Description of Figures.—*a*, upper motive cylinder; *b*, motive piston; *c*, pump chamber; *d*, piston of the pump; *e*, lower motive cylinder; *f*, fire box; *g*, coke valve; *h*, coke box; *i*, grate; *j*, coke chute; *k*, upper air conduit; *m*, air conduit of the pump; *n*, lower air conduit of the cylinder; *o*, *p*, part of the piston sur-

FIG. 3.—Section of the Cylinder.

rounded by air; *r*, valve of air conduit; *s*, suction valve; *t*, slide valve; *u*, door of the fire box; A B M N, travel of the crank.—*Revue Industrielle*.

THE HUDSON'S BAY RAILWAY.

THE construction of railways within the United Kingdom has now reached a stage at which many railway engineers have to submit to intervals of inaction, and, as the natural and healthy result of this condition, to look abroad for new fields of activity; and it is fortunate that the spirit maintained between the old country and the colonies opens a wide field. Any undertaking, moreover, that affects the safety, speed, and economy of the transport of our food supplies has an importance in that respect which raises it from the rank of other colonial developments having only a local interest. Northwest Canada is pre-eminently one of the colonies to which we may look for a large supply of grain and meat, and there can be little doubt of the immediate beneficial reaction on London of an improvement in the trade route from Manitoba. The supply of breadstuffs and meat from that immense field of produce need be limited only by the capabilities of the transport arrangements. The energy displayed by the Dominion Government in fostering schemes for the improvement of internal communication is most striking and praiseworthy. The Canadian Pacific Railway is not only a monument of engineering skill and intrepidity in grappling with and overcoming natural obstacles of the most formidable character, but it is a substantial proof of what the Dominion Government is prepared to countenance and assist with the view of developing the magnificent territory over which it presides. Strategic motives, or motives of economy of

distance, have, however, traced the Canadian Pacific Railway near the southern boundary of the Dominion, in effect on a nearly straight line from east to west, and north of it lie great granaries and pasture lands yet to be brought into touch with the old country. The railway in all its length from Montreal to Vancouver is like an elongated artery in the human body, and the veins to feed it from the north are still to be formed. Already a number of the necessary lines into the northern provinces are projected or in course of construction, and there can be no doubt that in the course of time we shall hear of their successful completion, with the result of an ever-growing development of the home trade of the colony.

Among the lines authorized by the Canadian Parliament, and now in course of construction in Northwest Canada, there is one known as the Winnipeg and Hudson's Bay Railway, which has already attracted some attention in this country, and is likely to assume considerable importance if its promoters are successful in their object of developing and improving the old Hudson's Bay trade route to Great Britain. This route has been successfully used by the Hudson's Bay Company for over two hundred and fifty years, and was—until recently—the only means of communication with their numerous trading posts on the prairies; and if the number of vessels sent out by the company to Hud-

As an advantage of detail, referring to the nature of the trade expected, it is pointed out that in the summer season the new route will be cooler, and that this peculiarity, added to the saving in distance, will tend to secure for it a large share of the meat and grain traffic from the United States as well as from Canada, because both of these classes of exports are benefited by a certain degree of cold. The line of railway—which has a total length of about 950 miles—is intended to follow the line of the Hudson Bay Company's trade route from Port Nelson to Lake Winnipeg, and by its western coast to reach the city of Winnipeg—the capital of Manitoba—and the famous Red River Valley. The western branch, separating at Grand Rapids, will serve Regina, the capital of the northwest territory and the center of the fertile belt. A considerable traffic is also anticipated by reason of the facilities which the railway will afford for the development of the fisheries of Hudson's Bay, which are known to be extensive. The whole line, for the purpose of construction, is divided into three sections: From Regina to Grand Rapids, 300 miles; from Winnipeg to Grand Rapids, 250 miles; and from Grand Rapids to Port Nelson, 400 miles. No particular engineering difficulties are anticipated, and only a small portion of the line traverses a rocky district, the remainder being located in prairie land or easy country. The sections throughout

MAP SHOWING PROPOSED HUDSON'S BAY RAILWAY.

son's Bay is less now than it formerly was, it is because since the establishment of railways to the south of Manitoba it costs them less to export by this route a great portion of the goods that they formerly dispatched by way of York Factory via Hudson's Bay. By the authorized line of railway above named it is proposed to connect Regina, its western terminus, and Winnipeg, its eastern—both on the Canadian Pacific Railway—with Port Nelson. The projectors claim for their route, which is shown on the accompanying map, enormous savings in distance by railway; while the distance by sea is practically the same as by other routes. The savings in railway transit by the Hudson's Bay route to Liverpool are given as follows: From Winnipeg over Montreal route, 775 miles; from Winnipeg over New York route, 1129 miles; from Winnipeg over Halifax route, 1618 miles; from Regina over Montreal route, 1081 miles; from Regina over New York route, 1435 miles; from Regina over Halifax route, 1924 miles. As to the navigation, the projectors are supported by the most recent reports of evidence collected on the subject by the Dominion Government from their own agents, stationed at various points on the Straits and Bay. They say on this authority that navigation for ocean steamships will be open in the Straits for at least four months, and frequently for six months of the year; that the harbor selected near the mouth of the Nelson River is never closed by ice, and that the river itself has a tidal navigation of twenty-five miles.

