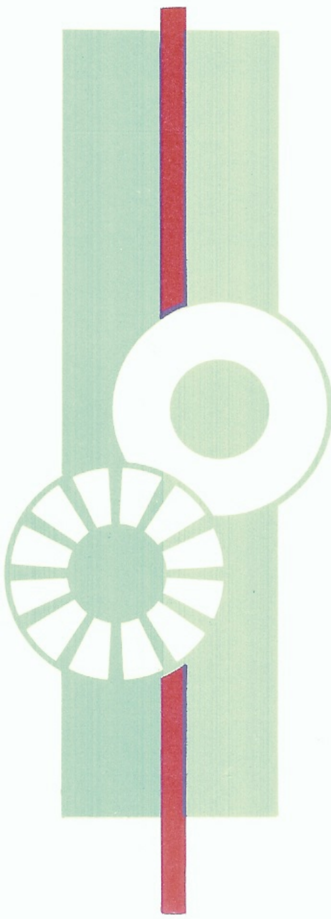
Behind the beauty of a modern dam, efficient generators convert water power to electricity, their huge rotors supported by carefully designed thrust bearings

THRUST BEARINGS

AS USED IN LARGE GENERAL ELECTRIC HYDRAULIC TURBINE-DRIVEN GENERATORS



GENERAL ELECTRIC

introduction

General Electric thrust bearings are simple, reliable, and readily applicable throughout the entire range of sizes and speeds in vertical machines. These bearings require no adjustment during assembly, need no scraping to fit the surfaces under load, and are automatically self-aligning to equalize the pressure distribution over the whole surface.

This bulletin, which describes the General Electric thrust bearing, includes an explanation of the function of each part in operation. The most important operating characteristics are discussed; a description of various forms of application for different types of machine construction is included; and a list of many of the important hydroelectric units equipped with these bearings is given. In more than 160 of the units in this list, the load on the General Electric thrust bearing is more than 1,000,000 pounds. The load on each of ten of these bearings is 3,000,000 pounds; fourteen bearings are loaded to slightly more than 3,800,000 pounds each; and the load on 12 bearings is more than 4,000,000 pounds each.

G-E THRUST

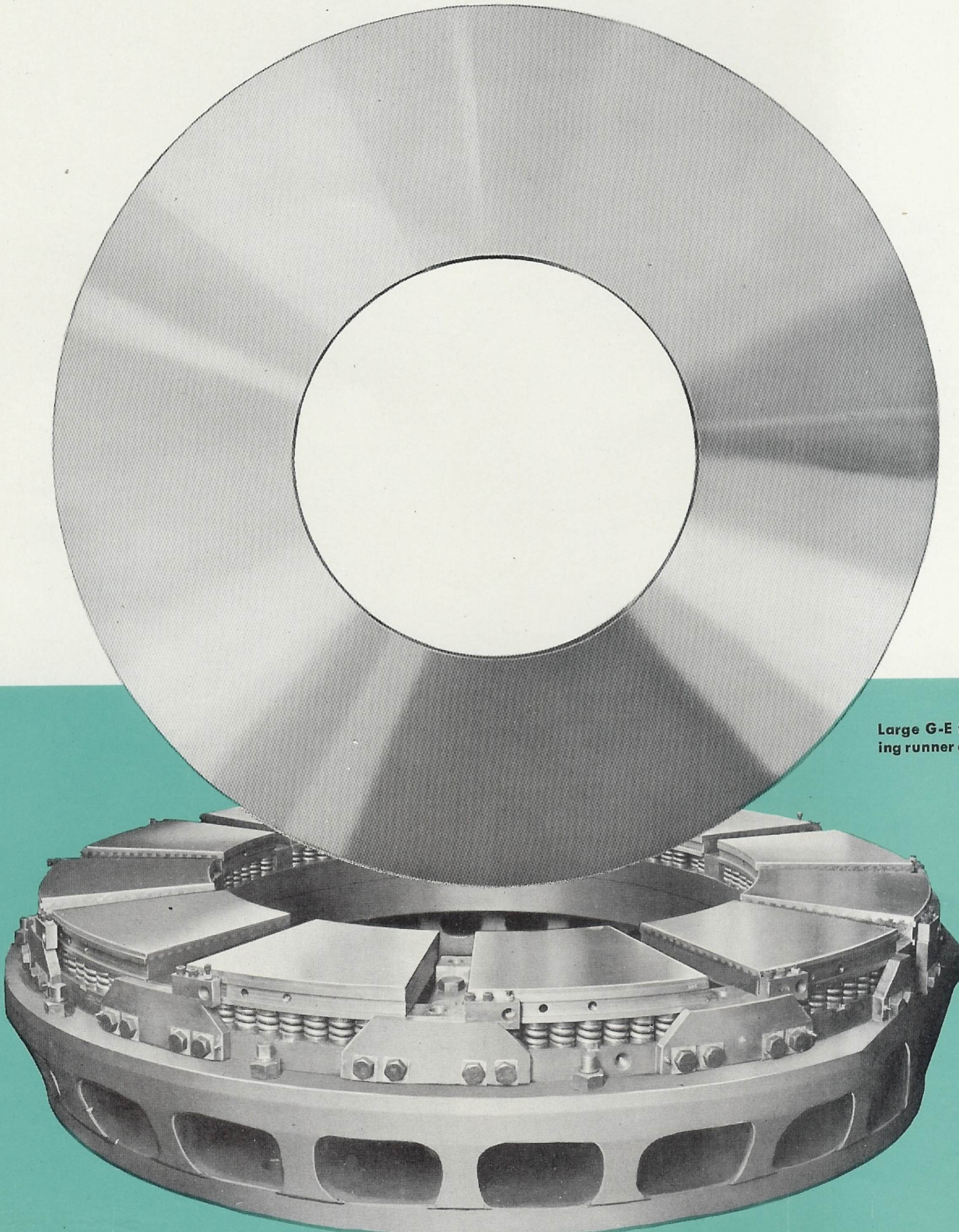
GENERAL ELECTRIC THRUST BEARINGS CONSIST OF THE FOLLOWING PARTS:

1. A rotating plate or "runner" rigidly attached to the shaft by means of a thrust collar, or integrally forged flange.

2. A set of relatively thin and flexible babbitted stationary segments.

3. A flexible support consisting of a number of precompressed springs.

The operation of the bearing depends upon the combination of these parts, but its distinctive feature is the stationary member and its spring support. These members are so proportioned that the oil film, at starting, is formed within a fraction of a revolution, is effective in avoiding metallic contact between the surfaces, and results in operaion with a low coefficient of friction.



Large G-E thrust bearing showing runner and segmental plates.

BEARINGS

RUNNER

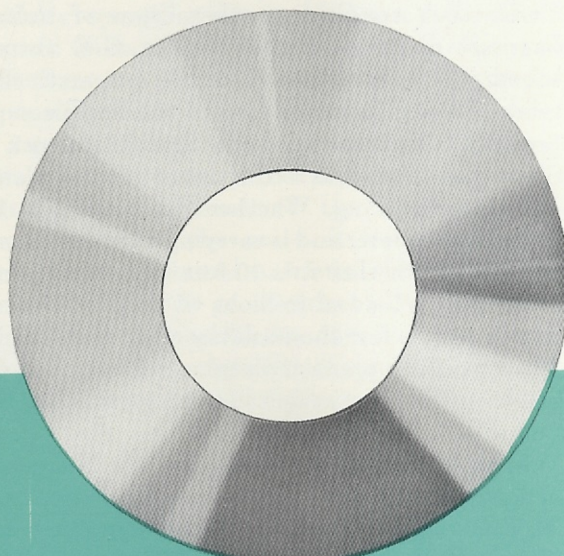
The rotating plate, or runner, consists of either fine-grained, hard cast iron or steel. Special procedures are followed in finishing the runner to insure proper flatness of the plate as a whole and to insure suitable smoothness of the bearing surface. The runner has no grooves, and is made in two pieces, if desired, for convenience in assembly.

Since most of the heat generated in the bearing is carried away by the oil, the action of the runner in circulating the oil is of great importance. The runner produces circulation in a circumferential direction, because the rotating surface drags a film of oil with it. Fresh oil for this action is supplied by the spaces between the segments. Just in front of the chamfer on the edge of the segments, the oil piles up because of the circumferential velocity head. This, plus the centrifugal action of the runner, causes radial oil flow. The combination of radial and circumferential oil circulation produced by the runner and the oil passages between the segments provides an abundant source of fresh oil for the film.

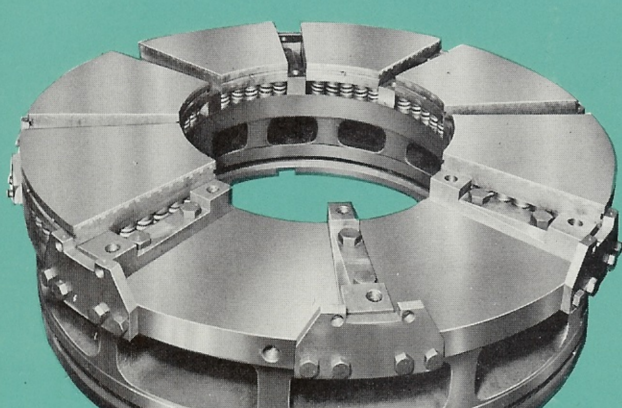
STATIONARY MEMBER

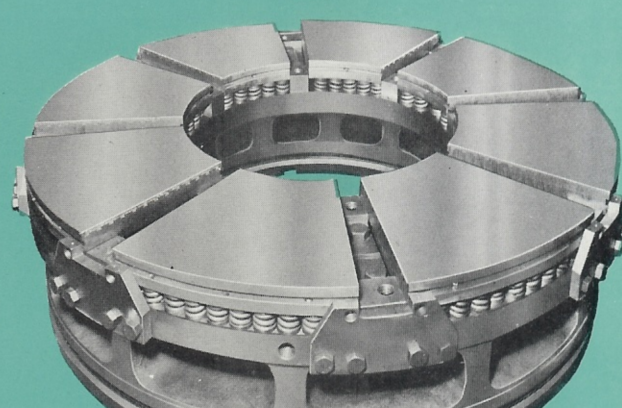
The stationary member consists of segments made of steel with a babbitted rubbing surface. The spaces between the segments insure a liberal supply of oil which the runner drags in between the bearing surfaces. In addition, these areas have a very important protective function. If foreign particles are in the oil, or if the bearing starts to wipe, the loose material tends to drop out of the oil film into these radial spaces.

The segments are flexibly supported on precompressed springs.



Views showing construction of runner, flexible stationary plate and spring support.





FLEXIBLE SUPPORT

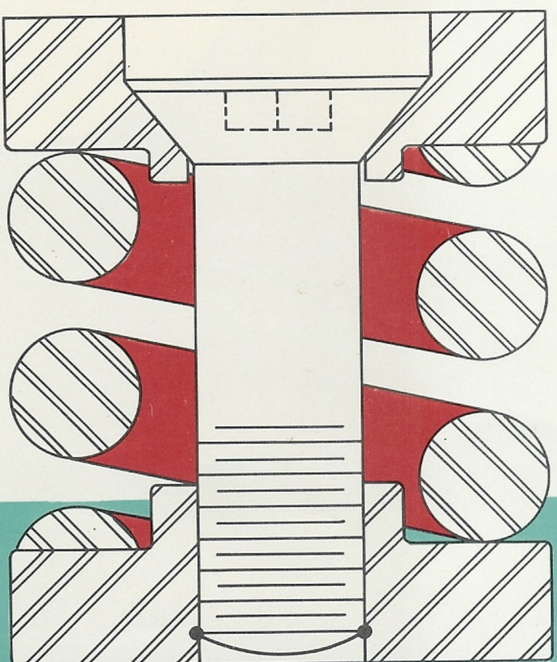
The distinctive feature of the General Electric thrust bearing is the combination of the flexible, stationary member and the distributed, individual springs which support it. These function to supply what every bearing needs, namely, an adequate oil film between the rubbing surfaces under all conditions. In all other oil-film types of thrust bearing, hand scraping of the babbitt is acknowledged as the best method of eliminating high local pressures, and of obtaining a satisfactory fit between the rubbing surfaces. Because of their distributed, flexible support, G-E thrust bearings have been put in successful service without fitting under load ever since their development in 1916.

High local pressures may develop in the bearing without the knowledge of powerhouse attendants, foundations may settle and proper alignment of shaft and bearings is disturbed. Under such conditions, other types of thrust bearings may fail, but with the G-E thrust bearing, high local pressures are automatically relieved by a slight yielding of the flexible support. The importance of this flexible support is directly proportional to the size of generator and the thrust bearing. Whether the bearing is 10 inches in diameter and is carrying a few thousand pounds, or whether it is 10 feet in diameter and is carrying a load of millions of pounds, the oil film is only a few thousandths of an inch thick. The flexible support maintains this oil film on the large bearings in spite of the great loads involved.

Each of the individual springs which support the stationary member is precompressed according to its proportion of the total load for which the bearing is designed. Theoretically, a precompressed spring will not deflect until the loading attains that of the precompression. However, measurements show that where the precompression is obtained by means of a screw in a tapped washer, as illustrated below, the desirable characteristic of small amplitudes of motion with small variations in loading is obtained. The result is a regular deformation as determined by the film requirements.

The compressed springs may be likened to a large number of safety valves under the babbitt. If pressures in local areas, due to slight faults in alignment or manufacture, are greater than those of the preloading of the springs, then the springs will automatically yield to avoid dangerous pressures.

Individual spring, showing method of compression.

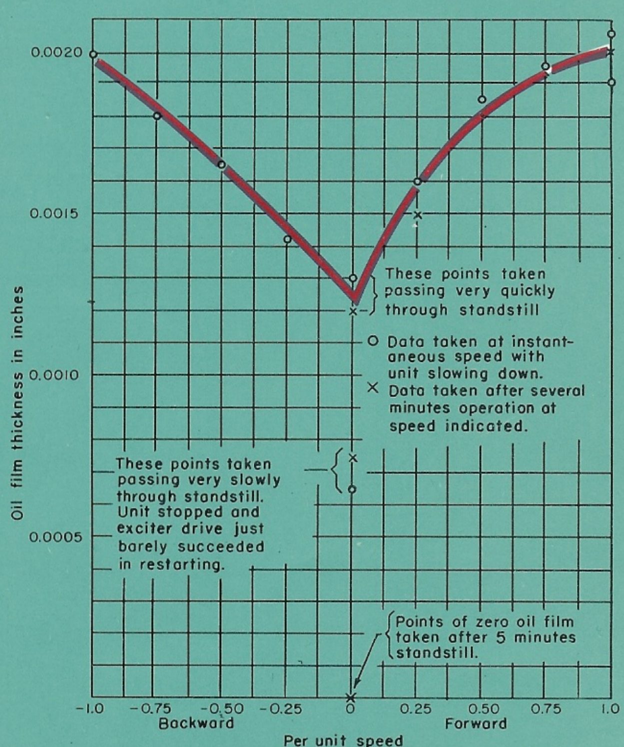


OPERATING CHARACTERISTICS

OIL-FILM THICKNESS AND STABILITY

The minimum value of the variable oil-film thickness already described is of the order of thousandths of an inch, and depends on such factors as load, speed, and oil viscosity. The curve below shows the variation of minimum film thickness with regard to speed for a particular machine. This relationship is not proportional to speed alone, but also involves time in a rather complicated manner. If a machine comes to rest after an oil film has once been established, that film persists for an appreciable time. The film has, therefore, an essentially stable characteristic not readily destructible by causes of short duration. Because of the residual oil film at zero speed, a very large machine, after it has started to rotate, can be maintained in motion by hand by one or two men. Two men can often restart a large machine and keep it rotating by hand, after it has been stopped for an instant.

This stability of the oil film was well demonstrated in the case of a G-E thrust bearing of 92 inches outside diameter with a normal speed of 88 rpm. As a result of a series of accidents, this bearing operated for more than two hours at 2 to 3 rpm, successfully carrying the weight of the rotating parts, about 1,400,000 pounds.



Curve showing variation of oil-film thickness with change of speed

WEAR AND NOISE AT STARTING

The progress made in the design and manufacture of G-E thrust bearings has produced a bearing that requires little attention during normal operation. There is practically no wear, with the possible exception of that which may occur at the instant of starting or stopping, when the oil film is thin. The wear under these conditions is small, for one reason, because of the inherent characteristic that oil has in forming an adsorbed coating on the surfaces, which has sufficient stability to persist until a complete film is formed. This stability is evidenced by the low coefficient of static friction occasionally observed. Another reason for small wear lies in the use of a babbitt with a minimum dry-wear rate.

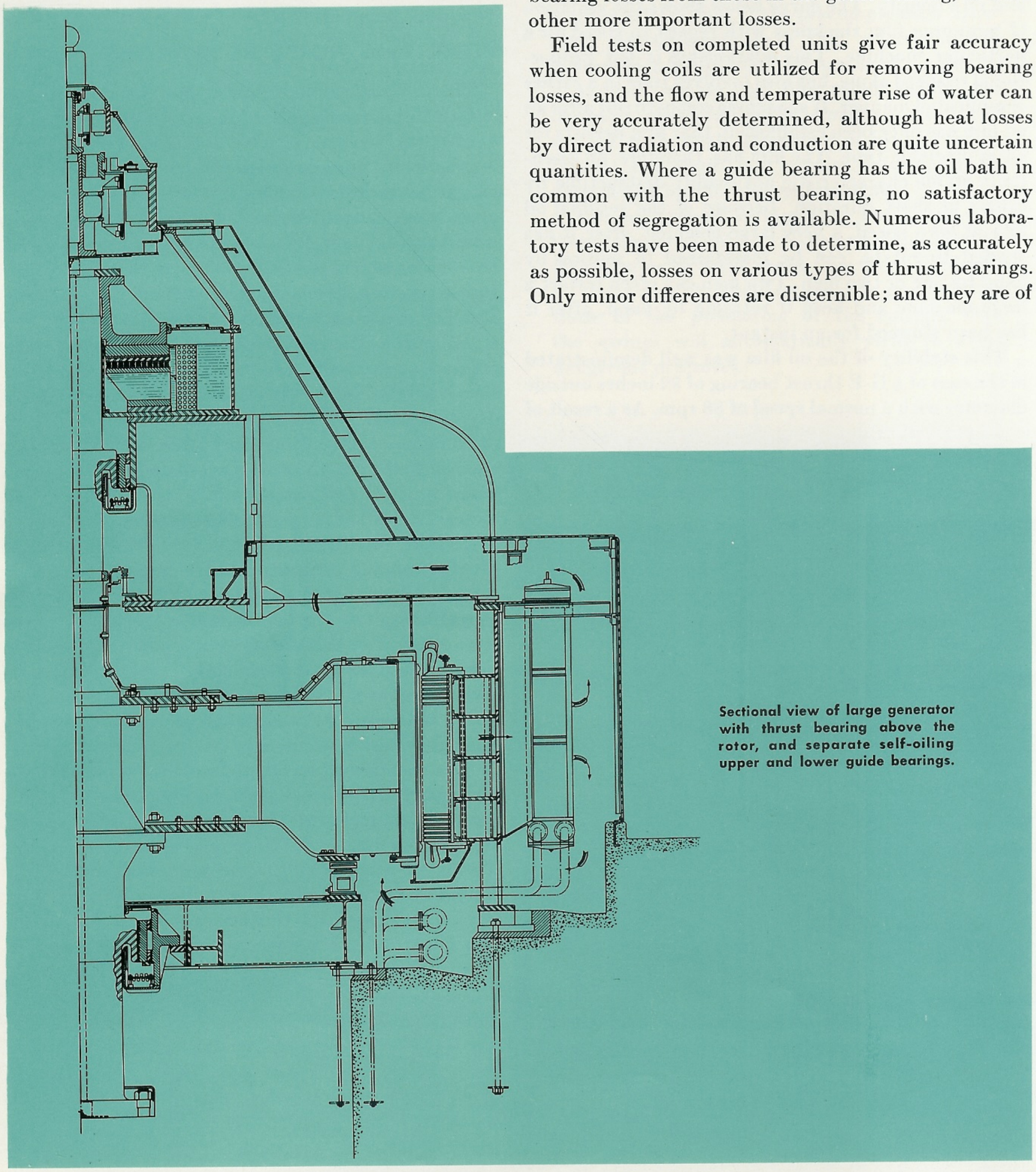
Many operating companies have noticed in their vertical units, after a shutdown period of any extent, that there is a distinctly audible noise at the instant of starting. This noise has been variously described as a grunt, twang, or groan. It does not appear to be peculiar to units with thrust bearings of any particular manufacture. Because of the apparently erratic characteristic of the noise, it has sometimes been erroneously attributed to frictional distress. Observations on a number of machines show that the total energy involved could be one hundred times the calculated noise energy without approaching the energy conditions which would exist at a bearing failure. By using a sound-level meter, it has been found that the major part of the sound generally emanates from some part of the structure which resonates freely, as, for example, a cover over the top of the oil housing. The starting of relative motion between surfaces initially at rest is an alternate change from static to sliding friction and then back to static, similar to the passage of a finger, at the proper angle, over a dull surface. When sufficient velocity is attained between the points of metallic contact, the static friction gives way to a lesser running friction. Hence, it can be seen that the starting of a vertical-shaft unit consists of a series of forward jumps and stops, until an oil film is formed which furnishes smooth operation of the bearing. During the period of jerky motion, resonating parts are set into vibration, producing the noise.

