PELTON

WATER WHEELS
and
ACCESSORIES

PELTON
WATER WHEELS
(IMPULSE TURBINES)
and
GOVERNORS

BULLETIN No. 19

THE PELTON WATER WHEEL COMPANY
[Incorporated]
Hydraulic Engineers

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Associated Companies
THE WM. CRAMP & SONS SHIP AND ENGINE BUILDING CO., I. P. Morris Department, Philadelphia
DOMINION ENGINEERING WORKS, LIMITED, Montreal
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Pacific Coast Manufacturers of
JOHNSON PLUNGER-TYPE VALVES
JOHNSON DIFFERENTIAL SURGE TANKS

Pacific Coast Representatives of
THE M. W. KELLOGG COMPANY
Manufacturers of Lap-Welded Steel Pipe for all purposes

Pacific Coast Representative and Warehouse for
CRAMP COMPOSITION METALS, including White Brass Ingots,
Manganese Bronze Ingots, High-Pressure Bearing Bronze, Welding Metals, etc

FOR FORTY YEARS

For forty years "THE PELTON WATER WHEEL" and other PELTON equipment have been recognized as standard the world over.

The PELTON WATER WHEEL COMPANY, however, has not rested content with the manufacture of hydraulic equipment of the highest quality of materials and workmanship, but has also applied the skill and experience of its engineers to the solution of the particular problems of each prospective user of power to the end that a dependable installation for power development, low in ultimate cost, might be provided.

The variation in local conditions under which hydraulic equipment for development of power must operate is so great that standardization in the ordinary sense of the word can be obtained only at the sacrifice of efficiency of operation. It is true that "type of design" and quality of materials and workmanship can be standardized, but the details of each installation must be varied to suit special requirements. The end that the Company constantly strives to attain is the production of power at the lowest ultimate cost per unit developed.

The association of the PELTON WATER WHEEL COMPANY with the I. P. Morris Department of the Wm. Cramp & Sons Ship and Engine Building Company places the experience and facilities of both companies at the service of the customers of either, a convenience which users of water power are coming more and more to appreciate.

This bulletin describes PELTON Water Wheels and Water Motors, or Impulse Turbines, together with the necessary accessory apparatus and equipment. Such wheels or turbines are adapted to driving all kinds of stationary machinery in mines, mills, factories and hydro-electric plants. PELTON Reaction Turbines are described in Bulletin No. 20, copies of which may be obtained upon application to the Company.

All the equipment described herein is manufactured exclusively by the PELTON WATER WHEEL COMPANY or its associated companies and is completely covered by patents.

Correspondence is invited concerning any contemplated hydraulic project. On receipt of the required data, as outlined on Page 24, the Company will be pleased to advise regarding the proper type and size of equipment to meet most effectively and economically the conditions involved.

THE PELTON WATER WHEEL COMPANY

SAN FRANCISCO, CALIFORNIA, U. S. A.

NEW YORK, NEW YORK, U. S. A.

THE DEVELOPMENT OF WATER POWER

THERE is perhaps no other field of engineering enterprise governed so completely by local conditions as is water-power development. Principal among the factors determining the design of water-wheel equipment in order to give the maximum of efficiency and general satisfaction are the following:

1. The water quantity curve throughout the year, taking account of both seasonal and daily variations.

2. The total head that it is possible or profitable to develop.

3. The present and expected load requirements.

4. The best speed for the generator or other driven machinery.

5. The availability and cost of storage.

6. Limitation of water-rights because of irrigation or other requirements that may prevent saving water at certain periods of the day or year, to be discharged later.

7. The length and size of the pipe line required.

Furthermore, for any particular project, special inter-relations between two or more of the above factors are likely to occur. A complete study by competent engineers of all conditions is necessary to the intelligent selection of water-wheel equipment.

The following outline of principal types of impulse-wheel apparatus is by no means exhaustive, but indicates some of the reasons for selecting certain equipment to fit certain conditions:

The simplest type of water-wheel apparatus is the PELTON Standard Wheel shown in Fig. 6 (Page 6). The timber-frame mounting is satisfactory for installation where the head is less than 400 feet for the smaller, and 300 feet for the larger wheels. For the higher heads, a concrete setting is essential, and it is desirable for any permanent installation, whatever the head. Similarly, cast-iron bedplates and metal housings are recommended for the larger or higher head installations.

Where the load is constant, or nearly so, or where a considerable variation in speed can be allowed, a Standard Wheel may be employed without any speed-regulating equipment. Usually, however, speed regulation, such as is afforded by a jet-deflector, is essential. The

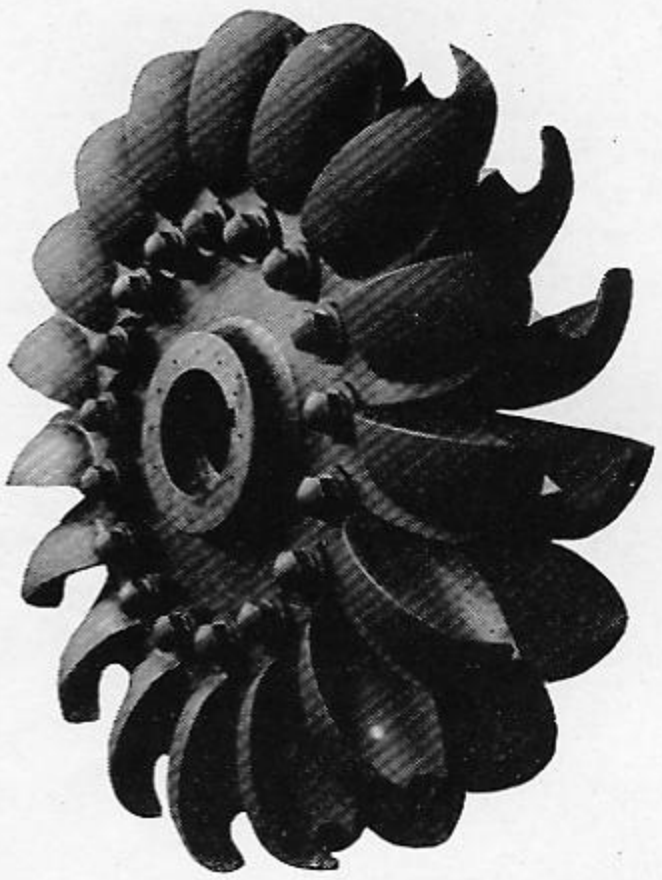


Fig. 1. Special PELTON runner with ellipsoidal buckets

mechanism of a jet-deflector is shown in Figs. 7 and 8. The deflector may be actuated to divert any desired part of the jet from striking the wheel.

In some few instances satisfactory regulation can be obtained with a hand-controlled deflector, but in general a governor is required. Governors are discussed on Pages 17 and 18, and a Standard Wheel regulated by a governor-operated jet deflector is shown in Fig. 7.

Frequently, in order to obtain a given output at a higher operating speed than is afforded by single-nozzle construction, a double nozzle may be used to advantage. Such double-nozzle wheels require twice the water quantity of a single-nozzle wheel of the same size and with the same head, and they develop twice the power. A double-nozzle wheel is shown in Fig. 8.

For many projects, particularly where the water quantity is relatively small, a PELTON Standard Water Motor, such as is illustrated in Fig. 9, will be found most suitable. These motors are entirely self-contained, and are shipped complete and ready for immediate installation.

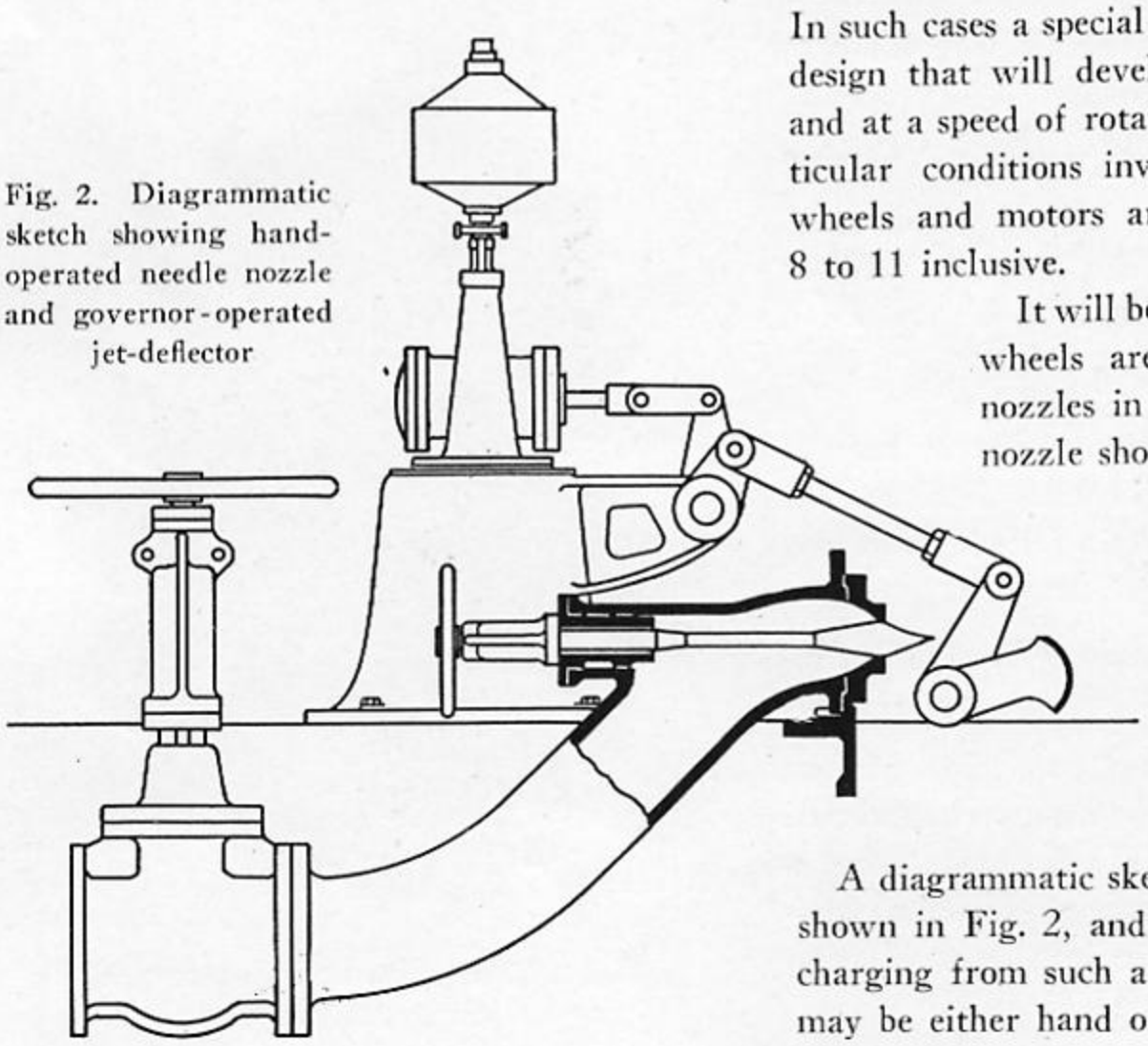


Fig. 2. Diagrammatic sketch showing hand-operated needle nozzle and governor-operated jet-deflector

In many instances the operating requirements may be such that no standard wheel or motor will be found suitable. Certain heads, speeds and horsepower capacities may be encountered that are beyond the rating of standard wheels. Especially is this likely when a compressor and generator, together with existing line-shafting, are to be driven by direct connection, or in any installation where the speed of the driven machinery will not permit an economical drive from a standard wheel. In such cases a special wheel is furnished of a design that will develop the required power and at a speed of rotation suitable to the particular conditions involved. Various special wheels and motors are illustrated on Pages 8 to 11 inclusive.

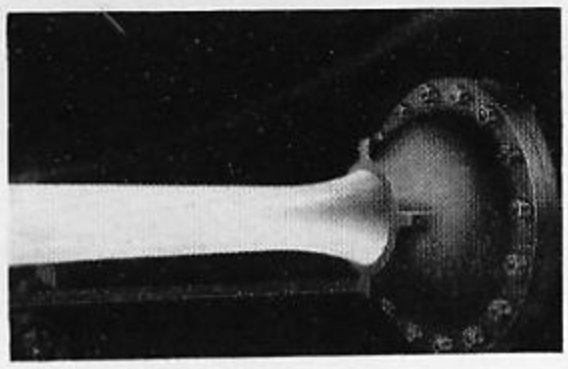


Fig. 3. Water discharging from a PELTON needle nozzle

It will be noted that many special wheels are equipped with needle nozzles in place of the plain rigid nozzle shown in Figs. 6, 7 and 8. The needle nozzle permits varying the size of the jet and consequently the power output at will, without changing nozzle tips, which would involve shutting down the wheel.

A diagrammatic sketch of a needle nozzle is shown in Fig. 2, and Fig. 1 shows a jet discharging from such a nozzle. Needle nozzles may be either hand or governor controlled.

Water diverted from a wheel by means of a jet deflector is wasted, while the needle nozzle permits the saving of water during periods of light load, providing storage is available. On the other hand, rapid variations in discharge caused by rapid movements of the needle result in dangerous fluctuations in pressure in the pipe line. Such fluctuations in pressure may cause damage to, or even collapse of the pipe line. The jet deflector, since it does not affect the rate of flow through the nozzle, does not affect pipe line pressures.

For this reason the needle nozzle alone is seldom used for regulating speed. Where the need for efficient use of the water available is such as to justify the expense, a combination of governor-controlled jet deflector and hand-operated needle nozzle, as shown in Fig. 4, is frequently supplied. The needle is set several times during the day in accordance with the probable load, or with the flow of the stream, or with both. The governor-controlled jet deflector takes care of the momentary variations in load. In this way a considerable amount of water may be stored during light load periods.

Plants of considerable size and with operating requirements calling for the highest efficiency and water economy are usually equipped with the auxiliary relief needle nozzle illustrated in Fig. 5. Such equipment is, however, too expensive to be justified for installations of small capacity.

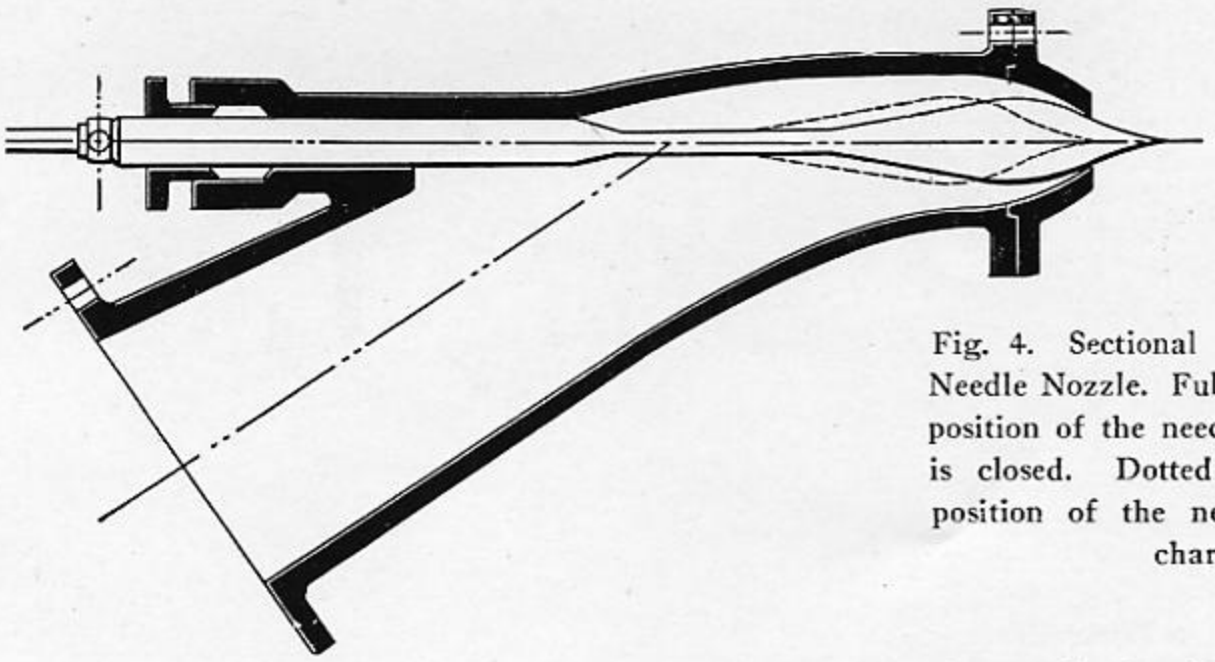


Fig. 4. Sectional view of PELTON Needle Nozzle. Full lines illustrate the position of the needle when the nozzle is closed. Dotted lines indicate the position of the needle with jet discharging

For most small plants the buckets shown in Fig. 6-8 are entirely satisfactory. Higher efficiency may, however, be obtained with the PELTON ellipsoidal buckets illustrated in Fig. 3. In each individual case the additional first cost must be balanced against the higher efficiency obtainable.

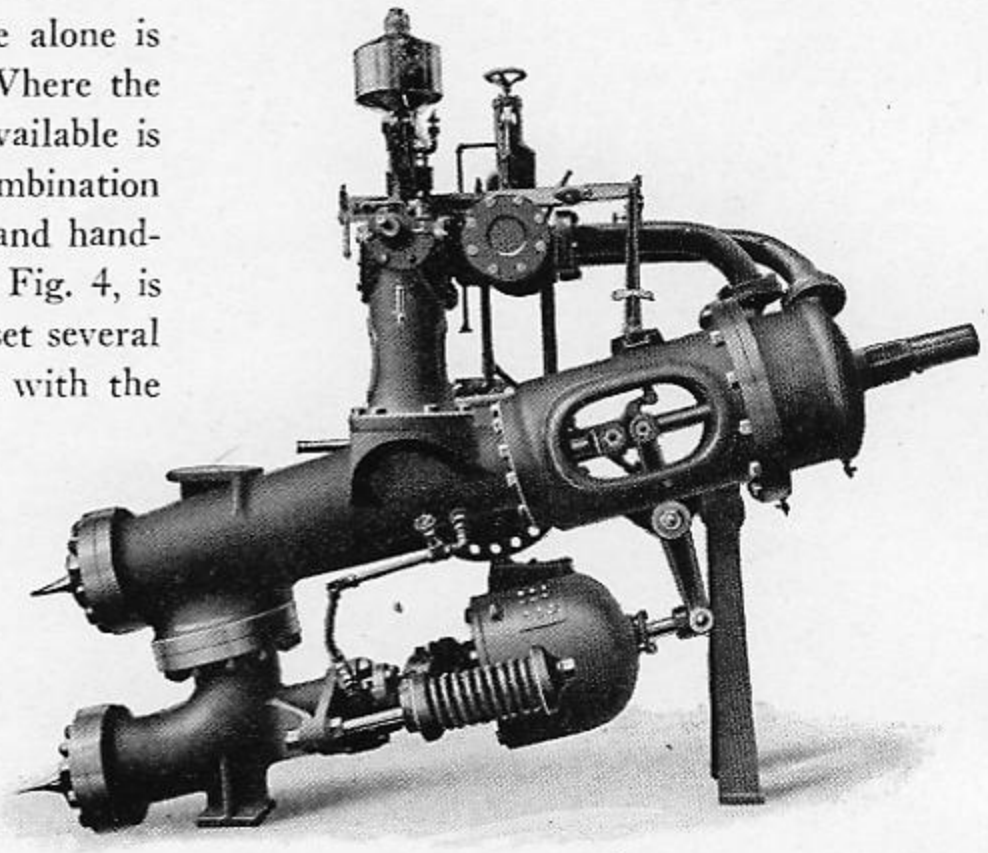


Fig. 5. PELTON auxiliary relief needle nozzle with direct-motion governor

STANDARD PELTON WATER WHEELS

Fig. 6. Standard PELTON Wheel. Equipment comprises one PELTON Wheel, with interchangeable cast-iron buckets. One steel shaft, key-seated for wheel and pulley. Three babbitted journal bearings and set collars. One nozzle of the rigid or plain type. Two interchangeable nozzle tips bored respectively for the full power of the wheel and for approximately three-quarters of the full power; or at purchaser's option, the nozzle tips may be bored for any amount of power within the range of the wheel's capacity. One flanged, bronze-mounted, single-disc gate valve of the outside-screw, rising-spindle type. One set of foundation bolts, frame bolts and washers. One blue print and bolt list to permit purchaser constructing the wood frame and cover housing at destination. For horsepower capacity, speed and water consumption of standard single-nozzle PELTON Wheels refer to Pages 26-28. Pulleys and timber frames are not furnished as a part of the standard equipment, but will be supplied when desired at an addition to the sales price.

