itself to the changes in accuracy while in operation.

X. CONCLUSION

We have given an outline of small and medium capacity induction motors specially designed to meet their various uses. It is regretted that space does not allow us to touch on many others, such as the H grade motors using silicon resin, motors with cone shaped rotors, speed control of cage type motors by magnetic coupling, totally enclosed water cooled type motors which cool the rotor centers with water. There are many other fields remaining in which induction motors may be specifically applied, and we hope that with the kind cooperation and understanding of our clients, we can further the rational use of electric motors.

30,000 kVA A. C. GENERATOR AND WATER TURBINE PRODUCED FOR UTSUBO POWER STATION, KANSAI ELECTRIC POWER CO., LTD., JAPAN

Part 1.—30,000 kVA Umbrella Type A. C. Generator

By

Yoshio Adachi

(A. C. Machine Div., Eng'g. Dep't.)

Synopsis

The umbrella type water turbine generator delivered to Utsubo power station, Kansai Electric Power Co., output being 30,000 kVA, speed 200 R. P. M. is the machine near to the manufacturing limit of umbrella type generator from the relation between output and speeed ; in this respect we may say the machine is the record of product. Since received the order, we devoted ourselves to design and manufacture, gathering all our technics, thus the machine has many such feature that we utilize " Gitter winding " for stator winding, the dimension of the thrust bearing is determined by fully considering the stability of rotor, we used thick steel plates for rotor yoke in order to increase the mechanical strength etc.

Having finished recently and being under installation of it, we report the outline of the machine construction and test result in our factory.

I. INTRODUCTION

The umbrella type water turbine generator deliver to Utsubo Power Station, Kansai Electric Power Co. is directly coupled with a 27,000 kW Francis water turbine, such as hereinafter described, output being 30,000 kVA, and speed 200 R. P. M. Referring to the world-wide examples of water turbine generators, a definite relationship between output and R. P. M. is respectively observed both for ordinary type and umbrella type, as shown in Fig. 1. The present generator attains almost to the limit of manufacturing possibility, and in this respect, we may say it is the record of the umbrella type generator.

Since having received the order, last spring, we devoted ourselves to design and manufacture, gathering all our technics, and having finished recently with satisfactory results of factory tests, and being now under installation, we report the outline of the machine for your reference.

II. OUTLINE OF GENERATOR

As wellknown to the art, the umbrella type A.C. generator has its thrust and guide bearings under the rotor spider, its upper guide bearing being dispensed with. For the reason that the thrust bearing and the guide bearing must be located as nearly as possible to the centre of gravity of the rotor its for stability, the rotor spider has, in

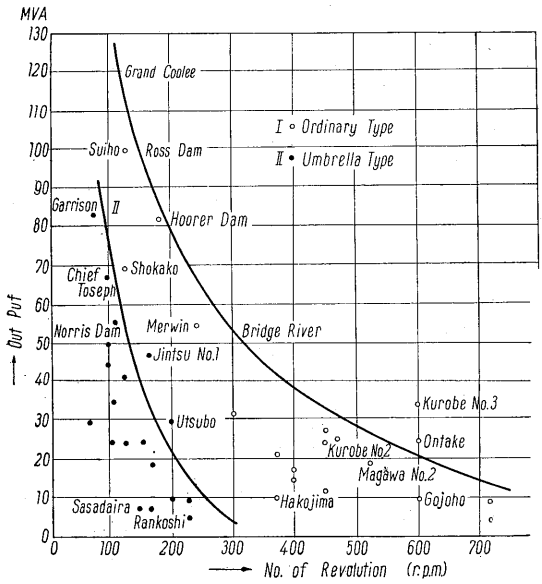

Fig. 1. Example of Water Turbine Generator.

general, an umbrella type construction. In case of an umbrella type generator, the upper bracket, being required only for supporting the exciter part, becomes simple and light in construction. The stationary frame, being required only for supporting the iron core, its winding and the load on the upper bracket, having no responsibility for the thrust of the water turbine, also becomes simple and light in construction as compared with that of the ordinary type. Since the lower bracket should house the thrust bearing and the guide bearing therein, it shouldbe constructed stronger than that of the ordinary type, but since its span is comparatively short, it is by no means bulky as much as the upper bracket of the ordinary type. In short, the characteristic features of the umbrella type generator are as follows:

a) The height of the machine is reduced and the shaft length is shortened.
b) Since the rotor is simply removed from the shaft, the lifting weight and height of the crane is reduced.
c) The height of the housing and the capacity of the crane may be reduced so that the cost of construction may be saved.
d) Easy centering in assembling and easy coupling between the shaft and the rotor.
e) The total weight of the generator is reduced by 10—13% if compared with that of the ordinary type.

The present generator has, of course, the abovementioned general characteristics of the umbrella type. In addition thereto, it has many advantageous features as hereinafter disclosed. Its general specification is as follows.

Main Generator

Type : Umbrella type, Rotary Field type,

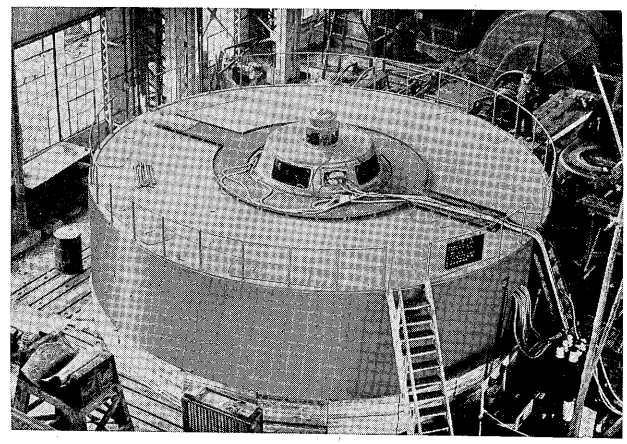

Fig. 2. 30,000 kVA Umbrella type Generator.

