Westinghouse

Steam Turbines

3600 Rpm.

INSTRUCTION BOOK

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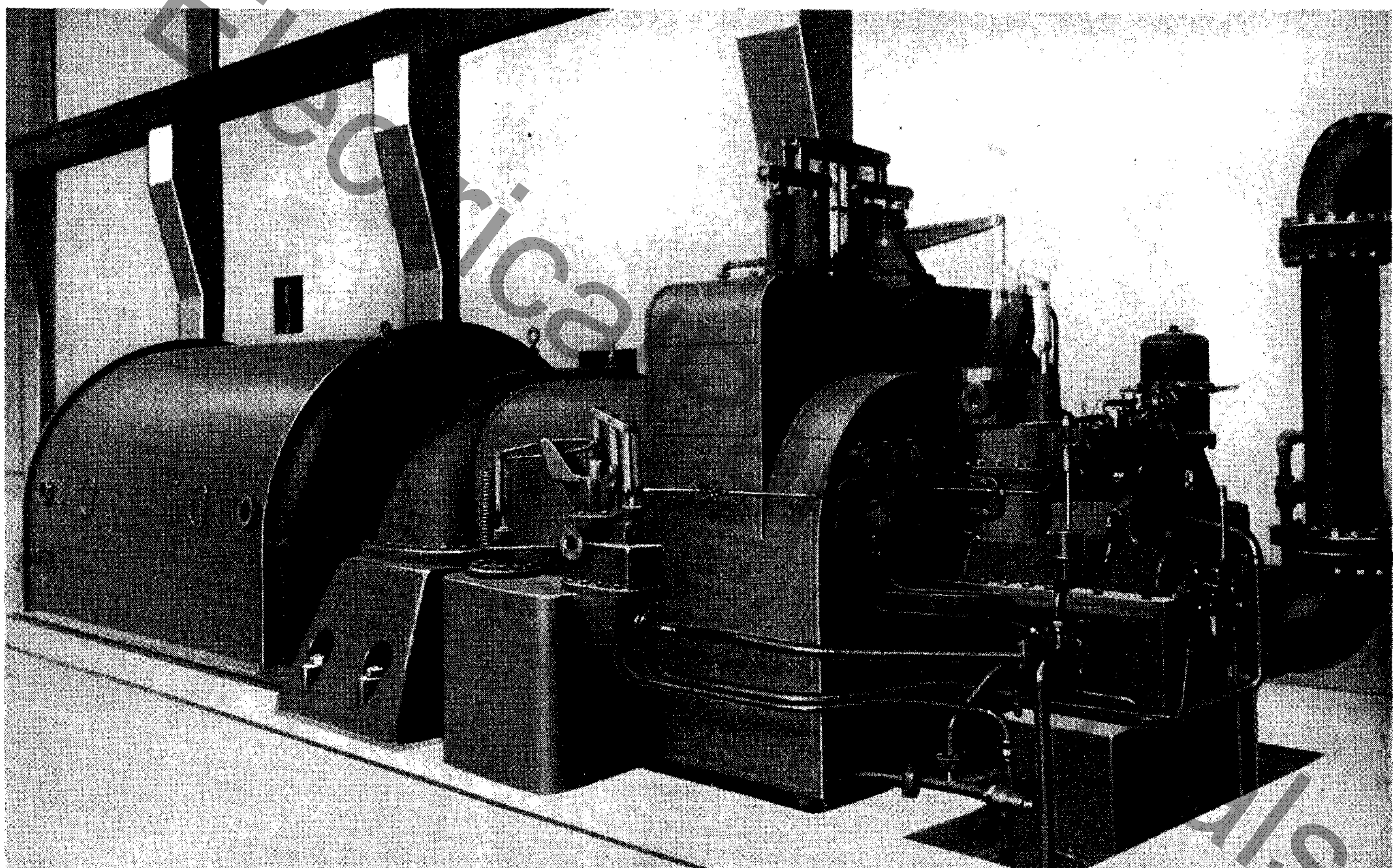

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Fig. 1—7500 Kilowatt Steam Turbine-Generator Unit

Westinghouse

Steam Turbines

Introduction

Although the turbine is simple in design and durable in its construction, and does not require constant manipulation and adjustment of valve gears, or taking up of wear in the running parts, 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. Any piece of machinery, no matter how simple and durable, if neglected or abused, will in time come to grief.

The experienced engineer understands, in a general way, the principles and operation of almost any piece of apparatus that he may come into contact with in the power house. At the same time there are cerain 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 of our engineers, places them in the position of being able to give valuable advice, orally or in this publication, on the care and operation of turbines. Further, since the inception of its turbine business in 1896, this Company has made a special effort to follow as closely as possible the field operation of the various units sold. The Company also manufacturing condensers, reduction gears and other power-house auxiliaries, is in a very good position to confer with a Purchaser not only regarding 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 pamphlet is to cover in a general manner the principle features of construction and methods of operation applying to the later type of Westinghouse turbines of medium capacity. 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, however, with numerous illustrations 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.

We will not attempt to describe here the fundamental principles of design or construction of steam turbines, as this can all be obtained very readily from text books and other publications, by the engineer. However, should more detailed information be desired, we will be pleased to furnish same on application to our nearest District Office.

The standard type of Westinghouse turbines includes a combination of impulse and reaction blading. The arrangement most commonly used consists of two rotating rows and one stationary row of impulse blades followed by a series of rows of reaction blades. However, many of these turbines are designed for special operating conditions and the blading arrangements may vary widely. For example: in some turbines the blading may be all impulse, in others it may be all reaction and in others it may be any one of the numerous combinations of impulse and reaction.

It will be noted that the portion of the cylinder carrying the reaction blades is bored conically. The purpose of this is, that the expansion of the steam may follow as near as possible the curve of its natural laws and all abrupt changes in diameter and sharp corners, which may cause eddy-currents and unnecessary losses are eliminated.

Condensing Turbine

This type of turbine is designed to operate with high pressure and high temperature inlet steam and with high vacuum at the exhaust. It is used primarily to develop electrical power in plants, where there is no demand for exhaust steam. The blading arrangement consists of two rotating rows and one stationary row of impulse blades followed by reaction blading.

In the larger sizes, openings are provided in the cylinders through which steam can be extracted at different pressures for feed water heating or process work. However, extraction at these points is not controlled automatically.

Figure 2 shows the construction of a typical turbine of this type.

Non-Condensing Turbine

This type of turbine is designed to operate with high pressure and high temperature inlet steam and with a positive back pressure at the exhaust. It is used to develop electrical power in plants where there is a demand for exhaust steam. The blading arrangement may consist of a combination of impulse and reaction blades, or it may be all impulse, depending on the steam conditions.

Many of these units are equipped with back pressure regulators which automatically control the inlet steam flow so as to maintain a constant pressure in the exhaust line. When such a regulator is used the electrical load carried, obviously, depends on the quantity of exhaust steam used. Consequently, other sources of power must be provided to carry the remainder of the electrical load.

