coarse coals. Many of the workable coal seams inclose layers or bands of such shale, and also sometimes pyritous bands which tend to deteriorate the coal. Taking the average of all the sections measured, the total number of seams in the productive measures is twenty-four, of which six are 3 feet or upward in thickness, and the total average thickness of coal may be stated at 46 feet. The similarity and persistency of the seams over great areas is very remarkable, although local variations are frequent. There is, therefore, no great uncertainty in regard to the equivalency of the various seams at different points. In establishing this there have to be taken into account the quality of the coal, the position and character of the various partings or bands of shaly matter, the mineral and fossil characteristics and the thickness of the strata between the seams, as well as the manner in which the folds and undulations have affected the general structure. In a few instances the coal seams are split by the gradual thickening of their argillaceous partings. Sometimes seams which are of workable thickness and good quality at one place become unavailable at no great distance. In the Blockhouse seam at Cow Bay and the Victoria seam at Sydney Harbor curious wedge-shaped masses of rock, similar to that overlying the coal, interrupt the continuity of the coal. The cleat or cleavage of the coal coincides with the joints of the accompanying sandstones, and is most prominent where the strata have been subjected to the greatest pressure. The coal seams are for the most part overlaid by a stratum of argillaceous shale, very frequently characterized by the occurrence of erect stems of sigallaria, often from 2 to 3 feet in diameter, and in one case nearly 5 feet, the spreading roots of the trees resting upon the upper surface of the coal. Instead of the usual roof shales, the coal is often followed by sandstone, and a bed of sandstone is almost invariably found to overlie the roof shales at no great distance above the coal.

Subordinate Basins in the Coalfield.—Along the sea coast the three anticlinal and four synclinal folds are well exposed, but the upward slope of the strata from the sea causes the coal measures in the latter to rapidly run out inland, leaving large portions of the coal seams to be worked beneath the sea, as at the Sydney and Victoria mines.

The Cow Bay Basin.—The seams of this basin have been exposed both by natural and artificial means on both sides of Cow Bay. The average breadth of the basin at the shore, between the outcrops of the lowest seam, does not exceed two miles and one third, and it diminishes gradually inland until it terminates at a point about six miles from the shore, as proved by several crop pits and boreholes on the various seams. On the South Head some of the lower seams crop out and are cut off by the ocean, thus constituting the eastern extremity of the coalfield as exposed on land. In all the sections at Cow Bay calcareous matter is very sparingly distributed—a remarkable exception to the general rule in this coalfield. On the South Head the coal seams are much more split up by clay and shale bands. The rocks underlying the Long Beach seam belong to the millstone grit. In the center of the basin are the Blockhouse and Gowrie mines, on the south side the South Head colliery.

The Glace Bay Basin.—The axis separating this from the Cow Bay basin skirts the northern shore of Cow Bay at Cape Percy or North Head, the opposite dips being visible in the precipitous cliffs. In striking contrast to the Cow Bay basin, that of Glace Bay is wide and has uniformly gentle dips on both sides; and includes 610 feet of strata overlying the highest beds of that basin, among which occurs the Hub seam, the highest workable coal seam in this district. The attitude of all the seams in the Glace Bay basin, extending for a length of about twelve miles, is a striking proof of the general regularity of deposit and absence of faults which characterize this district; but the section shows considerable thinning of the beds between the several coal seams as they are traced westward. The most important cannel coal found in this field lies 25 feet beneath the Hub seam, is 1 foot 2 inches thick, underlined by 9 inches of ordinary bituminous coal and by 1 foot 9 inches of coal, clay and carbonaceous shale in eleven bands; attempts have been made to work it, as it contains 30·07 per cent. of volatile combustible matter, 44·42 fixed carbon and 24·68 ash. In the Phelan seam, at a distance of half a mile from the shore, in the main level of the old Bridgeport mine, a shale parting has increased to 28 feet. The Ross seam at and near the Bridgeport shore is only 1 foot 8 inches in thickness, while at the Emery mine, not quite two miles and a half to the eastward, it averages 5 feet 3 inches. Situated in the Glace Bay basin are the Schooner Pond, Ontario, Caledonia, Glace Bay, Emery, Reserve, Lorway, Gardener, International and Bridgeport mines.

