

ON RECENT IMPROVEMENTS IN THE MECHANICAL ENGINEERING OF COAL MINES.

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In the management of Collieries, it may be safely asserted that the science of mechanical engineering is as important as mining engineering; and as coal has now to be worked at greater depths than formerly, and from greater distances underground, the application of suitable, effective, and economical machinery becomes more and more important. Thirty years ago a considerable quantity of coal was produced from pits near the outcrop of the various coalfields in the United Kingdom, and few collieries were raising such a quantity as 600 tons a day. At the present time, winding from depths of 700 or 800 yards, and hauling a distance of two miles underground, are conditions which are not unusual; and no mining engineer will open out a large coalfield with a view of raising a less output than 1,000 tons per day.

The intention of the author is to describe briefly some of the chief mechanical improvements, which have been devised to meet this altered state of things and to effect economy in the production of coal. The subject may be considered under the following heads:—

1. Sinking Shafts.
2. Pumping.
3. Winding Coal.
4. Production of Steam.
5. Haulage of Coal.
6. Coal Getting.
7. Ventilation of Mines.
8. Screening and Cleaning Coal.

1. SINKING SHAFTS.

The over-production, which took place in consequence of the large amount of capital expended in new coal winnings immediately after the inflated times of 1872 and 1873, caused the supply of coal to exceed the demand, and as a consequence very few pits have been sunk during the past twelve years. Hence there has been little change in this branch of mining; but several new arrangements connected with the sinking of pits may be of interest.

Freezing process.—In Germany a number of successful sinkings have been carried out by the Poetsch freezing process, which is of special service in cases where sinking has to be carried on through quicksand, and through a large quantity of water; and the process in this respect appears to have advantages over the Kind-Chaudron plan. Briefly Mr. Poetsch's system is to drive down freezing tubes through quicksands, eighteen tubes being used where a shaft was sunk of 11 feet diameter. These tubes are 6 inches diameter, and each contains an inner tube of 2 inches diameter, through which the freezing liquid descends, returning upwards through the annular space between the two tubes. As soon as the ground is frozen to the extent of an estimated radius of about 10 feet beyond the pipes, the shaft is sunk in the space within the tubes. The work has to be done by pick and drill, no blasting being permissible for fear of breaking the freezing tubes or the frozen casing. Attempts have been made to thaw out the frozen core in the centre of the shaft by steam jets, and by a boring apparatus; but these were found cumbrous to work, and produced a soft mud, into which the miners sank up to their knees.

Great depths.—In cases where the sinking of pits is carried to considerable depths, the hoppet or trunk which brings out the material excavated is usually brought up without guides. With the object of steadying the trunk and thus getting a greater speed, Mr. W. Galloway of Cardiff has designed an arrangement for carrying on sinking and walling simultaneously in a shaft, by means of guide ropes from which the walling scaffold is suspended; and several

pits have been successfully sunk by this process. In this plan two steel wire guide-ropes, attached to the walling stage in the shaft, pass over pulleys and are coiled upon the drums of a screw steam crab at some distance from the shaft; these drums can be worked simultaneously or separately for lowering and raising the stage. A rider sliding upon the ropes consists of three principal pieces of iron, namely: a cross bar in which there is a central opening 3 inches diameter, through which the winding rope runs loosely; and two vertical legs bolted to the cross bar, having two openings of 2 inches diameter for the guide ropes to pass through. A circular iron plate 6 inches diameter rests horizontally on the cap at the bottom end of the winding rope, and supports an india-rubber buffer 6 inches thick. The bottom extremities of the guide ropes have similar buffers, 4 inches diameter and 4 inches thick. The guide ropes are 5 ft. 6 ins. apart centre to centre. The walling stage is permanently suspended in the shaft by the guide ropes, and is of wood supported on an iron frame, and has a central opening 6 ft. 6 ins. square, through which the trunk can pass. At 10 ft. 6 ins. above the stage there is a similar construction called the roof, having an opening 5 ft. 6 ins. square; an iron ladder provides a means of access from the stage to the roof. When the end of the winding rope is raised above the walling stage, the rider is caught up by the buffer, and slides on the guide ropes; and when the end of the rope passes below the stage, the rider is left standing upon the buffers at the bottom of the guide ropes, while the trunk can be lowered to the bottom of the shaft.

Mr. Galloway has also adopted in South Wales a pneumatic water barrel for raising the water from the bottom of sinking pits, and saving the laborious and expensive mode of baling water into the trunk. The pneumatic barrel, when it reaches the bottom of the pit, is attached by an instantaneous coupling to a pipe, which passes down the shaft from an ordinary air-pump condenser constantly working upon the surface. The water is sucked into the barrel by means of a flexible hose, the height of the water being noted by a glass water-gauge. In this manner the water barrel is filled in about half a minute. By this process a sinking was taken down,

where 5,000 gallons of water per hour had to be contended with, at the rate of five yards a week; previously the same speed only was maintained with a feeder of not more than 500 gallons per hour.

Explosives.—In the use of explosives for sinking purposes, considerable advantage has been derived from firing a number of shots simultaneously by means of an electric battery, the effect being to obtain an accumulated force, and to reduce the amount of time lost by firing separate shots, and by missed shots.

Little progress has been made in the application of power drills for sinking shafts, it being found that sinking is carried on with almost equal advantage by hand as by machine, except in cases where very hard rock is met with. Schram's percussive drills are being used successfully in the tunnels forming part of the railway between Sheffield and Chinley; and have also been used in the sinking of a shaft by the Parkside Mining Co. In the latter case the drills were mounted on horizontal telescopic stretcher-bars, jammed between the walls of the shaft. These bars required only one setting for each round. The position which best suited for them was 20 inches from the bottom of the shaft, and this height allowed each row of holes to be bored at the requisite angle or pitch. Two machines were used, one on each bar; and each drill bored two or three rows of holes, each hole being from 5 feet to 7 feet deep. The number and depth depended upon the nature of the rock, whether free-shooting or otherwise. The sump was kept in the middle of the shaft; and the four centre-cut holes forming it were fired first and simultaneously by electricity. The remaining holes were fired by ordinary fuse, one hole liberating the other in the usual manner. The time required for taking down the drills, setting them, and boring the holes, and also for removing the gear, was from two to four hours. The firing of the holes and clearing out of the debris from the blasting occupied about sixteen hours; and the depth cut with each round of holes ranged from 5 feet to 7 feet. The speed attained in sinking with the machines was from $3\frac{1}{2}$ to 4 times that of hand work; and setting aside the cost of producing the compressed air, and any charges for first cost or depreciation of machinery, and

taking into account only labour and explosives, the cost by machine was £9 12s. per fathom as against £12 by hand.

2. PUMPING.

Under the head of pumping, reference may be made to the development of one department of colliery management which is often beset with many difficulties, namely underground pumping. Having tried for this purpose at a number of collieries the Parkin and Weston pump, the author thinks it right to state that, after years of experience of its working under many various conditions, it has proved itself one of the most satisfactory to deal with for underground pumping. It consists of a direct-acting compound engine, having the steam cylinders placed horizontally one behind the other, with a piston-rod common to both, which is also connected with the pump piston in the same line. The special feature of the pump is its non-liability to get out of order.

Another process of pumping by hydraulic power has been introduced by Mr. Moore of Glasgow, in which water is used for the purpose of transmitting power from the steam engine to the pump. The water is contained in pipes connecting the engine with the pump, and vibrates backwards and forwards in the pipes, thereby giving the pump a reciprocating motion similar to that of the engine; the water thus acts practically as a mechanical connection like a rigid coupling-rod.

The mode of dealing with the large quantity of water often met with in sinking pits has always been a matter of great importance, because of the following obstacles which have to be overcome:—first, the trouble of having constantly to lower the pumps, together with a consequent lengthening of the spears or rods; second, the difficulty of keeping the valves and working barrels in order, in consequence of the quantity of solid matter which is necessarily raised with the water; and third, the difficulty of carrying on sinking work with pumping appliances always at the bottom of the pit.

A form of sinking pump recently designed by Messrs. Bailey and Co. of Salford, Fig. 1, Plate 121, is now successfully at work at the

Cadeby new winning in South Yorkshire, and contends with the above difficulties in a very satisfactory manner. The pumps are hung in the shaft by wire ropes from the surface, and are easily lowered by means of powerful capstans as the sinking progresses. The special feature of this steam pump is that, instead of having an engine, with foundations, connecting-rod, quadrant and spears, all liable to wear and tear and mishap, the combined engine and pump is the only thing to be dealt with. Eye-bolts are provided at the top, by which it is suspended from chains or wire ropes, and lowered to follow the falling water. The pump consists of three hollow plungers. The upper pair A A are stationary, and surrounding them are sliding barrels B B, which are connected to the steam piston P. From the lower end of these barrels projects the bottom plunger C, double the diameter of the upper pair, and working into the third barrel D, which latter is secured by means of connecting-bolts to the steam cylinder. Thus there are two smaller barrels B B on the top of the larger ram C. There is a group of valves opening upwards in the junction between the smaller barrels and the larger ram, constituting the delivery valves; and another group of valves opening upwards at the bottom of the larger barrel D, constituting the suction valves. The action of the pump is as follows. As the bottom plunger rises, the water follows it up into the lower barrel D; at the same time the water in the upper barrels B B is forced up into the rising main M. In the down stroke, the water in the lower barrel D is forced up through the lower hollow plunger and delivery valves into the upper barrels and plungers, and thence into the rising main. Thus there is a continuous delivery in the up and down strokes. One of the upper plungers is open on the top, and forms the discharge orifice for the water into the rising main; and the other is closed, forming an air-vessel V, which is continuously charged with air through a suitable snifting valve fitted to the side of the pump nearest to that plunger, and below the delivery valves; this snifting valve permits a small quantity of air to be drawn in with every upstroke of the pump. The steam cylinder is fitted with the Davidson slide-valve. Six of these pumps have been supplied to the Denaby Main Colliery,

near Doncaster, and will together raise 300,000 gallons per hour through 300 feet. Each pump has its own winding drum and steel-wire rope, enabling each or all of the pumps to be raised or lowered at will. Two shafts are being sunk to a depth of 600 yards, and four pumps are in one shaft and two in the other. Each pump has a telescopic suction-pipe, which enables a depth of 9 feet to be sunk without lowering the pump.

A pumping engine of similar construction, known as the Straight-Line pump, is fixed at the Stanley Coal Co.'s colliery.

One difficulty in pumping in a sinking pit arises from the necessity for continually adding to the length of the rising main as the sinking goes down. This work is generally done at the bottom of the rising main; but a simple method has been devised by Mr. Hewitt whereby it is done at the top of the pit. A delivery pipe or nozzle, rather longer than one of the pipes forming the rising main, is inserted through a stuffing-box in the topmost pipe of the rising main; the latter goes down with the pumps as they are lowered, and the stuffing-box slides on the delivery nozzle, which remains fixed. When the stuffing-box gets low enough, the topmost pipe is unbolted and raised, sliding up on the delivery nozzle; and another length of pipe is added beneath it, for lengthening the top of the rising main. In this way the inconvenience of having a sliding suction-pipe at the bottom of the rising main is obviated.