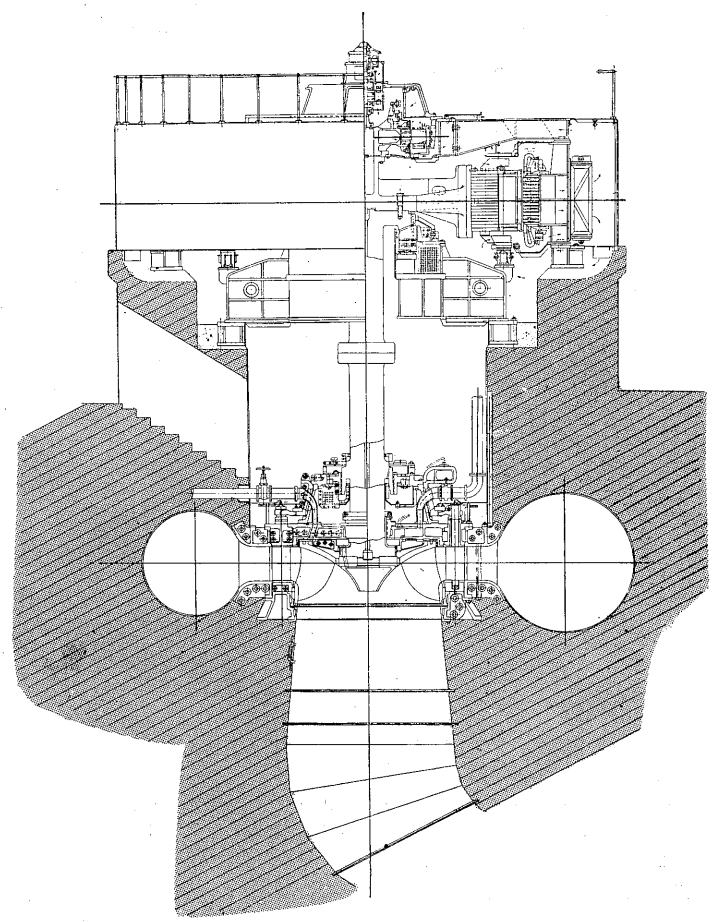

Fig. 3. Sectional Drawing of 30,000 kVA Generator and Francis Water Turbine.

Totally Enclosed Air Circulation type.

Number of Unit: 1 unit
Output : 30,000 kVA
Voltage : 11,000 V
Current : 1,570 A
Frequency : 60 C/S
No. of Rev. : 200 R. P. M.
Power Factor: 0.85 (lag)
Guaranteed Efficiency:

Load	100%	80%	60%	40%
With power factor 1.0	97.8%	97.6%	97.1%	96.0%
With power factor 0.85	97.2%	96.9%	96.4%	95.2%

Short Circuit Ratio: 1.2

	Main Exciter	Sub-Exciter
Output	250 kW	6 kW
Voltage	250 V	220 V
Current	820 A	27.3A
No. of Rev.	200 R. P. M	200 R. P. M

Since the exciter unit is of a telescopic type, in which the subexciter is contained into the commutator body, its appearance is not only smart, but also it has advantage of reducing the height of the generator.

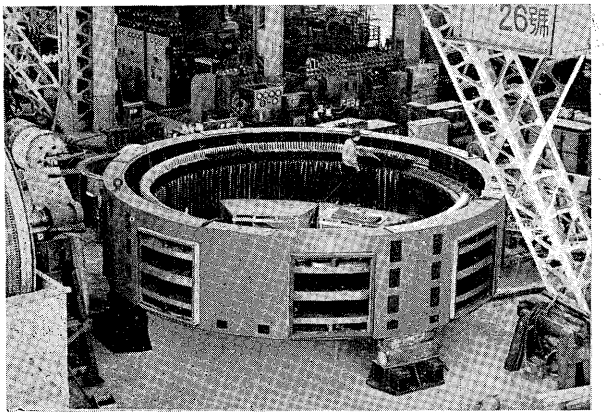

Fig. 4. Stator of 30,000 kVA Generator.

III. CONSTRUCTION OF STATOR

The stator frame is of a welded steel plate construction, splitted into four blocks from the requirements of transportation. The stator iron core is consturucted with silicon steel plates of T class half lapped, several axial air ducts being provided therethrough for increasing the cooling area, and fastened together through studs with sufficient strength for preventing relaxation due to impulses and vibrations. Every core disc, after being punched, is annealed in an air-tight condition for preventing the increase of core loss resulting from the stress due to stamping, and painted with a special paint for layer insultion. The press finger for core teeth is made of non-magnetic steel to prevent increase of core loss due to leakage magnetic flux.

Fig 5. Gitter Winding.

While, as the stator winding of the generator of this kind, a multiple star lap winding has hitherto been commonly adopted, with the present generator, Gitter winding of one coil, one turn is adopted to form a single star wave winding. With this winding, the conductor is divided into a number of elements of small section arranged in multiple layer in two parallel raw, which are transposed once in the stator core slot to decrease the deep slot effect of current due to the slot leakage magnetic flux, thereby preventing the increase of copper loss to utilize copper material most efficiently. The coil ends are rivetted together and solder finished to reduce the contact resistance as much as possible. With this system, the following advantages are obtained.

a) The cross sectional area of the conductor is reduced with the result of saving the copper material.
b) The dimension of the slot is reduced so that the generator may be constructed in compact form.
c) One coil, one turn winding obviates the fear of layer short and the use of differential protective relay.
d) For adopting wave winding, the connecting bars between the coils are not required.

As for insulation, micanite is heat pressed into the slot, and the coil end is wound with insulating tape such as mica tape or glass tape. Of course, asphaltic compounds are carefully impregnated throughout the coil to shut out any bubble therein. As for corona protection, the portion of the coil leading into the slot is coated with graphite of comparatively low resistance, while the portion thereof ranging within 25 mm. from the outlet of the slot is coated with graphite paint of comparatively high resistance, to obtain mild potential gradient, thereby serving to suppress the corona. The insulation test of the coil itself shows a very high breakdown voltage higher than 130 kV with impulse of standard wave form. The weak point ratio, that is the ratio of insulation resistance between the applied voltages 2.5 kV and 15 kV for 10 min. duration, was less than 1.3. The value of tan. δ under hot condition is about 10%, accompanying no hysteresis phenomena.

The Siemens Co. has adopted the Gitter winding for water turbine generators of large capacity after the World War II, Our Co. also intends to adopt the Gitter winding for water turbine generators, whose ratings exceed 20,000 kVA. The two 23,500 kVA generators installed at Jintsugawa Second Power Station, Hokuriku Electric Power Co., and the two 24,000 kVA generators which are now being designed and manufactured for Sudagai Power Station, Tokyo Electric Power Co., have also the Gitter winding.