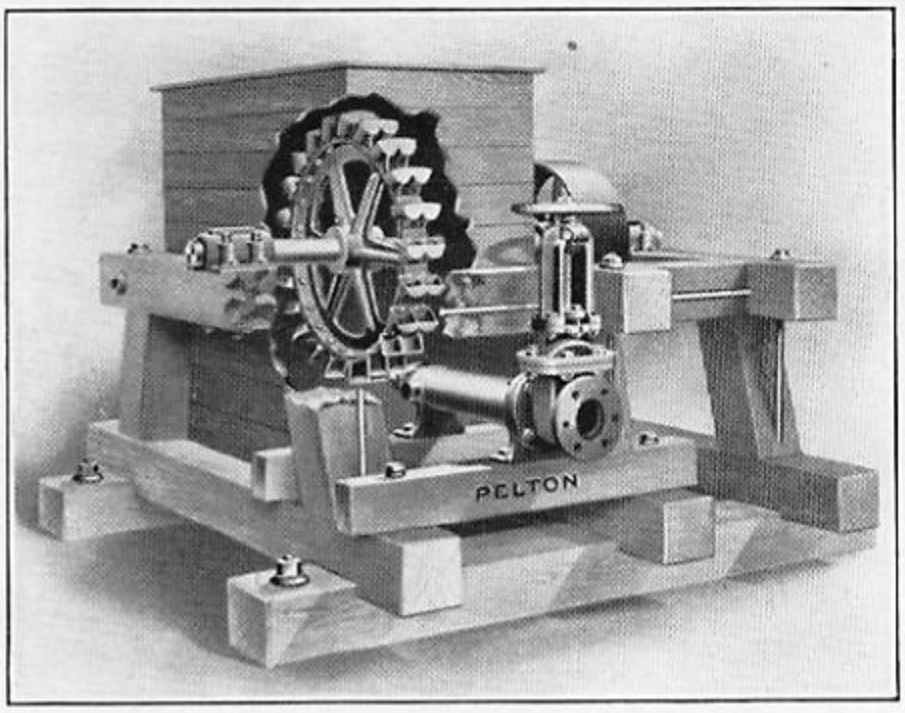


Fig. 6. Standard PELTON Wheel, with interchangeable cast-iron buckets

Where it is particularly important to limit the first cost of the installation, a Type D Wheel may be furnished. The general equipment of a Type D Wheel is the same as for a Standard Wheel, except that the buckets are cast integral with the rim instead of being bolted to it. Sizes and capacities of Type D Wheels are given on Page 26.

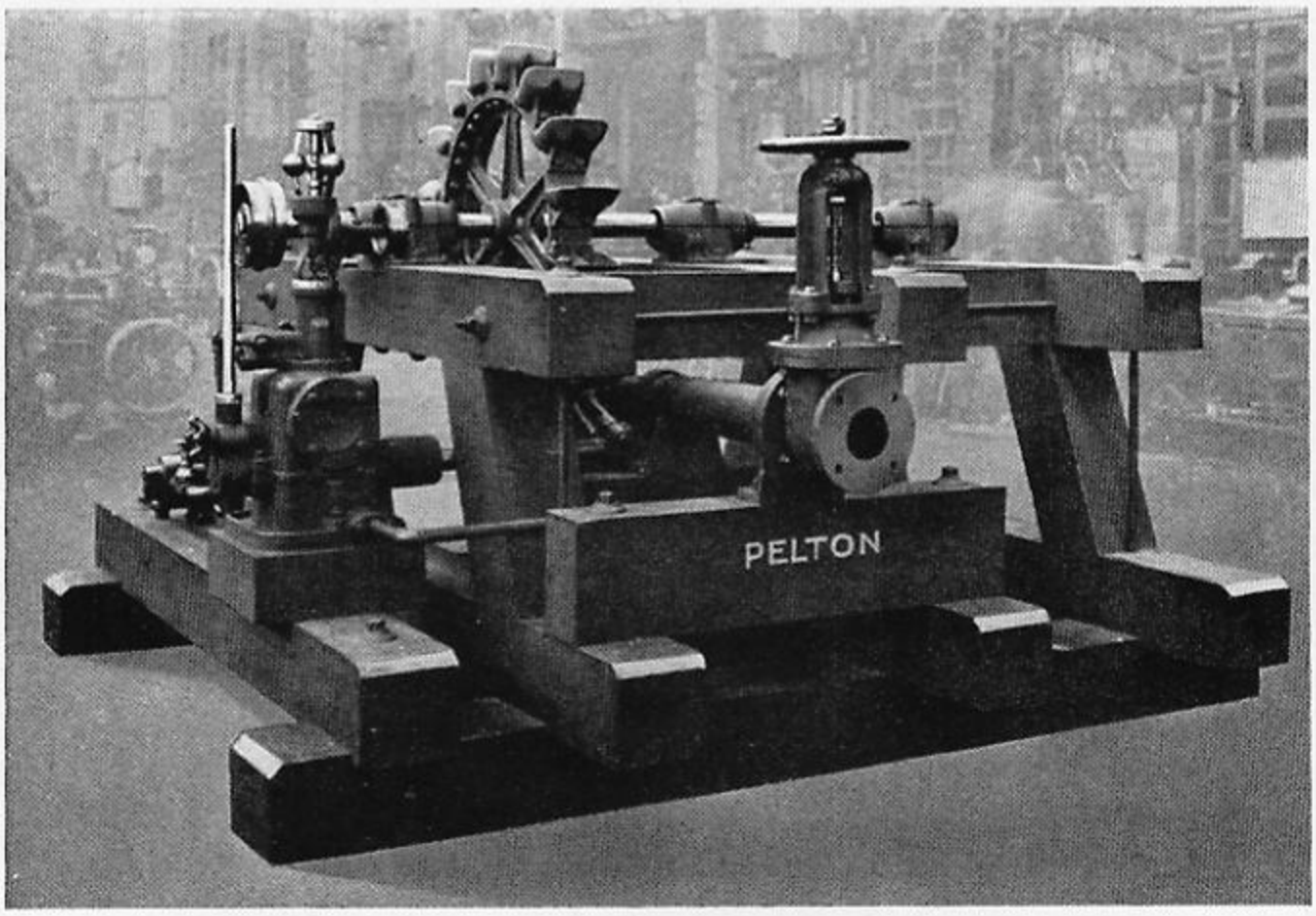


Fig. 7. Standard PELTON Wheel with governor-operated jet-deflector

STANDARD PELTON DOUBLE-NOZZLE WHEELS

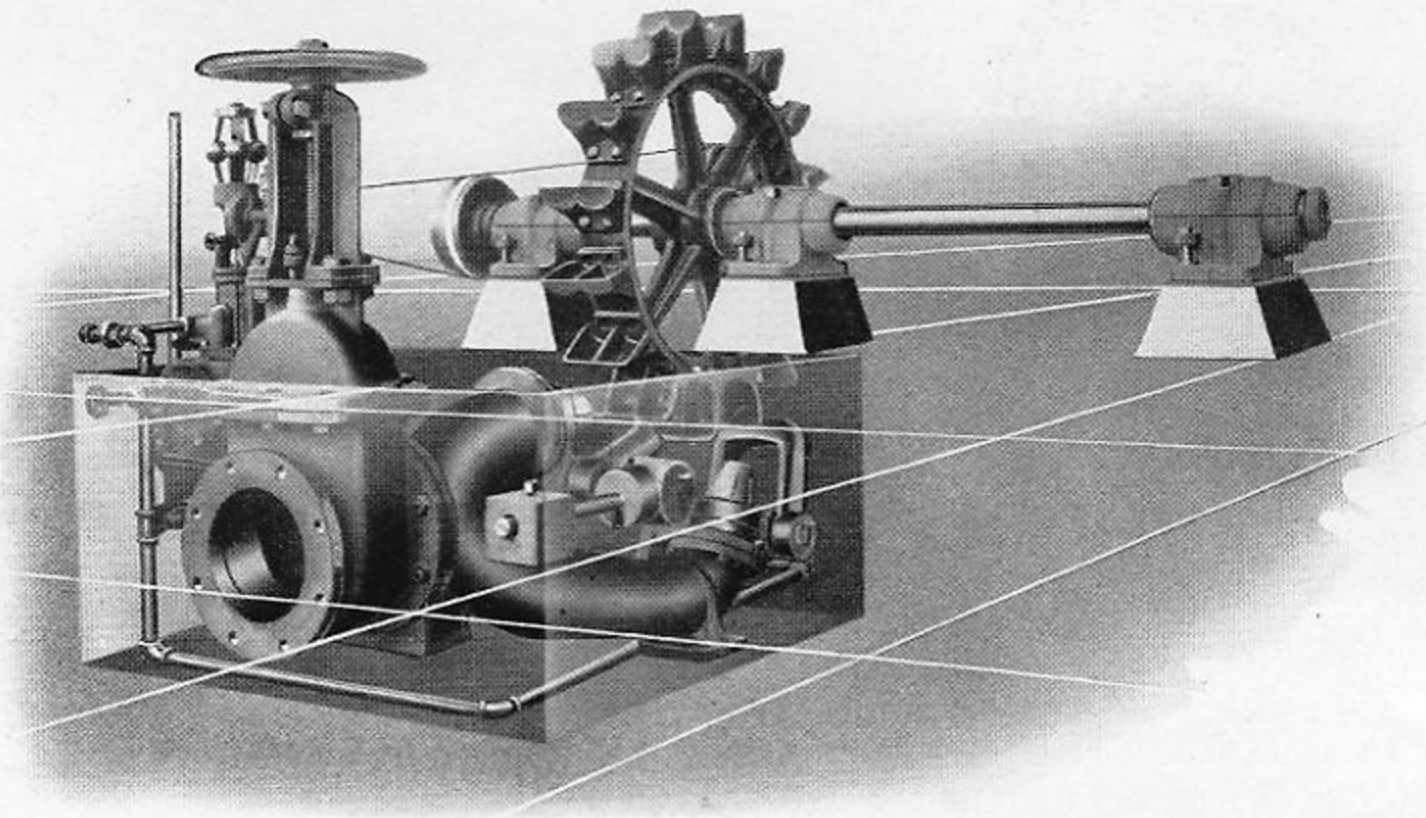


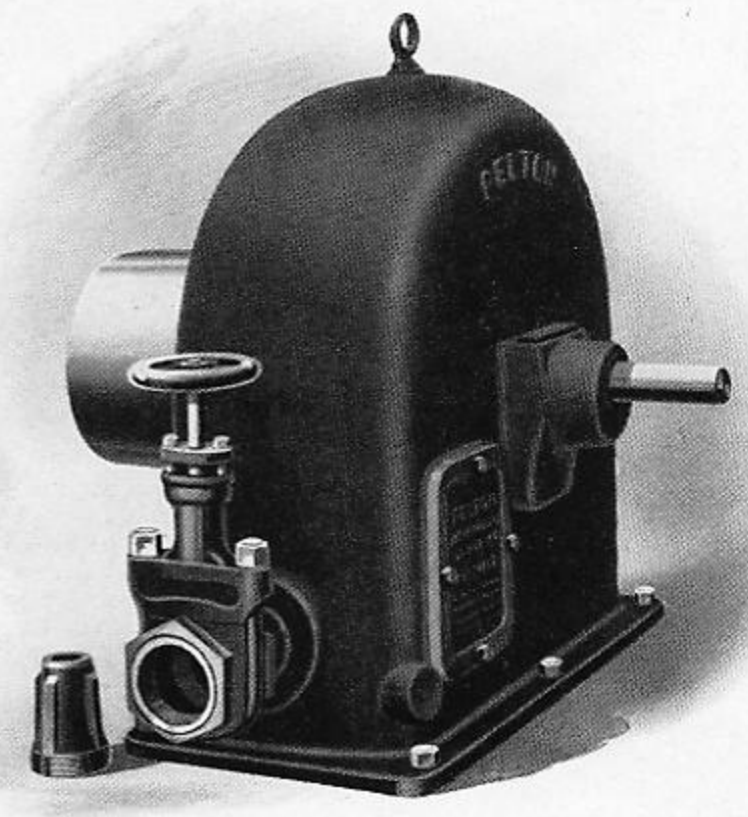
Fig. 8. Standard PELTON Double-Nozzle Wheel with governor-operated jet-deflectors

STANDARD PELTON WATER MOTORS

Fig. 9. Standard PELTON Motor. Equipment comprises one PELTON Wheel, two ring-oiling, bronze-bushed bearings; one steel shaft, projecting sufficiently to permit mounting a pulley on either side of the motor; one complete metal housing; gate valve, nozzle, and two interchangeable tips.

For horsepower capacity, speed, and water consumption of Standard PELTON Motors, see Pages 26 to 28.

Standard Motors are built in five sizes, namely, 6, 12, 15, 18, and 24 inches.



SPECIAL PELTON WHEELS AND MOTORS

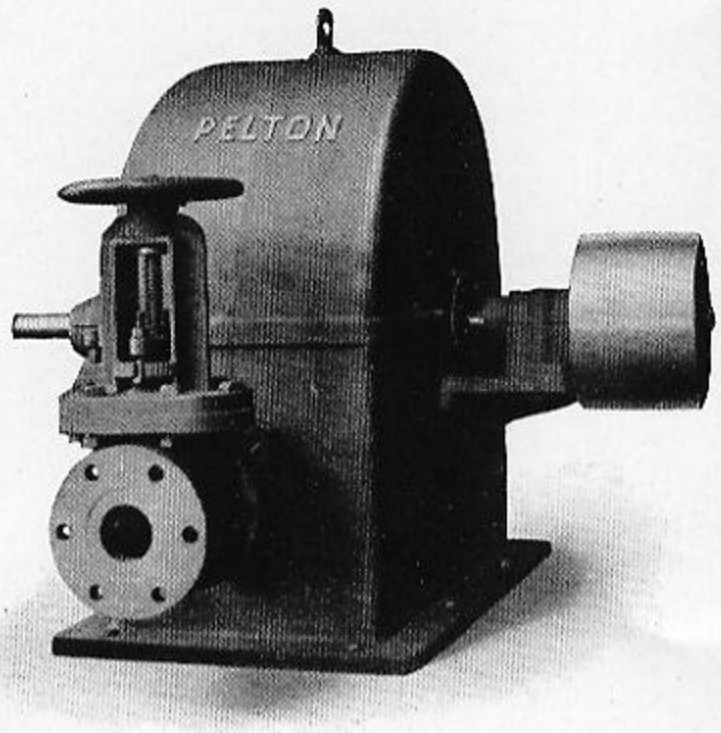


Fig. 10. Special PELTON Motor with parted housing

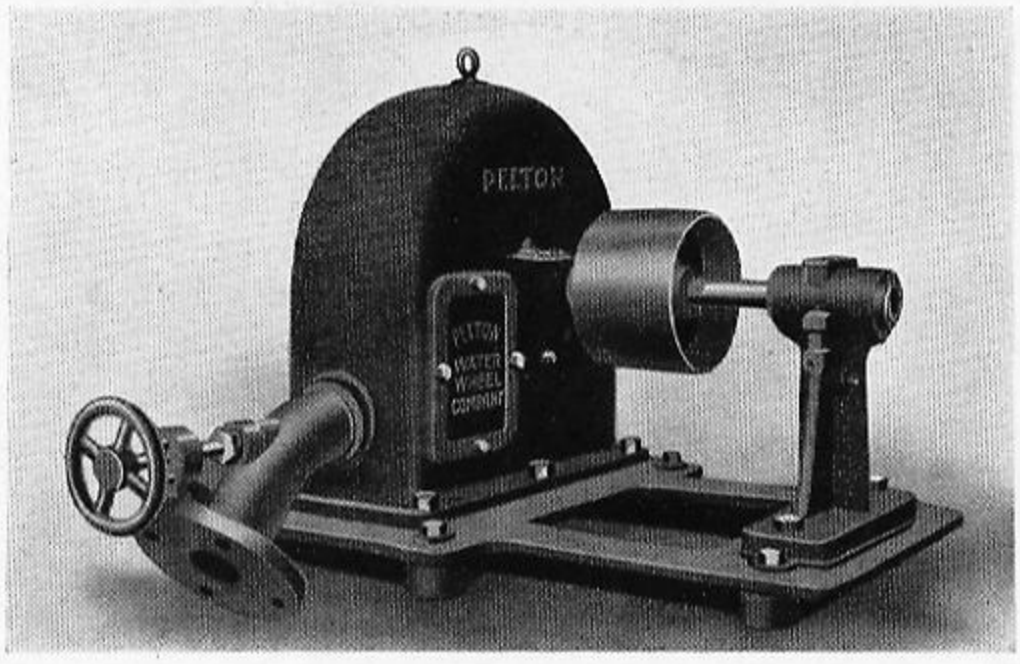


Fig. 11. PELTON Motor with outboard bearing, soleplate, and hand-operated needle nozzle.