have been laid out with the view of economizing works. Some large timber trestle bridges of the Howe truss type will, however, be required to bridge the gorges in which the rivers run. The railway throughout, both in works and permanent way, will be built to the same excellent standard as that of the Canadian Pacific Railway; and it is satisfactory to learn that the works in connection with the section immediately north of Winnipeg are now in progress and are being vigorously prosecuted, a shipment of 4400 tons of steel rails from England having been already made, while about forty miles of the line have been graded. Provision will be made along the route and at Port Nelson for the storage and rapid shipment of large quantities of grain, and for this purpose grain elevators constructed on the model of those already in use on the Canadian Pacific Railway and in the United States will be erected. The Provincial Government of Manitoba, as an evidence of the keen interest with which the undertaking is regarded in the Northwest, has given a guarantee to assist in the execution of the works, and the Dominion Government has reserved a magnificent area of 8,400,000 acres from the Crown lands adjoining the railway as a subsidy or free gift. The contractors for the construction of the line have had considerable local experience, having been engaged upon the works of the Canadian Pacific and other railways in Canada. The consulting engineers of the company are Sir F. J. Bramwell, F.R.S., and Mr. W. Shelford.—*The Engineer*.

ON THE DESIGN OF SLIDE VALVES.

By Prof. R. H. SMITH.

It is not intended here to say anything of the merits or demerits of the various kinds of slide valves. These differ greatly as to the frictional work spent in driving them, as to their steam tightness, as to their wearing qualities, and as to their more or less rapid opening and closing of the ports. The simple geometrical question alone of the relation between steam distribution and valve dimensions is to be dealt with, the valve being supposed driven by an ordinary eccentric.

The diagram shown in the engraving is almost identical with one constructed by myself in 1870 or 1871. The elementary principle of the device was suggested to me by a German draughtsman. He had a small brass disk about 2 in. in diameter, on which was described a circle divided into equal parts, and a series of parallel, equidistant straight lines, perpendicular to a scribed diameter, which was taken as the piston stroke and the valve stroke. At the center was pivoted a small arbor, on which were mounted two dial pointers taken to represent crank and eccentric. These could be clamped together at any angle, and the two could be rotated together by means of a small milled head. The instrument was a very rough one, incapable of accurate calculation; but its chief fault lay in the fact that no account was taken of the effect of the obliquity of the connecting rod.

The convenience of the instrument consisted in its obviating the necessity of drawing any circles on paper and of plotting off any angles with the dividers in working out slide-valve problems. It was an easy step to perceive that the same result could be obtained by a carefully drawn diagram on paper or cardboard, with various scales marked on it, and that in preparing such a diagram allowance could be made for the obliquity of the connecting rod by projecting the equal divisions of the piston stroke on the crank pin circle by means

BENIER'S HOT AIR ENGINE.

RULES TO FIND PROPER VALVE DIMENSIONS REQUIRED FOR GIVEN STEAM DISTRIBUTION.

1. Given Pre-admission to find Angle of Lead:

Find the desired point of pre-admission on the proper piston-stroke scale, and the point opposite this on the scale of angle-degrees. The angle between this point and the end of the stroke is the Angle of Lead. The sum of the Angle of Lead and of Angle of Lap is the angular advance.

2. Given Pre-admission and Cut-off to find Outside Lap:

Find Angle of Lead by Rule 1, and set it forward from point of cut-off found on proper piston-stroke scale. Half the remaining angle between the point so got and the end of the stroke is the Angle of Lap.

3. Given Pre-admission, Cut-off, and Release to find Inside Lap:

Find angular advance by Rules 1 and 2. Set the angular advance back from end of stroke. The angular difference between the point so got and the desired point of release as found on the proper piston-stroke scale is the Angle of Inside Lap, or of clearance if release is further back than point first got.

4. Given Pre-admission, Cut-off, and Compression to find Inside Lap:

Find angular advance by Rules 1 and 2. Set the angular advance back from the beginning of the stroke. The angular difference between the point so got and the desired point of compression as found on the proper piston-stroke scale is the Angle of Inside Lap or of clearance if the point of compression is further forward than the point first got.

