speaking, is it necessary to do a great deal of digging. In many places artificial waterways will only be necessary to connect one *coulée* with another. There are also an abundance of natural depressions which can readily be converted into reservoirs for the conservation of surplus water, as has already been done in the case of the Galt canal.

Meanwhile, pending the application of irrigation to the entire semi-arid belt of southern Alberta—a project which could only be undertaken by the Dominion government—the Canadian Pacific Railway has undertaken an irrigation scheme of very large proportions. The land transferred to the company by the Dominion government, as already explained, lies between Medicine Hat and Calgary, bounded on the south by the Bow River, and on the north by the Red Deer. The railway runs through its entire length. Mr. Elwood Mead, and other irrigation experts who have examined this land, state without hesitation that it is admirably adapted to cultivation so far as the quality of the soil is concerned, and they are convinced that irrigation is not only practicable, but that it will result in adding to the Canadian grain belt a large section of land hitherto unavailable except for grazing purposes.

Having secured this land from the government, the Canadian Pacific Company proceeded to mature its scheme. Engineers were sent out to examine and report upon the district; estimates were prepared, and plans and specifications for the gigantic work contemplated, and finally tenders were called for the first section. In the spring of 1904 a contract was let to a firm of contractors in Vancouver for the work, the price being three million dollars, and the canal, or rather its first section, to be completed inside two years. This first section is really the main canal, which starts from the east side of the Bow River, about three miles below Calgary, and runs for twenty miles across the level prairie. The canal is 60 feet wide at the bottom, 10 feet deep, and is designed to carry two thousand cubic yards of water per second.

This trunk canal brings the main body of water from the Bow River to the most convenient point for distribution. At its easterly end the water is turned into three secondary canals, located along the heights of land. By this means the irrigating streams are conveyed with the minimum of effort to the lands intended to be brought under cultivation. The company expect eventually to have four hundred miles of these canals along the Bow River, and the major portion have already been located. Of the three million acres in the tract acquired, about one-half will be placed under water, the balance being reserved for grazing and dairy farming.

The completed system of irrigation canals will cost in the neighborhood of \$4,000,000. In building the trunk canal alone, which is now nearing completion, 250,000,000 cubic feet of earth will have been taken out. The work is being done by means of steam shovels operated on railways, with every other modern engineering appliance which would facilitate the early completion of the canal. Considerably over half a million acres are now under water, and the irrigated districts are rapidly being extended on every side.

A comparison of the cost of this Canadian irrigation project with similar undertakings in the United States and India, to go no farther, brings out some rather interesting results. The Canadian Pacific Company estimate that their irrigation canals in Alberta will cost, taking in everything, about \$2.75 per acre. According to the report of the United States Industrial Commission, the cost of irrigation in the Western States has been from \$2 to \$5 an acre in the original pioneer ditches, increasing to \$12 an acre in the larger and more elaborate undertakings. The average annual cost of conveying the water has been about \$1.25 per acre, including cost of repairs and maintenance. In India, where 19,000,000 acres of land have been reclaimed at a total cost of \$127,000,000, the cost has been found to be \$6.65 an acre, the government of course having the advantage of very cheap native labor. The explanation of the very much reduced cost of the Canadian project is mainly the unusually favorable lay of the land, which, with the exception of a few deep cuttings and an occasional flume to carry the canal over some intervening *coulée*, will make the work of excavation comparatively light.

Irrigation in Alberta has not only increased the area of land adapted to the profitable cultivation of wheat, oats, and barley, but corn, potatoes, and other root crops are also being raised in rapidly-increasing quantities, a ready market being found for the entire surplus over local consumption in the mining districts of British Columbia, direct railway communication between Lethbridge and the mining country being afforded by the Crow's Nest branch of the Canadian Pacific Railway. One of the most interesting results of irrigation in the Lethbridge district has been the establishment of a large beet-sugar factory, supplied with beets grown on irrigated lands, which have been found to be peculiarly well adapted to this particular crop.

The practical wisdom of this widespread scheme of irrigation in western Canada is further illustrated by the fact that up to the present time, in spite of the dismal warnings which greeted their acquisition from the government of these semi-arid lands, the Canadian Pacific Railway Company have disposed of one hundred and fifty thousand acres of land in the Calgary district, at prices aggregating three-quarters of a million dollars.

