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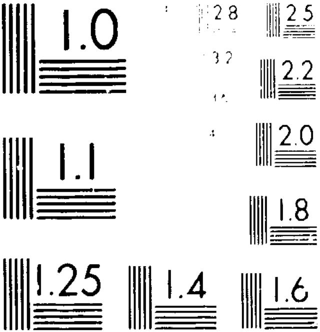
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MICRO-HYDRO POWER IN GUYANA*

by

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INTRODUCTION

In Third World countries like Guyana it would seem ironic that although there is an abundance of potential power sources, (e.g. water resources) these are the very countries that suffer chronic power shortages.

Most of the Third World countries are found in the Tropics where no heating facilities are necessary for the winter days, but one may argue that cooling may replace heating. However this author hastens to point out that cooling in the tropics can become a luxury which is ill afforded at a time of national and international energy crisis. All available power must be piloted into direct cash return projects to halt the downward trend of those economies not supported by petro-dollars.

Again this author holds the opinion that it does not matter which of the technologies be it modern or idigenous technology the emphasis must be placed on that one which can be successfully implemented almost immediately, without straining the national purse. What is intended here is to implement those projects that can bring in quick returns supported by the national purse for the benefit of all the people of their respective nations.

With this in mind and the emphasis laid on finance, it becomes obvious that schemes must be seen in their context and priority be given to those projects that can at least satisfy to some extent the national power needs, while at the same time creating opportunities for engineers, and technicians from the Third World to exercise their talents. This would also mean that confidence will be created on both sides - the engineers on the one hand and the decision makers on the other. Start small and grow big should be the motto.

THE WATER WHEEL

One of the oldest form of converting natural power sources to the benefit of mankind is the use of water - with water-turning wheels known as waterwheels. In fact the forerunners of the modern hydro-turbines were utilised many thousand of years ago to produce mechanical power from running water to irrigate fields and griding of grains. Since this technology was known so long ago then in a crisis why not implement these projects which are in any case low cost projects? The point to bear in mind here is that as experience is gained in the construction of these projects so will the efficiencies of the projects increase. Water wheels are most suitable for use in small communities which are situated in isolated places when the construction of transmission lines from the national grid makes it very expensive.

In Guyana there are very many such communities; therefore the need to serve these communities becomes clearer with each passing day such that the amenities that go with electrical energy can also reach them. Further relevant economic activities will surely develop in remote areas with the introduction of the availability of electrical energy.

Isolated communities will have small industrial plants which are being powered by their respective water wheels. Water power can be used directly as mechanical power or converting it into electrical power for transmission (short distances) to the point of usage, then converting back into mechanical power to do work. Heat for drying purposes is another form into which electrical energy can be readily converted. This heat can be used for the drying of crops.

Water Wheels use on most occasions low heads or no head as in the case of the water paddle.

Categories of water wheels are:

a) Over-Shot Water Wheels

b) Breast-Shot Water Wheels

c) Under-Shot Water Wheels

d) Water Paddle.

These wheels need not utilise the river bed if traffic in the river will be obstructed but can be used in a diverted power canal. However in streams where there is no traffic, utilization of the whole stream may become very economic. The main advantage of water wheels is that of low cost construction which Guyana should seriously look at in its present state of development. The technology of this type of energy convercion as mentioned before is centuries old and should therefore be implemented without delay since this would not require the necessary conventional expertise and concomitant delay normally a part of the whole process in the construction of larger hydropower stations. Further in the design of hydroplants driven by waterwheels would not have to be too conservative in its design criteria.

Water wheels can be built with local materials utilizing available labour within the country, while at the same time giving our manpower the vital and necessary experience in this field. Materials can be of greenheart which is well known as the "King in Water". Greenheart in conjunction with Claybricks as foundation and aluminium sheet for lining the buckets, should present a formidable and long lasting construction techniques. This has got to be economical when considering the erratic rise in the price of oil as compared with a low-cost construction and nearly no consumption of fuel.

DESIGN

The main parts of a micro-hydroproject - water wheel project consist of the following items.

a) Head flume (trough)
b) Substructure with water wheel pit
c) Water wheel
d) Transmission Line
e) Work Machines (Pumps & Sawmills etc.)
f) Superstructure - Dams Spillways etc.

The means or method by which water is taken to the Water Wheel will in the main decide the type of Water Wheel being used.

When the water is led from over the wheel it is known as an OVER SHOT WHEEL.

When the water is led to the wheel at about its breast it is known as a BREAST SHOT WHEEL.

When the water is led to the wheel at about its bottom it is known as an UNDER SHOT WHEEL.

When the wheel is placed in the water and it is the velocity of the water that turns the wheel it is known as the PADDLE WHEEL.

With the exception of the PADDLE WHEEL all the others would require a head. It should be noted here that it is the stream that would decide the available head which in turn decides the type of wheel to be applied.

The main characteristic of water wheels are the following:

1. Head $H = 0.4 - 12$ metres
   Discharge: $Q = 5.0 - 0.005$ cu.m/sec.
2. Speed: 2 to 15 r.p.m. (this can be increased to perhaps 100 - 140 r.p.m. under favourable conditions)
3. With varying hydrological conditions - Head and River Discharge - the speed of the wheel is variable.
4. The low cost construction of water wheels make them most economical even though the stream may be periodical and/or fluctuating.
5. The power potential of the water may be utilised even though the head is indeed very low (in the case of the water paddle no Head is required).
6. Construction, maintenance and repair are very simple hence its low-cost.
7. Efficiencies between 30 and 80 per cent can be obtained. (Water wheels operating under Higher Heads and Lower Speeds have greater efficiencies than those operating at Low Heads and Higher Speeds).

a) The Over Shot Water Wheel

From Appendix 1 the general layout of this type of water wheel can be seen. It may be observed that the water is being conveyed to the wheel by a trough over the wheel, hence the name "Over Shot".

This trough or Head Flume can be constructed from Greenheart and spouts the water onto the wheel through an orifice into buckets which are fixed to the wheel.

When this bucket is filled it moves on thus bringing the next bucket under the water jet to be filled up. Here it is quite clear that the wheel rotates primarily because of the WEIGHT of the water in the buckets of the wheel. (The Kinetic Energy is very small and in future will not be considered).

Having measured the height of the column 'h_0' of water from a centre line of the orifice, and the inflow velocity, C_0, the spouting velocity, C, is defined as

$$C = 0.9 \ (2gh_o + C_o^{2})^{\frac{1}{2}}$$

where 0.9 is a safe value of the velocity coefficient.

Say, $C_o = 1$ m/sec. and $h_o = 0.2$ m the spouting velocity, from the above formula

$$C = 2 \text{ m/sec.}$$

Therefore although the velocity of the water is 1 m/sec. the actual velocity of the water flowing into the buckets (spouting velocity) is 2 m/sec., for as low a height of water column as 0.2 m.

Let the height from the bottom of the wheel to the surface of the tail water be Z_u and the height from the top of the wheel to the jet center line be Z_o hence Z_o can be calculated as

$$Z_o = e/2 + \delta + \Delta Z$$

where e = height of the discharging orifice
δ = the thickness of the trough bottom
ΔZ = the air gap between the bottom of the trough and the top of the wheel not being more than 1 to 3 cm.

Having the above information and the Head "H" known, the diameter of the wheel can be calculated as

$$D = H - (h_o + Z_o + Z_u)$$

Application of the overshot type of wheel is usually recommended where the Head H is of at least 3m, therefore the diameter for a small wheel of this type will be

$$D = 2.5 \text{ m}$$

The peripherial speed of the wheel "u" is normally taken to be between 1.5 and 2 m/sec., hence from the well known formula

$$n = \frac{60u}{\pi D}$$

thus the speed range would be between

$$n = 15 \text{ and } 3 \text{ r.p.m.}$$

the bucket depth "a" is usually about 0.25 to 0.5 m.

The width of the wheel is governed by the discharge capacity of the water way. The following relation may be used to determine the width

$$\frac{\text{Discharge}}{\text{Wheel Width}} = 0.1 \text{ (or } 0.2) \quad \frac{\text{cu. m/sec.}}{\text{m}}$$

Water splashing over the sides of the bucket can be reduced by increasing its width somewhat say 20 to 30 cm.

Let the width of the spouting jet of water be "b " the height of the orifice can be obtained from

$$a = \frac{Q}{u\ b\ c} \qquad \frac{\text{cu. m/sec}}{\text{m.}\ \frac{\text{m}}{\text{sec}}} = \text{m}$$

Where u = contraction coefficient of water = 1

When the bottom flume of the trough is made of wood it should have a minimum thickness of about 40 mm.

One of the main "disadvantages" of water wheels is its low efficiency when compared to the water turbines. Whereas water turbines have efficiencies approximately 99%, that of the water wheel at best is 80% (at its lowest is 40%). However the usual efficiency factor is 65%. Efficiency can be improved by improving the following

a) Splashing and leakage

b) free height

and c) bearing friction and windage.

In terms of Guyana this means that at present the water is flowing without any energy being generated from it whereas even at a 65% efficiency we would still be saving on foreign exchange - purchasing of oil.

