High Pressure, Non-Condensing Turbine

INTRODUCTION

The steam turbine, like any other high grade machine, requires, for sustained efficiency and continuity of operation, a reasonable minimum of care and attention on the part of the operator. In order that the unit may receive such care and attention, it is necessary that the operators become thoroughly familiar, not only with the mechanical structure of the several parts of the turbine, but also with their purpose and, in a general way, with the reasons why they are so designed. The following brief instructions for the care and operation of the turbine have been prepared as an aid to the attainment of this desired information and it is hoped that they may be found to be broad enough in scope for that purpose.

GENERAL DESCRIPTION

This turbine is a single cylinder, combination impulse-reaction machine of the high pressure, non-condensing type. The normal speed is 3600 RPM and it is designed to operate with steam conditions of 1200 lb/in^2 ga., 900° F. total temperature and 260 lb/in^2 ga. maximum exhaust pressure. When operating under these conditions, the turbine will carry 35,000 Kw. at 80% power factor or a maximum load of 40,000 Kw. at 91.5% power factor.

In normal operation, this machine is superposed on condensing units. That is, the high pressure turbine exhausts into a nominal pressure header (which may or may not be supplied also by nominal pressure boilers) and supplies steam to the inlet of one or more condensing machines. When operating in conjunction with the nominal pressure boilers, the high pressure turbine operates with constant exhaust pressure. If the nominal pressure boilers are not used, the high pressure turbine may operate with constant exhaust pressure, or, by taking the pressure regulator out of service, it may be operated with the condensing turbines as a cross compound unit with variable exhaust pressure on the high pressure element.

The construction of the entire turbine is shown in Figure 1. (It should be noted that this illustration shows a side view below the horizontal centerline and a longitudinal section above the centerline.)

Cylinder

The cylinder is made of cast carbon molybdenum steel and is split in the horizontal centerplane to form a base and cover. Blade ring elements are cast integrally and passages are provided for by-passing the Curtis stage at maximum load. An important feature of this design is an annular steam belt extending around the entire cylinder at the high pressure end which equalizes the temperatures of the base and cover and thus greatly decreases the possibility of cylinder distortion. This chamber serves as the steam passage between the No. 1 inlet valve, located in the cover, and its nozzles, located in the base, and therefore is filled completely with steam as soon as the first valve is opened.

The method of supporting the turbine is arranged to allow the various parts to expand and contract freely without causing distortion. The cylinder is supported by four arms or lugs which are cast integrally at the top of the base, thus locating the point of support as closely as possible to the horizontal centerline. These arms rest on separate pedestals on which they are free to slide, being secured only loosely by bolts. At each end, the cylinder is connected to the pedestal by a single vertical pin placed on the longitudinal centerline, thus maintaining the correct axial and transverse position of the cylinder with relation to the pedestals. The