The Sydney Harbor Basin.—The next basin includes the Lingan, Barasois, Low Point and Sydney mines districts, extends from Indian Bay and Bridgeport Basin to Point Aconi, and embraces all the coal seams in the field. An anticlinal axis which skirts the north shore of Bridgeport Basin and runs thence westerly, parallel with the North Head anticlinal, to a point midway between McPhee and McKay Brooks on Sydney Harbor, divides this basin from that of Glace Bay. On the north side of this axis the rocks dip at angles varying from 12 degrees to 16 degrees at Lingan to 40 degrees at Victoria Mines. From Lingan to Low Point lighthouse the strike is nearly parallel to the shore, and brings the entire volume of the coal measures upon the cliffs in several fine sections which show 349 feet overlying the highest strata of the Glace Bay section; and the exposures on Sydney Harbor are equally fine. The Lingan, Victoria, Sydney and Collins mines lie in this basin.

The Bras d'Or Basin.—West of the Little Bras d'Or, a low broad anticlinal running from Point Aconi to Saunders Cove deflects the strata to the south to form this basin, which includes the Boularderie and Cape Dauphin districts. On the northwest side of Boularderie Island the coal measures are exposed in an unbroken section, extending, in the direction of the dip, over a distance of about six miles, from Point Aconi to the millstone grit, which here include two coal seams not workable. In the Boularderie district the coal has been very little developed. In the Cape Dauphin district only the lower part of the productive measures, probably as high as the horizon of the Sydney Mines main seam, is developed; the principal seam worked at the New Campbellton mine is the continuation of tho Blackrock or Number Three seam of the Sydney Mines section, and that underlying, cut in a vertical attitude in the tunnel near the mountain, is the equivalent of the Collins seam of the Little Bras d'Or. The Blackrock and New Campbellton collieries are situated within this district.

[FROM THE INDEPENDENT.]

KILAUEA VOLCANO SEEN ANEW.

By the Rev. SERENO E. BISHOP.

I HAVE just got home from a fresh visit to Kilauea, having there taken in a new aspect of its surging lake of fire. It impressed a vivid and terrible vision on the retina, of which I would tell.

Several of us had driven that day southwest from Hilo town and harbor, thirty-one miles. We had been seated over six hours in the comfortable four-horse stage. The road was superb, smooth, hard, of easy grade. More than half the way had been through magnificent forest, filled underneath with the splendid feathery fronds of the tree ferns. We had almost imperceptibly risen to an altitude of four thousand feet. The sharp summits of Mauna Kea rose boldly on our right, the grand dome of Mauna Loa confronted us—each fourteen thousand feet in height. Our last mile was on level ground, ending at the brow of a somewhat rapid descent into the district of Kau. There stood the rather pretty and very commodious Volcano House, on which we came quite suddenly.

Only as we drove up to the door was suddenly disclosed at our feet the immense caldera of Kilauea, its black floor stretching far away to the southwest. The abyss yawned deep below us. All around was rich vegetation and rank ferns. Then a precipice fell sheer six hundred feet. At the bottom was a black desert of recent lava overflows covering an area of six square miles. Two miles away rose unceasingly a dense column of white vapor, marking the site of the fire lake. There for thirty years past the outflows have been pouring out, and spreading over the caldera, until they have heaped up a very flat kind of cone, which is little more than one hundred feet below the level of the hotel. When I saw it forty years ago the depth of the caldera was uniform throughout, a level plain. Now the further end is swollen high above the rest.

Mine host, Peter Lee, a genial Norseman, helped us alight. "Mr. Lee, I must return in the morning; can you send me down the crater at once?"