Figure 3 shows the construction of a typical turbine of this type. Such units have been built to exhaust against back pressures as high as 300 lbs. gauge,

Mixed Pressure Turbine

This type of turbine is designed to operate with either low pressure of high pressure inlet steam, or a combination of both, and with high vacuum at the exhaust. Its most frequent application is, to develop electrical power in plants where there is an intermittent supply of low pressure steam available for which there are no other uses. The blading arrangement consists of two rotating rows and one stationary row of impulse blades followed by reaction blading. The high pressure steam is admitted to the impulse blades thru a standard steam chest while the low pressure steam is admitted directly to the reaction blades through a butterfly valve. Both high pressure and low

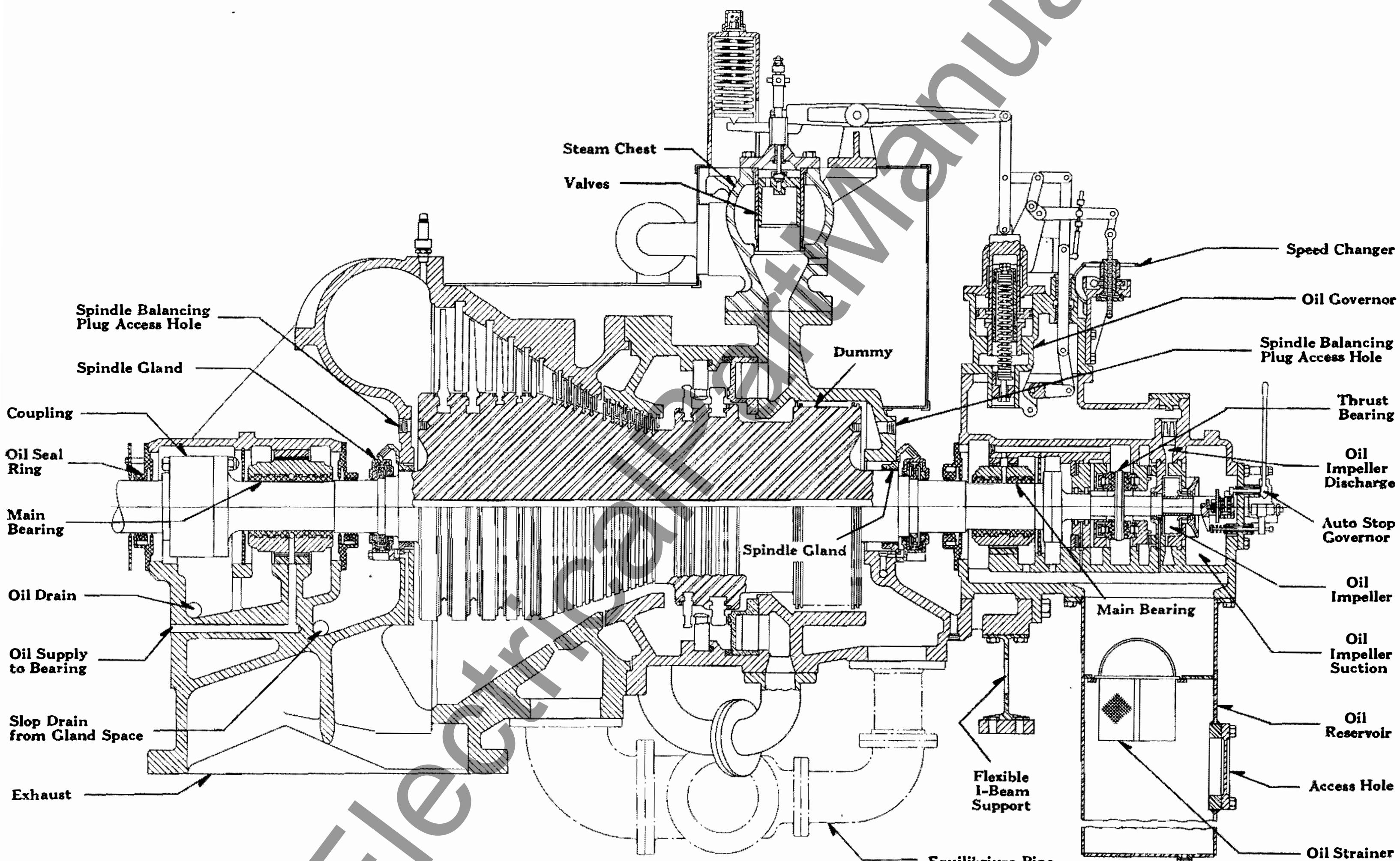

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Fig. 2—Condensing Turbine

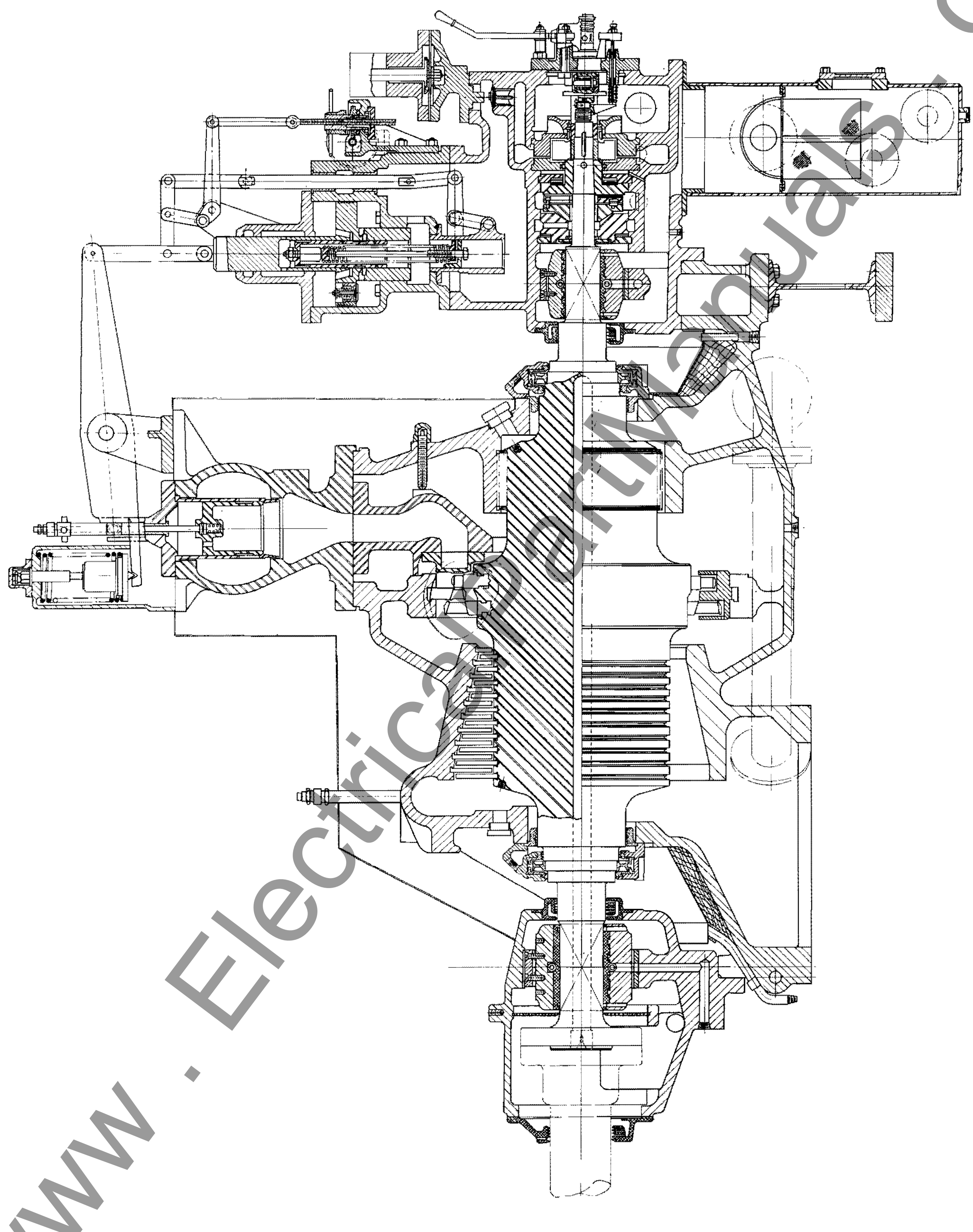

Fig. 3—Non-Condensing Turbine

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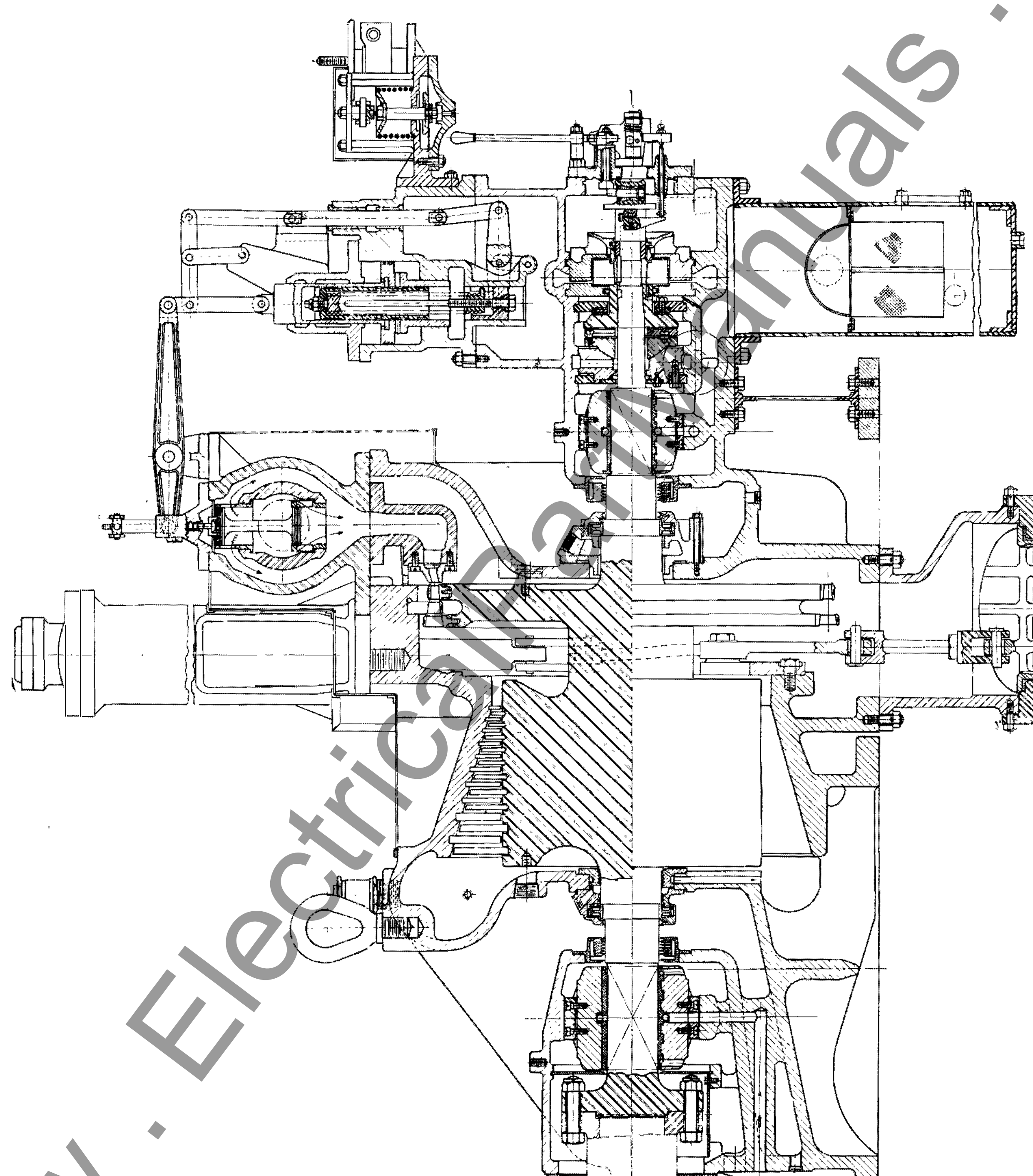

Fig. 4—Mixed Pressure Turbine

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pressure inlets are controlled by suitable governing mechanisms which are usually adjusted so as to use all of the low pressure steam available before admitting any high pressure steam.

The butterfly valve operating mechanism is actuated by a pressure regulator which can be adjusted to maintain a constant pressure in the low pressure steam header. With this arrangement, the butterfly valve admits steam to the turbine only when the pressure in the low pressure steam header exceeds the predetermined point.

Figure 4 shows the construction of a typical turbine of this type.

Low Pressure Turbine

This type of turbine is designed to operate with low pressure inlet steam and high vacuum at the exhaust. It is used to develop electrical power in plants where there is a continuous supply of low pressure steam. The blading consists of reaction blades only, the number of rows depending on the steam conditions.

Figure 5 shows the construction of a typical turbine of this type. In addition to the governor controlled butterfly valve (shown in the Figure) which admits steam to the blading; there is an automatic, quick closing throttle valve of the butterfly type which shuts off all steam if the turbine overspeeds.

Condensing, Bleeder Turbine

This type of turbine is designed to operate with high pressure and high temperature inlet steam and with high vacuum at the exhaust. It is used to develop electrical power in plants where there is a demand for process steam at one or more pressures below the inlet pressure. The blading arrangement usually consists of two rotating rows and one stationary row of impulse blades followed by reaction blades.

Steam is admitted through the main (or 1st stage) steam chest and passes through the blading until it reaches the first bleeder zone. Here, a part is bled out to supply the first bleeder system. In a **Single Bleeder Turbine,** that steam which is not used in the first bleeder system passes through the remainder of the blading to the condenser. In a **Double Bleeder Turbine,** that steam which is not used in the first bleeder system passes through the next group of blading until it reaches the second bleeder zone. Here, a part is bled out to supply the second bleeder system. The steam remaining, after the second bleeder system is supplied, passes through the next group of blading to the condenser.

The pressure in each bleeder system is maintained constant (within reasonably close limits) automatically by separate mechanisms. Between each bleeder zone and the next lower pressure blade group, there is a Grid Bleeder Valve. Each Bleeder Valve is located in the turbine cylinder and controls the flow of steam toward the exhaust, thus maintaining in the cylinder zone (on the high pressure side of the Bleeder Valve) that pressure which is desired in the corresponding bleeder system.