Coupling for Broken Pipes.—Owing to the liability of accidents through falls of roof, difficulties with haulage, and upheavals, there is frequently considerable trouble with the use of metal pipes underground; and it is important to adopt the best means of quickly repairing broken pipes. A process that has been used for some years in collieries with which the writer is connected is shown in Fig. 2, Plate 121. If both flanges are broken at a joint, or if a breakage takes place at the middle of the pipe, the loose flanges A A are slipped on to the pipe, and then the short tube B between them; the two flanges are then both bolted together, and perfect tightness is obtained by inserting india-rubber rings at I I. If

only one flange is fractured, only one ring A is used, which is bolted to the sound flange with the short tube B between.

The same object has been aimed at in a joint which is manufactured by Messrs. Howell and Co. at their steel tube works in Sheffield, as shown in Fig. 3, Plate 121. This joint is suitable for steam, water, or compressed air, and can be made to suit any size and thickness of piping. The joint itself is made outside the piping, thus reducing the risk of pieces of the packing material being drawn into the pipes.

Petroleum Engine.—The petroleum engine has come into use lately, and is driven by the same method as an ordinary gas engine. Petroleum is forced into a cylinder as spray, and is there volatilised by the heat from the working cylinder, and is exploded by an electric spark from a small storage or other cell. The oil used is about $1\frac{1}{4}$ to $1\frac{1}{2}$ pints per actual horse-power per hour. One of these engines, brought out by Messrs. Priestman Brothers of Hull, is now at work in the Nunnery Colliery at a distance of a mile and three quarters from the shaft, and is pumping about 40 gallons per minute through pipes 1,700 yards in length to a vertical height of 400 feet. It has not been long enough at work to prove its cost; but there is no doubt as to its being a very convenient arrangement. At another colliery, where it has been working for about two years, the cost for labour, paraffin &c., has been found to amount to $1\frac{3}{4}d.$ per horse-power per hour, the paraffin costing about $\frac{3}{4}d.$ per indicated horse-power per hour. The only risk in the use of the engine lies in having in the pit such a mineral oil as petroleum, and in the heat which is produced in the warming of the engine before its working is commenced; but to meet the circumstances of the case a protecting arrangement has been designed on the principle of the safety-lamp. At the Nunnery Colliery four of Grinnell's sprinklers have been attached to the rising main in the petroleum-engine house; and these will bring the whole pressure of water in the column into the engine-house in the form of a douche, if the temperature in the house is raised by any accident up to 155° Fahr. The action of the sprinkler depends upon the

heat melting a soldered joint, thereby liberating the cap which closes the nozzle, and so allowing the water discharge to take place. The advantage of this mode of pumping underground, over the modes of transmitting power by ropes, rods, compressed air, and electricity, lies in having the motive power directly at the pump.

3. WINDING COAL.

Guides.—The winding of coal from deep mines is a matter of great importance, as any loss of time is apt to affect seriously the output of a colliery. The old system of wooden guides is quickly giving place to wire-rope guides, of which two, three, or four are employed. An arrangement for applying these guides, in a manner which enables the cages to run at a minimum distance from each other without risk, is adopted at a Staffordshire colliery where the cages pass each other at a distance of only $3\frac{1}{2}$ inches apart. Three guide ropes are fixed on the outer side only of each cage, and run in thimbles attached to the cage; and between the two cages two more guide ropes are hung, to prevent the cages from touching each other; these two guide ropes are not connected with the cages at all. It is found that the cages rarely touch these inner guides; where the ropes hang, the sides of the cages are bushed with brass.

Another mode of enabling cages to run close together is by adopting steel rails as guides. This plan is used at the Nunnery Colliery, but is not to be recommended. Like the wooden guides, the steel rails cause some obstruction in the shaft, and the first cost is considerable; besides which there is serious wear, both of the rails and of the guides on the cages, if the least error in the perpendicularity of the cages takes place.

The four special points which require attention in dealing with the winding of coal are:—speed in winding; economy of fuel; quick changing of tubs; and wear and tear of ropes and cages.

Speed in Winding.—A number of endeavours have been made to obtain a combination of swift winding and economy of fuel by adopting automatic variable cut-off gear; but this is now in use at very few collieries in this country. Guinotte's gear has been

successfully applied at the Blackwell Colliery in North Derbyshire ; and whilst it is very effective in saving fuel, it somewhat retards the swift winding of coal.

Counterbalancing.—A good deal of attention has been paid to the counterbalancing of the full cage and the rope attached thereto. This has been done in the three following ways:—firstly, by a counterbalance weight working in a small shaft or staple, or running on a steep incline; secondly, by using a scroll-drum with varying diameters; and thirdly, by attaching to the bottom of both cages a rope, about equal in length and weight to the winding rope.

The first process was largely used some years ago in the North ; and it is somewhat singular that, in the large winding plants put up in the last twenty years, provision has seldom been made for counterbalancing. With regard to scroll-drums, their great weight often counteracts their useful effect; and, as far as the author knows, no drum has yet been made combining lightness with a sufficient difference between the smallest and largest diameters to constitute a thoroughly effective counterbalance. A drum designed to provide very fair conditions of counterbalancing is at work at the Ynysybwl Colliery, and varies in diameter from 18 feet to 33 feet; the depth from which coal is drawn is 500 yards, and the winding occupies 35 seconds.

The hanging counterbalance rope has come into use during the last fifteen years, and is simple and effective. The objections to it are that it contributes a new danger in the shaft in case of accident, and adds to the load upon the winding rope; but considering the way in which it economises fuel and promotes the speed of winding, it is remarkable that it has not been adopted upon a larger scale.

As illustrations of swift winding, it may be mentioned that at a colliery in North Derbyshire during the first week in June 6,809 tons were raised from a depth of 509 yards, the time of winding being from 7 a.m. to 3.30 p.m. At two other Derbyshire pits, 170 and 140 yards in depth, the speed of winding and changing has been brought to such perfection that tubs are drawn and changed three times in one minute.

On the continent an arrangement for winding, known as the Koepe system, has been adopted, but it has been used at only one colliery in this country. In this plan, shown in Fig. 5, Plate 122, the large winding drum is replaced by a pulley P, thus saving a considerable amount of dead weight, and consequently of first cost. The hanging counterbalance rope C below the cages is here used. The winding rope R always works in a straight line with the pulley wheels WW, and it is not found to slip on the driving pulley P. But this pulley requires considerable maintenance, and the cost of ropes is certainly higher where this mode of winding is adopted. A smaller winding engine will do the work with this system than with the ordinary drum ; but if a rope breaks, there is a likelihood of both cages falling to the bottom.

Compound engines for winding have been adopted to a limited extent.

Economical Banking.—In coal-winding, when a large quantity is drawn, a few seconds more or less in taking the full tubs from the cage at the pit top, and replacing them by empty ones, has a serious effect upon the work of the day. In recent years several improvements have been made in this respect.

Where a cage has only one deck, the quick changing of the tubs is easily accomplished. Where there are two decks, and these are lifted by the winding engine from one level to another whilst being emptied, there is both loss of time and wear and tear of the winding rope. A very common mode of meeting this difficulty is to provide arrangements at the top of the pit for emptying both decks simultaneously. This is done by having an extra platform above the main bank level ; and whilst the cage is being sent down the pit, the two full tubs which have been placed upon the upper platform are dropped down to the bank level by counterbalanced cages, which at the same time hoist up the empty tubs into position. Where however there are three decks, this is not so easy to carry out ; but at a colliery in North Derbyshire arrangements are being carried out to empty all three decks at once, and to bring all the tubs to one level during the winding.

With regard to changing tubs, it is of course understood that special power is required to push the full tubs out of the cage, and replace them by the empties; and various arrangements have been devised to reduce the manual labour required, two of which may be mentioned. In Mr. Fowler's plan the tubs are pushed out of the cage by small hydraulic rams; and the method works swiftly and economically, but has been adopted only upon a small scale hitherto. In Mr. Fisher's plan, the empty tubs intended for the cage on its arrival at the surface are placed upon a movable platform, of which the end furthest from the pit is raised by a small steam cylinder, thereby tilting the tubs into an inclined position immediately the cage reaches the surface and drops upon the keps. This sets in motion the empty tubs, which then get enough impetus to push the full tubs out of the cage. This arrangement works very satisfactorily, and may be seen at the Clifton Colliery, near Nottingham. A similar idea has been carried out by the writer in the construction of a cage at Nunnery Colliery, Fig. 7, Plate 122, which however is not yet put to work. The rails on which the tubs rest in the cage are hinged at one end, and when the cage reaches the top of the pit, and is lowered upon the keps, the other end of the rails is tilted upwards by the nose of the kep projecting above its catch, thus enabling the full tubs to run out easily.

A general difficulty in banking coal, which has not been properly dealt with until the last few years, arises from the fact that the empty tubs have to be put into the cage on the same level as the full tubs; and as the full tubs ought to have a fall to the screens of about 1 in 60 in order to run freely, it follows that, if they have to go a distance of 10 to 20 yards in order to get into position before going down the pit again, they have to be taken up hill. This point is now dealt with by mechanical creepers, which, by means of small lugs projecting up to the tub axles, push the empty tubs into such a position that before entering the cage they can rest upon rails inclined towards the shaft; and thus no labour is required to get them into position. The writer has adopted this plan with success at several collieries in the midland counties. It is part of a general system of banking at the Kibblesworth Colliery, which for a limited

output may be regarded as a very complete and economical arrangement.

A mode of holding back the empty tubs, when resting on a slight incline preparatory to passing into the cage, is shown in Fig. 6, Plate 122; by means of a treadle the tubs are set free, and run into the cage.

A contrivance introduced by Mr. W. Galloway of Cardiff, for regulating the speed of tubs descending an incline to the pit bottom, consists of a pair of long oak brake-beams, parallel with the rails, one on each side of the line, having a projecting angle-iron along their inner face; their upper ends are hinged to uprights at about the level of the top of the tub wheels; and their lower ends, which droop about 4 inches nearer to the rails, rest upon props, and are nearly counterbalanced by weights suspended over pulleys. The wheels of the tub entering at the upper end wedge themselves between the rails and the brake-beams, and would at once lift the beams and pass through without their velocity being materially reduced, were it not that the lower end of each brake-beam is controlled by a dash-pot, or cylinder filled with water and having a piston working loosely in it. While presenting little resistance to a slow movement, the dash-pot so checks the lifting of the brake-beam as effectually to regulate the speed of the tub to any velocity required.

