The Promise of Rail

RMS-1
A new concept in rail maintenance

Low cost conversion successfully tackles creep

The story of Sandy Hollow

Pandrivers'...Putting maintenance on the fast track

Conversion of AREA tieplates

Looking ahead with the advantage of hindsight

"Panlock"

It is encouraging to observe that throughout the world railways are once again a growth industry, offering highly industrialised societies and the developing nations alike an extremely viable and cost effective solution to the problems of moving people and freight.

In many nations the fortunes of rail have, in the past, come and gone—largely due to competition from other forms of transport, but the tables have turned and rail is now very firmly on the increase. Part of this is due to the expansion of freight traffic, particularly across continents and national boundaries, involving newly integrated transport systems linking road, rail, and ferry.

New designs of rolling stock—the 'piggyback' era, plus new types of roll-on roll-off ferryboats, allow maximum flexibility and substantial cost benefits.

In countries such as the United States, Canada, Australia and South Africa, improvements are being made to track and vehicle systems in order to handle increases in the movement of coal, mineral ores, bulk grain and fertilizers for internal use and export markets.

In the developing countries increased economic growth has produced a new demand for improved freight transport facilities to handle increasing agricultural and industrial output. In some of these nations, wealth depends on the successful exploitation of valuable ore deposits, necessitating the upgrading of existing rail links to handle higher speeds and heavier loads. In addition, the delayed impact of the 1974 oil crisis has now begun to manifest itself in a swing to rail as a more economical and less unreliable method of moving freight of all kinds.

As national and personal wealth increases, so the ensuing rising standards of living create a greater demand for intercity and urban passenger transport, while increased tourist development—particularly in the countries of South East Asia—demands new rail networks and replacement to common standards to enable effective links to be made between neighbouring countries.

Some third world countries in Africa and South America are totally landlocked and therefore heavily dependent on effective freight carrying routes to the sea through neighbouring countries, calling for considerable joint investment and co-operation between nations.

All over the world, cities with rapidly growing populations and congested road networks are turning to light rail and metro systems to satisfy capacity, energy conservation and anti-pollution legislation and these systems—although more expensive than roads initially—are being found to have lower subsequent maintenance costs. In addition, existing systems are expanding to meet growing or shifting populations and changing social habits.

In all of these different market areas Pandrol, with its long experience in railway track design and development throughout the world, is uniquely placed to assist in the realisation of tomorrow's rail projects, whether through the provision of essential hardware or in the supply of the more intangible know-how.

The promise of rail is as much a thing of the future as it was of the past.
Two years ago, Randrol International joined forces with Speno International in acquiring Speno Rail Services Co. as part of a planned programme of track-related research, development and expansion. One of the more visible results stemming from that merger has been the birth of a new concept in rail maintenance—RMS-1.

RMS-1 (Rail Maintenance System—1) is a fully automated self-supporting rail grinding system, encompassing advanced microprocessor controlled grinding techniques and continuous rail profile analysis equipment.

The need for such advances stems from the ever increasing problem of ensuring the most beneficial track maintenance from available maintenance budgets.

For many years, Speno rail grinders have been a familiar sight on many railroads. Now because the challenge presented by the need to preserve the rail is so great, Speno has launched new programmes into rail research, equipment design and service. The goal is to achieve a truly productive partnership with the railroads in the development and application of more economical processes for rail maintenance.

The Consequences of Corrugations and Surface Defects

Speno’s research programme has examined the effects of wheel loads on the fatigue life of rail and demonstrates that the life of the rail decreases logarithmically with increasing axle loads. Hence a doubling of the nominal load on the rail, such as occurs with a dynamic impact effect, results in a reduction of the life of the rail by a factor significantly greater than two.

This has been confirmed by actual studies of fatigue defect accumulation under different axle loads, where historical rail defect records were carefully collected for similar track conditions. The studies show that rail fatigue life under 100-ton (US tons) cars is 64% of the life under 70-ton cars and only 48% of the life under mixed traffic loadings.