The lower bracket is of welded steel plate construction having an oil tank for containing thrust and guide bearings therein, the arm of the bracket shall be splitted from the requirements of transportation. The inner diameter of the bracket is larger than the outer diameter of the flange of the generator shaft directly coupled to the turbine shaft. Accordingly, there is no need of splitting the oil tank into two parts, thus allowing its simple assembling and disassembling, and obviating the fear of oil leakage along their fitting surfaces. The lower bracket has 6 oil brakes and 6 oil jacks.

The upper bracket also is of a welded steel plate type, simple in consturuction, light in weight, because it is required only to support the weight of the exciter unit.

IV. ROTOR CONSTRUCTION

As the core length is long and the outer diameter of the rotor is comparatively small, no appreciable difference with respect to the distance between the guide bearing and the centre of gravity of the rotor is observed between umbrella type and T type spiders. Therefore, we adopted the strong T type construction. From this meaning, the present generator may be said as semi-umbrella type.

The spider is made of cast iron, and around its outer periphery, an annular yoke formed by re-

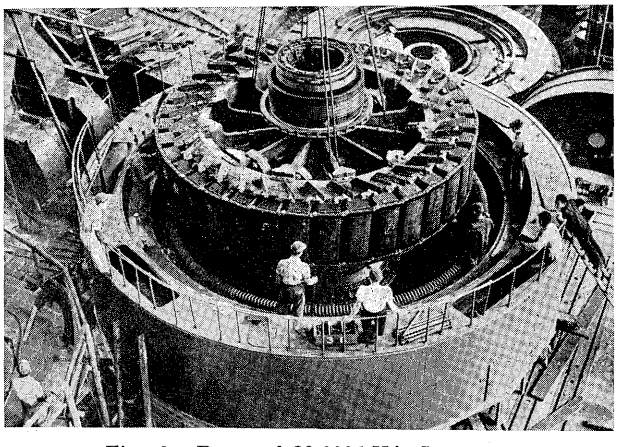

Fig. 6. Rotor of 30,000 kVA Generator.

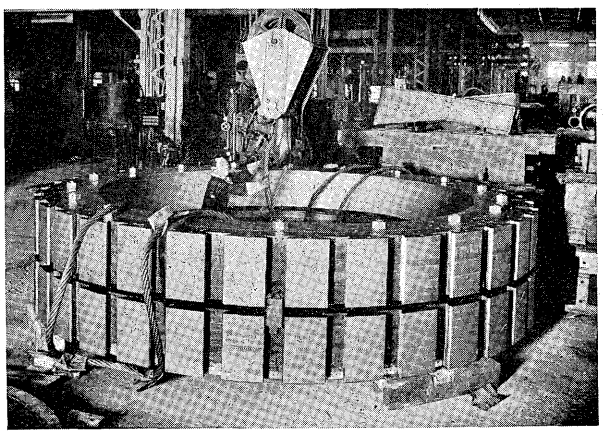

Fig. 7. Rotor Yoke of 30,000 kVA Generator.

aming through the thick steel plates lapped one another, is heat fitted, the spider and the yoke being coupled together through guide keys. The fastening allowance of the yoke is so selected that its stress may not amount to an excessive value under stationary conditions, while the allowance may be reduced to zero at overspeed when the valve of turbine is opened. Thus, since the fastening allowance becomes negative under runaway speed, the guide keys are used to prevent the yoke from becoming eccentric.

The magnetic pole comprises a laminated pole piece attached integrally with the pole core made of wrought iron by means of electric welding, which, in turn, is secured to the yoke through a dove tail key. For the purpose of improving the wave form of voltage, the magnetic pole is skewed by one slot pitch to suppress the higher harmonics due to slot. In this case, since mere mechanical skewing causes too much skew-effect for voltage wave form, care is taken to limit it to one electrical slot pitch skewing.

The magnetic pole piece is provided with a damper winding for preventing the vibration and suppressing the abnormal voltage. With the field coil, edgewise windings are used and after asbestos papers varnished with adhesive varnish are inserted therebetween as layer insulation, the con-

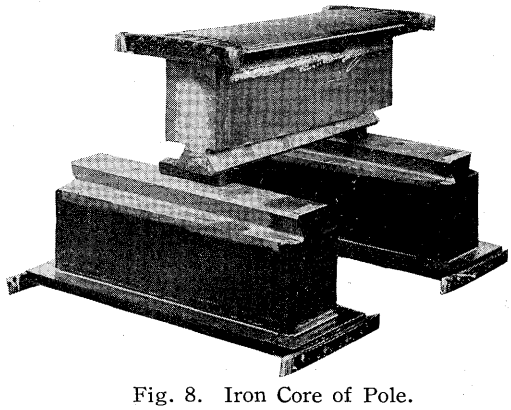

Fig. 8. Iron Core of Pole.

ductor surface also being varnished with adhesive varnish, the coil is tightly fitted upon a rigid iron bobbin insulated with micanite by means of sufficient heat pressing, thereby obviating the aging during operation.

The shaft is directly connected to the lower part of the spider, the foot of which is constructed as an additional block from the requirements of transportation so that it may fall into the transportation limit. The yoke is disassembled into individual blocks during transportation, and upon assembling at installing site, they undergo preheating to expand their inner diameter, thereafter being fitted on to the spider.

V. THRUST BEARING AND GUIDE BEARING

As the thrust bearing, a Mitchel type of one point supporting system is adopted. That is, an annular shoe is secured to the thurust bearing collar forged integrally with the shaft and several

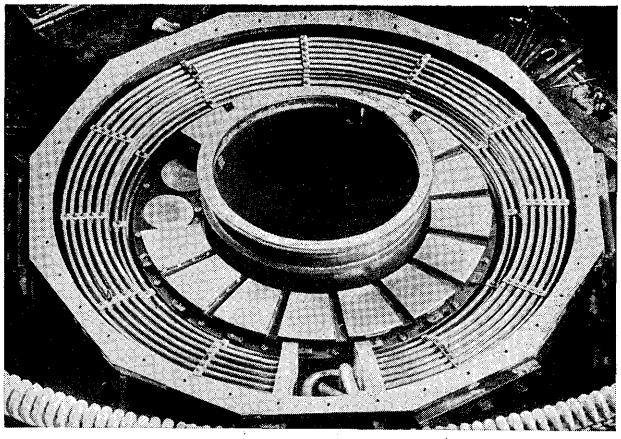

Fig. 9. Thrust Bearing.

bearing segments supported by disc spring are provided below the shoe. The guide bearing is provided around the outer periphery of the thrust bearing collar, it being splitted into several parts, but instead of being so-called segmental bearing, it is a cylindrical bearing having several oil ducts for forming suitable oil film. The centre of the bearing is made adjustable externally. The upper guide bearing is omitted, and both thrust and guide bearings are contained in an oil tank formed within the lower bracket to be immersed into oil, the oil being cooled through the cooling pipes in the oil tank. The guide bearing is so constructed that it may be disassembled or assembled without disassembling the generator rotor.

