tervals. It is an interesting fact, however, that such further subdivision of gate movement serves only to develop the shape of the curve during the intervals, and has no effect on the values at the end of each interval. In making studies of this character, it is often easier instead of using Mr. Gibson's formulas, to utilize the system of arithmetic integration, which will give correct results, although involving trial-and-error methods.

In order to compute the pressure-rise curve at points on the penstock other than at the gate, the gate movement must be divided into a number of divisions sufficient to cause the pressure waves to overlap. Thus, at least two divisions per interval must be used to compute the curve at a point half way up the penstock, at least four divisions per interval for a point three-quarters of the way up the penstock, and at least eight divisions per interval for a point seven-eighths of the way up the penstock. Referring to Fig. 11, where four divisions per interval were chosen, it is obvious that the pressure beyond the point, $3L/4$ from the gate, cannot be computed without a greater subdivision of the gate movement.

In this discussion the writer has endeavored, principally, to point out the trend of argument and application of existing data used in proving the theoretic correctness of Mr. Gibson's method of handling water-hammer problems. The method seems to be fundamentally sound, and deserves the careful thought of engineers.

PROPOSED TIDAL POWER DEVELOPMENT AT HOPEWELL

(Continued from page 366)

up the matter of borings with the provincial government very urgently last winter, but I was met at first with promises, and later with apathy, and I regret I could not undertake the expense of the matter personally. This summer I went twice to Hopewell, but could only obtain indirect evidence as to the depth of the rock under the muddy beds of the two rivers. The full line of the profile shows the depth of the top of the mud according to the admiralty chart, and there is strong presumptive evidence that the top of the rock does not lie more than 15 to 20 ft. below this. Where the "new wharf" was built at Hopewell, the mud soon washed out for a depth of 12 ft., when hard bottom was reached, and the outcropping of ledge rock at the mouth of the Memramcook indicates that rock bottom for a quarter of a mile is very near the surface. The shores at Hopewell, Fort Folly Point and Cole's Head are all rocky, and the nature of all rock in this locality is the same, viz., shaley sandstone to pure sandstone, sufficiently sound for making grindstones.

As to the best type of dam to build at Hopewell, I feel that I should offer no opinion, for the question of dam design is an engineering specialty and only an expert in this particular branch of engineering could decide the best type to adopt, and he only after a systematic line of borings were obtained along the proposed site. It has been suggested to me that a dam composed of hollow sections of concrete is a satisfactory and cheap type to build, the sections being built in a dry dock, floated into position and then sunk by filling the interior with rock and gravel. However, I doubt if this is a well proven system and, as I say, the question of best type should be decided by an expert of long experience.

Such estimates of cost that I have been able to make have been based on the cyclopean concrete type of dam. In considering the best type to build at Hopewell, the question of the tidal currents would have to be considered, and while these currents are not very swift, when the great height of the tide is considered, nevertheless they should receive attention. Fig. 4 shows some current measurements that I made this summer by using a ship's log attached to an anchored boat. When the tidal range was 38 ft., the channel current reached a maximum of 4.2 knots and you will note that although the flood current soon dies out, the ebb persists at near its maximum until almost the time for the next flood tide to begin. Out of the channel the current runs swiftly for much shorter periods, and the tidal current makes shoreward as the shores are approached, until we often have currents at right angles to the main stream. The dotted curve shows some measurements taken rather off the channel, with a tidal range of 28 ft., and the maximum under these conditions was 2.6 knots.

Before leaving the engineering problems that are presented by this novel plant, I will refer to three other items that should be considered.

The question of subnormal neap tides requires especial attention, for while my calculations are based on the least range, viz., 32 ft., of ordinary neap tides, nevertheless there are certain tides which occur sometimes three days a month, sometimes five days a month, and sometimes not at all in a month, which have a lower range than 32 ft., and may sometimes have a range as low as 24 to 25 ft.

Subnormal Neap Tides

Now, if our plant were built and running at full capacity, with a range of 32 ft., there would be an impairment of the regular capacity whenever these subnormal neaps occurred (which is about 15% of the time), and I think some provisions should be made to deal with them adequately.

One method might be to keep the turbines and generators well ahead of the normal demand and use these extra ones only during the subnormal neaps. Another method would be to keep the Memramcook shovelled out (as already described) well ahead of the regular requirements, and thus improve the average head. Yet another method would be to build a freshwater dam (say just below Turtle creek, about 5 miles west of Moncton) in which freshwater would be impounded and released only to make up the deficiency in head at subnormal neaps. Still another method would be to employ auxiliary steam power to assist the water-power during the water deficiency. One of the last two devices is nearly always resorted to in the case of ordinary hydro-electric plants situated on fresh water rivers. In nearly all districts the amount of rainfall varies enormously during the different months of the year, and the amount of run-off and discharge varies in a direct relation to the rainfall. As an example of this, the discharge at Grand Falls on the St. John river reached a maximum in May, 1909, 50 times greater than the maximum of October, 1900, and the mean discharge for the whole month of May was 20 times greater than the mean for October. In fresh water rivers a certain power may run into thousands of hosepower in the spring, but be reduced to hundreds in the fall of the year unless adequate means are resorted to in order to increase the deficiency of head.

In this matter, a tidal power scores heavily over a fresh-water power. In the case of the freshwater power, neither the time nor quantity of head deficiency can be predicted, but with a tidal power, both the amount and the deficiency are predicted by the tide tables several years in advance, and it will thus be much easier to provide for our head deficiency, which only, after all, amounts to 25% in quantity and occurs only 15% of the total time.

The best means of making up the deficit in the case of the Hopewell Tidal plant would be best figured out in the final estimates as that one which would maintain the normal output at a minimum of cost.

Sediment and Ice

The two other remaining engineering items are sediment and ice. At present the never-ceasing current flows up and down the two rivers, keeps the river mud stirred up, and the water of both rivers shows a considerable amount of sediment, and one would at first jump to the conclusion that this muddy grit (fine though it is) would produce much unusual wear on the turbines. However, what will happen as soon as the mouth of the Petitcodiac is closed by a dam? The mud in the water above the dam will undoubtedly settle, for it will have time to do so, and the water of the Petitcodiac will become clear. At present the water is never still, but with a dam, the rise and fall would be reduced to a few feet and the current would be sluggish.

In a similar way, the building of the dam would entirely alter the ice conditions. Once the dam was built, the whole