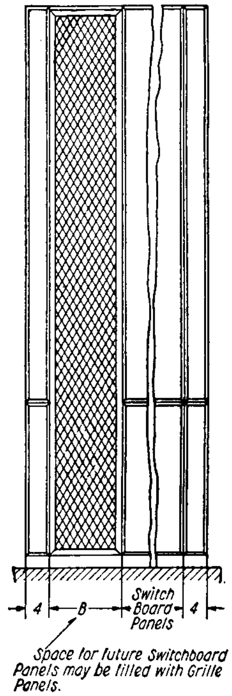


Fig. 242

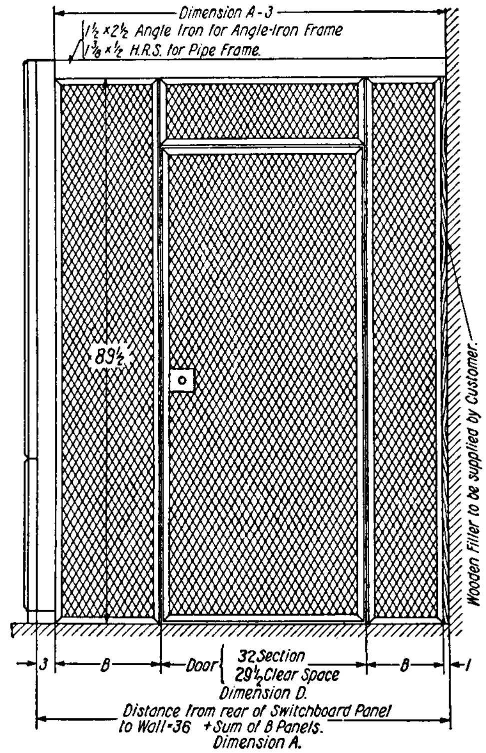


Fig. 243

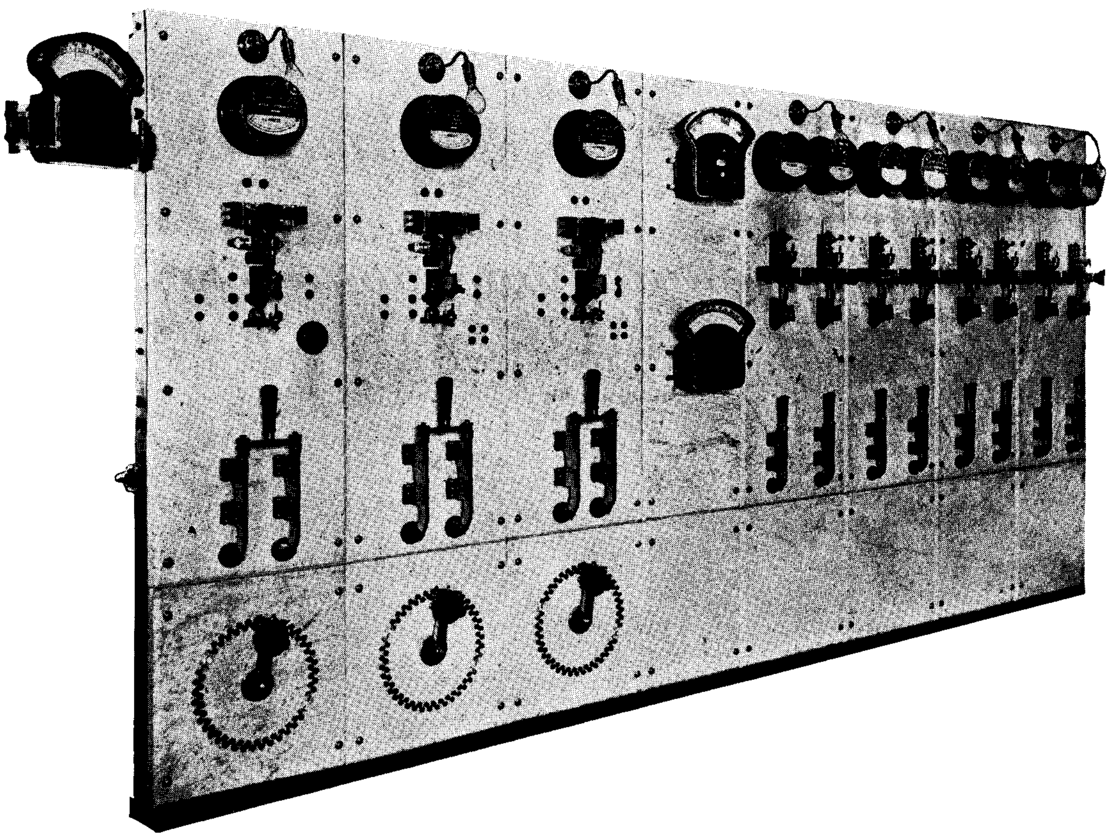


Fig. 244—Westinghouse switchboard installed 1896.

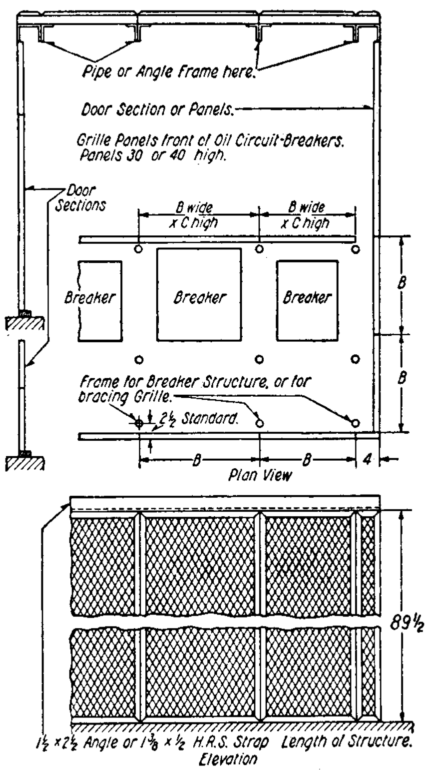


Fig. 245

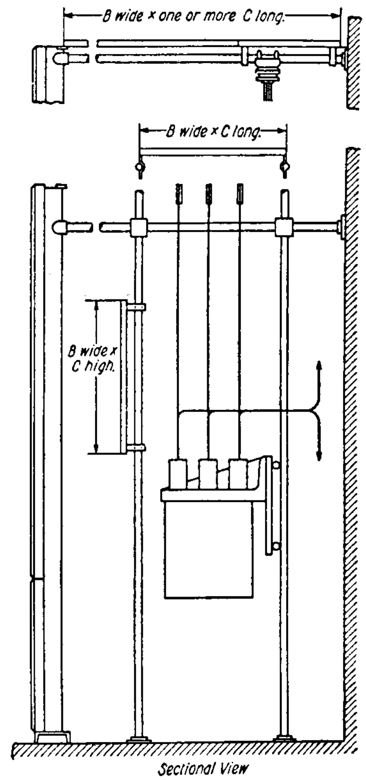


Fig. 246

WIRES AND CABLES

General—In selecting cable for electrical installations, consideration must be given to the numerous characteristics of the service such as voltage, current frequency, temperature, the prevalence of water, moisture, oil, acids, or corrosive gases. It is apparent that a great variety of cable designs will be required to cover the possible combinations of the imposed conditions. It is not advisable to list many of these wires and cables since the use of some is so limited.

Current Ratings—It is not advisable to list the current ratings of the various cables other than that provided by the National Electrical Code due to the wide fluctuation in the current carrying capacity in any given cable under the various conditions encountered in ordinary practice. If a tabulation of current carrying capacities is made which practically precludes the possibility of failure under any ordinary condition. the probabilities are that the cable will be uneconomical for most applications. On the other hand, if the carrying capacity is figured on a less liberal basis, the rating may be ill advised and a failure of the cable may result.

It is very important that particular care be taken in using cables in parallel. The way cables are placed when used in parallel has a great deal to do with the amount of current they will carry. If they are bunched, for instance, the inner cables will be unable to dissipate the required amount of heat and overheating will result.

In the following pages wires and cables which will meet the requirements of the majority of installations are listed and described. For other requirements special recommendation will be furnished upon receipt of the necessary information. For convenience and accuracy in ordering cable the form shown on page 99 should be used. This form indicates the information which is required.

The description of each class of wire or cable includes a reference to the specification number. A file of these specifications is maintained in each Westinghouse district office so that the detail characteristics of the conductor in question may be determined.

Cable Supports—Where cables are not run in conduits, suitable supports should be provided to keep them in position. These supports may be type R, type S or type P corresponding to the bus bar supports mentioned on page 83. Due consideration should be given to the stresses imposed under short-circuit conditions.

Where cables are installed in long vertical runs, they should be supported every ten feet. Where this is not practicable, it is sometimes necessary to fasten supporting clamps to the bare cables. This may be done by removing the insulation from the cable at the supporting points, care being taken to see that the cable support insulator is good for the voltage of the circuit. This method of supporting is especially advisable where the copper conductor is very heavy as it greatly lessens the chance of the conductors slipping through the insulation.

Taps and Splices—Taps and splices should usually be made in accordance with the recommendations of the cable manufacturers. "Frankel Solderless Connectors" as listed in the Westinghouse Catalogue of Electrical Supplies are often useful. Insulating tapes and soldering material are also listed in this catalogue.

Bending and Placing—The radius of the smallest curve over which a solid insulated wire or cable should be bent is six times the overall diameter.

Except in hot dry places such as for rheostats in furnace rooms, etc., recommendations are against bunching wires having only flame proof insulation. Rubber or cambric insulated wire should be used when bunching is necessary.

Rubber insulated wire or cable should not be installed in extremely hot locations as its safe operating temperature is relatively low.

Cable Insulation—Treat all circuits as if they were alive unless positive they are dead. Do not trust insulation as it is often insufficient except as a protection against accidental contact.

Lead Covered Cable—The ends of lead covered cable should not be unsealed until ready to connect as the exposed ends will absorb moisture.

In case of paper or varnished cambric insulated cable with lead covering provision must be made to prevent entrance of moisture at the ends unless the insulation is suitably impregnated as is the case with some of the varnished cambric insulated cables.

Grounding Metal Sheath Cable—Metal sheath cables carrying polyphase circuits must have sheaths grounded. This should be done at several different places.

Lead or bronze sheath single conductor cables carrying alternating-current must have their sheaths grounded at one point only, preferably in the middle and the cable sheath must be insulated from the supports at all other points. This prevents induced sheath currents. If the continuity of the sheath is broken at one or more points the individual sections of the sheath should be grounded each at one point.

Soldering Cable—When soldering cable in terminals, first tin the terminal well then cut into the insulation a sufficient distance from the end to clear distorted strands of cable. Measure back from first cut the amount of cable it is intended to insert in the terminal and cut the nsulation, then remove the insulation between the two cuts. Twist a small wire around the bare cable at the point of the first cut in the insulation and tin the bare cable. Saw off the distorted cable with hack-saw and proceed to solder the cable in the terminal.

In soldering heavy cables in the terminals, special care should be taken to heat and tin the terminals and cable thoroughly before soldering. Note particularly in this connection, that all tube terminals when supplied by Westinghouse are treated with a soldering flux.

The use of a soldering pot and dipper are much to be preferred to a torch since the soldering flux is likely to be burned when a torch is used. Several turns of cord or tape wrapped around the end of the insulation will prevent it from curling out of shape when the cable is heated.

Three-Conductor Cables—For three-phase generator leads where the current is small enough to permit the use of standard three-conductor cables, these are to be preferred to three single-conductor cables. It is not practical to make three-conductor cable larger than 500,000 circular mils, therefore, single conductor cables in parallel are recommended for larger capacities.

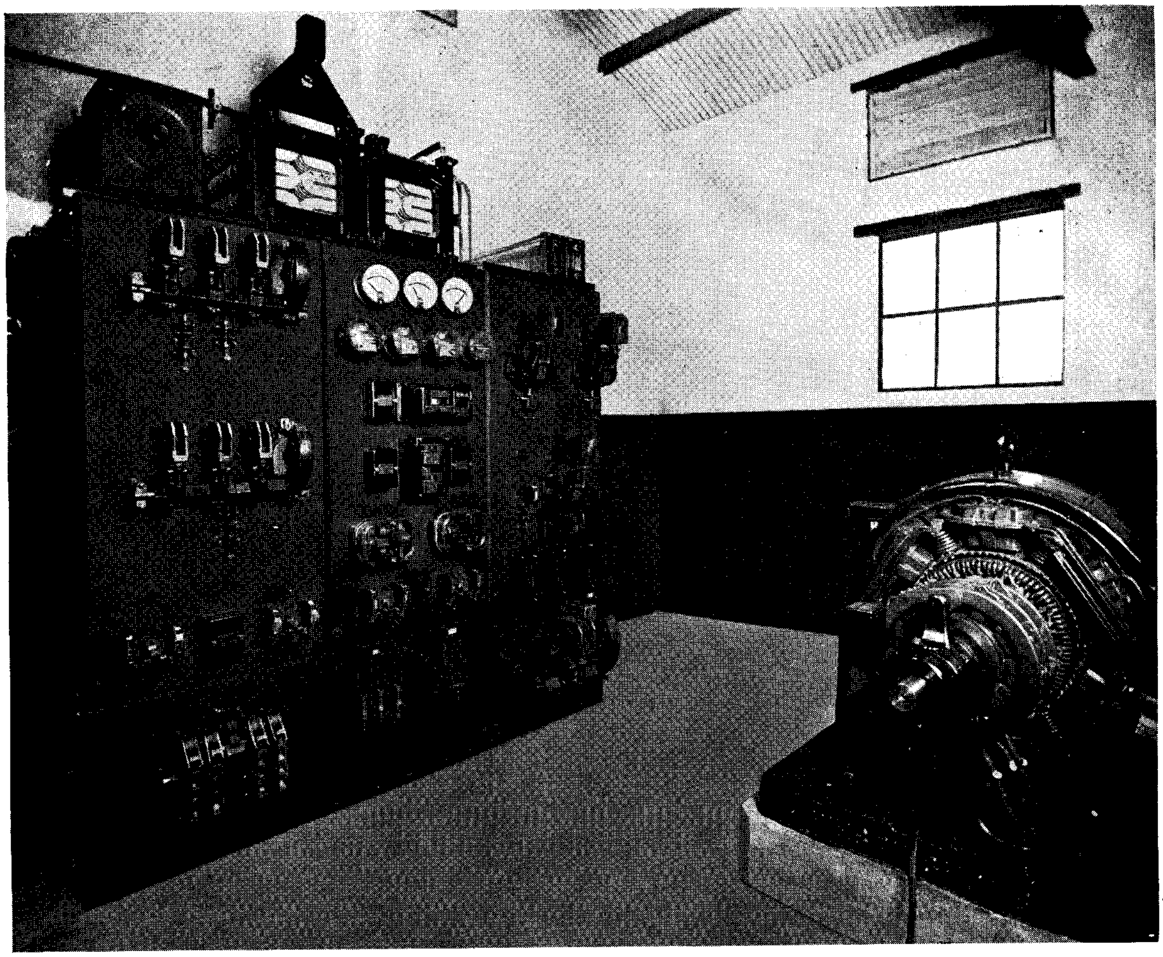


Fig. 247—Automatic substation for one 500 Kw., 600 V., D-C. railway synchronous converter.

Single-Conductor Cables—When single-conductor cables are used on alternating-current circuits in metal conduits, all of the phases of the circuit must be installed within the same metal conduit, for no single conductor should be surrounded by a complete iron circuit.

Flameproof Covering—Flameproof covering does not provide much insulation and therefore should be treated as a conductor for high-voltage leads and stripped back at the ends sufficiently to afford ample creepage distance. Black flameproof covering is provided for in the specifications. It has a greater moisture resistance than the white covering but does not have as high flameproof qualities.

End Bells—End bells must be used on circuits of over 2500 volts for lead-covered cables and should preferably be furnished on circuits of over 750 volts.

Where needed, both end bells and the compound for filling them should be purchased from a reliable manufacturer.

Selection of Cables—In selecting cables for a required application, the following information will be necessary:

1. Class of service as determined from classification list in the following paragraph.
2. Working voltage.
3. Amperes carrying capacity or circular mils.
4. Flexibility—whether solid, stiff, or flexible.

Classification of service. Each class of service is given a letter for convenience which will be used for reference.

(a) Cables located under water.

In wet ducts.

In ducts or metal conduits liable to be damp on account of condensation of moisture or other causes.

Open wiring in damp places, such as mines, etc.

(b) Cables in dry ducts or fireproof enclosures where conditions are such that they will never be damp or for open wiring outdoors where insulation is required.

(c) Cables for open wiring in dry places. (Not enclosed in compartments.)

(d) Cables for open wiring in hot places, either bunched together or separated. Used where rubber, varnished cambric or paper insulation would get too hot.

Class (d) cables cannot be bunched together in contact with each other where the voltage between conductors exceeds 75.

(e) Cables for heavy capacities, open or in compartments and on insulating supports, being further isolated by guards, barriers or elevation, so that insulation on the conductor may be dispensed with, or for outdoor service where insulation is not required.

After the classification has been determined, recommendation as to standard specifications on which to order the cable can be obtained from the table "Application Data and Standard Specifications" pages 95 and 96. A file of cable specifications is available in each district office, which gives detail dimensions and characteristics of each conductor listed.

(*) Wherever a P. D. Specification number appears in the table, it is understood that one or more sizes on this specification are carried in stock at East Pittsburgh, except the specifications marked thus (¶). A list of the particular sizes carried is given on pages 97 & 98 In some cases additional sizes are listed on the specification, but since they are not carried in stock the delivery date will be much longer.