If the bleeder pressure is comparatively high, the Bleeder Valve mentioned above is replaced by a Solid Diaphragm and the flow of steam to the next blade group is controlled by the valves of a Second Stage Steam Chest.

The Bleeder Valve or Second Stage Steam Chest (if one is used) are controlled by oil operated mechanisms which are actuated by Pressure Regulators. These Pressure Regulators can be connected so as to compensate for changes in bleeder demands, and thus carry the rated electrical load with the normal speed regulation.

Figure 6 shows the construction of a typical Single Bleeder using a Grid Bleeder Valve. Figure 7 shows a typical Double Bleeder using a Solid Diaphragm at the first bleeder zone and a Grid Bleeder Valve at the second bleeder zone.

Non-Condensing Bleeder Turbine

This type of turbine is designed to operated with high pressure and high temperature inlet steam and with a positive back pressure at the exhaust. It is used to develop electrical power in plants where there is a demand for process steam at one or more comparatively high bleeder pressures.

The automatic bleeder features are practically identical to those of the Condensing Bleeder described above. It should be noted, however, that with the Non-Condensing type, the exhaust can be used to supply one bleeder system.

If used in cases where the full electrical output is required, the demand of process steam from the exhaust must be sufficiently great to use the required steam flow. In other cases a back pressure regulator is used to maintain a constant pressure in the exhaust line, under which conditions the electrical load carried will depend on the proces steam requirements.

Figure 8 shows the construction of a typical turbine of this type.

Mixed Bleeder Turbine

This type of turbine (commonly called "bleed-in-bleed-out" turbine) is designed to operate with high pressure and high temperature inlet steam and high vacuum at the exhaust. It is suitable for applications where there is a demand for process steam and a supply of low pressure steam either or both of which may fluctuate. The blading arrangement usually consists of two rotating rows and one stationary row of impulse blades followed by reaction blading.

The applications most frequently found fall into two general classes:

First: when the process demand and low pressure supply are at different pressures. The process demand is then supplied by bleeder features similar to those of the Condensing Bleeder described above. The low pressure supply is inducted by features similar to those of the Mixed Pressure, also described above. Both controls can be connected to compensate for variations in flow, thus maintaining the required electrical load and speed regulation.

Second: when the low pressure suppy is at a pressure equal to or slightly higher than the process demand. The low pressure supply is then connected to the process header at a point external to the turbine. In such a case, the controls are similar to those of the Condensing, Single Bleeder described above. If the process demand is light, or the low pressure supply heavy, or both, steam will be inducted to the turbine so as to maintain in the process header that pressure for which the Pressure Regulator is set. If the process demand is heavy, or the low pressure supply light, or both, steam will be bled out of the turbine to maintain the same pressure in the process header. In this case also, the Regulator is connected to the main governor to compensate for variations in process demand, thus maintaining the required electrical load and speed regulation.

