Modular Walking Draglines

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Modulbauweise für Schürfkübelbagger
Construction modulaire pour des défonceuses tractées (draglines)
Tipo de construcción por módulos para palas de arrastre
モジュール式歩行用引綱
组合式行动式拉铲挖掘机
كلات السحب المترجحة المديولية

Summary

The development of walking draglines is presented in the context of current operational requirements and the design and development philosophy of the new breed of modular walking draglines is outlined in detail.

1. Early Walking Dragline Development

Quarry shovels and draglines were produced at Ransomes & Rapier Ltd., Ipswich from the early 1920s for mineral mining, and the company soon began the manufacture of large electric stripping shovels to remove overburden for the excavation of iron ore. As industry expanded, greater quantities of coal and iron were required and greater depths of overburden had to be removed to meet the increased demand.

This situation led to the manufacture of the first RAPIER walking dragline in 1939; the RAPIER W170 with 41.1 m boom and a 2.7 m³ bucket. Other units quickly followed; the diesel/electric W80 and the highly successful RAPIER W90 and RAPIER W150. Introduced in the early 1940s, these last two models were in production for 25 years and were exported to various parts of the world, being used in the open pit mining of clay, coal, ironstone and even diamonds. Walking draglines were gradually increasing in capacity, but were still a long way short of today's giant machines; even the W150 had a maximum boom length of 45.4 m and a maximum bucket capacity of 5.3 m³.

1948 saw the first of the large RAPIER walking draglines; the RAPIER W1400 weighing 1500 t which was supplied to strip up to 30 m of overburden from beds of ironstone in the UK. The boom was the first of its kind in the world; triangular in section and constructed of all-welded round tubular chords and lacings. The chords were gas-filled under pressure to detect any cracks which might occur in service; a feature which is still standard on the boom chords and *"A"* frame rear legs of today's larger walking draglines. Should a crack develop, the resulting drop in pressure triggers an audible and visible warning system in the cab, allowing immediate remedial action to be taken, thus minimising down-time and loss of output.

With booms up to 85.9 m in length and buckets up to 18.7 m³ capacity, the W1400 was probably the largest walking dragline in the world at the time.

Various machines were added to the RAPIER range over the years, culminating in the W1800, weighing 1750 t which could be supplied with a maximum boom of 92.3 m and the maximum bucket capacity was 34.4 m³. The last of these machines supplied to the National Coal Board in England has had its first overhaul after 25 years continuous work and is now back in production in South Wales.

The long history of innovation and engineering experience has led to the development of the new generation of RAPIER walking draglines, designed to give much higher outputs than the old machines, and with booms of rectangular lattice construction in high tensile tubular steel. These machines fall into two categories; the larger, all-electric powered walking draglines and the smaller, modular construction RAPIER W700.

2. Electrically Powered Ward-Leonard Control Machines

There are four walking draglines in this range; in ascending order of size they are the RAPIER W800, W1300, W2000 and W3000, all taking A.C. power from site supply and trailing cable via motor generator sets to D.C. motors on each motion.

The largest machine, the W3000, can be fitted with booms up to a maximum of 105.5 m and buckets up to a maximum capacity of 52.5 m³. Maximum suspended load is 158.58 t and the W3000 can operate at radii up to 101 m. Approximate working weight is 3200 t, but the 19.81 m diameter base ensures an average bearing pressure of only 0.98 kg/cm².

RAPIER walking draglines are controlled by one operator, and with such large machines, operator comfort is of paramount importance. The ergonomically-designed cab is insulated and air-conditioned, with seat and controls positioned to reduce fatigue throughout the shift. The cab is located well forward to give the operator 270° vision through the double-glazed windows and away from the machinery house. For night working, the boom lighting illuminates the work area to enable the operator to distinguish easily between overburden and pay mineral.

These larger machines are usually employed on long-life sites, working 24 hours a day with only one 8-hour shift each week for routine maintenance, the site has to be large for the machine to work for an economical length of time (Figs. 1 and 2).

Examples of machines working on long-life projects, include RAPIER W2000s employed in separate open pit coal mines in the USA. In Pennsylvania, a

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Volume 1, Number 2, May 1981 bulk solids handling

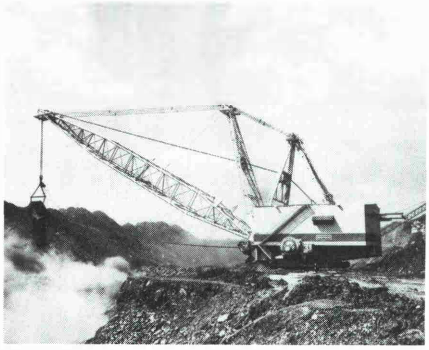

Fig. 1: W2000 walking dragline working in opencast coal mining in Pennsylvania, USA Machine is fitted with a 74.7 m boom and a 33.6 m³ capacity bucket

