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RAILWAY ADMINISTRATION

WE have in the past commented on Railway Workmanship, Supervision and Management in the hierarchy of Railway Personnel and now we wish to refer to Railway administration, the highest rung of the ladder.

In the old days, before the grouping of Railways, each Railway had its own individuality, its traditions, its pre-eminence among the Railways of India whether State managed or Company managed. Certain of the major Railways were looked upto as pioneers in the various fields of Administration and were expected to introduce new ideas, experiment with new materials from foreign sources, apply successful methods from abroad and in general give the lead, which other Railways then followed with a certain amount of caution and time lag.

One such Railway was the old Great Indian Peninsular Railway, which introduced for the first time in India, electric train lighting, spring loaded buffers, vacuum brakes, synthetic paints, roller bearing axle boxes, electric traction, the progress system of spare parts manufacture, the scheduling system of locomotives and carriage repairs and more recently the luxurious air-conditioned coaches running in the Indian Railways. Undoubtedly other of the leading Railways tried other materials and other ideas which added to the sum total of railway betterment.

It was the administrators of these Railways that left the impress of their personality, their foresight, their courage, their character and their indomitable will to succeed on the Railways they served and led. They had certain outstanding qualities, which made them born leaders of men in their respective fields of work and administration and even at inter-railway conferences their words were listened to with respect and even admiration by their colleagues.

It might not therefore be out of place if we were to analyse these qualities which made these men such successful Administrators, so that our present Railway Administrators may emulate their example and improve their own stature in the process.

Undoubtedly the outstanding quality of these men was that they were extremely intelligent. Now intelligence is defined in the English Dictionary as quickness in understanding. This is a natural characteristic of certain people and no amount of book learning can replace it. It may be a hereditary gift which children inherit from an intelligent father or mother or both. With intelligence, perception is sharpened so that the intelligent people can grasp a situation in the twinkling of an eye, appreciate the salient points of a book or an article in double quick time and jump two stages or more ahead in thought when discussing a problem or arriving at a conclusion. Intelligence is shown in playing a game of chess or bridge when the opponents moves are anticipated and forestalled when they are made. It, therefore, stands to reason that knowledge and experience acquired by an intelligent person whether from book, magazines or practice is carefully tabulated and tagged in the brain to be utilised quickly and completely when the need arises. It is, therefore, necessary that our Administrators be intelligent because without this quality their work will be of a poor standard. But intelligence alone is not enough, it must be accompanied by an ability to take quick action. However, intelligent a person may be, if he is vacillating or indecisive such a person lacks a very important quality of a good Administrator. Courage is incidental to quick decision and action. Some Administrators though convinced that their solution (after weighing it correctly) is the right one, hesitate to give a decision out of fear of consequences should such a decision be found to be wrong. It is rightly said "he who hesitates is lost" and this hesitancy in a critical situation may do serious damage to Railway working.

Courage is also necessary for introducing any new idea especially if it is original because its failure may have serious repercussions on the author. Administrators are paid for taking responsibility and if they shirk this important factor there is a serious flaw in their make and they are definitely not fit to occupy their high position.

An Administrator's reading in his special subject must be wide which will give him the clue at the way things are being done in other countries and the trend that must be followed up intelligently, studied and finally introduced on one's Railway. The many new ideas which I have mentioned as being introduced for the first time on the old G.I.P. Railway were by men of wide reading, a high degree of intelligence and courage and determination to make the matter a success on one's own Rly.

Policy making for his department as the Head of Department is another important aptitude of good Administrator. A policy is fraught with great potentialities for good or evil, and a clear and discerning judgement is essential before its introduction if it is to give its expected results.

Further Administrators must be able to inspire confidence in their subordinates, by their fair and unbiased dealings in all matters especially those concerning the promotion and welfare of their staff. This characteristic inspires the sense of loyalty to the Head of a Department and results in establishing a sense of duty even at personal sacrifice. On the other hand favouritism, nepotism and immature decisions cause a sense of frustration in the subordinates which is often reflected in the poor quality of the work.

An Administrator must know how to get the work done, not necessarily, how to do it. The right psychological approach to his subordinates often works wonders on the solution of a problem or a nasty situation and although individual merit may not receive its reward the prestige of the department soars higher and higher.