In referring to different modes of emptying cages, mention should be made also of the pit bottom, where of course equal despatch is necessary. In some cases it is difficult to arrange for several landings underground, and in others it is a convenience to have the coal brought out on two different levels. In cases where only one landing is available, the arrangement in vogue at a West Yorkshire colliery is found to act very satisfactorily. This is shown in Fig. 23, Plate 125, and consists of a movable platform P, large enough to hold both cages, which is suspended in the sump by means of two ropes coiled round separate drums; upon the drums are hung counterbalance weights W for the purpose of raising the platform P again to the level of the landing, after the cage has started on its journey up the shaft. A powerful brake on the drum is under the control of the onsetter, who lowers the cage into the sump, deck by deck, as it is charged. The advantages of this method are:—firstly, an

important saving of time, as the changing at the shaft bottom is done independently of that on the surface; secondly, prevention of strains upon the winding rope, such as would be occasioned by raising the bottom cage during the changing; thirdly, saving of steam; and fourthly, economy of labour compared with that needed for double landings.

Springs for protecting Cages.—Another point to be considered in the winding of coal is the wear and tear of ropes and cages; and various attempts have been made to reduce this, either by putting india-rubber under the journals of the winding pulleys, or by interposing rubber or springs in the connection between the cage and the rope; also by allowing the cage to drop on india-rubber or old hemp rope at the pit bottom. The pulley wheels at the Nunnery Colliery rest in this way on rubber, which however is practically of no service, as it so soon becomes hardened.

At two of the Nunnery Collieries an effective plan has been adopted, which saves the wear of cages, by reducing the shocks upon the rivets, and prolongs the life of the ropes, whilst at the same time it gives some assistance to the winding engine. It consists simply of four strong spiral springs, upon which the cage rests when it reaches the bottom of the shaft. These have been at work for a period of eight years. In the ordinary winding of coal, the bang of the cages at the pit bottom is a familiar sound. Where these springs are employed, this is entirely obviated. The depression of the cage when it reaches the pit bottom is about two inches, which is reduced to about one inch when the cage steadies, but increases again to two inches when the full tub takes the place of the empty one. When the cage is ready to be drawn up the shaft, the compressed springs below it contribute a certain propelling power the moment the rope is taut; and in this way the first strain upon the winding engine is to a certain degree relieved.

4. PRODUCTION OF STEAM.

It is sometimes thought that the question of economy of fuel at collieries is not of much moment, and it may be supposed that there

is not much information to be acquired by mechanical engineers from what is done at coal mines in the production of steam; but there are certain difficulties with which the managers of collieries have to deal, from which perhaps some useful lessons may be learnt. Where no coke ovens exist, the consumption of fuel at a colliery varies from 2 per cent. to about 10 per cent. of the output; and roughly speaking, this is equivalent, as part of the general working cost, to a cost per ton varying from $\frac{1}{2}d.$ to $3d.$ per ton, the variation being due to the class of boiler used, to the amount of pumping and haulage required, and to the selling value of the coal used for colliery consumption. Two special difficulties at a colliery are bad feed-water, and the need of utilizing inferior coal for boiler purposes. The latter point had to be considered in the case of the Nunnery Collieries, where six years ago new boiler plant was put down, which now constitutes one of the most complete and economical installations in the district. Without going into details, it may be briefly stated that the plant presents the following special features.

Firstly, the coal used is of a very inferior quality, and is scarcely fit for sale, containing as it does so much ash and impurity; and hand-firing was found to be almost impossible. Experiments were therefore made with a number of mechanical stokers. The machines tried were those known by the following names:—Bennis, the Helix, Hodgkinson's, Whittaker's, and Proctor's. After a series of careful trials, Proctor's stokers were applied four years ago to a group of seven Lancashire boilers, and are now working satisfactorily. These boilers consume about 60 tons of coal per day, yielding about 10 tons of ash and refuse. The Proctor stoker throws the fuel upon the fire-grate at various points.

Secondly, the ash &c. when drawn from the fire-place is apt to damage the front of the boiler, which is therefore protected by an iron apron made in one piece.

Thirdly, the boilers are set in a somewhat unusual way, the side flues being made larger than usual, and fitted with doors for enabling the boiler sides to be easily swept. The return gases are allowed to impinge upon the sides of the boiler to a height of 12 inches above the water line.

Fourthly, an economiser is placed at the back of the boilers, which consists of 350 tubes; and the gases leave the boilers at a temperature of about 400° Fahr., and reach the chimney at a temperature of about 280°.

Fifthly, the feed water is passed into the economiser by an exhaust injector, and reaches it at a temperature of 170°, leaving it at a temperature of about 280°; but the latter temperature varies when there is any incrustation within the economiser.

In cases where mechanical stokers are used, and where the coal can be supplied from hoppers above them, a carrier or endless belt is sometimes employed. In a scheme devised for utilizing such a carrier, the small coal for the boilers is taken slowly over the tops of the coal hoppers by the endless belt, filling each with coal. The same carrier passes down below the level of the floor in front of the boilers; and through a hole in the floor the ash from each boiler drops upon the returning belt, by which it is conveyed to a hopper or elevator. The same carrier is thus used for taking coal in one direction, and for bringing ash away in the other. The same work might be done by the adoption of two separate worms.

The mode of dealing with impure and deleterious water for boilers has undergone very little improvement in the last twenty years. Two important points have to be aimed at, namely:—(1) if the water contains a certain quantity of solid matter which precipitates on boiling, it is of little use trying to prevent this, and it is sufficient to endeavour to prevent the deposit from incrusting the various parts of the interior of the boiler, unless it can be precipitated before the feed water enters the boiler: (2) it is equally important to prevent the water used from corroding the inside of the boiler; and where a so-called boiler composition succeeds in softening the scale, it is liable to fail in preventing corrosion. At the Nunnery Company's Woodthorpe Colliery the scale has been kept soft by a contrivance known as Bower's separator, consisting of an external depositing-box, through which, by means of a vertical diaphragm coiled inside, the boiler water is caused to circulate slowly in a long spiral course, allowing ample time for the sediment to settle down to the bottom of

the box, whence it is blown off periodically. The flow through the separator takes place by natural circulation, consequent upon the difference of temperature between the hotter water entering the box from the boiler, and the cooler water returning from the box to the boiler.

Sufficient importance has not been ascribed, the writer believes, to the adoption of thin plates in steel boilers. Thirteen years ago, for a set of boilers for a colliery in Nottinghamshire, he adopted plates only $\frac{1}{4}$ inch thick, and these are working at the present time at a pressure of 60 lbs. In putting them in, it was thought that the saving they would effect by transmitting more heat would pay for the cost of renewing them in about seven years.

Within the last few years a special form of boiler flue has been adopted by Mr. Arnold of Barnsley, which it is stated with a thickness of plate of $\frac{3}{8}$ inch will stand a pressure of 500 lbs. without collapsing. The successive rings of plates forming the flue, instead of being truly cylindrical as usual, are rolled barrel-shape or slightly concave towards the longitudinal centre line of the flue, and are united by flanged joints; the bulged shape of the plates and the flanged joints together enable expansion rings to be dispensed with. Inside the flue is fixed a long water-tube, about half the diameter of the flue, sloping upwards at a slight inclination from the back end of the flue, where it communicates with the water space beneath the flue, to the front end immediately behind the fire-grate, where it communicates with the water space above the flue. It tapers slightly in length, being larger in diameter at the front end than at the back end, so as to facilitate the escape of the steam generated from the water passing upwards through the tube from back to front. Boilers with these flues and water-tubes have been adopted at the Denaby Main Colliery, near Doncaster.

Another mode of boiler setting may here be referred to, which, although it is not in use at collieries at present, appears to be of interest from the fact that in one respect it is a return to an old principle. It consists in the adoption of the old wheel flue, and has been brought out by Mr. Livet, who claims for it complete combustion of fuel, with a minimum quantity of smoke, and a low temperature of the gases escaping to the chimney.

Although the principle is not new, there are some special features in the plan which deserve notice. The gases are made to travel only twice the length of the external shell of the boiler; and at both ends of the boiler the flue is enlarged to form chambers, so as to reduce the speed of the gases for the purpose of obtaining complete combustion. The shape of the flues gives free access for inspecting the boiler, which is supported upon cast-iron saddles, thus preventing the brickwork from touching the boiler. The ample area and shorter length of the flues allow of a shorter chimney than is usual with ordinary modes of setting boilers; the height found by present practice to be most suitable is between 40 and 70 feet.

Gas Producer.—The Wilson gas producer is well known, but its application for the purpose of firing boilers has not been adopted on a large scale. At the Alfreton Collieries this mode of firing boilers was adopted in order to provide against making smoke. The coal is filled into the hopper H, Figs. 8 and 9, Plate 123, where it is kept from entering into the producer by the bell B. When a portion of the volatile matter has been emitted in the shape of smoke from the coal in the hopper, the bell is lowered, and the coal dropped into the producer. The steam for the jet is supplied from the boilers through a 1-inch steam pipe S, from which it is delivered into the tuyere T through the jet J. The object of the jet is to take in with the steam a certain proportion of air. The gases pass off through the flue F, which can be regulated by the valve D. There is another valve V, situated close to the boilers, which acts as a stop or regulator valve. The water stands in the bottom trough at the level shown. Holes R are provided for the purpose of stirring up the cinder, and for poking it into the water trough. This "water-bottom" producer makes more gas than the ordinary producers, to the extent of about 25 per cent. So far as the particulars kept extend, the total cost of repairs to the ordinary producers will run to about £20 a year, and to the water-bottom producers from £10 to £12 a year. The brickwork stands much better in the latter. The three producers used at the Alfreton Collieries require the following labour:—

				<i>s. d.</i>
Day shift.	1 superintendent who attends to feeding	.	.	4 10
	1 man wheeling away cinders &c., $\frac{1}{2}$ day at 3/6	.	.	1 9
	1 fireman in charge of boilers	.	.	4 3
				—
				<i>s. d.</i>
				10 10
Night shift.	1 superintendent at producers, cleaning &c.	.	.	4 10
	1 man cleaning	.	.	3 6
	1 man in charge of boilers	.	.	4 3
				—
				12 7
Total cost for every 24 hours	.	.	.	23 5
The cost of stokers in the ordinary way would be, say				—
	2 men at 4/3	.	.	8 6
	2 men at 3/6	.	.	7 0
				—
				15 6

In economy of fuel, it is found that there is a difference of about 15 per cent. in favour of careful hand-firing, as compared with firing by gas by this process.

Steam economiser.—A simple form of steam economiser, which is not generally known, is the Gosling economiser, consisting of a succession of three or more metal discs, placed transversely and centrally, one behind another at some distance apart, within the flue-tubes of Lancashire boilers; the discs are of smaller diameter than the flues, leaving a narrow annular space all round, through which the hot furnace gases are thus compelled to pass in close contact with the flue surface. The application is inexpensive, not amounting to more than about £15 per boiler. The saving effected is most marked where no cross tubes are used. The discs can be placed within the boiler flues in about an hour by an ordinary fireman. The engineer at the Beckton Gas Works reports the saving effected by these economisers, as proved by a number of tests, to be equal to 20 per cent.

5. HAULAGE OF COAL.

The subject of underground haulage is much too large and important to be dealt with here, except in the briefest manner; but some of the special systems and appliances which have been developed in recent years may be referred to.

