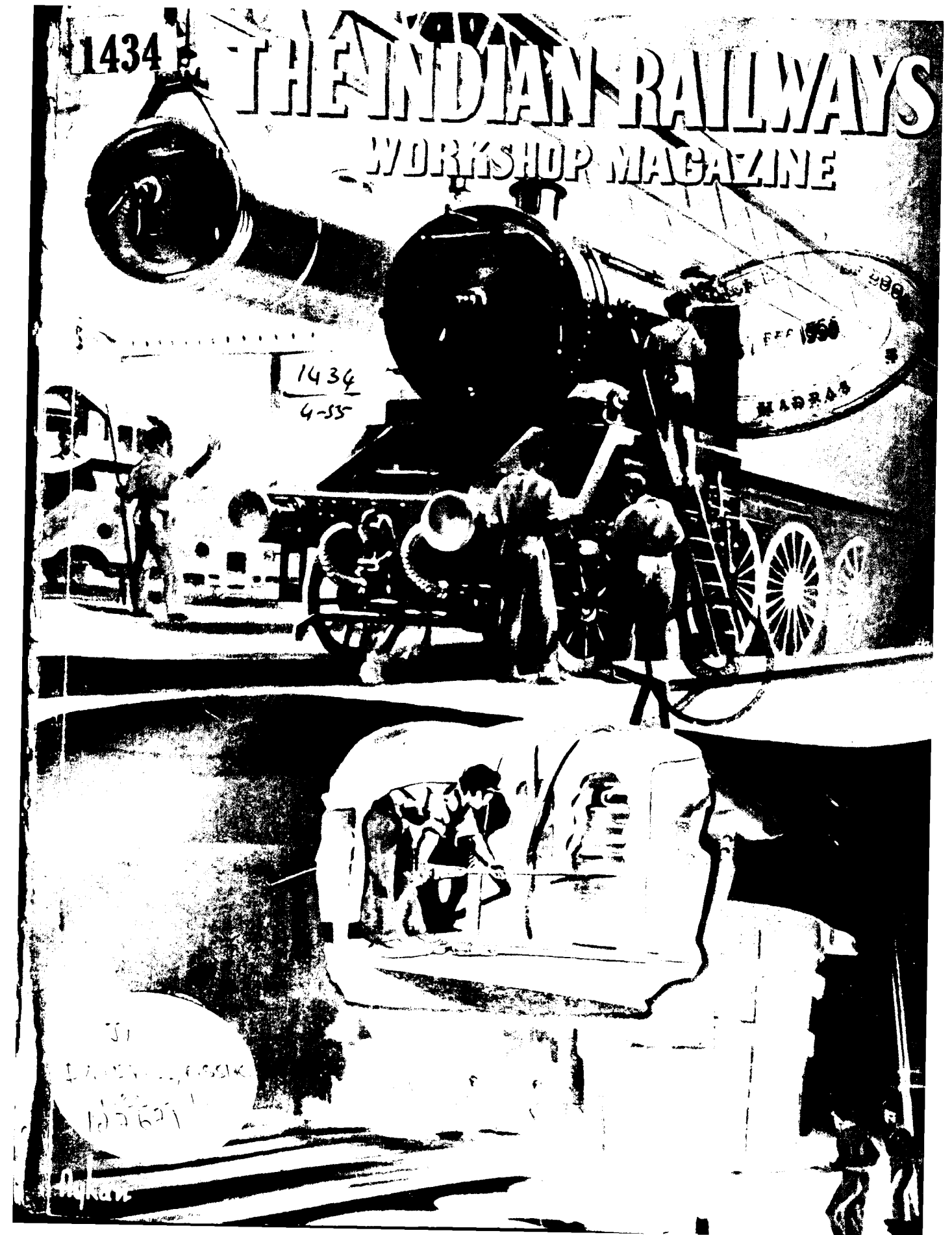




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THE INDIAN RAILWAYS

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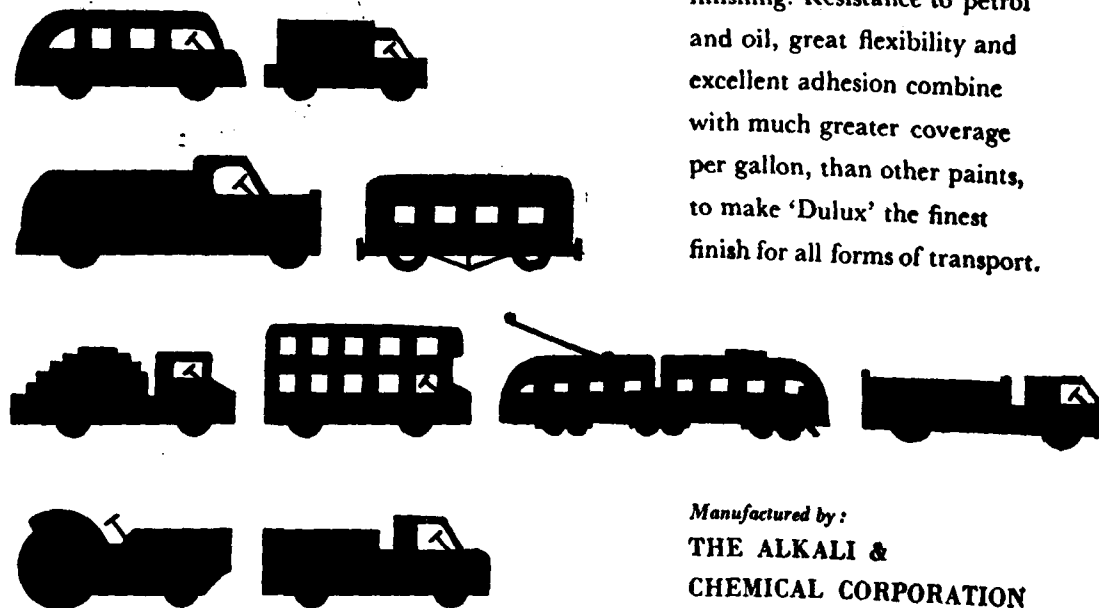
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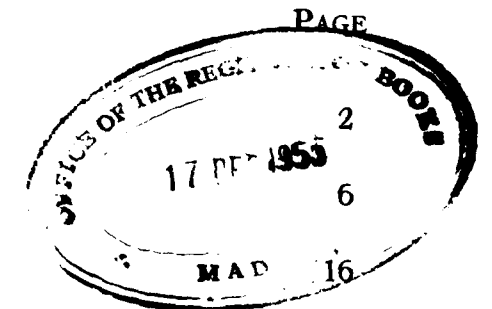
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WELDING & CUTTING ON INDIAN RAILWAYS

By A. P. Forsyth, A. M. I. W.

THERE are many varied uses to which welding and oxygen cutting are put on the Indian Railways to-day. Besides oxy-acetylene welding and manual arc welding many different and more uncommon welding processes are used including resistance welding, submerged arc welding and to a smaller but growing extent, argonarc welding. The uses of welding and cutting on the Railways can be divided into two groups; first their uses in the manufacture of new components, and secondly the use of these two versatile processes in the repair and maintenance of rolling stock, the permanent way, etc.

Some examples of both types of use will be given in this article along with a broad review of the lines along which welding as applied to railways may be expected to develop in the future as new, quicker and more efficient methods are adopted.

Oxygen cutting is used extensively in the manufacture of locomotives at Chittaranjan and Jamshedpur, the plates being cut to size before welding, usually by means of a cutting blowpipe mounted on a motor driven carriage. Often two or even three blowpipes are mounted together enabling the edges of thick plate to be cut and bevelled ready for welding in one operation. At present unfortunately, there is still in this country opposition to the use of flame cut surfaces as a preparation for welding, but in other industrialised countries the use of oxygen machine cutting is now accepted as the most efficient and economical method of shaping steel for this purpose; proof that fears of adverse effects from using this method of plate edge preparation are unfounded is shown by the fact that the British Admiralty, Lloyd's Register of Shipping and the U.S. Association of Insurance Offices Technical Committee have approved the use of:

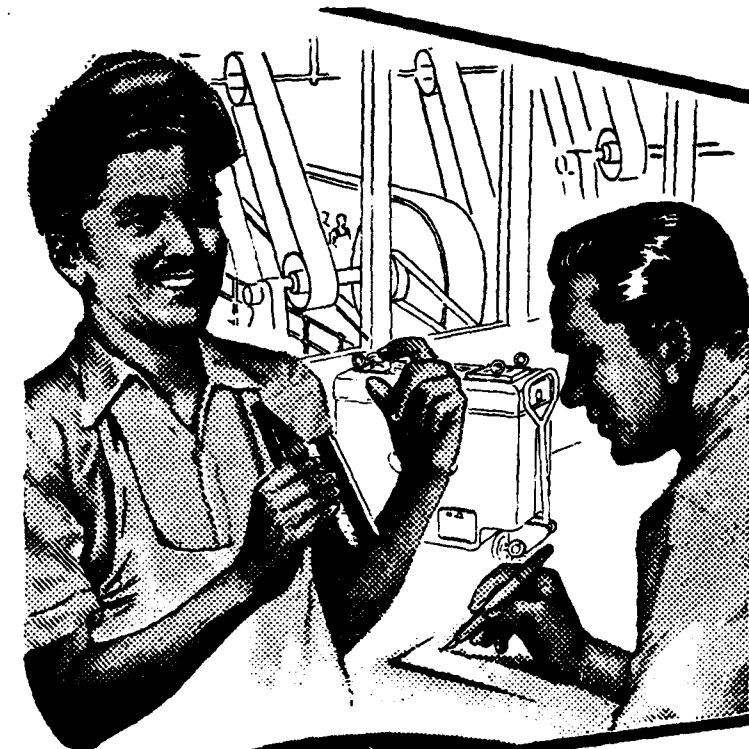
(a) Oxygen machine cutting for the preparation of welding edges on mild steel and low alloy steels.

(b) Oxy-acetylene flame gouging in the repair and replacements of welds.

Electric arc welding is used extensively in the making of fire-boxes, etc. The bar frames of the hundredth W. G. locomotive produced at Chittaranjan were each fabricated from three pieces of 5" thick steel welded together by manual arc welding, stress relieved and then flame cut approximately to shape prior to machining; this locomotive has now been in service for some time and no trouble from the welding can be detected. Subsequent bar frames have been welded by the automatic submerged arc welding process, also with complete satisfaction.

In carriage manufacture parts of the framework and roof are arc welded and as production gets into its stride at the Integral Coach Factory, Perambur, more and more welding will be used in this field. A growing use of welding in carriage manufacture in the making of carriage fittings, especially aluminium water tanks which can now be fabricated by argonarc welding. Many other fittings now being cast can be redesigned and fabricated by welding at very much lower cost than is now possible using a cast design.

In the wagon manufacturing field, welding is playing a more and more important part. The latest ore wagons which are a vital necessity with India's increased steel production under the second Five Year Plan are to have bodies of all-welded construction. This is a step in the right direction, overseas railways having been producing standard all-welded wagons for some years now.



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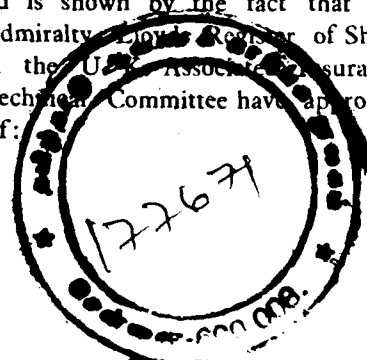
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Tank wagons are also being manufactured by two firms using automatic arc welding to ensure more speedy production of the barrels and at the same time, by cutting out a portion of the human element, to produce consistently sounder and neater looking welds.

In the U.K. wagon under-frames are cut and shaped to size from standard channels using special six-headed oxygen cutting machines and experiments are going forward here in order to help wagon manufacturers in this country to achieve greater production by introducing similar equipment.

The greatest use is made of welding and flame cutting in railway maintenance in this country, flame cutting being used extensively in the dismantling of locomotives when they come into the shops for repair. Arc welding is used to build up many of the worn shafts, tie rods, etc. so that after machining these parts are in a fit state to be reassembled; in this connection thought might be given to a more extensive use of hardfacing as distinct from building-up with mild steel. In many cases, extra wearing qualities could be achieved by depositing an electrode with a slightly higher alloy content which though still easily machinable has much improved wear resistant qualities.

Carrying this line of thought a little further, might not considerable savings be made if certain parts which are subject to wear were hardfaced by means of an electrode of this type when the component was new? This would give additional resistance to wear without the disadvantage of the high initial cost of making the complete part from an alloy steel.

Bar frames of locomotives which have cracked in service can, with suitable precautions, be repaired by welding. The usual method employed is to prepare the bar frames for welding by oxygen cutting.

A vee is cut from both sides of the bar so that the crack is completely removed and a double vee preparation obtained. This can be done without dismantling the complete bar frame and, in fact, is better done in this position as two operators can then work on the job welding simultaneously from each side. This has the advantage that heat distribution is equalised and distortion can be controlled as the welding is taking place by stopping one or other of the operators.

Cast iron cylinders and boilers are regularly repaired and put back into service by means of welding. Flame cleaning, a process which utilises the high temperature of the oxy-acetylene flame and the differential rates of expansion of rust and mild steel is used with considerable success for cleaning down locomotives on their arrival at the repair shops.

In carriage and wagon maintenance the most important use of welding is perhaps in repairing steel wagons by the application of patches.

The building-up or resurfacing of worn railway crossings by the oxy-acetylene process consists of depositing by means of the blowpipe suitable metal over the worn parts of the wing rails and the point of the crossing, the deposit being then hammer forged whilst hot to the required contour of the rail. The resurfacing gang consists of a welder, a hammer man and a flag man; one flag man can guard two welders if they are working on the same section, but co-operation between the welder and the flagman is essential. The biggest advantage of the oxy-acetylene resurfacing process is that it is carried out in situ without interruption to traffic; the equipment which consists of easily handled portable units, occupies very little space and is suitable for use in restricted positions and the initial

cost of the complete outfit is very low. Procedures have been worked out dependent on whether the crossing is subject to fast or slow traffic and experience shows that worn crossings resurfaced by properly trained men give not less than the service life of a new crossing.

Oxy-acetylene welding can be used for rail-bonding where electrification has taken place and in fact is the standard method of doing this in many countries.

In bridge work, the Indian Railways use standard welded spans but in this connection perhaps the greatest use of welding to date is in the repair, strengthening and widening of all types of bridges.

The possibilities for the increased use of welding and cutting in the Indian Railways in the future are immense and though the progress in the last year or two has been rapid with improved knowledge and design it should become even more so. The next decade should see the introduction of rolling stock which is all-welded, the welding being done perhaps by methods which are still at the present in the experimental stages. Already plans are being formulated for the introduction of aluminium loco cabs and as the easiest and most economical way of joining aluminium is by means of the inert gas metallic arc process, no doubt we shall see this method which has just recently been introduced in this country being used to a greater and greater extent.

India with her immense resources of bauxite and hydro-electric power will become a larger producer of aluminium and the increasing use of this metal in carriage construction can be foreseen. Again, the welding industry has the necessary tools ready at hand in the form of argonarc welding.

Automatic welding, either with submerged arc or with covered electrodes is already being used overseas for the production of railway wagons and in order to cope with India's ever increasing goods traffic this method, with a welding speed which is up to twelve times as fast as manual arc welding, seems to be the method which will be used in the future.

On the ordinary hand metallic arc welding side the future should see more and more components being fabricated rather than cast owing to the high cost of castings and already for example, fabricated axle boxes are being used overseas.

For the final look into the future, the latest welding process which has been developed in America and in Europe is of course the welding of mild steel by means of the inert gas metallic arc process. This method of welding which can be operated by hand or made automatic has already various wide uses in the welding of aluminium and stainless steel, copper, monel metal, etc., and with the introduction of the process to the welding of mild steel, it looks as though it will be the welding process of the future giving cheaper welding costs through greater speeds of production.

ALUMINIUM ON RAILWAYS

By A Correspondent

THE use of aluminium in the transport field—aircraft, rolling stock and road vehicles—has developed very rapidly during the last half century. Alloys of aluminium having strength comparable to that of steel and in addition possessing the inherent characteristics of this metal—lightness and corrosion resistance—are available in many different forms and varieties. By the extrusion process almost any intricate or complex shape of section can be produced, thereby allowing ingenuity in design which is not possible with steel. Aluminium alloys are also available in sheet, strip as well as cast form. India is very fortunate in having extensive deposits of high grade bauxite, the ore from which aluminium is extracted. The industry is fairly well established in the country and abundant supply is readily available.

PROPERTIES

The high resistance of aluminium to atmospheric corrosion and its weathering properties are well established facts. Sixty-year old structures are reported to be in a condition practically as good as new. This property and resultant durability coupled with its low weight (one-third that of steel), ease of manufacture and high strength give this metal a great advantage over other traditional materials in the transport field where the chief aim of designers is to reduce the non-revenue earning weight without sacrificing strength, safety and comfort.

ECONOMIC CONSIDERATIONS

For rail coach construction timber was the material used for decades, but the need to reduce deadweight and increase strength led to the construction of steel coaches. The current increasing desire to provide the passengers more amenities and comfort,

which means additional equipment or dead load, has now resulted in newer designs and use of this lighter metal.

Although the initial cost of aluminium is higher than that of the traditional materials, the economies resulting from its use makes its utilisation an attractive commercial proposition. Carriages of aluminium are much lighter than those made from timber or steel and consequently more coaches can be pulled by the same locomotive or with the same power, thereby increasing the payload and revenue. In cases where practical limitations prevent use of longer trains, speeds can be increased without any additional strain on locomotive or rail tracks, and thus faster schedules maintained. If preferred, the length of the train and its speed may be kept the same and a saving in operating cost realised by drawing lighter carriages with a smaller driving unit.

An idea of the importance of weight saving in rail transport can be had from the following statistics of the rail transport in India. The Railways have to haul fifteen tons for every ton of 3rd Class passenger traffic (16 passengers) and 40 tons for each ton of 1st Class passenger. The Indian Railways are currently spending Rs. 2,250/- for fuel for each ton of 3rd Class traffic. If five tons were reduced from the tare weight of each coach, this weight reduction would result in a fuel economy of 1½ crores per year or alternatively an extra lakh tons of additional passenger trains could be hauled without any extra cost.

In case of electrically driven trains, the cost of power is related to the weight being pulled. Experience has proved that with all-aluminium trains an economy of 15% in maintenance costs and 16% in fuel (electricity) is achieved.



ALUMINIUM IN TRANSPORT

Day after day aluminium serves rail and road transport efficiently. Aluminium bodies for passenger coaches, wagons, lorries and buses mean higher operating profits due to light weight, longer life, greater comfort. With the minimum of care aluminium gives lifelong trouble-free service.

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By the use of aluminium considerable economy in maintenance is also achieved as the metal has high resistance to corrosion. With normal inspection and care, it can be expected to last the full coach life and still retain a high scrap value which at the present time is 50% of the initial cost. Steel construction, on the other hand, requires extensive repairs throughout the carriage life and often actual replacement becomes necessary. Again, in case of aluminium panels, the paintwork remains in good condition a long time and repainting is required at much less frequent intervals. An important advantage of this metal is that, if desired, it can be left unpainted. The all-aluminium coaches recently introduced on the London Underground and Toronto Subway service have unpainted exterior surface with a semi-matt silvery appearance which appeals to the public. Thus there is the obvious economy in initial paint cost.

TECHNICAL CONSIDERATIONS

When aluminium is used for coachwork, the centre of gravity of the vehicle is lowered; this has a direct effect on the stability of the vehicle and improves the riding properties by minimising the sway. This is of importance particularly on the metre and narrow gauge railways where safety and maximum speed are to a great extent controlled by this factor. It also reduces the self stresses set up in the construction and influences collision behaviour.

Properly designed aluminium structures can have the same strength, rigidity, stiffness and sturdiness as steel structures and still be much lighter. Aluminium's lower elastic modulus and correspondingly higher resilience give a cushioning effect in case of accidents. Further, aluminium, unlike timber, is non-splintering, and unlike steel, is non-sparking. These are obvious advantages when considering the best material for vehicles in which the possibility of collision has always to be kept in view.

8

APPLICATIONS IN INDIA

Though aluminium has established itself as a proven material for railway vehicle construction during the last 50 years in U.S.A., U.K. and other European countries, its very limited adoption in this country is only of recent origin. It can, without any major changes in design or fabrication practice, be standardised for applications described here.

ALL-ALUMINIUM COACHES

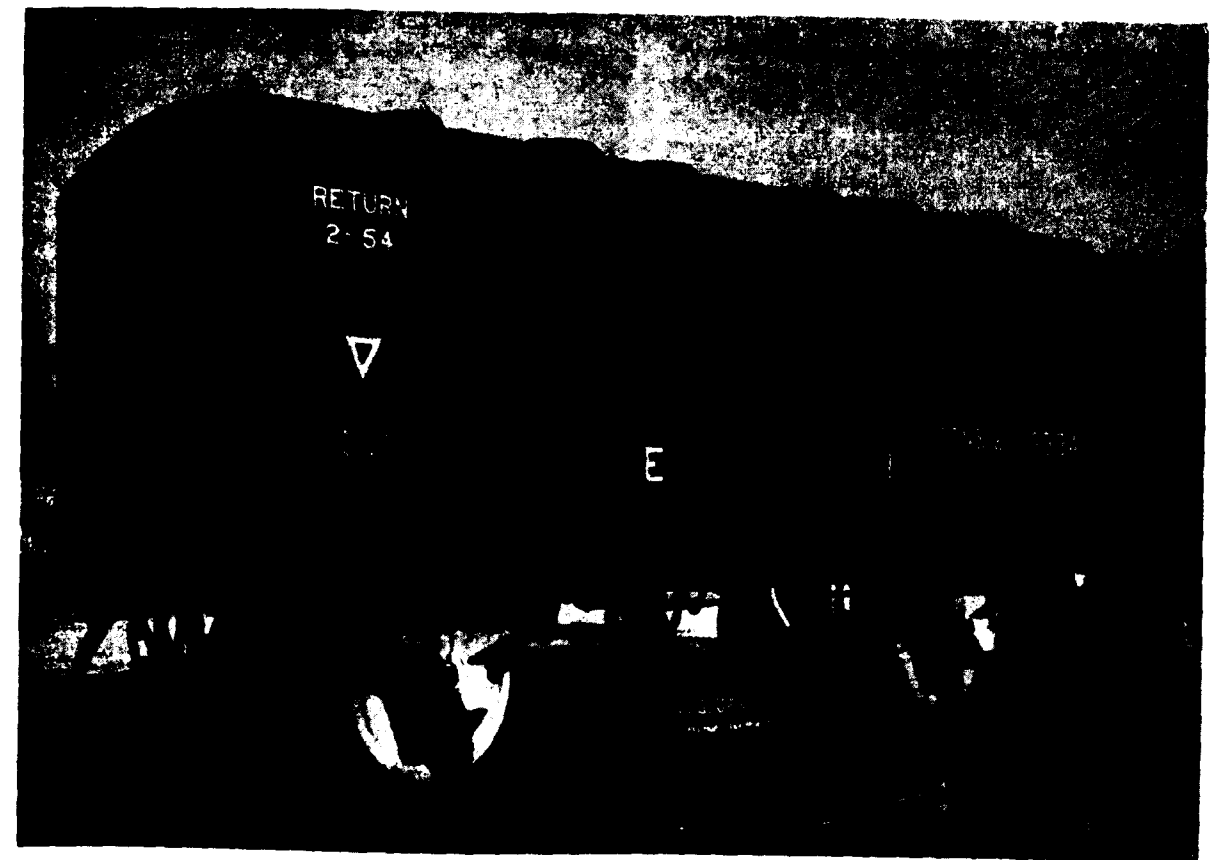
The modern tendency in railway coach construction is to reduce deadweight without sacrificing comfort and safety, and the necessity for economical coach building has led to the adoption of integral stressed skin construction. So far the metal used for this purpose was steel. However, the necessity to further reduce weight and maintain faster schedules have made the railway engineers turn to aluminium.