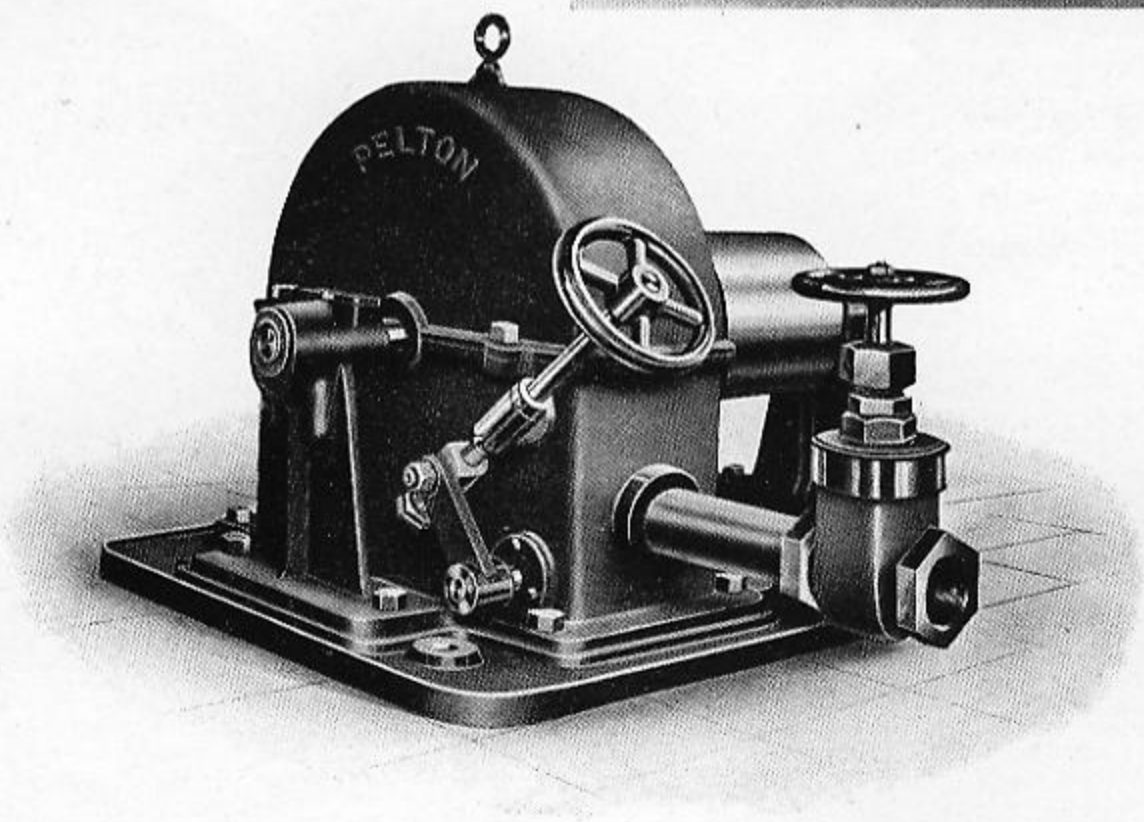


Fig. 12. PELTON Motor specially designed for high heads, and equipped with outboard bearing, soleplate, and hand-controlled jet-deflector

SPECIAL PELTON WHEELS AND MOTORS

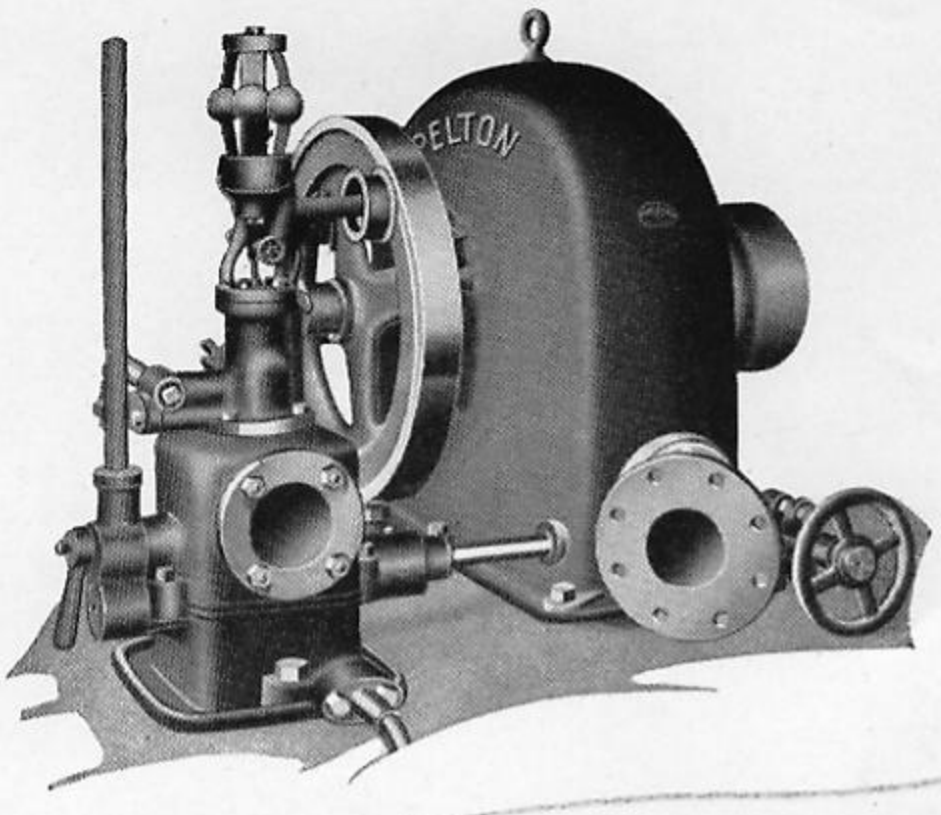


Fig. 13. Special PELTON Motor with flywheel, hand-operated needle nozzle, and governor-controlled jet-deflector

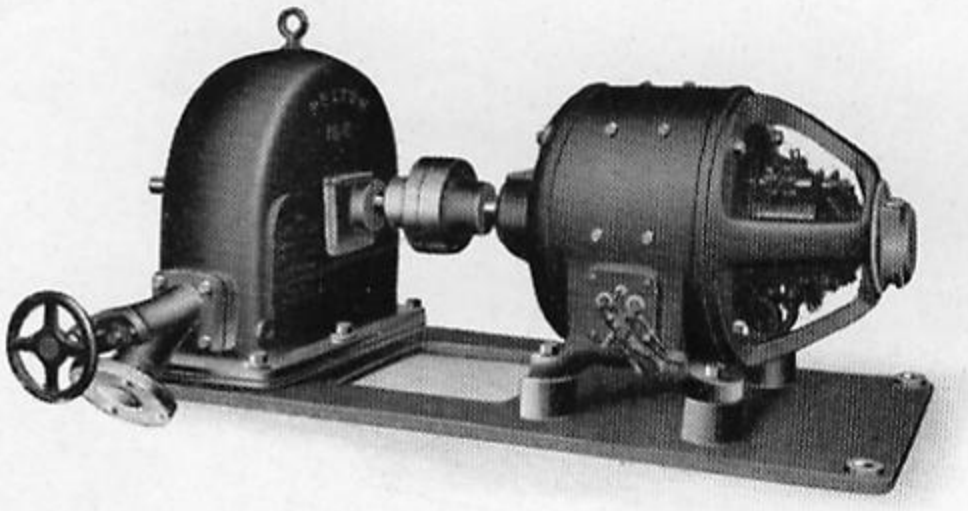


Fig. 14. PELTON Motor direct-connected to generator

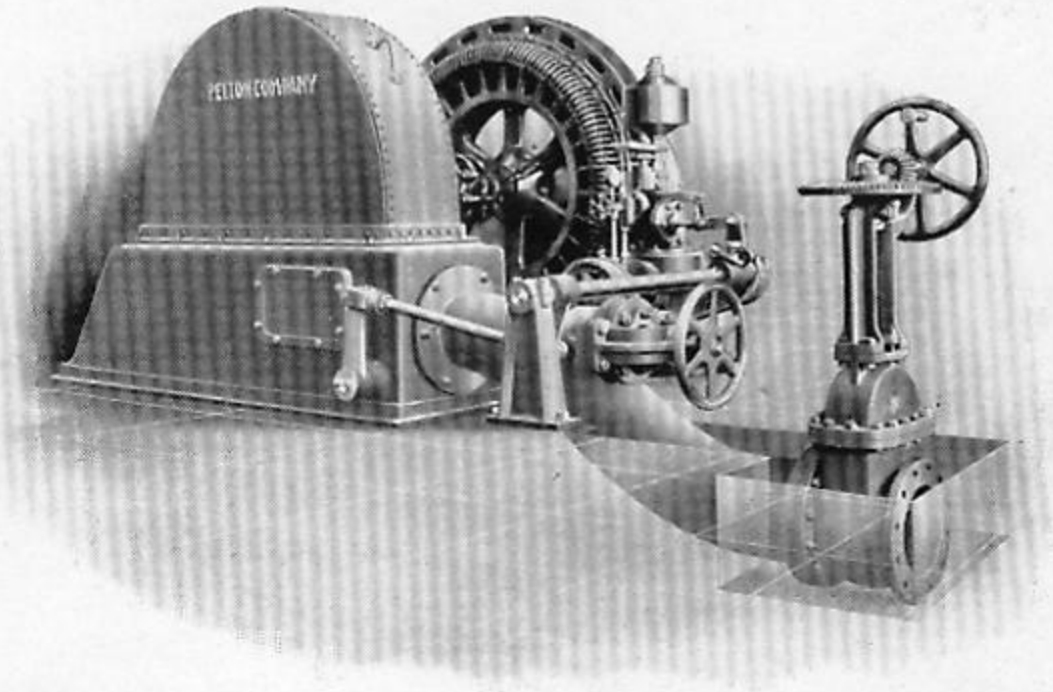


Fig. 15. Complete hydro-electric unit with single-overhung wheel, hand-operated needle nozzle and governor-controlled jet-deflector

SPECIAL PELTON WHEELS AND MOTORS

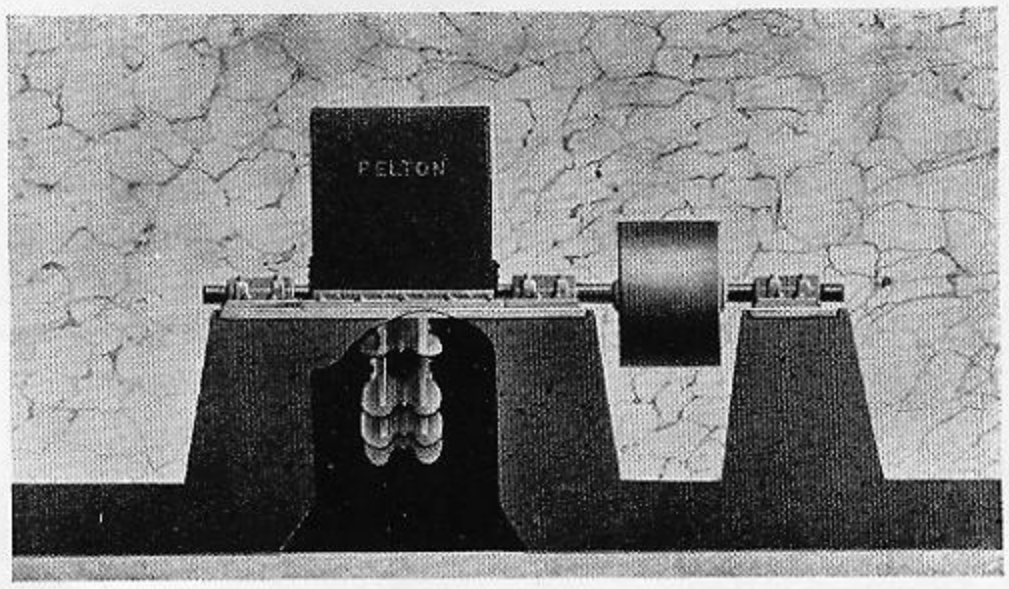


Fig. 16. PELTON Wheel with semi-masonry mounting

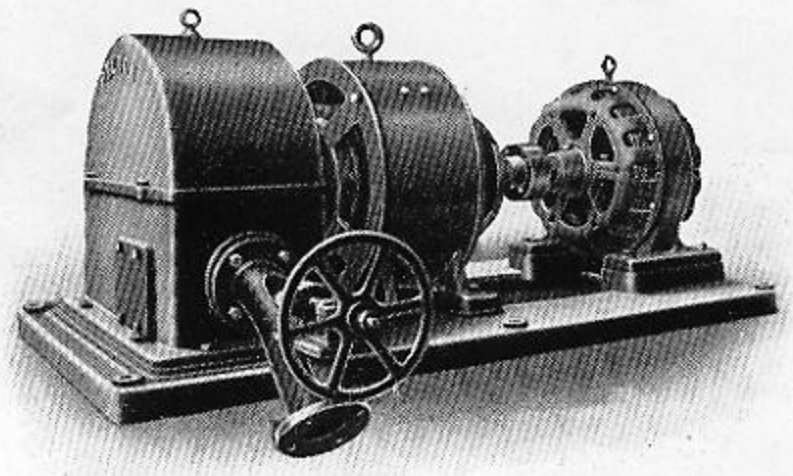


Fig. 17. PELTON Motor direct-connected to motor generator set and equipped with hand-operated needle nozzle

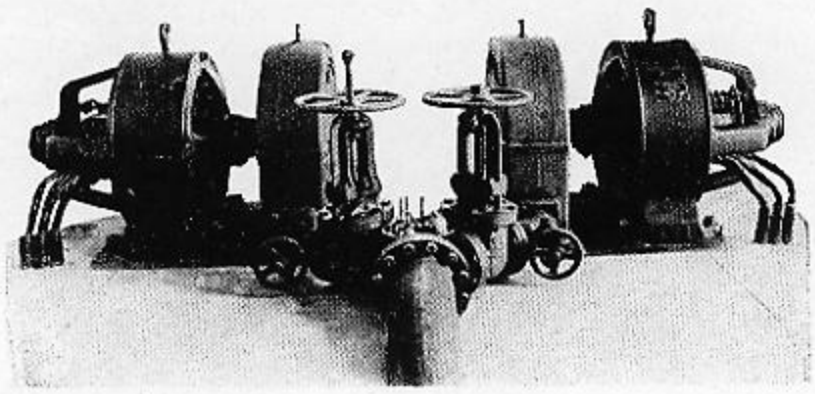


Fig. 18. PELTON Wheel direct-driving exciter units

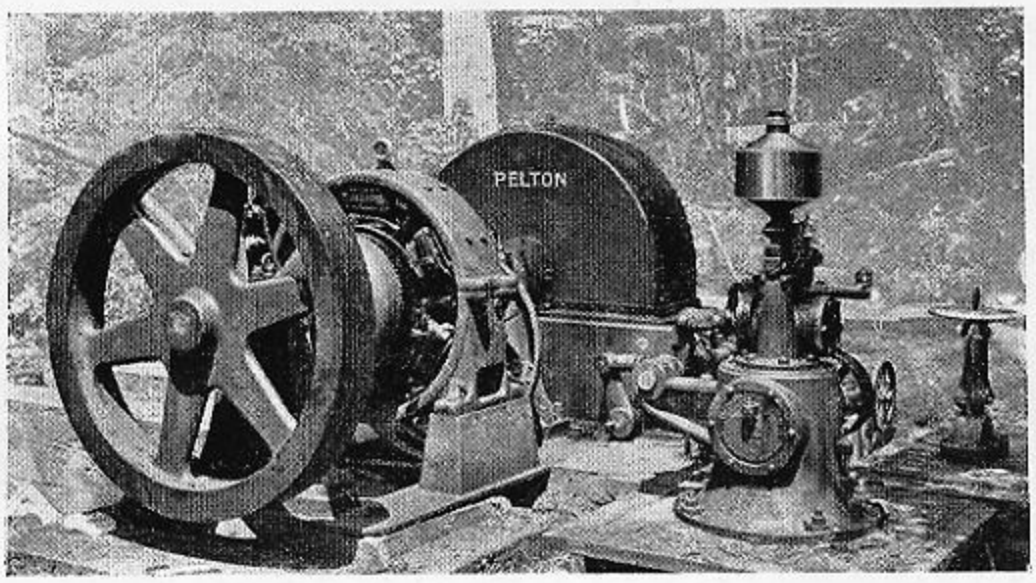


Fig. 19. Complete hydroelectric unit, equipped with flywheel, hand-operated needle nozzle and governor-controlled jet-deflector

SPECIAL PELTON WHEELS AND MOTORS

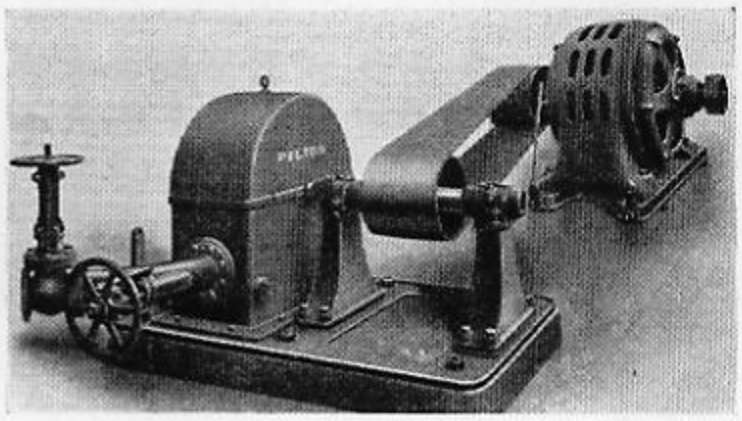


Fig. 20. PELTON Motor belt-connected to generator and equipped with hand-operated needle nozzle

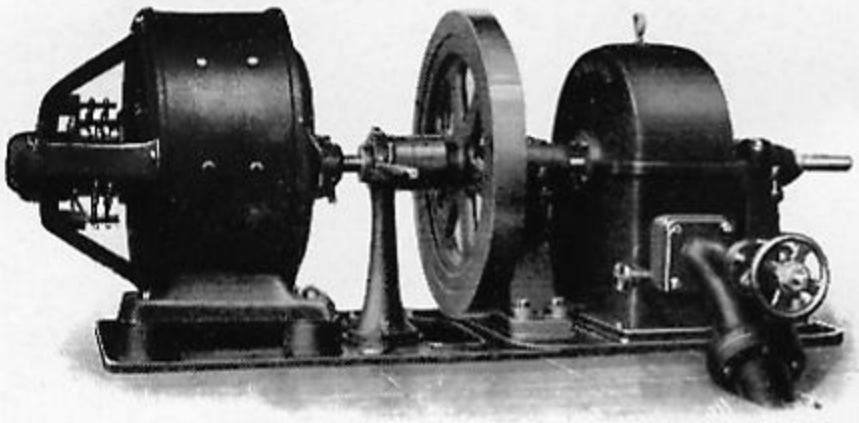
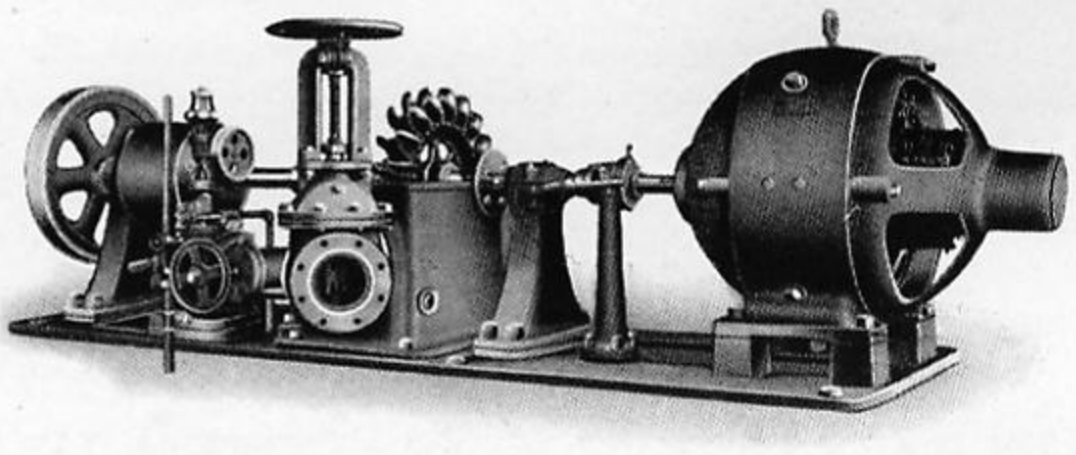


Fig. 21. PELTON Motor direct-connected to a direct-current generator. A jaw clutch is provided for ready disconnection of the generator to permit the use of the water wheel for driving other machinery

Fig. 22. Self-contained hydro-electric unit, equipped with flywheel, hand-operated needle nozzle, and governor-controlled jet-deflector. Note that a pulley and a clutch are provided permitting disconnecting the generator and driving other machinery. The upper housing of the wheel has been removed, showing the runner with ellipsoidal buckets.