The history of water wheels has shown that it was at first constructed of wood and even today small water wheels are still being constructed of wood.

It has been shown from the development of water wheels that the overshot wheel reaches a maximum efficiency when the peripherial speed of the wheel attains half the inlet velocity of the water.

From the diagram on appendix 1 the initial and final spilling positions are given as h_1 and h_2 respectively. Now should a linear function be assumed for the spilling process then the whole discharge can be said to leave the bucket at a height of

$$\frac{h_1 + h_2}{2} \quad \text{(m)}$$

above the tail water level.

All losses can be made equivalent to the loss of part of the head for the purpose of calculation the output of the wheel when compared to its input or to its efficiency i.e.

$$\text{Efficiency} = \frac{\text{Output}}{\text{Input}} = \frac{\text{Input-Losses}}{\text{Input}} = 1 - \frac{\text{Losses}}{\text{Input}}$$

When expressed as a percentage

$$\frac{\text{Output}}{\text{Input}} \times 100 = 100 - \frac{\text{Losses}}{\text{Input}} \times 100 \quad (\%)$$

The depths of the power canals should not exceed 1 m and is usually 0.5 m.

When the design of the buckets are being done, consideration should be given to the following points:

a) The outer edge of the bucket should be so designed that the water jet meets it at about 20 - 30 degrees.

b) Because of a spinning wheel the centrifugal forces thus created will tend to have the water rising towards the outer edge of the bucket. The water level in the bucket then cannot be considered to be level or horizontal This rise depends on the speed of the wheel.

c) Once the outermost speed of the bucket has been determined, bucket pitch and depth must be designed so that spilling does not occur too early. The buckets are usually designed to carry half of its capacity of water.

d) The number of buckets are completed from the equation

$$m = \frac{\pi D}{a}$$

Power output can be controlled by varying the inlet gate. e.g. Let us say the wheel slows up, this means that the discharge of water from the flume has diminished hence by closing the orifice of the gate partially it will re-establish the original water level (Head). However if the closure of the orifice is used to match the output of the wheel then the extra water due to a rise in the. power canal must be diverted through a spillway.

b) The Breast Shot Water Wheel

By allowing water in the Headrace to enter the wheel at breast height, the Breast Shot Water Wheel can be constructed. The advantage of this type of wheel over the Over-Shot Wheel is that the diameter can be larger than the available head of the river.

A diagram of this type of Water Wheel is found in Appendix 2.

From Appendix 2 it is obvious that the water control is achieved by gates which can be of the double type. These Wheels can be applied in conditions where variations of head is appreciable hence the use of the double gate - the bottom half is closed during high water and through the upper-half the water flows while during low water level the top half of the gate is closed and the water is being made to flow through the bottom half of the gate.

With this type of gate although the head codditions may vary the effáciency can be kept.fairly constant.

It is also to be observed from Appendix 2 that the bottom of the wheel pit must take the shape of the wheel and further, the opening between the wheel and the pit should be reduced to as small as possible if early emptying of the buckets is not to take place, thus reducing the efficiency of the wheel.

Some types of wheel use the wall as a boundary to the water in the buckets, however this will call for precision work and thus increase the cost. This author recommends that the buckets be so constructed as to be self-containing.

In this type of wheel although the bulk of the power produced is due to the weight of the water in the buckets, the momentum of the water would also contribute a fair share of the power finally attainable.

It is here recommended that these wheels be used under the following conditions:

H = 2 to

Q = 0.3 to 3.0 cu.m/sec.

The wheel Diameter is usually

D = H + 3.5 m

If we assume the safe speed of a point on the circumference of the wheel to be between 2.0 to 1.4 m.sec then the wheel speed will vary between

7 to 3 r.p.m.

According to the available literature the efficiency varies between

60% and 75%

The Undershot water Wheel

In the case of the undershot water wheel the water is received by the wheel on the "under" side as is shown in Appendix 3.

It should be noted here that it is not the weight of the water that causes the rotation of the wheel but the speed combined with the inertia of the following water that pushes the wheel around.

The question may now be asked at what point can one say that this is no longer a breast shot wheel but an under shot wheel? This can be "answered" by noting whether the weight of the water has been playing any significant part in the spinning of the wheel. Further the flume of the undershot wheel is slightly above tail water level and obviously very low heads can be used.

Heads used in this type of water wheel ranges between

0.4 to 3m

Discharge can be between

0.2 to 5 cu.m/sec

A distinct advantage of the undershot water wheel is that its efficiency does not drop significantly with a rise in tail water level as it operates quite well should it be immersed in water up to about 1.0 water.

The diameter of the wheel should be based upon the Head of water available for use and in fact being used on a particular scheme. This relationship should be

$$D = 3H \text{ to } 5H$$

with the larger diameters being utilised on the lower Heads.

With the above recommended Heads the diameter of this type of wheel

$$D = 2 \text{ to } 9 \text{ metres}$$

Let us say that a safe speed of the buckets on the wheel is between

1.3 to 1.0 m.sec

then the speed of the wheel is

$$n = 12 \text{ to a r.p.m.}$$

The wheel, out of sheer necessity must be placed in the water to depth up to one third of the Diameter. This is because of the fluctuation in the tail water level.

The width of this wheel may be determined by taking a discharge figure of 0.4 to 1.0 cu.m/sec
for each meter width of the wheel.

The efficiency of this type of wheel is dependent on the shape and position of the vanes. With the straight vanes the efficiency is about 30 to 40 per cent (it may even drop to 15 per cent). However with streamlined vanes it may even attain 70 per cent.

Regulation of the water wheel is done just as in the Overshot or Breast Shot Type of Wheels.

The Water Paddle

From appendix 4 it is clear that this form of the Water Wheel does not need a head. All of its energy is derived from the Kinetic Energy of the water.

It is shown in literature that the maximum kinetic energy used by the Paddle Wheel is 50% of that obtainable from the water passing the paddles.

With further inherent losses the "best" efficiency of the Paddle Wheel

$$\eta = 40 \text{ per cent}$$

THE BANKI TURBINE

The Banki Turbine is a very versatile machine that is not very sensitive to the variations of Head Water Level. Further, it is very easy to construct hence it lends itself to full utilization in Third World countries where manufacturing sophistication is not yet a reality.

This Turbine is between an impulse and a reaction turbine with an added feature that the water in passing the Turbine blades makes contact twice with the blades - once upon entering the runner blades and again upon leaving the runner blades.

The basic difference between the Banki Turbine and the conventional turbines is, that there is no axial flow of water, this means that water moves 90 degrees to the machine's shaft and at no time will there be any flow of water along the axis or shaft of the machine. This feature of the Banki Turbine is important since in effect it means that the runner diameter is independent of the wheel discharge. Indeed it is the width of the runner that is a function of the wheel discharge, i.e. the greater the flow of water the longer will be the shaft of the machine and not the diameter of the runner increasing or decreasing.

Water admission to the runner is indeed a very technical point and requires a great deal of experience, the absence of which would point to the only other solution - EXPERIMENTATION.

The discharge of water through the Turbine can be controlled in either one of two modes i.e. Manual or Automatic. Obviously automatic control is the more desirable mode but it would also mean increased costs. However it is here suggested that manual control be used initially - automation can be incorporated at any stage - in a country such as ours.

In appendix 5 a typical drawing of the Banki Turbine is shown and in Appendix 6 drawings of a proposed 1KW Turbine is shown having a head of 1.5 metres with a flow of 0.125 cumecs.

DESIGN

Once the available Head (H) and the Flow (Q) of the channel is determined, the next step is to ascertain the generator speed for this will eventually determine the Turbine Speed (n).

With this initial data the Diameter (D) of the Turbine is determined by the formula

$$D = 39.3 \frac{(H)^{\frac{1}{2}}}{n} \quad (m)$$

where H is in metres and n is in r.p.m.

The point to bear in mind now is that there must be a specific ratio between the width of the entrance cross-section of the supply flume and the diameter of the turbine which at all times must be maintained i.e.

$$S = KD$$

where $K = 0.2$

The thickness of the water within the runner is also to be considered if the turbine is not to be "choked up" with water thus preventing the designed speed to be made available to the generator. This thickness of water is found to be

$$d = 1.89\ S$$

Now the only parameter of the Turbine to be resolved is that of the width. This can be found from the formula

$$b = 0.02\ n\ \frac{Q}{H}$$

The approximate output of this Turbine is

$$N = 10\ QH \quad (HP)$$

where Q is in cumecs

H is in meters

Note that 1 metric HP = 746 watts

Example: Determine the main dimensions of a Banki Turbine for

H = 1.5 meters, Q = 0.125 cumecs. Select a runner diameter to match a generator speed of 1500 r.p.m.

<u>Solution</u>

With a belt or gear ratio of 1:10 the Turbine speed n = 150 r.p.m.