All of the control mechanisms referred to above are described in the various supplements to this book.

Foundation and Erection Suggestions

When building the foundation, due consideration should be given to the requirements specified on the official outline drawings.

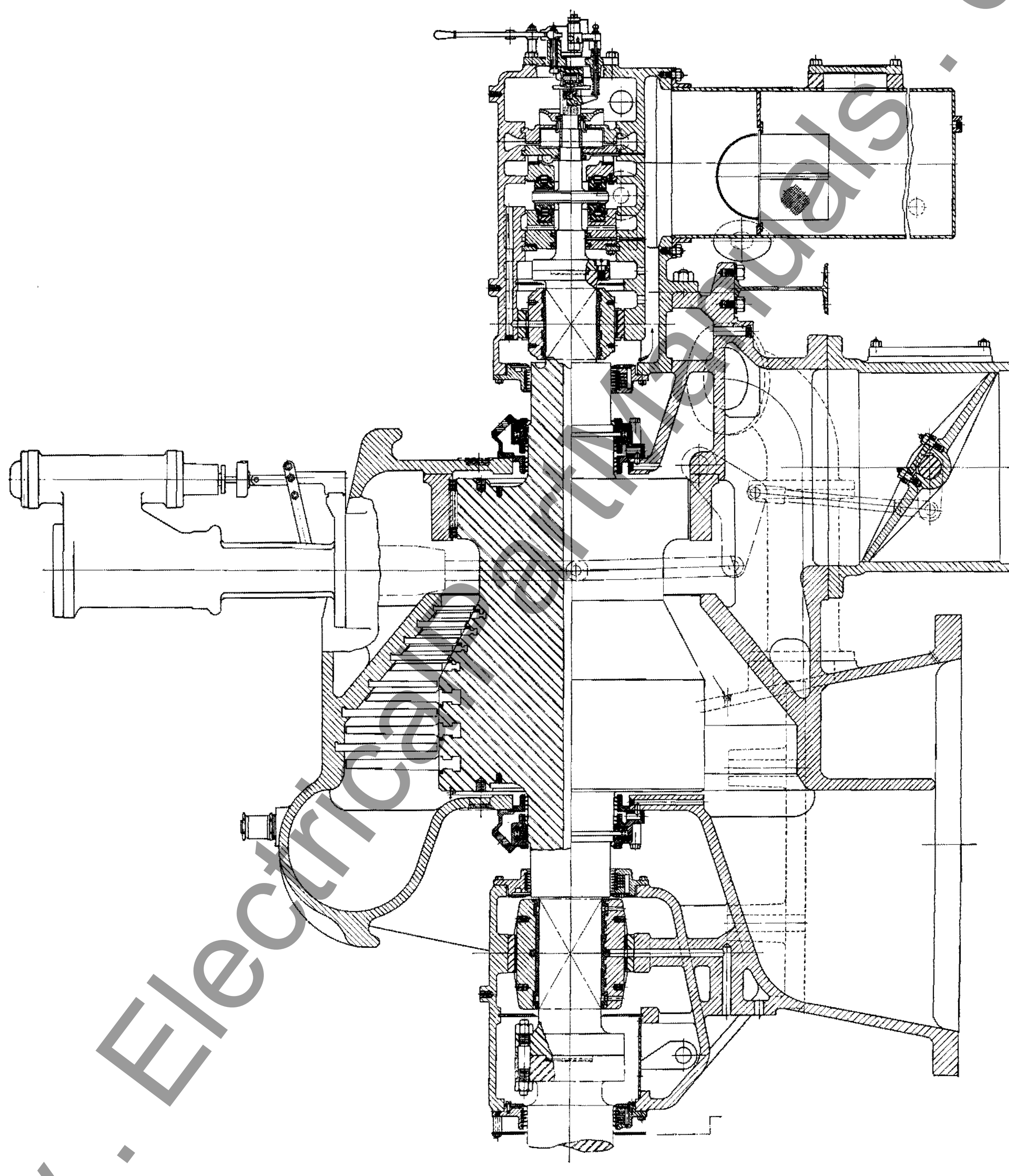

Fig. 5—Low Pressure Turbine

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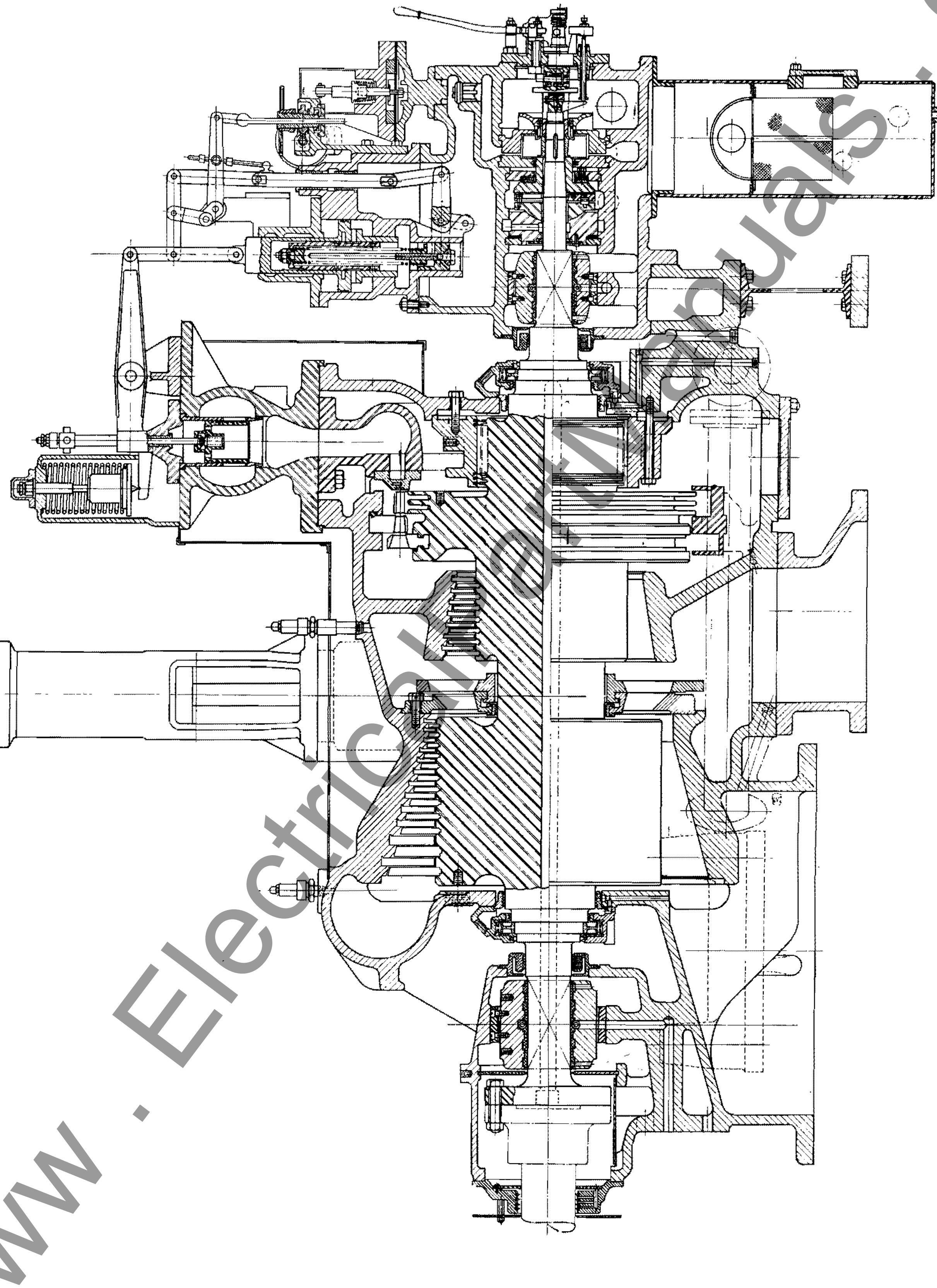

