Section III.—MACHINERY.

"Speeds of Overhead and other Cranes for the Economic Handling of Material."[1]

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Cranes may be defined as machines for lifting loads and moving them to another place. The hook of the crane must therefore have both vertical and horizontal movement; and the method by which the latter is obtained gives a means of classifying cranes. They may accordingly be classified as follows:—

1. *Fixed Cranes*, comprising:—
   (*a*) *Fixed Jib Cranes*, having rotary or slewing motion, with or without means of derricking the jib to vary the radius.
   (*b*) *Fixed Rotary Cranes*, having a trolley which can be racked in or out on a horizontal track, to vary the radius.

2. *Moving Cranes*, comprising:—
   (*c*) *Overhead Travelling Cranes*, having lifting, cross-traversing, and longitudinal-travelling motions.
   (*d*) *Gantry* or *Goliath Cranes*, identical with (*c*) except that the bridge rests on the ground by legs, instead of on an overhead runway.
   (*e*) *Cantilever Cranes*, being identical with (*d*) except that the supports are at the centre, instead of at the extreme ends, and run on a track of moderate gauge.
   (*f*) *Locomotive Cranes*, generally steam-driven, being identical with (*a*) except that they travel on a track.

There are many combinations and variations of these six classes. The motive powers which may be used comprise flying rope, square shafting, steam, hydraulic power, and electricity. The first two may be dismissed as already superseded; steam-power is now chiefly used for "locomotive" cranes with a wide radius of action. Where movements are sufficiently restricted to be always within range of a central power-generating plant, hydraulic- and electric-power are largely used. Electricity is rapidly displacing all other forms of power-transmission for cranes. Its advantages over

[1] *The Engineer*, vol. xcv. p. 620. *Engineering*, vol. lxxv. pp. 824 and 834.

hydraulic power are its greater economy, ease of transmission, flexibility, and less liability to trouble from changes of temperature. The advantages possessed by hydraulic power of greater simplicity and precision are being rapidly overtaken by improved electric appliances and methods of manufacture. The present Paper will therefore deal almost exclusively with electric cranes.

The most suitable form of electric energy is continuous current, at 220 to 500 volts. This is superior to alternating current on account of the greater starting-torque and acceleration given by the former. The operations of a crane involve a rapid succession of startings and stoppings; continuous running occupies an unimportant fraction of the time, and loads are very variable. Alternating-current motors, while efficient at full loads, can have a strong starting-torque only at the expense of efficiency. Continuous current, on the other hand, admits of easier regulation of motors, is cheaper in wiring, and can be stored in batteries to equalise a variable load. Series-wound motors, which automatically run faster with lighter loads, should be used if they are coupled permanently to the gearing. They should withstand 100 per cent. overloading for short periods, and much higher overloads momentarily without damage: which conditions are fulfilled by the ordinary tramway-type. Where motors run continuously, with clutch-connections to the gearing, they should be shunt-wound.

The proper speeds for a crane depend on the purpose for which it is intended. The ideal condition is rapid acceleration, uniform motion at a high speed, and quick slowing down. Rapid acceleration can be obtained by employing series-wound motors, if permanently coupled; or by the inertia of a continuously-running motor, if working through clutches. Quick stopping is effectively attained by an electric brake working on the armature shaft, applied by a weight or spring, and taken off by a solenoid in series with the motor. Such a brake is of almost universal application to the hoisting motor, and serves not only to prevent the load from accidentally running down, but also to stop the motor quickly, giving to the motion the exactitude and precision characteristic of hydraulic cranes. Most cranes are fitted with an additional mechanical brake, which prevents the load from descending fast enough to drive the motor.

(*a*) *Fixed Jib-Cranes.*—With these may be included cranes mounted on a carriage, and having a slow travelling-motion not in constant use. High speeds are necessary when jib-cranes are used for loading and unloading ships. In the most recent practice, hoisting is done by the hoisting-motor through a friction-clutch, and lowering by the foot-brake. An electric brake stops the motor when the current is cut off; but the hoisting-drum is disconnected, and lowering is accomplished independently of the motor, which need not reverse. In a typical 3-ton dock-crane of English make, the cycle of lifting, slewing, lowering, and slewing back, is performed in 43 seconds. In another recently-built 3-ton crane, the lifting-speed is 150 feet per minute, and the slewing-speed is three complete revolutions per minute. Derricking is more common in England than abroad, and may be done at slow speeds by a small motor. A single hoisting-rope is preferable for working light loads quickly. Slewing is done by a separate motor.