An unruffled demeanour in a threatening situation and an ability to think out a solution coolly and calmly without being hustled or jumpy and to act without loss of time singles out a good Administrator from a mediocre one.

As Junior Administrators start from the level of the Deputy Heads of Depts. it is in their interests that notice should be taken to cultivate these important characteristics, which will pay them dividends in the long run, as they advance higher and higher on the ladder of Administration.

As it is the Head of Department who sets the tone of his department so also the General Manager is the one who establishes the tone of the Railway in his dealings with staff and the general public. It is, therefore, a matter of paramount importance that Administrators at each stage be chosen with utmost care and circumspection, eschewing personal motives and considering the good of the Department and the Railway. Men of outstanding ability possessing most of the characteristics enumerated above should be elected and receive promotion over the heads of the mediocrites if a high standard of efficiency is to be the criterion of our Railway Administration.

Finally, if the Railway Board is composed from this high class of Railway Administrators without party politics coming into play in their selection, then we can expect high achievements at the level of our Railway Ministry with beneficial results to our country and its people.

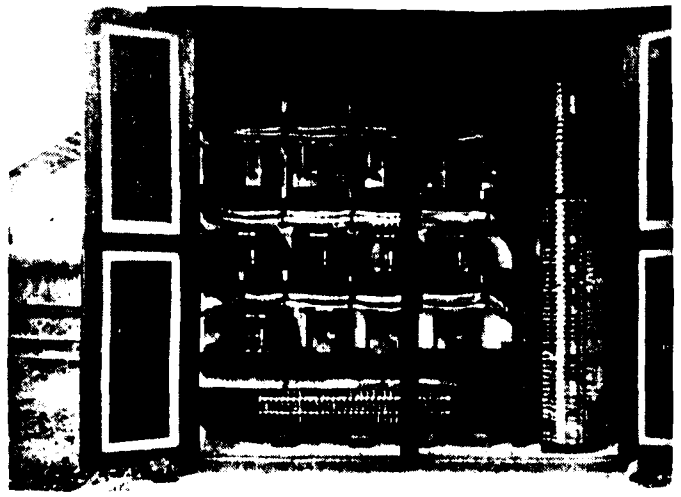
Cables and Connections for Railway Signalling and Interlocking Circuits

By *H. C. Towers*, M.I.E.E., M.I.R.S.E., M.Inst.T.

FOREWORD

IN the early days of railways the only electrical appliance concerned with train operation was the telegraph the use of which was initiated by the Great Western Railway in 1837 following successful experiments by the inventors, Cooke and Wheatstone. Later, electrical indicators of various types were introduced for performing a number of functions to assist train working. These appliances did not require many wires and an earth return was used as part of the circuit. No particular form of wiring was necessary and the quantity involved was small. The commencement of the present century saw the inauguration of power signalling in this country. Rapid progress was made with this form of signalling with the construction of the Piccadilly, Bakerloo and Kampstead lines of the then London Electric Railway and the electrification of the District line. The new signalling required a large number of wires for connecting the apparatus as compared with earlier telegraph circuits. During fifty years of development the quantity of electrical equipment and the number of wires has increased enormously. The present day demands are for quickly detachable, plug in apparatus and pre-wired relay racks and similar facilities.

The first power signalling installations constructed in the United Kingdom favoured the placing of relays and fuses in polished wooden cases. Those containing relays sometimes had glass doors of the lift out type. Except for very large installations, the fuses were generally mounted at the bottom of the relay cabinet this portion of the door having wooden panels. The incoming cables were brought into the basement of the signal box, where the electrical apparatus was usually housed, in wooden troughing or trunking. The cores were stripped of the outer insulation and protective sheath at the point where the relay cabinet was entered, taped, and run in smaller trunking, or treed, to the fuses. The wires were attached to the fuse bases by O or 1BA termina and fed through a hole in the mounting board into the main run. In nearly all these early installations it was the practice to hide the wiring out of sight but it may be assumed that the policy then was to secure its protection rather than to conceal it from view.



Relay and terminal cubicle constructed in brick and asbestos as used on Western Railway, Bombay section, India.

