placed by five locks; at Little Falls the four present locks are replaced by three enlarged locks; at Newark, the three locks of the present canal are replaced by one lock, and at Lockport the present five locks are replaced by three double locks. These and other changes in the number and type of locks reduce the total number on the entire canal, from the Hudson River to Buffalo, from 71 to 44 locks, making a decided reduction in the time necessary for passage of boats between those points, and effecting, of course, a material difference in the cost of maintenance and operation.

As we have already explained, the canal between Troy and Rexford Flats will lie almost continuously in the bed of the Hudson and Mohawk rivers, the change of elevation from one river to the other being secured by diverting the canal to the shore at suitable locations and building the locks in the rising ground. While the river presents more than sufficient width for canal purposes, it will have to be dredged to give the necessary depth. The section of the canal where it lies in the beds of the rivers will be 200 feet wide on the bottom, and must present at all stages at least 12 feet of water. The section on the Erie Canal itself will be that which was proposed in what is commonly known as the Nine Million improvement of 1895-6, and is shown in the accompanying drawings. In general this section is 50 feet wide on the bottom, with side embankments of 1¼ to 1, and a depth of 9 feet, except over aqueducts and permanent structures, where 8 feet of depth is provided for. The proposed improvement includes the cost of additional water supply for the summit level between Utica and Syracuse, which is secured by building reservoirs on various streams that lie to the south of the present Erie Canal.

From an engineering point of view, the most interesting part of the proposed reconstruction is the splendid flight of locks which is to be built at Cohoes to enable the canalboats to surmount the obstacle presented by the Cohoes Falls. The appearance of the locks is shown very clearly in the accompanying perspective view. The total difference of level between the Hudson and Mohawk rivers of 121 feet is overcome by three lifts of about 40 feet each, instead of the sixteen lifts which are necessary in the present canal on the westerly side of the river. The locks, which are built of concrete and masonry, are 328 feet long between the hollow quoins and 28 feet wide in the clear. The operation of locking is so well understood that it needs no detailed description here; but we may briefly state that the water is led from lock to lock by gravity through culverts which are built in the solid masonry, one on each side of each lock and parallel to its axis. These culverts are of the arched type, 5 feet in width and 7 feet in height. The water is led from the culverts into the chamber by means of two cast-iron pipes on each side. These pipes are 2 feet in diameter and 8 feet in length. The water supply to the culverts is controlled by butterfly valves at each end of the culvert.

The passage of a barge through the locks is as follows: After the barge has entered the first lock, the pair of miter gates behind it is closed, and the culvert valves are opened, allowing the water to flow from the first to the second chamber until it is at the same level in both. The miter gates separating the two chambers are then swung open, the barge passes through, the gate is closed behind it, and the second set of culvert valves is opened, repeating the process between the second and third chambers. These operations are repeated until the barge has passed through the whole series. The gates are of the type which has been used very successfully in the Canadian canals. They are 47.8 feet high, and with a full lock there will be a total pressure against each leaf of the gates of 607 tons. The gates are built of solid beams of timber, thoroughly well bolted together. Each beam is keyed to the next succeeding one, and iron rods extend through the whole from top to the bottom.

