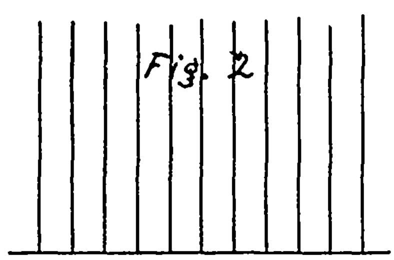
Through inaccuracies of the reducing motion, the action of the drum may not be correct in that the movement of the drum may not travel equal distances for equal distances travelled by the crosshead, and right here many errors take place. The reducing motion requires frequent examination when using the indicator. To determine the correctness of the reducing rig, place the engine on either centre, have the indicator properly attached to reducing motion; upon the paper or drum first draw a horizontal line by pulling the cord to drum, marking the position of crosshead upon the guides when at one of the centres, divide the travel or stroke into any number of spaces upon the guide, move the engine carefully until the crosshead mark is over the mark on the guide, and so on throughout the stroke, at the same time having the spring detached from indicator piston; raise the pencil vertically upon the paper from the horizontal line drawn as each station on the guide is reached; if, then, the divisions on the paper are equal as shown by Figure II., the principle of reducing motion is correct.



Frequently, however, error may take place after such a test, as the inertia of the drum due to its fast movement may cause it to reach or overthrow, and cause distortion of the card; this is particularly true at high speeds, as any effects from inertia will be shown by an increase in length of the diagram. The amount of this error has been found by experiment to be from 0.5 to 1.5 per cent. of the correct length of card, at 250 revolutions per minute, with the best tension on the drum spring. As the piping to indicator may cause error, care must be exercised again. The pipes may be too small or too great in length, may lack being properly clothed, and the steam rapidly condensing in the pipes may not be able to return back into the cylinder, and thus produce a rough and erroneous diagram.

It must then be noted that it is of first importance that the diagram shall be true, and when we note the freedom with which the indicator is used in many hands, doubts arise in one's mind as to the accuracy of many results obtained. Liability to error appears at every point, and the degree of error increases greatly with increase of speed, and we cannot be too critical in our use of the indicator. The errors we are not conscious of are the ones sure to mislead us. We require, then, that the conditions for a correct diagram shall be that the movement of the paper coincides with that of the piston, we require that the movements of the pencil shall simultaneously and precisely represent the changes of pressure of the steam in the cylinder end to which the indicator is attached.

I have gone at some length in the endeavor to show the liabilities of error in the use of the indicator, and to some this may appear as superfluous, but from observation of the use of the indicator in the hands of many who should know better, I have felt constrained to confine my remarks entirely to this part of the subject. Our next consideration will be that of the card.

THEORIES OF THE FORMATION OF ICE.

There are a great many things that are known about the nature of ice, but though the subject, like that of cement, is of never failing interest, some points in the behavior of ice are as great a mystery to the skilled engineers of this generation as they ever were to the American aborigines, whose untutored minds contemplated the formation and disappearance of ice in the forest streams of this country centuries ago. For instance, the very process of freezing is one the nature of which has not been positively solved. It is commonly supposed that once a skim of ice forms upon the surface of water, the accretion thereafter is all from beneath; in other words, that the freezing goes on at the bottom of the first shell of the ice—but is it so? Thomas Pringle, C.E., of Montreal—who has made ice formation the subject of years of practical study on river and lake—in a conversation with a representative of THE CANADIAN ENGINEER, expresses the confident opinion that ice grows from the surface, and not at the bottom, a theory which we do not remember to have been put forward on the subject. He has tested this point at various times and in a variety of ways. He has placed bricks on the surface of ice in a canal and found that in a comparatively short space of time the brick would be buried in the ice, and this process he has carried out until bricks would be buried to the depth of three feet in the ice. It might be objected that the heat of the occasional winter suns would warm the bricks sufficiently to sink in the ice, but he has disproved this by having the bricks covered with snow, which would completely exclude the sun's rays. Again, traces of snow are to be found in snow-covered ice where the cold is extreme and where the ice formation is rapid. Mr. Pringle's theory is that while ice is apparently dry and solid, it is in reality porous and that the growth of the ice is by the formation at the surface, to which the unfrozen water is drawn. So far from there being any growth on the under surface, there is actually a wearing away of ice there, as in running streams. Associated with this theory is the fact that ice will frequently grow to a level higher than the normal water surface; though sometimes, on the other hand, the surface of the ice is found to be below the water line, facts which may be tested by boring through lake ice.

The action of *frazile* and anchor ice—which are the same in their nature—involves more than one mystery which has never been solved. This ice forms in rapids on intensely cold days where the surface of the water is ruffled by wind, or agitated by the ripples of the rapids. Any one who has watched over a rapid of a Canadian river when the thermometer is below zero and the sky is clear, will have seen thousands of bright glistening lines, like cambric needles, mysteriously start from the surface and dive to the bottom. These are the materials that form frazile and anchor ice. They are formed in the first place under the agitation of the water, if not because of that agitation; but why do they dart down so rapidly, and why again are they not broken up by the same agitation and inequality of current below, as the water goes tumbling onward? These bright needles go darting down with a rapidity equal to the stream itself. What force draws them down, and what force holds them in masses of eight or ten feet thick in the midst of such a vast pressure as must be exerted by such a volume of water? There are holes in the St. Lawrence where "frazile" has been