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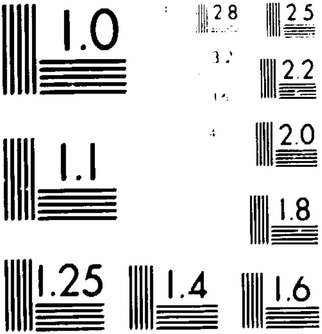

MICROCOPY RESOLUTION TEST CHART

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DEVELOPMENT AND APPLICATION OF MINI-HYDRO ELECTRIC GENERATING UNITS IN THE DEVELOPING COUNTRIES - INDIA*

by

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1. <u>Present position with regard to mini/micro Hydro-Electric Plants in India:-</u>

Development of microhydel schemes in India dates back to 1897, when a microhydel scheme was constructed near Darjeeling. This was followed by several schemes to provide power supply to isolated towns, specifically to Hill resorts.

As power development gained momentum in the country, attention concentrated not only on development of major hydro-electric and thermal projects and extensive transmission and distribution systems in order to provide power supply at economical tariffs; but interest was taken in the development of micro-hydel schemes as well.

In recent years, attention to provide power supply in remote parts of the country, which cannot be supplied power economically from the main transmission grids, or from other sources like diesel power, has gained urgency in the development of microhydel schemes. These recent developments are mainly concentrated along the Himalayan Ranges in J&K, Himachal Pradesh, U.P., Sikkim and Arunachal Pradesh; and in the hilly regions in Nagaland, Manipur and Meghalaya.

Among the various regions in the country, the Himalaya Region affords considerable scope for microhydel development. The streams in this region carry perenial discharges, assuring dependable availability of power all through the year. They also descend down rapidly, enabling concentration of high heads with relatively short water conductor systems. ANNEXURE I presents a list of microhydel schemes in operation in the various parts of India. It would be seen that the size of the schemes is mainly in the range of 5 KW to 1500 KW.

During this period, we have built up expertise in the country in the design, engineering and construction of microhydel schemes. A couple of manufacturers have also come up and specialised in the manufacture of microhydel generating units of various types and covering a large range of heads. We have also constructed about a dozen microhydel projects in Bhutan and Afghanistan. These have proved successful and more such schemes are being taken up in these countries with Indian assistance.

A couple of years ago, a team of Indian Engineers was invited by the Govt. of FIJI for looking into their hydroelectric potential and investigating some microhydel schemes. The team has completed detailed investigations for 4 Nos. of microhydel schemes in 4 different islands. These will be taken up for construction shortly.

2. <u>Plans for this activity in the next 5 to 10 years:-</u>

i) For local supply to the remote villages, installation of small units ranging from 100 KW to 500 KW is under active consideration in the States of J&K, Himachal Pradesh, U.P., Sikkim, Arunachal Pradesh, Nagaland, Manipur and Meghalaya. These projects are listed in the enclosed ANNEXURE II.

ii) For utilisation of small drops in the irrigation canals, installation of tubular and other types of units of capacities ranging from 1 MW to 5 MW is being considered by States like Jammu & Kashmir, Madhya Pradesh, Gujarat, etc., in the country. These projects are also listed in the ANNEXURE II.

3. <u>Research and Development work in this area:-</u>

i) While topographically the Himalayan Region is very attractive for development of microhydel schemes, the geology etc. of the terrain presents several problems. The streams also carry considerable quantum of silt, boulders etc., particularly during the monsoon period, presenting problem of their exclusion.

The steep hill slopes along which the water conductor systems have to be constructed also present difficulties from the point of view of stability. Protection against these tend to push up the cost of civil engineering features.

The design of diversion weirs, intakes and water conductor systems are being reviewed constantly to bring about economy and improvement so that rising costs can be neutralised and requirements of frequent repairs are kept to the minimum. Among the new designs adopted can be included the "trench type weir", which has been successfully tested in streams carrying silt and boulders.

ii) Manufacturers have developed standard generating sets with in-built flexibility for different heads, speeds and outputs. Since greater part load efficiencies are of not much consequence incase of small units, complicated and costly "Kaplan" turbines are not attractive in application in microhydel installations. Impulse turbines are used for higher heads, and propeller & francis type reaction turbines are in use for low heads. The axial admission (turgo) impulse units with higher specific speeds for an impulse turbine , effectively bridge the gap between the reaction turbine and the high head pelton wheel. A list of generating units manufactured in the country so far is enclosed in ANNEXURE III.

iii) Static self exciting and self regulating systems providing D.C. excitation in controlled form to the generator field, provide roubust and simple generators for most of the microhydel installations.

iv) In certain instances, where the units have to operate continuously in parallel with adequately strong local supply networks, a simpler arrangement employing induction generators is also being considered favourably.

v) With more and more potential sites of low head irrigation canal power stations being identified, manufacturers are actively considering development of "tubular" and other appropriate types of turbines suitable for low heads and higher discharges.

