# STATIONARY ENGINES AND GEARING AT COWLAIRS AND EDGE-HILL,

## ON THE INCLINES OF THE EDINBURGH AND GLASGOW, AND LONDON AND NORTH-WESTERN RAILWAYS.

(Illustrated by Five Plates.)

THE systems of machinery adopted for drawing up the trains on the two important inclines at Liverpool and Glasgow - the former on the London and North-Western, and the latter on the Edinburgh and Glasgow Railway - are similar in the apparatus employed. We have therefore selected, for our illustrations of the principle and mode of working in each, that in which the average gradient is highest, the incline longest, and consequently the power employed greatest. The incline at Glasgow is 1½ miles in length, and the average gradient is 1 in 44; while the length of the tunnel at Liverpool is 50 yards short of a mile, and the gradient is only 1 in 80.

The Glasgow and Cowlairs incline commences at the entrance to the tunnel at the Glasgow terminus, and terminates at Cowlairs station, where the engines, and consequently the main part of the gearing, are situated. The trains are drawn up the incline by an endless wire rope, which is carried upon guide-pulleys, as will subsequently be noticed, at a rate usually of 12 miles an hour, which is the slow motion ; when the train is light, this rate may, however, be increased to 20 miles an hour. Communication is maintained between the Cowlairs station and the foot of the incline, by means of an electric telegraph of Cooke and Wheatstone's construction.

### ENGINES AND GEARING ON THE LIVERPOOL INCLINE.

The Lime Street tunnel at Liverpool was opened for traffic on the 15th August, 1836. It is worked by a pair of engines (two cylinders) of the collective nominal power of 80 horses, while, as we shall afterwards see, the combined power of the engines at Cowlairs, near Glasgow, is upwards of 200 horse power. The driving-wheel pro-pelled by the engines at Edge-hill is 19 feet diameter, and round this traverses an endless hempen rope, 8½ inches in circumference. This rope is carried down and up the tunnel on cast-iron pulleys, 20 inches diameter, and the trains are attached to it by light messenger-ropes. The length of the tunnel, as already stated, is about 50 yards less than a mile, and the gradient 1 in 80. The rope is only used to convey trains up the incline. The time taken in bringing up an express train, say of six carriages, averages five minutes ; to bring up an ordinary train, five and a half or six minutes are required - the time varying very little on account of the weight. Cooke and Wheatstone's telegraph is used here also.

### ENGINES AND GEARING IN THE ENGINE-HOUSE AT COWLAIRS, NEAR GLASGOW.

(Plates I., II., and III.) PLATE I.— This plate contains an elevation of both the engines at Cowlairs, taken at an angle of forty-five degrees to the vertical planes of position—the eye, as in other mechanical drawings, being sup-posed at an infinite distance. The representation is therefore equally made an end and side elevation, being equidistant from the planes of both. The scale of the drawing is *three-eighths* of an inch to a foot (that is, 1/32 of the full size), and may be applied directly to all the vertical lines and rounds; but for horizontal lines the scale must be reduced to ¼ inch (more nearly 0.265 inch).

The engines, it will be perceived, belong to the high-pressure class. The steam cylinders are each 28 inches diameter, with 6 feet of stroke. They are supplied with steam by eight boilers, each 30 feet long by 5 feet diameter, with a flue of 20½ inches diameter. The general pressure in the boilers is 50 lbs. on the square inch; and the number of strokes of each engine per minute 19, so that the combined power, calculated by Tredgold's rule, is 205 H.P.

The drawing shows the working beams and spring beams, sup-ported upon a strong entablature, which rests upon four fluted columns, set on pedestals. The entablatures, columns, and pedestals, are all of cast-iron; the columns are turned at their upper ends, and accurately fitted and tottered into sockets bored in the entablature, as shown in fig. 1 of Plate IV., upon which all the principal dimensions are marked. All the centres in the beams are likewise fitted metal-and-metal, by boring and turning, and both the beams and the connecting-rods are turned and polished at their extremities, and feather-edged throughout their length. The details of the connecting-rods, with the dimensions marked, are given in fig. 2 of Plate IV. The construction of the links of the parallel motion is shown also in the same plate, in fall detail, fig. 3. These, of course, and the cranks and crank-shaft, are of malleable iron.

On the crank-shaft is placed a large spur-wheel of 12 feet diameter, 4 inches pitch, 15 inches breadth, and weighing eleven and a half tons. This wheel, which is shown in proportion and position in the drawing, communicates its motion, by a pinion of 6 feet 7 inches diameter, to the pulley gearing, by which the traction rope of the incline is worked, and which will subsequently be described. The other parts of the engines are more distinctly shown in the drawings of the two other plates.

PLATE II.— This gives a front view of the cylinders and nozzles, and shows the steam-pipes and valve-gearing, on a scale of one-fourth of an inch to the foot, or 1-48th.

PLATE III.— This exhibits the engines in-plan. In the one engine, the beam, spring beams, and entablature are removed, and the cylinder, nozzle columns, and main columns are shown in section, also on a scale of one-fourth of an inch to the foot, or 1-48th. The steam-pipe, a a, from the boilers, is fitted with stop-valves at the branches, b b, of the nozzles. These valves are opened and shut by a shaft communicating from the wheel, c, at the hand of the engineer.