The outstanding example of a revolutionary design of light alloy coaches which have now been developed in U.S.A. is the construction of the "Talgo" trains. Each coach rides on a single two-wheel truck at the rear and is led and supported at the front by the rear of the preceding coach. This eliminates to a great extent the tendency of the coach to climb the rail and has led to safer and faster speeds with considerable saving in time. This unique design together with all-aluminium construction has resulted in a weight reduction of 75% compared with orthodox steel coaches.

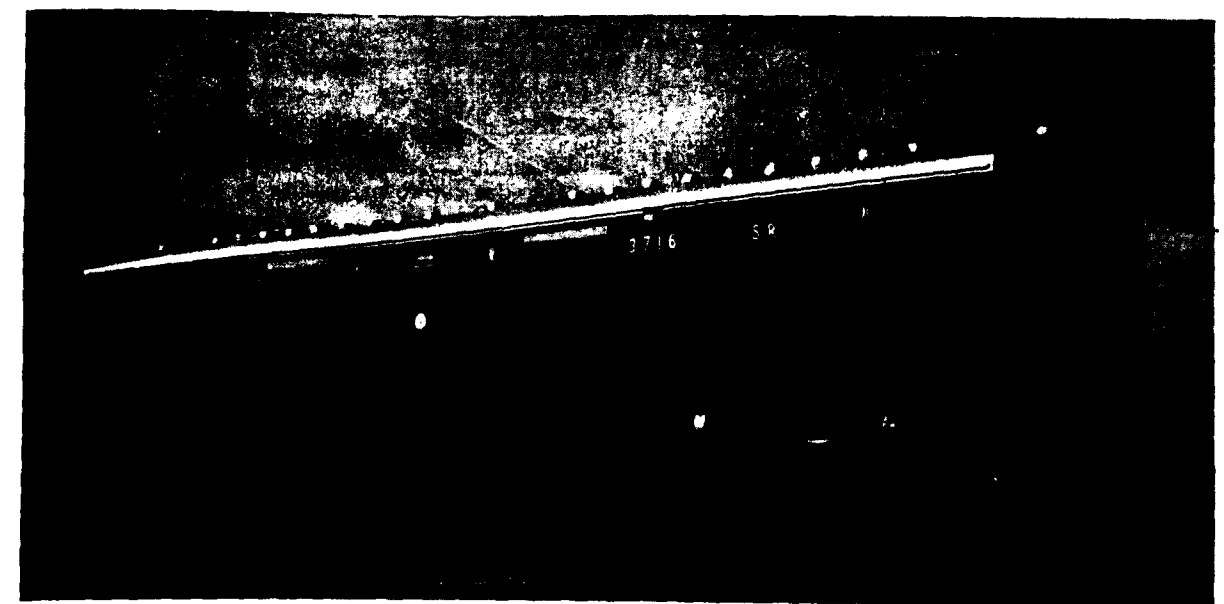
The substitution of aluminium for steel or timber in the superstructure of the standard coaches also results in substantial savings.

Amongst other producers of coaches in India, Hindustan Aircraft Limited of Bangalore produce metal (all steel) broad gauge coaches built on standard steel underframes. The Railway Board are, however, proposing to have all-steel metre gauge coaches built at this factory and the time is now ripe to

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Railway Wagon with Aluminium Body in use on the Indian Railways



Aluminium Panelled Coach built by Hindustan Aircraft Ltd., Bangalore

NOVEMBER 1955

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consider switching over to aluminium for the superstructure and the skinning for this type of stock. Ingenious use of extrusions can provide great scope of design of load carrying members and compact assemblies. A member which, in steel, would normally be fabricated from a number of sections can be extruded in aluminium as a single piece thus giving optimum saving in weight and production costs. An aluminium body structure will reduce the weight of a carriage by nearly $4/5$ tons, at an initial extra expenditure of approximately Rs. 8,000.

Such light trains will permit faster speeds. Moreover, this saving in weight of each coach, achieved by the use of aluminium, enables the attaching of an additional coach to a normal train of ten standard coaches and makes it possible to be hauled without any increase in the fuel cost. At the same time the revenue earning capacity will be increased as 75 additional passengers can be carried in this extra coach. Besides the above, there will be considerable economies owing to the other advantages, viz., freedom from corrosion leading to reduced maintenance and repair, longer life, less wear and tear of the moving gear, brake equipment and the rail track.

The aluminium stock recently introduced in London underground service was designed and built by the Metropolitan-Cammel Carriage & Wagon Co. Ltd., who are also supplying the design and technical assistance to Jessop & Co. Ltd. for the proposed construction of steel electrified stock in India. A change over to aluminium can therefore be effected without much difficulty, resulting in obvious advantages and improvements.

PANELLING

Direct substitution aluminium alloy panels in same thickness as used for steel will result in a weight saving of $1\frac{1}{2}$ tons per coach. They can easily be used on timber framed

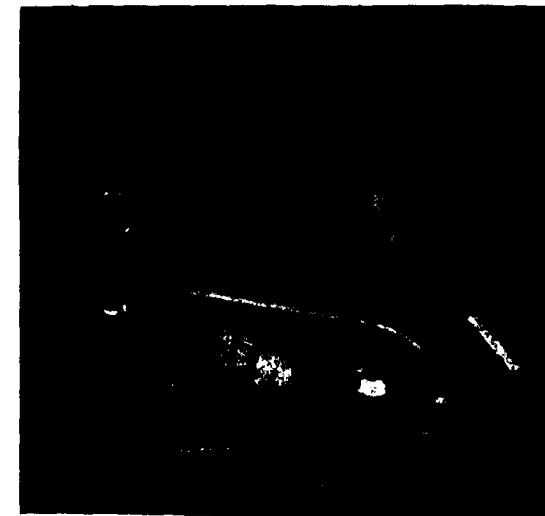
coaches being produced in the railway workshops, as well as on steel frame coaches manufactured by Hindustan Aircraft Ltd. and Jessop & Co. Ltd. The weight saving is of particular importance in Air-Conditioned coaches where due to the weight of the extra equipment installed, the total weight of the finished coach exceeds the weight the under-frame is designed to bear. If aluminium panels and fittings are used the coach would be $2/3$ tons lighter.

Steel panels, in spite of frequent repainting, have an average life of $6/8$ years—and much less when used on coaches running in coastal regions. Aluminium panels on the other hand will last with normal maintenance the life time of a coach which is estimated to be about 40 years.

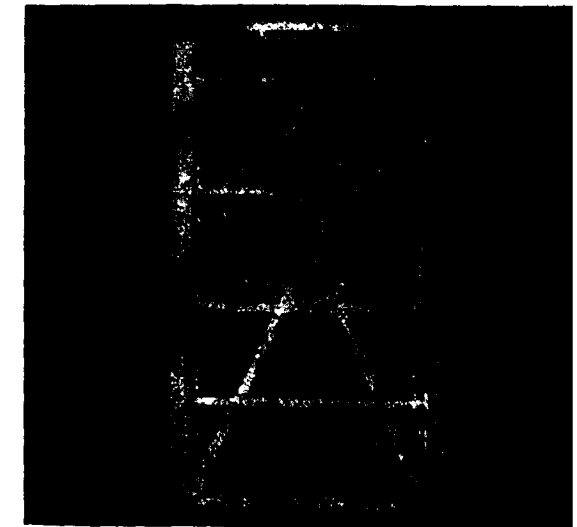
Narrow gauge coaches panelled in aluminium at the North Western Railways Workshops, Lahore, in 1928 have been in continuous service on the Simla-Kalka line for 27 years and a recent examination revealed no deterioration. A few coaches built by Hindustan Aircraft Ltd. panelled with aluminium also have so far shown no corrosion. Similar behaviour has been experienced in U. K. where no replacement of aluminium panels has been made even after 40 years service. Standardisation of aluminium for this purpose will result in a reduction in cost besides cut down imports of steel panel sheets now being used by the railway workshops.

WATER TANKS

Roof water tanks, fitted in coaches, are normally made from zinc sheets or galvanised (zinc coated) steel. Zinc sheets have to be imported and are more expensive than aluminium whereas the galvanised tanks which are only about 25% cheaper do not last more than $6/8$ years. Aluminium tanks are being installed in the Hindustan Aircraft coaches and will also be used in the Swiss designed integral coaches to be built at Perambur.



Some examples of interior fittings in aluminium.



A lavatory floor as installed in Gold Coast Railway coaches.



LEFT: Sliding door in cast aluminium alloy for the L.T.E. all-aluminium coaches built by Metropolitan-Cammel Carriage and Wagon Co. Ltd. (London Transport Executive).



Wall plaques in the Trianon bar of the British Railways Golden Arrow provide an excellent example of the decorative use of aluminium. The plaques are in high purity aluminium with anodised finish.

(Starkie Gardner Ltd.)

RIGHT: Slam-type railway carriage doors made as one-piece castings. These doors are used on the Dutch Railways.

Standardisation of aluminium tanks will reduce deadweight of a coach by about 600 lbs. and ensure supply of cleaner and rust-free water to the passengers.

WINDOWS

Rail coach windows in India are normally made from timber, which easily absorbs mois-

ture and warps, thereby resulting in jammed windows particularly in the wet season. Steel windows have been tried out but their heavy weight (about 10-12 lbs.) makes them difficult to handle. Aluminium windows can be designed to give the same sturdiness and protection and weigh only $5/6$ lbs. Besides



Aluminium buffers have been in use in Switzerland for over twenty years and are now firmly established. (Swiss Federal Railways).

reducing the deadweight of the coach by about 600 lbs. they require little maintenance, are easier to operate, last much longer and retain their attractive appearance throughout the life of the carriage.

ROOFING

Aluminium alloy sheets can be directly secured to roof structure to replace steel sheets or timber decking. This will reduce the weight by about 1000 lbs. Steel roof often requires frequent repairs or replacement whereas timber decking has to be covered with rubberoid which seldom lasts more than 4/5 years. Alternatively existing timber roofs can be covered with thin gauge aluminium sheets instead of rubberoid. This method has been extensively used for wagon construction in Switzerland. It has been proved that interior of aluminium covered structures remains cool and comfortable due to the metal's heat reflection properties.

FLOORING

Over one ton of dead-weight can be saved in a coach by use of specially developed aluminium floor in place of existing method of covering the timber decking with oxy-chloride flooring compound. This method comprises of floor sheets of aluminium corrugated section, which are secured to the

underframe members transversely all along the length of the coach. The upper corrugation grooves are then filled and covered with cork and rubber flooring. This method is being extensively used for construction of modern stock in Europe and America. Carriages with similar type of flooring have also been imported into India and are giving excellent service.

INTERIOR FITTINGS

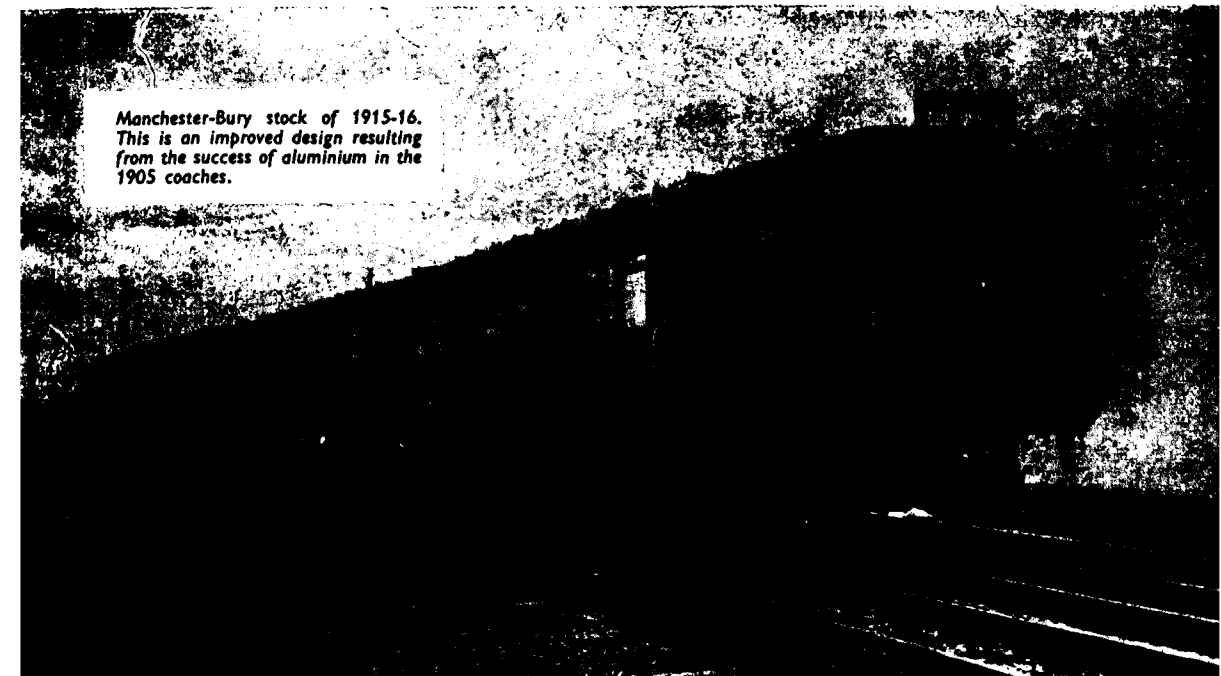
Many interior fittings of a railway coach can be made in aluminium. The metal has proved effective for bathroom walls, floors and toilet fittings. Aluminium seat frames, luggage racks, ceiling, partitions have adequate strength for their requirements and combine lightness, attractive appearance and good serviceability. These characteristics are of paramount importance when efforts are being made to give more comfort to the travelling public.



The tare weight of this wagon is reduced by 12½% by plating the sides and floor with clad aluminium alloy instead of steel. The discolouration on the side is an accumulation of coal dust and does not indicate deterioration. (Cambrian Wagon Works).

Aluminium seat frames are standard fitting in Metro-Cammel coaches, already well known in India.

The low weight of aluminium alloys makes them very suitable for outer as well as inner



Manchester-Bury stock of 1915-16. This is an improved design resulting from the success of aluminium in the 1905 coaches.

doors both of slam and sliding type. They are generally made of one piece casting. Aluminium doors have been used by the British, Dutch and Swiss Federal Railways and are giving years of trouble-free service.

Aluminium buffers are probably the most promising item for extensive use in under-frame equipment. The Swiss Railways have equipped a large number of coaches with aluminium buffers and have realized a weight saving of about 600 lbs. per coach.

GOODS WAGONS

Alloys of aluminium have been successfully used for plating the floor and body sides of goods and mineral wagons. As a result of their satisfactory trials with open mineral aluminium wagons since 1945, the British Railways have ordered a large number of them for carrying coal. Hopper wagons have also been in constant service for a considerable period in France, Canada and U. S. A.

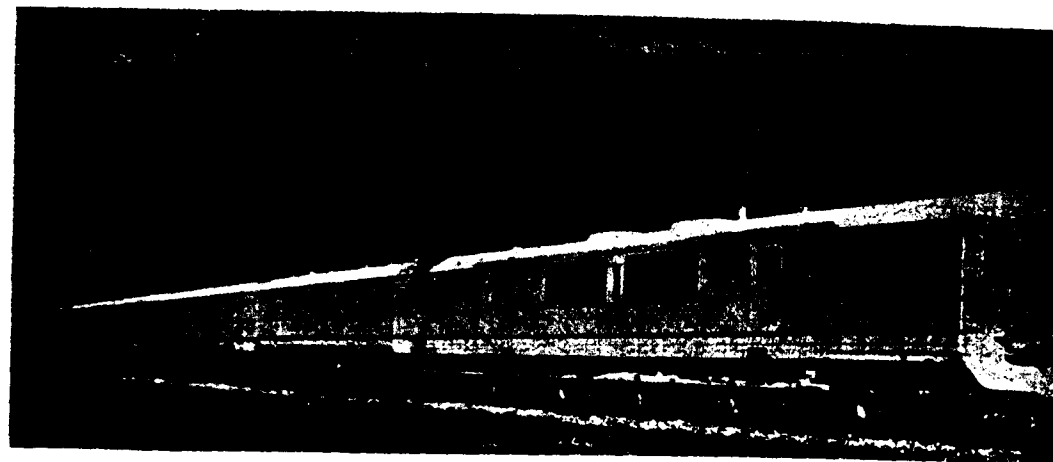
In India 100 wagons were plated with aluminium in 1949-50 and were put in service to examine the suitability of the metal for this purpose. So far they have suffered practically no corrosion.

In 1953 the Calcutta Port Commissioners plated the bottom panels including flooring of six open type wagons with aluminium. These were used for transport of wet coal ash, which has a high corrosive effect on steel and limits its maximum life to 1½ years. A recent examination after two years constant service revealed no signs of deterioration in the aluminium plates which are practically as good as new whereas the steel plates are showing signs of corrosion.

Complete plating of a wagon with aluminium costs initially about Rs. 1,000/1,200 more and reduces its tare weight by one ton thereby increasing the payload capacity by the same margin—an important advantage in carrying mineral traffic where, to meet the needs of the industry, the railways have had to permit overloading which has resulted in



*The demonstration A.C.F.-Talga train consisting of a locomotive, a baggage unit and a coach of five units. In this dramatic development all-aluminium construction has resulted in the coaches being only one-fourth the weight of conventional steel stock.
(Patentes Talga and American Car and Foundry Company).*



The Silver City Comet Diesel train has been in service on New South Wales Government Railways since 1937. (Ritche Bros. Ltd.)

increased wear and tear and higher maintenance expenses.

The use of aluminium even for the lower panels and flooring alone will result in considerable savings in maintenance to the Railways as experience has shown that corrosion first sets in here. This saving can be achieved by spending approximately Rs. 550/- extra per wagon.

CATTLE WAGONS

Cattle trucks have to endure very arduous conditions in service not only due to their

receiving harsh treatment from the hoofs and horns of animals but also on account of severe corrosion caused by animal excreta and the need for frequent washing. Consequently wood is often used although its absorbent nature reduces its durability and makes it rather difficult to keep clean. Aluminium successfully resists the corrosive effect of the animal excreta and, being non-absorbent, is hygienic, easily cleaned and durable.

GREAT BRITAIN

The earliest known use of this metal in railway stock was in 1905, when the Lanca-

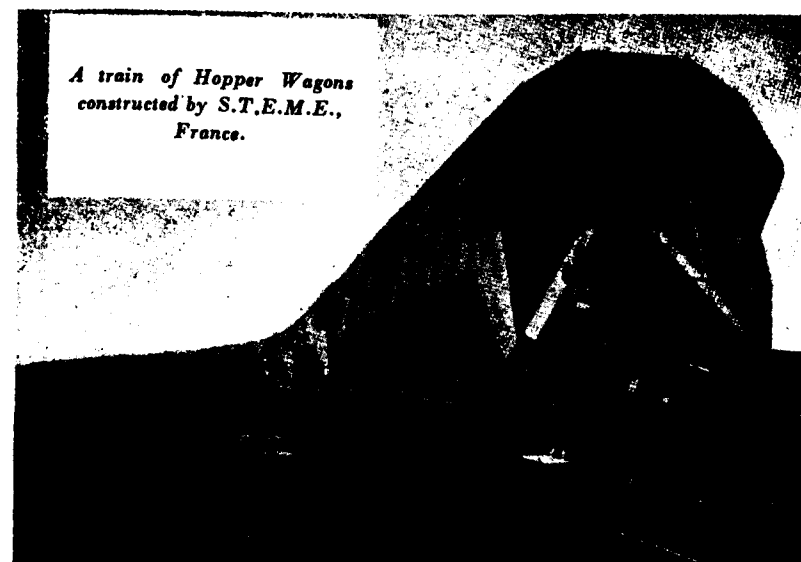
shire and Yorkshire Railway Co. panelled their electrified motor coach units with aluminium with success. More coaches were panelled in 1915-16 and this stock has been in service for 40 years and so far as is known no change has been made during that time. Gradual development since then has culminated in the biggest application of the metal—the London Transport Executives new aluminium stock. Ninety coaches are in service, while eighty more are under construction and an order for 500 additional ones is being placed. British railways have

Eagles". The latter were built by the American Car & Foundry Company, which recently developed the famous super speed 'Talga' trains now in use in Spain. This unique design which uses aluminium exclusively has resulted in a weight reduction of 75% permitting speeds of over 100 m. p. h. The "Santa Fe" and the "Chicago, Rock Island and Pacific Railroads" have placed orders for them, whereas the New York Central, the New Haven and Hartford and the Pennsylvania Railroads are considering use of it for new luxury trains.