The thrust bearing not only supports the weight of the rotating parts and the thrust of the water turbine, but also upon the inclination of the

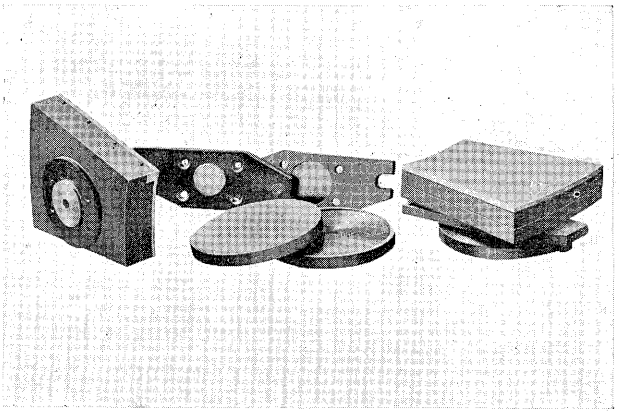

Fig. 10. Segment of Thrust Bearing.

thrust bearing surface it should produce reverse active moment on the thrust bearing surface to put back the inclination through the reverse action of the spring below the segment. That is, it has so-called restoring action. The limit of this restoring action is determined by the load on the bearing and the flexibility of the shaft in association with the external force (the centrifugal force and magnetic attractive force due to eccentricity) tending to incline the shaft. The stability of the rotor is held mainly for this restoring action, and the amount of the restoring action (reverse active moment) available while the thrust bearing bears a certain thrust load, is determined by the dimension of the bearing. In case of the umbrella type generator, the stability of the rotor is maintained so long as the condition $WR > 2PH$ is satisfied, where referring to Fis. 11, P is the external force tending to incline the longitudinal axis OO′; H the distance between the centre line QQ′ through the guide bearing and the centre of gravity of the rotor; R the radius of a circle passing through the centres of gravity of every bearing segments of the thrust bearing; W the thrust load. In this case, attention should be directed, in taking the value of W, to exclude the water turbine thrust in consideration of factory tests.

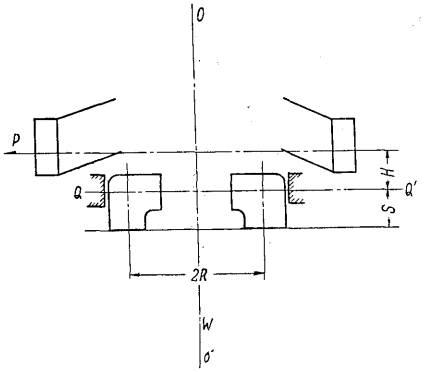

Fig. 11. Stability of Umbrella type Rotor.

Since this generator is designed almost at the limit of manufacture for an umbrella type, special consideration are taken with respect to the stability of the rotor. Its rotation was very stable under infavourable base conditions during factory test, and no vibration was observed even with 130% overspeed, it being astonishingly calm run.

VI. TESTING RESULT OF GENERATOR

The no load saturation curve and the 3 phase short circuit characteristic are as shown in Fig. 12, short circuit ratio being 1.23, voltage regulation 21.8% at power factor 0.85 and 11.8% at power factor 1.0, thereby sufficiently satisfying the guaranteed value. The efficiency at the rated power factor and at 1.0 power factor are as shown in Fig. 13.

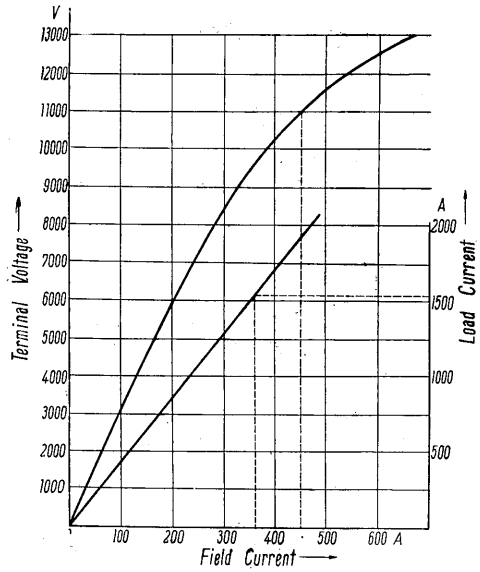

Fig. 12. No-load Saturation and Short Circuit Curve of 30,000 kVA Generator.

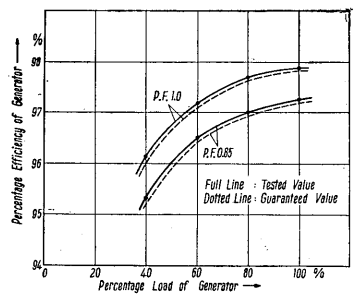

Fig. 13. Efficiency Curve of 30,000 kVA Generator.

The following table shows the test result of temperature rise at no load and short circuit conditions, but the numerical value serves only to your reference because the temperature rise test was performed under a condition similar to enclosed ventilated type, removing a portion of air duct from the relation of quantity of cooling water.

Temp. rise	Stator winding		Rotor winding	
	(thermo)	(resist)	(thermo)	(resist)
at No load test	23.0°C	15.6°C	15.0°C	10.2°C
at Short circuit test	26.5°C	40.0°C	12.5°C	—

As for the wave form of the stator voltage, in spite of the number of slots per pole per phase of the stator being an integer number, harmonics were not observed, the wave distortion factor being 1.6%.