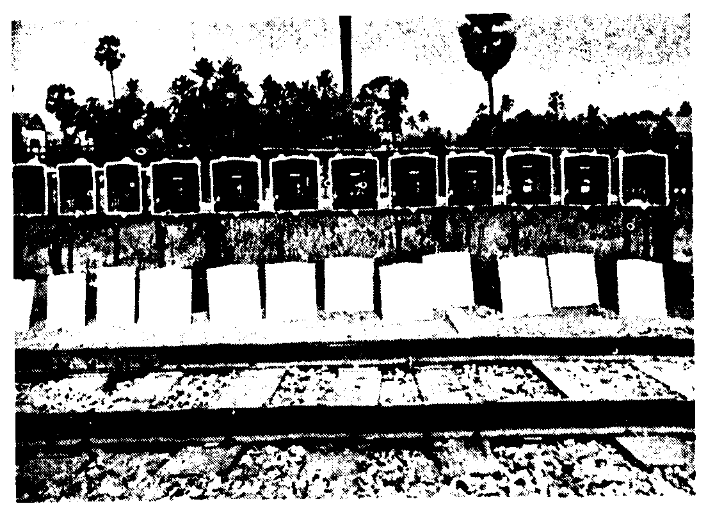
The cables were mostly run underground or through ducts the method depending on the locality and the nature of the ground to be negotiated. Some railways used wooden trunking of substantial section, mounted on short posts. Single wires were run inside the trunking. Other railways ran cored cable direct from the fuse case in the signal box to the function out on the track. For example, a power operated signal might require five wires for the operation and indication circuits. These would be run in a five core cable from the fuses direct to the signal post. If it was necessary to loop the cable through a point detection box it would be taken down to the permanent way and back again. Intermediate disconnection boxes were not considered then and often connections were made outside the signal box by means of plumbed joints. Cable faults were frequent particularly in damp places.

The year 1923 marked the commencement of the various extensions and modernisation of the London Transport Railways and this period initiated a new era in power signalling and the introduction of more modern methods in cabling and wiring. In early power installations, where a signal read over a pair of facing points, it had to detect that those points were correctly set and locked before it could show " Proceed ". This was accomplished by taking the signal control circuit through a contact box fixed to the point sleepers which

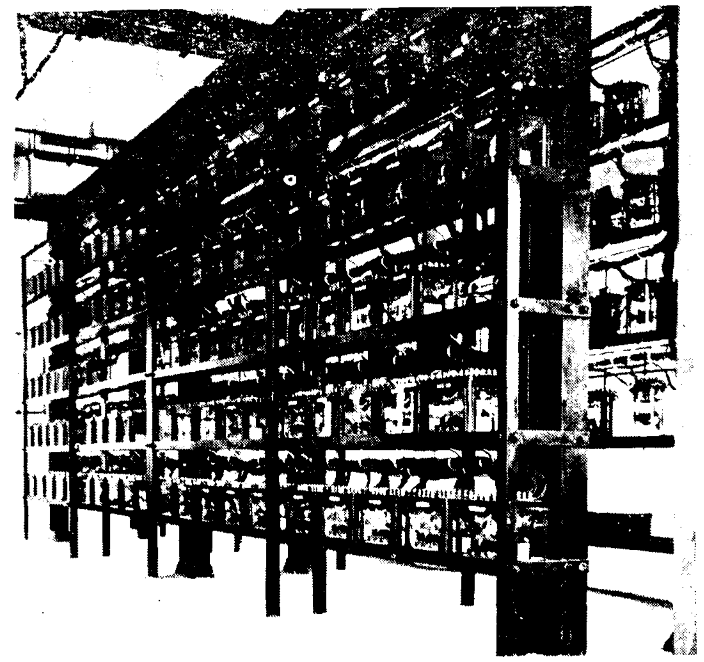
opened and closed contacts according to the position of the points. The practice of breaking the signal control cable for this purpose was not a good one and it introduced the possibility of failures and cable faults. The point detector was therefore made to operate a point detector relay in the signal cabin, the relay working on a polarised circuit being energised one way when the points were normal and the other when the points were reverse. The detection of the points by the signals was then carried out inside the signal cabin, with internal wiring, the signal control cable running direct to the signal. This principle of repeating functions out on the track by relays in the signal box and running cables direct to the apparatus they operate was introduced as general practice.

