ON

UNDERGROUND CONVEYANCE

IN THE

CLEVELAND DISTRICT,

WITH REMARKS ON THE ACTION OF THE CLIP-PULLEY, ETC.

BY WILLIAM COCKBURN.

The subject of the present paper is one of great importance in connection with the mining operations carried on in this country. It is at all times essentially necessary that the underground conveyance should be as economically conducted as the scientific principles can be arrived at which are called into requisition in general mining operations. In no case are those principles of cheap conveyance more needed than in the conveyance of ironstone in the Cleveland district.

I intend to lay before you a few facts and estimates in connection with the underground conveyance of the minerals in the district of Cleveland, and also the adaptation of a patent clip-pulley and portable-engine, as applied both to haulage and pumping operations now in use at the mines of Messrs. J. and J. W. Pease at Upleatham and Lofthouse. I also give plans and section of clip-pulley, portable-engine, portable-pump, self-acting inclines, engine-planes, and stationary-engine used for pumping.

The performances of horses underground have been so ably treated upon by the late Nicholas Wood, Esq., that it is unnecessary for me to make any remarks thereon. I will, therefore, at once proceed to show the cost of stationary-engines now working at Upleatham mines, after which I will also show the cost of hauling stone by Fowler's portable-engine, with patent clip-pulley attached, and, lastly, point out the advantages of the clip-pulley for pumping operations, self-acting inclines, and hauling underground; and also the conveyance of power to underground workings.

Vol. XVI.—1867.
The main winning at the Upleatham Mines is worked by a stationary-engine, with two cylinders placed horizontally, twenty inches diameter and three feet stroke, with two drums six feet diameter, both drums being fixed to the shaft, and driven by a spur-wheel. The drums are put in and out of gear alternately. This engine is only working with one drum at present, the length of the engine-plane being nearly 700 yards, with a gradient upon the average of 1 in 14:3. The engine is placed upon the surface. There are three boilers five feet diameter, thirty-five feet long, two of which are used at present; the pressure is 35lbs. per square inch upon the boiler. The distance from the boiler to the cylinder is about sixteen feet. The exhaust steam is emitted by a pipe direct out of the house-top; the length of the exhaust-pipe is about eighteen feet. This engine hauls a train of thirteen tubs, each containing thirty-two cwts. of ironstone, besides the weight of the tub, which is nine cwts. The average speed of the tubs travelling on the engine-plane is about seven-and-a-half miles per hour.

The quantity of work performed between November 4th, 1865, and July 12th, 1866, was 183,083 tons 4 cwts. on an average of 860 tons per day when at work, the cost of which, per ton, was 38d., including wire-ropes, coal, engine- and fire-man's wages, repairs and men attending engine-plane.

Plate XV. shows the engine-plane. This engine is employed hauling the ironstone up the incline.

The east-end of the Upleatham Mines is worked by a stationary-engine, with two sixteen-inch cylinders, three-feet stroke, with two loose drums, each seven feet diameter; one only working at the present time. There are three boilers connected with this engine, two of which only are worked at one time. This engine, like the other, is placed upon the surface, and is hauling ironstone up an engine-plane, having an average distance of 1,100 yards, on a gradient of one in sixteen. The load is thirteen tubs, each containing thirty-two cwts. of ironstone, and travelling at the rate of seven-and-a-half miles per hour. The quantity worked between March 28th, 1865, and January, 1866, was 279,349 tons eight cwts., on an average of 1,170 tons per day, when at work. The cost of which per ton, was 37d., including wire-ropes, coals, engine- and fire-man's wages, repairs, stores, and engine-plane men's wages, etc., etc.

The western portion of the Upleatham Mines was worked by a Fowler's portable double-cylinder engine, with patent clip-pulley attached, as shown on Plate XIX., from June 9th, 1863, up to the year 1866;
the engine has since been employed pumping water. The distance this engine worked was 1,550 yards. The average quantity of ironstone hauled per-day, as specified, was 750 tons, in small wagons, thirteen to the train, carrying nearly thirty-two cwts. each, and travelling at the rate of six miles an hour, at a cost of 38d. per ton. This could have been reduced to 22d. per ton, had another train of wagons being attached to the engine, which would not have incurred any extra cost, and would have increased the quantity to 1,300 tons per-day, after allowing for incidental stoppages.