Varnished cambric cable has been specified as an alternative in a great many cases and can be furnished if satisfactory to the customer. Varnished cambric cables of 26200 c.m. and larger have been approved by the National Board of Fire Underwriters for use in permanently dry places. They should therefore be satisfactory for classification (b) with weatherproof braid and classification (c), with flameproof braid. They can be worked to a higher current carrying capacity than rubber insulated cables and they are also cheaper in the larger sizes and higher voltages.

Paper insulated lead covered cables have been specified as an alternative to rubber insulated lead covered or varnished cambric insulated lead covered, since they have a higher current carrying capacity and are cheaper.

All rubber insulated cables have Standard National Electrical Code Rubber except those marked thus (§).

Symbols in the table have the following meaning:

R. I. L. C.—Rubber Insulated Lead Covered.
R. I. W. P.—Rubber Insulated Weatherproof Braid.
R. I. F. P.—Rubber Insulated and Black Flameproof Braid. (See description of black flameproof in subject matter.)
V. C. W. P.—Varnished Cambric Insulated and Weatherproof Braid.
V. C. F. P.—Varnished Cambric Insulated and Black Flameproof Braid.
V. C. L. C.—Varnished Cambric Insulated Lead Covered.
P. I. L. C.—Paper Insulated Lead Covered.

(†) On account of the limited demand, no P. D. Specifications are available for these cables. Where no specification is listed, or wherever an application is met with where the table does not apply, and no decision can be reached as to what should be furnished, the standard blank form on page 99 should be filled out with the necessary information and recommendation obtained (from the factory at East Pittsburgh or from a responsible cable company) as to the proper cable to supply.

(‡) There would be no advantage in a flexible standing with lead covering, over a stiff stranding, due to the stiffness of the lead.

(¶) Not carried in stock (§) Rubber is 30% Hevea and costs more than "Code" Rubber and does not have the Standard N. E. C. Rubber. (**) Gray flame-proof finish. (¶¶) Weatherproof and oil proof finish. (‡‡) Black slow-burning. (§§) For voltages up to 1500 only.

(††) These weather proof braids and extra flexible, costs more than standard flexi .e cables.

APPLICATION DATA AND STANDARD SPECIFICATIONS*

Voltage	Class of Service	CONDUCTORS RECOMMENDED							
		SINGLE COND.—FLEX.		SINGLE COND.—STIFF		SINGLE COND.—SOLID		THREE COND.—STIFF	
		Kind	P.D. Spec.	Kind	P.D. Spec.	Kind	P.D. Spec.	Kind	P.D. Spec.
0 to 600	(a)	R. I. L. C.	‡	R. I. L. C.	†	R. I. L. C.	1548¶	R. I. L. C.	1548¶ 1535¶
		V. C. L. C.	‡	V. C. L. C.	†	V. C. L. C.	†	V. C. L. C.	†
		P. I. L. C.	‡	P. I. L. C.	†	P. I. L. C.	†	P. I. L. C.	1536
	(b)	R. I. W. P.	3316§¶ 1504 1661§††	R. I. W. P.	4220 2753¶ 3317§¶	R. I. W. P.	1501	R. I. W. P.	2175¶ 2463¶
		V. C. W. P.	3726¶ 3980¶¶	V. C. W. P.	2579¶¶	V. C. W. P.	2496¶¶	V. C. W. P.	†
	(c)	R. I. F. P.	2984§¶ 2466 4305	R. I. F. P.	2465	R. I. F. P.	2474§ 2282	R. I. F. P.	†
		V. C. F. P.	†	V. C. F. P.	†	V. C. F. P.	2462¶** 3782¶	V. C. F. P.	†
	(d)	Slow Burning	†	Slow Burning	†	Slow Burning	1531¶ 3483‡‡	Not Manufactured	
	(e)	Bare	1487	Bare	†	Bare	1596	Not Manufactured	
601 to 2500	(a)	R. I. L. C.	‡	R. I. L. C.	1443¶	R. I. L. C.	1443¶	R. I. L. C.	†
		V. C. L. C.	‡	V. C. L. C.	†	V. C. L. C.	†	V. C. L. C.	†
		P. I. L. C.	‡	P. I. L. C.	†	P. I. L. C.	†	P. I. L. C.	†
	(b)	R. I. W. P.	1972§†† 1447	R. I. W. P.	1971	R. I. W. P.	1446	R. . I. W. P.	†
		V. C. W. P.	2580¶¶	V. C. W. P.	2116¶¶	V. C. W. P.	†	V. C. W. P.	†
	(c)	R. I. F. P.	4060§¶	R. I. F. P.	2574¶	R. I. F. P.	2449	R. I. F. P.	†
		V. C. F. P.	*	V. C. F. P.	†	V. C. F. P.	†	V. C. F. P.	†
	(d)	Not Required		Not Required		Not Required		Not Manufactured	
	(e)	Bare	1487	Bare	†	Bare	1596	Not Manufactured	

APPLICATION DATA AND STANDARD SPECIFICATIONS—Continued

Voltage	Class of Service	CONDUCTORS RECOMMENDED: Single Cond.—Flexible: Kind	Single Cond.—Flexible: P.D. Spec.	Single Cond.—Stiff: Kind	Single Cond.—Stiff: P.D. Spec.	Single Cond.—Solid: Kind	Single Cond.—Solid: P.D. Spec.	Three Cond.—Stiff: Kind	Three Cond.—Stiff: P.D. Spec
2501 to 7000	(a)	R. I. L. C.	‡	R. I. L. C.	2587¶	R. I. L. C.	†	R. I. L. C.	2589¶
		V. C. L. C.	‡	V. C. L. C.	†	V. C. L. C.	†	V. C. L. C.	†
		P. I. L. C.	‡	P. I. L. C.	2588¶	P. I. L. C.	†	P. I. L. C.	2590¶
	(b)	R. I. W. P.	3226§¶†† 1440	R. I. W. P.		R. I. W. P.	†	R. I. W. P.	†
		V. C. W. P.	2581¶¶	V. C. W. P.	2572¶¶	V. C. W. P.	†	V. C. W. P.	†
	(c)	R. I. F. P.	†	R. I. F. P.	2582	R. I. F. P.	†	R. I. F. P.	†
		V. C. F. P.	†	V. C. F. P.	†	V. C. F. P.	2573	V. C. F. P.	†
	(d)	Not Required		Not Required		Not Required		Not Manufactured	
	(e)	Bare	1487	Bare	†	Bare	1596	Not Manufactured	
7001 to 11,000	(a)	R. I. L. C.	‡	R. I. L. C.	†	R. I. L. C.	†	R. I. L. C.	†
		V. C. L. C.	‡	V. C. L. C.	†	V. C. L. C.	†	V. C. L. C.	†
		P. I. L. C.	‡	P. I. L. C.	†	P. I. L. C.	†	P. I. L. C.	†
	(b)	R. I. W. P.	†	R. I. W. P.	1612	R. I. W. P.	†	R. I. W. P.	†
		V. C. W. P.	†	V. C. W. P.	1612	V. C. W. P.	†	V. C. W. P.	†
	(c)	R. I. F. P.	†	R. I. F. P.	†	R. I. F. P.	†	R. I. F. P.	†
		V. C. F. P.	†	V. C. F. P.	†	V. C. F. P.	†	V. C. F. P.	†
	(d)	Not Required		Not Required		Not Required		Not Manufactured	
	(e)	Bare	1487	Bare	†	Bare	1596	Not Manufactured	
11,001 to 13,200	(a)	R. I. L. C.	‡	R. I. L. C.	1444¶	R. I. L. C.	†	R. I. L. C.	1539¶
		V. C. L. C.	‡	V. C. L. C.	†	V. C. L. C.	†	V. C. L. C.	†
		P. I. L. C.	‡	P. I. L. C.	†	P. I. L. C.	†	P. I. L. C.	1540¶
	(b)	R. I. W. P.	†	R. I. W. P.	†	R. I. W. P.	†	R. I. W. P.	†
		V. C. W. P.	†	V. C. W. P.	1569¶¶	V. C. W. P.	1569¶¶	V. C. W. P.	†
	(c)	R. I. F. P.	†	R. I. F. P.	†	R. I. F. P.	†	R. I. F. P.	†
		V. C. F. P.	†	V. C. F. P.	†	V. C. F. P.	†	V. C. F. P.	†
	(d)	Not Required		Not Required		Not Required		Not Manufactured	
	(e)	Bare	1487	Bare	†	Bare	1596	Not Manufactured	
13,201 to 22,000	(a)	R. I. L. C.	‡	R. I. L. C.	†	R. I. L. C.	†	R. I. L. C.	†
		V. C. L. C.	‡	V. C. L. C.	†	V. C. L. C.	†	V. C. L. C.	†
		P. I. L. C.	‡	P. I. L. C.	†	P. I. L. C.	†	P. I. L. C.	†
	(b)	R. I. W. P.	†	R. I. W. P.	3314¶	R. I. W. P.	†	R. I. W. P.	†
		V. C. W. P.	†	V. C. W. P.	†	V. C. W. P.	†	V. C. W. P.	†
	(c)	R. I. F. P.	†	R. I. F. P.	†	R. I. F. P.	†	R. I. F. P.	†
		V. C. F. P.	†	V. C. F. P.	†	V. C. F. P.	†	V. C. F. P.	†
	(d)	Not Required		Not Required		Not Required		Not Manufactured	
	(e)	Bare	1487	Bare	†	Bare	1596	Not Manufactured	
22,001 to 27,000	(a)	R. I. L. C.	‡	R. I. L. C.	†	R. I. L. C.	†	R. I. L. C.	†
		V. C. L. C.	‡	V. C. L. C.	†	V. C. L. C.	†	V. C. L. C.	†
		P. I. L. C.	‡	P. I. L. C.	†	P. I. L. C.	†	P. I. L. C.	†
	(b)	R. I. W. P.	†	R. I. W. P.	4089¶	R. I. W. P.	†	R. I. W. P.	†
		V. C. W. P.	†	V. C. W. P.	†	V. C. W. P.	1568¶¶	V. C. W. P.	†
	(c)	R. I. F. P.	†	R. I. F. P.	†	R. I. F. P.	†	R. I. F. P.	†
		V. C. F. P.	†	V. C. F. P.	†	V. C. F. P.	†	V. C. F. P.	†
	(d)	Not Required		Not Required		Not Required		Not Manufactured	
	(e)	Bare	1487	Bare	†	Bare	1596	Not Manufactured	
27,001 to 33,000	(a)	R. I. L. C.	‡	R. I. L. C.	†	R. I. L. C.	†	R. I. L. C.	†
		V. C. L. C.	‡	V. C. L. C.	†	V. C. L. C.	†	V. C. L. C.	†
		P. I. L. C.	‡	P. I. L. C.	†	P. I. L. C.	†	P. I. L. C.	†
	(b)	R. I. W. P.	†	R. I. W. P.	†	R. I. W. P.	†	R. I. W. P.	†
		V. C. W. P.	†	V. C. W. P.	†	V. C. W. P.	†	V. C. W. P.	†
	(c)	R. I. F. P.	†	R. I. F. P.	†	R. I. F. P.	†	R. I. F. P.	†
		V. C. F. P.	†	V. C. F. P.	†	V. C. F. P.	†	V. C. F. P.	†
	(d)	Not Required		Not Required		Not Required		Not Manufactured	
	(e)	Bare	1487	Bare	†	Bare	1596	Not Manufactured	

BARE AND INSULATED CABLE—INSULATED WIRE

East Pittsburgh Standard Stock Sizes

#1440, R.I.W.P. Cable, Flex. 7000 V.

Stranding	C.M.	Dia. Bare	Dia. Ins.	Max. Amperes* N.E. Code Rating	Wt. in Pounds per 1000 Ft.
19-.0226	9 700	.11	.72	24	310
49-.0226	25 000	.20	.85	48	450
61-.0285	50 000	.26	.91	77	570
259-.0201	105 000	.42	1.09	125	870
259-.0254	170 000	.53	1.20	175	1150
427-.0285	350 000	.77	1.43	300	1900

#1446, R.I.W.P. Wire—2500 V.

Stranding	C.M.	Dia. Bare	Dia. Ins.	Max. Amperes* N.E. Code Rating	Wt. in Pounds per 1000 Ft.
.051	2 600		.39	6	60
.081	6 560		.42	20	90
.129	16 600		.47	35	140
.229	52 400		.68	80	300
.410	168 000		.90	175	750

#1447, R.I.W.P. Cable, Flex.—2500 V.

Stranding	C.M.	Dia. Bare	Dia. Ins.	Max. Amperes* N.E. Code Rating	Wt. in Pounds per 1000 Ft.
19-.0142	3 800	.071	.41	15	70
19-.0179	6 100	.090	.43	19	85
19-.0226	9 700	.11	.45	24	105
19-.0285	15 000	.14	.49	33	135
49-.0226	25 000	.20	.62	48	210
49-.0254	32 000	.23	.68	54	240
61-.0285	50 000	.26	.71	77	310
133-.0254	86 000	.38	.87	105	510
259-.0254	170 000	.53	1.06	175	830
259-.032	270 000	.67	1.21	255	1240

#1487, Bare C. Cable Stranded, Stiff or Flex.

Stranding	C.M.	Dia. Bare	Dia. Ins.	Max. Amperes* N.E. Code Rating	Wt. in Pounds per 1000 Ft.
15-.005	375	.024			1.2
10-.0100	1 000	.040			3
19-.0142	3 800	.071			12
19-.0179	6 100	.090			19
19-.0285	15 000	.14			47
49-.0226	25 000	.20			75
49-.0254	32 000	.23			95
61-.0285	50 000	.26			150
133-.0254	86 000	.38			260
19-.072	98 000	.36			300
259-.0201	105 000	.42			320
37-.057	120 000	.40			370
61-.051	160 000	.46			480
259-.0254	170 000	.53			520
61-.057	200 000	.51			610
61-.064	250 000	.58			760
427-.0285	350 000	.77			1060

#1490, Two Cond. Flex. Cord, Twisted 300 V.

Stranding	C.M.	Dia. Bare	Dia. Ins.	Max. Amperes* N.E. Code Rating	Wt. in Pounds per 1000 Ft.
16-.0100	1 600	.050	.30†	3	
26-.0100	2 600	.065	.33†	6	
41-.0100	4 100	.080	.43†	15	

†Ins. dia. over 2 Cond.

Ex. Des.: 15 in. of 41— in. .0100, two cond. flex. cord #1490.

#1493, R.I.W.P. Cable, Extra Flex. (Thin Insulation)

Stranding	C.M.	Dia. Bare	Dia. Ins.	Max. Amperes* N.E. Code Rating	Wt. in Pounds per 1000 Ft.
19-.0179	6 100	.090	.21	19	35

#1501, R.I.W.P. Wire—600 V.

Stranding	C.M.	Dia. Bare	Dia. Ins.	Max. Amperes* N.E. Code Rating	Wt. in Pounds per 1000 Ft.
.064	4 100		.23	15	35
.081	6 560		.25	20	45
.102	10 400		.27	25	60
.129	16 600		.31	35	85
.144	20 700		.38	41	110
.162	26 200		.40	50	140
.204	41 600		.45	70	210
.258	66 600		.52	90	300

#1504, R.I.W.P. Cable, Flex. 600 V.

Stranding	C.M.	Dia. Bare	Dia. Ins.	Max. Amperes* N.E. Code Rating	Wt. in Pounds per 1000 Ft.
19-.0142	3 800	.071	.24	15	35
19-.0179	6 100	.090	.26	19	45
19-.0226	9 700	.11	.28	24	60
19-.0285	15 000	.14	.31	33	85
49-.0226	25 000	.20	.45	48	160
49-.0254	32 000	.23	.48	54	190
61-.0285	50 000	.26	.51	77	250
133-.0254	86 000	.38	.67	105	420
259-.0201	105 000	.42	.72	125	490
259-.0254	170 000	.53	.83	175	720

#1513, Single Cond. Flex. Cord (Thin Insulation)

Stranding	C.M.	Dia. Bare	Dia. Ins.	Max. Amperes* N.E. Code Rating	Wt. in Pounds per 1000 Ft.
10-.0100	1 000	.040	.10	2	
16-.0100	1 600	.050	.12	3	
41-.0100	4 100	.080	.15	15	
65-.0100	6 500	.10	.17	20	
165-.0100	16 500	.15	.24	35	

Ex. Des.: 15 in. of 41— in. .0100 single cond. flex. cord. #1513.

#1552, Flat Braided Bare C. Cable

Stranding	C.M.	Dia. Bare	Dia. Ins.	Max. Amperes* N.E. Code Rating	Wt. in Pounds per 1000 Ft.
384-.0050	9 600	.56 wide			
912-.0050	23 000	.81 wide			
240-.0100	24 000	.50 wide			
480-.0100	48 000	.75 wide			
768-.0100	77 000	1.06 wide			

#1563, B.C. Cable, Flex.

Stranding	C.M.	Dia. Bare	Dia. Ins.	Max. Amperes* N.E. Code Rating	Wt. in Pounds per 1000 Ft.
15-.0050	380	.023	.040		1.4

#1568, V.C.W.P. Wire and Cable, 27000 V.

Stranding	C.M.	Dia. Bare	Dia. Ins.	Max. Amperes* N.E. Code Rating	Wt. in Pounds per 1000 Ft.
.325	106 000		1.78	150	1380

#1569, V.C.W.P. Wire and Cable, 12000 V.

Stranding	C.M.	Dia. Bare	Dia. Ins.	Max. Amperes* N.E. Code Rating	Wt. in Pounds per 1000 Ft.
.204	41 600		1.12	85	510
19-.072	98 000	.36	1.29	150	770
259-.032	270 000	.67	1.62	305	1490

#1612, R.I.V.C. & W.P. Cable (Grounded Service for Locomotive Wiring) 11000 V.

Stranding	C.M.	Dia. Bare	Dia. Ins.	Max. Amperes* N.E. Code Rating	Wt. in Pounds per 1000 Ft.
19-.064	78 000	.32	1.48	100	1180

#1635, Bare C. Cable, Extremely Flex.