MULTI CORE CABLES

Although some railways prefer to use a separate cable for each point or signal, the general practice today is for all circuits to enter and leave the signal box in main cables which are looped into location cases at convenient situations along the cable route. The number of cores in a cable are usually kept to a standard number in order to avoid having a large number of cables of different sizes. For example, the smallest cable may be a 5 core and the largest 61 cores with intermediate sizes of 12 core, 10 core, 27 core, 37 core and 48 cores. The gauge of wire used is 0.064 or 0.044. Larger diameters are used in special cases while the size of the signal main supply cable varies proportionately with the load. The insulation and armouring of multi core cables is usually to the British Standards Specification or to the railways specification where some overseas installations are concerned.



Track and signal relay location using cast iron boxes. Western Railway, India.



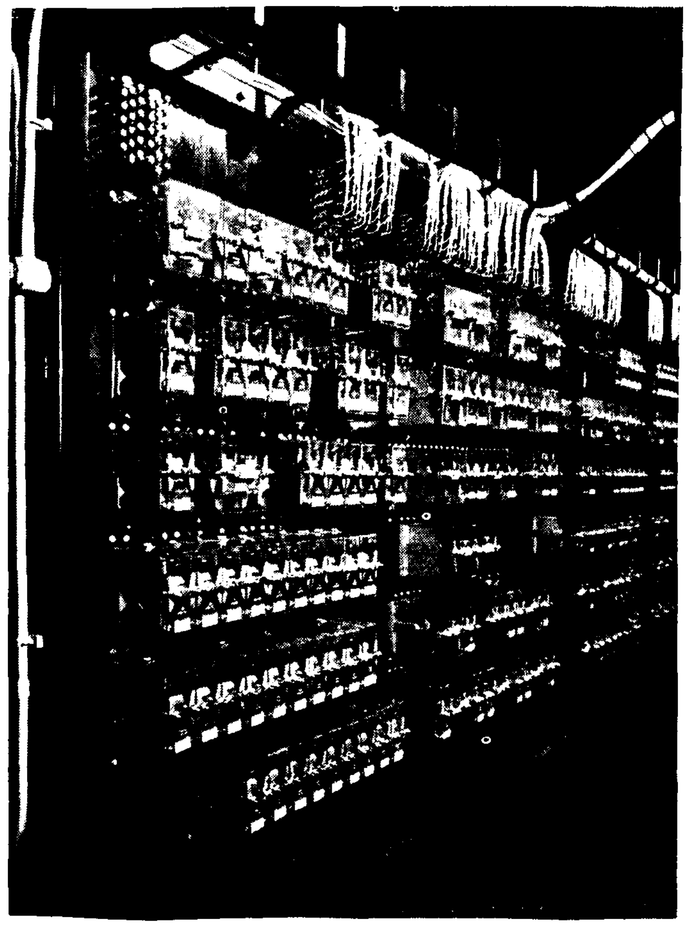
Part of relay rack in basement of signal box at Bandra, Western Railway, India. A steel platform between the two racks gives access to the interior of the power frame.

These cables are manufactured for burying direct in the ground and this is what most railways require. This leaves the earthwork immediately adjacent to the permanent way free of obstruction and the cables are not liable to damage in case of derailment. Some railways prefer to have their cables above ground running them in cable brackets fixed to short posts, spaced four to six feet apart. Another method is to use railposts fifteen to twenty feet high and twenty feet or more apart. The cables are slung from a steel messenger wire stretched tautly between the posts and regulated at intervals by adjusting screws. The signal supply main is generally run at the top of the poles consisting of two weather proofed insulated conductors spaced eight to ten inches apart by suitable insulators fixed to crossarms. The main signal cables are placed about three to four feet above formation level. This type of run is economical in some respect but unsightly in appearance.