Fig. 6—Condensing, Single Bleeder Turbine

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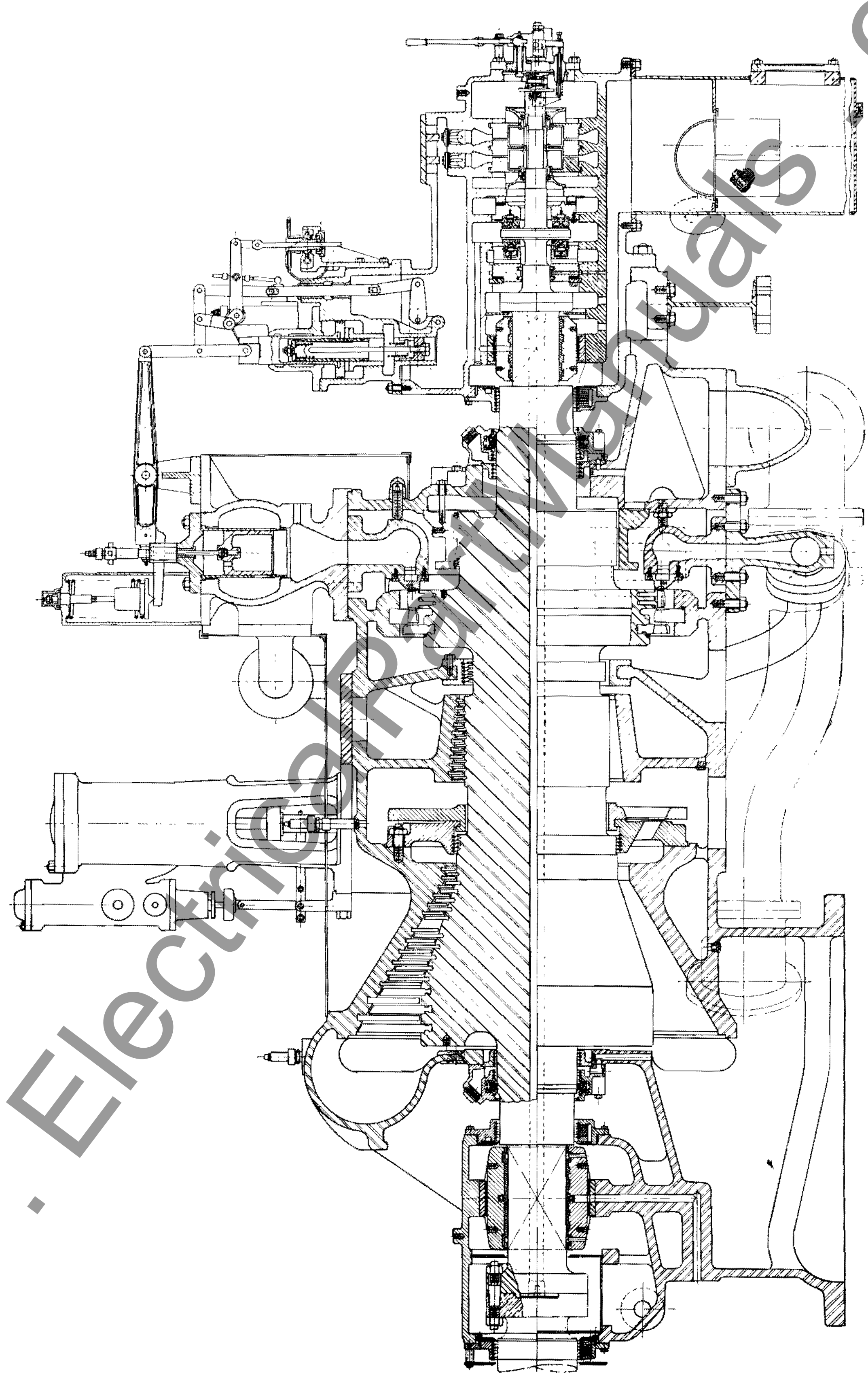

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FIG. 7—CONDENSING, DOUBLE BLEEDER TURBINE

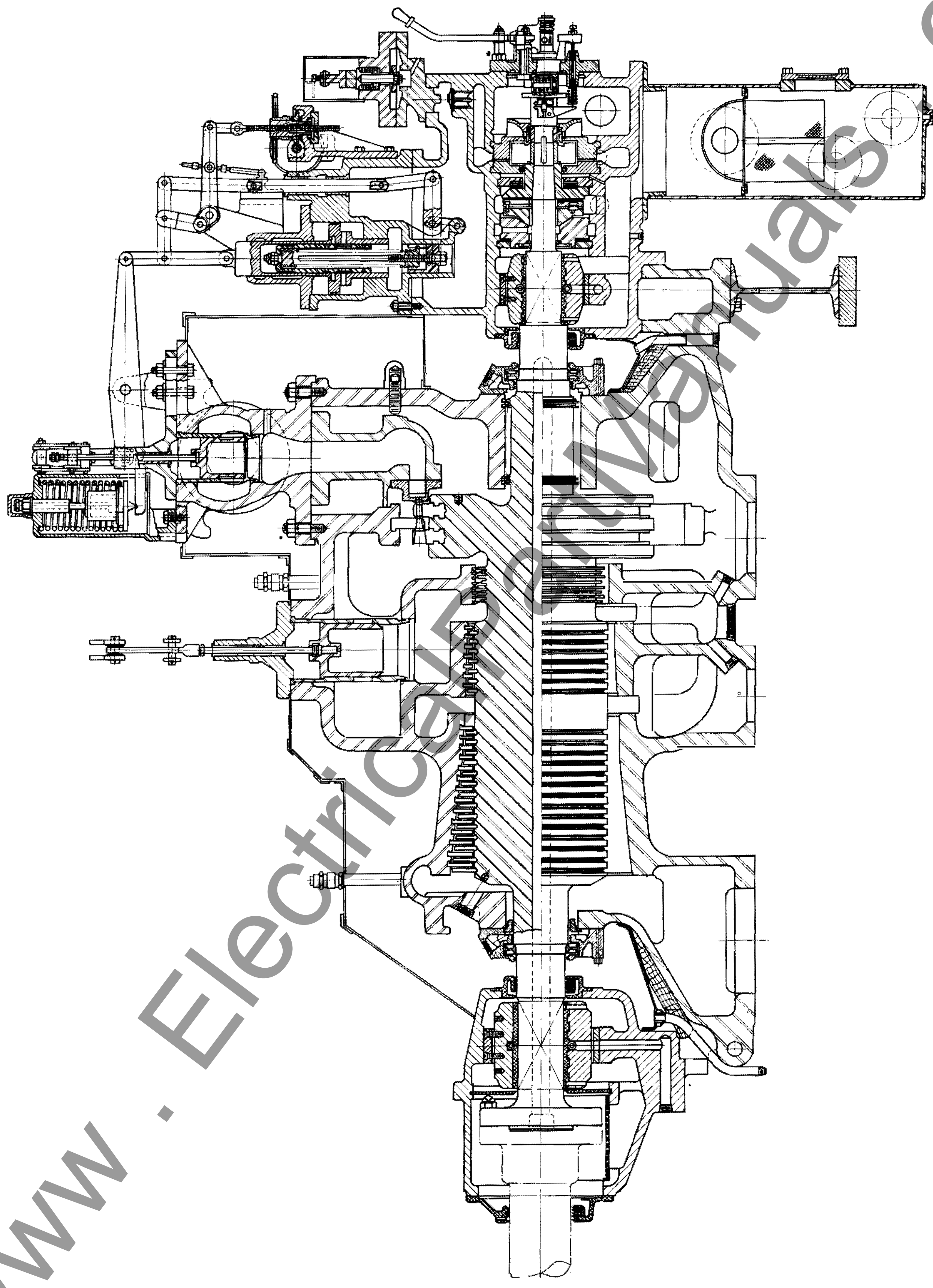

Fig. 8—Non-Condensing, Single Bleeder Turbine

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These drawings, however, are not intended to give the actual design of the foundation, as this must be made to suit the particular conditions of the individual power house. Its design is not limited like that for a reciprocating engine, and hence can be made in many ways, to suit the arrangement of condensers and auxiliary apparatus in the basement, as well as any peculiarities of building, etc. As the motion of the turbine is rotary, it is not necessary to provide heavy foundations, but at the same time it is necessary to provide a foundation such that any part of it will support its share of the weight of the turbine and generator without excessive deflection which might disturb the alignment of the machine.

