Westinghouse

Steam Turbines

20,000 to 35,000 Kw.

INSTRUCTION BOOK

Westinghouse Electric & Manufacturing Company

South Philadelphia Works South Philadelphia, Pa.

I. B. 5306

CONTENTS

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INTRODUCTION

Although the turbine is simple in design and durable in its construction, and does not require constant manipulation and adjustment, it is like any other piece of machinery in that it should receive intelligent and careful attention from the operator, and periodic inspection of the working parts that are not at all times in plain view. Any piece of machinery, no matter how simple and durable, if neglected or abused, will deteriorate abnormally.

The experienced engineer understands, in a general way, the principles and operation of almost any piece of apparatus that he may come in contact with in the power-house. At the same time there are certain mechanical features about any new machine that he must acquaint himself with, either from his own experience or the experience of others, and the latter supplemented and confirmed by the former is perhaps apt to be least costly.

The varied experience gained by steam turbine builders during the erecting, testing and operating of their equipment places them in the position of being able to give valuable advice concerning the care and operation of turbines. Since the inception of its turbine business in 1896, The Westinghouse Company has made a special effort to follow as closely as possible the field operation of the various units sold. As the Company also manufactures condensers, reduction gears and other power-house auxiliaries, it is in a very good position to confer with a purchaser regarding not only the care and operation of his turbine, but to offer advice on engineering matters concerning installation of turbine condenser and power-house apparatus generally.

The object of this book is to cover in a general manner the principal features of construction and methods of operation common to all Westinghouse turbines. It is, however, extremely difficult to enumerate all the things which should, or should not be done, in properly caring for a steam turbine, or in fact any similar piece of machinery. This book together with the illustrated supplements showing in detail the construction of the machines, and their component parts, should serve the operating engineer and assist him in properly caring for his installation.

FUNDAMENTAL PRINCIPLES OF THE STEAM TURBINE

A steam turbine depends for its operation on the effect of steam being expanded thru suitably formed passages, thereby attaining velocity. The steam, therefore, does work upon itself—the energy represented in the jet, having its exact equivalent in the expansive energy of the steam, less the unavoidable losses.

Essentially, there are but two general types of turbnes—"Impulse Turbines" and "Reaction Turbines". The fundamental principle stated above, applies equally well to both types. Frequently both types are employed in the construction of one turbine. Either type has its distinct advantages under certain conditions of steam volume and expansion. As will be seen later, both types are employed in the various turbines built by the Westinghouse Company, depending upon the conditions for which the one or the other is suited to give the best results.