"Yes; a party are just going down; you will have a cup of tea first; then I will have a good mule ready for you."

We started at five P. M., three ladies on "stride" saddles, four men mounted, besides one on foot, and the guide carrying lanterns for the return trip. We made fast time down the well-graded descent of six hundred feet, where we struck the black floor of knotted and humpy rolls of lava. An easy trail had been built over this since my visit two years before. We trotted rapidly on, crossing a rustic bridge over a chasm, and ascending the great lava flows of 1891. After one and a half miles of this, we left our animals in a little stone corral, and kept on afoot another half mile over the new lava of last May and June, rising about two hundred feet in that distance. The lofty brown walls of the caldera of Kilauea stretched far away around us on either side. The knurled and knobby rock under our feet grew warm. Steam rose from crevices at every step.

Suddenly, without premonition, we stood upon the rim of a horrific abyss, in whose depth lay the terrible fires of Halemaumau. From the lips of each newcomer broke the same irrepressible Oh-h! How many times I have heard that. It is a cry of wonder and horror. Deep below, vast, mighty, fearsome, lay the great burning lake. A dull red crust veiled the glow of its ten acres of surface. Bursting through this crust were playing here and there huge fountains of molten magma, the roar of whose surging came up to us. Stretching in every direction across its eight hundred feet of breadth glowed brilliant lines of crevice, creeping slowly from side to side, zigzag and crinkled, greatly resembling the lines of chain lightning, only not transient like them, though constantly but slowly changing.

The fire fountains call for careful description. Of these there are three classes. In the present fire lake, which dates from since the collapse of March, 1891, is a single large fountain of the first class, situated east of the center of the lake. It has a pulsating action, coming up two or three times a minute. It swells up in a huge blob or bubble, breaking and dropping with a heavy, crashing thud, driving a billow of fire in every direction. To the untrained eye it resembles in size a large haycock. Instrumental measurement shows it to vary from forty to fifty feet in diameter, and about thirty in height. By its persistent uniformity of action, this fountain has earned the name of "Old Faithful."

South of this, midway to the edge of the lake, is a group of active fountains, which commonly unite in one. This is of the second class. When in full action, an area of sixty by twenty feet forms a massive surge of tossing spray twenty feet high. This tossing up of the fire lasts several minutes, followed by longer intervals of quiet. A similar but much larger fountain is located west of "Old Faithful," again midway to the edge of the lake. This covers a space of one hundred and twenty by thirty feet, forming a constant mass of tossing spray thirty feet high. Spurts of fire are flung up one hundred feet. This spraying is accompanied with violent roaring. Like its sister fountain, it is very intermittent and irregular in action, though lasting often fifteen or twenty minutes.

A third form of fire fountain, and often terribly violent, appears at various points on the edge of the lake. These are points toward which a current sets on the surface. The current carries with it the crust. This is spongy, composed of numberless glassy vesicles filled with air or steam. As the crust approaches the edge, down into which the current plunges, great slabs of crust tilt up and dive below to their fiery doom. Ingulfed for a moment, the vapor contained in their vesicles is at once intensely heated and expanded. A violent explosion follows. A great body of the fluid fire blows high into the air, often with huge pieces of the dark crust. Down again is sucked molten fire and crust, and out again is vomited the dose. So the play goes on, and the lava spray flings high aloft.

I was strongly impressed by the strange persistence of the three fountains first named. They seem precisely identical in their style of activity and in their position in the lake with what they were in April, 1892. This persistence seems strange, when we consider the great changes which the lake has undergone since that date. It rose four hundred feet, and then subsided over six hundred. Meantime it filled up and built out a mass of solidified lava containing more than fifty million cubic yards of rock. Now it has settled much below what it was in 1892, carrying down with it several million cubic yards of rock which have melted up in its depths after floating for a while as islands; yet we find the same three fountains playing as they did before. The interior mechanism which maintains such uniformity of action is difficult to conjecture.