BEARING LOSS

In electric machines, bearing losses are relatively unimportant, as far as machine efficiencies are concerned, because of their small magnitude in comparison with other losses. Consequently, the main purpose in having accurate data on losses is associated primarily with methods of cooling or of otherwise dissipating bearing losses without excessive temperature rises.

The technical press is replete with articles discussing careful measurements and methods of observation to determine these losses accurately. These articles are significant in their lack of uniformity in results, simply because so many widely variable factors, such as temperature, oil viscosity, finish of parts, and loading conditions, all enter into the determination, to say nothing of the difficulties of segregating thrust-bearing losses from those in the guide bearing, or from other more important losses.

Field tests on completed units give fair accuracy when cooling coils are utilized for removing bearing losses, and the flow and temperature rise of water can be very accurately determined, although heat losses by direct radiation and conduction are quite uncertain quantities. Where a guide bearing has the oil bath in common with the thrust bearing, no satisfactory method of segregation is available. Numerous laboratory tests have been made to determine, as accurately as possible, losses on various types of thrust bearings. Only minor differences are discernible; and they are of



Sectional view of large generator with thrust bearing above the rotor, and separate self-oiling upper and lower guide bearings.

less significance than variations which accompany loading, temperature, and oil viscosity during operation. G-E thrust bearings are designed for loadings of approximately 400 to 600 pounds per square inch.

BEARING TEMPERATURES

What is the proper operating temperature for a bearing under full load? No single figure can be given, since this temperature depends on many factors such as speed, size of oil cooler, temperature of cooling water or surrounding air, and location of the thermometer bulb. Thus, the proper, normal temperature of a large bearing operating at high speed will be higher than that of a bearing with lighter duty.

Once a steady temperature has been reached during a period of normal load, one can assume that the bearing is functioning properly, whether the temperature seems high or low. Any trouble with a bearing is usually indicated promptly by a change in temperature. Therefore, the attendants should be alert to any change from the established normal for the bearing in question. It should be remembered that a thermometer in the bearing metal may read much higher than one in the oil.

TYPE OF CONSTRUCTION

BEARING ARRANGEMENT

A guide bearing can be either combined with the thrust bearing, that is, operating in the same oil bath, or it can be separately mounted and operated in an independent oil bath. It is current practice to design the majority of guide bearings, irrespective of location and arrangement, to be self-oiling, without the need of an external pump. Combined guide bearings can be made either solid or in segments for ready disassembly. For removal, the bearings are raised from their seats and split, if necessary. Separate guide bearings are made in two or more sections. After removal of the oil pans, the bearings can be lowered, split, and removed horizontally, without disturbing other parts of the unit.

The thrust and guide bearings of a vertical machine can be arranged in various relations to the rotor. The most common types are described below:

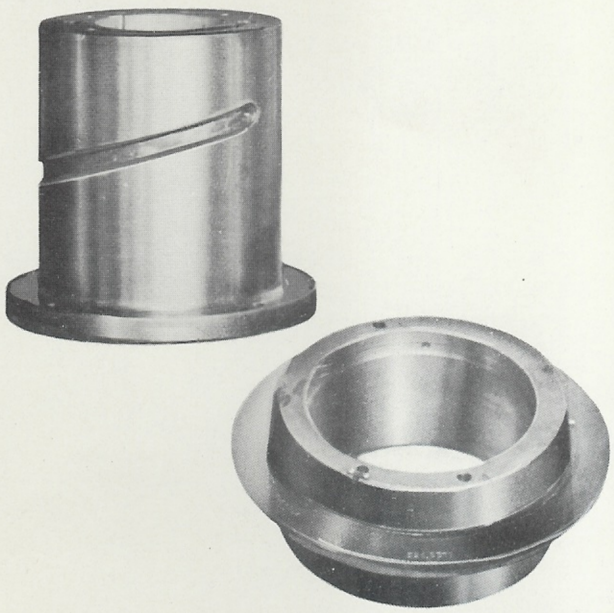
1. With the conventional bearing arrangement, in use for many years on vertical machines, the thrust bearing is located at the top of the machine, and both upper and lower guide bearings are employed. For small ratings, and for all ratings at high speeds, this arrangement is the only practical one because of the limited space in the pit beneath the machine.

In the smaller sizes, the upper guide bearing is of the "combined" type, acting on the thrust collar and operating in the same oil bath as the thrust bearing. The illustrations on pages 11 and 15 show the details of this type of construction and the way in which oil is supplied to the guide bearing through a passage in the thrust collar, which leads to a helical groove in the journal surface. This construction gives a very positive pumping of oil, even at low shaft speeds.

In larger sizes, where radial-arm brackets are desirable to support the very heavy loads encountered, it is often perferable to employ a separate upper guide bearing, located at the center of the radial arms; the thrust bearing is located in a shallow housing above the bracket. The illustration on page 10 shows a sectional view of such a machine.

2. In the second arrangement, the thrust bearing is located below the rotor, and both upper and lower guide bearings are supplied, as in the case of the conventional machine. Some characteristics of this type of construction are as follows:

a. To permit convenient handling of the bearing parts, this arrangement is most attractive for units of relatively large diameter corresponding to medium and large ratings at medium and low speeds.



Thrust collar and guide bearing, showing oil grooves.

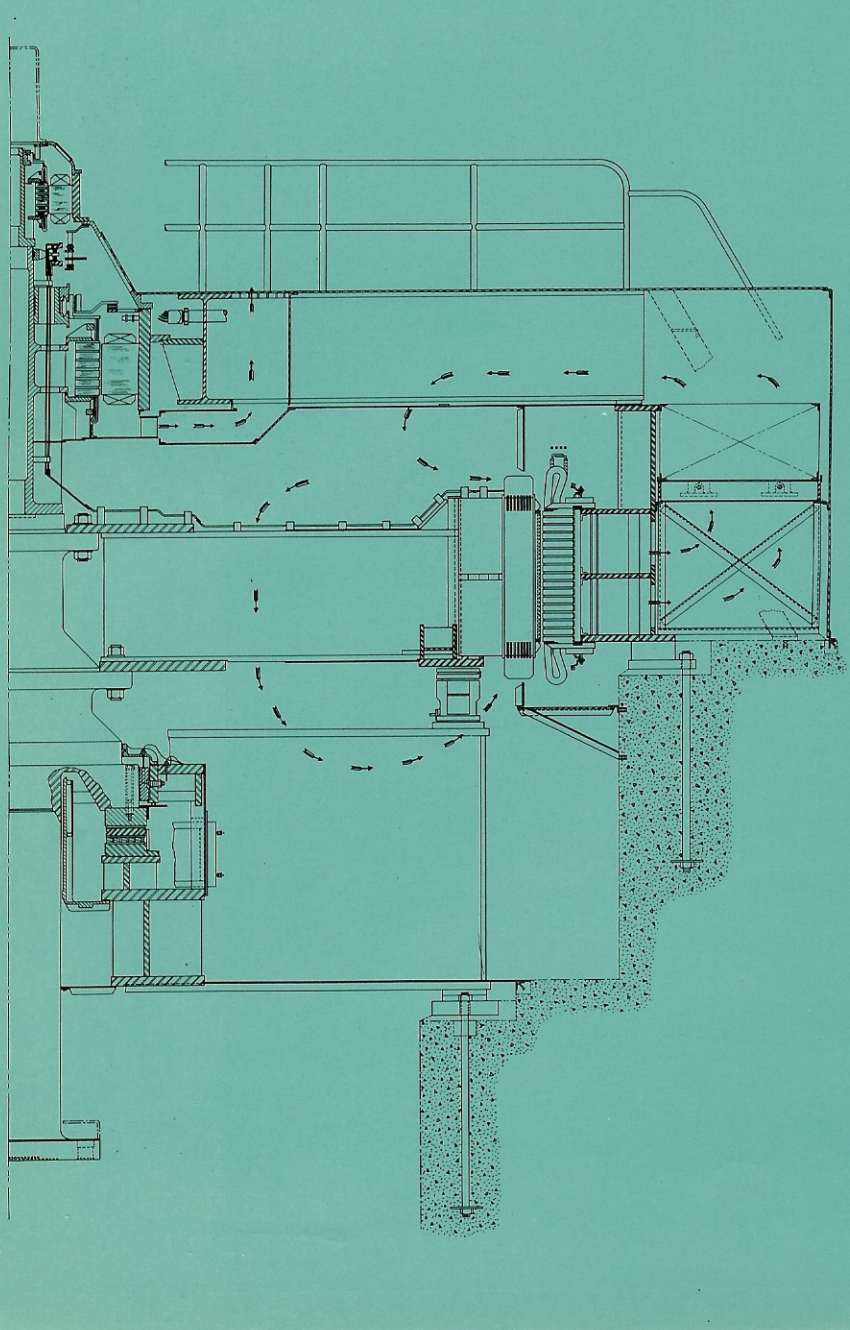
b. The coupling is located farther below the stator than in the conventional arrangement. If, in the design of the powerhouse, it is possible to lower the coupling with respect to the floor elevation, this construction may give lower headroom. In most cases where the coupling elevation is the initial point of reference, little benefit in headroom is derived from this arrangement, provided proper handling devices are used with each design. In many cases, parts other than the generator may determine the required headroom.

c. The rotor can be removed, thus making both rotor and stator accessible, without breaking the coupling or distuıbing the alignment of the shaft and lower bearings. This accessibility reduces the labor of reassembling the unit.

d. The heaviest lift for the crane is the rotor less shaft and hub, since the bearing is left in place to support the shaft, and the rotor is picked off separately.

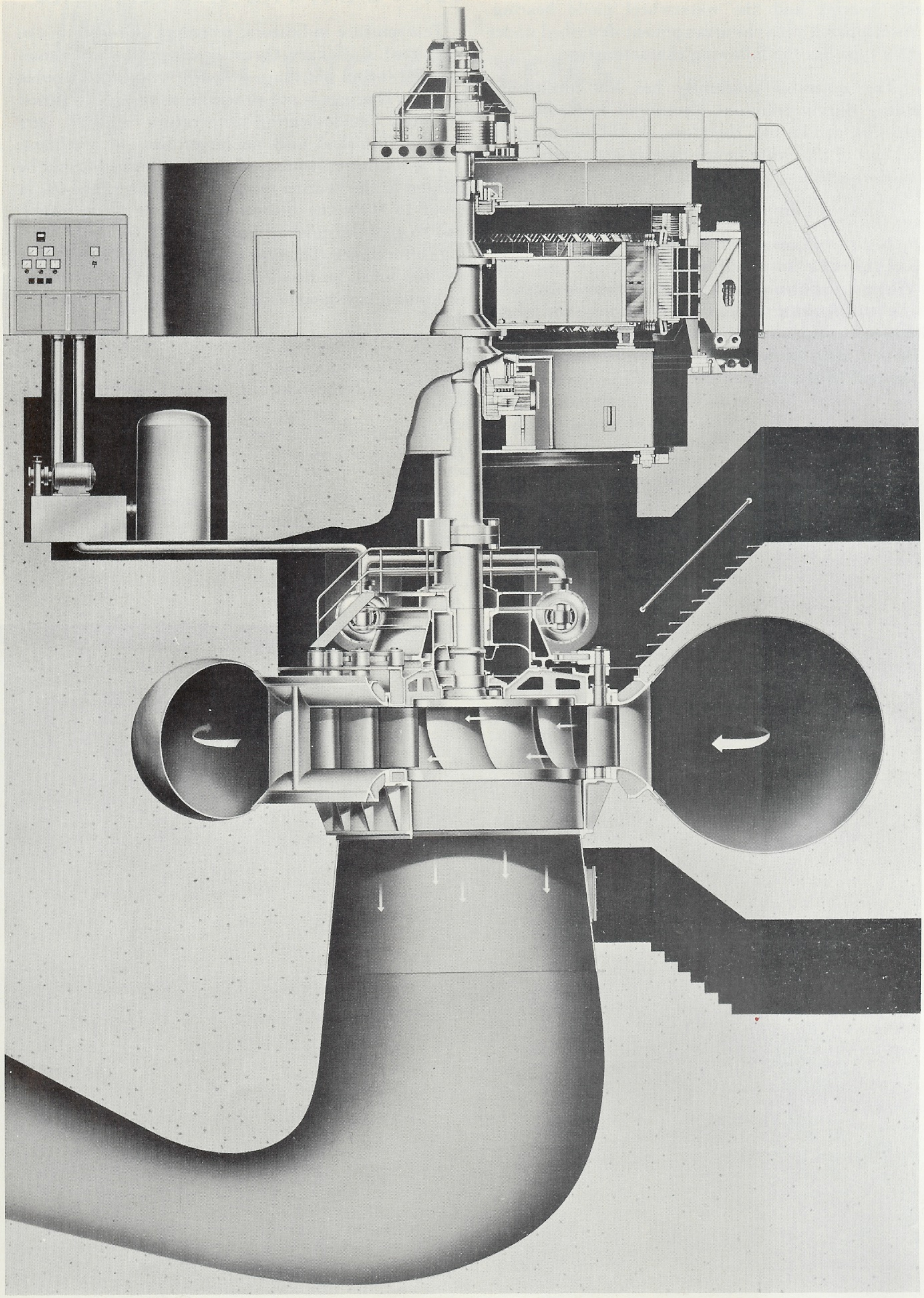
Either a combined lower guide and thrust bearing, or separate lower guide and thrust bearings can be used, depending upon size. The combined bearing, which is more common, is illustrated on pages 12, 13 and 14. The housing is integral with the bracket. The thrust-bearing runner also is in sections, and can be taken out sidewise through the covered openings. The guide bearing shown consists of separate segments which permit changing the bearing clearance and the position of the shaft. For dismantling, the segments can be raised and removed individually.

Starting in 1924, a number of machines of the over-hung type have been put in service. Originally, this construction was developed with a view to obtaining a saving in station headroom. In these machines the thrust and a guide bearing are placed below the rotor, and no guide bearing is used above the rotor.



Sectional view of hydraulic turbine-driven generator with combined guide and thrust bearing below the rotor and without upper guide bearing.

Sectional view of 50,000-kva, 105.9-rpm hydraulic turbine-driven generator with combined guide and thrust bearing below the rotor and self-oiling upper guide bearing, driven by a Francis-type turbine.



Alignment of the unit depends on the one generator guide bearing and the waterwheel guide bearing.

As compared with the arrangement described under 2, this type has the following characteristics:

a. The generator inherently has less mechanical stability during transient electric or hydraulic disturbances, and its use, therefore, should be limited to machines of moderate or low speeds and, preferably, of moderate size.

b. It may require slightly less headroom.

c. Testing of generators of this type with the waterwheel disconnected would be difficult.

Where an appreciable saving in station cost can be made by the minor reduction in headroom, and where the speed and characteristics are suitable, this construction may be justifiable. Other advantages are, in general, of a minor nature.

TEMPERATURE INDICATORS

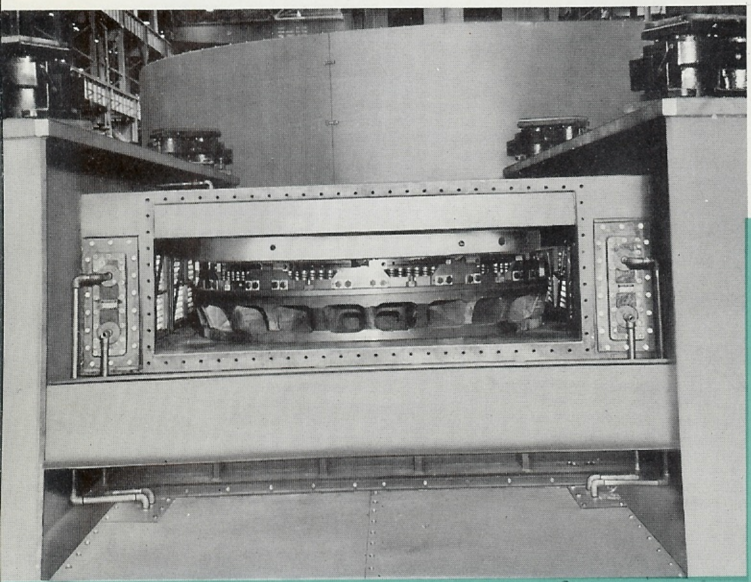
Temperature indicators, recorders or relays in the babbitted, stationary, thrust-bearing plates are recommended for all machines over 500 kva. Since trouble in guide bearings is not so serious as trouble in thrust bearings, guide-bearing-temperature devices are usually furnished only on larger sizes of machines.