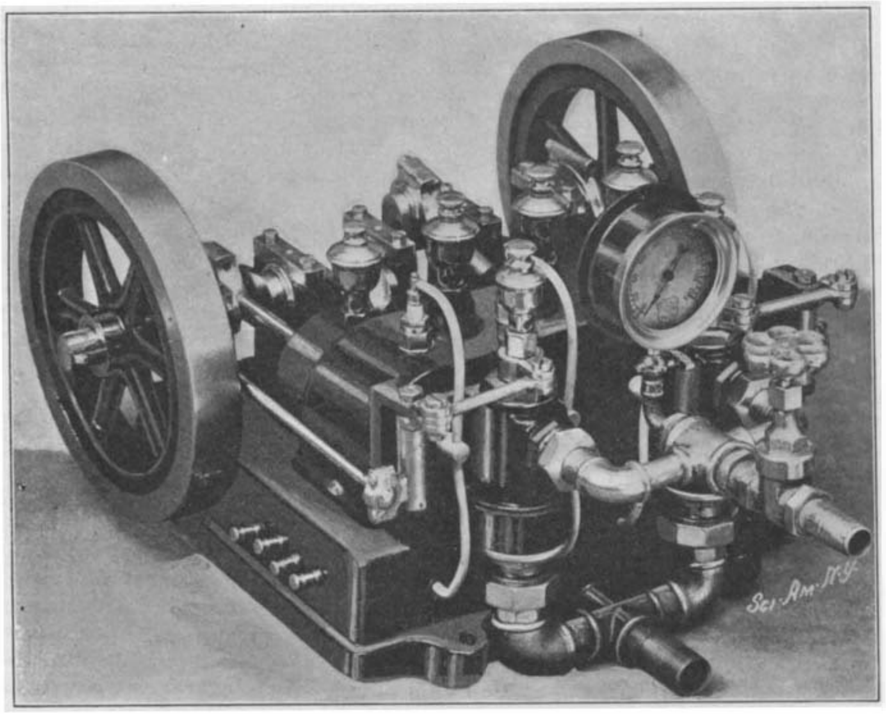
The enlarging of the canal to a depth of 9 feet and the lengthening of the locks will make it possible to greatly increase the size of the canalboats, or barges, as they will then be called. Instead of the present boats, capable of carrying only 240 tons of merchandise or 8,000 bushels of wheat, the canals will accommodate boats with a capacity of 800 tons or 30,000 bushels of wheat. Moreover, the time of transit from Buffalo to New York will be reduced from 430 to 400 hours, a saving of a day and a quarter, while it is estimated that the capacity of the canal will be increased from 3 1-3 tons an hour to 9 tons, about trebling the capacity.

A SELF-STARTING GASOLINE MOTOR OF NOVEL DESIGN.

The four-cylinder motor shown in the annexed illustration is the invention of Mr. G. Keller, of New York city. The motor is constructed somewhat similarly to a steam engine, and the adaptation of the principles of the latter to a gasoline explosive motor is the most interesting feature about it.

The gas from the carbureter enters through the main inlet pipe, on which is seen the throttle valve, and passes into each of the two valve chambers through simple, suction-lifted inlet valves, such as are found in any gasoline motor. It is then directed to one cylinder or the other by oscillating piston valves, the ports of which correspond with ports leading to the cylinders. These latter ports are also connected by the oscillating valves to the exhaust pipes seen at the bottom, when the pistons are on their upstrokes.

The oscillating piston valves that make this connection are operated by eccentrics on the motor shaft. One of these can be seen beside the right-hand flywheel, while the connecting rod of the other, with universal joint, is in plain view in the foreground. The sparking plugs are connected to two Splitdorf spark coils with vibrators, and the battery connections are seen on the base.



THE KELLER SELF-STARTING GASOLINE MOTOR.

The principle of operation of the motor is as follows: As the piston starts to descend, it begins to draw in a charge of explosive mixture. Electric sparks jumping across the gap at the spark-plug points continuously, immediately explode this gas, which drives the piston down. On the upstroke the burnt gas is exhausted, after which a fresh charge is drawn in and exploded as the piston starts to descend a second time. Thus it will be seen that we have practically a two-cycle motor that does not compress its charge. As the cylinders are four in number, 4 inches bore by 6 inches stroke, and as an impulse is obtained every one-quarter of a revolution, the motor will develop between 3 and 4 horse power at medium speeds, and will have a nearly constant torque. By compressing the gas in a small compressor (which can be located in the base of the motor) and introducing it under pressure to the cylinder, the same power can be obtained as from four ordinary two-cycle cylinders of the same size. The motor is light for its power, weighing complete about 150 pounds.

The motor, after it has been running a minute or two, can be stopped and started as often as desired, simply by switching off or on the electric current to the igniters. This was satisfactorily demonstrated to our representative by the inventor, who also ran two cylinders of the motor on gasoline and the other two on illuminating gas at the same time.

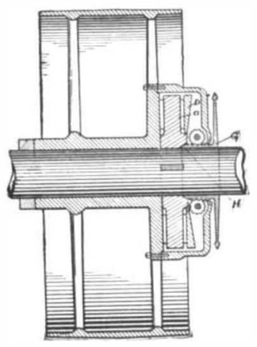
The motor can, furthermore, be run by steam or compressed air, and when so run is very powerful. A steam carriage equipped with a motor of this type would have an advantage over the ordinary vehicle of that character, in that, if the boiler should burn out, the operator could still proceed by connecting the inlet pipe of the engine to a suitable carbureter, and switching on the electricity to the spark coils and plugs.