4. <u>Lessons drawn in implementation of these schemes:-</u>

I) <u>Minimum Civil Works:-</u>

The cost of civil works, electrical equipment and establishment charges cannot be reduced proportionately in case of microhydel projects; and this results in making the cost per KW generated substantially higher, as compared with bigger projects. Under the present economic conditions, a representative microhydel scheme of say 1000 KW installed capacity with 4 units of 250 KW capacity each, under favourable conditions will cost anything between Rs.8,000/- per KW to Rs.14,000/- per KW, depending upon the civil engineering features involved. Out of this, the cost of electrical equipment would be of the order of Rs.2,500/- per KW to Rs.4,000/- per KW.

Apart from the initial capital cost, the cost of operation and maintenance, particularly repairs of civil structures such as water conductor systems and penstocks, is substantial. These repairs, when required to be carried out occasionally, result in prolonged shutdown of the power station.

Thus the success of a microhydel station depends upon keeping the civil works to the minimum. The microhydel schemes are, therefore, generally designed as run-of-the river developments for meeting limited power requirements, and also to minimise the capital investments and time required for construction of storage reservoirs. The storage required for meeting the diuranal variation of load is usually provided in the forebay, instead of at the diversion structures. Streams with sufficient dry weather flow and steep gradient offering ideal possibilities for microhydel development are usually selected for these schemes. A typical layout of a microhydel scheme is shown in the enclosed drawing No. MISC-GEN-MISC-124.

(ii) Necessity of Adequate Investigations:-

Before a microhydel scheme is conceived, minimum necessary investigations have to be conducted. Reconnaissance with reference to anticipated power requirements of the localities have to be assessed over a period of about 10 to 15 years. The discharge observations of the stream near the proposed off-take point, particularly during the lean months, form an important part of investigations. Though it is preferable to have long term observed discharge data for these streams, in the absence of such data, at least 2 to 3 years discharge measurements are necessary to arrive at a reasonable estimation of flow for design basis. Right angled, rectangular or trapezoidal notches constructed across the streams form reliable means for obtaining correct discharges in the hill streams. Besides hydrological observations, necessary topographical and minimum geological investigations are also required to be conducted to establish suitability and stability of ground for power channel penstock etc. Safety under flood conditions is also to be considered.

The tendency to save on the minimum investigations, in order to keep the initial gestation period and cost per KW generated on the lower side, because only a small quantum of power is involved, proves costly in the end; and is not recommended.

(iii) Careful consideration of economics involved:-

Before deciding to construct a microhydel station, a careful study is required to be made of the economics of constructing a microhydel station.

Small villages in remote hilly areas, where water for running the microhydel units can be tapped, are rarely situated within 15 Kms. from any grid. If they are within 15 Kms. from the grid, it is definitely economical to construct 11 kV line. Taking into account the difficult terrain, the cost of 3 phase 11 kV line in these parts is likely to be of the order of Rs.20,000/- per Km. That is, the construction of 15 Km. long 11 kV line will cost only about Rs. 3 lakhs, as compared to Rs. 60 lakhs, the cost of construction of a microhydel project of 1000 KW installed capacity.

If the distance from the grid is more than 15 Kms.which is likely to be the case, a 33 kV line is required to be constructed. This will serve to transmit 1 MW of power upto a distance of 50 kms. In the difficult terrain. considering the cost of 3-phase 33 kv line to be Rs.50,000/- per km, the 50-km long line will cost Rs.25 lakhs. Thus the construction of 3 phase 33 kv line to the extent of 50 km is also economical as compared with the cost of construction of a microhydel station within 1 MW installed capacity.

However, in such cases, the increase in the total energy generated in the grid from the microhydel generating units must also be noted; and installation of the microhydel station may be taken up from this point of view. The total per unit cost of power from the grid including the power generated from the microhydel station may go up only marginally, as the quantum of power generated from the microhydel station would be small in relation to power available from other sources in the grid.

Beyond a distance of 50 km from this grid, it is hardly worth considering construction of 66 kv line for transmission of power of the order of 1 MW or so. In such cases, as microhydel station can be installed as a means of developing the loads in the first instance. Ultimately as the load develops, construction of transmission lines can be resorted to, the microhydel station being used for augmentation of total energy available in the grid.