The sensitive elements of thermal devices should be located in the bearing metal rather than in the oil, in order to show the highest measurable temperature, and to give the quickest indication of change of bearing performance. The type and number of temperature devices must be decided locally, but the following equipment is recommended, in order of relative value:

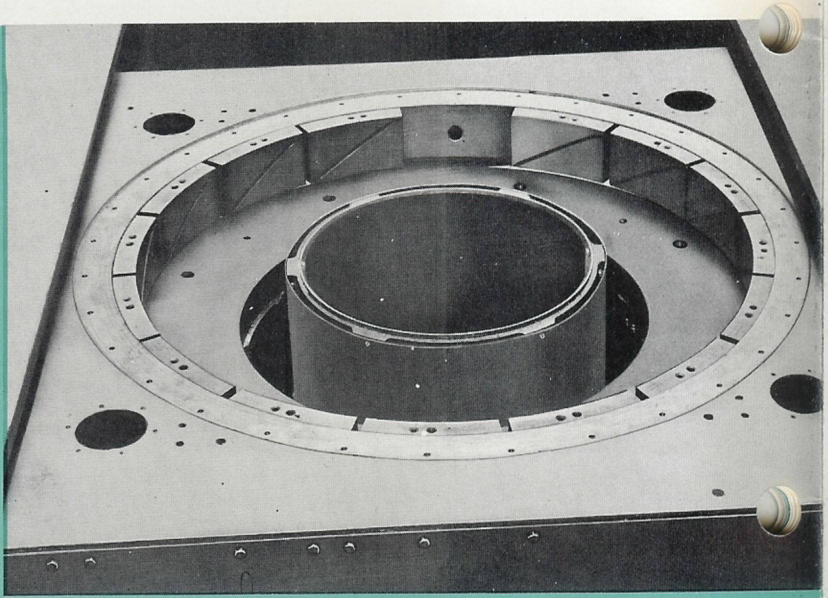
1. A dial-indicating thermometer with alarm contacts and a long, capillary tube, to permit the instrument to be located at the operator's control board.

2. One or two resistance-temperature detectors connected to a recorder.

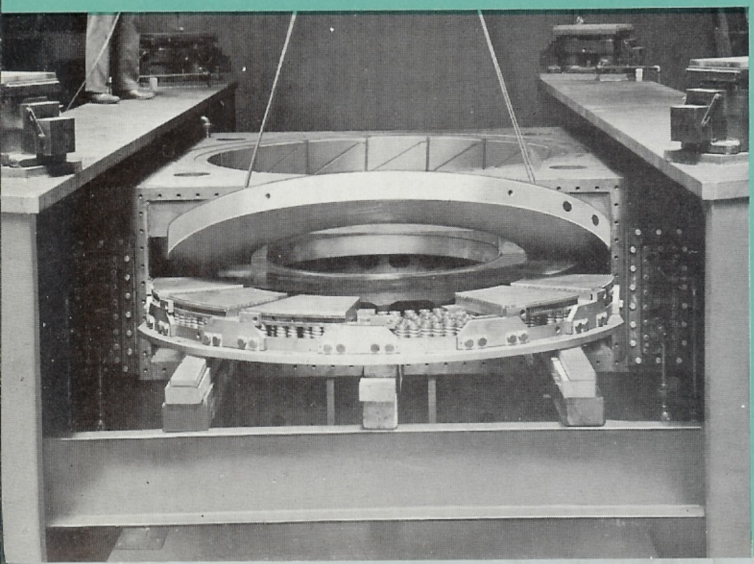
3. One temperature relay for emergency shutdown, in case of failure of the bearing.



Lower bearing bracket showing bearing base ring, spring cage, springs, babbitted segments and runner in position in bearing housing of large unit.



Lower bearing bracket with segment of guide bearing removed and with thrust bearing assembly in position.



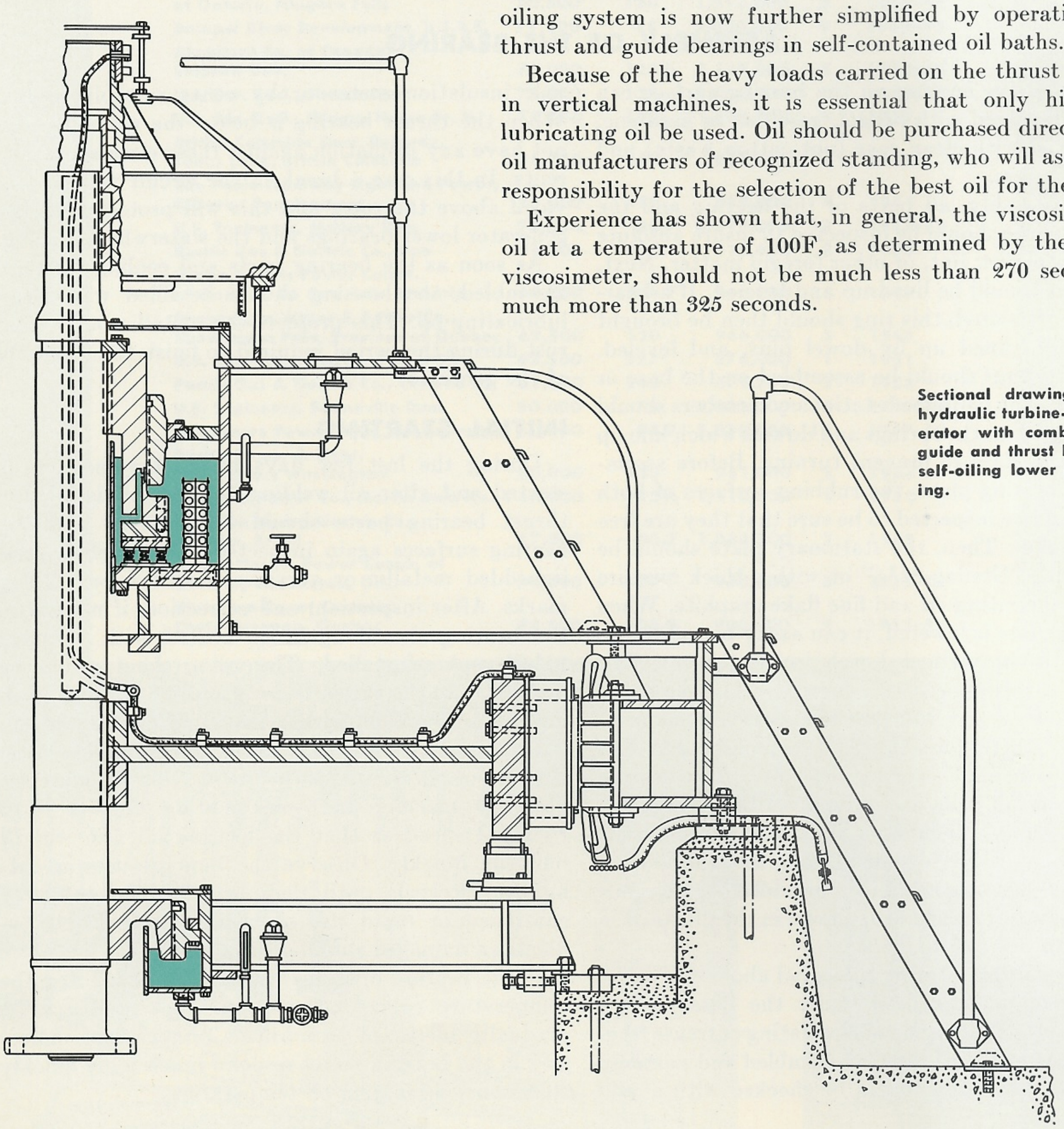
Lower bearing bracket with section of runner and half of spring cage showing springs and part of babbitted segments in position used for installing in bearing housings.

OILING SYSTEMS

Early practice employed station oiling systems in which all oil was circulated through the station filter and back to the bearings. In stations where the number of units was large, the piping required was quite complicated, and a unit oiling system was developed as an improvement. This latter system provided a small filter for each machine, and the oil was circulated through the filter and back to the bearings, usually by means of gear-driven pumps. It has been found that continuous filtering of oil is not necessary, and the oiling system is now further simplified by operating both thrust and guide bearings in self-contained oil baths.

Because of the heavy loads carried on the thrust bearings in vertical machines, it is essential that only high-grade lubricating oil be used. Oil should be purchased directly from oil manufacturers of recognized standing, who will assume the responsibility for the selection of the best oil for the service.

Experience has shown that, in general, the viscosity of the oil at a temperature of 100F, as determined by the Saybolt viscosimeter, should not be much less than 270 seconds, or much more than 325 seconds.



Sectional drawing of small hydraulic turbine-driven generator with combined upper guide and thrust bearing and self-oiling lower guide bearing.

INSTALLATION OF G-E THRUST BEARING

The simplicity of this bearing, which consists of only three principal parts—a stationary member, a rotating plate, and set of springs—and the inherently uniform loading obtained with the spring support, makes the General Electric thrust bearing the simplest and quickest to install or disassemble.

FACTORY FINISH AND PROTECTION DURING SHIPMENT

The bearing surface of the rotating plate is carefully ground and polished at the factory to obtain a true and smooth surface. The stationary, babbitted member is machined to a uniform thickness. Because of the flexibility of the member and its spring support, the G-E thrust bearing is put in service without fitting or scraping.

All steel or iron bearing surfaces are shipped from the factory with a protective coating to prevent rust. The rotating plate is packed in a special manner to prevent the protective coating from rubbing off and the polished-bearing surface from being scratched.

ASSEMBLY OF THE BEARING

The protective coating on the bearing surface can be easily dissolved with benzol, gasoline, or kerosene, and removed with clean rags (not cotton waste) and wooden scrapers.

Before assembly, all parts of the bearing and the bearing housing should be inspected to insure absolute freedom from dirt, lint, or other foregin matter. Next, the bracket should be lined up and leveled. If a bearing base ring is used, this ring should then be brought into position, lined up by dowel pins, and leveled. Next, the springs should be assembled on the base or spring cage. The babbitted stationary members should then be placed on the springs and dowels which line up and hold the plate to prevent turning. Before assembling the rotating plate, the rubbing surfaces of both plates should be inspected to be sure that they are free from scratches. Then, the stationary plate should be covered with "Gredag 81½" or with a thick mixture of heavy lubricating oil and fine flake graphite. When the runner plate is lowered, it can easily be rotated to line up with the vertical dowels in the thrust collar.

When the thrust bearing is located below the rotor, both stationary and rotating members are made in sections to make possible their assembly and disassembly without disturbing the rotor. The bearing parts are assembled in the order described above, but instead of being lowered over the top of the shaft the section should be carried horizontally into the bearing housing through large openings provided for this purpose. This is the arrangement shown in the illustration on pages 12, 13, and 14.

When the thrust bearing is located above the rotor, insulating material is used under the base ring to prevent flow to the bearing of circulating currents from the shaft. After the bearing is assembled and partially loaded, this insulation should be checked with a 500-volt insulation meter or by other suitable means. When the thrust bearing is below the rotor, it need not have any insulation against these circulating currents. In this case a break in the circuit will be provided above the rotor and this will protect both the generator lower bearings and the waterwheel bearing.

As soon as the bearing parts and cooling coils are assembled, the housing should be filled with clean lubricating oil. This protects the metallic parts from rust during the period required to finish the assembly of the generator.

INITIAL STARTING

During the last few days before the machine is started and after all welding has been finished, the thrust bearing parts should be removed and the bearing surfaces again inspected for scratches, rust, imbedded metallic or abrasive particles, or welding marks. After inspection, and correction, if necessary, the bearing should again be coated with "Gredag 81½" and reinstalled. The rotor should then be lowered onto the thrust bearing and the housing filled, flushed, and refilled with clean, carefully filtered oil.

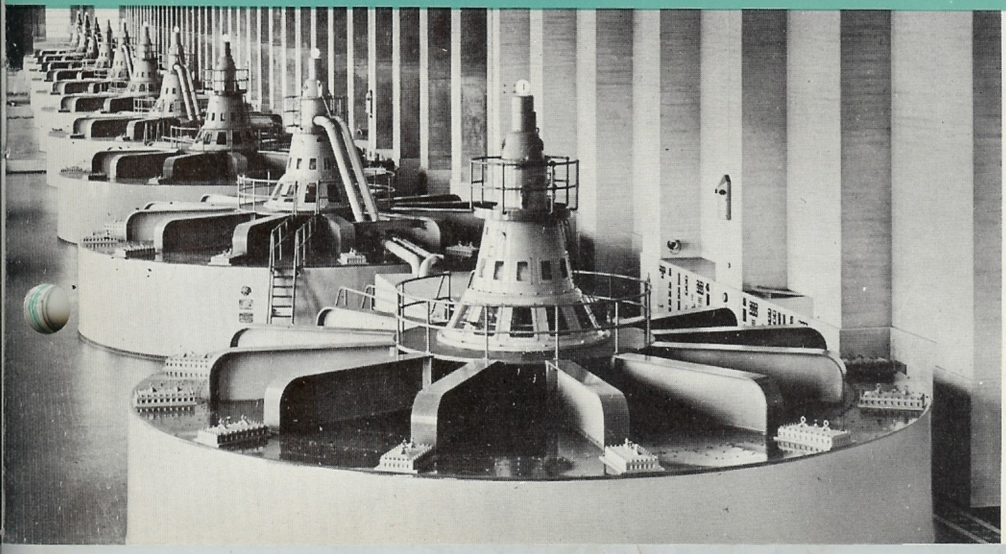
If there are cooling coils in the thrust bearing housing turn on the water just before starting the machine. Start the machine and quickly bring it up to ⅓ to ½ rated speed so that the bearing oil film will be built up quickly. Observe the temperatures at one-minute intervals until they become constant. Any continued or rapid rise of bearing temperature indicates a damaged rubbing surface.

If the bearing operates well at this speed and the temperature curve flattens out, the speed can be gradually increased to normal. Temperature indicators in the bearing metal respond much more quickly than those measuring oil temperature.

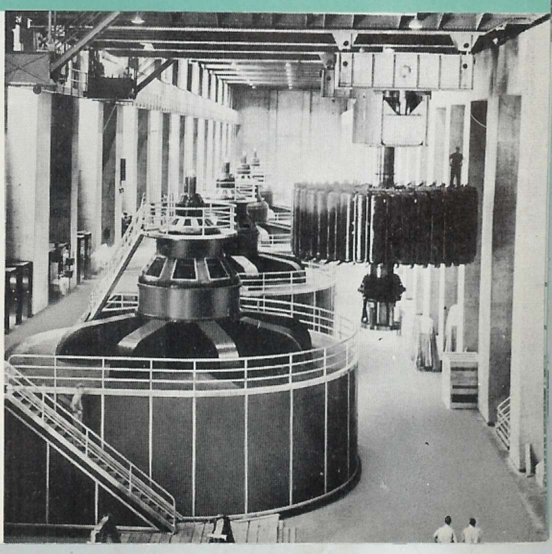
Partial List of Installations of Vertical-shaft Machines with G-E Thrust Bearings

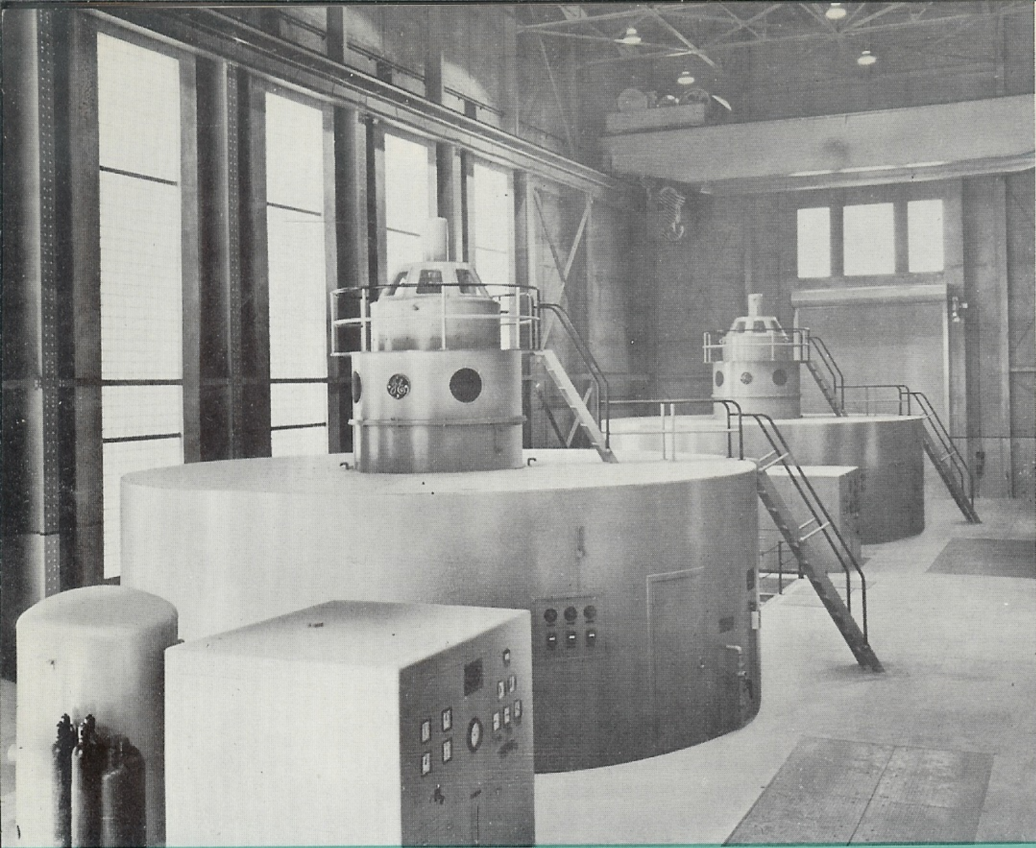
Purchaser	Machine Kva	Machine Rpm	Bearing Load Pounds	No. of Units	Approx Date of Installation
Aluminum Co. of Canada, Kemano, British Columbia	106,000	327	743,000	1	1953
U.S.S.R., Dnieprostroi	90,000	83.3	2,080,000	3	1947
U.S. Engineers, Garrison Dam	84,210	90	2,145,800	3	1954–55
U.S. Engineers, Garrison Dam	82,210	90	1,680,000	2	1959–60
U.S. Bur. Recl., Hoover Dam	82,500	180	1,786,000	3	1936–44
U.S. Engineers, The Dalles Dam	82,105	85.7	3,816,500	14	1957–60
Hydro-Electric Power Comm. of Ontario, Niagara Falls	80,500	150	1,311,000	6	1954–55
Dnieper River Development, U.S.S.R.	77,500	88	2,000,000	9	1932–33
Aluminum Co. of Canada, Shipsaw Dev.	75,000	128½	1,120,000	5	1943–44
U.S. Bur. Recl., Shasta Dam	75,000	138	1,500,000	5	1943–48
U.S. Bur. Recl., Hungry Horse Pr. H.	75,000	180	1,660,000	4	1952
British Columbia Elect. Railway, Jones Lake, British Columbia	75,000	360	515,000	1	1952
Sao Paulo Tramway Light and Power, Cubatao Development	75,000	450	335,000	4	1954
U.S. Engineers, McNary Dam	73,684	85.7	4,012,000	12	1953–55
Pacific Gas & Electric Co., Poe	69,000	225	819,600	2	1958
Hydro Electric Power Comm. of Ontario, De Cew Falls, Ontario	64,000	166.7	940,000	1	1947
Shawinigan Water & Power Co., Shawinigan Falls, Province of Quebec	62,500	120	966,000	3	1948
U.S. Bur. Recl., Hoover Power Pl.	62,500	257	878,000	1	1951
Pacific Gas & Electric Co., Caribou #2	61,000	240	471,735	2	1958
U.S. Engineers, Bonneville Dam	60,000	75	3,000,000	8	1940–43
N. Y. State Power Auth., St. Lawrence	60,000	94.7	2,579,000	16	1957–59
Pacific Power & Light, Lewis River, Washington	60,000	150	981,000	2	1953
Alabama Power Co., Martin Dam No. 4	60,000	112½	1,210,000	1	1952
Brazilian Hydro-Electric Co., Paraiba, Brazil	57,500	93.7	1,088,500	1	1949
Hydro-Electric Power Comm. of Ontario, Queenston, Ont.	54,000	187	950,000	5	1922–25
Aluminum Co. of Canada, Chute Savanne, Quebec	53,500	105.9	900,000	5	1952–53