The value of GD^2 of the rotor measured under the rotor coasting test was 2089 tm^2, thereby sufficiently satisfying GD^2 2000 tm^2 demanded by the water turbine.

From oscillograph, the build-up voltage of the main exciter was observed to be 784 V/S, the ceiling voltage being 470.5 V.

As the air cooler of the main generator, so-called U-fintube (tube with coiled fin) in used for the purpose of compactness and large cooling effect, and the result of temperature test using a testing wind tunnel was sufficiently satisfactory.

This is the general explanation of the outline of construction and results of factory test of our 30,000 kVA generator delivered to Utsubo power station, Kansai Electric Power Co. The present generator is not only the record of our Co. in capacity, but also it is the most noteworthy machine in the features that it was designed and manufactured gathering all excellent technics since establishment of our company, and demonstrates originalities in the points of design and manufacture.

Part 2.—27,000 kW Francis Water Turbine

By

Hisahiko Hosono

(Mech. Div., Eng'g. Dep't.)

Synopsis

The water turbine delivered to Utsubo power station, Kansai Electric Power Co. is the machine of the largest capacity manufactured in our company through pre-war and post war.

It is the buried system by concrete barrel, one man control and vertical shaft single wheel spiral Francis turbine having 27,000 kW maximum output, 69 m maximum effective head, 43.3 m³/s water quantity, 200 R. P. M.

For the design and manufacture of it, we payed a special prudence as it demonstrates our technics since establishment of our company. It is already sent except a part of the appartus, the installation of which being proceeding step by step at the actual sport, therefore we can expect that a power generation will begin at once.

I. INTRODUCTION

The water turbine delivered to Utsubo power station, (Utsubo, Sakashita-mura, Yoshiki-gun, Prefecture of Gifu), Kansai Electric Power Co. is the machine of the largest capacity manufactured in our company throughout pre-war and post-war.

For the design and manufacture of it, we payed special prudence as it demonstrates our technics since establishment of our company. It is already sent out except a part of the apparatus, the installation of which is now proceeding step by step at the actual site, the power generation being expected to begin very soon.

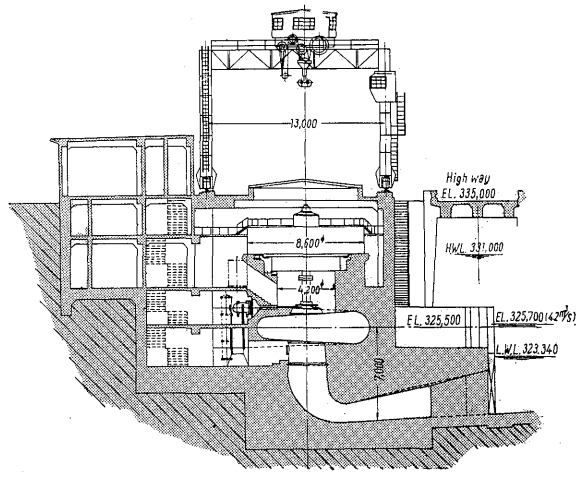

Fig. 1. Elevation of the Arrangement of Machines.

II. SPECIFICATION OF WATER TURBINE

Type	:	Vertical Shaft, Single Wheel, Single Flashing Spiral Francis Water Turbine
Number of unit	:	One Unit
Effective (Maximum) Head	:	69 m
Normal Maximum Output	:	27,000 kW
Quantity of Flow (with max. effective head)	:	43.3 m³/s
Number of Revolution	:	200 R. P. M.
Control System	:	One Man Control
Installation System	:	Buried System by Concrete Barrel
Speed Regulation	:	30%
Water Pressure Regulation	:	97m Water colum
Governor Closing Time	:	4.2 second
Governor Dead Time	:	0.2 second

Guaranteed Efficiency :

With effective (max.) head 69 m				
Load	100%	80%	60%	40%
Efficiency	92.1%	92.5%	88.8%	82.5%

Runaway Speed	:	374 R. P. M.
Draft Head	:	2.16 m

III. CONSTRUCTION OF WATER TURBINE PARTS

The present water turbine has many characteristic features in capacity and specification. While the inlet valve, has recently been prevailed to be dispensed with even for a plant of considerable high head, we believe, the present power plant is a noteworthy one as a test case with regard to this feature.

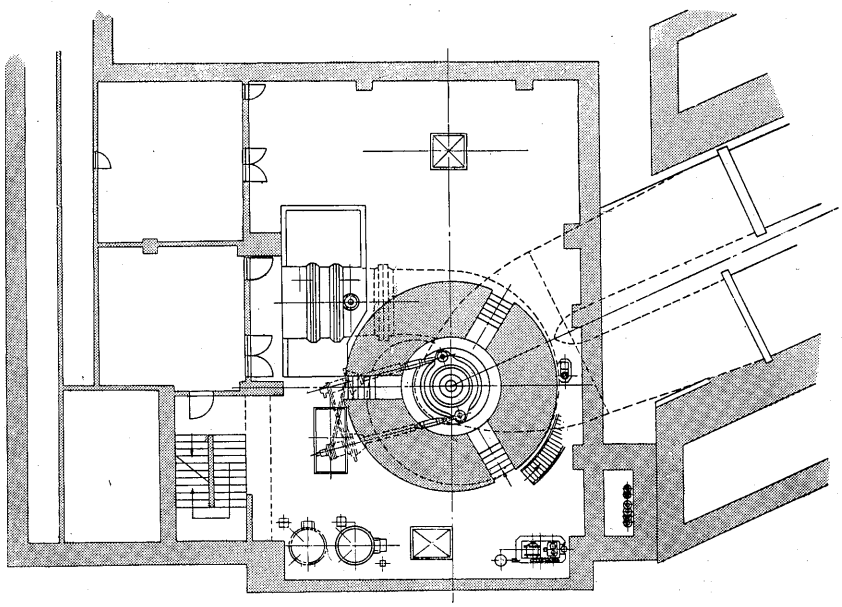

Fig. 2. Plan of the Arrangement of Machines.

Since it is intended to install one more unit in the near future, the present turbine is designed so as to be easily added with an inlet valve (a butterfly valve) in such occasion.

Further, special attention is paid with respect to the materials and constructions of the machine parts.