Since the nominal wheel load for 100-ton cars is 33 KIPS and 27 KIPS for 70-ton cars, it is evident that the doubling of the wheel loads reduces the life of the rail by more than half.

From these and other studies, it can be seen that one of the consequences of rail surface defects is a significant increase in the dynamic loading of the rail and a resulting substantial decrease in its service life. Elimination of these surface defects by rectifying and repolishing the rail head allows the life of the rail to be extended significantly in many cases.

The economics of such maintenance become readily appreciated by the consideration of the costs involved: typically, the replacement of a mile of unserviceable rail with new rail can be as much as 240,000 US dollars (materials and labour) while the cost...
of repainting the rail head in situ would cost as little as 400 to 800 US dollars per mile, depending on condition of the rail. If the track is ground on a periodic basis, the life of the rail will be significantly extended.

The design philosophy behind RMS-1 is based on the desire to provide the further benefits available in being able to analyse the rail head before and after the grinding operation—being able to alter the grinding pattern without stopping the grinding process—and reusing more grinding miles for every hour of track possession.

**RMS-1 . . . The System**

RMS-1 is a fully automatic self-propelled machine. It is 480 ft long, and has two 2,000 hp independent power units—one at either end. Each power unit has its own tank car holding fuel and water.

There are five grinding cars which house the crew and support facilities and under which are situated the one hundred and twenty 20 hp grinding motors.

The independent power units give the machine bi-directional capability, eliminating the need for turning. In addition, with two power units, the risk of breakdown and subsequent traffic delay is minimised. In service RMS-1 is extremely fast—in non-grinding travel it can accelerate from 0 to 30 mph in 30 seconds and has a maximum speed of 70 mph on level track, reducing to 39 mph on a 2% grade (two feet in every hundred). Thus it can operate under new rules, or as a train, fitting with ease into any traffic pattern. In the grinding mode, it can work at speeds from 1.5 mph to 5 mph.

Additional flexibility is provided by the food and fuel storage facilities and crew accommodation. Provision of these facilities means that the crew remain fresh and alert and the machine can be used in remote areas for long periods if necessary.

At the heart of RMS-1 are a series of advanced microprocessor control systems that ensure optimum use of the grinding equipment and provide real-time quality control through on-the-spot measurement of rail condition before and after grinding. Microprocessor controlled actuators also allow grinding to continue close up to both sides of crossings and turnouts with automatic lifting and lowering of the grinding heads at precisely determined points on the track.

**Operation**

As the RMS-1 approaches a rail section, measuring equipment housed in the tank cars automatically checks the rail profile.

RMS-1 has great sensitivity, grinding hard on peaks and gently in valleys using the patented “Speno Active Long Wave” technique. Consistent grinding pressure is maintained by “Autoload”, another Speno control exclusive.

Contour head grinding and widely varying patterns are accomplished by 40°/10°/40° grinding wheel angles spread over 120°-grinding heads, with automatic angle control on all motors. Accurate control of grinding allows precise metal removal of as little as 0.004 inch or as much as 0.006 inch, covering the full spectrum of rail maintenance problems.
Low cost conversion successfully tackles creep

One of the many advantages offered by Pandrol systems is their ability to update an existing track to modern standards of efficiency at relatively low cost.

A recent example has been on one of Liberia's main transport arteries, the railway from the LAMCO ore deposits at Nimba Yelepa, on the Liberia/Guinea border to the Port of Buchanan on West Africa's Atlantic coast.

The track, which took three years to build, falls more than 350 metres over its length and has a maximum gradient of 2% for loaded trains and 17% for empty. Along the line are eight unmanned passing sidings, two steel bridges over the St Johns River, one 82 metres long, plus twenty or more smaller bridges and viaducts.

Eight full ore trains a day leave Nimba Yelepa for the six hour journey to the coast, running at a maximum speed of 80 kph. Trains are made up of either three Henschel diesel electric locomotives and ninety ore cars of 90 tonne capacity or two locomotives and sixty cars; the ore loads being 8100 tonnes or 5400 tonnes respectively. The maximum train weight amounts to around 11,000 tonnes, with a permissible axle loading of 30 tonnes.

