or to the sudden arrest of one of the motors, which might result in damage to the generator armatures; and to provide also against racing of the Pelton wheel and dynamo, which would take place if the circuit was broken or the load suddenly thrown off one of the motors by a belt leaving the pulley. This has been accomplished in the following manner. Two electro-magnetic switches are placed in circuit with the dynamos and motors, and are so adjusted that, in the event of the current increasing to 3 amperes above its normal amount, one of them, and in the event of it decreasing to 3 amperes below it the other one, disconnects the line and motors from the circuit and throws into it in their place a set of iron wire resistance coils, constituting an artificial load of the normal amount. If anything occurs to the line of motors to cause an abnormal increase or decrease of current, the dynamos are therefore automatically protected and continue to work as if nothing unusual had occurred. When either of the switches comes into action, an electric bell calls the attention of the attendant. The contrivance has been found to answer well in practice, and has on several occasions saved the dynamos from the risk of damage. The conductors between the station and the dredge form a completely metallic circuit, and consist of bare copper wire of No. 4 S.W.G. supported upon Johnson-Phillip fluid insulators. The supports are old 40 lb. rails, with a short hardwood cross-arm bolted to each about 2 ft. from the top; this arm carries the insulators for the conductors, while a third insulator, bolted to the top of the rail, carries a telephone wire connecting the generator-house with the dredge, the length of line being about two miles. Between the ends of the conductors on the bank and the motors in the dredge the two cables consist of seven No. 16 copper wires, and are heavily insulated with vulcanized indiarubber. The shore ends are clamped to the conductors near to one of the poles, a supplementary pole having to be used occasionally when the river bed is too wide to admit of a single span to the dredge. The other ends of the cable pass over insulated pulley-blocks and are coiled as the dredge moves towards or from the shore. The electric motors, of which there are two, are also arranged in series and are exact duplicates of the dynamos, the object being to make the various parts of the machinery interchangeable, and to avoid a multiplicity of spare apparatus. A spare armature and field magnet are provided which will fit any one of the machines. One motor drives directly, through a belt, a centrifugal pump; whilst the other, geared to an intermediate shaft, drives the buckets, winches and revolving cylinder of the dredge. As it is sometimes necessary to vary the speed or to stop the motor that works the buckets, a variable iron wire resistance is provided by which its field-magnet coils can be shunted. The motor that drives the pump acts as a current-regulator, for, when the bucket motor is switched off, or its speed varied, the pump motor absorbs the surplus electrical energy—revolving faster and causing the pump to throw more water, which, however, does not cause inconvenience. By this means great simplification in the working of the plant is attained—an important factor when electrical apparatus is placed in the charge of unskilled hands. The frames and platof the dredge, which is 80 ft. long and 20 ft. wide, are entirely of steel, and where possible, all the framing, ladders, buckets, etc., are constructed of the same material. The buckets, which have each a capacity of 3½ cubic feet, are filled and discharged at a rate of about twelve per minute. This gives a lifting capacity, while dredging to a depth of 20 ft., of more than 90 cubic yards per hour, which is as large a quantity as can be economically treated on the tables for gold-saving purposes. The winches have separate barrels for the quarter, head and hoisting lines, which are of steel wire, and each barrel is driven by a large worm wheel. A vertical shaft carrying a worm wheel is connected with bevel wheels below the deck, which are provided with friction clutches so arranged that the barrels can be thrown in or out of gear by moving the winch handle to one side or the other, all the winches being driven by a shaft below the deck. The dredgings, boulders and gravel are delivered into a revolving cylinder 10 ft. long, constructed of bars set ¼ in. apart. Through these bars the gold and finer sand pass on to the tables, the stones and debris being retained and afterwards discharged direct into the river through the stone shoot. The tables are set at an inclination of 1 in 12 and are covered with baize upon which the gold is caught. The cloths are washed into tubs at intervals of eight hours and are then replaced on the tables. A 10½ in. centrifugal pump, driven at a speed of 600 revolutions per minute and with a lift of 16 ft. from the water level, supplies about 2,000 gallons of water per minute to the revolving cylinder. The dredge is lighted by two 10-ampere Brush arc lamps included in the power circuit in multiple series with the motors. They are controlled from a small switchboard on the vessel. A resistance coil to take 20 amperes is arranged as a shunt on the lamps, while the remaining 20 amperes is divided equally between two circuits, in each of which an arc lamp is placed. The switches are arranged so that if one of the lamps is switched off an equivalent resistance is thrown into the circuit in its place, the current in the circuit of the other lamp remaining unaltered. When the lamp is switched off it is entirely disconnected from the power circuit, so that it may be touched without danger of unpleasant shock. A third switch disconnects the resistances and lamps from the power circuit during the day time, when the lamps are not required. The full available output of the plant is not utilized and a reserve of power is always maintained. The working duties of the plant as observed are:—