5. Given Cut-off and Angular Advance to find Outside Lap:

From point of cut-off as found on proper piston-stroke scale, set forward the angular advance. The angle from point so got to end of stroke is the Angle of Outside Lap.

SLIDE VALVE DIAGRAM.

Scale on Diameter.—Valve travel; each half-travel divided into 50 equal parts. (These divisions being projected on 1st circle.)

Scale on 1st Circle.—Equal degrees of Angle; each semicircle divided into 180 degrees.

Scale on 2d Circle.—Piston Stroke divided into 100 equal parts; Connecting-rod = 2 Strokes. (Showing positions of Crank Pin for simultaneous positions of Piston.)

Scale on 3d Circle.—Piston Stroke divided into 100 equal parts; Connecting-rod = $2\frac{1}{2}$ Strokes.

Scale on 4th Circle.—Piston Stroke divided into 100 equal parts; Connecting-rod = 3 Strokes.

RULES TO FIND STEAM DISTRIBUTION DUE TO GIVEN VALVE DIMENSIONS.

1. Given Lap and Angular Advance to find Pre-admission:

Subtract from Angle of Lap and Lead, i. e., the angular advance, the Angle of Lap. Set the difference of these angles back from the beginning of the stroke. The point so got is the point of Pre-admission.

2. Given Lap and Angular Advance to find Cut-off:

Add the angular advance to the Angle of Lap. Set the sum of these angles back from the end of the stroke. The point so obtained is the point of Cut-off.

3. Given Inside Lap and Angular Advance to find Release or Exhaust:

Subtract from angular advance the Angle of Inside Lap. Set the difference of these angles back from the end of the stroke. The point so got is the point of Release.

4. Given Inside Lap and Angular Advance to find Compression:

Add the angular Advance to the Angle of Inside Lap. Set the sum of these angles back from the beginning of the stroke. The point so got is the point of Compression.

DEFINITIONS.

The "Angular Advance" is the angle between crank and eccentric, less 90 deg.

The "Angle of Lap" is the angle whose sine is the outside lap divided by the half-travel.

of circular arcs of connecting rod radius, instead of by perpendicular straight lines. In the diagram attached to this article this is done for three standard ratios of connecting rod length to crank throw. The connecting rod lengths chosen are 2, $2\frac{1}{2}$, and 3 strokes. The stroke is divided into 100 equal parts, and the corresponding positions of the crank pin are shown on the three outer circular scales for the above three connecting rod lengths. The actual connecting rod length in steam engines is never so much different from one or other of these as to make any appreciable difference in the slide valve calculation.

The inner circle is taken as 5 in. in diameter, and represents to different scales the paths of both crank pin and eccentric center. The horizontal diameter represents to the same two scales the strokes of piston and of valve. It is divided into 100 parts, only every fifth division being indicated by a vertical cross line. Considering it as the valve stroke, the corresponding positions of the eccentric center are projected on the circle by vertical straight lines, because the obliquity of the eccentric rod may be taken as practically nil. In slide valve design, all dimensions have to be considered in ratio to the half travel of the valve. Therefore, the half travel is conveniently divided into ten parts, each of these being subdivided into five. The one-fiftieths of the half travel are large, and easily divisible by eye, so that there is no difficulty in reading off the ratios to 1 per cent. of half travel.

In using the diagram, careful distinction must be made between the out and in strokes. The upper semicircle must be used in dealing with the in stroke, the lower with the out stroke. The diagram must be so used, whatever be the actual direction of rotation of the engine. The diagram can be used for the solution of two classes of converse problems—first, given the valve and port dimensions and the setting of the valve, to find the resulting steam distribution; secondly, given the desired steam distribution and the ratio of connecting rod length to stroke, to find the required valve dimensions and eccentric setting. In conjunction with the diagram, two sets of rules are given—first, four for the first class of problems, and second, five for the converse problems. These rules are so easily proved to be correct by a little careful consideration that it is hardly worth while to give demonstrations of their truth here. It will be sufficient to make one or two explanations as to the phraseology used and as to the general mode of procedure.

In the rules, the phrase "set off" such an angle is constantly used. This setting off is not to be performed with dividers. By help of the scale of angle degrees all the angles used are obtained in degrees, and the simplest mental addition and subtraction of degrees are alone needed for the plotting off of the angles from any of the points mentioned in the rules. If the mental arithmetical faculty be not developed in the operator, he can make his additions and subtractions on paper, but he should not substitute the use of the dividers for this arithmetic, because the prickings of the divider points

would rapidly destroy the diagram for all accurate purposes. The "angle of lead" is to be understood as the angle at which the crank stands before the dead point when steam admission takes place. The "angle of lap" is the angle beyond 90 deg. at which the eccentric stands when steam admission takes place. The "angular advance," is the sum of these two angles.