In proof of this, a Fowler's portable-engine, with clip-pulley attached, as before mentioned, is now at work at Loft House Mines. The actual cost of working per-ton of twenty cwts., is 2d., including all expenses in connection with it.

With these statements respecting the portable-engine, I come next to the patent clip-pulley, the description of which, given before the Institute of Mechanical Engineers, at Birmingham, on the 4th of May, 1865, I cannot improve upon.

"The clip-pulley consists of a series of pairs of jaws or clips, A and B as shown on Plate XVII., hinged round the circumference of the pulley, close together in a continuous line, forming a complete groove, in which the rope C works. Each pair of clips in succession, as it passes round to the point where the pressure of the rope upon the pulley commences, seizes hold of the rope as shown on Plate XVII., and continues to grip the rope throughout the half revolution, until reaching the point where the rope begins to leave the pulley, the clips fall open, being relieved from the pressure of the rope. The amount of grip is in all cases proportionate to the pull upon the rope, so as effectually to prevent any slipping. The only provision requisite to suit the clip-pulley for working with any size of rope, is to adjust the width of opening of the clips to the particular diameter of the rope to be driven, by widening or contracting the distance between the centres of motion of each row of clips. This adjustment is effected in a very simple and complete manner, by having the lower row of clips B centred upon a ring D which forms the circumference of one-half the depth of the pulley, and this ring is screwed upon the body of the pulley by a thread chased round its entire circumference, so that by turning the ring round in either direction the distance between the centres of the upper and lower clips is simultaneously increased or diminished in every pair to exactly the same extent; all of them being kept in perfect parallel positions. The ring D is held in the desired position by the bolt E which prevents it from turning."
"The lower clip B of each pair having a heavy overhanging lip F on the outside, is enabled to lift the upper clip A by means of a small finger G projecting from its inner end, and pressing upon the tail of the upper clip so that the clips always remain open, until receiving the pressure of the rope, and they fall open again and release the rope the moment the pressure is withdrawn. The stop H on the upper clip coming in contact with the body of the pulley prevents the clips from falling open too far. The action of the clip is thus just similar to the closing of a hand upon a rope, laying hold at once so firmly that the rope cannot slip, and retaining this hold uniformly until the rope is released altogether by the opening of the clips, so that all friction or surging from an imperfect hold is avoided, as well as any shifting of the rope at the beginning and end of its contact with the pulley, such as is inevitably the case in round or angular grooves."

"At the same time, by means of the ring D on which the lower row of clips are centred, the hold upon the rope can be adjusted to any desired amount, according to the power required to be transmitted, and it can be absolutely depended upon, when once adjusted, to continue working uniformly with the same amount of hold."

An important practical advantage found to result from the working of this clip-pulley, is that the rope is subjected to a continual pressure upon its sides whilst passing round the driving pulley, thus avoiding all tendency to the rope being flattened by the pull, as in an ordinary round bottomed groove, where the pressure of the rope is upon the bottom of the groove only. Also the groove in the clips being so curved as to fit the rope closely round a considerable portion of its circumference, the pressure preserves the form of the rope, and serves to consolidate it, by continually closing down all protruding wires, and preventing the deterioration of the rope by such parts passing the subsequent guiding-pulley. It may be remarked here, that these advantages of the clip-pulley, render it especially adapted for use in other positions where the rope is the medium of conveying power. It is believed that the action of the clip-pulley is mechanically correct, and that it will be found highly advantageous in transmitting power by means of ropes.

The clip-pulleys are working at various places in England, Scotland, and Wales. I will confine myself to those which are working immediately under my own inspection at Upleatham Mines. As before stated in the description of the portable-engine, a clip-pulley has been used satisfactorily in every point, in hauling ironstone on the level with a tail-rope part of the way, and up a gradient of one in twelve on to an incline-head, after
which it was, and is used for pumping water a distance of 363 yards, by a
double portable five-inch pump with a clip-pulley attached vertically,
the pump-rods being connected by cranks direct from the axle of the
pulley. The distance between the clip-pulley on the engine which is
placed horizontally, and the clip-pulley on the pumps which is placed
vertically is 363 yards. The gradient being 1 in 15·66, and the engine
standing seventy feet above the level of the suction-pipe; and the
perpendicular height between the suction-pipe, and delivery-pipe being
seventeen-and-a-half feet according to Plate XVIII.