A) *Water turbine proper.*

1) For facilitating the installation of the casing as simply as possible, the number of split blocks for transportation is minimized within the limitation of freight car. It is made of steel plates splitted into four blocks, (the winding end portion being, however, made integrally with speed ring for the convenience of manufacturing), every block comprising 5 steel plates butt welded with one another.

The speed ring made of cast iron is splitted into four blocks jointed with the casing through a three row rivet lap joint.

At the seam between splitted blocks are used both zigzag two row rivet lap joint and flange joint.

In the present power station, a water pressure test for the casing made of steel plates rivetted together was performed at the installing site for the first time in Japan, the result being satisfactory as there was no leakage of water observed.

2) As the guide bearing of the water turbine, a self-contained oil immersed type is adopted

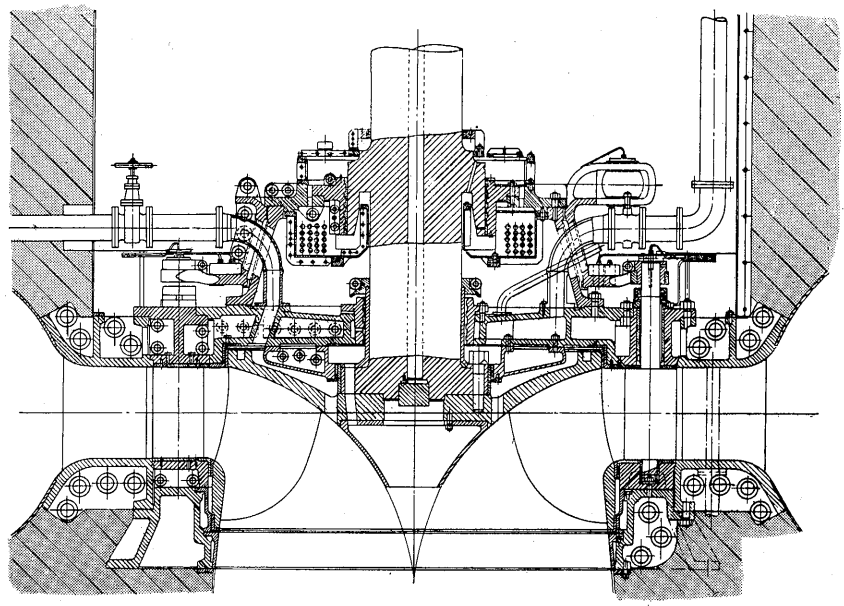

Fig. 3. Sectional View of Water Turbine.

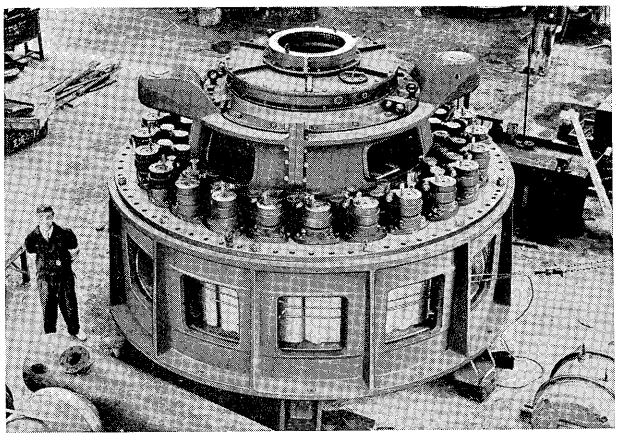

Fig. 4. Water Turbine Proper.

instead of an oil circulating system. We adopted this self-contained oil immersed type for the Second Shikaribetsu Power Plant, Hokkaido Electric Power Co., the operation of which was begun in Aug., 1953, and ascertained that the lubrication during both starting and normal running is very good, accompanying no leakage of both oil and water and giving always satisfactory results.

3) The packing of the main shaft is of a water

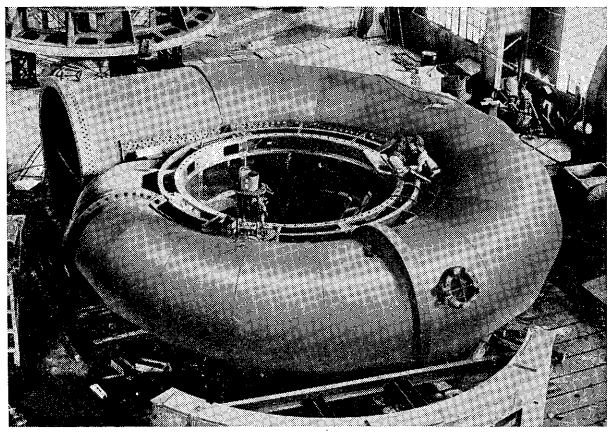

Fig. 5. Spiral Casing.

seal type, in which pressure water and grease are automatically supplied between it and the shaft liner so that leakage of water and penetration of air may be prevented.

4) The guide vane is so designed, taking into account the case when the oil pressure in the oil tank might be lowered, that it may be automatically closed up to the opening less than its no load opening by the water pressure acting on the guide vane itself.

5) The guide vane is provided with a thrust ball bearing so as to reduce the friction between the vane and the liner as small as possible.

6) Every sliding surface of the bearing, associated with guide vane, is provided with an automatic grease lubricating system, in which grease is supplied every 12 hours through a time relay.

7) The turbine shaft is directly connected to the generator shaft without interposing any intermediate shaft.

8) Upon disassembling, the turbine runner may be taken out by only removing the guide bearings, the inner cover, and the regulating wheel of the water turbine, without disassembling the guide vane and the guide vane portion of the upper cover.

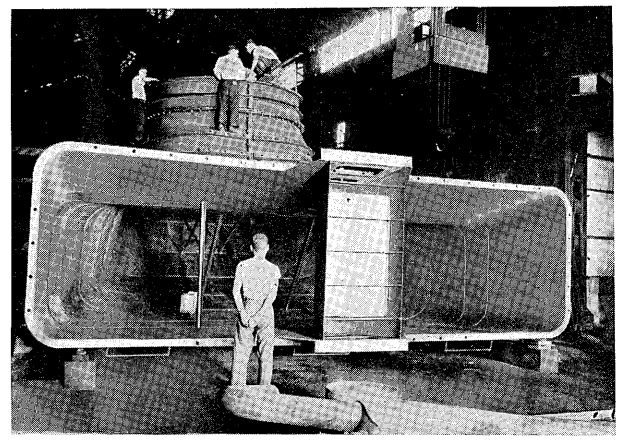

Fig. 6. Draft Tube Liner.