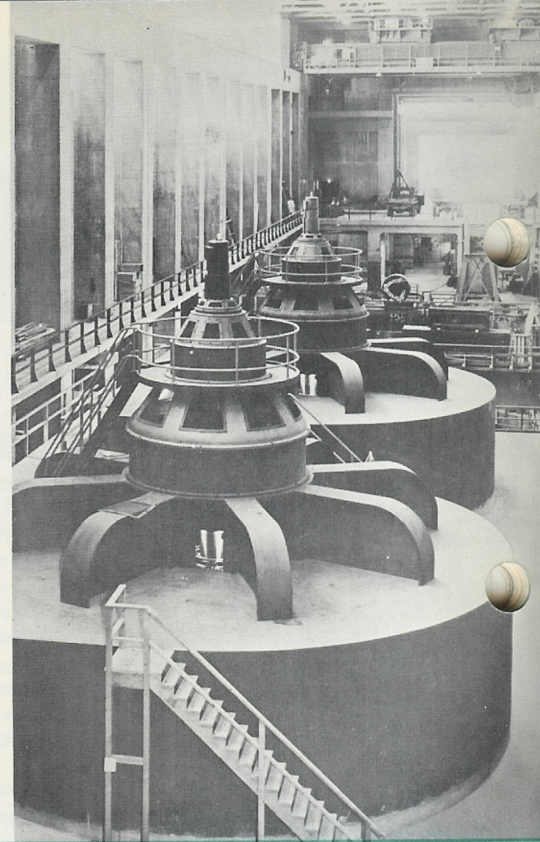
Eight 60,000-kva and two 48,000-kva, 75-rpm generators in the Bonneville Power Plant, Oregon



5 G-E generators, each rated 82,500-kva, 180-rpm in Nevada wing of Hoover Power Plant

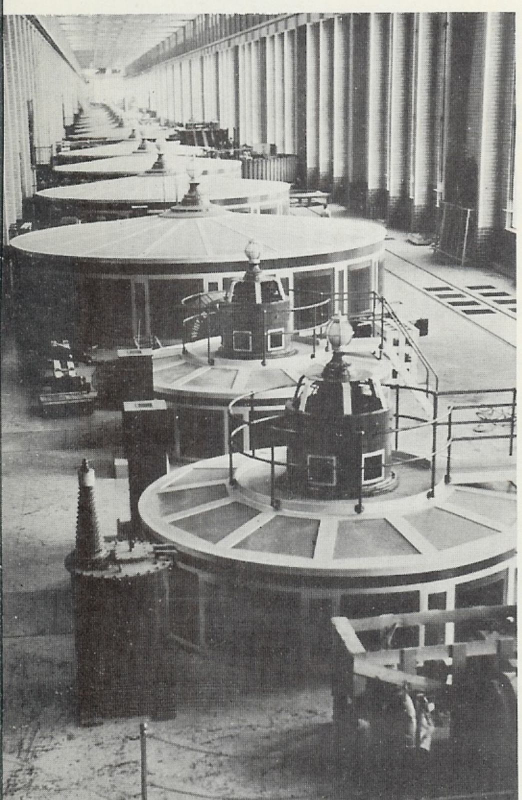






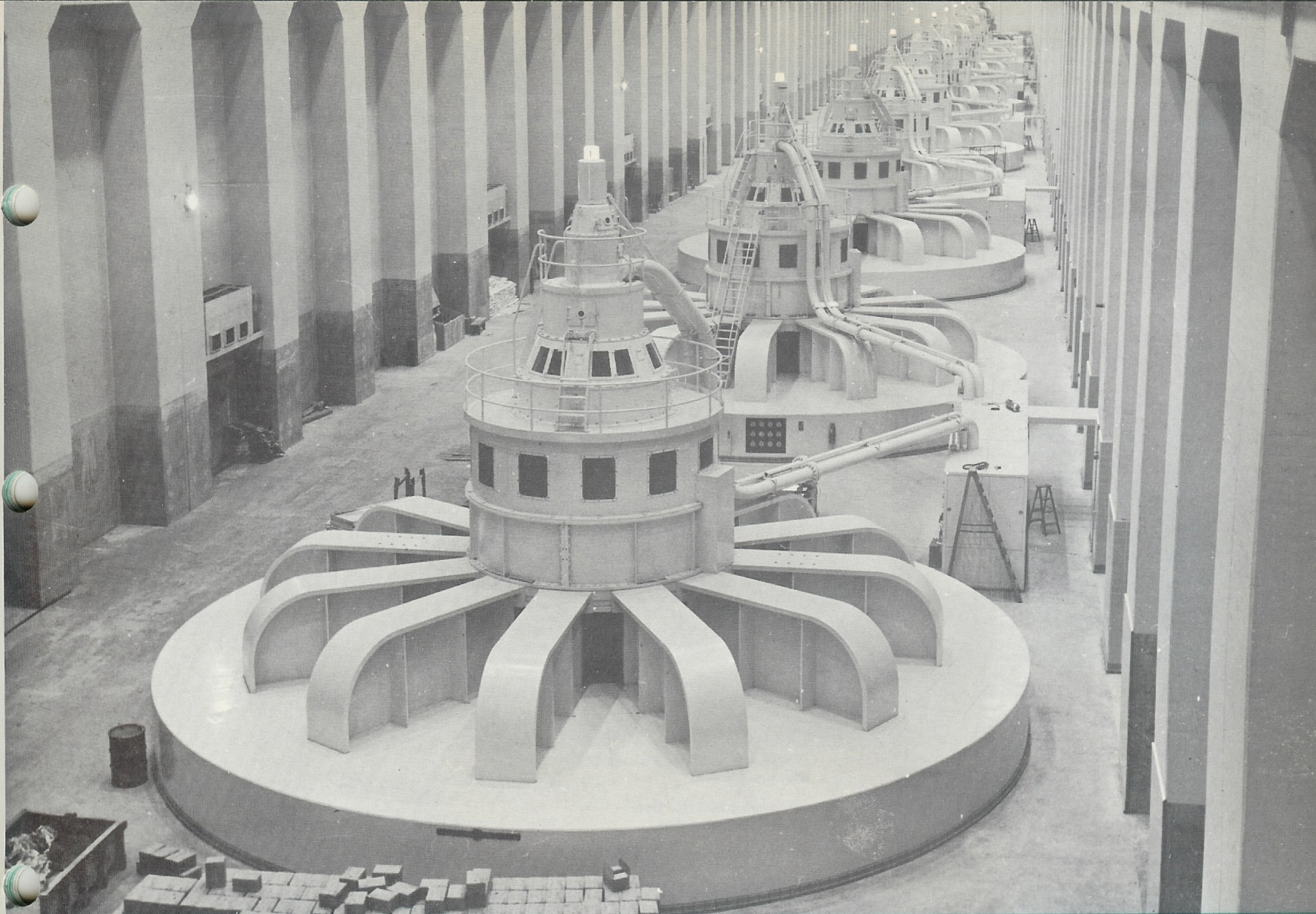
Two 37,500-kva General Electric generators in operation at the Cresta station of the Pacific Gas and Electric Company.

Two of five 75,000-kva, 138-rpm generators in the Shasta Power Plant, Central Valley Project, California.

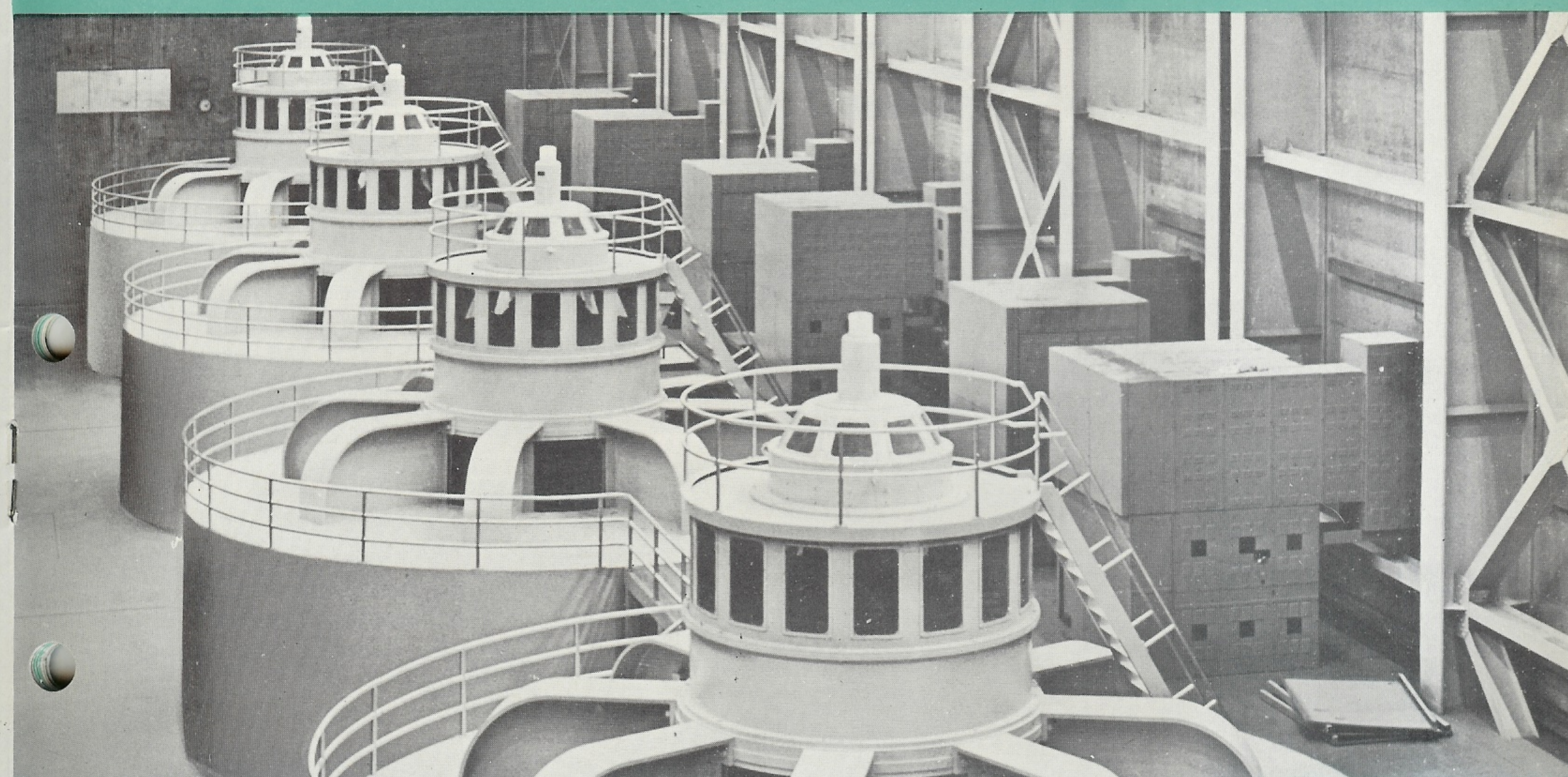


In the background, eight 46-625-kva, 75-rpm generators, Beauharnois Light, Heat and Power Company, Beauharnois, P.Q.

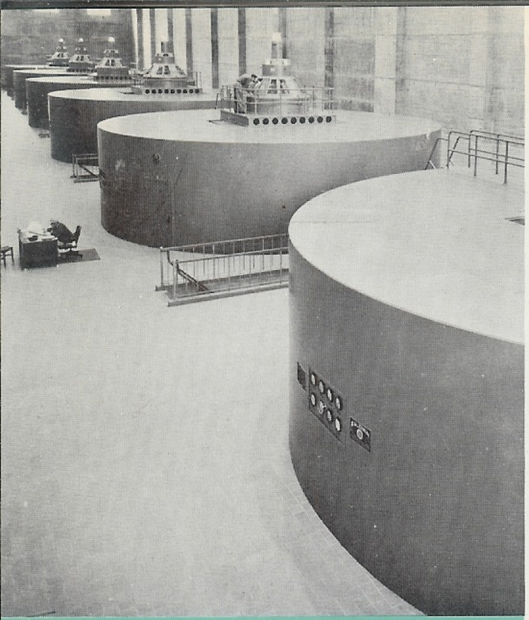
Purchaser	Machine Kva	Machine Rpm	Bearing Load Pounds	No. of Units	Approx Date of Installation
Shawinigan Water & Power Co., LaTrenche, Canada	53,000	128	858,000	5	1950–51
Beauharnois Lt. Heat & Pr., Beauharnois, Canada	51,400	75	1,370,000	3	1950–51
Beauharnois Lt. Heat & Power, Beauharnois, Quebec	50,000	75	1,370,000	4	1952–53
U.S. Engineers, Wolf Creek	50,000	105.9	1,186,000	6	1951–52
U.S. Engineers, Center Hill	50,000	105.9	1,186,000	3	1950–51
U.S. Bur. Recl., Grand Coulee, Pump Motors	50,000	200	640,000	2	1951
Pacific Gas & Electric Co., Pit 4	50,000	225	748,150	2	1955
Ontario Power Service Corp., Abitibi Canyon, Ontario, Canada	48,500	150	844,000	5	1932–33
U.S. Engineers, Bonneville Dam	48,000	75	3,000,000	2	1937
N. Y. Pr. & Lt. Corp., Spier Falls, N. Y.	47,000	82	1,300,000	1	1930
Beauharnois Light, Heat & Power Co., Beauharnois, Canada	46,625	75	1,350,000	8	1932–48
U.S. Bur. Recl., Davis Dam	45,000		1,380,000	5	1949
U.S. Engineers, Clark Hill	44,444	100	991,000	7	1952–54
Beauharnois Light, Heat & Power Co.	43,883	75	1,391,000	5	1932–39
U.S. Engineers, Lookout Point	42,222	128	1,026,000	3	1954
Sociedad Hidroeléctrica Ibérica Castro	42,000	107	1,267,000	2	1951
So. Calif. Ed. Co., Big Creek No. 4	42,000	257	704,000	1	1951
Susquehanna Power Co., Conowingo, Md.	40,000	82	1,400,000	4	1928
Shawinigan Water & Power Co., La Tuque, Canada	40,000	112½	650,000	5	1940–44
Shawinigan Water & Power Co., Shawinigan Falls, Canada	40,000	138	705,000	1	1922
Shawinigan Water & Power Co.	40,000	138	682,000	1	1928
Shawinigan Water & Power Co.	40,000	138	682,000	1	1929
Imatra, Finland	40,000	150	1,930,000	1	1951



Twelve G-E generators rated 73,684-kva, 85.7-rpm at the Walla Walla District, Corps. of Engineers, McNary Dam, Columbia River, Oregon.
Photo courtesy of Walla Walla District, Corps of Engineers



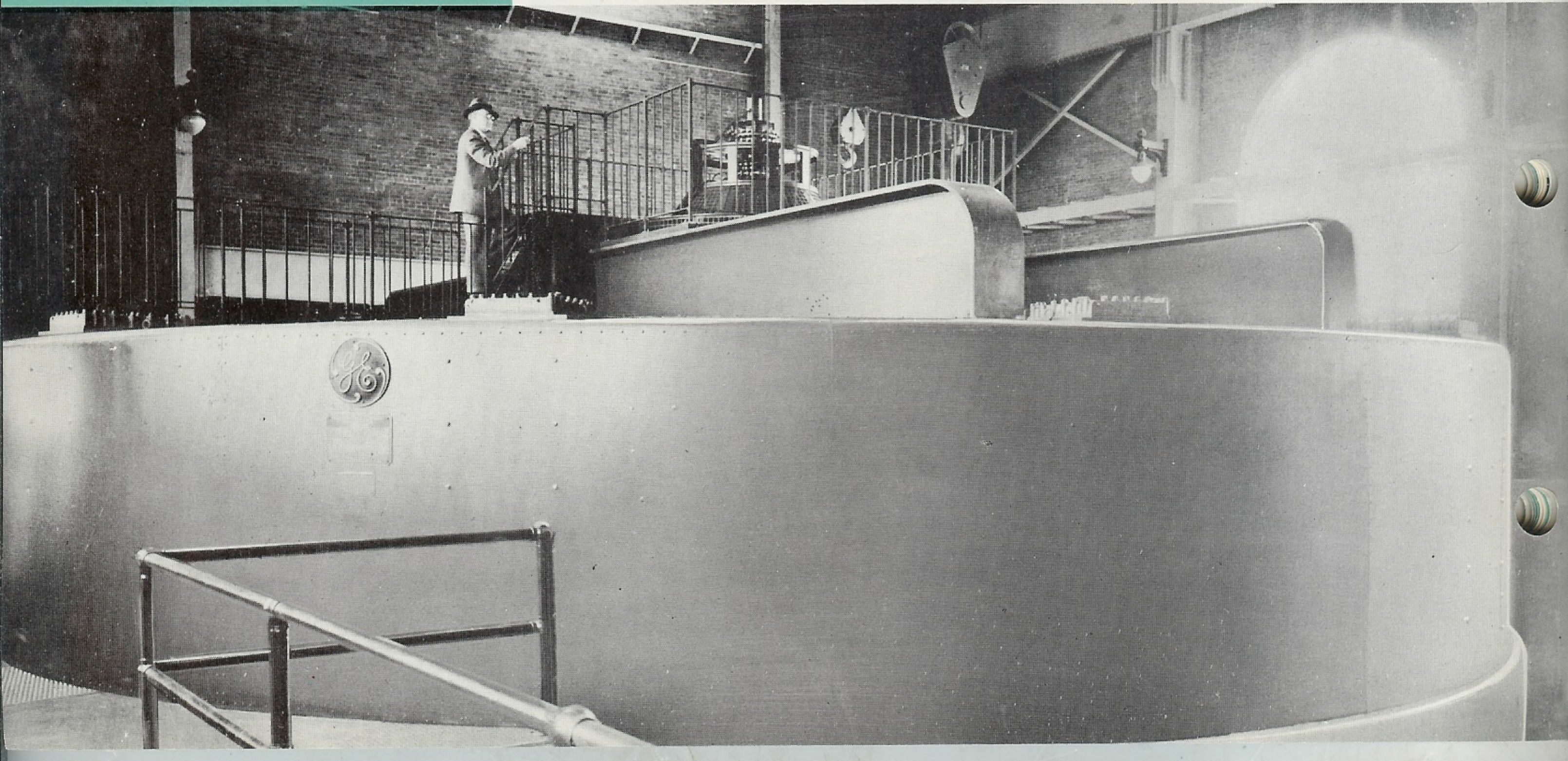
Four generators rated 75,000-kva, 180-rpm at U.S. Bureau of Reclamation, Hungry Horse Dam, Coram, Montana.