FRANCE

Between 1933 and 1936 sixty double decker coaches were put in service by C. F. D'Etat (now S. N. C. F.). No deformation or failures have occurred during their continuous service under most severe conditions—it is common practice to carry 300 people in each vehicle.

A welded aluminium three-coach unit put into service in 1935 has



also placed an order for 52 two-car aluminium units.

As a result of successful trials over the last 10 years, about 100 mineral wagons plated with aluminium have recently been put in service and orders for more are expected to be placed in the near future.

UNITED STATES OF AMERICA

Development in the use of light metal for rolling stock has been faster in the U. S. A. where aluminium has been used since the early thirties. Among others the most famous aluminium trains are the "New Haven Comet" and the "Missouri Pacific

been running satisfactorily. The most outstanding achievement of the French Railway engineers is undoubtedly the electric suburban aluminium carriages constructed on integral design principle in 1938.

Many closed hopper wagons built entirely in aluminium by S.T.E.M.E. Company were put into service in 1951. These wagons have a tare weight of 15 metric tons and carry a maximum payload of 65 metric tons.

SWITZERLAND

On the steep Bruning Branch of the Swiss Federal Railways (S.B.B.) are 32 all-aluminium passenger coaches.

Aluminium alloy sheets have been used as roof coverings in about 7000 goods wagons.

(Continued on page 16)

ANCHORING THE RAILS

By Our Engineering Correspondent

ONE of the greatest difficulties with which permanent way maintenance engineers have to contend is the longitudinal movement of the rails in track, generally referred to as "creep".

The movement may be prevented by the use of rail anchors, appliances which are firmly attached to the base of the rail in such position as to bear against the sides of sleepers. The function of these rail anchors is to transfer the creep load from the rail to the sleepers against which they bear so that it is absorbed by the resistance presented by the track ballast. Rail anchors must therefore be provided so as to distribute the creep load in such a way that each anchored sleeper is not called upon to withstand a greater force than it can resist without being pushed through the ballast. The intensity of the creep force and the resistance offered by the sleepers determines the number of anchors required to stabilise the track.

The rail anchors, manufactured by the P. & M. Co. (England) Ltd., which are supplied to suit any type and section of rail, consist of a single piece of heat treated spring steel. This anchors have a gripping power far in excess of



the resistance of sleepers to movement in the ballast. An important feature is that no special tool is required for applying the anchors to the rail and that once they are fitted no further maintenance attention is required.

Three other products of the same firm are, respectively, the P. & M. Rail & Flange

(Continued from page 15)

The advantages here are length of life and economy in maintenance.

AUSTRALIA

The "Silver City Comet" a five car diesel train, and other similar trains built in aluminium have been in operation since 1937.

CANADA

An aluminium train consisting of six cars built for the Toronto Transit Commissions

has been put in service in the new subway. A weight saving of $5\frac{1}{2}$ tons per coach has been achieved, which when compared to the body shell of steel cars shows a reduction of 50%.

The Roberval & Sanguenay Company has placed an order for 28 hooper cars that will be "all-aluminium" and they estimate these will do the job of 30 steel cars. They are in addition to 90 cars which have been in use since 1948-49.

"P. & M." RAIL & FLANGE LUBRICATORS



PHOTO BY COURTESY OF THE NETHERLAND RAILWAYS.

MODEL C.4 RUNNING RAIL LUBRICATOR *

The Lubrication of curve rails in order to reduce wear, both of Rails and of Wheel Flanges, and to decrease Curve Resistance, is now accepted as normal practice on most Railways.

The increasing use of Electric and Diesel-Electric Traction has thrown fresh emphasis on the necessity for efficient Curve Lubrication.

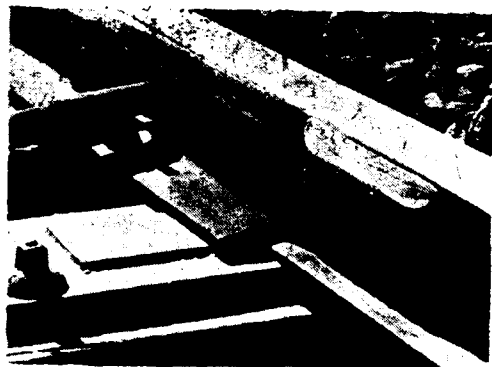
The Model C.4 "P. & M." Lubricator illustrated above provides the ideal solution to this problem. Its compact and robust design, simple maintenance and the complete absence of external pipe connections are of particular appeal to the Permanent Way Engineer.

"P. & M." LUBRICATORS are positive in action and operate efficiently irrespective of speed, axle loads and the state of maintenance of the track.

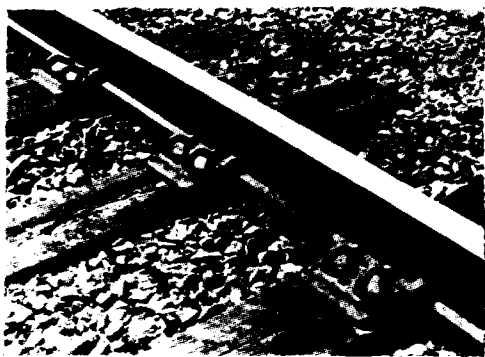
* Also supplied with 48" Greasing Plate.

THE P. & M. CO.
(ENGLAND) LTD

1A, GROSVENOR GARDENS, LONDON, S.W.1



Lubricator, the improved "MACK" Switch Point Protector and the P. & M. two-way rail bender.



"FAIR" RAIL ANCHORS in track service, Northampton District, London Midland Region, British Railways.

Following a careful study of track conditions and requirements in all parts of the world, the Company have designed and developed a range of graphite grease rail and flange lubricators which have become standard track appliances on a great number of railways.

These lubricators are supplied to suit all sections of rail, both bull head and flat bottom, and the range includes special models for use on electrified track with outside conductor rails and for check rail lubrication. Their latest model lubricator incorporates important improvements, including a larger grease container having a capacity of 20-lb and a modified design of pump plungers. The increased container capacity saves service time, while the piston-ended plungers give a more sensitive and positive pumping action.

The "MACK" Switch Point Protector is designed to relieve the switch blade of the initial impact of wheel flanges of vehicles taking turn-out and the severe grinding action which results in rapid wear of the switch at its weakest section.

The important advantage of the P. & M. two-way rail bender is that it operates with a double action, so that with one setting of the bender the rail may be sent in either direction. This feature is of particular value on check-railed curves, on electrified track with outside conductor rails and in point and crossing lay-outs. The standard model bender is suitable for use on flat bottom rail up to 90-lb. per yard while for heavier rails a special heavy duty model is supplied by the manufacturers.

Rolling Stock Production in Denmark

THE "SCANDIA" CARRIAGE WORKS

THE natural conditions, especially the features of the country, were among the reasons that led to Denmark early developing a quite widely spread net of railways there being no real hindrance to their construction. From the first, therefore, Denmark has been one of the foremost European countries in regard to the aggregate length of the lines, both as seen in the relative proportion to the number of the inhabitants and to the area of country.

From the very start both the State and private companies have been engaged in the running of the railways in Denmark: at present all the mainlines are owned by the State, while a number of the sidelines and also of independent local railways are private enterprises. In this connection it may be of passing interest to mention that it was just fifty years ago on January 1st this year that the Danish State Railways took over the railways which were started on an earlier date as private enterprises on the island of Zealand.

Seen on the background of the favourable natural conditions for the development of the railways already mentioned, it is more or less a matter of course that there should grow up in Denmark quite an important industry for the production of rolling stock and other railway material. A large concern within this domain is the "Scandia" Carriage Works in Randers, Jutland, founded as far back as 1861 by the firm that constructed the first north-south railway line in the eastern part of Jutland.

It was the making of material for laying the track and other supplies for the building of this railway that was the original purpose in the establishment of these Works, but the activity was continued and developed, and in

the course of time it has supplied the largest part of the railway rolling material required in Denmark both for the State railways and for the private concerns. The same Works have also supplied the material for the tramways in various Danish towns. The production extended rapidly and covered quite considerable orders from abroad. In the course of the years a great number of tramway cars have been built for some of the larger European centres, such as the German towns Leipzig, Erfurt and Halle, the Finnish capital Helsingfors as well as Leningrad and Warsaw, while railway material has been supplied to Germany, Norway and New Zealand and contracts for sleeping cars have been specially executed for the International Sleeping Car Co.

Thus the factory has been working through the whole period of the development of railways. The experience gained by two generations in the construction of material for railways and tramways has been of increasing service to the factory during the later years, and now the production covers all descriptions of rolling material for railways, from ordinary freightcars to special transport cars of all sizes, tanks and insulated refrigerator cars, as well as 2, 4 and 6 axle coaches of all types and with any equipment desired.

"Scandia" has also followed the developments which have taken place in the latest years as a consequence of the strong competition between the smaller railways and the auto route busses running on short distances. Thus all descriptions of motor-coaches are now being built by this firm, including the smaller types specially suited for use on local railways. These latter types are especially the 75-300 h. p. coaches for benzine, either for direct transmission of power through the gear or for electric

(Continued on page 20)

Hundred years of Rolling Stock Production in Sweden

By A Correspondent

MORE than a century has elapsed since 1847, when our firm was founded under the name of Trollhätte Mekaniska Verkstad (The Trollhättan Engineering Works). In 1850 the name was altered to Nydqvist & Holm, and in 1916 the firm was converted into a limited company, under the name of Nydqvist & Holm Aktiebolag (NOHAB).

To start with the manufacture comprised water turbines, steam engines, and various machine parts. After a few years the manufacture of locomotives was taken up, and the step was then not far to locomotives, which, as a matter of fact, from the very beginning

had been contemplated as a future speciality. The first locomotives were ordered by one of the private railways in Sweden, and the delivery began in 1865. One of these locomotives is now in the Railway Museum, Stockholm, and another of them was in service for 70 years before being scrapped. Many locomotives of our make are after more than 75 years still in daily service. The first three locomotives built for the Swedish State Railways were delivered in 1868.

We have always been anxious to make use of all improvements in the locomotive sphere, and in this connection may be mentioned that compound gears and superheaters were

(Continued from page 19)

transmission, and also the 150—1200 h. p. Diesel coaches either for direct driving or for electric transmission. All motorcoaches excepting the very largest Diesel vehicles, which may almost be regarded as locomotives, are fitted out as coaches and with compartments for post or luggage.

In the later years there have been established in all parts of Denmark a very great number of autobus routes, covering the country like a dense net, and in part co-operating with the State railways and the private railways in the transport of both passengers and freight. Here, too, the "Scandia" factory has found good work, and is now building autobusses of all descriptions.

The founders of the Scandia Works were the English firm Messrs. Peto, Brassy & Bett, who after some years transferred the factory to the Rowan family, and later, in

1875, a stock company was formed. Later, however, the concern again became a private undertaking, after having moved its works to a considerably larger site in the outskirts of Randers, where it has been repeatedly enlarged, until now it covers an area of 6 hectares, and comprises 24 larger and smaller buildings. In the factory's own grounds there are laid some 4000 metres of rails, and the workshops are extensive enough to allow of the simultaneous production of 200 goods wagons. The largest number of men working at the factory is 600, and its annual capacity of production is 600 goods wagons and 2-axled coaches and 80 bogie coaches.

Recently the firm has once again been converted into a stock company. The president of the company is the well-known shipowner M. A. P. Møller and the former Minister of Traffic, M. Steensballe, is a member of the board of directors. The managers are M. J. Waerum and M. Kaas Ibsen.



This is the diesel-electric locomotive built by us in collaboration with The Electro-Motive Division of General Motors Corporation, U.S.A. Maximum speed: 83 m.p.h. Output 1600 hp. / for the 20 ones ordered by the Danish State Railways, power has been stepped up to 1760 hp./

In Turkey it was tested under the most difficult conditions. Thus it pulled a train of 488 tons, in gradients of 20°/00 + curves, with great ease. The balanced speed was 15 m.p.h. The Turks use three steam locomotives to pull the equivalent.

Each of the locomotives of this type, delivered to Denmark, saves more than 600,000 Danish Crowns a year, compared with the steam locomotives, as per the latest figures received. A few months after the first locomotive had been put into service we received an additional order for another 20 ones.

WHY THE DANES ORDERED FURTHER 20 DIESEL-ELECTRIC LOCOMOTIVES FROM US.

The NOHAB — GM diesel-electric locomotive:

accomplishes as much work on one tank-car of oil as a steam locomotive on eight wagon-loads of coal;	will pay for itself in less than three years when compared with a steam locomotive;
is extremely economical in upkeep;	can be employed for all types of trains;
demand minimum servicing;	possesses great manoeuvrability;
adapts itself easily to traffic requirements;	offers increased acceleration;
gives exceptionally reliable service;	has the best overall transmission efficiency.

NYDQVIST & HOLM AKTIEBOLAG
TROLLHATTAN - SWEDEN

Cables: NOHAB

Telephone: 12590



applied at a comparatively early stage, and further, amongst the first 3-cylinder locomotives in Europe were those supplied by us in 1913. In 1925 we commenced to build steam turbine locomotives under licence from Aktiebolaget Ljungströms Angturbin, Stockholm, and amongst engines of this type may be mentioned the non-condensing turbine locomotives for iron ore transport, supplied by us to the Trafikaktiebolaget Grangesberg-Oxelösunds Järnvägar (The Grangesberg-Oxelösund Traffic Co's Railway).

Sweden's richness in water power soon led to the electrification of the Swedish State Railways. Electric locomotives had been built by us before 1900, but it was first in connection with electrification of the state railways that the manufacture of such locomotives became of real significance. The first of these locomotives was of the type I-C-I, a coupling rod type of locomotive, of which we have since delivered a great number. During recent years several private railways have been electrified, and locomotives of various types for these railways have been built by us.

Completion from omnibuses and lorries has, in instances where electrification has not been considered suitable, compelled the railways to motorize the service, and this induced us to take up the manufacture of motor driven locomotives and rail cars. The first rail car built was of the 4-wheel type but nowadays our rail cars are normally of the 8-wheel type with two bogies.

Our manufacturing programme comprises not only locomotives and rail cars but also other kinds of rolling stock, such as special wagons of various types, rotary snow ploughs and impregnating plants.

To meet the ever increasing demands considerable extensions of our workshops have been carried out time and again. Our works originally covered an area of 8,300

square metres, and they now extend over more than 205,000 square metres. Our shops with a floorspace of 59,000 square metres are fully equipped and up-to-date in every respect.

The placing of our works at Trollhättan was to a large extent dependent on access to water power and to a waterway to Gothenburg, Sweden's largest port. In 1922 a special quay was built and equipped with a crane allowing assembled locomotives to be lifted on board ships, specially built for the transport of locomotives. We have our own railway, with a length of 3 kilometres, connected to the Swedish State Railways and thereby also to the Continent. Trial runs of locomotives are made on our railway. We have also connection to the narrow gauge railway system of Western Sweden.

Our deliveries of locomotives have made the firm known far beyond the borders of Sweden. Scandinavia and Finland have early been our customers. Amongst other countries, to which we have supplied rolling stock of various kinds, may be mentioned The Argentine, Brazil, Iran, Netherlands, Poland, Portugal, Roumania, Turkey, U. S. S. R., and the Union of South Africa. Our deliveries have been large, especially to Iran, Turkey and U. S. S. R. In 1920, the Soviet Government ordered 1,000 heavy goods locomotives, one of the largest contracts in the history of the locomotive industry, which made further large extensions to our works necessary. In order to utilize the increased capacity of our works it was necessary to look for new markets.

Early in 1927 the Turkish Government favoured us with a rather unique and complicated commission. The contract entered into comprised the building of railways with a total length of 900 kilometres, and the delivery of 100 locomotives and 1,500 coaches and wagons of different types. The railways

(Continued on page 23)

350-H. P. Diesel-Electric Shunting Locomotives

A new Diesel-electric locomotive of 350 H.P. is described, 20 of which have been ordered by the Spanish national railways (RENFE). The general lay-out, electric transmission and control system of these locomotives incorporate several interesting new features.

THE Red Nacional de los Ferrocarriles Espanoles (RENFE) have ordered 20 Diesel-electric shunting locomotives of 350 H. P. for service in their large shunting yards. Ten of these units will be supplied by each of the two Sulzer licensees for Diesel locomotive engines in Spain, viz. La Maquinista Terrestre y Marítima S. A., Barcelona, and the Sociedad Espanola Babcock & Wilcox, Bilbao. These two companies, which are acting as general contractors, will build the mechanical part and two Diesel engines each in their own workshops, while the remaining 16 engines will be manufactured by Sulzer Brothers at Winterthur. The electrical equipment of the locomotives is being supplied by Crompton Parkinson Ltd., Chelmsford, England. The generators and traction motors will be constructed at Chelmsford, while the electrical control apparatus will be furnished by the Ateliers de Construction Oerlikon of Zurich.

These locomotives, the first and second of which were put into service in August and September 1953 respectively are designed to run under the following conditions:—

Minimum air temperature	14°F
Minimum air temperature in shade	104°F
Gauge	5 ft. 6 in.
Maximum admissible axle load	17 tons
Minimum radius of curves	328 ft.
Maximum speed	28 m.p.h.
The main particulars of the locomotive are:—	
Weight of locomotive, light but with 3 tons of ballast	45.1 tons
Fuel, lubricating oil, water, etc.	2.4 „
Maximum service weight	47.5 „
Minimum adhesion weight	49 „
Length over buffers	32 ft. 2 in.
Total wheel base	13 ft. 9 in.

(Continued from page 22)

were built in collaboration with the Danish firms Kampmann, Kierulff & Saxild A/S and J. Saabye & O. Lerche. The rolling stock was supplied by us. The whole contract was completed in nine years. The enterprise was followed by a similar commission given by the Iranian Government to the three collaborating firms, who under the name of "Consortium Kampsax" undertook the building of the Transiranian Railway. We supplied the rolling stock, consisting of locomotives, goods wagons, coaches, diesel-electric rail cars, some special wagons and a saloon-car for H.I.M. the Shah.

Since April 1950 there exists an agreement between us and the General Motors Corporation, Electro Motive Division, La Grange, with a view to build and market diesel-electric locomotives utilising General Motors Corporation's constructions and equipment sets consisting of diesel engine, main generator and other supplementary equipment.

The Swedish locomotive builders formed in 1945, a sales company, Swedish Locomotive Works Association Aktiebolag for the export of steam locomotives. Nydqvist & Holm Aktiebolag is a member of that association.

Driving wheel diameter	3 ft. 11 in.
Maximum width	10 ft. 4 in.
Maximum height above rail level	14 ft. 3 in.

Traction efforts at wheel rims :—

Maximum up to 2.5 m.p.h.	28,700 lb.
For one hour from cold at 5.1 m.p.h.	17,200 lb.
Continuous at 7 m.p.h.	13,800 lb.

The full Diesel engine output is utilised up to 22.5 m.p.h.

Fig. 1 shows one of these locomotives. The general arrangement and principal dimensions are given in Fig. 2. Fig. 3 illustrates the accessibility of the Diesel engine when the side doors of the engine compartment are opened.

These locomotives are capable of starting a maximum trailing weight of about 500 tons on the level and of accelerating it to about 12.5 m.p.h. within the time normally allowed in shunting operations. On a gradient of 10 per mille (1 in 100) a trailing weight of 400 tons can be hauled continuously at 7 m.p.h.

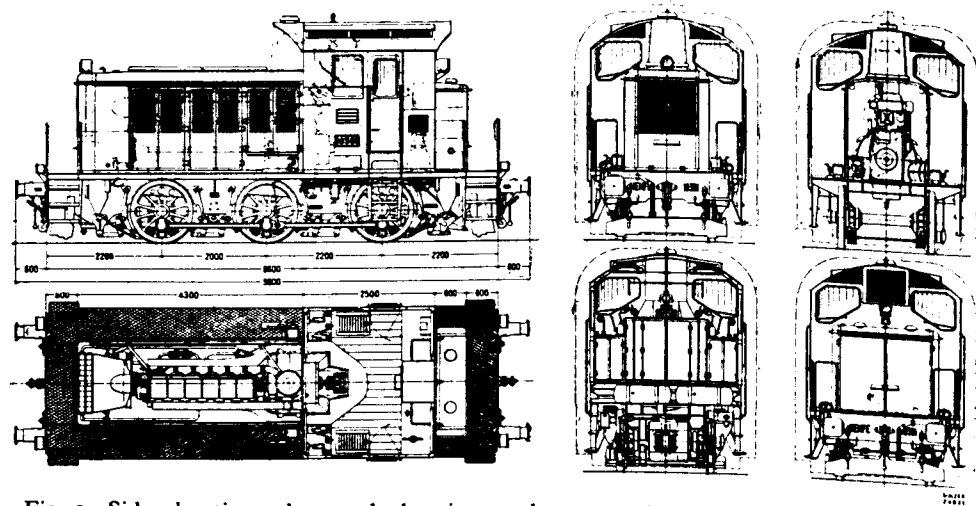


Fig. 2 Side elevation, plan, end elevation and cross-sections of the 350-H.P. Diesel-electric shunting locomotives of the RENFE (Dimensions in millimetres).

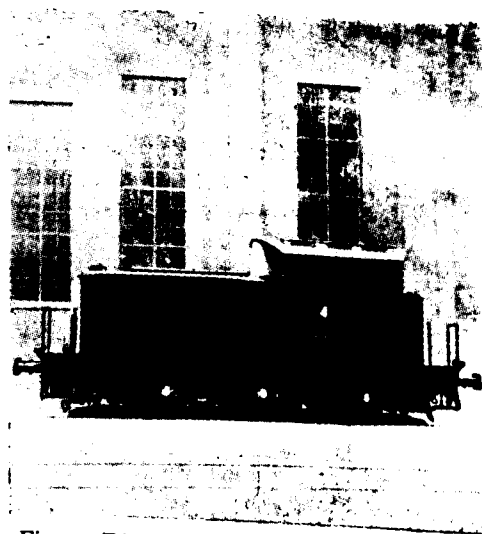


Fig. 1 Diesel-Electric shunting locomotive of 350 H. P. of the Red Nacional de los Ferrocarriles Espanoles (RENFE).