The track consists of 136 Ryley flat-bottomed rail, fastened to hardwood timber sleepers. As originally laid the track was jointed and fastened with 'Elastic Rail Spikes'. With the weight of the traffic, however, creep soon became a problem. To overcome this the rails were welded into a continuous length and the rail spikes replaced on all curves by DE fastenings, leaving 'Elastic Rail Spikes' only in straight sections of track. This did not completely solve the problem, so Pandrol offered LAMCO a simple conversation system that would confer the Pandrol Clip's excellent creep resistance and superior toe holding power at very low cost. This consisted of AREA Plan 9 baseplates fastened to the timber sleeper with rail spikes, each plate fitted with two hook-in shoulders, which locate in spike holes in the baseplate and carry two Pandrol 'Z Series' rail clips.

The system has the advantage of being able to be installed with nothing more complicated than a drill for the rail spike clearance holes, a crowbar to support the sleeper against the rail foot during assembly and a 7lb track hammer to fit the hook-in shoulders and drive home the clips.

In 1981/82 1000 trial sets of the Pandrol assembly were installed in the parts of the track with the worst creep conditions, such was their success that LAMCO have now ordered a further 110,000 sets.
The story of Sandy Hollow coal haul railway

In New South Wales, Australia, Pandrol helped to put a happy ending to the story of Sandy Hollow.

The Sandy Hollow railway line has had a colourful history and has been the subject of considerable public debate. It was started by government funding in the 1900's but, with limited public resources, the development ceased until the oil crisis made coal a highly desired commodity.

In 1911 it was estimated that the cost of the Sandy Hollow-Maryvale link would be $52.36 million. Later there were discussions between the Railways Commissioner and the Minister for Public Works detailing increases in construction costs since 1922. By 1932, the escalation in estimated cost had risen to $5.724 million. In July 1936, the long-awaited first sod was turned.

The next step in the story comes in 1975, when White Industries purchased the Ulan coal mine with the intention of greatly expanding production and seeking export orders.
Some three years later, in 1978, Mr G. White, Managing Director of White Industries, suggested that his company could finance the extension of the line to Ulan. Mitsubishi Development Pty Ltd purchased 40 per cent equity in the Ulan Coal mine and as a result Ulan Coal Mines Ltd (U.C.M.L.) was formed. This venture provided the financial strength to complete the mine and railway development.

In accordance with the agreement, all work became the responsibility of U.C.M.L. through their appointed Construction Managers, White Industries Limited. Major portions of the work were carried out under contract following the calling of public tenders, with the State Rail Authority of N.S.W. approving the calling of tenders, the contracts and the schedule of work. Technical advice to the Construction Manager was provided by Crooks Mitchell Peacock Stewart Pty Limited.

U.C.M.L. commenced contract and technical negotiations for the development of the line with the government. This involved the Premiers Department, the Department of Mineral Resources and Development.

Negotiations took 26 years. The initial agreement was signed on 15/5/200, but the final signing of the Agreement did not take place until the 12th December 1980 and the Enabling Letter on Christmas Eve, 1980.

During the negotiations it became apparent that the government was not willing to contribute funds nor facilities for the construction of the line. The following agreement was finally concluded:

- The whole of the project was to be financed by Ulan Coal Mines Limited.
- The design and construction were to be organised by U.C.M.L. to standards specified by the State Rail Authority of New South Wales.
- On completion, the line was to be handed over to the State Rail Authority of New South Wales, who would then operate and maintain it without interference from U.C.M.L.
- By way of strict enforcements on coal transported from Ulan, the State Rail Authority of New South Wales would repay the U.C.M.L. for the expenditure, plus interest.

In addition, U.C.M.L. negotiated that adjacent coal leases at Ulan be granted to the company to permit it to produce coal for a longer period and hence utilise the railway line it had funded.