9) The system for supplying air into the upper draft tube is one, in winch air volume regulated in response to the guide vane opening is conducted into the lower part of the runner through the runner itself from the inner cover, threby obviating a heretofore wellknown pipe opening to the central portion of the upper suction pipe.

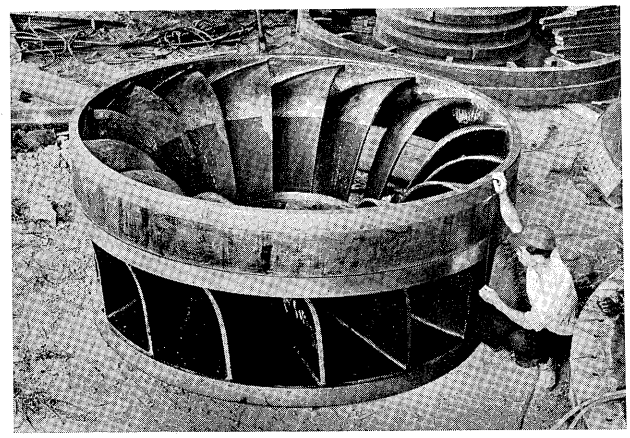

Fig. 7. Runner.

B) Speed Governor.

1) A cabinet type of the latest design is adopted, in which an universal actuator, pressure distributing valves, and cases for controlling

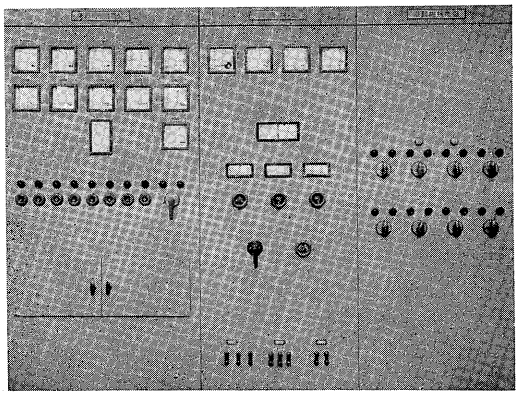

Fig. 8. Cabinet type Governor.

devices are contained, and at the board surface of which are attached hand operating handles, push button switches for electromagnets, switches for operating motors and various meters (indicators for guide vane, load limitation, speed regulation, and speed variation, pressure meters, temperature meters, tachometers and output meters etc.)

2) The universal actuator is of a motor-driven, totally enclosed, and automatic oil supplying type of the latest design in which a spring plate pendulum is provided.

3) Two servomotors are used, which are installed at the outside of the barrel on the underground 1st floor.

4) Since the inlet valve is now dispensed with, the servo-motor is so designed that its closing side is normally subjected to oil pressure whenever guide vanes are totally closed, thereby reducing the seam gaps between guide vanes themselves and minimizing the leakage of water.

C) Oil Pressure Device.

1) Unit system is adopted and oil pressure pumps are of the same type and function, each being directly coupled to a motor for normal use and to a sub-small water turbine for emergency use.

If required, however, the turbine driven oil pressure pump may normally be used, while the motor driven one for emergency case.

Specification of Oil Pressure Pump

Type	:	Gear Pump
Delivery Pressure	:	18 kg/cm^2
Delivery Quantity of oil	:	360 L/s
Number of Revolutions	:	850 R. P. M.
Required HP	:	30 HP

As the small water turbine, a Francis water turbine is adopted on account of high flood level. No speed governor is attached, and instead, for speed regulating purposes, a servo-motor for regulating the guide vane opening is equipped therewith to prevent over.speed at no load.

Specification of Small Water Turbine

Type	:	Vertical Shaft, Single Wheel, Single Flashing Spiral Francis Water Turbine
Max. Output	:	30 kW
Effective Head	:	30 m
Quantity of Flow	:	150 L/s
No. of Rev.	:	850 R. P. M.

2) Pressure oil delivered from the oil pressure pump is sent to a pressure oil tank through an unloader valve and an auxiliary tank to maintain rated oil level and rated oil pressure therein. The construction is such that the air to be supplied simultaneously in this case may be sent in a form of large air bubbles instead of being mixed with the oil.

3) An air compressor is equipped therewith so that the quantity of air required for maintaining rated level and oil pressure in the pressure oil tank may be supplied therein within 30 minutes.

D) Water Supply Device.

Water is delivered from an intermediate point of the penstock to an upper water tank, from which water may automatically be supplied to the water turbine, guide bearing of generator, thrust bearing, cooling pipes for oil and generator and other machine and apparatus through the control at the switch board or cabinet panel.

E) Drainage Device.

1) Two spiral pumps anb one auxilliary jet pump are provided for drainage of the station and water is sent outdoors out of drain pits on the underground 2nd floor.

2) One double suction, spiral pump equipped with a vacuum pump is provided for draining the draft tube.

3) The leakage of water from the upper cover of the water turbine is collected near the draft tube through natural flow and is normally sucked into and drained from the draft tube by utilizing its vacuum, the same being over-flown into exhaust pits when the exhaust through the draft tube becomes impossible owing to the rise of tail race level, therefrom being discharged outdoors through the aforementioned water exhausting pumps.

A check valve of a cork-ball type is provided with the draft tube for preventing reverse flow therefrom.

F) Control Device.

One man control system is adopted and the control devices are contained into the cabinet panel.

The control electro-magnetic valves are all of a clutch holding type, except that of the small water turbine, in which a holding coil is provided in addition to the actuating coil and the electromagnet is raised upon energization of the holding coil, and after it is firmly locked by a holding mechanism, the holding coil is de-energized.

In stopping the machine, a trip coil is energized to trip the holding mechanism, thereby dropping down the electro-magnetic valve. Thus, the operation may be continued even after the control electric source is cut off, and upon stopping, push button switch on the surface of cabinet board may only be pushed to mechanically trip the holding mechanism, thereby dropping down the electro-magnetic valve.

Further, since the trip coil is adapted to be controlled from both a. c. and d. c. source, the machine may be stopped from either of the a. c. and d. c. source.

IV. MODEL WATER TURBINE

A) Efficiency Test.