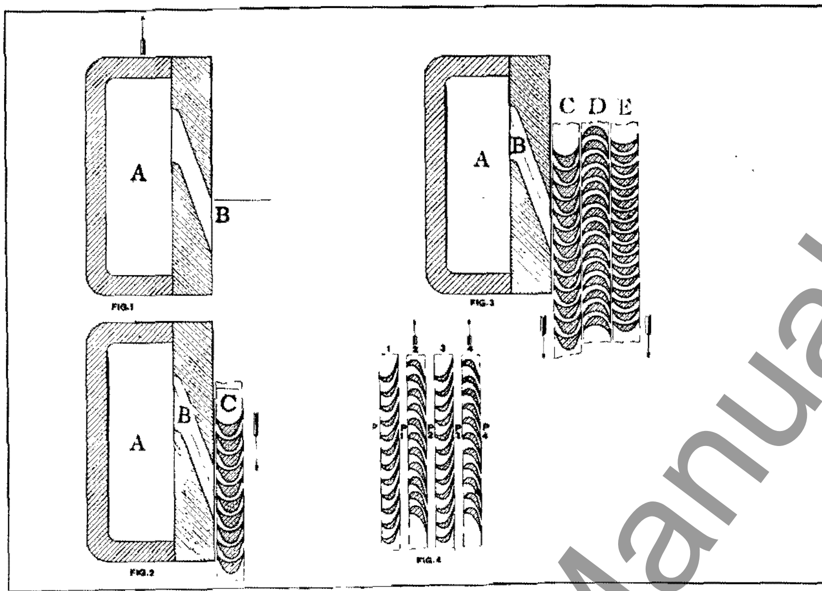


Fig.—1, 2, 3 and 4

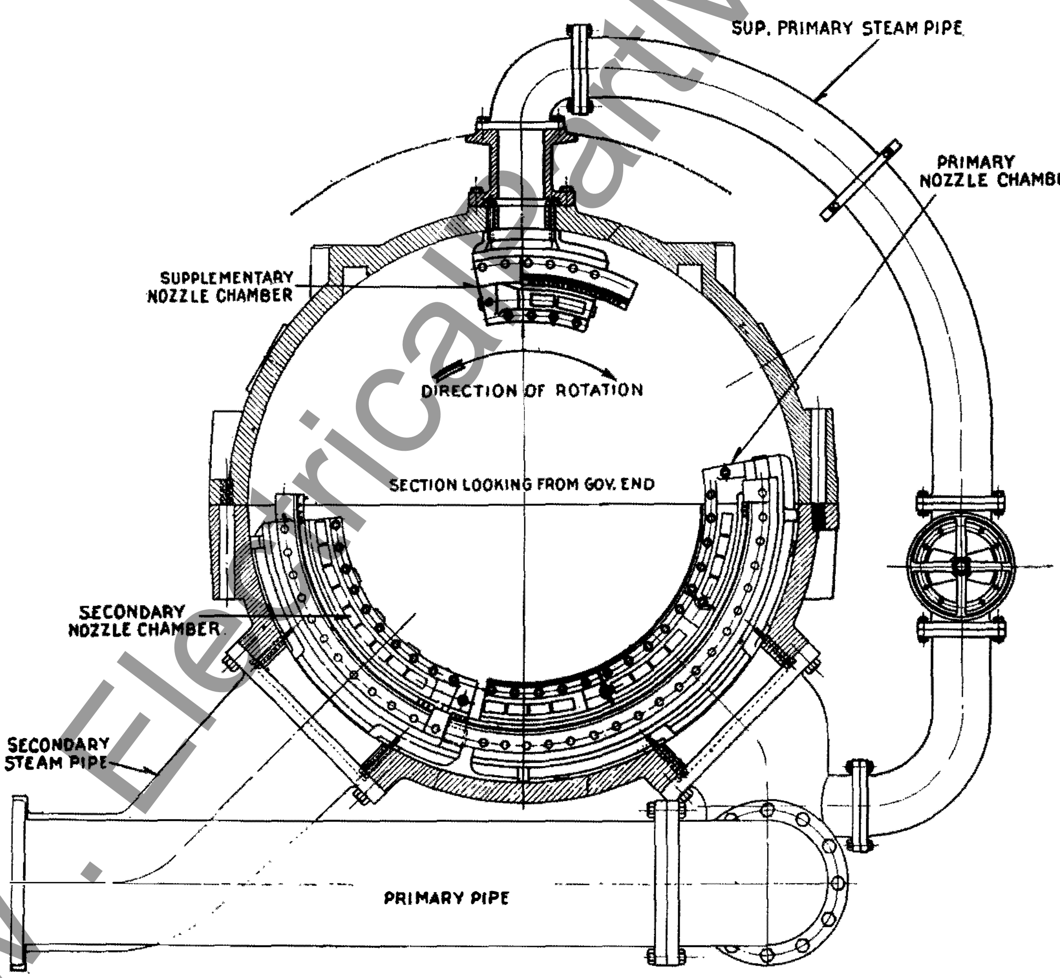


Fig. 5

Steam within a movable member "A" (Fig. 1) expanding thru a suitably formed nozzle "B", reacts on and may give motion to the movable member "A". This is the simplest form of reaction turbine, and the maximum efficiency is obtained when the velocity of the nozzle chamber equals that of the steam jet, for then the steam jet has no velocity with reference to the earth.

If instead, as in Fig. 2, the member "A" is not permitted to move, the steam jet will issue with considerable velocity, with reference to the earth, and should there be placed in front of this jet suitably formed blades or buckets "C", motion may be given the latter by means of the jet, constituting what is known as an "Impulse Turbine". In this case, theoretically, the maximum efficiency is obtained when the velocity of the buckets is one half that of the jet, and it then follows that the steam would leave the buckets with no velocity, with reference to the earth.

Sometimes the relation of velocity of steam jet to desired bucket velocity is great, so that the steam leaving the impulse element, (Fig. 2) will have such a high terminal steam velocity as to be inefficient. In such cases, it is frequently convenient to employ more velocity elements, as in Fig. 3. Here the steam issues with considerable velocity from the blades "C", passes thru the stationary blades "D", and is redirected onto the moving blades "E", from which it should issue with but little velocity, with reference to the earth.

Figures 2 and 3 represent diagrammatically, well known types of impulse turbines and are readily recognized. Commercial types of reaction turbines differ somewhat from the diagram Fig. 1. The one best known, commonly called the "Parsons type" is shown in Fig. 4. The steam is passing thru row 1, expands from the pressure "P" to the pressure "P_1". In thus expanding, the steam does work upon itself, and attains a velocity which, if designed for high efficiency, will permit the steam to enter the moving blades of row 2 without shock. The energy due to expansion in row 1, still remains in the steam in kinetic form so long as it is within the blade passages of row 2. A further expansion is provided in row 2—the steam expanding from "P_1" to "P_2". The velocity due to this, is given up by giving motion by reaction to the moving blades of row 2. The same cycle is repeated by expanding thru the stationary blade row 3, and moving blades in row 4, and so on, until the entire desired expansion is completed. Obviously, succeeding rows of blades must have greater passage areas to accommodate the increasing volume of the expanding steam.

From the above the main difference between commercial types of impulse and reaction turbines is seen to be in the form of the blade used. The blades in the impulse turbine are formed to most efficiently utilize the velocity of steam expanded in a row of nozzles before each wheel, there being no pressure drop thru the blades themselves. The blades in the reaction turbine, however, are all special forms of nozzles, there being a pressure drop thru each row of blades, use being made of the reactive force in each moving row.

TURBINE TYPES

Turbines are built of two types, i. e., straight reaction or a combination of impulse and reaction, using the elements most suitable from the standpoints of mechanical reliability and steam economy. The impulse element is better adaptable where steam volumes are small and the reaction where they are large.

Depending upon the capacity of the machine at a given speed, turbines are built single flow (i. e., the steam passing through the whole turbine in one axial direction) or of semi-double flow construction (i. e., the high pressure element being single flow with the low pressure elements double flow), and the straight double flow.

Conventional frequencies do not permit much latitude in the matter of speeds. Thus for 60 cycle service, 3600, 1800 or 1200 rpm. are the speeds available. Similarly, 1500 and 750 r. p. m. are the the speeds available for 25 cycle work.

rain and, as far as possible, from dust. The outgoing air from the generator may discharge immediately into the basement and so improve its ventilation, but care should be taken that this air cannot re-enter the air intake pipes.

In some instances, where the air in the power house is cleaner than outside, air may be taken from the basement, and discharged out-of-doors. It is, however, preferable for the ventilating air to be taken from out-of-doors, to obtain the most efficient results.

The greatest care should be exercised in laying out the ducts to avoid sharp turns, or anything that may restrict free flow.

It is sometimes possible in the open system to eliminate air ducts by devising partition walls in the basement, so that the generator may draw from one side, and discharge it at the other. There must then be suitable openings into the basement. to the space on either side of the partition wall, for the ingress and egress of air, one of which should open to the outside of the building. Care must of course be observed that it will be impossible for air leaving the generator to find its way to the intake.

Wherever possible closed systems should be installed with air coolers, so the temperature rise through the generator will be constant thruout the year. Such a system almost precludes the possibility of dust and dirt entering the generator so they may be operated for a much longer period without cleaning.

This system also greatly reduces the fire hazard in the electrical equipment. In the average closed system there is oxygen contained within the system sufficient to support combustion for only about 1% of the combustible insulating material in the generator. It is evident, therefore, that no serious fire would be liable to occur with the closed generator equipment.

However, if it is not possible or advisable to install the closed system, air washing plants are available and have much to recommend them.

CRANE

It is most neccessary that a suitable crane be furnished for handling the turbine parts. On the outline drawing. we give the weights which the crane should be capable of handling, as well as the head room neccessary for removing the various parts.

STEAM LINES

The arrangement of steam lines to turbines is one that should be carefully studied from the standpoint of the arrangement being such that there be provision for the expansion and contraction of both the turbine and the steam line, which will impose the least possible strain on the turbine structure.

