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GOVERNMENT OF MADRAS

DEPARTMENT OF ELECTRICITY

REPORT

ON THE

METTUR HYDRO-ELECTRIC DEVELOPMENT

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METTUR HYDRO-ELECTRIC DEVELOPMENT REPORT.

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FOREWORD.

A country in the initial stages of national development, such as this Presidency, must be continually seeking new sources of revenue from productive works in order to provide for the increasing cost of administration and employment for a growing population of professional men, skilled and unskilled workers which, at the same time, will increase the spending power of the population.

A prevailing belief still appears to exist that irrigation and transport have a prior claim on the attention and finances of the Presidency. Admitting the benefits which have accrued in the past from the development of irrigation and transport, it does not follow necessarily that other forms of economic development may be less advantageous.

With a remission of part of the land revenue, and a cry for reduced taxation, there is an urgent need for additional sources of national revenues. Water-power should be treated as a national asset in the same way as mineral resouces and exploited to the utmost limit. It has the advantage over the mineral resources in so far that it is not a wasting asset and is both an industry and a producer of new industries.

The spread of education has resulted in less inclination to follow agricultural pursuits, and our universities and colleges are turning out an increasing number of graduates every year who wish to follow a professional career. To-day there is only a limited opportunity for that class of men and it is the duty of the State to provide further opportunities for them or risk a social upheaval.

As far as this Province is concerned, it would be difficult to suggest any scheme more calculated to meet these conditions than the construction of other hydro-electric projects, provided that they can be proved to be economically justified.

One of the great functions of hydro-electric power is the creation of new industries, as much as the electrification of existing ones. Power and industry are thus developed along parallel lines and supplement each other.

The experience gained since the inauguration of the Pykara Hydro-Electric Scheme is encouraging. In spite of the fact that this undertaking has only been in operation a few months an increase in industrial development is apparent. This means more employment in industry while the undertaking itself has provided permanent employment for many engineers, artisans and other types of workmen. Operating expenses will be covered the first year and a contribution, which will progressively increase, is to be made towards the fixed charges.

The cost of industrial power whether derived from oil or electricity has been decreased all over the hydro-electric area while, due to the increased employment, the purchasing power of a large section of the community has been raised. These facts speak for themselves and are incontrovertible.

Four large textile mills have been converted to electric drive and three are in process of conversion. Two new electrified mills have been constructed and are in operation. Five, and a cement factory, are building, and one is projected. The progress in small power development and the electrification of g inning and other factories are equally encouraging.

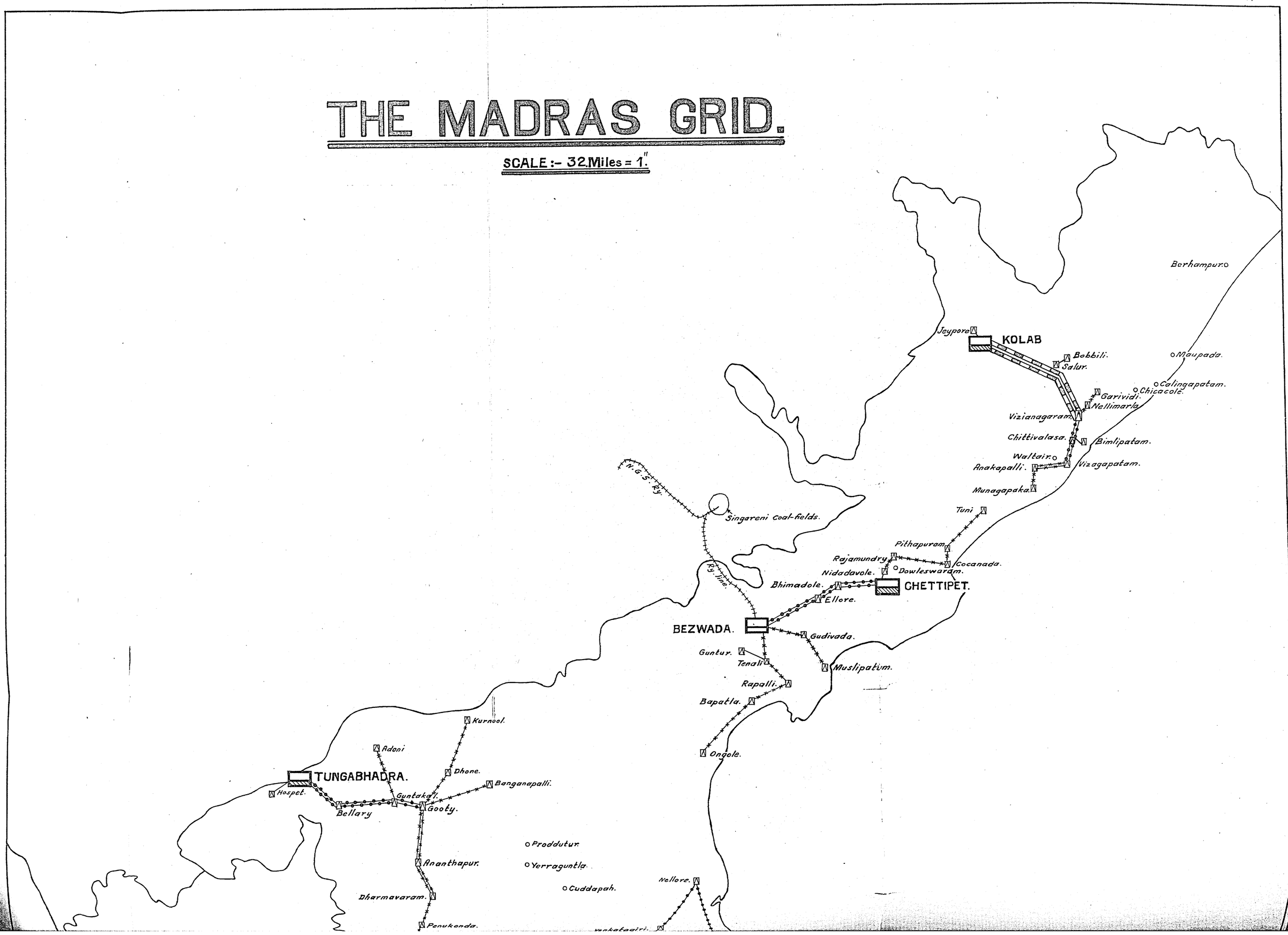
In the following pages the potential power and industrial possibilities of the Mettur Hydro-Electric area are discussed, the technical features of the scheme are described, the cost of the works shown, and the financial details and economic justification explained.

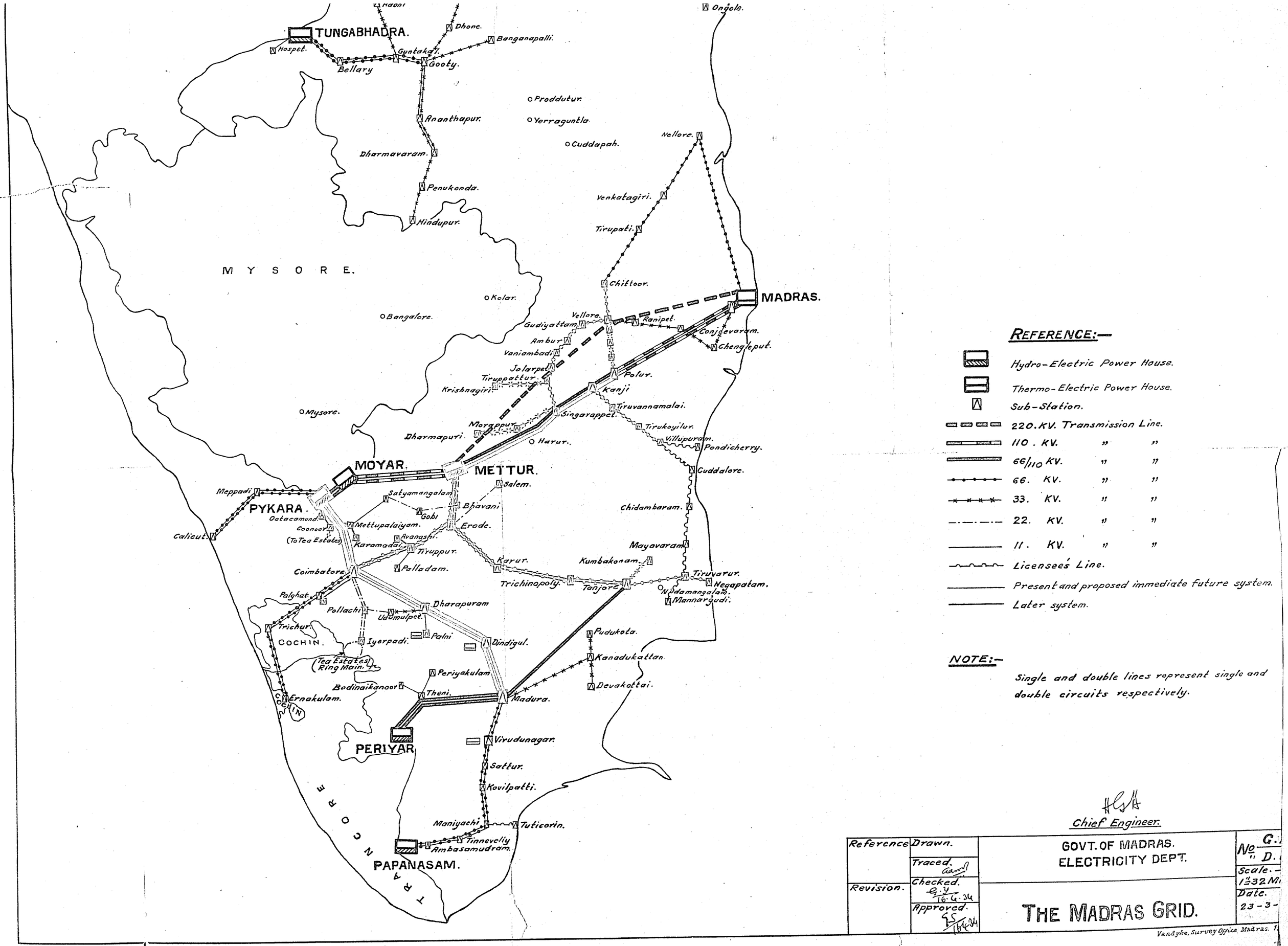
April, 1934.

H. G. HOWARD.

THE MADRAS GRID.

SCALE :- 32 Miles = 1".




TUNGABHADRA.
Hospet.
Bellary
Guntakal.
Gooty.
Dhone.
Banganapalli.
Ananthapur.
Dharmavaram.
Penukonda.
Hindupur.
Proddutur.
Yerraguntla.
Cuddapah.
Nellore.
Venkatagiri.
Tirupati.
Chittoor.
MADRAS.
Ongole.
M Y S O R E.
Kolar.
Bangalore.
Vellore.
Ranipet.
Gudiyattam.
Ambur.
Vaniambadi.
Jolarpet.
Tiruppattur.
Krishnagiri.
Conjeevaram.
Chengleput.
Polur.
Kanji
Tiruvannamalai.
Singarappet.
Tirukoyilur.
Villupuram.
Pondicherry.
Cuddalore.
Mysore.
Morappur.
Dharmapuri.
Harur.
MOYAR.
METTUR.
Salem.
Meppadi.
PYKARA.
Ootacamund.
Coonoor.
(To Tea Estates)
Calicut.
Satyamangalam.
Gobi
Bhavani
Erode.
Mettupalaiyam.
Avangshi.
Karamadai.
Tiruppur.
Palladam.
Coimbatore.
Karur.
Trichinopoly.
Tanjore.
Kumbakonam.
Mayavaram.
Chidambaram.
Tiruvarur.
Negapatam.
Vedamangalam.
Mannargudi.
Palghat.
Pollachi.
Udumulpet.
Dharapuram
Palni
Dindigul.
Trichur.
COCHIN.
Iyerpadi.
Tea Estates Ring Main.
Pudukota.
Kanadukattan.
Devakottai.
Periyakulam
Bodinaikanoor
Theni.
Madura.
Ernakulam.
COCHIN
PERIYAR.
Virudunagar.
Sattur.
Kovilpatti.
Maniyachi
Tuticorin.
Tinnevelly
Ambasamudram.
PAPANASAM.
T R A V A N C O R E
REFERENCE:—
Hydro-Electric Power House.
Thermo-Electric Power House.
Sub-Station.
220. KV. Transmission Line.
110. KV. " "
66/110 KV. " "
66. KV. " "
33. KV. " "
22. KV. " "
11. KV. " "
Licensees' Line.
Present and proposed immediate future system.
Later system.
NOTE:—
Single and double lines represent single and double circuits respectively.
Chief Engineer.
Reference
Drawn.
Traced.
Checked.
Approved.
Revision.
GOVT. OF MADRAS.
ELECTRICITY DEPT.
THE MADRAS GRID.
No. G.
" D.
Scale.
1"=32 Mi
Date.
23-3-
Vandyke, Survey Office, Madras.
Reg: No. 58. Copies 125.

Regarding Scheme No. 1, experience to-date indicates that it may not be economically feasible to develop industrial load at Mettur for some years, sufficient to absorb all the useful output of the plant. At the same time it seems that, even if it were possible to adopt such a measure, it would not be utilizing the power in the best interests of the public. Cheap power should be distributed as widely as economically justified.

No. 3 scheme might, at the outset, prove more profitable, but the primary power requirements of Madras cannot be met by Mettur until a special high voltage tie-line between Mettur and Pykara is constructed and this line is not economically feasible at present. It would appear to be more prudent to develop load in the outlying districts and gradually approach Madras.

No. 2 scheme is, in my opinion, by far the most favourable, as the benefits to the community are a maximum. It pre-supposes a limited industrial development at Mettur. Proposals have been advanced in this report as to the manner in which industrial development may be studied and the practical efforts which are to be made to ensure success; the main idea in view being that as many different industries, as may be found economically justified in certain areas, might be started, so that they may stand as examples for private interests to follow and to provide experience for other industrialists. In this connexion, the industrial estates of Sweden—where groups of industries have been centred around power sources—are very similar to what is projected for Mettur but the latter would be on a much smaller scale. This is discussed again under Industrial Development.

4. This report discusses No. 2 scheme of development.

CHAPTER 2.

Water available for Power.

5. The working tables of the Mettur Reservoir have been prepared by the Executive Civil Engineer and his staff in accordance with the latest rules published in the *Fort St. George Gazette* of December 12, 1933, and calculated for a minimum continuous output of 10,000 K.W. (13,330 h.p.) of primary power as, after careful study, it is considered that this block of power can be made available without prejudice to the revenues of the combined project.

6. However to ensure this amount of power, it has been found necessary to provide for a limited restriction of irrigation demands during exceptional periods which are expected to prevail twice in fifteen years. Such restrictions are considered reasonable and their financial effect is described later. The report of the Executive Civil Engineer in Appendix A brings out clearly that restrictions due to special power draft are inappreciable.

As the exceptional dry years cannot be forecasted, provision has to be made each year in anticipation. This involves, in some cases, an unnecessary restriction of power generation during the irrigation closure period, in order to ensure that the reservoir levels shall be kept up. This is unfortunate as it appears that, although a continuous generation of 10,000 K.W. can be maintained, another 10,000 K.W. can only be expected about 55 per cent of the time. If the output is allowed to drop to around 5,800 K.W. under such extreme conditions as existed in 1918 for two months in the year, and in 1928–29, then no special power draft is necessary nor any restriction of irrigation for power purposes only. This is shown in Chart M. 18 (B), facing page 3.

The actual restriction in irrigation necessary for a continuous generation of 10,000 K.W. is shown on curve No. M. 18, facing page 2, where it will be seen that twice in fifteen years it is expected that reductions of 40 per cent in irrigation over the whole area for about ten weeks may have to be undertaken to guarantee the power production as contemplated. It is equivalent for 1929—the worst year—to a special power draft of 6,391 million cubic feet or about 2½ per cent of the annual irrigation requirements, and in accordance with the water rates originally proposed, but not expected to be realized, a revenue of around Rs. 4,00,000. This would be the maximum penalty with which the power project could be charged in years of water shortage, or about once in eight years, if the working table M. 18 were adopted. It is proposed, however to adopt M. 18 (B) at the outset and let experience decide as to the practicability of adopting ultimately M. 18 or a table even more favourable to the power interests.

It may be emphasized here that it is only primary power which will be generated by water which is not also utilized for irrigation, and it is a very small percentage of the primary power block of 10,000 K.W. which might need special draft for power.

7. In the note on power available, the minimum continuous supply of primary power is shown as 10,000 K.W., but the load forecast only requires 5,850 K.W. which is around the limit fixed for primary power in the restricted scheme shown in working table M. 18 (B).

A-50 (A)

CHAPTER 1.

The Mettur Hydro-Electric Project with reference to Ultimate Plans for Electrification.

1. The Mettur Hydro-Electric Project forms part of a comprehensive scheme for the electrification of the Madras Presidency. The scheme has been studied in a general way, while a tentative ten-year plan of power development has been prepared. A sketch of the proposed initial transmission and generating system is shown on Plan No. G-1/D-1 facing this page. This incorporates the following proposed power systems ;—

Kolab.	Tungabhadra.	Pykara.
Chettipet-Rajahmundry.	Madras.	Periyar.
Bezwada.	Mettur.	Papanasam.

2. Excluding the Madras, Mettur and the Pykara Power Systems, the whole cost of the works visualized in this National Electricity Scheme should not exceed ten crores. This is not a high figure considering the extent of the work, and the power facilities and general amenities provided ; it is very modest compared with what has been spent in many other countries.

The National Scheme provides for the formation of power areas throughout the Presidency, and the gradual absorption of all sources of power where generated for public utility. Certain thermal stations may be selected for incorporation in the National Scheme, but the majority should be closed down for economic reasons.

It is not proposed to engage in the retail distribution of electric power where undertaken by progressive and efficient agencies. In fact such agencies whether private or public, and as may be approved, should be encouraged and assisted in every reasonable manner to distribute electrical energy as efficiently as possible, and also to earn a reasonable return on their investment. A modification of the Swedish system referred to elsewhere in this report is advocated. This ensures a healthy competition with the co-operation of State, between public and private effort. sec mp

The Pykara Power Area—Hydro-Electric—is now in existence. It is proposed that the Mettur Power Area—also Hydro-Electric—should be started now in conjunction with part of the Madras Power Area—Steam.

It is explained later that these three power areas will operate together and there will be a constant interchange of power to conform to the load and water conditions of each power system, so that each generating plant may be operated to the best advantage. Furthermore, in an emergency, any plant may supplement the generation of the others.

3. Schemes for the development of the Mettur power-site may be enumerated as follows :—

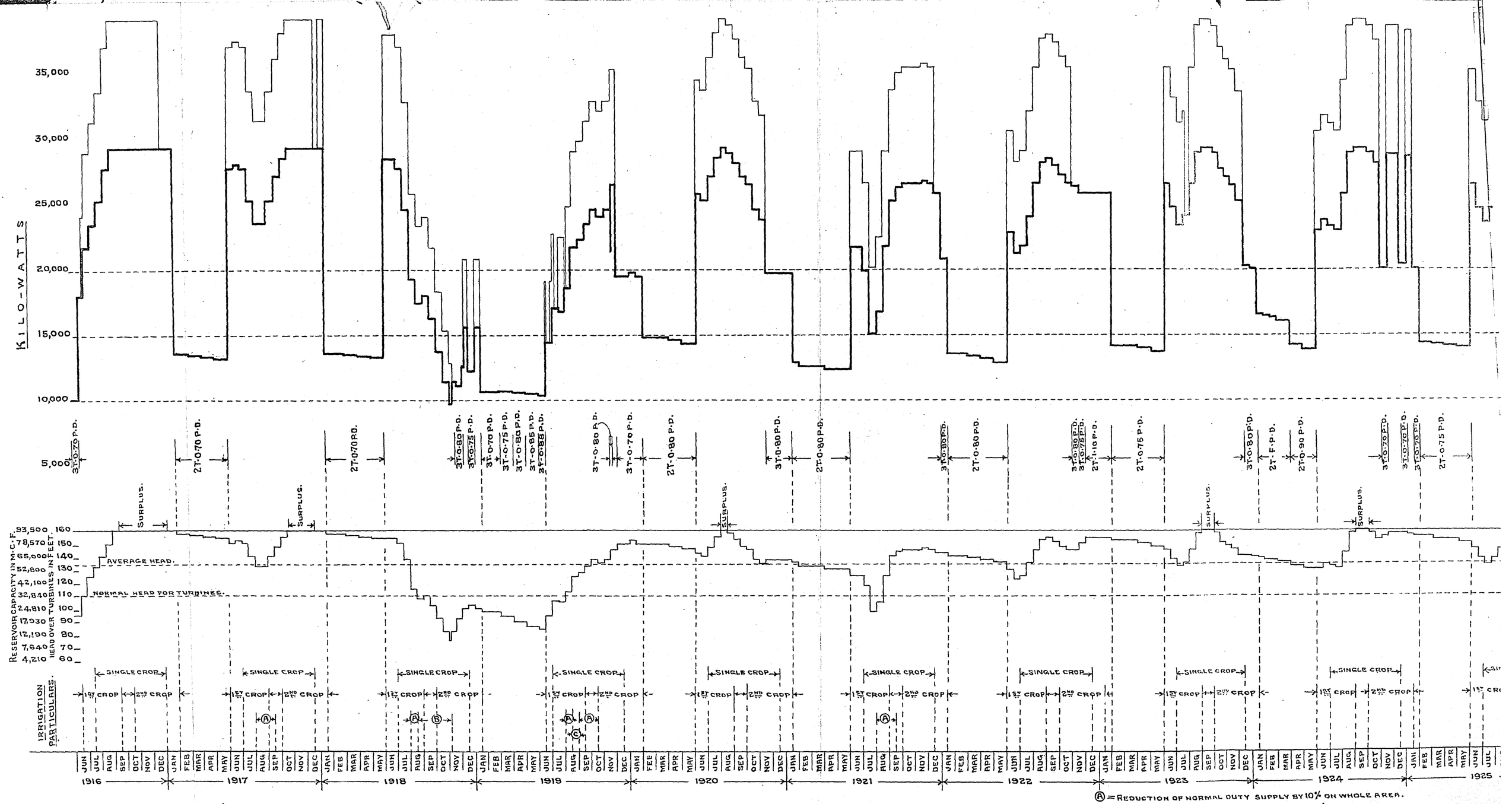
(1) Without a transmission system, but in conjunction with newly established factories and industries at the power-site sufficient in scope to absorb the useful power output of the plant.

(2) Same as (1) but connected up with the Pykara Hydro-Electric System so that a limited interchange of power might be effected : less intensive industrial development at Mettur, but a more extensive area to be covered : the port of Negapatam to be developed into an industrial centre, with transmission lines extending to Vellore and Madura, but not to Madras.

(3) With a transmission line to Madras, to operate in conjunction with the steam plant of the Electric Supply Corporation, distribute power in the districts between Mettur and Madras, and undertake a limited industrial development at Mettur, the latter plant being also linked with Pykara : the industrial area at Negapatam to be developed later, but provision made to transmit sufficient power for existing needs : the transmission of power to Madura to be postponed.

(4) Similar to (3) but to construct a steam plant near Madras and operate independently of the Electric Supply Corporation.

Of the above schemes, No. 4 may, I consider, be abandoned. Preliminary conversations with the Agent and Chief Engineer of the Corporation have been sufficiently encouraging to assume that there will be no difficulty in entering eventually into a working arrangement with that corporation and supply them with part of their load requirements if ever necessary or purchase power from them. They are averse to entering into any definite agreement until they are assured that power will be available on a given date, nor would it be reasonable, from a business point of view, to expect the corporation to commit themselves at this stage, with the project not even sanctioned.



Ⓐ = REDUCTION OF NORMAL DUTY SUPPLY BY 10% ON WHOLE AREA.
Ⓑ = ——"——"——"——40%——"——"——.
Ⓒ = ——"——"——"——10% ON OLD AREA & 40% ON NEW AREA

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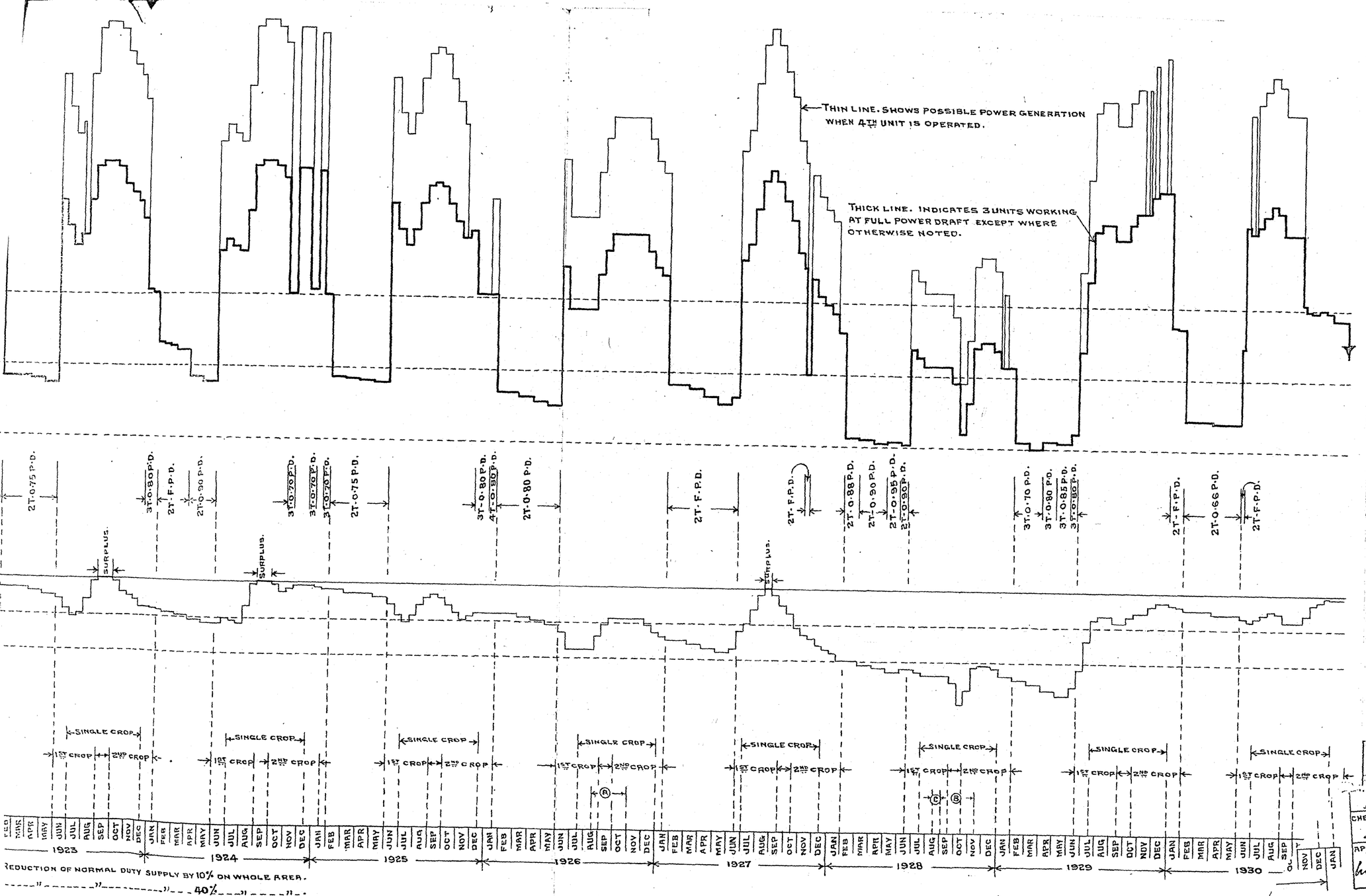


POWER CHART FOR THE PERIOD OF RECORD 1916-1930 SHOWING CONTINUOUS POWER THAT CAN BE GENERATED WHEN FULL IRRIGATION IS PROVIDED FOR IN BOTH THE OLD AND NEW AREAS UNDER DRAFT RULES FOR THE METTUR RESERVOIR PUBLISHED IN THE FORT ST. GEORGE GAZETTE ON 8-12-1933.

MINIMUM STORAGE IN RESERVOIR ON JUNE 16TH 14.035 MIL. C.F.T.

" " " " " AT ANY TIME (OCT. 1928) 8,928.

CONTINUOUS POWER GENERATION } FOR 100% OF TIME 10,000 K.W.

" " " " " 66% " " 12,000.

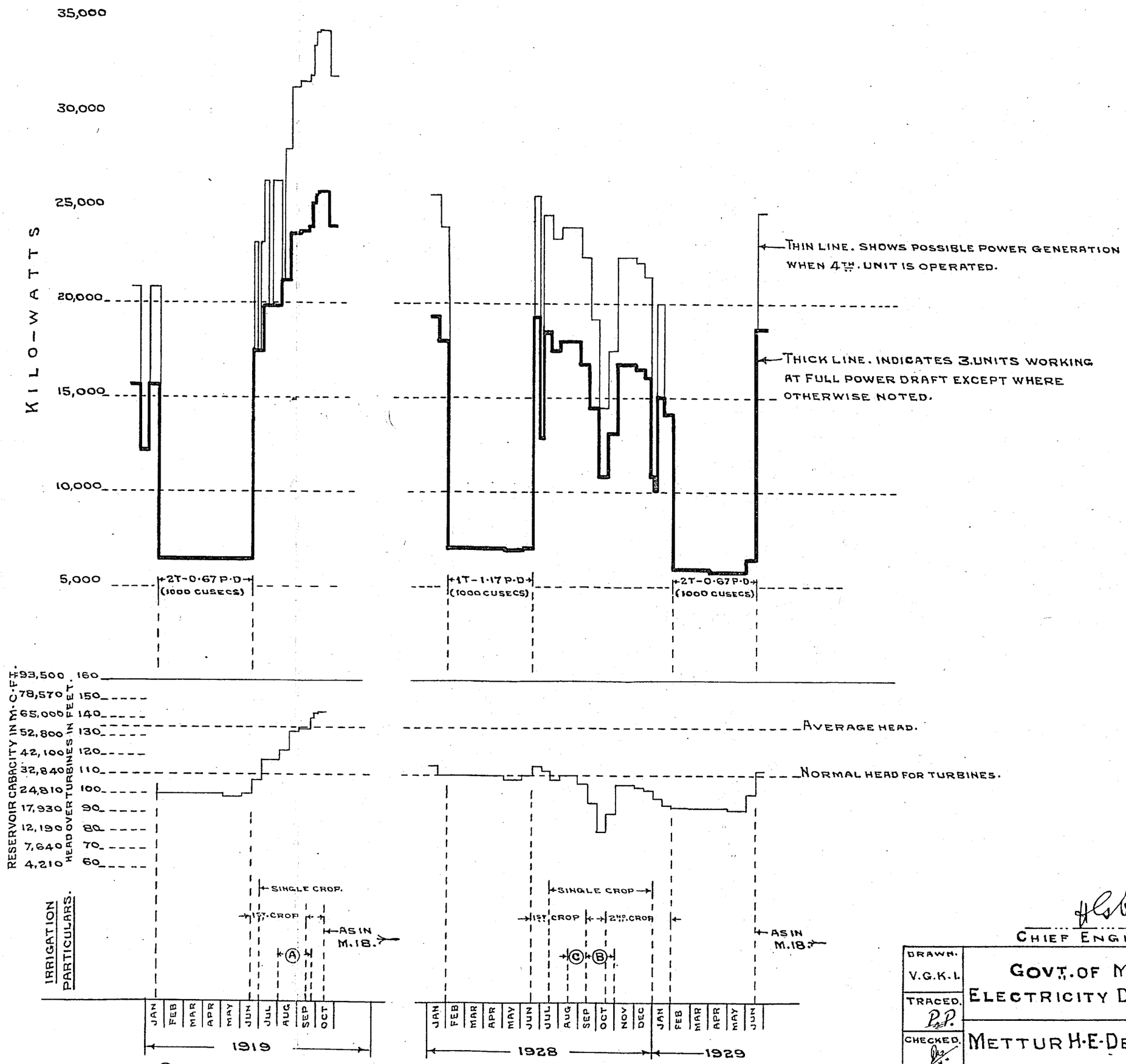
" " " " " 55% " " 20,000.

" " " " " 44% " " 26,000.

CHIEF ENGINEER

DRAWN V.G.K.I.	GOVT OF MADRAS. ELECTRICITY DEPARTMENT.	No. M:18
TRACED	METTUR H-E-DEVELOPMENT.	Scale as per chart
CHECKED	POWER GRAPH.	DATE 19/1/34
APPROVED		

VANDYKE, SURVEY OFFICE, MADRAS. 1934.



Ⓐ = REDUCTION OF NORMAL DUTY SUPPLY BY 10% ON WHOLE AREA.

Ⓑ = ... " . . . . . " . . . . . " . . . 40% . . . " . . . . " . .

Ⓒ = ... " . . . . . " . . . . . " . . . 10% ON OLD AREA & 40% ON

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. possible
er would
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gation policy
sions on the
rigation has to
to very serious
r-supply should be
irrespective of the
to co-ordinate all the

-supply and it would
regulated supply and
od that in many purely
orthodox seasons are by
more profitable opportuni-
ater at any time of the year
e selection of crops. Paddy
crops might be grown with

CHIEF ENGINEER.

DRAWN. V.G.K.L.	GOVT. OF MADR
TRACED. P.P.	ELECTRICITY DEPA
CHECKED.	METTUR H·E·DEVEL
APPROVED.	MODIFIED POWF FOR 1919 & 19

Any small deficiency can be made up from Pykara. Thus, if irrigation is to take precedence over power, irrespective of the economic resu' ., then the power scheme is still attractive under the conditions outlined.

8. There is yet another method by which the output of primary power may be increased, without interfering with irrigation.

From Chart M. 18 it will be seen that the potential power output at Mettur is very variable. Its economic value would be increased considerably if the primary output could be supplemented from another power soure at periods of low discharge from the reservoir. An even more favourable situation would be created if the amount of such supplementary power utilized could be returned during periods of high discharge from the reservoir. The interchange of power would have to take place ordinarily within a year. If the other power source is a hydro plant, either the regime of the two sources should be complimentary or a certain storage capacity should be available. In case of Pykara, unfortunately, the low water conditions coincide with the irrigation closure months and therefore storage is essential. This, however, can be easily provided by the construction of a storage reservoir at Mukurti in the bed of the Pykara river. An equivalent amount of power can be returned from Mettur in December and January to maintain the levels at Mukurti.

At present the maximum interchange of power between the two systems is limited by the capacity of the transmission lines between Coimbatore and Erode, which may be taken as 6,000 K.W. for normal working. The Pykara plant is able to generate a peak of 16,500 K.W. but the existing storage facilities only permit a continuous generation of 6,100 K.W. primary power equivalent to a regulated flow of 32 cusecs. Secondary power is available for eight months in the year.

The project report provides for a peak generation of 11,000 K.W. in the tenth year and 4,300 K.W. of continuous power.

Based on these estimates Pykara would always be able to supplement the Mettur generation with about 1,800 K.W. continuous or 3,600 K.W. at 50 per cent load factor, provided that any loss of storage would be made up by assistance from Mettur during December and January, if needed. Pykara would need however little if any assistance from Mettur. When the load justified the construction of the Mukurti Dam, the assistance to Mettur could be increased up to the capacity of the Coimbatore-Erode lines.

9. It may be argued, with reason, that the load demand in the Pykara area may be more favourable than forecasted for the ten-year period and less power would be available for Mettur. This is actually expected to be the case, but whenever the demand for power increases at a greater rate than forecasted in the project report, the capacity of the power system will be correspondingly increased to meet the requirements of the Pykara area itself and include a margin for emergencies and spare capacity as at present. It would therefore be reasonable to count upon an occasional supply of power up to about 5,000 K.W. from Pykara to supplement the primary output at Mettur.

10. In passing it should be observed that the area under irrigation is not expected to reach a maximum for a number of years, and there is every reason to suppose that the Mukurti reservoir would have been constructed sometime before the maximum irrigation draft is required.

In the meantime the Mettur power plant can be loaded down as speedily as possible to the maximum capacity of the plant and the revenue thus derived from power would supplement that obtained from irrigation and tend to make the combined project more attractive from a financial view point.

11. The water available for power purposes depends mainly upon the irrigation policy of Government. That policy so far as it is apparent from the recent decisions on the supplies from the Mettur reservoir would seem to be that any scheme of irrigation has to follow the traditional series of cultivation seasons. It is however open to very serious doubt whether it is in the best interests of the community that all water-supply should be regulated solely in the interests of the existing seasonal irrigation, irrespective of the claims of other national activities or without making an earnest effort to co-ordinate all the demands on the natural resources of the Presidency.

Irrigation seasons are determined solely by the natural water-supply and it would appear reasonable to assume that they could be modified to suit a regulated supply and that it is merely a question of educating the ryot. It is understood that in many purely tank-fed areas, and, in others commanded by lift irrigation, the orthodox seasons are by no means adhered to. It appears natural that there should be more profitable opportunities in perennial irrigation than in seasonal. Availability of water at any time of the year and in requisite quantities should give greater freedom in the selection of crops. Paddy cultivation seems to predominate now, but alternative crops might be grown with advantage.

At the same time it is recognized that it may not be practicable to make any changes in the irrigation regime for the old lands, but very careful consideration ought to be given to the possibility of a change in the seasons for new lands, as once any particular method of distribution is adopted, it will be difficult to get the ryots to accept a change.

12. A need for a change in the traditional irrigation policy was recognized, among others, by Mr. C. T. Mullings, C.S.I., at one time Engineer-in-Chief of the Mettur works, who advocated irrigation during the closure period. Had this policy been adhered to, a more attractive power project could have been submitted.

In the latest working tables already referred to and published in the Gazette of December 12, 1933, Government state that the tables are subject to modification at some future date. Such being the case it is not altogether improbable that proposals may be adopted eventually which will be more favourable to power generation.

13. An idea of the relative value of power and irrigation may be obtained from the following :—

The average water duty for paddy is 80

	Old area. RS. A. P.	New area. RS. A. P.
Water rates are—		
Single crop	5 0 0	15 0 0
First crop	5 0 0	15 0 0
Second crop	2 8 0	7 8 0
Single crop (tank-fed)	..	7 8 0

The quantities of water required per acre from the reservoir are—

	Old area. M. C.FT.	New area. M. C.FT.
(a) First crop	0·20	0·17
(b) Single crop	0·19	0·17
(c) Second crop	0·10	0·10

(i) An Industrial K.W. (3,000 hours) is worth Rs. 125 per year.

(ii) A Lift Irrigation K.W. (3,000 hours) is worth Rs. 130 per year.

(iii) An Electro-Chemical K.W. (4,000 hours) is worth Rs. 40 per year.

One K.W. will put 0·2 cusecs on the land (assuming an average lift of 24 feet and overall efficiency of 40 per cent) and pump 2·05 millions cubict feet during the season ; this will irrigate 12 acres at 80 duty.

An average K.W. at the reservoir requires 0·122 cusecs.

One Industrial K.W. (3,000 hours) requires 1·32 millions cubic feet.

One Lift Irrigation K.W. (3,000 hours) requires 1·32 millions cubic feet.

One Electro-Chemical K.W. (4,000 hours) requires 1·76 millions cubic feet.

1·32 millions cubic feet for irrigation will bring an average revenue of Rs. 95.

1·76 millions cubic feet for irrigation will bring an average revenue of Rs. 126.

For the same cost electric pumping will irrigate approximately double the area now served by bullock baling and is estimated to bring in additional land revenue at Rs. 2 per acre.

The following values are now arrived at :—

Equivalent irrigation (average).

	Power. RS.	Irrigation. RS.
One Industrial K.W.	125	95
One Lift Irrigation K.W.	130	95
plus enhanced land revenue K.W.	30	
One Electro-Chemical K.W.	40	126

The above comparisons bring out very forcibly the value of power and particularly when combined with irrigation. This is a very strong argument in favour of power generation, particularly when it is realized that the water rates may have to be reduced below those shown.

ten years which may be taken as low ; it is below the normal consumption in Mysore. In this connexion, the latest statistics available for some other countries may be particularly interesting and are enumerated as follows :—

Norway	3,300 kilowatt hours per capita.	Great Britain ..	370 kilowatt hours per capita.
Canada	1,900 ,,	France	350 ,,
Switzerland ..	1,350 ,,	Italy	270 ,,
Sweden	825 ,,	Mysore	9 ,,
		Madras ..	About 2 ,,

This list excluding Mysore and Madras has been extracted from Hydro-Electric Development in Sweden by Erik Upmark and published by the Swedish Water Power Association. The figure for Mysore is for normal consumption and excludes energy sold to the Kolar Gold Fields.

34. *Madras.*—I am assuming at the outset that no power will be transmitted to Madras, but that at a later date the Mettur and Madras systems will be linked up and a certain interchange of energy will take place between the two systems, depending upon load conditions.

For a long transmission system, such as projected, it would not be advisable to close down the steam plant of the Supply Company. This plant might be necessary in future as a standby, to supplement the hydro supply during low water periods, and eventually to supply power to an area north of Madras as far as Nellore, assisting generally in the widespread development of power as now contemplated.

Whether the plant would be operated eventually by Government or the Supply Company, the requirements of the immediate future could be met by the new 12,500 K.W. turbo-generator and the two 6,000—7,500 K.W. sets ; the remainder of the plant might be scrapped with part of the older boiler plant as soon as hydro-power becomes available as a standby. When the local load including that in the Northern area developed sufficiently, an additional unit of about 15,000 K.W. could be installed. This would provide an up-to-date and economical steam electric station which, together with hydro-power, should provide an electric supply service at minimum rates.

In other words the plant of the Madras Electric Supply Corporation would be in a similar position to the 'selected' stations operated by private undertakings for the account of the Central Electricity Board (England). This station would tend to grow in importance and size with the general increase in load on the Madras Grid.

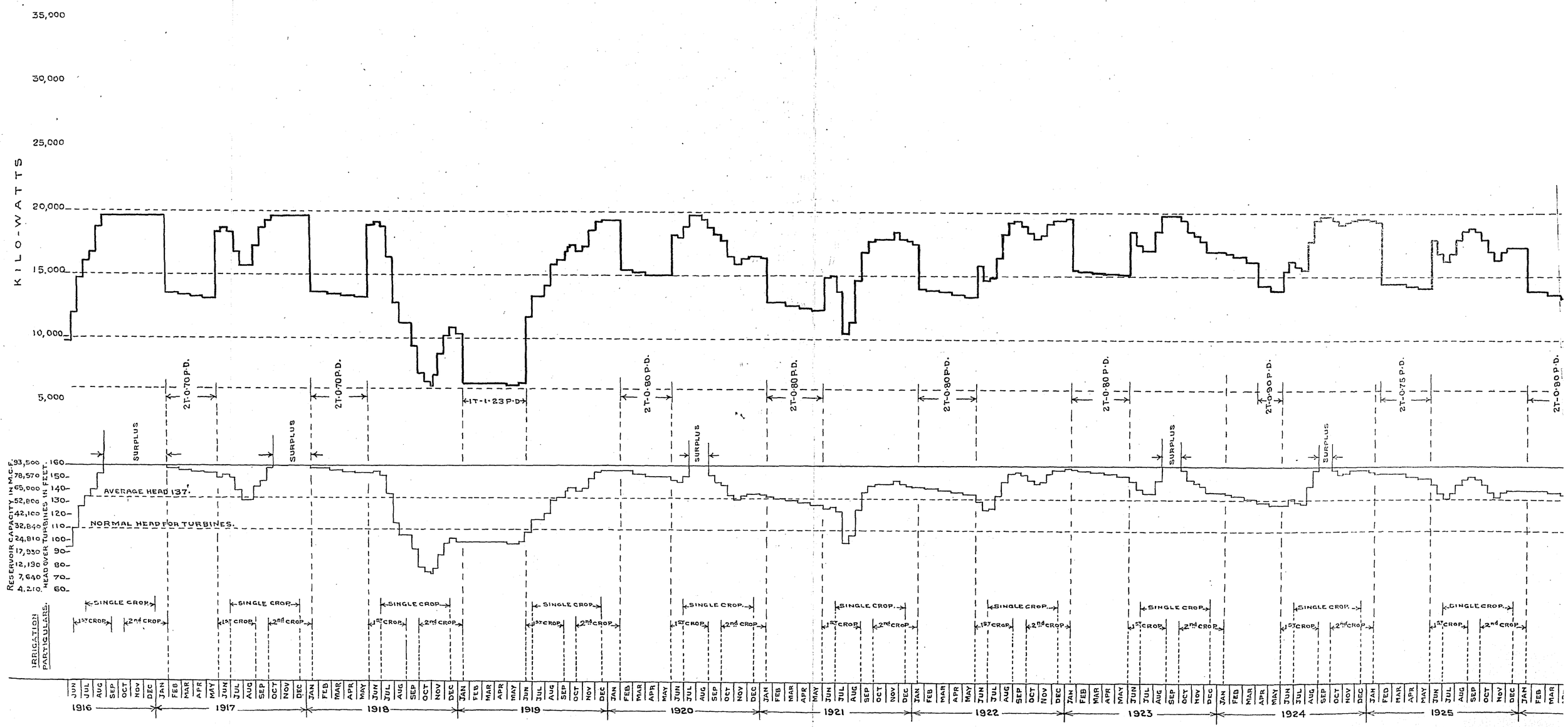
It would appear then that as Government would be the largest power producer in the Province, it might be desirable for the Madras Steam Plant to be operated as directed by Government and its representatives, so that all generating plants could be operated at maximum economy.

The peak load of the Madras Electric Supply Corporation is now nearly 11,000 K.W. an increase of 77 per cent in the past 5 years, while the consumption of power has increased 58 per cent during the same period. The mechanical horse-power installed in and around Madras—not yet electrified—is approximately 5,650 h. p. If a normal increase in installed machinery may be allowed and the fact recognized that the cost of electrical energy will tend to decrease, it cannot be considered unreasonable to assume that a peak load of 20,000 K.W. may be attained by 1940.

The Mettur transmission lines are now planned to terminate at Kanji, and could be extended to Madras in a few months if ever considered necessary.

The hydro steam combination is further discussed in Appendix D.

35. *Salem and Erode.*—These are licensed areas and the undertaking has been operating since 1932. The village of Bhavani and the South Indian Railway at Erode are supplied direct by the Electricity department. The load forecast of the Salem area is based on actual conditions. (A certain increase in the activities of the company now exploiting the local magnesite deposits may be reasonably anticipated, while increased industrial activity may also be expected.) The load situation at Erode is not satisfactory and the consumption is below normal. This is mainly due to the lack of support received by the licensees from the local authorities. As such a state of affairs can only be considered temporary—in fact it cannot be permitted to continue much longer—the load forecast for Erode is based on experience gained in similar towns in other parts of the Presidency. The Erode and Salem waterworks are expected to be electrified in the near future and provision has been made accordingly. The load of the South Indian Railway at Erode is based on actuals and an appreciable increase is contemplated by the Railway authorities. Karur is to be supplied with electricity this year and operated by the department for the first 3 years.