MECHANICAL PART

The locomotive frame is supported in plain bearings on three pairs of driving wheels. The latter are connected by coupling rods, giving a C axle arrangement. To allow of the necessary freedom in curves, the wheel flanges of the middle axle are machined down somewhat. The counterweights for the coupling rods are cast integral with the wheel

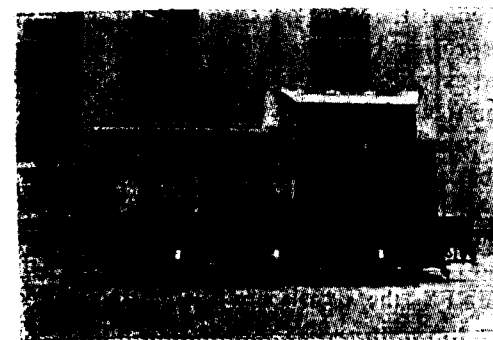


Fig. 3 The locomotive with the side doors of the engine compartment open.

centres. All these castings are made identical to facilitate manufacture and stocking, the counterweights for axles I and III being subsequently bored out to allow for the smaller masses to be balanced.

The second and third axles are each driven by a nose-suspended traction motor through toothed gears fitted on one side and having rims sprung on the Silentbloc system. The front axles participate in the tractive effort by way of the coupling rods.

The traction motors are flexibly supported by two prestressed parallel springs forming a single assembly which can be fitted and removed laterally.

The all-welded inside locomotive frame is carried through bolts by the laminated springs, which in their turn are suspended from axle boxes designed as plain bearings with forced lubrication. The suspension gear of the first and second axles is connected by equalisers.

The superstructure comprises, from front to rear; the engine compartment bolted to the locomotive frame, with the water and oil cooler at the front end; the driver's cab; and the projecting battery compartment. The engine and battery compartments are

low and narrow enough to permit a clear view of the track from the driver's cab. Platforms are provided around these compartments for the shunting personnel. The roof of the engine compartment is detachable over the whole length of the Diesel-generator group, so that the latter can be installed and removed as a whole. Narrower ventilation traps in the roof are also detachable and allow piston and liners to be comfortably removed from above during overhauls of the Diesel engine.

The louvred side doors of the engine compartment make the Diesel-generator group readily accessible. The group itself is supported on rubber pads on the top plate of the locomotive frame, so that it is effectively insulated from any deformation of this frame occurring in service.

The auxiliary generator and part of the main generator project into the front desk of the driver's cab. The end wall of the cab around the generator casing is provided with an air seal, so that the air for the Diesel engine and the generator is taken from the driver's desk. The intake for the fresh air is in the roof, which means that any dust raised by the locomotive does not contaminate the air used by the Diesel engine and for generator ventilation. Entering through a grating in the rear wall of the driver's cab, the air passes into a chamber below the roof and thence through a vertical duct to the driver's desk and the generator group. After leaving this group, it is led away in a further duct and is used for ventilating the traction motors.

The locomotive is fitted at each end with the normal lateral buffers and with central couplings. The fuel tank, of 275 gals. capacity, is located between the leading axle and the buffer beam, while the main water tank is placed below the cooler.

The vacuum for the built-in vacuum brake is generated by a rotary pump manufactured by the Swiss Locomotive and Machine Works with a displacement volume of 175 cu. ft. per min. The pump is driven by an electric motor fed either from the battery or from the auxiliary generator. While it runs at low speed in normal service, it can also be run at high speed for the purpose of releasing the brakes, the speed increase being obtained by weakening the field of the driving motor. The two brake cylinders are of cast iron and their pistons act on the same brake shaft. The total brake power on the driving wheels, which are braked on both sides, amounts to about 70% of the locomotive service weight at 70% vacuum in the brake cylinders. The hand brake enables all the driving axles to be braked to about 35% of the service weight. Two vacuum reservoirs are fitted, these being separate from the brake cylinders.

The driver's brake valve is combined with the controller of the vacuum pump group. An independent fine braking valve is also provided on either side of the driver's cab and is used for light braking.

The sanding gear is operated pneumatically by a push button on the driver's desk. The pneumatically controlled valve is fitted in the sanding nozzle and frees the air for the ejection of the sand. A valve located in the sanding pipe and actuated from the reverser shaft controls the air supply so that, with the use of a single push button, the sanding is automatically adapted to the direction in which the locomotive is travelling. The sand boxes are placed outside of the locomotive frame at front and rear and can be filled through covered openings in the platform.

The axle bearings are provided with forced lubrication in order to reduce lubrication work as far as possible. The horn guides are supplied with oil by two adjustable pumps driven from the crank pins of the

middle axle. Special attention has been given to the seals on either side of the nose-suspension bearings of the traction motors and axle bearings so as to keep oil consumption to a minimum. The pins of the spring suspension gear are fitted out for Tecalet lubrication.

The driver's desk is at the Diesel-engine end of the cab. In some zones of the RENFE the signals are on the right side of the track, in others on the left, this being a remnant of the different regulations applying on the various railways before they were united, by nationalisation, to form the RENFE. To allow for this, two sets of controls are fitted in the locomotives, one set being placed on either side of the driver's station. The controller, reverser and brake levers on the two sides of the desk are connected by horizontal shafts so that the levers on both sides perform the same movements. This offers the advantage that a manoeuvre begun on one side can be continued on the other. The appurtenant apparatus, such as controller and reverser drums and brake valve, are arranged horizontally.

The pressure and vacuum gauges, the push buttons for the sanding gear, the supplementary brake valve and the whistle gear are also provided in duplicate.

The front and rear windows of the driver's cab are of Sekurit safety glass and are fitted with Royal pneumatic windscreen wipers.

The main circuit apparatus is fitted inside the driver's desk in front of the generator and is readily accessible from both sides; the switches are placed on top of the desk.

A cabinet on the rear wall of the driver's cab houses the vacuum pump and the compressor group, each mounted on its own receiver. The hand brake is fitted in the same cabinet, while another on the rear wall between the windows accommodates the auxiliary circuit apparatus, the fuses and the

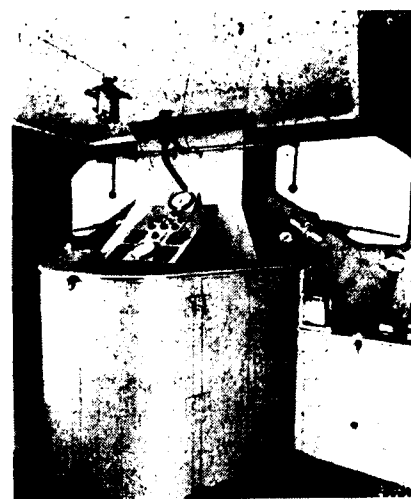


Fig. 4 Driver's cab in the 350-H.P. Diesel locomotive of the RENFE

instruments. The electric resistances are located in the roof of the driver's cab alongside the fresh-air duct. Fig. 4 is a view of driver's cab looking towards the engine compartment.

The battery compartment is arranged to allow good accessibility of the battery crates and to permit water to be replenished without removing the crates.

DIESEL ENGINES AND ACCESSORIES

The main data of the non-pressure-charged four-stroke Diesel engine of type 6LD22 fitted in the locomotives are :-

Number of cylinders	6
Cylinder diameter	220 mm. (8.7 in.)
Piston stroke	290 mm. (11.4 in.)
Continuous output	350 H.P. at 870 r.p.m.

Apart from the fact that the engine aspirates its own combustion air—whereas in recent years Sulzer Brothers have made almost exclusive use of pressure-charged engines for traction purposes—this engine type has all the essential features of the

standard LDA series which was described in Sulzer Technical Review No. 2 1947, and illustrated there in fig. 68.

Fig. 5 shows the Diesel-generator group from the valve-gear side. The crankcase and cylinder block are welded steel structures. Transverse members of steel plate carry the saddles of the crankshaft bearings and are welded to the side walls, also of steel plate. The sturdy structure thus produced is nevertheless light on account of

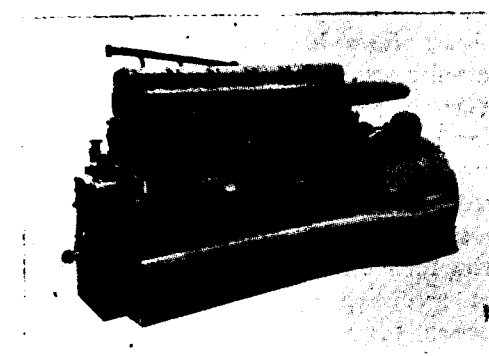


Fig. 5 Sulzer six-cylinder four-stroke locomotive Diesel engine with main and auxiliary generators. Continuous output 350-H.P. at 870 revs. per min.

the thin steel plate employed. The side walls are welded in their turn to the longitudinal members which carry the Diesel-generator group, being widened at the end to take the generator.

The cylinder block is also composed of welded transverse and longitudinal walls of steel plate. The running gear is easily accessible through large openings taking up the whole side area of the frame and fitted with screw-down covers (fig. 5). On the exhaust side there are two independent covers for running-gear inspection. There is also a special cover by each fuel pump in the main pump compartment cover. These covers can be removed without any bolts having to be unscrewed or other closing devices loosened.

Interchangeable water-cooled cylinder liners and individual cylinder heads simplify overhauls and permit simple replacement of worn parts.

The engine is of enclosed, dust-tight design, and all the lubricating points receive oil from a central forced lubrication system.

Drop-forged chromium-nickel steel connecting rods, which are machined all over so as to combine minimum weight with great strength, and forged aluminium pistons are further features of these engines.

Apart from its electric functions, the controller actuates a compressed-air regulating valve with which the pressure of the control air for the governor can be varied between 7 and 45 lb. per sq. in. A device fitted on the governor and operated by the pressure of this control air so regulates the spring force acting counter to the flyweights that graduated speeds can be maintained between 540 and 870 revs. per min. The governor is fitted with a servo-motor for varying the excitation of the generator as well as that for regulating the quantity of fuel. As explained below, the former servo-motor is so controlled by the governor

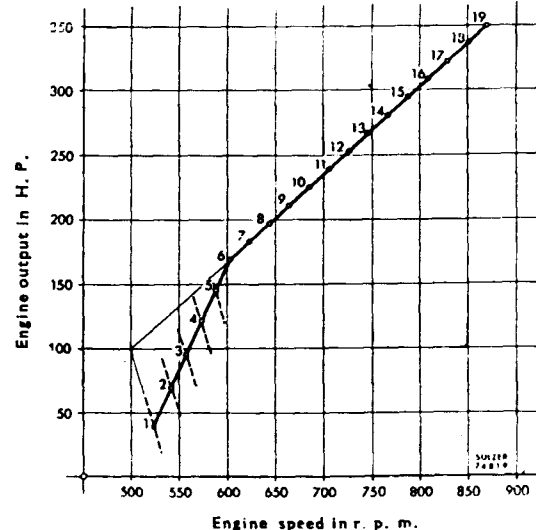


Fig. 6 Output and speed gradation of the 350-H.P. Diesel engine. The field regulator does not come into action on notches 1 to 5.

that a definite output corresponds to each speed of the Diesel engine (fig. 6).

The practically continuous speed control calls for the use of a vibration damper¹. The pendulum-type Sarazin damper fitted on this engine, as on other standard Sulzer locomotive engines, eliminates all dangerous torsional vibrations in the critical speed ranges.

Contacts operated by the oil and water pressures shut down the Diesel engine if any irregularity should cause either of these pressures to fall below the safety limit.

The cooling-water and fuel transfer pumps are combined in a group and driven by the Diesel engine through a V-belt. The cooling-water pump delivers the water from the main tank to an elevated auxiliary tank located behind the cooler, whence it flows to the Diesel engine and afterwards past a thermostat to the cooler, or, when the temperature is low, back to the main tank. The thermostat thus ensures that the cooling water comes up to normal working temperature as quickly as possible after the engine has been started up. It then keeps the water temperature constant within narrow limits, thus favourably influencing the thermal efficiency and the amount of wear occurring in the engine. Small-gauge pipes fitted between the highest points of the cooling-water piping before and after the engine and the vented auxiliary tank evacuate the air from the cooling system during engine operation and provide for air admission when the engine is shut down. With this piping arrangement, the water runs out of the cooler when the engine is stopped, so that there is no danger of its freezing. On the other hand, the water cannot run out of the engine, so that engine cooling is ensured under all circumstances from the moment of starting-up. The volume of the auxiliary tank is such that the engine cooling spaces are filled even if the water has cooled down

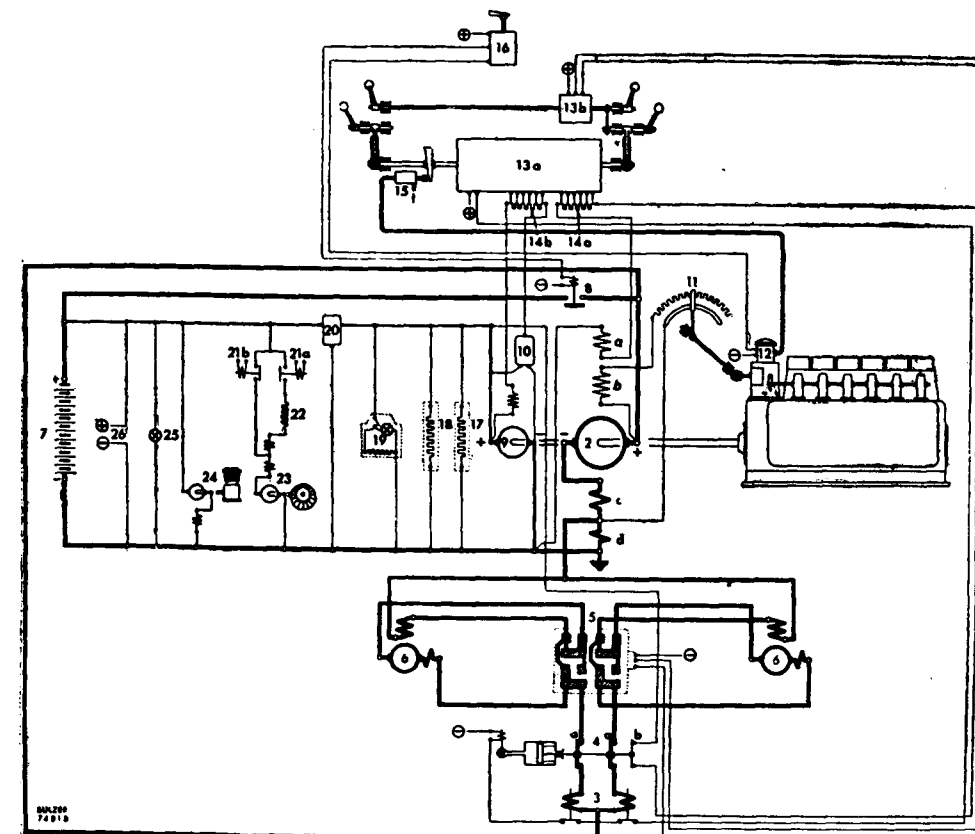


Fig. 7 Basic electric wiring diagram of the 350-H.P. Sulzer Diesel locomotive of the RENFE.

- DETAILS: 1. Diesel engine 2. Main generator (a) Separate excitation winding (b) Shunt winding (c) Differential compound winding (d) Starting winding 3. Maximum current relay 4. Main contactor (a) Traction motor contactors (b) Excitation contactor 5. Reverser 6. Traction motors 7. Battery 8. Starting contactor 9. Auxiliary generator 10. Voltage regulator 11. Field regulator 12. Governor 13. Controller (a) Main drum (b) Reversing drum 14. Regulating resistances (a) Separate excitation of main generator (b) Excitation of auxiliary generator 15. Pressure regulating valve 16. Starting and stopping switch 17. Heating system for driver's cab 18. Oil heating system for lubrication of axle-box guides 19. Feed heater 20. Paralleling apparatus 21. Vacuum-pump contactors (a) For low speed (b) For high speed 22. Series resistance 23. Vacuum-pump group 24. Auxiliary compressor group 25. Lighting circuit 26. Control circuit.

and the air has escaped from it, or if considerable losses have occurred as a result of evaporation.

The cooler fan is also driven by V-belt from the Diesel engine.

ELECTRICAL EQUIPMENT

The electric transmission embodies the principles adopted in Sulzer Diesel loco-

motives for many years. The main generator is designed for separate and shunt excitation and is differentially compounded, which ensures automatic limitation of the maximum current. The excitation is regulated in accordance with the position of the governor. In earlier designs this regulation took place in the separate excitation circuit. In the locomotives here described, the field regulation has been moved instead into the shunt excita-

tion circuit. This makes for specially favourable conditions for shunting locomotives.

To secure quick acceleration from rest, it is important in shunting work, to generate high tractive efforts in a short space of time and to maintain them up to the highest engine speed. This is obviously rendered more difficult by the fact that the governor-controlled field regulator switches resistances into the field circuit during the whole period of engine acceleration, short-circuiting them gradually only when the maximum engine speed is reached. If the separate excitation circuit is controlled, the excitation decreases during the return movement of the field regulator, causing a reduction of the tractive effort. The shunt excitation, on the other hand, has very little influence on the generator current at high load current and low voltage, and thus affects the tractive effort very little. If the field regulator raises the resistance in the shunt excitation circuit during acceleration of the engine, this accordingly has hardly any adverse effect.

Fig. 7 shows the basic electric wiring diagram of these locomotives.

Diesel engine 1 drives main generator 2, to which it is rigidly coupled, and auxiliary generator 9, the armature of which is mounted on the rotor of the main generator. The main circuits transmitting the output of the Diesel engine to the driving axles are shown in heavy lines on the diagram. Main generator 2 feeds the two traction motors 6 by way of maximum-current relays 3, the electro-pneumatically operated motor contactor 4 and reverser 5.

When Diesel engine 1 is started up, generator 2 is connected up to accumulator battery 7 by means of starting contactor 8. It is then excited by differential compound winding c and the additional starting winding d, now connected in series, and thus runs as series motor.

When the locomotive is running, main generator 2 is excited as follows: the separate excitation (winding 2a) fed by auxiliary generator 9 is gradually brought up to its maximum value on the starting notches with the aid of main drum 13a of the controller and resistances 14a, after which it remains at this level on all the higher notches. As already mentioned, field regulator 11 is in the circuit of shunt winding 2b and is controlled by governor 12 of the Diesel engine. It regulates the shunt excitation so as to maintain a definite output. The combined shunt and separate excitation, in conjunction with differential compound winding c, give generator 2 a steeply drooping current-voltage characteristic, which accounts for the limitation of the maximum current already mentioned and at the same time reduces the regulating range needed for field regulator 11.

At any position of governor 12 the engine runs at a constant speed corresponding to this position. The control valve of the servomotor belonging to field regulator 11 is then in the neutral position and field regulator 11 is at rest. If the load on the Diesel engine is now increased as a result of external factors, for instance because the train comes on to a steeper gradient, governor 12 moves towards position 10 and imparts an impulse to field regulator 11, causing it to switch in more resistance. The excitation of generator 2 is consequently reduced until the initial load conditions are restored.

The locomotive is driven with the aid of main drum 13a of the controller. A cam on the shaft of this drum operates a pressure regulating valve 15, which varies the air pressure acting on the pneumatic speed-adjusting device of governor 12. Inside this governor, a linkage between the speed-adjusting device and the control valve of field regulator 11 ensures that a definite governor position at which the field regulator comes to

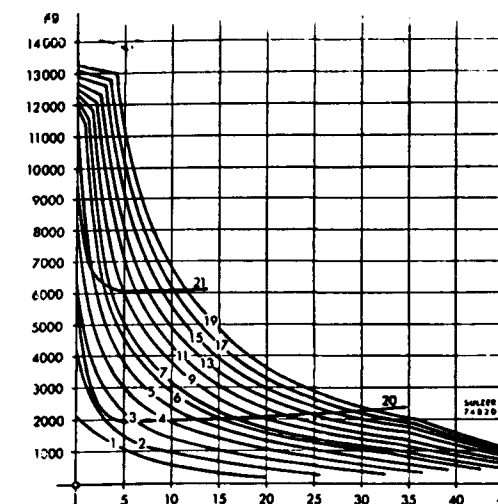


Fig. 8 Locomotive speed V in km per hour
Specific rolling resistance in kg. per ton on the straight: $3.5 + \frac{V^2}{1,500} + S$

Service weight of locomotive = 47.2 tons

1-19 Tractive effort at wheel periphery for the
20 Rolling resistance on the level with 500 tons
trailing load

21 Rolling resistance on gradient $S = 10^\circ/100$ with
400 tons trailing load.

rest is allocated to each speed setting. Each speed thus corresponds to a different, constant load. This results in a regular gradation of the tractive effort, as shown in fig. 8.

The other locomotive controls are the reversing drum 13b of the controller, for actuating reverser 5, and the starting and stopping switch 16, with which the starting contactor 8 can be closed or the Diesel engine can be shut down by electro-magnetic action on the governor.

Fig. 4 shows the driver's stand. The supplementary brake valve is visible on the extreme right. There follows the lever of the driver's brake valve with its vacuum gauge, and to the left of this the push button for the sanding gear. The next lever operates the controller and thus sets the speed of the engine. The lever above this is for the

reverser. Directly adjoining it is the pressure gauge for the air supply to the apparatus.

The Diesel-engine tachometer is placed in the middle of the control desk with the compressor switch to the right and the temperature compensation switch above this. The latter is used for switching in two resistance steps in the separate excitation circuit of the main generator when the engine is cold, so that the total resistance can be kept approximately constant irrespective of the temperature of the windings.

To the left of the tachometer is the starting and stopping switch, and above this the main switch for the control current. The lighting switches are higher up in the centre, with the speedometer at the top.

The pneumatically operated windscreen wipers are likewise visible in the photograph, as are also the overhead handles on both sides for the whistle gear and the driver's lamp. Under normal conditions the covers of this lamp are closed, as shown in the picture. Only a small adjustable slit is then open, and this directs the light on to the control desk. If the full light is required in the driver's cab when the locomotive is stationary, the covers can be opened.

There are no measuring instruments or signal lamps to register the pressure and temperature of the cooling water and lubricating oil on the driver's desk, as in view of the safety devices already described on further precautionary measures were considered necessary. Lamps and instruments of this kind only tend to cause confusion and are often found to fail precisely at times of danger.