The steam chest will either be bolted to the cylinder, arrangement A, or some part of the foundation adjacent to the cylinder, arrangement B. The throttle valve is bolted to the steam chest. It will be supported by springs in arrangement A, while in B, it will be bolted to the foundation.

When making up the steam piping the following general allowance should be made. The turbine expansion should be taken at full value; i. e. from cold to maximum temperatures; and the expansion of steam piping from saturated steam temperature to the maximum temperature. The pipe lengths should then be so adjusted that the pipe is sprung together cold with half the total expansion as figured above. In other words, by halving the expansion when bolting up, the stresses in the piping and flanges can be reduced to a minimum.

In arrangement A, extreme care should be taken to follow the method of connecting piping described above.

In arrangement B, the turbine is relieved of piping strains by the flexible pipe bends in the lines between the steam chest and the cylinder. In this case the amount of strain, due to the main steam line, on the steam chest is governed solely by the strength of the pipe fittings.

The piping layout should also be studied with the object of minimizing torsional stresses. This type of stress is very often overlooked when piping layouts are made.

EXHAUST PIPING

In the majority of installations the condenser supported on springs is bolted directly to the turbine. The condenser is thus constrained to move with the turbine. Wherever the condenser is located otherwise than directly below the turbine it may be necessary to provide an expansion joint between the turbine and its condenser.

In arranging the exhaust piping and foundation for expansion joints cognizance must be taken of the collapsing stress due to vacuum, which frequently imposes a very material load on the foundations. With a surface condenser immediately below the turbine, or equivalent construction, the stresse on the foundation cannot be avoided. With the exhaust pipe carried horizontally in either direction the stresses may be eliminated by permitting brackets, provided in the exhaust piping, to butt against the turbine bedplate. Failure to provide for this collapsing stress may cause the expansion joint to collapse lifting the pipe and perhaps the whole condenser, should it be of light construction.

It is desirable that exhaust steam should flow downward to the condenser.

The atmospheric relief valve should be of good construction to avoid air leakage. This valve may, with advantage, be furnished with a rubber seat which insures tightness and, as there is no oil in the exhaust, the rubber should last indefinitely. To preclude any change of air leakage these valves should be water sealed. The atmospheric relief valve, which should be of an automatic type, is necessary to prevent the building up of a dangerous pressure in the turbine cylinder in the event of failure of the circulating water supply. The recommended size is given in the outline drawing.

DRIPS AND DRAINS

The steam chest is provided with suitable atmospheric drains which must be disposed of in the usual way. The exhaust from the automatic stop governor, discharges steam only when the safety stop operates, and if it is found advisable to connect this to a drain pipe, it should be led into an open drain, as any appreciable back pressure will interfere with the desired free and instantaneous operation of the automatic throttle valve. The steam pipe, connecting the automatic throttle valve with the automatic stop governor, is provided with a tee fitting at the lowest point which should be arranged to connect to some means of maintaining this pipe free of water, such as a trap. It may be effectively drained by connecting it through a check valve to the main steam line, providing connection may be made at a point more than 4 feet lower than the pipe requiring to be drained. Care must be exercised that no circumstance can cause the dropping of pressure in the line or the main throttle valve will close causing interruption to service.

The pipe which is marked on the outline—"Slop Drain from Glands"—should be allowed to drain freely, and should not be connected in with other drips. There are also automatic drains in the turbine provided with orifices draining high pressure zones into zones of lower pressure. Some of these zones are also provided with atmospheric drains for use when starting. The outline drawing also shows atmospheric drains from steam pipe and throttle valve to be used when starting.

CONNECTIONS FOR GLANDS AND COOLING COIL

Water must be provided for the oil cooler, and also for sealing the glands. Nearly any source of cold water will suffice for the oil cooler providing it is reasonably clean. Deposit of any nature will tend to plug up the pipes and decrease the rate of heat transfer necessitating frequent cleaning.

The best arrangement for sealing the glands is a supply of condensate in an elevated tank. With some types of glands all the water supplied them passes into the turbine so if raw water containing foreign matter be used, scale will be formed in the glands and on the end of the spindle. Formation of scale or deposit in the glands impairs their proper functioning, while scale on the spindle is liable to cause unbalance.

Steam lines are connected into the top half of the glands for emergency steam sealing, should the water supply fail for any reason. Enough steam should be turned on so a small amount is escaping outward to insure a proper seal.

OPERATING AND INSPECTING SUGGESTIONS

The full list of instructions to be followed when starting or stopping our turbines as well as certain precautions to be observed during their operation will be found under the supplement No. 1. However, there are certain other suggestions which it is well to observe.

The oil leaving the bearings should not exceed 175°F. and sudden high rises of oil temperatures should be investigated immediately. These bearings are subject to a continuous circulation of oil and should give no trouble, and if a bearing wipes, there is some definite cause for it, such as a stoppage of oil supply or foreign matter in the oil etc., and the cause should be removed without delay.

In case superheated steam is used, the steam line thermometer should be read at intervals in order to make sure that the turbine is not being subjected to excessive variations of temperature.

Accidents to blading are of infrequent occurrence and not to be expected under normal operating conditions. However, should any sound of internal rubbing be detected the turbine should be shut down immediately, and the trouble located and rectified before any serious damage results. The engineer should not be misled by thinking any unusual sound too trivial to warrant investigation. Every irregularity should be looked into at once and in this way serious results may be averted. It is possible that after inspection, the bearing alignment may have been changed inadvertently, and the blade clearance decreased. Should any blades be damaged, and should there be insufficient time to make proper repair, the turbine may be put back into service if the damaged blades are removed. To preserve the turbine balance an equal number of blades should be removed from the spindle 180° around from the damaged section. If any considerable portion of any blade row is damaged, the entire row should be removed. The turbine will operate at some small sacrifice of economy until such time as it is convenient to make the proper repairs.

When a turbine is first put into service the oil strainers should be removed after a few hours' run and cleaned of any foreign matter that may have found its way into the oiling system. After the first few day's run, when the oil circulation has washed out the system, such frequent cleanings of this strainer should not be necessary, and the amount of dirt found will indicate how often it is advisable to take care of it. The strainer may be removed while the turbine is in operation, as explained in the description of the oiling system.

Frequent and sudden changes from condensing to non-condensing operation with the turbine under load should be avoided.