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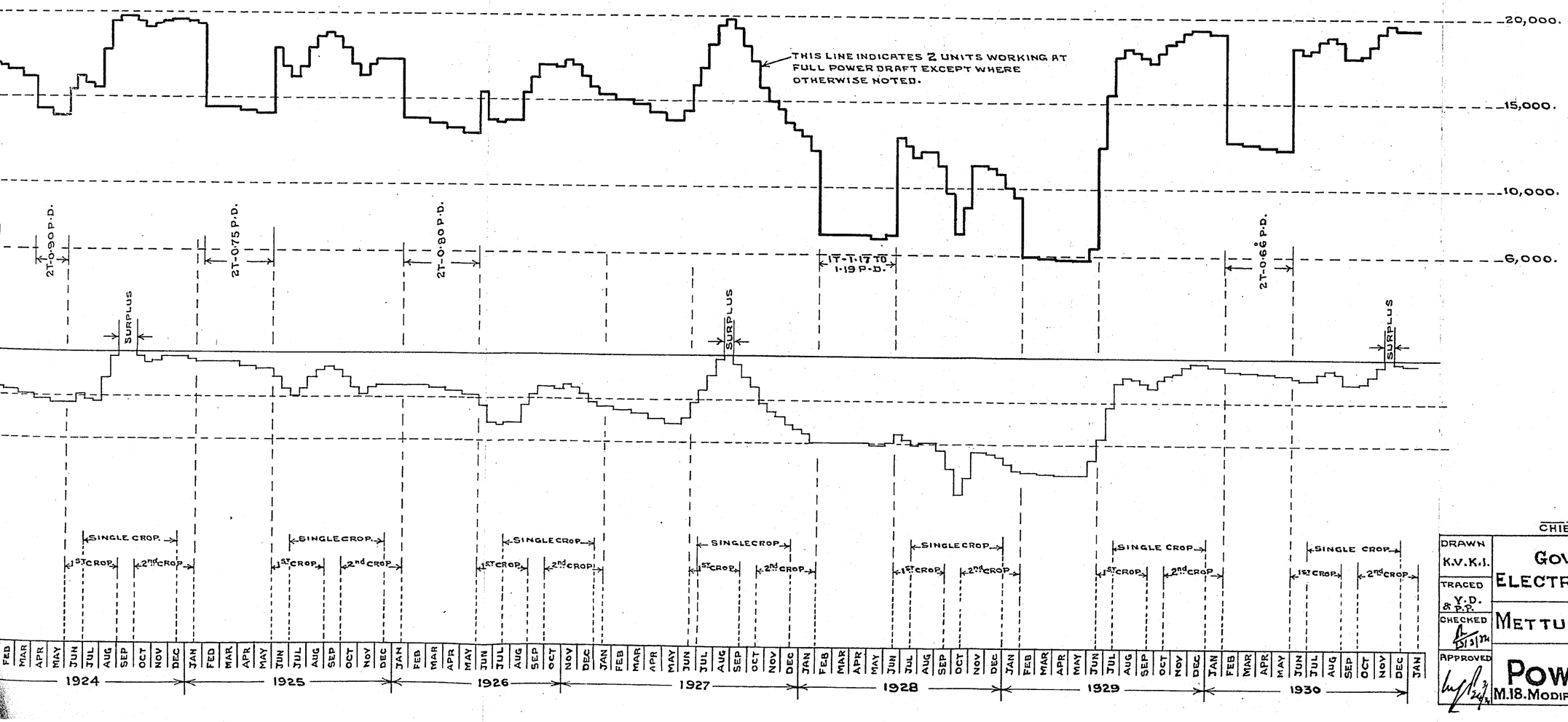
ten years which may be taken as low : it is below th

POWER CHART FOR THE PERIOD OF RECORD 1916-1930.
SHOWING CONTINUOUS POWER THAT CAN BE GENERATED WHEN FULL IRRIGATION IS PROVIDED FOR IN BOTH THE OLD AND NEW AREAS UNDER DRAFT RULES FOR THE METTUR RESERVOIR PUBLISHED IN THE FORT ST. GEORGE GAZETTE ON 8-12-1933.

	M.C.F.
MINIMUM STORAGE IN RESERVOIR ON JUNE 16TH.	14,035.
" " " AT ANY TIME.	9,000.

THIS POWER DURATION IS FOR FULL IRRIGATION DEMAND.
DURING 1ST. FEW YEARS OF OPERATION UNTIL THIS IS DEVELOPED THE MINIMUM GENERATION FOR 100% OF TIME WILL BE CONSIDERABLY HIGHER THAN 5,760 KW.

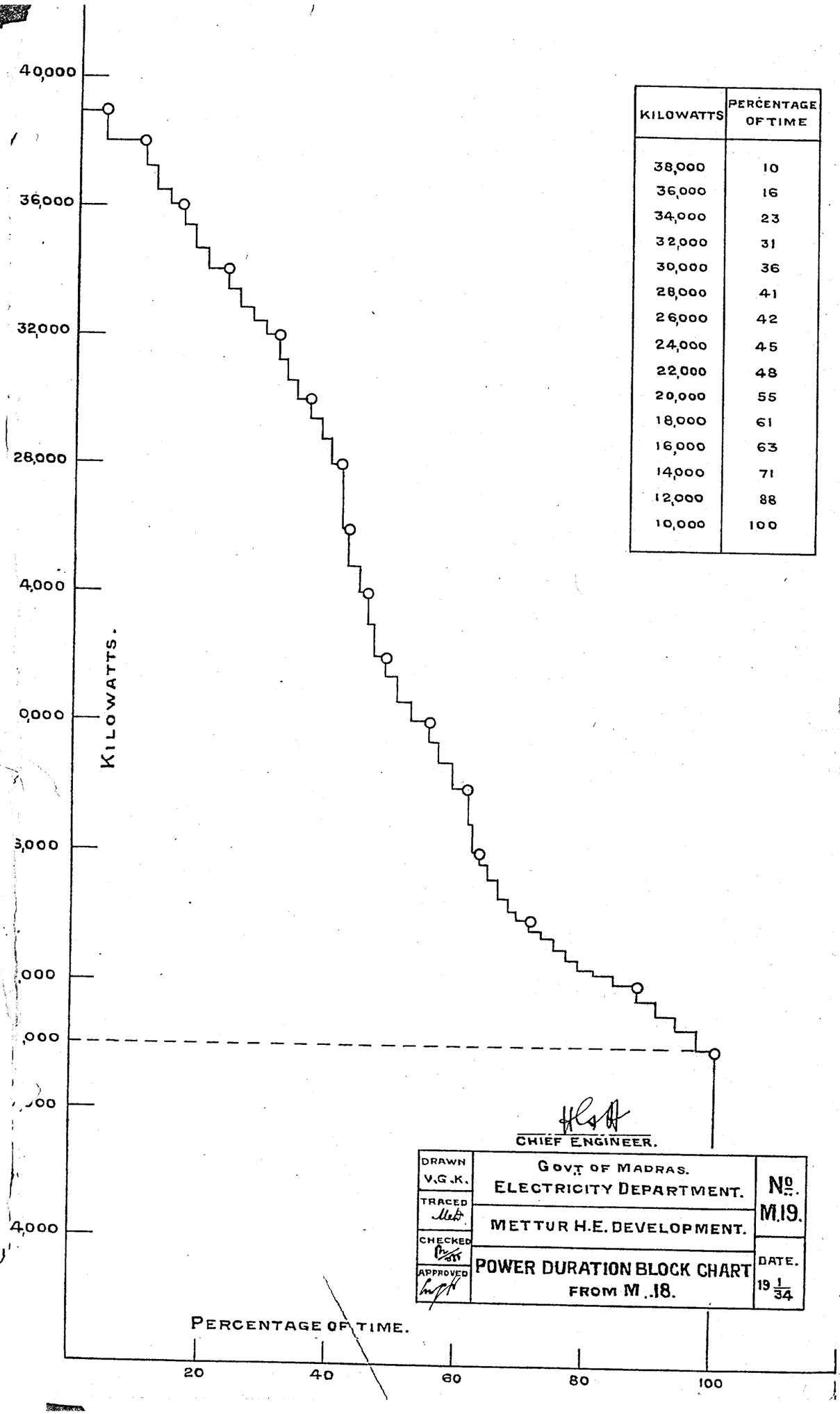
CONTINUOUS POWER GENERATION.		K.W.
FOR 100% OF TIME.		5,760
"	" 89% "	10,000.
"	" 85% "	12,000.
"	" 46% "	16,000.
"	" 7% "	19,560. MAX M'.



H.G.A.
CHIEF ENGINEER

DRAWN K.V.K.J.	GOVT. OF MADRAS ELECTRICITY DEPARTMENT	No. M:18C.
TRACED Y.D. & P.P.	METTUR H.E. DEVELOPMENT	SCALE AS PER CHART.
CHECKED 31/3/34	POWER GRAPH M.18. MODIFIED FOR TWO TURBINES ONLY.	DATE 23-3-34
APPROVED		

VANDYKE, SURVEY OFFICE, MADRAS. 1934



KILOWATTS	PERCENTAGE OF TIME
38,000	10
36,000	16
34,000	23
32,000	31
30,000	36
28,000	41
26,000	42
24,000	45
22,000	48
20,000	55
18,000	61
16,000	63
14,000	71
12,000	88
10,000	100

VANDYKE, SURVEY OFFICE, MADRAS.
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14. Generally speaking it will be only primary power shown as industrial in the table which will be generated during the closure period, but practically all secondary and tertiary power will be produced only during the irrigation season. Average revenues will then be—

	RS.
Primary power with flow irrigation	220
Lift irrigation and flow irrigation	255
Electro-chemical (tertiary power) and flow irrigation ..	166

15. It might be asked why consider irrigation at all except as a bye-product ?

The total water available in an average year is about three times that required for maximum power generation so that the real end in view is to ensure that all issues for power are used for irrigation as far as possible.

POWER AVAILABLE.

16. The duration curve M. 19 facing page 5 shows that 10,000 K.W. should be available 100 per cent of the time, 14,000 K.W. for 71 per cent of the time and 20,000 K.W. 55 per cent.

It should be possible therefore to generate and sell three classes of power—

(i) Primary which would be available at any time.

(ii) Secondary subject to a restricted use during the dry years but which could be made into primary power by assistance from Pykara or Madras.

(iii) Tertiary power generally available eight months in the year and best adapted for electro-chemical industries.

The maximum power available at the dam corresponding to the water conditions now assumed is as follows :—

Continuous Power.

	H.P.	K.W.
Primary	13,330	10,000
Secondary	5,330	4,000
Tertiary	8,000	6,000
	26,660	20,000

The maximum peak load permissible would be limited by the capacity of the station and the head on the turbines.

17. The design allows for four units each of 13,000 h.p. at full head—160 feet and developing 4,000 h.p. each at a minimum operating head of 73 feet. Only two units are to be installed at the outset and the remaining two when the load conditions justify the additional generating capacity.

The minimum head only occurs for a few days once in 15 years, when Pykara could make up easily the deficiency of 800 h.p. to 4,800 h.p. corresponding to a head of 80 feet which is proposed to be taken as the minimum operating head. Graph M. 18 (C) facing page 4 indicates the power available with only two units in operation.

We then have—

Maximum peak loads possible.

Operating head.	H.P.	K.W.	Power.
Minimum 80 feet	19,200	14,500	Primary.
Normal 110 feet	32,000	24,000	Primary and secondary.
Average 135 feet	42,800	32,000	Primary, secondary and tertiary.

It will be noted that the primary power peak is low at 14,500 K.W. considering that the continuous power available is 10,000 K.W. It is thus obvious that primary power should be sold at as high a load factor as possible if the maximum return is to be obtained from the plant. Any balance of continuous primary power available due to a restricted peak will have to be transferred to the secondary block.

28. The power house layout includes a pumping installation for the Salem water-supply.

29. The transmission layout is designed to form part of the future extensive Grid System contemplated for the whole Presidency and shown on plan No. G-1/D-1.

To begin with a single circuit 110 K.V. line is to be constructed to Kanji and will eventually form one of the tie lines to Madras. This line will be operated initially at 66 K.V. and supply secondary 66 K.V. transmission lines which will be constructed along a route of towns and villages to Vellore, while another line will feed the large licensed area of the South Arcot Electric Supply Company.

Other 66 K.V. lines will feed Trichinopoly and Negapatam via Erode. If the load development around Negapatam and Trichinopoly is greater than estimated, it may be found necessary in the future to construct a single circuit 110 K.V. line from Mettur to Negapatam or Tanjore via Salem.

At a later date a 110 K.V. line via Satyamangalam is projected to link up the Mettur and Pykara power houses.

Tentative designs of the 110 K.V. lines to Madras, and a receiving station with special regulating equipment have already been prepared for future guidance.

30. At the outset the Trichinopoly and Negapatam areas are to be supplied from Pykara. There is no objection to this during the period of development and light load. As soon as Mettur is in operation these lines will be more conveniently and economically fed from that plant. In the meantime the Madura extension should be constructed and the area supplied from Pykara, as soon as Trichinopoly-Negapatam lines are transferred to Mettur. When the load in the Madura area approached the capacity of the transmission lines from Pykara, the Periyar Power System would have to be constructed, the whole object in view being the sectionalizing of the transmission system and the construction of additional generating plants with due regard to voltage regulation and the stability of the generating equipment.

CHAPTER 4.

Load and Revenue Forecast.

31. The load and revenue estimates of the Pykara Hydro-Electric Project were prepared when business conditions were favourable and there was no sign of a downward trend. But in spite of the commercial depression of the past three years, the load and revenue figures, as forecasted in that Project Report, are expected to be exceeded and the whole undertaking to be on a paying basis from the sixth year instead of the tenth. The people of Southern India are gradually becoming "electrically minded" like those in other countries, hence there should be an increasing demand for electrification both in the home and industry.

32. The load and revenue forecast for Mettur has been based on experience already gained in the Pykara area and on the general and conservative calculations adopted in preparing that report. Information from Mysore and the United Provinces has also been drawn upon. In most cases, however, the load will be available, and only limited development work will have to be done.

33. The Mettur power area will comprise the districts of Salem, Trichinopoly, Tanjore, North and South Arcot, Chittoor, in the first place and Chingleput and Madras later.

It is proposed to extend lines and distribute electrical energy during the first few years to the towns and villages enumerated below. When load conditions justify the expenditure, additional lines will be constructed and other towns and villages incorporated in the general scheme of electrification.

Salem	(Licensed area).	Kumbakonam	(Licensed area).
Erode	(").	Vellore	(").
Bhavani.		Polur.	
Karur	(Licensed area).	Chittoor	(Licensed area).
Trichinopoly	(").	Chidambaram	(").
Tanjore	(").	Villupuram	(").
Mannargudi	(").	Cuddalore	(").
Negapatam	(").		

This embraces about 25,000 square miles with a population of approximately 12,000,000. The load forecast allows an average consumption of about 7 units per annum per capita in

ten years which may be taken as low; it is below the normal consumption in Mysore. In this connexion, the latest statistics available for some other countries may be particularly interesting and are enumerated as follows :—

Norway	3,300 kilowatt hours per capita.	Great Britain ..	370 kilowatt hours per capita.
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The Mettur transmission lines are now planned to terminate at Kanji, and could be extended to Madras in a few months if ever considered necessary.

The hydro steam combination is further discussed in Appendix D.

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36. *Trichinopoly.*—The licensed area is 150 square miles and includes many villages besides the towns of Trichinopoly and Srirangam. The area is administered by a progressive private Corporation and the load figures are based on their own actuals and calculations.

The South Indian Railway is excluded from this licensed area and is to be supplied with electrical energy direct by the Government Electricity department. The load figures are based on information supplied by the Railway Company's Engineers.

37. *East Tanjore.*—This is a licensed area of 911 square miles with Tiruvarur as the generating centre. This enterprise is to be managed by the same agency as the Trichinopoly undertaking, and is expected to commence operation this year. The load forecast is based on the estimates of the licensees and may be accepted. The preliminary source of power will be derived from an oil engine electric station which, in accordance with the terms of the licence, has to be closed down in 1939 and the power requirements supplied from a Government source. The district is rich and a profitable load should soon be obtained.

38. *Negapatam.*—This licence is held by a progressive agency which is also active in the industrial field. In addition to the normal requirements of light and power of the town, a steel rolling mill and later on a smelting plant are to be established. The load figures are based on information supplied by the licensee but it is reasonable to assume that they will be exceeded, once a supply of cheap hydro-electric power is assured. There are indications already that Negapatam may develop into a flourishing industrial centre. It is an ideal location for many factories.

39. *Kumbakonam.*—Is operated by the same licensee as Negapatam. Load figures are based on actuals and reasonable development. The licensed area is expected to be extended.

40. *Tanjore.*—This is operated by the local authorities. The management of this undertaking in the past cannot be considered as entirely satisfactory and is capable of considerable improvement. Load figures are based on the normal development of a town of this size in Southern India.

41. *Vellore.*—This undertaking is operated by a private licensee. The generation and sale of electrical energy, since operation started, are not up to expectations. The load potentialities are promising but need energetic and studied development. With the advent of hydro-electric power, and further experience, better results ought to be obtained. The load forecast is based upon probable actuals in the first year 1938 and normal development afterwards. The licensed area may be extended. There are several small leather factories in the district which should improve and extend once hydro-electric power is available.

42. *South Arcot.*—This area comprising 1,390 square miles is to be operated by a private licensee. It is expected to commence operation in 1935 and by the terms of the licence must take hydro-electric power within five years. The load forecast is based on the licensees' estimates, and should be exceeded. Last year the department received an enquiry for 2,000 h. p. in this area near Pondicherry but was unable to supply it. It is the centre of a large and increasing sugar growing district and the establishment of new factories is to be anticipated.

43. *Agriculture.*—An interesting note on electric pumping for irrigation has been prepared by the Executive Civil Engineer—Lieut.-Col. Platts—and his staff. It is reproduced in Appendix E. The possibilities of bringing a larger area of land under irrigation, increasing production, and introducing more profitable crops than paddy, are very clearly brought out. The benefits are threefold—a useful revenue accruing to Government from the sale of power, increased revenue to the agriculturist from a more extensive and improved cultivation of the land, and additional land revenue to Government.

The importance of electric pumping to agriculture in these areas must be emphasized, as the benefits are real and far reaching. It may be pointed out that Pykara power has not been utilized so far for electric pumping to any appreciable extent in the Coimbatore district. The scheme has only been in regular operation for twelve months and the staff is inadequate to attempt to organize a sales and propaganda campaign for this load at present. No matter what facilities are offered or how reasonable the cost of power, little progress will be made without a personal appeal and organized effort. To date 43 wells around Coimbatore have electric pumping sets totalling 264 h. p. or have signed agreements, and 235 h. p. more is expected in the immediate future. The rate for power was 1·25 annas per unit and has now been reduced to one anna. All actual consumers were obtained without any organized solicitation or canvassing and all are satisfied with the results. To develop this load a well organized business campaign must be started, when 2,000 h. p. ought soon to be reached. The advantages of electric pumping in the Mettur Hydro-Electric area are greater than in Coimbatore and the scope wider. From the point

of view of power generation, this load has the great advantage of synchronizing with the periods when irrigation water is available at Mettur for additional power generation and it forms a convenient market for this extra power.

It should be noted especially that a given quantity of water at Mettur during this period earns revenue from three sources :—

(*a*) Sale of power from pumping.
(*b*) Land revenue from lift irrigation.
(*c*) Revenue from flow irrigation.

The Executive Civil Engineer estimates that on a conservative basis a connected load of 9,000 K.W. could be developed in the Mettur area in ten years and about 18,000,000 units consumed.

Having in mind the success of electric pumping in the United Provinces and the arguments advanced in the note of Col. Platts, it may be considered a reasonable estimate, always provided that a properly organized business campaign is launched and continued.

For the purpose of this report it has been decided to adopt a somewhat lower figure. A demand of 250 K.W. is assumed for the first year, 400 K.W. for the second year and 550 K.W. for the third and 800 K.W. for the fourth on the assumption that the results of any organized effort will not be fully effective until the fourth year. For the following years a more or less constant increment is allowed up to 1,500 K.W. in the tenth year. The note on electric pumping has assumed a rate of one anna per unit to the agriculturist and on this basis promising results are shown.

The possibilities of lift irrigation throughout the Presidency have been referred to by many of the Agricultural Commissions which have visited Madras in the past, while occasional references are made to the subject in the local press. It would appear desirable that an organized investigation be made of the possibilities of constructing tube wells on an extensive scale in the drier areas of the Salem, North Arcot, and Chittoor districts and also to ascertain the feasibility of constructing pumping plants on the Palar, Amaravati, Pennar, Bhavani and other rivers. For this purpose an Executive Engineer of the Public Works Department may be put in charge of these studies. It would be desirable if Government would send him on deputation first to study the progress which has been made in lift irrigation in the United Provinces and the Punjab.

The practice of the United Provinces might well be followed. In that Province the Irrigation Department constructs the tube wells—generally about a cusec each—and pumping plants, builds the laterals, and sells water to the ryots on the basis of one anna per electrical unit, paying the Electricity department for the power consumed at an approximate rate of 0·75 anna a unit. This arrangement has been found to be commercially successful and local evidence states that the ryots would be prepared to pay a higher price for water if considered necessary.

In connexion with the introduction of electric pumping in the Mettur area, it is hoped that an organized campaign to encourage a general use of fertilizers—particularly nitrate of lime—will be undertaken.

There are thus great possibilities in the Mettur Hydro-Electric Project for assisting agriculture by—

(*a*) electrification of existing wells and increasing the flow ; decreasing the cost of lift irrigation ;

(*b*) bringing uncommanded areas under cultivation by sinking tube wells or pumping to higher heads ; (this has been carried out on an extensive scale in the United Provinces) ;

(*c*) utilization of agricultural and natural products in industry, i.e.—
Paddy, wheat, and other straw in the manufacture of strawboard.
Linseed, mustard, groundnuts, etc., for oil presses.
Salt for the manufacture of chlorine, hydrogen, caustic soda, bleaching powder.
Lime for the manufacture of nitrate of lime.

(*d*) manufacture of synthetic fertilizers from lime to mix with the cake—a by-product from the oil presses—and thus increase the yield and quality of the crops per acre.

44. *Madura.*—Madura is an industrial centre with numerous textile mills similar to Coimbatore. It is the centre of the cultivation of a high grade long staple cotton called Tinnevellies, and there is great scope for industrial development. The peak load of the Municipal Supply Scheme is around 500 K.W. at present and by 1938 the Engineer expects that figure to have reached 750 K.W. A municipal pumping load of 600 h. p. is also to be expected. The Madura and Dindigul loads are taken together and the original estimates given in the Periyar Report were based on detailed load surveys. The Dindigul

figures have been retained, but the Madura figures have been modified and based on experience around Coimbatore. The estimated revenue per K.W. year is lower than is actually being received in the Coimbatore area while the estimated load is very little greater, although the installed horse-power exceeds 10,000 and the population is around 180,000 against 95,000 for Coimbatore. It would be logical to assume that the estimates are not only safe but on the low side.

45. *General.*—A rural load consisting of a group of villages has been included.

The total population to be served is about 200,000 and include—

Tiruvannamalai.	Polur.	
* Gudiyattam.	Dharmapuri.	
* Vaniyambadi.	Krishnagiri.	
* Tiruppattur.	* Peranampattu.	
Ranipet.	* Umrabad.	
Walajapet.	* Jalarpet.	Railway junctions.
*Ambur.	Katpadi.	
Arni.		

Recently an application has been made for a licence to generate and distribute electric energy in an area which includes the villages marked * in the above list. The applicant has made a careful load survey and estimates that the demand will be 400 K.W. in the first year and 1,000 K.W. in the fifth year. The load forecast of this department for almost double the area is 440 K.W. the first year and 1,000 K.W. in the tenth year. The load survey of the applicant showed that in the smaller area there were more than 60 tanneries, about 20 rice mills and a few small sugar refineries. The load forecast may thus be taken as reasonable and the commercial possibilities of the area encouraging.

46. It will be noted that the load estimates include a special industrial development at Mettur or in the vicinity of the main lines and, owing to the importance of the subject, a special chapter has been devoted to it.

TABLE II.

Estimated Demand and Revenue.

Year.	Primary.		Secondary.		Tertiary.		Total.		At power-house K.W. *
	K.W.	Revenue. (in lakhs of rupees).	K.W.	Revenue. (in lakhs of rupees).	K.W.	Revenue. (in lakhs of rupees).	K.W.	Revenue. (in lakhs of rupees).	
1938 ..	6,230	7·764	1,100	0·88	..	..	7,330	8·644	7,250
1939 ..	7,640	9·519	1,200	0·960	..	..	8,840	10·479	8,750
1940 ..	8,970	11·129	1,550	1·240	..	..	10,520	12·369	10,395
1941 ..	9,680	11·872	1,750	1·400	5,000	2·000	16,430	15·272	16,305
1942 ..	11,050	13·349	2,200	1·760	5,000	2·000	18,250	17·109	18,120
1943 ..	11,675	14·103	2,400	1·920	5,000	2·000	19,075	18·023	18,930
1944 ..	12,500	15·093	3,100	2·480	5,000	2·000	20,600	19·573	20,480
1945 ..	13,125	15·847	3,300	2·640	5,000	2·000	21,425	20·487	21,300
1946 ..	13,900	16·707	3,400	2·720	5,000	2·000	22,300	21·427	22,160
1947 ..	† 14,345	17·167	3,500	2·800	5,000	2·000	22,845	21·967	22,760

	* Diversity factor.	Average over all losses. PER CENT.
Primary	1·15	12·5
Secondary	1·05	10
Tertiary	Negligible.	

† Primary power demand on plant 14,100 K.W.

CHAPTER 5.

INDUSTRIAL DEVELOPMENT.

47. When one realizes the industrial and power development which has taken place during the past ten years in other countries possessing no natural deposits of coal or oil—particularly Scandinavia, Switzerland, Ireland, Italy and Japan, it is surprising that there should have been any hesitation at all in a reasonable development of the natural power resources of this Presidency. In the cases mentioned above power usually preceded industrial development, but if power and industry can be developed along parallel lines the economic advantage is obvious. Existing economic conditions indicate that careful consideration should be given to a more vigorous development of special industries. The United Provinces, although an agricultural country like Madras, has by means of its hydro-electric power already developed electric pumping on an extensive scale and started small industries in connexion with agriculture; and further projects are under consideration.

The industrial progress of some of the neighbouring Indian States would indicate that, in time, the greater part of the requirements of this Presidency, in manufactured products, will be met by imports from our neighbours. It is not an enviable position for a country of the size and importance of the Madras Presidency. As I have mentioned several times in the past few years, no one wishes to see the Presidency industrially saturated and dependent upon an unstable export trade to absorb the output of its factories. But Madras is very remote from industrial saturation and there is an economic need for the establishment of certain industries. In Appendix G is given a list of some of the more important imports into Madras during 1926–29. In Southern British India, initiative in the industrial world has not been very marked in the past, and if any real movement is to be started it will probably be necessary for Government to take the lead. This may take the form of constructing and financing factories, which may be afterwards either operated by a public board, or better still leased out to experienced and efficient private interests on terms mutually satisfactory to both parties. An industrial organization is discussed elsewhere. During my recent visit to Sweden I was much impressed with the power development which is in progress in that country in spite of the general business depression. To date, the State has invested £16,000,000 or about Rs. 20 crores in power plants and transmission systems, representing about 30 per cent of the total power developed, the remaining being controlled by private interests. The State Power System has been in operation for about 20 years and a return of 5·5 per cent—after paying operating expenses—is obtained on the invested capital, of which nearly £1·5 millions represent accumulated interest charges during the unprofitable period. The indirect benefits, are, however, incalculable.

48. The combined system of power distribution by the State, communal authorities, and private interests, is generally referred to as the "Swedish System." It has the advantage of a certain amount of healthy competition which tends towards greater efficiency and lower rates. At the same time when private enterprise has not proved to be sufficiently progressive, the State has intervened and taken the initiative. It is of interest to note that in all cases where a State has been directly or indirectly concerned in the development of the natural power resources of a country, a Board or Commission has been appointed to manage and control such activities. In my opinion a Board is needed for Madras, not only for the control of electricity but for the development of industries—one supplements the other. This has been discussed in other communications and separate proposals on the formation of an Electricity and Industrial Board are to be submitted in the near future.

49. It is becoming increasingly apparent that the complicated modern economic structure of the world and the competition of nationally subsidized activities is tending to render the lot of private enterprise difficult, so that State or public control of finance and industry has to be seriously contemplated.

In Italy a consistent programme of large productive works both industrial and power has been undertaken during the recent economic crisis and financed by the issue of Government guaranteed bonds. It is stated that no trouble has been experienced in placing these bonds privately.

On page 1, I have advocated the establishment of a small industrial centre at Mettur and, having in mind the ultimate ecomomic value to the country of such a scheme, a fixed block of power has been reserved for this purpose.

The pamphlet on the Industrial potentialities of Mettur published by Government gives a useful description of the various industries which might be started at the power-site, and reference is invited to this interesting booklet. But industrial development requires careful planning and organization.

50. In the ten-year plan I advocated the formation of certain committees and sub-committees to deal with general recommendations for economic development. I believe, however, that the limited power industrial proposals advocated in this report will be brought to fruition quicker, and on a sounder economic basis, by a more direct method.

I would recommend that an energetic development division be formed and that the services of two qualified industrial engineers be requisitioned on a short term contract. These engineers should have had experience in manufacturing methods—particularly in the special branches under consideration. Their main duties would be the investigation of suitable industries to supplement the State Power Supply and the submission of practical schemes. Such reports would include not only a description and cost of the plant projected, but full details of production costs, supply of raw material, markets, and methods for the distribution and sale of the products. These engineers would be provided with suitable junior staff, who might become afterwards useful members of the industrial organization.

51. In addition to Mettur there are attractive power-industrial projects worthy of investigation as follows :—

(a) Papanasam Hydro-Electric Project combined with a much needed regulation of the irrigation supply on the Tambraparni River. A pulp and paper factory at Papanasam has been considered a commercial possibility for some time while further industrial development would appear possible around Tuticorin.

(b) Pykara power—and afterwards Thalipuzha—could be extended to Calicut where Cyanamide might be produced and the local factories reorganized and enlarged.

(c) Bezwada (steam) combined with a cement plant and sugar factories and the area generally developed.

(d) Chettipet (hydro)—Rajahmundry (oil). Lift irrigation and small industries are possibilities, while both in this area and that of Bezwada there would appear to be scope for margarine and ghee factories.

52. The investigations might be undertaken in the following order :—

(a) Industrial development in the Mettur Hydro-Electric Area (see Appendix C).
(b) Similar studies in the Papanasam Power area.
(c) Similar studies around Calicut.
(d) Similar studies in the Chettipet-Rajahmundry Project.
(e) Similar studies in the Bezwada Power area.

These studies if properly organized, should be completed in about 2 years and would be undertaken during the construction of the Mettur Plant and with the co-operation of the Directors of Industries and Agriculture. The cost of the studies should not exceed Rs. 1,50,000.

53. In Appendix C, I have discussed at greater length the possibilities of industrial development in connexion with the Mettur Power Project which may be summarized as follows.

Electric furnaces for special alloys could be erected capable of melting about 600 tons of pig and scrap iron per month, requiring approximately 330,000 units, and a demand of 1,500 K.V.A. with two shifts per day. Rolling mills, foundries and machine shops to utilize a part or all of the output would need a demand around 500 K.W. or a total of some 2,000 K.W. for the whole works. The existing workshops and equipment could be utilized to a great extent and the initial investment correspondingly reduced. In view of the establishment of rolling mills at Negapatem, care would be taken not to compete with them and the activities at Mettur might be confined to the production of ferro-alloys, stainless steel, brass, etc. The output of these furnaces and mills could be absorbed easily in the Presidency, the normal consumption being much in excess of the capacity of these small works. The question of the supply of pig and scrap iron would have to be studied and the location of the works would depend upon the result of these investigations. If much pig iron could be obtained from Mysore, Salem would appear to be the best location. If scrap steel and iron would form the main supply, Erode might be preferred as involving lower transport costs. To begin with, steel billets might be used.

The establishment of an alkali industry at or near Mettur would be of great economic value to the Province, and provide caustic soda, bleaching powder, chlorine and hydrogen —the latter could be used again for the hydrogenation of vegetable oils and for the manufacture of hydro-chloric acid. This industry requires a considerable amount of common salt and the cost of transport of the latter would be a limiting factor. The power demand of the proposed factory would be 1,200 K.W. with an annual consumption of approximately 6,000,000 units. Oil pressing plants could be established at Mettur and Pollachi and the cake by-product used with the nitrate of lime as a fertilizer.

A straw board factory to utilize paddy straw could be erected, as a good market exists for the product.

The above scheme appears to be the most satisfactory method of utilizing a large block of primary and secondary power. Alternatively the construction of spinning, weaving and dyeing mills combined with hosiery factory might be considered at any time, as the output of these mills could be absorbed easily in South India.

Tertiary power might be utilized to increase the capacity of the furnaces outlined above at certain periods in the year, or for the reduction of the Salem iron ores. A demand of about 1,500 K.V.A. could be anticipated for this purpose.

It is believed that a study of the production and probable consumption of calcium nitrate would justify the erection of furnaces for its manufacture. The only raw material needed is lime, which is available near Mettur. This process has the advantage that it is adaptable to a variation in the power supply. From 4,000 to 5,000 K.W. could be utilized in this industry.

In all these special cases the rates for power would be adjusted to meet the economic needs of the particular product manufactured, and to meet the competition of vested interests. Generally speaking, however, economic rates could not be given to electro-chemical industries unless located at or near Mettur. It would also seem that that part of the Mettur Camp known as Salem village might be transformed into a hygienic town of cottage industrialists somewhat similar to industrial communities met with in some parts of Europe—particularly France and Italy.

Among industries which might be considered are :—

Fabrication of tooth hair and clothes brushes.

Fabrication of combs.

Fabrication of buttons and umbrellas.

Metal Pressing—Hinges.
Bolts.
Small locks.
Brass work.
Metal polishing and electro-plating.
} The metal to be obtained from the Mettur Iron works.

Small looms (Yarn from local mills).

Preparation of starch and special foods from cereals. (Boxes to be made at Straw-board Factory.)

Government would provide and erect the equipment for each cottage. The supply of raw material and marketing of the products would be organized, while arrangements would be made for the necessary schools, broadcasting (particularly on industrial subjects) and other amenities. Each industrialist family or group would have to be "approved", and would be expected to pay a reasonable rental for the fully equipped cottages plus the cost of power—which under certain conditions, should not exceed 0·75 anna per unit. The organizing of such an industrial community could be undertaken by the Department of Industries and the Registrar of Co-operative Societies. The details will have to be worked out by a special committee.

The scheme for cottage industries outlined above would not be of particular profit to the power undertaking, but its general economic value and benefit to a certain section of the community seem to be so obvious as not to need further discussion.

TABLE III.

Summary of special Industrial loads which might be developed in the Mettur Industrial Area.

	K.W. of demand.		
	Primary.	Secondary.	Tertiary.
(1) Iron and Steel Works.*	1,000	1,000	..
(2) Smelting for alloys	..	..	1,500
(3) Reduction of Salem Iron ores	..	..	1,500
(4) Caustic soda and chlorine factory*	200	1,000	..
(5) Strawboard Factory*	250	..	..
(6) Oil pressing and hydrogenation *	..	200	..
(7) Spinning and Weaving	1,500	..	..
(8) Hosiery	700	..	..
(9) Nitrate of Lime Factory *	..	..	4,000
(10) Seasonal pumping *	..	1,500	..
(11) Cottage Industries at Mettur *	..	200	..

* It is assumed that these industries will be started.

Table IV.

Mettur Hydro-Electric Project Load Forecast.

Category.	Year. / Load.	1938. Demand K.W.	1938. Rate per K.W. Year. RS.	1938. Revenue in lakhs of rupees.	1939. Demand K.W.	1939. Rate per K.W. Year RS.	1939. Revenue in lakhs of rupees.	1940. Demand K.W.	1940. Rate per K.W. Year RS.	1940. Revenue in lakhs of rupees.
B.	1 Salem	500	125	·625	560	125	·700	620	125	·775
D.	2 Erode and South Indian Railway	360	130	·468	430	130	·559	500	125	·625
G.	3 Karur	150	130	·195	200	130	·260	250	130	·325
B.	4 Trichinopoly and South Indian Railway	1,600	120	1·920	1,750	120	2·100	1,900	120	2·280
B.	5 Kumbakonam (with nearby villages)	350	130	·455	400	130	·520	450	130	·585
C.	6 Tanjore	250	130	·325	300	130	·390	350	130	·455
H.	7 East Tanjore Licensed Area (911 square miles)	350	130	·455	450	130	·585	500	125	·625
I.	8 Negapatam	1,250	120	1·500	1,250	120	1·500	1,500	120	1·800
H.	9 South Arcot Licensed Area (1,390 square miles)	..	..	..	650	125	·813	800	125	1·000
C.	10 Vellore Licensed Area	330	130	·429	400	130	·520	450	130	·585
F.	11 Rural (12 small villages)	440	130	·572	550	125	·687	650	125	·812
S.	12 Agriculture	150	130	·195	200	130	·260	250	130	·325
S.	13 Mettur Industrial	500	125	·625	500	125	·625	750	125	·937
	Total Primary Power	6,230	..	7·764	7,640	..	9·519	8,970	..	11·129
	Demand at Plant (D.F. 1·15 plus 12·5 per cent losses)	6,100	..	..	7,500	..	..	8,775	..	..
S.	14 Mettur Industrial	1,000	80*	·800	1,000	80	·800	1,250	80	1·000
S.	15 Agriculture	100	80	·080	200	80	·160	300	80	·240
	Total Secondary Power	1,100	..	·880	1,200	..	·960	1,550	..	1·240
	Demand at Plant (D.F. 1·05 plus 10 per cent losses)	1,150	..	..	1,250	..	..	1,620	..	..
	Tertiary Power	..	..	..	..	..	..	..	..	..
S.	16 Mettur Industrial	..	..	..	..	..	..	..	..	..
S.	17 Miscellaneous	..	..	..	..	..	..	..	..	..
	Total Tertiary Power	..	..	..	..	..	..	..	..	..
	Demand at Plant (D.F. and losses negligible)	..	..	..	..	..	..	..	..	..
I.	18 Madura and Dindigul	1,500	120	1·800	2,300	120	2·760	3,100	115	3·565

* Nominal figure.

Revenue is up to bulk supply points. Retail revenues for pumps and villages are higher but will also require additional capital.

Category.	Year. / Load.	1941. Demand K.W.	1941. Rate per K.W. Year. RS.	1941. Revenue in lakhs of rupees.	1942. Demand K.W.	1942. Rate per K.W. Year. RS.	1942. Revenue in lakhs of rupees.	1943. Demand K.W.	1943. Rate per K.W. Year. RS.	1943. Revenue in lakhs of rupees.	1944. Demand K.W.	1944. Rate per K.W. Year. RS.	1944. Revenue in lakhs of rupees.
B	1 Salem	680	125	·850	750	125	·937	825	125	1·031	900	125	1·125
D	2 Erode and South Indian Railway	550	125	·688	600	125	·750	600	125	·750	650	125	·813
G	3 Karur	300	130	·390	300	130	·390	350	130	·455	350	130	·455
B	4 Trichinopoly and South Indian Railway.	2,050	115	2·360	2,150	115	2·470	2,250	115	2·590	2,350	115	2·700
B	5 Kumbakonam (with nearby villages)	500	125	·625	550	125	·688	600	125	·750	650	125	·813
C	6 Tanjore	400	130	·520	450	130	·585	500	125	·625	500	125	·625
H	7 East Tanjore Licensed Area (911 square miles).	550	125	·687	600	125	·750	650	125	·812	700	125	·875
I	8 Negapatam	1,500	120	1·800	2,000	115	2·300	2,000	115	2·300	2,250	115	2·590
H	9 South Arcot Licensed Area (1,390 square miles).	900	125	1·125	1,000	120	1·200	1,100	120	1·320	1,200	120	1·440
C	10 Vellore Licensed Area	500	125	·625	550	125	·687	600	125	·750	650	125	·813
F	11 Rural (12 small villages)	700	125	·875	750	125	·937	800	125	1·000	850	125	1·060
S	12 Agriculture	300	130	·390	350	130	·455	400	130	·520	450	130	·585
S	13 Mettur Industrial	750	125	·937	1,000	120	1·200	1,000	120	1·200	1,000	120	1·200
	Total Primary Power	9,680	..	11·872	11,050	..	13·349	11,675	..	14·103	12,500	..	15·094
	Demand at Plant (D.F. 1·15 plus 12·5 per cent losses).	9,470	..	..	10,810	..	..	11,420	..	..	12,230	..	..
S	14 Mettur Industrial	1,250	80	1·000	1,500	80	1·200	1,500	80	1·200	2,000	80	1·600
S	15 Agriculture	500	80	·400	700	80	·560	900	80	·720	1,100	80	0·880
	Total Secondary Power	1,750	..	1·400	2,200	..	1·760	2,400	..	1·920	3,100	..	2·480
	Demand at Plant (D.F. 1·05 plus 10 per cent losses).	1,835	..	..	2,310	..	..	2,510	..	..	3,250	..	..
S	16 Mettur Industrial	4,000	40	1·600	4,000	40	1·600	4,000	40	1.600	4,000	40	1·600
S	17 Miscellaneous	1,000	40	·400	1,000	40	·400	1,000	40	·400	1,000	40	·400
	Total Tertiary Power	5,000	..	2·000	5,000	..	2·000	5,000	..	2·000	5,000	..	2·000
	Demand at Plant (D.F. and losses negligible).	5,000	..	..	5,000	..	..	5,000	..	..	5,000	..	..
I	18 Madura and Dindigul	4,000	115	4·600	4,800	115	5·520	5,700	115	6·555	6,500	115	7·475

Category.	Year. Load.	1945. Demand K.W.	1945. Rate per K.W. Year.	1945. Revenue in lakhs of rupees.	1946. Demand K.W.	1946. Rate per K.W. Year.	1946. Revenue in lakhs of rupees.	1947. Demand K.W.	1947. Rate per K.W. Year.	1947. Revenue in lakhs of rupees.
			RS.			RS.			RS.	
B	1 Salem	975	125	1·220	1,050	120	1·260	1,115	120	1·340
D	2 Erode and South Indian Railway	650	125	·813	700	125	·875	730	125	·910
G	3 Karur	400	130	·520	400	130	·520	420	130	·550
B	4 Trichinopoly and South Indian Railway	2,450	115	2·820	2,550	115	2·930	2,650	115	3·050
B	5 Kumbakonam (with nearby villages) ..	700	125	·875	750	125	·937	730	125	·910
C	6 Tanjore	550	125	·687	600	125	·750	600	125	·750
H	7 East Tanjore Licensed Area (911 square miles)	750	125	·937	800	125	1·000	850	120	1·020
I	8 Negapatam	2,250	115	2·590	2,500	115	2·875	2,500	115	2·875
H	9 South Arcot Licensed Area (1,390 square miles)	1,300	120	1·560	1,400	120	1·680	1,500	120	1·800
C	10 Vellore Licensed Area	700	125	·875	950	125	1·180	750	125	·937
F	11 Rural (12 small villages)	900	125	1·125	500	125	·625	1,000	120	1·200
S	12 Agriculture	500	125	·625	1,000	120	1·200	500	125	·625
S	13 Mettur Industrial	1,000	120	1·200	13,900	..	16·707	1,000	120	1·200
	Total Primary Power	13,125	..	15·847	13,600	..	..	14,345	..	17·167
	Demand at Plant (D.F. 1·15 plus 12·5 per cent losses).	12,840	..	..	..	..	..	14,100	..	..
S	14 Mettur Industrial	2,000	80	1·600	2,000	80	1·600	2,000	80	1·600
S	15 Agriculture	1,300	80	1·040	1,400	80	1·120	1,500	80	1·200
	Total Secondary Power	3,300	..	2·640	3,400	..	2·720	3,500	..	2·800
	Demand at Plant (D.F. 1·05 plus 10 per cent losses).	3,460	..	..	3,560	..	..	3,660	..	..
S	16 Mettur Industrial	4,000	40	1·600	4,000	40	1·600	4,000	40	1·600
S	17 Miscellaneous	1,000	40	·400	1,000	40	·400	1,000	40	·400
	Total Tertiary Power	5,000	..	2·000	5,000	..	2·000	5,000	..	2·000
	Demand at Plant (D.F. and losses negligible)	5,000	..	..	5,000	..	..	5,000	..	..
I	18 Madura and Dindigul	7,300	115	8·395	8,200	115	9·430	8,500	115	9·775

CHAPTER 6.

The Madura Extension.

54. A technical description of the Madura Project has been prepared by the Executive Electrical and Mechanical Engineer and is given in Appendix H. An idea of the load prospects is given on page 11, while Table V gives details of the financial prospects of the scheme. It satisfies easily the formula used in the Pykara area for deciding whether an extension is profitable or not, which is briefly—the total revenue in eight years must exceed the capital expenditure on the works.

Table V.

	Load centres. Madura and Dindigul. Demand. K.W.	Rate.	Revenue in lakhs of rupees.	Dharapuram and Palni. Demand. K.W.	Rate.	Revenue in lakhs of rupees.	Total demand. K.W.	Total revenue in lakhs of rupees.
		RS.			RS.			
First year	1,500	120	1·800	120	130	0·156	1,620	1·956
Second year	2,300	120	2·760	150	130	0·195	2,450	2·955
Third year	3,100	115	3·565	180	130	0·234	3,280	3·799
Fourth year	4,000	115	4·600	210	130	0·273	4,210	4·873
Fifth year	4,800	115	5·520	240	130	0·312	5,040	5·832
Sixth year	5,700	115	6·555	270	130	0·351	5,970	6·906
Seventh year	6,500	115	7·475	300	130	0·390	6,800	7·865
Eighth year	7,300	115	8·395	330	130	0·429	7,630	8·824

	RS.
Total revenue in 8 years	43·010 lakhs.
Average annual revenue	5·376 „
Ratio $\frac{\text{Average revenue}}{\text{Capital outlay}}$	16·5 per cent.

The revenue in the first year will be Rs. 1·956 lakhs or 6 per cent of the capital outlay but is expected to rise rapidly to Rs. 8·824 lakhs or 27·2 per cent of the outlay in the eighth year. The average revenue for the eight years is Rs. 5·376 lakhs or 16·5 per cent of the Capital outlay.

55. After a careful study it has been decided to specify two 66 K.V. lines as it will be more economical to add a third 66 K.V. line in future—if ever needed—rather than install two 110/66 K.V. lines now. Once the Periyar Scheme is constructed it is doubtful if the interchange of power between the Pykara and Periyar Systems will exceed the capacity of the two 66 K.V. lines with a suitable synchronous condenser, for a long time. Provision for special voltage regulating equipment has been allowed in the estimates.

56. Owing to the high charging K.V.A. of the transmission system and its influence on stability and voltage regulation, it is not considered advisable to extend the Pykara transmission system to Madura until the Erode-Trichinopoly-Negapatam extension is transferred to Mettur.

57. It is, however, of some importance to supply the Madura district with hydro-power as soon as possible. At the time of writing an accident to a large generating unit in the Madura Power Station has necessitated the purchase of a block of energy from a neighbouring textile mill. The power situation can hardly be regarded as satisfactory and it is doubtful if the load potentialities of the district will be exploited satisfactorily until cheap hydro-power is available.

For a certain period the load will be developed with power from Pykara. When the demand approaches the capacity of the 66 K.V. lines, the Periyar Scheme will presumably be constructed and the area of supply extended east and south. The 66 K.V. transmission lines will then act as tie lines between the two systems as already explained in the Periyar Report.

CHAPTER 7.

Financial.

58. *Conversion Fund.*—This has been a success in the Pykara area. Many industrialists have availed themselves of the facilities granted and the fund has not only been instrumental in securing load for the plant but has undoubtedly been the means of starting factories which might not have otherwise been established. Advances are only granted on electrical equipment but it would be desirable to extend similar facilities to approved parties for the purchase of machinery.

It is assumed that a conversion fund will be available for the Mettur area. The total amount of advances which would probably be required is difficult to estimate at present,

but should be about Rs. 4·2 lakhs which is the same as for the Pykara Scheme. During the construction period a careful investigation would be carried out and the estimates submitted to Government.

59. *Distribution.*—It will be noted that the revenue forecast is based on probable rates at bulk supply points. The greater part of the load will consist of districts where distribution systems have already been constructed by licensees and are in operation, or to large consumers. The electric supply systems of some of the villages which it is proposed to electrify may be owned by the local authorities, but a certain number of the smaller villages and line extensions to agricultural districts may have to be undertaken by the Department. In such cases retail rates are charged and the margin between the wholesale and retail rates will be such that the fixed and operating charges on the added investment will be amply covered. These supplementary estimates will be prepared during construction as each separate scheme is investigated and submitted to Government for sanction. The above procedure has been followed successfully in the Pykara area.

60. *Depreciation.*—This has been calculated from the sixth year in accordance with the principles laid down for the Pykara Works. A similar method has been adopted by the Punjab and United Provinces Hydro-Electric undertakings. It may be of interest to note that the British Grid costing some £40,000,000 has not only postponed depreciation contributions during the development period but, at the outset, is paying debenture interest out of capital. This procedure is fully justified in a public utility scheme of such magnitude and importance.

The sinking fund has been calculated at the rate of interest charged on the capital expenditure and on the 'lives' accepted in the Pykara Report, less five years, to compensate for postponing contributions. The contributions may be changed to correspond to prevailing interest rates as it is presumed that the greater part of the funds will be invested in the properties.

61. *Operation and Maintenance.*—These allowances are taken as 2 per cent of the capital expenditure, a figure arrived at from experience obtained in the Pykara system.