Another wonderful persistence is shown in the way in which the lake has maintained the same outline or contour during the changes of level described. The many photographs made, as well as my own pencil sketches in 1892, have made this outline familiar. It approximates a circle, but is somewhat lenticular, with certain large indentations. I was surprised to observe that the outline of the lake continued to be substantially the same. It had much the same outline when it stood for months of last spring brimming over the top of its built up cone, and flooding the upper floor of Kilauea. The lake, in growing upward, evidently built up its shaft or well so that it preserved the same section throughout.

A short history of the lake is in place here. The inner crater of the volcano, known as Halemaumau, occupies a nearly circular area of about half a mile in diameter. Within this area the lava rises and falls, frequently overflowing and building up the main floor outside. In March, 1886, after some years of overflowing, Halemaumau collapsed. The lava broke through the shaft below and forced its way under the slopes of land southwest. The built up sides of the crater fell in, leaving a dark, gaping pit, half a mile in diameter and of great depth, the bottom filled with smoking rock ruin. Very slowly the fire arose again in the pit. An underground lake floated up on its bosom an enormous mound of the old debris. Around the sides of this mound appeared several small open lakes. The largest and most accessible of these, one and a half acres in area, was christened Dana Lake, on the occasion of the eminent geologist's visit in 1887. The lava and the great mound continued to rise, until by 1889, the rim was surmounted, and again for two years vast overflows built up the upper floor, raising the rim of Halemaumau about fifty feet. From this rim the floor of Kilauea stretches away on all sides at an easy grade.

Exactly five years to a day after the collapse of 1886, in March, 1891, a second collapse took place. The whole lofty mound suddenly fell into the depths; the same deep, half-mile-wide pit yawned as before. A considerable earthquake accompanied this collapse. It was a peculiar fact that this was simultaneous with a hurricane of extraordinary violence in Kusaie, three thousand miles west, which was attended by great barometric perturbations here. Such changes of atmospheric pressure upon the earth's surface evidently tend to excite displacements in its crust, causing seismic tremors.

This time the lava promptly returned in great force, rising steadily. When I saw it in April, 1892, it occupied the center of a black floor which it had made for itself, in the bottom of Halemaumau. The great pit was three times the diameter of the eight hundred foot lake. The perpendicular walls were three hundred and twenty feet down to the level of the lake. The same fountains were playing as described above. All that year and the next the lake intermittently rose higher and higher. After a time the frequent small overflows, as it brimmed over, formed a narrow dam some thirty feet high around its whole periphery, while the new floor around it sloped away toward the sides of the pit. In this condition, its form closely resembled the surface of an inverted saucer. Visitors would descend the pit and clamber up the low dam, and thrust poles into the molten lava. Seldom an hour passed, but somewhere it would brim over the dam, often in a great torrent, a piece of luck to the fortunate spectators, if they were not compelled to an unpleasant activity in escaping the hot gush.

By the beginning of the present year this inner cone, with its brimming lake atop, had surmounted the upper rim of the pit, and soon buried it in its overflows. The heavy winter rains no doubt increased the activity of eruption, as the waters percolated deep down and leaked into the shaft of fire. There was enormous overflow. The lake built itself higher and higher on its inverted saucer top, until it lacked only seventy feet of the level of the hotel floor. Floods of bright metal were constantly pouring over on one side and another. Even then the visiting went on, and tourists would clamber up and toast their faces peering over the edge.

Early in July a third but only partial collapse occurred. Some part of the bottom dropped out. Down, down sank the lake. The sides of new rock, left unsupported by the heavy liquid, began to fall in, with heavy shocks and great clouds of dust. Everybody rushed down from his breakfast, among them Minister Thurston and General Armstrong's brother Nevius. What they saw baffled description, as pile after pile of rock broke down into the lake, driving its surges far aloft. The level of the fluid sank to a great depth. The infall of the sides did not, however, involve the great area of the original pit which had been filled. There is now a pit larger than the lake, but only fourteen hundred feet wide, or a little more than half the diameter of the former pit.