The success of the Canadian Pacific Railroad's project has also encouraged others to invest capital in irrigation. The Robbins Irrigation Company, representing a group of English capitalists, has entered into

an agreement with the government of the province of Saskatchewan to spend a minimum of \$1,000,000 on the irrigation and improvement of 300,000 acres of land lying between the Bow and Belly Rivers, to the eastward of the Canadian Pacific Railroad irrigation works. It is the intention to settle on the irrigated tract a number of Canadian and American farmers who are familiar with the working of irrigated lands. Sugar-beet and canning factories will be erected by the company in the town of Medicine Hat, the climate of this district being particularly favorable to the production of many kinds of vegetables and small fruits.

INDUSTRIAL APPLICATIONS OF GYPSUM.—I.*

By ROBERT GRIMSHAW.

In entering upon a discussion of this subject, we must bear in mind that just as there are two general classes of steel, temperable or hardenable and non-hardenable, so there are two equally distinct varieties of gypsum or plaster of Paris—the quick-setting and the slow-setting; or stucco plaster and building or hydraulic plaster. These differ from one another in their manner of preparation and use, and in their physical qualities, although chemically they are not so far apart.

Stucco plaster is burned at a low temperature, and still contains considerable of the original water of crystallization. Its principal use is where good casts rather than hardness and closeness of pores are desired. It owes its value in this connection to the fact that when the "mix" is just about to take its final set, it expands sharply and tends to enter every crevice and cranny in the mold, and stay there.

There are three principal methods of getting there with casts of a clay or other model.

The first method yields but one cast; the other two permit of obtaining from six to six hundred, according to the nature of the article and the care taken in molding and casting.

According to the first method, the original is coated with a thin wash of dark-colored plaster cream, well applied with a brush so as to leave uncoated no crevice in the original. Next comes a well-laid-on layer of stiff plaster from two to six inches in thickness, according

must be filled with well-oiled cotton. Plaster is then to be laid on in considerable mass, care being taken not to lose the ends of the parting cords. When the mass has nearly set hard, both ends of each cord are to be drawn, so as to make sharp "parts" in the mold. When the mass has set hard the different parts are to be drawn away from the foot. In choosing the parting places, particular attention must be paid to getting clean work at the ankles, and if the cotton between the toes is not rightly arranged there will be difficulty in getting the foot free of the mold. The foot should not be left too long in the mold, as it is apt to swell and increase the difficulty of withdrawal. The work should be sharp enough to show the "goose-flesh" on the skin caused by the cold plaster.

Where many casts are to be made from a part mold it is best to shave its outer surface smooth and to give it a coat of shellac, and then to make a jacket of plaster over the whole, to keep the parts together in pouring.

In pouring most molds it is desirable to leave vents for the air to pass out; the resulting projections on the cast can be removed with a knife.

The third method of molding permits the use of originals that are slightly undercut. Here the mold is made of a glue composition something similar to that used for printers' rollers; the main components being glue and molasses or glycerin. The original may be of almost any kind—wood, metal, plaster or what not. It is first coated with a liberal clay jacket which is wiped down smooth. Then there is made over this an outer jacket of plaster. The thickness of the clay covering determines that of the glue mold. The original and the clay covering being removed from the outer plaster jacket, the clay is then washed off the original, the latter inserted in its former relative position in the outer jacket, and the space between the two poured with the glue composition. The original may then be removed from the glue mold, and this poured with plaster. In removing the original or cast, the mold gives considerably without danger of breaking or slumping.

In order to insure getting castings that will bear a little rough handling, the glue form may first be rinsed out with a thin plaster cream and then stuffed with a mass in which excelsior or other mechanical binding material is freely used.

In order to make a setting for a broken leg there is first wrapped around or laid upon the part to be cased, sterilized cotton wool or flannel; then over this there are wrapped gauze strips which have been thoroughly "stuffed" with the finest, most rapidly-setting plaster; the bandages are then wet with warm water, or if the work is done quickly enough each strip may be drawn through the warm water before it is wrapped around the limb.

In using plaster as a cement it must be remembered that it will not hold smooth surfaces.