The inventor has been four years in bringing the machine to its present state of perfection, and now makes it public for purposes of exploitation.

A GAS-ENGINE FRICTION CLUTCH.

There never has been a friction clutch absolutely faultless. The chief defects have been excessive cost of construction and inefficiency. The inventor of the friction clutch which forms the subject of the accompanying engraving has endeavored to provide a device which is intended not only to overcome the difficulties hitherto experienced, but which is also certain, easily handled, clean, self-contained, cheap, automatic, and self-adjusting. Arduous tests extending over some two years have demonstrated the efficiency of the clutch.

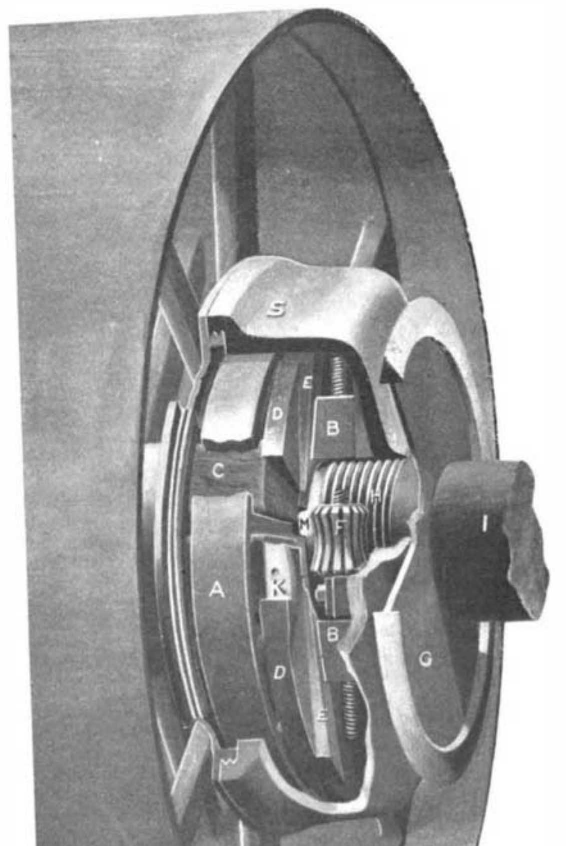
The gas-engine clutch, as its name implies, is peculiarly adapted for gas engines and clutch pulleys. In construction it comprises three principal parts—a crated disk or driver, *A*, containing the friction blocks; a pulley with a friction face-plate cast on the arms, to which the shell, *S* (Fig. 1), is secured by studs; and a starting plate or wheel, *G*.



PARTIAL SECTION.

The disk or driver, *A*, is keyed to the driving shaft. The shell, *S*, contains the worm gears, *F*, right and left hand screws, and wedge blocks, *B*, which work on the inclined planes of the friction plate, *D*. This plate is held tightly in place against the wedge blocks, *B*, by means of two coiled springs (not shown), and is carried around by lugs in the inside of the shell, which lugs fit into notches, *K*, on the edge of the plate. To the starting plate or wheel, *G*, a worm sleeve, *H*, is attached, having a bevel end, which end is in contact with the beveled opening of the crated disk, as shown in the diagram.

The starting and stopping mechanism comprises a lever (not shown), on one end of which is a small brake-shoe, formed with a V-shaped groove, fitted to the edge of the starting plate or wheel, *G*. On the outer end of the lever a sliding weight is carried. By moving the weight inwardly toward the clutch, the brake-shoe is caused to drop away from and to release the starting plate, so that the plate and worm sleeve will revolve with the shaft. The worm now turns the gears, and the resistance of the gears draws the conical end of the worm sleeve, *H*, into contact with the beveled opening of the crated disk, *A*, keyed on the shaft. This contact is sufficiently strong to turn the gears, *F*, and the right and left hand screws, thereby pushing the wedge blocks, *B B*, up inclined



THE PHILLIPS GAS-ENGINE CLUTCH.

planes, *E E*, gradually forcing the friction plate, *D*, into contact with the wooden blocks, *C*, until the load is driven. The heavier the load the greater is the resistance of the gears; hence the conical end of the worm is forced into firmer contact with the beveled opening in the crated disk, so that all the power needed to work the clutch is supplied.