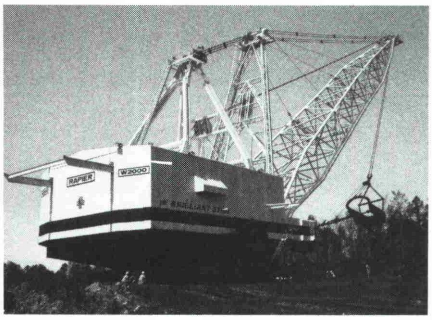

Fig. 2: W2000 walking dragline stripping overburden in an open-cast coal mine in Alabama, USA. Machine carries a 32.9 m³ bucket on a 85 m boom

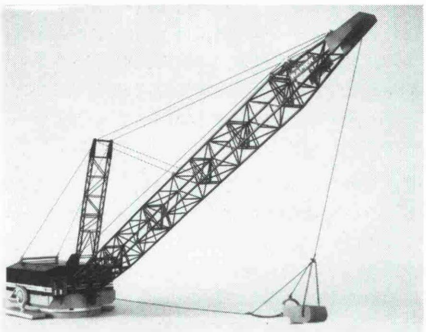

Fig. 3: W700 modular construction walking dragline. Maximum boom length 57.8 m, maximum bucket capacity 13 m³

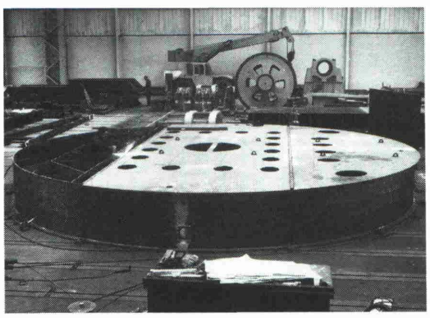

Fig. 4: An early stage in the manufacture of a W700, welding the top plating on a 9 m diameter tub. The three separate tub modules are clearly visible, as is the internal *egg-box* structure for strength and rigidity with minimum weight

W2000 is fitted with a 74.7 m boom and 34 m³ bucket, whilst another unit in Alabama carries a 33 m³ bucket on a 85 m boom. Other W2000 walking draglines are currently being erected in Jordan for phosphate mining and in the USA for opencast coal mining.

As previously stated, these machines are designed for longterm working on one site and are not normally required to be moved to new sites (although in 1974, after 22 years service, a RAPIER W1400 walked 21 km across country between sites in eight weeks), but the concept of the RAPIER W700 is totally different.

3. RAPIER W700 Modular Construction Walking Dragline

The RAPIER W700 is specifically designed as a dragline excavator for easy transportation between sites, for example, operating on large civil engineering projects such as a canal or dam construction, as a pull-back machine working in tandem with a larger dragline, or operating in smaller open pit mines or on site restoration and reclamation. With a maximum boom length of 57.8 m and bucket capacities up to 13 m³, the W700 is the smallest machine in the current RAPIER range (Fig. 3).

As an example of an application, the London Brick Company have recently ordered a W700 which will be put to work in their brickfields.

Typically, a walking dragline's task is to remove overburden, but in this case, it will be removed by scrapers, and the W700 will actually dig the clay. Again, a walking dragline normally dumps its bucket load, but the London Brick Co. machine will be used to fill a hopper, which in turn feeds a conveyor belt travelling towards the kilns.

Being designed to work on small scale projects, the W700 needs to be easily transported between jobs and is designed for rapid stripdown, easy road haulage and quick re-erection on another site. This is achieved by using modular-design and construction with fabricated modules dowelled and bolted together for rapid on-site assembly, as opposed to the larger machines, which are welded on site.

The W700 base consists of three modules and the rotate frame is made up of five modules, each complete with its own integrated machinery, electrical and auxiliary equipment (Fig. 4).

Usually these are shipped as complete fabricated sections for easy erection on site. The boom and mast are both of rectangular, lattice construction with sections flange-jointed and bolted together. This modular construction obviously cuts down erection and transport time and ensures minimum down time, maximum productivity and optimum return on capital employed. The five modules making up the rotate frame consist of the following:

Front module, housing the air reservoirs, boom, mast and fairlead mountings.

Swing module, containing the rotate gear boxes and two vertical slewing motors.

Walk module, carrying the transverse walk shaft, gears and eccentrics, and supports the main hoist and drag machinery, which is built as a separate unit.

Power module, containing the power units and associated components.

Ballast module, housing the ballast blocks to the required weight. The amount of ballast can vary to suit individual specifications and working conditions.