Plate XV. shows a section of the engine-plane at the main winning,
also ropes working from a clip-pulley attached to a stationary engine.
(Plate XVI.)—The engine is a common high-pressure with a twelve-
inch cylinder, a small pinion-wheel is attached to the fly-wheel shaft,
which is connected with a large wheel attached to the shaft of a five-feet
clip-pulley, placed vertically, from which the rope is taken nearly 700
yards to a portable nine-inch pump, to which is attached a five-feet
pulley. The pump-rods are connected to the shaft by means of cranks
direct from the axle of the pulley; the distance between the two clip-
pulleys is nearly 700 yards, and the perpendicular height between the
engine and the pump is 125 feet. The gradient is 1 in 14·3, the
delivery-pipe is nearly 400 yards above the pump, and the perpendicular
height the water is raised eighty-three feet. Only one of the nine-inch
pumps is working at present. The cost per day and night for labour
consists of the wages of two enginemen and two men attending to the
rope, sheaves, and pump. The quantity of stone laid dry by this engine
is equal to 1,200 tons per day, which makes the cost 25d. per ton for
all expenses connected with engine, pump, labour, and ropes.

Plate XX. is the plan and elevation of a portable double force-pump
driven by clip-pulley in the main winning.

A clip-pulley, six-feet diameter, working inside Upleatham mines,
down an incline with a gradient of 1 in 12, lowers down with ease and
safety thirteen tubs at one time, each containing above thirty-two cwtw.
of ironstone, independent of the weight of the tubs (weighing about
nine cwtw. each). This clip-pulley is managed by a boy fourteen years
of age, who has perfect control over the load, and can stop it in any
part of the incline desired without in the least injuring the rope, he
having frequently lowered the loaded set of thirteen tubs to the bottom
of the incline without the compensating balance of the empty set,
which proves the assertion formerly stated that it can be absolutely
depended upon when once adjusted.
A clip-pulley eight feet diameter is also used at these mines in lowering trucks down an incline of 1 in 11; the weight of each truck is on an average when loaded fifteen tons. Three of these trucks compose the quantity lowered down at one time. This clip-pulley has been recently placed to supersede a pair of twelve-feet drums, which have been used at these mines nearly nine years. The advantage to be derived from this is, that only one rope is required instead of two, thereby diminishing the original cost of ropes, and securing a greater uniformity in the wearing of the ropes, also a greater security in case of a break of the rope, the clips holding uniformly which is not so on a roll or drum.

From my experience in the working of clip-pulleys, I think that they are considerably more economical than the ordinary method of drums, and are capable of being applied to any place where a drum is or has to work. Also for pumping purposes, where the pumps have to be carried forward as the places progress, they cannot be superseded. The despatch with which the portable-pump, with the clip-pulley attached, can be removed is to be highly commended for mining operations.

Plate XXI. is a plan and elevation of a clip-pulley, applicable for conveying power to underground workings from engines placed upon the surface, the application of which the writer has not seen in operation, but from the experience already acquired he is perfectly satisfied that it is suitable for the purpose, and he intends putting it into operation the first opportunity that presents itself.

Plate XXII. is a drawing of a thirty-horse portable-engine with clip-drum attached vertically.

Plate XXIII. is a drawing of a five-inch double-acting pump, driven by the portable-engine Plate XIX. at the inclination shown on Plate XVIII.

Messrs. Bell Brothers have several of these pulleys pumping, etc., etc., also Messrs. Boleckow and Vaughan.

A clip-pulley four feet diameter has recently been erected, and is now working with perfect success at Cowpen Colliery, under G. B. Forster, Esq.

Plates XV. to XXIII. illustrate Mr. Cockburn’s paper on Underground Conveyance in the Cleveland District, and on the Clip-pulley.
The minutes of the Council were read, and a second sum of £50 was, on the recommendation of the Council, voted for the use of the Tail-rope Special Committee, to enable them to prosecute their investigation and experiments further.