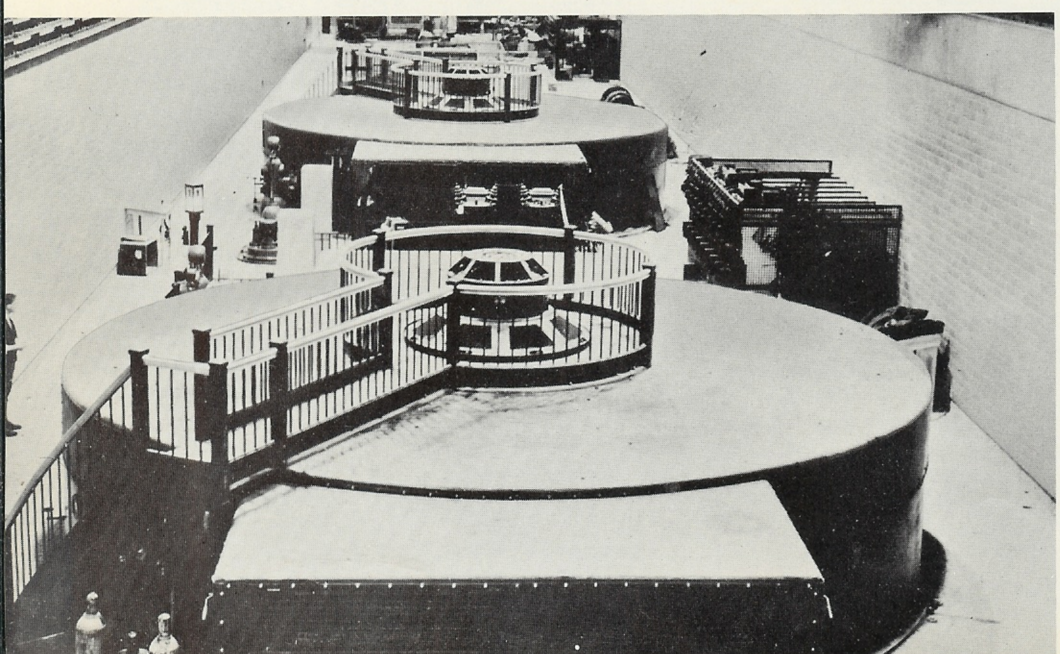
Six generators rated 50,000-kva, 105.9-rpm, at Wolf Creek Power Plant, Jamestown, Kentucky.

Purchaser	Machine Kva	Machine Rpm	Bearing Load Pounds	No. of Units	Approx Date of Installation
Pyhakoski, Finland	40,000	150	2,060,000	2	1950–51
Department of Public Works, Maractai Development, New Zealand	40,000	166.7	530,000	5	1949
Pacific Gas & Electric Co., Butt Valley	40,000	200	588,500	1	1958
Pacific Gas & Elec. Co., Pit 5	40,000	300	575,000	2	1944
Lindoso, Portugal	40,000	333	533,000	1	1950
Alabama Power Co., Martin Dam, Ala.	37,500	120	690,000	3	1926
Pacific Gas & Electric Co., Cresta, Calif.	37,500	180	680,000	2	1949
Quebec North Shore Power Co., Manicouagan, Quebec	37,500	112½	816,000	2	1953
Niagara Mohawk Power Corp., Stewart's Bridge	37,500	105.9	960,000	1	1952
Saltos del Duero, Spain	37,000	187	1,123,680	3	1932–33
Tennessee Valley Authority, Joe Wheeler Power House	36,000	86	1,835,000	2	1936
U.S. Engineers, Gavin's Point, S. D.	35,100	75	2,231,000	3	1955-56
Safe Harbor Water Power Corp.	35,000	100	1,921,000	2	1934–40
South Carolina Public Service Auth., Santee Cooper	34,000	120	1,430,000	2	1941
Central Maine Power Co., Indian Pond	33,333	128	737,500	1	1954
T.V.A., Cherokee Nos. 2 and 4	33,333	95	890,500	2	1953
Pacific Gas & Electric Co., Salt Springs	33,000	400	266,000	1	1952
Northern Quebec Power Co., Quinze River	32,500	107	740,000	1	1949–50
Winnipeg Electric Co., Seven Sisters Falls	32,500	128	1,160,000	3	1949–53
Government of Uruguay, Rione	32,000	125	1,954,000	4	1945–48
Sociedad Hidroeléctrica Iberia Iberdura Saltos del Duero, Villalcampo, Spain	32,000	125	726,000	3	1948
Tallassee Power Company, Badin, N. C.	31,250	156	525,000	1	1922
Central Hudson Gas & Elec. Corp. Neversink	31,250	300	465,000	1	1951
U.S. Engineers, Old Hickory	31,250	75	1,980,000	4	1957
California Oregon Power Co., Clearwater No. 2	30,588	450	341,000	1	1953

A 47,000-kva, 82-rpm generator, New York Power and Light Corporation, Spier Falls, N.Y.



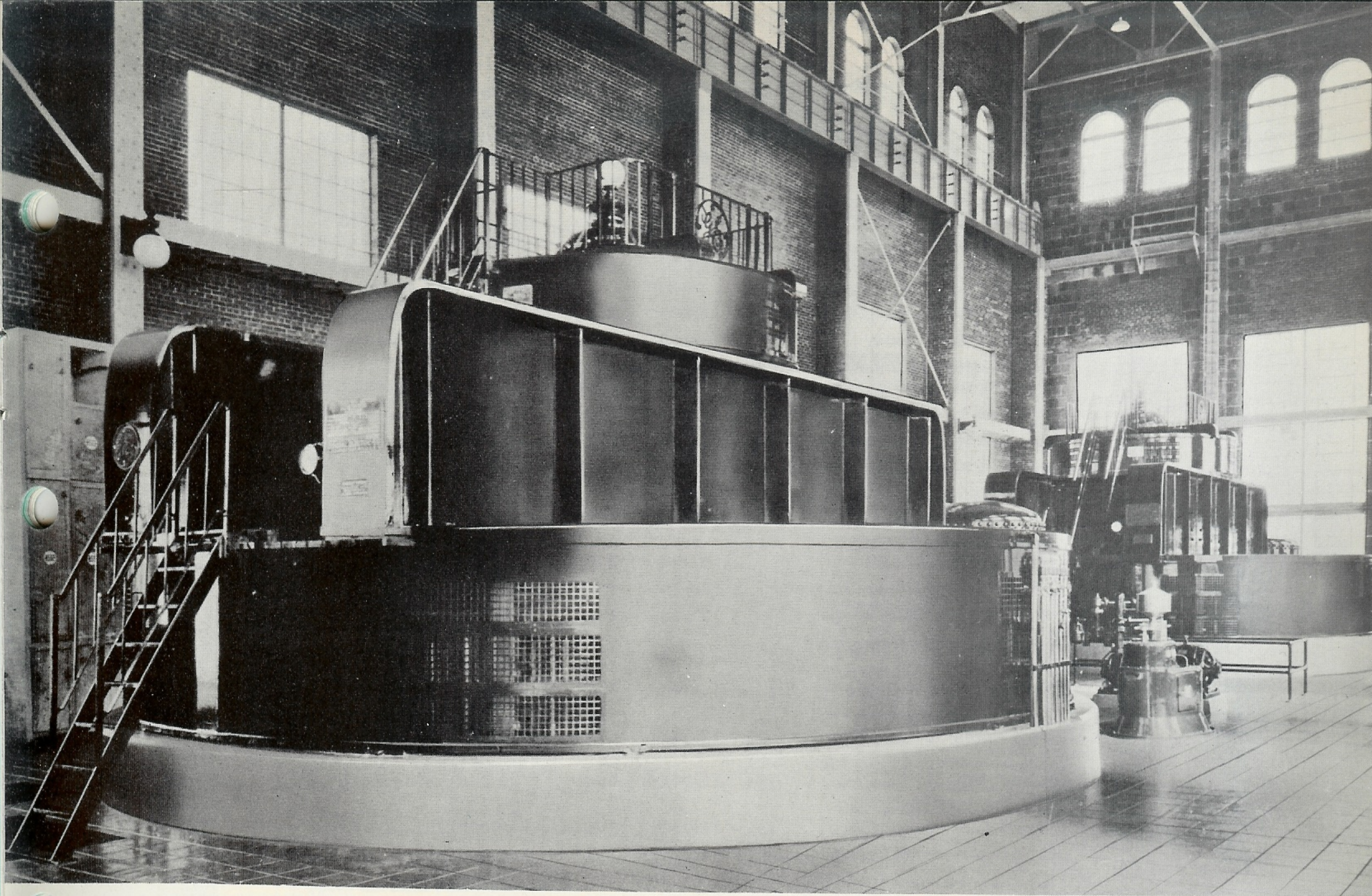
Purchaser	Machine Kva	Machine Rpm	Bearing Load Pounds	No. of Units	Approx Date of Installation
Tallassee Power Co., Badin, N. C.	23,160	154	422,000	1	1923
Hidroelectrica Iberica, Cinca, Spain	23,000	428	169,000	2	1930
Gatineau Power Co., Farmers Rapids	22,500	90	532,000	1	1947
Rio de Janeiro Tramway L & P, Vigario Pumping Station	22,500	166	248,000	3	1950-53
Empresa Nacional de Electricidad Abanico, Chile	21,500	375	272,000	4	1947-50
California Oregon Power Co., Slide Creek	21,176	200	350,000	1	1950
Alabama Power Company, Mitchell Dam	20,000	100	640,000	3	1922-23
Central Nebraska Public Power & Irrigation District, Johnson Canyon No. 2	20,000	164	335,000	1	1940
Showa Power Company, Denryoku, Japan	20,000	200	356,000	3	1928
Nippon Elec. Pr. Co., Komaki, Japan	20,000	200/ 167	350,000	2	1926
Mexican Lt. & Pr. Co., Necaxa, Mex.	20,000	300	160,000	1	1950
Rochester Gas & Electric Co.	19,700	164	365,000	1	1928
Alabama Power Co., Yates Dam, Ala	19,000	80	645,000	2	1928
Southern Power Co., Charlotte, N. C.	18,750	100	497,500	7	1925-26
Holyoke Water Power Co.	18,750	128½	884,000	1	1951
Public Service Co. of New Hampshire Berlin, New Hampshire	18,750	128.5	412,000	1	1948
Powell River Company, Powell River, B. C.	18,000	333	248,700	2	1931-47
City of Los Angeles, Calif.	17,500	428	350,000	1	1920
Union Electrica Madrilena Bolarque, Spain.	17,500	187	290,000	2	1954
Hydro Electric Power Comm., Chenaux, Ontario	17,000	94.7	960,000	8	1950-51
Cerro de Pasco Copper Corp.	17,000	257	290,000	4	1935-36,54
Hidroeléctrica Española, Cinca, Spain	17,000	375	260,000	1	1926
Puget Sound Power & Lt. Co., Rock Island Development	16,667	100	1,160,000	4	1931-32
U. S. Bur. Recl., Canyon Ferry	16,667	150	417,000	3	1952
U. S. Bur. Recl., Estes Power Plant	16,667	400	254,000	3	1950
Central Maine Power Co., Indian Pond	16,667	180	329,000	1	1954
Spruce Falls Power & Paper Co.	16,500	164	301,000	5	1929-31
U.S. Engineers, Albeni Falls	15,778	54.5	1,427,000	3	1954
Hidroeléctrica Ibérica, Cinca, Spain	15,555	500	124,000	3	1920-25

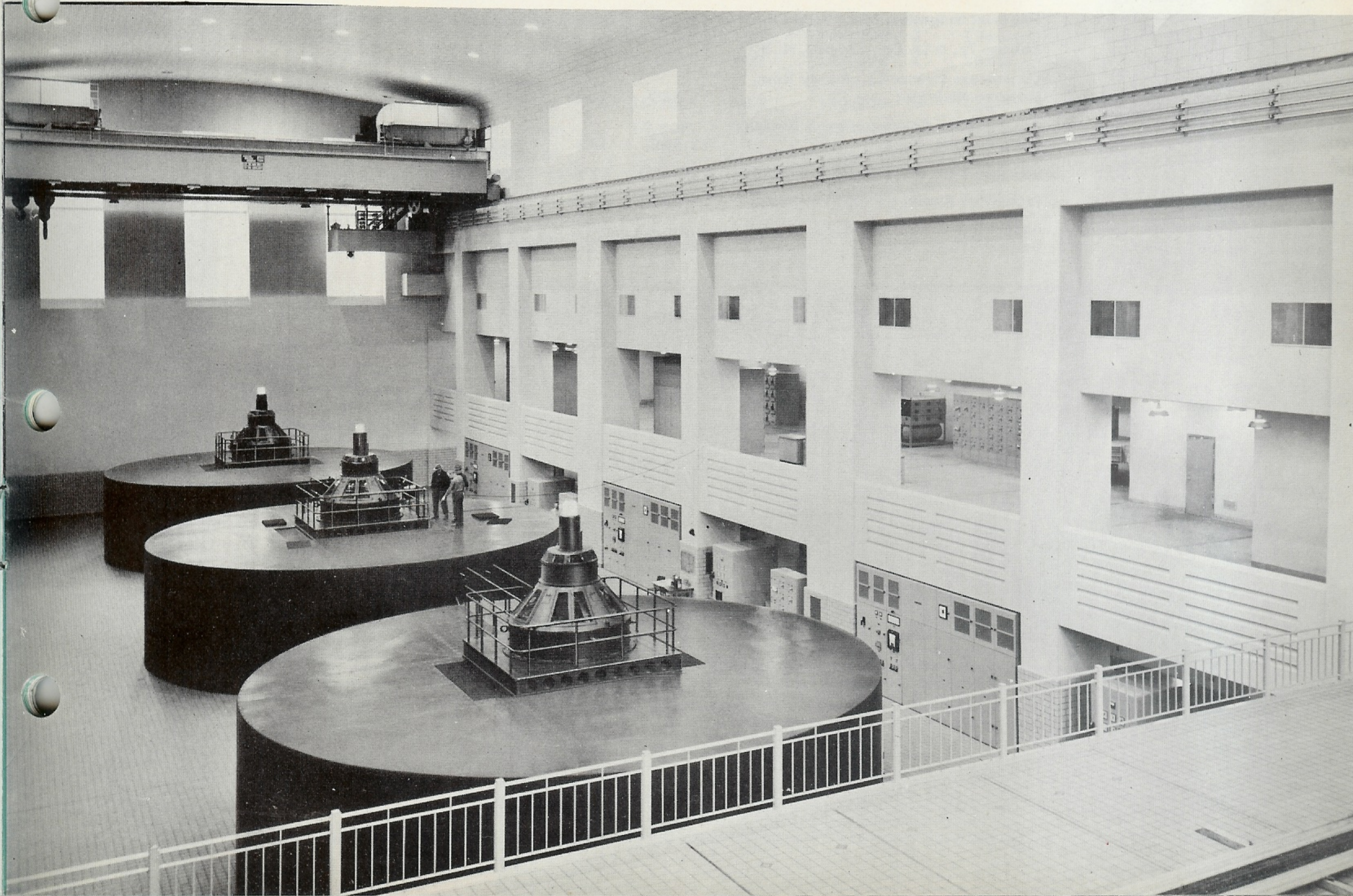


Two 19,000-kva, 80-rpm, generators, Alabama Power Company, Tallahassee Development, Ala.

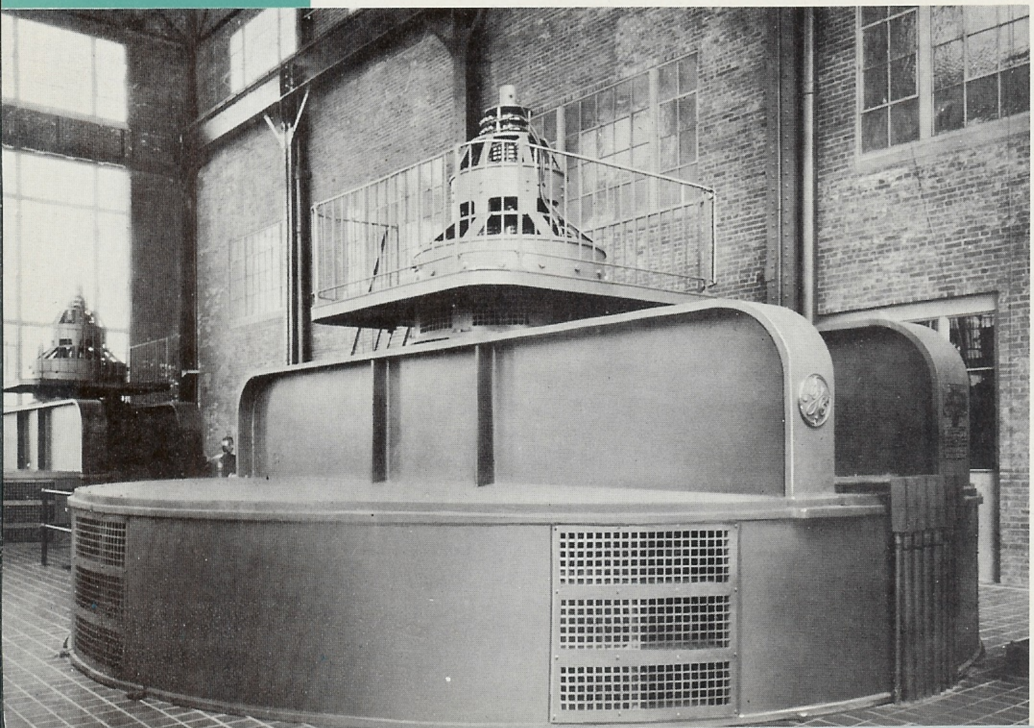
Three 50,000-kva, 105.9-rpm generators at Center Hill Power Plant, U.S. Corps of Engineers, Spencer, Tennessee

Two of four 16,667-kva,100-rpm generators at Rock Island Station of Puget Sound Power and Light Co., Wash.