The total cost of construction of the line was estimated at $60 million to June 1982. Construction began during early 1982, beginning with clearing and surveying. On 4th September 1980, the Premier of N.S.W., Mr. Wran, turned the first sod at a commencement ceremony and at Ulan on 15th October 1982, Mr. Wran performed the opening ceremony.

Mr Wran has indicated that the final section of the Sandy Hollow line from Gulgong to Maryvale, a distance of 72 km, will also be completed. No date has yet been set for this project.

The total length of standard gauge 8'3"/435mm line from Muswellbrook to Ulan is about 150 km, passing through four tunnels and over 560 metres of bridges. About 50 per cent of all track is curved, the sharpest curve being 6.20 degrees.

The railway line itself is single track designed to the highest standards of any line in N.S.W. It is planned to take 16 coal trains per day at 80km/h on this line, with all trains being 4.2km long and each train carrying 4,100 tonnes of coal per day.

The rail fastening system comprises Pandrol Brand type e 2000 series clips, high density polyethylene rail pads, glass reinforced nylon insulation and cast iron S.G.I. Pandrol shoulder anchors. A Pandrol 'o' was to install the Pandrol rail clips during construction and subsequent de-stressing operations. The Pandrol system was installed in concert with the tracklaying fleet.

The Ballast used is 2900mm x 250mm wide x 212mm deep at the rail seat. These sleepers were based on a modified British Rail design. A sleeper factory was established at Denman and 290,000 sleepers were manufactured at a rate of more than 800 per day. Approximately 16,000 tonnes of 53 kg/m rail was used on the project. Construction was programmed to lay at a rate of 6.6 km per week. The fully welded track was laid by a special machine, the Plasser ETA1000 which laid the track at an average of 1.3 km per day.

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GENERAL TECHNICAL DATA

- Track Gauge: 4'8"9'/1435mm
- Axle Load: 25 tonnes
- Sleeper Spacing: 600 mm
- CWR: 53 kg/m initially interchangeable with 60 kg/m
- Sleeper Size: Concrete monoblock, 25.5 metres long—286 kg each
- Turnouts: 1 in 15 on timber bearers, total number 11 with Pandrol fastenings
- Bridge Deck: Timber transom/Pandrol rolled steel sleeper plates
- Level Crossings: Special prefabricated type at main road crossings
- Maximum Gradient: 1 in 80 compensated to against unladen train
- Sharp Curve: 6°-12171 chains
- Rail Fastening: Pandrol Brand type e series clips, G.R.N. Insulators, HDPE rail pads and S.G.I. Pandrol shoulders
- Ballast: 300mm below sleepers—crushed basalt
- Bridging Total Length: 950 metres

Footnote: We would like to thank the State Rail Authority of New South Wales and Crooks Mitchell Peacock Stewart Pty Limited for assistance in preparing this article.
Driving Pandrol rail clips or removing them for de-stressing or other maintenance operations is extremely simple, needing nothing more than a hammer or one of the specially designed hand tools, such as the 'Panpuller'.

But to get things really moving calls for something faster—one of the purpose-built Pandriver systems, specially designed for fast installation and removal of Pandrol clips.

At the bottom of the range is the Mk I, a lightweight, portable unit powered by a 3 hp, air-cooled petrol engine. The Mk I weighs just 144 kg and is capable of installing or extracting two clips simultaneously at a speed of six sleepers per minute.

For clip installation the unit requires a team of two, one to operate the unit, the other to place the clips. The clips are pre-positioned by hand such that the centre leg is
More sophisticated is the Pandriver Mk V, designed to be taken to or near the working site on a trailer or wagon and then to travel under its own power at up to 12 mph in forward or reverse directions. The unit is powered by a 20 hp diesel engine and is available for standard or narrow gauge. It can be fitted with a cabin or canopy to afford protection for the driver.

The unit is designed to install or extract all four clips simultaneously at a rate of 750 sleepers per hour and can be supplied with a magazine feed system for totally automatic installation of Pandrol e-series clips. A separate last extraction module can be supplied which will remove two clips per sleeper at up to 9000 clips per hour.