Sl. No.	Transmission voltage	Maximum distance for 5% to 6% voltage regulation	Power that can be transmitted economically
1.	11 kv	11 km (to 20 km)	500 KW
2.	33 kv	33 km (40-50 km)	1 MW to 1.5 MW
3.	66 kv	66 km (50-60 km)	10 MW to 13 MW
4.	132 kv	132 km (120 KM)	40 MW to 50 MW

(iv) Installed capacity of microhydel schemes:

Earlier, microhydel projects were defined as hydel stations having a total installed capacity of about 1000 kW or less, with generating units installed being either a single unit of 1000 kw capacity, or a number of smaller units with a total capacity of 1,000 kw.

Now because of shortage of fossil fuels, and pollution problem, interest in utilising small canal drops for installation of hydel units of upto 2-3 MW capacity is building up. These sets are being used for supplying power to irrigation pumping sets for utilising sub-soil water, and for augmentation of power generation in the grid.

It will, therefore, be necessary to classify hydel stations having a total installed capacity of upto 5 MW, as micro/mini hydel stations.

(v) Operation and Maintenance:

Because of the remoteness of most of these micro hydel stations, it is usually difficult to get trained personnel to run and maintain these power stations. The trend is, therefore, to design and manufacture units which are simple to run and maintain, so that the micro hydel installations can be manned even with untrained personnel, who will be able to take charge of the power stations, after only a few days' lessons/training in power station itself. Subsequently, when the area grid gets extended to cover these remote areas, it will be advantageous to run the micro units in parallel with the main grid. This would require some simplification of turbine governors etc., so that fluctuations of outputs and voltages of the micro units is minimised and attention need be given to this aspect.

5. Socio-Economic Aspects:-

The per capita electric power consumption, now-a-days, considered to be an index of advancement and well-being any society. Since Independence in 1947, India has also taken long strides in the generation and utilisation of electric power. As against the total installed capacity of about 1700 MW in 1947, Generating Units thermal, hydro, and nuclear, totalling to about 22000 MW, have been installed through sustained and planned efforts during the last 30 years.

However, because of the peculiar geographical features, a large number of remote villages in the hilly regions have yet to see an electric light in their vicinity. In order to make these villagers aware of the advantages of use of electricity, and to bring them in the mainstream of development being achieved in the rest of the country by raising their standard of living, it is necessary to make electric power available to them by constructing microhydel projects, and extending transmission lines. Even in certain areas of plains, where small falls in canals or rivulets are available, installation of microhydel projects at these locations can also prove useful for supply of electric energy to surrounding areas independently or in conjunction with the grid supply, if and when available.

Microhydel schemes can play a major and very important role in such electrification of remote villages, thus contributing in the Rural Electrification Programme presently being implemented, which makes considerable social impact on the local population. The higher initial capital costs and higher operation and maintenance costs in case of many of these projects, as compared with the major hydel projects should be viewed, in the context of the social aspects, the alternatives for energy supply in a time perspective, as also a long range view of energy sources. With the social aspects being foremost in considerations, long term loans at concessional interest rates as well as special consideration given to lower returns in such cases, could be viewed in relation to financial viability of the schemes.

6. Technology Transfer and suggestion for programme suited for countries of ESCAP Region.

The quantum of power available from microhydel stations being small, these schemes do not get into the limelight in the power development of any country. The practices adopted in the construction of modern and bigger power stations do not necessarily suit the construction of such small stations. The requirement of equipment for microhydel stations is also limited; and many manufacturers of hydel generating units are not attracted to develop small units. Even in a big country like India, where sites and conditions for microhydel development are favourable, there are hardly a couple of firms manufacturing small units.

It is, therefore, necessary that whatever technology transfer is to take place on this subject, has to be on International basis, to be of some significance. The private manufacturing companies cannot be expected to take lead in this matter, on purely commercial considerations; and steps in this regard should therefore better be initiated by the state Governments themselves.

Most of the countries in the Asian and Pacific region being developing countries, are way behind in electric power generation, and are facing similar problems in this field, such as advancement and simplification of technology and financing problems. Exchange of technology could, therefore, be beneficial. India has developed expertise in the planning, design and construction of microhydel schemes as well as in the manufacture of small generating units and associated switchgears, which it could make available. India can advise countries in the ESCAP region on:-

1. Conducting of preliminary surveys for the collection of hydrological, topographical, geological and electric power demand data for that country.