62. *Capital Expenditure.*—The estimated total capital expenditure up to the first year of operation is Rs. 1,30,17,800, but of this amount only Rs. 74,86,000 represents an additional investment, the balance Rs. 55,31,800, is the expenditure already incurred on the pipes and valves at Mettur, the Erode-Salem 22 K.V. system, and the Trichinopoly and Negapatam extensions. These districts lie within the Mettur Hydro-Electric area and will form part of the project. For this reason the expenditure already incurred on the works will be debited to the present scheme.

63. *Financial Results.*—Table VI on page 22, gives the results when calculated at 6 per cent interest, but as it is believed that 5 per cent will represent more nearly the average rate of interest, Table VII has been drawn up. These statements have been prepared in accordance with the rules for productive works.

Table VI shows that with normal load development, a net return of over 4 per cent may be expected in the first year, which is unusually favourable for a project of this nature. In the tenth year the return on the sum at charge is expected to be 8·5 per cent with an accumulated revenue surplus of Rs. 9,67,000. If the average interest rate is fixed at 5 per cent, then the return is 8·22 per cent, owing to the higher contributions for depreciation, but the accumulated surplus has amounted to Rs. 24·26 lakhs. The project should thus prove to be highly remunerative.

It is to be particularly noted that the above forecast assumes a limited industrial development at Mettur and the utilization of a block of tertiary power in the third year.

The project is remunerative even without the inclusion of the revenue due to special industrial loads, but it must be emphasized again that unless Government accept the minimum industrial programme recommended in this report—the development may be either by the State or private enterprise assisted and controlled by the State—these special industries will be started in the neighbouring states. Hyderabad is already proving a serious competitor in the oil industry and considering the construction of a factory for the manufacture of chlorine, caustic soda and bleaching powder. This factory if ever established should be able to supply the needs of Southern India for some years. Madras must however be first in the field.

In view of the prevailing low prices of commodities, the revenue per K.W. has been based on lower figures than actually received in the Pykara area, but if business conditions improve and prices rise, a higher revenue per K.W. may be obtained, if required.

The average revenue per K.W. of primary power demand at Pykara is now Rs. 150 per K.W. per year, while these estimates are based on an average figure of Rs. 123·5.

It will be noticed that a large surplus is anticipated by the tenth year. It is submitted, however, that after a reasonable return on the investment has been assured to Government, the surplus should be devoted to the benefit of the consumers of electrical energy by decreasing rates, extending lines to the less profitable areas for the benefit of the agriculturist, and assisting new industries to establish within the power areas.

Attention may also be directed to the fact that the financial statement does not visualize the sale and distribution of all the available energy at Mettur, and that if the power possibilities of the plant are efficiently developed in conjunction with industrial enterprise, then even more attractive results are possible.

64. To summarize, from whatever angle the project may be examined, it is seen to be a profitable undertaking, if efficiently managed, and it should prove to be a sound investment for Government to make.

Table No. VI.

Financial Forecast.

(Interest rate at 6 per cent.)

Year of operation.	Capital outlay up to the year.	Capital outlay during the year.	Interest at 6 per cent on the capital outlay up to the year plus half outlay during the year.	Operation and maintenance.	Depreciation and renewals.	Total expenses. (5 + 6).	Gross revenue.	Net revenue. (8 − 7).	Net return on capital outlay. 9/2 × 100.	Surplus after deducting interest charges. (9 − 4).	Accumulated surplus.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	RS.	RS.	RS.	RS.	RS.	RS.	RS.	RS.	PER CENT.	RS.	RS.
Construction period ..	1,30,17,800	..	..	..	..	..	..	..	..	..	− 7,00,000 *
1st year	1,30,17,800	9,85,000	8,10,600	2,60,300	..	2,60,300	8,64,400	6,04,100	4·63	− 2,06,500	− 9,06,500
2nd year	1,40,02,800	2,19,000	8,46,700	2,80,000	..	2,80,000	10,47,900	7,67,900	5·48	− 78,800	− 9,85,300
3rd year	1,42,21,800	26,19,200	9,31,900	2,84,500	..	2,84,500	12,36,900	9,52,400	6·70	+ 20,500	− 9,64,800
4th year	1,68,41,000	6,03,500	10,28,600	3,36,800	..	3,36,800	15,27,200	11,90,400	7·07	+ 1,61,800	− 8,03,000
5th year	1,74,44,500	4,29,500	10,59,600	3,48,900	..	3,48,900	17,10,900	13,62,000	7·84	3,02,400	− 5,00,600
6th year	1,78,74,000	1,36,000	10,76,500	3,57,500	2,86,000	6,43,500	18,02,300	11,58,800	6·50	82,300	− 4,18,300
7th year	1,80,10,000	70,000	10,82,700	3,60,000	2,88,100	6,48,100	19,57,300	13,09,200	7·25	2,26,500	− 1,91,800
8th year	1,80,80,000	70,000	10,86,900	3,62,000	2,89,300	6,51,300	20,48,700	13,97,400	7·75	3,10,500	+ 1,18,700
9th year	1,81,50,000	50,000	10,90,500	3,63,000	2,90,400	6,53,400	21,42,700	14,89,300	8·20	3,98,800	+ 5,17,500
10th year	1,82,00,000	..	10,92,000	3,64,000	2,91,200	6,55,200	21,96,700	15,41,500	8·50	4,49,500	+ 9,67,000

* Interest during construction period.

Financial Forecast in the 10th year of operation.

	RS.
Capital outlay	1,82,00,000
Accumulated surplus after payment of all charges including interest	9,67,000
Sum at charge	1,82,00,000
Net revenue	15,41,500
Percentage of return	8·5 per cent.

Table No. VII.

Financial Forecast.

(Interest rate at 5 per cent.)

Year of operation.	Capital outlay up to the year.	Capital outlay during the year.	Interest at 5 per cent on the capital outlay up to the year plus half outlay during the year.	Operation and maintenance.	Depreciation and renewals.	Total expenses. (5 + 6).	Gross revenue.	Net revenue. (8 − 7).	Net return on capital outlay. 9/2 × 100.	Surplus after deducting interest charges. (9 − 4.)	Accumulated surplus.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	RS.	RS.	RS.	RS.	RS.	RS.	RS.	RS.	PER CENT.	RS.	RS.
Construction period ..	1,30,17,800	..	..	..	..	..	..	..	..	..	− 7,00,000*
1st year	1,30,17,800	9,85,000	6,75,500	2,60,300	..	2,60,300	8,64,400	6,04,100	4·64	− 71,400	− 7,71,400
2nd year	1,40,02,800	2,19,000	7,05,600	2,80,000	..	2,80,000	10,47,900	7,67,900	5·48	+ 62,300	− 7,09,100
3rd year	1,42,21,800	26,19,200	7,76,600	2,84,500	..	2,84,500	12,36,900	9,52,400	6·70	1,75,800	− 5,33,300
4th year	1,68,41,000	6,03,500	8,57,100	3,36,800	..	3,36,800	15,27,200	11,90,400	7·07	3,33,300	− 2,00,000
5th year	1,74,44,500	4,29,500	8,83,000	3,48,900	..	3,48,900	17,10,900	13,62,000	7·83	4,79,000	+ 2,79,000
6th year	1,78,74,000	1,36,000	8,97,100	3,57,500	3,30,000	6,87,500	18,02,300	11,14,800	6·25	2,17,700	+ 4,96,700
7th year	1,80,10,000	70,000	9,02,200	3,60,000	3,33,000	6,93,000	19,57,300	12,64,300	7·04	3,62,100	+ 8,58,800
8th year	1,80,80,000	70,000	9,05,800	3,62,000	3,34,000	6,96,000	20,48,700	13,52,700	7·50	4,46,900	+ 13,05,700
9th year	1,81,50,000	50,000	9,08,800	3,63,000	3,36,000	6,99,000	21,42,700	14,43,700	7·95	5,34,900	+ 18,40,600
10th year	1,82,00,000	..	9,10,000	3,64,000	3,37,000	7,01,000	21,96,700	14,95,700	8·22	5,85,700	+ 24,26,300

* Interest charges during construction period.

Financial Results for the 10th year of operation.

	RS.
Capital outlay	1,82,00,000
Accumulated surplus after payment of all charges including interest	24,26,300
Sum at charge	1,82,00,000
Net revenue	14,95,700
Percentage return	8·22 per cent.

CHAPTER 8.

Construction Programme.

65. It is estimated that the scheme can begin operation within three years from date of Government sanction. Specifications for the machinery and equipment will be put in hand in anticipation and should be ready for issue on receipt of sanction. The programme of work would be as follows :—

First year—

(1) Issue of specifications and enquiries for plant. Receipt and scrutiny of tenders—Award of main contracts for plant.
(2) Preliminary work at Mettur Power House site—Foundations.
(3) Transmission line final surveys.
(4) Land acquisition for sub-stations, patrol houses, etc.

Second year—

(1) Superstructure of Mettur Power House.
(2) Power plant begins to arrive—Erection commences.
(3) Erection of transmission line in northern area.
(4) Erection of sub-station buildings.

Third year—

(1) Power House completion.
(2) Plant erection completion.
(3) Transmission line erection completion.
(4) Sub-station erection completion.
(5) Testing preliminary to beginning of operation.

66. The whole of the southern area, comprising the Erode-Trichinopoly-Negapatam extensions would be in operation before Mettur is completed and would be running as part of the Pykara System. Supply to this area will be undertaken from Mettur immediately the Power House is ready. The capital outlay in the southern area will in the first instance be taken on the Pykara system and the debit transferred to Mettur from the first year of operation of the latter.

67. *Capital expenditure.*—The programme of capital expenditure will be as shown in Table No. VIII below. The debit already raised on account of the pipes, gates and valves which have been installed in the course of the construction of the Mettur Dam has been included in the outlay for the first construction year.

Table No. VIII.

Year and period.	Civil Works and Power House.	Transmission lines.	Sub-stations.	Total.
	RS.	RS.	RS.	RS.
Construction period.				
First year	13,40,000	1,00,000	60,000	15,00,000
Second year	14,00,000	12,00,000	2,00,000	28,00,000
Third year	17,60,000	19,00,000	6,06,000	42,66,000
Transfer of debits from Pykara system to Mettur system on account of the southern area—to be done when operation commences.	..	27,58,800	16,93,000	44,51,000
Sub-Total ..	45,00,000	59,58,800	25,59,000	1,30,17,800
Operation period.				
First year	..	7,58,000	2,27,000	9,85,000
Second year	..	1,75,000	44,000	2,19,000
Third year	15,00,000	5,38,200	5,81,000	26,19,200
Fourth year	..	2,49,500	3,54,000	6,03,500
Fifth year	..	2,51,500	1,78,000	4,29,500
Sixth year	..	50,000	86,000	1,36,000
Seventh year	..	50,000	20,000	70,000
Eighth year	..	20,000	50,000	70,000
Ninth year	..	30,000	20,000	50,000
Tenth year	..	..	..	..
Grand total ..	60,00,000	80,81,000	41,19,000	1,82,00,000

Summarizing, the initial capital outlay will be just over Rs. 130 lakhs. Extensions within the first ten years will cost Rs. 52 lakhs, making a total project outlay of Rs. 182 lakhs, but if the debit transfers from sections of the system already in operation are excluded, the net capital initial expenditure is only Rs. 74·86 lakhs.

The proportion of the outlay spent in the different parts of the system is as follows :—

	Stage. Initial.	Final.
	PER CENT.	PER CENT.
Civil Works and Power House	35	33
Transmission lines	45	44
Sub-stations	20	23
Total ..	100	100

Interest Charges.—Interest charges are reckoned at both 5 per cent and 6 per cent in the financial forecast calculations.

Simple interest payable on the moneys utilized during the construction period amounts to Rs. 7 lakhs, and this amount is taken as arrears in simple interest and dealt with in the financial table accordingly.

CHAPTER 9.

Recommendations.

68. For the many economic reasons which have already been advanced in this report and as a further attempt to utilize in an economic manner, part of the water power which is now going to waste in this Presidency, work on the Mettur Power Project ought to be started as soon as possible.

69. As a necessary adjunct to the Power Project, a special expert industrial organization should be immediately formed along the lines already formulated, and an Executive Engineer, Public Works Department, deputed to investigate the possibilities of lift irrigation in the area.

The construction of the power system should take from two and a half to three years. The studies of the industrial and agricultural schemes for the Mettur Power area should be completed in nine months, and sanctioned in 15 months, leaving about 18 months for the erection of the factories and pumping installations—which is considered sufficient time.

Power, industry and agriculture will be suitably co-ordinated, there will be no costly development period for the Power Project to contend with, and the whole enterprise should show a profit from the first year of operation. I am also of the opinion that the Province will derive greater economic benefit eventually if this scheme is adopted and Madras omitted until such time as load and power conditions justify a further increase in the capacity at Pykara. The high voltage line between Mettur and Pykara may then be constructed, lines built to Madras, and power transmitted to that area from both Pykara and Mettur.

70. To summarize—

Having in mind—

(*a*) That this Province offers greater possibilities of a reasonable industrial development than most countries to-day.
(*b*) The satisfactory results of the Pykara Scheme and encouraging commercial outlook.
(*c*) The need of new sources of revenue and employment.
(*d*) The economic policies which all countries are now adopting.

I recommend that—

(1) The broad aspect of the Mettur Hydro-Electric Project in a scheme of national economy and industrialization, as now presented, be recognized.
(2) The construction of the scheme be sanctioned on its financial merits and importance in the national plan of economic development already discussed in these pages.
(3) The following should be immediately formed :—
   (*a*) An expert industrial organization to investigate and carry out the industrial plant referred to in this report.
   (*b*) A Public Works Department Division for the investigation of the possibilities of lift irrigation in hydro-electric areas.
   (*c*) A committee to establish the cottage industrial communities.

(4) As a supplementary work, and in view of the need of cheap hydro-electric power in the Madura district, the construction of the Coimbatore-Madura extension be commenced during the last year of the construction of the Mettur Project so that electrical energy may be transmitted to the Madura district immediately the Trichinopoly and Negapatam loads are transferred to the Mettur Hydro-Electric system.

CHAPTER 10.

Summary of Estimates by Main Heads.

	Cost in lakhs of rupees.		
	Initial.	Anticipated within ten years.	Total.
Civil Works and Power Station	45·00	15·00	60·00
Transmission lines	59·588	21·222	80·81
Sub-stations	25·59	15·60	41·19
Total	130·178	51·822	182·00

Details.

Civil Works and Power Station.

Gates, etc., already installed	* 10·80	..	10·80
Power House buildings	9·30	0·20	9·50
Power House generating and control equipment	14·00	11·20	25·20
Power Station auxiliaries	2·54	1·50	4·04
Tailrace	0·37	..	0·37
Main transformer station	6·11	2·00	8·11
Permanent roads and bridges	0·12	..	0·12
Permanent buildings	1·52	..	1·52
Permanent water-supply and fire protection	0·12	..	0·12
Permanent tools and equipment	0·12	0·10	0·22
Total	45·00 (34·20 plus 10·80).	15·00	60·00

* Already constructed.

All clearing accounts, viz., engineering and construction equipment, establishment and general charges, temporary camp and contingencies have been distributed among the account heads.

Transmission Lines.

		Cost in lakhs of rupees.		
		Initial.	Anticipated within ten years.	Total.
Northern Area.				
1 Mettur-Kanji	66/110 K.V.	13·95	..	13·950
2 Kanji-Polur	,,	..	2·480	2·480
3 Singarappet-Chittoor	66 K.V.	8·82	..	8·820
4 Kanji-Villupuram	,,	..	4·950	4·950
5 Singarappet-Dharmapuri	33 K.V.	..	2·145	2·145
6 Tiruppattur-Krishnagiri	,,	..	1·495	1·495
7 Polur-Vellore	,,	..	2·015	2·015
8 11 K.V. lines	..	0·75	5·500	6·250
Southern Area.				
1 Mettur-Erode	66 K.V.	5·18	..	5·180
2 Erode-Trichinopoly	,,	* 10·40	..	10·400
3 Trichinopoly-Tanjore	,,	† 4·34	..	4·340
4 Tanjore-Negapatam	,,	† 4·50	..	4·500
5 Tanjore-Kumbakonam	33 K.V.	† 1·625	..	1·625
6 Mettur-Erode-Salem	22 K.V.	* 3·410	..	3·410
7 11 K.V. and 22 K.V. local lines	..	‡ 1·029	1·500	2·529
Telephone lines.				
Northern area	..	3·008	1·137	4·145
Southern area	..	* 2·576	..	2·576
		59·588 (32·000 plus 27·588)	21·222	80·810

* Already constructed or under construction as part of Pykara Hydro-Electric System and cost transferred to Mettur Hydro-Electric Project.

† Expected to be constructed or under construction as part of Pykara Hydro-Electric System and cost transferred to Mettur Hydro-Electric Project.

‡ Part expected to be constructed or under construction as part of Pykara Hydro-Electric System and cost transferred to Mettur Hydro-Electric Project.

All clearing accounts, viz., engineering and construction equipment, establishment and general charges, temporary camp and contingencies have been distributed among the account heads.

Substations.

	Voltage.	Cost in lakhs of rupees. Initial.	Anticipated within 10 years.	Total.
Northern Area.				
1 Singarappet switching station	66/110/33	2·00	1·00	3·00
2 Kanji switching station	66/110	0·24	0·07	0·31
3 Tiruppattur	66/33-11	0·66	0·58	1·24
4 Jalarpet	66/11	0·66	..	0·66
5 Vaniyambadi	66/11	0·66	..	0·66
6 Ambur	66/11	0·66	..	0·66
7 Gudiyattam	66/11	0·66	..	0·66
8 Vellore	66/33-11	1·32	1·00	2·32
9 Chittoor	66/11	0·66	..	0·66
10 Future station	66/11	..	0·66	0·66
11 Krishnagiri	33/400	..	0·20	0·20
12 Dharmapuri	33/400	..	0·20	0·20
13 Morappur	33/400	..	0·20	0·20
14 Tiruvannamalai	66/11	..	0·66	0·66
15 Villupuram	66/11	..	2·02	2·02
16 Future station between 14 and 15	66/11	..	0·66	0·66
17 Polur	66/110-33/11	..	1·72	1·72
18 Five future 33 K.V. substations between Polur and Vellore.	33/400	..	1·00	1·00
19 Voltage regulating equipment	..	..	2·00	2·00
Southern Area.				
20 Erode	66/22	3·95* 1·00	..	4·95
21 Karur	66/11	1·00*	..	1·00
22 Trichinopoly	66/11	4·06*	0·97	5·03
23 Tanjore	66/33-33/3·3	1·68†	0·80	2·48
24 Tiruvarur	66/11	1·20†	..	1·20
25 Negapatam	66/11	2·4 †	1·00	3·40
26 Kumbakonam	33/11	0·43†	0·22	0·65
27 33 K.V. substation between Tanjore and Kumbakonam at three places.	33/400	0·15†	0·30	0·45
28 Salem	22	0·10†	..	0·10
29 Bhavani	22/400	0·05†	0·66	0·11
30 6-22 K.V. substations in Erode-Salem and Erode-Mettur lines.	..	0·14	0·28	0·42
31 Mettur	22/400	0·24†	..	0·24
32 Part debit for voltage stabilizing equipment	..	1·67†	..	1·67
Total—Substations		25·59 (8·66 plus 16·93)	15·60	41·19

* Already constructed or under construction as part of Pykara Hydro-Electric System and cost transferred to Mettur Hydro-Electric Project.

† Expected to be constructed or under construction as part of Pykara Hydro-Electric System and cost transferred to Mettur Hydro-Electric Project.

All clearing accounts, viz., engineering and construction, equipment establishment and general charges, temporary camp and contingencies, have been distributed among the account heads.

H. G. Howard,
Chief Engineer for Electricity.

APPENDIX A.

Civil and Hydraulic Design.

General.

As the Cauvery Irrigation system and the Mettur Reservoir Project have already been described in detail in other publications, the salient characteristics of the Dam as they concern the proposed power plant will only be given here.

2. The Reservoir Project was designed purely as an irrigation work and construction was begun in 1925. In the following year it was decided to incorporate, at a low level in the Dam, outlet pipes for the development of hydro-electric power, if required, later.

3. A tentative power scheme was worked out and eventually four cast iron pipes of 8′ 6″ diameter each with the necessary controls were decided on and ordered. These were fitted with needle type discharge valves of 6′ 0″ diameter and jet dispersers for use during construction and for irrigation supply control. The pipes and valves were erected in 1930 and have been in use since.

The inlets are provided with trash screens and emergency shutters as shown in the plan.

4. The Dam is of gravity section and built of rubble masonry in cement mortar. Its height above river bed-level is 180 feet and in addition to the four hydro-electric pipes referred to above, which are 150 feet below F.R.L., there are two sets of irrigation supply sluices, the low level ones being 120 feet below F.R.L. and the high level ones 70 feet.

5. The surplus is passed through an escape some distance away on the left flank. The channel from this joins the river bed about two miles below the Dam and floods will therefore only back up the tail water of the turbines to a slight extent. In the absence of any exact data 6 feet has been assumed for this.

6. The development is designed as a base-load plant to be linked up with Pykara and the steam-station at Madras.

It is proposed to install four variable head Francis turbines, one of which will normally be spare, but all four are required together at occasional periods of low head. The irrigation draft from the Reservoir, excluding surplus, will vary from a maximum of 32,000 cusecs to nothing, though a minimum of 1,000 cusecs will be let down throughout the period of closure.

The head over the pipes varies from 160 feet to 60 feet according to the water level in the Reservoir.

The outputs and drafts for the four turbines together will be 52,000 h.p. taking 4,110 cusecs at the highest head and 10,240 h.p. taking 2,560 cusecs at the lowest.

7. The Reservoir Working Table M-18 has been designed so as to draw off as little water as possible specially for power, consistent with maintaining a minimum output of 10,000 K.W. The lowest actual working head over the turbines shown by the table is 73 feet. This table is taken as the basis of the scheme and shows what power can be generated when the full irrigation ultimately contemplated has been taken up. The present short period of record shows that to maintain this minimum power output small irrigation restrictions would be required in the worst years. It is expected however that a longer period of record and slight modifications in irrigation practice framed so as to make the best use of the water will enable more favourable power results to be obtained. The Table M-18 may therefore be regarded as a conservative estimate.

For the first few years until irrigation is fully developed and the plant is loaded up there will be ample water to completely satisfy both services.

8. The transmission and distribution systems served by the station are described in Appendix B.

The plant is intended to take the base load for its own area eastwards and the Trichinopoly portion of the growing Pykara area. In both, but particularly the former, a considerable seasonal pumping load is expected to be developed for well irrigation.

9. The development will be made in two stages, two units only being put on at first and the other two added in the third or a later year. The power house will be built to its full size however in the first instance as the saving through deferring the construction of the eastern 80 feet of the superstructure would be very little and not worth the inconvenience it would cause.

Water available for power.

10. When the four hydro-electric pipes were put in, it was estimated from the Reservoir Irrigation Working Tables that 2,750 cusecs could be made available for power development continuously throughout the year and the Power Scheme provided for four units, each to be served by a separate pipe capable of discharging 1,000 cusecs, one being spare. These Working Tables provided for the existing irrigation seasons from June 1 to January 15 on the old ayacut of 1,038,000 acres and 43,000 acres under Vadavar extensions, but a postponement of the first-crop area under the Grand Anicut Canal of 258,000 acres from 1st September to 15th February and second-crop area under the same to an extent of only 105,000 acres out of 258,000 acres from 15th February to 31st May.

11. In the summer of 1933 preliminary designs for the plan and power house were prepared for the above conditions of flow. These provided for turbines designed for heads varying from 60 feet to 160 feet, each to take a maximum of about 1,000 cusecs and to have a speed of 167 R.P.M. A normal flow of 850 cusecs at 110 feet head was decided on and the following table shows the output and discharges required at the different heads:—

Head in feet.	Loss of head in pipe, etc., in feet.	Net head in feet.	Actual discharge required in cusecs by each turbine.	Actual discharge in million cubic feet per day by each turbine.	Horse-power.
160	9·0	151·0	1,028	88·8	13,040
150	8·5	141·5	994	85·9	12,320
140	8·0	132·0	962	83·1	11,200
130	7·25	122·75	927	80·1	10,160
120	6·6	113·4	889	76·8	9,120
110	6·2	103·8	849	73·4	8,000 (Normal).
100	5·5	94·5	810	70·0	6,920
90	5·0	85·0	770	66·5	5,840
80	4·5	75·5	725	62·6	4,800
70	4·0	66·0	685	59·2	3,680
60	3·5	56·5	640	55·3	2,560

12. With all four turbines working at the lowest head 10,240 h.p. could be produced with a maximum consumption of 2,560 cusecs. With three working at the highest head 39,120 h.p. could be produced with a consumption of 3,084 cusecs and with four working at the highest head 52,160 h.p. consuming 4,112 cusecs.

13. The Reservoir Working Tables were prepared by the Irrigation Department from measured flows over the period 1916 to 1930 which years include the exceptionally dry one of 1918 and the dry period 1927 to 1929. The former year is the driest in the 50-year period of record of the Pykara catchment and may therefore be taken as the worst year to be expected.

14. They provided for the irrigation demands as then contemplated with a minimum dry weather discharge of 2,750 cusecs and from the flows and heads shown power generation was calculated throughout the period of record.

15. In June 1933, however, the Irrigation Development Board decided against this change in seasons on the New Ayacut with the result that no irrigation draft would be required after the end of January and any water let down between then and June in excess of the 1,000 cusecs being passed on from Sivasamudram, would be special power draft. By restricting the period of irrigation and thus accentuating the seasonal variations these alterations prejudiced power generation considerably, but later modifications in the Reservoir Irrigation Rules have largely eliminated the differences.

16. Fresh tables were prepared based on irrigation drafts conforming to the Rules laid down in Appendix A of Volume IV of the Cauvery Reservoir Project Papers but modified in agreement with the Irrigation Department to meet the new conditions regarding transmission losses and providing for a minimum storage in the reservoir of 14,000 million cubic feet on June 16. These tables provided for old and new areas of 1,038,000 and 301,000 acres, respectively.

17. They showed that with certain permissible restrictions in duty under special circumstances until 24 per cent or 72,000 acres of the new area had been brought under cultivation a minimum continuous power generation of 21,500 h.p. was possible for 95 per cent of the time. The absolute minimum was 16,000 h.p. and applied for less than half a month or only ¼ per cent of the period of record. It was contemplated that this table would be operative for a number of years.

18. A second table providing for the irrigation of the whole of the new area showed a minimum continuous power generation of 14,500 h.p. for 95 per cent of the time and an absolute minimum of 13,000 h.p. for ¼ per cent, with restrictions applied in normal duty supply in the second-crop period.

19. In the meantime further modifications were proposed in the irrigation demands which resulted in the preparation of new draft rules for the reservoir which were published in the *Fort St. George Gazette* of December 12, 1933. Under these rules, amongst other changes, 43,000 acres of what had previously been classified as new area were transferred to the old area and therefore demanded preferential water-rights as regards restriction in duty at times of shortage. The new area was thus reduced from 301,000 to 258,000 acres and the previous power generation tables were no longer applicable.

20. *A new table M-18 was therefore prepared in accordance with the abovementioned rules (referred to hereafter as "1933 Draft Rules") and is appended herewith and taken as the basis of this report. The results are illustrated graphically in chart M-18 and the power duration is extracted in M-19 facing pages 2 and 5.*

In this table the turbine consumptions and outputs given in paragraph 11 supra have been adopted and although it is probable that these characteristics will be modified slightly in accordance with manufacturer's designs, the difference will not be sufficient to appreciably affect the general results shown. The reservoir capacities used in this table are given in Statement I.

STATEMENT I.

METTUR RESERVOIR CAPACITY TABLE.

Reduced level. +	Head over Turbine in feet.	Effective capacity in mill. cubic feet.	Remarks.
639	..	..	Centre line of pipes.
660	..	220	
670	..	1,180	Low level irrigation sluices.
680	..	2,780	
690	60	5,160	Minimum head for which turbines will be designed.
700	70	8,500	
703	73	8,928	Minimum storage in reservoir at any time.
710	80	12,980	
713·5	83·5	14,035	Minimum storage in reservoir on June 16th in any year.
720	90	18,600	High level irrigation sluices.
730	100	25,400	
740	110	33,300	
750	120	42,500	
760	130	53,100	
770	140	65,200	
780	150	78,600	
790	160	93,500	F.R.L. and maximum head over turbines.

21. The table has been so framed as to maintain a minimum continuous power generation of 10,000 K.W. for 100 per cent of the time and shows that with certain restrictions in irrigation duty this can be done. In general whenever the irrigation draft is below that required to generate 10,000 K.W. the draw off from the reservoir is limited to that figure. These restrictions are marked (*a*), (*b*) and (*c*) on the Power chart ; (*a*) and (*c*) being provided for in Volume IV of the C.R.P. papers but (*b*) not. This latter occurs on two occasions in the period of record and is only due to the special power draft to an inappreciable extent. Trials show that the 1933 Draft Rules for irrigation alone are inapplicable without some such restriction and that the reductions proposed are largely necessitated by irrigation.

22. Details of these special restrictions in duty are as follows :—

1918.—The reduction of 40 per cent is applied from August 16th to November 6th. At the commencement of this period the storage in the Reservoir is 24,357 million cubic feet and after applying the reduction the storage is 9,834 million cubic feet on November 7th. During the period 81,627 million cubic feet is drawn for irrigation and the inflow is 70,010 million cubic feet.

If full irrigation duty were allowed the total irrigation draft would be 132,930 million cubic feet and the reservoir would be emptied by about the end of September and there would be a hypothetical deficiency of 48,400 million cubic feet on November 7th. The situation is ameliorated by the fact that during the period 1,361 million cubic feet are let down for special power draft on five days. This quantity is used for irrigation and reduces the restriction to something less than 40 per cent.

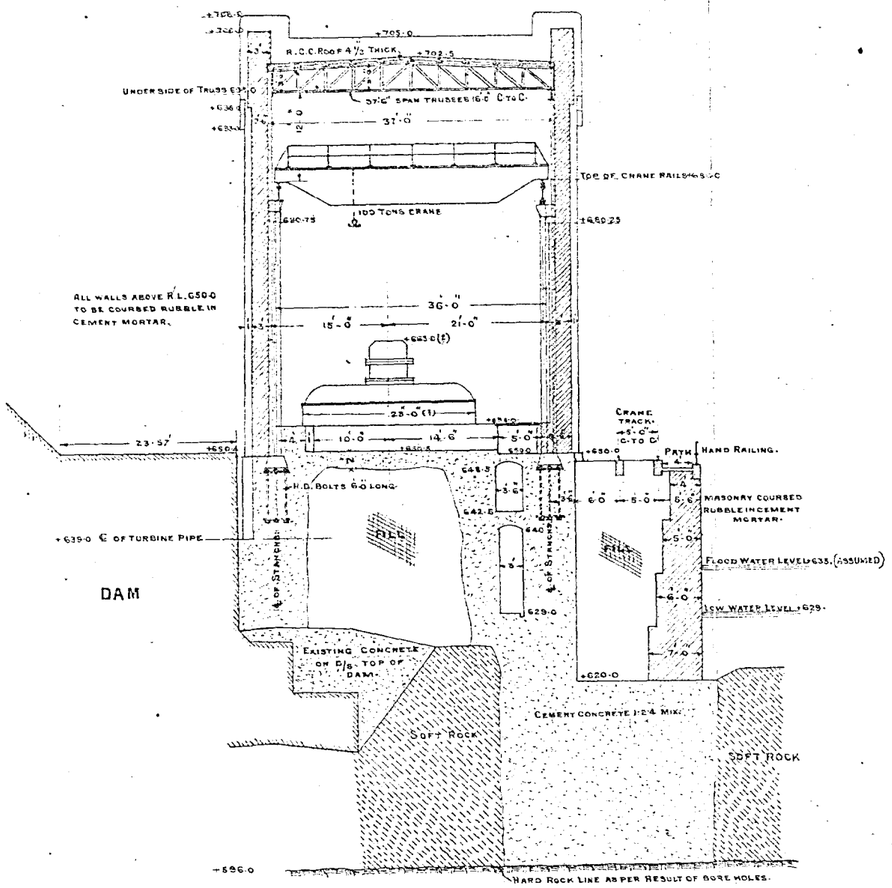
The reservoir is almost full in January 1918 and the special power draft between then and June, over and above the 1,000 cusecs passed down from Sivasamudram is only (17,014 — 12,986) 4,028 million cubic feet.

Even if a surplus is assumed on July 1st and irrigation alone provided for, there would be a deficiency by November 7th of 41,570 million cubic feet.

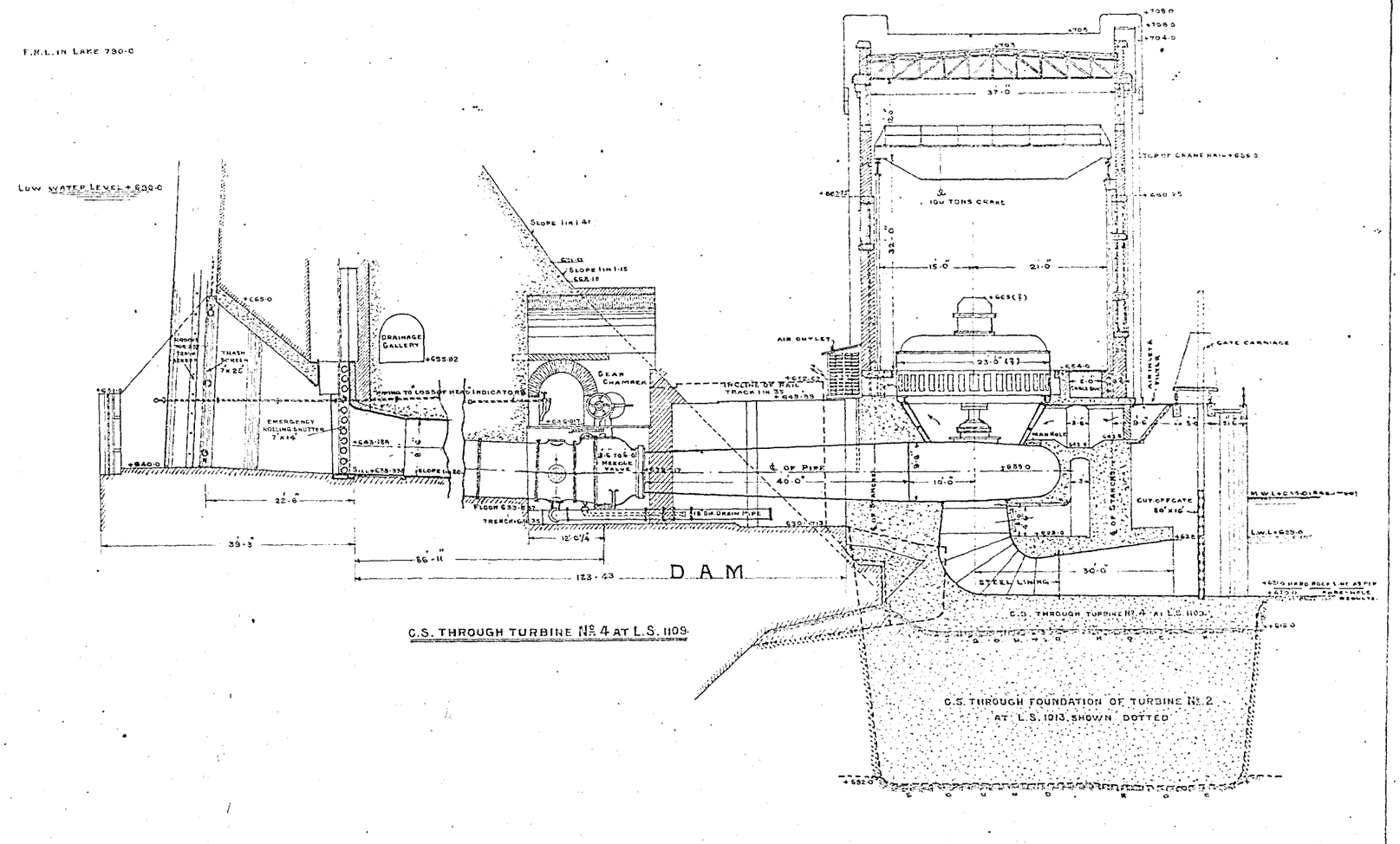
23. 1928.—The reduction of 40 per cent is applied from September 1st to November 15th and would be required for irrigation alone without any special power draft. During the period 114,000 millions cubic feet are drawn off for irrigation against a total requirement of 157,750.

If the full irrigation draft were taken the reservoir would be emptied in October and there would be a deficiency of 41,800 million cubic feet. The reduction in duty would be lessened by about 700 million cubic feet of special power draft being taken during the period and passed into the canals for irrigation.

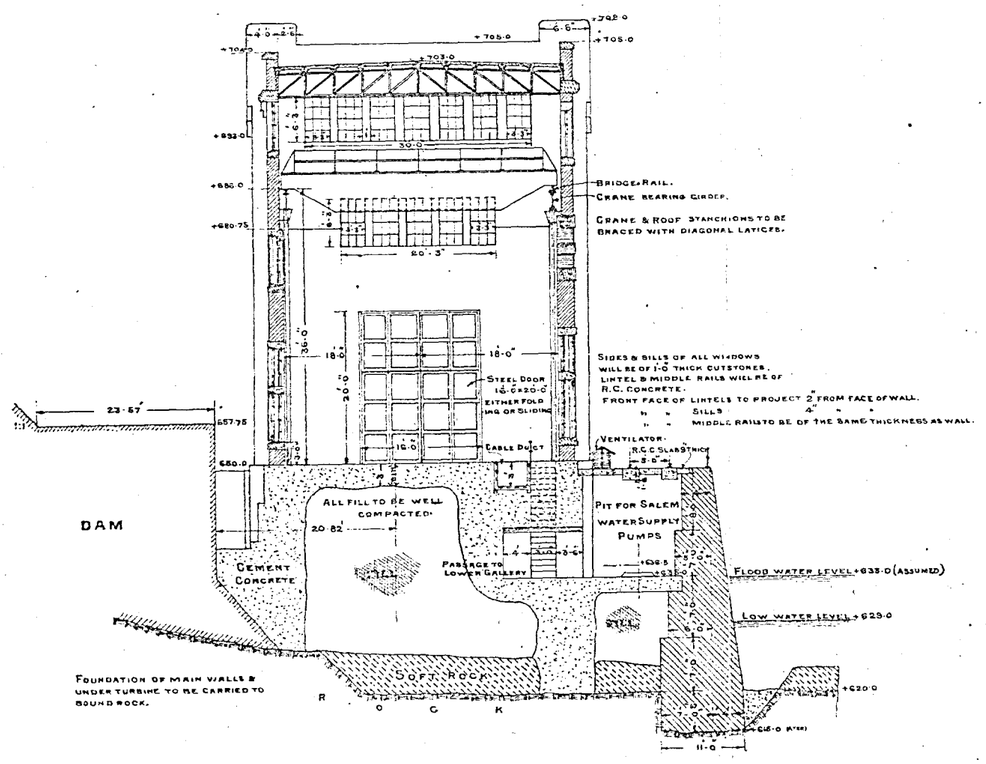
24. To see to what extent the avoidance of these restrictions, in so far as they are caused by special power draft, would have on power generation, a new Table M-18 B has been prepared. This shows the output when no special power draft at all, beyond the 1,000 cusecs always permitted, is taken during the periods of closure which precede the seasons in which irrigation normal duty had to be reduced. A reservoir working rule providing for restriction of power draft during closure to 1,000 cusecs whenever the storage in the reservoir is below 35,000 million cubic feet at the end of the irrigation season enables this to be done.



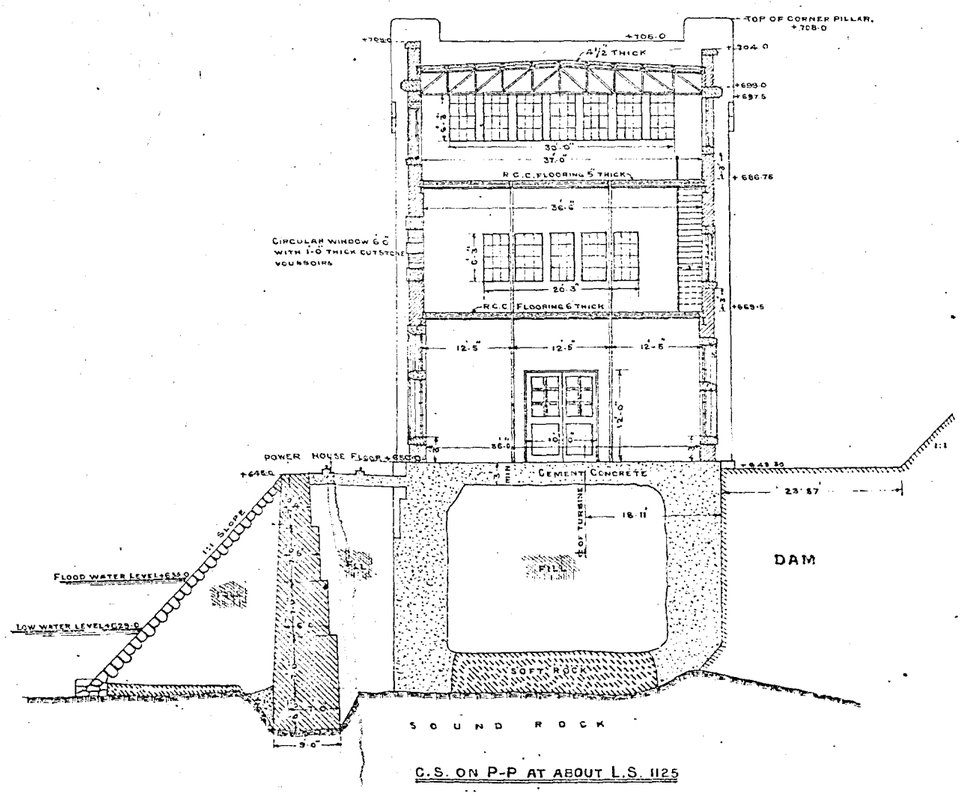
C.S. ON L-L AT ABOUT L.S. 1069.



C.S. THROUGH TURBINE No. 4 AT L.S. 1109.



CROSS SECTION ON M-M AT ABOUT L.S. 935.

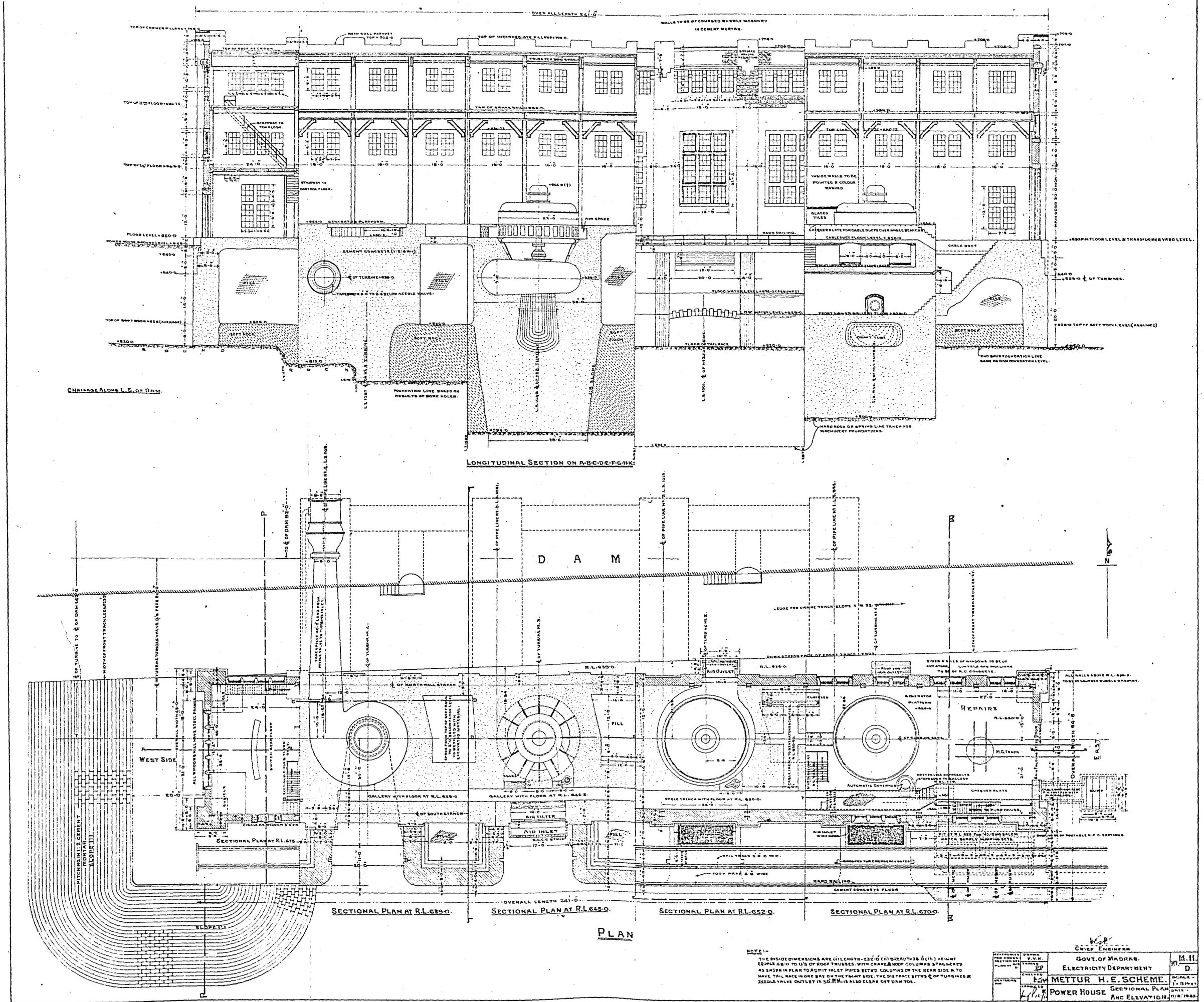


C.S. ON P-P AT ABOUT L.S. 1125

DATA	
NUMBER OF TURBINES	4.
NET HEAD	60 TO 180.
OUT PUT (EACH MACHINE)	4500 TO 6000 HP.
SPEED	167 R.P.M.

Chief Engineer.

REFERENCE	DRAWN K.V.K.	GOVT OF MADRAS ELECTRICITY DEPARTMENT	No. M.112 D
	TRACED	METTUR H.E. SCHEME.	SCALE 1/8"=1'-0"
REVISION.	CHECKED	POWER HOUSE- SECTIONS	DATE 12/5/23
	APPROVED		



NOTE:-

THE INSIDE DIMENSIONS ARE (i) LENGTH = 232'-0" (ii) BREADTH = 38'-0" (iii) HEIGHT EQUALS 48'-0" TO U/S OF ROOF TRUSSES. WITH CRANE & ROOF COLUMNS STAGGERED AS SHOWN IN PLAN TO ADMIT INLET PIPES BETWEEN COLUMNS ON THE REAR SIDE & TO HAVE TAIL RACE IN ONE BAY ON THE FRONT SIDE. THE DISTANCE BETWEEN ℄ OF TURBINES & NEEDLE VALVE OUTLET IS 50'-0". P.H. IS ALSO CLEAR OFF DAM TOE.

