13TH APRIL, 1905.

JEFFREY CHAIN COAL CUTTING MACHINE.

BY J. W. BRAGG.

The problem of mechanical coal cutting as an alternative to the miner with his pick is one which has exercised the minds of colliery proprietors and managers for a great number of years, but it is only within the last quarter of a century that this problem has been satisfactorily solved by the evolution of machines which are both efficient and economical.

The first idea of the inventor was to imitate as closely as possible the operation of the pick miner, and consequently the puncher machine was brought out in various forms; when the principle of the pick machine was broken away from, the cutter bar machine was introduced, and this type was soon superseded by the chain machine, carrying cutting bits in its solid links; the problem was then well on the way to solution; the pick machine has, however, been greatly improved and it does very good work under certain conditions.

It is not proposed to follow the course of development of the chain machine as now manufactured, but to describe the construction of one of the Standard types and the method of working it in the coal mine. The machine selected is the Chain Breast Machine, as built by The Jeffrey Manufacturing Company of Columbus, the pioneers in the introduction of this class, now so largely used in the United States of America. This Company in 1877 brought out the breast form of design, the motive power being compressed air, and to our present ideas the machine was rather crude. Gradually the machine was developed, and installations made in the pits in spite of severe opposition on the part of the miners, who looked upon mechanical coal cutting as an intrusion on the domain of labour, and who resisted it to the utmost of their power: each shipment of machines required a special escort on the journey from the factory to the mines to protect them from men who were on the look out for opportunities to wreck them; and all statements made as to the benefits which the miners themselves would reap from the introduction of the machines were scornfully discredited; the managers persisted, however, and the machines were installed; the men began to see that the openings for labor were not reduced, and that they could earn as good wages with the machines as before, and generally better, and with less labor to themselves, until finally they swung round and at the present time it is difficult in the bituminous coal mines of the United States to get men who will work with the hand picks.

The purpose of the machines of all types is to undercut the seam of coal at the working faces so that it can be shot down easily, ready for loading into the mine cars, or skips as they are called in this country.

There are many difficulties met with and to be overcome in designing an efficient coal cutter, and all the conditions under which the machine must work are against success. One of the most essential requisites for the successful operation of any machinery is a solid foundation, or, if that is unprocurable, as in the case of locomotives, then a solid track must be provided upon which the machine can move. The designer of a coal cutting machine can count on neither of these; the machine must, to a certain extent, provide its own foundation, and this can only be secured by stiffening the frame, and giving it weight and strength to resist distortion from the strains put on it by screw jacks which take their thrust from the roof of the mine, and which bind the machine firmly on to the floor. This method of obtaining solidity introduces the objection that extra weight is added to the machine beyond what is actually necessary for the operation of cutting the coal; as weight is an item which militates against the ease of moving the machines about the pit from one working face to another, it may be contended that what is gained in one way is lost in another. The manufacturers of the Jeffrey cutters consider that the gain is largely on the side of the heavier machine, as the strengthening of the frame eliminates the possibilities of breakdowns and of straining the working parts in the event of the machine not being properly handled: to take an instance:—The skid upon which the back portion of the machine rests during the operation of cutting may be placed too far forward by a careless runner, which would result, if the frame were weak, in the outer frame being bent into a bow shape when the strain from the holding jacks is applied, in which case the feed gear wheels would bind in the rack at the top of the frame and would cease to work.

Another point to be considered in the design is the construction of the machines to a standard pattern, which shall be capable of overcoming the difficulties to be met with, not in one mine only, but which shall be certain of working successfully in any mine into which it is proposed to introduce the machines, without the necessity of making any special provision to meet local conditions. In fact each machine must be capable of almost universal application as far as coal cutting is concerned.

Again, in the matter of mining machines, the standardisation of parts is essential; there is probably no other machine which is subjected to the same amount of rough treatment as a coal cutter. It must necessarily be in the hands of a class of men who are unaccustomed to machinery, and who may be, for a time at least, prejudiced against it. The nature of the work which the machine has to perform is such that a penetrating dust constantly surrounds it, finding its way into working parts and bearings, producing wear between surfaces in contact and necessitating occasional renewals.