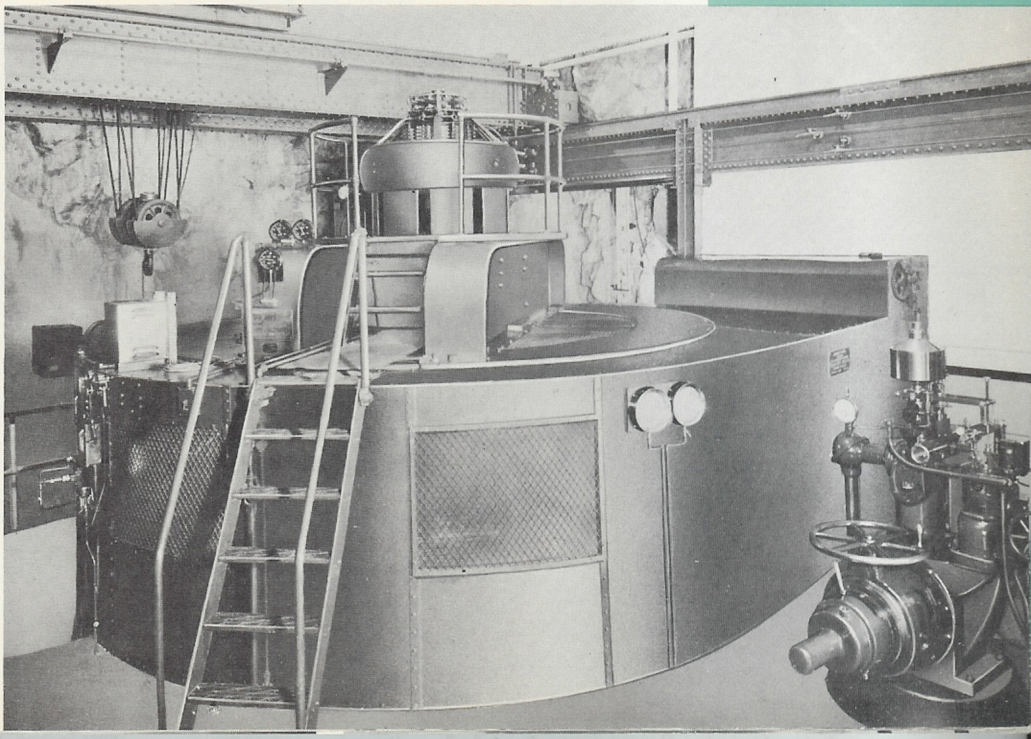


Purchaser	Machine Kva	Machine Rpm	Bearing Load Pounds	No. of Units	Approx Date of Installation
Hydro Electric Power Comm. of Ontario, Alexander Dev.	15,000	100	388,000	3	1930
Hydro Electric Power Comm. of Ontario, Alexander Dev.	15,000	150	607,000	1	1945
Minnesota Power & Light Co., Thomson Power Plant, Minnesota	15,000	400	170,000	1	1949
U.S. Engineers, Dexter	15,000	128	746,000	1	1955
Platte Valley Public Pr. Dist., North Platte, Neb.	14,500	257	216,000	2	1935
Ebro Ir. & Pr. Co., Spain, Camarasa Dev.	14,060	375	298,000	1	1930
Ebro Ir. & Pr. Co., Spain, Camarasa Dev.	14,060	375	298,000	1	1925
Ebro Ir. & Pr. Co., Spain, Camarasa Dev.	14,060	375	240,000	2	1920
Corporación de Fomento de la Producción Pilmaiquén	13,500	200	275,000	1	1950
Great Northern Power Co., Duluth, Minn.	13,500	360	150,000	1	1919
Great Northern Paper Co., Maine	13,500	267	208,000	2	1953
Northwestern Power & Light	13,333	225	325,000	1	1928
Salt River Valley Water Users' Association, Ariz.	13,000	150	312,500	1	1930
Kehin Electric Power Co., Japan	13,000	375	210,000	2	1922
California Oregon Power Co., Soda Springs	12,941	164	262,000	1	1951
California Oregon Power Co., Fish Creek	12,941	450	88,000	1	1951
Louisville Hydro-Elec. Co., Ohio Falls Dev.	12,550	100	712,000	8	1928
Lower Colorado River Auth., Inks Dam	12,500	112	340,000	1	1939
New York Power & Light Corp., Elmer J. West Station	12,500	112	296,000	2	1930
Imperial Irrigation Dist., Drop #4	12,500	138	625,000	1	1950
Cohoes Pr. & Lt. Co., Cohoes, N. Y.	12,500	150	225,800	1	1925
Consumers Power Co., Hardy Dam, Oxbow, Michigan	12,500	164	280,000	3	1931
Brazos River Conservation & Recla. Dist., Temple, Texas	12,500	171	336,000	2	1941
Georgia Rail. & Pr. Co., Tugaloo, Ga.	12,500	171	200,000	4	1921
Indústrias Klabin do Parana, Brazil	12,500	200	286,000	1	1951
Pacific Gas & Electric Co., San Francisco, Calif.	12,500	225	225,000	2	1921



Two 12,500-kva, 112-rpm generators, New York Power and Light Corp., Elmer J. West station, Conklingville, N. Y.

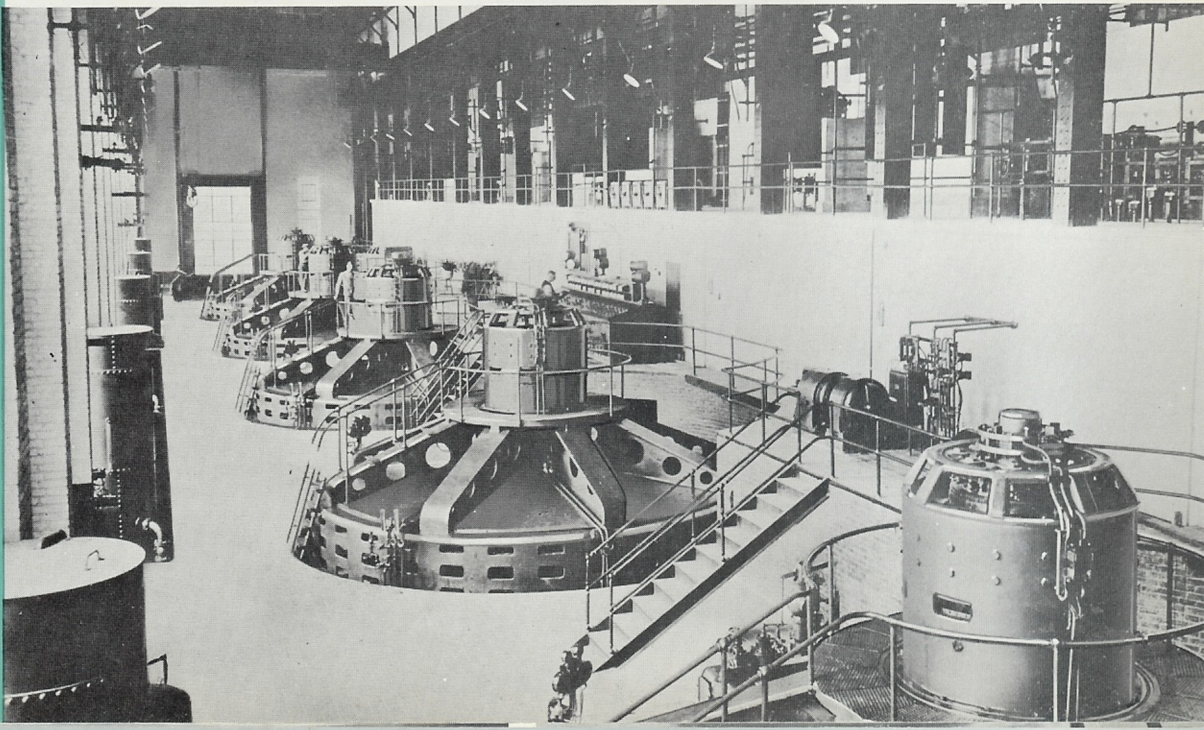
Purchaser	Machine Kva	Machine Rpm	Bearing Load Pounds	No. of Units	Approx Date of Installation
Adirondack Power & Light Corp., Schenectady, N. Y.	12,500	300	180,000	2	1924
Unión Eléctrica Madrilena, Las Picadas, Spain	12,500	300	175,000	2	1950
St. Lawrence Valley Pr. Co.	12,500	360	146,000	1	1928
British Columbia Pr. Comm., Whatshun	12,500	600	190,000	2	1950
Empresas Unidas de Energía Eléctrica, S. A., El Salto, Colómbia	12,500	600	80,000	5	1940–50
Imperial Irrigation District, Drop No. 4	12,500	138.5	625,000	1	1949
Americana No. 3, Brazil	12,500	200	221,000	1	1953
New Brunswick Power Comm., Tobique Narrows	12,500	225	415,000	2	1953
Hollinger Gold Mines	12,000	125	317,000	2	1924
Abitibi Electric Dev. Co.	12,000	128	340,000	2	1926
Powell River Power Co.	12,000	250	205,000	1	1926
Société Généralé Des Forces Hydroélectriques du Katanga, Belgian Congo	12,000	375	173,000	1	1929
Central Maine Power, Union Falls Station, Maine	12,000	225	409,000	2	1949
Nantahala Power & Light Co., Tennessee Creek	12,000	600	116,000	1	1954
La Céntral Hidroeléctrica de Caldas Colombia, S. A.	11,800	514	117,300	2	1950
Washington Water Power Co., Spokane, Wash.	11,750	106	375,000	1	1921
International Boundary & Water Comm.—Falcon Dam	11,667	164	270,400	6	1953
Braden Copper Co.	11,429	450	138,000	1	1948
South Carolina Public Service Authority Santee Copper	11,350	200	554,000	1	1941
Salt River Valley Water Users' Assoc., Ariz.	11,100	300	206,000	3	1925
Gulf Power Co., Clark City, Quebec	11,000	200	207,000	2	1953
Great Lakes Pr. Co. High Falls Michipicoten River	10,750	240	182,000	1	1950
Tokio Hydro-Electric Co., Japan	10,700	250	256,000	3	1925
Hydro-Electric Power Comm. of Ontario, Nipigon, Ont.	10,600	120	441,000	4	1924–25
Gifu Electric Power Co., Japan	10,125	257	250,000	3	1925
Montreal Light, Heat & Pr. Co. Inc., Montreal, Canada Cedar Rapids Plant	10,000	55	550,000	8	1918–24



An 8000-kva, 257-rpm generator, Spaulding Power House, Pacific Gas and Electric Co.

Purchaser	Machine Kva	Machine Rpm	Bearing Load Pounds	No. of Units	Approx Date of Installation
Montreal Island Power Co.	10,000	86	595,000	6	1929
City of Winnipeg, Slave Falls, Ontario	10,000	94.7	590,000	4	1946–48
Alabama Power Company	10,000	180	240,000	1	1930
Indústrias Klabin do Parana, Brazil	10,000	200	195,000	1	1947
Panama Canal Zone, Madden Dam	10,000	214	237,000	3	1935–41
Great Lakes Power Co., Montreal River, Ont.	10,000	277	149,300	2	1937–41
Great Western Power Co.	10,000	400	250,000	4	1928–29
Shinyetsu Elec. Power Co., Japan	10,000	600	166,000	2	1922
National Power Corp., Caliraya, P.I.	10,000	720	103,000	4	1941–50
Manila Electric Co., Botocan, P. I.	10,000	720	170,000	1	1948
Cumberland Co. Pr. & Lt. Co., Cataract Dev.	9,500	164	454,000	1	1937
Rio de Janeiro Tramway L & P	9,500	166	167,000	3	1950-53
St. Cecilia Pumping Station, Eugene Water Board, Eugene, Oregon	9,412	171.4	415,000	1	1949
Ganyetsu Denryoku K. K. Japan	9,400	150	406,000	6	1928
Northern N. Y. Utilities Corp., Soft Maple Development	9,375	225	154,000	2	1925
Northern N. Y. Utilities Corp., Oswegatchie Development	9,375	360	150,000	2	1922
East Bay Municipal Utilities Dist., Valley Springs, California	9,375	450	103,500	2	1928
Daido Denryoku K. K., Japan	9,000	150	250,000	2	1926
International Paper Co., Sherman Island Dev.	9,000	150	200,000	4	1922
Cohoes Lt. & Pr. Corp., Cohoes, N. Y.	9,000	180	160,000	1	1921
Great Lakes Power Co., Montreal River, Ont.	9,000	257	163,600	2	1939–42
Idaho Power Co., Upper Salmon, Idaho	9,000	112.5	475,000	2	1947
U. S. Bureau of Recl., Mary's Lake, Colo.	9,000	327	154,000	1	1950
Newfoundland Light & Power Company, Horse Chops Dev.	9,000	450	114,000	1	1953
Braden Copper Co., Chile	8,850	450	151,700	2	1928–29
Tallassee Power Co., Badin, N. C.	8,750	90	260,000	1	1922
Adirondack Pr. & Lt. Corp., Spier Falls Dev.	8,500	164	170,000	1	1923
Central Maine Power Company	8,000	112	288,000	3	1926
Great Lakes Power Co., Scotts Falls, Ontario	8,500	225	360,000	2	1952-53
Manitoba Hydro Electric Bd., MacArthur Falls	8,500	85.7	492,000	8	1954-55
Central Maine Power Company, Solon	8,000	150	361,000	1	1940
Price Brothers, Chicoutimi, Quebec	8,000	189	155,000	2	1922
Pacific Gas & Electric Co.	8,000	257	150,000	1	1928
Wateree Power Company, Charlotte, N. C., Fishing Creek Development	7,500	97	276,000	5	1916
Amoskeag Manufacturing Co., Manchester, N. H.	7,500	112	207,500	1	1924
Algoma District Power Co., Michipicoten Harbor, Ontario	7,500	240	157,700	2	1929–30
U. S. Engineers, Philpott Reservoir	7,500	277	182,000	2	1951
Hakusan Water Power Co., Japan	7,500	514	129,000	2	1925
Price Brothers, Brochet Development	7,500	180	324,000	1	1953
Adirondack Power & Light Co., Sprite Creek, N. Y.	7,300	600	64,500	1	1923
Municipality of Reykjavik Ljosafoss, Iceland	7,250	136.3	209,000	1	1944
Beauharnois Const. Co., Beauharnois, P. Q.	7,200	180	258,450	2	1932
Tallassee Power Company, Badin, N. C.	7,000	90	255,000	2	1919

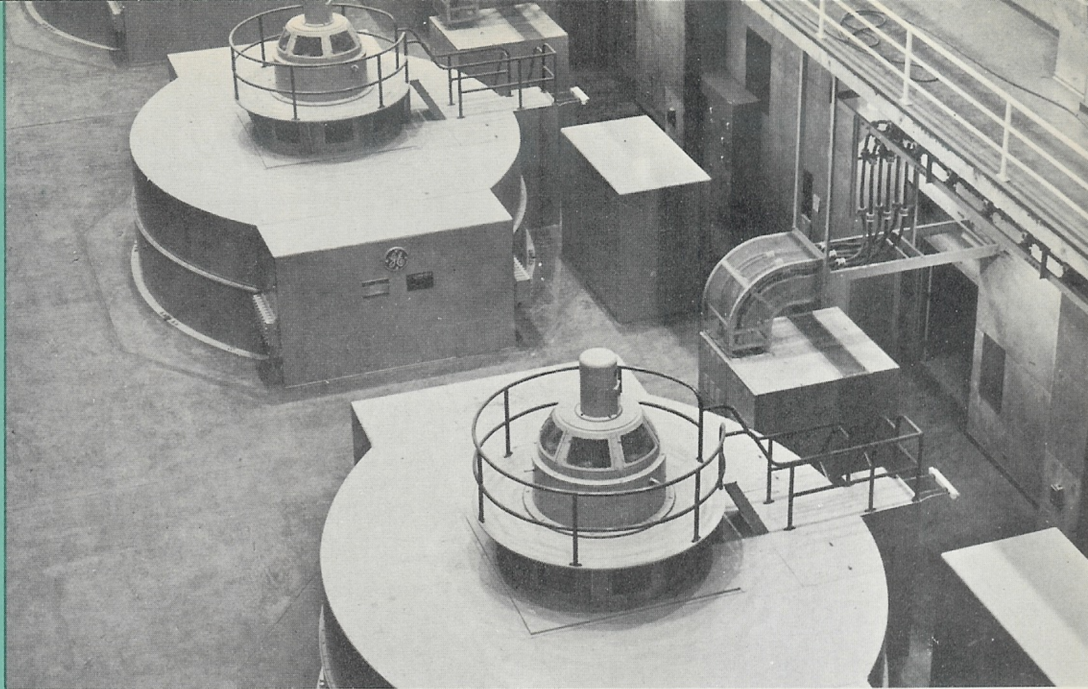
Purchaser	Machine Kva	Machine Rpm	Bearing Load Pounds	No. of Units	Approx Date of Installation
Department of Mines & Resources, Snare River, North West Territory, Canada	7,000	128.5	214,000	1	1948
Green Mountain Power Co., Waterbury, Vermont.	6,900	327	142,700	1	1953
Tokyo-Hydro-Electric Co., Japan	6,880	250	220,000	3	1925
Central Maine Pr. Co., Solon	6,500	171	300,000	1	1950
Amoskeag Mfg. Co., Manchester, N. H.	6,250	112	205,000	2	1922
Hydraulic Race Co., Lockport, N. Y.	6,250	200	232,000	1	1941
Finance Board for Greenwood County, Buzzard's Roost, S. C.	6,250	240	281,000	3	1939
Avon River Power Co., N. S.	6,250	257	99,000	1	1941
Phoenix Utility Co., Brazil Chibarro Station	6,250	450	80,000	1	1930
Green Mountain Power Co.	6,250	600	81,000	1	1926
Public Electric Light Co., St. Albans, Vt.	6,250	200	285,100	1	1948
Wisconsin River Power Co., Petenwell, Wis.	6,250	164	265,000	4	1949
Jaguari, Brazil	6,250	360	95,000	1	1952
Imperial Irrigation District, Drop No. 2	6,250	100	404,000	2	1953
Kanawha Valley Power Co.	6,150	90	422,000	3	1937
New England Power Co., Vernon, Vt.	6,000	75	250,000	2	1921
Kanawha Valley Power Co.	6,000	90	403,000	6	1935
Imperial Irrigation Dist., Drop 3	6,000	100	403,000	1	1940
Power Commission of Crisp Co., Warwick, Ga.	6,000	128	320,000	1	1941
Southern Canada Power Co.	6,000	150	165,000	2	1924
Southern Canada Power Co.	6,000	150	155,000	4	1924
City of Nelson, British Columbia	6,000	164	150,000	1	1949
Great Northern Paper Co.	6,000	171	255,000	2	1939
Mattaceunk, Maine			230,000	2	1940–42
East Kootenay Power Co.	6,000	360	83,340	2	1923
City of Nelson	6,000	163.6	150,000	1	1949
U.S.S.R.	5,625	150	387,000	2	1944
Northern N. Y. Utilities, Norfolk Plant	5,625	164	329,500	1	1927
Gatun Hydro-Elec. Station, Panama Canal	5,625	187	117,000	3	1944–47
Empresa Nacional de Electricidad, S. A. Pilmaiquen, Chile	5,600	250	123,000	3	1944–47



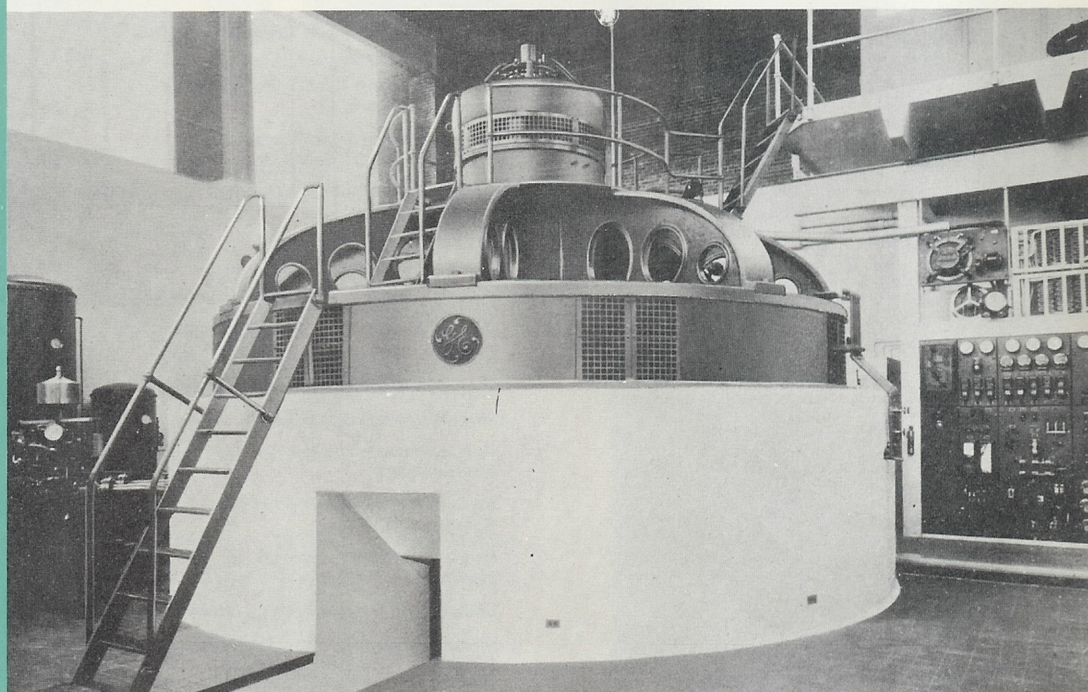
Five 7500-kva, 97-rpm generators Fishing Creek Plant, Wateree Power Co., Charlotte, N.C.