Steel Sleepers.—The ordinary life of a wooden sleeper used underground varies very much with the temperature and the degree of moisture which exist in a pit; but as a rule the ordinary sleepers will last only for a few years; and for the usual gauge of tramroad the cost of the hard wood sleepers is about fourpence each. The writer has adopted steel sleepers on a large scale, and the main roads of the Nunnery Colliery are laid with these throughout, of the form shown in Figs. 16 and 17, Plate 124; in Fig. 18 is shown the attachment of the rail to the sleeper. These sleepers cost 1s. 3d. each, and in their duration and the saving in labour they have fully repaid the extra outlay. Another form of steel sleeper is shown in Figs. 19 and 20.

The Endless-Rope system of haulage has been largely adopted during recent years; but very little development of the endless-chain system has taken place, the reason probably being that it is more difficult to apply efficient driving power to a chain than to a rope; also the weight to be carried when chain is used is greater, the respective weights of the ordinary endless chain and endless rope being about 18 lbs. and 3 lbs. per yard.

Two principal systems of slow endless-rope are in vogue, namely that in which the rope is carried on the top of the coal tubs, and that in which it is carried below. With regard to the practice of carrying the rope over the tubs, there has been little improvement in the mode of connection which was in use twenty-five years ago, namely a small chain, one end of which is wrapped round the rope a few times, the other end being attached to the draw-bar hook of the tub. Where however the slow-running endless-rope on the ground is in use, a large number of clips or modes of attachment have been brought out; several of these are shown in Figs. 10 to 15, Plate 124, and may be described as follows.

Smallman's Clip, Figs. 10 and 11, Plate 124, is made chiefly of cast or malleable iron. It is working very heavy gradients satisfactorily, and is easily detached from the rope.

Fisher's Clip is made of wrought-iron, with a malleable bush to clasp the rope, as shown in Fig. 13, Plate 124. The hinge is at

the bottom, below the rope; and the clip can easily be attached to the rope, and secured by the sliding cap or hoop. The bushes are made of soft metal, and are easily replaced when worn. A boy is required both to attach and to detach this clip. It is taking 7-cwt. tubs down an endless-rope self-acting incline, with a gradient of about 1 in $3\frac{1}{2}$ in the steepest part; and the present rope has been at work over six years.

Woodthorpe Clip, Fig. 14, Plate 124, is made entirely of wrought-iron, and is constructed on the same lines as the Fisher clip; but the hinge is here above the rope, which gives it a pincer action. The advantage of this clip over the Fisher clip consists in the means provided for adjusting its gripping power, by lowering the hoop or cap as the rope wears the clip away; this enables the Woodthorpe clip to be worked without bushes.

Hanson's Clip requires a boy to attend to it when in use, and is available for hauling heavy trains up to 20 tons. It grips the rope by a wedge action, and is attached and detached by means of a short lever. It has worked for many years at the Nunnery Collieries very satisfactorily, both on heavy gradients and round curves.

Nunnery Screw Clip, Fig. 12, Plate 124, has been at work for some years in the Nunnery Parkgate seam. It is made of wrought-iron, and the weakest part is the loop, which is constructed so as to give way when the tub gets off the tramway. The jaw which grips the rope is about 5 inches in length, and is tightened by a screw. It is hauling ten tubs, and is capable of working on steep gradients and round curves.

Cannock Chase Clip also grips the rope gradually by a jaw tightened by the slow action of a screw, and thus avoids a sudden strain on the rope. A hinged link from the jaw to the drawbar of the tub allows the clip to adjust itself to the flexibility of the rope.

Nunnery Detaching Clip, Fig. 15, Plate 124, was designed with the view of having the tubs automatically detached from the rope, which is gripped by two jaws, jointed at the point where the clip is attached to the drawbar of the tub. An arm stands out on each side

from the cap or hoop. These arms strike against a sloping surface at the point of detachment, and by raising the cap set the tub at liberty; the raising of the cap forces the jaws apart, and liberates the rope. This clip has worked very well with single 10-cwt. tubs upon a gradient of about one in four. It can work however only upon a straight road.

Tail-Rope system.—One or two points may here be mentioned which indicate some improvements within the last few years. It has usually been the practice to have all tail-rope engines working with spur gear, with the object not only of multiplying power, but also of getting a gradual start in running the haulage. The adoption however of direct-acting engines has proved quite successful; and this plan is now working at the Nunnery Colliery, where the speed of the train reaches about 15 miles an hour. Another improvement in the design of haulage engines is the adoption of a friction clutch in place of the old-fashioned dog-tooth clutch, which was liable to breakage and difficult to put into gear. The friction clutch can be easily put in and out of gear whilst the engine is in motion.

In tail-rope haulage the wear of the sheaves used for conducting the ropes is often serious, but takes place only in the trod of the wheel; the whole wheel has therefore to be renewed, whilst the rest of it is practically unworn. This point has been successfully dealt with by the adoption of a false trod of cast-iron or steel in the larger class of wheels; and a section of this, as now used in some Yorkshire collieries, is shown in Fig. 21, Plate 125.

An important point in dealing with underground haulage is the lubrication of the axles of coal tubs; and some years ago the chief new processes in vogue were described by the writer in the Transactions of the North of England Institute of Mining Engineers (1876, vol. xxv, page 215). Since then a process has been devised by Mr. Elliott, which has been adopted at a number of collieries, and may be referred to as a successful invention. In the ordinary mode of oiling by hand, time is lost in the screening of coal, as the banksman who tips the tub loses time whilst the

axles are oiled ; and both in the ordinary process of greasing, and in the use of india-rubber or cogged wheels, a good deal of oil is wasted, and thrown about the tubs and the screen bank. In Elliott's lubricator, shown in Fig. 4, Plate 121, a cap of sheet steel encloses each axle bearing ; and a layer of felt within it absorbs sufficient oil at one lubrication to last from one to three months if the roads are dry. The axles are less worn in dusty or wet roads, because the covers to some extent prevent the oil from being washed off, and prevent dirt from getting to the bearings. The adaptation of this lubricator to haulage sheaves and rollers is also carried out. When the first tests were made with this lubricator, it was tried by running a single bearing in a dusty chamber with just the weight it would bear in ordinary practice ; and one application of oil was found to last for a number of revolutions equivalent in distance to a run of 3,000 miles.

Another mode of haulage, which is a combination of the tail-rope and endless-rope systems, has been brought out by an engineer in Cumberland, and is in operation in a colliery under the writer's charge in North Derbyshire. The general arrangement may be described as follows. The rope is endless, and is driven by an ordinary drum, round which it is passed three times. It may be applied to either one or two roads. The tubs are run in trains with a bogey tram at each end, when the road is undulating, these trams being attached to the rope by screw clamps. A number of full and empty trains may travel at the same time, and a speed of ten miles an hour may be attained. The attendant can instantly detach his train from the rope, in case of an accident. This plan saves one-third in the length of rope, and it is found to answer well in working round curves. The life of the ropes compares favourably with that of haulage ropes used in other systems.

Steep Haulage.—An interesting mode of hauling coal in the case of steep seams is illustrated in Fig. 22, Plate 125, which represents an incline jig in use at the Silverdale mines in Staffordshire. The seam lies at an inclination of 35° to the horizontal, which is too steep to allow the tubs to run down upon their own road ; and therefore a

special carriage is used, upon which the tubs are placed singly. These self-acting jigs are about 200 yards in length, coal being supplied from a number of levels on both sides. A counterbalance tram, which runs down the side of the main carriage road, is lighter than the loaded tub and carriage, but heavier than the empty tub and carriage. The incline man can therefore stop the carriage for coal at the end of any level, which could not easily be done if two carriages were worked side by side. This system enables a narrower road to be used than would otherwise be necessary.

Haulage by Electricity is at present in its infancy, but has already been successfully applied in Yorkshire. An electric motor has recently been designed by Messrs. Walker and Immisch, for dealing with roads of various inclinations. This machine is intended to provide mechanical haulage in remote parts of extensive mines, where the introduction of rope haulage would be both costly and uneconomical. The advantages which electricity offers as a cheap system of transmission with high efficiency render it the most convenient power, where it can be used with safety, as can be done on the main haulage roads in most mines. In ordinary rope haulage a large portion of the engine power is absorbed by friction, to which the wear and tear of ropes is principally due. By making the rope stationary, the power required to move the rope, and the wear and tear caused by the friction, are both avoided. The electric motor is mounted on a wooden carriage, and derives a supply of electricity from an overhead conductor by means of a traveller, and actuates through gearing a clip pulley, say 2 feet diameter on tread, on which the stationary rope rests. On the clip pulley being driven in one direction or the other, the locomotive will move forwards or backwards, and the power of the motor will be applied to drawing the load. As the driver will be with the load, there is no need of signalling to a distant point. The advantages claimed for the plan are the following:—(1) the saving of all the power required in ordinary haulage to keep the rope in motion, which in consequence of the friction is a considerable part of the total work done; (2) a saving in the life of the rope, in consequence of the abolition of

such friction ; (3) a rope made from cheaper wire can be used ; and (4) all lubrication of rollers and pulleys is dispensed with.

6. COAL GETTING.

Coal-cutting Machines.—Very little progress has been made during the last twenty years in the replacement of manual labour by machinery for the getting or hewing of coal. It was thought at first that such machinery would be economical only in the case of coal seams which were both hard and thin ; but experience has shown that the only two conditions which are essential to success are a fairly strong coal and a good roof. Without going into details as to the merits of various plans, it may be sufficient to mention that at a colliery in South Yorkshire, with which the writer is connected, about 700 tons of coal per day are cut by a rotary machine, the design of which has been arrived at as the result of many years' experience. It consists of a horizontal wheel, armed with cutters fixed round its circumference, and driven through gearing by a pair of horizontal cylinders working right-angled cranks on a horizontal shaft ; the whole is mounted on a carriage travelling along rails. The first cost of a coal-cutting plant, including air-compressor, pipes, and coal-cutting machine to cut about 300 tons per day, is about £3,500. There is a distinct saving of labour in the use of the machine, but this has not as yet been of much advantage to the coal owner ; the chief advantages are that a larger quantity of round coal is produced, and the most arduous and therefore the most expensive part of a collier's work is done by machinery. Coal-cutting machines driven by electric motors are not uncommon in America, but have only recently been adopted in England. One is at work at a colliery near Leeds. A comparison of this system with the machine driven by compressed air does not as yet appear to show any advantage.

Drills.—The employment of machinery to deal with the more arduous portion of the miner's work becomes yearly of more importance ; and whilst the undercutting of the coal can now be

done extensively by mechanical means, so the drilling of holes in coal and stone, which was formerly done entirely by hand, by means of percussion drills, is now performed by mechanical drills. With an effective machine for drilling holes for blasting, of which the ordinary cost is 18s. and the weight 60 lbs., one man will drill a hole in coal to a depth of three feet in a minute and a half, as compared with fifteen minutes required for drilling a similar hole by hand by the old method. For drilling holes in stone, a machine is now largely used, of which the cost is about £6 and the weight about $1\frac{1}{2}$ cwt. This machine will drill a hole in hard stone in twelve minutes to a depth of three feet, the time taken by manual labour with the ordinary drill being thirty-five minutes.