Chief Engineer

REFERENCES FOR CONSTRUCTION PLAN OF DAM	DRAWN V.V.K.	GOVT. OF MADRAS. ELECTRICITY DEPARTMENT
	TRACED	METTUR H.E. SCHEME.
	CHECKED	POWER HOUSE SECTIONAL PLAN AND ELEVATION.
PLOTTING	APPROVED	

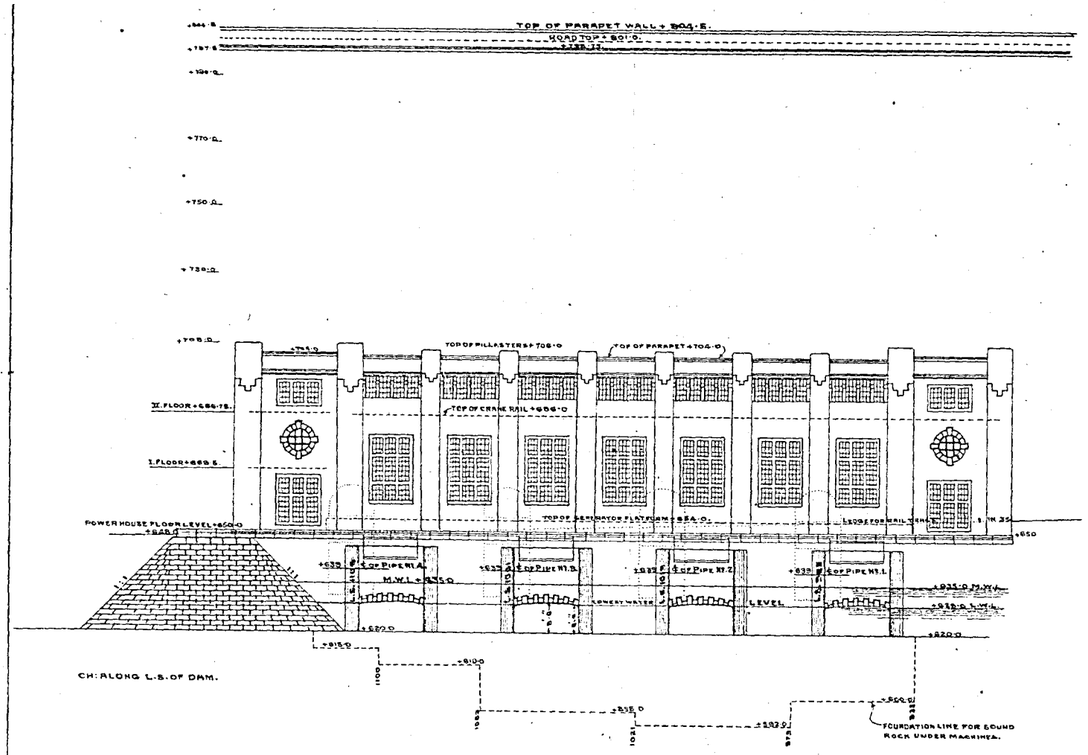
No. M.11. D.

SCALE 1" = 8 FEET

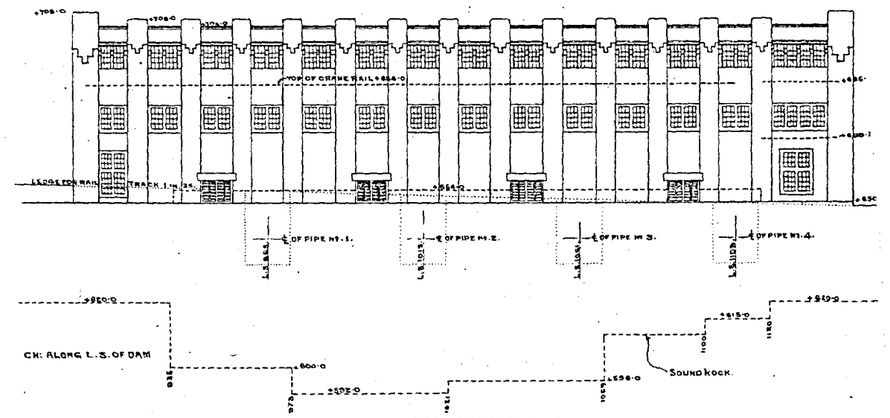
DATE 11/8/1933

REG. NO. 2335 E. COPIES 150.

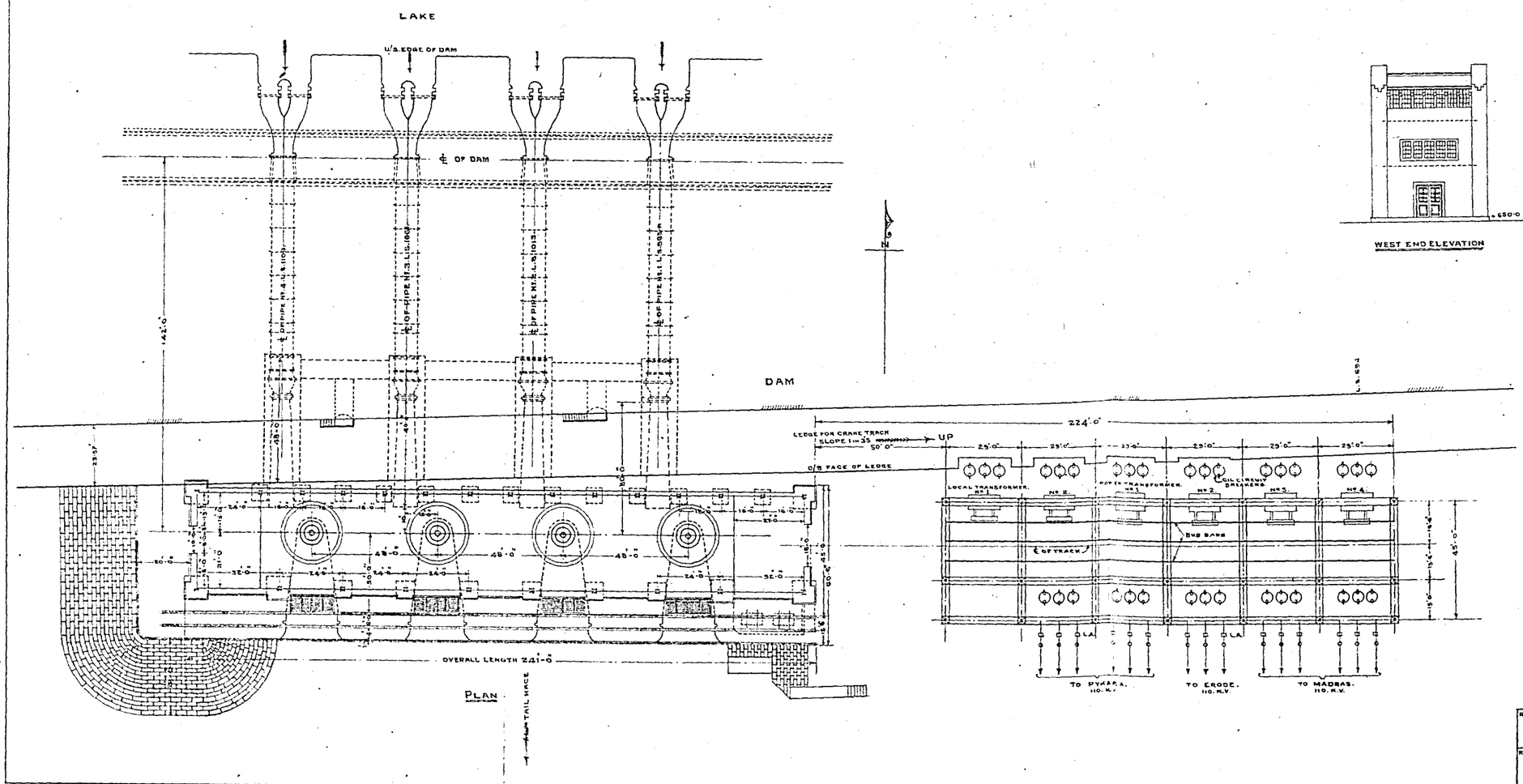
HEAD DRAWN, SURVEY OFFICE, MADRAS. 1933



SOUTH SIDE ELEVATION

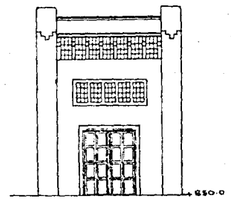


NORTH SIDE ELEVATION



PLAN

WEST END ELEVATION



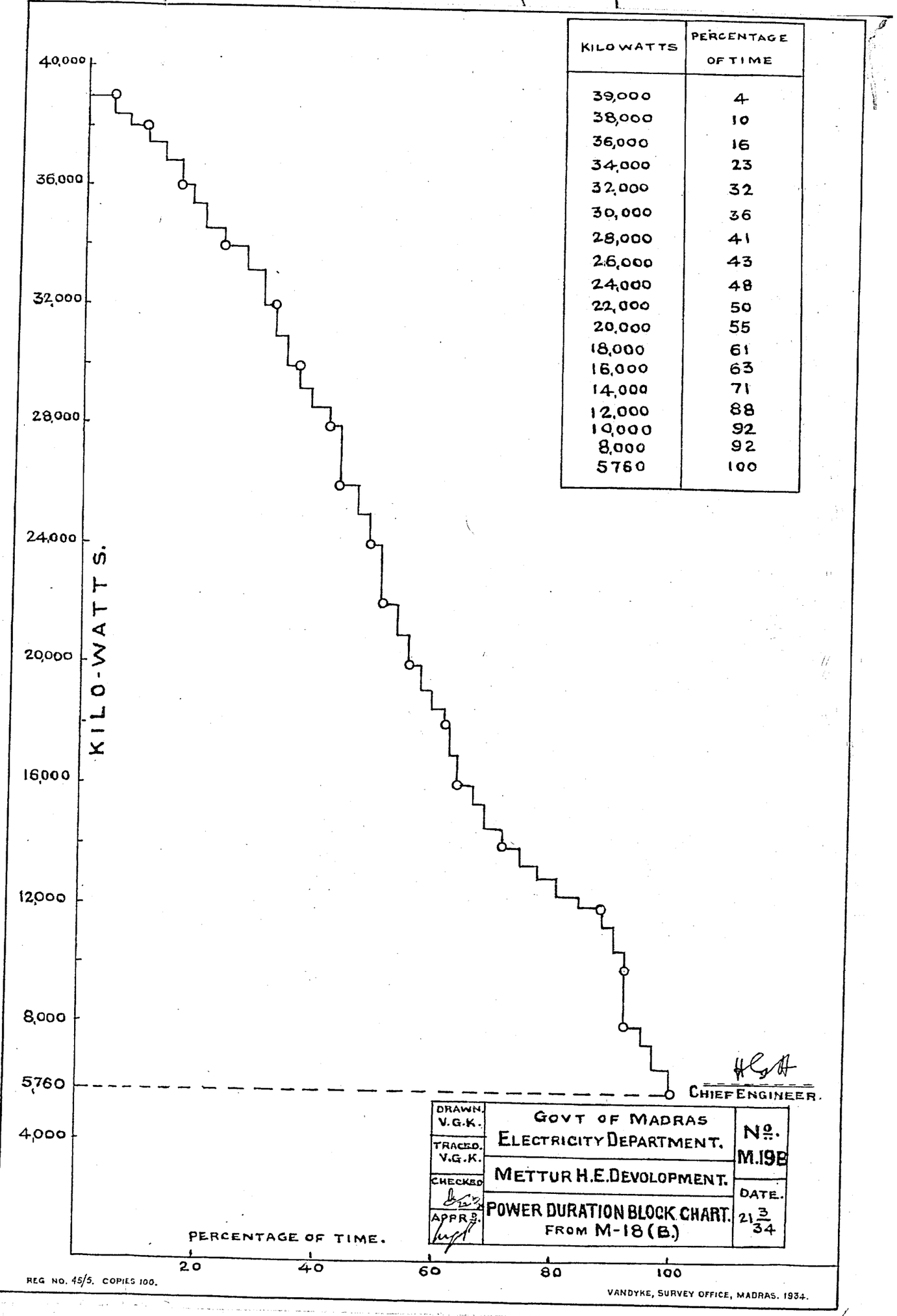
EAST END ELEVATION

CHIEF ENGINEER

REFERENCES FOR	DRAWN K.V.K.	GOVT. OF MADRAS. ELECTRICITY DEPARTMENT.	No. M.10. D.
	TRACED		
REVISION FOR	CHECKED	METTUR H.E. SCHEME	SCALE:- 1"=20.
	APPROVED 12-1-33	POWERHOUSE - GENERAL.	DATE:- 4-8-1933.

HELIO-ZINCO., SURVEY OFFICE, MADRAS. 1933.

REG. No. 213 OCP/EC. 100



KILOWATTS	PERCENTAGE OF TIME
39,000	4
38,000	10
36,000	16
34,000	23
32,000	32
30,000	36
28,000	41
26,000	43
24,000	48
22,000	50
20,000	55
18,000	61
16,000	63
14,000	71
12,000	88
10,000	92
8,000	92
5760	100

25. The table only differs from Table M-18 in the 3 years 1919, 1928 and 1929 and so is only reproduced for those years. It is illustrated by chart M.18-B which shows the power output and irrigation restrictions in the same way as M-18. 1918 is a year of such complete failure that no working rule can be made to apply to it. In the other years in which irrigation restriction had to be applied under Table M-18, M.18-B shows material reductions in these restrictions consequent on the reduced power generation during the preceding closures.

26. Table M. 18-B shows a minimum power production with 1,000 cusecs of 5,760 K.W. which could be generated by 2 turbines working at 0·67 power draft. The power duration for this Table is illustrated in Chart M. 19-B facing this page.

This is the power that can be generated with no interference to irrigation and with four turbines installed. Compared with M-19 it is extremely unattractive as a power scheme, great sacrifices in base power output having to be made to provide for small benefits to irrigation.

27. For the first years, however, until the whole ayacut is taken up for irrigation and until a satisfactorily full load has been built up for power there is no reason for scarifices to either interest.

It is proposed therefore as the first stage of development to instal only two turbines and not to interfere with irrigation in any way.

Chart M. 18-C facing page 4 is a power graph illustrating this and shows the approximate output with both units working.

Spare capacity would be available either from Pykara or by one unit only being required at times. One unit operating at average head of 135 feet and 1·2 power draft will generate 10,000 K.W.

28. It may be noted that in all periods of irrigation closure, either one turbine only or two at partial power draft are required to generate the continuous base load. At these times daily peaks up to the full plant capacity at the concerned head could be met, the minimum being about 8,640 K.W.

29. By the second stage of development the period of record of riverflow measurements will be extended and is expected to show better average results than the short 14½ year period on which M-18 is based. Irrigation requirements will also be more exactly known though it is possible that until the full new area is taken up an unnecessarily liberal supply may be given on account of water plenty.

If the opportunity is taken, experience will also have been gained in changes in irrigation seasons and it may have been found possible to put the Mullings proposals into practice and let down about 2,750 cusecs continuously throughout the closure.

By the time the load on the plant has developed sufficiently therefore to necessitate the installation of the other two units it is probable that the power generation forecast shown in Chart M-18 may be very materially improved.

Power house and plant.

30. As already stated the full development will consist of four variable head Francis turbines of the approximate characteristics given in paragraph 11. The Power House designs show the complete installation. The estimates provide for the full-size building but with two units only being constructed at the first stage and the other two units being installed in the third year. The two first machines will occupy the positions marked 4 and 3 at the western end of the building.

31. The general layout and main architectural features are shown in plan M. 10-D and structural details and sections in M. 11-D and 12-D.

32. The pipes have been built into the Dam at 48 feet centres and as it is desirable for the Power House to be situated as near as possible to the foot of the Dam, this wide spacing necessitates a long and expensive building. Various alternatives were considered to provide a more economical layout than the ordinary type of Power House with overhead travelling crane and rough designs were prepared for

(*a*) an internal travelling gantry instead of the overhead travelling crane :
(*b*) an outdoor station with travelling gantry : and
(*c*) the power station moved downstream sufficiently to enable the pipes to be brought together to 32 feet spacing of the turbines.

None of these alternatives were found to be satisfactory and a steel framed building of the full length with overhead travelling crane has been finally adopted.

33. *Foundations.*—Eight bore holes were sunk at the site in March last and disclosed irregular rock levels. The excavation for the Dam had shown that the sound rock is formed into steep ridges and valleys and at one place the foundations had to be carried down 80 feet below river bed level. The bore holes show sound rock at the reasonably high level of + 620 over the western one-third of the building. Further east, they show layers of soft rock which produce no core, underlying considerable depths of hard rock. Some of the bore holes also showed springs at low levels.

The Executive Engineer, Construction Division (East), who made the borings and had also founded the Dam, was of opinion that the hard rock into which he took the bore holes can be regarded as absolutely sound and an undeniable foundation for the turbines. He based his opinion on his knowledge of the rock under the dam and considered that hard rock may be taken as solid below water spring level.

As a spring occurs in one instance in hard rock which over-lies a layer of soft rock, however, it will be desirable to verify this further when the foundations have been excavated.

For design and estimating purposes, hard rock has been assumed at the levels given by the bore hole results and these have been adopted and are shown in the plans.

The downstream toe of the Dam has not in all cases been carried down to this sound rock level but is stated to be nowhere founded on rock of safe bearing strength lower than 12 tons per square foot. This would normally be considered ample for the Power House but in view of the presence of the underlying strata of soft material, the foundations for a diameter of 30 feet under the turbines are shown as being carried down to the levels indicated by the bore holes. In a few places this will necessitate the demolition for short lengths of a few feet of the toe of the Dam.

This question of the rock foundations to a certain extent influenced the distance at which the turbines are sited below the needle valves and is so fixed that it involves as little demolition as is possible and at the same time provides sufficient length of taper pipe for recovery of pressure head.

A massive track ledge for carrying the construction towers runs on a gradient along the downstream edge of the Dam at about the level of the Power House and is shown in the Sections. This track ledge is of Dam quality masonry and the Power House is sited as close to it as possible without necessitating the demolition of considerable quantities of existing work to get down to the solid rock for the machine foundations.

34. *Building.*—The building will be a steel-framed structure with walls of coursed rubble masonry in cement mortar to be in keeping with the general appearance of the Dam.

In order to provide an uninterrupted waterway for the draft tubes and at the same time to avoid placing stanchions over the inlet pipes, it has been necessary to design the steelframe in 24 feet bays on the downstream side and 16 feet bays on the upstream side. This necessitates the roof trusses being carried from the upstream stanchions to intermediate points between the downstream stanchions. Manufacturers may be able to offer better means of getting over this difficulty but the spacing and positions of the stanchions as shown should be adhered to.

A 100-ton overhead travelling crane will run the full length of the machine room and the repair shop. The western end of the building is designed in three stories to accommodate the switchgear, house transformers, batteries, office, etc., and the eastern end which is covered by the travelling crane will serve as the repair shop for both the power plant and the transformers which are immediately east of it.

The roof will be of reinforced concrete carried on the abovementioned steel trusses.

35. *Downstream cut-off gates.*—Grooves have been provided in the downstream walls to accommodate these gates which will be 20′ × 16′ and there will be a 5 feet gauge track along the face of the building on which the gate-carriage will run. It is proposed to have one gate only mounted on its own carriage which can be moved from one tail race to another according to which machine is required to be isolated.

A space of 3 feet has been provided between these gates and the draft tube to enable easy access to be obtained to the latter.

36. *Salem water-supply pumps.*—At the eastern end opposite to and with access from the repair shop a basement annexe has been provided to accommodate the Salem Water-Supply pumps which are proposed to be installed to pump water from the tail race to a high level reservoir.

37. *Transformer yard.*—This will be immediately east of the Power House and the layout of the structures is shown in plan M. 10-D. The yard will be graded to the same level as the Power House floor. Three main H.T. lines will emanate from here, one to the east towards Madras and two to the south-west to Erode. A fourth is shown in the drawing as going to Pykara but this will not be required until the second stage. All three lines leave the yard on the south and will be turned on their terminal towers. Those to Erode and Pykara will follow the same route for some miles and can span the river bed from terminal towers on the western bank.

38. *Estimates.*—Detailed estimates for the Power House building have been prepared based on costs of similar items of work in connexion with the Dam but increased suitably to allow for greater intricacy and smaller quantities.

The rates presume that local materials required in large quantities such as, building stone, concrete aggregate and sand, will be collected while the Mettur plant is still working. It would also cheapen the foundation work if the excavation can be completed while the Dam quarry contractors and larger air compressor plant are still available.

The total cost of the complete building comes to Rs. 8,20,000 but if the machines are brought to 32 feet centres, which is an alternative design that was considered, a net saving of about Rs. 1,25,000 might be effected.

A summary of the Civil Engineering estimates have been combined with those for the electrical works and included in the estimates of the Executive Electrical and Mechanical Engineer shown in Appendix B.

Detailed estimates are on file.

M. G. PLATTS,
Executive Engineer, Civil Engineering Division.

TABLE No. M-18.

Mettur Hydro-Electric Development.

Reservoir Working Table for the period of Record 1916 to 1930 based on the irrigation drafts as per rules published in the *Fort St. George Gazette* on 8th December 1933 and special power drafts required at other times to maintain a minimum power output of 10,000 K.W. continuous except on flood days during irrigation season when 20,000 is aimed at. The above rules provide for irrigation drafts as per appended Duty Statements (*a*), (*b*), (*c*) and (*d*) which are maintained except for short periods when reductions in duty, as noted, have to be applied.

These reductions are only partially necessitated by the special power drafts and are required to some extent by the irrigation draft alone.

	Acres.
Existing ayacut: Single crop	904,000 (includes 31,000 acres under Vadavar Extension.)
Existing ayacut: Double crop	159,500 (,, 12,000 do.)
New ayacut: Single crop	186,000 do.
New ayacut: Double crop	72,000 do.
Total	1,321,500

The table has been prepared for the following additional working rules:—

(1) The storage in the reservoir is not allowed to fall below 14,000 million cubic feet on June 1st in any year.
(2) Do. do.
(3) Whenever the storage in the reservoir is below 45,000 million cubic feet at any time. 8,800 million cubic feet at the end of the irrigation season (January 15th or 31st) the special power draft during the following closure is limited to that required to generate 10,000 K.W. continuous. For higher storages the generation during closure has been regulated to the permissible special power draft, though in actual operation these would have to be predetermined according to a draft-storage scale.

Month and year.	Reservoir losses.			Irrigation.		Power.					Power generation.				
						Consumption and number of turbines.									
	Reservoir capacity at beginning of month in million cubic feet.	Inflow in million cubic feet.	Irrigation draft in million cubic feet.	Transmission losses in million cubic feet.	Evaporation losses in Reservoir in million cubic feet.	Head in feet.	In cusecs.	In million cubic feet.	Special power draft in million cubic feet.	Totals of columns (4), (5), (6) and (10).	Reservoir capacity at end of the month in million cubic feet.	Continuous K.W. from three units or less.	K.W.	Number of days available.	Total K.W.	Remarks.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
1916.																
June .. 1–15	14,000	13,799	..	..	− 196	95	790 × 3 × 0·7.	2,150	− 2,150	− 2,346	25,453	10,050	..	..	10,050	
16–30	25,453	27,275	− 11,359	..	− 250	110	(840 × 3) (840 × 4)	3,450	− 2,277*	− 13,886	38,842	(18,000) 18,000	..	..	(18,000) 24,000	First crop starts on 16th June.
July .. 1–15	38,842	29,511	− 10,558	..	− 238	125	908 × 4	4,707	− 376	− 11,172	57,183	21,690	6,000	½	23,920	
16–31	57,183	23,845	− 24,120	− 10	− 205	132½	930 × 4	5,174	− 73*	− 24,508	56,460	23,450	7,230	15	31,260	Single crop starts on 16th July.
August .. 1–15	56,460	48,098	− 33,131	− 10	− 310	140	962 × 4	4,986	− 894*	− 34,345	70,813	25,200	8,400	15	33,600	
16–31	70,813	37,241	− 18,573	..	− 340	150	994 × 4	5,498	..	− 18,913	89,141	27,720	9,240	16	36,960	
September .. 1–15	89,141	28,185	− 25,031	− 52	− 377	160	1,028 × 4	5,328	− 355*	− 25,815	91,511	29,340	9,780	15	39,120	First crop ends on 15th September.
16–30	91,511	34,164	− 18,415	..	− 380	160	1,028 × 4	5,328	− 1,776	− 20,671	105,104	29,340	9,780	15	39,120	
October .. 1–15	93,500	21,256	− 17,855	− 23	− 328	160	1,028 × 4	5,328	..	− 18,206	93,500	29,340	9,780	15	39,120	
16–31	93,500	43,401	− 31,151	..	− 228	160	1,028 × 4	5,683	− 1,066	− 32,545	93,500	29,340	9,780	16	39,120	Second crop starts on 16th October.

Month and year.		Reservoir capacity at beginning of month in million cubic feet.	Inflow in million cubic feet.	Reservoir losses. Irrigation. Irrigation draft in million cubic feet.	Reservoir losses. Irrigation. Transmission losses in million cubic feet.	Reservoir losses. Evaporation losses in Reservoir in million cubic feet.	Reservoir losses. Power. Head in feet.	Reservoir losses. Power. Consumption and number of Turbines. In cusecs.	Reservoir losses. Power. Consumption and number of Turbines. In million cubic feet.	Special power draft in million cubic feet.	Totals of columns (4), (5), (6) and (10).	Reservoir capacity at end of the month in million cubic feet.	Power generation. Continuous K.W. from three units or less.	Power generation. Additional power possible from 4th turbine. K.W.	Power generation. Additional power possible from 4th turbine. Number of days available.	Power generation. Total K.W.	Remarks.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	15)	(16)	(17)
1916.																	
November ..	1–15	93,500	20,360	– 5,056	..	– 260	160	1,028 × 4 ..	5,328	– 2,131	– 7,447	(106,413 / 93,500)	29,340	9,780	15	39,120	
	16–30	93,500	28,446	– 9,647	..	– 260	160	1,028 × 4 ..	5,328	– 1,035	– 10,942	(111,004 / 93,500)	29,340	9,780	15	39,120	
December ..	1–15	93,500	7,209	– 3,023	..	– 260	160	1,028 × 4 ..	5,328	– 2,305	– 5,588	(95,121 / 93,500)	29,340	9,780	15	39,120	
	16–31	93,500	6,944	– 5,039	– 8	– 260	160	1,028 × 4 ..	5,683	– 319	– 6,526	(93,918 / 93,500)	29,340	9,780	16	39,120	Single crop ends on 31st December.
1917.																	
January ..	1–9	93,500	2,893	– 2,144	..	– 156	160	1,028 × 3 ..	2,398	– 254	– 2,554	(93,839 / 93,500)	29,340	..	..	29,340	
	10–15	93,500	1,254	– 1,647	– 10	– 104	160	1,028 × 3 ..	1,598	..	– 1,761	92,993	29,340	..	..	29,340	
	16–31	92,993	3,707	– 5,716	– 54	– 260	160	1,028 × 3 ..	4,262	– 96*	– 6,126	90,574	29,340	..	..	29,340	Second crop ends on 31st January.
February ..	1–28	90,574	2,408	..	..	– 502	157½	1,020 × 2 × 0·7.	3,453	– 3,453	– 3,955	89,027	13,500	..	..	13,500	
March ..	1–31	89,027	2,666	..	..	– 750	156	1,014 × 2 × 0·7.	3,802	– 3,802	– 4,552	87,141	13,390	..	..	13,390	
April ..	1–30	87,141	2,580	..	..	– 1,100	155	1,010 × 2 × 0·7.	3,669	– 3,669	– 4,769	84,952	13,310	..	..	13,310	
May ..	1–31	84,952	2,666	..	..	– 1,200	154	1,008 × 2 × 0·7.	3,780	– 3,780	– 4,980	82,638	13,240	..	..	13,240	
June ..	1–15	82,638	4,139	– 7,479	– 1,248	– 410	150	994 × 4 ..	5,154	– 75	– 9,212	77,559	27,720	9,240	15	36,960	First crop starts on 1st June.
	16–30	77,559	14,818	– 6,927	– 76	– 417	152	1,001 × 4 ..	5,190	– 692*	– 8,112	84,265	28,040	9,350	15	37,390	
July ..	1–15	84,265	15,647	– 28,383	– 344	– 310	150	994 × 4 ..	5,154	..	– 29,037	70,875	27,720	9,240	15	36,960	Single crop starts on 1st July.
	16–31	70,875	16,300	– 26,961	– 400	– 290	140	962 × 4 ..	5,318	..	– 27,651	59,524	25,200	8,400	16	33,600	
August ..	1–15	59,524	22,473	– 27,438	– 192	– 285	132½	936 × 4 ..	4,851	..	– 27,915	54,082	23,450	7,810	15	31,260	10 per cent reduction of normal duty supply from 1st August to 15th September.
	16–31	54,082	28,024	– 23,898	– 115	– 285	132½	936 × 4 ..	5,174	– 323	– 24,621	57,485	23,450	7,810	16	31,260	First crop ends on 31st August.
September.	1–15	57,485	27,729	– 15,690	– 28	– 310	140	962 × 4 ..	4,986	– 920	– 16,948	68,316	25,200	8,400	15	33,600	
	16–30	68,316	31,398	– 16,237	..	– 333	147½	986 × 4 ..	5,112	– 1,439*	– 18,009	81,705	27,090	9,030	15	36,120	
October ..	1–15	81,705	23,317	– 13,398	..	– 310	155	1,011 × 4 ..	5,241	– 1,123*	– 14,831	90,191	28,530	9,510	15	38,040	Second crop starts on 1st October.
	16–31	90,191	29,517	– 19,253	– 3	– 327	160	1,028 × 4 ..	5,683	– 1,776	– 21,359	(98,349 / 93,500)	29,340	9,780	16	39,120	
November ..	1–15	93,500	12,279	– 8,423	..	– 260	160	1,028 × 4 ..	5,328	– 146	– 8,829	(96,950 / 93,500)	29,340	9,780	15	39,120	
	16–30	93,500	15,070	– 3,049	..	– 260	160	1,028 × 4 ..	5,328	– 2,131	– 5,180	(103,390 / 93,500)	29,340	9,780	15	39,120	
December ..	1–15	93,500	6,310	– 5,543	..	– 260	160	1,028 × 4 ..	5,328	– 2,329	– 5,632	(94,178 / 93,500)	29,340	9,780	15	39,120	Single crop ends on 15th December.
	16–20	93,500	1,926	– 642	..	– 85	160	1,028 × 4 ..	1,776	– 1,134	– 1,861	(93,565 / 93,500)	29,340	9,780	6	39,120	
	21–31	93,500	3,008	– 2,925	– 5	– 175	160	1,028 × 3 ..	2,930	– 69	– 3,174	93,334 / ..	29,340	..	..	29,340	

Month and year.		Reservoir capacity at beginning of month in million cubic feet.	Inflow in million cubic feet.	Reservoir losses. Irrigation. Irrigation draft in million cubic feet.	Reservoir losses. Irrigation. Transmission losses in million cubic feet.	Reservoir losses. Evaporation losses in Reservoir in million cubic feet.	Reservoir losses. Power. Head in feet.	Reservoir losses. Power. Consumption and number of Turbines. In cusecs.	Reservoir losses. Power. Consumption and number of Turbines. In million cubic feet.	Special power draft in million cubic feet.	Totals of columns (4), (5), (6) and (10).	Reservoir capacity at end of the month in million cubic feet.	Power generation. Continuous K.W. from three units or less.	Power generation. Additional power possible from 4th turbine. K.W.	Power generation. Additional power possible from 4th turbine. Number of days available.	Power generation. Total K.W.	Remarks.
1918.																	
January ..	1–15	93,334	3,289	– 5,269	– 50	– 260	160	1,028 × 4 ..	5,328	– 337	– 5,916	90,707	29,340	9,780	15	39,120	Second crop ends on 15th January.
	16–31	90,707	1,857	..	..	– 250	157½	1,028 × 2 × 0·7.	1,973	– 1,973	– 2,223	90,341	13,500	..	..	13,500	
February ..	1–28	90,341	2,408	..	..	– 500	157½	1,028 × 2 × 0·7.	3,453	– 3,453	– 3,953	88,796	13,500	..	..	13,500	
March ..	1–31	88,796	2,666	..	..	– 750	156	1,014 × 2 × 0·7.	3,802	– 3,802	– 4,552	86,910	13,390	..	..	13,390	
April ..	1–30	86,910	2,580	..	..	– 1,100	155	1,010 × 2 × 0·7.	3,669	– 3,669	– 4,769	84,721	13,310	..	..	13,310	
May ..	1–31	84,721	2,666	..	..	– 1,200	154	1,008 × 2 × 0·7.	3,780	– 3,780	– 4,980	82,407	13,240	..	..	13,240	
June ..	1–15	82,407	11,202	– 9,535	– 566	– 420	154	1,008 × 4 ..	5,226	– 458	– 10,979	82,630	28,450	9,480	15	37,930	First crop starts on 1st June
	16–30	82,630	14,725	– 8,832	– 987	– 420	154	1,008 × 4 ..	5,226	– 439	– 10,670	86,677	28,450	9,480	15	37,930	
July ..	1–15	86,677	19,950	– 30,771	– 271	– 320	150	994 × 4 ..	5,154	..	– 31,362	75,265	27,720	9,240	15	36,960	Single crop starts on 1st July.
	16–31	75,265	6,505	– 33,700	– 680	– 280	137½	954 × 4 ..	5,220	..	– 34,660	47,110	24,620	8,200	16	32,820	
August ..	1–15	47,110	3,532	– 25,515	– 550	– 220	115	869 × 4 ..	4,506	..	– 26,285	24,357	19,260	6,420	15	25,680	10 per cent reduction of normal duty supply from 1st to 15th August.
	16–31	24,357	30,303	– 18,408	– 35	– 203	107½	840 × 4 ..	4,643	– 1,161	– 19,807	34,853	17,400	5,800	16	23,200	40 per cent reduction of normal duty supply from 16th August to 6th November except on days of surplus flow from free catchment.
September.	1–15	34,853	13,782	– 16,664	– 118	– 209	110	849 × 4 ..	4,404	..	– 16,991	31,644	18,000	6,000	15	24,000	
	16–30	31,644	10,455	– 17,719	– 175	– 184	102½	820 × 4 ..	4,251	..	– 18,078	24,021	16,180	5,380	15	21,560	
October ..	1–15	24,021	7,377	– 15,363	– 200	– 130	92½	780 × 4 ..	4,044	..	– 15,693	15,705	13,750	4,580	15	18,330	Second crop starts on 1st October.
	16–31	15,705	6,862	– 11,340	– 120	– 110	82½	736 × 4 ..	4,070	– 200	– 11,770	10,797	11,390	3,790	16	15,180	
November ..	1–6	10,797	1,231	– 2,133	– 23	– 38	75	705 × 4 ..	1,462	..	– 2,194	9,834	9,540	3,180	6	12,720	
	7–15	9,834	7,524	– 844	..	– 60	82½	736 × 3 ..	1,717	– 1,195	– 209	15,259	11,390	..	..	11,390	Full normal duty supply from 7th November.
	16–30	15,259	17,888	– 9,372	..	– 105	92½	780 × 3 × 0·8. 810 × 3 × 0·8	2,966	– 1,618*	– 11,095	22,052	11,000 12,460	..	..	11,000 12,460	Single crop ends on 15th December.
December ..	1–15	22,052	8,042	– 3,378	..	– 123	100	810 × 4	3,864	– 505*	– 4,006	26,088	15,570	5,190	12	20,760	
	16–31	26,088	3,647	– 458	..	– 126	102½	820 × 3 × ¾ ..	2,391	– 2,097	– 2,681	27,054	12,130	..	..	12,130	
1919.																	
January ..	1–15	27,054	2,408	– 5,019	– 65	– 124	100	810 × 4 ..	4,200	..	– 5,208	24,254	15,570	5,190	15	20,760	Second crop ends on 15th January.
	16–31	24,254	2,146	..	..	– 120	97½	800 × 3 × 0·7.	2,322	– 2,322	– 2,442	23,958	10,470	..	..	10,470	
February ..	1–28	23,958	2,408	..	..	– 240	97½	800 × 3 × 0·7.	4,064	– 4,064	– 4,304	22,062	10,470	..	..	10,470	
March ..	1–31	22,062	2,666	..	..	– 335	94	786 × 3 × ¾ ..	4,736	– 4,736	– 5,071	19,657	10,580	..	..	10,580	
April ..	1–30	19,657	2,580	..	..	– 465	90	770 × 3 × 0·8.	4,788	– 4,788	– 5,253	16,984	10,510	..	..	10,510	
May ..	1–31	16,984	2,666	..	..	– 492	86	752 × 3 × 0·85.	5,134	– 5,134	– 5,626	14,024	10,370	..	..	10,370	
June ..	1–15	14,024	2,700	..	..	– 163	84	743 × 3 × 7/8. 790 × 4	2,526	– 2,526	– 2,689	14,035	10,270 14,360	.. 4,780	.. 2	10,270 19,140	
	16–30	14,035	21,519	– 5,884	– 242	– 198	95	790 × 3 ..	3,549	– 1,507*	– 7,831	27,723	14,360	..	..	14,360	First crop starts on 16th June.
								790 × 4					14,360	4,780	5	19,140	
								834 × 4					17,030	5,680	5	22,700	Single crop starts on 1st July.
July ..	1–15	27,723	13,081	– 7,128	..	– 189	106	834 × 3 ..	3,628	– 2,106*	– 9,423	31,381	17,030	..	..	17,030	
	16–31	31,381	23,803	– 28,690	– 301	– 178	105	830 × 4 ..	4,589	..	– 29,169	26,015	16,780	5,600	16	22,380	
								859 × 3					18,630	..	..	18,630	
August ..	1–15	26,015	53,011	– 34,297	..	– 215	112½	859 × 4 ..	4,232	– 668	– 35,180	43,846	18,630	6,210	12	24,840	10 per cent reduction of normal duty supply from 1st to 15th August.
	16–31	43,846	34,869	– 28,197	– 11	– 255	125	903 × 4 ..	5,021	..	– 28,463	50,252	21,690	7,230	16	28,920	10 per cent reduction on old area and 40 per cent on new area from 16th to 31st August.
September ..	1–15	50,252	26,959	– 28,755	– 89	– 265	127½	910 × 4 ..	4,757	..	– 29,109	48,102	22,270	7,430	15	29,700	First crop ends on 15th September. 10 per cent reduction of N.D.S. from 1st September to 15th October.
	16–30	48,102	35,696	– 20,597	– 1	– 282	132½	936 × 4 ..	4,851	..	– 20,880	62,918	23,450	7,810	15	31,260	
October ..	1–15	62,918	32,854	– 34,413	– 119	– 260	137½	953 × 4 ..	4,941	..	– 34,792	50,980	24,620	8,200	15	32,820	
	16–31	60,980	26,954	– 28,606	– 802	– 250	135	945 × 4 ..	5,222	..	– 29,658	58,276	24,030	8,010	16	32,040	Second crop starts on 16th October.
November ..	1–15	58,276	12,169	– 2,801	..	– 208	137½	953 × 4 ..	3,492	– 2,174*	– 5,183	65,262	24,620	8,200	15	32,820	
								978 × 3 × 0·8.					21,170	..	..	21,170	
	16–30	65,262	21,165	– 8,872	..	– 225	145	978 × 4	4,654	– 910*	– 8,585	77,842	26,460	8,820	12	35,280	
December ..	1–15	77,842	4,031	– 868	..	– 235	150	994 × 3 × 0·7.	2,706	– 2,003*	– 2,742	79,131	19,400	..	..	19,400	Single crop ends on 15th December.
	16–31	79,131	5,741	– 1,125	..	– 235	150	994 × 3 × 0·7.	1,886	– 1,760*	– 3,120	81,752	19,400	..	..	19,400	

Month and year.	Reservoir capacity at beginning of month in million cubic feet.	Inflow in million cubic feet.	Irrigation. Irrigation draft in million cubic feet.	Irrigation. Transmission losses in million cubic feet.	Reservoir losses. Evaporation losses in Reservoir in million cubic feet.	Reservoir losses. Power. Consumption and number of turbines. Head in feet.	Reservoir losses. Power. Consumption and number of turbines. In cusecs.	Reservoir losses. Power. Consumption and number of turbines. In million cubic feet.	Reservoir losses. Power. Consumption and number of turbines. Special power draft in million cubic feet.	Reservoir losses. Totals of columns (4), (5), (6) and (10).	Reservoir capacity at end of the month in million cubic feet.	Power generation. Continuous K.W. from three units or less.	Power generation. Additional power possible from 4th turbine. K.W.	Power generation. Additional power possible from 4th turbine. Number of days available.	Power generation. Total K.W.	Remarks.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
1920.																
January ..	81,419	2,820	— 912	..	— 210	152½	1,003 × 3 × 0·7	2,728	— 2,001 *	— 3,163	81,182	19,600	..	..	19,600	Second crop ends on 31st January.
16–31	81,182	3,210	— 2,085	— 12	— 225	160	994 × 3 × 0·7	2,880	— 1,124 *	— 3,456	81,182	19,400	..	..	19,400	
February ..	81,182	2,494	..	..	— 417	160	994 × 2 × 0·8	3,848	— 3,848	— 4,318	79,550	14,780	..	..	14,780	
March ..	79,350	2,066	..	..	— 706	160	994 × 2 × 0·8	4,200	— 4,260	— 4,966	77,059	14,780	..	..	14,780	
April ..	77,059	2,580	..	..	— 1,030	147½	986 × 2 × 0·8	4,000	— 4,090	— 5,120	74,519	14,420	..	..	14,420	
May ..	74,519	2,066	..	..	— 1,130	146	981 × 2 × 0·8	4,206	— 4,506	— 5,336	71,849	14,260	..	..	14,260	
June ..	71,849	1,915	— 7,325	— 1,849	970 × 2 × 0·8	142½	4,626	— 134	— 9,093	64,071	64,071	13,780	..	..	13,780	First crop starts on 1st June.
					970 × 4							25,830	8,610	13	34,440	
June ..	64,071	16,596	— 9,063	— 102	— 375	140	962 × 4	4,986	— 2,357	— 11,867	68,900	25,200	8,400	15	33,600	
16–30	68,900	20,594	— 18,010	— 60	— 310	147½	986 × 4	5,112	— 1,032 *	— 19,412	79,082	27,090	9,030	15	36,120	
July ..	79,082	42,231	— 22,478	..	— 338	155	1,011 × 4	6,590	— 1,747 *	— 24,565	93,500	28,580	9,510	16	38,090	
											93,500					
16–31	79,082	42,231	— 22,478	..	— 338	155	1,011 × 4	6,590	— 1,747 *	— 24,565	104,163	29,340	9,780	12	39,120	
August ..	93,500	37,762	— 26,705	..	— 304	160	1,028 × 4	4,262	..	— 27,099	93,500	..	..	..	..	
1–12	93,500	37,762	— 26,705	..	— 304	160	1,028 × 4	4,262	..	— 27,099	93,500	29,340	9,780	12	39,120	
13–16	93,500	4,908	— 1,768	— 28	— 76	160	1,028 × 4	1,066	..	— 5,866	92,642	20,340	9,780	3	39,120	
16–31	92,642	22,878	— 20,382	— 163	— 380	157½	1,020 × 4	5,038	..	— 29,925	85,495	28,940	9,640	16	38,580	First crop ends on 31st August.
September ..	85,495	16,070	— 25,186	— 213	— 349	152½	1,003 × 4	5,196	..	— 32,748	76,417	28,120	9,380	15	37,500	
16–30	76,417	19,572	— 18,025	— 65	— 330	147½	986 × 4	5,112	..	— 18,420	73,669	27,090	9,030	15	36,120	
October ..	73,669	20,088	— 22,758	— 121	— 281	145	978 × 4	5,082	..	— 23,160	70,597	26,460	8,820	16	35,280	Second crop starts on 1st October.
16–31	70,597	8,880	— 24,983	— 403	— 270	137½	963 × 4	5,270	..	— 25,646	53,831	24,620	8,200	16	32,820	
November ..	53,831	13,780	— 5,725	— 3	— 200	124	941 × 4	4,872	— 1,642 *	— 7,470	60,141	23,800	7,930	15	31,730	
16–30	60,141	4,565	..	— 101	— 208	137½	953 × 3 × 0·8	2,774	— 3,173	— 3,173	61,533	19,090	..	..	19,090	
December ..	61,533	4,066	— 2,273	— 2	— 208	137½	953 × 3 × 0·8	2,065	— 1,162 *	— 3,178	62,421	19,090	..	..	19,090	Single crop ends on 16th December.
16–31	62,421	2,434	— 1,167	— 4	— 208	137½	953 × 3 × 0·8	3,163	— 2,005	— 3,375	61,480	19,090	..	..	19,090	
1921.																
January ..	61,480	1,458	— 3,483	— 55	— 208	137½	953 × 3 × 0·8	2,965	— 395	— 4,141	58,797	19,090	..	..	19,090	Second crop ends on 16th January.
1–15	61,480	1,458	— 3,483	— 55	— 202	135	945 × 2 × 0·8	2,089	— 2,089	— 2,290	57,882	12,820	..	..	12,820	
16–31	58,797	2,408	..	..	— 390	132½	936 × 2 × 0·8	3,622	— 3,622	— 4,012	56,278	12,500	..	..	12,500	
February ..	57,882	2,408	..	..	— 420	140	952 × 2 × 0·8	4,107	— 4,107	— 4,747	52,829	12,190	..	..	12,190	
1–28	56,278	2,408	..	..	— 420	140	952 × 2 × 0·8	4,107	— 4,107	— 4,527	54,324	12,500	..	..	12,500	
March ..	54,324	2,066	..	..	— 640	139	958 × 2 × 0·8	3,963	— 3,963	— 4,893	52,190	12,190	..	..	12,190	
1–31	52,190	2,066	..	..	— 640	139	958 × 2 × 0·8	3,963	— 3,963	— 4,893	49,972	12,190	..	..	12,190	
April ..	49,972	2,580	..	..	— 860	130	957 × 2 × 0·8	3,846	— 3,846	— 4,705	47,267	12,190	..	..	12,190	
1–30	47,267	2,580	..	..	— 860	130	957 × 2 × 0·8	3,973	— 3,973	— 4,923	45,408	12,190	..	..	12,190	
May ..	45,408	2,066	..	..	— 930	130	957 × 2 × 0·8	3,707	— 4,476	— 4,707	43,201	12,190	..	..	12,190	First crop starts on 1st June.
1–31	43,201	2,066	..	..	— 930	130	957 × 2 × 0·8	3,707	— 4,476	— 4,707	41,025	12,190	..	..	12,190	
June ..	41,025	3,356	— 4,247	— 1,161	— 315	125	908 × 4	4,707	— 7,201 *	— 7,920	38,258	21,090	7,230	15	28,920	
16–30	38,258	15,294	— 5,900	— 810	— 315	125	908 × 4	4,707	— 7,601	— 13,801	31,795	19,890	6,630	15	26,520	Single crop starts on 1st July.
July ..	31,795	5,522	— 30,926	— 625	— 214	117½	879 × 4	4,557	— 1,106 *	— 32,300	27,358	14,960	4,990	16	19,950	
16–31	27,358	14,195	— 22,761	— 290	— 162	97½	800 × 4	4,424	..	— 23,588	18,663	16,790	5,590	15	22,380	Reduction of 10 per cent to 15th September.
August ..	18,663	46,972	— 26,687	..	— 180	105	830 × 4	4,302	— 1,521	— 32,397	36,238	16,790	..	..	..	N.D.S. from 1st August.
1–15	36,238	46,210	— 26,625	..	— 255	125	908 × 4	5,021	— 798	— 27,578	64,870	21,690	7,230	16	28,920	First crop ends on 31st August.
September .	64,870	37,817	— 20,197	..	— 305	140	962 × 4	4,980	— 665	— 21,167	71,520	25,200	8,400	15	33,600	
16–30	71,520	22,458	— 25,546	— 90	— 326	144	975 × 4	5,052	..	25,960	68,018	26,200	8,740	15	34,940	
October ..	68,018	18,008	— 97,88	— 47	— 280	145	978 × 4	5,070	— 1,227	— 11,342	74,664	26,460	8,820	15	35,280	Second crop starts on 1st October.
16–31	74,664	10,905	— 23,374	— 200	— 280	145	978 × 4	5,408	..	— 28,564	67,755	26,460	8,820	16	35,280	
November ..	67,755	13,344	— 3,402	..	— 224	145	978 × 4	5,070	— 2,704	— 6,330	74,749	26,460	8,820	15	35,280	
16–30	74,749	7,638	— 7,638	— 61	— 224	146	981 × 4	5,088	..	— 7,928	72,814	26,720	8,900	15	35,620	
December ..	72,814	3,345	— 7,398	— 101	— 224	146	978 × 4	5,070	..	— 7,718	65,441	26,460	8,820	15	35,280	Single crop ends on 15th December.
16–31	65,441	2,005	— 3,680	— 24	— 220	142½	970 × 3	4,023	— 400	— 4,333	67,013	25,830	..	..	25,830	