In the ceramic industries plaster of Paris is the right bower, or sheet anchor, or whatever one chooses to call it, that will indicate its value and indispensability. It owes its high position to two qualities—the fact that it can be so readily formed into almost any desired design, and its great porosity and absorbent nature. This being the case, molds may be readily made in any desired quantity from the original design, or the gypsum itself may be employed in making the original. These molds may be made of any desired degree of porosity, to suit the character of the mass that is to be poured or pressed therein. Further, the molds are light—which is more than can be said of the slate molds which are so largely employed by pewter founders.

A most important use of gypsum is in interior decorations, and these may be either cast and applied, or swept in place. Here one can use either pure plaster of Paris, or a mixture of that and lime alone, or sand and lime together, or layers of mixture overcoated with pure gypsum.

In using lime as an adulterant, the plaster may be run down as low as 20 per cent by weight. As regards the amount of sand that can be worked in, that depends on the sharpness—of the sand, not of the contractor. The strength of the mass may be increased by the addition of glue to the water, also by the employment of calves' hair; cows' hair is apt to be too coarse.

Only one thing must be borne in mind in this connection—the lime which is mixed with the gypsum must not be too fresh, else there would result blow holes in the surface of the work, and further the mass would set too quickly. The sand must be sharp and free from clay. Either hard or soft water may be used, but it should be clean.

In later years builders have made use of many kinds of mixtures of stucco plaster with less costly materials, in the form of slabs for partitions and even outside walls, and have also made use of plaster in connection with wire cloth of more or less open mesh, for partitions made in place, as distinguished from those made up of previously-manufactured slabs or boards. Most of these forms have served their purpose well, when the adulterant was not too plentiful or too worthless. Sand, lime, ashes, cocoa fiber, excelsior, hair, rushes, hoop iron, and various other binding and reducing materials have been used with more or less success. Unfortunately, the use of coal ashes and of old plaster has given such material a bad name. But where good materials are properly used, there has been no dissatisfaction. And as there is no patent on the simple forms, which are mostly the best, it is a pity that the use of plaster in building has not been more widely introduced. In Europe, gypsum flooring tiles, where materials are to be stored, and there is not

METHOD OF SECURING THE JOINTS.

to the subject. When this has hardened, the clay original is removed by digging out and washing, so that no clay remains in the mold, even in the finest interstices, representing the finest projecting parts of the original. The next step is to fill these fine crevices with a very thin plaster cream, so as to insure a sharp cast. This satisfactorily attained, the main cavity of the mold may be filled with a stiffer mass and allowed to set. To insure the penetration of the first pouring into the finest interstices, the mold is "rinsed out" as it were; the swaying motion throwing the liquid into the crevices and letting the air escape. If it is desired to make a light casting, either to save plaster or for any other reason, the heavier portions need not be filled; to reduce weight, the core may be dug out, and to save plaster, a core of wood or other material may be introduced at the desired distance from the periphery of the mold, to determine the thickness of the casting. The mold is then to be removed by hammer, knife, and chisel; the dark layer tells how deep to go.

The advantage of getting a plaster cast instead of a clay model is that the cast is sightlier and will not crack with dry weather nor slump down in wet.

To make a two-part plaster mold of a flat object, as the human hand in outstretched position, or a coin or medal, a layer of soft plaster is prepared, and the object to be cast pressed therein until the natural parting line is reached. It is advisable to oil the surface of the original, to prevent it sticking in the mold. The surface of the lower mold may be given a light coat of shellac, and then a fence having been built out of cardboard, to limit the size of the upper mold, plaster is poured upon the original and lower mold. When this has set, the upper part may be lifted off, and the original withdrawn from the lower half of the mold. In order to avoid losing the mold by breakage at the time of making, or later, it is well not to be sparing of plaster.

