turbines—X. to XIII.—in respect of efficiency; and on Table VII. (below) the results of tests of the regulation of the Turbines XII. and XIII. of this series are stated. The wheels of these turbines are fitted with Pelton blades. The forms of the blades certainly differ from the original Pelton shapes, and are constructed as the result of study and experience of individual turbines which have been in practical use. This variation is also partly apparent in the shapes of the efficiency-curves. The important conclusions to be drawn from these series are the following:—

1. At about 55 per cent. of full load all the four turbines show efficiencies which lie between 84 and 85 per cent.

2. The most favorable efficiencies vary between 84 and 89 per cent.

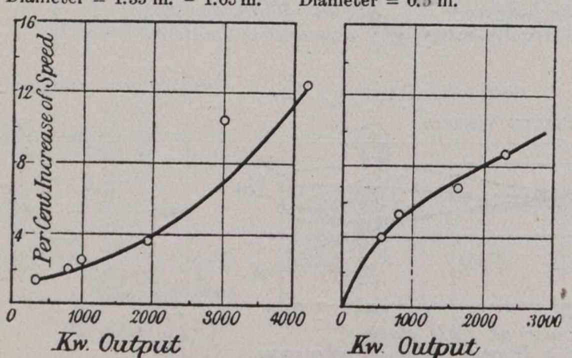
3. The efficiency is lower than 80 per cent. only under loads which are below 25 to 30 per cent. of the full load.

4. These definite results hold within wide limits of head and load (90 m. to 850 m. head, and 300 to 6050 horse-power); and it is to be noted that confirmatory results are obtained also from tests of other turbines of the same kind.

TABLE VII.—*Results of Tests of Governing of Turbines XII. and XIII.*

Both turbines are governed by oil-pressure Servo-motor.

Turbine XII.	*Turbine XIII.*
The turbine is fitted with automatic pressure regulation.	**The turbine is fitted with jet cut-off gear.**
Normal 375 revs. per minute.	**Normal 630 revs. per minute.**
Head H = 350 m.	**Head H = 850 m.**
Fly-wheel moment of inertia $g\ D^2$ = 55,000 sq. kg.-m.	**Fly-wheel moment of inertia $g\ D^2$ = 13,000 sq. kg.-m.**
Max. pressure variation, 1.8 per cent.	**Max. pressure variation, 3.9 per cent.**
Length of supply-pipe = 925 m.	**Length of supply pipe = 2130 m.**
Diameter = 1.35 m. - 1.05 m.	**Diameter = 0.5 m.**



The test with 3000 kw. load is questioned.

Regarding the results of the tests of the governing of Turbines XII. and XIII., set out upon Table VII., it may be noted that both turbines, as also Turbines X. and XI., are fitted with the well-known nozzles with pointed governing needles. These needle nozzles, due to Abner Doble, regulate the supply of water according to the momentary demand for power following small and gradual changes of load, by the movement of the needle which takes place under the influence of an automatic speed-regulator.

Following sudden changes in the load, very important variations of pressure arise in the long supply-pipes which accompany this design of turbine. In order to avoid these, turbine XII. is furnished with an automatic pressure-regulator with a Servo-motor similar to that of turbine IX., whose regulating mechanism is put into activity by the Servo-motor of this speed-regulator.

In Turbine XIII., the automatic pressure-regulation arising through sudden loading takes place in the following manner:—In the first instants following the decrease of load, the jet issuing from the nozzle is deflected, by the interposition of a shutter inserted between the nozzle and the wheel under the influence of an appropriate automatic regulating mechanism, for the purpose of hindering the access of the water to the wheel; through this the supply of hydraulic energy to the wheel is diminished, while the flow of water from the supply-pipe is still not decreased; no sudden rise of pressure in the pipes can therefore take place. In the succeeding time-period the shutter is gradually withdrawn again, and the needle displaced in the nozzle as necessary for the re-establishment of normal steady condition. The insertion of the needle thus follows so slowly that no important increase of pressure can arise.

Also on Table VII. there are stated the important leading dimension data alongside of the diagrams in the same manner as on Table V. The influence of the very large fly-wheel mass in Turbine XII. makes itself apparent here also, along with the smaller variation of speed. One recognizes, however, through comparison of the two diagrams upon Table VII. and Table V. that the absence of the large fly-wneel mass in Turbine XIII. is compensated for by the quickness of the governing action operated by the deflection of the jet.

It should be further mentioned that in all the turbines mentioned here the test results obtained give better values than those guaranteed by the firms who supplied the plant. The results here set forth confirm satisfactorily the proposition stated at the beginning of this paper—that the design of turbines has almost reached the limit of attainable perfection.

In regard to the efficiency there is not to be expected much further advance in the future; the problem of governing can still be considered as not yet completely solved, since there still appears in view a series of applications which will influence the further development of this problem. The electrification of railways may be mentioned as one example. But one may well express the hope, considering the experience of the results already reached, that with the help of the material and intellectual instruments now available, technical science will be able to find a satisfactory solution of these future, and perhaps often much more difficult, problems.

SEWAGE EXAMINATION.

In examining sewage the process does not differ greatly from the chemical examination of water, a description of which was given in this journal some few weeks back.

The operations which are generally gone through are the determination of specific gravity, chlorine, sulphates, carbonic acid, ammonias, total solid residue. The specific gravity may be determined by a hydrometer, but a small flask and a good balance are to be preferred. The chlorine factor is determined by a standard solution of silver nitrate consisting of 4.79 grammes of silver nitrate to the litre. Potassium chromate is used as an indicator.

To determine the sulphuric acid factor, a measured quantity is taken, say 100 c.c. or 200 c.c., and acidified with a little pure hydrochloric acid, and if necessary it is filtered; it is heated to boiling and a moderate excess barium chloride added. The liquid is boiled and allowed to cool, the precipitate collected, washed, dried, ignited and weighed.

The amount of barium sulphate multiplied by 0.3434 gives the amount of SO_3 per 100 c.c., and this multiplied by 10 gives the proportion per million. In measuring the CO_2, it is usual to use 250 c.c., but 100 c.c. will give satisfactory results; an excess of clear lime water is added the mixture (which should be made in a bottle containing a good stopper) is shaken, and the precipitate allowed to settle. The liquid is decanted and filtered. This precipitate needs very