A report was also read by the Special Committee, appointed November 3rd, 1866, to revise the duties of Secretary. The report was adopted by the general meeting; and the sum of £25 per-annum was voted unanimously to Mr. Doubleday on his resigning of the duties of Secretary.

The following new members were elected:—Mr. John Thompson, Norley Colliery; Mr. D. G. Dunn, Greenfield Colliery, Hamilton, N.B.; Mr. W. France, Upleatham; Mr. Wm. B. Harrison, Norton Hall, Cannoch, Staffordshire; Mr. Thos. Dawson, Garmondsway Moor, near Ferryhill. Mr. Wm. Armstrong, jun., Londonderry Collieries, Seaham Harbour, was elected a graduate.

Mr. D. P. Morison read a paper on Underground Conveyance at Pelton Colliery.

Mr. Daglish said, this paper seemed to corroborate his own.

Mr. Morison said, one thing ought to be borne in mind. The engine had been reduced to a common velocity; but to arrive accurately
at results in horse-power, the diameter of the coils on the drums ought to be taken into consideration.

Mr. Daglish said, he did not think the horse-power was the measure of resistance so much as the diagram. Horse-power was to a great extent boiler-power.

Mr. Morison said, the size of the diagram was increased in proportion to the speed at which the engine was working. Consequently, you have an increase of the diagrams, and, on account of the speed, in case the engine has more work to do, more steam would have to be introduced. In both cases the diagrams are increased.

Mr. Daglish—By letting the steam in faster, you would have much the same diagram, but an increased number of strokes.

Mr. Morison—The reason you have a higher power is that the diameter of your drum is increased so much; and with this additional power, instead of seventy-six horse-power absorbed by the ropes, it only comes to something like forty-eight.

Mr. Daglish said, this was even higher than he made it out to be in the special instance he had given in his paper. He thought it something under fifty per-cent. He made forty-three horse-power out of ninety-four.

Mr. Morison—What is the length of your rope?

Mr. Daglish—2500 yards.

Mr. Morison said, as he had mentioned in his paper, no doubt the increased friction at the curves did make a difference. On a straight line a man with a winch at 5 to 1 could move the rope along; the power must be lost at these curves.

Mr. Daglish said, a member, who, he hoped, would have been here, was possessed of a good deal of valuable information on the subject. He had had occasion to go into experiments, not in the same form, but bearing upon it—the friction of belts for turning machinery. He believed Mr. Ramsbottom had made extensive experiments, and found that in belts for travelling cranes seventy-five per cent. of the power was absorbed.

Mr. G. B. Forster said, that was rather a different question. It showed the great loss caused by using belts.

Mr. Daglish said, he believed that curves caused a great loss of power with tail-ropes.

Mr. Morison said, it was on this account that in the west way, which was 600 yards shorter, the power required to move the ropes was almost the same.
Mr. Steavenson stated, in confirmation of the results obtained by Mr. Daglish, as to the large per-cent age of power absorbed by the machinery and ropes when hauling tubs upon engine-planes, that he had made experiments upon an engine with two cylinders of twenty-inches diameter and three-feet stroke, the plane being 1,700 yards long, with two curves in it, the one three chains and the other four chains radius.

The diagrams were taken at a speed of forty-six revolutions per minute; their scale being \( \frac{\text{ft}}{\text{rev}} \).

No. I., Plate XXIV.—The ends of the main- and tail-ropes were coupled together without any tubs attached. It shows that forty-two H.P. was required, simply to move the engine and ropes.

No. II., Plate XXIV.—This diagram was taken when hauling forty-five tubs up a gradient of one in thirty-one, and gives the gross force applied, namely, ninety-one H.P.

These experiments, therefore, afford as a result 53.85 per-cent. of the power applied as effective, and 46.15 lost in friction, etc.

This agrees very closely with the figures of Mr. Daglish (see p. 56, Vol. XVI.); the difference in amount utilised being 5 per cent.

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<th>By Mr. Daglish</th>
<th>By Mr. A. L. Steavenson</th>
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<td>To drag load</td>
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<td>Ditto ropes and engine</td>
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<td>Per-cent age of force effective</td>
<td>54.26</td>
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Practically these results may be considered as proving the accuracy of each other, but they are not strictly correct as to the power utilised, because the friction of machinery running without its load is very different when the machine has its load on, and the results are, therefore, better than they should be, and I hope to be able, at an early date, to show what the work done in hauling the tubs really is, taking into account their weight, ascertained friction, and the height and speed; also, by application of a dynamometer, to find the force passing through the rope, the remainder being the loss in the engine.