In designing the foundation, provision should be made for the necessary air ducts for ventilating the generator. Also, an allowance should always be made for at least one inch of grout on top of the foundation.

While concrete is to be preferred wherever practicable due to its mass, it is often convenient to install the turbine on structural steel because of the greater amount of space left in the basement for auxiliary apparatus. To secure ample rigidity, the maximum total deflection of the foundation structure should not exceed .020". To avoid undersirable resonance, the natural frequency of any part of the unit, foundation, piping, or building structure, should not be close to the speed of rotation or to the frequency of the generated current. In using structural steel, it is very convenient to run in one-half to one inch of lead between the turbine frame and the steel work, so that the load at each support will be evenly distributed over the entire surface of the support, as there is liable to be some slight mis-alignment in the steel work. The greatest care must be exercised to insure the lead surface being complete. With a structural steel or concrete foundation the final leveling should not be done until the entire weight of the turbine, generator and condenser is in place, after which the grout may be poured.

The use of structural steel encased in concrete has been found to be very satisfacory for foundation work. This type combines the strength and space advantages of steel with the desirable mass effect of concrete.

Generator Air Ducts

The outline drawing indicates the air duct connections, and gives minimum area of opening, but does not lay down any hard and fast lines of construction. The air supply should be drawn from outside of the building in order to obtain the coolest air possible, because the cooler the air furnished, the greater will be the limits of the load which may be carried by the generator. The inlet to the air intake pipe should be protected from the rain and, as far as possible, from dust, and be covered with a wire screen of ½" mesh or finer.

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

In some instances, where the air in the power house is cleaner than outside, (in a cement plant for example) air may be taken from the basement, and discharged out-of-doors. It is, however, preferrable 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 to eliminate air ducts by devising partition walls in the basement, so that the generator may draw air 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 excercised so that it will be impossible for air leaving the generator to find its way to the intake.

Air washing plants are available and have much to recommend them. Generators may be operated, for much longer periods without cleaning. Also, by their humidifying effect the washers materially reduce the temperature of the air entering the generator and hence increase the permissible output of the generator.

Crane

It is most desirable that a suitable crane be furnished for handling the turbine should it be necessary to make repairs, and in order that the periodical inspections will not be neglected because of the difficulty of handling the parts. On the foundation plan we give the weights which the crane should be capable of handling, as well as the head room necessary for removing the various parts.

It perhaps is not out of place to remark that a turbine rotor cannot be handled with a pinch bar and a screw jack.

Steam Lines

In the arrangement of both the steam and exhaust lines, care should be taken to properly support the pipe so that no strains will be imposed on the turbine, due to the weight or expansion of the piping.

When the steam comes from below the floor, and there is a loop in the steam line between the header and turbine, a steam separator and trap should be furnished. If this loop is not properly drained, water may accumulate at times of light load, and be carried over into the turbine in a solid slug when the load is suddenly increased. While there is no danger of the serious results that are almost certain to occur in a reciprocating engine, a slug of water is by no means desirable, as it will cause the turbine speed to decrease considerably, and impose undue strains on the machine.

In the case of a low or mixed pressure turbine, a receiver-separator of ample capacity should be used so that not only the water, but the oil and foreign matter as well, which may be carried over in the exhaust from the reciprocating engines, will not pass into the turbine.

Every precaution should be taken to provide the turbine with dry steam, as any moisture is not only in itself a source of loss, but also further impairs the economy because of the additional fluid friction caused thereby.

Exhaust Piping

When the condenser is suspended directly below the turbine an expansion joint in the line between the turbine and condenser is not necessary, but the weight of condenser with circulating passages full of water must be considered in designing the foundation. If the condenser is located otherwise, an expansion joint of approved design is required, and is furnished by the purchaser. In this case cognizance must be taken of the unbalanced loads due to external atmospheric pressure.

It is desirable that exhaust steam should flow downward to the condenser except, of course, in cases where the barometric condensers will be used, when there should be an entrainer at the base of the riser.

When the turbine is provided with water glands only, it should always be started up non-condensing and not subjected to vacuum until it has attained sufficient speed to allow the water glands to seal effectively. The reason for this is that if a vacuum were established in the condenser, or even the air pump operated with the turbine at rest, or before the glands were sealed, a certain amount of air would be drawn into the casing at each end of the spindle, which would result in some distortion of the spindle, causing it to run out of true until such time as it had become evenly heated throughout its length. When there is no gate valve between the turbine and condenser, some means of forced injection must be provided for jet condensers. When surface condensers are used the circulating pump should be started up before starting the turbine so that the turbine may be started up non-condensing and the vacuum established afterward.

This general rule, of course, does not apply to low or mixed pressure turbines.

It is not necessary that the automatic relief valve and atmospheric exhaust pipe be as large as the main exhaust to the condenser, but, this connection should not be less than given in the note on the foundation plan where two sizes are indicated, one for protection and the other for use when it is desired to carry maximum noncondensing load. This valve may be furnished with a water seal and a rubber seat which insures tightness. As there is no oil in the exhaust, the rubber will last indefinitely. It is also necessary that the valve be automatic, because if it be without this feature and the throttle valve should be opened while the valve to the condenser is closed, the turbine would be subjected to greater pressure than it is calculated to withstand. There is a spring loaded valve on the turbine itself, but this is quite small and simply serves as a sentinel, and is not sufficiently large to protect the turbine.

Drips and Drains

The turbine cylinder is provided with suitable drains to carry off condensation while the turbine is shut down and during the starting period. These drains should be connected so as to discharge to atmosphere at a point where the escape of a small amount of steam is not objectionable.

The pipe which is marked on the outline drawing—"Drain from Glands"—should be allowed to drain freely, and should not be connected with other drips. There is also shown on the outline drawing, a drain from the throttle valve, which needs no comments.

Water Connections to Glands and Oil Cooler

Water must be provided for the oil cooler, and also for sealing the glands. The two systems may be used conjunctively or separately, and may be connected in several ways, always keeping in mind that there must be a constant pressure at the glands.

In any case, a small amount of the sealing water will pass by the glands into the turbine and if the condensed steam is returned to the boilers, the water used for the glands must be of such character that it will not be injurious to the boilers. Whether the water so used is returned to the boilers or not, it should never contain an excessive amount of lime or solid matter, as a certain amount of evaporation is continually going on in the glands which will deposit scale and necessitate frequent disassembling for cleaning. If this scale is allowed to form it may also be deposited on the turbine rotor, throwing the machine out of balance. There is also danger of it filling up the space in which the gland runner works to such an extent as to cause mechanical contact which may produce serious vibrations.

The following is intended to indicate various methods of connecting the glands and the oil cooler. The choice of method, however, will depend upon the conditions in each individual power plant:

First—When there is a cheap supply of good water, the same water that is used for cooling the oil may be utilized for the glands. Such an arrangement is shown on diagram #1. The discharge from the oil cooler is connected to the gland water inlet line (shown on the outline drawing). This same cooler discharge is connected to an overflow through a relief valve which is adjusted to maintain the desired pressure at the glands. It should be noted that the connection "M" (in dot and dash line on the diagram) for circulating water through the coupling end gland is provided only on the non-condensing machines.

Second—When there is a limited supply of good water for the glands and a large and cheap supply of poorer water which is suitable for use in the oil cooler, the cooler and the glands should be connected separately, each to its own supply. Such an arrangement is shown on diagram #2. The oil cooler discharge is connected directly to the sewer or similar waste line. The good water supply is connected to the gland water inlet line (shown on the outline drawing) and also to an overflow through a relief valve. This relief valve is adjusted to maintain the desired pressure at the glands. As previously noted the connection "M" for circulating water through the coupling end gland is used only on non-condensing machines.

In many cases it is desirable to take the water for the glands from the condensate pump discharge line at a point between the pump and the feed water heater. In such cases, the gland water overflow should be returned to a feed water tank.

With any of the above gland water arrangements, the water pressure can be maintained, by an overhead tank in the overflow line instead of a relief valve, if so desired. The tank, of course, must be located at the proper elevation to give the required pressure.