As soon as the speed of the wheel is brought up to the driving member (which is the crated disk containing the friction block) the winding action of the worm sleeve ceases. Should the clutch slip, however, this winding action is automatically resumed.

No manipulation is required to start the clutch. As soon as the sliding weight is moved in, the brake drops away from the starting plate. Thereby the worm is released, which then runs with the shaft and begins to wind up the frictions. In order to stop the clutch, the sliding weight is moved outward on the lever; a slight additional pressure stops the starting plate and worm. The gears thereupon begin to turn around the stationary worm, reversing the direction of the screws and drawing back the wedge blocks, thereby releasing the friction blocks and stopping the clutch. The driving power of the device is claimed to be limited only by the strength of the material. The patents on the clutch have been acquired by Mr. Thomas Henry Smith, Jamestown, N. Y.

THE MANUFACTURE OF STEEL RAILS.

In the vast field of industry included in the operations of the United States Steel Corporation, there is none of greater importance than the manufacture of steel rails. For not only does rail-making call for the services of a great industrial army, but the steel rail has contributed more than any other cause to the rapid weaving of that marvelous network of railways which now covers every State of the Union. Its high quality and skillful design have rendered possible the great increase in power, weight and capacity of American engines and rolling stock, and a low cost of operation which is the wonder and despair of European railroad systems.

The celebrated Edgar Thomson Works, which are devoted exclusively to the manufacture of steel rails, are situated on the Monongahela River, a few miles from the city of Pittsburg. Here some 4,000 men are employed night and day in turning out steel rails at the rate of 5,000 to 6,000 every twenty-four hours, the rails varying in weight from 25 to 100 pounds per yard and in length from 30 to 60 feet, the average rail being 30 feet in length and weighing about 75 pounds to the yard. The 60-foot rail is something of a novelty, although it has been rolled in this length for several years. It is open to the objection that in northern States, where the range of temperature is large, the spacing of the rail-ends at the joints has to be so wide that it is difficult to preserve an even and noiseless rail-joint; hence, the call for 60-foot rails comes chiefly from southern States, where the range of temperature is small.

The first point of interest in these works is the stock-yards, which are laid out parallel with the long line of blast furnaces. Here are to be seen huge piles of iron ore, coke and limestone. The iron ore is brought from the company's iron mines in the lake district, being carried in the company's own ships to Conneaut on Lake Erie, where it is transferred by special ore-handling machinery to trains of pressed-steel ore cars, in which it is hauled over the company's own road to Bessemer. The trainloads of ore are brought into the yard and run on to a trestlework, where the hopper bottoms of the 50-ton cars are opened and the contents dumped on the stock heap. The coke is brought in from the great Connellsville coke region, and the limestone, which is used in the blast furnace for a flux, is brought from the quarries at Tyrone. As showing the scale on which the Edgar Thomson furnaces are operated, it may be mentioned that there are in these works no less than fifty miles of standard gage track, and that in twenty-four hours' time there is consumed in the furnaces 200 carloads of ore, 175 carloads of coke, and 75 carloads of limestone.