If it be desired to make a cast of the human foot, the part must first be thoroughly oiled, then the parting lines drawn thereon; or perhaps it would be better to make these beforehand. Then fine, strong cords are laid along the parting lines, and held there with a little fine plaster cream. The spaces between the toes

*Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

much tramping thereon, are not unknown; but the principal application is for what Americans would call plaster lumber for partition walls. The usual thickness is from one to three inches; the width is generally a fraction of a meter—25 and 50 centimeters being the most usual; and the length runs from two to two and a half meters. When we remember that such "boards" are lighter than water, can be sawed, cut, and planed, hold screws, hooks, and nails quite well, and can be made at any season of the year, it is a wonder that they are not more used. They are dry, fireproof, and bad conductors of heat and sound; further, they do not harbor vermin. Their only fault—I am speaking of those which are made of stucco plaster—is that they have not a very high compressive strength, so that although they will bear their own weight as well as a brick wall, they cannot be relied upon to hold up roofs and upper floors. Where, however, it is required that a partition wall shall carry weight, the use of a suitable mixture of stucco and hydraulic gypsum will solve the problem in a satisfactory manner. If required for outer walls stucco slabs should be protected against weathering; asphalt would be good enough but its appearance is not highly attractive, and a wash of cement is therefore preferable. In this connection, however, it must be remembered that cement should not be applied directly to the plaster; there should be a preparatory coat of lime wash, or better yet a very thin lime-plaster coating.

Gypsum plaster has the advantage in dyeing establishments, tanneries, wash-houses, etc., of preserving iron beams, etc., from rusting, and wood from rotting.

Where plaster lumber is used, the joints may be secured either by wire nails driven in diagonally where there is no studding, or by sheet-iron binders made out of square pieces each with two cuts from two opposite edges, as in Fig. 1, in which *a* represents the thickness of the planks, and which pieces are folded over as seen in Fig. 2, which represents part of a joint, and shows how the wings of the clamping piece are folded over. Of course, except in the case of warehouses and other buildings where the appearance does not matter, partition walls thus clamped need a coat of plaster to make them sightly. It is usual to make such plaster planks smooth on one side and rough on the other; where they are to be given a finishing coat, the rough side is put out. I have cast them on glass and marble slabs to get the smooth side; the rough side is easily enough obtained, but it is well not to err on the side of smoothness on the face which is to hold a plaster coat.

Where the slabs are very long it is wise, for safety in transportation, to stiffen the slabs with rushes, twigs, or even straw, laid lengthwise, as this is the direction in which the greatest stiffness is required. Thick twigs are, however, to be avoided, as they cause cracking by absorbing water from the plaster; it is better to use thin ones and to soak them well in water before using.

It is a good plan to make walls of a double layer of thin slabs, one layer running vertically and the other horizontally; wire nails from one layer to the other will give great stiffness. Where it is desired to secure great non-conductivity to heat or sound, there should be an air space between the two layers of the double wall; and in this case vertical studding may be used, or for greater cheapness one strong upright at each end of the wall, with tightly-strained galvanized wire (about No. 4) to give stiffness against lateral strains. But another way, and a very good one, is to cast the slabs with ribbed projections on the back, in such direction that they will cross each other in the wall and give mutual support, while still preserving in great part the air-space feature.

If one wishes a roof that shall be fireproof, non-conductive to heat, and light on the rafters, stucco plaster will solve the problem—if rightly used. Thin plaster boards are nailed on the rafters, then the whole run with a three-quarter-inch layer of gypsum concrete, consisting of stucco plaster with either sharp sand or good sharp screened coal ashes. Over this comes a layer of asphalt roofing paper, and the whole is then given a coat of iron ore ground in fish oil, and strewed with sand or fine gravel while the paint is still wet. This is of course best suited for comparatively flat roofs. For a so-called Gothic roof, say 60 degrees, the rafters may be overlaid with inch hemlock boards; then asphalt paper, then plaster and ashes (laid on with a float) about half an inch or less in thickness; then slates. A slate roof thus laid will not rattle in the greatest storm that ever comes up, and all the lightning-rod men and telephone men in town can climb over it without being able to loosen a slate.

Up to this point I have considered principally stucco slabs or boards made elsewhere than at the place of building; there remains to be considered a method of construction very largely adopted in Germany, in which galvanized woven wire, expanded metal and the like come into play, and the surfaces are formed of fresh plaster in the desired outlines and surfaces. The mass is usually a mixture of lime and gypsum often with cow hair as binding material and sometimes with sharp sand. For partition walls the wire cloth is strained between standards, plastered on both sides and then given an outer coat with no hair. To prolong the time of setting, and also to increase the strength of the mass, glue water is often used.