On the thrust end gland of condensing turbines and on both glands of non-condensing turbines, the sealing water must be allowed to circulate through the glands in order to keep its temperature below 212 degrees Fahrenheit. If this is not done, the water in the glands will become heated from the main castings of the machine and will evaporate. This evaporation will make the glands appear as though they are leaking badly though in reality it is nothing more than the water in the glands boiling, which is nevertheless equally objectionable. In this case the piping is arranged according to diagram #1 and #2, using both discharge lines "M" and "N". These valves should be opened just enough to allow sufficient circulation to keep the temperature of the gland water below the boiling point. If the gland supply is pure, this water discharged should be led to a feed tank, or some place where its heat can be conserved.

Operating and Inspecting Suggestions

Before connecting the steam line to the turbine inlet, the whole line clear back to the boilers should be blown out with live steam to remove all scale from the pipe, as well as any other foreign matter that might have been left in the piping during erection.

All parts of the oiling system should be thoroughly cleaned as the turbine

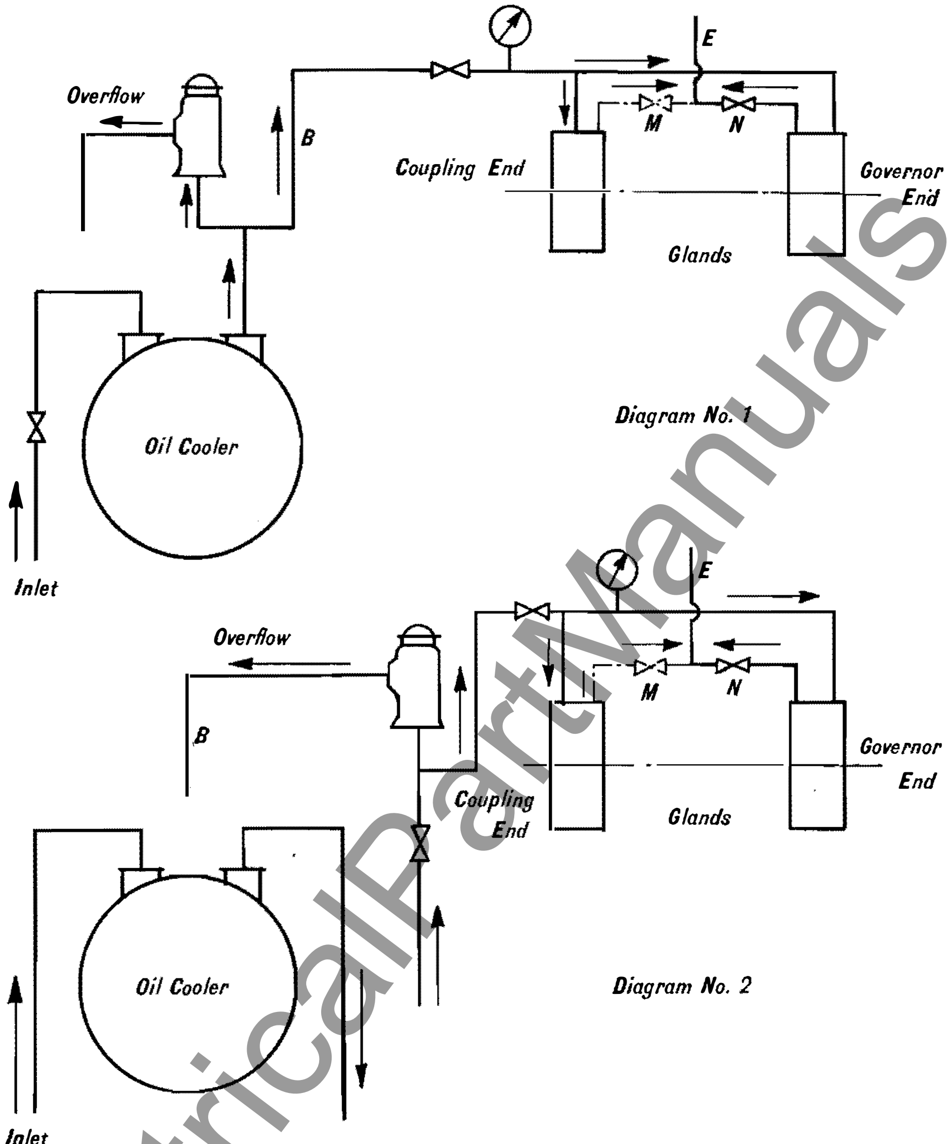


Fig. 9—Methods of Connecting the Glands and the Oil Cooler

is being erected. For a new installation, it is advisable to put a small quantity of oil in the reservoir and circulate it (by means of the auxiliary oil pump) to wash out the system. This oil should then be removed and new oil put in before operating. The oil removed can be purified and used at a later time.

Enough oil should be provided so that when the turbine is running at full speed, the oil level in the reservoir as shown in the gauge glass is within the limits given on the indicator plate. Although there is a strainer in the oiling system, it is well, as a matter of precaution, to strain the oil either before putting it into the turbine or to pour it into the reservoir through a fine mesh screen or cloth.

When a turbine is first put in service, the oil strainer should be cleaned at frequent intervals (say every 30 minutes) until it is certain that no more dirt is coming through. This can be done while the turbine is in operation.

The entire oiling system must be kept free of water, dirt, grit and other impurities at all times. If there is any doubt as to the cleanliness of the system, all pipe lines should be disconnected and the pipes and cored passages blown out with kerosene and compressed air.

All "Warming up" of the turbine must be done with the **spindle rotating.** When starting, open the throttle valve a sufficient amount to start the spindle rolling immediately, then close it and open it again just enough to keep the spindle rolling. Keep it rolling slowly until the machine is heated sufficiently to bring up to speed. The length of time required, of course, depends on the size of the turbine. The above procedure is important because as long as the turbine is standing still it is impossible to warm it uniformly all over. With small quantities of steam passing through, the hottest steam will remain at the top, falling to the lower portion as it is cooled, with the natural result that neither the spindle nor the cylinder will be straight, the former running out of true as soon as it is revolved. It is, therefore, necessary to get it revolving as quickly as possible, and really do the warming up after the machine is in motion.

Unless the turbine is equipped with steam seal glands, it should be started up non-condensing, and not subjected to vacuum until it has attained sufficient speed to allow the water glands to seal effectively. The reason for this precaution is that if a vacuum were established in the condenser or even the air pump operated with the turbine at rest, or before the glands were sealed, a certain amount of air would be drawn into the casing at both ends of the spindle, which would result in some distortion of the spindle, causing it to run out of true until such time as it has become evenly heated throughout its length.

After the turbine is up to speed and under control of the governor, it is well to make sure that the speed is correct. It is also well at this time, while there is no load on the turbine, to be sure that the governor controls the machine with a high vacuum and the throttle wide open. It might be that the main poppet valve is leaking or that it has sustained some injury not evident when the last inspection was made. The action of the valves, the control of the governor and the automatic stops should be noted each time the turbine is started up or shut down. Should there be any defects, steps should be taken to correct them and make necessary adjustments at the first opportunity, as small defects rapidly become serious.

Where conditions will permit, it is better to build up the load gradually so that there may be no sudden heavy demand upon the boilers with the possibility of water being drawn over into the turbine.

It should hardly be necessary to state that while the turbine is running it should be given the same careful and systematic attention demanded by any high class engine. That is, at regular intervals the engineer should inspect and note the temperature of bearings and oiling systems, the water pressure on the glands, pressure of steam and action of governor and valves. Should any irregularity be detected, such as loss of gland water or insufficient oil supply, he should immediately locate the cause and correct it.

The amount of water circulated through the oil cooler should be regulated so that the temperature of the oil leaving the cooler will **never be less than 100°F.** At temperatures below 100°, the viscosity of the oil increases rapidly, and may affect the proper functioning of the oil system. The temperature of the oil leaving the bearings will vary with different units and conditions. However, an oil return temperature of 120° to 160°F. is considered good practice.