Month and year.	Reservoir capacity at beginning of month in million cubic feet.	Inflow in million cubic feet.	Irrigation. Irrigation draft in million cubic feet.	Irrigation. Transmission losses in million cubic feet.	Reservoir losses. Evaporation losses in Reservoir in million cubic feet.	Reservoir losses. Power. Consumption and number of turbines. Head in feet.	Reservoir losses. Power. Consumption and number of turbines. In cusecs.	Reservoir losses. Power. Consumption and number of turbines. In million cubic feet.	Reservoir losses. Power. Consumption and number of turbines. Special power draft in million cubic feet.	Reservoir losses. Totals of columns (4), (5), (6) and (10).	Reservoir capacity at end of the month in million cubic feet.	Power generation. Continuous K.W. from three units or less.	Power generation. Additional power possible from 4th turbine. K.W.	Power generation. Additional power possible from 4th turbine. Number of days available.	Power generation. Total K.W.	Remarks.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
1922.																
January ..	67,013	2,628	— 2,371	— 7	— 220	142½	970 × 3 × 0·8	3,017	— 900	— 3,498	66,143	20,600	..	..	20,600	Second crop ends on 16th January.
16–31	66,143	2,405	..	..	— 220	140	962 × 2 × 0·8	1,994	— 1,094	— 2,214	66,334	13,440	..	..	13,440	
February ..	66,334	2,408	..	..	— 420	140	962 × 2 × 0·8	3,723	— 3,723	— 4,143	64,590	13,440	..	..	13,440	
1–28	64,590	2,066	..	..	— 640	139	958 × 2 × 0·8	4,107	— 4,107	— 4,747	62,518	13,320	..	..	13,320	
March ..	62,518	2,580	..	..	— 940	137½	955 × 2 × 0·8	3,963	— 3,963	— 4,893	60,205	13,130	..	..	13,130	
1–31	60,205	2,066	..	..	— 1,010	133	945 × 2 × 0·8	4,047	— 4,047	— 5,057	57,814	12,820	..	..	12,820	
April ..	57,814	2,076	— 9,333	— 2,478	— 332	130	927 × 4	4,866	— 930	— 12,463	47,427	22,860	7,620	15	30,480	First crop starts on 1st June.
1–30	47,427	2,011	— 7,576	— 1,555	— 298	122½	898 × 4	4,699	..	— 9,428	40,910	21,105	7,035	15	28,140	
July ..	40,910	30,603	— 20,616	— 8	— 234	125	908 × 4	4,707	— 941*	— 21,799	49,714	21,690	7,230	15	28,920	Single crop starts on 1st July.
16–31	49,714	28,937	..	— 1,639 *	— 270	135	945 × 4	5,222	— 1,524 *	— 28,995	64,919	24,030	8,010	16	32,040	
August ..	64,919	30,135	— 14,719	— 13	— 325	145	978 × 4	5,070	— 1,524 *	— 14,969	80,085	25,200	8,400	15	33,600	
1–15	80,085	29,901	— 25,900	— 78	— 318	152½	1,003 × 4	5,644	— 347 *	— 26,082	83,304	28,125	9,375	16	37,500	First crop ends on 31st August.
16–31	83,304	27,327	— 23,865	— 67	— 334	154	1,008 × 4	5,223	..	— 29,480	84,345	28,570	9,520	16	38,090	
September ..	84,345	16,248	— 24,611	— 207	— 342	151	997 × 4	5,172	..	— 30,060	75,533	27,090	9,030	15	36,120	Second crop starts on 1st October.
16–30	75,533	16,533	— 19,660	— 146	— 288	147½	986 × 4	5,112	— 1,032 *	— 19,412	79,082	27,090	9,030	15	36,120	
October ..	79,082	42,231	— 22,478	..	— 338	155	1,011 × 4	6,590	— 1,747 *	— 24,565	93,500	28,580	9,510	16	38,090	
											93,500					
16–31	79,082	42,231	— 22,478	..	— 338	155	1,011 × 4	6,590	— 1,747 *	— 24,565	104,163	29,340	9,780	12	39,120	
August ..	93,500	37,762	— 26,705	..	— 304	160	1,028 × 4	4,262	..	— 27,099	93,500	..	..	..	..	
1–12	93,500	37,762	— 26,705	..	— 304	160	1,028 × 4	4,262	..	— 27,099	93,500	29,340	9,780	12	39,120	
13–16	93,500	4,908	— 1,768	— 28	— 76	160	1,028 × 4	1,066	..	— 5,866	92,642	20,340	9,780	3	39,120	
16–31	92,642	22,878	— 20,382	— 163	— 380	157½	1,020 × 4	5,038	..	— 29,925	85,495	28,940	9,640	16	38,580	First crop ends on 31st August.
September ..	85,495	16,070	— 25,186	— 213	— 349	152½	1,003 × 4	5,196	..	— 32,748	76,417	28,120	9,380	15	37,500	
16–30	76,417	19,572	— 18,025	— 65	— 330	147½	986 × 4	5,112	..	— 18,420	73,669	27,090	9,030	15	36,120	
October ..	73,669	20,088	— 22,758	— 121	— 281	145	978 × 4	5,082	..	— 23,160	70,597	26,460	8,820	16	35,280	Second crop starts on 1st October.
16–31	70,597	8,880	— 24,983	— 403	— 270	137½	963 × 4	5,270	..	— 25,646	53,831	24,620	8,200	16	32,820	
November ..	53,831	13,780	— 5,725	— 3	— 200	124	941 × 4	4,872	— 1,642 *	— 7,470	60,141	23,800	7,930	15	31,730	
16–30	60,141	4,565	..	— 101	— 208	137½	953 × 3 × 0·8	2,774	— 3,173	— 3,173	61,533	19,090	..	..	19,090	
December ..	61,533	4,066	— 2,273	— 2	— 208	137½	953 × 3 × 0·8	2,065	— 1,162 *	— 3,178	62,421	19,090	..	..	19,090	Single crop ends on 16th December.
16–31	62,421	2,434	— 1,167	— 4	— 208	137½	953 × 3 × 0·8	3,163	— 2,005	— 3,375	61,480	19,090	..	..	19,090	
1921.																
January ..	61,480	1,458	— 3,483	— 55	— 208	137½	953 × 3 × 0·8	2,965	— 395	— 4,141	58,797	19,090	..	..	19,090	Second crop ends on 16th January.
1–15	61,480	1,458	— 3,483	— 55	— 202	135	945 × 2 × 0·8	2,089	— 2,089	— 2,290	57,882	12,820	..	..	12,820	
16–31	58,797	2,408	..	..	— 390	132½	936 × 2 × 0·8	3,622	— 3,622	— 4,012	56,278	12,500	..	..	12,500	
February ..	57,882	2,408	..	..	— 420	140	952 × 2 × 0·8	4,107	— 4,107	— 4,527	54,324	12,500	..	..	12,500	
1–28	56,278	2,408	..	..	— 420	140	952 × 2 × 0·8	4,107	— 4,107	— 4,747	52,829	12,190	..	..	12,190	
March ..	54,324	2,066	..	..	— 640	139	958 × 2 × 0·8	3,963	— 3,963	— 4,893	50,408	12,190	..	..	12,190	
1–31	52,190	2,066	..	..	— 640	139	958 × 2 × 0·8	3,963	— 3,963	— 4,893	49,972	12,190	..	..	12,190	
April ..	49,972	2,580	..	..	— 860	130	957 × 2 × 0·8	3,846	— 3,846	— 4,705	47,267	12,190	..	..	12,190	First crop starts on 1st June.
1–30	47,267	2,580	..	..	— 860	130	957 × 2 × 0·8	3,973	— 3,973	— 4,923	45,408	12,190	..	..	12,190	
May ..	45,408	2,066	..	..	— 930	130	957 × 2 × 0·8	3,707	— 4,476	— 4,707	43,201	12,190	..	..	12,190	
1–31	43,201	2,066	..	..	— 930	130	957 × 2 × 0·8	3,707	— 4,476	— 4,707	41,025	12,190	..	..	12,190	
June ..	41,025	3,356	— 4,247	— 1,161	— 315	125	908 × 4	4,707	— 7,201 *	— 7,920	38,258	21,090	7,230	15	28,920	First crop starts on 1st June.
16–30	38,258	15,294	— 5,900	— 810	— 315	125	908 × 4	4,707	— 7,601	— 13,801	31,795	19,890	6,630	15	26,520	
July ..	31,795	5,522	— 30,926	— 625	— 214	117½	879 × 4	4,557	— 1,106 *	— 32,300	27,358	14,960	4,990	16	19,950	Single crop starts on 1st July.
16–31	27,358	14,195	— 22,761	— 290	— 162	97½	800 × 4	4,424	..	— 23,588	18,663	16,790	5,590	15	22,380	
August ..	18,663	46,972	— 26,687	..	— 180	105	830 × 4	4,302	— 1,521	— 32,397	36,238	16,790	..	..	..	Reduction of 10 per cent to 15th September. N.D.S. from 1st August.
1–15	36,238	46,210	— 26,625	..	— 255	125	908 × 4	5,021	— 798	— 27,578	64,870	21,690	7,230	16	28,920	First crop ends on 31st August.
September .	64,870	37,817	— 20,197	..	— 305	140	962 × 4	4,980	— 665	— 21,167	71,520	25,200	8,400	15	33,600	
16–30	71,520	22,458	— 25,546	— 90	— 326	144	975 × 4	5,052	..	25,960	68,018	26,200	8,740	15	34,940	
October ..	68,018	18,008	— 97,88	— 47	— 280	145	978 × 4	5,070	— 1,227	— 11,342	74,664	26,460	8,820	15	35,280	Second crop starts on 1st October.
16–31	74,664	10,905	— 23,374	— 200	— 280	145	978 × 4	5,408	..	— 28,564	67,755	26,400	8,820	16	35,280	
November ..	67,755	13,344	— 3,402	..	— 224	145	978 × 4	5,070	— 2,704	— 6,330	74,749	26,460	8,820	15	35,280	
16–30	74,749	7,638	— 7,638	— 61	— 224	146	981 × 4	5,088	..	— 7,928	72,814	26,720	8,900	15	35,620	
December ..	72,814	3,345	— 7,398	— 101	— 224	146	978 × 4	5,070	..	— 7,718	65,441	26,460	8,820	15	35,280	Single crop ends on 15th December.
16–31	65,441	2,005	— 3,680	— 24	— 220	142½	970 × 3	4,023	— 400	— 4,333	67,013	25,830	..	..	25,830	

Month and year.		Reservoir capacity at beginning of month in million cubic feet.	Inflow in million cubic feet.	Reservoir losses. Irrigation. In Irrigation draft million cubic feet.	In Transmission losses million cubic feet.	Evaporation losses in Reservoir in million cubic feet.	Power. Head in feet.	Consumption and number of turbines. In cusecs.	In million cubic feet.	In draft in Special power million cubic feet.	Totals of columns (4), (5), (6) and (10).	Reservoir capacity at end of the month in million cubic feet.	Power generation. Continuous K.W. from three units or less.	Additional power possible from 4th turbine. K.W.	Number of days available.	Total K.W.	Remarks.
(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17
1924—*cont.*																	
September	1-15	93,500	30,719	− 20,070	− 5	− 379	160	1,028 × 4 ..	5,328	..	− 20,454	103,765	29,340	9,780	15	39,120	
	16-30	93,500	7,475	− 4,867	..	− 379	160	1,028 × 4 ..	5,328	− 3,226	− 8,472	93,500 92,503	29,340	9,780	15	39,120	
October ..	1-15	92,503	7,595	− 12,964	− 184	− 318	157½	1,020 × 4 ..	5,286	− 1,639 *	− 15,105	84,993	28,940	9,640	15	38,580	Second crop starts on 1st October.
	16-31	84,993	7,539	− 10,024	− 125	− 310	152½	1,003 × 4 ..	5,544	− 1,386 *	− 11,845	80,687	28,130	9,370	16	37,500	
November ..	1-15	80,687	9,804	− 833	..	− 250	155	1,011 × 3 × 0·7	2,752	− 1,919	− 3,002	87,549	19,970	..	..	19,970	
	16-30	87,549	8,179	− 7,188	− 39	− 253	157½	1,020 × 4 ..	5,286	− 105 *	− 7,585	88,143	28,940	9,640	15	38,580	Single crop ends on 15th December.
December ..	1-15	88,143	5,956	− 5,594	− 16	− 253	157½	1,020 × 4 ..	5,286	− 228 *	− 6,091	88,008	28,940	9,640	15	28,580	
	16-31	88,008	4,789	− 3,329	− 3	− 253	157½	1,020 × 3 × 0·7	2,960	− 179	− 3,764	89,033	20,250	..	..	20,250	
1925.																	
January ..	1-15	89,033	3,560	− 6,130	− 64	− 250	156	1,014 × 4	5,262	..	− 6,444	86,149	28,690	9,560	15	38,250	Second crop ends on 15th January.
	16-31	86,149	3,137	..	..	− 248	155	1,011 × 3 × 0·7	2,935	− 2,935	− 3,183	86,103	19,970	..	..	19,970	
February ..	1-28	86,103	2,408	..	..	− 496	155	1,011 × 2 × 0·75	3,669	− 3,669	− 4,165	84,346	14,270	..	..	14,270	
March ..	1-31	84,346	2,666	..	..	− 720	152½	1,003 × 2 × 0·75	4,028	− 4,028	− 4,748	82,264	14,060	..	..	14,060	
April ..	1-30	82,264	2,580	..	..	− 1,080	152½	1,003 × 2 × 0·75	3,898	− 3,898	− 4,978	79,866	14,060	..	..	14,060	
May ..	1-31	79,866	2,666	..	..	− 1,175	150	994 × 2 × 0·75	3,994	− 3,994	− 5,169	77,363	13,860	..	..	13,860	
June ..	1-15	77,363	2,862	− 11,461	− 2,866	− 394	145	978 × 4 ..	5,070	..	− 14,721	65,504	26,460	8,820	15	35,280	First crop starts on 1st June.
	16-30	65,504	4,797	− 8,386	− 2,191	− 364	137½	953 × 4 ..	4,941	− 1,318 *	− 12,259	58,042	24,620	8,200	15	32,820	Single crop starts on 1st July.
July ..	1-15	58,042	31,659	− 33,891	− 278	− 263	132½	936 × 4 ..	3,851	..	− 34,432	55,269	23,450	7,810	15	31,260	
	16-31	55,269	47,557	− 32,752	− 67	− 281	137½	953 × 4 ..	5,270	− 988 *	− 34,088	68,738	24,620	8,200	16	32,820	
August ..	1-15	68,738	32,631	− 26,169	− 8	− 326	145	978 × 4 ..	5,070	..	− 26,503	74,866	26,460	8,820	15	35,280	First crop ends on 31st August.
	16-31	74,866	32,948	− 27,670	− 45	− 338	150	994 × 4 ..	5,498	..	− 28,053	79,761	27,720	9,240	16	36,960	
September.	1-15	79,761	31,463	− 29,552	− 86	− 343	152	1,001 × 4 ..	5,100	..	− 29,981	81,243	28,040	9,350	15	37,390	
	16-30	81,243	14,444	− 21,937	− 187	− 338	150	994 × 4 ..	5,154	..	− 22,462	73,225	27,720	9,240	15	36,960	Second crop starts on 1st October.
October ..	1-15	73,225	19,599	− 22,410	− 159	− 280	145	978 × 4 ..	5,070	..	− 22,858	69,966	26,460	8,820	15	35,280	
	16-31	69,966	10,037	− 21,735	− 292	− 267	140	962 × 4 ..	5,318	..	− 22,294	57,709	25,200	8,400	16	33,600	
November ..	1-15	57,709	6,31[illegible]	− 3,562	− 34	− 202	135	945 × 4	4,406	− 1,807 *	− 5,605	58,415	24,030	8,010	9	32,040	
	16-30	58,415	11,194	− 2,512	..	− 208	137½	945 × 3	3,706	− 1,672	− 4,392	65,217	24,620	..	..	24,030	
December ..	1-15	65,217	2,049	− 474	..	− 215	140	953 × 3 .. 962 × 3 × 0·8	2,992	− 2,565	− 3,254	64,012	20,160	..	..	24,620	
	16-31	64,012	8,272	− 4,497	..	− 215	140	962 × 3 × 0·8	3,191	− 3,191	− 7,903	64,381	20,160	..	..	20,160	Single crop closes on 15th December.
1926.																	
January ..	1-15	64,381	4,137	− 4,932	− 21	− 215	140	962 × 4 × 0·8	3,989	..	− 5,168	63,350	20,160	6,720	16	26,880	Second crop closes on 15th January.
	16-31	63,350	3,244	..	..	− 215	140	962 × 2 × 0·8	2,128	− 2,128	− 2,343	64,251	13,440	..	..	13,440	
February ..	1-28	64,251	2,408	..	..	− 430	140	962 × 2 × 0·8	3,724	− 3,724	− 4,154	62,505	13,440	..	..	13,440	
March ..	1-31	62,505	2,666	..	..	− 625	137½	953 × 2 × 0·8	4,332	− 4,332	− 4,957	60,214	13,130	..	..	13,130	
April ..	1-30	60,214	2,580	..	..	− 908	135	945 × 2 × 0·8	3,917	− 3,917	− 4,825	57,969	12,820	..	..	12,820	
May ..	1-31	57,969	2,666	..	..	− 975	132½	936 × 2 × 0·8	4,010	− 4,010	− 4,985	55,650	12,500	..	..	12,500	
June ..	1-15	55,650	1,825	− 10,814	− 2,996	− 320	127½	918 × 4 ..	4,758	..	− 14,130	43,345	22,280	7,420	15	29,700	First crop starts on 1st June.
	16-30	43,345	4,582	− 13,131	− 2,850	− 268	115	869 × 4 ..	4,506	..	− 16,249	31,678	19,260	6,420	15	25,680	
July ..	1-15	31,678	29,634	− 16,544	− 1,330	− 207	115	869 × 4 ..	4,506	− 601 *	− 18,682	42,630	19,260	6,420	15	25,680	
	16-31	42,630	44,178	− 52,850	− 366	− 207	115	869 × 4 ..	4,806	− 300 *	− 53,723	33,085	19,260	6,420	16	25,680	Single crop starts on 16th July.
August ..	1-15	33,085	30,839	− 18,571	..	− 222	115	869 × 4 ..	4,506	− 2,100 *	− 20,893	43,031	19,260	6,420	15	25,680	
	16-31	43,031	52,321	− 41,792	− 23	− 256	125	908 × 4 ..	5,020	− 628	− 42,699	52,653	21,690	7,230	16	28,920	First crop ends on 31st August.
September.	1-15	52,653	22,235	− 16,596	− 49	− 283	132½	936 × 4 ..	4,851	− 647	− 17,575	57,313	23,440	7,820	15	31,260	Ten per cent reduction of N. D.S. from 16th August to 31st October.
	16-30	57,313	33,761	− 25,307	− 27	− 302	137½	953 × 4 ..	4,941	...	− 25,636	65,438	24,620	8,200	15	32,820	Second crop starts on 1st October.
October ..	1-15	65,438	12,927	− 18,529	− 151	− 260	137½	953 × 4 ..	4,941	..	− 18,940	59,425	24,620	8,200	15	32,820	
	16-31	59,425	22,455	− 19,874	− 100	− 260	137½	953 × 4 ..	5,270	− 329	− 20,563	61,317	24,620	8,200	16	32,820	
November ..	1-15	61,317	10,733	− 7,074	− 7	− 208	137½	953 × 4 ..	4,941	− 457	− 7,746	64,304	24,620	8,200	15	32,820	
	16-30	64,304	3,165	− 9,528	− 159	− 208	137½	953 × 4 ..	4,951	..	− 9,895	57,574	24,620	8,200	15	32,820	
December ..	1-15	57,574	3,949	− 8,766	− 120	− 195	132½	936 × 4 ..	4,851	..	9,081	52,442	23,440	7,820	15	31,260	
	16-31	52,442	2,823	− 7,664	− 116	− 183	127½	918 × 4 ..	5,075	..	− 7,963	47,302	22,280	7,420	16	29,700	Single crop closes on 31st December.
1927.																	
January ..	1-15	47,302	2,721	− 4,181	− 37	− 177	125	908 × 4 ..	4,707	− 40	− 4,435	45,588	21,690	7,230	15	28,920	Second crop ends on 15th January.
	16-31	45,588	2,885	..	..	− 170	123	900 × 2 ..	2,490	− 2,490	− 2,660	45,813	14,150	..	..	14,150	
February ..	1-28	45,813	2,508	..	..	− 340	122½	898 × 2 ..	4,347	− 4,347	− 4,687	43,534	14,070	..	..	14,070	
March ..	1-31	43,534	2,666	..	..	− 490	120	889 × 2 ..	4,762	− 4,762	− 5,252	40,948	13,680	..	..	13,680	
April ..	1-30	40,948	2,580	..	..	− 705	117½	879 × 2 ..	4,557	− 4,557	− 5,262	38,266	13,260	..	..	13,260	
May ..	1-31	38,266	2,666	..	..	− 770	115	869 × 2 ..	4,656	− 4,656	− 5,426	35,506	12,840	..	..	12,840	
June ..	1-15	35,506	11,781	..	..	− 280	117½	879 × 2 ..	2,279	− 2,279	− 2,559	44,728	13,260	..	..	13,260	
	16-30	44,728	26,413	− 12,421	− 130	− 332	130	927 × 4 ..	4,806	− 1,316 *	− 14,199	56,942	22,860	7,620	15	30,480	First crop starts on 16th June.
July ..	1-15	56,942	27,035	− 22,045	− 171	− 270	135	945 × 4 ..	4,896	− 1,087 *	− 23,573	60,404	24,030	8,010	15	32,040	Single crop starts on 1st July.
	16-31	60,404	113,201	− 92,320	..	− 305	145	978 × 4 ..	5,408	..	− 92,625	80,980	26,460	8,820	16	35,280	
August ..	1-15	80,980	106,479	− 96,929	− 47	− 360	155	1,011 × 4 ..	5,241	..	− 97,336	90,123	28,530	9,510	15	38,040	
	16-18	90,123	18,759	− 14,226	..	− 73	160	1,028 × 4 ..	1,066	..	− 14,229	94,583	29,340	9,780	3	39,120	
	19-24	93,500	27,956	− 30,047	..	− 146	160	1,028 × 4 ..	2,131	..	− 30,193	93,500 91,263	29,340	9,780	6	39,120	
	25-27	91,263	3,774	− 4,661	..	− 73	160	1,028 × 4 ..	1,066	..	− 4,734	90,303	29,340	9,780	3	39,120	
	28-30	90,303	3,788	− 2,775	..	− 73	160	1,028 × 4 ..	1,066	..	− 2,848	91,243	29,340	9,780	3	39,120	
	31	91,243	1,242	− 1,320	..	− 74	160	1,028 × 4 ..	355	..	− 1,344	91,141	29,340	9,780	1	39,120	
September.	1-15	91,141	13,828	− 27,459	− 341	− 360	155	1,011 × 4 ..	5,241	..	− 28,160	76,806	28,530	9,510	15	38,040	First crop ends on 15th September.
	16-30	76,806	31,860	− 35,843	− 157	− 335	147½	986 × 4 ..	5,453	− 301	− 36,636	72,030	27,090	9,030	15	36,120	
October ..	1-15	72,030	12,364	− 20,973	− 212	− 275	142½	970 × 4 ..	5,028	..	− 21,460	62,934	25,830	8,610	15	34,440	
	16-31	62,934	5,742	− 20,533	− 370	− 240	132½	936 × 4 ..	4,851	..	− 21,143	47,533	23,450	7,810	16	31,260	Second crop starts on 16th October.
November ..	1-15	47,533	7,503	− 4,570	− 54	− 183	127½	918 × 4 ..	4,203	− 1,038 *	− 5,845	49,191	22,280	7,420	8	29,700	
	16-30	49,191	5,443	− 7,341	− 95	− 177	125	908 × 4 ..	4,707	..	− 7,613	47,021	14,850	..	..	14,850	
December ..	1-15	47,021	3,052	− 7,590	− 113	− 163	120	889 × 4 ..	4,608	..	− 7,866	42,207	21,690	7,230	15	28,920	
	16-31	42,207	2,495	− 4,651	− 54	− 154	117½	879 × 4 ..	3,645	− 13	− 4,872	39,830	20,520	6,840	15	27,360	Single crop ends on 15th December.
1928.																	
January ..	1-15	39,830	2,323	− 6,620	− 107	− 154	115	869 × 4 ..	4,506	..	− 6,881	35,272	19,890	6,630	16	26,520	
	16-31	35,272	2,788	− 4,560	− 114	− 144	110	849 × 3 ..	3,524	..	− 4,818	33,242	19,260	6,420	15	25,680	
February ..	1-29	33,242	2,494	..	..	− 288	110	849 × 2 × ⅞ ..	3,900	− 3,900	− 4,188	31,548	18,000	..	..	18,000	Second crop ends on 31st January.
March ..	1-31	31,548	2,666	..	..	− 420	107½	840 × 2 × 0·9	4,048	− 4,048	− 4,468	29,746	10,500	..	..	10,500	
April ..	1-30	29,746	2,580	..	..	− 600	105	830 × 2 × 0·9	3,872	− 3,872	− 4,472	27,854	10,440	..	..	10,440	
May ..	1-31	27,854	2,766	..	..	− 633	102½	820 × 2 × 0·95	4,173	− 4,173	− 4,806	25,714	10,070	..	..	10,070	
June ..	1-15	25,714	6,019	..	..	− 230	105	830 × 2 × 0·9	1,936	− 1,936	− 2,166	29,567	10,250	..	..	10,250	
	16-30	29,567	9,149	− 8,006	− 940	− 230	105	830 × 4 ..	4,302	− 159	− 9,335	29,381	10,070	..	..	10,070	
July ..	1-15	29,381	13,841	− 16,656	− 1,332	− 171	102½	820 × 4 ..	4,251	..	− 18,159	25,063	16,780	5,600	15	22,380	First crop starts on 16th June.
	16-31	25,063	38,070	− 40,267	− 190	− 167	100	810 × 4 ..	4,480	..	− 40,624	22,509	16,170	5,390	15	21,560	
August ..	1-15	22,509	48,788	− 43,860	− 140	− 180	100	810 × 4 ..	4,200	..	− 44,180	27,117	15,570	5,190	16	20,760	Single crop starts on 16th July.
	16-31	27,117	28,395	− 28,395	− 150	− 180	100	810 × 4 ..	4,480	..	− 28,725	22,899	15,570	5,190	15	20,760	
September.	1-15	22,899	32,642	− 29,737	− 85	− 180	100	810 × 4 ..	4,200	− 280 *	− 30,282	25,259	15,570	5,190	16	20,760	10 per cent reduction of N.D.S. on old area and 40 per cent on new area from 16th to 31st August.
	16-30	25,259	11,851	− 21,053	− 253	− 164	95	790 × 4 ..	4,095	..	− 22,370	14,740	14,360	4,780	15	19,140	First crop ends on 15th September. 40 per cent reduction in N.D.S. on whole area from 1st September to 15th November.

Month and year.		Reservoir capacity at beginning of month in million cubic feet.	In flow in million cubic feet.	Reservoir losses. Irrigation. In draft in million cubic feet.	Reservoir losses. Irrigation. In losses in million cubic feet.	Reservoir losses. Evaporation losses in Reservoir in million cubic feet.	Reservoir losses. Power. Head in feet.	Reservoir losses. Power. Consumption and number of Turbines. In cusecs.	Reservoir losses. Power. Consumption and number of Turbines. In million cubic feet.	Reservoir losses. Power. Special power draft in million cubic feet.	Reservoir losses. Power. Totals of columns (4), (5), (6) and (10).	Reservoir capacity at end of the month in million cubic feet.	Power generation. Continuous K.W. from three units of less.	Power generation. Additional power possible from 4th turbine. K.W.	Power generation. Additional power possible from 4th turbine. Number of days available.	Power generation. Total K.W.	Remarks.
(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
1928—*cont.*																	
October ..	1–15	14,740	12,599	− 17,888	− 169	− 104	80	725 × 4 ..	3,756	− 250	− 18,411	8,928	10,800	3,600	15	14,400	
	16–31	8,928	30,583	− 20,387	..	− 130	90	770 × 4 ..	4,256	− 164	− 20,681	27,830	13,140	4,380	16	17,520	Second crop starts on 16th October.
November ..	1–15	27,830	28,575	− 24,072	..	− 135	106	834 × 4 ..	4,322	..	− 24,207	32,198	17,030	5,680	15	22,710	
	16–30	32,198	15,989	− 17,399	− 58	− 140	107½	840 × 4 ..	4,353	..	− 17,597	30,590	17,390	5,800	15	23,190	
December ..	1–15	30,590	22,778	− 21,572	− 13	− 140	107½	840 × 4 ..	4,353	..	− 21,725	31,643	17,390	5,800	15	23,190	
	16–31	31,643	3,461	− 6,948	− 101	− 132	105	830 × 4 ..	4,374	− 322*	− 7,503	27,601	16,719	5,590	16	22,380	Single crop ends on 31st December.
1929.																	
January ..	1–15	27,601	2,654	− 4,232	− 47	− 123	100	810 × 3 / 810 × 4	3,920	− 34	− 4,436	25,819	15,570 / 15,570	.. / 5,190	.. / 12	15,570 / 20,760	
	16–31	25,819	3,026	− 4,864	− 122	− 123	100	800 × 3 ..	3,360	..	− 5,109	23,736	15,570	..	..	15,570	Second crop ends on 31st January.
February ..	1–28	23,736	2,408	..	..	− 240	97	798 × 2 × 1·05 or 3 × 0·7.	4,054	− 4,054	− 4,294	21,850	10,390	..	..	10,390	
March ..	1–31	21,850	2,666	..	..	− 335	94	786 × 2 × 1·05 or 3 × 0·7.	4,420	− 4,420	− 4,755	19,761	9,880	..	..	9,880	
April ..	1–30	19,761	2,580	..	..	− 465	90	770 × 3 × 0·8	4,788	− 4,788	− 5,253	17,088	10,510	..	..	10,510	
May ..	1–31	17,088	2,666	..	..	− 492	86	752 × 3 × 0·85	5,138	− 5,138	− 5,630	14,124	10,370	..	..	10,370	
June ..	1–15	14,124	14,148	..	..	− 193	93	782 × 3 × 0·8	2,432	− 2,432	− 2,625	25,647	11,000	..	..	11,000	
	16–30	25,647	19,056	− 10,320	− 52	− 233	105	830 × 4 ..	4,302	..	− 10,614	34,089	16,780	5,600	15	22,380	First crop starts on 16th June.
July ..	1–15	34,089	50,591	− 21,587	..	− 243	125	903 × 4 ..	4,707	− 941*	− 22,771	61,909	21,690	7,230	15	28,920	
	16–31	61,909	55,213	− 45,076	− 29	− 292	140	962 × 4 ..	5,318	..	− 46,297	70,825	25,200	8,400	16	33,600	Single crop starts on 16th July.
August ..	1–15	70,825	29,881	− 32,199	− 143	− 320	142½	970 × 4 ..	5,028	..	− 32,662	68,044	25,830	8,610	15	34,440	
	16–31	68,044	28,202	− 26,203	− 172	− 320	142½	970 × 4 ..	5,363	− 335*	− 27,030	69,216	25,830	8,610	16	34,440	
September.	1–15	69,216	21,916	− 29,936	− 201	− 305	137½	953 × 4 ..	4,941	..	− 30,442	60,690	24,620	8,200	15	32,820	First crop ends on 15th September.
	16–30	60,690	23,670	− 20,524	− 83	− 305	137½	953 × 4 ..	4,941	..	− 20,912	63,448	24,620	8,200	15	32,820	
October ..	1–15	63,448	25,212	− 15,250	..	− 275	142½	970 × 4 ..	5,028	− 269*	− 15,794	72,866	25,830	8,610	15	34,440	
	16–31	72,866	15,633	− 16,558	− 71	− 294	145	978 × 4 ..	5,408	..	− 16,923	71,576	26,460	8,820	16	35,280	Second crop starts on 16th October.
November ..	1–15	71,576	10,289	− 3,118	..	− 225	145	978 × 3 / 978 × 4	4,309	− 1,339*	− 4,682	77,183	26,460 / 26,460	.. / 8,820	.. / 6	26,460 / 35,280	
	16–30	77,183	11,173	− 5,846	− 10	− 235	150	994 × 3 / 994 × 4	4,638	− 1,018*	− 7,109	81,247	27,720 / 27,720	.. / 9,240	.. / 9	27,720 / 36,960	
December ..	1–15	81,247	6,943	− 5,070	− 4	− 240	152½	1,003 × 3 ..	4,417	− 72*	− 5,386	82,804	28,120	..	..	28,120	
	16–31	82,804	3,717	− 5,191	− 45	− 240	152½	1,003 × 4 / 1,003 × 3	4,849	− 235	− 5,711	80,810	28,120 / 28,120	9,380 / ..	8 / ..	37,500 / 28,120	Single crop ends on 1st December.
1930.																	
January ..	1–15	80,810	2,285	− 2,746	− 16	− 240	151	998 × 2 ..	2,586	− 268	− 3,270	79,825	18,560	..	..	18,560	
	16–31	79,825	2,636	− 4,864	− 122	− 234	150	994 × 2 ..	2,749	..	− 5,220	77,241	18,480	..	..	18,480	Second crop ends on 31st January.
February ..	1–28	77,241	2,208	..	..	− 460	147½	986 × 2 × ⅔ ..	3,181	− 3,181	− 3,641	76,008	12,040	..	..	12,040	
March ..	1–31	76,008	2,666	..	..	− 690	147½	986 × 2 × ⅔ ..	3,522	− 3,522	− 4,212	74,462	12,040	..	..	12,040	
April ..	1–30	74,462	2,580	..	..	− 1,020	145	978 × 2 × ⅔ ..	3,380	− 3,380	− 4,400	72,642	11,760	..	..	11,760	
May ..	1–31	72,642	2,666	..	..	− 1,125	145	978 × 2 × ⅔ ..	3,493	− 3,493	− 4,618	70,690	11,760	..	..	11,760	
June ..	1–15	70,690	2,338	− 3,062	− 272	− 385	142½	970 × 2 × 9 / 970 × 3 × 6	3,017	− 359*	− 4,078	68,950	17,220 / 25,830	..	..	17,220 / 25,830	First crop starts on 1st June.
	16–30	68,950	6,770	− 9,572	− 1,422	− 380	140	962 × 4 / 962 × 3	4,654	− 532*	− 11,906	63,814	25,200 / 25,200	8,400 / ..	11 / ..	33,600 / 25,200	
July ..	1–15	63,814	27,496	− 16,621	− 54	− 297	142½	970 × 4 ..	5,028	− 1,006*	− 17,978	73,332	25,830	8,610	15	34,440	Single crop starts on 1st July.
	16–31	73,332	27,826	− 28,181	− 177	− 304	145	978 × 4 ..	5,408	..	− 28,662	72,496	26,460	8,820	16	35,280	
August ..	1–15	72,496	27,766	− 18,360	− 65	− 336	148	988 × 4 ..	5,106	− 1,510*	− 20,271	79,991	27,220	9,070	15	36,290	
	16–31	79,991	18,065	− 29,796	− 293	− 330	146	981 × 4 ..	5,421	..	− 30,419	67,637	26,710	8,900	16	35,610	First crop ends on 31st August.
September.	1–15	67,637	14,286	− 17,975	− 225	− 313	140	962 × 4 ..	4,986	− 322*	− 18,835	63,088	25,200	8,400	15	33,600	
	16–30	63,088	21,624	− 18,964	− 44	− 313	140	962 × 4 ..	4,986	..	− 19,321	65,491	25,200	8,400	15	33,600	
October ..	1–15	65,491	11,097	− 8,098	− 33	− 270	140	962 × 4 / 962 × 3 × 0·8	4,188	− 1,200*	− 9,601	66,987	25,200 / 20,160	8,400 / ..	9 / ..	33,600 / 20,160	Second crop starts on 1st October.
	16–31	66,987	14,245	− 2,007	..	− 282	145	978 × 3 × ⅔ ..	3,042	− 1,900	− 4,189	77,043	19,850	..	..	19,850	
November ..	1–15	77,043	10,130	− 466	..	− 240	152½	1,003 × 3 × 0·7	2,728	− 2,364	− 3,070	84,103	19,680	..	..	19,680	
	16–30	84,103	9,063	..	..	− 250	155	1,011 × 3 × 0·7	2,751	− 2,751	− 3,001	90,165	19,970	..	..	19,970	
December ..	1–15	90,165	1,090	− 66	..	− 255	157½	1,020 × 2 ..	2,642	− 2,576	− 2,897	88,037	19,290	..	..	19,290	Single crop ends on 15th December.
	16–31	88,037	3,963	..	..	− 253	157	1,018 × 2 ..	2,816	− 2,816	− 3,069	88,931	19,240	..	..	19,240	
1931.																	
January ..	1–15	88,931	2,881	− 487	..	− 253	157	1,018 × 2 ..	2,640	− 2,153	− 2,893	88,919	19,240	..	..	19,240	Second crop ends on 15th January.
	16–31	88,919	2,625	..	..	− 253	157	1,018 × 1 × 1·1	1,549	− 1,549	− 1,802	89,742	10,580	..	..	10,580	

* Denotes "Partial recovery for irrigation from Special Power Draft."

Mettur Reservoir.

Duty Statement (*a*) showing irrigation draft in *million cubic feet per day* when first crop commences on 1st June, second crop on 1st October and single crop on 16th July.

Commencement of crop.	Period.		Cauvery.	Vennar.	Grand Anicut Canal.	Lower Anicut.	Total.	*Deduct* for portion above Grand Anicut.	Net total.
First crop ..	June ..	1–15	322	283	155	..	760	— 81	679
		16–30	322	283	155	13	773	— 81	692
	July ..	1–15	322	283	155	13	773	— 81	692
Single crop ..	July ..	16–31	897	783	319	193	2,192	— 34	2,158
	August ..	1–15	833	736	319	193	2,081	— 23	2,058
		16–31	791	693	300	193	1,977	— 16	1,961
End of first crop on 31st August.	September.	1–15	705	626	224	193	1,748	— 16	1,732
		16–30	1,080		176	193	1,449	..	1,449
Second crop begins on 1st October.	October ..	1–15	1,080		262	138	1,480	— 18	1,462
		16–31	1,080		262	138	1,480	— 18	1,462
From 1st November as per Old Project Rules.									

Duty Statement (*b*) showing irrigation drafts in *million cubic feet per day* when first crop commences on 1st June, second crop on 1st October and single crop on 1st July.

Commencement of crop.	Period.		Cauvery.	Vennar.	Grand Anicut Canal.	Lower Anicut.	Total.	*Deduct* for portion above Grand Anicut.	Net total.
First crop ..	June ..	1–15	322	283	155	..	760	— 81	679
		16–30	322	283	155	13	773	— 81	692
Single crop ..	July ..	1–15	897	783	319	13	2,012	— 34	1,978
		16–31	833	736	319	193	2,081	— 23	2,058
	August ..	1–15	791	693	300	193	1,977	— 16	1,961
		16–31	791	693	300	193	1,977	— 16	1,961
First crop ends on 31st August.	September.	1–15	705	626	224	193	1,748	— 16	1,732
		16–30	1,080		176	193	1,449	..	1,449
Second crop begins on 1st October.	October ..	1–15	1,080		262	138	1,480	— 18	1,462
		16–31	1,080		262	138	1,480	— 18	1,462
From November duties are as in old project report.									
	November ..	1–15	(47 + 43 + 424) = 514		(52 + 66) = 118	Included in previous columns.	632	Already deducted.	632
		16–30	514		118	Do.	632	Do.	632
	December ..	1–15	(60 + 54 + 254) = 368		(65 + 40) = 105	Do.	473	Do.	473
		16–31	(71 + 64) = 135		76	Do.	211	Do.	211
	January ..	1–15	(102 + 92) = 194		110	Do.	304	Do.	304

Duty Statement (*c*) showing irrigation draft in *million cubic feet per day* when first crop commences on 16th June, second crop on 16th October and single crop on 16th July.

Commencement of crop.	Period.		Cauvery.	Vennar.	Grand Anicut Canal.	Lower Anicut.	Total.	*Deduct* for portion above Grand Anicut.	Net total.
First crop ..	June ..	16–30	322	283	155	13	773	— 81	692
	July ..	1–15	322	283	155	13	773	— 81	692
Single crop begins.	July ..	16–31	897	783	319	193	2,192	— 34	2,158
	August ..	1–15	833	736	319	193	2,081	— 23	2,058
		16–31	791	693	300	193	1,977	— 16	1,961
First crop ends on 15th September.	September.	1–15	791	693	300	193	1,977	— 16	1,961
		16–30	705	626	224	193	1,748	— 16	1,732
	October ..	1–15	1,080		176	138	1,394	..	1,394
Second crop begins on 16th October.	October ..	16–31	1,080		262	138	1,480	— 18	1,462
November onwards same provisions as in old project working tables.									
	November ..	1–15	(47 + 43 + 424) = 514		(52 + 66) = 118	Included in previous columns.	632	Already deducted.	632
		16–30	514		118	Do.	632	Do.	632
	December ..	1–15	(60 + 54 + 254) = 368		(65+40) = 105	Do.	473	Do.	473
		16–31	368		105	Do.	473	Do.	473
	January ..	1–15	(71 + 64) = 135		76	Do.	211	Do.	211
Second crop ends on 31st January.		16–31	(102 + 92) = 194		110	Do.	304	Do.	304

Mettur Reservoir—cont.

Duty Statement (*d*) showing irrigation draft in *million cubic feet per day* when first crop begins on 16th June, second crop on 16th October and single crop on 1st July.

Commencement of crop.	Period.		Cauvery.	Vennar.	Grand Anicut Canal.	Lower Anicut.	Total.	*Deduct* for portion above Grand Anicut.	Net total.
First crop begins. Single crop on 1st July.	June ..	16–30	322	283	155	13	773	— 81	692
	July ..	1–15	897	783	319	13	2,012	— 81	1,931
		16–31	833	736	319	193	2,081	— 34	2,047
	August ..	1–15	791	693	300	193	1,977	— 23	1,954
		16–31	791	693	300	193	1,977	— 23	1,954
First crop ends on 15th September.	September.	1–15	791	693	300	193	1,977	— 16	1,961
		16–30	705	626	224	193	1,748	— 16	1,732
	October ..	1–15	1,080		176	193	1,449	..	1,449
Second crop starts on 16th October.		16–31	1,080		262	138	1,480	— 18	1,462
	November.	1–15	514		118	Already included.	632	Already deducted.	632
		16–30	514		118	Do.	632	Do.	632
	December.	1–15	368		105	Do.	473	Do.	473
		16–31	135		76	Do.	211	Do.	211
	January ..	1–15	194		110	Do.	304	Do.	304
Second crop ends on 31st January.		16–31	194		110	Do.	304	Do.	304

TABLE M. 18 (B).

Mettur Hydro-Electric Development.

This is similar to Table M. 18 except that additional working rule (3) is as follows :—

(3) Whenever the storage in the Reservoir is below 35,000 million cubic feet at the end of the irrigation season the special power draft during the following closure is limited to 1,000 cusecs not.

This change only affects the table in the three years 1919, 1928 and 1929 to which it is therefore confined. The base power generation is considerably reduced during the four to five months period of closure in each of the years and irrigation is slightly benefited during the subsequent season by a reduction in the periods of restriction. This benefit to irrigation is shown for the sake of example as a curtailment of the period of special restriction of duty but it may be varied in any way to best suit the irrigation needs.

Restriction of power has to be applied during the closure of 1929 though irrigation demands in the subsequent season were fully met in Table M. 18.

Name and year.		Reservoir capacity at beginning of month in million cubic feet.	Inflow in million cubic feet.	Reservoir losses. Irrigation. Irrigation draft in million cubic feet.	Transmission losses in million cubic feet.	Evaporation losses in Reservoir in million cubic feet.	Power. Head in feet.	Consumption and number of turbines. In cusecs.	In million cubic feet.	Special power draft in million cubic feet.	Totals of columns (4), (5), (6) and (10).	Reservoir capacity at end of the month in million cubic feet.	Power generation. Continuous K.W. from three units or less.	Additional power possible from 4th turbine. K.W.	Number of days available.	Total K.W.	Remarks.
(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
1919.																	
January ..	16-31	24,254	2,146	..	..	— 123	100	1,000	1,376	— 1,376	— 1,499	24,901	6,410	..	..	6,410	
February ..	1-28	24,901	2,408	..	..	— 246	100	1,000	2,408	— 2,408	— 2,654	24,655	6,410	..	..	6,410	
March ..	1-31	24,655	2,666	..	..	— 369	100	1,000	2,666	— 2,666	— 3,035	24,286	6,410	..	..	6,410	
April ..	1-30	24,286	2,580	..	..	— 554	100	1,000	2,580	— 2,580	— 3,134	23,732	6,410	..	..	6,410	
May ..	1-31	23,732	2,666	..	..	— 608	98	1,000	2,666	— 2,666	— 3,274	23,124	6,350	..	..	6,350	
June ..	1-15	23,124	2,700	..	..	— 214	100	1,000	1,290	— 1,290	— 1,504	24,320	6,410	..	..	6,410	
	16-30	24,320	21,519	— 5,884	— 242	— 245	107½	840 × 4 × 2 ..	3,722	— 1,610*	— 7,981	37,858	17,400	5,800	2	23,200	First crop starts on 16th June.
								840 × 3 × 8					17,400	..	..	17,400	
July ..	1-15	37,858	13,081	— 7,018	..	— 215	117½	840 × 4 × 5					17,400	5,800	5	23,200	
								879 × 4 × 5 ..	3,798	— 2,216*	— 9,449	41,490	19,890	6,630	5	26,520	Single crop starts on 1st July.
	16-31	41,490	23,863	— 28,690	— 301	— 215	117½	879 × 3 × 10					19,890	..	..	19,890	
August ..	1-15	36,087	53,011	— 34,297	..	— 250	122½	875 × 4 ..	4,851	..	— 29,206	36,087	19,890	6,630	16	26,520	
								899 × 3 ..	4,423	— 698	— 35,245	53,853	21,105	..	..	21,105	10 per cent reduction of N.D.S. from 1st August to 26th September.
								899 × 4					21,105	7,035	12	28,140	
	16-31	53,853	34,869	— 29,639	— 20	— 290	133	938 × 4 ..	5,184	..	— 29,947	58,775	23,560	7,850	16	31,410	
September.	1-15	58,775	26,959	— 28,755	— 89	— 290	134	941 × 4 ..	4,878	..	— 29,134	56,600	23,800	7,930	15	31,730	First crop ends on 15th September.
	16-22	56,600	10,420	— 7,128	— 1	— 135	135	945 × 4 ..	2,499	..	— 7,264	59,756	24,030	8,010	7	32,040	
	23-26	59,756	13,083	— 7,223	..	— 78	140	962 × 4 ..	1,329	..	— 7,301	65,538	25,200	8,400	4	33,600	
	27-30	65,538	12,983	— 7,015	..	— 102	142	968 × 4 ..	1,339	..	— 7,117	70,604	25,700	8,570	4	34,270	
October ..	1-15	70,604	32,854	— 36,588	— 159	— 278	142½	907 × 4 ..	5,028	..	— 37,025	66,433	25,830	8,610	15	34,440	Second crop starts on 16th October.
								(Table will be as per old one as no restriction was applied in old table from 16th October 1919).									
1928.																	
January ..	1-15	39,830	2,323	— 6,620	— 197	— 154	115	869 × 4 ..	4,506	..	— 6,881	35,272	19,260	6,420	15	25,680	
	16-31	35,272	2,788	— 4,560	— 114	— 144	110	849 × 3 ..	3,524	..	— 4,818	33,242	18,000	6,000	16	24,000	Second crop ends with 31st January.
February ..	1-29	33,242	2,494	..	..	— 288	110	849 × 1 × 1·17.	2,494	— 2,494	— 2,782	32,954	7,020	..	..	7,020	
March ..	1-31	32,954	2,666	..	..	— 435	110	849 × 1 × 1·17.	2,666	— 2,666	— 3,101	32,519	7,020	..	..	7,020	
April ..	1-30	32,519	2,580	..	..	— 645	110	849 × 1 × 1·17.	2,580	— 2,580	— 3,225	31,874	7,020	..	..	7,020	
May ..	1-31	31,874	2,666	..	..	— 700	108	840 × 1 × 1·19.	2,666	— 2,666	— 3,366	31,174	6,950	..	..	6,950	
June ..	1-15	31,174	6,019	..	..	— 256	110	849 × 1 × 1·17.	1,290	— 1,290	— 1,546	36,647	7,020	..	..	7,020	
	16-30	36,647	9,149	— 8,085	— 940	— 268	115	869 × 4 ..	4,002	..	— 9,293	36,503	19,260	6,420	13	25,680	First crop starts on 16th June
								869 × 2					12,840	..	..	12,840	
July ..	1-15	36,503	13,841	— 16,656	— 1,332	— 200	112	857 × 4 ..	4,446	..	— 18,188	32,156	18,500	6,170	15	24,670	
	16-31	32,156	38,070	— 40,267	— 190	— 190	108	840 × 4 ..	4,653	..	— 40,647	29,579	17,510	5,840	16	23,350	Single crop starts on 16th July.
August ..	1-15	29,579	48,788	— 43,860	— 140	— 210	110	849 × 4 ..	4,404	..	— 44,210	34,157	18,000	6,000	15	24,000	
	16-31	34,157	24,507	— 28,395	— 150	— 210	110	849 × 4 ..	4,698	..	— 28,755	29,899	18,000	6,000	16	24,000	10 per cent reduction of N.D.S. on old area and 40 per cent on new area from 16th August to 15th September.
September.	1-15	29,899	32,642	— 36,709	— 210	— 196	105	830 × 4 ..	4,302	— 286	— 37,401	25,140	16,785	5,595	15	22,380	First crop ends on 15th September.
	16-30	25,140	11,851	— 21,953	— 253	— 164	95	790 × 4 ..	4,368	..	— 22,370	1,461	14,355	4,785	15	19,140	40 per cent reduction in N.D.S. from 16th September to 31st October.
October ..	1-15	14,621	12,599	— 17,888	— 169	— 104	80	725 × 4 ..	3,756	— 250	— 18,411	8,809	10,800	3,600	15	14,400	
	16-31	8,809	39,583	— 20,387	..	— 130	90	770 × 4 ..	4,256	— 164	— 20,681	27,711	13,140	4,380	16	17,520	Second crop starts on 16th October.
November ..	1-15	27,711	28,575	— 27,867	— 30	— 135	105	830 × 4 ..	4,302	..	— 28,832	28,254	16,785	5,595	15	22,380	
	16-30	28,254	15,989	— 17,399	— 58	— 135	105	830 × 4 ..	4,302	..	— 17,592	26,651	16,785	5,595	15	22,380	
December ..	1-15	26,651	22,778	— 21,572	— 13	— 135	104	826 × 4 ..	4,284	..	— 21,720	27,709	16,540	5,510	15	22,060	
								818 × 4 ..					16,060	5,350	13	21,410	Single crop ends on 31st December.
	16-31	27,709	3,461	— 6,948	— 101	— 127	102	818 × 2 ..	4,322	— 316	— 7,492	23,678	10,700	..	..	10,700	
1929.																	
								800 × 2 ..					9,980	..	..	9,980	
January ..	1-15	23,678	2,654	— 4,237	— 47	— 120	97½	800 × 4 ..	3,870	— 30	— 4,234	22,098	14,960	4,990	13	19,950	
	16-31	22,098	3,026	— 4,864	— 122	— 112	94	786 × 3 ..	3,259	..	— 5,098	20,026	14,110	..	..	14,110	Second crop ends on 31st January.
February ..	1-28	20,026	2,408	..	..	— 224	93	1,000 ..	2,408	— 2,408	— 2,632	19,802	5,910	..	..	5,910	
March ..	1-31	19,802	2,666	..	..	— 330	92½	1,000 ..	2,666	— 2,666	— 2,996	19,472	5,880	..	..	5,880	
April ..	1-30	19,472	2,580	..	..	— 495	92	1,000 ..	2,580	— 2,580	— 3,075	18,977	5,840	..	..	5,840	
May ..	1-31	18,977	2,666	..	..	— 534	91	1,000 ..	2,666	— 2,666	— 3,200	18,443	5,760	..	..	5,760	
June ..	1-15	18,443	14,148	..	..	— 220	100	1,000 ..	1,290	— 1,290	— 1,510	31,081	6,410	..	..	6,410	
	16-30	31,081	19,056	— 10,329	— 52	— 263	112½	859 × 4 ..	4,458	..	— 10,644	39,493	18,630	6,210	15	24,840	

The reservoir will surplus to the extent of 1,500 million cubic feet nearly in November 1930 if the table be continued with this capacity, on the same conditions of previous table subsequent to 1st July 1929.