Purchaser	Machine Kva	Machine Rpm	Bearing Load Pounds	No. of Units	Approx Date of Installation
U. S. Engineers, Sault Ste. Marie, Mich.	5,333	80	475,000	3	1950
Power Commission of Crisp County, Cordele, Ga.	5,000	100	304,000	1	1929
Cumberland County Pr. & Lt. Co., Maine	5,000	120	290,000	1	1927
Beebe Island Corporation	5,000	150	252,000	2	1932
Ebro Irrigation Co., Spain	5,000	167	225,000	2	1930
U.S.S.R.	5,000	250	155,000	1	1944
Turlock & Modesto Irrigation Dist., Calif.	5,000	300	145,000	3	1922
Northern N. Y. Utilities Co., Moshier Creek Station	5,000	400	76,000	2	1928
New England Power Co., Searsburg Dev.	5,000	360	67,000	1	1922
Dept. Rwy. and Canals, Welland Canal, Thorald, Ont.	5,000	360/400	96,500	3	1931
U. S. Engineers, Cincinnati, Ohio	5,000	180	208,000	6	1942
Comisión Federal de Electricidad, Tonilita, Mexico	5,000	514	63,000	2	1948
Great Lakes Power Co., MacPhail Falls, Ontario	5,000	200	160,000	2	1953
Grafanhoto Hydro Plant, Brazil	4,600	300	127,000	4	1944–45
Hydro-Elec. Power Comm. of Ontario, Ranney Falls, Campbellford, Ontario	4,500	120	195,000	2	1921
Northern N. Y. Utilities Corp., Deferiet, N. Y.	4,500	128	128,000	3	1925
Androscoggin Elec. Co., Lewiston, Me.	4,500	138	282,000	1	1928
Northern States Power Company, Chippewa Falls, Wisconsin	4,500	138	267,500	6	1928
International Paper Co., Niagara Falls, N. Y.	4,500	300	130,000	2	1919
Jamaica Public Service, Roaring River	4,500	800	82,000	1	1948
Pacific Gas & Electric Co., Murphy's Power House	4,500	400	52,300	1	1953
Consumers Power Co., Jackson, Mich.	4,444	90	175,000	2	1918
Braden Copper Company, Chile	4,444	514	225,000	1	1917
Metropolitan District Water Supply Comm., Oakdale, Massachusetts	4,375	324	92,000	1	1950
Montana Light & Power Co., Troy, Montana	4,375	360	73,400	1	1949
Lower Sturgeon Power Co.	4,000	136	125,000	2	1922
Marimbondo Falls Development, Brazil	4,000	250	197,000	2	1926
Realty Development Corp., Hillsboro, N. H.	4,000	300	76,000	1	1926
La Cie Hydraulique de Portneuf	4,000	360	114,000	1	1925
Ibigawa Electro Chemical Co., Japan	4,000	514	116,000	2	1920
Ibigawa Electro Chemical Co., Japan	4,000	514	44,000	2	1920
Central Maine Power Co., Skowhegan Dev.	3,750	100	144,000	4	1920–23
Northern Electric Co., Kells, Michigan	3,750	100	93,000	2	1927
Power Corp. of N. Y., Norfolk, N. Y.	3,750	150	250,000	1	1927
Great Northern Paper Co., Millinocket, Me.	3,750	171	174,000	1	1935
Northern N. Y. Utilities Corp., Oswegatchie, N. Y.	3,750	180	85,700	2	1923
Great Northern Paper Co., Dolby Rips, Me.	3,750	240	165,000	1	1930
Public Electric Lt. Co., Clark's Falls, Vt.	3,750	240	157,000	1	1938
Public Electric Co., Milton, Vermont	3,750	277	89,000	2	1930–37
City of Danville, Va.	3,750	450	59,000	3	1938
Bathurst Lumber Co., Nipisiquite, N. B.	3,600	300	87,000	2	1922
Bathurst Lumber Company	3,600	300	98,800	1	1929
State of New York, Crescent, N. Y.	3,500	90	190,000	4	1923–24
Alpena Power Co., Alpena, Mich.	3,500	128	95,000	1	1924

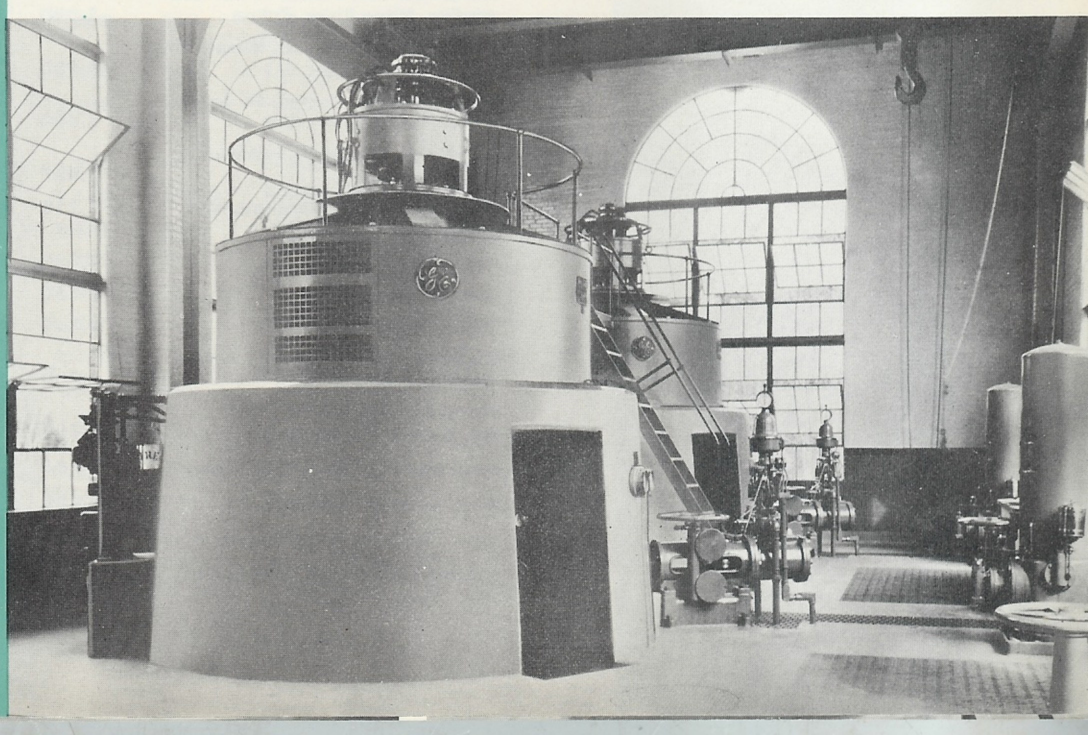
Two of six 11,667-kva, 164-rpm generators at Falcon International Dam.



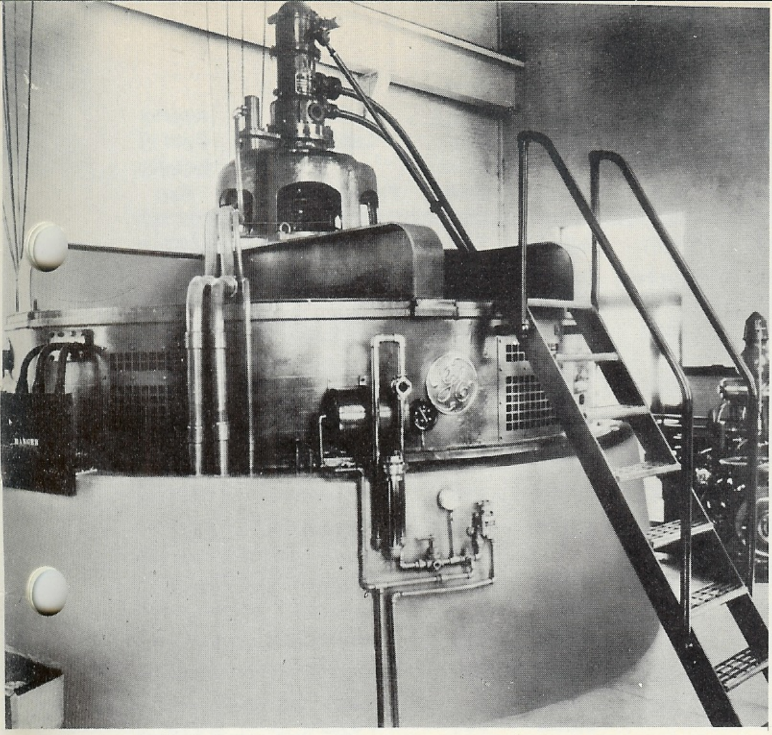
A 5000-kva, 120-rpm generator, West Buxton Station, Cumberland County Power and Light Co., Portland, Me.

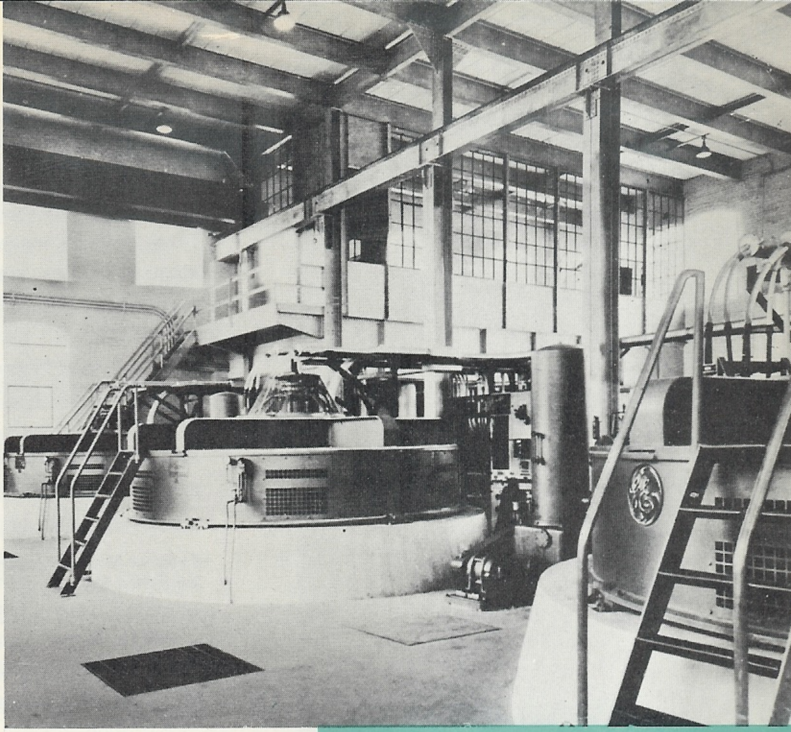


Two 5000-kva, 400-rpm generators, Moshier Creek Station, Northern New York Utilities Co., Croghan, N.Y.



Purchaser	Machine Kva	Machine Rpm	Bearing Load Pounds	No. of Units	Approx Date of Installation
West Canadian Hydro Elect. Corp., Shuswap Falls, B. C.	3,500	257	97,800	1	1942
City of Los Angeles, Calif., San Fernando Plant	3,500	500	52,500	2	1921
Georgia Railway & Power Co., Seed, Ga.	3,400	225	84,000	2	1926
Consumers Power Co., Jackson, Mich. Foote Development	3,333	90	150,000	3	1917
Lake Superior Dist. Pr. Co., Tony, Wis.	3,300	164	80,000	2	1922
A.N.I.E.M., Senggoeroeh	3,300	273	76,000	1	1941
Ujigawa Electric Co., Japan	3,300	514	58,000	3	1924
Great Northern Paper Co., Millinocket, Me.	3,250	171	155,000	2	1935
Western N. Y. Utilities Corp., Medina, N. Y.	3,200	250	78,500	1	1923
Public Service Co., Newark, N. J.	3,200	300	85,500	2	1921
Appalachian Elec. Power Co. Reusens Station	3,125	164	124,000	3	1931
Bar Harbor & Union River Power Co., Ellsworth, Me.	3,125	200	61,000	1	1924
South Carolina Gas & Electric Co., Spartanburg, S. C.	3,125	225	77,000	1	1924
Lake Superior Dist. Power Co., Tony, Wis.	3,125	240	59,000	1	1925
Orillia L & W & Pr. Commission, South Falls, Ontario	3,125	257	160,000	1	1950
Blue Ridge Power Co., Spartanburg, S. C.	3,125	600	38,000	2	1919
Town of Jonquiére, Province of Quebec	3,125	257	160,000	1	1949
Power Comm. of Crisp County, Cordele, Ga.	3,000	100	144,000	1	1929
Wolverine Power Co., Wenigar Station	3,000	138	101,000	2	1934
Texas Hydro Electric Corp.	3,000	180	157,000	3	1931
U. S. Bureau of Recl., Prosser Power Plant	3,000	200	155,000	1	1932
St. Lawrence Valley Pr. Corp., Potsdam, N. Y.	3,000	225	75,000	2	1925
Dept. of Interior, Bureau of Reclamation, Guernsey Plant	3,000	240	90,000	2	1927
Western N. Y. Utilities Co., Medina, N. Y.	3,000	300	67,000	1	1918
Ware Shoals Mfg. Co., Ware Shoals, S. C.	3,000	360	113,000	1	1940
Northwest Territories, Power Commission, Mayo River, Yukon	3,000	450	49,000	1	1952
Nova Scotia Pr. Co., St. Margarette Bay, N. S.	2,900	300	90,000	2	1922
New Brunswick Pr. Co., St. John, N. B., Musquash Pr. Dev.	2,900	300	90,000	3	1921
Energie Electrique Du Sud-Ouest, Mauzac, France	2,857	55	310,000	4	1919
General Dev. Co., Oswego, N. Y.	2,750	128	217,000	5	1926
Spruce Falls Power Co., Kapuskasing, Ont.	2,750	180	72,000	4	1922
Spruce Falls Power Co.	2,750	180	120,000	1	1922
International Eng., Ceylon	2,750	333	77,400	2	1951
Cia Prada de Electricidade S. A., São Paulo, Brazil	2,750	500	42,500	2	1947–50
Sherritt Gordon Mines, Laurie River, Manitoba	2,750	200	82,000	2	1952
U. S. Bureau of Recl., Gila Valley	2,745	212	58,000	1	1941
Corporation of Nelson	2,650	240	74,000	1	1928
Kimberly-Clark Co., Niagara, Wis.	2,625	240	64,000	1	1916
Northern New York Utilities Co., Watertown, N. Y.	2,500	120	75,000	3	1920





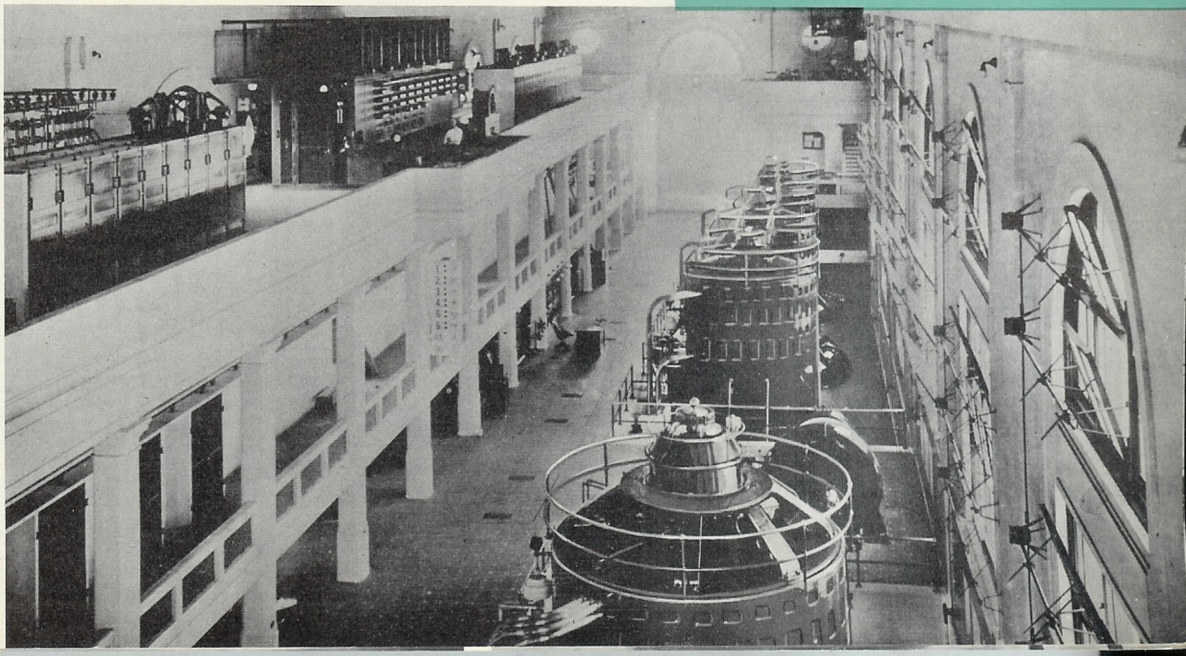
A 3000-kva, 180-rpm generator, Texas Hydro-electric Corp., near Sequin, Texas

Three 3125-kva, 164-rpm generators, Appalachian Electric Power Co., Reusens, Va.