Applying quotation

$$D = 39.3\ \frac{(H)^{\frac{1}{2}}}{n} \quad (m)$$

$$= 39.3\ \frac{(1.5)^{\frac{1}{2}}}{150} \quad (m)$$

$$= 39.3\ \frac{1.22}{150} \quad (m)$$

$$= \frac{48}{150} \quad (m)$$

$$= .32 \quad (m)$$

$$D = \underline{\underline{32\ cm}}$$

Ratio between entrance width of flume and diameter of turbine

$$S \quad KD$$

$$= 0.2 \times 32$$

$$S = \underline{6.4}\ cm.$$

Thickness of water in runner

$$\begin{aligned} d &= 1.89 \quad S \\ &= 1.89 \times 6.4 \\ d &= \underline{\underline{12}} \text{ cm} \end{aligned}$$

Width of runner

$$\begin{aligned} b &= 0.02 \, n \, \frac{Q}{H} \quad (m) \\ &= 0.02 \times 150 \times \frac{0.125}{1.5} \\ &= 0.2 \times 10 \times 0.125 \\ &= 2 \times 0.125 \\ &= .250 \\ &= .25 \ (m) \\ b &= \underline{\underline{25}} \text{ cm} \end{aligned}$$

Power output

$$\begin{aligned} N &= 10 \quad QH \ (HP) \\ &= 10 \times 0.125 \times 1.5 \quad (HP) \\ &= .125 \times 15 \quad (HP) \\ &= 1.875 \quad (HP) \end{aligned}$$

Since 1 HP = 746 (W)

Therefore 1.875 HP = 1.4 KW

Efficiency of these Turbines 80% = 1.4 x 0.8 = 1.12 KW at Generator

Low Capacity Plants

Low capacity Plants are the most suitable for development in Guyana. Under this terminology it is assumed that the output is 100 KW with heads of an average height of 60 - 100 metres and discharge capacity of 20 to 100 litres per sec, but no distinctive limits can be drawn.

Obviously Low Capacity Plants or Midget Stations have their economy boosted in the fact that their diversion wier, intake and power canal are designed for simplicity at their lowest cost. Again all the conservative factors involved when designing large Hydrostations are not to be taken on the conservative side but can be relaxed a great deal with some of them not even being considered.

Should an area lend itself to the development of a series of similar Low Capacity Plants then serious consideration must be given to the manufacturing of prefabricated reinforced-concrete and concrete elements in series for the wier, the intake and in some cases the power-house also.

Low Capacity Plants with medium and high heads usually have a forebay, supplied by a power canal.

The forebay conteins.

1. The Spillway Gate, made of timber.
2. A Sill, made of concrete or stones.
3. A Screen, made of timber-greenheart.
4. An Intake Gate - made similar to that of the Spillway Gate.
5. Clay Brick Block for anchoring the penstock and its intake.

The Penstock for these plants are made of wood. The smaller penstocks are supported on trestles of simple design or it m[illegible]n be buried if the terrain permits (on record there exists a pens[illegible] 550 metres long having a head of 21 metres made of timber).

One of the many variable type construction of a typical midget power station is shown in Appendix 7.

Francis or Pelton Turbines are usually installed in medium and high heads, however it is to be noted that Banki Turbines have been used successfully up to a head of 60 metres. Francis Turbines for Low Capacity plants are usually of the horizontal shaft arrangement while the Pelton is of the vertical shaft arrangement. In this case transmission gears are dispensed with, because the turbines can be connected directly to generators. Again because of this connection, generators with speed ranging from 750 to 1500 r.p.m. can be manufactured very economically

The regulating needles of Midget Pelton Turbines, can be operated by hand although automation can be introduced to replace and/or alternate the hand operation.

Hydraulic conditions would point to the requirement of steel scroll casings when Francis Turbines are to install at low head power stations, however the cost of these steel scroll casings are simply astronomical and hence rendering their application prohibitive.

Consideration must therefore be given to what is termed Open Flume Settings (O.F.S.). See appendix 8. Now O.F.S. monopolise Midget Power Stations design.

Horizontal shafts are employed at Midget Power Stations except for very low head between 1 metre and 2.5 metres, in which case the vertical shaft setting is used. The Horizontal shaft setting has the advantage of reducing cost by making the installation of the transmission drive very much easier. Appendix 3 shows a typical Open Flume Setting with a Francis Turbine installed.

The power canal leads to a forebay which is of clay brick construction, the powerhouse placed in line with the headrace is also of clay bricks with the spillway at the side of the powerhouse made of clay bricks too.

Where the terrain is of sand or sandy clay or of any loose material it stands to reason that the forebay, the spillway and tail-water bay must be stabilised. This stabilization should take the form of using clay bricks extensively.

The spillway is a gate of simple vertical lift type of timber. One provision in this type of spillway is that the channel must be lined with energy dissipators perhaps in the form of sills to break the jet of water under pressure by a cushion. This sill is also made of clay brick.

A sill with a screen above it and a simple bridge made of timber can form the powerhouse intake assembly.

The screen is placed between the sill and the bridge from which point, the screen can be conveniently cleaned from time to time - a hand rake can be used.

The bridge can be made by having two timber beams across the stream with boards being placed between the timber beams to form the bridge.

The inlet gate to the powerhouse can be operated from the screen bridge. This gate is also of the timber type and is similar to that of the spillway gate in construction.

The lowest point of the supply flume is connected to the tail-water by means of a drain pipe fitted with a cutoff valve.

This is to dewater the supply flume should it become necessary.

The location of the turbine is made after considering the hydrology of the intended scheme.

In Midget Stations a crane is too expensive to have installed and instead, a hoisting tackle is used inside the powerhouse. Automatic or manual regulator is also found within the powerhouse and so too is the switch gear box.

At the end of the tailwater pit grooves for stop-logs are inserted in the connecting walls. Closing is effected by having two rows of timber with an earth fill between them.

The floor of the powerhouse is made of reinforced concrete with ribs. The wall between the machine room and the Turbine Flume is also of reinforced concrete with care being taken to have proper water seals installed. The other walls of the powerhouse may utilise clay bricks in their construction. The roof of the powerhouse is made of timber truss and shingles for its covering.

In cases where the powerhouse has to be located on pervious materials such as sand a cut off wall must be placed in the foundation of the powerhouse. The depth of the cut off wall would depend on the position of the impervious sublayer or the required length of the seepage path. Timber piles are used for this purpose.

The concrete wall seperating the supply flume from the machine room has to make accommodation for a water-tight connection. This is because the turbine runner is in the supply flume while the generator is in the machine room.

In some cases the elbow of the draft tube is made to pass through the wall Appendix 8 while in most cases the turbine cover that is nearer the wall is bolted onto the wall by means of an annular flange embeded into the concrete wall.

The cost of Midget Power Stations can be further reduced if the size of the powerhouse can be reduced. This is attained by arranging for the machine floor to be above the headwater level (See Appendix 9 ~~IX~~). For the horizontal setting the only parts that are necessary for the transmission of energy, from the turbine to the generator are the pulleys and belts. The pulleys here have a double function, that is it does not only transmit energy but it is also used to increase speed by means of a ratio between driving and driven pulleys.

One of the most considered advantage of the Horizontal type setting is that the bearings are less costly than its vertical type counterpart and also assembly, repairs and maintenance work are much easier, hence less costly.

It should be borne in mind that at heads of one 1 m to 2.5 m vertical shaft settings would require at least 1 m of water to cover the turbine runner. This 1 m of water is necessary if air is not to enter the turbine by means of whirlpool and drastically reduce the turbine efficiency.

Where the discharge of the stream is high even vertical shaft setting may prove to be inadequate in preventing air from entering the turbine. Under these conditions spiral casing is indeed a necessity. (See Appendix10).

A closer examination of Appendix10 shows that the inlet gate hoist has been placed inside the machine room, thus allowing its operation from within. Again in this Horizontal Shaft Setting, the generator can be driven by bevel gears. If the speed of the turbine being manually operated then the handle of the control unit can also be placed in the machine room. If the turbine is controlled automatically then the speed sensitive governor is attached to the transmission through which the belt drives.

Fixed blade propeller are also being used in Midget Power Stations due to their capacity to accommodate both high speed and discharge while occupying a relatively small space. In most Midget Stations a vertical draft tube is used instead of the elbow type, the reason being the cutting down on cost with relatively small loss of head.

Some manufacturers design and build tubular or bulb units which are being installed by very simple methods i.e. by bolting on the unit to a prepared concreted structure and also bolting on the supply flume as well as the draft tube at their respective places.

THE PRESENT POSITION

Guyana at the moment is having two small and one medium hydropower sites considered as a start towards larger projects in the future. The two small sites are in isolated areas. It is expected that when the medium scheme comes on stream it shall be utilized in the national grid, to increase the reliability of supplying the nation with power.

The two small sites are:

(1) Wamakaru and
(2) Eclipse Fall

The medium site is known as Fumatumari.

(1) Wamakaru

Initially the project is of the order of 500 kw from a head of nearly 500 m. It is situated in the South-Western part of Guyana.

This small hydroplant when completed shall serve the area isolated from the national grid and at the moment using desired fuel as the source of power.