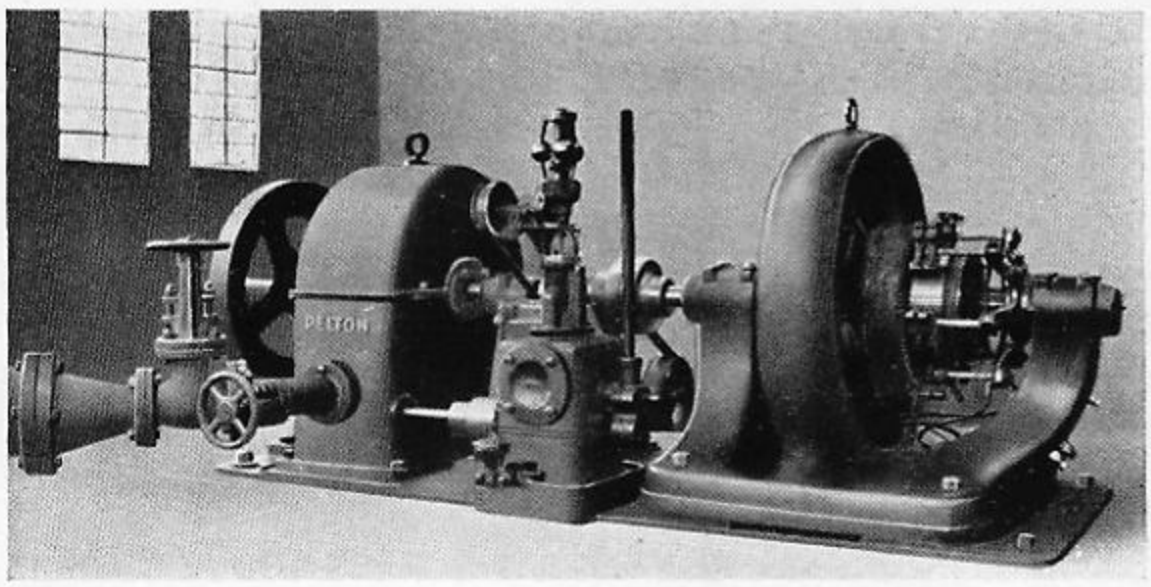


Fig. 23. A similar hydro-electric unit except that there is no pulley or clutch

PELTON LABORATORY MOTORS

Many universities and engineering schools have availed themselves of the opportunity of furnishing practical instruction to students by means of the laboratory motor shown in Fig. 24. This is a tangential water wheel having a pitch diameter of 12 inches. It is made of gun metal and has interchangeable ellipsoidal buckets of the same material fastened by means of turned steel studs, driven into reamed holes. The ring-oiling pedestal bearings support the shaft upon which is mounted the overhung wheel-runner. Space is provided on the shaft for either a pulley or a prony brake. A cast-iron housing with heavy plate glass sides affords opportunity for observing the action of the wheel, and particularly the path of the jet from the time of entering the bucket until reversal, as well as the clearance of the succeeding bucket without interference.

Water is discharged upon the buckets by a needle nozzle arranged for hand regulation. The needle is of gun metal machined to correct hydraulic curves, and both it and the buckets are of the same type as similar parts used on PELTON Wheels in commercial plants. The unit is substantially built, is self-contained and is mounted upon an iron bedplate.

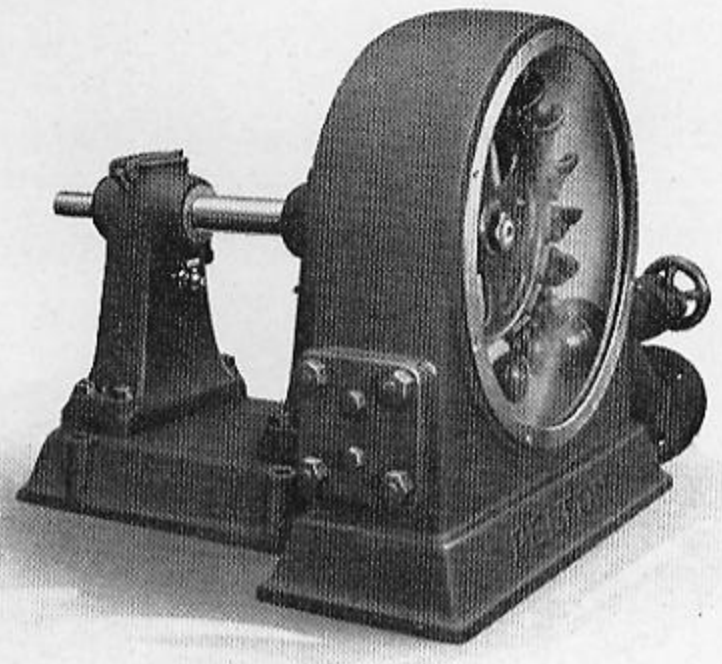
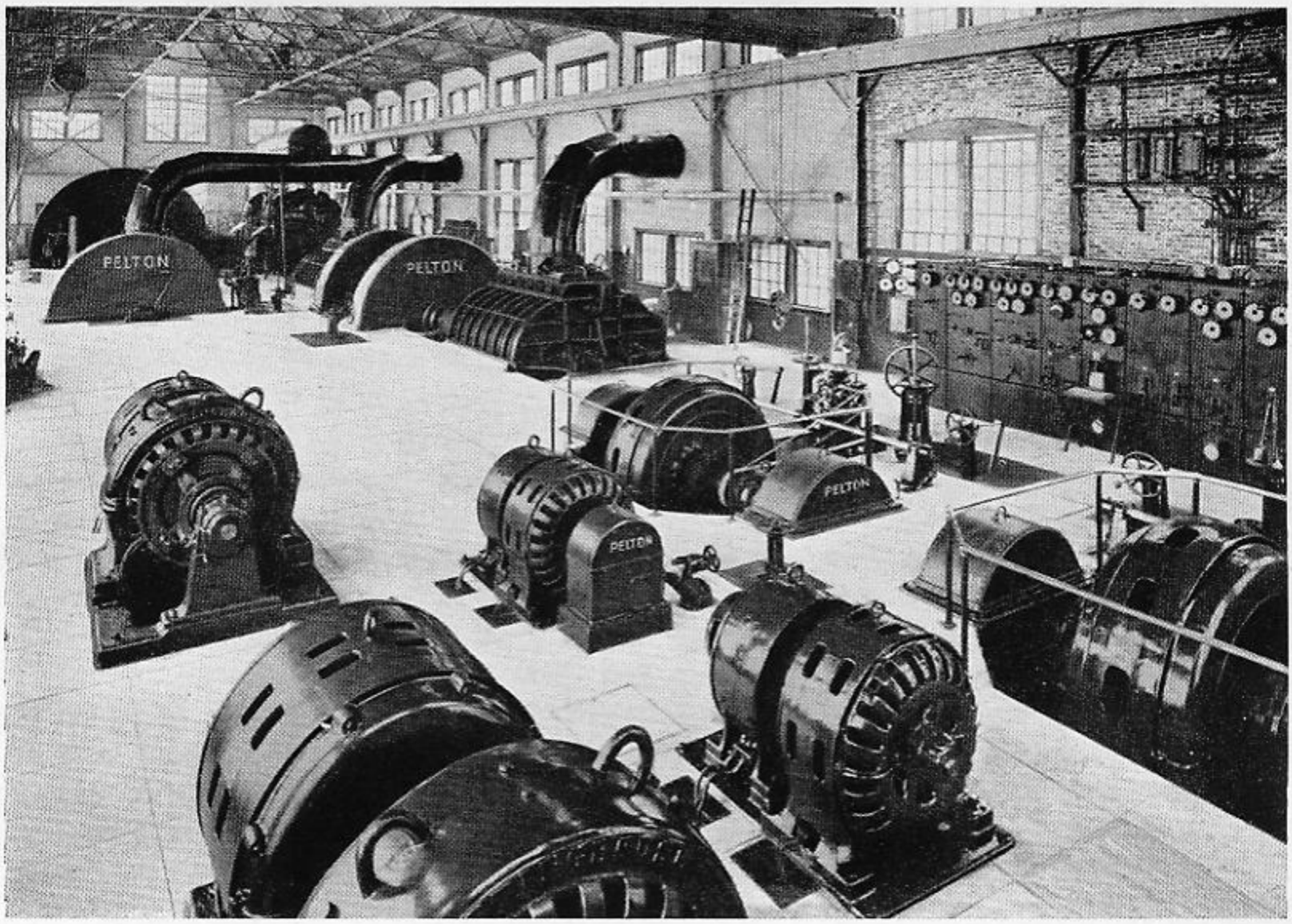


Fig. 24. PELTON laboratory motor

FARM LIGHTING & OTHER ISOLATED PLANTS

There are many localities where central station current is not obtainable but where water power can easily be developed. An installation of this character is usually required to operate with only occasional attention, and at the same time the first cost must be held low to prevent too great a fixed charge per unit of output. The simplicity of the impulse wheel design and the accuracy of regulation obtainable with a PELTON Governor cause this type of construction to be well fitted to meet the above requirements.

Since the farm lighting plant must be suited not only to local conditions, but also to the funds available, no general rules regarding kind of plant can be laid. Figs. 8, 22 and 23 show different types in actual service at the present time.



Interior of Plant of Granby Consolidated Mining, Smelting & Power Company at Anyox, British Columbia

THIS plant is particularly interesting as illustrating the flexibility of PELTON Impulse Wheels, since all the varied power requirements of the company's mine and copper smelter are supplied in this way.

In the background of the photograph will be seen a 1400-horsepower, single-runner wheel equipped with an auxiliary relief needle nozzle. This wheel is direct-connected to a blowing engine, the runner of the wheel being mounted on the main shaft of the blowing engine between the high and low-pressure cylinders. The governor of the water wheel is also inter-connected with the pressure regulator of the blowing engine so as to control by changes in speed of the wheel the output and pressure of the air supplied by the blowing engine.

Immediately behind the blowing engine is a cross-compound air compressor, direct-driven by a 1200-horsepower impulse wheel of the same general design as that described in connection with the blowing engine.

In the middle distance are three Connersville blowers each driven through special gearing by an 800-horsepower impulse wheel.

In the right foreground are two 1400-horsepower wheels direct-driving generators supplying electric energy for various purposes, including mine haulage. The exciters are also impulse wheel driven.

This photograph was taken in 1914, shortly after the installation of the original equipment. About four years later a 1000-horsepower wheel was installed to drive another generator, making the total capacity of the plant 8400 horsepower. Recently, increased need for power caused the company to arrange for a 5000-horsepower PELTON Vertical Reaction Turbine, which will be placed in service early in 1924.

APPLICATIONS OF PELTON WHEELS AND MOTORS

(Other Than Hydroelectric)

Although PELTON Wheels and Motors are principally employed for driving electric generators, they are also suited to running almost every other kind of machinery. The illustration on pages 14 to 16 by no means exhaust the possible applications, but are given merely to indicate a few of the many ways in which PELTON Wheels are rendering service to the power user.

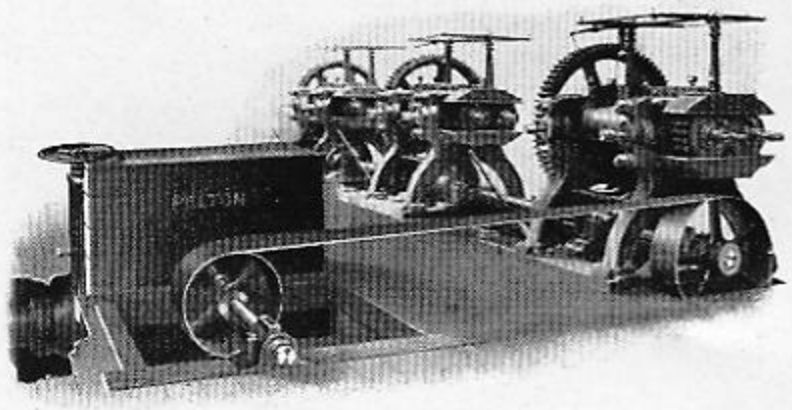


Fig. 25. PELTON Wheel driving a plantation rubber mill

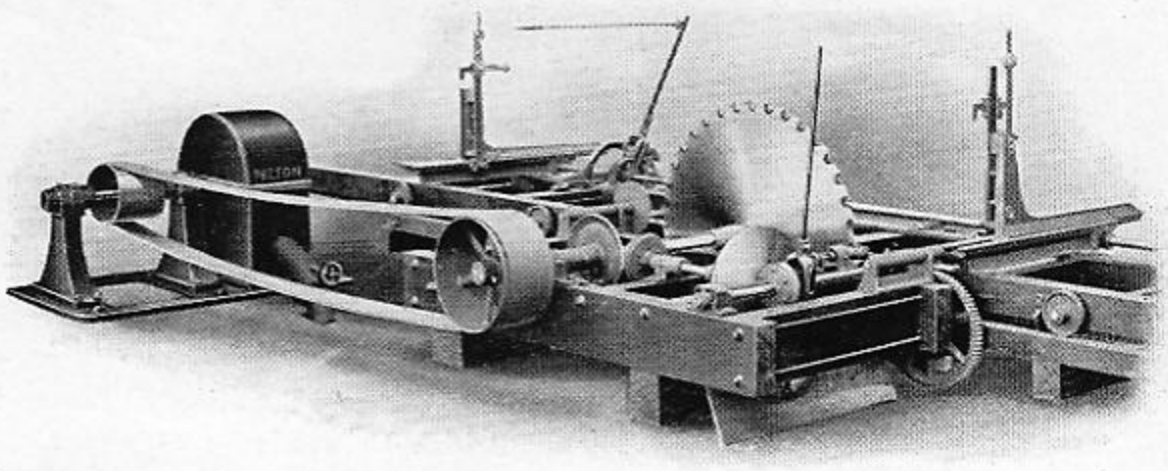


Fig. 26. PELTON Motor belt-driving a sawmill

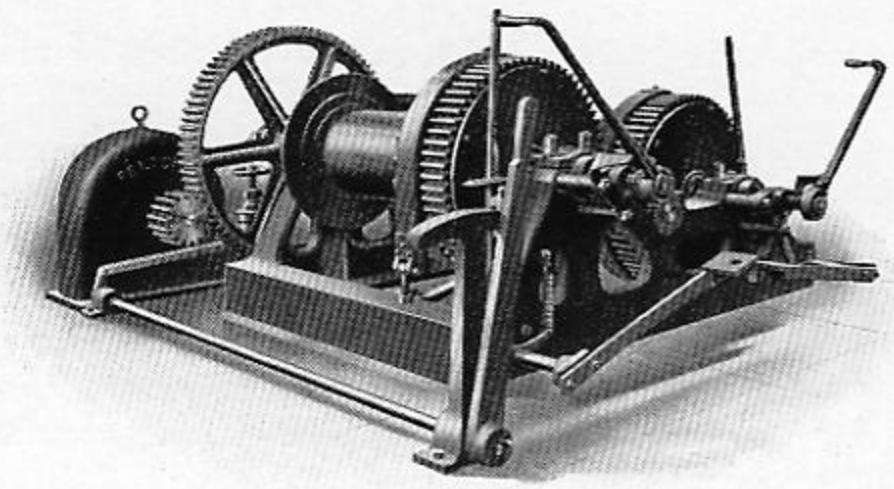


Fig. 27. Standard PELTON Motor geared to double-drum hoist

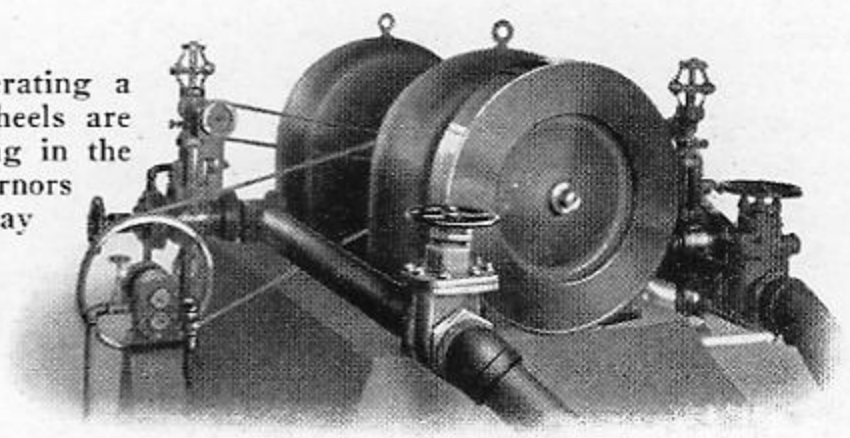


Fig. 28. Two PELTON Motors used for operating a cable tramway for conveying lumber. The wheels are connected in opposition, the buckets of one facing in the opposite direction to those of the other. The governors are so adjusted that when the speed of the cableway gets below normal, water is admitted to the driving unit and power is developed. When the speed rises above normal, water is shut off the power wheel, so that the force of the water neutralizes the excess power of the cableway.

APPLICATIONS OF PELTON WHEELS AND MOTORS

(Other Than Hydroelectric)

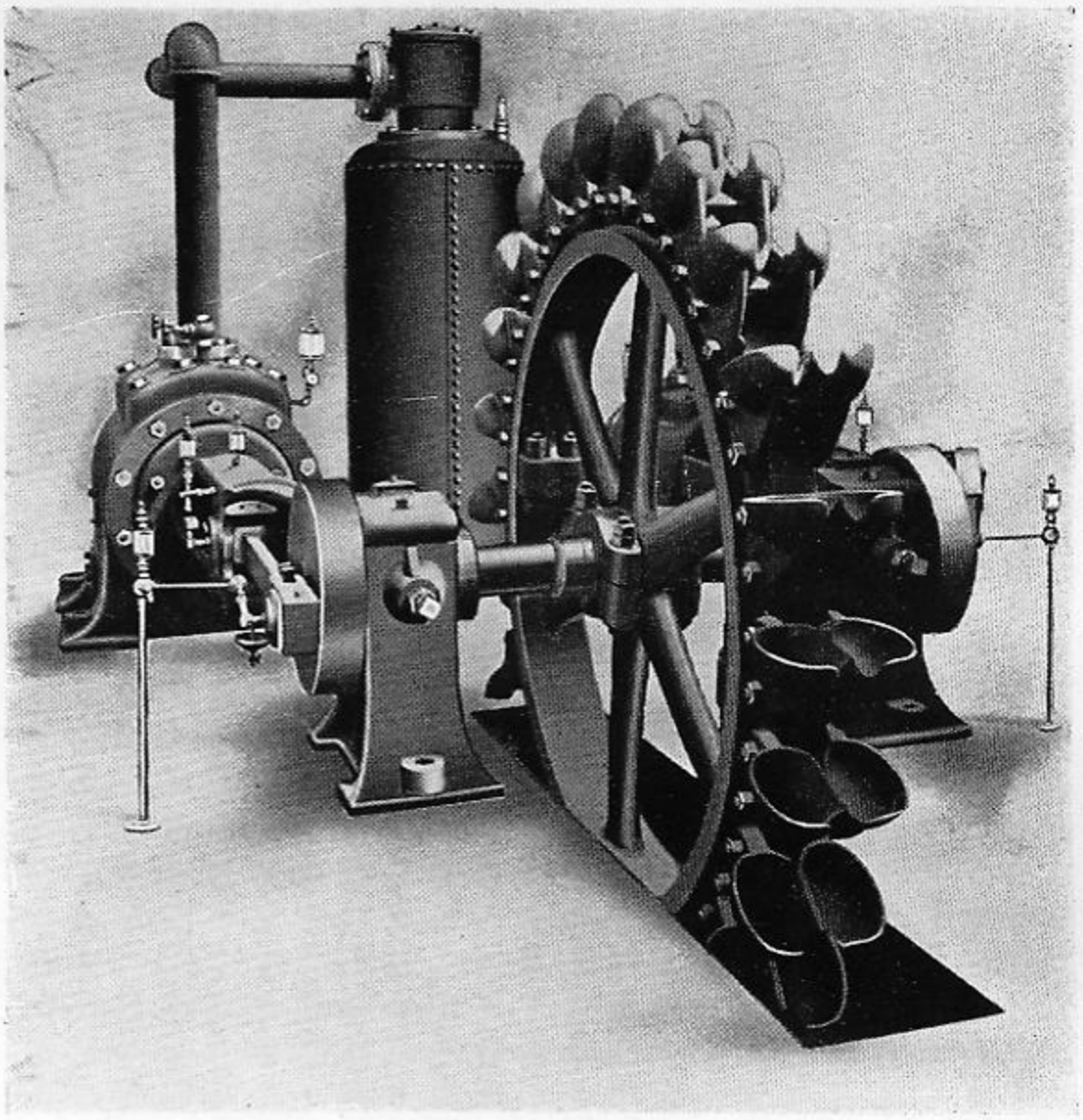


Fig. 29. PELTON Wheel direct-connected to duplex air compressor. In such case the wheel acts both as a prime-mover and as a flywheel, being designed with the latter service in mind. Wheels of unusually large diameter are sometimes required in order to give the proper compressor speed. PELTON Wheels are also sometimes belted to compressors, the ordinary flywheel being retained.