A more expensive partition is made by using two layers of wire cloth with a space between, and plastering each on one side only. Many of the apparently massive vaulted ceilings that one sees in modern buildings in the old style are only wire cloth and plaster; the short thick columns are of studs overlaid with

wire cloth or expanded metal and given a gypsum jacket, which is usually carried out in scagliola or breccia imitation. Sometimes, indeed, such columns conceal the steam and gas pipes, and in some cases they are even the chimneys.

Another constructive feature which we owe to the French is ceilings of I beams with wooden cross laths between them, on which plaster is poured, after a temporary board ceiling is laid under the beams to keep the plaster from going clear through. When the temporary ceiling is removed, the under side of the layer of lath and plaster is given a finish coat, and the floor is laid on the beams as in the case of any other ceiling.

I reserve the consideration of the applications of hydraulic gypsum for a separate article.

(To be concluded.)

DEPTH INDICATOR FOR TORPEDO BOATS.

By the English Correspondent of SCIENTIFIC AMERICAN.

AN ingenious and interesting apparatus has recently been devised for the purposes of indicating the depth of water in which a torpedo boat is traveling, by Messrs. Elliott Brothers, of Lewisham, London, based upon the results of the interesting experiments that have been carried out by Mr. Harold Yarrow, of the well-known Yarrow firm of naval shipbuilders of Poplar-on-Thames.

When the British Admiralty contracted with certain shipbuilders some four years ago for the construction of the "river class" of torpedo-boat destroyers, the feature of which was the embodiment of heavier scantlings than had been previously adopted, difficulties were experienced by the builders in connection with the speed attained by the vessels upon the trials. These craft ranged from 550 to 600 tons displacement, and the stipulated speed was 25.5 knots. Formulating the designs of this new class of destroyer with those that had been previously constructed, it was calculated that 7,000 indicated horse-power would be sufficient to produce this speed; but when the trials were commenced,

INDICATOR FOR TORPEDO BOATS INTENDED TO SHOW THE DEPTH OF WATER IN WHICH THE BOAT IS TRAVELING.

it was discovered that the possibility of attaining this contracted speed with the horse-power calculated was somewhat remote. Messrs. Yarrow & Co., who had some of the vessels in hand, carried out a series of progressive trials with the destroyer "Usk" upon the measured mile off the Maplin Sands upon the east coast near the estuary of the Thames, and the results thereby obtained demonstrated the fact that when the speed approached that guaranteed, a very small advance in speed was attained for a considerable increase in the horse-power. This peculiarity was common to all the other builders of the sister ships, with the exception of the firms who carried out their trials on the Skelmorlie measured mile.

In view of the fact that the various vessels were of practically identical design, and that the depth of water on the Skelmorlie mile is about 40 fathoms, which is far in excess of that in the case of the Maplin and other trial grounds off the east coast, it was concluded that the wide variation obtained in the results was due to the differences in the depth of water in which the trial runs were made. In order to test this conclusion, Mr. Harold Yarrow embarked upon a series of prolonged experiments for the purposes of ascertaining the effect of the depth of water upon the speed of vessels, especially in regard to these torpedo-boat destroyers. The militating effects of shallow water upon the speed of vessels has frequently been investigated, especially by Sir William White, but Mr. Harold Yarrow as the result of his investigations discovered many marked peculiarities, which he communicated in an interesting and instructive paper to the British Institution of Naval Architects. For the accumulation of the data experiments were carried out with models in the testing tank simultaneously with the practical trials with a destroyer of 400 tons in a depth of 40 feet of water. These latter tests practically confirmed the results of the tank experiments, for when the steam pressure was raised from 100 pounds to 125 pounds, the increase in speed was only one-half knot; while when the pressure was raised from 125 pounds to 150 pounds, the rise in speed was no less than 5 knots. These combined experiments showed upon the carefully-prepared records that were

taken, that at places the rise in speed is very small in comparison with the increase in power, while at others the rise in speed is very great in proportion to the increase in power. The diagram also showed the inclination of the vessel and the approximate height of the stern wave with reference to the stern of the boat, and one noticeable feature was that the marked increase of the inclination and stern wave occurs at those points where the power increases rapidly with but a very small acceleration in the speed.