Stranding	C.M.	Dia. Bare	Dia. Ins.	Max. Amperes* N.E. Code Rating	Wt. in Pounds per 1000 Ft.
150-.0020	600	.034			1.8
280-.0020	1100	.043			3.4
1183-.0020	4700	.090			14

#1661, R.I. Triple B.C. & W.P. Cable, Extra Flex., 30% Hevea, 600 V.

Stranding	C.M.	Dia. Bare	Dia. Ins.	Max. Amperes* N.E. Code Rating	Wt. in Pounds per 1000 Ft.
91-.0179	29 000	.20	.56	50	190
133-.0159	34 000	.24	.59	56	240
259-.0142	52 000	.30	.66	80	280
259-.0179	83 000	.38	.77	100	450
427-.0159	108 000	.43	.83	130	575
703-.0142	142 000	.50	.90	160	710
703-.0159	180 000	.56	1.02	185	880

#1971, R.I.W.P. Cable, Stiff—2500 V

Stranding	C.M.	Dia. Bare	Dia. Ins.	Max. Amperes* N.E. Code Rating	Wt. in Pounds per 1000 Ft.
7-.081	46 000	.24	.69	70	320
7-.102	73 000	.31	.76	90	420
19-.072	98 000	.36	.85	125	530
19-.081	125 000	.41	.89	150	620

#1972, R.I. Triple B. C. & W. P. Cable, Extra Flex., 30% Hevea 2500 V.

Stranding	C.M.	Dia. Bare	Dia. Ins.	Max. Amperes* N.E. Code Rating	Wt. in Pounds per 1000 Ft.
259-.0142	52 000	.30	.81	80	360
259-.0179	83 000	.38	.94	100	500
551-.0179	180 000	.57	1.17	185	900
703-.0159	180 000	.56	1.16	185	900

#2031, Triple B. C. Cable, Flex.

Stranding	C.M.	Dia. Bare	Dia. Ins.	Max. Amperes* N.E. Code Rating	Wt. in Pounds per 1000 Ft.
16-.0100	1 600	.050	.16		
41-.0100	4 100	.080	.18		
19-.0179	6 100	.090	.20		
19-.0226	9 700	.11	.22		

#2054, Bare C. Cable, Extra Flex.

Stranding	C.M.	Dia. Bare	Dia. Ins.	Max. Amperes* N.E. Code Rating	Wt. in Pounds per 1000 Ft.
259-.0050	6 500	.11			20
525-.0050	13 000	.16			40
910-.0050	23 000	.20			70

#2116, V.C. & W.P. Cable, Stiff 2500 V.

Stranding	C.M.	Dia. Bare	Dia. Ins.	Max. Amperes* N.E. Code Rating	Wt. in Pounds per 1000 Ft.
7-.0254	4 500	.075	.40	18	80
7-.040	11 000	.12	.46	30	120
7-.064	29 000	.19	.61	60	220
7-.102	73 000	.31	.73	110	420
19-.072	98 000	.36	.82	150	530
19-.091	160 000	.46	.93	210	750
19-.114	250 000	.57	1.05	300	1140
37-.102	380 000	.71	1.20	390	1590
61-.102	630 000	.92	1.41	565	2550

#2164, 15—Cond. Jumper Cable, 30% Hevea, 600-2500 V.

Stranding	C.M.	Dia. Bare	Dia. Ins.	Max. Amperes* N.E. Code Rating	Wt. in Pounds per 1000 Ft.
15-Cond.	4 100		1.53		1150

#2282, R.I.F.P. Wire 600 V.

Stranding	C.M.	Dia. Bare	Dia. Ins.	Max. Amperes* N.E. Code Rating	Wt. in Pounds per 1000 Ft.
.081	6 560		.26	20	45
.102	10 400		.28	25	60

#2333, Single Cond. Flex. Cord 300 V.

Stranding	C.M.	Dia. Bare	Dia. Ins.	Max. Amperes* N.E. Code Rating	Wt. in Pounds per 1000 Ft.
16-.0100	1600	.050	.14	3	

Ex. Des.: 42 in. of 16— in. .0100 single cond. flex. cord #2333.

#2449, R.I.F.P. Wire—2500 V.

Stranding	C.M.	Dia. Bare	Dia. Ins.	Max. Amperes* N.E. Code Rating	Wt. in Pounds per 1000 Ft.
.102	10 400		.47	25	100
.162	26 200		.58	50	190
.204	41 600		.65	70	260
.258	66 600		.71	90	350
.365	133 000		.86	150	630
.460	212 000		.96	225	900

#2463, R.I.B.C. & F.P. Cable Mult. Cond.—600 V.

Stranding	C.M.	Dia. Bare	Dia. Ins.	Max. Amperes* N.E. Code Rating	Wt. in Pounds per 1000 Ft.
2 of 19-.0226	9 700	.11	.62		170
3 of 19-.0226	9 700	.11	.66		230
3 of 19-.032	19 000	.16	.84		400
4 of 19-.0226	9 700	.11	.72		280
4 of 19-.032	19 000	.16	.92		500
4 { 2 of 19-.0179 2 of 19-.032 }	6 100 19 000	.090 .16	.76		360
6 of 19-.0226	9 700	.11	.88		420
6 of 19-.032	19 000	.16	1.12		740
8 of 19-.0226	9 700	.11	.96		575

Ex. Des.: 273 in. of { 2-19— in. .0179; 2-19— in. .032 } four cond. cable #2463.

#2465, R.I.F.P. Cable, Stiff—600 V.

Stranding	C.M.	Dia. Bare	Dia. Ins.	Max. Amperes* N.E. Code Rating	Wt. in Pounds per 1000 Ft.
7-.051	18 000	.15	.37	35	100
7-.064	29 000	.19	.44	50	160
7-.081	46 000	.24	.50	70	230
7-.091	58 000	.27	.53	80	280
7-.102	73 000	.31	.56	90	340
19-.064	78 000	.32	.64	100	360
19-.072	98 000	.36	.68	125	430
19-.081	125 000	.41	.73	150	510
19-.091	160 000	.46	.78	175	630
19-.107	220 000	.54	.87	225	870
37-.091	310 000	.64	1.01	275	1200

Westinghouse Switchboards

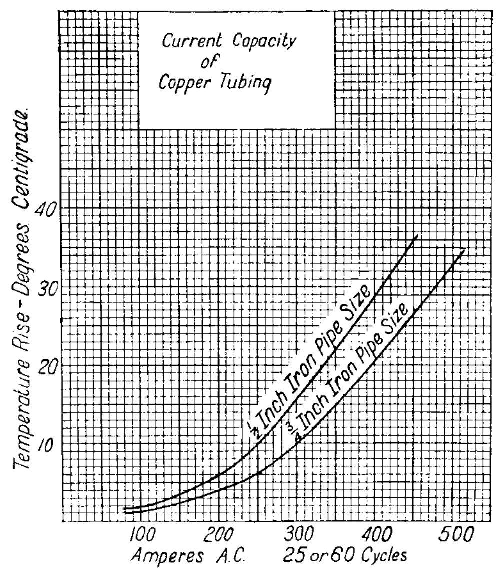


Fig. 252—Current Carrying Capacity of Copper Tubing

INSULATING CONNECTIONS

In general, bare connections above 750 volts should not be allowed in the switchboard room where the conductors are readily accessible. Usually connections above 6,600 volts are out of reach and generally so well protected by space insulation as to make other insulation unnecessary except on oil circuit-breaker terminals and connections. See Page 21.

Obviously it is difficult to furnish such connections insulated as the insulation should be continuous over all joints and terminal lugs.

All connections and terminals below 750 volts where oil circuit-breakers or enclosed switches are used should be insulated or at least enclosed so as to be accessible to authorized persons only.

Connections even though insulated are generally unsafe to handle when alive. The insulation guards only against accidental contact.

Insulating a connection has a tendency to increase the temperature rise of a conductor and the customer should check the carrying capacity of the connection carefully before insulating especially if the connection was designed to be left bare by the manufacturer.

gested in the following table. Over the outside layer of the varnished cambric there should be applied cotton tape half-lapped and this may be followed by two coats of Westinghouse No. 652 flame-resisting paint.

Westinghouse varnished cambric treated cloth No. 1219 one inch wide, .010 thick is carried in stock and is therefore available for quick shipment. This cloth carries 36 yards to the roll and 64 yards to the pound. It is made from high grade materials and is cut on just the angle and with the right amount of tack needed to assure a good smooth uniformly taped job.

Voltage Range	*Number of Half-Lapped Layers	Amount of 1-Inch Cambric Tape in Yds. per Lineal Foot of Conductor			
		Rod ½″	Rod 1″	Bar ¼x2″	Bar ¼x4″
0–1000	3	3.52	6.60	9.5	17.5
1001–2000	4	4.78	9.0	12.9	23.5
2001–3000	4	4.78	9.0	12.9	23.5
3001–4000	5	6.17	11.4	16.4	29.7
4001–5000	6	7.65	13.9	19.9	36.0
5001–6200	7	9.25	16.5	23.6	42.3
6201–7600	8	10.1	19.2	27.4	48.8
7601–8800	9	12.7	22.1	31.3	55.3
8801–10000	10	14.5	24.8	35.3	62.0
10001–11600	11	16.4	27.9	39.4	68.8
11601–13400	12	18.4	30.8	43.7	75.7
13401–15400	13	20.5	34.0	48.0	82.7
15401–17400	14	22.6	37.1	52.5	89.8
17401–19400	15	24.9	40.0	57.0	97.0
19401–21200	16	27.2	43.8		
21201–23200	17	29.6	47.2		
23201–25000	18	32.1	50.8		
25001–26800	19	34.7	54.5		
26801–28000	20	37.2	58.0		
28001–30400	22	42.9	65.6		
30401–32800	24	48.8	73.7		
32801–35200	26	55.0	82.0		
35201–37600	28	61.6	90.6		
37601–40000	30	68.5	99.5		

*It should be noted that each half lapped layer equals two thickness of tape. As an example for the 1001-2000 voltage range 4 half lapped layers are required, this is equal to 8 thickness of tape.

HIGH VOLTAGE CONDUCTORS

Corona effect on high tension conductors may be reduced by using the following minimum sizes of conductors.

METHOD OF MAKING GROUNDS

Recommendations of the National Electric Light Association on the practices and methods of making grounds are given in the following:

Water Systems—Water piping systems afford by far the best grounding systems obtainable and should be used for grounding purposes where possible. Due to their great extent, water systems have a very low resistance usually only a fraction of an ohm. Furthermore, they are of a very permanent nature and connections to them are generally easy to install and inspect.

Water systems have such a comparatively low ground resistance that where they are in proximity to pipe or plate grounds it has been found that a difference of potential will exist between the two during ground fault conditions, which may constitute a hazard to life unless they are connected together. An additional hazard may also exist when ground current resulting from a fault foreign to the stations returns to a piping system which is isolated from the station ground. For safety considerations therefore, water pipes when adjacent to equipment to be grounded should always form an integral part of the grounding system. Since there is no danger to water pipes of electrolysis by stray alternating-current, the permission to ground to water system should not be difficult to obtain especially in view of the great advantage to the public in the protection of life and the slight disadvantage if any to the water utilities. In making connections to water piping systems it is, of course, advisable to ascertain if the piping is large enough and if the material used in the pipe joints has a low enough resistance and sufficient thermal capacity to carry the maximum possible ground fault currents. Care should also be exercised to electrically connect all parts of the piping system liable to be physically disconnected and to shunt the pipe system where necessary around meters and shut-off stopcock in order to keep the connection with the underground piping system continuous.

Pipe Grounding—In out of the way places where water piping systems are not available it is generally necessary to resort to artificial grounds such as pipe or plate grounds. The present tendency seems to be away from the use of plate grounds and toward the greater use of pipe grounds due principally to the fact that in most cases the same results can be obtained with driven pipes at a much less expense than with plates. Although a single pipe ground has a higher resistance than a single plate ground a pipe ground resistance of almost any desired value can be obtained by multiple grounding, that is by connecting numerous pipes in parallel. In this way a ground of a given resistance can be obtained more economically with pipes than with the use of plates and in addition the multiple pipe ground will have the advantage of providing a well distributed ground which is a very important requirement. Fig. 254 shows the variation in resistance when pipes are used in parallel.

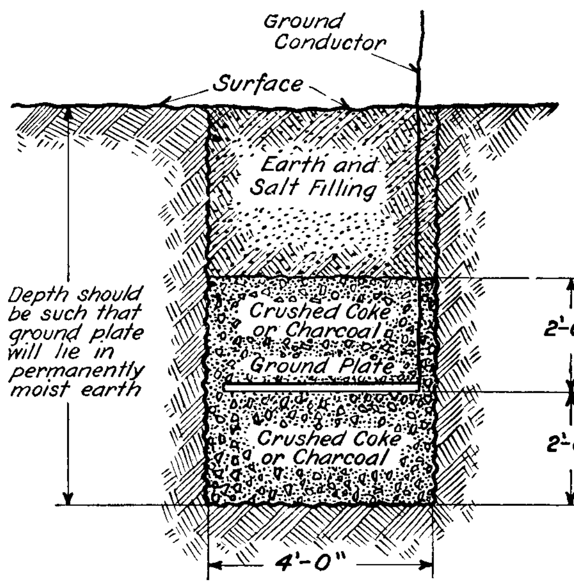


Fig. 253—Method of Making Ground Connections

In general ¾″ pipe is sufficient and should be driven ten feet, not less than six, in moist soil and in all cases should be below the frost line. Where pipes must be driven to greater depth in order to reach the proper soil conditions 1″, 1¼″ or 1½″ may be preferable in order to stand the strain incident to driving.

Either black or the galvanized pipe may be used providing it has a clean surface, presents no grease, paint or other insulating coating.

As about 90% of the resistance of a pipe ground falls within a radius of six to ten feet around the pipe the best results will be obtained by using a spacing of at least six feet, each pipe is in this manner kept out of the dense current field of the other and a minimum resistance is obtained for the group of pipes as a whole.

The electrical conductance of any soil is by means of the electrolytes formed by moisture combining with the soluble acids, alkalies and salts and where they are lacking their artificial introduction will show excellent results. Where artificial treatment is used it should be renewed periodically.

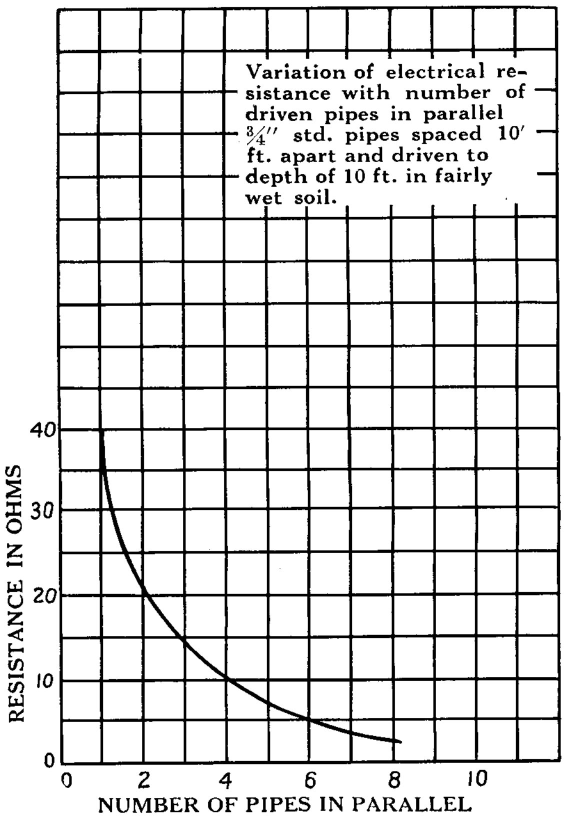


Fig. 254

Plate Grounds — In those cases where pipes cannot be driven and the soil conditions are not of the best, plate grounds may be desirable. One method of making a good plate ground is to dig a hole four feet square until permanently damp earth is reached. See Fig. 253. Cover the bottom of the hole with charcoal about pea size, over this lay ten square feet of tinned copper plate. Solder and rivet the copper ground wire securely across the entire length of the ground plate, cover the ground plate with two feet of crushed coke or charcoal then fill the hole with earth with plenty of common salt sprinkled in it, using running water to settle. The size of ground wire or cable should be of sufficient current carrying capacity to prevent fusing. Special care is necessary in power stations where the generator neutral points are grounded to have the ground cable of sufficient capacity to carry the current which may flow in case of short circuits or grounds on the system.

Strip Grounds—Strip grounds also work out very well where the soil conditions are poor. When burying a strip ground it is well to remember that for a given length of strip the wider the distribution the more effective the ground connections that will be obtained which means that the strip should be buried in approximately a straight line. It appears from the data available on strip grounds that after a depth of three feet has been reached there will not be a further marked decrease of resistance with increasing depth.

Inspection and Testing of Grounds—To obtain continuous and reliable service from grounding systems requires a systematic routine inspection and the measurement of the electrical resistance of ground electrodes and all connections comprising the system.

The usual practice is to make these tests at intervals of one year. This can be considered as a satisfactory interval as serious deterioration by corrosion, except where chemicals or coke are used, cannot be expected in a single year. The possibility of mechanical injury, however, exists at all times, and visual inspections should be made at shorter intervals in order that any defects which may exist can be remedied at the earliest practicable moment.

For further details on grounding refer to National Electric Light Association Publication No. 256-20 serial report, Electric Apparatus Committee Subjected Practices and Methods in AC Substation Grounding.

UNIVERSAL WEMCO-C INSULATING OIL

General—Wemco-C oil is a Westinghouse universal oil of special grade employed for insulating and cooling all oil-insulated apparatus manufactured by the Westinghouse Electric & Manufacturing Company, including transformers, oil circuit-breakers, induction feeder regulators and other oil-insulated and oil-cooled apparatus.