It is rather interecting to note that the diesel fuel has to be transported by air and its cost of transportation is even more expensive than the actual cost of the fuel. Activity in this savannah area is mostly cattle rearing hence cold storage is one of the main users of electricity.

(2) Eclipse Fall

This project is found in the North-Western region of Guyana and when completed shall have an initial installed capacity of about 2MW.

The Eclipse hydroproject is also in an isolated area and shall bring power to these areas that are now being serviced by Diesel Plants. Here again transportation and supply of fuel is the problem and although it is not by air it is very strainuous and unreliable.

At the moment power is not supplied on a 24-hour-a-day basis but at specified times of the day and night.

Activity in this area is mainly agricultural based, hence preservation crops will be one of the main users of electricity.

Tumatumari

At this area on the Potaro River a gold mining company had set up business and was in short supply of power, hence they constructed a small hydropower station to supply their machines to extract gold. After their operations this station was abandoned, leaving all the machinery and infrastructure intact.

The Guyana Government rehabilitated this hydroproject and at the moment has plans to upgrade it from 1.5MW to 44.5 MW.
It is seen that this amount of electricity shall be sent into the national grid via a 138 KV transmission line.

RECOMMENDATIONS

1. That Guyana and indeed the third world countries start looking and utilizing their hydropower resources, however small they may be. Starting at points of isolated but inhabited areas that are at present consuming fossil fuel as a source of energy to those areas that possess economical and viable resources to be exploited, once cheap power is made available.
2. That micro, small and medium schemes be constructed in that order by nationals from the National Budget.
3. That after a series of micro, small and medium hydropower plants have been constructed by nationals and the National Budget cannot support large projects,then and only then must international agencies be engaged in financing the project, since by this time a team of national experts shall have grown.

CONCLUSION

With every passing day it is becoming more and more evident that hydropower must replace the conventional energy source. It is also rather ridiculous that mankind on the whole has spent so much time and money on a non-renewable source of energy and has even built up his whole technology on that basis.

For the developing nations especially Guyana where there is an abundance of renewable source of energy hydropower must be developed now. It is known that to develop hydropower the capital investment is very high while maintenance cost is almost negligible. These two apparent opposing factors can be "solved" by going into the construction of micro hydropower schemes.

Again when one considers the random rise in the price of fossil fuel, it becomes almost imperative to construct even "uneconomical" schemes immediately with the knowledge that sooner rather than later the schemes shall have become viable. On the other hand should it be seen in the light that time will certainly make these schemes economical and <u>then</u>, it should be embarked upon, is indeed a fallacy. It is here argued that not only is the price of fuel going upwards but the price of almost all items is skyrocketing at a rate even higher than the rate of rise of the price of fuel.

Under these circumstances time will only make the schemes more uneconomical rather than economical.

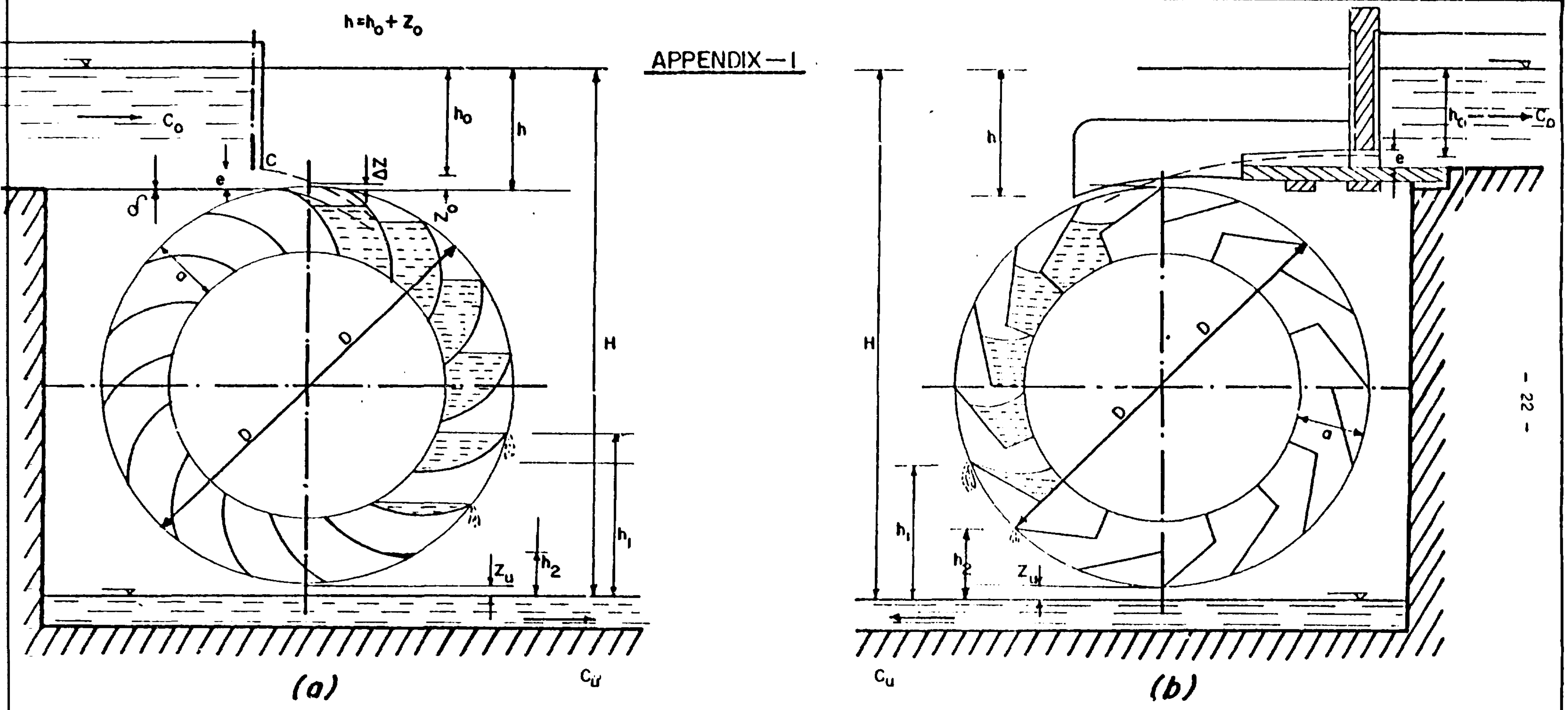
Let us look at this whole idea from another perspective and say that we had embarked on a particular hydropower scheme, which, say in 1975 was uneconomical, but a decision was taken against this background to construct this scheme. In 1980 when one looks at this scheme it obviously had become viable. If this scheme was to have been constructed in 1980 then it may still have been uneconomical perhaps even more uneconomical than in 1975, because of the difference in the rate of rise in prices between oil and imported materials for construction.

It was mentioned above that microhydropower schemes would bring a compromise between the two apparent opposing forces. This is so because, whereas in large conventional schemes a whole set of conservative decisions have to be taken and each one of those decisions increases the cost of the scheme, however, in microhydropower schemes most of these conservative decisions are not even considered.

Another point to bear in mind is that the mare quantum of money involved makes micro-hydropower attractive, that is it does not require large amounts of foreign exchange.

Dams for micro-hydropower schemes should not be designed along the lines of conventional dams, but unconventional designs must be adopted as a matter of urgency. Dam designs such as the "ramp" using logs must be given serious thought. Again the use of clay bricks as dams for micro-hydropower schemes must also be considered. These forms of dams were used in ancient Egypt, and today's China. Guyana can certainly learn from others experiences in this field.