At periodic intervals the thrust bearing settings and the turbine spindle end travel clearances should be checked and a careful record kept. Should there be any great discrepency between the settings or clearances found and those previously taken the cause should be investigated at once. The proper method of taking these clearances etc., is given in the pamphlet describing the thrust bearing.

As is customary with engines of any type, the turbine should be opened and inspected periodically. General central station practice indicates that this annual inspection is warranted. The rotor, valves, bearings, oil cooler, etc., should all be carefully examined. If the valves show any sign of cutting they should be ground to their seats. The oil cooler may show a deposit from the oil on one side or from the water on the other side, thus interfering with the circulation of the oil and the effectiveness of the cooling surface. If the bearings or cooler tubes show an excessive oil deposit, the brand of oil should be investigated.

The governor should be cleaned and inspected and the knife edges examined for wear.

The glands and dumies should be examined the blading should be carefully inspected, and in case there is any deposit of mud or scale from the boilers, it should be cleaned out and steps taken to prevent further deposits if possible.

During an inspection it is always desirable to check up the clearance over the tips of the blades. This is accomplished by removing liners one by one from under the keys on the under side of the main bearings. This allows the spindle to be lowered in the cylinder, a distance equal to the thickness of the liners removed. Several trials should be made, removing additional liners the same amount from each bearing at each trial, and revolving the spindle by hand until the tips of the blades just begin to rub. As the liners are of known thickness expressed in thousandths of an inch, the clearance can be obtained with great exactness.

In a similar manner the spindle may be raised above its original position, and the top clearance determined; it may then be moved sidewise in either direction and the side clearances measured.

OILING SYSTEM

The turbine equipment includes the main oil reservoir, main and auxiliary pumps, oil cooler, strainer, and oil piping.

A float gauge with a rod projecting from the tank indicates the level of the oil. Care should be exercised to keep the float between the proper marks on the indicator to insure proper lubrication of the turbine at all times. This level should be kept high enough so there is a continuous overflow into the station filter system insuring a constant renewal of the oil.

Complete and detailed discussions with schematic illustrations of the particular oil system used are in the supplements.

OILS

The turbine system having been once charged with oil, the consumption is negligible and only due to leakage or spilling. Therefore, the cost of the lubricating oil may be regarded as of minor importance compared to quality.

As there are a number of different brands of oil on the market suitable for turbine lubrication we will not here recommend a particular brand but will confine ourselves to some general statements concerning the lubrication problem of steam turbines.

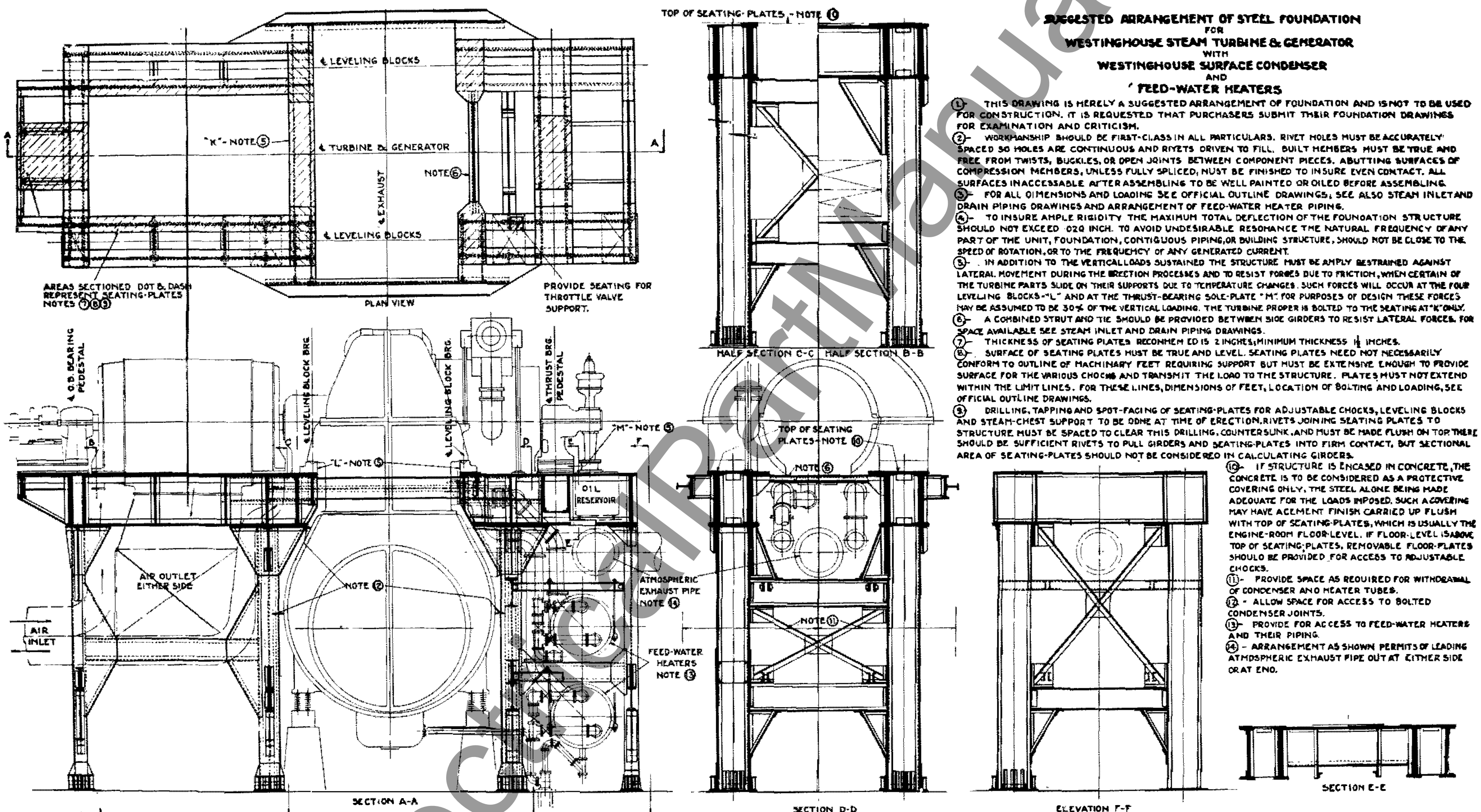
Inasmuch as a large quantity of oil is in circulation in the turbine at a temperature of from 100 to 150 deg., which temperature is conductive to chemical reaction should the necessary elements be present, it is, therefore, important that the oil be a pure mineral oil, free from acid. Sometimes mineral oils are adulterated with animal fats, which will, in the course of time, decompose, forming acids, corroding the various metals entering into the turbine construction with which the oil comes in contact.