It has been the practice to supply several grades of insulating oil for these applications. The desirability of a single grade of oil thus very much simplifying stocks, has been generally recognized and for several years, the

National Electric Light Association has been urging the apparatus manufacturers to provide such an oil. After a long period of research and development in connection with the oil refiner, all of the various properties required have been provided in Wemco-C oil which makes it universally and particularly well adapted for these applications.

Even though insulating oils have the proper characteristics, a uniformly suitable quality cannot be furnished unless the manufacturer has completely standardized production and thoroughly trained his personnel. This involves not only the refining of the oil, but also the cleaning and filling of the containers to prevent contamination by water or other foreign materials. It is not economical for the customer to test each drum or can of oil as there is too much risk of contamination and the cost would be prohibitive. Oil should, therefore, be bought from the manufacturer who can be relied upon to furnish the uniform quality necessary The Westinghouse Company recommends Wemco-C oil, and the performance of its oil-insulated apparatus cannot be guaranteed when unapproved oils are used.

Wemco-C oil should not be mixed with oil of other manufacturers.

Dielectric Strength—The most important property of insulating and cooling oils is high dielectric strength. Tests made in accordance with specification D-117 of the American Society for Testing Material place the dielectric strength of Wemco-C at a high voltage value.

Viscosity—The viscosity is of great importance in transformers, since one of the main functions of the oil is to cool the apparatus which it insulates. The more sluggish the oil the slower will be its circulation through the apparatus and the transfer of heat from the windings will be correspondingly slower.

On circuit-breakers, tests have shown that oil of considerable fluidity has a distinct advantage in the opening of heavy short circuits. It is also particularly important for the oil to maintain its fluidity over the range of temperature obtained in service, as viscous oil would slow down the motion of the contacts and interfere with the operation of the apparatus. These requirements are adequately met in Wemco-C oil. Wemco-C oil pours at a very low temperature. On account of its low freezing temperature, the oil retains its fluidity at low temperatures, making it particularly well adapted for use in outdoor circuit-breakers and transformers.

Pour Test—This test is made in accordance with specification D-97 of the American Society for Testing Materials. The oil sample is placed in a standard bottle and chilled until it freezes. The lowest temperature at which the oil will flow at all is called the pour test of the oil. Wemco-C oil has an extremely low pour test or freezing temperature.

Moisture—The dielectric strength of oil is seriously affected by even a minute trace of water Wemco-C oil is produced under conditions which insure its cleanliness and dryness in the sealed container. In circuit-breakers and to a lesser extent in transformers, the oil may receive some water in service and it is important that the oil have the property of quickly separating from the water. This property is known as demulsibility and is determined by the precise R. E. (resistance to emulsion) test in which the sample of oil is subjected to steam and the time required for separation of the oil and water is noted. Wemco-C oil is so refined as to provide very good demulsibility.

Chemical Reaction—The presence of traces of mineral acid or alkali used in purification of insulating oil or of free sulphur which might form acid is not permissible as either would reduce the dielectric strength of the oil and would also attack the materials of the apparatus. Wemco-C oil contains no mineral acid, alkali or free sulphur. All oil contains some non-corrosive organic acids, but these are not objectionable in small quantities.

Deposit—Transformer oil should be as free as possible from any tendency to produce a deposit under service conditions. A deposit is objectionable primarily because it clings to the coil windings and fills the oil ventilating ducts, seriously affecting the cooling action. Wemco-C oil is practically free from deposit and no difficulty will be experienced under normal operating conditions.

Flash Point and Fire Point—The flash point is determined by heating the oil in a standard open cup until the temperature is reached when vapor can be ignited with a taper held close to the surface of the oil. The fire point is the temperature at which the vapor will continue to burn under these conditions. Operating experience has shown that the tested flash point of Wemco-C oil is sufficiently high to insure the safe operation of all Westinghouse apparatus.

Color—It is important that insulating oil be light in color so that the apparatus may be inspected when under oil. This applies to transformer terminal boards below the oil level, to floor mounted circuit-breakers where a periscope is employed in the inspection of contacts under the oil and in many other applications. Wemco-C oil is very light in color.

REPAIRING SWITCHBOARD PANELS

Plugging Holes in Slate or Marble Panels—When changes or repairs are made on switchboard panels, holes are occasionally exposed due to the removal of some piece of apparatus. For plugging such holes on black marine finish slate or marble, the following process may be used. Fill the holes with litharge and glycerine cement, pressing it firmly and leaving an excess of cement at the top of the hole (about ⅛ of an inch) to compensate for the shrinking. Prepare cement in the following proportions.

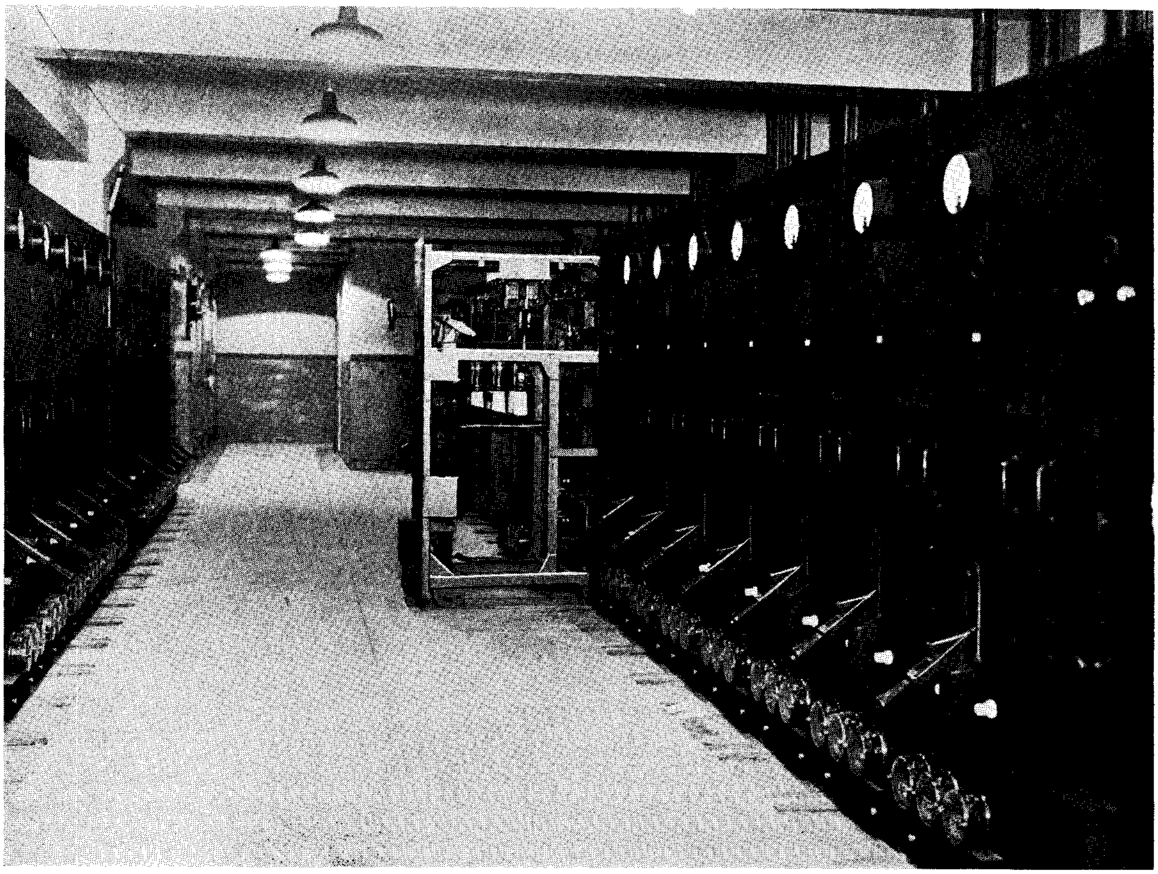


Fig. 255—Installation View of a Truck-Type Switchboard—One Truck Withdrawn Showing Details
For instructions on installation, Operation and Maintenance of Truck Type Switchboards, refer to Instruction Book 5326.

Extinguishing Fire—While Wemco-C oil is not readily inflammable any insulating oil will ignite when subjected to extremely high temperatures. Therefore, proper precaution against fire should be taken.

Suitable means should always be provided for drawing off oil and extinguishing fire. The best way to extinguish burning oil is to smother the flames so that the supply of fresh air will be cut off. Chemical fire extinguishers may be used for this purpose but under no circumstances should water be used.

See Instruction Book 5336 on Westinghouse Insulating Oil for Oil Circuit-Breaker which gives further details.

Litharge—1 pint
Lamp black—¼ pint

Thoroughly mix the above materials and sieve through a 50 mesh screen. Use three parts of the powder and one part glycerine by weight mixing it carefully to a smooth paste. Only a sufficient amount of this mixture should be made for use at one time, as it hardens very quickly.

After filling the hole allow the cement to dry for approximately 12 hours. Then rub down to the level of panel with a rotten stone rubbing brick taking care not to injure surrounding surfaces after which the part plugged and the immediate surrounding surface of the panel should be sprayed and rubbed down with a very fine sand paper or emery cloth, allowing the lacquer to dry before rubbing with emery paper. This spraying of lacquer and rubbing with emery cloth should be repeated until a neat looking job has been obtained.

The holes, if small, may also be plugged with plaster of paris and painted or colored to match up with panel material.

Various colored sealing waxes may be used to patch polished marble panels.

Removing Oil Stains—To remove oil stain from polished marble apply a mixture of benzine and plaster of paris, letting it remain on the stain for 48 hours then remove and clean panel.

Refinishing Switchboard Panels—To change a polished marble panel to black marine, the polish should be entirely removed by rubbing down with a piece of pumice stone and then the surface should be sprayed with lacquer, care being taken to cover apparatus mounted on panel so that it does not receive the spray.

About one quart of lacquer is required to spray two coats on ten square feet of surface.

Black marine finish may be removed from a panel by rubbing with a piece of waste soaked in lacquer thinner.

The finish of Black Marine Slate or Steel Panels may be cleaned by wiping with a chamois skin which has been immersed in luke warm water and wrung out.

Black Marine finished slate or steel may also be cleaned by wiping with slightly oiled waste.

Sharpening Drills—When slate or marble is to be drilled, the drill should be specially sharpened, the point should be ground the same as for iron except the heel should be entirely ground off. See Fig. 256.

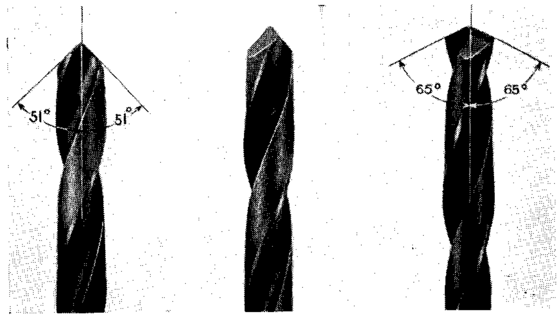


Fig. 256—Drill Shown Is Properly Ground for Drilling Marble or Slate
NOTE—This view shows three different positions of the same drill.

GROUND DETECTING EQUIPMENT

It is usually necessary to have some ground detecting equipment for any ungrounded system. Direct-current railway switchboards, where one side is grounded, three-phase, four wire systems with the neutral grounded or other similar systems with a grounded connection, do not need and cannot utilize any ground detector devices. Any grounds on a wire not intentionally grounded would, of course, result in a short circuit and the tripping of breakers or blowing of fuses will give all necessary indication of ground. All lamps in the diagrams are 110 volts, unless otherwise stated in description.

D-C. Circuits—For low voltage two wire direct-current circuits, it is customary to connect lamps between each wire and ground the lamps being designed to give full brilliancy under the full operating voltage between wires. On D-C. systems when no grounds exist, the lamps will be operating under half voltage and will glow accordingly. If the lamps do not give any indications whatsoever, either the main circuit is not energized or the lamp circuit is broken. With no ground on the system the lamps will burn dimly as but half line voltage is mpressed on each lamp. A ground on one wire will result in the extinguishing of the lamp connected between that wire and ground, while the remaining lamp will increase to full brilliancy.

Single Phase—Single-phase, low-voltage systems are arranged in the same manner as for two wire direct-current circuits.

Two Phase—Two phase, low-voltage systems are considered as two independent, two wire circuits.

Three Phase—For three-phase systems there are three sets of lamps, one set between each wire and ground or the three sets of lamps may be considered as being connected in star, the neutral of the star being grounded. In case of a ground on the wire, the lamps connected between that wire and ground go out and the other lamps increase to full brilliancy.

Three Wire D-C.—On a 110-220 volt, three wire direct-current system with ungrounded neutral, three lamps can be connected in series between one outside wire and the neutral with a ground between the lamp connected to the neutral and the two remaining lamps connected to the outside wire. The voltage rating of each lamp will be the same as the voltage from the outside wires to neutral. With no ground on the system, each lamp will have 1/3 of the voltage from the outside wire to netural impressed on it. With a ground on the line to which the ground detector lamps are not connected, all lamps will go up to full brilliancy. With a ground in the outside wire to which the two lamps are connected the two lamps will be extinguished and the single lamp will go up to full brilliancy. With a ground on the neutral the single lamp will be extinguished and the two lamps will burn at half brilliancy. See Fig. 257.

Ungrounded A-C. Systems—On ungrounded alternating-current systems of 600 volts or less, ground indications are provided by lamps connected from each line wire to ground. A continuous indication is provided from 1 to 300 volts inclusive, and above this a push-

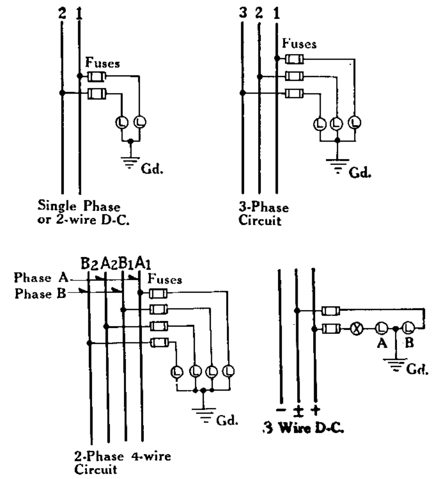
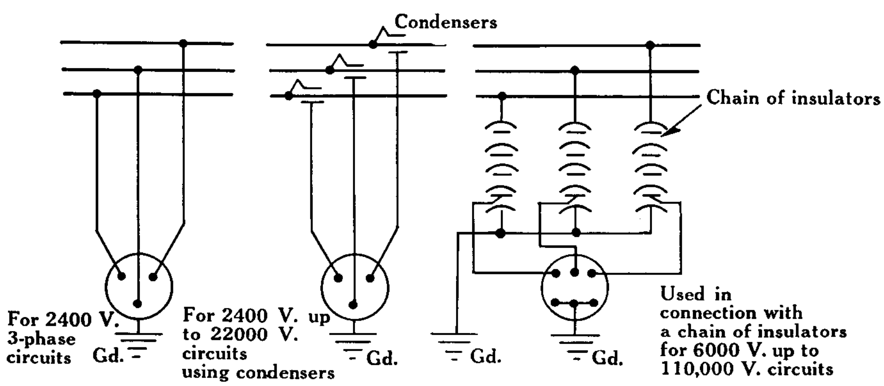
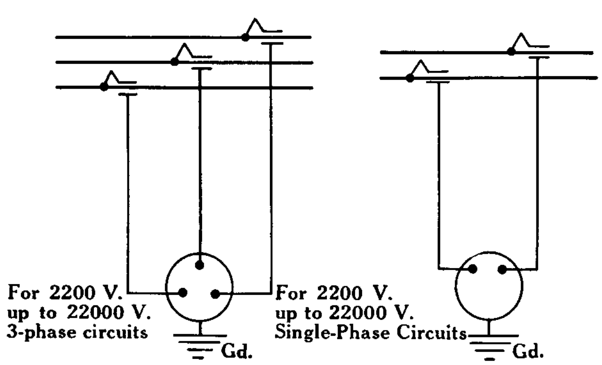


Fig. 257—**Diagrams of Ground Detector Equipments Using Lamps Only**

For 125-250-V. use three 110-V. Lamps.
For 250-500-V. use three 220-V. Lamps.
(L) = Ground detector lamp on front of panel.
(X) = Ground detector lamp on rear of panel.



TYPE SN THREE-PHASE ELECTROSTATIC GLOW METERS.



TYPE TG THREE PHASE ELECTROSTATIC GROUND DETECTOR

TYPE TG SINGLE PHASE ELECTROSTATIC GROUND DETECTOR

Fig. 258—**Diagrams of electrostatic glow meters and ground detectors**

button is used in the ground wire so that the circuit is clear from grounds, except when testing.

Voltages 2200 Up—For voltages from 2200 up, a continuous ground indication may be obtained by using Westinghouse electrostatic ground detectors connected to the line by condensers or Westinghouse electrostatic glow meters, which are connected to the line by condensers or on voltages above 33,000, by using sections of an insulator column as a condenser as shown in Fig. 258.

SYNCHRONIZING

The fundamental condition necessary in order that synchronous apparatus may be connected to a system already in operation is that the electromotive forces of the incoming machine and of the system to which it is connected shall be approximately the same at each instant. This requires that the frequencies be the same; that the two voltages be equal, as indicated by a voltmeter; and that the two voltages be in phase.