A turntable is built into the machine which can be lowered to support its own weight on a turntable and allow the machine to be swung round by hand for travel in the opposite direction. This turntable may also be used in conjunction with the rail clamps to lift the rails for pad changing or positioning of de-stressing rollers.

Finally, the Pandriver Mk VII which has the distinction of being able to operate successfully on worn and flanged rail. With lower drive power than the Mk VI (output of 30 bhp), the vehicle has 4-wheel drive and can still travel at 30 mph in either direction on a maximum incline of 1:20. Operated by one man, the Mk VII will install four clips per sleeper simultaneously and has a separate extraction module capable of removing two clips per sleeper at a constant speed of 3-5 mph in reverse. As with the Mk V the unit features a turntable which may be used with jacks and rail clamps to lift the rail for de-stressing operations.
Conversion of AREA tieplates to the 'Pandrol' system using hook-in shoulders

1. Conversion to the Pandrol clip system is made using one field side (painted red) and one gauge side (painted black) hook-in shoulder per rail seat and two v Series or PF Series rail clips.

2. Seen from either the track or the gauge side the hook-in shoulder is always fitted into the right hand tie/spike/CRS spike hole. Depending on the spike pattern, however there may not be a hole drilled in the sleeper at the appropriate point. In this case a clearance hole, the same diameter as the spike hole, should be drilled into the sleeper to a depth of not less than 2 inches. Do not attempt to drive a shoulder through the spike hole without drilling this hole as the shoulder stem may distort. Remove the righthand spikes securing the tieplate to the sleeper at either side of the rail.

3. Place a crowbar underneath the sleeper and lever it upwards so that the tie plate is held firmly against the rail foot. This contact must be maintained for the rest of the operation. Failure to do so might cause the shoulder stem to foul the bottom of the tie plate.

4. Take the appropriate field side or gauge side conversion shoulder and, holding as near the vertical as possible, insert the shoulder stem into the spike hole in the tie plate. With the end of the stem firmly engaged beneath the rail foot, force the shoulder down by hand with a rotating motion towards the sleeper.

5. With a 7 lb hammer drive the shoulder downwards until it meets the tieplate; this will install the shoulder in the correct position.

6. Take a rail clip and introduce the centre leg of the clip into the shoulder housing. Repeat for the other side of the rail seat and the crowbar can be released as the clips will hold the sleeper to the rail. (The clips are inserted in opposite directions on either side of the sleeper.)

7. Using the Painpuller or a hammer, partly drive the clip into the shoulder housing. Do not drive the clip fully home since, if completely installed, the front arch of the clip could foul the tie spike hole on smaller tie plates such as AREA Plan 9.

8. Using one of the spare spike holes, drive the tie spikes removed in (2) into the sleeper with the straight part of the head towards the side of the shoulder.

9. The sleeper can now be lowered, the crowbar removed and the clips driven fully home.

10. Hook in shoulders are marked and painted as follows:
- Field side—marked 0, painted Red
- Gauge side—marked 1, painted Black.
Looking ahead with the advantage of hindsight

In the face of competition from other forms of transportation, the world's railways are using technology to increase their operating efficiency, to provide safer and more reliable services and to reduce running and maintenance costs.

One of the more important areas and possibly the most vital, is the track itself — its ability to carry the traffic and the costs involved in its maintenance. Great savings have been made with the introduction of machines to undertake routine ballast maintenance and track alignment, replacing legions of men who were formerly employed to carry out this demanding task by hand. Equipment is now available to lay new track and renew old that requires only a fraction of the labour force needed previously. In addition, new track components and particularly rail fastening components have been designed and developed specifically to reduce the maintenance effort required.