2. Identifying potential sites for mini/micro/hydro-electric development.

3. Investigations of such projects and preparation of project reports.

4. Supply of microhydel generating units and associated switchgear and control panels.

5. Construction of civil structures, installation, commissioning and testing of the generating units and other equipment at the microhydel power stations.

6. Operation and maintenance of the microhydel schemes.

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ANNEXURE -I

MICROHYDEL PROJECTS UNDER OPERATION

Sl. No.	Name of the Project	Gross Head(M)	Installed Capacity
	I. Uttar Pradesh:		
1.	Garur	21	1 x 25 kw
2.	Bageshwar	50	1 x 50 + 1x18.4 kw
3.	Champawat	76	2 x 100 kw
4.	Uttarkashi	93	3 x 200 kw
5.	Bhatwar	107	2 x 25 kw
6.	Dharasu	12.2	1 x 5 kw
7.	Barkat	13.7	1 x 5 kw
8.	Rudraprayag(Interim)	55	1 x 30 kw
9.	Genti Chera	300	2 x 100 kw
10.	Deoprayag	89	2 x 50 kw
11.	Rudraprayag (Tilwara)	65.5	2 x 100 kw
12.	Chamoli	110	3 x 200 kw
13.	Guptakashi	230	2 x 100 kw
14.	Badrinath (Interim)	30.5	1 x 30 kw
15.	Simli	12.2	1 x 5 kw
16.	Pipalkoti (Interim)	12.2	1 x 5 kw
17.	Joshimath (Interim)	-	1 x 25 kw
II.	**Himachal Pradesh:**		
1.	Nogli	72	2 x 250 + 4x500 kw
III.	**Jammu & Kashmir**		
1.	Jammu	-	2 x 300 kw
2.	Udhampur	-	2 x 320 kw
3.	Rajouri	-	1 x 560 kw
4.	Ponch	-	3 x 98 + 2x30 kw
5.	Bhandurwah	-	1 x 560 kw

IV. Arunachal Pradesh:

1.	Passighat	55	2 x 100 kw
2.	Rahung	126	3 x 250 kw
3.	Basar	123	3 x 50 kw
4.	Dirrang	-	1 x 40 kw
5.	Kalaktang	12.2	1 x 10 kw
6.	Taksing	-	1 x 10 kw
7.	Bomdila	122	3 x 30 kw
8.	Tezu	44	4 x 100 kw

V. Manipur :

1.	Leimakhong(Stage I)	-	600 kw.

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ANNEXURE II

MICROHYDEL SCHEMES UNDER EXECUTION

Sl. No.	Name of Project	Gross Head (M)	Installed Capacity
I.	Uttar Pradesh:		
1.	Koti	46 M	2 x 100 kw
2.	Charchula	278 M	2 x 100 kw
3.	Harsil	177.7 M	2 x 100 kw + 1 x 300 kw
4.	Pandu Keshtwar	117 M	3 x 250 kw
II.	Himachal Pradesh:		
1.	Rongtong	44 M	2 x 50 kw + 2 x 250 kw
2.	Holi	173 M	3 x 1500 kw
3.	Killar	37 M	2 x 50 kw
4.	Rukti	79 M	4 x 375 M
5.	Sissu	27.7 M	2 x 50 kw
6.	Thirot	256 M	2 x 1500 kw
7.	Baner	173 M	4 x 1500 kw
8.	Neogal	156 M	4 x 1500 kw
9.	Binwa	230 kw	3 x 2500 kw
III.	Jammu & Kashmir :		
1.	Tangdar	-	2 x 300 kw
IV	Arunschal Pradesh :		
1.	Along	36 M	4 x 100 kw
2.	Towang	221 M	4 x 500 kw
3.	Zero	213 M	4 x 500 kw
4.	Dirrang	136 M	3 x 500 KW
5.	Tuting	36.5 M	3 x 50 kw

6.	Kalaktang	12.2 M	3 x 10 kw
7.	Taksing	-	3 x 10 kw
8.	Anini	-	2 x 50 kw
V.	**<u>Manipur</u> :**		
1.	Leimakhong (Stage II)	79 M	3 x 100 kw
2.	Nangarugkhong	-	300 kw
3.	Kharamlak	-	1500 kw
4.	Likrurilok	-	50 kw
5.	Lokchao	-	500 kw
VI.	**<u>Bhutan</u> :**		
1.	Mongar	182.5 M	3 x 130 kw
VII	**<u>Afghanistan</u>:**		
1.	Bamiyan	27 M	3 x 250 kw
2.	Samangan	42 M	2 x 100 kw + 3 x 100
3.	Faizabad	54 M	3 x 85 kw
VIII.	**<u>Gujarat</u> :**		
1.	Ukai	18.3 M	2 x 2.5 MW