With regard to the tools used by the miners themselves, it is of course of special importance to have these of the best possible construction. Interchangeable picks are now largely used, some having the wooden haft capped with a steel socket or bridle, through which the pick head is inserted and locked securely by a steel wedge, whilst others made with an eye-hole in the head slide upon the pick shaft and can be rigidly fixed thereto.

A coal heading machine, which has already been applied on an extensive scale, has been brought out by Mr. Stanley of Nuneaton. It cuts an annular groove about 5 feet diameter in the face of the heading, leaving a core which either falls or is broken off as the work proceeds. The coal and slack are passed back behind the machine, and loaded into tubs, ample room being left for the passage of men and material on one side, without moving the machine back. It travels on two broad central tandem wheels, working on the floor of the heading; and during the process of cutting is fixed by screw-jacks to the top and sides. The frame of the machine carries a longitudinal central screwed shaft, which is made to advance, while the frame, carrying the engine that drives the shaft, remains fixed in the heading. On the front end of the screwed shaft is mounted a pair of opposite arms, each carrying at its extremity a long face-cutter projecting forwards horizontally. By their revolution an annular groove is thus cut, until it has reached the required depth, when the driving wheel is thrown out of gear, and the jacks are slacked; and

after the cut coal has been removed, the frame by other gearing is run forward along the central screwed shaft, ready to be set for another cutting. The speed at which the heading can be driven varies according to the nature of the seam and surroundings in which the machine is put to work. In favourable coal a distance of a yard an hour can be averaged for some time; but it is hard work for the men to follow it up for any length of time, on account of the large quantity of stuff to be handled. In the Nuneaton Colliery a distance of $64\frac{1}{2}$ feet has been done in 24 hours in a dip heading inclining about 1 in 5, and the difficulty of loading in the heading such a quantity of material as this yielded was the main hindrance; on the level the tubs could have been dealt with more easily. A machine was lately sent to Colorado in the United States of America, on condition that it should cut in the first instance at the rate of 2 feet an hour for 24 hours in three shifts. The seam in which it was tried was unfavourable, because the core had to be all wedged off, being free from joints or partings. The terms of contract however were fulfilled.

Steel Girders.—During the last eight years there has been a great development of the use of steel girders and props underground, in place of wooden beams and props; and at the Nunnery Colliery there are now in the pit girders to the value of about £5,000. It was found that the dampness of the pit caused the timber to rot, or to become unsafe in about two years. The advantages of steel over timber are:—(1) extra durability, and thus reduction in the cost of repairs. (2) The girders can be used again and again; because when they are bent, as is frequently the case, they are sent to the steel works and straightened. (3) They are light and handy; the weight of a 10-foot steel girder as used at the Nunnery Colliery is 166 lbs., whilst a beam of Norway timber of similar strength weighs about 300 lbs. (4) The small space they occupy allows extra area for ventilation, the increased area being from 5 per cent. to 10 per cent. of the total airway. In Figs. 30 to 33, Plate 127, are shown steel girders in use at the Nunnery Colliery; and Figs. 24 and 25, Plate 126, show props and beams of drawn steel, as made by Messrs. Howell and Co. of Sheffield.

7. VENTILATION OF MINES.

The elements of danger, waste, and inconvenience in furnace ventilation for mines have caused an almost general adoption of mechanical ventilators; and many endeavours have been made to improve the ventilating fans which were in existence twenty years ago.

Fans.—The considerations to be aimed at in selecting a mechanical ventilator are as follows:—first cost of fan, engine, and foundation; future cost of maintenance; economy of fuel and stores; useful effect of fan. Several committees of mining engineers have been formed to report upon the relative merits of various machines; and as at the present time a series of exhaustive experiments are being made by a Committee of the Northern Institute of Engineers, it may be sufficient if in this paper the writer simply mentions some of the chief types of ventilating fans in operation in this country. These fans are:—the Guibal fan, Walker's improved Guibal fan, Cockson's, Schiele's, Capell's, Waddell's, and Lupton's fans.

The Guibal fan is that most largely adopted, and is so well known that it needs no description. In Walker's improved Guibal fan the chief variation in the style is the increased strength, designed with the view of obtaining the same results with a smaller diameter of fan; and the air, instead of being admitted as in the Guibal fan on one side only, is admitted on both sides. The Guibal movable shutter is replaced by an anti-vibrating shutter, which is very effective in its action.

The tendency recently has been to adopt fast-running fans, which however are most suitable where limited quantities of air are required. Four years ago the writer adopted this principle at the Woodthorpe Colliery, near Sheffield, by applying an 8-foot Cockson fan, driven direct without gear by one of Willans and Robinson's direct-acting engines, which runs very quietly at a speed of 280 revolutions per minute. At this speed the fan gives about 58,000 cubic feet of air per minute, with 3 inches water-gauge. The engine

since it was started has run about 500 million revolutions, and has cost a very small amount for repairs.

The actual economy in the useful effect of a fan depends upon the cost of fuel ; but bearing in mind that the useful effect is found to vary from about 15 per cent. to 70 per cent., the matter is of importance ; and in the ordinary carrying on of a colliery the quantity of fuel used in driving a fan engine, which practically never stops working, may be said to be one-fourth of the entire fuel used. The following would be the comparative economical results of various useful effects, in the case of a fan producing a current of 100,000 cubic feet of air per minute with 3 inches water-gauge, assuming that the consumption of coal is 10 lbs. per indicated horse-power per hour, and that the coal used costs 5s. per ton :—

Useful Effect. Per cent.		Cost of Coal per annum.		Saving compared with 15 per cent.
15	..	£462
30	..	£230	..	£232
40	..	£172	..	£290
50	..	£138	..	£324
60	..	£115	..	£347
70	..	£99	..	£363

In connection with ventilating machines, a simple contrivance which the writer is adopting at the Nunnery Colliery may here be mentioned. A new engine-house which is now being completed will be ventilated by taking a pipe from the roof, and passing it into the fan chamber ; the air leaving the house will pass up through two ventilators placed in the roof, and thence to the fan.

8. SCREENING AND CLEANING COAL.

Probably more progress has been made in this department of colliery management than in any other during the past few years ; partly owing to seams being worked in which there is an increased proportion of impurities to deal with, and partly because the old screening appliances were not effective in separating the slack from the larger coal, and dividing it into different classes. Another difficulty which has had to be overcome is the tendency to break the

coal, both in emptying the tub upon the screen, and in passing the coal from the screen or belt into the coal wagon.

Tipping.—On leaving the cage the first step to be taken with a tub of coal, after it has been weighed, is to get its contents placed upon the screen; and it is obvious that, no matter how efficient a contrivance to do this may be, some breakage must take place. A great improvement is effected by tipping the tub over backwards instead of forwards, so that the coal then falls upon the upper and nearest part of the screen.

In Fig. 26, Plate 126, is shown a still greater improvement, since the upper part of the tippler here forms, as it were, an enclosing lid to the tub. The forward part of the lid opens automatically by sliding back as the tippler revolves, and thus tends to empty the tub gradually. This process is successfully applied at some collieries in the north of England.

In Figs. 27 and 28, Plate 126, is illustrated what is known as the Rigg tippler, which has the advantage of emptying the tub gradually, but retains the disadvantage of losing a considerable portion of the useful screening surface below it, because the tub is still tipped forwards. To this tippler is sometimes applied a door D, which boxes the coal in; and a restraining weight on the door causes it to open gradually when the tub is tipped. This tippler is cumbersome but effective.

The revolving tippler is fixed in three different ways: either lengthways or across the screen, in both of which cases the tub is withdrawn backwards, after being emptied on to the screen; the third method is to allow the tub, after being emptied, to be pushed forwards through the tippler by the succeeding full tub.

In Fig. 29, Plate 126, is illustrated an adaptation of the revolving side-tippler which the writer regards as being most effective both in quickly emptying the tub, in saving breakage, and in passing the coal on to the screen in the best manner. With an ordinary large tub the weight of the side tippler is such that two men are required to turn it over swiftly. In this improved tippler however, the moment the tub is in position, the movement of a handle puts into

gear the wheel W driven by a belt; and steam power being thus applied, the tub is turned right over through an entire revolution, thus returning immediately to its original position. It is then pushed out of the tippler, and passes away to the winding cage. A further improvement consists in the addition of a curved plate P, which is fixed at its lower end R, but yields to pressure at its upper end; it thus breaks the fall of the coal as the tub is tipped, still allowing the coal to reach the screen at the earliest possible moment.

Screening.—Formerly coal was passed over parallel screening bars made of cast-iron; and the open space through which the slack had to pass was to the width of bar in the ratio of about 1 to 2. An improvement consists in using bars made of steel and attached together by rods; and here the ratio of open space to metal varies from 2 to 1, down to 1 to 1, according to the width of the screen. The evil of these fixed screens was that the coal had in many cases to be dragged down to the bottom of the screen by rakes; and whether it went down in this way or by gravity, it was liable to carry with it a considerable portion of small coal.

These difficulties have been overcome by the adoption of jiggling screens constructed of steel wire, in which the proportion of open space to solid surface is about 4 to 1. The jiggling of the screen consists of a mechanical lateral movement of from 4 to 8 inches horizontally backwards and forwards, which at 80 to 90 revolutions a minute is effective in dividing the large coal from the small. It enables the length of the screen to be shortened, and thus the height of the heapstead formation of the colliery can be reduced by several feet. It is of course desirable in a jiggling screen to dispense with surplus weight. The weight of a light steel parallel-bar screen, 12 feet long by 5 feet wide, compared with that of a wire screen of the same dimensions, is 500 lbs. compared with 300 lbs.

Belts.—Following the example of Continental engineers, there has been a considerable development in the use of carrying bands or belts, for the purpose both of sorting coal and of removing impurities. These carrying bands may be said to be confined to two

descriptions: namely the wire belt, which consists of an endless length of woven wire; and the steel-plate belt, which consists of two or three endless chains, carrying steel plates varying in width from 6 inches to 14 inches.

A method of screening has been brought out by Mr. G. C. Greenwell, Jun., whereby the ordinary vibrating screens are done away with, the coal being carried by a travelling belt, which consists of a series of chains, travelling between bars fixed longitudinally, as shown in Figs. 34 to 38, Plate 127. The bars are of different sections, so as to leave narrower or wider spaces between themselves and the chains, as shown in the transverse sections. Thus the slack falls through the first or narrowest spaces at S; then the nuts through the next wider at N; afterwards the cobbles through the widest spaces at C; and the still larger coal is delivered from the shoot at the far end of the belt. The dirt is picked out by hand along the course of the belt, as on an ordinary belt.