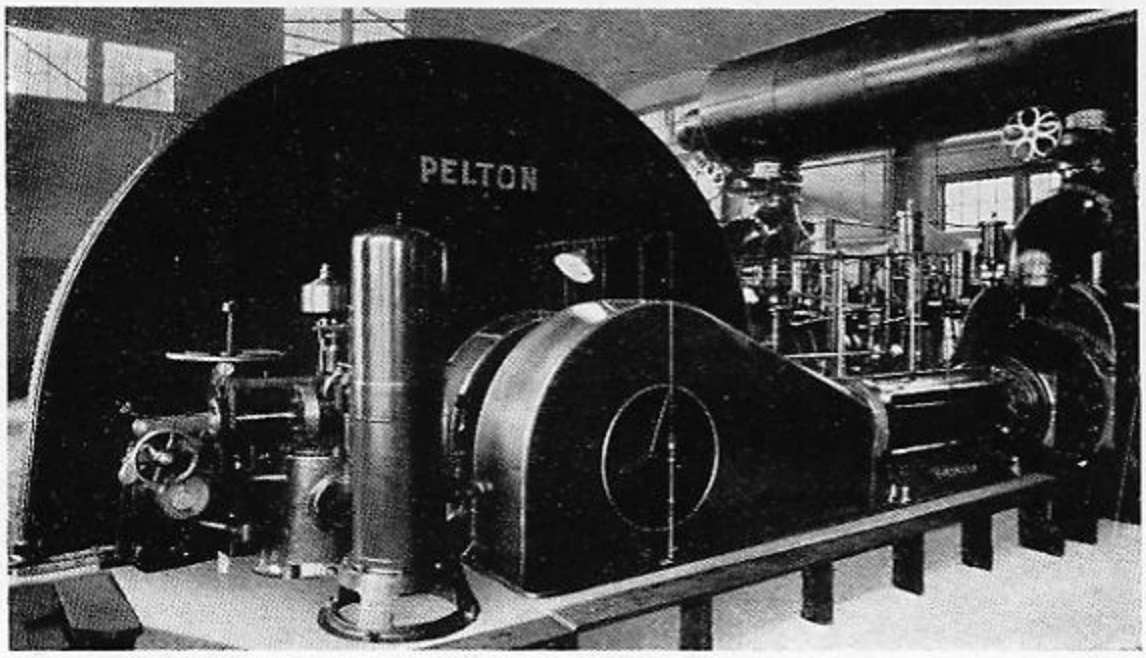


Fig. 30. PELTON Wheel direct-driving air compressor at plant of Granby Consolidated Mining, Smelting & Power Company, more completely described on Page 13.

APPLICATIONS OF PELTON WHEELS AND MOTORS

(Other Than Hydroelectric)

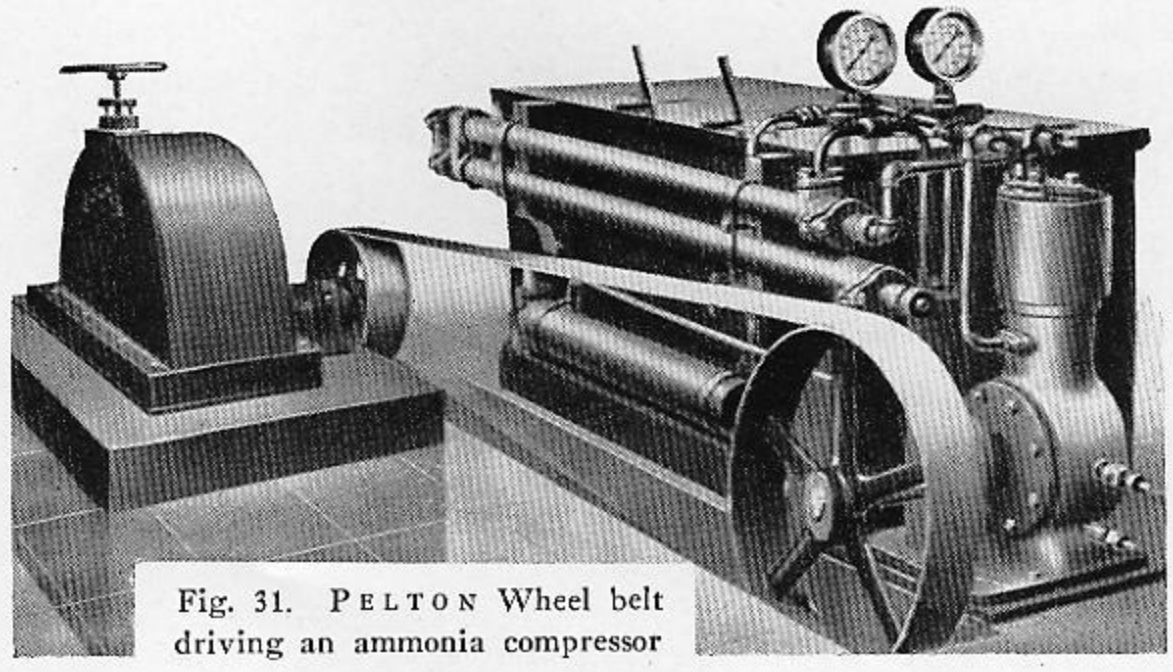


Fig. 31. PELTON Wheel belt driving an ammonia compressor

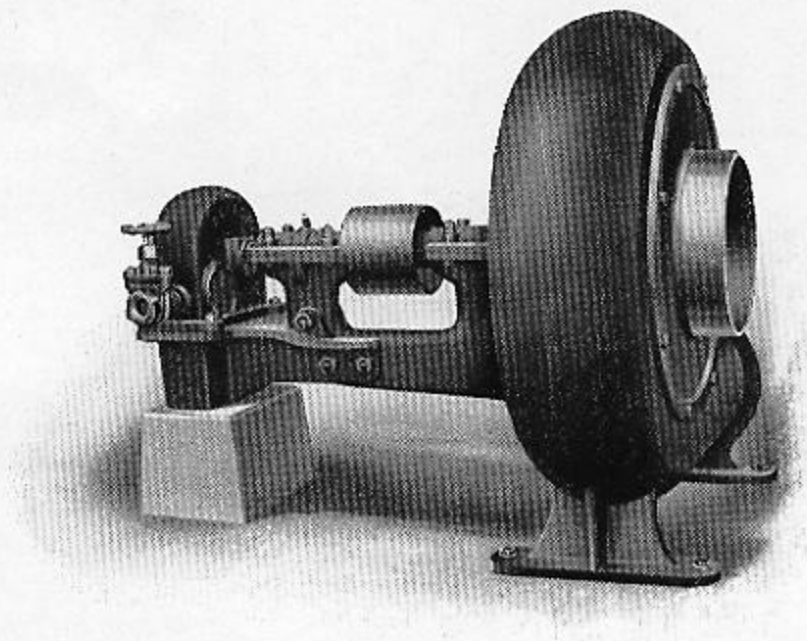


Fig. 32. PELTON Motor, direct-connected to blower

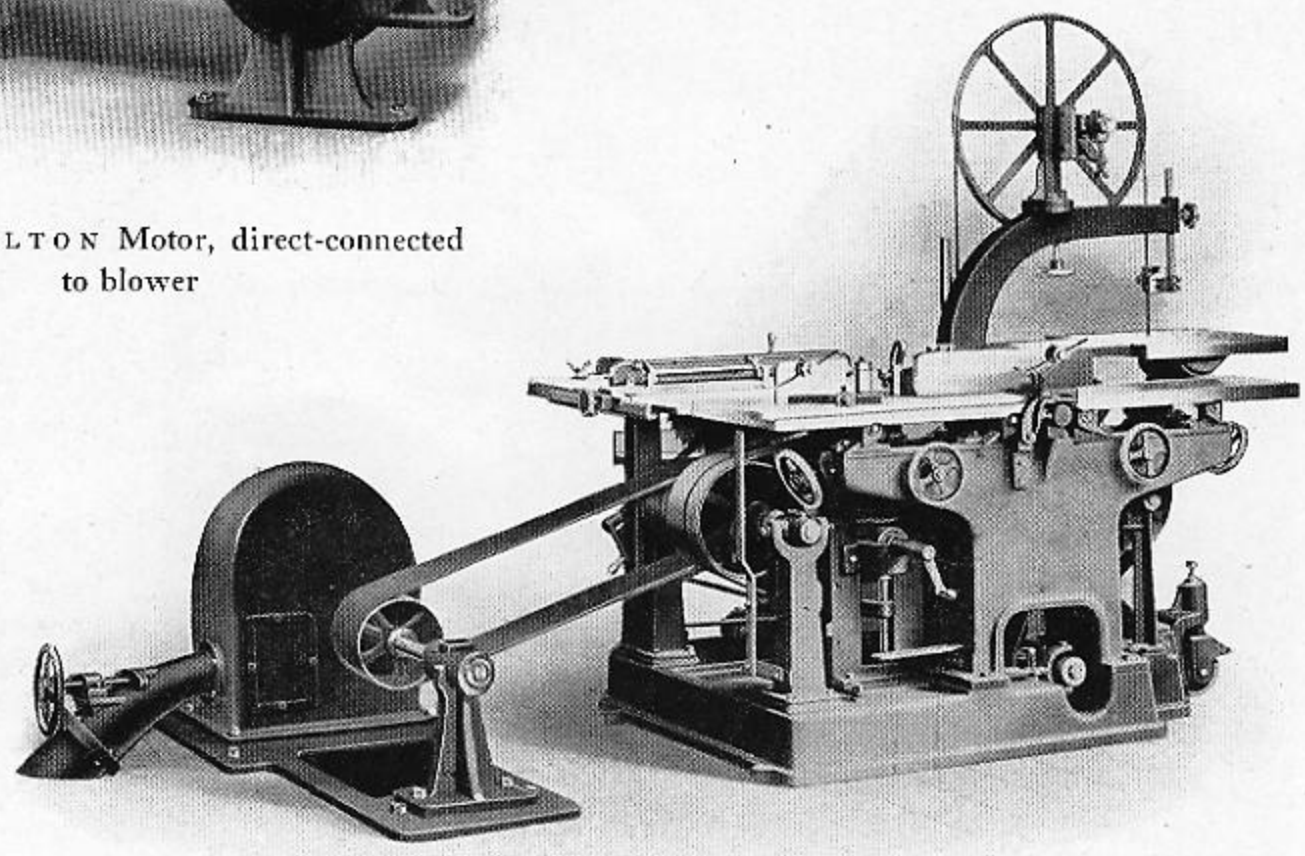


Fig. 33. PELTON Motor belted to Universal Wood-working Machine

GOVERNORS

PROPER speed regulation of hydraulic prime movers subjected to rapid and severe fluctuation of load requires the provision of governing apparatus. The PELTON WATER WHEEL COMPANY has developed a complete line of governing equipment ranging from the small type O governor described more fully below to those required for largest hydroelectric plants, as well as special sets designed to meet unusual conditions. All PELTON Governors are of the oil-presure, open-sump type, and are the product of careful design and workmanship.

The type O governor is used with relatively small units where the amount of governor effort required for speed regulation is not great. The oil pressure is produced by means of a small rotary pump which is belt-connected to the main shaft of the wheel. The pump operates continuously and an automatic unloading device is provided in order to by-pass such oil as is not required for the operation of the governor. The governor head is separately belt-driven from the shaft. The total amount of power required by both the head and the pump is negligible. Where conditions require it, a water circulating system for cooling the oil is provided.

The accuracy and simplicity of Type O Governors makes it possible to apply them satisfactorily to wheels already in use, and many have been purchased for that purpose. Full information will be furnished upon receipt of data as outlined on Page 24.

For larger units various standard and special designs have been developed, several of which are illustrated herewith. The larger designs have independent oil-pumping systems and independent oil-pressure accumulating tanks.

While all governors control the speed of the wheel by varying the amount of water effectively applied, the method of attaining this

Fig. 34. PELTON Type O Governor

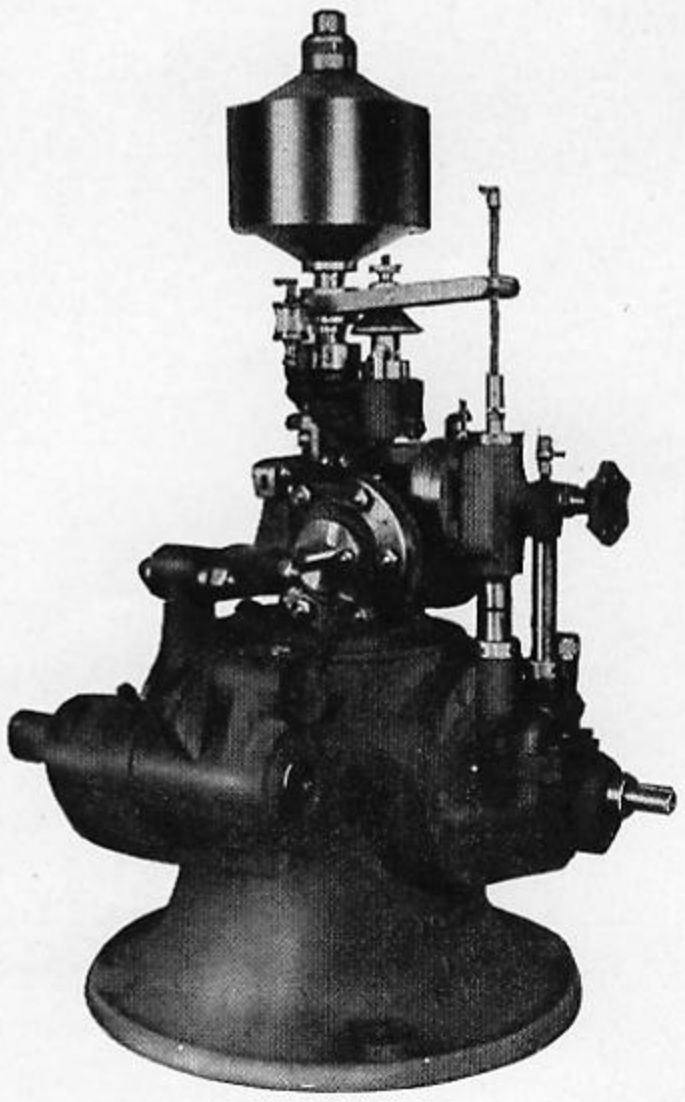


Fig. 35. PELTON Type O-1 Governor

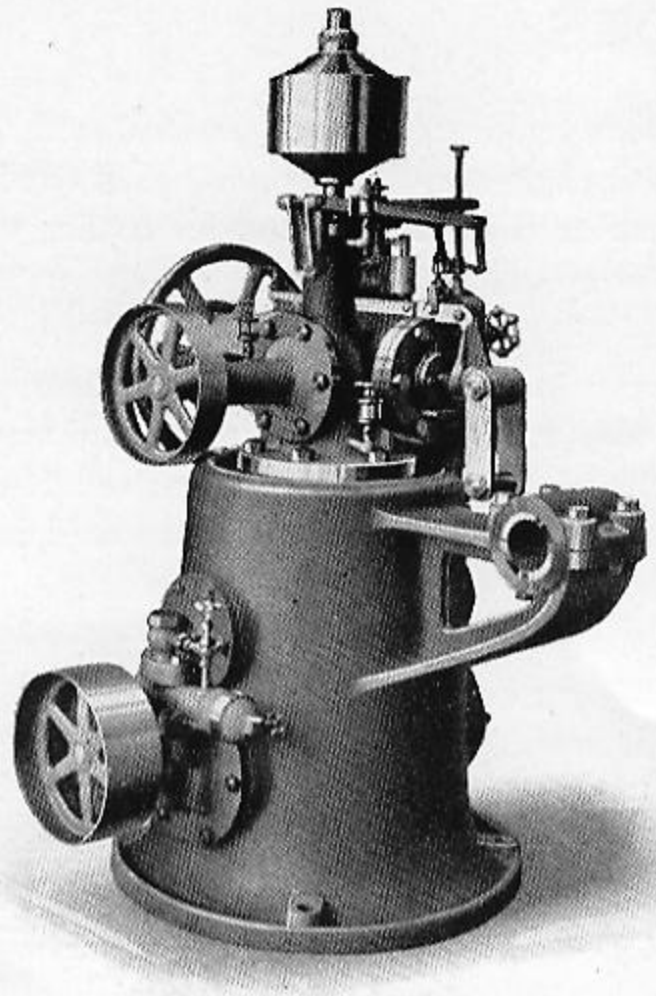


Fig. 36. PELTON Type O-3 Governor

regulation depends upon the character of the entire installation. A complete study of the project is required before definite recommendations can be made.

The direct-motion governor, which is applicable to needle nozzles provided with auxiliary relief, is illustrated in Fig. 5, Page 5. It will be noted that the linkage required in other types of governor is eliminated, the servomotor acting directly upon the needle nozzle. This is a distinct advantage, since it eliminates the troubles that result from wear on this linkage.

All governors are given a running test in the shop before shipment and are thoroughly investigated and adjusted to insure proper functioning. A record is kept of the operating characteristics of each machine. Complete instructions accompany each governor.