Purchaser	Machine Kva	Machine Rpm	Bearing Load Pounds	No. of Units	Approx Date of Installation
Power Corp. of N. Y., Norwood, N. Y.	2,500	120	182,000	1	1927
Power Corp. of N. Y., Raymondville, N. Y.	2,500	120	182,000	1	1927
Northern Electric Co., Kells, Mich.	2,500	120	100,000	1	1927
U. S. Engineers	2,500	128	178,000	1	1932
Corp. of Sherbrooke, Quebec, Canada	2,500	150	130,800	2	1927
Connecticut Lt. & Pr. Co., Scotland, Conn.	2,500	150	138,000	1	1938
Consolidated Water Power and Paper Co., Wisconsin Rapids, Wis.	2,500	150	172,000	3	1942
So. Carolina Pub. Serv. Authority	2,500	180	82,000	1	1950
Utah Power & Light Co., Ashton, Idaho	2,500	180	75,000	2	1925
Gatun Hydro-Elec. Station, Panama	2,500	250	75,000	3	1918
Virginia Railway & Power Co., Petersburg, Va.	2,500	277	58,400	1	1923
Bangor Hydro-Electric Co.	2,500	360	105,000	2	1938
Hiroshima Electric Co., Japan	2,500	450	41,000	2	1927
Usina Hidro-Eléctrica, Paulo Afonso, Brazil	2,500	500	117,300	1	1948
U. S. Bur. Recl., Shasta Dam	2,500	600	80,000	2	1942
City of Los Angeles, Calif., Franklin Canyon Plant	2,500	600	45,000	1	1921
Alabama Electric Cooperative, Inc.	2,500	138.5	100,000	1	1949
E. L. Philips Co., Keuka, N. Y.	2,500	720	50,000	1	1929
U.S. Engineers, Sault Ste Marie	2,500	128	157,800	1	1954
Ashton & St. Anthony Pr. Co., Idaho	2,400	225	80,000	1	1918
Appalachian Power Co., Fries, Va.	2,300	97	116,000	3	1915–24
Georgia-Alabama Pr. Co., Albany, Ga.	2,250	88	115,000	3	1921–25
St. Regis Paper Co., Black River, N. Y.	2,250	100	96,000	2	1921
Northern N. Y. Utilities Co., Black River, N. Y.	2,250	100	106,000	1	1922
Wisconsin Valley Elec. Co., Wausau, Wis.	2,250	100	107,000	3	1921–24
Oswego River Pr. Corp., Oswego, N. Y.	2,250	138	130,000	3	1928
Power Corp. of N. Y., Herrings, N. Y.	2,250	138	139,000	3	1924
Ludlow Mfg. Co., North Wilbraham, Mass.	2,250	150	90,000	2	1925–33
Green Bay & Miss. Canal Co., Kaukauna, Wis.	2,250	150	125,000	2	1928

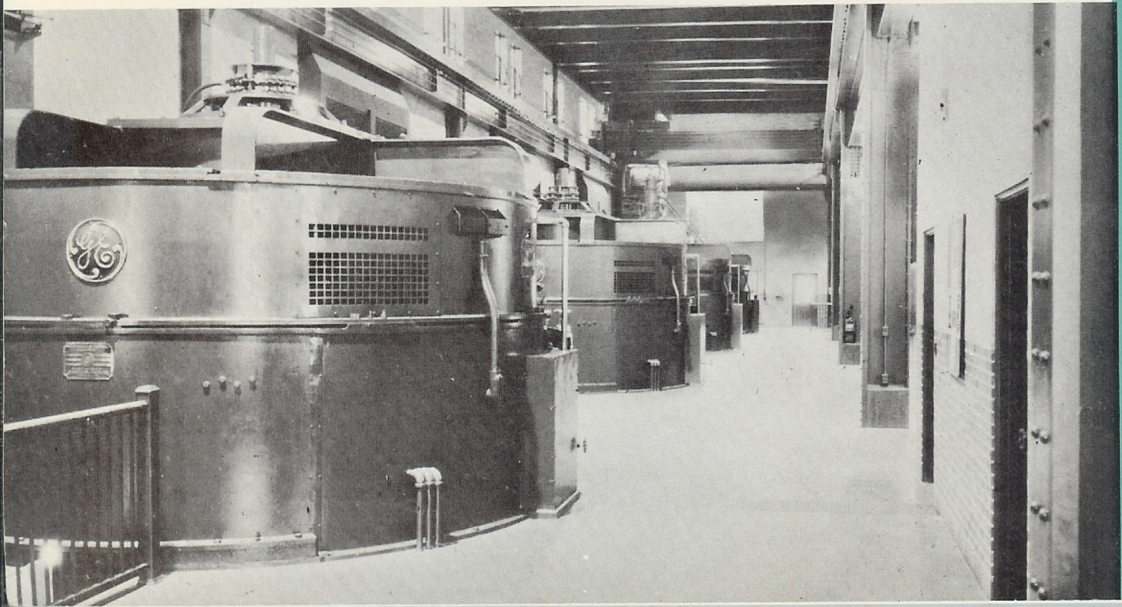
Purchaser	Machine Kva	Machine Rpm	Bearing Load Pounds	No. of Units	Approx Date of Installation
Texas Power Corp.	2,250	180	66,000	2	1927
Public Service Co. of N. H., Eastman Falls	2,250	240	112,000	1	1937
Orillia Light & Power Comm., Minden, Ont.	2,250	277	74,800	2	1936
Dryden Pulp & Paper Co.	2,200	164	119,700	1	1928
North Counties Hydro-Elec. Co., Dayton, Ill.	2,100	200	118,000	1	1924
Elec. Reduction Co., Buckingham, P. Q.	2,040	225	116,000	1	1938
Bangor Hydro-Electric Co.	2,000	120	132,000	3	1942–49
Horshoe Lumber Co., River Falls, Ala.	2,000	138	90,000	2	1924
Central Maine Power Co., Augusta, Me.	2,000	150	70,000	1	1918
Northern N. Y. Utilities Co., Croghan, N. Y.	2,000	225	50,000	1	1923
Jackson Mills, High Shoals, N. C.	2,000	240	112,000	1	1937
Milwaukee Elec. Ry. Co., Milwaukee, Wis.	2,000	300	76,000	1	1915
Peninsular Power Co., Pine River, Wis.	2,000	360	51,000	2	1921
Beaver River Power Corp., Croghan, N. Y.	2,000	400	42,000	3	1925
Explotaciones Hidroeléctricas, Castillonroy, Spain	1,933	300	106,000	1	1942
Oswego Falls Pulp & Paper Co., Fulton, N. Y.	1,875	65	122,000	3	1915–16
Mond Nickel Co., Canada	1,875	100	142,000	1	1924
Bangor Hydro-Electric Co.	1,875	128	123,000	2	1938
Northern Canada Power Co., Timmins, Ontario	1,875	136	72,000	1	1916
City of Idaho Falls	1,875	138	133,000	2	1940–46
Central Maine Power Co., Waterville, Me.	1,875	150	110,000	1	1924
Holyoke Water Power Co., Holyoke, Mass.	1,875	150	86,000	1	1922
Maine Public Service Co., Squapan, Me.	1,875	200	118,000	1	1942
The J. P. Lewis Co., Beaver Falls, N. Y.	1,875	240	92,000	1	1938
U.S.S.R.	1,875	273	136,000	2	1944
Nippon Suiden K. K. Japan	1,850	257	90,000	3	1921
Great Lakes Power Co., Sault Ste. Marie, Ont.	1,800	65	180,000	3	1921
Wis. Valley Power Co., Merrill, Wis.	1,750	112	92,000	3	1924
Saranac Pulp & Paper Co., Plattsburg, N. Y.	1,750	150	92,000	1	1924
Texas Power Corp.	1,750	164	110,000	2	1927
Redlands Water & Power Co., Grand Junction, Colo.	1,750	257	110,000	1	1932
Puget Sound Power & Light Co., Rock Island, Wash.	1,750	300	116,000	1	1931
Kyoto Electric Co., Japan	1,750	300	70,000	2	1919
Santa Rosa, Brazil	1,750	300	52,000	1	1954
Escanaba Paper Co., Groos, Mich.	1,700	200	60,000	3	1921
General Electric S. A., Rio de Janeiro	1,675	300	80,000	1	1923
J. & J. Rogers Co., Ausable Forks, N. Y.	1,650	400	38,000	1	1926
Greenfield Elec. Light & Power Co., Shelburne Falls, Mass.	1,625	164	110,000	1	1925
Red Bluff Water Pr. Control Dist.	1,625	277	61,000	1	1937
Jaguariahiva, Brazil	1,625	400	38,000	1	1950
Kanuchuan Power Co., Ilford, Manitoba	1,600	128	114,000	1	1934
Mitsui Company, Japan	1,600	450	47,000	1	1923
Nova Scotia Power Co., French Village, N. S.	1,600	514	41,000	2	1922
U. S. Engineers, Memphis, Tenn.	1,560	240	98,000	9	1941

Purchaser	Machine Kva	Machine Rpm	Bearing Load Pounds	No. of Units	Approx Date of Installation
Texas Power Corp.	1,550	150	89,000	2	1927
Holyoke Water Power Co., Holyoke, Mass.	1,500	106	77,000	2	1924
Moreau Manuf. Co., Feeder Dam, N. Y.	1,500	120	70,000	5	1922
Virginia Railway & Power Co., Richmond, Va.,	1,500	120	78,000	1	1923
York Haven Water & Power Co., York Haven, Pa.	1,500	120	73,000	1	1924
Hydro-Electric Power Comm. of Ontario, Rat Rapids	1,500	128½	113,900	1	1937
River Falls Power Co., Ghant, Alberta	1,500	138	74,000	1	1925
Priest Rapids Irrigation Dist., Priest Rapids, Washington	1,500	150	131,000	1	1941
Great Northern Paper Co., Anson, Me.	1,500	150	89,000	5	1924
City of Idaho Falls, Idaho	1,500	150	95,000	2	1928-35
Wolverine Power Co., Edenville, Mich.	1,500	200	47,000	1	1925
Alpena Power Co., Alpena, Mich.	1,500	200	45,000	1	1924
Bangor Hydro-Elec. Co.,. West Enfield, Me.	1,500	200	78,000	2	1927
Consolidated Water Power & Paper Co.,. Wisconsin Rapids, Wis.	1,500	200	114,000	1	1942
Village of Morrisville, Vt.	1,500	225	46,000	1	1924
Bibb Mfg. Co., Porterdale, Ga.	1,500	240	45,000	2	1926
International Paper Co., Saranac Lake, N. Y.	1,500	400	42,000	2	1922
City of Allegan, Allegan, Michigan	1,500	112.5	139,000	1	1946
City of Rivière du Loup	1,500	400	33,100	1	1949
U.S.S.R.	1,400	176	130,000	2	1944
Dryden Paper Co., Eagle River, Ontario	1,400	240	59,800	1	1938
U. S. Bureau of Recl., Gila Valley	1,380	277	33,000	1	1941
St. Lawrence Valley Pr. Co.,. Eel Weir Power House	1,375	100	136,000	2	1928
Wausau Paper Mills, Wis..	1,375	100	70,000	1	1928
So. N. H. Hydro-Elec. Co., Beecher Falls, Vt.	1,375	164	110,000	1	1927
Itaiguara, Brazil	1,375	360	65,250	1	1950
City of Cookeville, Tenn.	1,375	720	19,000	1	1929



In the foreground, a 5625-kva, 187-rpm generator, and in the background, three 2500-kva, 250-rpm generators, Gatun Hydroelectric Power Station, Canal Zone

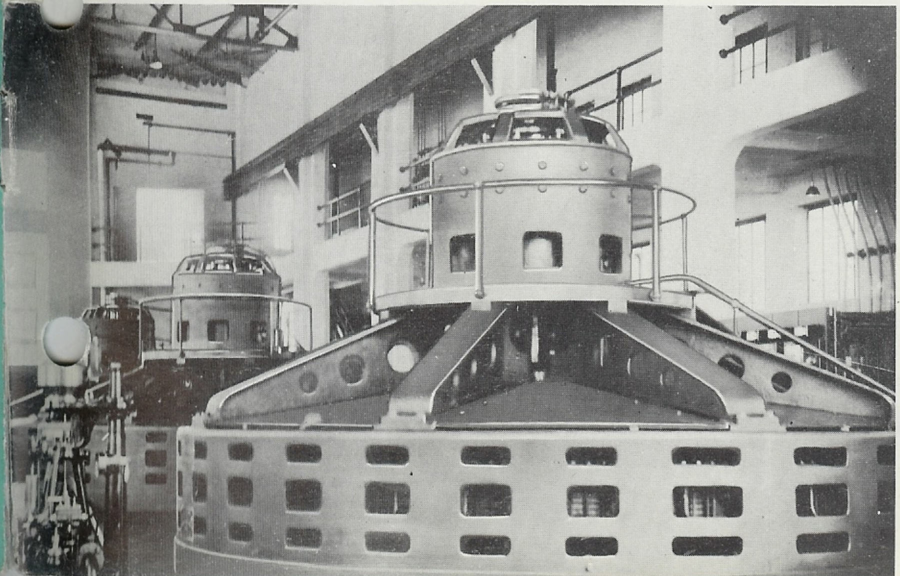
Purchaser	Machine Kva	Rpm	Bearing Load Pounds	No. of Units	Approx Date of Installation
Georgia & Alabama Pr. Co., Albany, Ga.	1,350	164	51,000	1	1920
Cia Eléctrica Caiua S. A., Quatiara Station, São Paulo, Brazil	1,350	257	41,000	1	1946
Central Maine Power Co., Auburn, Me.	1,300	164	43,000	1	1923
South America Gold & Platinum Co.	1,250	72	104,000	1	1923-29
Dominion Textiles Ltd., Magog, Quebec	1,250	133	83,000	2	1920
Northern N. Y. Utilities Corp., Watertown, N. Y.	1,250	150	91,000	2	1925
Montreal Lt. Ht. & Pr. Co., Montreal, Canada, Cedar Rapids Plant	1,250	150	48,500	3	1921-24
Piedmont Mfg. Co., Piedmont, S. C.	1,250	150	72,000	1	1937
Millers Falls Paper Co.,	1,250	277	65,000	1	1938
Puerto Rico, Loiza Dam	1,250	327	48,000	2	1951
Red Bluff Water Pr. Control Dist.	1,250	360	44,000	1	1937
Tomahawk Kraft Paper Co., Tomahawk, Wis.	1,250	164	106,000	3	1924
Union Elec. Lt. & Pr. Co.	1,250	164	90,000	1	1927
Florida Power Corp., Dunnellon, Fla.	1,250	164	90,000	1	1926
Saranac Pulp & Paper Co., Plattsburg, N. Y.	1,250	180	64,500	1	1924
Keith Paper Co., Turner Falls, Mass.	1,250	225	42,000	1	1918
Portland Ry. Lt. & Pr. Co., Portland, Ore.	1,250	240	45,000	1	1924
North Counties Hydro-Electric Co., Dayton, Illinois	1,250	257	81,000	2	1924
City of Martinsville, Va.	1,250	300	63,000	1	1931
Orange County Public Service Co., Middletown, N. Y.	1,250	360	36,000	4	1922-25
U. S. Engineers, Bull Shoals	1,250	600	22,500	2	1950
Hydro-Electric Power Comm. of Ontario, Sills Island Development	1,200	120	109,600	1	1942
Hunter's Point Dry Dock	1,160	600	53,000	3	1943
City of Rochester, Minn.	1,150	225	34,500	2	1918
Iowa-Illinois Gas & Elec. Co., Moline, Ill.	1,125	100	113,000	4	1941
City of Alegan, Mich.	1,125	120	110,000	1	1935
Canadian Cottons, Ltd., Cornwall, Ont.	1,125	144	83,000	3	1921
Strathmore Paper Co.	1,125	180	44,000	1	1930
Village De Mont Laurier, Quebec	1,125	180	83,500	2	1950



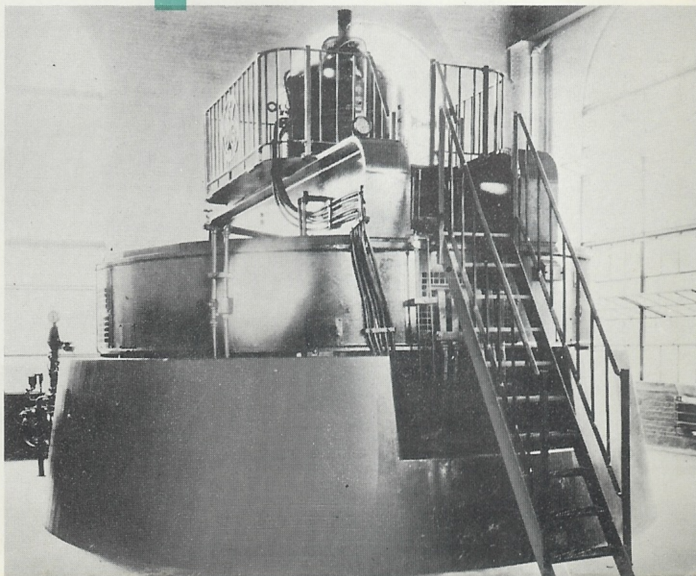
Four 3300-kva 150 rpm generators, New England Power Association, McIndoes Falls, Vt.

Purchaser	Machine Kva	Machine Rpm	Bearing Load Pounds	No. of Units	Approx Date of Installation
Village of Swanton, Vt.	1,125	360	40,000	1	1929
Arrowhead Mills, Fulton, N. Y.	1,020	150	50,000	2	1918-19
Nashua, Mfg. Co., N. H.	1,000	100	63,000	2	1920
Corp. of Hull, Quebec	1,000	100	60,000	1	1917
Idaho Power Co., Boise, Idaho Swan Falls, Plant	1,000	109	51,500	4	1918
St. Louis Pr. & Improvement Co., Cloquet, Minn.	1,000	120	80,000	3	1922
Little Falls Water Pr. Co., Minn.	1,000	120	75,000	2	1920
West Missouri Power Co., Osceola, Mo.	1,000	120	105,000	2	1927
Fulton Lt. Ht. & Pr. Co., Fulton, N. Y.	1,000	150	70,000	1	1924
Carthage Paper Makers, Inc.	1,000	150	76,000	1	1938
Sibley Manuf. Co., Augusta, Ga.	1,000	164	50,000	1	1921
City of Holyoke, Mass.	1,000	180	75,000	1	1938
Marathon Paper Mills	1,000	200	75,000	1	1926
Pacific Portland Cement Co.	1,000	200	69,500	1	1950
U.S.S.R.	1,000	273	136,000	2	1944
Alaska Elec. Lt. & Pr. Co.	1,000	277	26,000	1	1950
Village of Hardwick, Vt.	1,000	514	41,000	1	1938
Chemical Paper Mfg. Co., Holyoke, Mass.	1,000	200	68,000	2	1935
Millstead Mfg. Co., Ga.	1,000	225	70,000	1	1924
Auburn Woolen Mills	1,000	257	57,000	1	1932
Androscoggin Mills, Lewiston, Me.	1,000	257	34,000	1	1925
Grafton County Lt. & Pr. Co., Lebanon, N. H.	1,000	360	33,000	1	1921
Melones Mining Co., Calif.	1,000	360	24,000	1	1920
Churchill River Pr. Co., Manitoba	1,000	400	48,000	2	1929
U. S. Reclamation Service, Shoshone Project	1,000	600	28,000	2	1921
J. & J. Rogers, Ausable Forks, N. Y.	1,000	600	18,000	1	1930

Three 1875-kva, 65-rpm generators, Oswego Falls Pulp and Paper Co., Fulton, N. Y.



A 2500-kva, 120-rpm generator, Power Corp. of New York, Norwood, N. Y.



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THRUST BEARINGS

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