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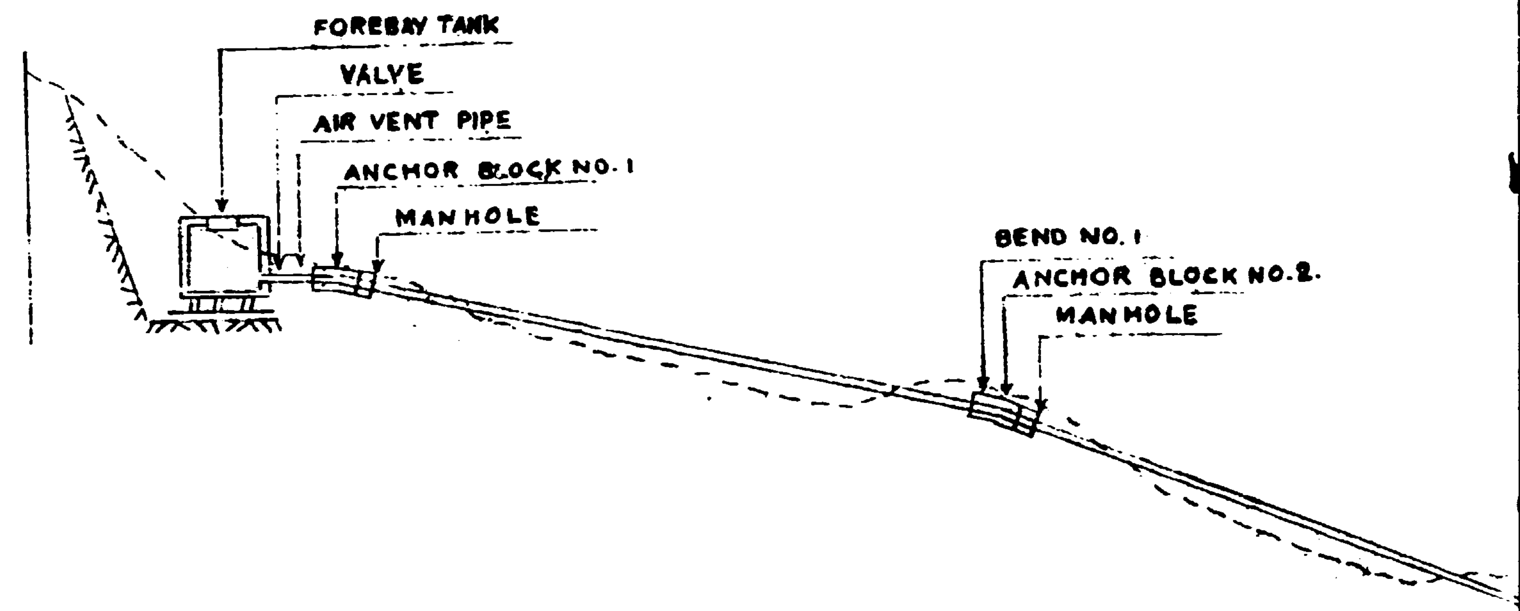
ANNEXURE-III

LIST OF MICRO HYDEL GENERATING UNITS (SUPPLIED BY INDIAN FIRM) INSTALLED

Sl. No.	Year of supply	Site	State	Type	Qty.	Capacity	Head (M)	Dis-charge LPS
1.	2.	3.	4.	5.	6.	7.	8.	9.
1	1963	Moticher on Kakrapar weir	Gujarat	900 HPT	1 No.	250 kw	13.8	2900
2	1963	Lahaul & Spil-ti Valley	Himachal Pradesh	430 VF	5 Nos.	50 kw	23.0	355
3	1964	Barapani	Assam	9-T-25	2 Nos.	25 kw	61.0	68
4	1965	Genthi Chhere	U.P.	27AP-100	2 Nos.	100 kw	266.0	543
5	1965	Champawat, Almora	U.P.	30P-100	2 Nos.	100 kw	133.0	111
6	1966	Lahaul & Spilti valley.	Himachal Pradesh	500 VFIA	3 Nos.	100 kw	23.0	710
7	1966	Bijanbari Darjeeling	West Bengal	54P-1000E	2 Nos.	1000 kw	230.0	590
8	1966	Rudraprayag, Garhwal	U.P.	16.5T-100	2 Nos.	100 kw	61.0	590
9	1966	Guptakashi, Garhwal	U.P.	27 AP-100	2 Nos.	100 kw	221.0	645
10	1966	Dharasu Garhwal	U.P.	200 VFIC	1 No.	5 kw	12.2	71
11	1966	Simli, Distt. Garhwal.	U.P.	200 VFIV	1 No.	5 kw	12.2	71
12	1966	Simli, Distt. Garhwal	U.P.	200 VFIC	1 No.	5 kw	12.2	71
13	1966	Pipalkoti	U.P.	200 VFIC	1 No.	5 kw	12.2	71
14	1966	Rukti Khad	Himachal Pradesh	250 VF3A	2 Nos.	50 kw	36.5	207
15	1966	Mehbar Khad	-do-	250 VF3A	2 Nos.	100 kw	58.0	304
16	1967	Garur, Distt. Ghamoli	U.P.	250 VF3A	1 No.	25 kw	20.0	191.5