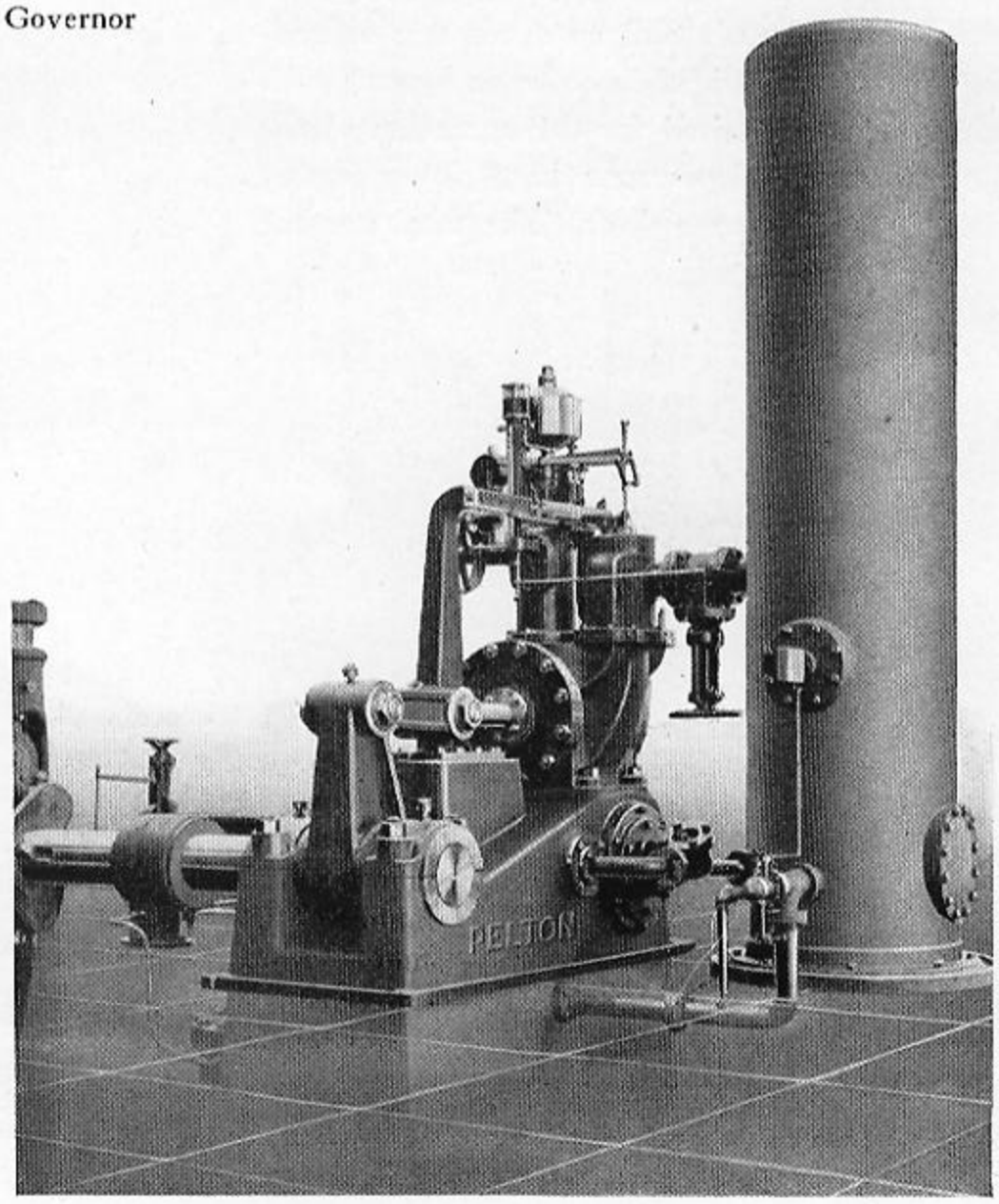


Fig. 37
PELTON Type O-40
Governor

VALVES

THE standard type of GATE VALVE is shown in Fig. 37. For heavy pressure, particularly where the valve is operated by hand, suitable gearing is employed. Gate valves may also be operated by hydraulic cylinder, water motor, or electric motor.

For certain conditions, particularly where a large quantity of water is to be handled, BUTTERFLY VALVES will be found to give more satisfactory service than gate valves. The lem of controlling the flow of water in pipe lines and conduits, the pressure in the pipe line itself operating the plunger or needle. This type of valve is in use on many of the largest hydroelectric projects, both in the United States and Canada. It is built in all sizes and to withstand the heaviest pressures.

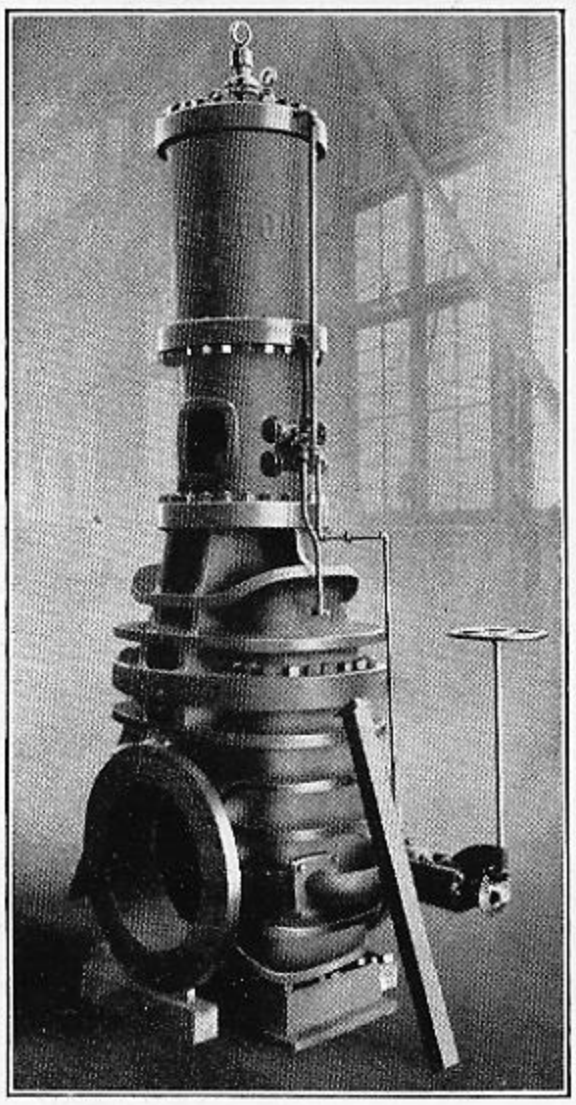


Fig. 39. PELTON hydraulic-operated gate valve for 1750 foot head

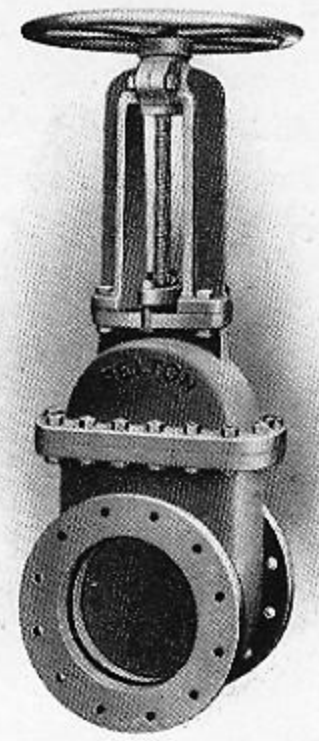


Fig. 38. Standard PELTON hand-operated gate valve

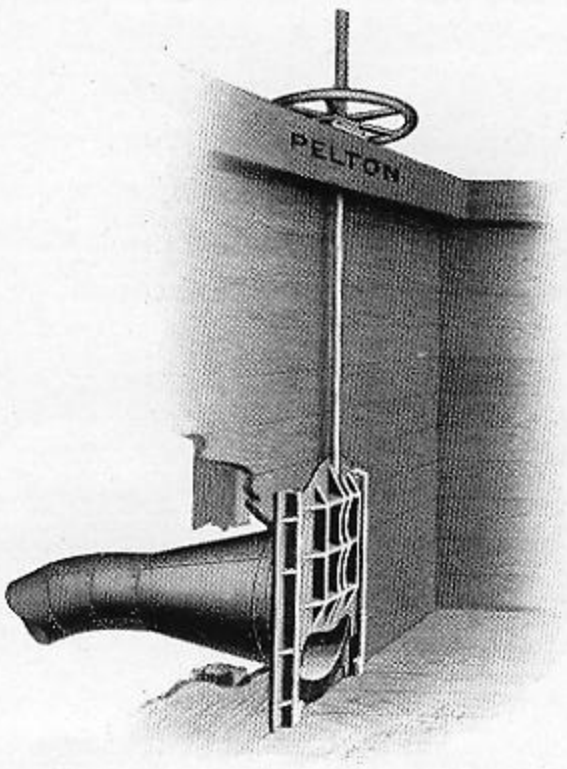


Fig. 40. Iron body, bronze-mounted Head Gate with taper pipe, for controlling water flow into pipe lines

PELTON WATER WHEEL COMPANY was the pioneer in the development of butterfly valves for hydroelectric projects and is in a position to advise regarding the application of such valves to specific developments.

The JOHNSON PLUNGER-TYPE VALVE* applies the needle-valve principle to the prob-

*The PELTON WATER WHEEL COMPANY is the Pacific Coast manufacturer of Johnson Needle Type Valves and the Johnson Differential Surge Tank.

PIPE LINES

IN SELECTING the proper pipe line for a water wheel installation, care should be taken to consider all factors, particularly the size of the pipe with respect to the maximum power to be developed by the wheel, the maximum pressure, and the suitability of the method of joining the pipe sections. While any exhaustive discussion of this branch of hydraulic engineering would manifestly be out of place, the following general notes and suggestions are here submitted for the assistance of those interested in water power development.

FRICTION

The principal loss of head in a pipe line is caused by friction when the water is flowing. Friction is affected largely by the velocity of the flow, the area of the pipe, and its interior condition. Anything that tends to retard the flow will affect the carrying capacity of the pipe; for example: pipes frequently become pitted, and, in addition, a sedimentary deposit, due to chemical properties of certain waters, will increase the friction loss. The nature of the pipe and the construction and character of the joints also affect the amount of friction and, consequently, the loss of head. Tables of friction losses in, and the carrying capacities of, various sizes and kinds of pipe will be found in the various engineers' pocketbooks and in standard works on hydraulics.

PRESSURE BOX ON FOREBAY

At the head of the pipe line where the water enters, should be constructed a box or reservoir of such size that there will always be sufficient depth of water over the intake of the pipe to prevent air being drawn in along with the water. If the water carries grit or sand in suspension, it is good practice to enlarge the pressure box so that the water entering it from the source of supply (ditch or flume) will be brought to practically zero velocity before entering the pipe. This will allow sand or other material carried in suspension to settle. A valve or opening should be provided at the bottom of the pressure box to permit removing the material collected.

HEAD GATES

Where head gates are employed to control the flow into the pipe line, special gates are furnished by the PELTON WATER WHEEL COMPANY and should be used in connection with an air-inlet pipe situated on the first length of pipe connected to the pressure box.

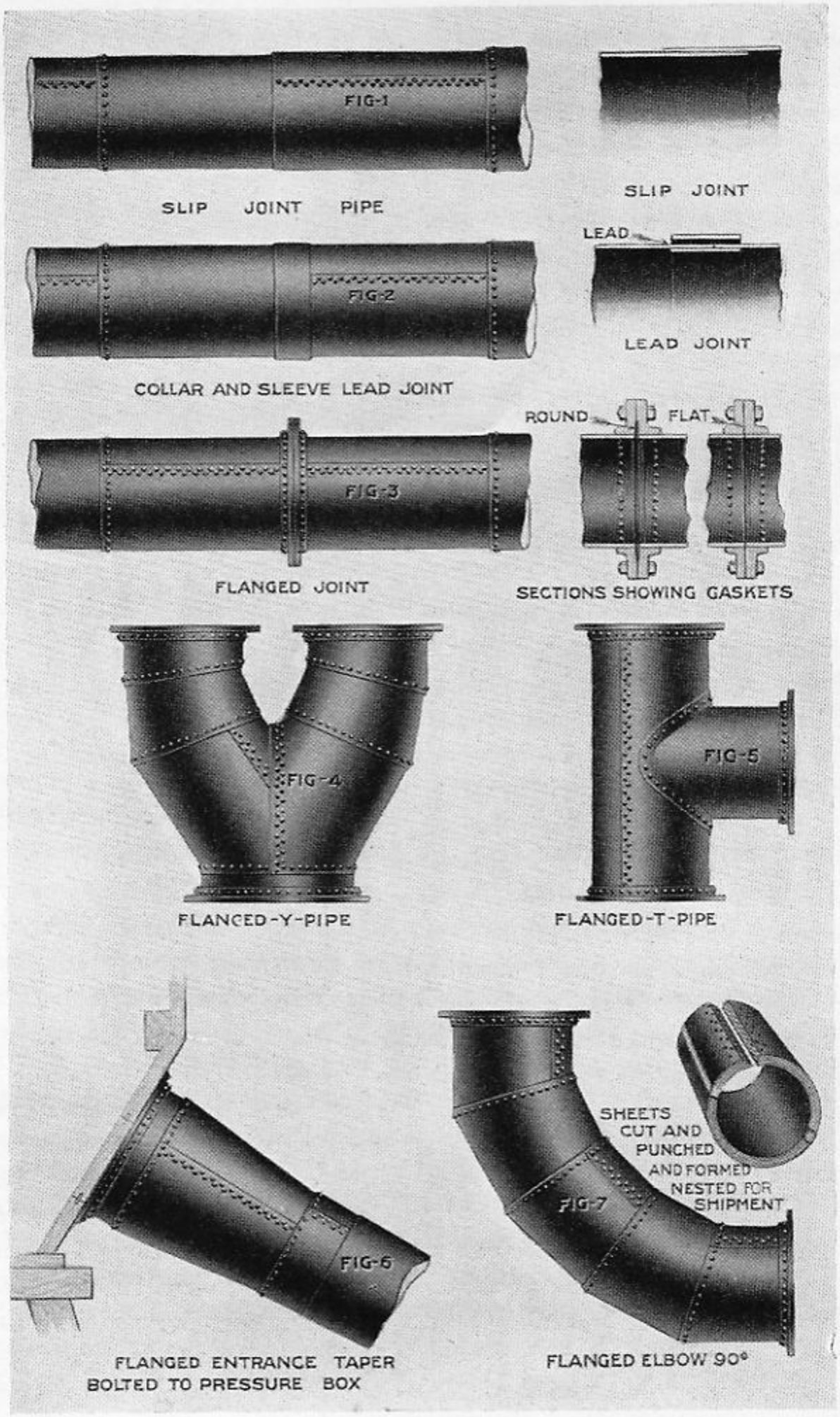
AIR VENTS

In addition to the air vent mentioned in the paragraph preceding, automatic air valves should be installed on all "high points" of the line and wherever else entrained air is likely to collect. "Pockets" of air retard the water flow in the pipe. Automatic air valves should also be used to admit air in the requisite amount when the pipe line is emptied of water. Unless sufficient effective vents of this nature are provided, there is a possibility of the pipe collapsing from the formation of a vacuum.

NESTING PIPE

A bundle, or "nest" of pipe may consist of two or more sections of different diameters telescoped within each other and blocked securely to keep the bundle intact. In this manner the weight of a pipe shipment may be made to correspond more nearly to the space it displaces, an important consideration when steamer freight rates are based on a "weight or measure, ship's option," basis, forty cubic feet of displacement of a shipment being usually considered as equivalent to one ton of dead weight.

Nesting of pipe is equally important in railroad shipments, for frequently, because of the small weight of the pipe in proportion to space occupied, a full weight carload cannot be loaded except when nesting is resorted to.



Types of Riveted Steel Pipe Joints and Specials

TYPES AND GRADES OF RIVETED STEEL PIPE

As designer of complete hydraulic plants, the PELTON WATER WHEEL COMPANY also specializes in hydraulic pipe lines, gate valves, expansion joints, flanges, relief valves, special fittings, such as "Y" pipes, elbows, etc.

Pipe for various installations is manufactured of several different types and of different materials, according to the requirements of each particular installation. The joints for these different types of pipe vary also, according to the head involved and the size of pipe. Some of these various types of pipe and joints are shown on Page 21.

CUT AND FORMED PIPE

When pipe lines are to be installed in locations where transportation is difficult the pipe is often manufactured in sheets. These sheets are cut to size and rolled for proper diameter. Then the holes are punched and the sheets "nested." The sheets are riveted together at destination and the pipe is laid in the usual manner, after being coated with asphaltum.

SLIP-JOINT PIPE, FIG. 1, PAGE 21

This kind of pipe is manufactured in sections of convenient length, with one end of each section tapered slightly so that it may be driven securely into the large end of the corresponding section and make a water-tight joint. Slip-joint pipe is satisfactory for heads of less than 300 feet.

COLLAR AND SLEEVE LEAD JOINT PIPE, FIG. 2, PAGE 21

Where pipe sections are to be joined by means of collar and sleeve lead joints, the two ends of the pipe should butt together, and a sheet steel ring or band placed around the joint (as illustrated), after which molten lead is poured between the band or collar and the pipe, completely filling the space. On cooling, the lead must be firmly caulked in place. Pouring clamps, furnished in order, are of great assistance in making lead joints. The work should preferably be done by competent men having had previous experience in this class of pipe laying.

While collar and sleeve lead joints may be used under heads as high as 700 feet, more or less, depending upon the pipe diameter, it has been found, considering all factors, that flanged joints may be used to great advantage as a substitute.

FLANGED JOINT PIPE, FIG. 3, PAGE 21

Flanges are furnished of cast iron and steel, also rolled steel. Flanges are recommended for pressures beyond the limit considered good practice for slip joints. They may be riveted to the pipe sections in the shop or at the trench side. Bolts, gaskets, and rivets are supplied, and special tools in addition when so ordered. Round gaskets held by a recessed groove are furnished for heavy hydraulic pressure, and flat or sheet rubber gaskets for moderate pressures.

Pipe lines, say, 20 inches or more inside diameter are sufficiently large to permit continuous riveting, consequently, flanges need not necessarily be used for joining the sections.

LAP-WELDED STEEL PIPE

In many instances stresses in penstocks are so great that lap-welded must be used in place of riveted pipe. The PELTON WATER WHEEL COMPANY is the Pacific Coast representative of the M. W. Kellogg Company of Jersey City, manufacturers of lap-welded pipe for all pressures, and is in a position to advise regarding the design and construction of penstocks for all conditions.

HYDRAULIC INFORMATION

FRICTION HEAD AND EFFECTIVE HEAD

WHEN water flows through a pipe line, some power is lost because of friction of the water in the pipe. Friction loss depends on the length of the pipe line, the diameter of the pipe and the quantity of water which flows through the pipe. It is, therefore, necessary in estimating the power to be developed by a water wheel to subtract the friction head from the "gross" or total head to determine the "effective head" under which the wheel actually operates. The tables on pages 27 and 28 are based on effective head.

Friction varies widely with the kind of pipe and on whether the pipe is new or old. Unless the purchaser is familiar with pipe conditions, his interest will be better served by permitting the Company to select the proper pipe for his water wheel installation, than if he were to make his own choice. It is necessary that the purchaser answer the questions on page 24 of this bulletin when requesting advice and estimates of cost.

STORAGE

A uniform flow of water at the wheel is desirable. If the stream flow is sufficient at all times to provide the required power, the construction of a reservoir will not be required. If, however, the low-water flow of the stream is insufficient, a reservoir must be provided to store water during periods when the wheel is not operating, or when the flow is greater than that required by power needs.