The voltage of auxiliary generator 9 is kept constant by resistances 14b regulated from main control drum 13a and by voltage regulator 10.

The cooling-water pump and cooler fan, as already stated, are driven mechanically in these locomotives, while the cooling air is supplied to the traction motors by the fan of the main generator. Only brack vacuum pump 23 and auxiliary compressor 24 are driven by electric motors, as they may have to be used when the Diesel engine is not in operation. In this case the groups in question are fed from battery 7. When vacuum pump 23 starts up, contactor 21a is first closed. The motor then has the full field and resistance 22 is switched on, so that the pump runs at low speed. Contactor 21b next connects the motor to the main circuit with reduced field and without the series resistance, and group 23 then runs at high speed. Lighting circuit 25 and the control circuit 26 are also connected to battery 7.

Heaters 17 for the driver's cab, oil heaters 18 for the lubrication of the axle-box guides and food heater 19 receive their current from the auxiliary generator. This arrangement was chosen partly because the equipment is required only during locomotive operation and partly because the driver might easily forget to switch off these circuits after stopping the Diesel engine, with the result that the battery would be run down unnecessarily.

Auxiliary generator 9 is connected in parallel with battery 7 by the charging or parallel-

ing apparatus 20 as soon as the auxiliary generator has reached the voltage required for charging the battery after the starting of the engine. The auxiliary services connected to battery 7 are then fed from the auxiliary generator. As soon as the engine is shut down, paralleling apparatus 20 disconnects the battery from the auxiliary generator.

CONCLUSION

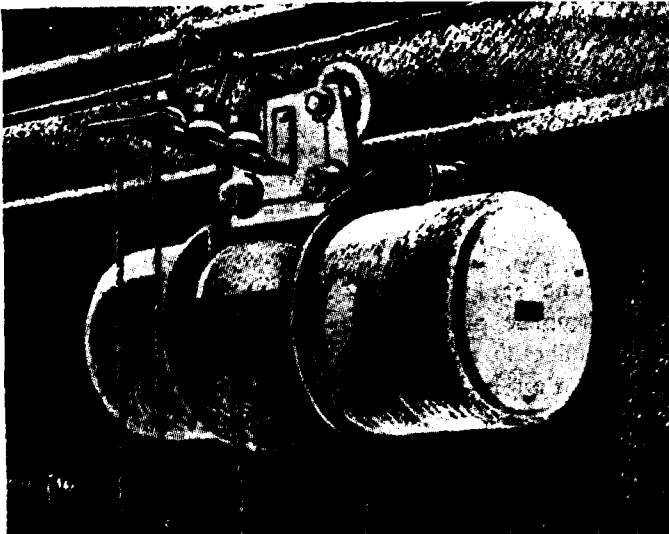
The first locomotive ran its initial trials on the stations and in the neighbourhood of Barcelona in July 1953. The maximum trailing load was 700 tons. Trains of this weight were hauled over gradients up to 1 in 100. The starting acceleration in shunting service was very good, and after passing the first starting notches the tractive effort remained constantly at the maximum level during the period required by the engine to reach the desired speed and then to attain the nominal output corresponding to this speed (fig. 8).

The RENFE has since ordered 20 further Diesel locomotives of 550 H. P. from Henschel & Sohn, Kassel, Germany. In these units the Henschel Diesel engine, built under Sulzer licence, will drive the four coupled driving axles through a Voith hydraulic gear. These locomotives are intended for shunting and normal line service and will have a maximum speed of 50 m.p.h.

A TUBULAR QUIZ

Tube liners, when used for articles subject to fatigue or stress (e. g., 'bus seats and tubular furniture) often have a mitred end, or the tube wall is brought down to a feather edge. Why is this?

The liners are placed in the tubes at a position where the maximum stresses occur. If the ends of the liners were cut square a sudden change in the cross sectional area of the assembly would result and cause a concentration of stress under load. By mitre-ing the liner ends or tapering the liner wall the stress is more distributed thereby straining the metal more evenly and avoiding local fatigue failures.

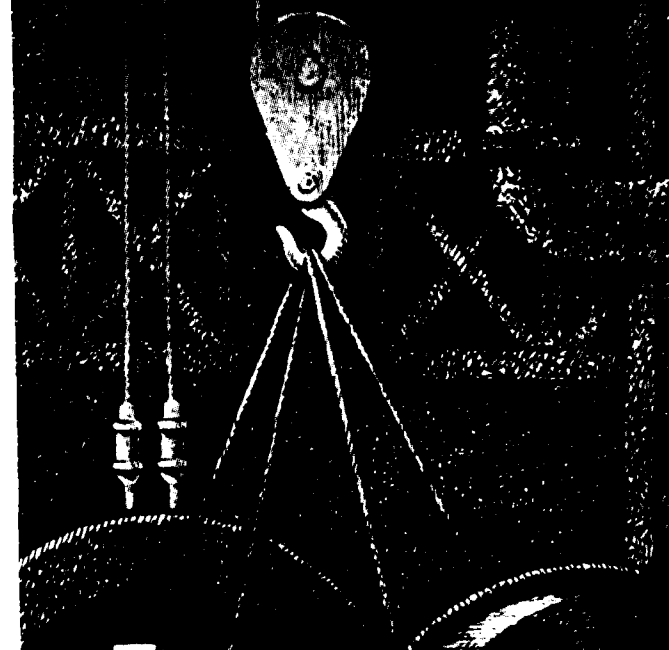


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Is it a Rail Revolution ?

We invite the attention of our Railway Engineers to this article which contains quite a lot of interesting information on Track Maintenance. We hope they would take advantage of the tips on Track Maintenance problems which confront them in their day-to-day activities.—Ed. IRWM.

WHEN one man can quite easily carry and operate the complete plant to cut through a 95 lb. Bullhead rail in 8 minutes or a 113 lb. Flat Bottom rail in 10 minutes, then indeed a revolution in rail track maintenance has taken place.

By the application of the most advanced knowledge of petrol engine design to the special problems of the Maintenance Engineer, the Howard Pneumatic Engineering Company of U. K. have evolved equipment which has already saved thousands of man-hours and costly delays on railway systems all over the world.

By scientific design and the use of special alloys, rugged strength and precision operation have been combined with extremely light-weight. Years of practical operation under the toughest conditions of climate and road-bed have brought many testimonials from experienced railway engineers and where practical experience has indicated some modification to "John Bull" Equipment, this has been carried out until the manufacturers can state with complete confidence that whatever the track maintenance problem, it can be handled more easily, more economically, more efficiently with the "John Bull" than by any other machine or method in the world.

Why the world's largest railway companies find that the John Bull equipment makes track maintenance an easier and cheaper job here are the reasons. Firstly there are attachments for Sawing rails and steel sections, grinding rails, boring holes and screwing screws in sleepers besides drilling holes in rails. Secondly the "John Bull" engine and attachments are entirely independent of any outside

source of power, such as electricity or compressed air. It is so light and well balanced that it can be carried easily by one man. Each attachment requires only one operator, with the exception of the Coach-Screwing and Sleeper Boring Equipment which requires two men. It takes only a moment to fix the equipment in position and it can be removed within a few seconds in an emergency. Machine work is carried out to the most exacting standards of accuracy. The high speed at which it operates, saves man-hours, and cuts costly hold-ups. It takes only a minute to change from one attachment to another, making it possible to carry out several jobs on site with the same machine.

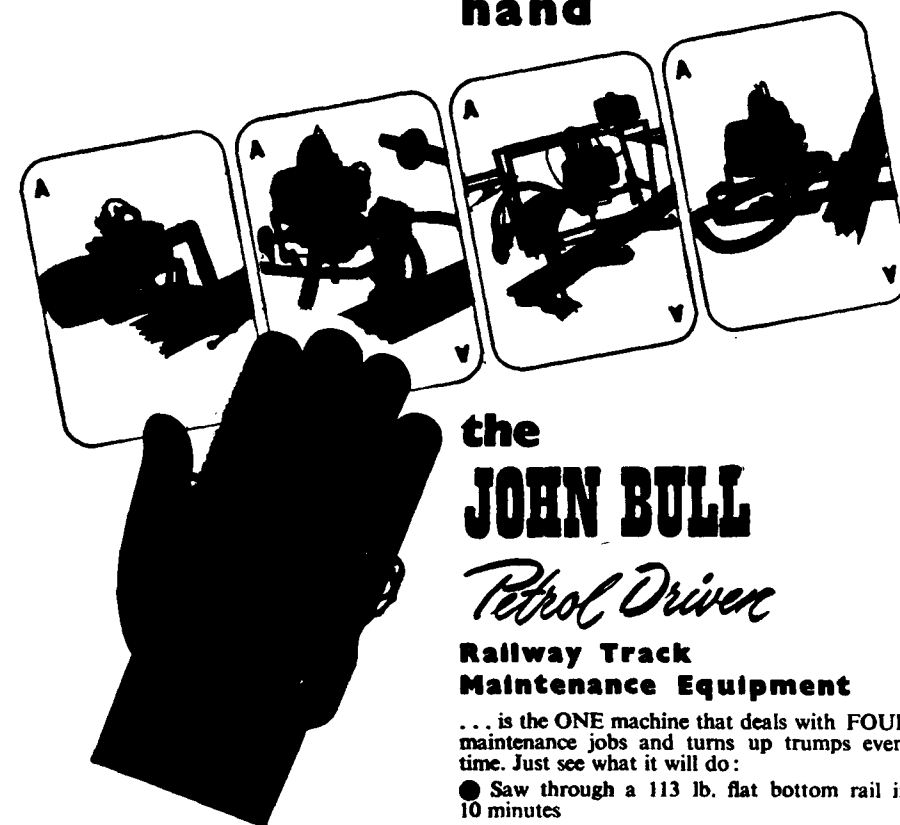
Now let us discuss with John Bull's range of attachments which are indispensable for Track Maintenance Engineer.

The John Bull magneto Petrol Drill is acknowledged to be the most easily portable rail repair equipment in the world. A comparative study will prove that the "John Bull" has no equal in the railway world. The John Bull Petrol Drill is the prime mover for the following attachments : —

Rail Saw, Sleeper Boring and Coach Screwing Machine, Rail Grinder and Rail Drill.

The purpose of Rail Sawing attachment is to cut up rails, accurately, quickly and at low cost—with no risk of shattered or burnt rail ends, or the possibility of fissures so easily started by torch-cutting or the nick-and-break method. It saves an enormous amount of time and labour when

**FOUR
ACES
in ONE
hand**



the
JOHN BULL
Petrol Driver

Railway Track Maintenance Equipment

... is the ONE machine that deals with FOUR maintenance jobs and turns up trumps every time. Just see what it will do :

- Saw through a 113 lb. flat bottom rail in 10 minutes
- Bore holes through sleepers or drive coach screws home in 4 to 10 seconds
- Grind rails or scratch-brush rust from structural work
- Drill a 1½" dia. hole through a 95 lb. Bull Head Carbon Rail in less than ½ minute. Also, when fitted with slow speed gearbox and used with No. 2 Heavy Duty Rail Clamp, drill a 1½" dia. hole through 95 lb. 14% Manganese Rail in 4½ minutes.

Yet it is so light, it can be carried in ONE HAND...

Made in England by

THE HOWARD PNEUMATIC ENGINEERING CO. LTD

Distributed in India by KHANDLWAL BROTHERS LTD

166 Dr. Dadabhai Naoroji Road, P.B. No. 338, Bombay 1

dealing with wheel-burned rails, worn fish-plate surfaces and split ends and prefabrication of points and crossings. It will cut through a 113 lb. flat bottom rail just in ten minutes, mild steel sections upto 6" x 4" at a rate of 75 strokes a minute.

The Rail Grinding attachments is used for grinding rails after welding and removing rust from structural work in preparation for painting. The engine is clamped to a convenient spare rail section and the power transferred to the grinding wheel or wire-scratch brush by means of a flexible shaft take-off. A high-speed gearbox means maximum coverage per man-hour, while the exceptional ease of handling and lightness of the equipment greatly reduces operator fatigue.

The Coach-Screwing and Sleeper-Boring Equipment weighs only 110 lbs. by using high-grade steel and light alloys of great tensile strength, including power unit for boring and screwing. This makes it an easy job the two operators to bore and screw sleeper after sleeper without effort and without stopping. The boring and screwing gear is very easily started, stopped and reversed by two Bowden wires and levers convenient to the operator's hand. This powerful compact machine combines the sturdy construction required for heavy day in and day out duty, with the amazing lightness and simplicity of operation which distinguish all "John Bull" track maintenance machines. This machine will bore holes through sleepers in 4 to 10 seconds depending on their thickness; it will also

screw the coach screws right home in the same time. There is no danger to the operators during use because all moving parts are enclosed by the light-weight but robust tubular frame. For screwing down the coach screws, a specially constructed slipping clutch is provided. The tension can be so adjusted that the screws can be taken down to the correct tightness without bursting the wooden ferrule.

For Drilling Carbon Steel Rails the simplest equipment is the "John Bull's" Universal Rail Drilling Clamp complete with John Bull Magneto Petrol Drill. The very act of clamping this attachment to the rail aligns the drill bit and keeps it in position. This attachment has been specially designed for drilling rails on permanent way tracks. It can be attached to the rail in less than one minute, and is fitted with a jig plate to ensure accurate drilling. These jig plates are made to suit both flat bottom and bull headed rails of all sizes. One setting of this attachment is necessary for drilling both holes to accept fishplate. This equipment will drill a 1" diameter hole in a high carbon rail at the rate of 1 1/4" per minute—and a 1 1/2" diameter hole through a 95 lb. 14% manganese rail in 4 1/2 minutes. Holes can be drilled up to 2" in mild steel or cast iron, and up to 1 1/4" in manganese steel. This enables one operator to drill hole after hole, every one of which is absolutely straight and accurate—with no tapering or distortion.

A TUBULAR QUIZ

What is a Torque Reaction tube?

A tube connecting the gear-box and rear axle housing of an automobile for the sole purpose of resisting the turning effect of the rear axle housing. It encases the propeller shaft and is used mainly on chassis which adopt the transverse springing where the axle housing cannot be held rigid by fixing it to the spring.

Indian Railways' Requirements of Rolling Stock & Equipment

WE understand the Ministry of Railways (Railway Board), Government of India, propose to obtain from established and reliable manufacturers rolling stock and other Railway equipment shown in the list below. Manufacturers in Europe, United Kingdom and North America can obtain copies of the Indian Railways Global Procurement Programme of Rolling Stock 1956-57 giving the particulars of items required and explaining the procedure for submission of quotations, from the Director-General, India Store Department, Government Building, Bromyard Avenue, Acton, London W.3. Manufacturers in other countries and authorized agents in India of all foreign manufacturers can obtain such copies from the Chief Design Engineer, Central Standards Office, Baroda House Annexe, New Delhi, at a cost of rupees two per copy.

List of Rolling Stock and Railway Equipment.

LOCOMOTIVES

Broad Gauge

- 93 Nos. 'WP' Class Locomotives.
- 60 Nos. 'WG' Class Locomotives.
- 34 Nos. 'WH' Class Locomotives.

Metre Gauge

- 10 Nos. Diesel Shunting Locos.
- 28 Nos. 'YG' Class Locos.

Narrow Gauge

- 12 Nos. 'ZB' Class Locomotives 2-6-2 type.
- 6 Nos. Steam Locomotives 2-8-2 type.

LOCOMOTIVE BOILERS

- 5 Nos. 'WM' type.
- 5 Nos. 'XT' type.
- 5 Nos. 'YS3' type.

FIRE BOXES

- 54 Nos. A/CWD type.
- 15 Nos. MAWD type.

WAGONS

Broad Gauge

- 2,250 Nos. Covered Wagons 'CR' type.
- 2,297 Nos. Open Wagons 'O' type.
- 16 Nos. Anhydrous Ammonia Tank Wagons 'TAL'.
- 7 Nos. Underframes for Anhydrous Ammonia Tank Wagons.
- 21 Nos. Bogie well wagons 'BWL'.
- 1 No. Bogie Well Wagon of welded construction 'BWS'.
- 16 Nos. Hydrochloric Acid Tank Wagons 'THA'.
- 766 Nos. Bogie Hopper Wagons with side discharge 'BOBS'.

Metre Gauge

- 4,169 Nos. Covered Wagons 'MC' type.
- 4 Nos. Bogie Well Wagons 'MBW'.
- 125 Nos. 'MBOC' type Wagons.

WHEELSETS

Broad Gauge

- 26,440 Sets 16 ton to Drg. No. WA-23 Alt. 6.

Metre Gauge

- 20,414 Sets 12 ton to Drg. No. WA-36 Alt. 5.
- 3,600 Sets 10 ton to Drg. No. WA-42 Alt. 5.

Narrow Gauge

- 200 Sets 6 ton to Drg. No. WA-3011 Alt. 2.

AIR-CONDITIONING EQUIPMENT

- 88 Nos. 2 1/2 tons capacity A.C.

(Continued on page 38)

Punched Card Accounting and Electronics

IT is difficult to-day to visualise a world totally lacking the extraordinary benefits the employment of electricity has conferred on the whole human race. Everyone is conscious of the fact, however, that with its powerful aid the boundaries of scientific knowledge have been extended far beyond the limits charted even half a century ago.

In the sphere of electronics, spectacular and significant developments have occurred within recent years. Now, with the introduction of electronic principles in the design of calculating and computing

machines, the way is open to the acquisition of even greater knowledge of the universe in which we live and the creatures who inhabit it.

These machines, known more popularly to the layman as "Electronic Brains", capable of comprehending all four rules of arithmetic; of operating in accordance with programmes which they can modify themselves whenever necessary; equipped with "memories"; able to translate data automatically into a language more suited to their own requirements and finally, to calculate at speeds

(Continued from page 37)

COACHING STOCK

Broad Gauge

- 48 Nos. I.R.S. Bogie Coaching Underframes with roller bearing axle boxes, wheels and axles.
- 12 Nos. I.R.S. Bogie Coaching Underframes with side operated hand brakes, but without wheels and axles.
- 125 Nos. I.R.S. Bogie Coaching Underframes with top operated hand brakes, but without wheels and axles.
- 180 Nos. I.R.S. Bogie Coaching Underframes without wheels and axles.
- 50 Nos. I.R.S. Four-wheeled Coaching Underframes with side operated hand brakes but without wheels and axles.

Metre Gauge

- 40 Nos. I.R.S. Bogie Coaching Underframes with roller bearing axle boxes, wheels and axles.

- 22 Nos. I.R.S. Bogie Coaching Underframes with side operated hand brakes, but without wheels and axles.
- 191 Nos. I.R.S. Bogie Coaching Underframes with top operated hand brakes, but without wheels and axles.
- 297 Nos. I.R.S. Bogie Coaching Underframes without wheels and axles.
- 50 Nos. I.R.S. Four-wheeled Coaching Underframes with side operated hand brakes, but without wheels and axles.
- 150 Nos. Third Class fully furnished Bogie Coaches, complete in all respects, ready for service.
- 100 Nos. Bogie Combined Motor and Parcel Vans.

Narrow Gauge

- 50 Nos. I.R.S. Bogie Coaching Underframes without wheels and axles.

reckoned in milliseconds, are obviously destined to make history.

THE ELECTRONIC COMPUTER

For the benefit of those who are interested to know more about these electronic machines, an attempt will be made here to give a brief non-technical description of one of these machines known as HEC Electronic Digital Computer, evolved by the British Tabulating Machine Co. Ltd., whose counterpart in India is Hollerith (India) Limited. Of course, this description cannot by any means do justice to these machines, whose performance is almost beyond the realms of belief.

The Hec Electronic Computer is a *general purpose* data processing machine designed primarily for commercial computation by electronic methods in combination with standard electro-mechanical Hollerith punched card equipment, and using 80-column Hollerith punched cards for the reception of data and instructions. The Hec will record, analyse, remember, calculate, compare, and tabulate the multitude of individual transactions which constitute in the widest sense the "book-keeping" of any organisation. It is a machine tool of remarkable versatility suited to the diverse accounting and statistical requirements of Government, Commerce and Industry—to the varied needs of the Accountant, the Actuary and the statistician.

This machine possesses the ability to execute automatically lengthy sequences of arithmetical operations, tirelessly and at lightning speed. It is equipped with a "memory" to enable it to retain numbers. It is able to exercise judgment, to discriminate according to prescribed criteria and to choose between alternative courses in the process of its computing.

Just a few technicalities in brief:—

INPUT

Input is from a standard 80-column card via the card feed unit. These cards may be

(Continued on page 40)

punched in any notation—for example decimal, sterling, gallons and firkins. Simultaneously, with the transfer of numerical data to the Electronic Unit, the output units may receive alphabetic or numeric information directly from the input cards.

OUTPUT

Output from the Electronic Unit may be printed or punched. When printed the output is to the print unit of the input Tabulator and when punched to the punch mechanism of the output Gang Punch. The Electronic unit is also designed to compute during printing.

MAGNETIC DRUM STORAGE

It is the Magnetic Drum which gives the Electronic Computer its ability to carry out long sequences of arithmetic operations without human intervention. On the drum are stored both instructions and numbers in the form of magnetic spots, a method not unlike that use on voice recording machines.

PROGRAMME CONTROLLER

The Programme Controller consists of a valve register which reads instructions from the drum and causes the other components of the Electronic Unit, the Input and Outputs to carry out the instructions.

ARITHMETIC UNIT

For adding, subtracting, multiplying or dividing operations. It consists of four valve registers. In this article, it is not possible to give a description of the versatility derived from the properties and inter-connexions of these four registers.

APPLICATIONS OF HEC

Hec can supply quickly and accurately the essential figures on which policy and planning can be confidently based. Whereas it may once have been necessary to use past history as an approximate guide to present conditions

Railway Carriage Painting

By R.E.T. HANSON, A.R.I.C. and T. WHITFIELD

PRACTICALLY all the products and methods of application known to the surface coatings industry are used by the railways for one purpose or another. The products range from fine quality interior wood finishes to anti-corrosive paints for bridges and other structural steelwork. The methods of application vary from brushing to the more recent developments such as the 'hot-spray' processes. To generalise on railway painting is difficult because of the varying conditions of service and climate encountered in different parts of the world. A comprehensive treatise on railway painting could not therefore be undertaken within the scope of a single article. Accordingly this paper deals only with materials and application techniques which are used in carriage painting.