The blast furnaces, of which there are nine, are massive cylindrical structures of brick and steel, each about 90 feet in height and of varying external and internal diameter. The mouth of the furnace has an internal diameter of 15 feet, which increases in the first 60 feet of its depth to a diameter of 20 feet, the increase being given to allow of an easy descent of the charge as it is reduced. The wall is 3 feet in thickness, and its weight is borne upon a circle of massive cast-iron columns. From its largest diameter the furnace tapers down to a diameter of 12 feet at the point where the hot-blast tuyeres are introduced, and from these tuyeres to the bottom of the furnace it is cylindrical in form, the diameter here being 12 feet throughout. The walls are built of brick with an outer casing of sheet iron and an inner lining of firebrick. The upper 60 feet of the shaft is called the body; the lower, tapering portion, the bosh; and below this is the hearth or crucible, into which the molten iron collects and from which it is tapped off. In the earlier days of steel manufacture, the furnace gases were allowed to escape into the air, but now the mouth is closed by a cast-iron bell which is opened only when a fresh charge is to be introduced. The confined gases are led from the top of the furnace by a large wrought-iron pipe, and conducted to a set of four hot-blast stoves, which are about 20 feet in diameter and 90 feet in height and have their interior filled with a mass of honeycombed firebrick. The hot gases are ignited at the base of the stove by the admission of a proper amount of air, and the hot products passing through the firebrick raise it to a high temperature. When the proper degree of heat is reached, the gases are turned into the next stove, and the cold-blast from the blowing engines is turned in at the bottom of the heated stove, and passing up through the brick work, absorbs the heat therefrom, and issues at a temperature of 1,300 to 1,400 degs. Fah. The difference between the temperature of the cold-blast and the issuing hot-blast represents the heat which is saved from the gases and restored to the blast furnace. The heated air is introduced at the bottom of the blast furnace through a number of water-cooled tuyeres. The raw coke, limestone and iron-ore are carried up to the charging platform of the furnace by means of electrically operated elevators, and the charging goes on continuously. Under the fierce heat of the hot-blast, the charge is maintained in a state of reduction almost to the top of the furnace, and when the material finds its way in the form of slag and molten iron to the bottom of the furnace, it is drawn away, the slag being tapped off from the top of the hearth and the molten metal from the bottom or crucible. From the time of putting a charge in at the top of the furnace to the time of drawing off the metal, is ordinarily about thirty hours. The slag is drawn off into trains of massive iron ladles, which are mounted on trucks running on a broad-gage track. These ladles, which have a capacity of 10 tons, are nicely balanced on trunnions, and are easily tipped for unloading the slag, which is at present being used for filling in the low ground on the property of the Edgar Thomson Works.

The molten iron is tapped into 17-ton ladles, which are drawn in trains of five or six to another part of the works, where their contents are poured into the metal-mixers. These latter are large, oblong iron boxes, each of which has a capacity of 175 tons. The train of ladles is drawn on to a raised track, where each ladle in succession is brought opposite the mixer and its contents poured in. The object of the mixers is to bring the mass of molten metal to a uniform temperature and quality, since the iron from one furnace may vary from that from another. The mixers are kept full all the time, and the contents are continuously being poured out by the tipping of the mixer into other 17-ton ladles in which the mixed metal is carried to the Bessemer converters.

The converter is a huge egg-shaped vessel built of heavy wrought-iron plate, lined internally with refractory materials and carried on trunnions, one of which is hollow and serves to conduct the air blast to the bottom of the converter. Here there are fifteen or twenty tuyeres of fire clay, each of which is perforated with a number of ⅜-inch holes. By this arrangement between 150 and 200 separate streams of air are forced up through the body of the molten metal during the process known as the "blow." The converter charge is about 15 tons. When the blast is turned on, the air rushes up through the body of the metal, and its oxygen combines with the carbon, silicon, manganese, etc., in the iron, the combustion of these elements serving to raise the temperature of the metal until it reaches the stage known as the "boil." The process is carried on for 15 or 20 minutes, until all the impurities are burned out and only pure, or practically pure, iron remains. The blast is then shut off, and the charge is emptied into a 15-ton ladle. At the same time a certain amount of molten spiegeleisen is poured into the ladle with the iron, the proportion of spiegeleisen being such as to introduce into the metal the proper amount of carbon and manganese for the quality of steel rail that it is intended to roll. The ladle with its 15 tons of molten steel is placed on what is called the pouring stand, underneath which runs a small railway on which are trains of cast-iron ingot molds, each truck or car carrying two of the molds. The pouring ladle is provided with a nozzle and stopper in the center of its dome-shaped bottom, the discharge of the metal being regulated by a lever at the side of the ladle, as shown in the accompanying illustrations. The ingot molds are drawn by hydraulic power successively beneath the ladle and filled. After the ingots have set, the train of molds is hauled out to the yard and stripped, then the ingots are immediately taken to the pit-heating furnace, or the "soaking pits" as they are called, where they are heated for rolling into "blooms." These ingots are of the proper composition of steel required for the particular quality of rail which is being rolled, and they constitute what might be called the raw material of the rail-making department, an illustrated description of which will be given in a later issue.