1	2	3	4	5	6	7	8	9
17	1967	Bageshwar, Distt: Chamoli	U.P.	250 VF3A	1 No.	50 kw	44.2	166
18	1967-68	Uttarkashi Distt: Garhwal	U.P.	16.5T-250	2 Nos.	250 kw	90.0	425
19	1967-68	Chamoli	U.P.	16.5T-250	2 Nos.	250 kw	108.0	354
20	1968	Nogli	Himachal Pradesh	400 HFG	2 Nos.	500 kw	72.0	1000
21	1969	Kdarnath (Harsil)	U.P.	30-P-100	2 Nos.	100 kw	114.0	130
22	1969	Gharola Scheme	Himachal Pradesh	9T-50	1 No.	50 kw	91.5	84
23	1969	Badrinath (Pandu-keshwar).	U.P.	16.5T-250	2 Nos.	250 kw	99.0	335
24	1969	Bhatwari	U.P.	15AP225	2 Nos.	25 kw	107.0	35
25	1969	Deoprayag	U.P.	9T-50	2 Nos.	50 kw	87.5	83.5
26	1969	Pangi	Himachal Pradesh	250 VFeA	2 Nos.	50 kw	48.8	153
27	1969	Jorthang	Sikkim	13.5T-100	2 Nos.	100 kw	78.0	190
28	1969	Rongli	Sikkim	300 VFIB	2 Nos.	50 kw	30.0	250
29	1969	Manule	Sikkim	400 VFIC	1 No.	100 kw	30.5	500
30	1969	Phoobsering T.E.	West Bengal	15P-50E	1 No.	50 kw	237.0	33.1
31	1969	Namring T.E. Distt. Darjeeling.	-do-	30P-100	1 No.	100 kw	131.0	113.5
32	1969	Nagri Farm T.E.	-do-	15P-50E	1 No.	50 kw	189.0	41
33	1969	Wangdi	Bhutan	16.5T-100	3 Nos.	100 kw	712.0	193
34	1970	Koti	U.P.	300VFIC	2 Nos.	100 kw	40.0	332
35	1970	Rimbi	Sikkim	300VFIC	2 Nos.	100 kw	36.6	410
36	1970	Thubro, T.E.	West Bengal	30P-100E	1 No.	100 kw	165.0	93.5