An important point in dealing with impurities is the mode of getting rid of the dirt which is picked out of the coal. At the Nunnery Collieries this dirt is conveniently dealt with by dropping it into hoppers running parallel with the belts; from these hoppers it passes into wagons, which carry it away through a subway under the sidings direct to the hoist.

Suitable means of grinding and washing coal have become of greater importance during the past few years, and have been adopted at a number of collieries. One great difficulty in washing coal has been in dealing with the quantity of sludge, or extremely fine coal, which has frequently been thrown away; but a mode of collecting it for use has now been adopted in Scotland and also in Wales.

The last point to be referred to in connection with cleaning and screening the coal is the manner in which it can be passed into the wagons with the least amount of breakage. There are four modes of doing this, which are more or less effective:—either firstly, by lowering and raising the outer end of the delivery shoot, thereby increasing and diminishing the steepness of its slope; or secondly, by a subsidiary shoot, hinged on the outer end of the fixed shoot and held up by a counterpoise, which gives way gradually under the

weight of the coal delivered upon it; or thirdly, by adding a telescopic sliding prolongation to a fixed shoot, so as to lengthen it or shorten it without altering its slope, the outer end of the telescopic slide being at a lower or higher level according as it is protruded to a greater or less extent; or fourthly, by delivering the coal from the shoot into a bucket or scoop, which when full descends slowly under the restraint of a counterpoise, and automatically empties itself on touching the floor of the wagon or the surface of the coal already deposited thereon. The object in every case is to reduce to a minimum the height of free fall through which the coal has to drop. The peculiar manner in which the joints in the belt render it difficult to prevent the breakage of coal has been dealt with at the Nunnery Collieries by the adoption of a double plate.

The writer feels that he has been able to refer only in a brief and superficial manner to the wide range of subjects embraced in this paper. Many of the appliances here alluded to are worthy of special papers which would describe them more fully. The reference here made however to the numerous mechanical appliances, upon which the mining engineer has to rely in order to promote economy in the Working of Collieries, will serve to indicate how closely the sciences of mining and mechanical engineering are allied.

Discussion.

Professor ARNOLD LUPTON considered the paper just read was most interesting and valuable; and the author was thoroughly qualified to speak about improvements in mining during the last thirty years from his own experience over the whole of that period. No doubt the improvements which had been introduced had resulted in nearly trebling the production of coal, and had been such as to engage the attention of engineers of all classes.

Mention had been made in page 361 of the method of sinking through quicksand by means of freezing. That method was especially applicable where quicksand was met with at a considerable depth below the surface. Where it was at the surface, it could be dealt with by piling, or by the pneumatic method; but where it was met with at a great depth, the shaft could not be widened out to the requisite diameter for applying the ordinary method of piling, and the pneumatic plan was out of the question, owing to the great pressure involved. By the pneumatic process he had himself sunk a pit through quicksand to a depth of about 100 feet under a pressure of four atmospheres, which was about as great as it was convenient for the men to work in. In a diving dress a man could work at a much greater depth than in a diving bell; but a little over 100 feet depth was as far as it was advisable for the men to work in; at that depth they got along fairly well. The pneumatic process was exceedingly simple, and was well known to all bridge-builders, who constantly sunk foundations by that means. But there was a difference between sinking a shaft and a bridge foundation. For the latter it was necessary to sink a hole, which had then only to be filled up with concrete. But in sinking a shaft, not only had a circular hole to be carried down into the ground, but then the difficulty was to make a watertight joint between the cylindrical tubing and the solid strata at the bottom, without filling up the shaft with concrete.

The speed of winding at Ynysybwl Colliery (page 369), from a depth of 500 yards in 35 seconds, representing an average of 30 miles an hour, would involve a maximum speed approaching

2 L 2

(Professor Arnold Lupton.)

60 miles an hour in the shaft, which it would be admitted was a considerable speed, rendering it necessary that all the machinery and appliances should be in perfectly good order. It should be borne in mind that throughout this country about 500,000 men or more went down a pit every morning, and came up every night, and it rarely happened that any of them met with a fatal accident in the shafts of any of the mines. That fact spoke volumes for the care taken by the rope-makers, engine-builders, and engine-drivers.

As to economy of fuel in winding engines, he considered it was not requisite in colliery engineering to adopt the refinements which elsewhere were found advantageous. It was only necessary to make the valves and ports large enough, in order to secure a great improvement. Twenty years ago he had made an enquiry into the winding engines throughout the country, and he then found that fully one-third of the power of the steam was wasted through not having the ports and valves of sufficient area, particularly the exhaust port. In this respect the engines had not been much altered since that time; and although the ports and valves might have been ample enough for a slow-moving engine, they were not so for a winding engine going at 700 or 800 feet per minute. Had James Watt had the designing of these engines, he was quite sure he would have made the ports and valves large enough, so as not to take one-third of the steam power in the engine simply to drive the exhaust steam out of the cylinder.

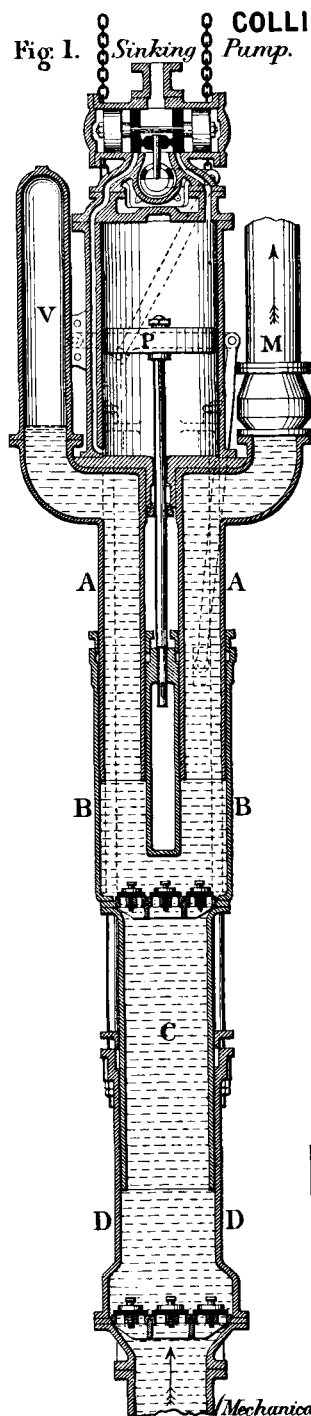
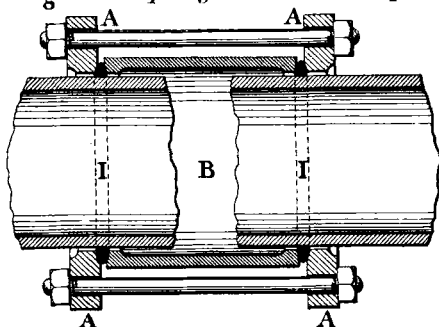
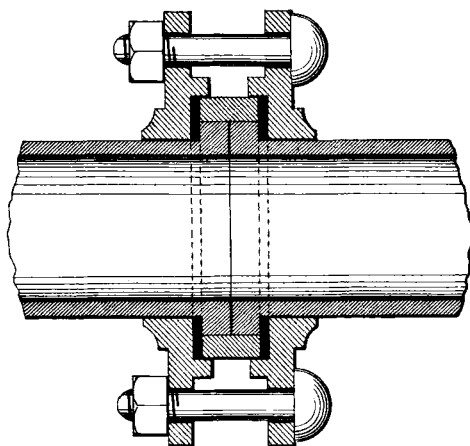
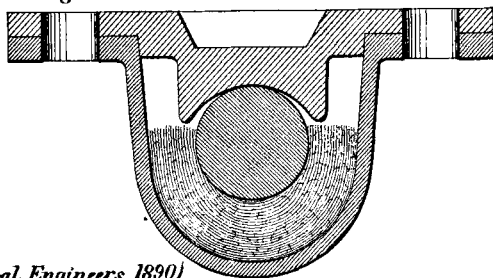
The feature of the ventilating fan designed by himself (page 387) was the utilisation of the skin-friction of the fan, instead of having it altogether wasted. As the fan revolved and the air from the mine entered into it, there was of course a great deal of surface friction between the fan itself and the air outside; this friction was utilised for the ejection of the air from the casing, with the result of effecting a considerable economy in the working of the fan.

In reference to the use of electricity for transmitting power in mines (page 383), he could not quite agree that it was *the most* convenient power, though he did quite agree that it was *a* convenient power. No doubt those who had used it in Yorkshire for underground pumping and haulage had found it both convenient and satisfactory.

Mr. BAINBRIDGE said that the paper had dealt with a large number of items in colliery engineering, every one of which was meant to effect some saving in labour, fuel, or repairs. There were between 3,000 and 4,000 collieries in this country, and 75 per cent. of the appliances described in the paper were not yet employed at all in more than half a dozen collieries. The paper was of course addressed especially to those mechanical engineers who were interested in coal mines; and he had endeavoured to draw their attention to the matters which from his own experience he was led to think chiefly required consideration at the present time in colliery engineering.

He expressed his gratitude to Professor Hicks, the principal of Firth College, for his kindness in providing for showing so well by lime-light the drawings illustrating the paper; and he congratulated him upon the success of the arrangements he had so obligingly made for darkening the room and lightening it again in so short a time as only about a minute and a half.

The PRESIDENT had great pleasure in inviting the Members to join him in a cordial vote of thanks to Mr. Bainbridge for his acceptable paper. Dealing as the author did with collieries mainly in the Sheffield district, he had none the less contributed an amount of information and experience which could not fail to prove of practical value to mechanical engineers concerned with coal mines in all the other districts also throughout the country.