Pressure of water in the pipes	228 lb. per square inch.
" at the valve	195 lb. "
" at the nozzle	188 lb. "
Speed of the Pelton wheel	447 revs. per minute.
Water used per minute	108 cubic feet.
Power of the Pelton wheel	88 horse power.
Total electromotive force of the dynamos	1,170 volts.
Total current of the dynamos	30 amperes.
Total electrical output	47 horse power.
Loss of power transmitted through two miles of line	5.2 horse power.

The cost of the entire installation was:—

Dredge	£2,600
Race and flume	500
Intake, pipes and valves	600
Electrical plant	2,500
Cartage of material to the site of the works	800
Total	£7,000

The cost of working the machinery with three shifts of eight hours each, as obtained from the results of three years' work, has been:—

	Per week.
Wages, including dredgemaster and electrician	£25
Renewals, maintenance, oils, brushes, etc	5
Management, office, rates and taxes	5
Total cost	£35

Notes on Modern Steel Works Machinery.*

By Mr. James Riley, Glasgow.

Amongst the many results of the introduction of mild steel into engineering work may be mentioned the development of the various mechanical appliances used in the process of manufacture of that metal into the finished forms of sectional bars, plates, &c. As engineers have become better acquainted with its many excellent qualities, and have realized the possibilities opened up by its use, their demands on manufacturers have steadily increased for plates and bars of greater area, strength and weight. Conversely, manufacturers have stimulated these demands by costly outlay on improved machinery, designed to deal with masses and weights which but a few years ago would have been looked upon as unattainable. This continuous emulation has resulted in the massive installations of machinery to be found in the most modern steel works.

Rolling-mill Engines.—The improvements or modifications which have been made of late in rolling-mill engines have been in the direction of largely increased strength and power, and of careful attention to the designing of details, these latter perhaps small in themselves, but in the aggregate having an important bearing on the economical working of the engines, and on the diminution of the cost of maintenance. In these days of keen competition, when rigid economy is essential in order to reduce costs to a minimum, it is important that the consumption of steam should be reduced to the lowest possible; hence for pull-over or non-reversing mills compound condensing engines have been introduced with automatic valve-gear, which are working with a consumption of not more than 3 lb. of fuel per indicated horse-power per hour, in place of the old wasteful engines which consumed from two to even four times that quantity. With reversing-mill engines also attention has been turned to the economizing of steam, and trials have been made with compound engines. Compound reversing engines have not proved economical, when applied to mills—such as cogging or roughing mills—where the pieces being rolled are of short length and necessitate frequent reversals; while their use has been accompanied with troubles and difficulties in other directions, which have more than counterbalanced the small economies possible. Where water is available in sufficient quantity, it has beee utilized in condensers, connected either with single engines or with several engines from which the exhaust steam is led to the condensers at a central station. The use of central condensing stations for a number of engines appears to have received more attention on the continent than in this country: it is stated that recently this plan has been adopted there in several instances, and with satisfactory results both in economy and otherwise. The only instance known to the author where the plan has been adopted on a large scale in this country is at the North-eastern Steelworks at Middlesbrough, where a central condensing and pumping station of considerable magnitude has been put up by Mr. Cooper; and, although no definite statement has yet been made as to results, they are believed to be not unsatisfactory. The consideration of rolling-mills will here be limited to those engaged in the production of plates; and cogging mills are naturally the first to be dealt with.