This smaller present breadth makes the great depth of the pit far more impressive and terrible than ever before. After making careful comparisons of the height of the walls with the known breadth of the lake, I arrived at the conclusion that it was nearly or quite six hundred feet down. This is much more than others have called it. It is a most hideous and terrible well of fire. I have never seen any sight so grand, so dreadful. One seemed to be looking down into the fiery depths of the heart of the globe and searching out the terrible secrets of its molten interior. There was something of the colliding and clash of the gigantic inner forces which gravity has imprisoned within this thin smiling earth crust on which we so securely and unthinkingly disport. There those forces are slightly unsealed to our quailing vision.

Before an hour had passed the darkness began to close down, and the brilliance of the fires to blaze forth. Heavy clouds of vapor often obscured the sight. It was seldom that the whole lake could be seen at once. The vapor was innocuous—pure steam, with a faint whiff of sulphurous acid. High up around the cliffs shone out incandescent points of light, recesses where still molten lava lingered, preserved from cooling in the spongy, non-conducting rock. Every few minutes fragments of rock would scale off the cliffs and dash down toward the lake. A considerable mass plunged in on the opposite side. An enormous surge arose, splashing high upon the talus of the cliff and saturating the loose pile of rocks with fire. Out from their interstices for some minutes continued the living fire to pour, in streaming cascades, over a breadth of sixty feet in width and height.

These night views of the lake and its fountains have an immense fascination. The brilliance is intense. The play of fountains and crevice gleam is constantly varying. Fire is alive in giant might and activity. It is in colossal play, foaming, flinging, tossing, surging. It is always hard to tear away from the spectacle. Two of us who had often seen it, and a mother who yearned to be back to her babe, tore ourselves away early, and, trudging and riding by lantern light, reached our inn at nine o'clock. The others came in after ten; telling how, after we left, the whole surface had broken up into a glorious, tossing sea of fire.

It is the regular thing for the evening parties from the crater to get a hearty ten or eleven o'clock supper. Sometimes, when very tired, we first take a hot steam sulphur bath. The nights are chill at that latitude, and when the house is full, as it was that night, the three parlor fireplaces are burning merrily, as indeed they do much of the cool day hours. During this summer, a large number of island residents have tarried at this delicious upland retreat. Foreign tourists are more numerous in the winter. Now that the splendid road from Hilo is complete and the journey up is converted into a delight, both residents and foreigners will be attracted in greatly increased numbers.

Our good government has been getting on securely and comfortably these few weeks without the protection of any United States warship. The Charleston is now calling here for coal, en route to China. Three German ships have come in on a like errand. The fallen queen is still pretending to the ignorant natives that Mr. Cleveland is going to restore her, and that all of them who take the oath for the republic will be hanged when she returns to power. This farce cannot last much longer. It may avail to deter a majority of the natives from registering in time to vote at the election near at hand.

IMPROVED HYDRAULIC CAPSTANS.

By ARTHUR RIGG.

HYDRAULIC capstans as hitherto constructed are wasteful in their use of pressure water, actually taking more when running unloaded than when performing their full work. It is mainly from this cause that there has been comparatively little extension in the use of hydraulic engines, and as the governing arrangement now to be described proportions the quantity used according to the demand for power, there is now no further reason why the application of these useful and convenient motors should not become greatly extended.