The course selected for the runs was seven miles in length at the mouth of the Thames, the depth of water ranging from 20 feet to 100 feet. The investigations carried out were of an exhaustive character, and were made with every care. The steam pressures ranged from 40 pounds to 200 pounds, the pressures being accurately regulated by the control of the stop valves on the steam pipe, a surplus pressure being maintained in the boilers. Every minute during the runs observations were made concerning the revolutions of the engines; the inclination of the vessel read from a twenty-foot level; the height of the stern wave above or below the deck at the stern, and indicator diagrams twice on each run. The variations in the number of revolutions on each run with a constant pressure were taken as a guide to the resistance in preference to indicator diagrams, as being more positive than the latter, since any increase or reduction of resistance to the vessel would instantly show itself by a reduction in the number of revolutions.

The results attained were highly interesting in character, and exemplified in a striking manner the effects of passing through varying depths of water and their influence upon the resistance to the vessel. For instance, when working at 100 pounds pressure and at approximately 19 knots speed, the resistance in passing from a depth of 55 feet to shallow water of 24 feet was very appreciably increased, demonstrated by the fact that the revolutions fell from 278 to 250 per minute with a constant pressure of steam. Simultaneously the inclination of the boat was considerably augmented, from $2\frac{1}{2}$ inch to nearly 5 inch in 20 feet, while the height of the stern wave also increased. It was pointedly shown that the inclination of the vessel taken in conjunction with the revolutions enabled a very fair estimate of the depth of the water between the limits of 20 feet and 100 feet to be obtained, and as a result of this observation Mr. Yarrow advanced the theory that this feature might be turned to valuable account for navigating purposes, for indicating the depth of water in which a vessel might be traveling at any moment. For instance, if the destroyer be running at about 19 knots and the navigating officer does not desire to approach nearer the shore than 24 feet of water, immediately the inclination rises to $4\frac{1}{2}$ inches in 20 feet he knows that his limit is being approached. In determining this basis of calculation, proper data concerning the characteristics of each vessel must be obtained, and then the depth of water under the boat at any time can be approximately calculated.

The indicator shown in the accompanying illustration is based upon the hypotheses advanced by Mr. Yarrow as the result of his investigations, and was recently exhibited before the Institution of Civil Engineers, where it aroused wide interest. The device consists of six spirit levels hinged, and which can be separately set and clamped to any small inclination. They are carried in position by two vertical pillars as shown, and the latter are attached to a hinged base, the top of which can be set level by the operation of an adjusting screw, there being a fixed spirit level to indicate when the hinged base is horizontal.

The operation of the indicator is very simple. It is placed in a convenient position upon the navigating bridge, and when the vessel is at rest set level. As the inclination of the vessel for each speed corresponds to the depth of water, such as, for instance, at a speed of 16 knots at a depth of 30 feet, the inclination is $1\frac{1}{2}$ inches in 20 feet, and for 18 knots an inclination of $2\frac{1}{4}$ inches in 20 feet, etc. No. 1 hinged level is set to an inclination of $1\frac{1}{2}$ inches in 20 feet. If the boat is traveling at 16 knots, when the bubble passes to the other side of the level the officer can see that the depth of water is about 30 feet. No. 2 hinged level is similarly set to an inclination of $2\frac{1}{4}$ inches, corresponding to 20 feet of water, and if the boat is running at 18 knots when the bubble travels to the other side of the level, the depth of water is 3 feet, and so on for higher speeds and other levels.

In order to ascertain the inclination at which to set the levels, experiments with one boat of each type would have to be carried out, but once the inclinations corresponding to the various speeds for a given depth are ascertained, the accuracy of the instrument is not impaired by any practical alteration in the trim due to lading. Any change of trim that may be necessary at a later date, due to a different lading, can be allowed for and adjusted as required, so that the base of the instrument is always level. The speed of the vessel can be determined with sufficient accuracy for the operation of the instrument from the revolutions of the engines.

The utility of this instrument from a navigation point of view is apparent, since the officer in charge can ascertain at any moment when the vessel is approaching shallow water, without having recourse to sounding or other means of determining his position. Especially useful would it prove in foggy weather, or when progressing along an unknown coast. In rough weather, owing to the pitching of the vessel, the instrument is naturally, from the nature of its design, not available; but on the other hand, owing to the fact that in foggy weather the water is generally calm, its utility is readily recognizable.