Cogging-mills.—In the earlier days steel slabs to be rolled into plates were made from ingots under the hammer. Labor difficulties and possible economies led the author early in 1884 to put down at Blochairn Works the first cogging-mill used for this purpose. Recent slab-cogging mills are in all essential features like that pioneer mill, but are much larger and stronger, and therefore are capable of dealing with heavier ingots, yielding much larger and heavier slabs. Modifications have also been made in the machinery for tilting up the ingots and slabs for alternate edge and flat rolling.

A good example of a slab-cogging-mill was made recently by Messrs. Lamberton & Co. for the Wishaw Steelworks. The rolls of that mill are 8 feet 6 inches long and 40 inches diameter, and at both ends have grooves in which slabs 54 inches wide can be rolled on edge. The housings for both rolls and pinions are massive, and well fitted for their work. The pinions of cast steel are 48 inches in diameter, and have helical teeth 36 inches long, with shrouds or flanges at the ends. The spindles are of steel; the upper has spherical ends, and is supported from the pinion housing at one end and from the top-roll chock at the other. The mill is fitted with screwing-down gear, driven through gearing by a pair of steam-engines; and an indicator is fitted to guide the screwer. Live rolls of steel are fitted back and front of the rolls, and are driven by a steam-engine with cylinders 9 inches diameter by 15 inches stroke through gearing in the ratio of three to one. In front of the mill is a set of tilting machinery. The turning levers are placed on movable carriages, which traverse to and fro across the front of the rolls as required, being actuated by hydraulic power. Thus the ingot or slab can not only be turned from flat to edge or *vice versa*, but can also be traversed from one end of the rolls to the other. The cradle for receiving the ingot and lowering it upon the feed rollers is of massive character, being designed to deal with ingots up to 10 tons in weight. It is controlled by hydraulic power acting through a ram, which carries a sliding block taking on to the pin of a crank fitted on the axle of the cradle. The mill is driven by a pair of massive engines having cylinders 46 inches diameter by 60 inches stroke, and gearing in the ratio of one and three-quarters to one.

A cogging of quite a different kind was designed in 1890 to meet some special requirements at the Blochairn Steelworks, and to embody some modifications suggested by the author's experience with the ordinary cogging-mill. Up to that time the widest slabs in cogging-mills did not exceed 36 inches. Slabs of much greater width were then required under special circumstances; and it was decided to adapt the mill to produce them up to 60 inches wide. It was also decided not to turn them up on edge, thus dispensing with the necessity for the powerful and somewhat cumbrous, as well as expensive, tilting gear which would have been required for such wide slabs. Furthermore, experience had shown that in the course of years the cost of maintenance of the live roller gearing was considerable; and it was decided to dispense with this, and to adopt other methods of moving the ingots and slabs to and from the mill. These considerations led to the mill being made of the universal kind, with one pair of horizontal rolls for work on the flat, and one pair of vertical rolls for work on the edge of the slabs. Every part of this mill is made of steel. The housings are massive and are fine examples of the steelfounder's art. Besides the usual provisions connected with horizontal rolls, the housings have also provision for the footsteps and bearings of the vertical rolls, as well as for the strong horizontal shaft by which the latter are driven. Furthermore, one of the vertical rolls is made to move forwards and backwards across the mills, so as to put work on the edges of the slabs, and has a traversing motion through 28 inches, so that slabs can be made of any width from 60 inches down to 32 inches. With these arrangements it was contemplated that armorplates up to nearly 5 feet wide might be rolled in this mill, with their edges so well finished that comparatively little machine work would be required upon them. With a view to the transverse motion of the vertical roll, provision was made in the housings for the necessary screws and nuts by which it is effected, as well as for the slides and guides necessary for keeping the roll in the true vertical plane. Hence it will be seen that,

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