APPENDIX B.

Electrical Design.

1. The power generated is stepped up to 66 K.V. for transmission to centres of consumption. This voltage can later be raised to 110 K.V. and the clearances of the outdoor transformer yard structure and of the transmission towers going east, have been designed for this higher voltage. Drawing No. M.27/D-1 gives the electrical layout.

2. The turbines will be rated at 13,000 horse-power each and have been described in the appendix A and referred to in the first part of the report.

3. Two 12,500 K.V.A., 3-phase, 50-cycle, 11,000 volt generators are to be installed initially and two more in the third year of operation. They are all tied to a single 11 K.V. bus through oil circuit breakers. From the two take off

(*a*) 2—(eventually 3 within 10 years) 12,500 K.V.A. transformers for stepping up power for transmission to the distant centres ;

(*b*) supply to the local industrial load with provision for a transformer if necessary ; and

(*c*) supply to the auxiliary services. Each is controlled by its own oil circuit breakers and provision of reactors would ensure limiting of short circuit disturbances.

4. The step-up transformers are connected to duplicate H.T. busbars through oil circuit breakers and selector disconnecting switches. Three outgoing circuits are provided for the present, one for supply to the northern districts of North Arcot, Chittoor and South Arcot and two for the southern districts of Salem, Trichinopoly and Tanjore. Provision is made for a second outgoing feeder for the northern area later.

5. The high tension bus is divided into two sections one of which will always be operating at 66 K.V. supplying power to the southern area, while the other section will eventually be converted to 110 K.V. for transmission of power to Madras and Moyar. The two sections will for the present be connected by switches to be removed later when one section is to operate at 110 K.V.

6. For voltage control and stability of the system a reactor would be installed later if required. This would be coupled to the H.T. bus through an oil circuit breaker. The bus is capable of future extension to permit the take off of two ties lines for linking up with the Pykara-Moyar system.

7. *Transformer station.*—This will be an outdoor station adjacent to the Power-house consisting, for the present, of a 3-bay galvanized steel structure providing location for the 66 K.V. oil circuit breakers, the transformers, the H.T. busses, the outgoing feeder oil circuit breakers and lightning arresters. The layout is indicated in drawing No. M 28/D-1.

8. *Transformers.*—Two units each of 12,500 K.V.A. rating suitable for operation on 3-phase, 50-cycle supply with ratio 11,000/66,000 volts will be installed. The third unit to be installed in the third year will have double ratio H.T. windings capable of giving either 66,000 or 110,000 volts on the secondary with primary voltage at 11,000. The initial connexions will be for 66,000 volts. The windings will be connected delta on the L.T. side and star on the H.T. side and standard tappings will be provided.

9. *Outgoing lines.*—Each of the three outgoing lines will be provided with two selector disconnecting switches, an oil circuit breaker and a line disconnecting switch. A Thyrite or other suitable type of lightning arrester will also be installed on each line.

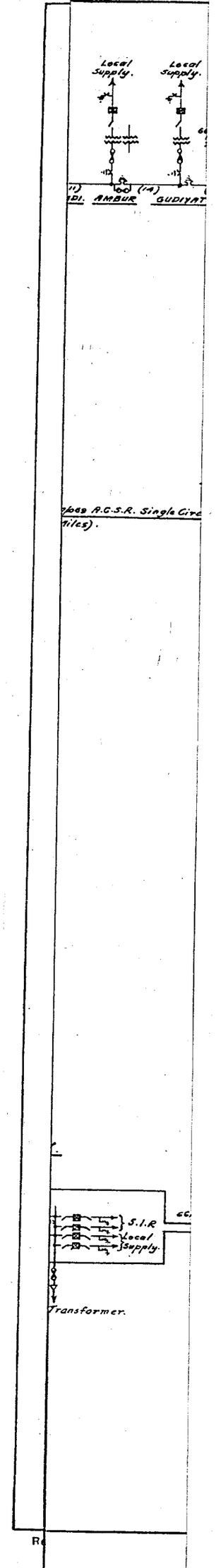
10. *Auxiliary equipment.*—Power for auxiliaries as also for Mettur local demand will be supplied from an auxiliary bus fed through an oil circuit breaker and reactor from the 11 K.V. bus. Two station transformers of 250 K.V.A. each will step the voltage down to 400 for supply to the motor generator sets, local lighting, pumps and other uses. A small 100 h.p. station service turbine set will be installed for emergency use.

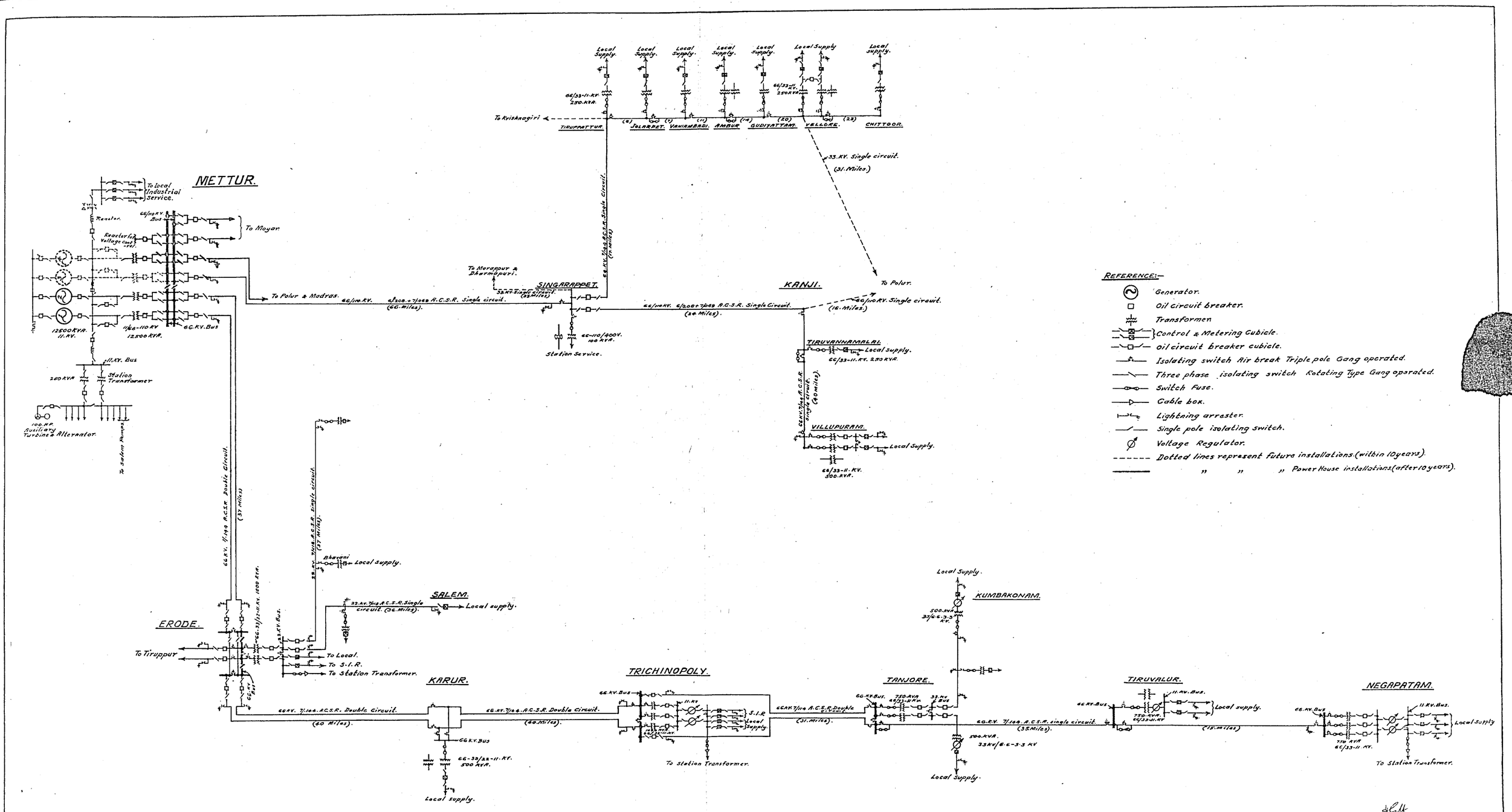
11. A 200 ampere-hour 110 volt storage battery will provide D.C. for the operation of the oil circuit breakers, relays and emergency lighting circuits.

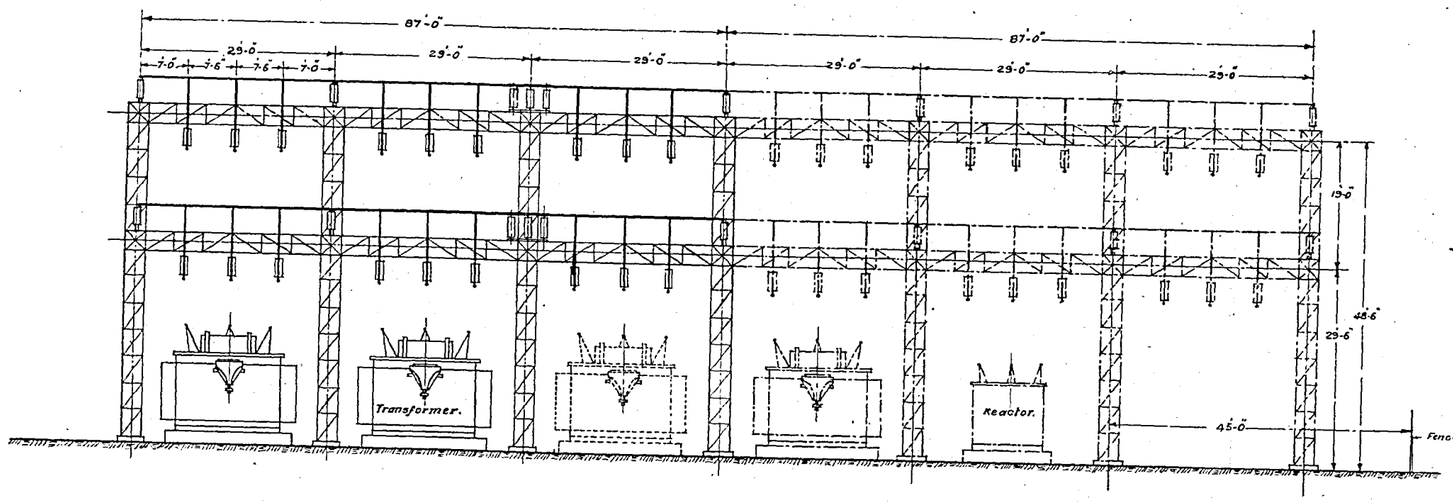
12. It is also proposed to install two pumping sets for Salem water-supply.

13. *Protection.*—Protective gear for generators and transformers against internal phase to phase and earth faults will be provided. Over-voltage and over-frequency relays for the generators and external overload and earth leakage relays for the transformers will also be installed. A complete fire protection equipment for the generators and the station plant will be ordered.

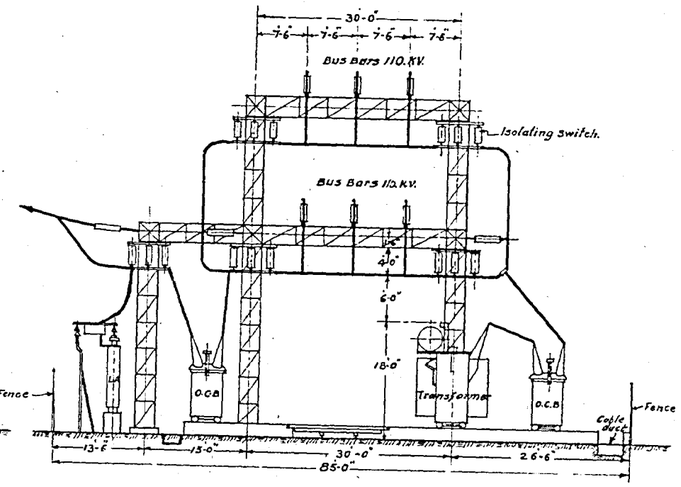
14. *Estimates.*—A summary of the estimates for the Civil Works and Power-station is given in Table I. The estimates for the civil works have been prepared by the Executive Civil Engineer. Detailed estimates are on file.




METTUR.
To local Industrial Service.
To Mayar.
Reactor.
66/110 KV. Bus
Reactor for Voltage control.
12500 KVA. 11. KV.
11/66-110 KV 12500 KVA.
66. KV. Bus
11. KV. Bus
200 KVA
Station Transformer
100 HP Auxiliary Turbine & Alternator.
To Sulur Pumps
To Polur & Madras.
66/110 KV.
6/208 + 7/064 A.C.S.R. Single circuit.
(66. Miles).
To Morappur & Dharmapuri.
SINGARAPPET.
52 KV. Single circuit. (33 Miles)
66-110/400 V. 100 KVA.
Station Service.
66 KV. 7/144 A.C.S.R. Single Circuit. (70 Miles)
66/110 KV. 6/208 + 7/064 A.C.S.R. Single Circuit.
(24 Miles).
KANJI.
To Polur.
66/110 KV. Single circuit.
(16. Miles)
TIRUVANNAMALAI.
Local supply.
66/33-11. KV. 250 KVA.
66 KV. 7/144 A.C.S.R. Single circuit. (40 miles).
VILLUPURAM.
Local Supply.
66/33-11. KV. 500. KVA.
Local Supply.
66/33-11. KV. 250. KVA.
To Kriskhagiri
TIRUPPATTUR.
JOLARPET.
VANIAMBADI.
AMBUR.
GUDIYATTAM.
VELLORE.
CHITTOOR.
33. KV. Single circuit.
(31. Miles.)
66 KV. 7/144 A.C.S.R. Single Circuit. (70 Miles)
66 KV. 7/144 A.C.S.R. Double Circuit. (37 Miles)
33 KV. 7/144 A.C.S.R. single circuit. (37 Miles).
Bhavani
Local Supply.
SALEM.
33 KV. 7/144 A.C.S.R. Single circuit. (36. Miles).
Local supply.
ERODE.
To Tiruppur
66/33-11. KV. 1000 KVA.
33 KV. Bus.
To Local.
To S.I.R.
To Station Transformer.
66 KV. 7/144. A.C.S.R. Double Circuit.
(40 Miles).
KARUR.
66 KV. Bus
66-33/22-11. KV. 500 KVA.
Local supply.
66 KV. 7/144. A.C.S.R. Double Circuit.
(40. Miles).
TRICHINOPOLY.
66 KV. Bus
11. KV
S.I.R.
Local Supply.
To Station Transformer.
66 KV 7/144 A.C.S.R. Double circuit.
(31. Miles).
TANJORE.
66. KV. Bus.
750 KVA 66/33-11 KV.
33 KV. Bus
66. KV. 7/144. A.C.S.R. single circuit.
(35 Miles).
500 KVA. 33 KV/6.6-3.3 KV
Local Supply.
Local Supply.
500 KVA 33/6.6-3.3 KV.
KUMBAKONAM.
TIRUVALUR.
66 KV. Bus
11. KV. Bus.
750 KVA. 66/33-11 KV
Local supply.
(15. miles)
NEGAPATAM.
66 KV. Bus
11 KV. Bus.
750 KVA 66/33-11 KV.
Local Supply
To Station Transformer.
REFERENCE:-
Generator.
Oil circuit breaker.
Transformer
Control & Metering Cubicle.
Oil circuit breaker cubicle.
Isolating switch Air break Triple pole Gang operated.
Three phase isolating switch Rotating Type Gang operated.
Switch Fuse.
Cable box.
Lightning arrester.
Single pole isolating switch.
Voltage Regulator.
Dotted lines represent Future installations. (within 10 years).
" " " Power House installations (after 10 years).
Chief Engineer.
Reference
Drawn K.R.
Traced C.V.D.K.
Revision.
Checked C.V.
Approved
GOVT. OF MADRAS.
ELECTRICITY DEPT.
METTUR H.E. DEVELOPMENT.
ELECTRICAL LAY-OUT.
No. M.27
F.D.I.
Scale:-
Date. 27-3-33
Reg. No. 52/1 Copies 100
Helio-Zinco., Survey Office, Madras. 1934.



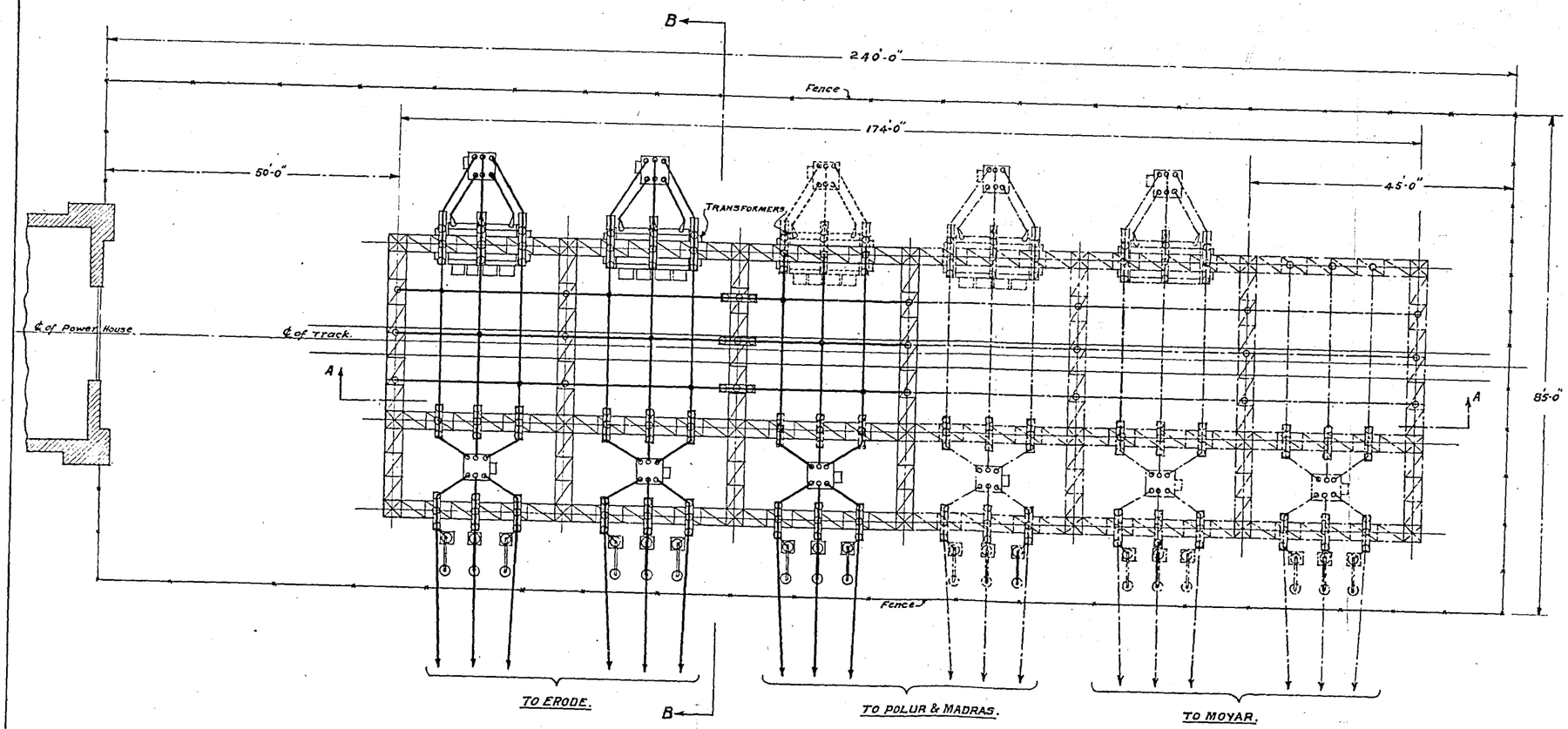
SECTION. A.A.



SECTION. B.B.

Reference:-

- Generator.
- Oil Circuit Breaker.
- Transformer
- Oil Circuit Breaker cubicle.
- Isolating switch Air Break Triple pole Gang operated.
- Three Phase Isolating switch Rotating Type Gang operated.
- Lightning Arrester.
- Single Phase Isolating switch.
- Chain Dotted Lines Represent Future Installations (after 10 years)
- Dotted Lines Represent Future Installations (within 10 years).



PLAN

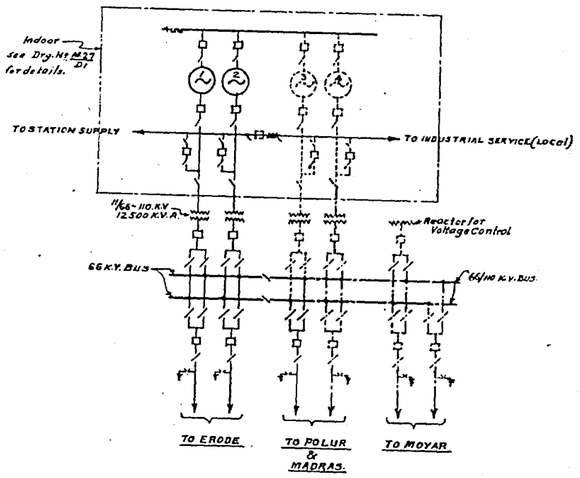


DIAGRAM OF CONNECTIONS.

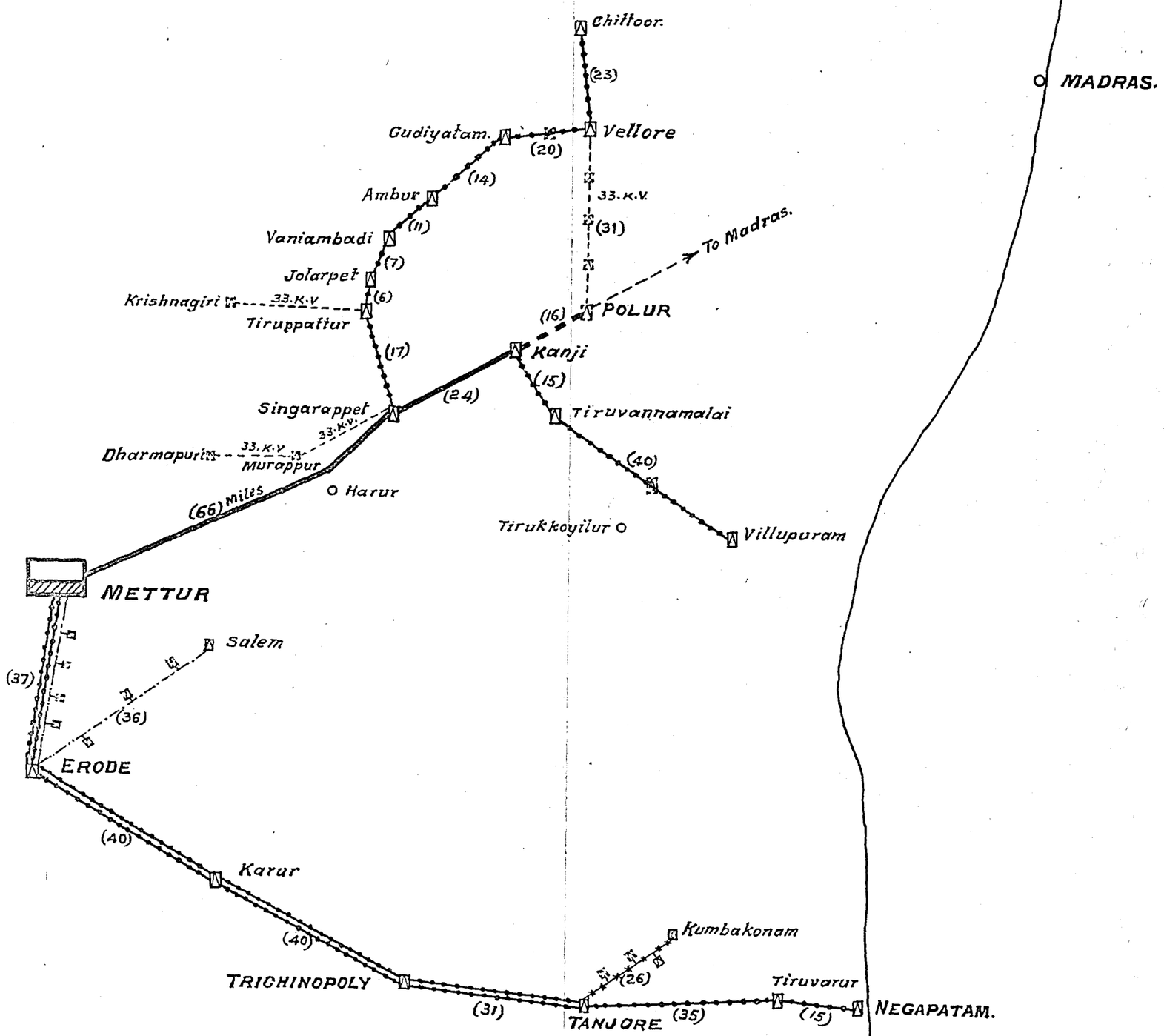
NOT TO BE USED FOR CONSTRUCTION.

Chief Engineer.

Reference	Drawn. K.R.	GOVT OF MADRAS ELECTRICITY DEPT.	No. M.28 / D.1
	Traced. C.T.S.M.	METTUR H.E. DEVELOPMENT.	SCALE:-
Revision	Checked. 5.5.34	METTUR STEP-UP TRANSFORMER STATION.	DATE:- 5-5-34.
	Approved. 5.5.34		

HELIO. ZINCO, SURVEY OFFICE, MADRAS, 1934.

REG. No. D4/1 COPIES. 100.



REFERENCE:-

- Hydro Power Station.
- Sub-Station 110 & 66.K.V.
- Sub-Station 33, 22 or 11 K.V.
- 66/110.K.V. Transmission Line.
- 66. K.V. ------- " -------- "
- 33. K.V. ------- " -------- "
- 22. K.V. ------- " -------- "
- ------ Future equipment & Lines.
- (40) Distance in Miles.
- o Location of Towns.

Chief Engineer.

Reference	Drawn K.R	GOVT OF MADRAS ELECTRICITY DEPT.	No. M.26 / F.2
	Traced. C.V.D.N.	METTUR H.E DEVELOPMENT.	Scale. 1" = 20 Miles
Revisions.	Checked. 23-3-34	METTUR SYSTEM.	Date. 22-3-34
	Approved.		

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TABLE I.

Civil Works and Power station.

Account No.	Description.	First year.	Third year.	Total.
		In lakhs of Rupees.		
M. 140.	Gates, pipes, etc., already installed and debited to this scheme	10·80	..	10·80
M. 150.	Power-house buildings	7·31	·20	7·51
M. 160.	Power-house generating and control equipment	11·00	9·00	20·00
M. 170.	Power-station auxiliaries	2·00	1·20	3·20
M. 180.	Tail race	·30	..	·30
M. 190.	Main transformer station	4·80	1·60	6·40
M. 200.	Permanent roads and bridges	·10	..	·10
M. 220.	Permanent buildings	1·20	..	1·20
M. 230.	Permanent water-supply and fire protection	·10	..	·10
M. 240.	Permanent tools and equipment	·10	·10	·20
	Sub-total ..	37·71	12·10	49·81
X	Contingencies	2·00	·60	2·60
010.	Establishment	1·30	·60	1·90
020.	General charges	2·69	1·20	3·89
030.	Engineering and construction plant	·60	·20	·80
040.	Temporary camp	·70	·30	1·00
	Totals ..	45·00	15·00	60·00

15. *The transmission system.*—The transmission lines can be classed under two heads—

(1) the northern area lines comprising the 66/110 K.V., 66 K.V. and 11 K.V. trunk and branch lines serving the North and South Arcot districts and Chittoor ; and

(2) the southern area lines of 66 K.V., 33 K.V., 22 K.V. and 11 K.V. trunk and branch lines serving Salem, Erode, Trichinopoly and Tanjore districts.

Drawing No. M. 26/F-2 is to illustrate the system.

16. *Northern area.*—A trunk line designed for 66/110 K.V. [illegible] and carrying a single circuit will be erected between Mettur and Kanji, 90 miles [illegible] follow the route surveyed for the Mettur-Madras line and when supply to Mad[illegible] line will become part of the main trunks that will be necessary. The clearance [illegible] 10 K.V. operation and the conductor will be the same as has been chosen for [illegible] line, viz., 6/·208, + 7/·0693 A.C.S.R.

17. At Singarappet, 66 miles from Mettur, a sectionali[illegible] rected and a lighter 66 K.V. line will take off therefrom in a northerly directi[illegible] for feeding Vellore, Chittoor and the intervening towns and villages. This line will be designed only for 66 K.V. operation and will carry a single circuit with A.C.S.R. 7/·144 conductor. It will be 98 miles long. The line will be tapped at a number of substations en route and power will be stepped down to 11 K.V. and 400 volts at these places. To serve the local areas round each substation, secondary lines at 11 K.V. will be needed. The exact route length of such secondary lines cannot be estimated now, but provision for 15 miles initially with 120 miles further extensions within 10 years has been made as adequate.

18. Kanji will initially be the terminal station of the 66/110 K.V. line from Mettur, but the line will be extended to Polur in the third year. From Kanji a light 66 K.V. line similar to the Singarappet-Chittoor line, will be constructed in the first year of operation, leaving for Villupuram and passing through Tiruvannamalai on the way. Substations at Tiruvannamalai, at Villuppuram and at an intermediate point will tap the line for local supplies. At Villupuram energy for the South Arcot licensee will be sold in bulk.

19. *Southern area.*—Trichinopoly and Tanjore district loads are at present proposed to be fed from Pykara through the Erode-Trichinopoly line under construction and the Negapatam extension under contemplation. As soon as Mettur Power-station is ready the loads will be transferred on to it, relieving Pykara. Mettur is nearer and in every way better suited for supplying this area than Pykara.

20. A 66 K.V. double circuit line will be erected from Mettur to Erode to carry this southern area load. The capital costs of the Erode-Trichinopoly extension, the Negapatam extension and of the Erode-Salem-Mettur 22 K.V. Scheme will all be transferred to the Mettur Project, corresponding credit being given to the Pykara Scheme capital outlay.

21. The southern area will then have—

(*a*) a 37-mile 66 K.V. double circuit line from Mettur to Erode to carry the full power demand of the area,

(*b*) 22 K.V. lines from Erode to Mettur and Erode to Salem serving as secondary lines feeding Bhavani, Salem and the intervening towns, villages and agricultural loads,

(*c*) a 66 K.V. double circuit line from Erode to Trichinopoly and Tanjore with a similar but single circuit extension to Negapatam,

(*d*) a 33 K.V. single circuit line 25 miles long from Tanjore to Kumbakonam,

(*e*) substations at Erode, Karur, Trichinopoly, Tanjore, Tiruvarur, Negapatam and Kumbakonam to supply bulk power to the local licensees and others, and

(*f*) twenty miles of 11 K.V. and 22 K.V. lines for local distribution.

22. *Telephone communications.*—The main 66/110 K.V. and 66 K.V. circuits are throughout paralleled by single circuit telephone lines mounted on separate poles. The lines will be located at a distance from the power lines to prevent inductive interference. These telephone lines will be erected through the Government Telegraph Department in accordance with their standard practice.

23. Provision has been made for this in the estimate at the rate of Rs. 1,600 per mile.

24. The 33 K.V. lines will carry the telephone line on the same poles and its cost is included in the line cost ; 11 K.V. distribution lines will not carry any telephone lines.

25. *Extensions.*—The following are the projected extensions of the transmission system in the first ten years of operation.

First year.—66 K.V. line from Kanji to Villupuram.

Third year.—66/110 K.V. line from Kanji to Polur.

33 K.V. line from Singarappet to Dharmapuri.

Fourth year.—33 K.V. line from Tiruppattur to Krishnagiri.

Fifth year.—33 K.V. line from Polur to Vellore.

26. 11 *K.V. and* 22 *K.V. lines.*—Provision for extension of these lines has been made for every year and by the end of ten years, it is expected there would be about 175 miles of these in service.

27. *Mechanical characteristics.*—Table No. II gives complete information on the mechanical characteristics of the lines comprised in the system. The route mileages, normal spans, conductor sizes and their clearances are all detailed. The factors of safety adopted are in general 2·5 for towers and 2·0 for conductors.

28. Drawing No. M. 33/D-1 is to show the different types of towers and poles to be adopted.

TABLE II.

Mechanical characteristics of transmission lines.

Item number and description of section.	Voltage.	Number of circuits.	Route miles.	Normal span.	Tower or pole.	Height of Tangent pole or Tower.	Power conductor.	Ground wire.	Clearances on Tangent pole or Tower. Vertical.	Clearances on Tangent pole or Tower. Horizontal.	Clearances on Tangent pole or Tower. To ground.	Insulators. Number in suspension.	Insulators. Number in strain.	Factors of safety under normal conditions. Tower or Pole.	Factors of safety under normal conditions. Conductor.	Factors of safety under normal conditions. Ground wire.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
	K.V.		MILES.	FEET.		FEET.	A.C.S.R.	STEEL.	FT. IN.	FT. IN.	FT. IN.					
Northern area.																
1 Mettur-Kanji section.	66/110.	1	90	1,050	Tower.	62	6/·208 + 7/·069	7/9 S.W.G.	10 6	17 0	21 0	7	8	2·5	2·0	2·5
2 Singarappet-Chittoor.	66	1	98	750	Do.	45	7/·144	7/10 ,,	6 6	12 0	20 0	5	6	2·5	2·0	2·5
3 Kanji-Villupuram ..	66	1	55	750	Do.	45	7/·144	Nil.	6 6	12 0	20 0	5	6	2·5	2·0	..
4 11 K.V. lines ..	11	1	15	300	Pole.	30	7/·0935	Nil.	2 6	3 0	20 0	Pin type.	1	2·5	‡ 2·0	..
5 Kanji-Polur extension.	66/110.	1	16	1,050	Tower.	62	6/·208 + 7/·069	7/9 S.W.G.	10 6	17 0	21 0	7	8	2·5	2·0	2·5
6 Polur-Vellore extension.	33	1	31	400	Pole.	36	7/·118	Nil.	4 0	4 6	20 0	Pin type.	3	2·5	‡ 2·0	..
7 Singarappet-Dharmapuri.	33	1	33	400	Do.	36	7/·118	Nil.	4 0	4 6	20 0	Do.	3	2·5	‡ 2·0	..
Tirupattur-Krishnagiri.	33	1	23	400	Do.	36	7/·118	Nil.	4 0	4 6	20 0	Do.	3	2·5	‡ 2·0	..
9 11 K.V. Extensions.	11	1	110	300	Do.	30	7/·0935	Nil.	2 6	3 0	20 0	Do.	1	2·5	‡ 2·0	..
Southern area.																
1 Mettur-Erode ..	66	2	37	750	Tower.	52	7/·144	7/10 S.W.G.	6 6	12 0	20 0	5	6	2·5	2·0	2·5
2 Erode-Tanjore ..	66	2	111	750	Do.	52	7/·144	7/10 ,,	6 6	12 0	20 0	5	6	2·5	2·0	2·5
3 Tanjore-Negapatam.	66	1	50	750	Do.	45	7/·144	7/10 ,,	6 6	12 0	20 0	5	6	2·5	2·0	2·5
4 Tanjore-Kumbakonam.	33	1	25	400	Pole.	36	7/·118	Nil.	4 0	4 6	20 0	Pin type.	3	2·5	‡ 2·0	..
5 Erode-Salem-Mettur.	22	1	73	350	Do.	36	7/·118	Nil.	3 0	3 6	20 0	Do.	2	2·5	3·1	..
6 11 K.V. Lines ..	11	1	20	300	Do.	30	7/·0935	Nil.	2 6	3 0	20 0	Do.	1	2·5	‡ 2·0	..
7 11 K.V. Extensions.	11	1	30	300	Do.	30	7/·0935	Nil.	2 6	3 0	20 0	Do.	1	2·5	‡ 2·0	..
8 22 K.V. Extensions.	22	1		350	Do.	35	7/·0935	Nil.	3 0	3 6	20 0	Do.	2	2·5	‡ 2·0	..
Telephone lines on separate poles where power lines run on towers—																
(a) Initial	L.T.	1	349	300	Pole.	As required.	No. 10 or No. 11 S.W.G. copper.	Nil.	As required.			L.T. Pin and shackle.		2·5	‡ 2·0	..
(b) Extensions ..	L.T.	1	71	300	Do.	Do.	Do.	Nil.	Do.			Do.	..	2·5	‡ 2·0	..

29. *Electrical characteristics.*—Tables III and IV give the electrical characteristics of the various transmission lines with 66 K.V. constant at the remotest ends of the system, viz., Chittoor in the north and Negapatam in the south; the maximum voltage variations on Mettur H.T. bus will be as follows :—

	1st year.	10th year.
Northern area—		
(a) Distributed load	1,900 K.W.	6,000 K.W.
(b) Voltage variation at Mettur due to loads in Northern area	4·7 %	14·1 %
Southern area—		
(a) Distributed load	5,000 K.W.	10,000 K.W.
(b) Voltage variation at Mettur due to loads in southern area	11·1 %	21·7 %

To the above figures have to be added the drops in the transformers at the sending and receiving ends. To keep the voltage fluctuation at the consumers' terminals within the statutory limits, voltage regulators at different load centres are provided for, initially for the Southern area and in the 3rd year for the Northern area. Further, automatic line drop compensators will be installed on the generators to enable partial compensation of the line drops. Other methods of improving the regulation for example duplicating the lines or of increasing conductor size would not be economical.

30. *Charging K.V.A.*—The total charging K.V.A. of the transmission system which the generators at Mettur will have to handle is about 11,000 for 66 K.V. operation.

31. *Estimates.*—A summary of the estimates for capital outlay for the transmission system is given in the Table No. V below. The initial expenditure will be Rs. 59·588 lakhs rising to Rs. 80·81 lakhs in the tenth year.

TABLE III.

Electrical Characteristics of Mettur-Erode-Trichinopoly-Negapatam 66 K.V. Transmission Lines (Southern area) without synchronous condensers.

(Transformers at sending and receiving end not included.)

Year of operation.	K.W.		Voltage.		Current.		P.F.		K.V.A.		Regulation		
	Mettur.	Total load on lines.	Mettur.	Nega-patam.	Mettur amps.	Load centre amps.	Mettur.	Load centre.	Mettur.	Load centre.	Varia-tion at Mettur.	Line drop.	Effi-ciency.
											PER CENT.	PER CENT.	PER CENT.
All years (no load)	410	0	63,150	66,000	58·0	0	·065 lead.	..	6,300	..	..	— 4·3	..
First year	5,400	5,000	70,450	66,000	51·7	55·0	·856 lead.	·80 lag.	6,300	6,250	11·1*	6·8	92
Tenth year	11,600	10,000	77,450	66,000	86·4	110	·997 lag.	·80 lag.	11,650	12,500	21·7*	17·4	86·5

* Voltage regulators at different load centres and automatic line drop compensator on Mettur generators are provided to bring down the voltage variation at consumers ends within statutory limits.

TABLE IV.

Electrical Characteristics of Mettur-Singarappet-Chittoor-Villupuram Transmission Lines without synchronous condensers.

(Transformers at sending and receiving ends are not included.)

Year of operation.	K.W.		Voltage.		Current.		P.F.		K.V.A.		Regulation.		
	Mettur.	Total load on lines.	Mettur.	Chittoor.	Mettur.	Load centre.	Mettur.	Load centre.	Mettur.	Load centre.	Voltage varia-tion at Mettur.	Line drop.	Effi-ciency.
											PER CENT.	PER CENT.	PER CENT
All years (no load)	160	..	62,350	66,000	41·3	..	·035 lead.	..	4,500	..	..	— 5·5	..
First year	2,010	1,900	65,450	66,000	34·4	20·8	·51 lead.	·80 lag.	3,800	2,400	4·7	— ·8	94·5
Tenth year	6,500	6,000	71,650	66,000	52·1	65·7	1·0	·80 lag.	6,500	7,500	14·1*	8·6	92·5

* Voltage regulators at different load centres and automatic line drop compensator on Mettur generators are provided to bring down the voltage variation at consumers ends within statutory limits.

TABLE V.

Transmission system—Estimate of Capital Expenditure.

Item number and transmission lines.	Expenditure in lakhs of rupees. Initial.	First year.	Second year.	Third year.	Fourth year.	Fifth year.	Sixth year.	Seventh year.	Eighth year.	Ninth year.	Tenth year.	Total.
NORTHERN AREA.												
66/110 K.V.—												
1 Mettur-Kanji	..	..	..	..	..	..	..	..	..	..	..	..
2 Kanji-Polur	13·950	..	..	2·480	..	..	..	..	..	..	..	..
66 K.V.—												
3 Singarappet-Chittoor	..	..	..	..	..	..	..	..	..	..	..	..
4 Kanji-Villupuram	8·820	4·950	..	..	..	..	..	..	..	..	..	..
33 K.V.—												
5 Singarappet-Dharmapuri ..	..	..	..	2·145	..	..	..	..	..	..	..	..
6 Tiruppathur-Krishnagiri ..	..	..	..	..	..	..	..	..	..	..	..	..
7 Polur-Vellore	..	0·750 (15 miles)	1·250 (25 miles)	0·500	1·495	2·015 0·500	0·500	0·500	0·200	0·300	..	..
11 K.V. Lines	..	..	..	..	..	..	..	..	..	..	..	..
Telephone Lines—												
Mettur-Polur	1·440	..	..	0·257	..	..	..	..	..	..	..	..
Singarappet-Chittoor ..	1·568	0·880	..	..	..	..	..	..	..	..	..	..
Kanji-Villupuram ..	..	..	..	..	..	..	..	..	..	..	..	..
	26·528	7·080	1·250	5·382	1·995	2·515	0·560	0·500	0·200	0·300	..	..
SOUTHERN AREA.												
66 K.V.—												
1 Mettur-Erode	5·180	..	..	..	..	..	..	..	..	..	..	..
2 Erode-Trichinopoly	10·400	..	..	..	..	..	..	..	..	..	..	..
3 Trichinopoly-Tanjore	4·340	..	..	..	..	..	..	..	..	..	..	..
4 Tanjore-Negapatam	4·500	..	..	..	..	..	..	..	..	..	..	..
33 K.V.—												
5 Tanjore-Kumbakonam ..	1·625	..	..	..	..	..	..	..	..	..	..	..
22 K.V.—												
6 Mettur-Erode-Salem	3·410	..	..	..	..	..	..	..	..	..	..	..
11 K.V. and 22 K.V.												
Local lines	1·029	0·500	0·500	..	..	..	..	..	..	..	..	..
Telephone lines	2·576	..	..	..	..	..	..	..	..	..	..	..
Total for Southern Area ..	33·060	0·500	0·500	..	0·500	..	..	..	..	..	..	..
Total for Northern Area ..	26·528	7·080	1·250	5·382	1·995	2·515	0·560	0·500	0·200	0·300	..	80·810
Grand total ..	59·588	7·580	1·750	5·382	2·495	2·515	0·500	0·500	0·200	0·300	..	..

32. *Substations.*—Table VI is to give details of all the substations in the system such as voltages, transformer capacities and capital outlay required. The stages in which extensions would be needed are also indicated.

33. The initial capital expenditure is Rs. 25,59,000 rising to Rs. 41,19,000 in ten years.

TABLE VI.

Details of substation equipment and cost.