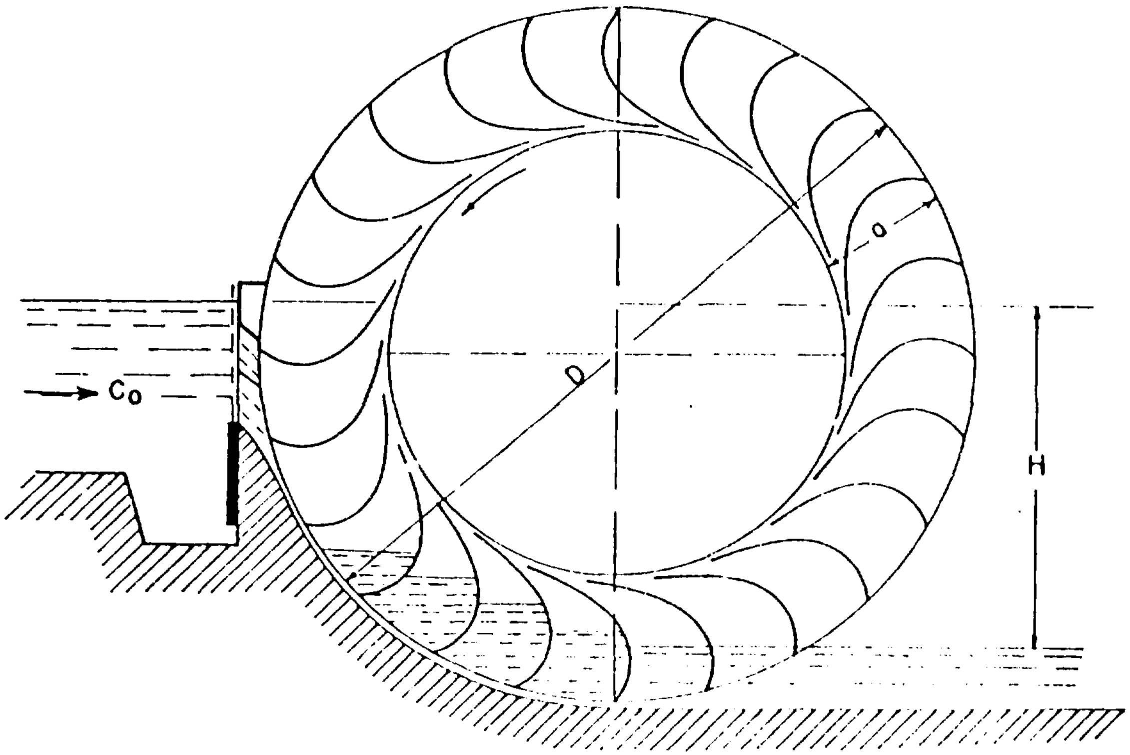
APPENDIX—I



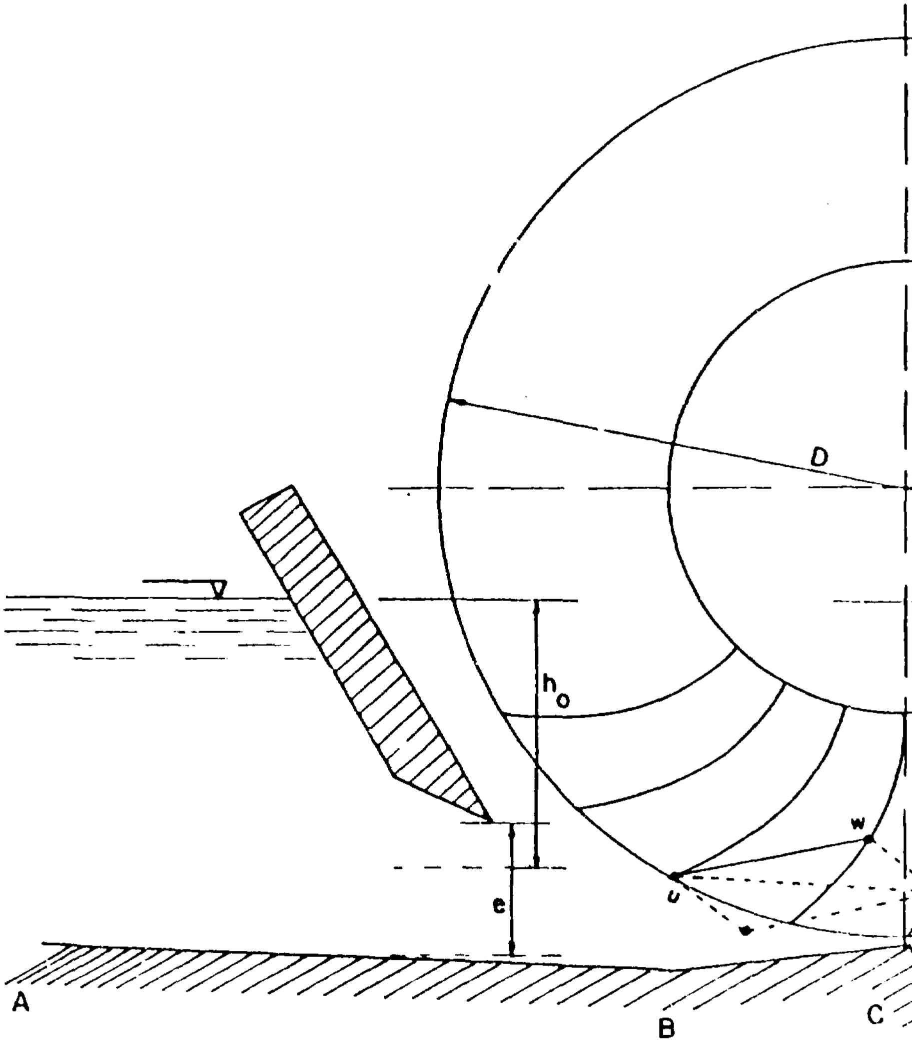
(a) (b)

OVERSHOT WATER WHEELS

Appendix 2.