An oil which contains solid or viscid substances, which become separated from the oil and may choke up the oil passages and deposit on the cooling coils, interfering with the heat transmission, should be avoided.

One of the most prolific causes of trouble with some turbine oils, when water is present, is their emulsification into a more or less solid, jelly-like substance. It is important that the oil used be capable of readily separating from water, and have the physical characteristics of not emulsifying when violently agitated.

Another cause of trouble is oxidation of the oil forming sludge. An oil with the least sludge forming tendency should be selected.

The oil used for lubrication should in general have a viscosity of 140 to 250 seconds Saybolt at 100° F. Oils within this viscosity range have satisfactorily lubricated all makes of turbine for many years and such service is the criterion by which an oil should be chosen.


SUGGESTED ARRANGEMENT OF STEEL FOUNDATION
FOR
WESTINGHOUSE STEAM TURBINE & GENERATOR
WITH
WESTINGHOUSE SURFACE CONDENSER
AND
FEED-WATER HEATERS
(1)- THIS DRAWING IS MERELY A SUGGESTED ARRANGEMENT OF FOUNDATION AND IS NOT TO BE USED FOR CONSTRUCTION. IT IS REQUESTED THAT PURCHASERS SUBMIT THEIR FOUNDATION DRAWINGS FOR EXAMINATION AND CRITICISM.
(2)- WORKMANSHIP SHOULD BE FIRST-CLASS IN ALL PARTICULARS. RIVET HOLES MUST BE ACCURATELY SPACED SO HOLES ARE CONTINUOUS AND RIVETS DRIVEN TO FILL. BUILT MEMBERS MUST BE TRUE AND FREE FROM TWISTS, BUCKLES, OR OPEN JOINTS BETWEEN COMPONENT PIECES. ABUTTING SURFACES OF COMPRESSION MEMBERS, UNLESS FULLY SPLICED, MUST BE FINISHED TO INSURE EVEN CONTACT. ALL SURFACES INACCESSABLE AFTER ASSEMBLING TO BE WELL PAINTED OR OILED BEFORE ASSEMBLING.
(3)- FOR ALL DIMENSIONS AND LOADING SEE OFFICIAL OUTLINE DRAWINGS; SEE ALSO STEAM INLET AND DRAIN PIPING DRAWINGS AND ARRANGEMENT OF FEED-WATER HEATER PIPING.
(4)- TO INSURE AMPLE RIGIDITY THE MAXIMUM TOTAL DEFLECTION OF THE FOUNDATION STRUCTURE SHOULD NOT EXCEED .020 INCH. TO AVOID UNDESIRABLE RESONANCE THE NATURAL FREQUENCY OF ANY PART OF THE UNIT, FOUNDATION, CONTIGUOUS PIPING, OR BUILDING STRUCTURE, SHOULD NOT BE CLOSE TO THE SPEED OF ROTATION, OR TO THE FREQUENCY OF ANY GENERATED CURRENT.
(5)- IN ADDITION TO THE VERTICAL LOADS SUSTAINED THE STRUCTURE MUST BE AMPLY RESTRAINED AGAINST LATERAL MOVEMENT DURING THE ERECTION PROCESSES AND TO RESIST FORCES DUE TO FRICTION, WHEN CERTAIN OF THE TURBINE PARTS SLIDE ON THEIR SUPPORTS DUE TO TEMPERATURE CHANGES. SUCH FORCES WILL OCCUR AT THE FOUR LEVELING BLOCKS-"L" AND AT THE THRUST-BEARING SOLE-PLATE "M". FOR PURPOSES OF DESIGN THESE FORCES MAY BE ASSUMED TO BE 30% OF THE VERTICAL LOADING. THE TURBINE PROPER IS BOLTED TO THE SEATING AT "K" ONLY.