It will be obvious, then, that, to make a commercial success of mining machines, the component parts must be standardised and spare parts must fit any machine: to effect this end, one pattern only is manufactured. A minimum cost for repairs is a very important item to be taken into account in judging the relative merits of different types of machines, and is probably THE most important, as upon it will largely depend the ultimate success or non-success of the cutters. A breakdown means not only throwing the attendant runners idle, but may result in a serious diminution in the day's output of coal, and upsetting the work of the pit until repairs are effected. The absence of good light in the working places increases any trouble from such a breakdown. When everything is in semi-darkness it is by no means an easy matter to locate trouble, and especially so if the space in which the machine is working is cramped as frequently happens.

A machine which will stand up to its work with few breakdowns is infinitely preferable to one which may possibly cut the coal faster while it is in actual operation, but which is constantly calling for attention and repairs, and is for half its life in the workshops on the surface. The absence of complicated mechanism is a step towards the desired end, and this has been rigidly kept in view in the design of the Jeffrey machine.

The locality of the Jeffrey Company's Works, that is to say the centre of the Pennsylvania and Ohio coal field, is such as has materially assisted in the development and design of a practical coal cutting machine. Every detail has been tested in actual work before its design has been allowed to become a standardised portion of the machine. The Company have on their staff a number of practical miners who are also skilled engineers, and who are capable of testing at the coal face new suggestions and proposed improvements, and of reporting as to their efficiency or otherwise. As an example:—Should it be desired to test a new design for any portion of the gearing, the experimental piece is fitted to a machine in the works, and the machine shipped off to an adjacent mine in charge of an expert, and a trial run is made of sufficient duration to test the new piece for continuous working; the expert makes his report favorably or otherwise, and his suggestions are acted upon: the machines are thus kept up-to-date, and may be said to have been built up at the face of the coal and designed to overcome difficulties which actually present themselves, not in one particular but in a number of mines.

To sum up now the characteristics of a good coal cutting machine, it must possess the following qualities:—

1. Strength to withstand the rough usage which it encounters in every mine.

2. It must not be so cumbersome as to give trouble in moving it about the bord, or in transportation through the mine from one bord to another.

3. It must be standardised in its parts, and be capable of overcoming the difficulties met with, not in one particular mine, but in any mine in which it is thought advisable to install a plant.

4. Simplicity of working parts.

5. Economy in the consumption of power.

6. Good workmanship and good material in construction.

It may be well to state that it is not claimed for the machines that they can be worked with commercial success in every mine: if the dip of the seam is excessive, say, for instance, 1 in 5, or if there is a large quantity of dirt such as pyrites at the cutting level, or if there are large rolls in the floor such as are in some of our southern mines, or if the roof is treacherous it may not be advisable to replace the hand picks with machines; but in mines where none of these conditions exist the advantages are all on the side of the machines.

MOTIVE POWER.

The choice of motive power lies between electricity and compressed air, and in mines where there is no inflammable gas, or it exists in very small quantities, there need be no hesitation in the use of electricity: each system has its partisans. For the electric power it may be said—

1. The initial cost of installation is lower than for compressed air except in gassy mines where the cables may need high insulation.
2. It is much more flexible for the transmission of power to all parts of the mine; it is easier to lead copper cables than iron pipes through headings and workings, and to remove them when a district is worked out.
3. Electric motors are more efficient than compressed air motors.
4. A good quantity of light is always available at switches and other points along the headings where the cables are run; and this point is a much more important one than might appear to those unacquainted with the difficulties attendant on working by the dim light supplied by miners' lamps.

The voltage in an electric installation in no case exceeds 550 volts at the generating station, and is not so high as to be dangerous to human life.

In a gassy mine there is no alternative to compressed air as the motive power, and if large pipes are provided to carry the quantity of air required to work the machines, and the pipe line is kept free from leaks, there is no great loss of pressure between the compressor and the machines. The pipe line needs the exercise of care in laying down: every leak means loss of power, and high pressures either of compressed air or electricity are very apt at finding weak places along the line, and for economical reasons it is advisable under either system to have the pressures reasonably high.

Whichever system of motive power is employed it is well to let there be plenty of it, and it is not good policy to figure too closely to the estimated power required for a number of machines. An extra call will be made sooner or later, and it is of the utmost importance to be able to secure ample power immediately it is required.