Item number and substation.	Voltage ratio.	Installed transformer capacity. Initial. Numbers.	Initial. K.V.A.	Later. Numbers.	Later. K.V.A.	Capital cost. Initial. Lakhs of rupees.	Later. Lakhs of rupees.	Probable year of extension.
NORTHERN AREA.	K.V.							
1 Singarappet switching station.	66-110/33 ..	..	..	2	250	2·00	1·00	3rd.
2 Kanji switching station ..	66/110	..	..	..	..	0·24	0·07	3rd.
3 Tiruppattur	66/33-11	1	250	1	250	0·66	0·58	4th.
4 Jalarpet	66/11	1	250	..	..	0·66	..	..
5 Vaniyambadi	66/11	2	250	..	..	0·66	..	..
6 Ambur	66/11	1	250	..	..	0·66	..	..
7 Gudiyattam	66/11	1	250	..	..	0·66	..	..
8 Vellore	66/33-11	3	250	1	250	1·32	0·50	4th.
				1	250		0·50	5th.
9 Chittoor	66/11	2	250	..	..	0·66	..	..
10 Future station	66/11	..	..	1	250	..	0·66	6th.
11 Krishnagiri	33/400 Volts. ..	..	..	2	100	..	0·20	4th.
12 Dharmapuri	33/400 ,, ..	..	..	2	100	..	0·20	3rd.
13 Morappur	33/400 ,, ..	..	..	1	100	..	0·20	3rd.
14 Tiruvannamalai	66/11	..	..	1	250	..	0·66	1st.
15 Villupuram	66/11	..	..	3	500	..	1·54	1st.
				1	500	..	0·48	5th.
16 Future station between 14 and 15	66/11	..	..	1	250	..	0·66	4th.
17 Polur substation	66-110/33-11 ..	..	..	2	250	..	1·72	3rd.
18 Five future 33 K.V. substations between Polur and Vellore	33/400 Volts. ..	..	..	1	100	..	0·40	5th.
				1	100			
				1	100	..	0·20	6th.
				1	100	..	0·20	7th.
				1	100	..	0·20	9th.
19 Voltage regulating equipment	..	..	..	..	..	..	2·00	3rd.
SOUTHERN AREA.								
20 Erode	66/22	2	1.000	..	..	4·95	..	..
21 Karur	66/11	2	500	..	..	1·00	..	..
22 Trichinopoly	66/11	3	1,000	1	1,000	4·06	0·97	4th.
23 Tanjore	66/33	2	750	1	750	1·68	0·40	3rd.
	33/3·3	1	500	1	500	..	0·40	5th.
24 Tiruvarur	66/11	2	750	..	..	1·20	..	..
25 Negapatam	66/11	3	750	1	750	2·40	0·50	4th.
				1	750	..	0·50	8th.
26 Kumbakonam	33/6·6	2	500	1	500	0·43	0·22	2nd.
27 33 K.V. Substation between Tanjore and Kumbakonam at three places	33/400 Volts. ..	1	50	..	..	0·15	..	..
				1	50	..	0·15	2nd.
				1	50	..	0·15	3rd.
28 Salem	22 K.V.	..	..	..	..	0·10	..	..
29 Bhavani	22/400 Volts. ..	1	25	1	50	0·05	0·06	4th.
30 Six 22 K.V. substations in Erode-Salem and Erode-Mettur lines	22/400 Volts. ..	1	50	..	..	0·07	..	..
		1	50	..	..	0·07	..	..
				1	50	..	0·07	1st.
				1	50	..	0·07	2nd.
				1	50	..	0·07	3rd.
				1	50	..	0·07	4th.
31 Mettur	22/400 Volts. ..	..	..	..	..	0·24	..	..
32 Part debit for voltage stabilizing equipment	..	..	..	..	..	1·67	..	..
			Total capital expenditure—			25·59	2·27	1st.
							0·44	2nd.
							5·81	3rd.
							3·54	4th.
							1·78	5th.
							0·86	6th.
							0·20	7th.
							0·50	8th.
							0·20	9th.
							41·19 lakhs	

Stations in Northern Area.

34. *Switching Stations.*—Two switching stations are proposed on the 66/110 K.V. trunk line from Mettur to Kanji, one at Singarappet and the other at Kanji.

35. *Item* 1—*Singarappet.*—The 66 K.V. light line to Vellore and Chittoor will branch at this station. Since its length is 98 miles, the charging K.V.A. to be dealt with when switching will be 1,900. Similarly the charging K.V.A. of the arm going to Kanji and Villupuram will be 1,500. It is hence proposed to instal oil circuit breakers at Singarappet to control both the arms and the station will have a control house, battery and house transformer. Local village load may, if required, be supplied off this house transformer.

36. Later, loads at Dharmapuri and Morappur are expected to justify a 33 K.V. line from Singarappet and provision has been made for 2 Nos. 66/33 K.V. step down transformers of 250 K.V.A. each.

37. The clearances of the structure at Singarappet will be for the eventual 110 K.V. operation, but the circuit breakers will be only for 66 K.V. operation initially.

38. Provision for voltage regulating and system stabilising equipment has been made at this station and will be installed when needed. Estimates have taken this on the third year of operation tentatively. The layout of the initial station is shown in drawing No. M. 30/D-1.

39. *Item* 2—*Kanji.*—This is a simple station with horn type disconnecting switch on the 66-110 K.V. line to tap off the 66 K.V. branch line to Villupuram.

40. No local supply is likely and no provision for L.T. supply is made.

41. *Item* 17—*Polur.*—The main 66–110 K.V. line will be extended up to Polur in the third year as the demand is expected to justify it. Considerable pumping load is expected between Vellore and Polur and provision for a 33 K.V. line linking Polur and Vellore has been made in the fifth year with step-down transformers at Polur and five other stations in the section.

42. *Items* 3 *to* 7, 9, 10, 14 *and* 16—*Tiruppathur, Jalarpet, Vaniyambadi, Ambur, Gudiyattam, Chittoor, Tiruvannamalai and future stations.*—These stations are to tap the 66 K.V. Singarappet-Chittoor line and the Kanji-Villupuram line at load centres for supply of bulk power at 11 K.V. to local distributing licensees. The layout of each station is very simple as shown in drawing No. M. 31/F. 2. The 66 K.V. side is controlled by a gang switch and fuse. 250 K.V.A. transformers are proposed for stepping-down to 11 K.V. and a minimum of spare units will serve the whole group of stations. The 11 K.V. side will be controlled by oil circuit breakers and each outgoing feeder will similarly be equipped with oil circuit breakers. Overload and earth leakage protection will be provided for these L.T. circuits. It is essential to have the most economical design for these substations as the loads will be principally rural and agricultural. More costly or refined equipment cannot be afforded nor is it necessary.

43. Provision for a later installation of two similar stations, one in the Vellore area and the other in the Villupuram area, has been made, their locations depending on load requirements.

44. *Item* 8—*Vellore*—This is similar to the above substations, but additional transformers for 33 K.V. supply to the Polur area are provided at a later stage.

45. *Items*, 11, 12, 13 *and* 18—*Future* 33 *K.V. Sub-stations—Krishnagiri, Dharmapuri, Morappur and others.*—These are not included initially but the local demands in the areas concerned are expected to justify extension of supply to them. These stations are standardized with H.T. switch fuses and L.T. breakers with 100 K.V.A. transformers as indicated in drawing No. M. 32/F-2. L.T. supply will be at 400 volts as the towns concerned being under Panchayats. Government might have to undertake local distribution. The cost of local distribution has, however, not been provided for in these estimates.

46. *Item* 15—*Villupuram.*—This substation is to be erected in the first year of operation. This would be similar to the ordinary 66 K.V. station but would have three 500 K.V.A. transformer units initially with a later additional unit. Bulk supply to the South Arcot licensee will be made at this point, the licensee distributing the power to the Cuddalore, Chidambaram and Pondicherry areas through his own lines.

47. *Item* 19—*Voltage regulating equipment.*—Provision for this equipment has tentatively been made in the third year of operation.

Stations in Southern Area.

48. The substations in this area are expected to be nearly all of them, functioning by 1935 as parts of the Pykara Scheme. They are to be transferred to the Mettur Scheme when Mettur Power House is ready and the necessary adjustment of capital accounts made.

49. It is not proposed to describe these stations in any detail as such information is already available in the different sanctioned Scheme Reports. But additional equipment and further substations will be needed when the area comes under Mettur and these are detailed below.

50. *Item* 20—*Erode.*—The present Erode Substation will be extended to receive the 66 K.V. double circuit lines from Mettur. The functions of this station will then be

(1) to receive and transmit 66 K.V. power from Mettur to the Trichinopoly and Tanjore districts;

(2) to step-down power to 22 K.V. for supply to Erode-Salem-Bhavani area; and

(3) to serve as a link between the Pykara System and the Mettur System for the interchange of power in emergencies. Drawing No. M. 29/D-1 shows the proposed extensions.

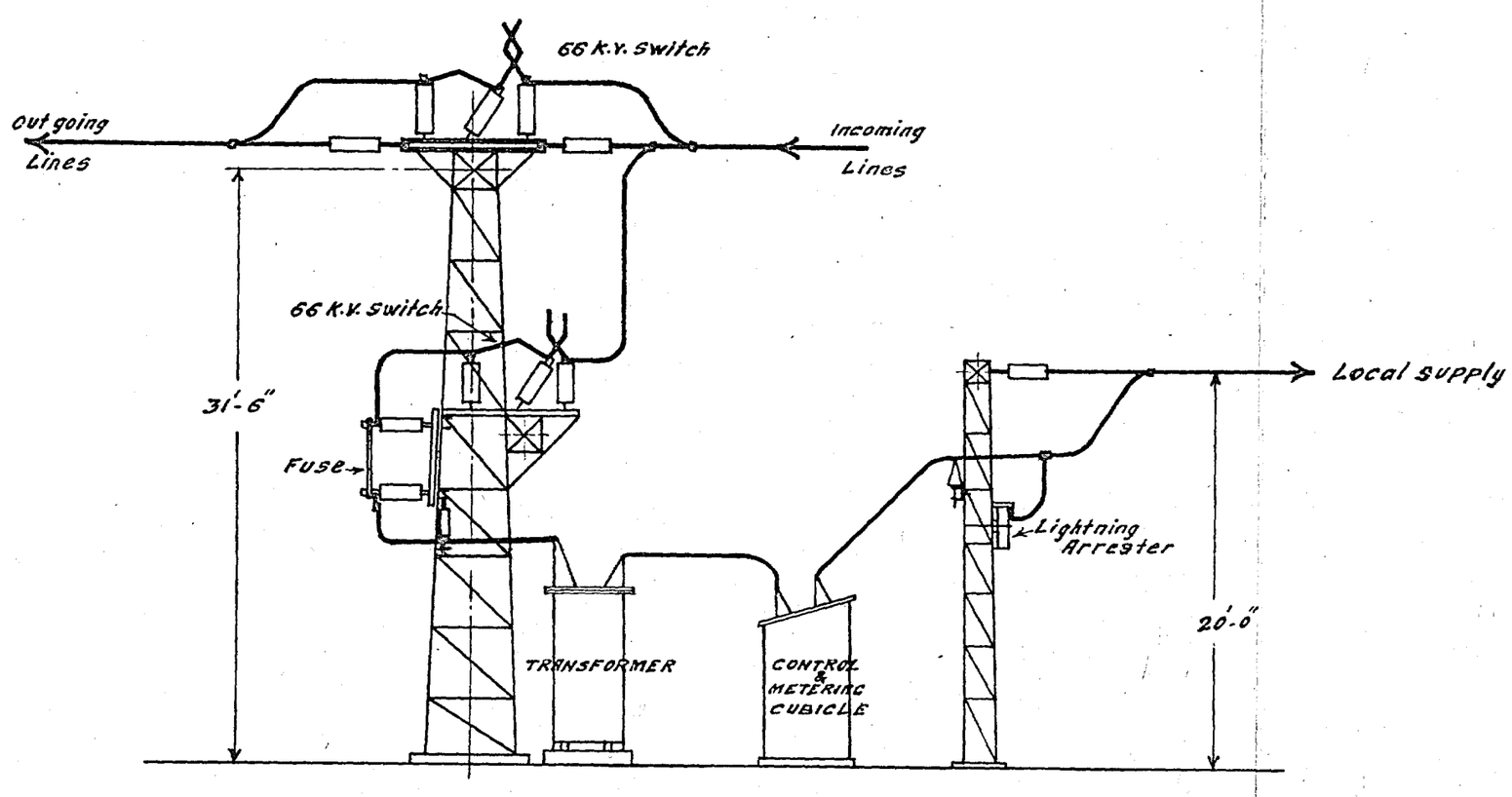
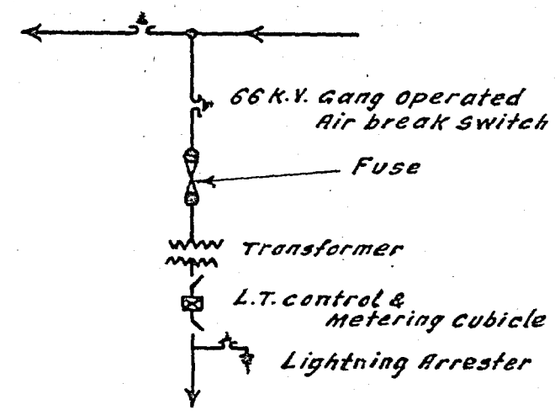
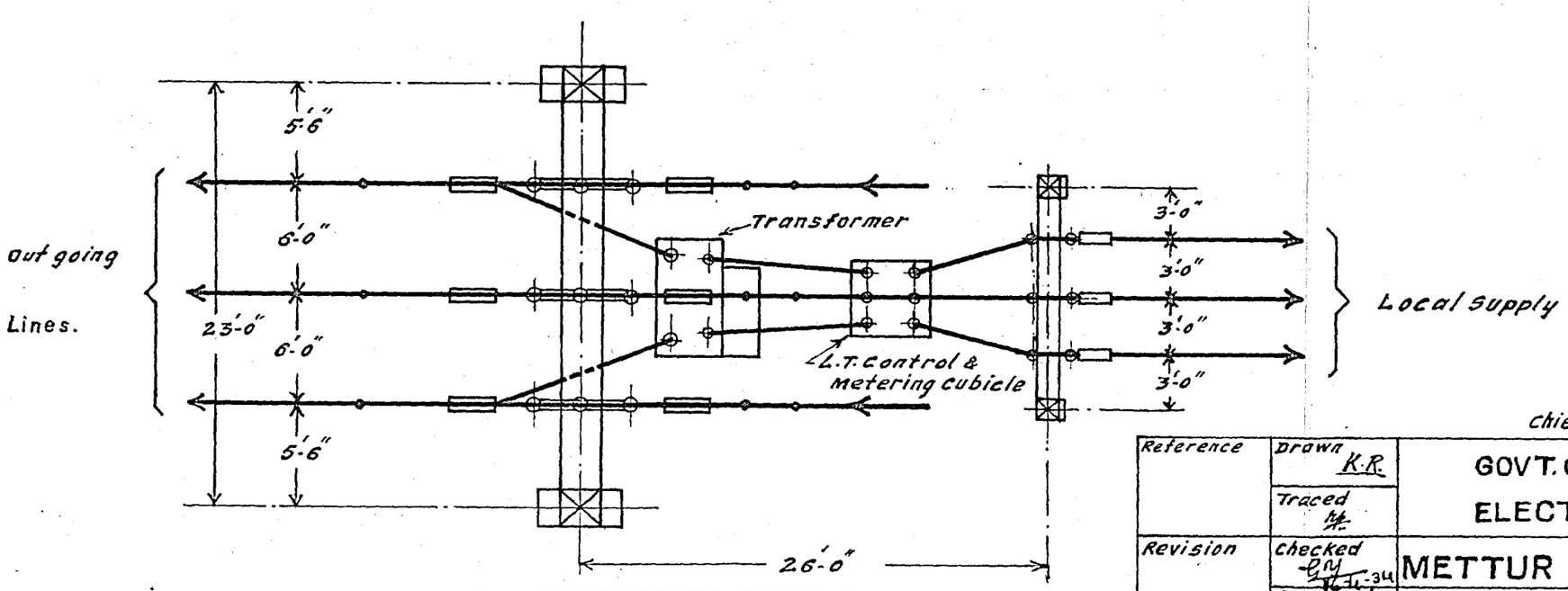


Diagram of Connections





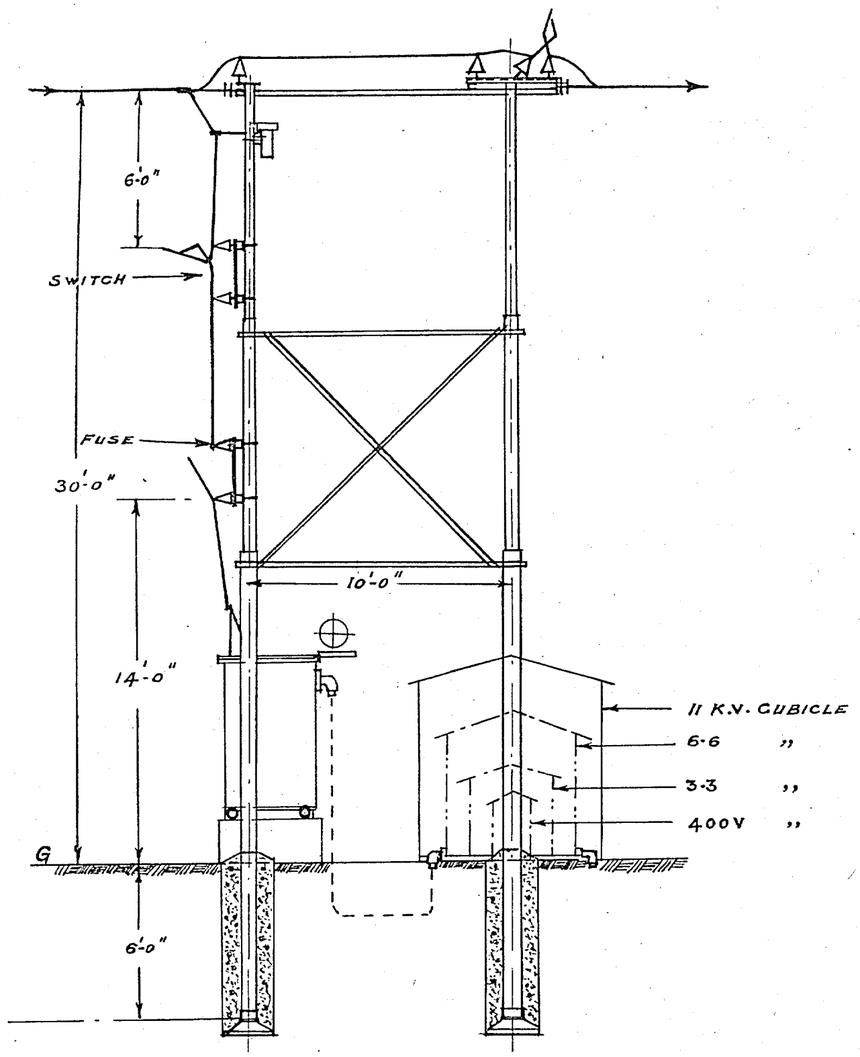
Chief Engineer

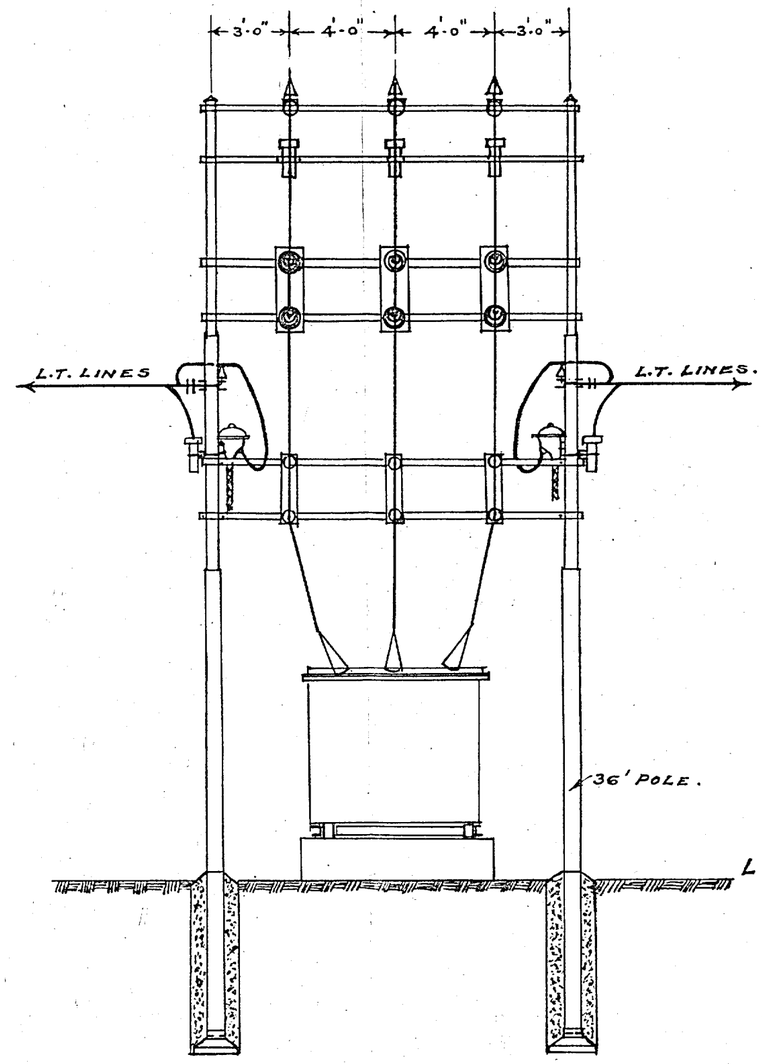
NOT TO BE USED FOR CONSTRUCTION

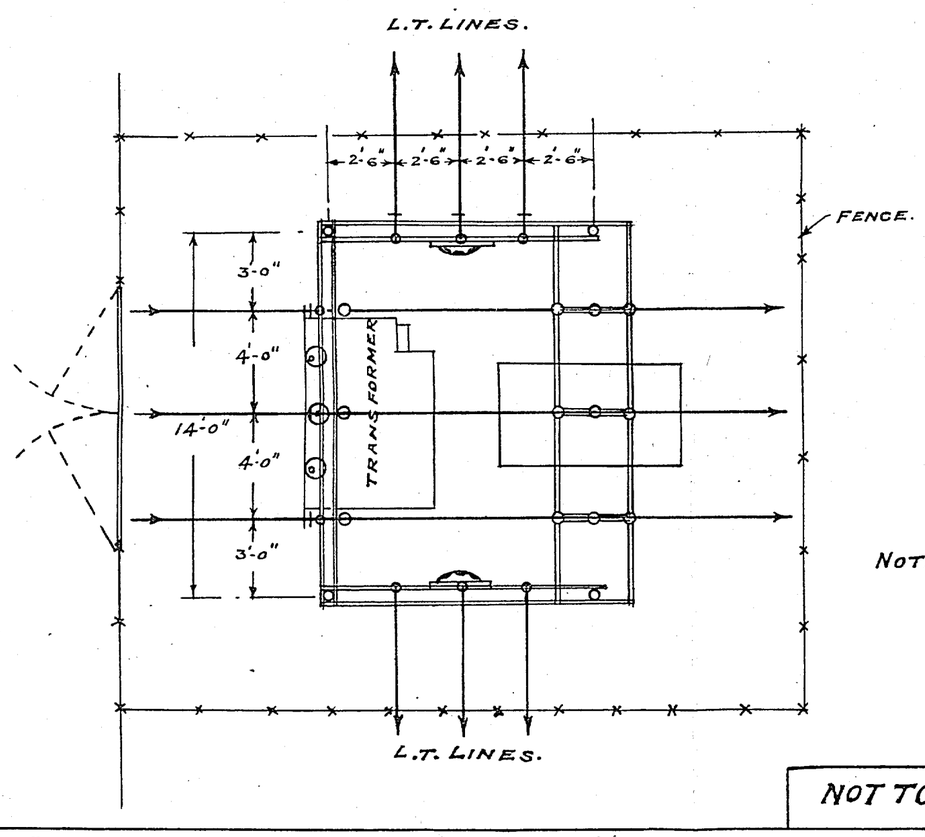
Reference	Drawn K.R.	GOVT. OF MADRAS	No. M 31 / F.2
	Traced	ELECTRICITY DEPT	
Revision	Checked	METTUR H.E. DEVELOPMENT	Scale 1" = 8'
	Approved	TYPICAL 66.KV. SUB-STATION.	Date 20-3-34.

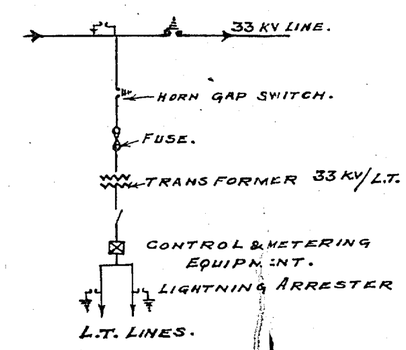
Reg: No. 49/2 Copies. 100.

Vandyke, Survey Office, Madras 1934.









KEY DIAGRAM.

NOTE :-

SUITABLE FENCING TO BE PROVIDED AROUND THE STRUCTURE.

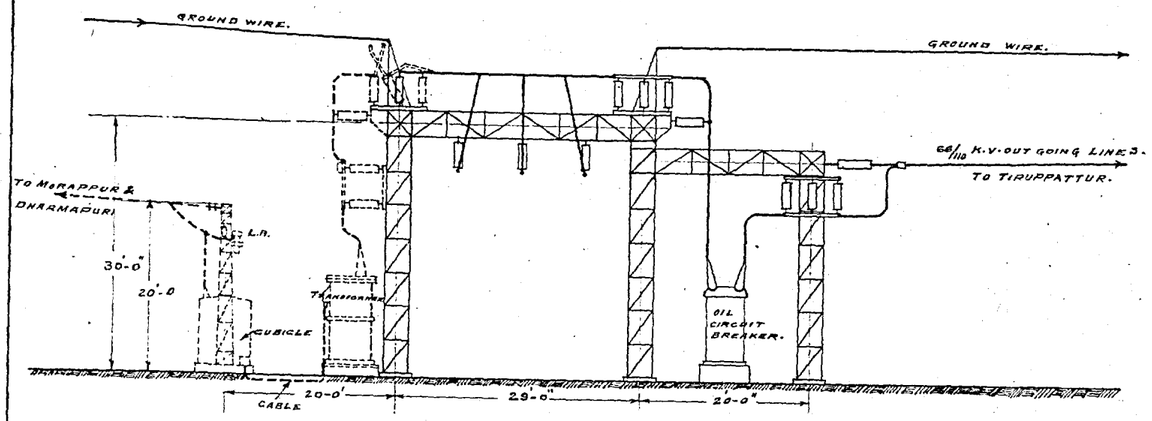
(sd) H.G.H.
CHIEF ENGINEER.

NOT TO BE USED FOR CONSTRUCTION.

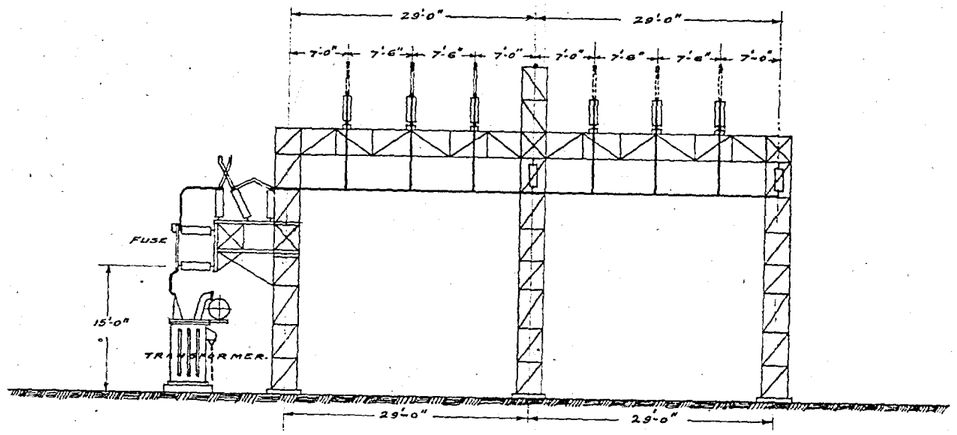
REFERENCE	DRAWN. A.S.	GOVT OF MADRAS. ELECTRICITY DEPT.	No M.32 / F.2
	TRACED. C. Gundurey.	METTUR H.E. DEVELOPMENT.	SCALE:- 1" = 5'
REVISION	CHECKED E.Y. 5.4.34	TYPICAL 33 K.V. SUB-STATION.	DATE:- 27-3-34
	APPROVED G.S. 5.4.34		

Reg: No. 52/2 Copies. 100.

Vandyke, Survey Office, Madras. 1934.



SECTION A.A.



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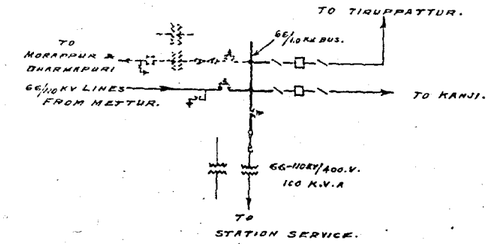
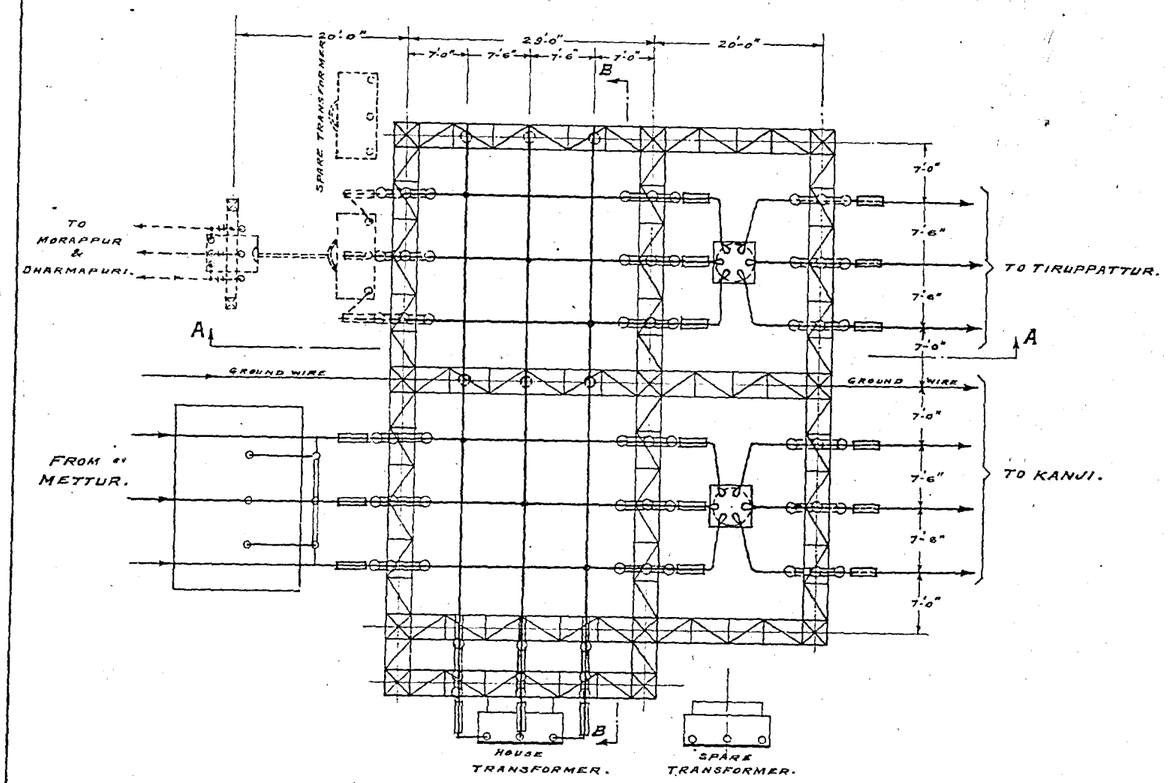




PLAN.

REFERENCE:-

- TRANSFORMER.
- HORN GAP SWITCH, TRIPLE POLE GANG OPERATED.
- FUSE.
- OIL CIRCUIT BREAKER.
- ISOLATING SWITCH ROTATING TYPE TRIPLE POLE.
- LIGHTNING ARRESTER.
- FUTURE.

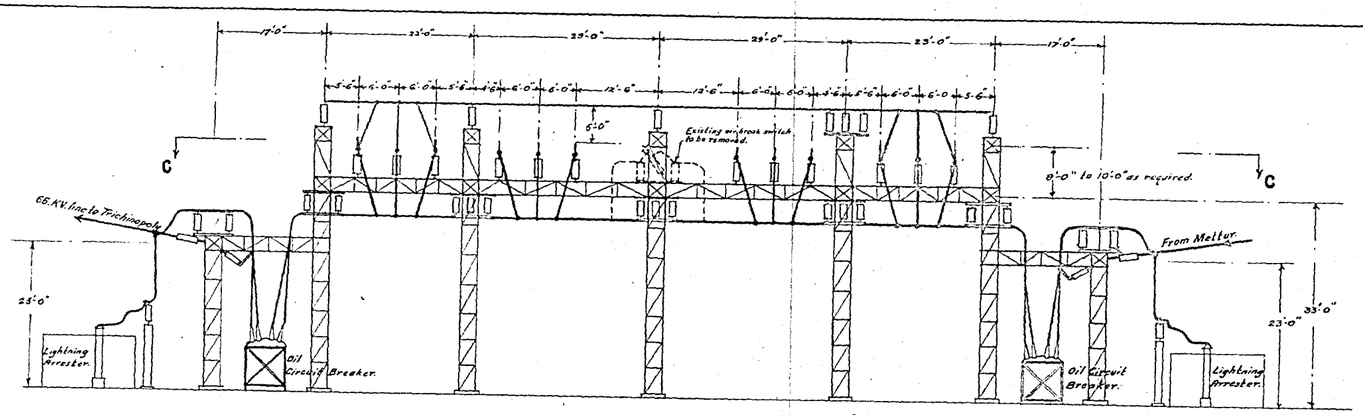
NOT TO BE USED FOR CONSTRUCTION.

CHIEF ENGINEER.

REFERENCE	DRAWN. K.R.	GOVT OF MADRAS. ELECTRICITY DEPT.	No. M.30. D.I.
	TRACED.		
REVISION.	CHECKED.	METTUR H.E. DEVELOPMENT.	SCALE:-
	APPROVED.	SINGARAPPET SWITCHING STATION. 66/110 K.V.	DATE:- 5-5-34.

HELIO, ZINCO, SURVEY OFFICE, MADRAS. 1934.

REG No. 84/3 COPIES. 100



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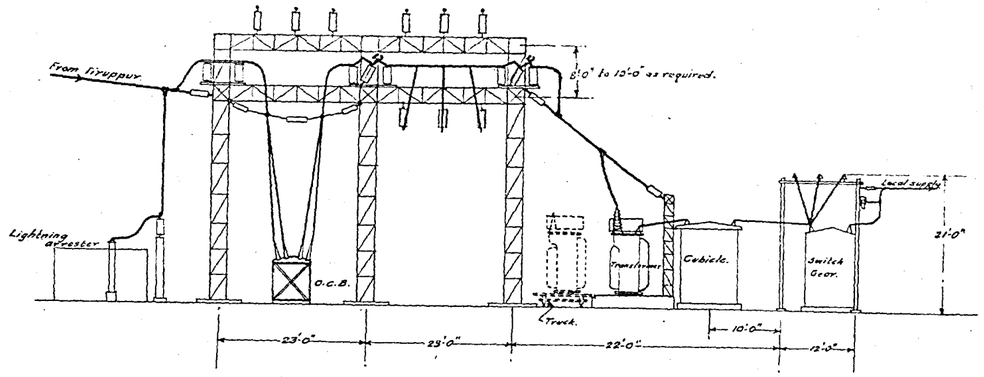

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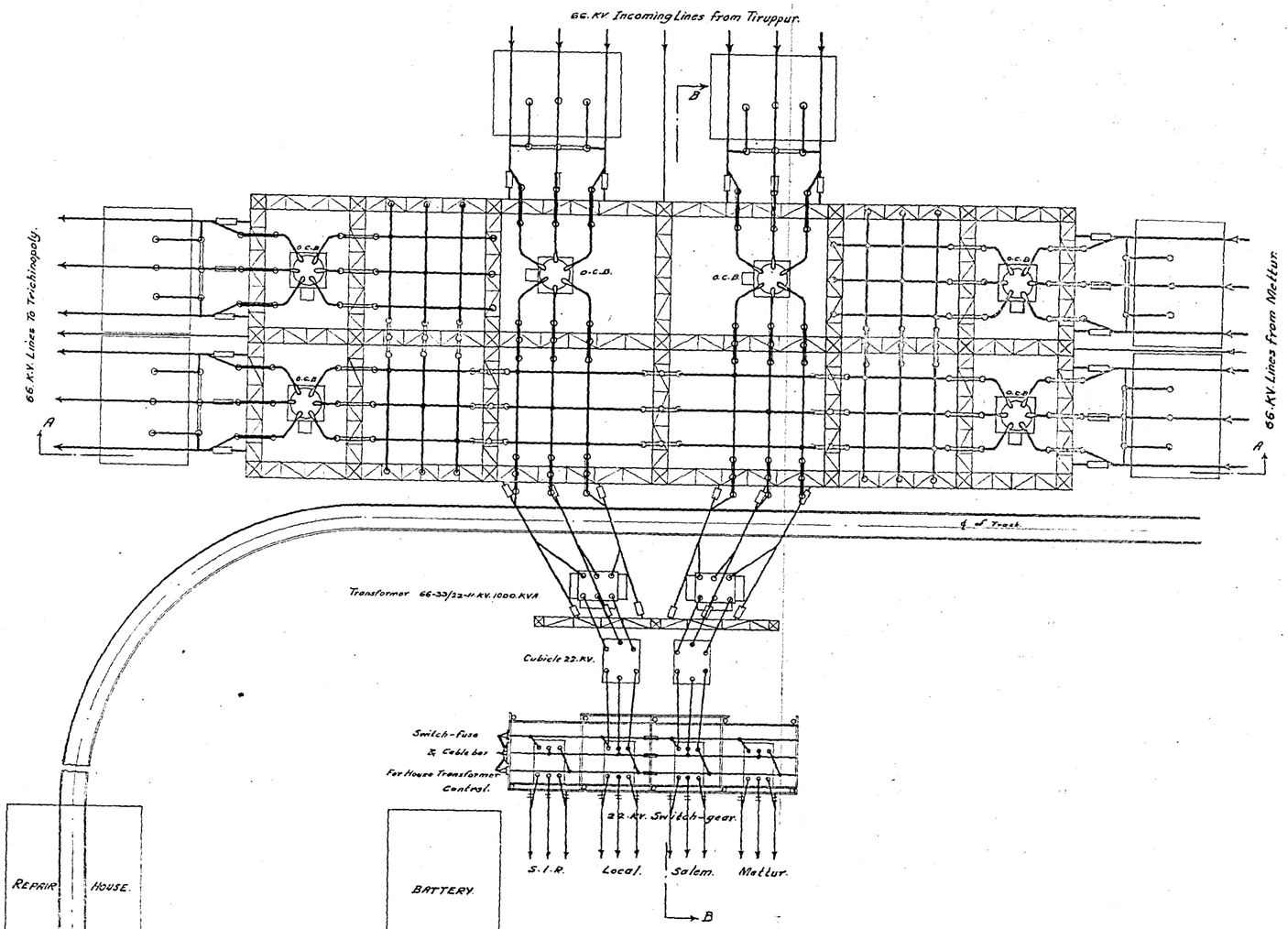

PLAN AT CC.

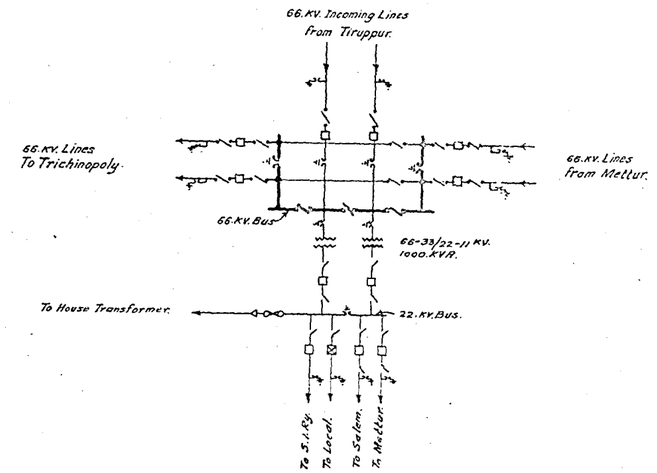

Diagram of Connections.

REFERENCE:-

- Transformer.
- Oil circuit breaker and disconnects.
- Control & Metering Cubicle.
- Isolating Switch air break Triple pole gang operated.
- Fuse.
- Single pole isolating switch.
- Three phase isolating switch rotating type gang operated
- Lightning arrester.
- Cable box.
- Existing equipment.
- Extensions under Mettur Scheme.

NOT TO BE USED FOR CONSTRUCTION.

Chief Engineer.

Reference.	Drawn.	GOVT. OF MADRAS. ELECTRICITY DEPT.	No. M.29 / D.I.
	Traced		
Revision.	Checked	METTUR H.E. DEVELOPMENT.	Scale.
	Approved.	ERODE SUB-STATION (EXTENSIONS).	Date. 7-5-34

REG. No. 84/2 COPIES. 100.

HELIO. ZINCO. SURVEY OFFICE, MADRAS 1934.

51. Pykara power may be said to stop normally with supply at Tiruppur, the intervening Tiruppur-Erode line being the tie between the two systems.

52. *Items* 21, 22, 23, 24, 25, 26, 28, 29 *and* 31—*Karur, Trichinopoly, Tanjore, Tiruvarur, Negapatam, Kumbakonam, Salem, Bhavani and Mettur* (22 *K.V.*).—These are all expected to be in operation before Mettur is started. Their intial capacities are shown in table No. VI as also the extensions contemplated later. It will be noticed that Trichinopoly is provided with three 1,000 K.V.A. units initially, and one more unit than has been provided in the Erode-Trichinopoly extension scheme under construction. The cost of this addition has been included in the present estimates. So also a further 750 K.V.A. unit at Negapatam has been included.

53. *Item* 27—33 *K.V. Stations between Kumbakonam and Tanjore.*—The 33 K.V. line passes through a very populous and prosperous area in this section and three-33 K.V., 50, K.V.A. substations, one immediately and two later, are proposed to be located at convenient points for local electrification.

54. *Item* 30—22 *K.V. Substations in the Erode-Salem-Bhavani area.*—Similar stations on the 22 K.V. lines in this area are expected to be remunerative and six of them are proposed—two to be installed immediately and four later as needed.

55. *Item* 32—*Voltage regulating equipment.*—In view of the long distances between the Power House and centres of consumption, such equipment would be needed sooner or later and provision therefore has been made. For the southern area, this equipment would be located at Trichinopoly.

G. SUNDARAM,
Executive Engineer, Electrical and Mechanical Division.

APPENDIX C.

Note on Industrial Development at Mettur.

The establishment of factories at Mettur would be governed mainly by the following considerations :—

(i) The supply of the necessary raw materials and, when not available locally, the cost of transporting them to Mettur.
(ii) The cost of production compared with present market values of the finished product.
(iii) Cost of transportation to the various markets.
(iv) The demand for the product in Southern India.
(v) The characteristics of the power service required.
(vi) The initial investment.
(vii) Labour supply.

A steady demand exists in Southern India for the products of the following important industries :—

(*a*) Cotton spinning and weaving mills,
(*b*) bleaching, dyeing and finishing plants for (*a*),
(*c*) hosiery factories with (*b*),
(*d*) manufacture of vegetable fats by the hydrogenation process,
(*e*) the alkali industry and the production of hydrogen (for the hydrogenation of oils), caustic soda, chlorine (for bleaching powder), hydro-chloric acid and sodium carbonate,
(*f*) pulp and paper industry,
(*g*) strawboard factories,
(*h*) reduction of Salem iron ores,
(*i*) the manufacture of high grade steel from the pig-iron produced from local ores and also from scrap,
(*j*) the production of ammonia and its compounds,
(*k*) the production of calcium nitrate, and
(*l*) the exploitation of the magnesite deposits at Salem.

Of the above list, items (*a*), (*b*) and (*c*) could be established at Mettur at any time, without much study, and be operated at a profit, as all the requirements for a profitable industry are met by locating such factories near Mettur.

As already mentioned the aim should be to create new industries rather than add to those already existing so that, unless the power demand should not be up to expectations, industries under (*a*), (*b*) and (*c*) may be ruled out.

Item (*f*).—A pulp and paper industry is of great importance and serious study should be given to the possibility of starting this industry, either at Mettur or Papanasam. A strawboard factory utilizing paddy straw might well be established at Mettur.

The production of ammonia and its compounds-particularly cyanamide-should be considered in the near future, but Mettur does not seem to be a particularly satisfactory location for a factory. Coal is required and it would appear that a large cynamide factory could be established on a profitable basis near Calicut, Pykara to supply the power initially. At some future date the power requirements would be met from power developed at a site nearer the coast At least one economical power development is possible.

Of the remaining items, it is believed that (*d*), (*e*), (*g*), (*h*), (*i*), (*k*) and (*l*), should be considered first as the most desirable industries for starting up at or near Mettur.

An immediate investigation should be started to decide upon the comparative economic possibilities of establishing these industries.

For the purpose of this report it is assumed that within the first year of operation, a straw-board factory, the establishment of an Alkali Industry with an oil-pressing plant equipped for hydrogenation and the production of steel shapes and castings, would be in progress, to be followed later by a factory for the production of Calcium Nitrate, while studies of the possibility of manufacturing paper and pulp and the reduction of the Salem Iron Ores would have been completed. As a justification for the above assumption short notes on these proposals follow.

Salem Iron Ores.

The only important deposits in India of magnetite iron ore are located in Mysore and at Salem.

A good deal of doubt appears to exist regarding the quality of the Salem Iron Ore deposits and whether the iron content is high enough to render exploitation commercially feasible. Having in mind the great progress and improvements which have been made in the past decade or so in the methods used for the reduction of iron ores and the manufacture of steel and also that on at least two occasions in the past, viz., in 1853 and 1877, large iron companies were formed to exploit these ores and built furnaces, established foundries, puddling forges, rolling mills and Bessemer converters, it would seem that another survey of these deposits would be amply justified, and reliable analysis of as many samples as necessary, taken from spots located all over the site, undertaken.

It is believed that if after suitable investigation the quality of these ores is satisfactory and other conditions promising, two small electric furnaces might be constructed as an experiment for reducing sufficient ore to provide pig iron to be used in the manufacture of specially high grade steel at Mettur.

Locally made charcoal would be necessary and could be made in the dry weather. During the wettest six months of the year, smelting could take place and most of the labour engaged in charcoal burning during the dry months could be utilized at the smelting works for the other half of the year.

If 24-hour shifts were employed and only reduction works of modest capacity constructed, the investment would not be large, and a working year of about 4,000 hours spread over six months should allow reasonable return on the investment. Such a schedule of operations would permit of surplus power being used for smelting with corresponding economy.

A 6-ton smelting furnace would cost about £7,000 and require a demand around 1,500 K.V.A. A more even production might be obtained by operating two furnaces each during a different shift. It requires about 2,000 K.W.H. to produce 1 ton pig iron. Charcoal is better than coke for electric furnaces and is available locally. In addition to charcoal small quantities of lime and sand are required and can be obtained from local deposits. According to Canadian experience the following are the proportions of an average charge :—

	LB.
Ore	400
Charcoal	125
Limestone	25
Sand	6

The charcoal in this case was reported as being of an inferior quality. Electric smelting is admittedly costly, even when power rates are low, but has been found economically feasible elsewhere on a large scale—particularly in Sweden, while the electric reduction of magnetite ores in Canada is a thriving industry.

When the cost of producing steel from pig iron by means of an electric furnace, as distinct from the reduction of iron ores to produce pig iron, is compared carefully, the case is much in favour of electrical methods for steel production and, in the case of ferro-alloys, generally to be preferred.

The production of steel from cold scrap requires about 650 K.W.H. per ton as an average.

The cost of selected scrap laid down in Mettur would be about Rs. 23. As considerable quantities of scrap are being exported from Madras at present, the requirements of Mettur will be met quite easily.

To utilize the pig iron produced from the various furnaces, rolling mills to manufacture standard shapes, sections, and possibly plate, together with a small foundry for turning out special steel castings would be established. A nail factory might also be built. A galvanizing plant could be erected, and corrugated roofing sheets and lattice supports for transmission and distribution lines manufactured. In this connexion it would be practicable to design a light lattice pole as a substitute for the imported tubular pole. This in itself would be a thriving industry as a constant demand exists for these poles all over the Presidency. The existing workshops and machinery could be used to a great extent and form part of the works, and there appears to be no reason why these shops cannot be utilized in the immediate future to fabricate mechanical fittings for the Pykara system and municipal undertakings.

If the project would be carefully studied, planned and designed, it should be possible to establish a profitable iron and steel industry. But care would have to be taken not to interfere with any similar industries which might be established in the meantime by private interests.

The reduction furnaces for Salem Ores and auxiliaries would require, at the outset, about 1,500 K.V.A. or say 2,400,000 units of tertiary power.

The steel furnaces and rolling mills would require approximately 2,500 K.V.A. of primary and secondary power. The furnaces could operate 24 hours daily about 8 months in the year, the rolling mills 9 months and the assembly and machine shops 12 months about 9 hours daily.

The production of Nitrate of lime.

On account of the benefits to agriculture, which is the greatest industry in the Province, it is considered that a block of power should be reserved for the production of artificial fertilizers. Owing to the fact that the energy cost would have to be very low, only secondary or tertiary power could be utilized. Due consideration would have also to be paid to the question of interruption of supply of energy, low initial investment, and availability of raw materials.