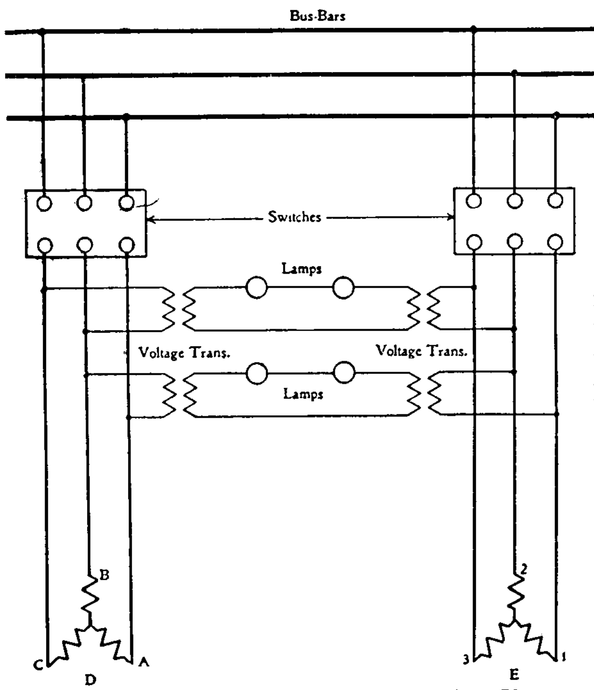


Fig. 259—Connections for Synchronizing Three-Phase Generators

The elementary principle employed in determining when generators are at the same frequency and in phase is illustrated by Fig. 260 in which A and B represent two single-phase generators, the leads of which are connected to the bus-bars by switches C and two series of incandescent lamps which are connected as shown. As the electromotive forces change from the condition of phase coincidence to that of phase opposition, the flow of current through the lamps varies from a minimum to a maximum.

When the electromotive forces of the two machines are exactly equal in phase, the current through the lamps is zero. As the difference in phase increases, the lamps light up and increase to a maximum brilliancy when corresponding phases are in exact opposition. From this condition the lamps will decrease in brilliancy until completely dark, indicating that the machines are again in phase. The rate of pulsation of the lamps depends upon the difference in frequency, i.e., upon the relative speed. It is usually necessary to place voltage transformers between the main circuits and the synchronizing circuits to reduce the voltage at the switchboard to safe limits, as shown in Fig. 259.

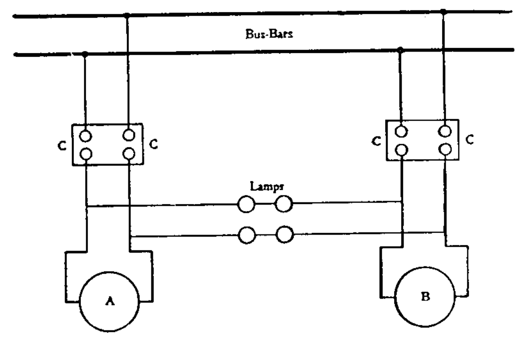


Fig. 260—Connections for Synchronizing Low Voltage Single-Phase Generators

In order to determine whether the lamps will be bright or dark for a given synchronizing connection when the machines are in phase, disconnect the main leads of the first generator at the generator and throw in the main switches of both generators with full voltage on the second generator. Since both machine circuits are then connected to one machine, the lamp indication will be the same as when the main or paralleling switches are open and both machines are in phase. If the lamps burn brightly and it is desired that they be dark for an indication of synchronism the connections of one of the voltage transformer primaries or one of the secondaries should be reversed. Dark lamps as an indication of synchronism are recomended. The lamps should be adapted for the highest voltage which they will receive, i.e., double the normal voltage.

Phasing-Out—In the case of polyphase machines, it is not only necessary that one phase be in synchronism with one phase of another generator but the sequence of maximum values of voltage in the several phases must be the same. The "phase rotation" must therefore be checked before making permanent connections. The necessary connections for two three-phase generators are shown in Fig. 260.

Connect the generators temporarily to their switches so that the phases of D will be in parallel with those of E. For example, connect phase A-B to 1-2; phase B-C to 2-3; and phase C-A to 3-1. Connect synchronizing apparatus in any two phases as phase 1-2,A-B and phase 2-3, B-C. Test out the synchronizing connections with machine D running at normal speed and voltage, the leads disconnected from D at the generator and the paralleling switches closed. Having changed the synchronizing connections, if necessary, so that both sets of lamps will be the same when indicating synchronism, open the paralleling switches, reconnect the leads of maching E and bring it up to normal speed and voltage. Then observe the two sets of synchronizing lamps. If their pulsations come together, i.e., if both sets are dark and both are bright at the same time, the phase rotation of the two generators are the same and the connections are correct for paralleling the generators when the lamps are dark. If, however, the pulsations of the lamps alternate, i.e., if one is dark when the other is bright, reverse any two leads of one machine and test out the synchronizing connections again, changing them if necessary so that they are the same when indicating synchronism. The lamps will now be found to pulsate together, and the generators may be thrown in parallel at the proper indication. Synchronizing apparatus in one phase only is sufficient for paralleling the generators after the first time.

The procedure in synchronizing a generator with an existing power system is the same, the phase rotation of the generator being changed if necessary, to agree with that of the system.

The paralleling of two phase generators is accomplished in a similar manner. In case of incorrect phase rotation the two leads belonging to either phase must be reversed instead of any two leads.

The standard winding of Westinghouse two phase armatures is of the open type with separate circuits. The four leads are marked A-1, B-1, A-2, B-2, in regular consecutive order around the armature. The two terminals A-1, A-2, constitute one of the main circuits or phases and B-1, B-2, the second main circuit of phase which will give the full electromotive force of the machine.

SYNCHRONOSCOPE

A synchronoscope is an instrument that indicates the difference in phase between two electromotive forces at every instant. By its aid the operator can see whether the incoming machine is running fast or slow, what the difference in speed is and the exact instant when it is in synchronism. These conditions cannot be observed with certainty by the use of lamps alone and it is usual practice for large machines to have their synchronoscope and lamps.

The synchronoscope has a pointer which shows the phase angle between the incoming and running machines. This angle is always equal to the angle between the pointer and the vertical position marked on the dial of the instrument. When the frequencies of the two machines are equal the pointer stops at same position on scale and when the machines are in phase the pointer coincides with the marker at the top of the scale.

In order to check the synchronoscope connections, proceed in the same manner as previously described for determining whether lamps will be bright or dark for a given synchronizing connection. If the synchronoscope pointer stops at the bottom, reverse the leads at the upper terminals. If it stops in the same position the connections to the upper terminals are made to the wrong phase.

Detailed instructions for synchronizing generators, frequency changer sets, and synchronous converters are given in the instruction books which are shipped with the machines.

PHASE ROTATION

In connecting reactive factor meters, power factor meters, reverse power relays, etc., it is necessary to see that the phase rotation is in accordance with that indicated on the wiring diagram.

This cannot be checked from the direction of rotation of the apparatus itself as the physical direction of rotation of any given piece of apparatus is not necessarily the same as the direction of the phase rotation.

In the case of a reactive factor meter or a power factor meter this can readily be checked by following the directions given on the instruction cards for these instruments and

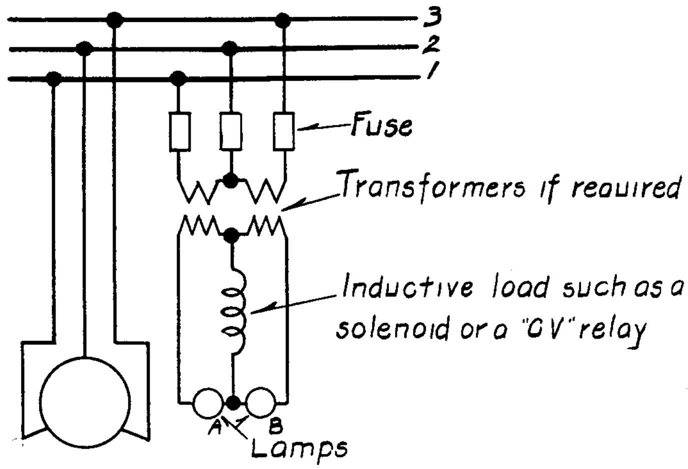


Fig. 261

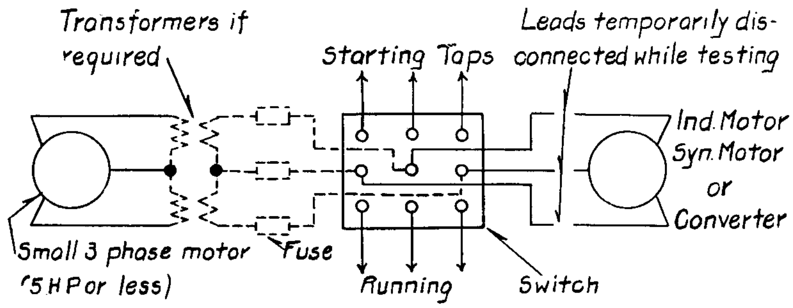


Fig. 262

this will serve, as a check on the balance of the apparatus.

Lamps and Inductive Load — Another method is by means of lamps and inductive load connected as shown in Fig. 261.

When connections are made as shown in Fig. 261, one of the lamps will be brighter than the other. If lamp A is brighter than lamp B, phase rotation is counter clockwise, i.e., 1-2-3. Conversely if lamp B is brighter than lamp A, the phase rotation is clockwise, i.e., 3-2-1.

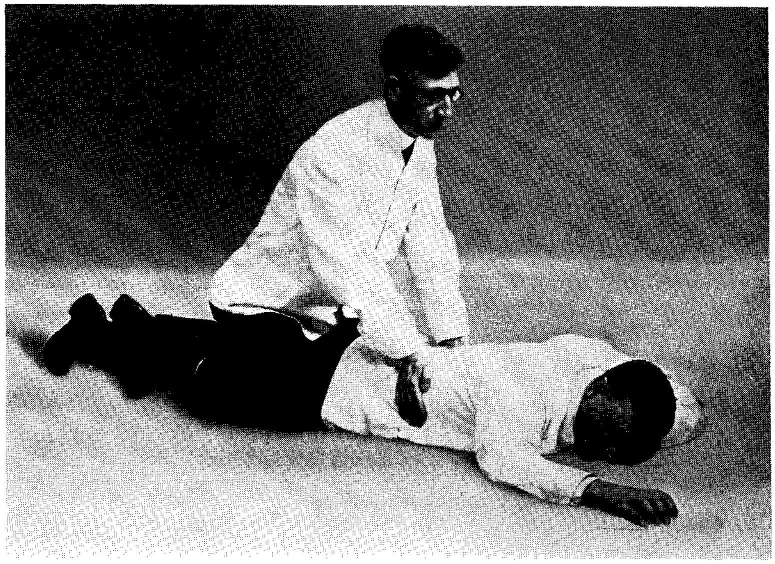
On special order the Westinghouse Electric & Manufacturing Company can supply complete equipment of lamps and reactance mounted in compact and convenient portable form for the above service.

Three-Phase Motors—In making connections to starting taps for induction motors and self starting synchronous motors or converters, it is often difficult to check the relative phase rotation on the starting and running positions. This is however, of the utmost importance as it is obvious that if the starting position tended to produce rotation in one direction and the running side of the switch tended to produce rotation in the opposite direction, the apparatus would probably be seriously damaged when operation was attempted.

Phase rotation may be checked in this case by the lamp and inductance method as previously described or it may be more convenient to use a small three-phase motor which may be connected directly to the running side of the switch and direction of rotation noted. The switch should then be operated and the motor stopped, the starting side of the switch should be closed, then if the direction of rotation of the motor is the same it becomes evident that connections are consistent.

THE PRONE PRESSURE METHOD OF RESUSCITATION

The American Gas Association, The National Electric Light Association and the National Safety Council are endeavoring to give the widest publicity possible to the Prone Pressure Method of resuscitation which is equally applicable to cases of apparent death from electric shock, drowning or asphyxiation from poisonous fumes.



FIRST POSITION
Fig. 263—Place hands on victim's sides with the ball of the thumb resting on the floating ribs well away from the spine.

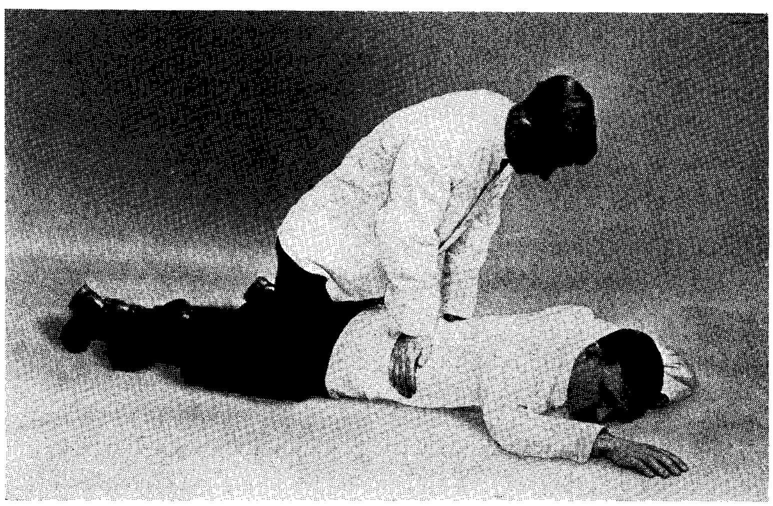
Many persons meet death from these causes every year when a few simple measures would have saved their lives. The victims are seldom killed outright and only need to have their breathing restored artificially.

The Prone Pressure Method of resuscitation is exceedingly simple, easily and quickly learned and involves the services of but one person and no mechanical apparatus.

Artificial Respiration—To properly understand artificial respiration, it is necessary to familiarize oneself with normal breathing. As we know, the lungs themselves have very little to do with our breathing. They are just two bags which hold the air that is taken into the body. The diaphragm muscle is a broad, fan-shaped muscle which divides the trunk into two compartments, and is the real organ of breathing. In the lower compartment are the stomach, intestines, etc.; in the upper, the heart and lungs.

The diaphragm muscle has an up-and-down motion like the piston in an engine. This motion is continuous unless something interferes, such as electrical shock, poison gas, or drowning, which temporarily paralyzes it, causing breathing to cease.

Breathing is almost a mechanical process.



SECOND POSITION
Fig. 264—With arms held rigid, swing your shoulders forward bringing your weight to bear gradually and evenly on the patient until you count three then resume the original position as shown in Fig. "A" while counting two. Repeating about twelve times a minute. Victim should show signs of life in ½ hour. Note position of victim with head on side resting on left arm so that tongue may hang out of mouth.

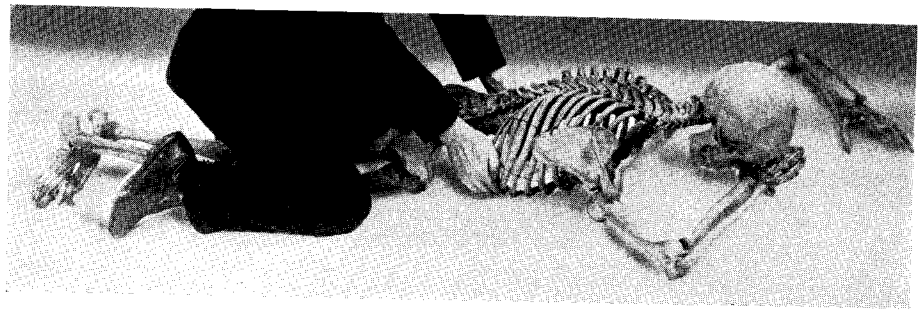


Fig. 265—Only cover the two floating ribs with the hands as shown when giving the Schaeffer method of resuscitation.

When the diaphragm is up, it pushes against the lower border of the lungs and forces the air out. Then it drops down and by atmospheric pressure the lungs are again filled.

When a person is asphyxiated from electrical shock, poison gas or drowning, this muscle stops its up-and-down motion and falls down into the abdomen and the lungs are then full of air. The fact that the lungs are full of air in these asphyxiations makes it possible to perform artificial respiration.

The organs below the diaphragm such as the stomach, intestines, etc., are freely movable and are utilized in Schaeffer's Prone Pressure Method. Pressure is exerted on the body below the diaphragm, and these freely movable organs are forced up against the diaphragm which in turn is forced against the lungs and the air is forced out. Pressure is then released, and these organs all drop down again and air is sucked into the lungs.

Method of Operation—Start treatment immediately and as near the scene of the accident as possible.

The victim should be placed on his stomach with head resting sideways on one arm so that the tongue of its own weight drops out of the throat as shown in Fig. 263.

The operator should kneel, straddling the victim well below the waist facing toward head; his hands on the victim's side, with the ball of the thumb resting on the floating ribs well away from the spine, as shown.

The operator should then swing forward with arms rigid, slowly bringing his weight to bear evenly on the patient until he counts three, as in Fig. 264. The original position should then be resumed as shown in Fig. 263, while counting two.

The operation is to be repeated about twelve times a minute.

The fingers and the thumb should be parallel, so that they will be on the floating ribs (two bottom ribs) only, as in Fig. 265.

If the fingers are spread out, as in Fig. 266, about five ribs will be covered thus in some degree, defeating the purpose.

The treatment should be started immediately; every second is precious as a man can live only about three minutes without air. When help arrives a doctor should be called. The victim usually shows signs of life within a half hour, but if not, the operation should be continued two hours, more, if necessary, or intil stiffening of the body occurs.

When the patient begins breathing without aid, he should be placed on a stretcher, kept warm, and removed to the hospital or his home. Under no circumstance should he be allowed to walk. In all cases he should be kept in bed for several hours and under observation for not less than 48.

Gassed cases should be kept in bed two or three days if possible and be watched very closely for the first 12 hours. In case of relapse the operation as indicated above should be repeated.