(6)- A COMBINED STRUT AND TIE SHOULD BE PROVIDED BETWEEN SIDE GIRDERS TO RESIST LATERAL FORCES. FOR SPACE AVAILABLE SEE STEAM INLET AND DRAIN PIPING DRAWINGS.
(7)- THICKNESS OF SEATING PLATES RECOMMENDED IS 2 INCHES; MINIMUM THICKNESS 1½ INCHES.
(8)- SURFACE OF SEATING PLATES MUST BE TRUE AND LEVEL. SEATING PLATES NEED NOT NECESSARILY CONFORM TO OUTLINE OF MACHINERY FEET REQUIRING SUPPORT BUT MUST BE EXTENSIVE ENOUGH TO PROVIDE SURFACE FOR THE VARIOUS CHOCKS AND TRANSMIT THE LOAD TO THE STRUCTURE. PLATES MUST NOT EXTEND WITHIN THE LIMIT LINES. FOR THESE LINES, DIMENSIONS OF FEET, LOCATION OF BOLTING AND LOADING, SEE OFFICIAL OUTLINE DRAWINGS.
(9)- DRILLING, TAPPING AND SPOT-FACING OF SEATING-PLATES FOR ADJUSTABLE CHOCKS, LEVELING BLOCKS AND STEAM-CHEST SUPPORT TO BE DONE AT TIME OF ERECTION. RIVETS JOINING SEATING PLATES TO STRUCTURE MUST BE SPACED TO CLEAR THIS DRILLING, COUNTERSUNK, AND MUST BE MADE FLUSH ON TOP. THERE SHOULD BE SUFFICIENT RIVETS TO PULL GIRDERS AND SEATING-PLATES INTO FIRM CONTACT, BUT SECTIONAL AREA OF SEATING-PLATES SHOULD NOT BE CONSIDERED IN CALCULATING GIRDERS.
(10)- IF STRUCTURE IS ENCASED IN CONCRETE, THE CONCRETE IS TO BE CONSIDERED AS A PROTECTIVE COVERING ONLY, THE STEEL ALONE BEING MADE ADEQUATE FOR THE LOADS IMPOSED. SUCH A COVERING MAY HAVE A CEMENT FINISH CARRIED UP FLUSH WITH TOP OF SEATING-PLATES, WHICH IS USUALLY THE ENGINE-ROOM FLOOR-LEVEL. IF FLOOR-LEVEL IS ABOVE TOP OF SEATING-PLATES, REMOVABLE FLOOR-PLATES SHOULD BE PROVIDED FOR ACCESS TO ADJUSTABLE CHOCKS.
(11)- PROVIDE SPACE AS REQUIRED FOR WITHDRAWAL OF CONDENSER AND HEATER TUBES.
(12)- ALLOW SPACE FOR ACCESS TO BOLTED CONDENSER JOINTS.
(13)- PROVIDE FOR ACCESS TO FEED-WATER HEATERS AND THEIR PIPING.
(14)- ARRANGEMENT AS SHOWN PERMITS OF LEADING ATMOSPHERIC EXHAUST PIPE OUT AT EITHER SIDE OR AT END.
℄ LEVELING BLOCKS
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℄ TURBINE & GENERATOR
℄ EXHAUST
NOTE (6)
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PROVIDE SEATING FOR THROTTLE VALVE SUPPORT.
TOP OF SEATING-PLATES - NOTE (10)
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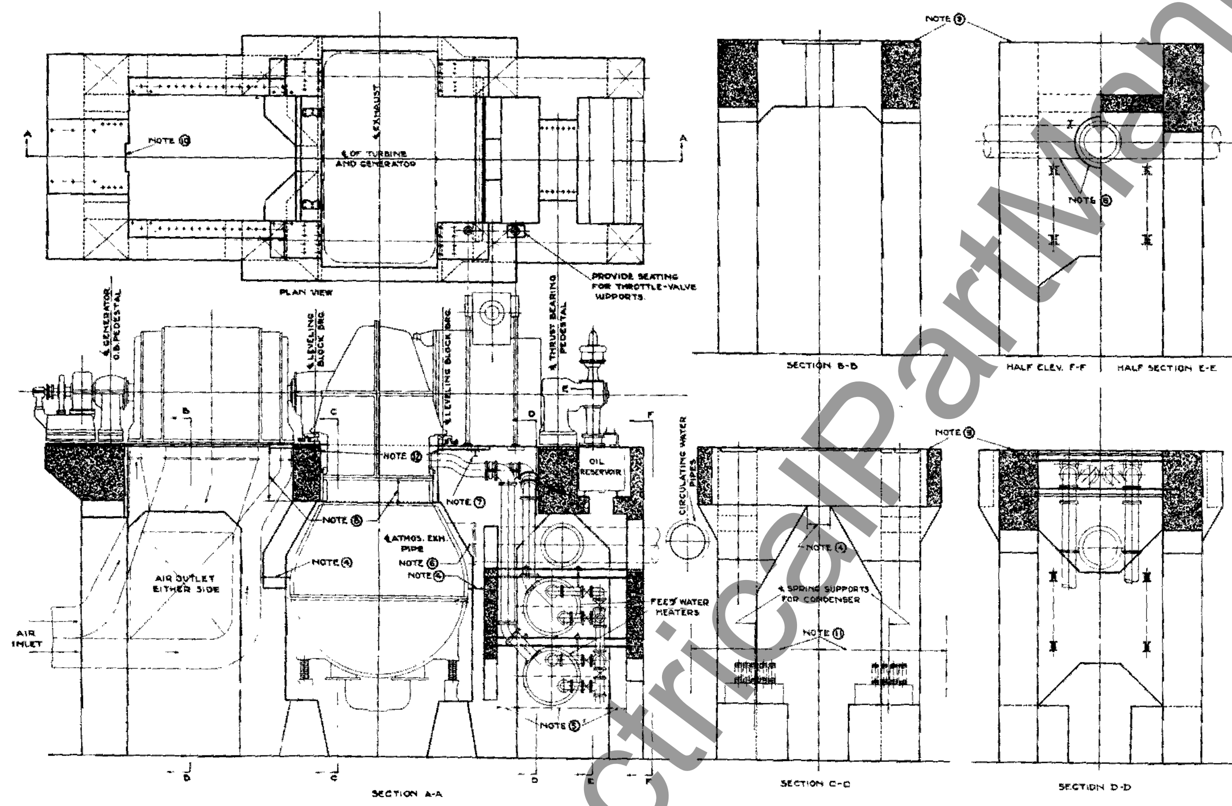
HALF SECTION B-B
℄ O.B. BEARING PEDESTAL
℄ LEVELING BLOCK BRG.
℄ THRUST BRG. PEDESTAL
"M"- NOTE (5)
"L"- NOTE (5)
OIL RESERVOIR
AIR OUTLET EITHER SIDE
AIR INLET
NOTE (12)
ATMOSPHERIC EXHAUST PIPE NOTE (14)
FEED-WATER HEATERS NOTE (13)
TOP OF SEATING PLATES-NOTE (10)
NOTE (6)
NOTE (11)
SECTION A-A
SECTION D-D
ELEVATION F-F
SECTION E-E