The first requirement of any painting system is adequate surface preparation. This

is particularly important in the case of metal surfaces.

PRETREATMENT OF STEEL

Steel which is used for carriage construction is of two main forms. These are sheet for panelling and bar, such as 'tophat' section channelling, for frame construction. Steel sheeting is normally supplied in a scale-and-rust-free condition and is usually covered with a temporary protective coating of oil. In order to provide a good key for the priming coat it is important to remove this oil and also to etch the metal surface. The oil can be removed by any of the usual degreasing processes; one of the best being that which employs trichlorethylene vapour.

The removal of grease and oil should be followed quickly by etching and painting because the degreased surface is very prone

(Continued from page 39)

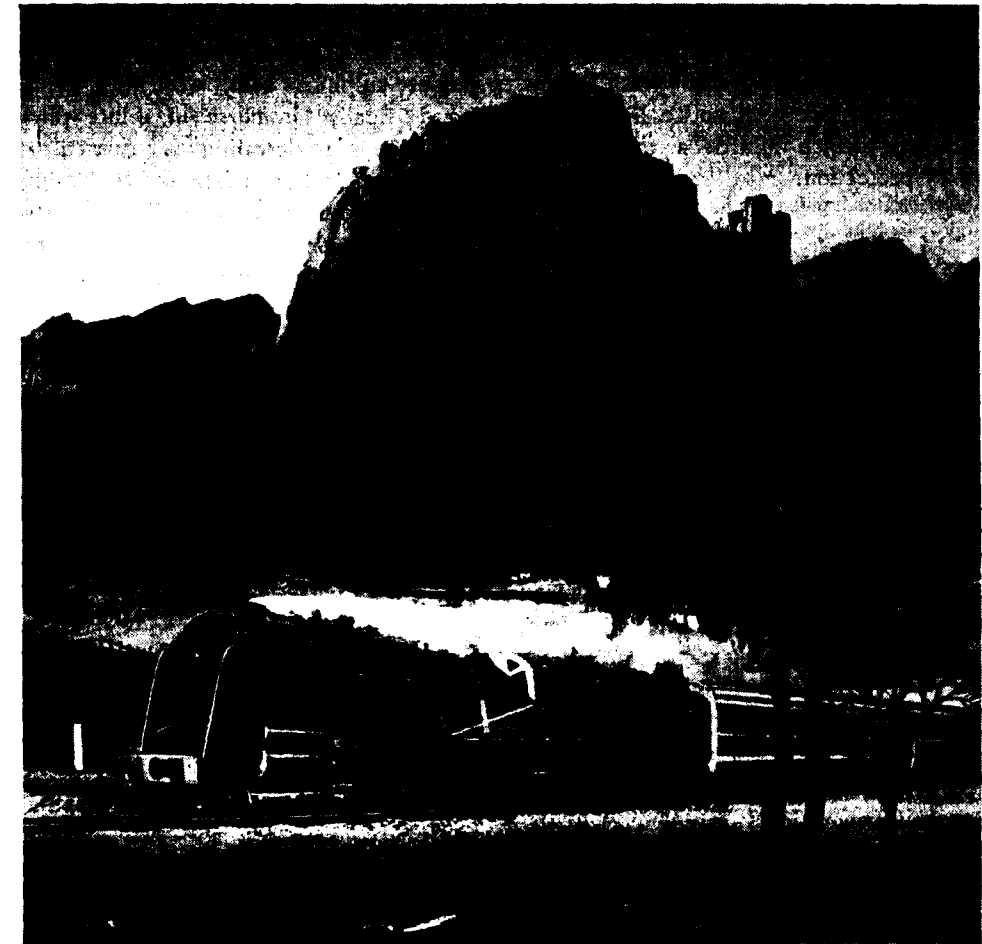
and requirements with the Hec Electronic Digital Computer, capable of performing in hours, calculations that formerly took weeks, up-to-the-minute situation reports, can now be obtained even on a day-to-day basis, if required.

Payroll, Stores Control, Sales Accounting are a few of the accounting procedures which provide ample scope for a machine of Hec's versatility and resourcefulness. Indeed, whenever, it is advantageous to handle complex calculations at high speed, wherever it is desirable to accelerate accountancy production and obtain relief from the time-consuming, unrewarding drudgery of manual methods, Hec can be relied upon to supply

the answer. In all aspects of purchasing, production, sales, distribution, market research, stock, statistics, and financial accounting, the Hec Electronic Computer is available to promote economy. Secure efficiency, and to accelerate the presentation of essential information.

TO CONCLUDE

And thus in the words of Von Leibnitz, distinguished German philosopher and scientist, who shares with Sir Isaac Newton credit for the development of calculus, we may conclude: "It is unworthy of excellent men to lose hours like slaves in the labour of calculation which could be safely relegated to anyone else if machines were used".



Tubes under Pressure

Yes—the boiler tubes of a locomotive must be made to stand up to pressure. Tru-Wel boiler tubes are made to the exacting requirements of British Standard 1654/1950—and the way they stand up to their work is a major tribute to the Electric Resistance Welded method of manufacture, developed by Tube Products for over 25 years.



TUBE PRODUCTS LIMITED, OLDBURY, BIRMINGHAM A  PRODUCT

to rusting. The need for immediate painting can be overcome to some extent by pretreatment with a phosphoric acid wash. This gives a slight surface etch and a light phosphate coating which affords a measure of temporary protection.

Improved surface preparation can be obtained by the use of a proprietary phosphating process such as 'Parkerizing', 'Bonderizing' or 'Walterisation'. These processes all have the effect of producing, by chemical action, a layer which is protective, matt and eminently suitable for painting. A less effective but nevertheless valuable alternative treatment, after degreasing, is to apply either by spray or brush, a coat of self-etching wash-primer. These wash-primers function by etching the surface and at the same time depositing a thin layer of film-forming material containing rust-inhibiting pigment. This treatment should be regarded only as a form of surface preparation and not as a substitute for a coat of priming paint. It is valuable in securing good adhesion to metal surfaces. If, as is sometimes the case, galvanized steel sheet is used for panelling it should be etched with a mordant solution before painting.

The steel bars which are used in carriage frame construction are usually covered with a coating of millscale. A simple method of scale removal is to allow the steel to weather and rust outdoors. This facilitates the removal of the scale by subsequent chipping and wire brushing. If the bars are lying on the ground it is necessary to turn them over periodically to ensure that all surfaces are exposed to the weather. The weathering process can be accelerated by periodically wetting with water or brine. This method of descaling is not costly, but it is time consuming, and not wholly satisfactory because of the difficulties experienced in the removal of loose scale and rust by subsequent scraping and wire brushing.

Scale can be removed efficiently by acid pickling. The usual method is to immerse in dilute sulphuric acid, wash with warm water and finally immerse in dilute phosphoric acid.⁽⁶⁾ If descaling is carried out by sulphuric acid only, followed by washing with water, there is a possibility of traces of sulphates being left on the surface of the steel. These sulphate deposits have been reported to be corrosion accelerators.⁽⁶⁾ The final wash with phosphoric acid leaves the steel with a light coating of iron phosphate which, though thin, nevertheless, provides a temporary measure of protection against corrosion. Pickling is carried out in tanks and therefore may not be a convenient treatment for large steel sections such as carriage under-frame members. These bigger metal sections will normally be descaled by weathering followed by very careful scraping and wire brushing.

A method of descaling which is applicable to heavy structural steel is flame-cleaning. In this method the steel ought first to be exposed to weather in order to loosen millscale. The loose millscale and rust can then be removed by flame-cleaning with oxy-gas burners. After flaming, the surface deposits are removed by wire-brushing and are then swept off. The priming paint should be applied while the metal is still warm so that no moisture condensation will occur. This painting on a warm surface promotes better drying, and the quenching action of the cold paint on the hot surfaces results in the paint being drawn into the interstices of the surface. Care must be taken when flame cleaning that overheating does not occur as this can cause buckling.

PRETREATMENT OF LIGHT ALLOYS¹

Pretreatment processes and paint systems which are employed in the finishing of aluminium and its alloys differ from those used in the treatment of ferrous metals. The first step is to remove grease, dirt and loose deposits. This may be carried out

by use of solvent or by mild alkaline cleaners. It is possible to roughen the surface sufficiently by use of abrasives but chemical etching is less laborious and is wholly satisfactory. Good results in chemical pretreatment can be obtained with proprietary light metal enchants which may be brushed or sprayed. Any deposit which is left by these enchants should be washed off with water and the surface should be allowed to dry before painting is commenced. Self-etching wash primers provide a useful pretreatment for aluminium and its alloys and are especially suitable in cases where aluminium sheets etc. may form part of an assembled carriage. As in the case of steel pretreatment, these wash-primers can be sprayed or brushed. Wash-primer films dry within a few minutes to a condition which permits handling. Other treatments suitable for aluminium sheet before assembly, are bath processes such as chromic-sulphuric acid, 'Pylumin' and 'Alocrom'.

METHODS OF APPLICATION

The methods used for the application of paint to railway carriages are usually determined by the kind of finish which is required and the facilities which are available. Spray painting has the advantage of speed and of allowing the use of quick drying coatings. Against this must be set the greater adaptability of brush painting and the initial cost of installing spraying and ventilating plant. Brush application is of course desirable, if not essential, in the case of paints containing lead because of the toxic hazards associated with the spraying of paints which are 'Lead Paints' within the meaning of the Lead Paint Act. With priming paints the best results are considered to be obtained by brush application because this ensures adequate penetration into surface irregularities.

A recent development in spray painting is the 'hot-spray' technique.² In this process the viscosity of the paint is reduced by heat

instead of the usual paint thinners. A typical hot spray unit is constructed as follows. A pressure tank is used to hold the paint which is forced by pressure into a heating coil (150-200°F.) From this coil the paint is forced to the spray gun, where a bye-pass valve allows some of it to return to the heater thus ensuring a constant supply of hot paint at the gun. Compressed air to atomize the paint is supplied to the gun by a separate air line. The advantage of the 'hot-spray' system is that thicker films are obtained thereby enabling a reduction in the number of coats. At the same time a considerable saving is made by reducing the required amount of thinners which merely evaporate into the air. This applies particularly to cellulose lacquers which are much used for the interior woodwork of carriages. Other advantages are:— reduction in labour costs; operation at more constant temperatures regardless of weather conditions; less solvent fumes to inhale; and less spray mist rebounding from the surface during spraying.

The methods of metal pretreatment and paint application already mentioned refer to carriage painting in general and not to Indian Railway practice in particular. Painting schedules, however, must take into account the conditions of service peculiar to India.⁽⁷⁾⁽⁸⁾ Carriages in India are subjected to extremes of climatic conditions which may range from tropical and sandy desert country to cold mountain regions. In addition, the corrosive influence common to all railways e.g. acidic gases from the combustion of coal, may be encountered.

BOGIE FRAMES

Here the function of the paint is protective rather than decorative. The recommended treatment, after carrying out the necessary surface preparation, is priming with red lead and finishing with two or more coats of bituminous paint. Good quality chassis black paint should be used if lettering has to be done on top.

WHEELS AND SPRINGS

These are usually coated with bituminous paint.

CARRIAGE ROOFS (Exterior)

The main roofing materials employed in carriage construction are steel sheets and canvas covered wood. The treatment of the steel sheeting follows the practice described later for body-side panelling with regard to surface preparation and priming. Suitable finishing coats for carriage roofs, especially in the tropics, are good durable white paint or aluminium paint.

Wooden roofs will normally be first coated with a white lead based priming paint. The canvas is then bonded to the wood by means of a white lead based bedding compound. This bedding compound is also brushed over the top surface of the canvas and the whole system allowed to harden before the finishing paint is applied.

Two coats of a similar paint to that suggested for steel roofs should be used for finishing.

The interior surfaces of steel roofs should be primed and then finished with bituminous emulsion paint in a similar fashion to that suggested later for interior body shells. Wooden roof interiors should be prime coated and may then be finished with a purely protective and durable coating.

EXTERIOR COACH PAINTING

The choice of paint for the exterior surfaces depends upon the materials of construction. Carriage bodies may consist of wooden frames to which the steel panelling is attached by means of screws. The screw holes in the panels are countersunk and the filling of these holes presents one of the most difficult problems in carriage painting. During the service life of the carriage these screws tend to work loose due to vibration and shock, with

a consequent tendency to cracking and flaking of the filler and paint. Another method of construction employs a steel frame to which the panelling is fastened by spot welding. This method gives a more continuous surface. If it is desired to have a protective coat on the frame and panelling prior to welding then special coating materials must be used. This is because ordinary paint films usually offer such a high resistance that the welding operation is made difficult. A priming paint which may be used for this purpose is one based on zinc dust. This type of paint contains a high proportion of zinc powder and a very low proportion of organic binding material. It has excellent anti-corrosive properties when used as a priming paint for steel and it is electrically conducting.

STEEL PANELLED CARRIAGES

After cleaning and adequate surface preparation any good quality rust inhibiting priming paint can be used. One of the best appears to be that which is based on red oxide and aluminium powder. Adhesion of this paint is excellent and good results have been obtained in Britain.⁽¹⁾ Two coats are usually applied followed by a coat of brushing filler. A hard knifing stopper is next used where necessary. A further coat of brushing filler is then applied and again the hard stopper where required. Any filling and stopping, especially over screw holes, is then "faced off" and the whole surface rubbed down before the undercoat is applied. If the brushing filler is different in colour from the stopper and primer it can be used as a "trace" to prevent over zealous rubbing down from damaging the primer. If the priming coat is damaged it should be touched up before further painting is attempted. A lead colour undercoat is suitable as the next coat. This might be based on zinc oxide in a long oil binder. A feature of this paint system is that the adhesion of the primer to the metal is greater than the adhesion of the finishing

coats to the lead colour undercoat. In the event of mechanical damage the fracture tends to occur at the boundary between the lead colour undercoat and the finishing coats, thus leaving a coat of primer and undercoat for prevention of corrosion.⁽¹⁾

One U. K. Railway painting Schedule, as laid down in 1936, serves to illustrate the coats involved :—

- 2 coats Red Oxide/Aluminium Primer
- 1 coat Lead Colour Undercoat
(Zinc Oxide Pigment)
- 2 coats Red Oxide Undercoat for Lake
- 1 coat Madder Lake
- 1 coat Glaze
(Mixture of Lake and Varnish)
- 3 coats of Varnish. Filling and stopping is carried out where necessary.

The system is maintained by recoating with varnish every alternate year with occasional colour coats at greater intervals. It is stated⁽¹⁾ that a life of approximately sixteen years can be obtained by this method of painting. These materials are based on oleo-resinous varnishes. It is possible to reduce the number of coats by using paints based on long oil alkyd resins together with alkyd based finishing varnish.

It will be realised that, whatever system is adopted the use of poor quality cheap paints is false economy. Labour in application forms the major part of the total cost and this is the same irrespective of the quality of the paint which is used. The difference in performance between good quality and poor quality paints is accentuated by the rigorous conditions which are encountered in service. Only by the use of first class materials can be need for frequent repainting be reduced.

Careful consideration should be given to the choice of colours and in this connection reference should also be made to the recom-

mendations of Mr. Fancutt, (Superintendent, Chemistry Division, B. T. C.) after his visit to India in 1937. He advised the use of red oxide pigments which are extremely permanent under Indian conditions. This recommendation has been noted and in 1950 the use of a colour scheme was adopted wherein a red oxide colour for body sides was specified. Where it is necessary to use greens, yellows, reds and blues due consideration should be given to light fastness, chemical stability and especially sulphur dioxide resistance. Lead Chromate pigments are prone to attack by sulphur dioxide and the use of a more chemically stable yellow pigment is recommended. Examples of stable and light fast pigments are Monastral Blue, Hansa Yellow, Toluidine Reds and Alizarin Madder Lakes.

The interior body shells of carriages demand careful treatment because they may be subjected to extensive corrosion which would remain undetected for long periods. It is therefore desirable to use a good protective system. The current practice in the U.K. is to use one coat of Red Oxide Primer followed by three heavy coats of bituminous emulsion.

LIGHT METAL ALLOY COACHES (3)

Under certain conditions it has been found that unpainted light alloy coaches have had a certain amount of success. Other coaches have been unpainted but anodised before fabrication. Anodising is an electrolytic process which produces a thick and compact oxide layer on aluminium. This oxide layer is highly protective and provides an ideal surface for painting.

INTERIOR COACH PAINTING

The function of interior paints in coaches is mainly decorative but coatings should be hard, tough, smooth and stain resisting. Mar resistance is important because these coatings must stand up to a great deal of

wear and tear. Good quality paints are therefore required.

The normal three coat treatment of primer, undercoat and finish should be regarded as a minimum schedule. The finishing coat must be capable of standing up to the conditions already mentioned. In the case of ceilings, which are usually painted white, there are the additional requirements of being non-yellowing and hard in order to resist staining by tobacco smoke. The paint must also withstand frequent cleaning.

Where better class coach interiors are finished with veneered woods it has been common practice, in the past, to use french polish. This process requires considerable skill and is time consuming. Nitro-cellulose lacquers have been used for some time, but these coatings have the disadvantage of forming films which are highly inflammable.⁽⁵⁾ For this reason the use of ethyl-cellulose lacquers is advocated. This type of lacquer forms films having a low rate of flame spread. Ethyl-cellulose coatings can be used in the same way as conventional nitro-cellulose materials and, by using the correct solvents, can be 'pulled over' to give highly satisfactory finishes. The 'hot spray' technique, which has been mentioned earlier, offers advantages when applying cellulose lacquers because the required build can be obtained with fewer coats. Orthodox cold spraying methods produce thin films so that multiple coats of lacquer are required to achieve the desired 'build'. By use of the 'hot spray' technique less thinners are required so that good film build can be obtained with fewer coats. It is also claimed that hot spraying of cellulose lacquers minimises the tendency to blush in cold and/or humid atmospheres.

Good film build can also be achieved by the use of cold catalysed lacquers. The best of these are probably the acid catalysed urea/alkyd types which can be sprayed or

brushed. These lacquers are tough and durable but, of course, they cannot be 'pulled over' and more attention must be paid to filling and general surface preparation. The fire-retarding properties of these lacquers are good and are similar to those of ethyl-cellulose coatings. Cold setting lacquers have also been recommended as finishers for wood and lino floors.

As was stated at the beginning of this article the paint requirements of railways cover a very wide field. The new film-forming materials available to the paint industry will, no doubt, further widen the range of surface coatings available in the future. Of these newer materials mention should be made of the recently introduced epoxy resins and silicone resin which are promising.

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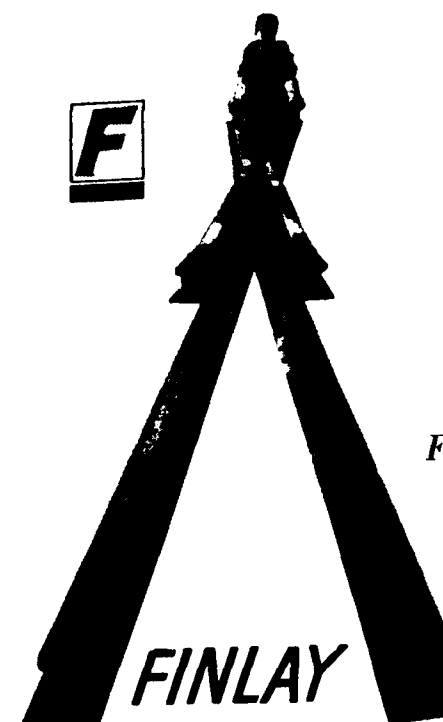
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Review of painting practice in Britain and modification to meet Indian requirements.

A TUBULAR QUIZ

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CROMOCORD

For welding low-alloy high-tensile steels. All-position. Weld metal gives Mn=0.8%, Cr=1%, Mo=0.2%.

NICROMOLYCORD

For welding low-alloy high strength steels. All-position. Weld metal gives Mn=0.8%, Cr=1%, Ni=2.5%, Mo=0.7%.

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To give a surface of 280 Brinell on mild steel. For rails, rope-winding wheels, etc.

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To give a surface of 300 Brinell on mild steel.

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To give a surface of 600 Brinell on mild steel, and carbon steels. The deposit must be quenched for maximum hardness.

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Role of Arc Welding in Steel Economy Project

By S. V. Nadkarni, M.Sc., A.M.Inst.W. (Lond.)

IT is in the fitness of things that arc welding should be called upon to play a major role in big projects everywhere in India to-day. Arc welding has been recognised all over the world as the most versatile and efficient method of joining metals. The Planning Commission has also been quick to realise the need of popularisation of welding in India, of drastic changes in our design and fabrication methods so that riveting is replaced as far as possible by welding. In fact, the Planning Commission has listed "Popularisation of Welding" as a major step in the successful implementation of the Steel Economy Project which is now being looked after by the Indian Standards Institution.

WHAT IS ARC WELDING

Welding may be defined as a method of joining metals by heating the edges or surfaces to a plastic or molten state and allowing them to solidify together with or without the application of pressure. When, in welding, the edges are allowed to melt before solidifying together without the application of pressure, the process is called fusion welding. Fusion welding can be accomplished in two ways: one, in which the heat necessary is obtained from an oxy-acetylene flame, the process being commonly called gas welding and the other in which the heat is obtained from an electric arc, the process being known as arc welding. Arc

welding has proved itself to be the most versatile of the various methods and is the most popular.

In arc welding, the arc is struck between an electrode and the base metal to be welded. (See Fig. 1). The electrode is held in a holder with an insulated grip, and this holder is linked by means of welding cable to one terminal of an electrical equipment called welding generator or a welding transformer. The base metal is connected to the other terminal.