It is also necessary to reconcile these results with the extensive experiments conducted by the late Mr. Nicholas Wood (and referred to by me at our last meeting, see p. 286, Vol. III.), upon the moving power required to drag out the rope on a plane where the inclination is sufficient to avoid the necessity for applying a tail-rope, and by which it is proved that a power equal to one-twenty-eighth of the weight is sufficient to drag the rope, over sheaves and rollers, nearly 2,000 yards. There can...
be no doubt as to the accuracy of these figures; and I believe the great loss of power will be found in properties of the tail-rope, peculiar to itself, and in curves. Then, if we look further on in the same paper, at page 294, we find the average performance of the Springwell engine to be 53·4 per-cent. of the pressure upon the piston; and in Mr. Nicholas Wood's general results, page 313, he gives the efficient performance of engines on an average, with tail-rope, 40 per-cent., and without, 50 per-cent. The conclusion to be arrived at from all these experiments and results is that there is great room for improvement, but whether by endless-chain, the atmospheric railway, locomotive, or some principle yet to be evolved, I do not at the present time wish to enter upon.

Mr. Greig said, he would give some information on the haulage of ropes in steam ploughing at a future day. He had not got his experiments completed yet.

Mr. G. B. Forster inquired if there was any increase of friction allowed for when they put the load on to the engine.

Mr. Daglish said, Mr. Morison suggested five per-cent. That was not much. There was a greater strain on the drum when it was loaded; but the rope itself formed the great portion of the load.

The President said, they were very much indebted to Mr. Morison for his paper. He would now call on the Tail-rope Committee to read their report.

Mr. Cochrane, as secretary of the Committee, read the following report:

TO THE NORTH OF ENGLAND INSTITUTE OF MINING ENGINEERS.

Gentlemen,—The Committee appointed on the 14th July, 1865, to report upon the various systems of the underground haulage of coals have now the pleasure of presenting their first Report.

The grant of £50, which was made to them in September, 1866, and the purchase, by your Council, of instruments required for the investigation, have enabled them to carry on the experiments necessary for attaining the objects which the Institute had in view when appointing this Committee.

Of the five systems which the Committee have to report upon, they have examined the endless-chain, and they are now engaged with the tail-rope. They think it advisable to present their report on the endless-chain at once, as the results are very interesting. They also present a report on one mode of using the endless-rope.

The endless-chain system has been tested at Burnley, in Lancashire, principally at the collieries under the direction of Mr. Waddington, where it is carried out more largely and more perfectly than at any other collieries; and the Committee consider that they have among these reports the most effective work of which this
system is capable. It is highly satisfactory, and to many members of the Institute will be surprising. It is a system which, in the opinion of the Committee, answers remarkably well in conditions similar to those which prevail in the Burnley district, and it can and no doubt will be largely used in other coal-fields, when its merits are known.

The following appear to be some of the chief advantages of this system. The first construction is very simple and cheap. The way need not be levelled; faults may be surmounted at almost any gradient. The direction can be varied as required by the angle of the mitered or other gearing at any station. The rails need not be so good, or so expensively laid as for high speeds. There are no sheaves to support the chain; hence a great saving in wear and tear. The length of chains is only twice the length of road instead of three times, as required for tail-ropes. The chains last twelve years, and then work lighter "ginneys." The working of the ginneys is very simple; there is no waiting for sets on the main or branch roads; tubs may be run on or off the main line without stopping, and with no sidings. There is no waste of power by drum-brakes, and the tubs descending help those ascending. No idleness is possible when the ginney is going.

The line of rails and chain is so easily and quickly extended in any direction, that putting distances are very short; in the Burnley district, about thirty yards on an average.

The Fowler's Clip-pulley has been tested at Shireoaks: it is at present of limited use, and at this colliery is not extensively applied. A trial on a larger scale and of different arrangement, in the North of England, is being made, and the Committee purpose to make further experiments. The difficulty of adaptation to branches and curves, also to varying gradients, is an objection to this system.