Fig. 6



SUGGESTED ARRANGEMENT OF REINFORCED CONCRETE FOUNDATION
FOR
WESTINGHOUSE STEAM TURBINE & GENERATOR
WITH
WESTINGHOUSE SURFACE CONDENSER
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FEED-WATER HEATERS.

①— THIS DRAWING IS MERELY A SUGGESTED ARRANGEMENT OF FOUNDATION AND IS NOT TO BE USED FOR CONSTRUCTION. IT IS REQUESTED THAT PURCHASERS SUBMIT THEIR FOUNDATION DRAWINGS FOR EXAMINATION AND CRITICISM.
②— FOR ALL DIMENSIONS AND LOADING, SEE OFFICIAL OUTLINE DRAWINGS, SEE ALSO SUGGESTED ARRANGEMENT OF SEATING PLATES, ARRANGEMENT OF FEED-WATER HEATER PIPING ETC.
③— CONCRETE MUST BE ADEQUATELY REINFORCED FOR THE LOADS SUSTAINED, WITH PROPER PROVISION FOR LATERAL FORCES. TO INSURE AMPLE RIGIDITY THE MAXIMUM TOTAL DEFLECTION OF THE FOUNDATION STRUCTURE SHOULD NOT EXCEED .020 INCH. TO AVOID UNDESIRABLE RESONANCE THE NATURAL FREQUENCY OF ANY PART OF THE UNIT, FOUNDATION, CONTIGUOUS PIPING, OR BUILDING STRUCTURE, SHOULD NOT BE CLOSE TO THE SPEED OF ROTATION, OR TO THE FREQUENCY OF ANY GENERATED CURRENT.
④— ALLOW SPACE FOR ACCESS TO BOLTED CONDENSER JOINTS.
⑤— PROVIDE FOR ACCESS TO FEED-WATER HEATERS AND THEIR PIPING.
⑥— ARRANGEMENT AS SHOWN PERMITS OF LEADING ATMOSPHERIC EXHAUST PIPE OUT AT EITHER SIDE OR AT END.
⑦— A COMBINED STRUT AND TIE SHOULD BE PROVIDED BETWEEN SIDE GIRDERS TO RESIST LATERAL FORCES RESULTING FROM FRICTION WHEN TURBINE FEET SLIDE ON THEIR SUPPORTS, DUE TO TEMPERATURE CHANGES. FOR SPACE AVAILABLE SEE OUTLINE DWG.

⑧— EXHAUST CONNECTION IS OMITTED WHEN MINIMUM HEAD-ROOM IS REQUIRED, AND STRUCTURAL STEEL MUST BE USED WHERE GIRDERS BECOME TOO SHALLOW FOR ADEQUATE STRENGTH IN REINFORCED CONCRETE.
⑨— GROUTING IS CARRIED UP FLUSH WITH TOP OF SEATING PLATES, WHICH IS USUALLY THE ENGINE-ROOM FLOOR LEVEL. IF FLOOR LEVEL IS ABOVE TOP OF SEATING PLATES, REMOVABLE FLOOR PLATES MUST BE PROVIDED FOR ACCESS TO ADJUSTABLE CHOCKS.
⑩— IN SOME CASES A CUT-OUT IS REQUIRED FOR COLLECTOR LEADS. SEE GENERATOR LEAD DRAWING
⑪— PROVIDE SPACE AS REQUIRED FOR WITHDRAWAL OF CONDENSER AND HEATER TUBES.
⑫— THE LOADING UNDER LEVELING BLOCKS IS HEAVY AND CONCENTRATED, IN ADDITION TO THIS THE LOADING WILL ACT AT AN ANGLE TO THE VERTICAL, DUE TO FRICTION. TO GUARD AGAINST FAILURE OF THE CORNER THE CONCRETE MUST BE HEAVILY REINFORCED AT THESE POINTS. BARS SHOULD BE MEDIUM IN SIZE BUT CLOSELY SPACED AND EXTEND WELL BACK INTO FOUNDATION. SEE VIEW OF LEVELING BLOCKS ON SEATING PLATE DRAWING AND NOTES IN CONNECTION WITH SAME.

FOR SEATING PLATES SEE DWG 5D80785

Fig. 7

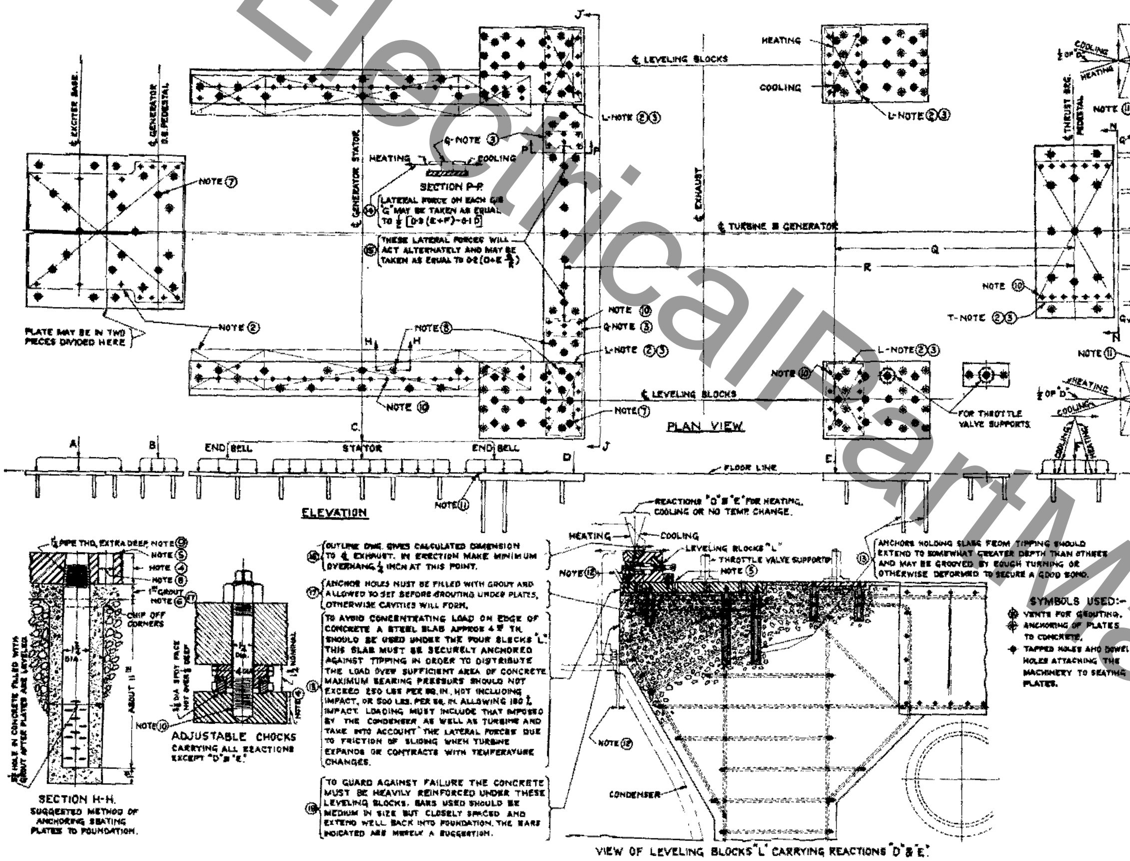


Fig. 8

SUGGESTED ARRANGEMENT OF SEATING PLATES
FOR
REINFORCED CONCRETE FOUNDATION
FOR
WESTINGHOUSE STEAM TURBINE AND GENERATOR.