The electrode is generally a metallic rod covered concentrically along its length with a chemical material called "flux". One end

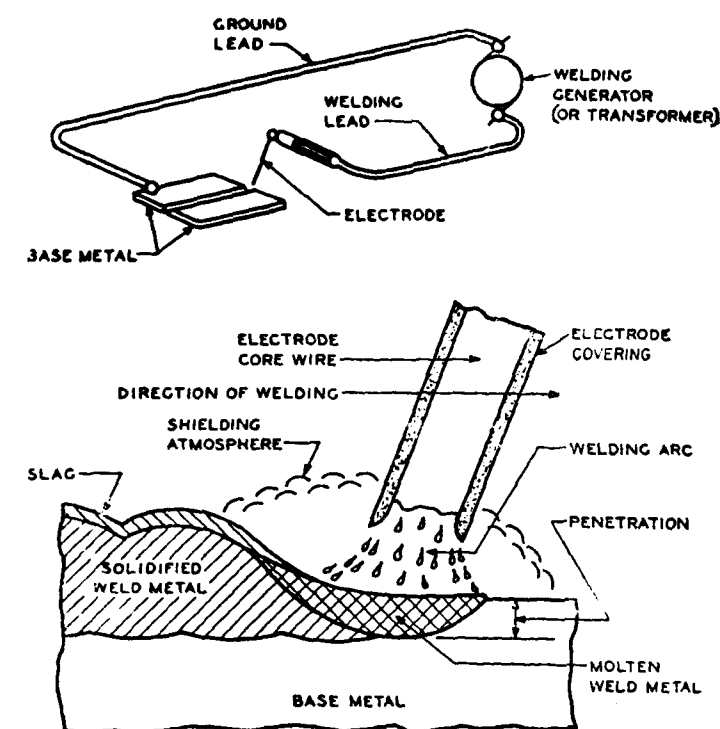


Fig. 1

NOVEMBER 1955

of it is kept bare upto an inch or so, so that it can be held in the jaws of the electrode holder to carry the current to the other tip. When this other tip is touched to the base metal, withdrawn, and held a fraction of an inch away, an arc of intense heat is formed. This arc which has a temperature of about 6900°C, becomes a miniature furnace with two extremely hot spots, one on the electrode and the other on the work just under it. The portion of the work melts under intense heat and forms a small pool or crater and simultaneously the electrode also melts at the tip and deposits itself in the crater. As the arc travels further down the joint, the metal in the crater just behind the arc is solidifying into a dense joint. Obviously, feeding the electrode down all the time as it melts and maintaining the same arc length and its speed of travel call for skill on the part of the welder.

ADVANTAGES

Switching over from riveted designs to welded designs seems a far cry. It is not merely a matter of substitution but of complete reorganisation. Welders have to be trained, right types of electrodes have to be obtained, very often joints have to be bevelled for obtaining complete fusion and steps have to be taken to avoid porosity and cracks in welds and distortion of the assembled parts. Rigid inspection methods have to be laid down, right grades of steel have to be selected as higher carbon contents in the steels may lead to hardness and brittleness in the weld or in the heat-affected zones next to the weld, and high sulphur contents may cause porosity in the weld metal. However, advantages in favour of welding are so overwhelming that any amount of organisational work is worthwhile.

The advantages of welded steel construction can be summarised as follows :

1. Welding decreases weight and cost of structural members which need not be weakened by rivet holes.

2. Saves material in structural connections by making them more compact, and in some cases, by eliminating connection materials altogether through the direct welding together of members or structural elements.
3. Saves cost in fabricating, fitting and assembly by eliminating operations of punching, drilling, countersinking, etc., and by reducing the amount of handling of heavy pieces in the shop; also provides greater flexibility to keep pace with other fabrication and erection operations.
4. Provides greater freedom in architectural and structural design, and better appearance (when steel work is exposed), because of smoother surfaces and outlines.
5. Facilitates economical and convenient alterations and additions to structures, with a minimum need for removal of existing walls, partitions, floors or other members and with no field drilling of holes for connections to existing members; also results in a minimum of noise and other inconvenience to occupants.
6. Reduces corrosion and cost of cleaning, painting and maintenance of exposed steel work, because of the smooth surfaces provided by welded construction, which prevent the accumulation of corrosive dust and other matter in the framing of powerplants and industrial buildings, and which discourage corrosion in coal bunkers and other coal handling equipment. Corrosion is generally greater in rivets than in base metal, but welds are more corrosion resistant than base metal.

7. Eliminates leakage at joints in storage tanks, service piping, etc.

In order to obtain a more convincing picture of the superiority of welding or rivet-

ing in steel construction work, the following table is reproduced. It has been prepared by the Air Reduction Company of New York, from data reported for various examples of welded bridge and building construction :

Class of Structure.	Saving in Weight compared to riveted structure.
Rigid-Frame or Arched Roof Buildings, Auditoriums, Hangars, etc.	20-26%
Mill Buildings, etc. with Roof Trusses	10-15%
Industrial Handling Equipment	15-30%
Girder and Arch Bridges	15-30%
Truss Bridges	10-20%
Continuous Rolled Beam Bridges with cover plates, splices, stiffeners, etc.	10-15%
Conventional Tier Buildings	5-10%
CLASS OF MEMBER OR UNIT	
Truss-Type Bents for Mill Buildings	20-30%
Built-up Plate Girders	20-35%
Trusses	15-28%

OVERCOMING WELDING DIFFICULTIES

Changeover from riveting to welding requires some amount of forethought and caution because, to the uninitiated, welding presents a number of unforeseen difficulties.

During welding, steels are subjected to structural, dimensional, and compositional changes which have an important bearing on what is called weldability. First, in a process like arc welding, metal is melted and often must resolidify under conditions that are approximately the same as those encountered in chill casting. Second, the base metal adjacent to the weld is unavoidably heated momentarily to a maximum temperature that varies, with the distance from the weld, from the melting temperature of the steel to room temperature. Third, the temperature and phase changes taking place introduce in the weld volume changes which cause plastic flow and residual stresses and which may lead to cracking.

Again, structural distortion in one form or another is incident to all forms of welding, and if improperly controlled may be sufficiently severe to render the welded assembly nearly useless. It is caused by two factors : The thermal contraction or shrinkage of the weld metal on cooling from molten to atmospheric temperature and the different expansion and contraction of the metal adjacent to and affected by the heat of the weld.

Difficulties such as those described above have been successfully overcome by using weldable steels, applying preheat or postheat treatments wherever necessary, and by a proper sequence and procedure of welding.

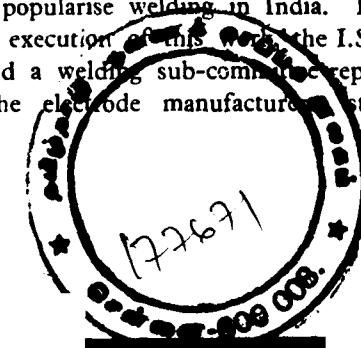
POPULARISATION OF WELDING

Earlier, mention has been made of the work started by the Indian Standards Institution to popularise welding in India. For successful execution of this work, the I.S.I. has formed a welding sub-committee representing the electrode manufacturers, steel

(Continued on page 52)

NOVEMBER 1955

THE INDIAN RAILWAYS WORKSHOP MAGAZINE



WORKSHOP OF THE MONTH

POWERS-SAMAS ACCOUNTING MACHINES

EARLY in 1914 a Mr. James Powers brought to England from America a group of statistical machines working on what was then a remarkable new principle involving the use of punched cards. The 1914-18 war held up the development of the use of these machines in this country, but in 1919 a wholly British company was established for the purpose of their manufacture and sale. This company, first known as the Accounting and Tabulating Corporation of Great Britain Limited (later to become Powers-Samas Accounting Machines Limited) commenced production early in 1921 in a small factory comprising four bays erected on the site of the present factory at Aurelia Road, Croydon. By the end of 1921 the total staff numbered 150 and limited quantities of four different machines only were being manufactured.

To-day the factory at Croydon employs 3,000 workpeople, covers an area of $5\frac{1}{2}$ acres and manufactures approximately 3,000 machines annually in over a hundred different models. Various other factories at Chertsey, Crayford, Croydon and Kirkby have been established for handling the production of cards, the manufacture of electronic equipment and for extensive research work.

Although there is considerable variety in the type of machines produced, the function of them all is the manipulation of standard sized cards containing significant perforations for the purpose of producing mechanically and efficiently the many accounting and statistical records required by industry, commerce and government.

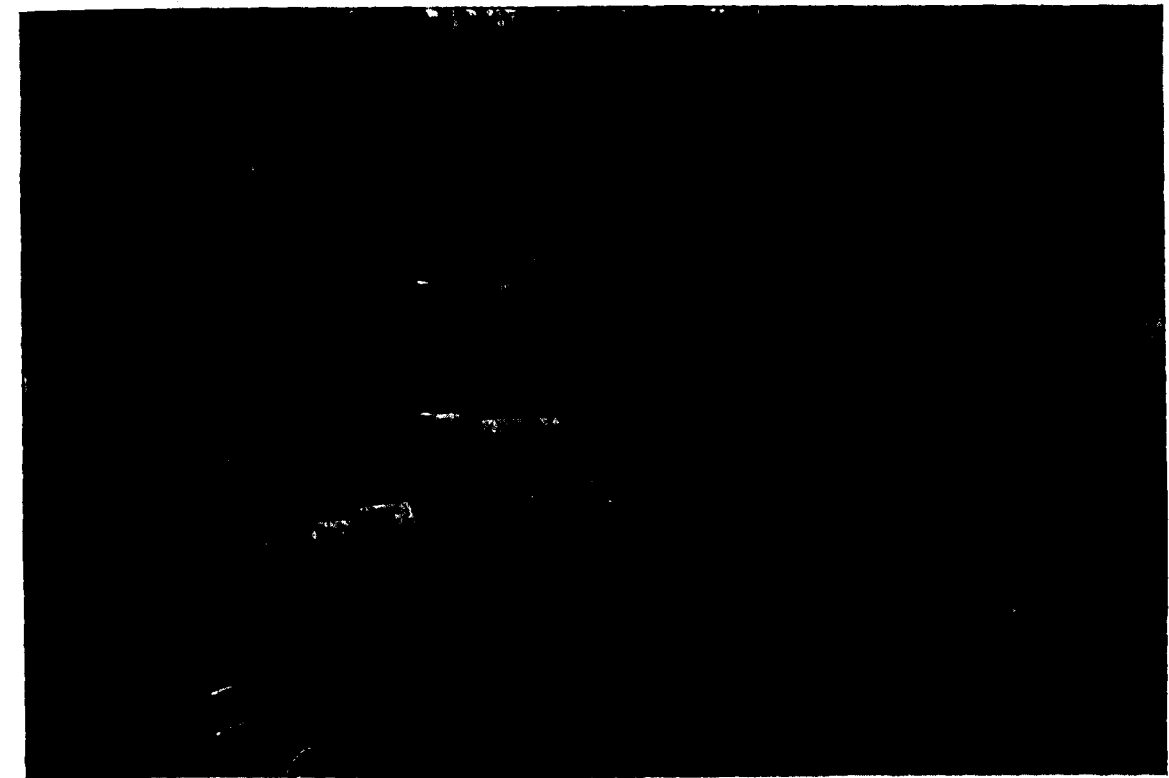
(Continued from page 51)

makers, welding inspectors, and leading designers and fabricators in steel. This Sub-Committee is bringing out a series of codes and specifications on arc welding electrodes and equipment, on arc welded applications such as bridges and pipelines. Courses are being prepared for the systematic training and testing of welders, and steps are being taken for the setting up of welding schools in the country. A series of hand books for the instruction of welders, welding supervisors, welding inspectors and welding engineers is being published.

FAITH IN WELDING

Faith in the efficacy of welding is an important requisite for its popularisation and faith cannot be born merely by the availability of published codes and handbooks. Thanks to the enterprising spirit of those in

charge of such projects as the Integral Coach Factory and the Chittaranjan Locomotive Works, welding is being accepted and put to test on important fabrication jobs. Welding is being organized on many other projects. Hindustan Shipyards at Vizagapatnam are also organising a welding school in view of the growing use of this process in ship-building. All-welded Vaitarna-cum-Tansa pipeline in Bombay is a triumph of welding. Standard arc welding electrodes, equal to the world's best, are now manufactured in India, and almost all these projects use exclusively Indian-made electrodes. One enterprising electrode manufacturer has already introduced what are called "Low-Hydrogen" electrodes in this country which are specially meant for the fabrication of high tensile steels and these are already finding large scale application in the various projects like Perambur Coach Factory, D.V.C. etc. etc.



An extensive view of the Final Testing Department.

There are three main categories of equipment, viz: Punches of various kinds for perforating the holes in the cards; Sorting machines for classifying the punched cards, and Tabulating machines for producing the accounting, costing, or statistical records from the classified punched cards; and each user needs one or more machines from each of these three categories.

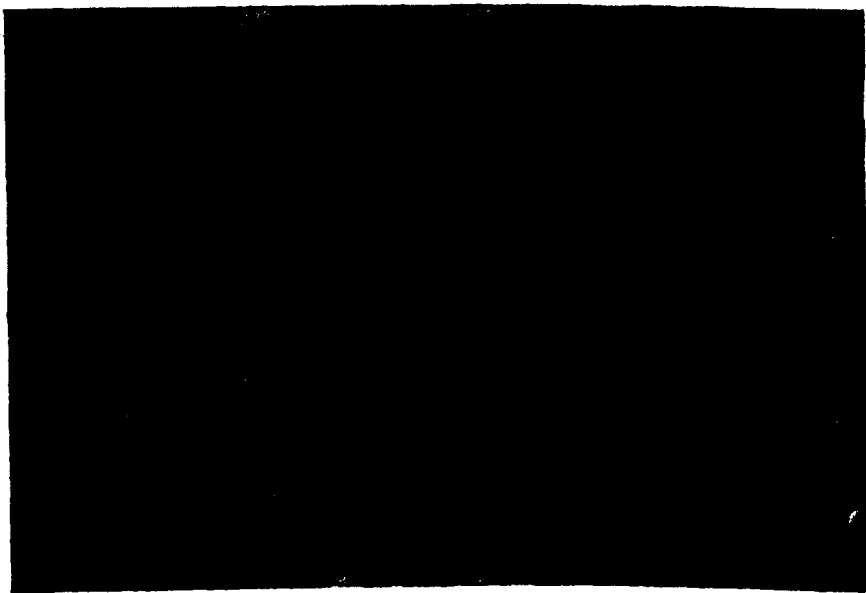
Many thousands of parts are used in the construction of each of the machines which are called upon to work at considerable speed and to a high degree of accuracy. Consequently much of the work is high precision engineering demanding also rigid control and inspection methods.

Skilled assembly work is also an important feature of the factory organisation particularly in the manufacture of the Tabulators which are all built to customers' special requirements.

Although many thousands of the high precision piece parts are common to all tabulators produced, it is nevertheless true that all such machines differ in greater or lesser degree in their final construction; hardly any two machines are alike in every detail.

The factory can be truly described as a fully integrated light engineering works, because except for the production of sand castings and drop forgings, it is entirely self-contained. During the thirty-four years it has been established, the management have constantly sought out the most up-to-date techniques in order to be in the forefront of development of both the product and the methods of manufacture.

Within the limitation of its somewhat piecemeal growth, the factory has been so arranged as to eliminate as far as possible all unnecessary transportation of materials or



A section of the Dining Hall. The trophies give some indication of Sports Club activities.

parts. The raw materials are received at one end and the work gradually flows through unidirectionally towards the finished stores and despatch bay at the other end.

It will be appreciated that much of the work carried out is such as will be found in any well organised factory engaged in the light engineering industry. Consequently even if space permitted, a detailed description of the work of the various production units would be somewhat monotonous. In this rapid glance round the factory, therefore, only matters of unusual interest will be mentioned.

On commencing a tour of the factory one of the first things that arrests the attention is the tool store located alongside the raw materials store. Drills, reamers and similar small tools are all meticulously arranged, being clearly labelled and marked according to a simple but very efficient colour code. The heavier tools are stored at such a height and in such a manner as will obviate all unnecessary lifting, the heaviest being left on their transportation platforms ready to be picked up when required by the Lansing-Bagnall loaders which are employed.

In addition to this main tool store a number of sub tool stores are located at various important centres in the factory. These sub tool stores are equipped with such tools as are necessary to the work of the particular section they service.

Adjoining the Tool Store are the Machine Shops equipped with batteries of the latest automatic lathes, millers, grinders, capstans, borers and drilling machines. Among the last mentioned are a number of multi-head drilling machines specially constructed for the drilling of pin plates and die plates. The drilling of these plates is a very important function in the manufacture of Powers-Samas Punched Card machines, the annual production of which calls for many thousands of plates each containing up to 780 holes of a density of approximately 32 per square inch and of extreme accuracy, both as regards diametral size and positioning.

In order to obtain this extreme accuracy of working, special purpose multi-head drilling machines have been developed and built by the factory, embodying modifications to Becker Vertical Mills and the provisioning of special multi drilling heads containing thirteen



A close-up of one of the Multi-head Drilling Machines.

spindles. It is interesting to note that in the development of these machines, it has been necessary to divorce the driving motor from the machine and motors are now mounted on a separate gantry in order to remove all vibrations from the work head. This method has resulted in a considerable increase in drill bush life as well as an increase in the accuracy obtainable.

The most up-to-date techniques are employed in the deburring of the many small parts produced in the machine shop and a notable feature is the Barrel Finishing Plant which embodies the latest Barrelling techniques. It is a completely self-contained plant in which a motorised transporter, guided by a centre rail sunk in the floor, moves from end to end of the plant, providing fully mechanical loading and unloading. A battery of five roto finish barrels are in use, and other equipment includes two washing machines with hoppers and vibrator feeds, a magnetic

separator, a belt elevator and demagnetiser, a centrifugal drier, and chip storage bins, chip trays and stands.

In an average Powers-Samas Tabulator there are over 5,000 springs of various shapes and sizes and in order to ensure reliable working it is essential that all those which perform a similar function in a machine shall be consistent in their size and qualities of compression or tension. To this end the company has a well equipped Spring Department responsible for the complete manufacture of every type of spring used in Powers-Samas machines. Standard machines are used, including those by Bennett and sleeper and hartley augmented by *ad hoc* hand operated tools for setting up and twisting end coils, etc. Inspection is an important feature of this department, each and every spring being individually tested within very fine limits based on its particular function in the machines.



A close-up showing the bending operation on Connection Box wires—in the background is a typical Connection Box.

In the spring department are also produced the many hundreds of miles of Bowden inner and outer cables which are required particularly for the automatic key punches and automatic sorters. For this work a special machine, designed and made in the factory, is employed.

An important section of the factory is the connection box department. It should be explained that a connection box is a separate interchangeable unit for fitting into a tabulator to provide a controlling link between the card sensing mechanism and the printing and adding mechanism. The connection box is in effect, an aluminium frame containing a quantity of rigid wires (one for each punching position of the card) so controlled that they can move vertically within given limits but maintain fixed positions laterally. The vertical movement is necessary because in tabulating, the connection box is located immediately over the card so that as the pins of the sensing mechanism pass through the holes punched in the card, they raise the corresponding wires which in turn control the appropriate printing and adding mechanisms.

The design of the connection box depends on the card form to be tabulated and on the positioning of the information to be printed from it by the tabulator. The factory receive the instructions concerning the building of these boxes on simple standardised diagrams which have then to be converted into working diagrams indicating the full detailed manufacturing instructions concerning the exact length and shape of each wire in the box, as on these qualities depends in a large measure the positioning of the tabulated information. Whilst mass production methods can be employed in some of the early operations on connection box wires, their bending and assembly into the connection box frame are essentially piecework operations due to the necessity for dealing with each box separately. Moreover, the bending of the wires (done with special tools produced in the tool-room) demands a high degree of skill and the

staff engaged on this work have all had many years of experience.

The manufacture of type heads requires a separate section of the factory. Unlike the typewriter which prints only one character at each stroke, the Powers-Samas Tabulator will print up to as many as 100 characters at each stroke in one line. This means, of course, that the printing mechanism of each machine must incorporate in each printing position or sector as it is called, sufficient type heads to cover the printing requirements of that sector. In the case of sectors which print alphabetical and numerical characters there are at least 36 type characters per sector, so that in some tabulators there are as many as 2,500 type heads per machine. All type used in Powers-Samas machines is made throughout at Croydon and a glance at the well stocked shelves of the type store give an interesting indication of the international nature of the Powers-Samas business for the store contains supplies of type for nearly every alphabet of the world.

The Sheet Metal Section is responsible for the production of all machine covers and also for most of the card storage and filing equipment marketed by the Company. Many thousands of card trays and cabinets, as well as all the covers for new machines, are being produced every year in this section by orthodox methods. The covers after being cut and shaped in the sheet metal section are passed forward to a special section of the assembly bay, where they are "tailored" to the particular machine for which they are intended.

Having thus ensured an extremely good fit, the covers for each machine are sent as one unit through to the painting department, where they are given the appropriate stove enamel finish. In this way, all risk of having a variation in the shade of finish in any one machine is obviated.

Two features may be mentioned. Firstly, in line with the Company's progressive policy,

a sanson Water Washing Spray Booth is installed, thus ensuring that the employees engaged in the spraying of the enamel on the various machines, furniture, etc., are able to work in the purest atmosphere possible. Secondly, the painting department is equipped with the latest type of infra-red stoving oven, through which the parts pass on a slow motion overhead conveyor. In this connection, it should be noted that the greatest care is exercised to ensure that the finish of each machine is uniform and up to standard.

Considerable space is, of course, occupied by the various unit and final assembly departments. In the case of certain machines, e. g., punches and sorters, these are practically of a standard design. This is not so, however, with the tabulator, as each of these machines has to be dealt with separately due to the numerous variations in the arrangement and design of the adding and printing mechanisms. Problems of space and labour have, therefore, had to be overcome with the result that our final assembly staff now represents in the aggregate many hundreds of years of skilled engineering experience.

From final assembly the machines pass to the final testing department prior to being released for despatch to the user.

Here they are first of all tested to ensure that they function correctly and then, where necessary (and this applies particularly to the tabulators) they are tested to ensure that they will provide the results required by the user for whom they have been prepared. This involves trying out on the machines the user's actual work, under operating conditions as near as possible to those that will apply after installation.

As an appreciable proportion of the machines are sent overseas, it has been necessary to provide power at frequencies and voltages of sufficient variety to cover conditions in all parts of the world. This has been done by arranging the department so that certain sections can be fed by the appropriate current from a special alternator supplied for this purpose by Electro-Dynamic Construction Co., Ltd. This generator is unique in that no other generator has yet been found to provide such a multiplicity of output from one installation. With an input of 400 volts, 50 cycles, 3 phase, and an output of 10KVA it has a voltage range of 100/250 volts and a frequency range of 65/25 cycles both being controlled within 5 per cent at any selected setting at any load. Its speed range is 1950/750 r. p. m.