A clip-pulley for endless-chains may prove to be a desirable arrangement, reducing friction and preventing much of the noise which occurs at each "ginney." It has received the attention of the inventor of the clip-pulley, and the Committee hope to give a description of it in a later report.

Your Committee regret that hitherto they have been unable to obtain permission to test the endless-rope, as employed at Cinderhill, where a slow speed and a double line of way are adopted, and several sets are running simultaneously on the full and empty sides. It seems desirable that the slow and regular delivery should be adopted in this system in preference to that used at Shireoaks; there is much, however, to be done to accommodate this system to an extensive underground place, and probably it will be found that gearing similar to that of the endless-chain, as already described, will be required at branches to make it practically useful.

The Committee have expended up to the present time the sum of £38 9s., leaving a balance in hand of £11 11s. They consider that the information which is being obtained will satisfy you as to the expediency of making a further grant which will be necessary in order to complete the experiments.

The Committee beg to remind you that it is in consequence of the gratuitous services of the engineer, and the facilities afforded to them at the various collieries, that the expense falls so lightly on the Institute, and they take the earliest opportunity of thanking Mr. G. H. Wright, who acted in that capacity for the first
two months, and Mr. E. Bainbridge who succeeded him, and is still working for them. These gentlemen volunteered to carry out the experiments wherever the Committee wished, and the Committee have only borne the actual expenses. The attention and skill which have been devoted to the work are sufficiently evidenced by the results which the Committee now lay before you. The Committee also beg to record their thanks to the owners and managers of the collieries where they have been allowed to conduct experiments. Expense and inconvenience have no doubt been incurred by them, but every facility has been gladly afforded, and information given in such detail as deserves the warmest thanks of the Institute.

(Signed) WM. COCHRANE,
Hon. Sec.

Mr. G. B. Forster, assisted by Mr. E. Bainbridge, gave a detailed account of the experiments, which were illustrated by diagrams. After a brief conversation on the subject, the President called on Mr. J. P. Harper to read a paper "On Harper's Improved Safety-cage Apparatus."

After reading the paper, Mr. Harper said the invention was in course of being patented. It was designed for ordinary iron-wire conductors, and the principle was that of compression. It pressed not only the side, but the whole circumference of the conductor. The effect of this was that the conductors were preserved uninjured.

Mr. Nelson Smith produced his model of Broadbent's Patent Safety-cage, and again pointed out the merits of that invention. Wherever it was used the ropes had been found uninjured.

The President said, they were indebted to Mr. Harper, who was a member of the Institute, for his paper. He believed that he (the President) was one of the first that tried Fourdrinier's Safety-cage. Previous to that time it had been the custom to examine the ropes, and now it became necessary to watch the safety-cage. For his part he preferred looking after the ropes. These cages might be better than Fourdrinier's. He saw some safety-cages working at Lord Fitzwilliam's collieries last week. They were said to answer very well; but they never had been called into use, and, therefore, one could not say whether they would hold or not.

Mr. Smith said, at Titus Salts' both ropes broke, and the cage fell full twelve inches. It was the means of saving the lives of the men in the cage.

The meeting then broke up.

Plate XXIV.—Diagrams to illustrate Mr. Steavenson's experiments and remarks, p. 103.
PLAN AND SECTION OF ENGINE PLANE SHOWING PUMPING ARRANGEMENTS AT PLEATHAM MINE.

RATES OF INCLINATION

1 in 12
1 in 17
1 in 17
1 in 12
1 in 20
1 in 8

SECTION

ENGINE PLANE
UNDER LEVEL DRIFT

PLAN

PUMP

GATUN LINE 102 + FEET BELOW ENGINE
PLAN AND ELEVATION OF PUMPING ENGINE AT UPLEATHAM MINES.
PLAN AND SECTION SHOWING PUMPING ARRANGEMENTS IN THE WEST SIDE WORKINGS AT UPLEATHAM MINES.
WITH CLIP PULLEY PLACED HORIZONTALLY.

Scale:
DOUBLE PUMP.
PLAN AND ELEVATION OF CLIP PULLEY,
for converting Power to Underground Winways.
PORTABLE ENGINE, 30 HORSE POWER
with Top Pulley attached Vertically.

Scale
DOUBLE PUMP.