

The run-off of the stream being computed both in depth in inches and in acre-feet for each month, the run-off for the period during which observations of run-off were made is found by the summation of the amounts of run-off for the several months making up this period.

Winter Records.—Perhaps the greatest difficulties in stream measurements are met with in the early part of the winter, just as the streams are commencing to freeze up. Especially is this true in the swift-running streams in or near the mountains. Needle and anchor ice often form in large quantities in rapids, and, flowing in masses with the water, make gaugings very difficult and unreliable. Even after a permanent ice cover is obtained at the gauging station this ice will, in some cases, obstruct the channel below the station and cause "back-water."

A further difficulty is that the surface ice usually forms along the edges of the stream for some time before forming in the centre of the channel. At first this may be broken away if the stream is small and open-water measurements made, but later it is necessary to take some observations through holes in the ice along the edge. As the streams get farther away from the mountains their velocity decreases, and fewer rapids occur along their course. There is then less trouble with needle and anchor ice, and a permanent ice cover forms much more quickly.

It is often necessary to choose a new section for winter observations. This should be done before freeze-up, for then the width, depth, uniformity of flow and the conditions above and below can be easily noted. The most suitable stations for winter measurements are those which have a long stretch of very smooth, sluggish water above and a rapid fall below.

In winter as in summer, the daily discharges of a stream are computed from frequent discharge measurements and daily gauge height observations. The discharge measurements are made through holes in the ice from five to ten, or even twenty feet apart, depending upon the size of the stream, and large enough to allow the current meter to pass through freely. The gaugings are made in the same manner as at open sections except that the depth of the stream is taken as the distance from the bottom of the ice to the bed of the stream. The soundings, however, are always referred to the surface of the water in the holes, the distance from the surface of the water to the bottom of the ice being measured and subtracted from the soundings to obtain the depth.

The vertical velocity-curve method is usually used for the determination of the mean velocity in the vertical. A curve is plotted for each vertical, and the mean velocity is determined in the usual manner. These curves vary greatly as to form for different kinds and conditions of channel.

It is found that when all the holes are opened on a small, swift stream there are sometimes vertical pulsations of the water in the holes, which affect the velocity readings. This can usually be avoided by only opening one hole at a time, and filling it in again with ice and snow as soon as the observation is finished. It can also be overcome by inserting a thin sheet of galvanized tin or iron at the bottom of the hole after the meter has been lowered into the water. The meter should always be held near the upstream side of the hole.

In using the meter care must be taken to keep it under the water as much as possible to prevent ice from forming around the bearings. It is a good plan to clean

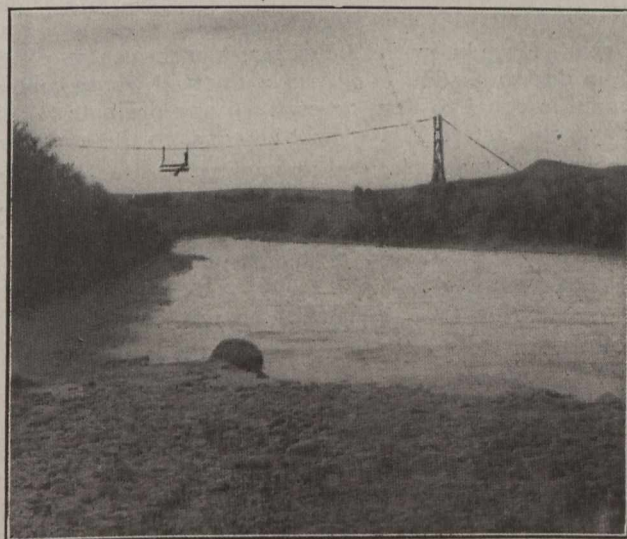
and oil the meter indoors before starting out to make a gauging.

Gauge Observations.—The gauge is usually read once a day, the observer cutting a hole in the ice and noting the elevation of the water and gauging the thickness of the ice by means of an L-shaped ice-gauge. Notes are taken as to needle ice, slush, snow, ice-jams, and any sudden temperature changes.

Any form of gauge may be used, but the chain-gauge is the most satisfactory, as the staff-gauge, being frozen to the ice, heaves with it, and also in cutting away the ice from around it the figures are effaced. The automatic gauge gives trouble with the well freezing over.

While the run-off, particularly during the winter months, does not vary directly in accordance with the precipitation, the rate at which it reaches the streams is, of course, dependent almost entirely upon the climatic conditions.

There is, therefore, very little surface run-off, and in Canada which make it exceptionally difficult to make estimates of the daily discharge during the winter. The gauge height in many cases fluctuates very much, and often sudden rises or drops occur. These rises are often



Gauging Station on Frenchman River.

explained by the fact that during very cold spells a great deal of slush, frazil and anchor ice is formed and chokes up the channel, thus raising the surface of the water, when in reality the discharge is decreasing. Then, again, a chinook causes a sudden rise in temperature and the discharge is often increased, while at the same time the gauge height gradually lowers, evidently because the warmer weather and water have melted out a lot of the ice from the channel and given it a greater carrying capacity.

In order to make reliable estimates of the daily discharge, gaugings must be made at short intervals and the weather conditions and temperatures in the whole of the drainage area above the stations must be very carefully studied.

The weather conditions and temperatures at the gauging station are not always typical for the whole drainage basin above, and care must, therefore, be taken to have the meteorological observations made at some other place, or, if necessary, at two or more places. Of course, care must be taken to study all the possible conditions which may affect the estimates.