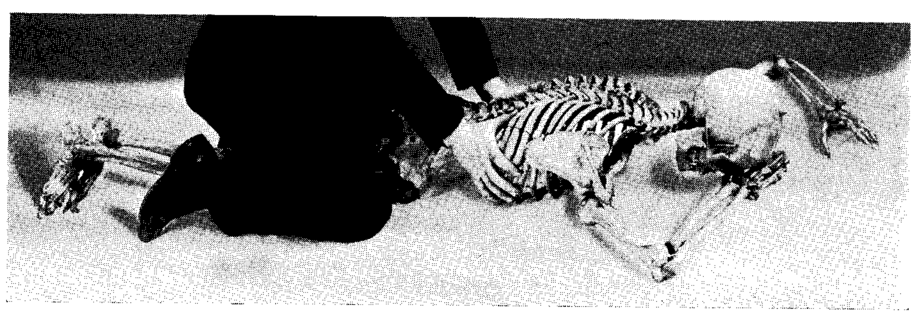


Fig. 266—Do not cover all five ribs with the hands as shown above when giving the Schaeffer method of resuscitation. See Fig. 265 for correct method.

SAFETY FIRST SUGGESTIONS

Loose nails should not be permitted to remain strewn promiscuously on any floor, scaffold, working platform, or other place where persons walk.

All upturned or protruding nails should be withdrawn or clinched into the wood.

Where any shock or explosion hazard exists, belts and rapidly moving parts of machines should be grounded to eliminate static electricity. In the presence of explosive gases or dusts, no metal planks or metal lacings should be used.

Heavy, reinforced cords only should be used in connection with portable lamps or tools. They should be kept well insulated and should be laid or strung so as not to create a tripping or catching hazard.

Electricians working above ground should always wear safety belts. On high tension work rubber gloves should be worn. Such gloves should be tested daily to detect the presence of holes. If necessary ground chains should be used.

Wherever possible, no work should be performed on electrical equipment until the current has been turned off. Switches, which have been opened for that purpose should be locked or blocked open and a suitable warning device placed thereon.

Tanks, pipes, or drums used in the storage, handling or use of flammable or explosive volatile liquids or oils should be properly grounded to carry off any static electricity that may be generated.

Ladders, temporary platforms and supports should be strong and safe, so as to eliminate any possibility of collapse when loaded.

Rope slings should be checked periodically to insure that they are in good condition and care should be taken to see that they are not overloaded.

Worn out or faulty tools should be discarded.

Only in extreme emergencies should men be permitted to work around live parts and then this work should be performed only by experienced men. Many fatal accidents have occurred working around low voltage circuits and investigation has proven that such fatalities were due to the victims being in poor physical condition. It is, therefore, well when possible to have the physical condition of all men working around live parts checked periodically. Every precaution should be taken, tools should be insulated, mats should be provided and such insulated tools, etc., should be tested frequently to insure that they are in good condition.

All connections should be considered alive until the men expecting to work on them assure themselves personally that the circuits are dead and every possible precaution should be taken to see that there is no possibility of an operator throwing "juice" on the line while men are working on it. It is advisable to ground circuits by a wire or chain until the work on them has been completed.

Avoid loose clothing while working around moving machinery.

The links in lifting chains should be annealed frequently when subjected to long hard usage.

In case of fire do not use liquid fire extinguishers until all circuits have been made dead.

All temporary openings in the floor should be railed off.

When men are working overhead, Danger signs should be displayed below to this effect.

EMERGENCY LIGHTING

Care should be taken to see that the switchboard is properly illuminated both in the front and rear. This is usually done by the plant lighting system and it is also suggested that this system be provided with certain emergency lighting circuits service in order that the switchboard and associated apparatus will not be put in total darkness at any time.

In those stations where storage batteries are available change-over of emergency lighting may easily be accomplished as on failure of the regular lighting supply, the emergency lights may be thrown on the battery through an automatic throw-over switch, a diagram of which is shown in Fig. 267.

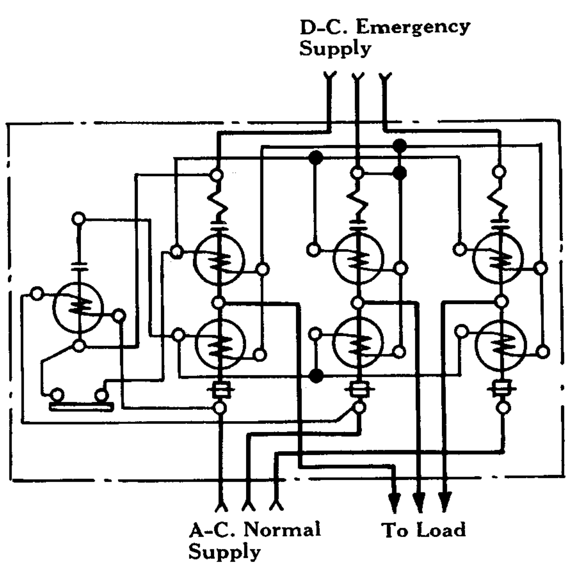


Fig. 267

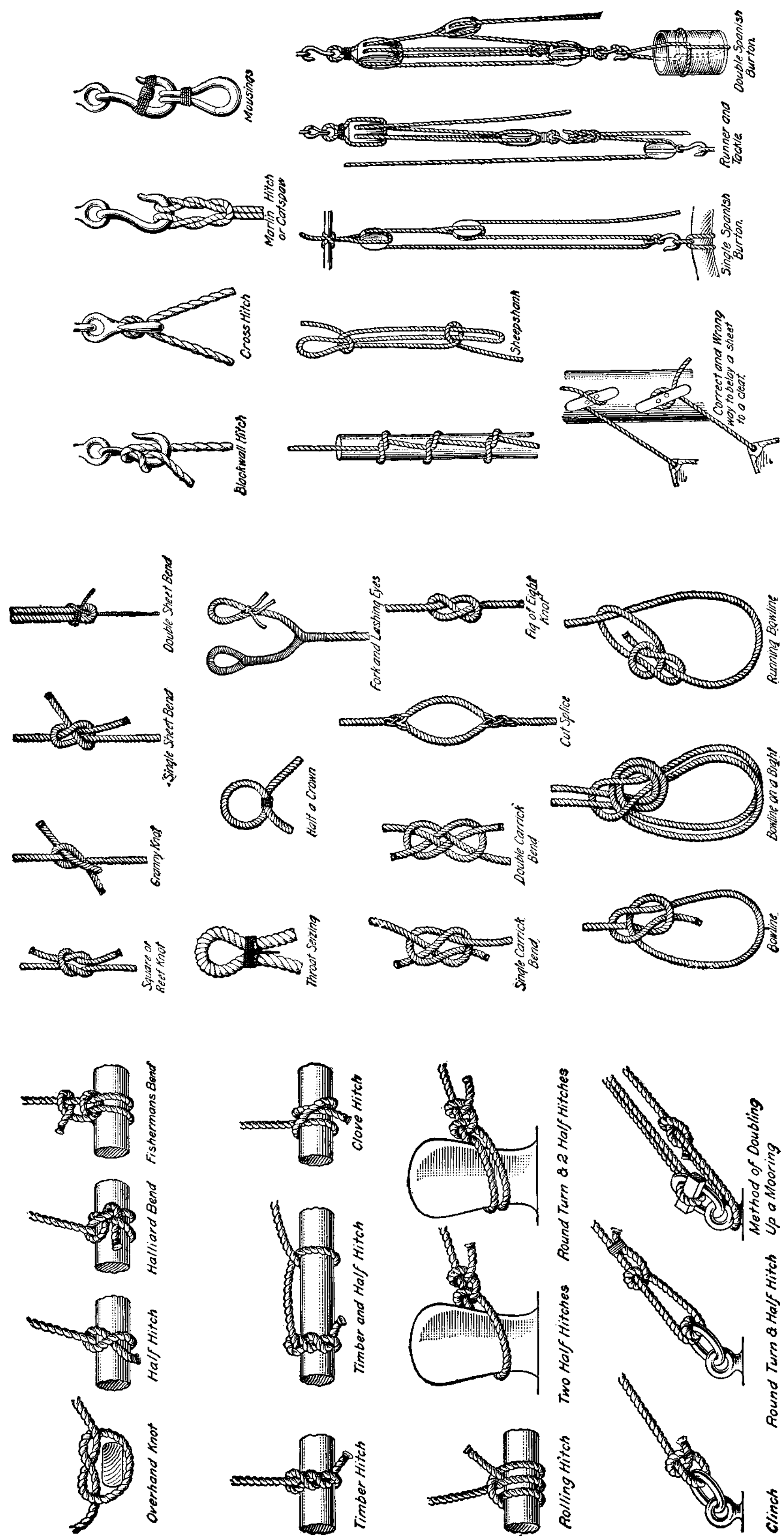


Fig. 268—Bends and Hitches.

(The above figures printed by permission of the International Text Book Company)

GENERAL OPERATING SUGGESTIONS

Before starting up the plant it is recommended that the operators familiarize themselves with the instructions referring to the different pieces of apparatus. All instrument, meter, and relay connections should be checked with the diagram to insure that they are correct. In order to bring out any weak spots in the installation it is desirable before putting the switchboard into actual service to try out the different parts by putting a current through them at a reduced voltage. Any weak spots during this trial period should be carefully noted and steps taken to remedy them.

The switchboard should also be given careful inspection at periodic intervals to insure that all parts are in the best condition. This applies to wire, cable, copper connections, especially insulation, etc.

Care should be taken to see that all parts are operating within safe temperature values. Obviously when making these inspections accidents due to short circuit or grounding of the connections should be avoided. Only experienced men should be used for this work.

Marking the name or number of the circuits on operative devices will often avoid confusion, especially when the stat˙on is started for the first time and will be of considerable help to new operators. When starting up the stations a careful check should be made to see that all switches, carbon and oil circuit-breakers are open and that all operating parts are in good condition so that no trouble will occur.

Regular checking and testing of instruments and relays will show up any parts or pieces of apparatus which may need adjustment or repairs.

The general premises especially the switchboard room should be kept clean. Compressed air or a hand bellows very often answers for cleaning the switchboard, especially the rear. The front may be wiped off with slightly oiled rags if black marine, slate or steel panel.

Regular and systematic inspection of all equipment should be made. Some companies obtain very good results by furnishing their inspectors with detail lists covering points which have to be checked and reported on at stated intervals.

INDEX TO INSTRUCTION BOOKS, PART CATALOGUES AND INSTRUCTION CARDS

In the following list will be found a number of instruction books, cards and part catalogues which give detailed information on the installation, operation and maintenance of switchboards and associated equipment.

We will be glad to furnish upon request the copies in which you are interested.

Instruction books, cards and part catalogues may be obtained from the nearest district office or address the Westinghouse Electric & Manufacturing Co., Distributing Division, Department of Publicity, East Pittsburgh, Pa.

	Instruction Book	Part Catalogue*	Instruction Card
CARBON CIRCUIT-BREAKERS			
Maintenance of Carbon Circuit-Breakers	5202		
Type CA		6174	1431
Type CA Hand-Operated			526
Type CA Electrically-Operated			527
Type CA Breaker Reverse Current Mechanism			528
Type CA Breaker Shunt Trip Attachment			556
Type CA Breaker Undervoltage Trip			558-A
Type CL	5241	6207	1432
OIL CIRCUIT-BREAKERS			
A-C. Solenoid Operating Mech. for Large Oil Circuit-Breakers		6232	
Ball Lock Mech. for Oil Circuit-Breakers	5358		
Direct A-C. Trip Attachment			591-A
Hand Reset Undervoltage Release Attachment			1451, 1462
Transformer and Undervoltage Release Attachment			1450
Motor Operating Mechanism—Type CF	5334	6231–1	
Motor Operating Mechanism—Types M and MB	5278	6231	
Overload Time Element Dash Pot used with Oil Circuit-Breakers			539-B
Types BA, B-2 and B-13	5251	6135–1	794
Types B-16 and B-20	5346		
Types CO-11 and CO-22	5271-A	6218	
Type CO-111	5376	6188–111	
Type D		6202	195-B
Type E-8 Solenoid Operated			636
Type E-8	5252	6192–8	
Type E-9	5252	6192–9	
Type E-16	5268	6192–16	

***Part Catalogues are useful only for ordering renewal parts.**

	Instruction Book	Part Catalogue*	Instruction Card
OIL CIRCUIT-BREAKERS (Continued)			
Type E-17	5268	6192–17	
Type F			197-E
Type F-1		6185–1	
Type F-1 Hand-Operated			584-A
Type F-2		6185–2	
Type F-2 Electrically-Operated, Single-Throw			531
Type F-3		6185–3	572-A
Type F-10	5248-A	6197	1337-A
Type F-10 Breaker Shunt Trip Attachment			1397
Type F-11	5229-F	6186	{ 1036, 1037, 1038
Type F-22	{ 5229-F, 5279	6195	
Type F-33	5238	6196	
Type FO Oil Circuit-Breaker		6186–1	1509
Type G-1	5235	6189	1181
Type G-11	5235	6189–1	1181
Type G-22	5235	6189–2	
Type G-222	5235	6189–2	
Type I	5314	6200	
Type I Non-Automatic			196-B
Type M Automatic Change Over Switch			
Type MF	5335		
Type O–11	5296-A	6191–11	
Type O–22	5296-A	6191–22	
Type O–33	5347	6191–33	
Types O-221, O-331 and O-441	5331-A		
Types OE-6 and OE-7	5267	6212	
Type QF	5240	6203	
Undervoltage Trip for Mechanically Operated Oil Circuit-Breakers			592-A
METERS			
Ammeters			298-B
D-C.			299-E
Switchboard			297-F
Type DX		6216	{ 1235-A, 1383-A
Type DY		6217	{ 1237-B, 1342
Type SX		6216	{ 1235-A, 1383-A, 1396
Type SY		6217	1237-B
Type U Graphic		6190–1	404-D
Type U Graphic			405
Demand Meters			
Type RA Recording	5177-D		
Type RI Kv-a.	5332-A		
Frequency Meters			
Type DY		6217	1240
Type SY		6217	1240
Glow Meters			1046-A
Graphic Meters	5096		
Solenoid Operated	5096		
Type R Recording	5329		
Type U	5152-B		
Ground Detectors			
Type SN Glow Meter			1046-A
Type TG Static			25-A
Power Factor Meters			{ 145-E, 931
Type DY		6217	1341
Type SY		6217	1239-B
Reactive Factor Meters			501-C
Synchronoscopes			
Type SY		6217	26-G
Temperature Indicators			
Dial Type Hottest Spot			1388
Swbd. Type Hottest Spot			1389
Switchboard Type			948-C
Type SX Thermal Couple			1395

***Part Catalogues are useful only for ordering renewal parts.**

	Instruction Book	Part Catalogue*	Instruction Card
METERS—Continued			
Voltmeters			298-B
D-C.			299-E
Switchboard			297-F
Type DX		6216	1235-A
Type DY			1327-B 1342
Type SX		6216	1235-A 1396
Type SY			1237-B
Type U Graphic		6190-1	403-E
Watthour Meters			
Calibration Data			664 678-A
Two Wire D-C.			300-B
Type CW-6		6213	382-A
Type OA Switchboard			949-A 980 1428
Type OA Polyphase Switchboard			950-A
Type OB		6055-4	1334 1429
Type RA			942
Type RA Recording Demand	5177-D	6209	697
Wattmeters			
A-C.			298-B 354
Type DY			1340
Type DY Single-Phase			1238
Type SY Single-Phase			1238
LIGHTNING ARRESTERS			
Types A, AK and AL Electrolytic	5127-D	6179-1	
Types AR Electrolytic	5244	6179-4	1165-A
Type LV			1355-A 1362
Type MP		6179-7	1249
Type SV	5299-C		1347
OIL			
Insulating Oil for Oil Circuit-Breakers	5336		
REGULATORS			
Extended Broad Range Type Voltage Regulators	5339		
Rheostat Type of Generator Voltage Regulators	5290-A	6194	
Voltage Regulator for A-C. Generators	5155-C	6194	
Voltage Regulators for Self Excited D-C. Generators	5301		
Generator Voltage Regulator			1487
RELAYS			
Oil Filled Thermal Overload	5291		
Phase Balance Current Relay			1307
Type BT Protective		6161	
Type BT Transfer			694-A
Type CD			1122
Type CO Overcurrent and Directional	5319	6161	552-K
Type COA Overcurrent and Directional	5319		
Type CP Protective		6161	
Type CQ Phase Balance Current	5318		
Type CR Overcurrent and Directional	5186-B 5319		
Type CRA Overcurrent and Directional	5319		
Type CT Protective		6161	
Type CT Temperature Overload	5356		
Type CV Protective		6161	698-A
Type CW Protective	5333	6161	
Type CZ Protective	5287-A		
Type C Operation Indicator for Induction Relays	5286		
Type D			174-D
Types M, MC, MF and MS	5320		
Types OA, OL, OS and OX	5312		
Type S-1 Control Relay		6221	
Type TO Instantaneous			594
SWITCHBOARDS AND SWITCHING EQUIPMENT			
Non-Automatic			
Switchboard Details		6131	
Truck Type Switching Equipment	5326		
Automatic			
Automatic Switching Equipment for Rotating Machines	5324		
Synchronous Visual Type Supervisory Control	5353		
Synchronous Visual Type Supervisory Control	5350		
Type R Current Balance Transmitters	5329		

***Part Catalogues are useful only for ordering renewal parts.**

MEASURATION OF SURFACES AND VOLUMES

Area of rectangle = length × breadth.
Area of triangle = base × ½ perpendicular height.
Diameter of circle = radius × 2.
Circumference of circle = diameter × 3.1416.
Area of circle = square of diameter × .7854.

$$\text{Area of sector of circle} = \frac{\text{area of circle} \times \text{number of degrees in arc.}}{360}$$

Area of surface of cylinder = circumference × length + area of two ends.
To find the diameter of circle having given area: Divide the area by .7854, and extract the square root.
To find the volume of a cylinder: Multiply the area of the section in square inches by the length in inches = the volume in cubic inches. Cubic inches divided by 1728 = volume in cubic feet.
Surface of a sphere = square of diameter × 3.1416.
Solidity of a sphere = cube of diameter × .5236.
Side of an inscribed cube = radius of a sphere × 1.1547.
Area of the base of a pyramid or cone, whether round, square or triangular, multiplied by one-third of its height = the solidity.
Diam. × .8862 = side of an equal square.
Diam. × .7071 = side of an inscribed square.
Radius × 6.2832 = circumference.
Circumference = 3.5446 × $\sqrt{\text{Area of circle}}$.
Diameter = 1.1283 × $\sqrt{\text{Area of circle}}$.
Length of arc = No. of degrees × .017453 radius.
Degrees in arc whose length equals radius = 57° 2958′.
Length of an arc of 1° = radius × .017543.
Length of an arc of 1 Min. = radius × .0002909.
Length of an arc of 1 Sec. = radius × .0000048.