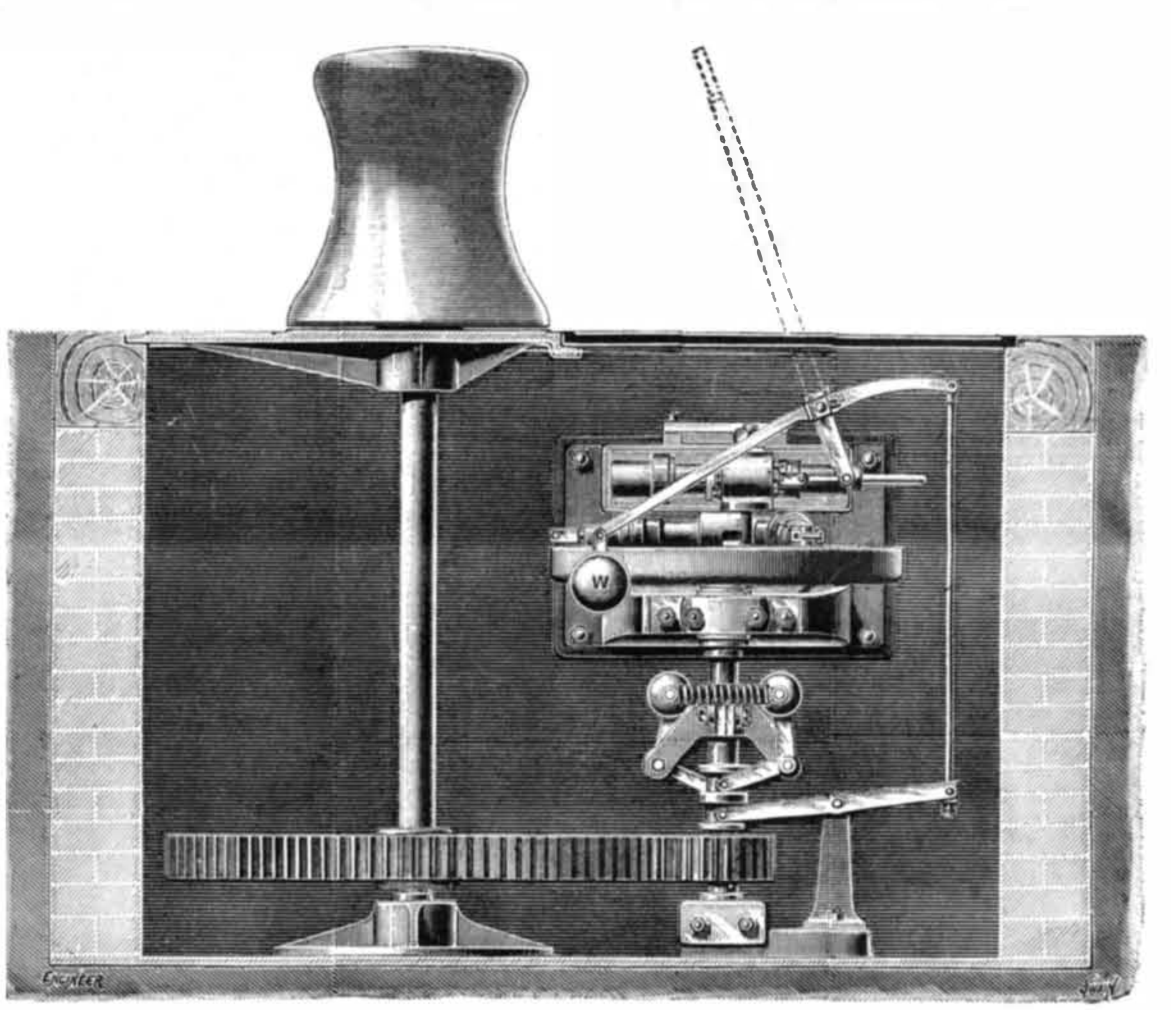
The hydraulic power supply companies practically restrict their sphere of operations to working lifts and cranes, as their pressure water is so much more costly than gas or steam power, and few opportunities occur where this convenient but costly power can be used for anything else. It does not seem to have occurred to these companies that it might pay much better to supply a cheaper power for a more extended class of customers than to keep up the out of date system of high prices and restricted output. As if to handicap still further the use of such hydraulic engines as have been hitherto put up, they use the same quantity of water when running at the same speed whether there be a full load or none, thus comparing in extravagance with a steam engine provided with a throttle valve, and using steam throughout its stroke. Any arrangement, therefore, by which the stroke can be altered in proportion to variations in load improves the economical working of hydraulic engines much as the working of steam engines was improved when an earlier cut-off gave the advantages derivable from expansion. What with the original high cost of water pressure and its wasteful application, it is not surprising that hydraulic engines have not, up to the present time, become generally used for obtaining power, although their extreme convenience as compared with gas engines or steam engines is allowed on all hands. Before a governor can be applied, it is necessary to arrange for a variable stroke, which cannot well be managed with an ordinary crank. A reduction of speed seems the simplest method for regulating power, but as a uniform speed is so generally required, very few cases occur where this plan can be followed. For cranes or hoists regulation may be carried out by providing two or more rams and a system of valves, whereby one or more rams can be put into action, thus giving relatively proportionate powers. Such systems, however, are inapplicable to engines turning shafts, or at least they would be so inordinately costly and complicated as to preclude their general use, and an alteration in stroke remains the sole convenient and practical method whereby hydraulic engines can be satisfactorily regulated, and the speed maintained at a uniform rate.