Another difference between the W700 and the larger RAPIER walking draglines is the power supply. The larger machines are electrically driven; when a unit is purchased specifically to work on one site for a number of years, it makes economic sense to make longterm plans and bring the power supply to the site, if indeed such a supply does not already exist. This strategy might prove to be uneconomic for shorter term working — the type of operation for which the RAPIER W700 has been designed — and so the W700 can be built to be powered either electrically by trailing cable for sites with existing power, or by two diesel engines, thus making it completely independent of the site power supply. Even when powered electrically, the W700 differs from the all-electric machines; the latter have D.C. motors for each motion, whereas the W700 has one A.C. motor driving through a mechanical transmission system (Fig. 5).

With maximum boom length, the RAPIER W700 has an approximate working weight of 447 t. Diameter of the base is 9 m, giving an average bearing pressure of 0.86 kg/cm², and the maximum allowable suspended load is 38.56 t.

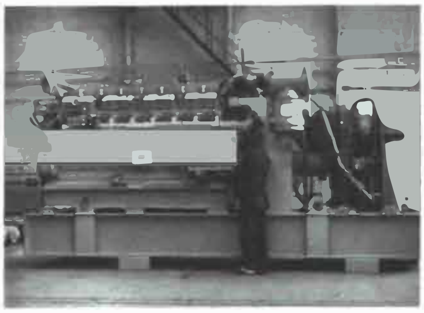

Fig. 5: The main engine for a diesel-powered W700 walking dragline, with modulated clutch and torque converter. Engine is 16 cylinder 'V' type with 970 kW rating at 1300 rpm

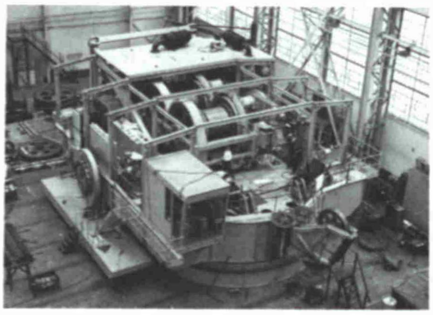

Fig. 6: An example of the extensive pre-despatch trial erection carried out at Ipswich, showing a W700 undergoing final testing prior to being stripped down and shipped

4. Pre-Despatch Erection

An important factor in the manufacture of all RAPIER walking draglines is the substantial amount of erection carried out in the factory before shipping. Wherever possible, major components (except the boom) are trial erected, levelled and bolted together to check accuracy of fitting and to minimise on-site erection time and avoid start-up delays — if the components fit at the factory, then they will fit on site. Components are then dismantled, shipped and re-erected on site by a specialist team under the company's supervision.

In the case of the W700, this pre-erection procedure is extended. Virtually a complete base machine is assembled on the factory floor. The base, rotate frame, operator's cab, walk shoes and associated machinery are assembled before the walking dragline is finally stripped down and shipped (Fig. 6).

A high degree of precision and accuracy is necessary to achieve a fast site erection and therefore trial erection at Ipswich is carried out on floor plates which cover the whole area of 4,645 m^2 of the walking dragline assembly shop. These plates are level to a tolerance of plus or minus 0.4 mm. This method of trial erection was shown to considerably reduce final assembly time when a W2000 was erected and working in the USA in the remarkably short time of 8 1/2 months, despite appalling weather conditions.

5. Walking Draglines — The Future

The efficient use of energy and making the best possible use of the world's fuel resources are two of the main subjects concerning the world today. Recent heavy increases in the cost of oil, and concern over dwindling oil reserves have prompted many countries to re-appraise their energy programmes and to seek alternative energy sources.

There are disadvantages to most of these alternatives; wind, solar and wave-powered generators are still very much in the early stages of development and time is needed to research and expand these sources, while nuclear power is a highly emotive issue on social and environmental grounds. The deficiencies of these systems have led to an increase in the popularity of coal as an alternative energy source, at least until some efficient and viable method of producing energy is developed to replace fossil fuels.

Any up-surge in demand for coal obviously leads to an increase in open-cast coal mining, which is quicker and less expensive than deep mining, and in turn means increased use of walking draglines and other mining machinery.

Coal is by no means the only mineral obtained by open-cast mining and, just as increased demand by industry for raw materials led to the introduction of RAPIER walking draglines in the 1930s and 1940s, the continuing need for more and more minerals will ensure that open pit mining continues and expands. As industry uses up material deposits, greater depths of overburden will have to be removed to expose new seams, and a walking dragline is still the most simple and efficient method of removing large quantities of material and dumping it in the worked out sections of the mine.

Walking draglines have a future as long as open-cast mining of minerals continues. As open pit mines increase in depth, a walking dragline could well be the best type of machine with which to remove the overburden and help restore the site afterwards; a condition being imposed more and more on mining companies. Indeed, wherever geological conditions allow, mine planners look first to big draglines as being the most economical muck shifters.

Ransomes & Rapier Ltd. are one of only four companies in the Western World who design and manufacture walking draglines, and the only company in the UK, the others being American-based.