π = Proportion of circumference to diameter = 3.1415926.
π^2 = 9.8696044.
$\sqrt{\pi}$ = 1.7724538.
Log. π = 0.49715.
$1/\pi$ = 0.31831.
1/360 = .002778.
$360/\pi$ = 114.59.

Lineal feet	× .00019	= Miles.
Lineal yards	× .0006	= Miles.
Square inches	× .007	= Square feet.
Square feet	× .111	= Square yards.
Square yards	× .0002067	= Acres.
Acres	× 4840	= Square yards.
Cubic inches	× .00058	= Cubic feet.
Cubic feet	× .03704	= Cubic yards.
Circular inches	× .00546	= Square feet.
Cyl. inches	× .0004546	= Cubic feet.
Cyl. feet	× .02909	= Cubic yards.
Links	× .22	= Yards.
Links	× .66	= Feet.
Feet	× 1.5	= Links.
Width in chains	× 8	= Acres per mile.
183.346 circular inches		= 1 square foot.
2200 cylindrical inches		= 1 cubic foot.
Cubic feet	× 7.48	= U. S. gallons.
Cubic inches	× .004329	= U. S. gallons.
U. S. gallons	× .13367	= Cubic feet.
U. S. gallons	× 231	= Cubic inches.
Cubic feet	× .8036	= U. S. bushel.
Cubic inches	× .000466	= U. S. bushel.
Cyl. feet of water	× 6	= U. S. gallons.
Lbs. Avoir.	× .009	= Cwt. (112)
Lbs. Avoir.	× .00045	= Tons. (2240)
Cubic feet of water	× 62.5	= Lbs. Avoir.
Cubic inch of water	× .03617	= Lbs. Avoir.
Cyl. feet water	× 49.1	= Lbs. Avoir.
Cyl. inch water	× .02842	= Lbs. Avoir.
12 U. S. gallons of water		= 1 cwt.
240 U. S. gallons of water		= 1 ton.
1.8 cubic feet of water		= 1 cwt.
35.88 cubic feet of water		= 1 ton.
Column of water, 12 inches high, and 1 inch in diameter		= 341 lbs.
U. S. bushel	× .0495	= Cubic yards.
U. S. bushel	× 1.2446	= Cubic feet.
U. S. bushel	× 2150.42	= Inches.

METRIC CONVERSION TABLE

Millimetres × .03937 = inches.
Millimetres ÷ 25.4 = inches.
Centimetres × .3937 = inches.
Centimetres ÷ 2.54 = inches.
Metres × 39.37 = inches.
Metres × 3.281 = feet.
Metres × 1.094 = yards.
Kilometres × .621 = miles.
Kilometres ÷ 1.6093 = miles.
Kilometres × 3280.8693 = feet.
Sq. Millimetres × .00155 = sq. in.
Sq. Millimetres ÷ 645.1 = sq. in.
Sq. Centimetres × .155 = sq. in.
Sq. Centimetres ÷ 6.451 = sq. in.
Sq. Metres × 10.764 = sq. ft.
Sq. Kilometres × 247.1 = acres.
Hectare × 2.471 = acres.
Cu. Centimetres ÷ 16.383 = cu. in.
Cu. Centimetres ÷ 3.69 = fl. drams.
Cu. Centimetres ÷ 29.57 = fluid oz.
Cu. Metres × 35.315 = cu. ft.
Cu. Metres × 1.308 = cu. yds.
Cu. Metres × 264.2 = gals (231 cu. in.)
Litres × 61.022 = cu. in.
Litres × 33.84 = fluid oz.
Litres × .2642 = gals. (231 cu. in.)
Litres ÷ 3.78 = gals. (231 cu. in.)
Litre. ÷ 28.316 = cu. ft.
Hectolitres × 3.531 = cu. ft.
Hectolitres × 2.84 = Bu. (2150.42 cu. in.)
Hectolitres × .131 = cu. yds.
Hectolitres ÷ 26.42 = gals. (231 cu. in.)
Grammes × 15.432 = grains.
Grammes ÷ 981. = dynes.
Grammes (water) ÷ 29.57 = fluid oz.
Grammes ÷ 28.35 = oz. avoirdupois.
Grammes per cu. cent. ÷ 27.7 = lbs. per cu. in.
Joule × .7373 = ft. lbs.
Kilo-grammes × 2.2046 = pounds.
Kilo-grammes × 35.3 = oz. avoirdupois.
Kilo-grammes ÷ 907.2 = tons (2000 lbs.)
Kilo-grames per sq. cm. × 14.223 = lbs. per sq. in.
Kilo-gr. per Metre × .672 = lbs. per ft.
Kilo-gr. per cu. Metre × .062 = lbs. per cu. ft.
Kilo-gr. per Cheval × 2.235 = lbs. per Hp.
Kilo-Watts × 1.34 = Horsepower.
Watts ÷ 746. = Horsepower.
Watts × .7373 = ft. pounds p. second.
Calorie × 3.968 = Btu.
Cheval vapeur × .9863 = Horsepower.
(Centigrade × 1.8) + 32 = deg. Fahr.
Franc × .193 = Dollars.
Gravity Paris = 980.94 centimetres per sec. per sec.

USEFUL INFORMATION

To find circumference of a circle multiply diameter by 3.1416.

To find diameter of a circle multiply circumference by .31831.

To find area of a circle multiply square of diameter by .7854.

To find area of a triangle multiply base by ½ perpendicular height.

To find surface of a sphere multiply square of diameter by 3.1416.

To find cubic contents of a sphere multiply cube of diameter by .5236.

To find side of square of area equal to given circle multiply diameter by .8862.

To find diameter of circle of area equal to given square multiply side by 1.128.

To find area of a sector of a circle, multiply ½ length of arc by radius.

In a right angle triangle, the square of the hypotenuse is equal to the sum of the squares of the other two sides.

Doubling the diameter of a pipe increases its area four times.

A gallon of water (U. S. Standard) weighs 8½ pounds and contains 231 cubic inches.

A cubic foot of water contains 7½ gallons, 1728 cubic inches and weighs 62½ pounds.

To find the capacity (U. S. gallons) of cylindrical tanks, square the diameter expressed in inches, multiply by the length and by .0034.

To find the pressure in pounds per square inch of a column of water multiply the height of the column in feet by .434.

One horsepower (engine rating)—33,000 foot pounds per minute.

One boiler horsepower. The evaporation of 30 pounds of water per hour from a feed water temperature of 100° F. into steam at 70 pounds gauge pressure.

One square inch = .00694 square foot.

One cubic inch of cast iron weighs .26 pounds.

One cubic inch of cast steel weighs .28 pounds.

One cubic inch of brass weighs .31 pounds.

One cubic inch of copper weighs .32 pounds.

One cubic inch of lead weighs .41 pounds.

The equivalent of one Btu. of heat = 778 foot-pounds.

PHYSICAL DATA

The equivalent of one calorie of heat = 426 kg-m. = 3.968 Btu.

One cubic foot of water weighs 62.355 pounds at 62° Fahr.

One cubic foot of air weighs 0.0807 pounds at 32° Fahr. and one atmosphere.

One cubic foot of hydrogen weighs 0.00557 pounds.

One foot-pound = 1.3562×10^7 ergs.

One horsepower hour = 33000×60 foot-pounds.

One horsepower = 33000 foot-pounds per min. = 550 foot-pounds per second = 746 watts = 2545 Btu. per hour.

Acceleration of gravity (g) = 32.2 feet per second per second = 980 cm. per second per second.

One atmosphere = 14.7 pounds per square inch = 2116 pounds per square foot = 760 mm. of mercury.

Velocity of sound at 0° Cent. in dry air = 332.4 metres per second = 1091 feet per second.

Velocity of light in vacuum = 299,853 km. per second = 186,325 miles per second.

Specific heat of air at constant pressure = 0.237.

A column of water 2.3 feet high corresponds to a pressure of 1 pound per square inch.

Coefficient of expansion of gases = $\frac{1}{273}$ = 0.00367.

Latent heat of water = 79.24.

Latent heat of steam = 535.9.

CENTIGRADE DEGREES. To convert into the corresponding one in Fahrenheit degrees, multiply by $\frac{9}{5}$ and add 32. To convert it into the one in Réaumur degrees multiply by $\frac{4}{5}$. To convert it into the one on the Absolute scale, add 273.

FAHRENHEIT DEGREES. To convert it into the one in Centigrade degrees, subtract 32, and then multiply by $\frac{5}{9}$, being careful about the signs when the reading is below the melting point of ice. To convert it into the one in Réaumur degrees, subtract 32 and multiply by $\frac{4}{9}$. To convert it into the one on the Absolute scale, subtract 32, then multiply by $\frac{5}{9}$ and add 273: or multiply by 5, add 2297, and divide by 9.

AREAS AND CIRCUMFERENCES OF CIRCLES

Diameter	Circumference	Area
1/64	.049087	.00019
1/32	.098175	.00077
3/64	.147262	.00173
1/16	.196350	.00307
3/32	.294524	.00690
1/8	.392699	.01227
5/32	.490874	.01917
3/16	.589049	.02761
7/32	.687223	.03758
1/4	.785398	.04909
9/32	.883573	.06213
5/16	.981748	.07670
11/32	1.07992	.09281
3/8	1.17810	.11045
13/32	1.27627	.12962
7/16	1.37445	.15033
15/32	1.47262	.17257
1/2	1.57080	.19635
17/32	1.66897	.22166
9/16	1.76715	.24850
19/32	1.86532	.27688
5/8	1.96350	.30680
21/32	2.06167	.33824
11/16	2.15984	.37122
23/32	2.25802	.40574
3/4	2.35619	.44179
25/32	2.45437	.47937
13/16	2.55254	.51849
27/32	2.65072	.55914
7/8	2.74889	.60132
29/32	2.84707	.64504
15/16	2.94524	.69029
31/32	3.04342	.73708
1.	3.14159	.78540
1/16	3.33794	.88664
1/8	3.53429	.99402
3/16	3.73064	1.1075
1/4	3.92699	1.2272
5/16	4.12334	1.3530
3/8	4.31969	1.4849
7/16	4.51604	1.6230
1/2	4.71239	1.7671
9/16	4.90874	1.9175
5/8	5.10509	2.0739
11/16	5.30144	2.2365
3/4	5.49779	2.4053
13/16	5.69414	2.5802
7/8	5.89049	2.7612
15/16	6.08684	2.9483

Diameter	Circumference	Area
2.	6.28319	3.1416
1/16	6.47953	3.3410
1/8	6.67588	3.5466
3/16	6.87223	3.7583
1/4	7.06858	3.9761
5/16	7.26493	4.2000
3/8	7.46128	4.4301
7/16	7.65763	4.6664
1/2	7.85398	4.9087
9/16	8.05033	5.1572
5/8	8.24668	5.4119
11/16	8.44303	5.6727
3/4	8.63938	5.9396
13/16	8.83573	6.2126
7/8	9.03208	6.4918
15/16	9.22843	6.7771
3.	9.42478	7.0686
1/16	9.62113	7.3662
1/8	9.81748	7.6699
3/16	10.0138	7.9798
1/4	10.2102	8.2958
5/16	10.4065	8.6179
3/8	10.6029	8.9462
7/16	10.7992	9.2806
1/2	10.9956	9.6211
9/16	11.1919	9.9678
5/8	11.3883	10.321
11/16	11.5846	10.680
3/4	11.7810	11.045
13/16	11.9773	11.416
7/8	12.1737	11.793
15/16	12.3700	12.177
4.	12.5664	12.566
1/16	12.7627	12.962
1/8	12.9591	13.364
3/16	13.1554	13.772
1/4	13.3518	14.186
5/16	13.5481	14.607
3/8	13.7445	15.033
7/16	13.9408	15.466
1/2	14.1372	15.904
9/16	14.3335	16.349
5/8	14.5299	16.800
11/16	14.7262	17.257
3/4	14.9226	17.721
13/16	15.1189	18.190
7/8	15.3153	18.665
15/16	15.5116	19.147

Diameter	Circumference	Area
5.	15.7080	19.635
1/16	15.9043	20.129
1/8	16.1007	20.629
3/16	16.2970	21.135
1/4	16.4934	21.648
5/16	16.6897	22.166
3/8	16.8861	22.691
7/16	17.0824	23.221
1/2	17.2788	23.758
9/16	17.4751	24.301
5/8	17.6715	24.850
11/16	17.8678	25.406
3/4	18.0642	25.967
13/16	18.2605	26.535
7/8	18.4569	27.109
15/16	18.6532	27.688
6.	18.8496	28.274
1/8	19.2423	29.465
1/4	19.6350	30.680
3/8	20.0277	31.919
1/2	20.4204	33.183
5/8	20.8131	34.472
3/4	21.2058	35.785
7/8	21.5984	37.122
7.	21.9911	38.485
1/8	22.3838	39.871
1/4	22.7765	41.282
3/8	23.1692	42.718
1/2	23.5619	44.179
5/8	23.9546	45.664
3/4	24.3473	47.173
7/8	24.7400	48.707
8.	25.1327	50.265
1/8	25.5254	51.849
1/4	25.9181	53.456
3/8	26.3108	55.088
1/2	26.7035	56.745
5/8	27.0962	58.426
3/4	27.4889	60.132
7/8	27.8816	61.862
9.	28.2743	63.617
1/8	28.6670	65.397
1/4	29.0597	67.201
3/8	29.4524	69.029
1/2	29.8451	70.882
5/8	30.2378	72.760
3/4	30.6305	74.662

CURRENT FOR 1 KV-A.

Voltage	1 Phase or D-C.	2 Phase	3 Phase
110	9.09	4.55	5.25
125	8.00	4.00	4.62
220	4.55	2.27	2.63
240	4.17	2.08	2.40
250	4.00	2.00	2.31
275	3.64	1.82	2.10
300	3.33	1.67	1.92
370	2.70	1.35	1.56
440	2.27	1.14	1.31
480	2.08	1.04	1.20
500	2.00	1.00	1.15
550	1.82	.909	1.05
575	1.74	.869	1.00
600	1.67	.833	.962
650	1.54	.769	.888
750	1.33	.666	.770
1,100	.909	.455	.525
1,150	.869	.434	.502
1,200	.833	.417	.481
2,080	.481	.240	.277
2,200	.455	.227	.263
2,300	.435	.217	.250
2,400	.417	.208	.240
3,300	.303	.152	.175
3,500	.286	.143	.165
4,000	.250	.125	.144
4,150	.241	.121	.139
5,500	.182	.0909	.105
6,600	.152	.0758	.0875
11,000	.0909	.0455	.0525
12,000	.0833	.0417	.0481
13,000	.0769	.0385	.0444
13,200	.0758	.0379	.0437
16,500	.0606	.0303	.0350
22,000	.0455	.0227	.0263
33,000	.0303	.0152	.0175
35,000	.0286	.0143	.0165
40,000	.0250	.0125	.0144
44,000	.0227	.0114	.0131
55,000	.0182	.00909	.0105
60,000	.0167	.00833	.00962
66,000	.0152	.00758	.00875
70,000	.0143	.00714	.00825
80,000	.0125	.00625	.00722
100,000	.01000	.00500	.00577
110,000	.00909	.00455	.00525
135,000	.00741	.00370	.00428
140,000	.00714	.00357	.00412
180,000	.00555	.00278	.00321

BREAKING STRAIN OF MANILA ROPE

Circumference in Inches	Weight Per Foot in Pounds	Breaking Strain Tons	Breaking Strain Pounds
¾	0.019	0.28	560
1	0.033	0.39	784
1½	0.074	0.78	1,568
2	0.132	1.36	2,733
2½	0.206	2.14	4,278
3	0.297	3.06	6,115
3½	0.404	4.27	8,534
4	0.528	5.78	11,558
4½	0.668	7.39	14,784
5	0.825	9.18	18,368
5½	0.998	10.97	21,952
6	1.190	12.77	25,536
6½	1.390	14.56	29,120
7	1.620	16.35	32,704
7½	1.860	18.14	36,288

BREAKING STRAIN OF MANILA ROPE
Continued

Circumference in Inches	Weight Per Foot in Pounds	Breaking Tons	Strain Pounds
8	2.110	19.93	39,872
9	2.670	23.52	47,040
10	3.300	27.10	54,208
11	3.990	30.69	61,376
12	4.750	34.27	68,544
13	5.580	37.86	75,712
14	6.470	41.44	82,880

DIMENSIONS AND WEIGHTS OF STANDARD STEEL PIPE

Standard

Sizes Inches	Diameter, Inches External	Diameter, Inches Internal	Thickness Inches	Weight Pounds per Foot	Threads per Inch
½	0.840	0.622	0.109	0.850	14
¾	1.050	0.924	0.113	1.130	14
1	1.315	1.049	0.133	1.678	11½
1¼	1.660	1.380	0.140	2.272	11½
1½	1.900	1.610	0.145	2.717	11½
2	2.375	2.067	0.154	3.652	11½
2½	2.875	2.469	0.203	5.793	8
3	3.500	3.068	0.216	7.575	8

Extra Strong

Sizes	Diameter, Inches External	Diameter, Inches Internal	Thickness Inches	Weight Pounds per Foot
½	0.840	0.546	0.147	1.087
¾	1.050	0.742	0.154	1.473
1	1.315	0.957	0.179	2.171
1¼	1.660	1.278	0.191	2.996
1½	1.900	1.500	0.200	3.631
2	2.375	1.939	0.218	5.022
2½	2.875	2.323	0.276	7.661
3	3.500	2.900	0.300	10.252

Double Extra Strong

Sizes	Diameter, Inches External	Diameter, Inches Internal	Thickness Inches	Weight Pounds per Foot
½	0.840	0.252	0.294	1.714
¾	1.050	0.434	0.308	2.440
1	1.315	0.599	0.358	3.659
1¼	1.660	0.896	0.382	5.214
1½	1.900	1.100	0.400	6.408
2	2.375	1.503	0.436	9.029
2½	2.875	1.771	0.552	13.695
3	3.500	2.300	0.600	18.583

SEAMLESS BRASS AND COPPER TUBE IRON PIPE SIZES

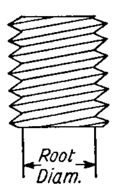
Nominal Size Inches	Wt. per Ft., Lbs. Brass	Wt. per Ft., Lbs. Copper	Nominal Size Inches	Wt. per Ft., Lbs. Brass	Wt. per Ft., Lbs. Copper
⅛	0.246	0.259	1	1.740	1.829
¼	0.437	0.459	1¼	2.557	2.698
⅜	0.612	0.644	1½	3.037	3.193
½	0.911	0.958	2	4.017	4.224
¾	1.235	1.298	2½	5.830	6.130

MACHINE BOLT AND M.B. TAP BOLT DATA AMERICAN (NATIONAL) FORM.