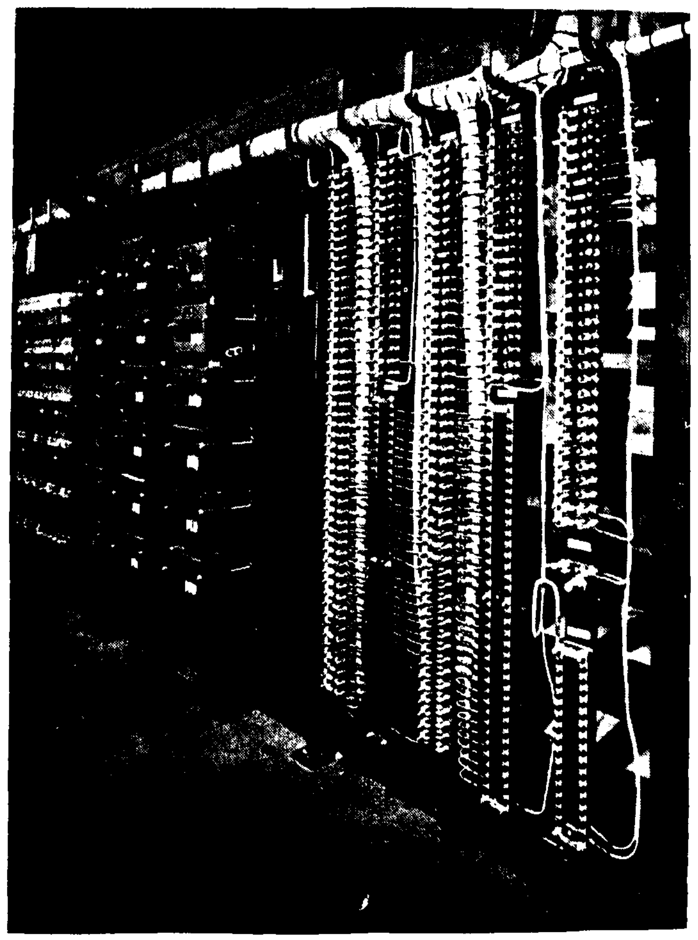
When cables run on posts have to cross the tracks they are sometimes run into concrete troughing. This troughing is made in varying cross section and length and has a removable cover to permit inspection and for cleaning out the trough. Other fitments for concrete troughing include cornering, for changing direction, usually about 90 degrees and risers, for bringing the cable up from formation to cable run level. Concrete trunking is reinforced and strong enough to stand the ordinary wear and tear of the permanent way. It is not affected by damp or termites the two chief reasons for not using wood.

LOCATIONS

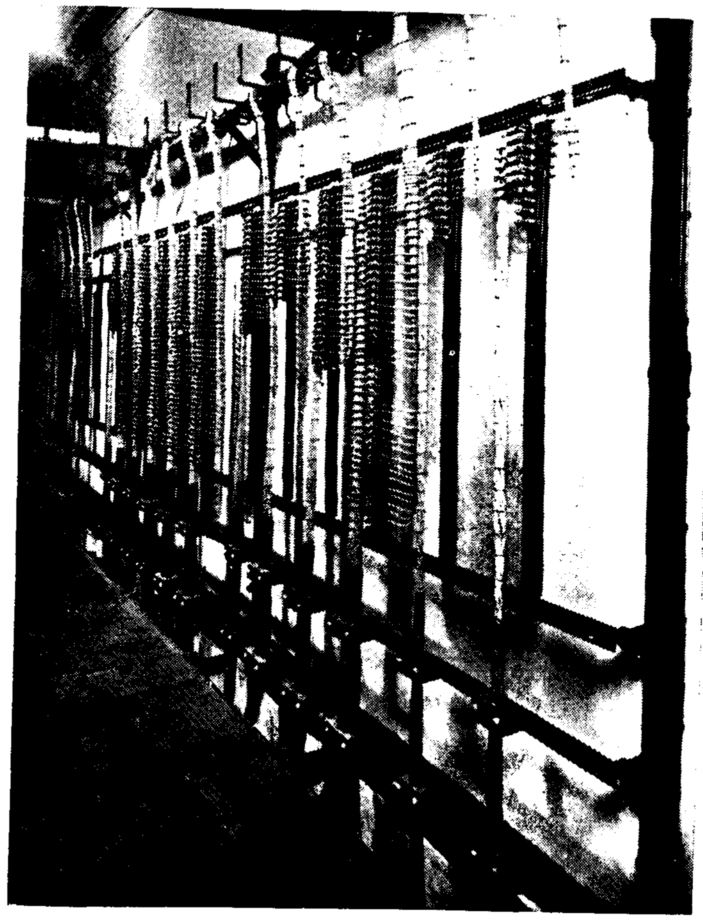
In most signalling schemes there are a number of track circuits situated too far from the signal box to have the track relay placed there. It is necessary to house the track relay at the track circuit and use a track repeater relay, operated by the track relay, in the signal box. In the case of railways with four or more tracks there may be quite a number of track relays to house at one place. In earlier works each relay was accommodated in its own individual cast iron case. The appearance of a number of these cases can be seen in the accompanying photograph. If the lids are not distinctly marked with the designation of their contents, the signal lineman may lose time when tracing a fault. A much more convenient arrangement is to place all the relays, fuses, etc. in a cubicle or location case. The railway on which the writer was Chief Signal Engineer used brick cubicles manufactured by the Signal Department staff. These brick cubicles had a corrugated asbestos roof and teakwood doors with asbestos panels. The cubicle was constructed on a substantial concrete base wide enough for staff to stand on when the doors were open. The corrugated roof was also large enough to extend over this space and thereby shelter the staff, and the apparatus, during heavy rain. This is not the case with individual, cast iron relay boxes which give no protection at all from rain once the cover is removed. The inside of the cubicle was fitted with a steel framework provided with shelves for supporting track relays and other equipment with a framework at one side for the fuse bases, terminal blocks etc. the cable terminations being made at this point. The wiring diagram of the location, position of fuses etc. was fixed inside one of the doors and suitably protected from damage. This form of construction was found very suitable for tropical climate for the combination of asbestos roofing and brick sides kept the apparatus cool. The over-