Fig. 1. *Sinking Pump.*Fig. 2. *Coupling for broken Pipe.*Fig. 3. *Pipe Joint.*Fig. 4. *Lubrication of Tub Axles.*

(Mechanical Engineers 1890)

Fig. 5.
*Winding with
Endless Rope.*

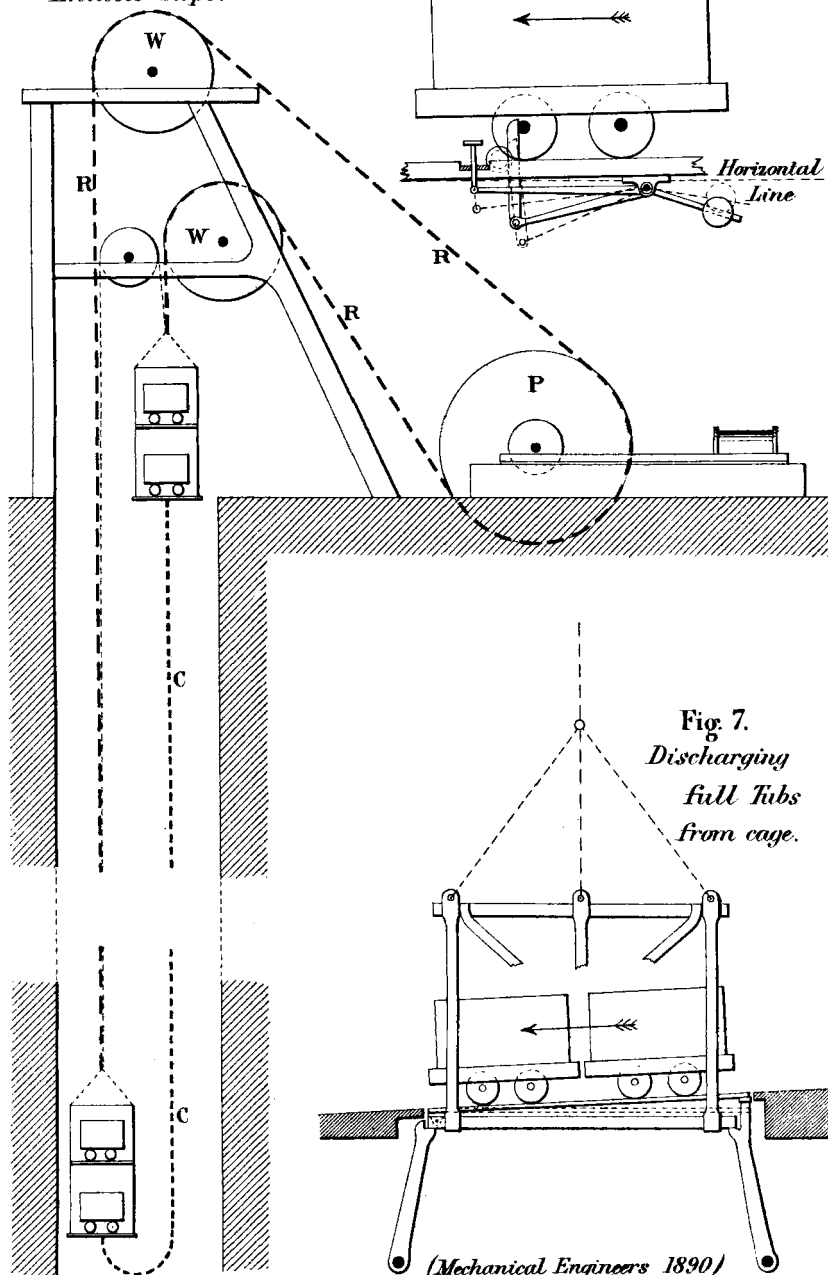


Fig. 6. *Holding back empty Tubs.*

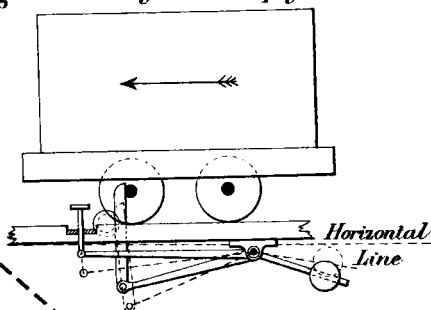
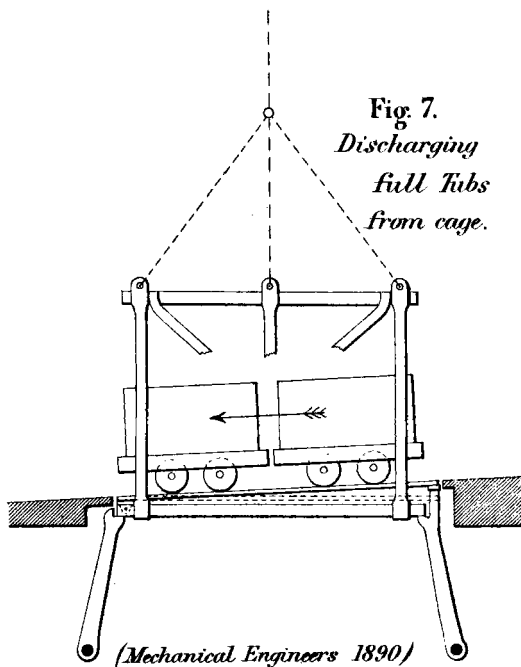


Fig. 7.
*Discharging
full Tubs
from cage.*



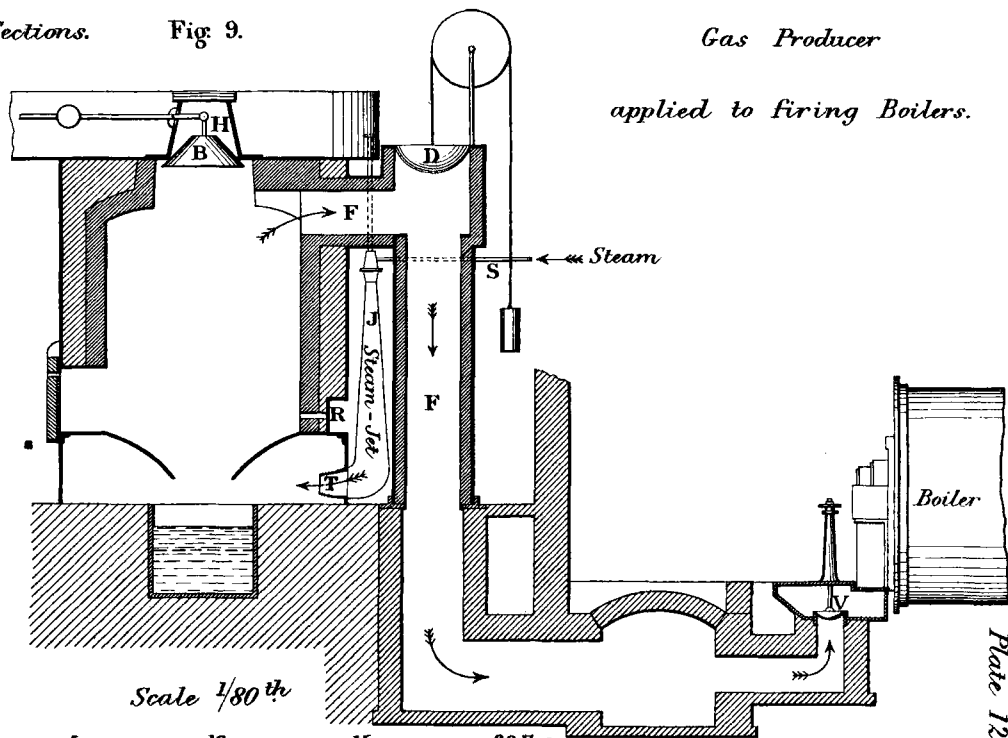
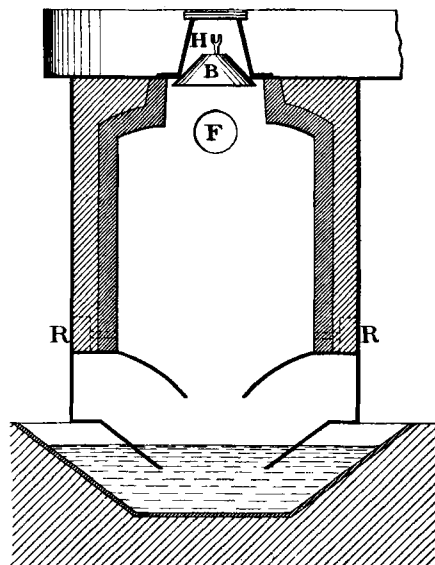
(Mechanical Engineers 1890)

COLLIERY ENGINEERING.

Plate 123.

Fig. 8. *Vertical Sections.*

Fig. 9.



(Mechanical Engineers 1890)

Scale $1/80^{\text{th}}$

A horizontal scale bar with markings at 0, 5, 10, 15, and 20 Feet.

Plate 123.

COLLIERY ENGINEERING.

Plate 124.

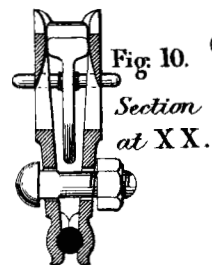


Fig. 10.
Section
at XX.

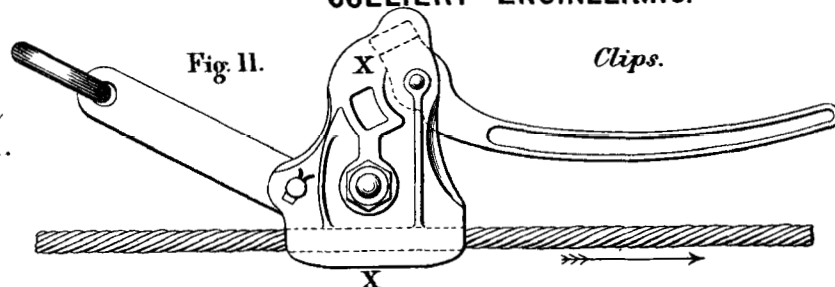


Fig. 11.

Clips.

Steel Sleepers.

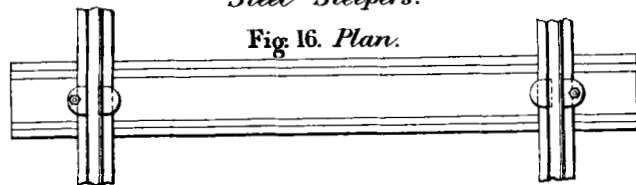


Fig. 16. Plan.

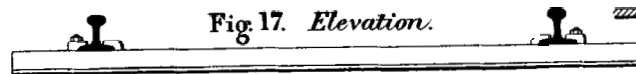


Fig. 17. Elevation.

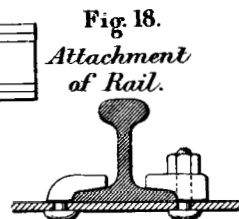


Fig. 18.

Attachment
of Rail.

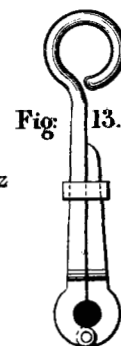


Fig. 13.

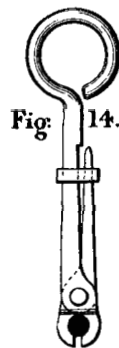


Fig. 14.

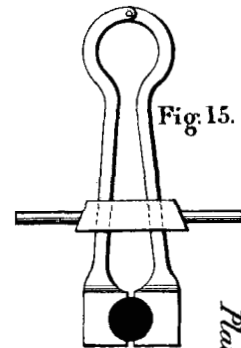
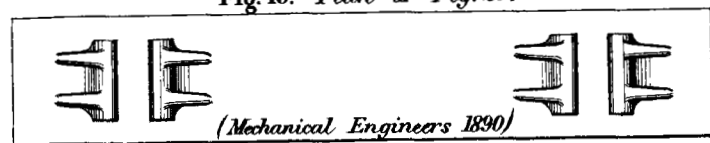


Fig. 15.

Fig. 19. Plan of Fig. 20.



(Mechanical Engineers 1890)



Fig. 20. Section of Fig. 19.

Plate 124.

COLLIERY ENGINEERING.

Plate 125.