(*b*) *Fixed Rotary Cranes.*—These are usually for heavy loads where speed is unimportant.

(*c*) *Overhead Travelling Cranes.*—These are used in steel-works, engineering-shops, foundries, etc., and should have a separate motor for each of the three motions, controlled by an operator at one end of the bridge. If horizontal movement is effected by a continuously-running motor and clutch-gear, the suddenness of starting sets up swinging of the load, which is obviated by the more gradual acceleration of separate motors. The longitudinal travelling is usually the quickest motion, as the distances covered are relatively great. If the load is habitually lifted by a sling, and if a single slinger is employed, the longitudinal speed is limited by the speed at which he can walk from one point to the other, and it is useless to exceed this. Assuming the slinger to walk at 4 miles per hour, or 350 feet per minute, he should start as soon as the load leaves the ground, and should be at the depositing point when it nearly touches the ground. His presence is unnecessary during most of the actual lifting and lowering. The crane should therefore travel faster than the man, and should overtake him half way. The maximum useful speed is thus 400 or 450 feet per minute, depending on the average run. With a practised operator, cross traversing takes place simultaneously with longitudinal travelling, and occupies no extra time. In the latest American practice, two slingers are employed, one at each end of the shop, rendering much higher speeds possible. In one instance longitudinal travel is at the rate of 800 feet per minute, and cross traversing at 250 feet per minute.

If the crane is of large capacity, an auxiliary hoisting-drum or an independent trolley for light loads saves both power and time. In Appendix I. are given the speeds of typical modern cranes for shops, by both English and American makers, indicating that English speeds are still considerably below American.

Apart from the motor, a mechanical efficiency of $66\frac{2}{3}$ per cent. in the lifting mechanism itself may be assumed with good workmanship, and if only spur-gearing is used. Worm-gearing reduces this by about 10 per cent. under the best conditions, and is popular in Germany, although not considered good practice in England or America. Longitudinal travelling is much accelerated by having the runway track smooth, designed to resist lateral stresses equal to one-fifth the capacity of the crane. The bridge-tracks should be designed to resist lateral stresses equal to one-fourth the capacity of the crane.

The longitudinal- and cross-traversing gears are sometimes provided with electric brakes to prevent over-running, thus imparting a feeling of confidence to the operator, and enabling him to work at higher speeds. In calculating the brake horse-power of these motors, a tractive force of 50 lbs. and 35 lbs. per ton of total weight should be assumed for longitudinal- and cross-traverse respectively, assuming level tracks, and spur-gearing, and reasonably large track-wheels.

(*d*) and (*e*) *Gantry and Cantilever Cranes.*—These differ chiefly in the gauge of the ground track, and the consequent design of the bridge; the former are wide-gauge and the latter narrow-gauge. They are generally of large dimensions, and are used for moving materials from one point to another in an open space, or in shipbuilding yards. The mechanism is arranged on either of two plans. On the first, the operator's cage is attached to the main structure, and contains one motor with reversing-clutches for controlling the various drums, to which motion is transmitted by ropes. This gives a light trolley, with power to start and stop almost instantaneously, and rapid motions in all three directions. But the complication of three ropes is an objection, and the operator is badly placed for overseeing the work. In the second plan, the operator's cage is on the trolley, and he is always over the hook. This does away with all ropes, except for lifting; but makes the trolley heavy, owing to the weight of the two motors and gearing. The whole structure must therefore be stronger. Opinion is divided as to which plan is best.

The following speeds are typical of a shipbuilding cantilever-crane actuated by ropes and clutches. Hoisting-speed, with 13 tons, 125 feet per minute; with $4\frac{1}{2}$ tons, 350 feet per minute; with $\frac{1}{2}$ ton, 750 feet per minute; trolley-traverse, 400 to 800 feet per minute, according to load; longitudinal travel, 400 to 700 feet per minute. In some instances the trolley-traverse reaches 1,200 feet per minute, and the longitudinal travel 900 feet per minute.