Chain Breast Machines, or, as they are occasionally named, Heading Machines, from the fact that they are largely used for driving the headings quickly and turning off the entrances to the bords. It has been stated at times that these machines are not efficient in undercutting the coal in bords of twenty-four feet width and upwards. That they are the most extensively used machine in America for both wide and narrow work, and that they have proved themselves to effect such a saving over the system of holing by hand as to warrant their extensive installation for bord and pillar work is a sufficient answer to the above statement.

The original Jeffrey breast machine carried in front of its frame a horizontal steel bar in which were set a number of steel cutters: the bar was rotated on its axis by a driving chain from gearing operated by the Compressed Air Motor, set on a sliding carriage inside the main frame of the machine. As the bar revolved it was at the same time fed forward under the coal, the motor carriage also advancing along a rack inside the frame; the steel cutters cut out the coal in a four inch kerf to a depth of five or six feet, and a width of approximately three feet six inches for each undercut. If we imagine a motion at right angles to its axis being given to the revolving cylinder of a musical box, we should get a similar motion to that of the revolving cutter bar in which the cutters take the place of the projecting pins on the musical box cylinder.

On the completion of one undercut the cutter bar was withdrawn from under the coal, moved across the coal face the width of the undercut, 3ft. 6-in., the machine set and another cut made, and so on across the bord.

This machine had one or two weak points:—If one of the cutters broke off there was not another to take up the cutting in its particular line, and the bar had to be forced forward by crushing the coal. This is an objectionable feature with all revolving bar machines, though in some makes an oscillating motion is given to the bar by which this trouble is partly overcome. In the old Jeffrey machine, again, there was no provision for discharging the slack from the kerf as the bar advanced. These machines did good work, however, and some of them are still in commission, but the Jeffrey Company no longer manufacture this type. It has been discarded in favour of the present chain breast machine which is now described.

The electric machine and the compressed air machine are similar with the exception of the motors, and provided the same amount of power is applied to the driving wheel of the cutter chain in each case, they are equally efficient as coal cutters. Taking the electric machine first. The machine consists of four main parts—

1. The outside frame with front and back jacks.
2. The inside frame round which the cutter chain revolves.
3. The motor and carriage which are attached to the inside frame, and
4. The cutter chain into which the cutters are fixed.

Plate IV., Fig. 1 is a diagrammatic view of the machine, and Fig. 2 shews the method of gearing down from the armature to the chain driving sprocket. The outside frame is built up entirely of steel, and consists of two steel channel bars and two steel angle bars firmly fastened together by means of heavy steel braces. A heavy steel casting joins the channel bars at the front end of the bed frame and forms the guide for the inside frame. At the rear end of the frame is a solid steel housing which carries the cross bar for supporting the rear jack. The strength of the assembled frame is sufficient to prevent any distortion from the strain put on to it by the front and back jacks, when pressure is applied through them to clamp the machine firmly on the floor. Along the tops of both sides of the outside frame are the feed racks, the machine cut teeth of which point downwards so as to gear into the revolving pinions which work in bearings fixed in the motor carriage. By this means the inside frame with the cutter chain revolving round it is advanced or withdrawn according as it is required to make the undercut, or to withdraw the frame after the undercut is made.

The front jack is hinged to the outer frame and is quite short in length, as it is required to take pressure from the coal face just over the machine. It is canted slightly to one side to overcome the tendency which the machine has to draw sideways into the coal while the chain is cutting. The rear jack is not a fixture to the frame; the lower portion of it branches out into two arms, the ends of which rest on the cross-bar mentioned above and the pressure is taken from the roof of the mine. The jack is make of such a length as will allow of its being set at an angle to secure the proper horizontal and vertical pressure being brought simultaneously on the outside frame—the length of the jack is naturally regulated by the thickness of the coal seam.

The inside frame round which the cutter chain slides moves backwards and forwards within the outer frame, and consists of a forged steel centre rail, a cutter head and the steel guides in which the cutter chain runs. It is trilateral in shape, the base being the cutter head at the front of the machine, and the apex at the driving sprocket wheel. At each angle of the base an idler wheel is fixed to carry the cutter chain. The steel guides reach along the sides of the