SPEED AND EFFICIENCY

A PELTON Water Wheel will develop power at its best efficiency when revolving at its correct speed. The diameter of a water wheel determines merely the speed at which it should revolve for a given head. The effective head and water quantity alone determine the horsepower capacity. Standard PELTON Wheels are of fixed diameters and capable of handling certain water quantities, consequently, the capacities and speeds are determind and may be ascertained by consulting the tables on pages 27 and 28.

For example: Referring to page 28 it will be noted that a standard 4-foot single nozzle wheel, under a head of 450 feet will develop 286 horsepower when revolving at a speed of 401 R. P. M. If it were desired to obtain more power, but to maintain the speed at 401 R. P. M., a 4-foot wheel of special construction could be built which would develop as much as 600 horsepower, but it would require a proportionately greater amount of water. This would be accomplished by using larger buckets on a wheel of the same diameter.

HORSEPOWER OF WATER

The gross or theoretical power of water may be obtained from the following formula:

H=Effective head in feet at nozzle.

Q=Quantity of water in cubic feet per minute.

Then .00189×Q×H=Gross horsepower.

Another simple formula for quickly ascertaining the actual power of water, based on second-feet flow, (cubic feet per second) and assuming the wheel efficiency as 80%, is as follows:

Q=Cubic feet per second.

H=Effective head in feet.

H. P.=Actual wheel H. P. based on 80% efficiency.

$$\text{Then H. P.} = \frac{Q \times H}{11}$$

One cubic foot per second (1 second foot) is equivalent to 646,316.9 U. S. gallons per day of 24 hours; .09072 actual water wheel shaft H. P. at 80% water efficiency under one foot effective head.

The weight of one cubic foot of fresh water at a temperature of 50° Fahrenheit is approximately 62.408 pounds.

DATA REQUIRED FOR ESTIMATES

IN ORDER that the proper type and size of wheel may be determined, definite information and answers to the questions below should be furnished.

1. HEAD OR PRESSURE

State the vertical distance in feet between the level of the water at proposed inlet of pipe line (ditch, flume or forbay), and the floor level where water wheel will be placed. This measurement is termed the static, or gross head. When feasible this should be determined with a surveyor's level.

2. WATER QUANTITY

State the amount of water available in cubic feet per minute, cubic feet per second, or gallons per minute. If the quantity is given in miner's inches, state the head, in inches, to the center of the opening of the measuring box; otherwise an exact understanding of the amount cannot be obtained owing to the different interpretation as to quantity placed on the miners' inch in various localities.

State maximum, minimum and average water quantity available and over what period of time is the stream flow at its lowest. Do not state the quantity as being sufficient to fill a pipe of any given diameter, as such information is unreliable.

The simplest and most acurate method for determining the quantity of water flowing in a stream is by the use of a weir, as described below. Proceed as follows: Get a plank of sufficient length and width so as to cross the stream and intercept it (see Fig. 41). Saw a rectangular notch in this plank at the middle, the length of the notch being about two-thirds of the width of the stream. Place the plank across the stream as shown in Fig. 41. The plank must be firmly anchored and all leaks stopped. Bevel the sides and bottom of the notch sharply up-stream. Drive a peg near the center of the stream and about 4 feet up-stream from the plank. Bring the top of this peg level with the bottom of the notch, using a straight edge and a carpenter's level. Next measure with an ordinary rule the depth of the water over the top of the peg, as is shown in Fig. 41. From this depth, in inches, the number of cubic feet flowing in the stream per minute can be obtained from the accompanying table. Suppose the weir to be 72 inches long, and the depth of water over the stake to be 11⅝ inches, follow down the left-hand column of the figures in the table until you come to 11 inches; then run across the table on a line with the 11 until under ⅝ on top line, you will find 15.85. This multiplied by 72, the length of weir, gives 1141.2, the number of cubic feet of water passing per minute.

3. STORAGE

Can the water be impounded by a dam or reservoir? If so, state the storage capacity in cubic feet.

4. PIPE LINE

What length of pipe line is necessary to secure the gross head? Measurement should be made along the slope of the ground where pipe will ultimately be laid. If the pipe line is already installed, state the length of each diameter and whether of wood, stave, riveted or lap-welded steel. Where a pipe line is already conveying water for other purposes, as to existing wheels, state the total water quantity that is being used.

5. DRIVEN MACHINERY

The speed of, and power required for, operating the driven machinery should be specified. State if an electric generator, compressor, mill, etc., is to be driven. Where the PELTON Wheel is to drive the machinery by belting, state the diameter, face and speed of driven pulley.

6. POWER FLUCTUATIONS

How often does the load fluctuate and what amount of power is constantly thrown on or off?

TABLE FOR WEIR MEASUREMENTS

Giving Cubic Feet of Water Per Minute, that will flow over a weir 1 inch long and from 1/8 to 20 7/8 inches deep.

Depth Inches		1/8	1/4	3/8	1/2	5/8	3/4	7/8
0	.00	.01	.05	.09	.14	.19	.26	.32
1	.40	.47	.55	.64	.73	.82	.92	1.02
2	1.13	1.23	1.35	1.46	1.58	1.70	1.82	1.95
3	2.07	2.21	2.34	2.48	2.61	2.76	2.90	3.05
4	3.20	3.35	3.50	3.66	3.81	3.97	4.14	4.30
5	4.47	4.64	4.81	4.98	5.15	5.33	5.51	5.69
6	5.87	6.06	6.25	6.44	6.62	6.82	7.01	7.21
7	7.40	7.60	7.80	8.01	8.21	8.42	8.63	8.83
8	9.05	9.26	9.47	9.69	9.91	10.13	10.35	10.57
9	10.80	11.02	11.25	11.48	11.71	11.94	12.17	12.41
10	12.64	12.88	13.12	13.36	13.60	13.85	14.09	14.34
11	14.59	14.84	15.09	15.34	15.59	15.85	16.11	16.36
12	16.62	16.88	17.15	17.41	17.67	17.94	18.21	18.47
13	18.74	19.01	19.29	19.56	19.84	20.11	20.39	20.67
14	20.95	21.23	21.51	21.80	22.08	22.37	22.65	22.94
15	23.23	23.52	23.82	24.11	24.40	24.70	25.00	25.30
16	25.60	25.90	26.20	26.50	26.80	27.11	27.42	27.72
17	28.03	28.34	28.65	28.97	29.28	29.59	29.91	30.22
18	30.54	30.86	31.18	31.50	31.82	32.15	32.47	32.80
19	33.12	33.45	33.78	34.11	34.44	34.77	35.10	35.44
20	35.77	36.11	36.45	36.78	37.12	37.46	37.80	38.15

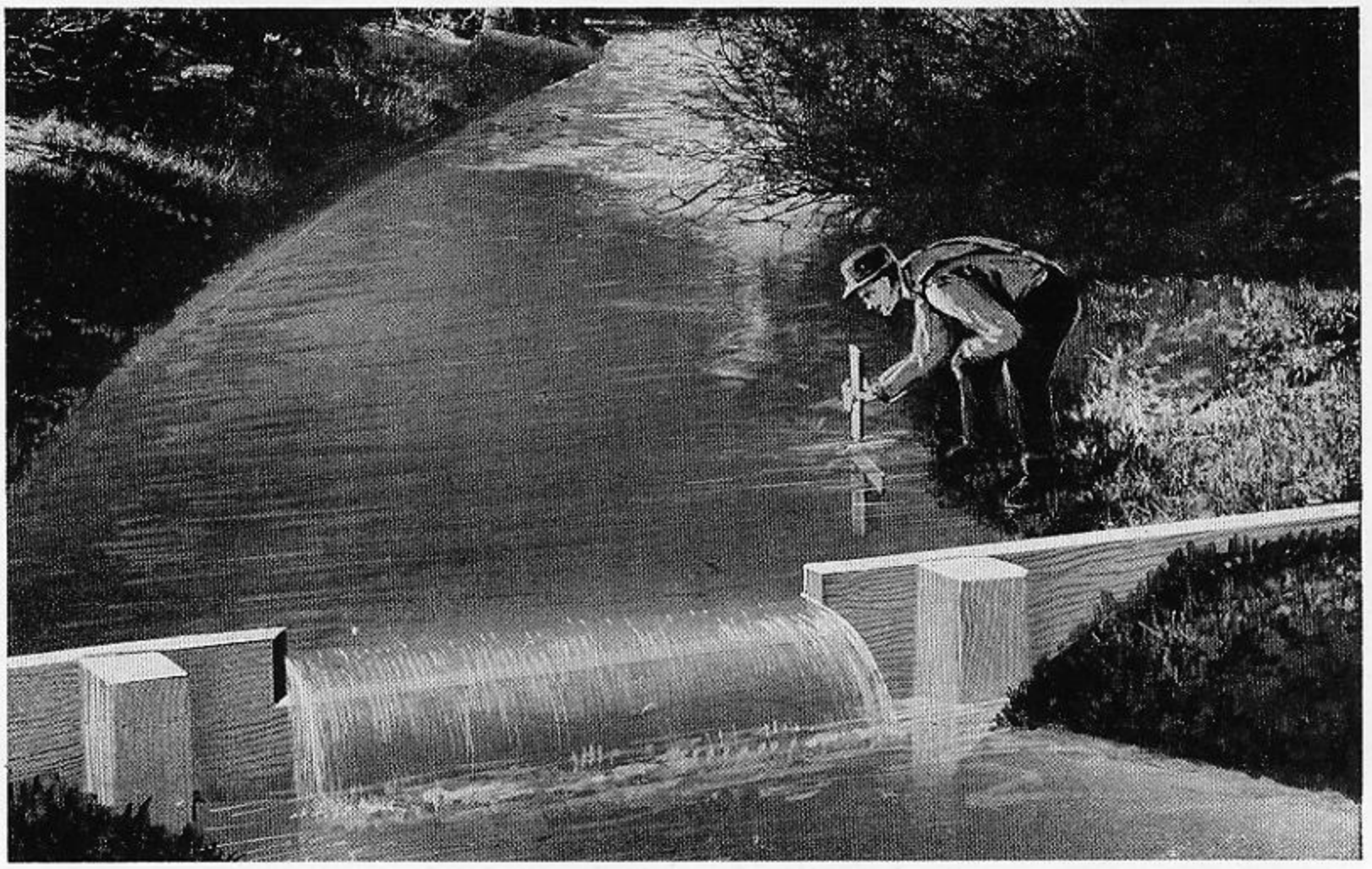


Fig. 41 A Weir correctly constructed, showing the method of measuring the amount of water flowing in a stream

PELTON WATER WHEEL TABLES

PAGES 27 and 28 are devoted to tabulated data pertaining to the speed, power and water discharge of standard type motors and standard single-nozzle PELTON Wheels, and do not apply to special wheels. Double-nozzle wheels, 3 feet to 6 feet in diameter, inclusive, develop twice the power, requiring twice as much water as single-nozzle wheels—as explained on Page 5.

The term "head in feet," first column, refers to the effective head when the water is flowing in the pipe, all pipe losses having been deducted. It is important to bear this statement in mind to avoid confusion with the term "static head," which represents the pressure that would exist with the gate valve of the wheel closed and no water flowing in the pipe line.

Immediately below the figures indicating the effective head in feet is given the equivalent pressure expressed in pounds per square inch; for example: 500-feet head is equivalent to a pressure of 216.70 pounds per square inch.

Below the figures representing the pounds pressure is given the spouting velocity in feet per minute at which the water issues from the nozzle.

The horsepower mentioned is the maximum actual shaft horsepower developed by standard PELTON Wheels and standard type motors when rotating at their correct speeds.

The term "cubic feet" is the water volume (cubic feet per minute) required to develop the stated power. The quantity is computed on a basis of 80 per cent wheel efficiency, which should be regarded as approximate, the actual efficiency in any given case depending upon the local conditions.

Special PELTON Wheels are required for heads exceeding 300 feet in the larger sizes, and 400 feet in the smaller.

Special PELTON Motors are required for heads exceeding 230 feet.

Type D Wheels are built in five sizes, namely, 12, 15, 18, 24, 30 inches. The capacities for the first four sizes are the same as for the corresponding standard wheels or motors. The capacity of the 30-inch wheel is the same as that of the 3-foot standard wheel, but the speed for a given head is about 30 per cent greater. Type D Wheels are intended for timber-frame mounting and should not be used for heads exceeding 250 feet.

Correspondence regarding proposed developments will be facilitated if the information outlined on Page 24 is furnished promptly.

Fig. 42. Typical Flume and Pressure Box for small installation, showing headgate, pipe-intake, and spillway in place

PELTON WATER WHEEL TABLES

Indicating the Horsepower, Required Water Quantity in Cubic Feet per Minute and R. P. M. for Standard Single-Nozzle Wheels and Standard Type Motors. See Explanatory Notes, page 26.

Head in Feet		SIZE OF WHEELS								
		6 Inch	12 Inch	15 Inch	18 Inch	24 Inch	3 Foot	4 Foot	5 Foot	6 Foot
20	Horse-power	.05	.12	.20	.37	.66	1.50	2.64	4.18	6.00
8.66 lbs.	Cubic Feet	1.65	3.97	6.61	12.20	21.75	49.60	87.20	138.0	198.0
2152	R. P. M.	675	359	289	243	177	111	85	67	55
30	Horse-power	.10	.23	.38	.69	1.22	2.76	4.88	7.69	11.04
13.00 lbs.	Cubic Feet	2.20	5.06	8.36	15.09	26.83	60.80	107.3	169.2	243.0
2635	R. P. M.	826	439	352	298	216	135	103	82	68
40	Horse-power	.15	.35	.59	1.06	1.89	4.24	7.58	11.85	16.96
17.34 lbs.	Cubic Feet	2.47	5.78	9.74	17.50	31.20	70.00	125.2	195.6	280.0
3043	R. P. M.	956	508	407	344	251	157	119	95	78
50	Horse-power	.21	.49	.84	1.49	2.65	5.98	10.60	16.63	23.93
21.67 lbs.	Cubic Feet	2.78	6.47	11.09	19.68	35.00	78.95	140.0	219.5	316.1
3397	R. P. M.	1068	567	455	385	280	176	134	107	88
60	Horse-power	.28	.65	1.10	1.96	3.48	7.84	13.94	21.77	31.36
26.00 lbs.	Cubic Feet	3.08	7.15	12.10	21.56	38.30	86.23	153.4	239.4	345.2
3727	R. P. M.	1170	621	498	421	307	193	146	116	97
70	Horse-power	.35	.82	1.39	2.47	4.39	9.88	17.58	27.51	39.52
30.34 lbs.	Cubic Feet	3.30	7.73	13.12	23.30	41.45	93.20	165.8	259.5	373.0
4025	R. P. M.	1265	672	539	455	332	208	158	126	104
80	Horse-power	.43	1.00	1.70	3.01	5.36	12.04	21.44	33.54	48.16
34.67 lbs.	Cubic Feet	3.55	8.25	14.04	24.85	44.23	99.60	177.0	277.0	398.0
4303	R. P. M.	1350	717	576	486	354	222	169	135	111
90	Horse-power	.51	1.20	2.03	3.60	6.39	14.40	25.59	40.04	57.60
39.01 lbs.	Cubic Feet	3.74	8.80	14.88	26.40	46.81	105.6	187.6	293.6	422.2
4564	R. P. M.	1434	762	611	516	376	236	179	143	118
100	Horse-power	.60	1.40	2.32	4.21	7.49	16.84	29.93	46.85	67.36
43.34 lbs.	Cubic Feet	3.96	9.25	15.31	27.80	49.45	111.2	197.6	309.3	444.9
4811	R. P. M.	1512	802	644	545	396	249	189	151	124
110	Horse-power	.69	1.62	2.74	4.86	8.64	19.44	34.58	54.11	77.76
47.67 lbs.	Cubic Feet	4.14	9.72	16.45	29.19	51.86	116.7	207.5	325.0	467.1
5046	R. P. M.	1586	841	676	570	415	261	198	158	131
120	Horse-power	.79	1.84	3.12	5.54	9.85	22.18	39.41	61.66	88.75
52.01 lbs.	Cubic Feet	4.35	10.12	17.16	30.47	54.20	122.0	216.8	339.1	488.2
5271	R. P. M.	1657	879	706	596	434	272	207	165	137
130	Horse-power	.89	2.08	3.53	6.25	11.11	25.02	44.46	69.53	100.08
56.34 lbs.	Cubic Feet	4.52	10.57	17.93	31.76	56.47	127.2	225.8	353.4	509.0
5486	R. P. M.	1724	915	735	620	452	284	215	172	143
140	Horse-power	.99	2.33	3.94	6.99	12.41	27.96	49.64	77.71	111.85
60.68 lbs.	Cubic Feet	4.68	11.00	18.60	33.00	58.60	132.1	234.5	367.1	527.2
5693	R. P. M.	1790	950	763	644	469	295	223	178	148
150	Horse-power	1.10	2.58	4.37	7.75	13.77	31.01	55.08	86.22	124.04
65.01 lbs.	Cubic Feet	4.85	11.36	19.23	34.12	60.58	136.6	242.5	379.4	546.2
5893	R. P. M.	1852	982	790	667	484	305	231	184	153
160	Horse-Power	1.22	2.84	4.82	8.54	15.17	34.16	60.68	94.94	136.65
69.34 lbs.	Cubic Feet	5.04	11.74	19.92	35.30	62.65	141.2	250.8	392.2	564.7
6086	R. P. M.	1914	1016	816	688	502	315	239	190	158
170	Horse-power	1.33	3.11	5.28	9.35	16.61	37.42	66.46	103.99	149.68
73.68 lbs.	Cubic Feet	5.18	12.10	20.53	36.40	64.64	145.7	258.3	404.6	582.7
6274	R. P. M.	1970	1046	840	709	517	324	246	196	163

PELTON WATER WHEEL TABLES

Indicating the Horsepower, Required Water Quantity in Cubic Feet per Minute and R. P. M. for Standard Single-Nozzle Wheels and Standard Type Motors. See Explanatory Notes, page 26.