(1)— THIS DRAWING SHOWS A SUGGESTED ARRANGEMENT ONLY AND IS NOT TO BE USED FOR CONSTRUCTION. IT IS REQUESTED THAT PURCHASERS SUBMIT THEIR FOUNDATION DRAWINGS FOR EXAMINATION AND CRITICISM.

(2)— OUTLINE OF MACHINERY FEET ARE INDICATED BY DOT AND DASH LINES. SEATING PLATES NEED NOT NECESSARILY CONFORM TO OUTLINE OF FEET BUT MUST BE EXTENSIVE ENOUGH TO PROVIDE SURFACE FOR THE VARIOUS CHOCKS AND TO DISTRIBUTE THE LOAD OVER SUFFICIENT AREA OF CONCRETE. PLATES MUST NOT EXTEND WITHIN THE LIMIT LINES. FOR POSITION OF LIMIT LINES, DIMENSIONS OF FEET, LOCATION OF BOLTING, LOADING, ETC., SEE OFFICIAL OUTLINE DWGS.

(3)— THE SEATING PLATES MUST BE ADEQUATELY RESTRAINED AGAINST LATERAL MOVEMENT DURING THE ERECTION PROCESSES AND TO RESIST FORCES DUE TO FRICTION WHEN CERTAIN OF THE TURBINE PARTS SLIDE ON THEIR SUPPORTS DUE TO TEMPERATURE CHANGES. SUCH FORCES OCCUR AT THE FOUR LEVELLING BLOCKS "L" AND AT THE THRUST BEARING SOLE PLATE "T." THE REACTION OF THESE IS AT THE GIBS "G," WHERE THE TURBINE IS SECURED AGAINST MOVEMENT ON THE FOUNDATION. NOTE THAT THESE LATERAL FORCES ACT AT SOME HEIGHT ABOVE TOP OF SEATING PLATES AND PRODUCE MOMENTS. FOR PURPOSES OF DESIGN THE VALUE OF LATERAL FORCES MAY BE BASED ON A MAXIMUM COEFFICIENT OF FRICTION OF 0.3 AND A MINIMUM OF 0.1

(4)— THICKNESS OF SEATING PLATES RECOMMENDED:-
FOR GENERATOR, GENERATOR D.S. PEDESTAL, EXCITER AND GIBS "G", 2 INCHES.
FOR THRUST BEARING PEDESTAL "T," 3 INCHES.
FOR LEVELING BLOCKS "L," 4 INCHES.

(5)— SURFACE OF PLATES MUST BE REASONABLY TRUE AND LEVEL. THOSE UNDER LEVELING BLOCKS "L" TO BE MACHINED ON UPPER SURFACE AND CAREFULLY LEVELED BEFORE GROUTING.

(6)— ALLOW 1 INCH BETWEEN CONCRETE AND PLATES AND FILL WITH CEMENT GROUTING AFTER PLATES ARE LEVELED. SEE ALSO NOTE 17.

(7)— PROVIDE HOLES IN PLATES TO ACT AS VENTS WHEN GROUTING. HOLES MAY BE 2 TO 3 INCHES DIA. AND LOCATED ABOUT AS INDICATED.

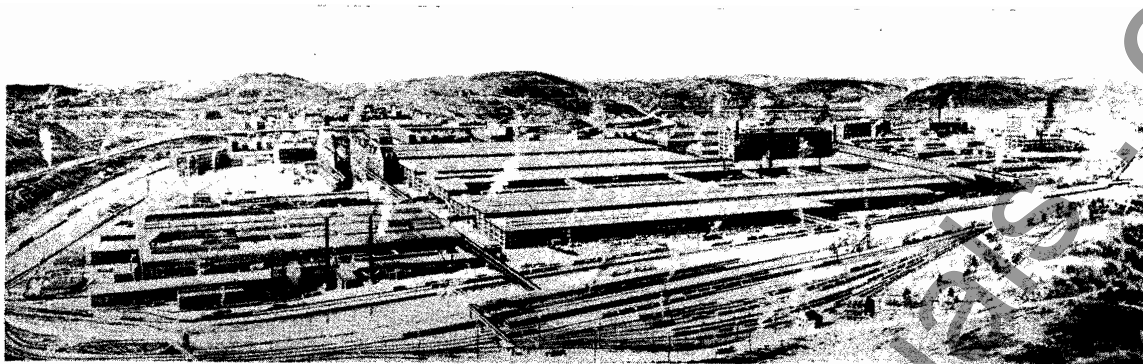
(8)— PLATES MAY BE ANCHORED TO CONCRETE AS SHOWN IN DETAIL SECTION "H-H." ANCHORS MAY BE LOCATED ABOUT AS INDICATED. SMALL VENT HOLES MAY BE PROVIDED NEAR ANCHORS.

(9)— ANCHORS MUST BE RIGIDLY ATTACHED TO PLATE. A DRIVE FIT RIVETED OVER INTO A SHALLOW COUNTERSINK OR A WRENCH-TIGHT THREAD, PREFERABLY A PIPE THREAD OF EXTRA LENGTH, ARE SOME OF THE METHODS SUGGESTED. SEE SECTION "H-H." IF RIVETED, ANY ENDS THAT COME UNDER LEVELING BLOCKS "L" MUST BE CHIPPED FLUSH.

(10)— DRILLING, TAPPING, SPOT-FACING OR REAMING OF SEATING PLATES FOR ATTACHING MACHINERY TO BE DONE AT TIME OF ERECTION. ANCHOR AND VENT HOLES MUST BE SPACED TO CLEAR THIS DRILLING.

(11)— DESIRABLE TO JOIN PLATES BY ELECTRIC WELDING.

(12)— SEATING PLATES MAY PROJECT BEYOND THE LEVELING BLOCKS ON THE TURBINE EXHAUST CHAMBER SIDE IN ORDER TO DISTRIBUTE LOADS "D" AND "E" OVER MORE AREA. THIS IS LIMITED BY STAYBOLT NUTS ADJACENT TO EXHAUST FLANGE.



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

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

Lamps
Locomotives
Motors 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

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

Starting, lighting and ignition systems, embracing: Starting motor generators, ignition units, lamps, headlights, switches, etc.

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

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

Westinghouse Electric & Manufacturing Company

East Pittsburgh, Pa.

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San Francisco, Cal., Fobes Supply Co
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