1	2	3	4	5	6	7	8	9
37	1970	Imphal	Manipur	13.5T-100	3 Nos.	100 kw	76.5	190
38	1970	Kalaktang	Arnna-chal Pradesh	250 VFIB	2 Nos.	10 kw	12.2	133
39	1970	Tewang	-do-	200VFIC	1 No.	5 kw	12.2	71
40	1970	Gorckz	Papua & New Guinea	350HFIB	1 No.	200 kw	63.1	478
41	1971	Rehung	Arunachal Pradesh	16.5T-250	3Nos.	250 kw	133.0	267
42	1971	Besar	-do-	9T-50E	2 Nos.	50 kw	97.6	75.5
43	1971	Passighat	-do-	250VF3B	2 Nos.	100 kw	53.3	283
44	1971-72	Dharchula	U.P.	21P-100	2 Nos.	100 kw	275.0	52
45	1972-73	Tashigong	Bhutan	16.5T-250	3 nos.	250 kw	171.0	213
46	1972-73	Gidakom	-do-	16.5T-250	5 Nos.	250 kw	171.0	213
47	1972-73	Chardeh Ghorband	Afghanis-tan	13.5T-100	3 Nos.	100 kw	76.5	190
48	1973	Along	Arunachal Pradesh	400 VFIC	4 Nos.	100 kw	30.5	594
49	1973	Tuting	-do-	250VF3A	3 Nos.	50 kw	36.5	207
50	1973	Mongar	Bhutan	30P-130	3 Nos.	130 kw	180 kw	142
51.	1973-74	Kohima	Nagaland	16.5T 500E	3 Nos.	500 kw	180	100
52.	1974	Lakhimpur	Assam	350HFIB	3 Nos.	220 kw	61	600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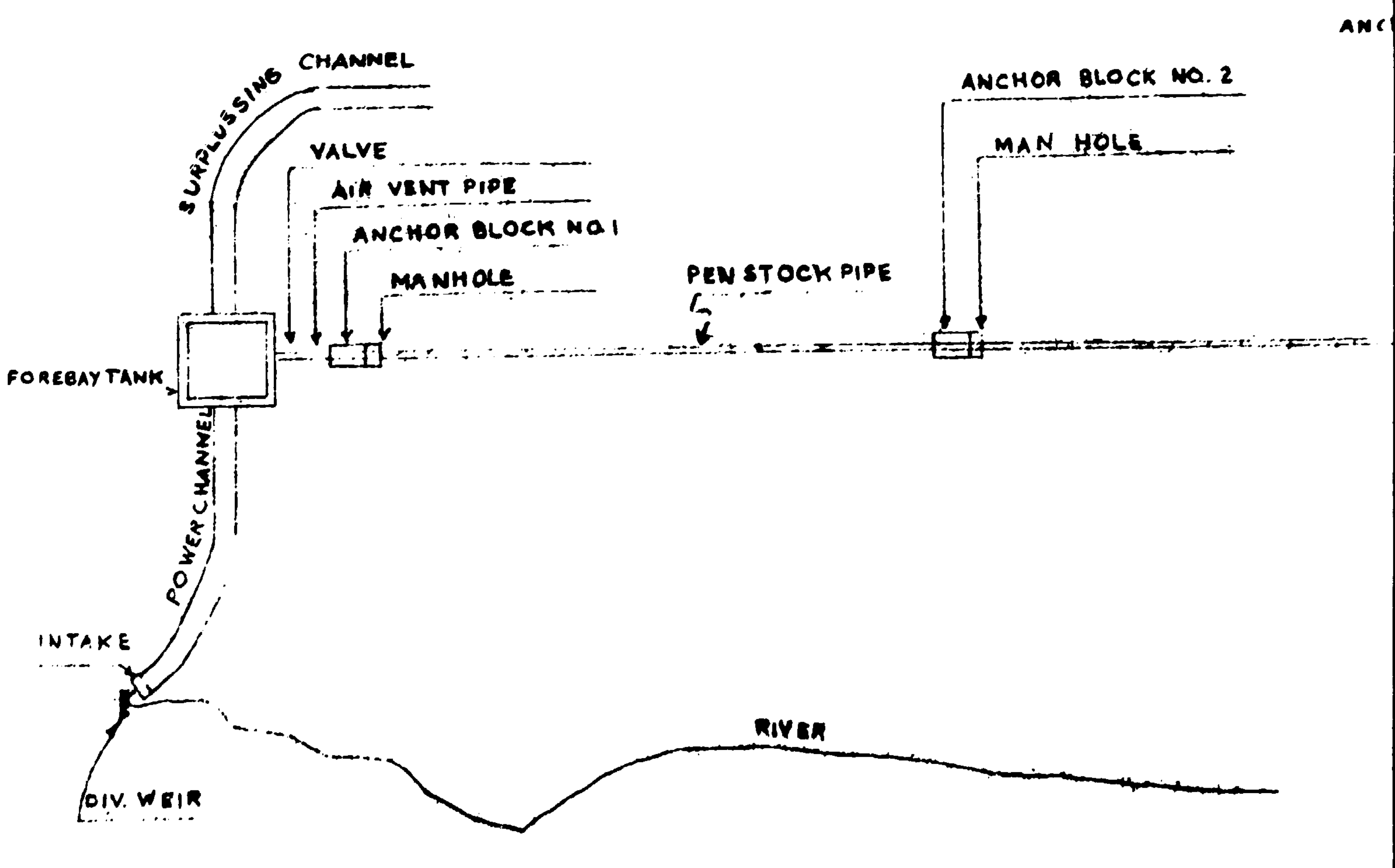
VALVE
AIR VENT PIPE
ANCHOR BLOCK NO. 1
MANHOLE
BEND NO. 1
ANCHOR BLOCK NO. 2.
MANHOLE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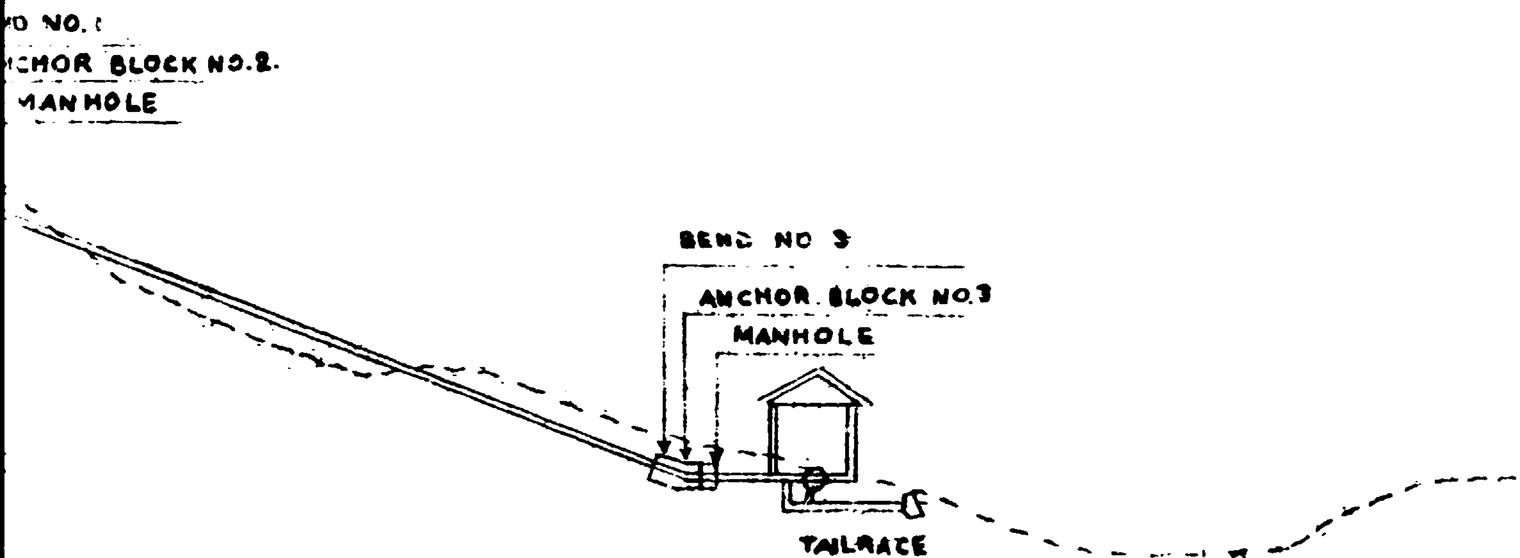
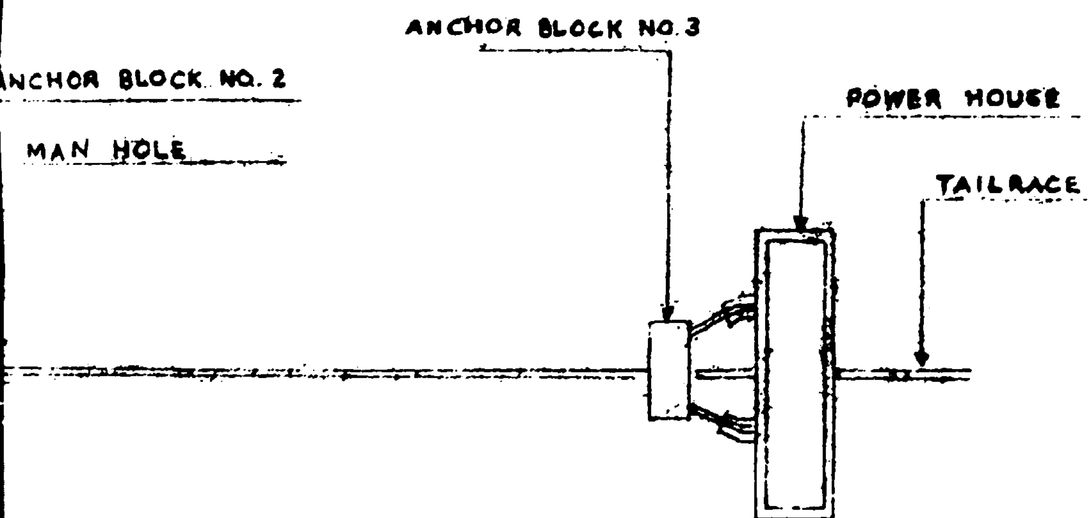
SECTION 1





TYPICAL LAYOUT OF MICRO HYDEL SCHEMES

SECTION 2