The curious ice caves of northern Arizona have been found to be apparently inexhaustible mines of ice. A company has been organized to mine this ice.

Engineering Notes.

A method of utilizing boiler-furnace clinker adopted at some works near Rouen has the threefold advantage of turning to account a waste product, the cost of removing which is considerable, of separating for further use the particles of incompletely-burnt coal, and of affording, with very little labor, a building material equal to brick or the best limestone. The treatment consists in a picking out of the coal particles, a breaking for reducing the pieces to the size of a nut, mixture of the substance with slaked lime, molding the paste thus obtained into bricks, and finally their drying.

When railroad tracks are laid over marshy ground or on an uneven roadbed, the fishplates become loosened, and the rails work up and down. This movement of the rails results in the battering of the ends and the rounding of the corners, thereby destroying the rail, which must be discarded long before the body is worn out. For the purpose of preventing the battering of the ends of the rail, Mr. W. E. Coyan of Homestead, Penn., has devised a rail, only the ends of which are hardened. Mr. Coyan attains his result by treating the rails when hot with a case-hardened fluid, and then with a tempering fluid.

Consul Winslow, of Liege, reports the discovery of a soft-coal basin at Asch, in the province of Limbourg, a few miles to the north of Liege. The coal much resembles that found at Westphalia, Germany. It contains from 18 to 20 per cent of volatile matter. The first vein was discovered at a depth of about 1,640 feet, and between this and 1,968 feet five veins have been discovered, ranging from 2.6 to 6.6 feet. It is thought that this basin covers about 24,700 acres. A German company from Westphalia has begun to develop a mine, and the John Cockerill Company, that has extensive mills at Seraing and shipyards at Antwerp, has decided to build large works in the basin.

The experiments which the British Admiralty have been carrying out for some time past with the Temperley-Miller marine cableway, for coaling warships while traveling, have been attended with so much success that it has been decided to send the collier "Muriel," which was equipped with the apparatus specially for these tests, to sea with one of the fleets. A cableway approximately 400 feet in length was stretched between the collier and the battleship "Trafalgar," which took her in tow. While traveling at from seven to ten knots an hour the battleship was coaled at an average rate of thirty tons an hour. When the distance was decreased a maximum rate of forty tons an hour was reached.

A new line of refrigerator steamships for service between this country and Great Britain is to be established. The new line will be controlled by a British-American syndicate. The boats will run with weekly sailings from Bristol. One line will travel between Bristol and New York, a second between Bristol and Boston; and a third line between New Orleans and Bristol. The principal purpose of the third is to facilitate and expedite the transit of the Californian produce to the English markets. The railroad runs from California to New Orleans will be two days shorter than to New York. Fruit will be carried over the Texas Pacific & New Orleans Railroad. A great warehouse is being built at Bristol containing 1,000,000 feet of space, capable of storing 12,000 to 15,000 tons of general produce. Already an extensive cold storage plant has been erected. New docks are being constructed, and several improvements with the existing accommodation are being carried out, at a cost of over $5,000,000. This project is the outcome of the recent visit of the British manufacturers to this country.

In view of the spirited competition British manufacturers are encountering at the hands of foreigners, they are displaying a keen enterprise in drawing attention to their goods. During the present year there will be no less than five industrial exhibitions held on a large scale in various parts of the country. Owing to the coronation festivities, there will be a large influx of foreigners to Great Britain during the coming summer, and British manufacturers intend to avail themselves of such an opportunity to the fullest extent. The largest and most important of these trade exhibitions will be that which is to be celebrated at Wolverhampton. It will cover ten acres of space for the display of exhibits, which are coming from all quarters of the globe. The exhibition will be modeled to a great extent on that recently held at Glasgow. The erection of two great central halls is now in progress. One is to be of the Palais de l'Industrie type, measuring 376 by 148 feet; and the other is being built on somewhat similar lines to the Paris Trocadero, and covering 348 by 128 feet. These two buildings have a combined superficial area of some 100,000 square feet. Another important exhibition will be the Australasian Exhibition to be held at the Royal Exchange. The American Exhibition to be held at the Crystal Palace will occupy some 800,000 square feet, while in Ireland the Cork Exhibition, judging from the strong support it is receiving, promises to be a success.