It is to be distinctly understood that the diagram enables one to calculate only angles and ratios of the valve dimensions. Evidently, any standard diagram could not give directly absolute dimensions. The port breadth has to be found from the required area of port. Call it b . Say that a ratio, q , has been calculated by help of the diagram for outside lap divided by half travel. Then from this we find the half travel = $\frac{b}{1-q}$

and therefore the outside lap = $b \frac{q}{1-q}$

If we wish to make the cut-off the same on out and in stroke, we find two different values of q for the two strokes, i. e., for the two outside laps. That obtained for the out stroke is always the larger of the two if the two angles of lead be taken the same. For example, if the connecting rod were two strokes in length, and the

cut off — were desired for both out and in strokes, and

an angle of lead of 10 deg. were wished, then for in stroke we would have "angle of lap" = $\frac{1}{2}(180 - 129 - 10 \text{ deg.}) = 25 \text{ deg.}$, and consequently $q = 0.42$. For the out stroke we find "angle of lap" = $\frac{1}{2}(180 - 106\frac{1}{2} - 10) = 31\frac{1}{4} \text{ deg.}$, and therefore $q = 0.53$. If now b were taken the same for both ports, the half travel as calculated

from the first figure, $0.42, \left(\frac{b}{1-0.42} = \frac{b}{0.58}\right)$ would be less

than that from the second, $0.53, \left(\frac{b}{1-0.53} = \frac{b}{0.47}\right)$

Now the two half travels cannot be unequal. We must therefore have either unequal cut-offs, or unequal port openings for the two ends of the cylinder. It will generally be preferable to have unequal port openings. We must then calculate the half travel from one of the two ratios, q , obtained, and from the q obtained for the other end of the valve calculate the port opening and lap from this half travel. Thus, suppose that in the above example it has been reckoned that $\frac{3}{4}$ in. steam port opening was required. If we calculate half travel from the 0.42 for in stroke, we would have half

travel $\frac{0.75}{0.58} = 1.29$, and lap = $1.29 - 0.75 = 0.54$. Then for

out stroke we would have lap = $1.29 \times 0.53 = 0.68$, and therefore port opening $1.29 - 0.68 = 0.61$. But this port opening is less than has been settled as necessary. We must therefore proceed in the other order, and calculate the half travel from the 0.53 obtained for the out

stroke; thus half travel = $\frac{0.75}{1-0.53} = 1.60$, and there-

fore lap = $1.60 - 0.75 = 0.85$. For in stroke we then obtain lap = $1.60 \times 0.42 = 0.67$, and therefore steam port opening = $1.60 - 0.67 = 0.93$. This is in excess of the required opening, but so far as simple steam admission is concerned, this excess is no evil, whereas the deficiency obtained by the previous dimensions is a decided evil. The larger valve travel of course involves more waste of frictional work in driving the valves, and in some cases this evil may be considered to overbalance the evil of deficient opening of the steam port at one end. But this cannot be considered the standard case, and therefore we should generally follow the rule to design the half travel by help of the ratio, q , obtained for the cut-off on out stroke. We then from this half travel calculate the lap for in stroke, and we will find that the steam port opening for in stroke is in excess of what is absolutely required.—*The Engineer.*

ON THE REMARKABLE EFFECTS OF ADDING SACCHARINE MATTER TO MORTARS.

By SAMUEL CROMPTON.

A LETTER from Mr. Thomson Hankey "On a New Use of Sugar"—*London Times*, October 13—has given rise to wide discussion and inquiry. At a time when the price of sugar is so low, and, as I shall show, when the use of a very small quantity of it, or of treacle, adds largely to the strength of mortar, and makes Portland cement itself set with great rapidity, it seems to me that I may do a service to engineers by laying before them the scientific grounds on which I was led to experiment on the subject, and the remarkable results which have been obtained.

The practical importance of this addition of saccharine matter to mortar I will state briefly to begin with, and will give a few illustrations:

I mixed in a small jar some Portland cement and brown sugar, adding water and stirring. I took out a little of the cement for an experiment, and when I tried an hour after to take out more, I found that the remainder had already set.

My neighbor, Mr. Rowland, weighed carefully Portland cement and sand into four small jars. To two he added different sugars, to the third treacle, but to the fourth no saccharine matter. On the day following the cement had set—we do not know how much earlier, for it was not examined—in all the jars with saccharine matter. Mr. Holden, Jr., the foreman of a builder, examined all of them on the Monday following the Friday on which they had been mixed. On pressing the cement to which the treacle had been added, he said, "I might press the bottom of the jar out before I can make impression on this." He then put his finger into the jar in which there was no saccharine matter, and stirred up the cement, which had not set at all, and which did not set till a day or two after. It may be objected that it