Fifty years at the forefront of resilient rail fastenings design and development has provided Pendrel with a wealth of knowledge covering all aspects of permanent way engineering around the world. Throughout this time the demands on the track have steadily increased as speeds and axle loads have gone up in an effort to remain competitive. Permanent way engineering has, to a great extent, remained a practical art, but with these increasing demands, a much greater understanding of the total track behaviour is required if designers are to efficiently develop systems and components. To gain such experience and data, Pendrel has embarked upon a new research and development programme. Much of the work is being carried out in a new dynamics laboratory which has been built at Workspol in Nottinghamshire and equipped with the most up to date computer controlled servo-hydraulic testing rigs. Here, components are instrumented and their performance monitored supported by in-track measurements made under operational service.

Dynamic forces have a very significant effect upon track performance and these are being studied, theoretically and practically. Pendrel's approach to understanding track behaviour is based upon a triad of very closely related activities comprising theoretical analysis, laboratory simulation and in-track measurements. In general the factors that dictate the direction of any research programme tend to be 'trend' related. Our research programme is no exception. Higher axle loads, greater speeds, longer heavier unit trains and minimum disruption to traffic for maintenance requirements are the trends which dictate the direction of current research into the behaviour of the structure of the permanent way.

The Importance of Rail Pads

The increasing cost of timber and the decreasing availability of the species which provide good railway sleepers have caused many railways to change to the use of concrete. The concrete sleeper, however, lacks the natural vibration damping characteristics of timber and dynamic forces tend to be developed and transmitted through to the ballast. These forces are of growing significance and the only opportunity to isolate them from the sleeper occurs at the rail/sleeper interface where a rail pad can be interposed. The pad is one of the least accessible components in the track system and its replacement is a time consuming and relatively expensive operation requiring track occupation. To be effective, therefore, it must have a long life under service conditions. Polyurethanes, in various forms, provide a good basic long life material but have poor vibration attenuation properties while rubbers, both natural and synthetic, have better vibration attenuation properties but a shorter life. In physical terms, surface shaping can have a significant effect upon the overall performance of the pad and thickness is also a very important factor. Although small in size, the rail pad is of vital importance in modern track design and part of Pendrel's research effort is specifically aimed at the design and development of a small, improved range of pads, each suited to the specific needs of the various types of rail application.
Ever since the introduction of bull-head rail the problem of holding it securely in the chair has caused track maintenance engineers considerable headaches.

One of the earliest methods used was to drive a wooden key between the rail and the chair. This was usually made of English oak, but in corrosive tunnel conditions these keys were usually specified. Unfortunately, as with so many things, the traditional British product is no longer available in sufficient quantity and in recent years British Rail has had to turn to Japanese oak to fill the gap. By some trick of nature, it is not readily absorbent and so once its natural moisture has evaporated it tends to dry out during the summer months. This results in shrinkage and, if unchecked, the key falls out of the chair.

An alternative method used on many tracks is the steel key. These have many advantages over their timber counterparts as they are less affected by weather conditions and are very successful in arresting longitudinal rail creep. However, they do tend to fall out in very cold conditions. Another problem is that steel keys are apt to be crushed and fall out when used on check rails, so much so that the generally accepted rule has been to use only wooden keys in the check rail and steel keys in the running rail. Such systems of fastening are clearly uneconomic since to ensure track safety it is often necessary to re-drive wood and steel keys daily on particularly busy sections. In addition, once a steel or wooden key has fallen out or has been over driven through a chair it may be deformed.

Faced with such problems British Rail engineers asked Pandrol if a key could be developed that, once driven, would lock into the chair and not fall out. After extensive in-track testing of three candidate designs, Pandrol came up with the Pandlock. This proved to be extremely successful as shown by the fact that even after nine months use they were still firmly in position on check and running rails that had previously needed re-driving every day. Test lengths were installed at Staines Station in Middlesex, fitted to all types of old bull-head chairs on bull-head running and check rails, and in the Birmingham area, where they were installed on bull-head check rails and flat-head running rails using chair types CCX Pan 9/51 and CCX Pan 9/44 (Note: 51 and 44 denote flangeway clearance).

Now with the system proven in use, Pandrol have received orders for 6000 Pandlocks with interest being shown from all Regions of British Rail.