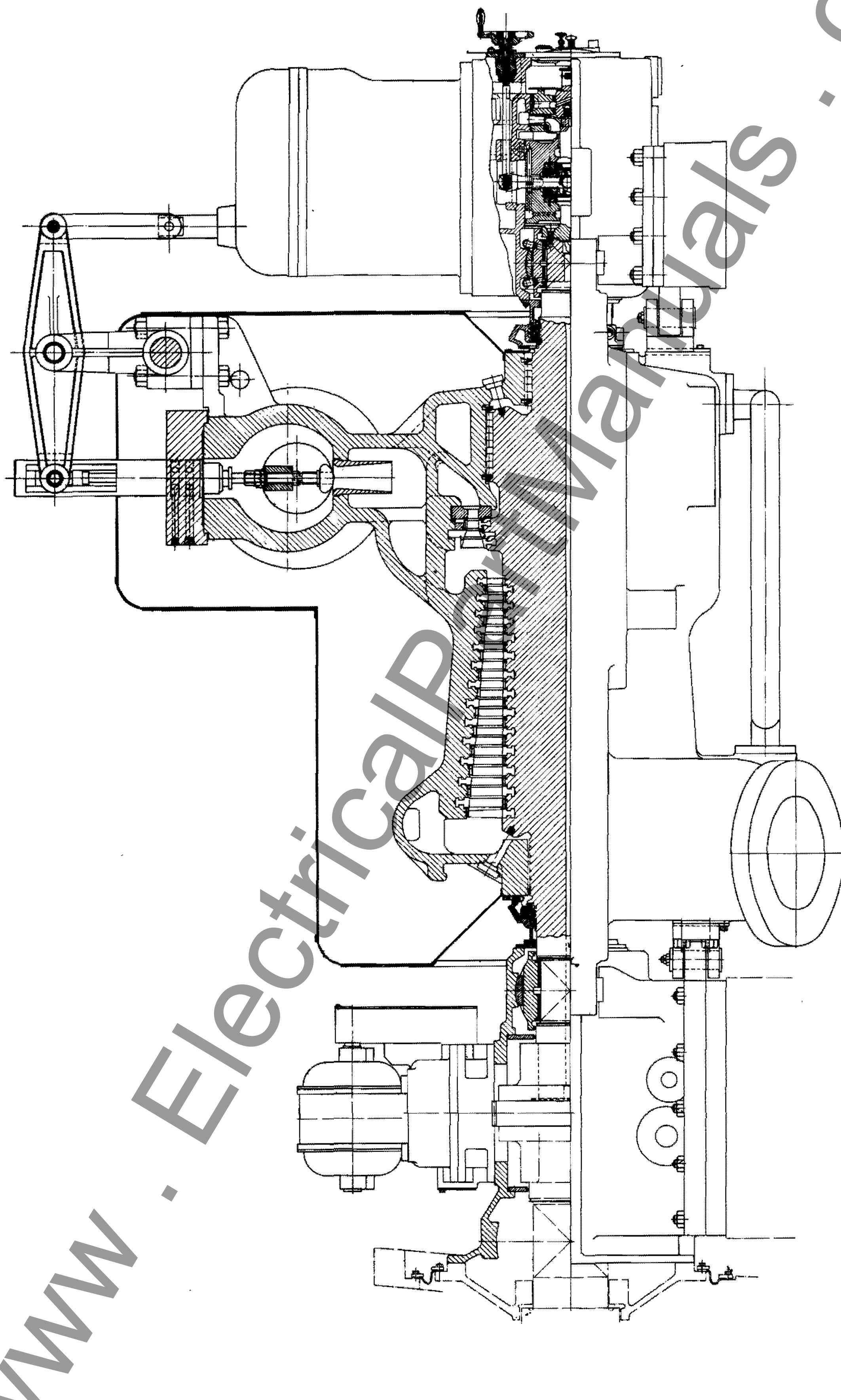

Fig. 1 - 35000 Kw., 3600 RPM Superposed Steam Turbine

exhaust end pedestal is anchored to the foundation seating plates by keys and gibs and serves to anchor the entire unit. The inlet end pedestal is free to slide axially on its base, but is held against transverse movement by an axial key, placed on the longitudinal centerline, between it and the base. Any tendency to tilt is limited by side gibs which are fitted with ample clearance to allow free movement axially.

The base and cover of the cylinder are bolted together by large studs. In order to obtain the proper stress in each of these studs, they must be tightened sufficiently to stretch them a definite amount. The correct method to obtain this stretch is described in Supplement No. 102, Rev. 2.

The central portion of the cover flange face is recessed in order to obtain higher unit pressures on the joint. To relieve thermal stresses in the thick flanges, transverse slits are cut to a depth determined by their location.

Rotor

The turbine rotor is machined from a solid forging of chrome nickel molybdenum steel with a central inspection hole drilled through its entire length. A separate stub shaft is bolted to the inlet end to form the thrust bearing collar and to carry the oil impellers and overspeed trip. The coupling end is connected to the generator field by a rigid coupling and the main rotating element thus formed is carried in four bearings.

Blading

The blading consists of a single Curtis stage followed by 13 pairs of rows of reaction type. Throughout the blade path, the massive rotating and stationary parts are separated by relatively large clearances, and the small clearances are maintained by thin seal strips. These strips are made of a special alloy material with excellent wearing qualities and if contact should occur, the strips wear away without resulting in any damage to major parts.

The various blade types are described in the following I.B. leaflets:-

Curtis stage - - - - - - - - - Supplement 273.

Reaction

1st 9 pairs of rows - Supplement 302.
Last 4 pairs of rows - Supplement 303.

Balance Piston

The inlet end of the rotor is machined to form a single stage dummy which is designed to over-balance the thrust on the blading and thus produce a thrust toward the inlet end of the machine under all operating conditions. With this arrangement, any floating of the rotor, such as is possible in case of loss of load, can occur toward the exhaust end only, thus temporarily increasing the axial running clearance by the amount of clearance in the thrust bearing.

The steam leakage past the balance piston seals is led through an external pipe connecting to the turbine exhaust.

The balance piston labyrinth seals are of the axial clearance type and are described in Supplement 232, Rev. 1. During starting and stopping periods, the rotor must be moved (by means of the thrust bearing adjusting mechanism) to the start and stop position which increases the clearance over these seals.

Control

Steam is admitted to the turbine through an inverted, hydraulically operated, combination hand throttle and automatic trip valve. It is located below the floor, directly in front of the turbine, and is connected to the steam chest by two pipes, one on each side.

A cylindrical type strainer is built in the main valve body and is accessible from the operating floor level.

This valve is described in I.B. 6110.

The steam flow to the blading is controlled by seven, governor controlled, plug type valves, located in the steam chest which is cast integrally with the cylinder cover. Valves No. 1 and No. 2 admit steam through an annular chamber surrounding the cylinder dummy ring to nozzle groups located in the cylinder base. Valves No. 3 to No. 6 inclusive admit steam to nozzle groups located in the cylinder cover. Valve No. 7, which is for overload purposes, bypasses the Curtis stage and admits steam directly to the reaction blade group.

The governor, mounted on the thrust housing cover, is of the pressure transformer type described in I.B. 6129. Oil is used as the control and operating medium. The complete system is described in I.B. 6132.

Operation and Maintenance

A recommended procedure for operating the turbine is given in I.B. 6135. While these instructions are quite specific, it is impossible to cover all details. Hence, they do not in any way relieve the operator of using sound judgment and exercising due caution.

Likewise, it is impossible to give any detailed procedure for maintenance work. It is believed that the illustrations and descriptions of the detail parts as given in the Instruction Books should enable the Maintenance Engineer to care for the apparatus properly.

There is one point which must be borne in mind and bears repetition in this book. Before raising the cylinder cover, the rotor must be moved toward the coupling end .040 inch from the "Running" position. This additional clearance is absolutely necessary to avoid damaging the axial seal strips on the blading. The rotor should be moved by means of the thrust bearing adjusting mechanism described in I.B. No. 6116.