A study of the various products would indicate that the manufacture of calcium nitrate by the Schloesing Process meets the requirements better than any other fertilizer. The investment in plant is not high compared with the manufacture of other electro-chemical fertilizers. The only raw material needed is lime, which is obtainable near Mettur. The product is a fertilizer in good demand and is especially suitable for sugarcane, and alkali soils. It is handled and stored easily in a warm climate. The process permits, when required, the manufacture of nitric acid.

A small factory of 4,000 K.W. would be able to produce about 20,000 tons of calcium nitrate (or approximately 3,000 tons of pure nitrogen) during six months in each year. This should be large enough at the outset and there would be no question as to absorbing this small amount, particularly in conjunction with oil cake referred to elsewhere. The revenue to the power undertaking would be about Rs. 1,60,000 for the six months. The energy consumption in this process is high but, on the other hand, the investment costs are low.

Another process, the Pechkranz, produces calcium nitrate or sulphate of ammonia by means of ammonia synthesis. Hydrogen and Ammonia are also produced. This requires less than half the energy consumption—ratio 22 K.W.H./55 K.W.H. per kilogram $Ca(NO_3)_2$—but nearly 4 times the capital investment. This process has now been improved upon by the 'Bamag' Electrolyser, manufactured by Messrs. Escher Wyss & Cie from whose publications I have obtained much of the above information. It is clear that a careful study is necessary before a selection of the plant is made.

The Alkali Industry.

This is a most important new industry and deserves very careful investigation. The only raw material needed is common salt, which is a Government monopoly, so that, not only would new products be manufactured, but the production of salt would be materially increased.

At first sight it would appear that an alkali industry could be better started at the coast near the salt fields. The cost of power would be higher at the ports and the average cost of transport of the finished product to the markets, is possibly higher from the coast than from a centre near Mettur.

The cost of salt laid down at Mettur is about Rs. 20 per ton and, having in mind the above arguments, cost of power and transport of the finished product, it would appear that the establishment of an alkali industry near Mettur will be found to be amply justified. It is also possible that the cost of delivered salt may be reduced.

Having regard to the needs of the Province and possibly the neighbouring States (if we get in ahead of them) a plant requiring about 1,200 K.W. would be probably of sufficient capacity at the outset. According to the Department of Industries a plant of this capacity would require annually 105,000 cwt. of common salt and could produce—

67,500 cwt. of Caustic Soda.
60,000 cwt. of Chlorine.
18,000 cwt. of Hydrogen.

A certain proportion of the caustic soda could be converted into—

Sodium carbonate and
Sodium bi-carbonate.

The Chlorine would be required for bleaching powder and hydrochloric acid, while hydrogen might be used for the hydrogenation of vegetable fats and also for the manufacture of hydrochloric acid.

As far as can be ascertained a factory of the above capacity would require a maximum of 5,000,000 K.W.H. annually.

With regard to the manufacture of fertilizers and chemical products, it may be argued that vested interests would not permit such industries to be started. It would appear that, in all cases to avoid undue competition, it would be advisable to come to a satisfactory arrangement with such interests, even to the extent of transferring the factories to their control, always provided that the factories were regularly operated. Failing such an arrangement, competition would have to be faced and the usual measures taken to meet it.

Oil pressing.

A factory for the manufacture of oils and vegetable fats should be profitable.

Ground nuts and seeds are available locally as the raw product, but if the production of mustard seed, gingelly, linseed, and other similar crops could be encouraged locally and less paddy grown, the ryot should benefit.

A small factory with an output of 2,000 tons per year requiring 200 K.W. is proposed at the outset. This would utilize locally grown produce and the hydrogen manufactured at the local factory. The cake by-product of this factory would be used for mixing with the synthetic fertilizers.

In connexion with oil pressing it may be noted that a small factory was recently started in Pollachi but closed down temporarily after some 2,000 tins of stock had been accumulated. Yet the local demand is far in excess of the output of this factory. This is an example of the difficulty with which small industrialists have to contend in organizing the distribution and sale of their products.

Oil pressing plants have been established in the agricultural districts of the United Provinces and appear to be flourishing, while Hyderabad is becoming a serious competitor to Madras in supplying the needs of this Presidency in oil.

Manufacture of strawboard.

This is another factory which might be profitably established and where agricultural by-products can be utilized, the raw material for the factory being paddy or wheat straw.

Great progress has been made in the United Provinces in the development of industries in connexion with Agricultural products.

Investigations regarding the practical feasibility of the establishment of these industries should be carried on simultaneously with the construction of the power scheme, as discussed in the body of the report.

H.G.H.

APPENDIX D.

Note on Steam Hydro-combination.

It has been shown in Chapter 2 that the maximum primary power available from Mettur under the water conditions assumed in this report is 10,000 K.W. continuously or 14,500 K.W. at a load factor of approximately 70 per cent.

Now the peak load of the Madras Electric Supply Corporation is nearly 11,000 K.W. at present and expected to exceed 20,000 K.W. by 1940. It is obvious then that Mettur can never meet the power requirements of Madras without the aid of supplementary power from another source. This supplementary power can be supplied by Pykara when a special tie line is constructed to Mettur. To justify the construction of such a costly high voltage line, a large block of power would have to be transmitted and the capacity of the Pykara station increased. This provision is contemplated in future but not for some years, and then only in combination with the steam plant. The small interchange of power between Pykara and Mettur referred to elsewhere in the report is for supplementing the local supply only.

The load forecast shows that practically the whole potential power output—supplemented by Pykara over existing lines—will be needed for power requirements of the areas adjoining Mettur to the east and south.

Should the Madras Station and Mettur be tied together in future, an interchange of power, at different periods of the year, might be effected with benefit to the Department and the Corporation. This would be particularly effective when load developed around Madras but outside the licensed area. It would not be profitable however to construct high voltage lines to Madras for a smaller block of power than about 5,000 K.W. When the time came to develop load in the Madras area it would probably be found more economical to provide a supply from the steam plant.

The capacity of the existing steam plant is as follows :—

(*a*) 1—12,500 K.W. turbo-generator (New).
(*b*) 2— 7,500 K.W. ,,
(*c*) 1— 6,000 K.W. ,,
(*d*) 2— 2,000 K.W. ,,

37,500 K.W.

There is thus ample generating capacity for the immediate future needs, but consideration might be given later to the substitution of some of the older sets by a more modern unit.

Particular attention has been paid in recent years to the overall efficiency of the Steam Plant and many improvements have been introduced and adopted. A new 12,500 K.W. set was erected and put into operation towards the end of last year, the result being that the cost per unit generated has been radically reduced. In 1932 a unit was being generated for about 0·45 anna excluding fixed charges and depreciation ; by the end of this year the equivalent cost is expected to be 0·282 anna per unit.

Hydro-electric power cannot be brought 200 miles and sold at such a low figure, it could only compete if the fixed charges were added to the generating costs. Hydro-electric power, under present conditions, can only be considered as an economic possibility for Madras when it is instrumental in avoiding capital expenditure for new plant and equipment.

Under normal conditions no load can be expected from the Supply Corporation until it is found necessary to increase the capacity of their Basin Bridge Station. When such a contingency arises, it will be possible to make up the deficiency from Mettur, the actual rate being based on the estimated cost per unit which would have been generated by a new set at the load factor of the system and including all generating costs and fixed charges. It is however questionable if primary power will ever be available at Mettur for Madras—unless Pykara is extended and a tie line already referred to constructed. But when considered economically feasible the two systems might be tied together and act as a mutual standby and avoid capital expenditure on spare plant.

A steam plant at Madras is included in the extensive power scheme shown on plan No.G-1/d·1 ; there would be thus no point in attempting to scrap it. Furthermore an interchange of power between Madras and Mettur is contemplated in this report to supplement the Mettur output and to provide for a gradual development of load in future, north of Madras.

Once it has been found economically possible to link the Madras and Mettur Schemes together, a very flexible power system would result and a steam-hydro-combination should eventually be arrived at which will be more economical than either scheme taken independently.

H.G.H.

APPENDIX E.

Mettur Hydro-Electric Development.

Irrigation Pumping Load.

A large potential seasonal pumping load for well irrigation exists in the five districts which will be served by the transmission system from Mettur to Madras and the following information has been prepared to show its feasibility and the extent to which it is likely to develop.

2. Well irrigation is principally used for safeguarding crops grown under natural rainfall or more or less precarious means of irrigation, such as, tanks and river floods. It is also largely used for increasing the yield from such lands by double or occasionally treble crops.

3. It is mainly applied to paddy cultivation, one or more of the different crops being raised generally at the following seasons :—

First crop	June to September.
Second crop	October to January.
Third crop	February to May.

The number of crops varies according to the land, local rainfall or irrigation water available and when these are favourable and well irrigation can be fully utilized three crops are produced at present over small areas. A large proportion of the total acreage served by wells, however, is limited in output mainly on account of the high cost of, or lack of facilities for, lifting the water on to the land. With cheap electric power available it is anticipated that three crops or other more profitable long crops would be much more general.

4. (*a*) The economics of well irrigation from the point of view of the agriculturist will first be examined and it will be shown that electric pumping will be a profitable enterprise for holders of lands of all sizes but particularly the larger ones.

(*b*) The characteristics of the concerned districts will next be examined and an estimate made of the probable pumping load that can be developed with its financial benefits to the Power Project, Land Revenue and Agricultural welfare generally.

(*c*) Finally it will be shown how these seasonal loads can be conveniently fitted on to the Power Development Scheme.

5. *Well irrigation economics.*—As the cultivation of paddy preponderates heavily over that of any other crop in the districts under consideration this will be taken as the basis of the examination.

6. In the districts concerned in which crops are not secured by a reliable irrigation system paddy cultivation begins in or after May according to the amount of the pre-monsoon rains or mango showers and attempts are made to raise two crops between then and January.

The land is ploughed after the showers and transplanting is done with well water irrigation. South-west monsoon rains are expected from June and when these are favourable, the first crop is raised either by direct rainfall supplemented by well irrigation or by water from the rainfed tanks. When the south-west monsoon is poor or fails, however, the success of the crop becomes dependent on well irrigation, and in a bad year to provide this by Mhote baling is generally beyond both the physical and financial capacity of the cultivator.

7. After harvesting this crop about the end of August, he ploughs and transplants for the second crop some time in September in the hope of a favourable north-east monsoon to mature it. Here again in unfavourable years well irrigation has to be relied on to make up for the natural rainfall deficiency. This crop is harvested about the end of January and large areas are allowed to lie fallow from then until May.

8. Many lands, however, which have facilities for well irrigation produce a third short paddy crop entirely by this means from February to May.

9. An unfailing supply of well water on the land would ensure these first two crops with increased yields or substitute long and more profitable crops which require water throughout the year.

Long and other crops, such as, sugarcane, ragi, tobacco, gingelly, onions, etc., are raised at their respective seasons in lands best suited for the purpose but only to the extent to which well irrigation is available and the agriculturists' ability to utilize it fully. The relative values of these crops compared with paddy are given later and indicate that at present prices their higher yields are likely to act as an inducement to agriculturists to adopt electric pumping to make their cultivation possible.

10. Lift irrigation from wells is at present carried out by three means as follows :—
By bulls, by picotta and by oil engine pumping.

The first two methods are as yet practically universal and for the small holder will probably continue in favour after the advent of electric power on account of the cultivator having to keep bulls for ploughing and other purposes. This does not apply to larger areas, however, and on these the failure of crops is generally due to inability from one cause or another to lift water on to the land.

11. As both bulls and human labour on the farm are used for such a variety of other purposes, it is not possible to estimate with any degree of accuracy the cost of lift irrigation from wells by these means.

Making due allowance for the use of bulls for carting, etc., and for value of manure, the net cost chargeable solely to baling and ploughing for a pair of Mhote bullocks may be taken as ranging from Rs. 6 to Rs. 11 per month or an average of Rs. 8–8–0. Their average useful life is about three years and their cost about Rs. 150 a pair. When they are no longer fit for baling their value for ploughing will be about Rs. 50 a pair. Their depreciation therefore for baling purposes may be taken as being 100/3, or say Rs. 30 per year.

A good pair of Mhote bullocks will lift from an average well about 40 buckets or 1,600 gallons of water per hour. In the usual 7-hour day this is 11,200 gallons, which is the quantity required per acre per day to mature a crop, though three times this quantity is needed for puddling. A pair of Mhote bullocks are therefore required for approximately each acre.

12. The cost of baling with Mhote bullocks per acre for an average of two rice crops a year is therefore taken as—

	RS.
Maintenance at Rs. 8–8–0 per mensem for 12 months, say	100
Depreciation	30
	130

With electric pumping the equivalent costs would be—

Current *	18
Interest, depreciation and operation of plant	12
Ploughing bulls at Rs. 5 per mensem for 12 months	60
Ploughing bulls—Depreciation	10
	100
The balance in favour of electric pumping per acre per year is therefore	30

* This item is taken from Table III, column 12, at 1 anna per unit.

It is thus evident that for paddy which is by far the most usual crop and, as is shown later in Table II, one of the least profitable ones, there are substantial economies for the agriculturist who adopts electric pumping.

13. To arrive at the cost of lifting water with manual labour by picotta is even more difficult and as it is both more expensive and less prevalent than baling with bullocks, separate costs need not be attempted and the above figure of Rs. 130 per acre is taken to apply to this also.

14. Pumping by oil engines is utilized to such a small extent that the cost would not affect the average obtained for Mhote baling. Less than ½ per cent of the total area in the Presidency under well irrigation is served by oil engine pumping.

15. Under the present system of baling water by Mhote, the agriculturist tries to increase the productivity of the land by raising more crops and utilizing his bulls throughout the year. With electric pumping the tendency would be to produce longer and higher yielding crops involving less ploughing and field labour.

16. The relative values of the various crops that are cultivated by well irrigation have been extracted and tabulated in Table III along with the current consumption required by each for electrical pumping. This forcibly illustrates the great incentive that cheap electric power would create at present prices to either convert paddy lands or bring new lands under such profitable long crops as sugarcane and turmeric or paddy and onions, chillies, etc.

17. Rice is at present an uneconomic crop and is only now grown in the districts under review to meet local needs and to keep the agricultural life of the country going.

Paragraph 12 showed that the cost of cultivation of this low value crop can be reduced by the adoption of electric pumping. For the higher valued long crops its effect is not only more marked but it makes their cultivation physically possible whereas at present over a large proportion of the area under ordinary seasonal conditions it is not so.

The situation is already to some extent adjusting itself to current price levels by portions of small holdings being brought under these more valuable long crops so as to enable both owners and cultivators to get the rice required for their wants and also cash for interest and other payments.

With facilities for cheap electric pumping this transition is likely to be greatly stimulated.

Characteristics of Districts and Estimate of Pumping Load with Financial Results.

18. The Districts which will be served by the Mettur transmission system are—

(1) Salem with 1,472 ryotwari villages, 12 rural towns and 1 municipality.

(2) North Arcot with 1,678 ryotwari villages, 12 rural towns and 6 municipalities.

(3) Chittoor (southern half) with 300 (about) ryotwari villages, 4 rural towns and 2 municipalities.

(4) South Arcot with 2,215 ryotwari villages, 12 rural towns and 3 municipalities.

(5) Chingleput with 1,497 ryotwari villages, 7 rural towns and 3 municipalities.

Trichinopoly, Tanjore and part of Coimbatore will also come within the range of the system but not to the full extent of the others. Agriculture is the main occupation throughout these districts.

19. The cultivation seasons have been evolved from the climatic conditions which are indicated from the rainfall statement below :—

Districts.	South-West monsoon—June-September (four months).		North-East monsoon—October-December (three months).		Dry weather—January-March (three months).		Hot weather—April-May (two months).		Total rainfall for the year in inches.
	Rainfall in inches.	Percentage of annual rainfall.	Rainfall in inches.	Percentage of annual rainfall.	Rainfall in inches.	Percentage of annual rainfall.	Rainfall in inches.	Percentage of annual rainfall.	
		PER CENT.		PER CENT.		PER CENT.		PER CENT.	
1 Salem ..	14·8	45	11·2	34	1·2	4	5·5	17	32·7
2 North Arcot.	18·0	47	14·8	40	1·4	4	3·5	9	37·7
3 Chittoor ..	15·0	45	14·1	42	1·4	4	3·0	9	33·5
4 South Arcot.	16·6	36	24·8	54	1·9	4	2·7	6	46·0
5 Chingleput ..	15·8	35	27·0	57	1·8	4	1·9	4	46·5

Note.—This shows approximately equal south-west monsoon and dry weather rainfall in all districts but increased N.E. in the two coastal districts.

20. In the three inland districts of Salem, North Arcot and Chittoor the cultivation seasons are as described in paragraphs 6 and 7.

Generally speaking in these districts the best crops are produced between June and September and it pays the agriculturists handsomely to spend money on ensuring the success of these. Fortunately it is at this period that the Mettur Power Scheme generates at its maximum capacity.

In the coastal districts of South Arcot and Chingleput the areas commanded by the Vellar, Pennar and Palar rivers having their catchments in Salem and North Arcot districts and ore, utilize the south-west monsoon freshes in these rivers and have the same agricultural sons and methods as in the central districts, with better facilities for irrigation during the north-st monsoon and in the dry weather. Sugarcane is also largely cultivated in these tracts, due to the above advantages and the existence of good wells with high sub-soil water level. In the remaining parts of the two coastal districts, the cultivation season begins very late between September and October and ends by January. Sugarcane cultivation here is sparse and only in fields of 1 or 2 acres under wells.

22. By making well irrigation both possible and profitable the Mettur Scheme can thus be made to benefit the agriculturists of these districts to some extent in the same way that it will benefit Tanjore agriculture for which it was solely designed.

23. To enable an estimate to be made of the acreage that can be expected to utilize electric pumping for well irrigation the particulars shown in Table I (below) have been extracted from the Season and Crop Reports of the Board of Revenue.

TABLE I.

District.	Cultivable waste other than the fallow lands.	Percentage of total area cultivable (column 8).	Current fallow.	Percentage of total area cultivable (column 8).	Area sown.	Percentage of total area cultivable (column 8).	Total area available for cultivation.	Area irrigated from various sources.	Percentage of area sown (column 6).	Percentage of total area cultivable (column 8).	Number of wells used for irrigation.	Area irrigated by wells or spring channels.	Percentage of well and spring channel irrigation to total irrigation.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	ACS.		ACS.		ACS.		ACS.	ACS.				ACS.	
								Average 1929 to 1932.					
Salem ..	637,536	22	472,243	17	1,623,866	60	2,733,645	192,500	12	7	70,200	117,200	61
North Arcot.	223,059	13	369,073	21	1,139,881	66	1,732,013	366,200	31	22	119,500	113,000	31
Chittoor (whole).	604,966	36	344,753	21	731,436	43	1,681,155	269,600	37	16	22,700	91,400	34
South Arcot.	201,598	12	402,317	21	1,278,405	67	1,882,320	487,200	36	24	51,500	82,800	17
Chingleput ..	144,280	13	190,712	17	777,921	70	1,112,913	480,400	63	45	22,200	42,800	9

Note.—This table shows that the percentage of irrigated area to both the area sown and the total cultivable area [columns (10) and (11)] is low in the inland districts and probably offers considerable scope for expansion if not with open wells at least with deep tube wells.

In 1932–33 the total irrigated area in the five districts was 18·9 lakhs of acres of which 4·3 lakhs were irrigated by wells. Of these, 2·8 lakhs were independent well irrigation and 1·5 lakhs well irrigation used to supplement tank irrigation. In addition about 1·6 lakhs were irrigated by spring channels.

Out of the total of 18·9 lakhs of acres there were thus 5·9 lakhs or about 31 per cent which were irrigated by labour employing means for which electric pumping would be an economical substitute.

In Trichinopoly there are a further 105,000 acres under wells and spring channels available for conversion.

The average ayacut of each well is a little under 2 acres.

24. The total number of oil engine well pumping installations in the whole Presidency in 1926 was 313 and in 1931—737.

The numbers are insignificant in most districts but are comparatively large in South Arcot and Coimbatore, the former claiming 305 and the latter 140 out of the total of 737. Pumping by oil engines is conducted on too small a scale to enable any useful information as to the rate of growth to be deduced from it, but it may be noted that in South Arcot during the above quinquennium the number of oil engine pumping sets increased by 200 per cent and the proportion of oil engined well irrigation to total well irrigation from about $1\frac{1}{4}$ per cent to 4 per cent. South Arcot is a large sugarcane growing district and the oil engine pumping is mostly used for this crop.

Oil engines are generally a more expensive and troublesome source of power to ryots than electricity for pumping so that even this small area and rate of growth under them indicates good prospects for electric power.

25. In paragraph 23 it was shown that there are 5·9 lakhs of acres at present being irrigated from wells in the five districts and about 7 lakhs, if Trichinopoly is added. This is only about 6·5 per cent of the total cultivable area in those districts so that with a cheap and easy method of irrigation considerable expansion may be expected.

26. There are no appropriate statistics which indicate the rate of conversion to electric pumping that may be expected in the existing area under well irrigation and any rate assumed must necessarily be purely conjectural. Considering its great advantages on existing lands under well irrigation and the still greater advantage it offers by both open and tube wells for lands not now so irrigated which form 93·5 per cent of the whole, an annual rate of conversion of 1 per cent of the existing area under wells has been taken.

Thus in the five districts and Trichinopoly 7,000 acres per annum only out of over 9 millions of cultivable area are assumed as adopting electric pumping.

27. The resulting load on the Mettur plant will now be examined.

Table III shows the power required for the various crops at their respective seasons. As estimates are being based on the most prevalent one of paddy an average of 260 units per acre per year will be taken for either the first and second crops or the single and the late second. These involve maximum loads per acre of 1·54 K.W. from June to September and 1·2 K.W. from

October to January and are based on a 12-hour pumping day. The sizes of motors and rates of pumping will of course vary according to numbers and capacities of wells in different groups or ownerships.

Taking the acreage given in paragraph 26, in 10 years there will be a maximum seasonal demand of—

$$10 \times \frac{7{,}000}{12} \times 1{\cdot}54 \quad \text{or} \quad 9{,}000 \text{ K.W.}$$

and allowing a liberal diversity factor a load on the plant of say 5,000 K.W. and an energy consumption of about 18 million units.

At 0·5 anna unit the additional income to the power scheme would thus be about Rs. $5\frac{1}{2}$ lakhs at the tenth year.

28. *Seasonal Power Development to meet these loads.*—The power graph M-18 shows that in every year with the exception of a few weeks in 1918 there is a possible surplus generation of power between June and January over and above the basic load of 10,000 K.W. of about 10 to 30,000 K.W.

As this pumping load is designed by both nature and time-long agricultural practice to synchronise with the periods that irrigation water is available for surplus power generation, it forms a most convenient and advantageous market for the seasonal production peaks.

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TABLE II.

Yields and values, etc., for different crops per acre of land irrigated by Electric Pumping.

Serial number.	Kind of crop: I crop.	Kind of crop: II crop.	K.W.H. required to mature crop per acre: I crop.	K.W.H. required to mature crop per acre: II crop.	Cost of power at 1 anna per K.W.H.: I crop.	Cost of power at 1 anna per K.W.H.: II crop.	Cost of power at 1 anna per K.W.H.: Total.	Yield per acre and value of crops at current prices. I crop. Yield in pounds.	I crop. Rate.	I crop. Value.	II crop. Yield in pounds.	II crop. Rate.	II crop. Value.	Value of by-products such as hay, fuel, etc.	Annual total value.	Rank of crop in the order of best return to cultivator per acre.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
					RS. A. P.	RS. A. P.	RS. A. P.		RS. A. P.	RS. A. P.		RS. A. P.	RS. A. P.	RS.	RS.	
1	Paddy ..	Paddy ..	150	125	9 6 0	7 13 0	17 3 0	2,400	0 0 6·4	80 0 0	1,400	0 0 6·4	46 10 8	15	142	7
2	Ragi ..	Ragi	39	70	2 7 0	4 6 0	6 13 0	1,800	0 0 5·5	51 9 0	1,200	0 0 5·5	34 6 0	10	96	12
3		Cotton	84		..	..	5 4 0	..	..	..	250	0 4 6	70 5 0	5	75	13
4		Sugarcane	260		..	..	16 4 0	..	..	..	6,400	0 0 11	367 0 0	10	377	1
5		Turmeric	207		..	..	12 15 0	..	..	..	3,000	0 2 0	375 0 0	Nil	375	2
6	Combined crops—															
(a)	Paddy ..	Ragi	150	70	9 6 0	4 6 0	13 12 0	2,400	0 0 6.4	80 0 0	1,200	0 0 5·5	34 6 0	12	126	9
(b)	Do. ..	Cumbu ..	150	39	9 6 0	2 7 0	11 13 0	2,400	0 0 6·4	80 0 0	1,000	0 0 5	26 0 8	10	116	10
(c)	Do. ..	Cholam ..	150	39	9 6 0	2 7 0	11 13 0	2,400	0 0 6·4	80 0 0	1,500	0 0 5	39 1 0	15	134	8
(d)	Do. ..	Gingelly ..	150	39	9 6 0	2 7 0	11 13 0	2,400	0 0 6·4	80 0 0	280	0 1 0	17 8 0	9	107	11
(e)	Do. ..	Groundnut ..	150	39	9 6 0	2 7 0	11 13 0	2,400	0 0 6·4	80 0 0	2,000	0 0 6	62 8 0	10	153	6
(f)	Do. ..	Onion	150	194	9 6 0	12 2 0	21 8 0	2,400	0 0 6·4	80 0 0	15,000	0 0 3	234 6 0	15	329	4
(g)	Do. ..	Chillies ..	150	155	9 6 0	9 11 0	19 1 0	2,400	0 0 6·4	80 0 0	2,000	0 2 0	250 0 0	10	340	3
(h)	Ragi ..	Tobacco ..	39	207	2 7 0	12 15 0	15 6 0	1,800	0 0 5·5	51 9 0	1,200	0 1 8	125 0 0	5	182	5

TABLE III.

Serial number.	Crop.	Inches of water required per crop.	Period. From	Period. To	Period. Months.	Depth of well.	Number of waterings.	Total cubic feet per acre per crop required.	Cubic feet of water per watering.	Equivalent flow in cusecs at one hour per watering.	Power in K.W. with 40 per cent of pump efficiency required for column (10).	Energy required in units for whole crop season.	Interval of watering.	Daily energy consumption per acre.	Area irrigated daily per K.W.H.
(1)	(2)	(3)	(4)		(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
		INCHES.				FEET.					K.W. UNITS.	UNITS.		K.W.	ACS.
1	Sugarcane	50	February ..	December ..	11	24	40	181,500	4,540	1·26	16·50	260	Once a week ..	0·93	1·01
2	Paddy, first crop ..	30	15th June ..	15th September.	4	24	100	108,900	1,089	0·30	1·54	154	Daily	1·54	0·65
3	„ single crop ..	37½	August	15th January ..	6	18	120	136,125	1,134	0·315	1·21	145	Do.	1·21	0·83
4	„ second crop..	25	October	February ..	4	18	80	90,750	1,134	0·315	1·21	97	Do.	1·21	0·83
5	Late crop	30	January	May	4	24	120	108,900	908	0·25	1·28	154	Do.	1·28	0·78
6	Cotton	13	September ..	July	11	30	12 *	47,190	3,933	1·01	7·04	84	At odd intervals ..	0·25	4·00
7	Chillies	30	January and February.	April and May. ..	4	24	24	108,900	4,537	1·26	6·45	155	At interval of five days.	1·29	0·78
8	Onion	37½	..	..	5	24	30	136,125	4,537	1·26	6·45	194	Do.	1·29	0·78
9	Turmeric	40	April	December or January.	8–9	24	30	145,200	4,840	1·35	6·91	207	Once a week ..	0·99	1·00
10	Tobacco	40	December ..	April	4–5	24	30	145,200	4,840	1·35	6·91	207	At interval of five days.	1·38	0·72
11	Ragi (cumbu and cholam) (monsoon crop).	9	June	August	3	20	15	32,670	2,178	0·61	2·60	39	Once a week ..	0·37	2·70
12	Ragi (cumbu and cholam) summer crop).	13½	January	April	3	24	20	49,000	2,450	0·68	3·48	70	Once in six days ..	0·58	1·72

Factors of well lifts—

(1) Salem .. Instead of 24′ to 18′, lifts are 36′ to 27′ in this district. So factor for well lifts and corresponding pumping costs will be 1·5 times the figures entered in the statement above.

(2) South Arcot.	Do.	20′ to 15′	do.	do.	0·83	do.
(3) North Arcot.	Do.	24′ to 18′	do.	do.	1·00	do.
(4) Chingleput.	Do.	20′ to 15′	do.	do.	0·83	do.
(5) Chittoor ..	Do.	24′ to 18′	do.	do.	1·00	do.
(6) Trichinopoly.	Do.	24′ to 18′	do.	do.	1·00	do.
(7) Coimbatore.	Do.	36′ to 27′	do.	do.	1·50	do.

* In later four months.

APPENDIX F.

Some useful statistics.

Town.		Population.	Approximate K.W. demand.	Annual consumption.	Consumption per head of urban population.
1 Madras City		6,47,000	11,000	32,000,000	49·5
2 Bangalore		3,06,000	10,000	42,860,000	140·0
3 Mysore City		1,03,000	4,460	14,550,000	141·0
4 Saharanpur ..	United Provinces area.	62,000	Not available.	272,000	3·4
5 Hardwar ..		31,000	,,	332,000	9·8
6 Roorkee ..		12,000	,,	49,000	4·1
7 Coimbatore ..	Pykara area.	95,000	350	800,000	8·4
8 Pollachi ..		22,000	75	180,000	8·1
9 Tiruppur ..		18,000	100	220,000	12·0
10 Mettuppalaiyam.		11,500	30	50,000	4·35

Items 4 to 6 and 7 to 10 are the results of the first year of operation, and *do not include* H.T. Industrial load.

Estimated and actual system peaks.

	K.W. demand. First year.	K.W. demand. Tenth year.	Incremen in per cent.
(*a*) Ganges Canal (United Provinces) ..	3,200 *	15,100	372
(*b*) Pykara [2]	3,100 *	11,000	255
(*c*) Mettur	6,100 [3]	14,100 [3]	130
(*d*) Mysore [1]	8,160 *	14,460	77

* Actuals.

1 Excluding Kolar Gold fields.

2 Excluding Madura, Trichinopoly and Cochin or other special extensions.

3 Excluding special industrial load.

Note.—(*a*), (*b*) and (*c*) are new and similar developments while (*d*) has been in service for about 30 years and is tending to reach saturation.

Population of some towns within the Mettur Hydro-Electric Area.

Karur	19,850	Conjeeveram	65,000
Tiruppattur	18,299	Tanjore	66,000
Arni	17,446	Salem	1,02,000
Villupuram	20,127	Madura *	1,82,000
Tiruvarur	20,371	Trichinopoly	1,42,000
Chittoor	22,018	Vedaranniyam	15,000
Mannargudi	22,764	Dharmapuri	14,815
Vaniyambadi	22,940	Rasipur	14,438
Ambur	24,217	Panruti	13,952
Gudiyattam	24,688	Turaiyur	13,801
Chidambaram	25,084	Krishnagiri	12,850
Tiruvannamalai	27,769	Tiruvottiyur	12,042
Mayavaram	31,887	Polur	11,626
Erode	33,000	Attur	11,697
Negapatam	48,000	Ranipet	11,583
Vellore	57,000	Walajapet	11,000
Cuddalore	59,000	Bhavani	6,896
Kumbakonam	62,000		

* Not in Mettur Hydro-Electric area.

APPENDIX G.

Imports of British and foreign articles into the Madras Presidency for the years 1926–27 to 1928–29 as furnished by the Director of Industries.

(*Imports by rail are not included.*)

Nomenclature.	Approximate value in lakhs of rupees (average per year).	Remarks.
Brushes and brooms—		
Brushes (paints and varnish) ..	3	These figures will include a wide variety of brushes made from different materials, the market in India for any one class of brush is limited.
Toilet brushes	5	
Other brushes	5	
Building and engineering materials other than iron, steel or wood—		
Firebricks	3	If these are made of magnesites, we have good deposits of this mineral in the Salem district. Firebricks are made at Jamshedpur.
Buttons of all sorts—		
Metal	10	....
Other sorts	23	Raw materials (bones, etc.) are available. The department is managing on behalf of a private factory, a button factory. Buttons may be manufactured as cottage industry.
Candles of all kinds	2	Raw material—vegetable and fish-oil—are available. Once the Kerala Soap Institute proposed to interest itself on its manufacture in the Institute. The demand for candles however is falling off owing to the advent of electricity and the cheapness of kerosene.
Chemicals and chemical preparations excluding chemical manure and medicines—		
Bleaching materials—		
Bleaching powder (calcium hypochlorate, chloride of lime).	7	Bleaching powder which is prepared from chlorine and slaked lime can be manufactured in India by electrolysis process, but only on a very large scale in conjunction with a hydro-electric project.
Carbide of calcium ..	7	....
Copper sulphate	3	Copper scraps can be had in the country. The sulphate can be made from it.
Soda compounds—		
Bicarbonate	8	....
Bichromate	3	....
Caustic soda	19	Caustic soda is produced from the electrolysis of an aqueous solution of common salt; manufacture in India might be practicable in conjunction with a hydro-electric project such as Mettur.
Sodium carbonate	60	Caustic soda can be converted into sodium carbonate.
Hardware excluding cutlery and electroplated ware—		
Builders hardware such as locks, hinges, doorbolts, etc.	34	....
Domestic hardware other than enamelled ironware.	11	....

Nomenclature.	Approximate value in lakhs of rupees (average per year).	Remarks.
Manures—		
Artificial and mineral manures—		
Muriate of potash	6	....
Nitrate of soda	11	....
Sulphate of ammonia ..	28	The difficulty attending the manufacture of ammonia sulphate and other similar fertilizers is that only very large units can pay and the question whether a factory in India could produce at the price at which they could be imported remains to be examined.
Others	16	....
Fish manures	3	....
Metal manufactures—		
Bars and channels	11	....
Rice bowls	1	....
Steel angle and tee	62	....
Spring	4	....
Bars other than cast steel ..	171	....
Cast—		
Tool steel—high speed ..	4	....
Carbons	2	....
Cast steel bars	3	....
Other cast steel	2	....
Iron and steel—		
Anchors and cables	7	....
Beams, channels, pillars, girders and bridge work.	145	....
Bolts and nuts	36	....
Fencing materials including fencing wire.	23	....
Hoops and strips	52	....
Nails, rivets and washers ..	51	....
Pipes and fittings cast	25	....
Rails, chairs and fishplates including those for railways.	74	....
Sheets and plates—		
Galvanized—		
Corrugated	679	These sheets are being produced in India and the manufacture is likely to develop at the expense of the imported.
Plain	64	....
Wire nails	26	....
Other manufactures of iron or steel.	107	....
Oils—Essential—		
Synthetic	1	....
Coconut	45	This should diminish gradually.
Linseed	9	....
Paper and paste board—		
Paper packing	44	....
News printing	47	....
Other sorts	49	....
Writing paper and envelopes—		
Writing paper in large sheets ..	47	....
Note and letter paper and envelopes.	6	....
Envelopes imported separately.	7	....
Old newspapers in bales and bags.	38	....
Other kinds of paper	25	....
Paper manufactures	13	....

Nomenclature.	Approximate value in lakhs of rupees (Average per year).	Remarks.
Paste board, mill board, card board of all kinds—		
Straw boards	13	
Other kinds	13	
Manufacture of paste board, etc.	4	
Farinaceous and [illegible]ent foods—		
Farinaceous foods in bulk	48	
Ghee	2	
Starch and Farina—		
Starch	19	
Textiles—Cotton—		
Twist and yarn—		
Grey unbleached Nos. 1 to 10 ..	1	1927–28.
11 to 15 ..	3	1927–28.
16 to 20 ..	10	
21 to 25 ..	2	
26 to 30 ..	2	
31 to 40 ..	202	
41 to 50 ..	16	
51 to 60 ..	61	
61 to 100.	36	
Above 100.	3	
Grey twofolds doubles	76	
White bleached 31 to 40	14	
Above 50 ..	22	
White twofolds doubles	39	
Coloured 1 to 20	4	
21 to 25	3	
26 to 30	1	Under one lakh in 1928–29.
31 to 40	46	
41 to 50	1	Under one lakh in 1928–29.
Above 50	10	
Coloured twofolds doubles ..	9	
Mercerised cotton twofolds ..	96	
Manufactures—		
Blankets	43, 36, 23	Cumblies are manufactured on a large scale. This can be developed in this country.
Canvas	7	
Handkerchiefs and shawls in the piece—		
Handkerchiefs	11	
Shawls	5	
Hosiery—		
Stockings and socks	22	There are several hosiery and knitting factories and this can be developed in this country.
Underwear	115	
Other sorts	5	
Lace and Patent net	10	
Piece goods—		
Grey unbleached—		
Plain grey—		
Dhoties, sarees and scarves ..	6, 1, 1	Local manufacture is possible, Manchester yarn being used for higher counts, though it would take some years to attain perfection.
Drills and jeans	38	
Jaconets including Madopalems mulls and cambrics	185	
Long cloth and shirtings ..	559	
Sheetings	40	
Table cloth and domestics ..	1	
Unspecified descriptions ..	1	
Bordered grey chadders ..	2	
Dhoties, sarees and scarves ..	1,201	

Nomenclature.	Approximate value in lakhs of rupees (Average per year).	Remarks.
White bleached—		
Checks, spots and stripes	41	This is a matter of gradual advancement.
Dhoties, sarees and scarves ..	345, 191, 130	
Drills and jeans	29	
Jaconets, Madopalems and cambrics and muslins	69	
Lawns	74, 41, 37	
Long cloth and shirtings	354	
Mulls	573	
Nainsooks	166	
Sheetings	1	
Twills	57	
Unspecified descriptions	40	
Coloured, printed or dyed—		
Printed goods—		
Cambrics including Madopalems, muslins, mulls and jaconets ..	58	
Checks, spots and stripes ..	8	All this can be attempted locally, the turnout may not seem elegant at first, but gradually the fabrics can be improved.
Dhoties	14, 1, *	* Under one lakh.
Drills and jeans	81	
Flannel and flannellets	29	
Lungis	23	
Prints and chintz	177	
Sarees and scarves	101	
Sateens	20	
Shirtings	89	
Twills	46	
Woven lungis and sarongs ..	33	
Unspecified descriptions ..	22	
Dyed goods—		
Cambrics including Madopalems, mulls, muslins and jaconets ..	84	
Checks, spots and stripes	56	
Drills and jeans	31	
Flannels and flannellets	13	
Italian cloth and Sateens	118	
Lungis	1	
Prints and chintz	5	
Sarees and scarves	10	
Shirtings	100	
Twills	57	
Woven lungis and serongs	2	
Unspecified descriptions	89	
Woven coloured goods—		
Cambrics including Madopalems, muslins, mulls and jaconets ..	13	See my remarks above.
Checks, spots and stripes	40	
Coatings, and trouserings, including Kashmere Serge and Tweeds ..	69	
Dhoties	1	
Drills and jeans	50	
Flannel and flannellets	12	
Lungis and sarongs	62, 34, 15	
Sarees and scarves	18, 15, 10	
Shirtings	70	
Twills	25	
Velvet and velveteens	17	
Unspecified descriptions	95	
Tents of all descriptions	85	
Rope	10	
Thread sewing	74	
Other sorts of manufatures ..	28	

Nomenclature.	Approximate value in lakhs of rupees (Average per year).	Remarks.
Flex—		
Canvas	19	
Piece-goods	3	
Threads, sewing	2	
Other sorts	9	
Haberdashery and Millinery—		
Lace and embroidery	42	
Towels not in the piece	10	
Other sorts	72	
Hemp manufactures	2	
Jute manufacture—		
Canvas	2	
Gunny bags	17	
Cloth—gunny..	14	
Rope and twine	1	
Other kinds	2	
Silk—		
Silk yarn, noils and warps	70	May be undertaken locally.
Manufactures—		
Goods of silk mixed with other materials	35	
Silk piece-goods	248	
Thread for sewing	2	
Other sorts	5	
Wool—		
Manufactures—		
Blankets and rugs other than floor rugs.	10, 15, 63	
Carpets and floor rugs	32	Can be done locally.
Hosiery	19	
Piece-goods	296	
Shawls	38	
Other sorts	2	
Artificial silk—		
Artificial silk yarn	128	
Piece-goods of cotton and artificial silk.	341	
Other sorts	12	
Other textiles	2	1928–29.
Umbrellas and umbrella fittings—		
Umbrellas complete including parasols and sunshades.	7	Can be done locally following the example of the Umbrella Factory at Calicut.
Umbrella fittings	49	

APPENDIX H.

Extension Scheme from Coimbatore to Madura.

The proposal is to extend the supply of Pykara power to Madura by taking a 66 KV. double circuit line to that place from Coimbatore. The line will be 125 miles long and will pass through Dharapuram and Dindigul. The layout of the extension scheme will be as shown in drawing No. P. 1130/F.3.

Transmission line.—This will be practically identical with Erode-Trichinopoly line under construction and utilizes 7/·144 A.C.S.R. conductor. It is expected that its capacity would be adequate to transmit the probable loads for a number of years and provision has been made for voltage regulating equipment at Madura should need arise.

The regulation data for the line are given on page 72 for different loads.

It is probable that within the first five to eight years, the Periyar scheme would be taken up for construction, in which case, this line would form the tie between Periyar and Pykara. The need for such a tie was discussed in the report on the Periyar Scheme and it was pointed out that in the dry weather months recourse would have to be made to Pykara.

The voltage of the line is fixed at 66 KV. which would be quite adequate for a number of years to come, especially as the initial operation of Periyar is also to be at this voltage. The operation of Pykara and Periyar at 110 KV. is so remote and the saving in capital cost in preferring 66 KV. to 66/110 KV. for this tie line voltage so substantial that there was no difficulty in deciding on 66 KV.

A telephone line on separate poles will be erected running parallel to the power lines.

Dharapuram will be a sectionalizing substation and provision for supplying power to Palni therefrom through a single circuit 11/22 KV. line has been made.

Fifteen miles of 11 KV. lines have further been included in the estimates for local bulk distribution in the whole scheme.

Substations—Coimbatore.—Additional equipment will be needed at this place for the control of the outgoing lines. Two 66 KV. oil circuit breakers, disconnecting switches and lightning arresters are provided for.

Dharapuram.—This is a Sectionalising Station with provision for local town and Palni supply. Two 500 KVA-66/33-11 KV. transformers will be installed. 11 KV. control cubicles are provided for the local town supply circuit and for the line leaving for Palni.

Palni.—Palni will be a 11 KV. substation with 2-150 KVA transformer units. These would be located within the present power house and connected to the L.T. distribution system.

The cost of the existing power house and equipment less depreciation and salvage, is also to be debited to the capital cost of the extension.

Dindigul.—This is an ordinary 66 KV. substation similar to Karur with 2—750 KVA-66/33-11 KV. transformer units. Debit on account of the existing oil-engine plant has been included in the estimates as for Palni.

Madura.—The layout of this station is similar to that in the Periyar report except that it is confined to the supply of the city load only. The incoming lines are controlled by oil circuit breakers and 3—3,000 KVA-66/33-11 KV. transformers are provided. Four outgoing 11 KV. feeders have been provided for local supply.

Estimates.—The total capital outlay for the extension is Rs. 32·5 lakhs. A summary of the estimates is given below.

SUMMARY OF ESTIMATES.

Coimbatore-Madura 66 KV. Extensions.

Item number.	Quantity.	Description of work.	Rate.	Per.	Total amount.
(1)	(2)	(3)	(4)	(5)	(6)
		SUMMARY OF ESTIMATES.			
	MILES.		RS.		RS.
1	125	Coimbatore-Madura 66 KV. double line	14,000	Mile.	17,50,000
2	125	Coimbatore-Madura telephone line	1,600	,,	2,00,000
3	24	Dharapuram-Palni 11/22 KV. 7/·118 A.C.S.R. single circuit line	5,000	,,	1,20,000
4	15	Local 11 K.V. lines	5,000	,,	75,000
5	..	Madura Receiving Station	L.S.	..	4,50,000
6	..	Dindigul Substation	,,	..	96,000
7	..	Dharapuram Substation	,,	..	1,32,000
8	..	Additional gear at Coimbatore	,,	..	1,00,000
9	..	Palni Substation	,,	..	18,000
10	..	Voltage regulating equipment	,,	..	1,59,000
11	..	Cost of Dindigul Oil-Engine Station to be debited to this scheme	,,	..	1,00,000
12	..	Cost of Palni Oil-engine Station to be debited to this scheme	,,	..	50,000
			Total ..		32,50,000

VOLTAGE REGULATION.

(a) *Coimbatore-Madura 66 KV. 7/·144 A.C.S.R. double circuit line—125 miles.*

Equivalent load at Madura.	Voltage variation at Coimbatore with 66 KV. constant at Madura.
	PER CENT.
2000 KW. at ·8 P.F.	3·6
4000 KW. do.	7·2
6000 KW. do.	10·8
8000 KW. do.	14·4

Charging KVA. 4800.

(b) *Dharapuram-Palni 11/22 KV. 7/·118 A.C.S.R. single circuit line.—*

Load at Palni.	Voltage variation on line.	
	PER CENT.	
100 KVA.	2·45	At 11 KV. operation.
200 KVA.	4·9	
300 KVA.	7·35	

NOTE.—Voltage regulating equipment will be installed at load centres as and when required in order to bring the voltage variation at consumer's terminals within permissible limits.

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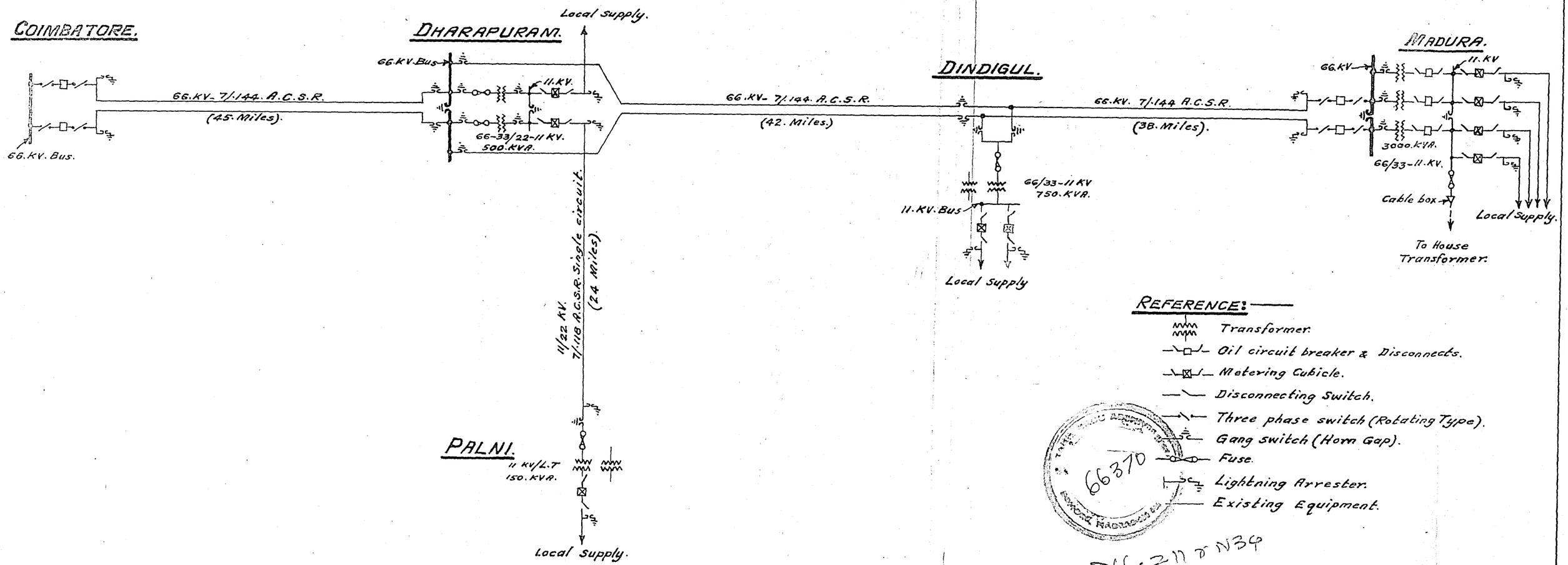

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N34

Chief Engineer.

Reference.	Drawn. K.R	GOVT. OF MADRAS. ELECTRICITY DEPT.	No. P.1130. F.3.
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