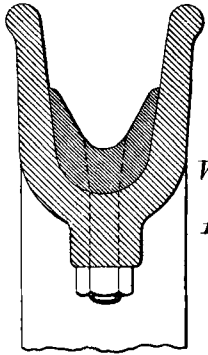


Fig. 21.
Wheel with
false Trod.

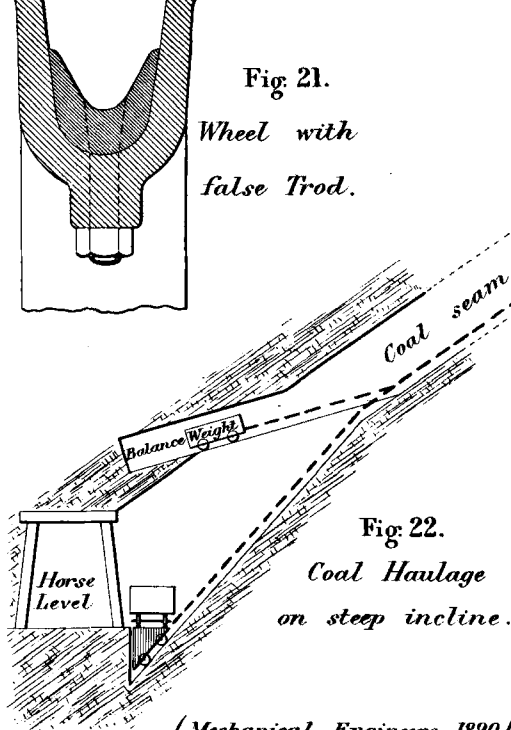


Fig. 22.
Coal Haulage
on steep incline.

(Mechanical Engineers 1890)

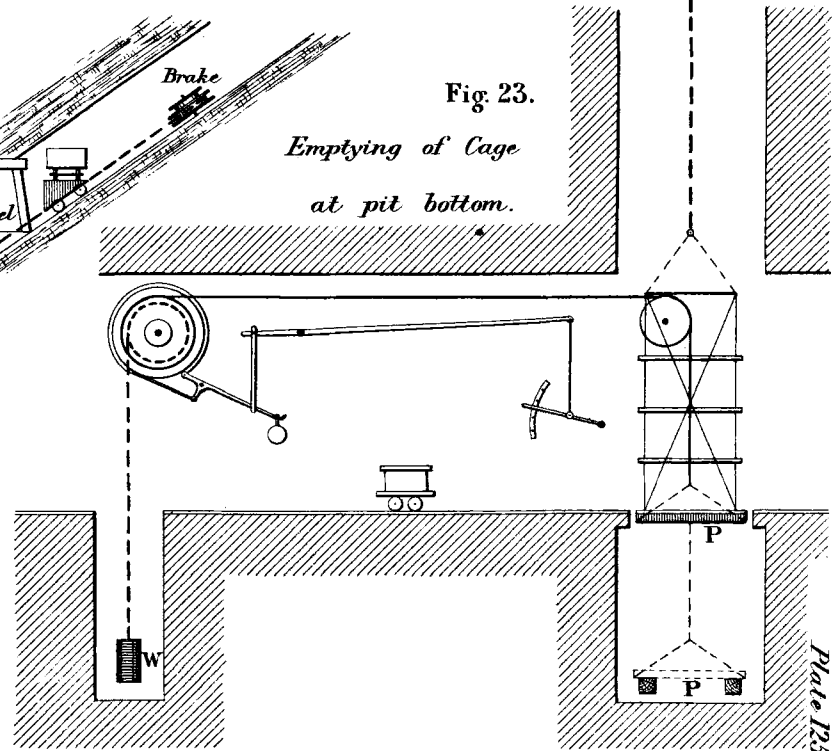


Fig. 23.
Emptying of Cage
at pit bottom.

Plate 125.

Tubular Steel Prop and Beam.

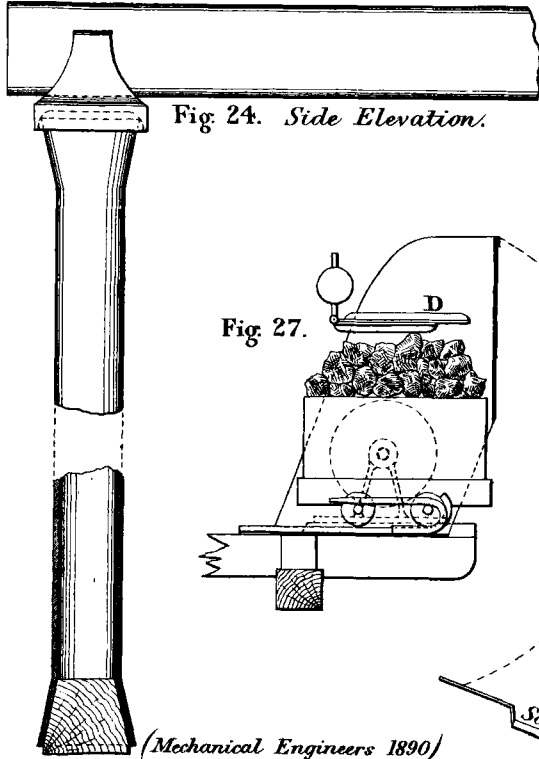


Fig. 24. *Side Elevation.*

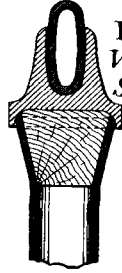


Fig. 25.
Vertical Section.

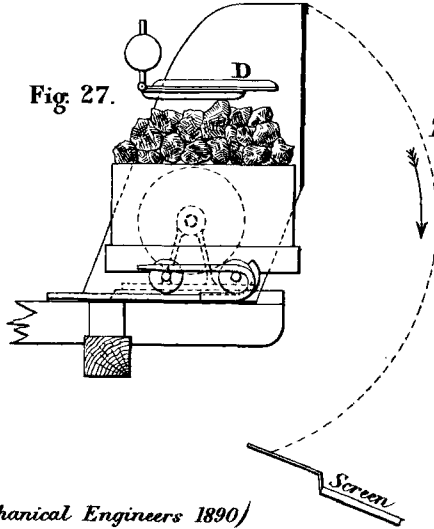
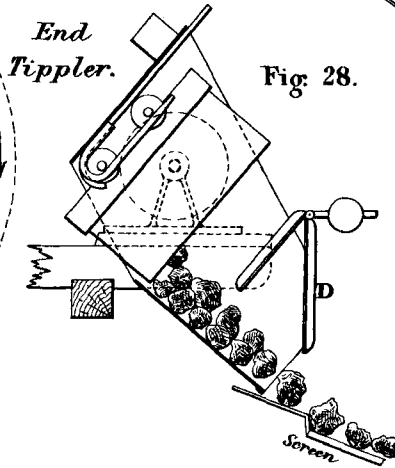


Fig. 27.



End Tippler.

Fig. 28.

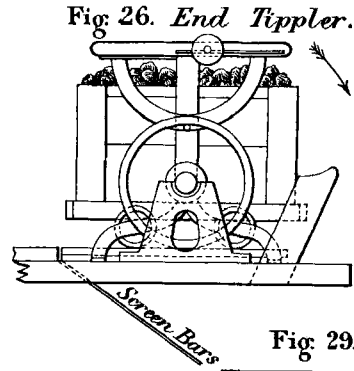


Fig. 26. *End Tippler.*

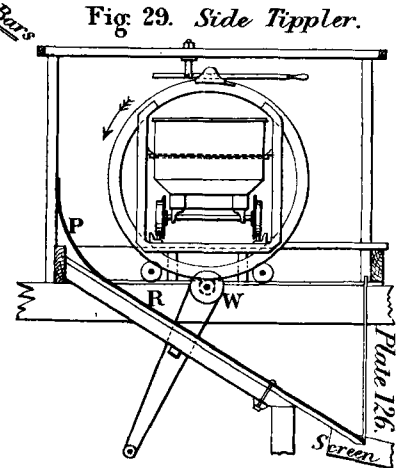


Fig. 29. *Side Tippler.*

(*Mechanical Engineers 1890*)

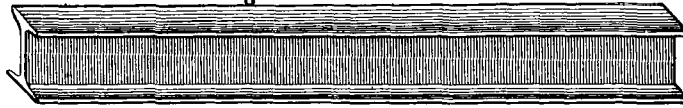
COLLIERY ENGINEERING.

Plate 127.

Fig. 30.



Fig. 31.



Steel Girders.

Fig. 32.

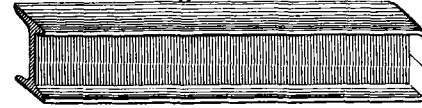


Fig. 33.



Screening by Travelling Belt.

Fig. 34. Plan.

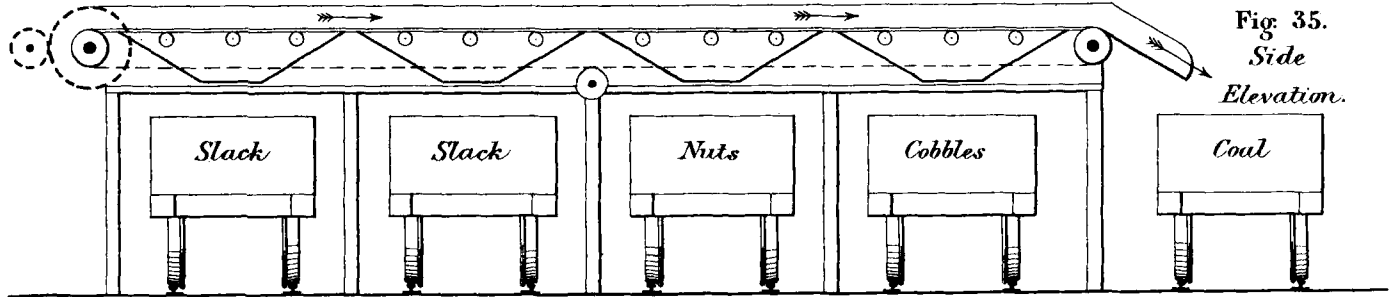
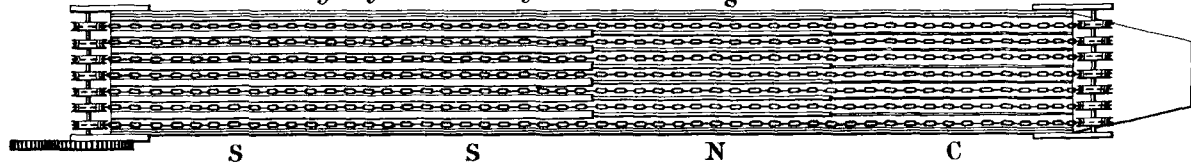


Fig. 35.
Side
Elevation.

Fig. 36. Section at S. Slack.



Fig. 37. Section at N. Nuts.



Fig. 38. Section at C. Cobbles.

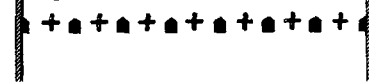


Plate 127.

(Mechanical Engineers 1890)