The nozzles are cast in one piece, and fitted with piston-valves working in two cylinders, as shown in elevation in the main figure, and also separately by d d in the section, by the figure marked No. 1 in Plate II. The figure marked No. 2, in the same plate, shows the nozzles in plan. The ports or steam passages from the valve-cylinders are formed by oblong openings, placed diagonally in the periphery of the cylinders, to prevent any unequal wear of the pistons. The pistons of the valves are worked from the wyper-shafts, e e, by the levers connected to the hollow stuffing-boxes, f f, attached to the piston-rods.

The starting-bars, g g, of both engines, are placed at the side of the engine-house, near the wheel for the steam-valve, so that the engineer, when working the engines, may be able to see down the incline from one of the engine-house windows.

The wyper-shaft of the near engine is hollow, to allow the shaft of the far engine to pass through it. The cylinders and nozzles are joined by planed faces, metal-to-metal.

The waste steam from the steam-cylinders is blown into a heating-chest by the exhaust pipes, h h. This chest is filled with shelves, leaving a space alternately at the ends of the shelves for the passage of the steam and the water. The construction is indicated by dotted lines in the main figure, and is also shown separately in section in Plate II. Each engine has attached to it a cold-water pump, k k, which draws the water from the pond, and throws it into the top of the heating-chest, and passing down through the shelving, it condenses and abstracts the heat of the waste steam. The feed-pumps, p p, take the heated water from the bottom of the chest to the boilers.

The boilers are placed close to the engine-house, and a range of pipes, 10 inches diameter, conveys the steam to the main steam-pipe, and thence to the nozzles. The steam-pipe of each boiler has a stop or shut valve; there are also two valves upon the main steam-pipe in the engine-house, worked by a shaft communicating to the hand of the engineer.

PULLEY GEARING FOR WORKING ENDLESS ROPE.

(Plates IV., V.—Scale one-fourth inch to the foot.)

As already stated, the power of the engines is transmitted to the pulley gearing for working the endless rope, by the large spur-wheel upon the intermediate or crank-shaft of the engines. This wheel, A, works into a pinion, n, of 6 feet 7 inches diameter on a first motion shaft, and likewise into another pinion of the same size on second motion shaft. This last is not seen in fig. 4 of Plate IV., but is shown in the plan of the engines, Plate III. These shafts are connected by two pinions of different sizes, in order to obtain two speeds on the line; the pinion, D, on the first motion shaft, is 8 feet diameter, and that on the second motion shaft, 5 feet diameter. The main wheel, A, on the crank-shaft, can be geared into either of the first pinions, B, at pleasure, according as the slow or quick speed is desirable—the quick speed being had when the pinion, B, upon the first motion shaft is in gear, and the slow speed when the corresponding pulley upon the second motion shaft is in gear.

For the purpose of effecting this change of speed, the first motion shaft is provided with a strong clutch-coupling, v, and both shafts set upon sliding pillow-blocks, t t. To change from the quick to the slow speed, the moveable half of the coupling, v, is slid back upon its shaft ; the moveable pillow-blocks are then taken back to bring the pinion out of gear with the main wheel, A ; the pillow-blocks of the second motion shaft are then shifted forward, till its first pinion, B, is brought into gear with the main wheel, A, and its second, or 5-feet pinion, into gear with the 8-feet pinion, D, which is fast upon

the main pulley-shaft : the operation is then complete. The arrangement is shown very clearly in the plan, Plate II., and by fig. 4 of Plate IV.

The main pulley, P, which is placed under the line of rails as shown in the elevation, Plate V., is 18 feet diameter, has three grooves for the rope in its periphery, and weighs 27 tons. It is fitted accurately together in eight arms, and an equal number of segments, to a centre, as shown by fig. 5 in Plate IV. It carries a drag race, v, strongly bolted to the arms, through which, by means of its strap, the engines may be instantly stopped in case of accident. The friction-strap is of malleable iron, lined with plate copper, that it may act the more energetically, and be less liable to heat while bringing the pulley to rest. This strap is worked by a wheel, s, shown in Plate III.

From the main pulley, the rope passes over two 10-feet double-grooved pulleys, E and F, weighing about 10 tons each ; one 10-feet single-grooved pulley, G, of about 4½ tons, and a 7-feet single-grooved pulley, .a, of about 2½ tons. The pulley, F, is placed horizontally upon a carriage or frame, set upon rails, as shown in Plate V., and has a run of 20 yards, To the end of the carriage is attached a chain, which passes over a pulley at the end of the rails, and descends into a well, suspending a weight of about 4 tons as a counterbalance, and to keep the rope taut. The pulley, H, is also placed horizontally, opposite pulley, F, for the purpose of reversing the direction of the rope. All the pulley centres are of malleable iron, running in brass-bushed pillow-blocks. The main pulley-shaft is also of malleable iron, and 12 inches diameter.

The course of the rope is indicated in direction by arrows, marked both on the elevation and plan given in Plate V. On the ascending side of the line, it enters upon the main pulley, P, from which it turns to the pulley, E, forming two turns and a half upon r, and one and a half upon E. It then leads to the boggie pulley, F, making one and a half turns upon it, and half a turn upon the pulley, H, passing from pulley, F, to pulley, G., and then to the descending line, where, near the mouth of the tunnel at Queen Street, it passes round a pulley of 10 feet diameter, placed horizontally under the rails. This pulley is shown by fig. 6 in Plate IV. The rope then leads up the incline, and is supported throughout by a series of guide-pulleys set about 18 feet apart. These pulleys are built of wood upon iron centres, with malleable iron spindles passing through them, which run in brass bearings; they are set in neat cast-iron boxes, fixed in the ground between the rails.

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