The following speeds are typical of a 5-ton yard cantilever-crane of 200 feet span, with a motor for each motion, and two out of three motors and gears carried on the trolley:—hoisting-speed with full load, 100 feet per minute; longitudinal travelling, 300 feet per minute. For shipbuilding and other purposes, where the longitudinal travelling is important, it is suggested that better service at less cost may be obtained by two or more light rapid cranes of small capacity on parallel overhead runways.

Gantry-cranes, with or without an added cantilever, are largely used for unloading minerals in buckets from ships or stock piles, and are made in England, America, and Germany. Longitudinal travel need not be rapid, being seldom used; but lifting and cross-traversing are rapid, and are done by one motor through clutches and ropes. The bridge or cantilever is frequently inclined downhill towards the ship or picking-up point, in order to use gravity, assisted by a counterweight and tail-rope, for the run-out, the speed being checked by a foot-brake. Remarkable speeds are obtained by these means. A complete cycle of operations, including delivery of the bucket to the end of a 200-foot bridge, can be performed in one minute. The speed of the trolley uphill with full bucket is 800 feet per minute, and the return speed downhill is 1,000 feet per minute.

The Brown Hoisting Company have constructed ore-unloading machinery at West Superior, having an automatic grab-bucket of 1¼ ton capacity. The lift is 40 feet, and the delivery is 150 feet from the wharf edge. A complete cycle of operations is performed in 30 seconds, and 1,000 cycles have been done in 10 hours, inclusive of moving the machine from hatch to hatch of the ship.

A new development in America is to fit such gantry-cranes with independent motors and a "man-trolley," which carries the operator and also the hoisting- and traversing-motors and gears. In one crane now being constructed, the trolley is designed to support a grab-bucket of 8 tons capacity for iron ore. The loaded trolley will weigh 35 tons, and will carry machinery of 500 horse-power. It is intended to travel on a horizontal bridge at 1,000 to 1,200 feet per minute, and to hoist at the rate of 300 to 350 feet per minute.

A still later development is to place the operator on the trolley, but without any driving mechanism. All motors, gearing, driving-drums, and controllers, are situated in a house attached to the main structure. The operator, from his position on the trolley, works the controllers through miniature controllers, somewhat after the manner adopted in an electric elevator. By this plan the combined advantages are obtained of a light trolley, and of perfect supervision over the work by the operator.

(*f*) *Locomotive Steam-Cranes.*—These are largely used and deservedly popular, because of their mobility on an ordinary track without electric connections. The boiler is used as a counterweight, and a single pair of engines drives through clutches the lifting, slewing, derricking, and travelling motions. Typical speeds in such cranes of American manufacture are given in Appendix II.

The following speakers took part in the discussion of the subject:—Messrs. T. Matthews, E. B. Ellington, A. Jamieson, H. Davey, A. T. Tannett-Walker, C. J. Hobbs, and P. Stothert.

[APPENDIXES.

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APPENDIX I.

SPEEDS OF ELECTRIC OVERHEAD TRAVELLING CRANES FOR SHOPS.
(SUNDRY ENGLISH MAKERS.)

Lifting Capacity.	Speed with Full Load, in Feet per Minute.			
	Hoisting.		Cross Traversing.	Longitudinal Travelling.
	Main.	Auxiliary.		
Tons.	Feet.	Feet.	Feet.	Feet.
100	$3\frac{1}{2}$	14	50	80
100	2	7	50	60
50	6	24	70	125
50	3	30	40	80
40	3	..	50	80
20	10	40	100	200
10	10	..	60	150
5	20	..	60	150
3	30	..	60	150
3	30	..	100	325

American Practice.—The usual American practice for shop cranes is: longitudinal travelling, 300 to 450 feet per minute; cross traversing, 100 to 150 feet per minute; and hoisting, 10 to 50 feet per minute, according to the capacity.

APPENDIX II.

SPEEDS OF LOCOMOTIVE STEAM-CRANES (AMERICAN).

Lifting Capacity.	Speed with Full Load, in Feet per Minute.		Speed of Slewing. Complete Revolutions per Minute.
	Hoisting.	Travelling.	
Tons.	Feet.	Feet.	Revs.
3	135	520	6
5	75	460	5
10	$42\frac{1}{2}$	500	4
20	25	300	$2\frac{1}{2}$