Model spiral casing, draft tube, runner and others of a reduced scale 1 : 5.56 of the actual size, are used for commercial tests in the presence of customers.

The measured value of efficiency reduced to actual runner using Moody's formula I is shown in Fig. 9 and it is seen that the result exceeds the guaranteed efficiency.

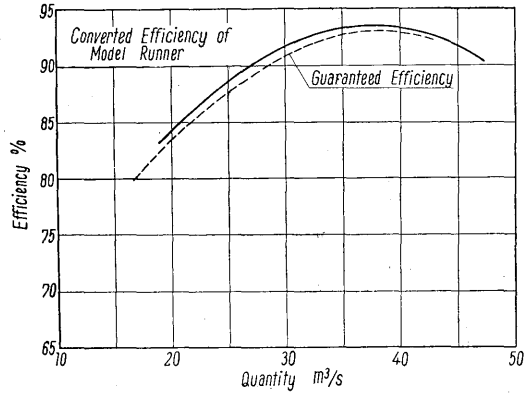

Fig. 9. Efficiency-water Quantity Curve.

B) Automatic Closing Test for Guide Vanes.

This test was performed at a time nearly the same with that of the efficiency test, and after various discussions, satisfactory characteristics as shown in Fig. 10 is attained.

C) Index Method Test.

The index method is a method for measuring quantity of flow, which recently begins to prevail, but not yet generally accepted.

We adopted this method for Utsubo Power Plant and the results obtained from the measuring points as shown in Fig. 11 are shown in Fig. 12.

D) Scraping test between Guide Vanes and Upper and Lower Liners thereof.

Occasionally, there occurred a problem on materials with respect to the clinging phenomena between the guide vane (18/8% stainless

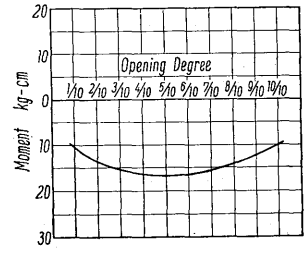

Fig. 10. Hydrauric Moment of Guide Vane-Guide Vane Opening.

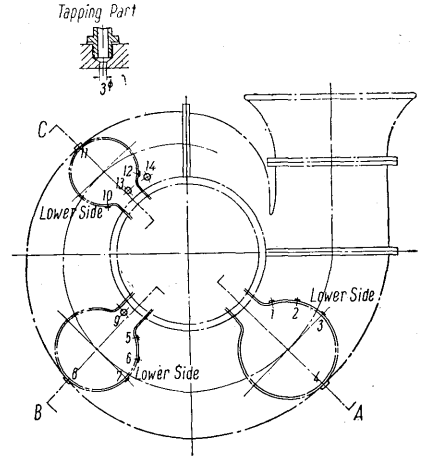

Fig. 11. Measuring Points of Index Method.

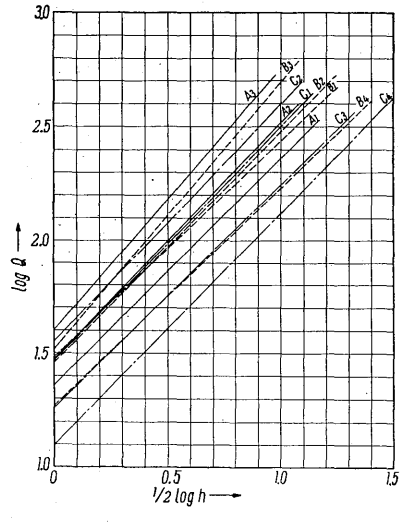

Fig. 12. $1/2 \log h$-log Q Curves.

steel) and its upper and lower liners (13% stainess steel). Accordingly, a model test is immediately performed with a spare guide vane. From the results, we observed that the clinging phenomena would not occur provided the gap between the moving and fixed materials exceeds 0.1 mm.

Since the actual machine had this gap of 0.2–0.25 mm when measured at installed site, we believe that no clinging phenomena would occur.

In the foregoing, we disclosed and explained the outline of the water turbine unit delivered to Utsubo Power Station and the results of its model test. At the final of this discription, we must express our sincere gratitude for the kind advices of Kansai Electric Power Co. in manufacturing and installing the present water turbine.

Introduction of Products

30,000 kVA FURNACE TRANSFORMER WITH ON LOAD TAP SWITCH

(Produced for Messrs. Electro Chemical Industries, Ltd.)

Fuji Denki Seizo K. K. is outstanding in our country for excellency of engineering techniques, and is proud of the Fuji Furnace Transformer, the performance of which eclipses any produced before. Recently we have completed a 30,000kVA capacity Furnace Transformer for our client, the Electro-Chemical Industry Co., Ltd. and is a record breaking achievement for us in the post-war period. The new Siemens techniques, and our many years of experience were applied in manufacturing this transformer. It is of the same type as the three phase 40,000 kVA transformer ordered by the Manchurian Electro Chemical Industry Co., Ltd. which construction was unfortunately suspended before completion because of the war's end. The indirect voltage method, in which the series transformer is inserted in the secondary side for adjusting of load voltages in the secondary side, has been adopted.

We introduce herewith an outline of Specifications.

Oil circulating water cooled type, with on load tap changer.

Single phase 60 C Three sets of 10,000kVA transformers.

(comprising series transformer)

Primary Voltage	60,000 V
Secondary Voltage	255 V–145 V (5 V step, 23 stages)
Secondary Current	47,600 A (Furnace current 82,300 A)
Bank Connection	△—人／／／
Total weight	42tons Net weight 22.5tons Oil capacity 11,200 L

Core and Coil

The core is of the core type, with both the main and series transformer having a rectangular section same as the shell type. The silicon steel sheets used are those which have undergone severe testing and have passed sheet testing by sheet-measuring instruments.

In order to improve cooling efficiency such construction technique have been adopted as installing an oil way at right angle to the steel sheet pile, and another oil way paulled to the pile as a passage to the coil line under a coil yoke, considering the thickness of the silicon steel sheet pile.

The primary voltage of ordinary type furnace transformers are limited to 30 kV at the most, and we have adopted the disk type copper sheet coil made of copper sheet cut out in a circular shape and arranged high and low voltage winding in sandwitch type. However, in this case when the voltage is 60 kV, the above method cannot be applied as the thickness of insulating material between the high and low voltage increased to