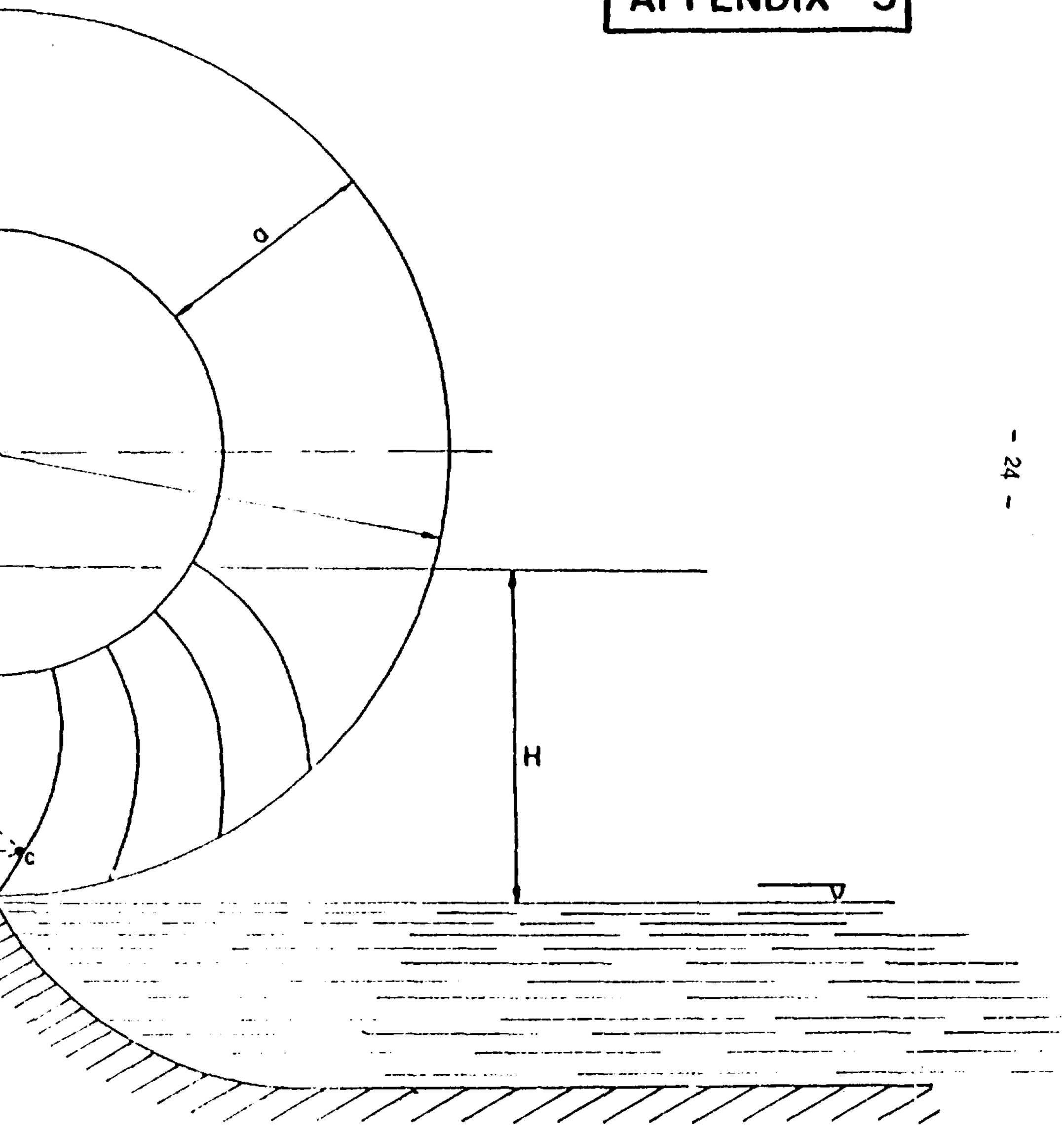


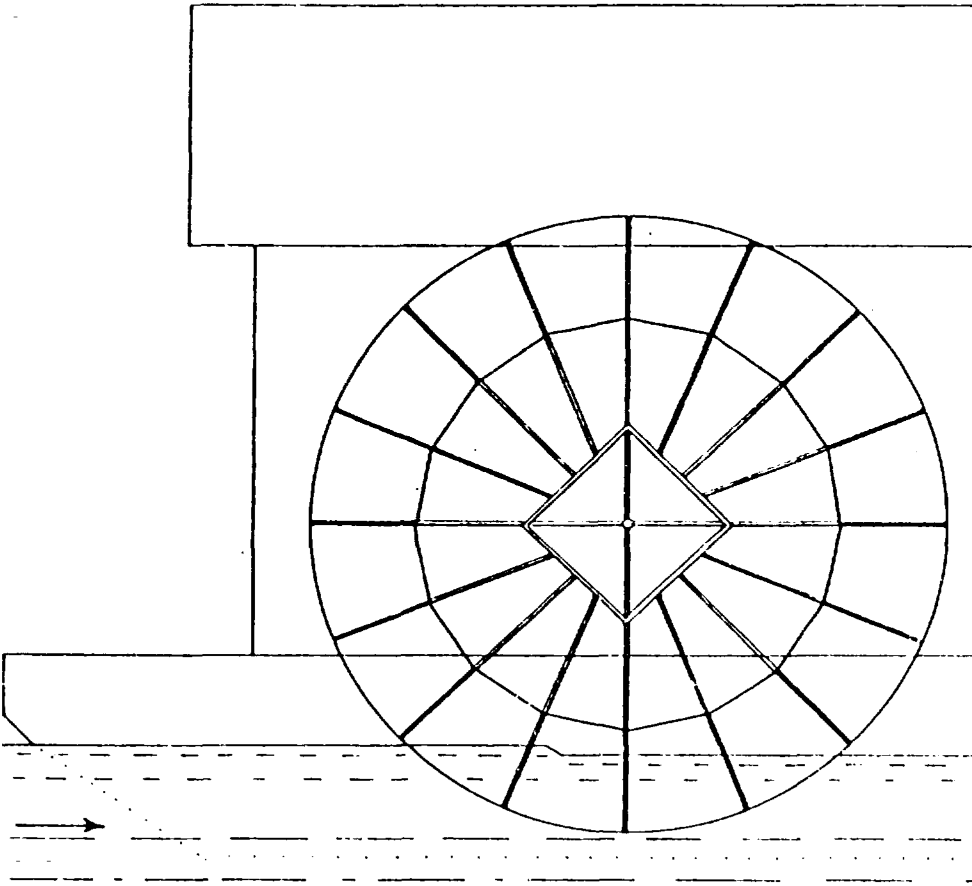
BREAST -SHOT BUCKET TYPE WATER WHEEL



UNDERSHOT WATER WHEEL

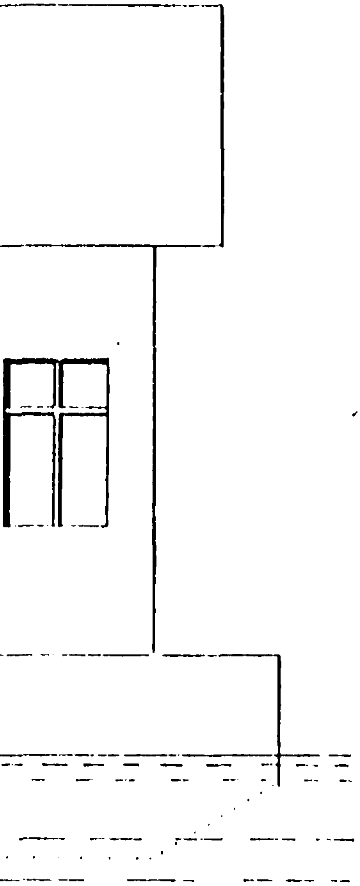
APPENDIX 3



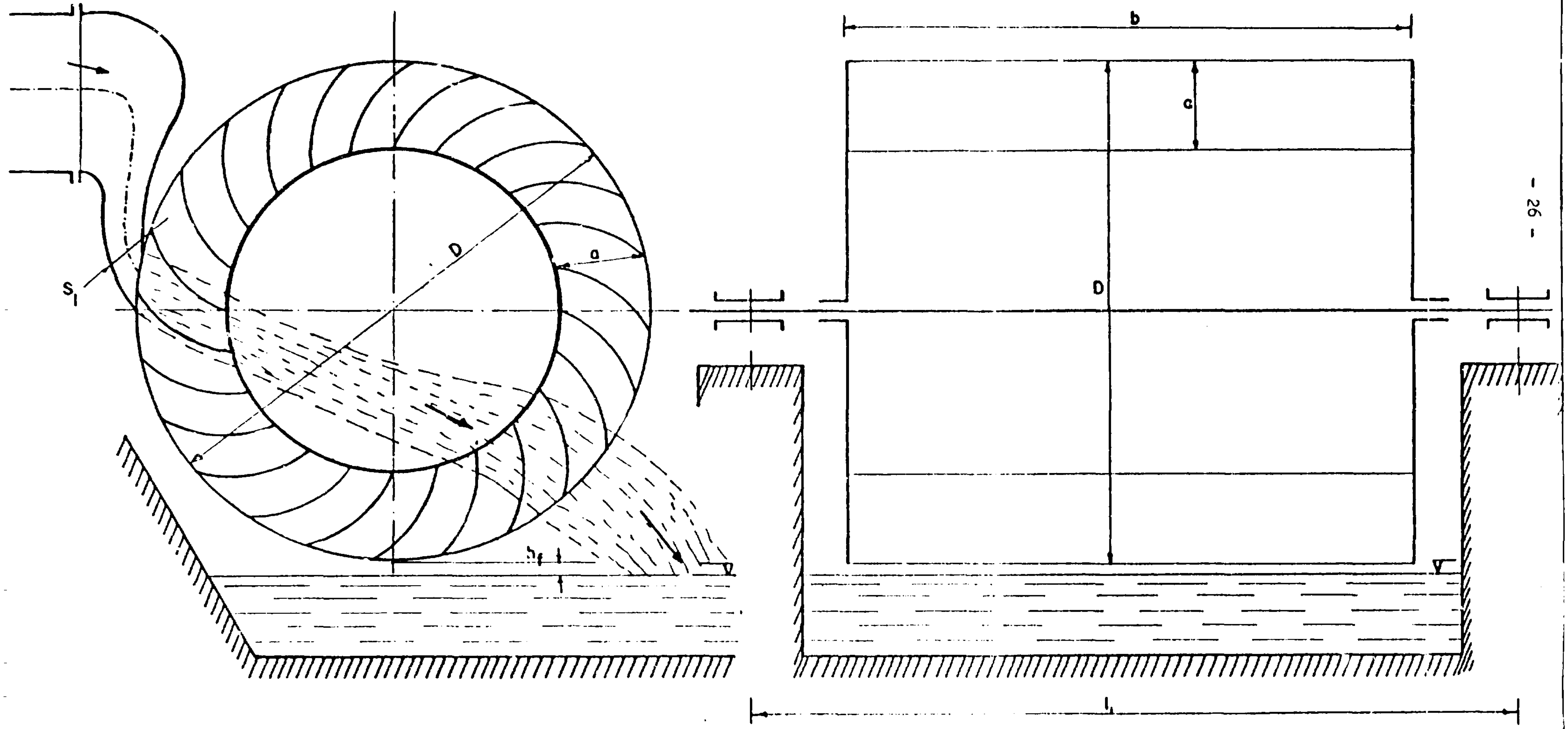


PADDLE WHEEL

Appendix 4

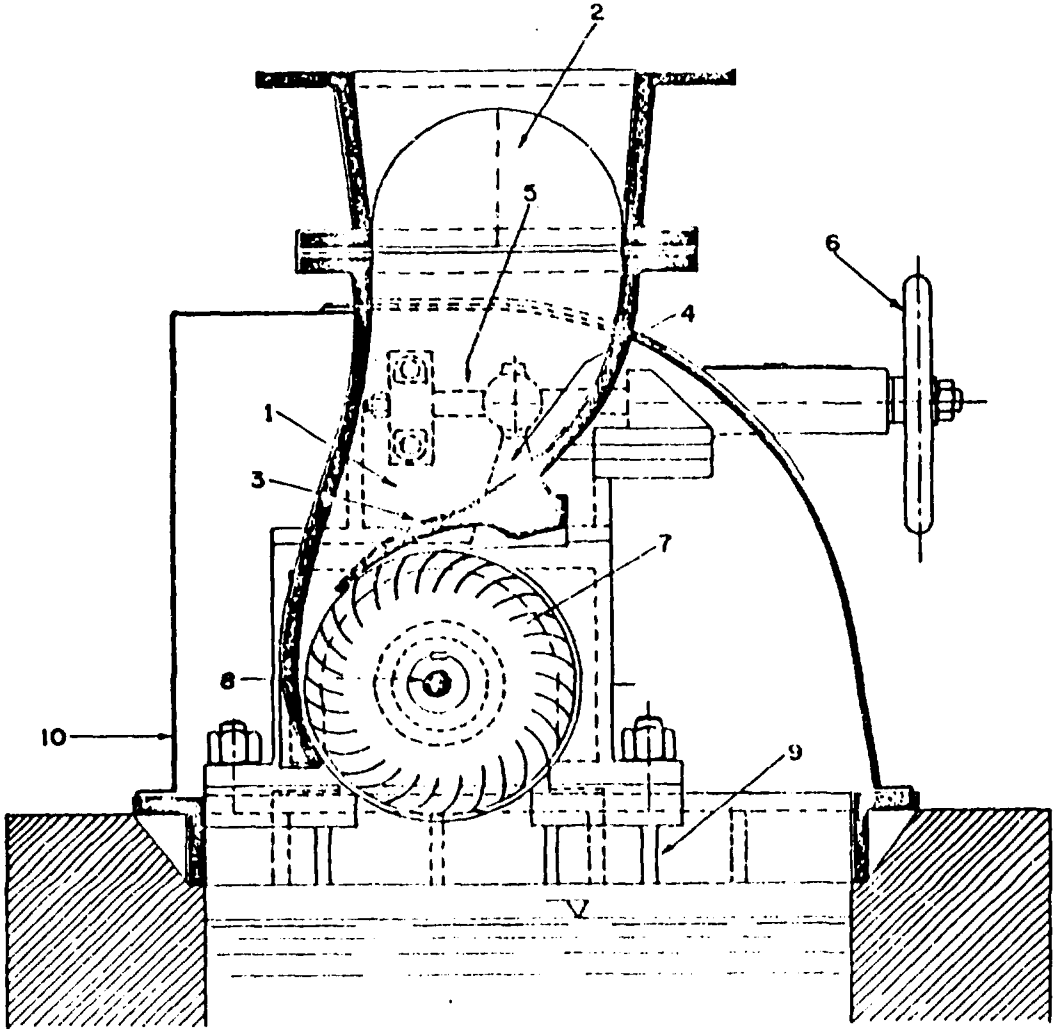


Title :- SCHEMATICAL DRAWING OF A BÁNKI TURBINE APPENDIX-5