Diameter	Threads Per Inch	Root Diameter
1/4	20	.185
5/16	18	.240
3/8	16	.294
1/2	13	.400
5/8	11	.507
3/4	10	.620
7/8	9	.731
1	8	.837
1 1/4	7	1.065
1 1/2	6	1.284
1 3/4	5	1.491
2	4 1/2	1.712
2 1/2	4	2.176
3	3 1/2	2.629
3 1/2	3 1/4	3.100
4	3	3.567

MACHINE SCREW DATA

Size	Threads Per Inch	Max. Diam.	Root Diam.
2	56	.086	.063
4	40	.112	.080
6	32	.138	.097
8	32	.164	.123
10	32	.190	.149
14	24	.242	.188
5/16	18	5/16	.240
3/8	16	3/8	.294



WOOD SCREW DATA

Size	Max. Diam.
2	.086
4	.112
6	.138
8	.164
10	.190
14	.242
18	.294
24	.372

DECIMAL EQUIVALENTS

of Eights, Sixteenths, Thirty-seconds and Sixty-fourths of an inch.

1/64	0.015625
1/32	0.03125
3/64	0.046875
1/16	0.0625
5/64	0.078125
3/32	0.09375
7/64	0.109375
1/8	0.125
9/64	0.140625
5/32	0.15625
11/64	0.171875
3/16	0.1875
13/64	0.203125
7/32	0.21875
15/64	0.234375
1/4	0.250
17/64	0.265625
9/32	0.28125
19/64	0.296875
5/16	0.3125
21/64	0.328125
11/32	0.34375
23/64	0.359375
3/8	0.375
25/64	0.390625
13/32	0.40625
27/64	0.421875
7/16	0.4375
29/64	0.453125
15/32	0.46875
31/64	0.484375
1/2	0.500
33/64	0.515625
17/32	0.53125
35/64	0.546875
9/16	0.5625
37/64	0.578125
19/32	0.59375
39/64	0.609375
5/8	0.625
41/64	0.640625
21/32	0.65625
43/64	0.671875
11/16	0.6875
45/64	0.703125
23/32	0.71875
47/64	0.734375
3/4	0.750
49/64	0.765625
25/32	0.78125
51/64	0.796875
13/16	0.8125
53/64	0.828125
27/32	0.84375
55/64	0.859375
7/8	0.875
57/64	0.890625
29/32	0.90625
59/64	0.921875
15/16	0.9375
61/64	0.953125
31/32	0.96875
63/64	0.984375

GAUGE EQUIVALENTS

Sheet Steel Plate Sizes		Twist Drill Sizes	Steel Wire Sizes		Twist Drill Sizes	Steel Wire Sizes
U.S.G.	No.	T.D.G.	S. W.G.	No.	T.D.G.	SWG.
.500	7/0			39	.0995	.099
.469	6/0			40	.0980	.097
.438	5/0			41	.0960	.095
.406	4/0			42	.0935	.092
.375	3/0			43	.0890	.088
.344	2/0			44	.0860	.085
.313	0			45	.0820	.081
.281	1	.228	.227	46	.0810	.079
.266	2	.221	.219	47	.0785	.077
.250	3	.213	.212	48	.0760	.075
.234	4	.209	.207	49	.0730	.072
.219	5	.206	.204	50	.0700	.069
.203	6	.204	.201	51	.0670	.066
.188	7	.201	.199	52	.0635	.063
.172	8	.199	.197	54	.0595	.058
.156	9	.196	.194	55	.0550	.055
.141	10	.194	.191	55	.0520	.050
.125	11	.191	.188	56	.0465	.045
.109	12	.189	.185	57	.0430	.042
.0938	13	.185	.182	58	.0420	.041
.0781	14	.182	.180	59	.0410	.040
.0703	15	.180	.178	60	.0400	.039
.0625	16	.177	.175	61	.0390	.038
.0563	17	.173	.172	62	.0380	.037
.0500	18	.170	.168	63	.0370	.036
.0438	19	.166	.164	64	.0360	.035
.0375	20	.161	.161	65	.0350	.033
.0344	21	.159	.157	66	.0330	.032
.0313	22	.157	.155	67	.0320	.031
.0281	23	.154	.153	68	.0310	.030
.0250	24	.152	.151	69	.0293	.029
.0219	25	.150	.148	70	.0280	.027
.0188	26	.147	.146	71	.0260	.026
.0172	27	.144	.143	72	.0250	.024
.0156	28	.141	.139	73	.0240	.023
.0141	29	.136	.134	74	.0225	.022
.0125	30	.129	.127	75	.0210	.020
.0109	31	.120	.120	76	.0200	.018
.0102	32	.116	.115	77	.0180	.016
.0094	33	.113	.112	78	.0160	.015
.0086	34	.111	.110	79	.0145	.014
.0078	35	.110	.108	80	.0136	.013
.0070	36	.107	.106			
.0066	37	.104	.103			
.0063	38	.102	.101			

U.S.G. = United States Standard Gauge.
T.D.G. = Twist Drill & Steel Wire Guage.
S.W.G. = Stubs' Steel Wire Gauge.

Letter Sizes for Twist Drills

A	.234	H	.266	O	.316	V	.377
B	.238	I	.272	P	.323	W	.386
C	.242	J	.277	Q	.332	X	.397
D	.246	K	.281	R	.339	Y	.404
E	.250	L	.290	S	.348	Z	.413
F	.257	M	.295	T	.358		
G	.261	N	.302	U	.368		

PROGRESS REPORT

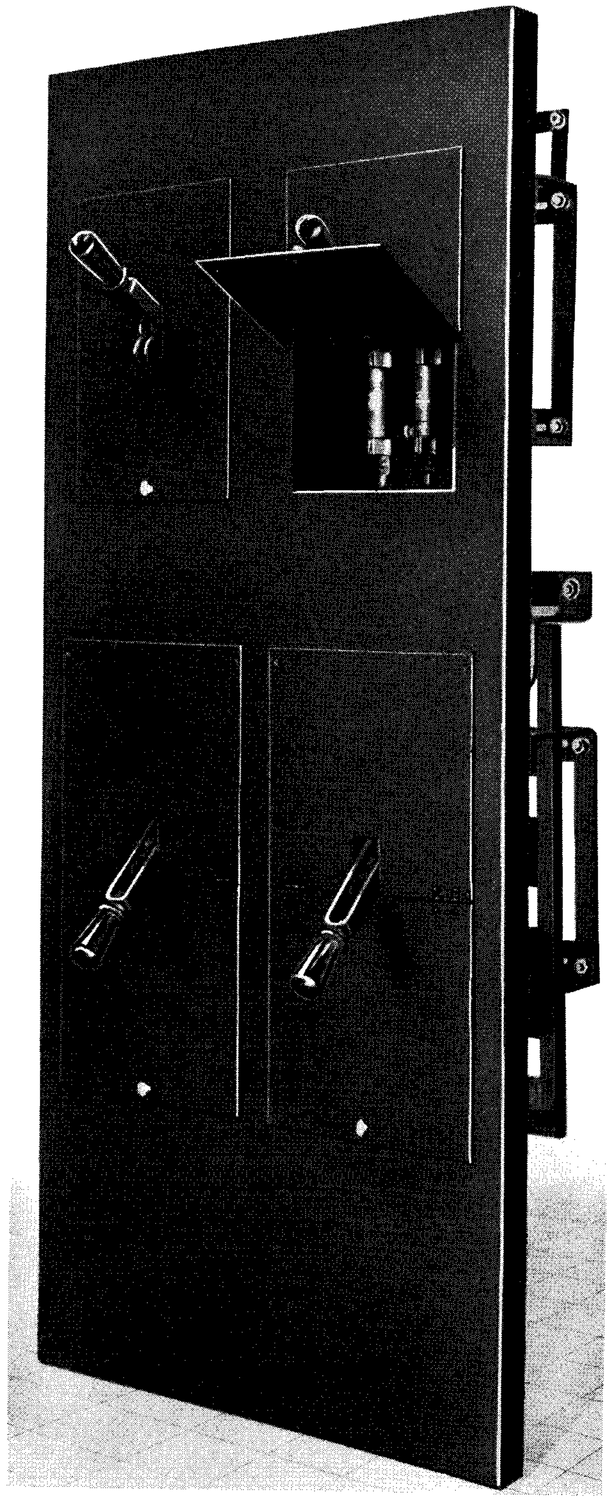
The following is an example of a progress report which has worked out quite satisfactorily on a number of large field installations. The report shown below is arranged for weekly progress indications although this period may be changed to suit the requirements. In a similar manner the headings and sub-headings will probably differ somewhat on every installation and may also be changed to suit. This form when made on a sheet approximately 17 x 22 will provide ample space for one year with all of the headings or sub-headings which it is ordinarily desired to use.

	March				April				May					June				July				August					Sept.			
OIL C. BKRS. AND REACTOR COMP.	1 Wk	2 Wk	3 Wk	4 Wk	1 Wk	2 Wk	3 Wk	4 Wk	1 Wk	2 Wk	3 Wk	4 Wk	5 Wk	1 Wk	2 Wk	3 Wk	4 Wk	1 Wk	2 Wk	3 Wk	4 Wk	1 Wk	2 Wk	3 Wk	4 Wk	5 Wk	1 Wk	2 Wk	3 Wk	4 Wk
1st, 2nd, 3rd and 4th Floors.		12	16	20			25		40																					
Type 0-33 Pole Units																														
Control Panels for C. B.																														
Remote Contr. Details			4%	5%	\	3	5																							
Operating Pipes																														
Operating Mechanisms																														
Disconnecting Switches																														
Reactors	50%																													
Cell Compartment Doors																														
Reactor Comp. Doors																														
D-C. Bkr. Vent Pipe																														
Cell Structure							\																							
Inserts & Mtg. Bolts	\	10	15	20	25	35	45																							
GENERAL EQUIPMENT																														
Conduit-Power, Contr. Meter	\	8	10	22	35	45	50																							
Control Cable																														
Feeder Cable																														
Instr. Transf. Fuse Blocks																														
Bus Supports & Bushings																														
Bolts and Inserts	\	15	20	35	40	V																								
Copper Connections H. T.																														
Battery F-25																														
Battery for Sup. Control																														
Generator Leads																														
Outside Ground to Piling																														
Test Bus																														
Lightning Arresters																														
Battery Motor-Generators																														
Ground Bus																														
Supervisory Contr. Equip.						\	5																							
Copper Connections L. T																														
TURBINES—GENERATORS																														
25000 Kv-a. Gen. No. 1						|	30																						
25000 Kv-a. Gen. No. 2							10																							
25000 Kv-a. Gen. No. 3							10																							
1000 Kv-a. Emerg. Set																														
500 Kw. Motor-Generators & Reactors																														
Turbine No. 1																														
Turbine No. 2																														
Turbine No. 3																														
TRANSFORMERS																														
25000 Kv-a. Main	90	V																												
1500 Kv-a. House Service	90	V																												
Reactors & C. T for H. Transf.																														
RHEOSTAT PLATFORM																														
Field Breakers																														
H. T. SWITCHBOARDS																														
Main Control Desk																														
Trunk Line Control Swbd.																														
House Service " "																														
Trunk Line Relay "																														
House Service " "																														
Metering Switchboard																														
Metering Pedestals																														
Temp. Indicating Panels																														
Terminal Boards Dwg.																														
L. T. SWITCHBOARDS																														
250 Volt D-C. Board																														
Battery Distr. Board																														
Battery M-G. "																														
Truck Swbd.		90	V																											

LEGEND

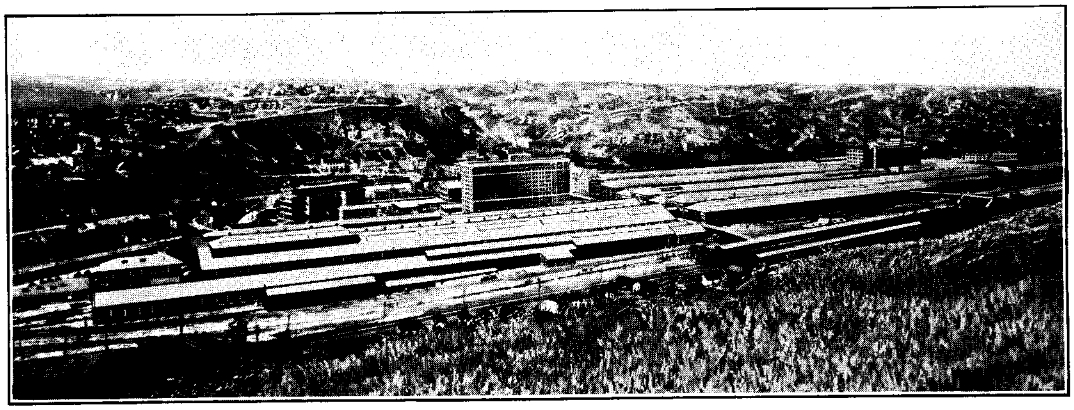
- % Completion of Foundations & Forms
- Date of Completion by Gen'l Contractor
- Other Work Incomplete
- Shortage of Mtl.
- Material Rc'd
- Installation Started
- Connections of cable started
- 25 % of Progress
- Changes to be made
- Installation Compl't'd
- Ready for Service
- Inspections

Percent Total Completion ☐



Westinghouse Dead Front Switchboard — Knife Switch Type

Note: Our cold rolled stretcher level steel panel is shown also the latest design of Dead Front Knife Switches. Accessibility is obtained by removable covers over each switch. Fuse doors are interlocked with the switch handles so that they cannot be opened when switch is closed.



The Company's Works at East Pittsburgh, Pa.

Westinghouse Products

A few of the Westinghouse Products are listed below and will furnish some idea of the great variety of electrical apparatus manufactured by the Company and the many extensive fields for their use.

For Industrial Use

Instruments
Motors and controllers for every application, the more important of which are: Machine shops, woodworking plants, textile mills, steel mills, flour mills, cement mills, brick and clay plants, printing plants, bakeries, laundries, irrigation, elevators and pumps.
Welding outfits
Gears
Industrial heating devices, such as: Glue pots, immersion heaters, solder pots, hat-making machinery and electric ovens.
Lighting systems
Safety switches

For Power Plants and Transmission Lines

Carrier current equipment
Circuit-breakers and switches
Condensers
Controllers
Control switches
Frequency changers
Fuses and fuse blocks
Generators
Insulating material
Instruments
Lamps, incandescent and arc
Lightning arresters
Line material
Locomotives
Meters
Motors
Motor-generators
Portable Power Stands, 110 volts
Rectifiers
Regulators
Relays
Solder and soldering fluids
Stokers
Substations, portable and automatic
Switchboards
Synchronous converters
Transformers
Turbine-generators

For Transportation

Locomotives
Railway equipment
Marine equipment

For Mines

Automatic substations
Lamps
Locomotives
Motor for hoists and pumps
Motor-generators
Portable substations
Switchboards
Line material
Ventilating outfits

For Farms

Fans
Household appliances
Motors for driving churns, cream separators, corn shellers, feed grinders, pumps, air compressors, grindstones, fruit cleaning machines and sorting machines.
Generators for light, power and heating apparatus.
Portable Power Stands, 32 Volts
Radio Apparatus
Transformers

For Office and Store

Electric radiators
Fans
Arc lamps
Incandescent lamps
Sol-Lux lighting fixtures
Small motors for driving addressing machines, dictaphones, adding machines, cash carriers, moving window displays, signs, flashers, envelope sealers, duplicators, etc.
Ventilating outfits

For Electric and Gasoline Automobiles and the Garage

Battery charging outfits
Charging plugs and receptacles
Lamps
Instruments
Motors and controllers
Small motors for driving lathes, tire pumps, machine tools, polishing and grinding lathes.
Solder and soldering fluids
Tire vulcanizers

For the Home

Electric ware, including: Table stoves, toasters, irons, warming pads, curling irons, coffee percolators, chafing dishes, disc stoves, radiators and sterilizers.
Automatic electric ranges
Fans
Incandescent lamps
Radio apparatus
Sol-Lux lighting fixtures
Small motors for driving coffee grinders, ice cream freezers, ironing machines, washing machines, vacuum cleaners, sewing machines, small lathes, polishing and grinding wheels, pumps and piano players.
Sew-motors.