Head in Feet		SIZE OF WHEELS								
		6 Inch	12 Inch	15 Inch	18 Inch	24 Inch	3 Foot	4 Foot	5 Foot	6 Foot
180	Horse-power	1.45	3.39	5.75	10.19	18.10	40.77	72.41	113.30	163.08
78.01 lbs.	Cubic Feet	5.32	12.44	21.10	37.40	66.39	149.5	265.8	416.0	598.5
6455	R. P. M.	2024	1074	863	728	530	333	253	201	167
190	Horse-Power	1.57	3.68	6.24	11.05	19.63	44.21	78.53	122.87	176.86
82.35 lbs.	Cubic Feet	5.46	12.80	21.73	38.46	68.36	153.8	273.3	427.8	615.6
6632	R. P. M.	2079	1104	887	749	544	342	260	207	171
200	Horse-power	1.70	3.97	6.74	11.93	21.20	47.75	84.81	132.70	191.00
86.68 lbs.	Cubic Feet	5.61	13.10	22.25	39.40	70.00	157.6	280.0	437.8	630.0
6804	R. P. M.	2132	1138	910	767	559	351	266	213	175
210	Horse-power	1.83	4.28	7.25	12.84	22.81	51.38	91.26	142.78	205.52
91.01 lbs.	Cubic Feet	5.76	13.45	22.80	40.38	71.73	161.6	287.0	448.5	646.2
6972	R. P. M.	2186	1162	933	787	573	360	273	218	180
220	Horse-power	1.96	4.59	7.77	13.77	24.46	55.09	97.85	153.10	220.36
95.35 lbs.	Cubic Feet	5.88	13.78	23.33	41.30	73.41	165.4	294.1	459.8	661.0
7136	R. P. M.	2240	1190	955	805	587	369	280	223	185
230	Horse-power	2.10	4.90	8.31	14.72	26.15	58.89	104.60	163.66	235.56
99.68 lbs.	Cubic Feet	6.03	14.07	23.85	42.28	75.00	169.1	300.0	469.9	676.2
7297	R. P. M.	2291	1216	976	823	600	377	286	228	189
240	Horse-power	2.24	5.23	8.86	15.69	27.87	62.77	111.50	174.45	251.10
104.02 lbs.	Cubic Feet	6.16	14.47	24.38	43.15	76.65	172.6	306.6	480.0	690.5
7454	R. P. M.	2339	1243	997	841	612	385	292	233	193
250	Horse-power	2.38	5.56	9.42	16.68	29.63	66.74	118.54	185.47	266.96
108.35 lbs.	Cubic Feet	6.28	14.67	24.86	44.00	78.20	176.1	313.0	490.0	705.0
7607	R. P. M.	2387	1268	1019	858	626	393	298	238	197
260	Horse-power	2.52	5.89	10.05	17.69	31.43	70.78	125.72	196.71	283.15
112.68 lbs.	Cubic Feet	6.40	14.96	25.53	44.95	79.86	179.8	319.5	500.0	720.0
7758	R. P. M.	2435	1293	1038	876	638	401	304	243	201
270	Horse-power	2.67	6.24	10.67	18.72	33.26	74.90	133.05	208.17	299.63
117.02 lbs.	Cubic Feet	6.53	15.27	26.10	45.81	81.38	183.3	325.8	509.9	733.5
7906	R. P. M.	2482	1318	1059	894	650	408	310	247	205
280	Horse-power	2.82	6.59	11.16	19.77	35.12	79.11	140.51	219.84	316.44
121.35 lbs.	Cubic Feet	6.65	15.57	26.28	46.65	82.81	186.9	331.9	518.6	746.5
8051	R. P. M.	2530	1342	1083	911	663	416	316	252	208
300	Horse-power	3.13	7.31	12.38	21.93	38.95	87.73	155.83	243.82	350.94
130.02 lbs.	Cubic Feet	6.88	16.09	27.25	48.25	85.66	193.0	343.0	536.2	771.6
8334	R. P. M.	2620	1390	1121	942	686	432	327	261	216
350	Horse-power	3.94	9.21	15.61	27.64	49.09	110.56	196.38	307.25	442.27
151.69 lbs.	Cubic Feet	7.43	17.38	29.43	52.13	92.51	208.6	370.6	579.2	834.0
9001	R. P. M.	2830	1503	1207	1020	741	465	354	282	234
400	Horse-power	4.82	11.25	19.07	33.77	59.98	135.08	239.94	375.40	540.35
173.26 lbs.	Cubic Feet	7.95	18.55	31.47	55.70	98.95	223.2	396.0	619.9	891.8
9623	R. P. M.	3024	1605	1289	1089	793	497	378	302	250
450	Horse-power	5.75	13.43	22.76	40.29	71.57	161.19	286.31	447.95	644.78
195.03 lbs.	Cubic Feet	8.44	19.70	33.40	59.16	105.1	236.6	420.0	657.0	945.0
10207	R. P. M.	3210	1704	1370	1155	841	528	401	320	265
500	Horse-power	6.74	15.73	26.66	47.20	83.83	188.80	335.34	524.66	755.20
216.70 lbs.	Cubic Feet	8.90	20.76	35.20	62.31	110.9	249.3	442.5	692.5	997.6
10759	R. P. M.	3381	1797	1443	1218	886	556	422	337	280

PELTON REACTION TURBINES

THE specific purpose of this bulletin is to furnish complete and concise data to those primarily interested in the application of impulse turbines, water motors and their accessories. Comparatively little space, therefore, is given over to Reaction Turbines. It is desired merely to mention a few of the outstanding reasons for the prominent position occupied by PELTON in the reaction field.

The PELTON WATER WHEEL COMPANY was originally founded for the purpose of building impulse wheels, but it was soon realized that Reaction Turbines had a very definite field of application. Consequently the Company expanded its scope of engineering service to supply the needs for Reaction Turbines of all types. For the past twenty years PELTON has not only been a pioneer but a recognized leader in the design and construction of these units. PELTON achievements particularly in high-head developments have already established several world's records and the success of these installations has been most noteworthy.

Through the association with the Wm. Cramp & Sons Ship and Engine Building Co. of Philadelphia in March, 1922, the combined facilities of the two institutions have been placed at the disposal of those interested in power development. The interchange of ideas, patents and designs has proved of inestimable value to the patrons of both organizations.

The illustrations shown on this and the following page gives some conception of the design of PELTON Reaction Turbines. Fig. 45 is of unusual significance for at the time of installation of these prime movers in 1920 they were the highest-head Reaction Turbines

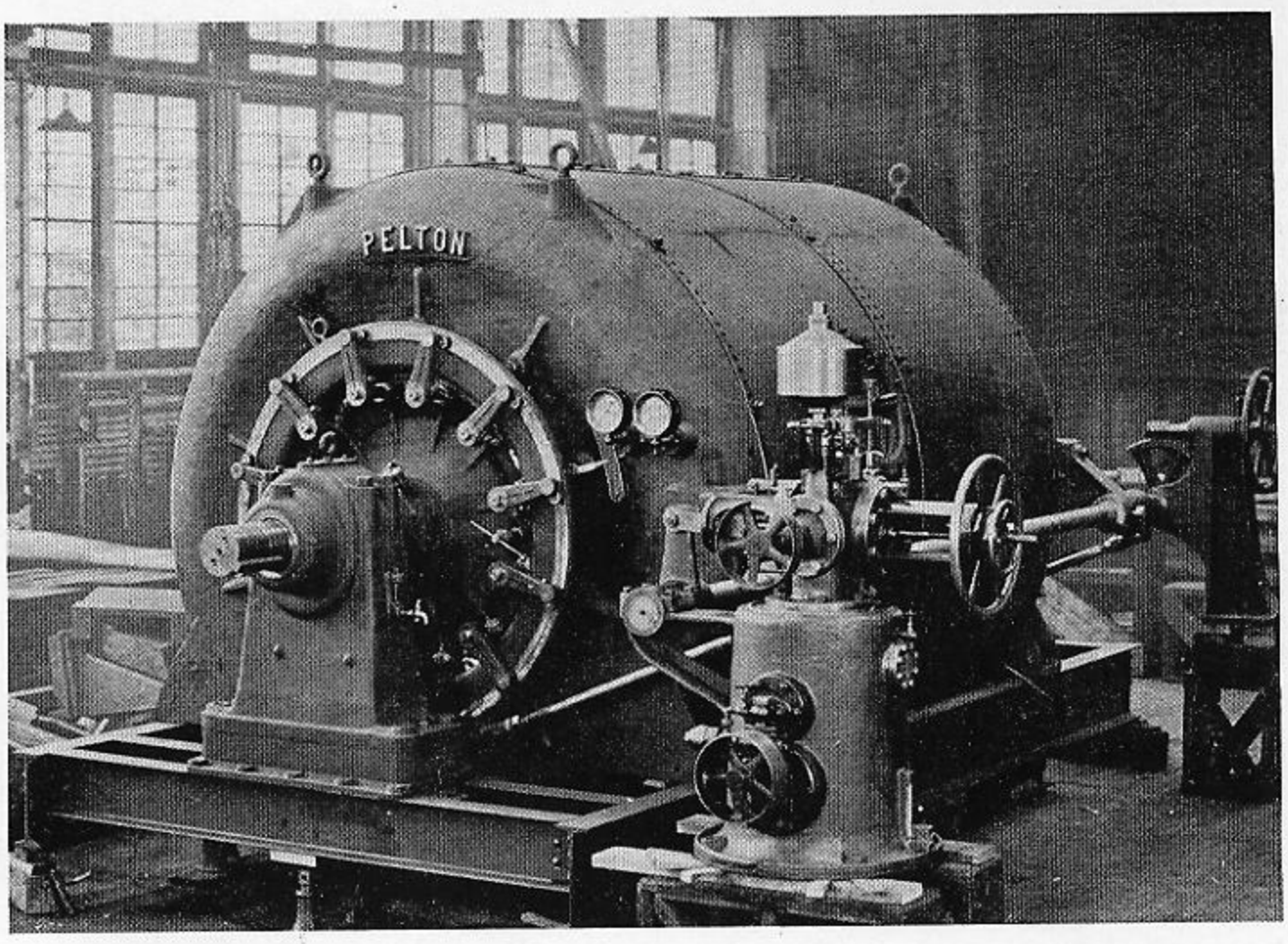


Fig. 43. Shop assembly of one of two PELTON cylindrical-case Reaction Turbines installed in Korea. Each unit develops 800 horsepower under a 38-foot head.

in the world. They were built for the Kern River No. 3 plant of the Southern California Edison Co. and have been operating with marked success. The record established by these pioneer high-head units was surpassed by the installation of a similar PELTON unit in 1924 in the Oak Grove plant of the Portland Railway Light & Power Co. in Oregon. This turbine develops 35,000 horsepower under an effective head of 860 feet. Both of the foregoing units were exceeded in physical dimensions by the three PELTON Reaction Turbines built for the Pit No. 3 plant of the Pacific Gas & Electric Co. in Northern California. These turbines operate under a 280-foot head and develop 30,000 horsepower.

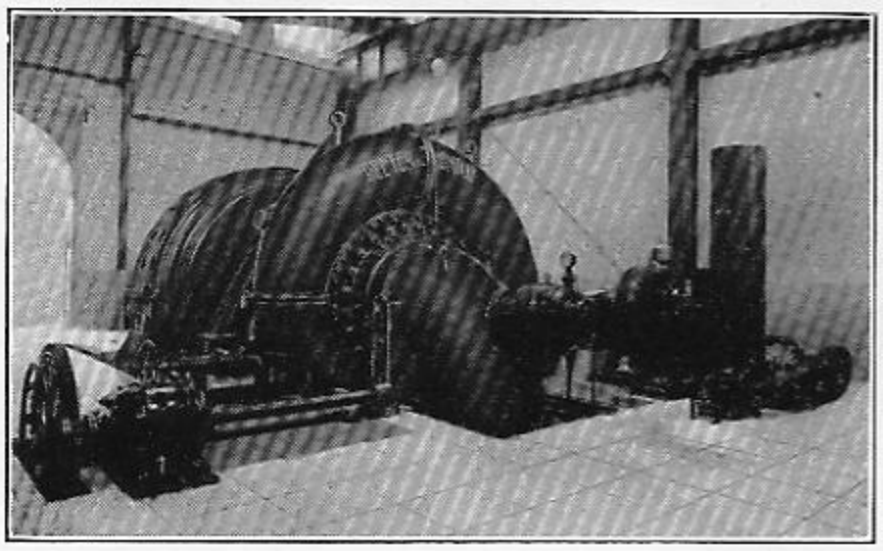


Fig. 44. 20,000 horsepower PELTON spiral-case horizontal single-overhung Reaction Turbine installed in the Wise plant of the Pacific Gas & Electric Co. in California

For obvious reasons there are no standard designs in turbine equipment. Each new project imposes a new set of conditions in stream flow, head, specific speed, etc., all of which must be individually analyzed in order to select the equipment which will provide the greatest efficiency at the lowest ultimate cost.

A special bulletin covering Reaction Turbines has been issued by the Company to include all possible engineering data in connection with the use of this type of prime mover. Copies will be gladly mailed upon application.

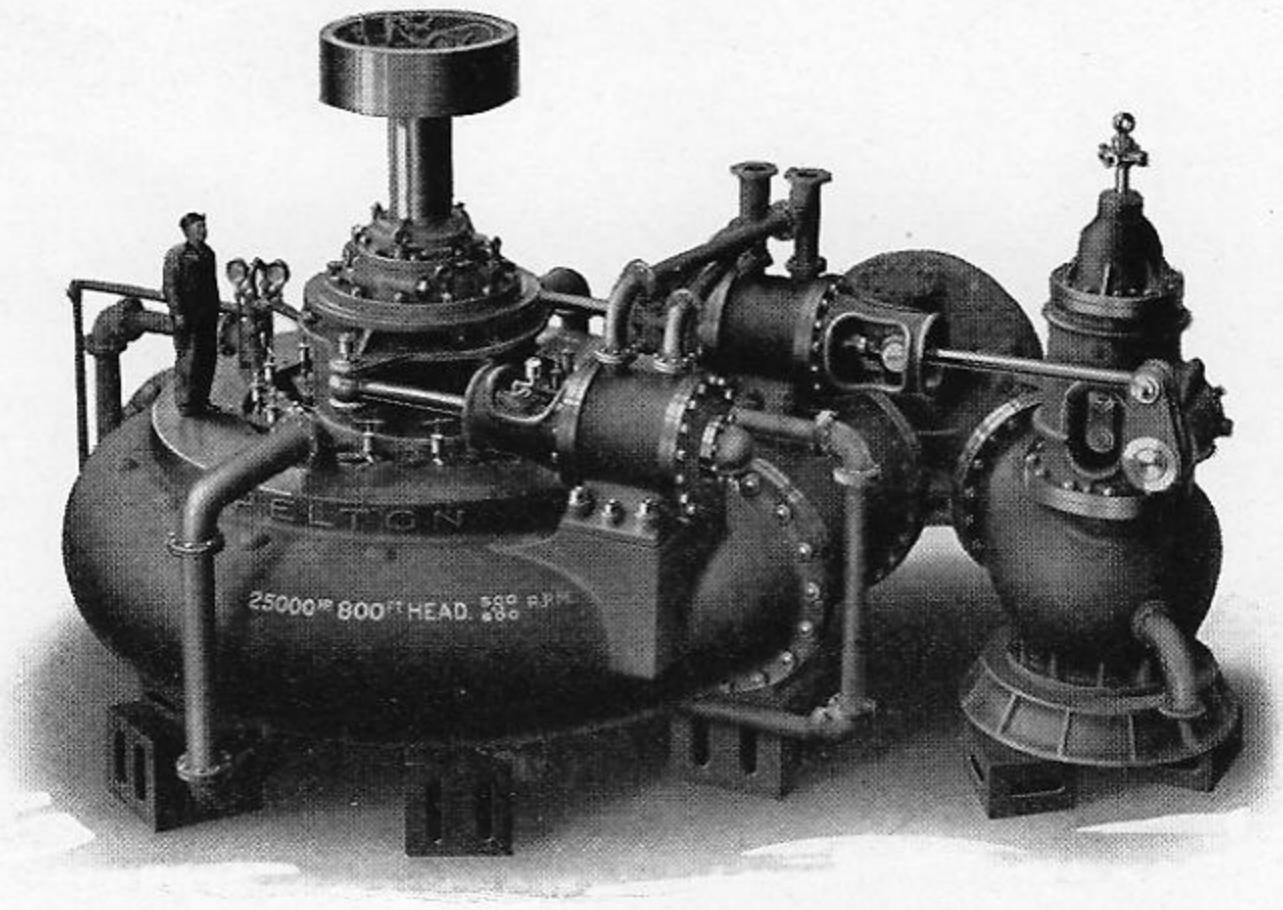


Fig. 45. Shop assembly of a 25,000 horsepower spiral-case vertical Reaction Turbine. Two of these units installed in the Kern River No. 3 plant of the Southern California Edison Co.

PELTON CENTRIFUGAL PUMPS

THE PELTON WATER WHEEL COMPANY builds centrifugal pumps for all classes of service and for any combination of head, volume of water pumped, speed, and type of drive. They are being driven by electric motors, gasoline engines, tractors, water wheels, reaction turbines and steam engines; in fact, by practically every kind of prime mover. They may be direct-connected to the prime mover or may be driven by belts or gearing.

Some of the principal types of pumps manufactured are illustrated herewith. For further information write for Bulletin 18, describing pumps for irrigation and general utility, or for Bulletin 10, describing single and multi-stage pumps for heavy duty.

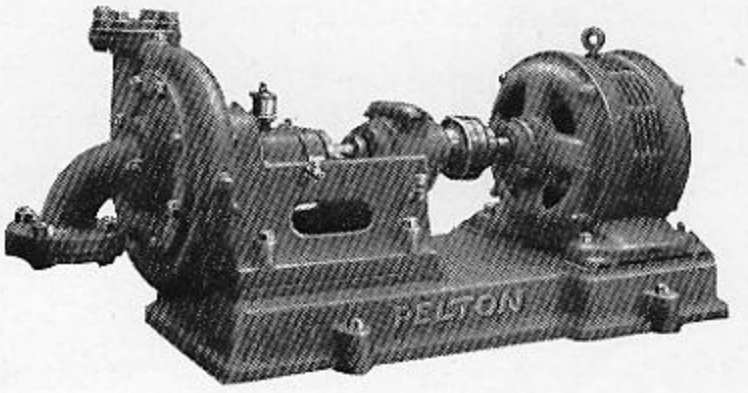
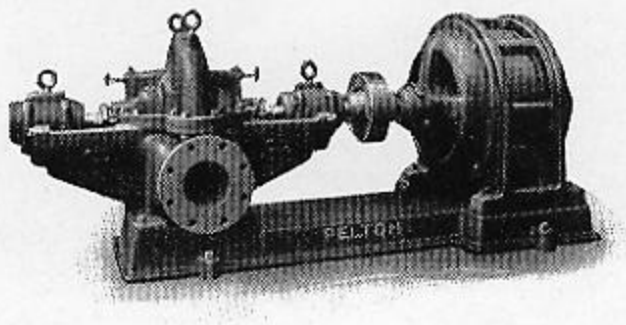


Fig. 46. PELTON Standard Single Suction Single Stage Volute Pump, for irrigation and general utility service

Fig. 47. PELTON Standard Double Suction Single Stage Volute Pump, for medium and low-head service



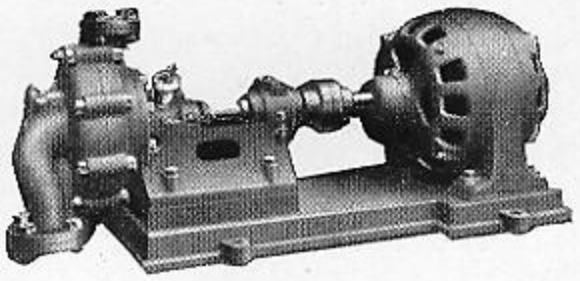


Fig. 48. PELTON Standard Two-stage Pump for medium and high-head service handling small quantities of water

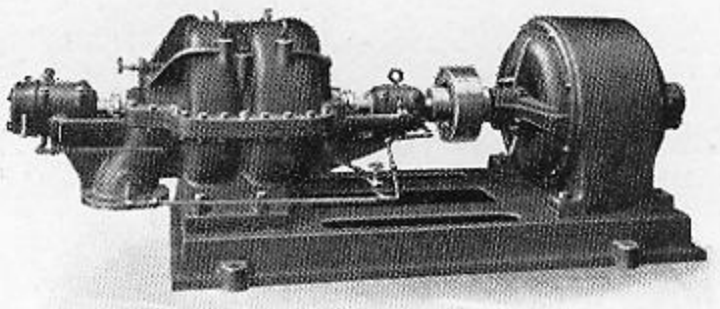


Fig. 49. PELTON Standard Multi-stage Turbine Pump, for high-head service

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