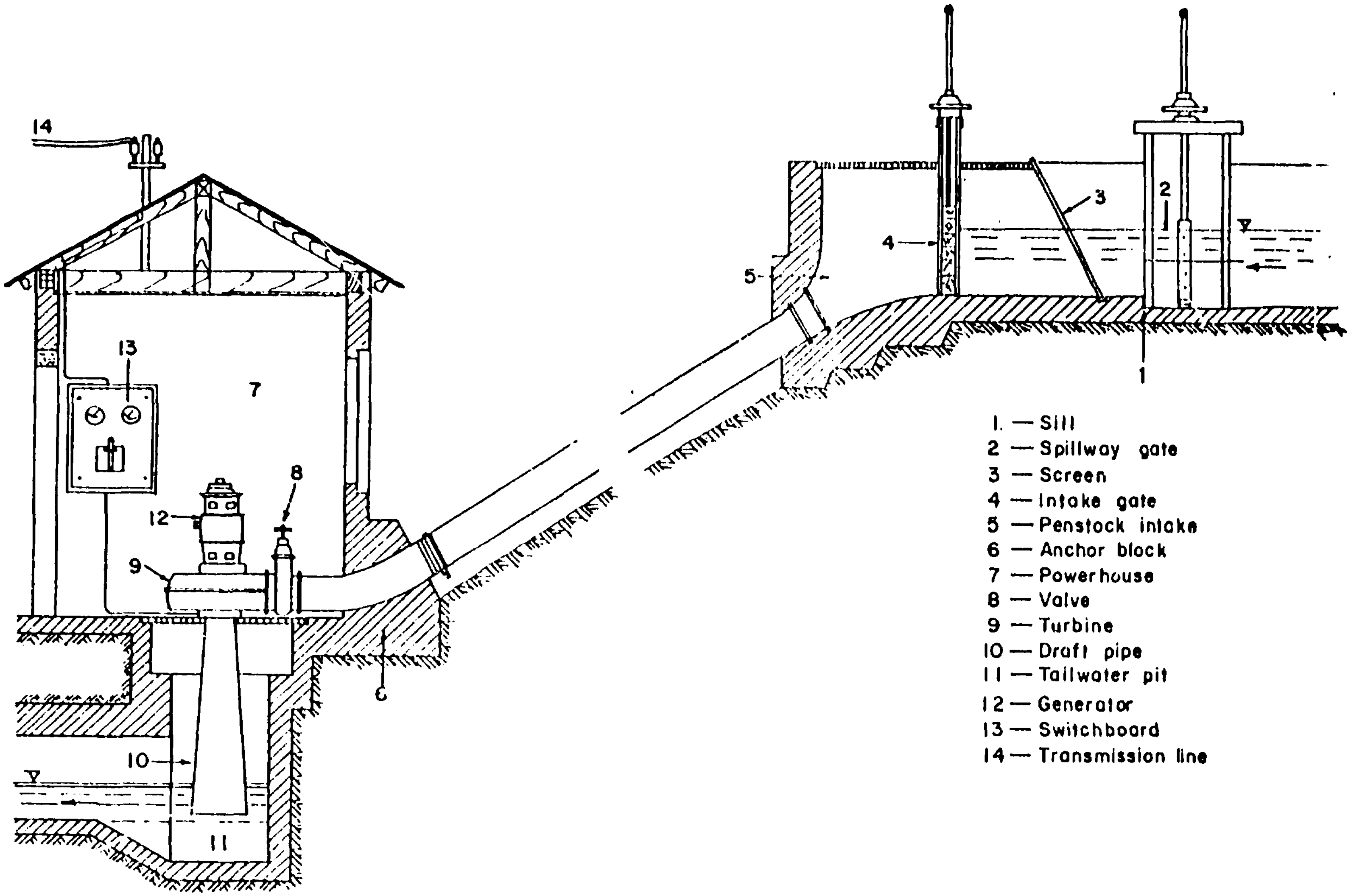
Appendix 6.

1. —— Confuser
2. —— Transition piece
3. —— Regulating lip
4. —— Regulating lever
5. —— Regulating shaft
6. —— Handwheel
7. —— Runner
8. —— Shaft
9. —— Base frame
10. —— Hood



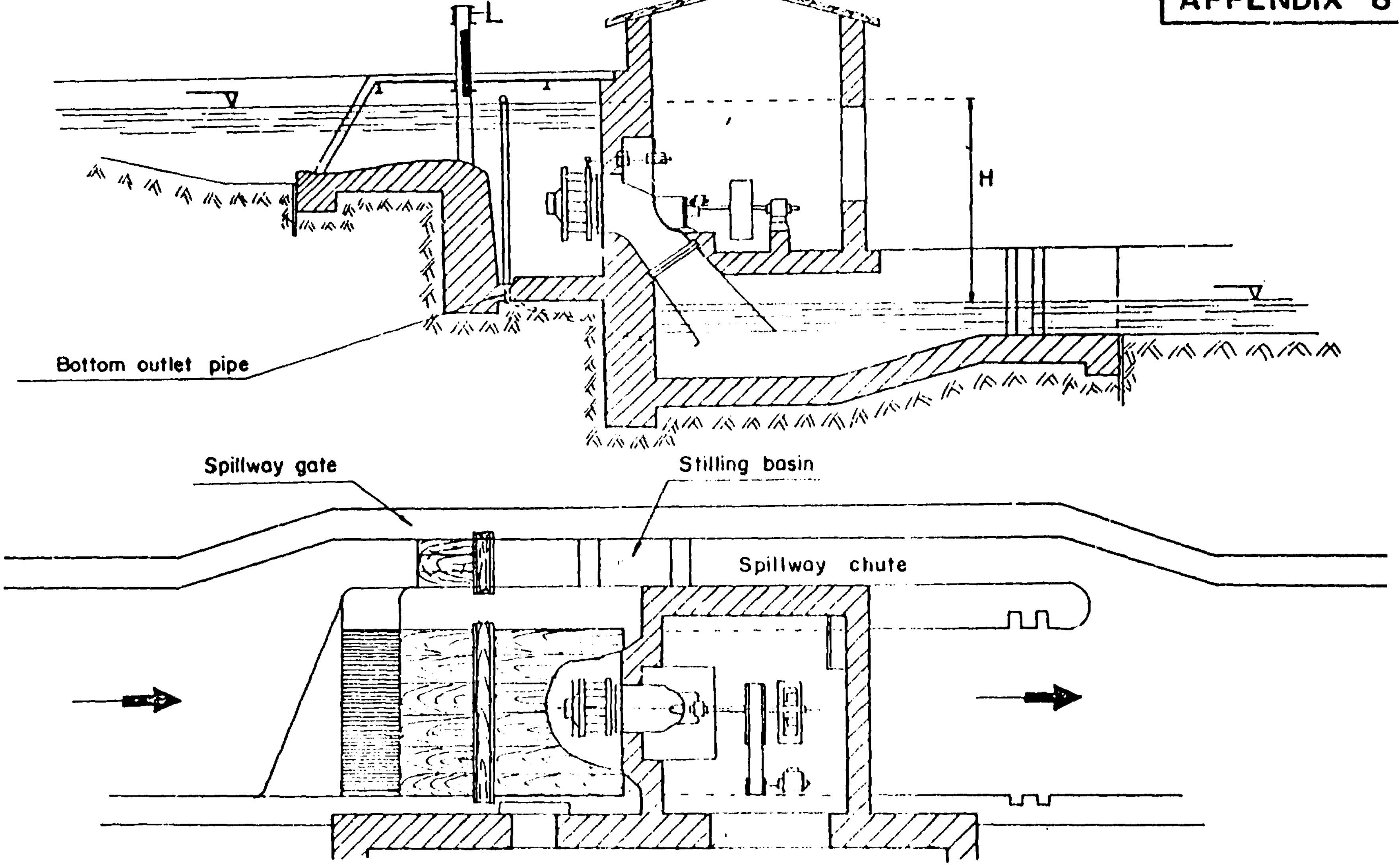
DETAILS OF A BANKI TURBINE

Appendix 7.