(By courtesy: Works Management)

A TUBULAR QUIZ

What is the effect of Molybdenum, Chromium and Nickel on Steels?

All three elements have the effect of enabling steels to be hardened in thicker cross sections or with less rapid rates of cooling than in the case of plain carbon steels. From this point of view molybdenum has the strongest effect and nickel the least effect of the three metals in question. They all have a strengthening effect on steel and provide a better combination of strength and toughness than the carbon steels. Among other specific effects of the metals mentioned, chromium in sufficient quantities confers resistance to scaling and rusting, and molybdenum improves the creep properties of low carbon steels at high temperature.

STOCKTON AND DARLINGTON RAILWAY 1825

INTRODUCTION

IN the North East of England, on the banks of the River Tees, lies the two towns of Stockton and Darlington. In 1825, an important event took place. That was the opening of a Railway line joining these two towns. The following article, mainly extracted from the "Northern Echo" Railway Centenary Supplement published in 1925 at Darlington gives an interesting picture of the preliminary steps leading up to the opening of this Railway, the first Railway in England and probably the World to be set up with the authority of an act of Parliament for the conveyance of Passengers and using steam locomotives as Motive Power. The article also sketches briefly the life of George Stephenson (1781—1848) who has been aptly honoured as "The Father of Railways".

The development of industry and increase of population in the closing years of 18th century brought with them the need for more adequate means of transport of both goods and men. This natural demand led directly up to the Railways.

The method that then existed for transport, not only hampered trade through long delays but led to shortages in some places and abundance in others. In 1762, a journey from Darlington to London cost Rs. 2250 for a distance of about 250 miles including stop overs in wayside inns. With the development of industrial revolution, the need for bulk transport of commodities arose. To meet this need, the idea of canals was mooted but finally the pioneers of Railways triumphed. Then in 1825, the S. & D. Rly. came into existence, the first line in England and the whole world over which passengers were ever transported by a steam locomotive. Subsequent development was very fast. From 20 miles in 1825, the figures for track miles rose to 6621 in 1852 and in 1925 there were 360,000 miles of ground



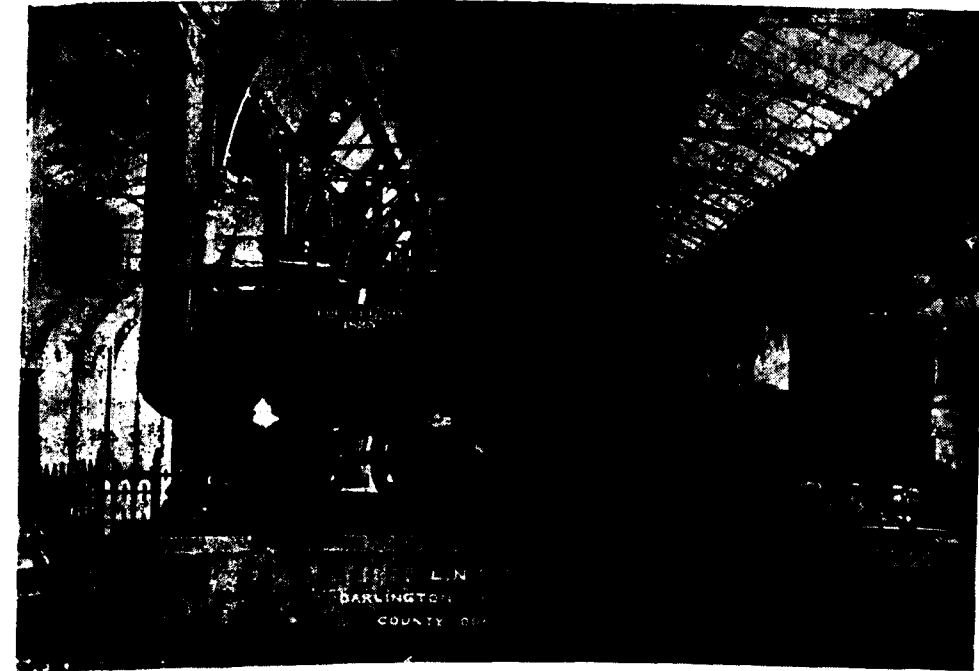
George Stephenson.

level, overhead and underground railways in use all over the world.

ORIGIN OF RAILWAYS

The S. & D. Rly. opened on 27th September, 1825 was not the first Railway in the world nor was "Locomotion" (the first engine which hauled its first train) the first locomotive in the world. But the S. & D. Rly. was the first Railway in England with powers from Parliament to carry passengers, and the first passenger Railway to adopt Steam locomotives. The S. & D. Railway gave the world a new mode of fast and economical transport which brought to completion the great industrial revolution.

In the beginning of the 19th century, there were 3 methods of transport available on the public roads :—



1. Heavy wagons for heavy goods with a speed 2 to 2½ mph. Charge 8 pence (6 annas) per ton per mile.
2. Light vans for light goods with a speed of 3-4 mph. Charge 1 Shilling (12 annas) per ton per mile.
3. Coaches for passengers with an average speed of 8-9 mph. and carried 10 passengers and 1½ tons luggage. Charge 3d. to 4d. (2½ to 3 annas) per passenger miles.

The first railways were of wooden rails and the crude wagons were hauled along the line by horses. The first of such wooden railways was laid at New Castle about 1602. It was 1776 before the first railway with iron rail was laid near Sheffield. A controversy, on relative advantages of cast iron and wrought iron rails took place and finally wrought iron won the day. All these railways till about 1804 were operated by using horses, the wagons running on rails laid on Stone sleepers and secured by pins or nails. Having thus sketched briefly the evolution of

the railroad till 1825, a similar sketch on development of the locomotive will be interesting. In 1804, Trevithick, regarded by many as inventor of the Steam Locomotive built a locomotive which ran on the rails of a South Wales Colliery. Then in 1812, Blenkinsop constructed a rack and pinion type locomotive. In 1813, Hedley built the first smooth wheel adhesion locomotive. George Stephenson produced his first machine in 1814 benefitting by the previous experience of Trevithick, Blenkinsop and Hedley. This locomotive was used in Killingworth Colliery railroad.

STOCKTON AND DARLINGTON RAILWAY—ITS CONSTRUCTION

The act of Parliament pertaining to the S. & D. Railway was passed in 1822 and while the Board of Directors were busy with schemes for its construction, there appeared on the scene the colliery engine—Wright who was to become famous all over the world as the Father of Railways, George Stephenson in April 1821 went to Darlington to convince the Edward Pease, one of the

Directors of the Company that he could construct a railway line to be operated with steam locomotives which would be more economical than the projected tram line with horses. He thus secured his appointment as Engineer for the survey and construction of the line that was to inaugurate a revolution in the methods of transport throughout the world. Stephenson was then 40 and totally unknown but in 20 years time, his name had become a household word all around the world and an ultimate authority on Railway engineering.

At this stage, it may be worthwhile to digress a little and concern ourselves for some little time on the life and work of George Stephenson who is universally honoured as the "Father of Railways". The fame of Stephenson as an Engineer rests of course, on the outstanding part he played in the development of Railways in England and abroad—Construction of S. & D. Rly. in 1823, L & M Rly. in 1826 which involved laying a track on marshy land, a tunnel, a large cutting and a Viaduct—proved his genius for overcoming natural obstacles, while the historic performance of his famous Rocket at the Rainhill trials of 1829 showed his equal mastery of mechanical problems. Then until his death in 1848, he was recognised as an undisputed authority on all matters connected with Rly. development whether constructional, operational or economic.

To appreciate the character of this man who rose to such eminence, it is necessary not only to consider his great achievements but also to bear in mind the nature of the road which he had to travel and the obstacles he had to surmount. Judged in the light few men deserve greater honour than George Stephenson. He was born on 8th June, 1781 in a miners' one roomed, clay floored dwelling under circumstances of appalling poverty and spent his childhood in surroundings unthinkable in the England of to-day. His parents were honest and hard working and endowed

him with a strong constitution and active brain and taught him the virtues of industry, thrift and perseverance. At 12, he started work at the Colliery picking dirt from coal. He never went to School and remained illiterate until 18. The world was however his University and the countryside and colliery were his class rooms. He was gifted with a keen observation and an intense desire to understand everything he saw. At 18, he first learnt to read and write by giving up his leisure to attend night classes after his days work in the colliery. He was thus able to consult books to gain a knowledge of the principles underlying the facts that he observed. At 21, he married but at 25 he was left a widower with a son to look after. He earned extra money to repairing and making boots, mending watches, clocks and doing tailoring and thus saved money for the education of his son Robert who in later days was destined to take his father's preeminent position in the Railway World. In 1813, his plan to build a locomotive for hauling the coal wagons in the colliery was accepted by his employers and thus took the first step that was to lead him to fame.

Soon after getting to work Stephenson decided that inalleable iron rails would be better than Cast iron rails even though he had an interest in a firm making cast iron rails. In actual construction, both cast iron and wrought iron rail were used. The first sod of the line was cut in autumn of 1821 and in January 18th 1822, presented his report and estimates after surveying the country. In this report, Stephenson suggested a new alignment for the track to avoid irregular ground and sharp curves. This report was accepted and George Stephenson was appointed Engineer of the Company on £ 660/- per annum out of which he was expected to pay his assistants. The gauge of the rails laid was "practically" 4'-8½" which in course of time was adopted as standard by the Railways of Britain and many other countries of the world.

In 1823, George Stephenson along with his son Robert and others started the locomotive Building firm Robert Stephenson and Company in New Castle and the first locomotive to haul a passenger train was "Locomotion" and was built by this firm.

The S. & D. Railway at the time of its opening was a modest undertaking consisting of a single line of rails with four sidings to the mile to serve as crossing places. There were no Railway Stations, as we know them to-day. Stone walls were used to fence the line. Fish bellied wrought iron rails were mostly used. The rolling stock of the Company on the opening day consisted of one locomotive engine, one railway coach and 150 wagons.

"The opening of the line was made the occasion of tremendous rejoicing. In a measure it was a national event, the fate of many projected Railways depended upon its success and the directors had done their utmost to make it so." "From daybreak streams of sight-seers began to gather. As it would be expressed to-day, "All roads led to Darlington." "It is recorded that, before starting, Locomotion let off a little steam to the consternation of the "Johnny Raws" around her who fled in all directions." "The blue-sashed men were all in their places—one between each pair of wagons to brake when necessary—and "the beasts of the field and the birds of the air seemed to view with wonder and with awe the machine, which now moved forward at a rate of 10 to 12 miles per hour, with its train of 38 carriages, weighing some 80 tons or 90 tons.

1. Locomotive engine with engineer (Mr. Stephenson) and assistants.

2. Tender, with coals and water—next six wagons loaded with coals and flour—then an elegant covered coach, with the committee and other proprietors of the railway—then 21 wagons fitted up on the occasion for passengers—and, last of all, six wagons loaded with coals, making altogether a train of 38 carriages, exclusive of the engine and tender.

"The coach had no springs of any kind, and yet the motion was fully as easy as in any coach on the road. A very slight jolt is felt, accompanied with a click or rattle every time the wheels pass over the joints of the several rails, and also at the breaks which occur at different passing places, and then, if anything, feels harsher than in a coach. At any bends of the road, or other places where the view is obstructed, the coachman blows a horn to give warning of his approach to any wagons or vehicles that may be coming or going on the way. Some parts of the way were laid with rails of cast iron, joined at every four feet, and in coming upon these, the jerks and jolts were more frequent, more audible, and more sensible, resembling exactly, as the coachman justly observed to us, the clinking of a mill hopper."

From such simple beginnings has developed the Railways of the present day. The steam locomotives after attaining their peak of operating efficiency have given place to Diesel locomotives and at present an automatic locomotive is being planned. The passenger coaches have become the last word in travel. While we progress it is worthwhile to fall back and think of those men of olden times who by their foresight set the world on the path of rail roading.

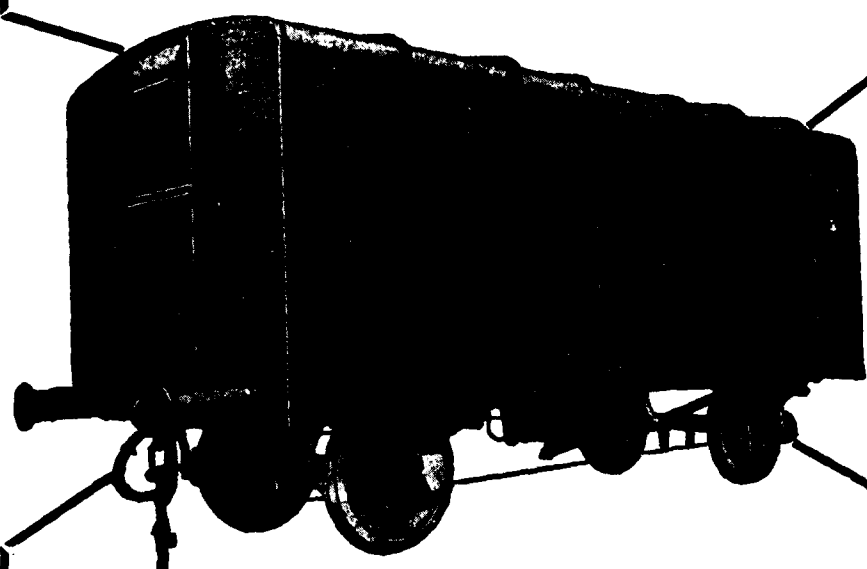
A TUBULAR QUIZ

What is a Calrod tube?

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Editorial Notice

The Editor invites contributions from the Engineers and Works Managers of Railway Workshops as well as company-managed Engineering Workshops in the form of original articles, research write-up, production technique etc. relating to Workshop practices in India and abroad. Besides, suggestions for the technical improvement of various aspects of Railway Workshop practice are also invited with suitable write-ups accompanied by photographs wherever possible.

Contributions are accepted on the distinct understanding that they are sent solely to "THE INDIAN RAILWAYS WORKSHOP MAGAZINE". The Editor accepts no responsibility for the views and statements of the contributors.

All contributions intended for publication in any particular issue should reach the Editor at least 30 days prior to the scheduled date of publication. This Journal is issued quarterly i.e. February, May, August, November.

All published contributions are paid for at our usual rates.

Editor.

Distinguished Visitors at the Integral Coach Factory

(From our Correspondent)

THE Integral Coach Factory in Madras is on its march towards progress. The first all-steel light-weight coach was 'launched' by the Prime Minister of India, Mr. Jawaharlal Nehru on October 2, 1955. The second coach rolled out of the Factory in the last week of November, 1955. This is one of the four vehicles nearing completion and the others will be ready within a month's time. In the first year of its working the Integral Coach Factory will turn out 20 coaches with components imported from Switzerland. Thereafter increasingly large proportion of Indian made components will be used.

The I. C. F. has begun to occupy a place of pride in the national activities of our country. It has become one of the most important places to be seen in Madras. In November it had the good fortune of receiving three dignitaries from three foreign States, the most important of them being the Soviet leaders.

Mr. P. O. Ururuka, Minister for Industries, Nigeria visited the I. C. F. on November 25. The Minister who had come to India to study the implementation of the various projects and plans, evinced keen interest in the working of the Factory. He described

the Integral Coach Factory at Perambur as "a gem in the industrial crown of India."

On the same day Their Majesties the King and the Queen of Nepal paid a visit to the Factory. After going round the Factory Their Majesties had tea with the Chief Administrative Officer and other principal officers. Speaking on the occasion Mr. Sadagopan referred to the cultural ties between India and Nepal from time immemorial and expressed the hope that their visit would serve to strengthen the friendly relations between the two countries.

A silver replica of the coach being manufactured in the Factory was presented to the King by Mr. Sadagopan and an album, containing photographs of the growth of the project, bound in rosewood, inlaid with ivory was presented to the Queen. Accepting the souvenirs, the king of Nepal said he was extremely grateful for the warm reception that he had received not only here but also elsewhere in India. He was greatly impressed by what he had seen, His Majesty added.

SOVIET LEADERS VISIT I. C. F.

The visit of Marshal Bulganin, Prime Minister of Union of Soviet Socialist Republic and Mr. Khrushchev, Secretary of the Soviet Communist Party on November 28, was a great event in the history of the Integral Coach Factory. Mr. Khrushchev not only saw the Factory but gave valuable suggestions for the improvement of the same. Apart from being an able politician he displayed his knowledge in engineering by his friendly criticism that 80 per cent of the steel used in the construction of the Factory could have been saved by using reinforced concrete.

On arrival, the distinguished guests were received by Mr. K. Sadagopan, Chief Administrative officer at the gaily decorated

lawns in front of the three-storeyed Administrative office which was illuminated on the occasion. At the entrance of the hall, photographs were displayed dealing with the various stages of development of the factory. Mr. Sadagopan explained the salient features of the seven crore project. As soon as he had finished description of the fabrication of steel and erection of steel works, Mr. Khrushchev interrupted and asked whether he could say a few words about the pictures of the project shown to them.

"I am telling you," he said, "because in our Soviet Union also we are criticising our own engineers and structures. I can say you are wasting too much steel in this construction. I think you could have economised about 80 per cent of the steel wasted here if you had used the new method of combining concrete and metal (reinforced concrete)".

Mr. Sadagopan informed the guest that they were going in for both types of construction and that they had employed reinforced concrete in some of their constructions. Mr. Khrushchev said, "you have to use the more progressive method of reinforced concrete." Mr. Sadagopan told him that he would take the party round the Factory and show some of the reinforced concrete constructions. He then explained the Staff Colony, Recreation Club, Technical training School and other features of the project. He also pointed out that in the construction of the Administrative Office building where they were standing they had used reinforced concrete.

But Mr. Khrushchev who was critical said, "I would never advise you to use reinforced concrete here, but only concrete blocks. Reinforced concrete should be used only for the supports and not for the walls. This building has only three floors and you can use only concrete blocks without any steel. Supports for these floors must be built with the help of reinforced concrete."

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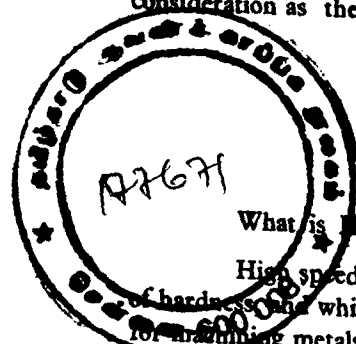
At this stage, Mr. O. S. Murthi, Civil Engineer in charge of construction of I. C. F. said that the Administrative Office had been constructed with provision for adding a fourth floor in the future. The structural frame of the building was of steel work resting on R. C. C. pile caps over groups of piles. Mr. Khrushchev replied, "Even if you have three more floors, the concrete blocks will be enough."

The Soviet leaders then drove into the workshops and inspected the Machine Shop, Millwright Shop, Sheet-Metal Shop and the Main Assembly Shop. Later they returned to the Administrative office where they were entertained to tea. Mr. Murthi took the opportunity to explain to Mr. Khrushchev that steel works were used only for the workshops and that only after calling for competitive tenders for both types of construction, they decided on steel structures. They also took the time factor into consideration as they wanted about 2½ years

for erecting the concrete structure. Mr. Khrushchev told Mr. Murthi that he did not believe it and that he was firm in his conviction that reinforced concrete should be used in the place of steel. Even in Russia, he said, their engineers also had a fancy for steel structures and most of them did not like his criticism. They, however, had only medium-sized factories in Russia, he added.

Mr. Khrushchev expressed his appreciation of the layout of the staff colony. He said the existence of the Technical Training School showed foresight on the part of the authorities because feeding a huge factory with trained personnel was a vital problem. He requested the authorities not to misunderstand him for his criticism. Mr. Sadagopan replied that there could be no progress without divergence of views.

The Soviet leaders were each presented with a album, containing photographs of the I. C. F. in the making.



A TUBULAR QUIZ

What is High Speed Steel?

High speed-steel is a type of alloy tool steel which can be heat-treated to a high degree of hardness and which retains its hardness at quite high temperatures. It is therefore suitable for machining metals at high speeds. The most widely used composition contains approximately 18% tungsten, 4% chromium and 1% vanadium.

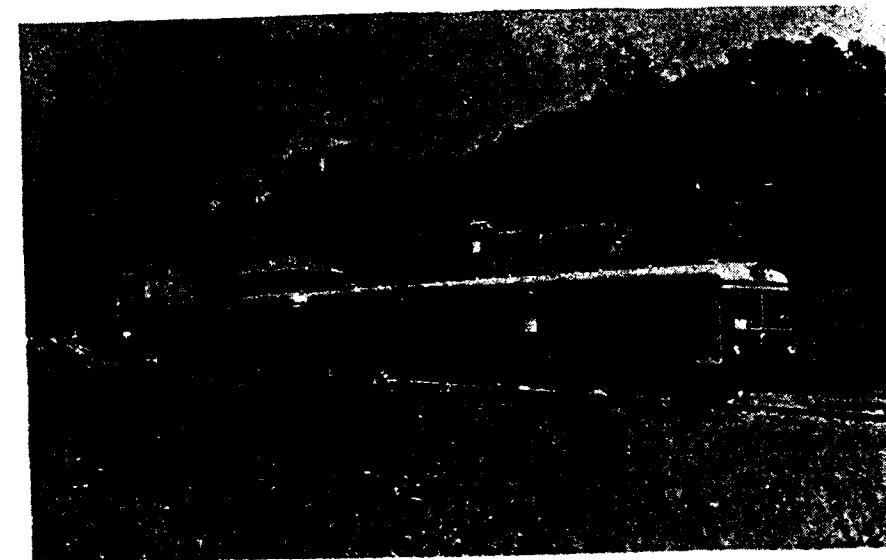
What is the difference between air and oil hardening?

Air hardening denotes the hardening of steel by cooling in air from a temperature above the critical point, whereas oil hardening denotes hardening by quenching in oil. The treatment should be chosen to suit the composition of the steel in question.

What is Yield Point?

This is the lowest stress at which a material under load undergoes an increase in length without increase of the applied load. For practical testing purposes it is often taken as the stress at which a visible permanent increase in the distance between gauge points on a test piece can be detected when using dividers.

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