In spite, however, of such drawbacks accompanying the use of hydraulic engines, great numbers are used at railway stations, docks, and other places, for driving capstans, and the surpassing convenience of such an unfailing power, so easily distributed, is found to compensate for the waste attendant upon its use. In order to mitigate, in some degree, the losses which occur when such capstan engines are running unloaded, it is usual to design their ports and passages extremely small, so that friction through them shall prevent too rapid a current, and also shall limit the speed at which the capstan can run when unloaded. Then the reciprocation of their rams frequently reverses the current of water, and this operation entails a series of destructive shocks upon the engine. Nevertheless, the combined effect of insufficient passages and the reversal of currents at a tremendous pressure imposes a limit—of utterly unscientific and wasteful character, it is true—upon the speed at which such capstans can be driven.

Capstan engines are made with two rams, having cranks at right angles, or with three cylinders, acting on the same shaft and cranks at 120°, so that they will start when water is turned on, and their dimensions are such as to provide an ample reserve to start a load beyond the nominal power at which they are intended to work. If we take the case of a capstan engine driven by three single acting engines set radially around the same crank and at 120° to each other, it is well known that the crank receives a tolerably uniform tangential effort, and a fairly regular movement ensues. But because of the crank turning round it is highly inconvenient to alter its radius, for this has already been attempted with results by no means successful from a practical point of view. If, now, we regard the same three cylinder engine as having its crank centers fixed, so that when pressure is turned on the pistons will drive the capstan by revolving round the main shaft center while the cylinders revolve around the crank center, we get exactly the same results as to power by the ordinary system, with more than one very distinct advantage. As the crank has now become stationary, it is easy to move its center nearer or further from that of the main shaft, and all difficulty as to its regulation is at an end. If the crank centers be 3 in. apart, then the stroke becomes 6 in.; but if these centers be closed together until only 1 in. apart, then the stroke becomes 2 in., and there is the further utility in being able to alter the stroke, that its full available power may be brought into operation.

In hauling vessels, a curious effect is shown by the capstan running at a high speed at about one-third stroke while drawing in the slack rope; then it acts with full energy until the load begins to move, and afterward keeps changing between its shortest and longest stroke, as the cable tightens or slackens. Thus the governor keeps up a constant watch, and always regulates the stroke according to the load, however that may alter. As the capstan runs unloaded at one-third stroke, it may fairly be assumed that the average quantity of water used will, at most, be under one-half of that which would have been used had the hydraulic engine been unprovided with any governing arrangements. As three tons, moved at the rate of 60 feet per minute, requires at least 20 horse power exerted by the main hydraulic pumping engines, it is obvious that any contrivance by which this demand can be reduced to one-half represents a somewhat important economy, and one that justifies any additional cost of a secondary engine, with its valves and governor, to gain. It means a saving of one-half the existing engine power, or doubling the number of capstans that might be employed on a railway or docks driven by the same power; and as it is well known current expenses very soon represent an enormous interest upon capital, such a saving at so moderate an expense is a thing that, in the present days of keen competition, no company can afford to neglect.