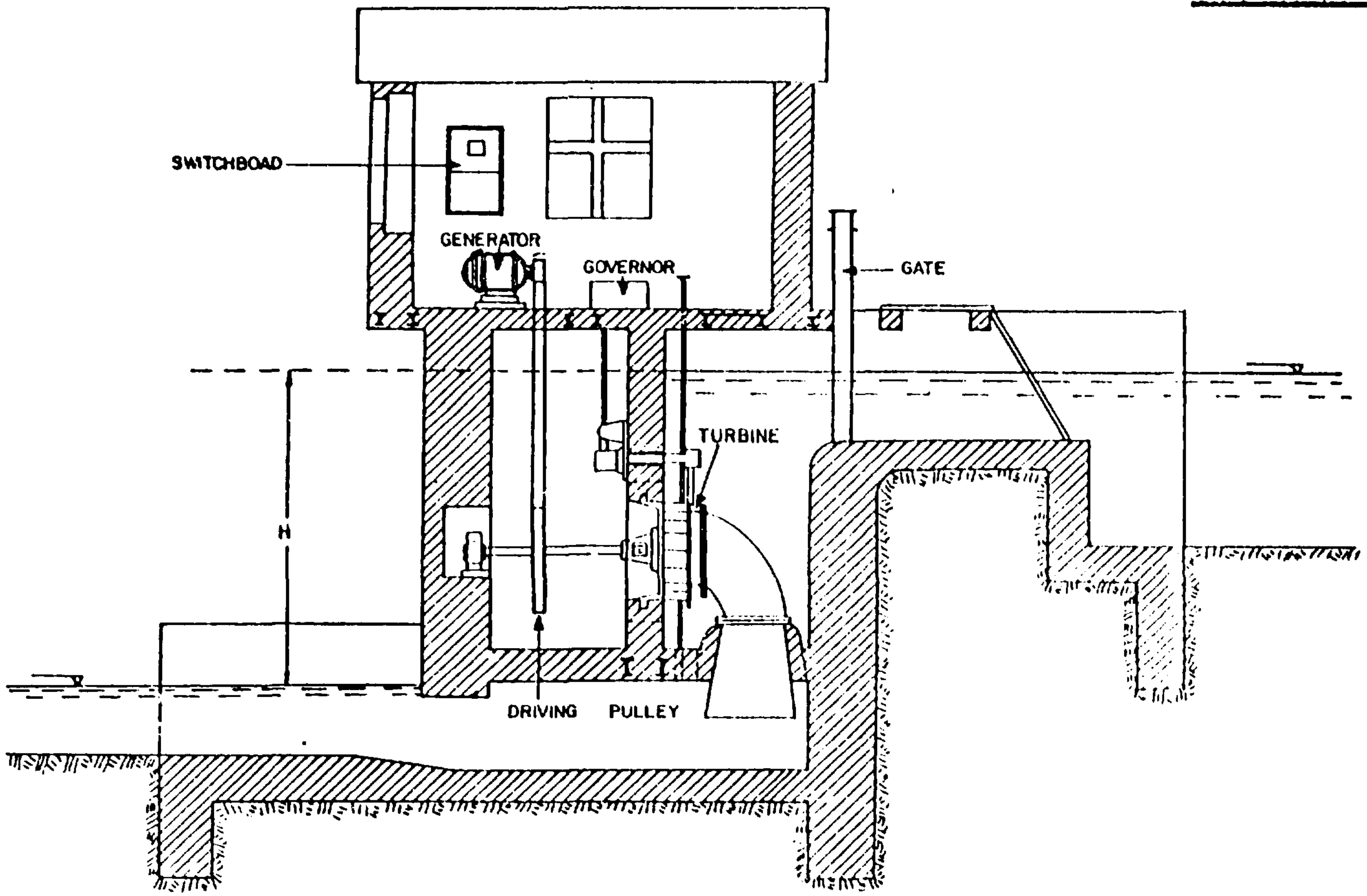
TYPICAL LAYOUT OF HIGH-HEAD AND MEDIUM-HEAD MIDGET POWER PLANTS

APPENDIX 8



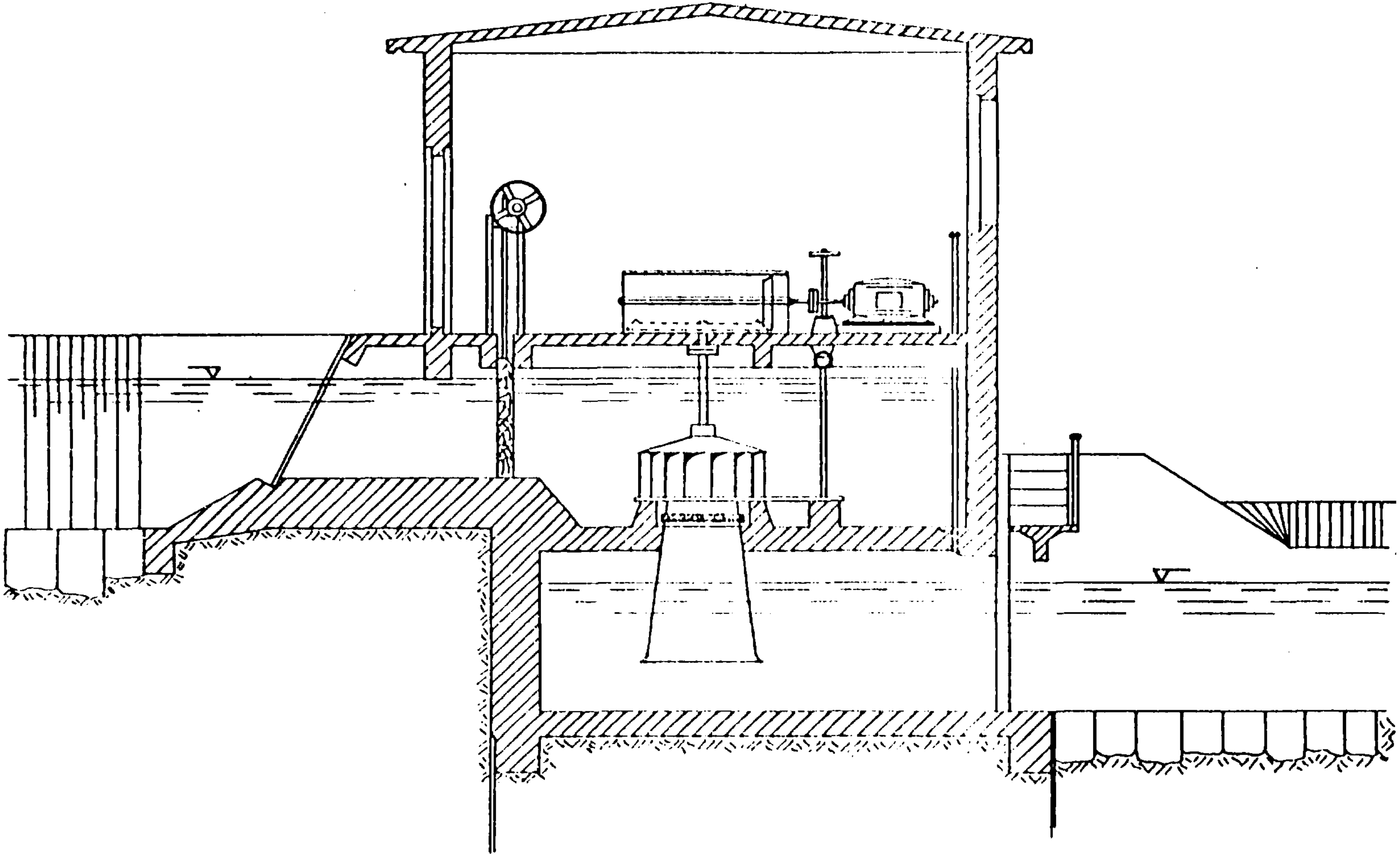
LOW HEAD MIDGET POWER STATION IN OPEN-FLUME SETTING

APPENDIX - 9·



LOW-HEAD MIDGET POWER STATION WITH HORIZONTAL-SHAFT MACHINES & A RAISED MACHINE HALL· GENERATOR DRIVEN BY BELT·

APPENDIX 10



LOW-HEAD MIDGET POWER STATION WITH VERTICAL-SHAFT FRANCIS TURBINE IN OPEN-FLUME SETTING. GENERATOR DRIVEN BY BEVEL GEAR.