No alarm should be felt if the turbine bearings are very warm, as there is no danger as long as the hand can be borne on them even momentarily. However, should a bearing show signs of distress, as evidenced by smoke or burning oil, the unit should be shut down immediately without attempting to nurse it back into condition. These bearings are supplied with a continuous circulation of oil and should give no trouble. If a bearing starts to burn, there is some definite cause for it, such as a stoppage of oil supply, foreign matter in the oil, or a tight bearing cap, and the cause should be removed without delay. In case superheated steam is used, the thermometer should be read at intervals in order to make sure that the turbine is not being subjected to excessive variations of temperature.

While accidents to blading are of infrequent occurrence and not to be expected under normal operating conditions, should any sound of rubbing or grinding be defected 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 during an 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 a proper repair, the turbine may be put back into service if the damaged blades are removed. If any considerable portion of any blade row is damaged, the entire row should be removed. The turbine will operate at some sacrifice of economy until such time as it is convenient to make the proper repair.

Frequent and sudden changes from condensing to non-condensing operation with the turbine under load should be avoided. Should it be necessary to cut out the condenser, the vacuum should be reduced as slowly as the existing conditions will allow, so that no stresses will be set up in the turbine casing, by reason of sudden changes of temperature in the exhaust end.

In shutting down the turbine, the vacuum should be broken as soon as the turbine throttle is closed so that as the turbine comes to rest, cold air will not be drawn in through the glands on the heated spindle. Also do not leave the gland water running, as it may leak over into the bearing and pedestal reservoirs.

As is customary with engines of any type, the turbine should be completely dismantled and inspected periodically, as once a year. The word **dismantled** is used in its fullest sense, and means that the rotor, valves, bearings, oil cooling tubes, etc., should all be removed. If the valves leak excessively, new valves and bushings should be installed. These valves cannot be ground to their seats. The cooler tubes 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 an excessive oil deposit is found, the brand of oil should be investigated, because in time, the piping may become clogged, imperiling the safety of the bearings by restricting the oil supply.

The governor should be inspected, and thoroughly cleaned, as otherwise, dirt may collect and interfere with the free operation of the control mechanism.

The glands should be examined for any deposit of lime from hard water. Also 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 a renewal of this condition.

Oil

A suitable lubricating oil is of utmost importance and its selection should be given very careful consideration. In general, it has been found that the oil recommended by the lubricating specialists of any of the reliable oil Companies is satisfactory.

The outstanding requirements of a turbine oil are as follows:

It should be a pure mineral oil, free from animal or vegetable adulterants.

It should be free of acid and acid forming constituents.

It should be of the highest degree of refinement, to insure as nearly absolute purity as possible.

It should have a high resistance to emulsification.

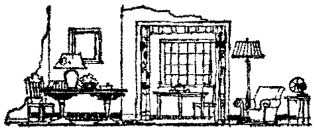
It should have a high resistance to oxidation.

It should have a high resistance to sludge formation.

For use in turbines directly connected to generators, the oil should have a "Saybolt" viscosity of 140 to 200 seconds at 100°F. temperature.

When reduction gears are used with the turbine and the same oil is used for both, it should have a "Saybolt" viscosity of 250 to 350 seconds at 100°F. temperature.

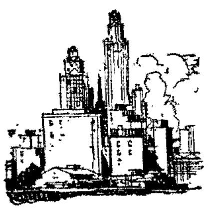
Westinghouse Products



Homes—Farms

Air Heaters
Auto Engine Heaters
Automatic Irons
Automatic Percolators
Automatic Ranges
Cozy Glow Heaters
Curling Irons
Fans
Hot Plates
Light and Power Plants
Lighting Equipment
Mazda Lamps
Motors for
- Buffers and Grinders
- Ice Cream Freezers
- Ironers and Washers
- Refrigerators
- Sewing Machines
- Vacuum Cleaners

Newel Posts
Panelboards
Rectigon Chargers for Automobile and Radio Batteries
Rectox Trickle Charger
Refrigerators, Electrical
Safety Switches
Sollaire Luminaires
Sol-Lux Luminaires
Solar Glow Heaters
Table Stoves
Tumbler Water Heaters
Turnover Toasters
Vacuum Cleaners
Wall-Type Heaters
Waffle Irons
Warming Pads
Water Heaters



Buildings

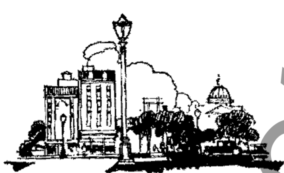
Arc Welding Equip.
Circuit-Breakers
Elevators and Control
Glue and Solder Pots
Instruments and Relays
Kitchen Equipment
- Bake Ovens,
- Hot Plates, Ranges

Lighting Equipment
- Brackets, Newels and Lanterns
- Reflectors & Lamps
- Sol-Lux Luminaires

Lightning Arresters
Micarta Trays
Meters
Meter Service Switches

Motor Generators
Motors and Control for:
- Coal and Ash-Handling Equipment
- Compressors
- Elevators
- Fans and Blowers
- Laundry Equipment
- Refrigerating Equip.
- Vacuum Cleaners
- Water & Sump Pumps

Panelboards
Synchronous Converters
Safety Switches
Solar Glow Heaters
Stokers
Switchgear
Transformers



City Improvements

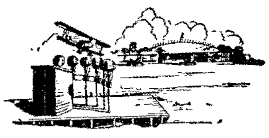
Airport Floodlights
Automatic Substations
Constant Current Regulators
Control Apparatus
Elec. Railway Equip.
Lighting Units
Mazda Lamps
Ornamental Standards
Parkway Cables
Street Brackets
Streethoods

Offices and Stores

Air Heaters
Bread-baking Oven
Elevators and Control
Fans, Desk and Exhaust
Fuses
Lighting Equipment
Mazda Lamps
Meters
Micarta Desk Tops
Motors for
- Adding Machines
- Addressing Machines

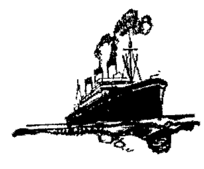
Motors for
- Coffee and Meat Grinders, etc.
- Dictaphones
- Envelope Sealers
- Fans and Blowers
- Pumps
- Refrigerating Machines

Panelboards
Safety Switches
Switches
Tumbler Water Heaters



Aviation

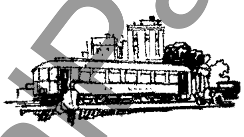
Approach, Boundary, Hangar, and Obstruction Lights
Arc Welding Equip.
Floodlight Projectors
Motor Generators
Reflectors
Transformers
Mazda Lamps
Micarta
- Cabin-lining Plate
- Fairleads
- Hinge Bearings
- Propellers
- Pulleys
- Tailwheels



Ships

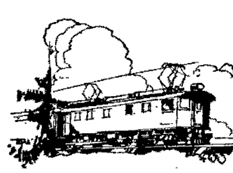
Circuit-Breakers
Condensing Equipment
Deck Winch Motors
Elec. Heating Appar.
Eng. Room Auxiliaries
Fans and Blowers
Fuses
Generating Equipment
Instruments
Light and Power Plants
Lighting Equipment
Micarta Trays
Motors and Controllers
Ovens, Ranges and Galley Equipment
Panelboards
Propulsion Equipment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

Safety Switches
Switchgear



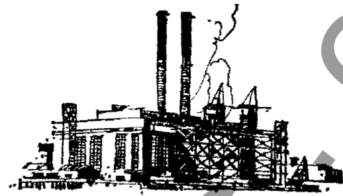
Electric Railways

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



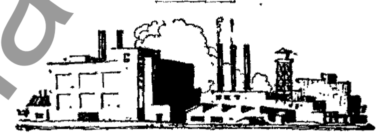
Railroads

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



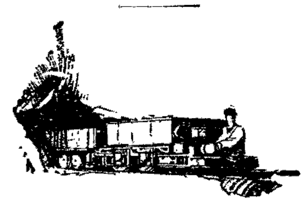
Electric Service Companies

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



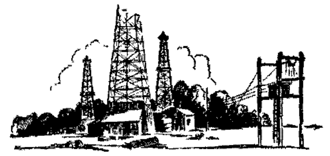
Mills and Factories

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



Mines

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



Oil Fields

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