It is sometimes useful to have the power of reversing a large capstan, particularly when new cables are being used. These sometimes acquire a kink which cannot be quickly released, and it may become necessary to cut and sacrifice a new cable to let a vessel go free. By reversing the capstan, however, a cable can be released, and the handle—shown dotted—is intended for this purpose. The governor acts only for the usual



RIGG'S IMPROVED HYDRAULIC CAPSTAN.

by transferring the crank center to that opposite the main shaft the engine reverses.

Having secured this mechanical convenience, it is no longer necessary to contract the area of water passages, for these can be made as large as desired, and the arrangements for governing, by altering the stroke, are all that remain to be carried out. There is now no appreciable loss by friction, and the full pressure may be admitted under the rams, and the speed can be maintained constant, while the power can be regulated in a thoroughly scientific manner by causing the stroke to vary as the governor balls move in or out. As a considerable pressure is required to move the center carrying the cylinders, it is necessary to provide a supplementary engine, as a "relay," to perform this duty, leaving the governor to move its valves and so determine how long the stroke shall be with any current load, and the engine running at any predetermined speed. The method by which this operation is carried out is shown by the accompanying illustration.

This figure shows a three-ton capstan driven by a revolving engine, with the general arrangements of its governor—an apparatus of any ordinary kind. When the intended speed has been reached, the governor balls extend themselves, and through the intervention of levers and connecting rods, the valves of the subsidiary engine are actuated, so as to shorten the stroke of the main engine until it runs at any speed for which the governor has been arranged. The same speed is kept up while winding slack rope, and as this can now be made much faster than usually permitted with other capstans, a very adequate control is maintained and the capstan quickly gets hold of its load. As the rope tightens speed reduces, and the governor balls close together, permitting the weight, W, to descend and act upon the valves of the subsidiary engine in such a manner that the main engine has its stroke increased, and the hauling power of the capstan shows a corresponding augmentation, even until

direction of hauling, but does not act when reversing is adopted for a few moments in order to release a cable. As there are no reversals in the direction of currents when driving one of these engines, it follows that there are no severe shocks in running, and this fruitful cause for the destruction of packings, if not for the breakdown of engines, is absent in those of the revolving type. If the water should not be flowing into one cylinder, it will be flowing into another, and that which is in any one cylinder when the inlet closes revolves with it at considerable velocity, and in no case is brought to rest, as in any other type of engines with reciprocating pistons. It is this evil caused by stopping and starting a column of water which so quickly injures the packings of these engines where such shocks occur. In the revolving type either cup leathers or ordinary packing glands can be used, and both are found extremely durable. The cylinder bosses and valve faces are somewhat peculiar in their construction. Their external packings are made of hydraulic leather, and there is a piston within the boss of that cylinder which is furthest from the valve face for the purpose pressing all the bosses together, and for resisting any pressure against the face of No. 1 cylinder that would tend to force it away from the valve face. By the operation of such a balance piston, all the cylinder faces are retained in proper, easy contact, and waste is prevented.

These engines have been running for many years, and although the relay engine, with its valves and governor, may seem somewhat complicated to those who see it for the first time, these additions are by no means so intricate as the Corliss or any other gear used for a like object—the economizing of power in the use of steam; as the cost of water power from an accumulator is necessarily greater than that of the steam power by which its pressure is obtained, it follows that the economical use of water is of correspondingly greater consequence than the economical use of steam.—The Engineer.