Rack of plug in relays in signal box relay room. (British Railways)



Fuse board and plug in relays in signal box relay room. (British Railways)



Cable termination board and terminal blocks in signal box relay room. (British Railways)

hanging roof also sheltered maintenance personnel from sun and rain in the monsoon season. The cost of these cubicles was much less than a steel location case.

There are instances where the signals at manually worked signal boxes were converted to multi-aspect colour light signals with track circuiting. The points continued to be worked manually by means of rodding. The basement of a mechanical signal box is not very suitable for accommodating electrical signalling equipment and in such case a small cubicle or relay room, of the same brick and asbestos construction, was built on the outside of one of the signal box walls.

Electrical developments in this country and overseas have made such progress in recent years that it is hardly possible to find a place where an electrical supply is not available. On overseas railways there are, however many stations where electrical signalling plants have to be powered from primary batteries. Some types of batteries require periodical cleaning and changing of the electrolyte. This work is best done outside the signal box basement and for this reason the same type of brick cubicle were used for battery accommodation and were very successful.

An alternative to the locally constructed brick cubicle is the sheet steel location case which is supplied in several sizes. These cases are fitted to an individual railway's requirements and can be used as cable junction points, distribution points and also accommodate relays, local transformers and rectifiers, batteries etc.

A location case is positioned close to a group of signals, points, track circuits or other functions. Separate cables are run from the location to the function but they all join the main cable terminating or looping into the case. For example, two 61 core cables run from the signal box to the first location case. Here wires have to be distributed to two multi-aspect signals, a pair of points and two track circuits requiring probably 17 wires in all. These were contained in one of the 61 core cables which continues to the next location case as a 48 core cable, the next standard size. The 17 wires are connected to the functions concerned by short lengths of 3, 5 or 7 core cable, as required. The connections to track circuits is by means of single wire and is of necessity of heavier section than the cable cores. Four wires are attached to the running rails, two at each end of the track circuit. These wires are subjected to heavy vibration and have to be flexible and heavily insulated. A 7/.029 wire is a fairly standard section and this is protected by insulation in accordance with the requirements of the British Standard Specification for signal cables. The single wires are run direct from the running rails to the terminals in the location case. The number and size of cables between location cases diminishes as the distance from the case to the signal box, increases. The first location case attached to the signal box, and farthest from it, may have only a 7 core cable running from it to the next case. Here the size of the cable running from the second to the third case changes from 7 core to 19 core and so on. The cables connecting the last location case, or cases, to the signal box, may be as many as five or six 61 core cables.

The number of cables cores terminating in a signal box relay room depends on the size of the installation and may be from several hundred to several thousand. The great increase in the number of wires has made original methods obsolete and at the present time the normal way is to terminate cables on to fuses or terminal blocks fixed to open racks. The racks are made of steel, fixed to the wall of the relay room, with the terminal blocks screwed to verticle steel strips.

The cables enter the relay room by means of an open trough at floor level. The cores are separated, taped and suitably finished and attached to the terminals on the blocks.

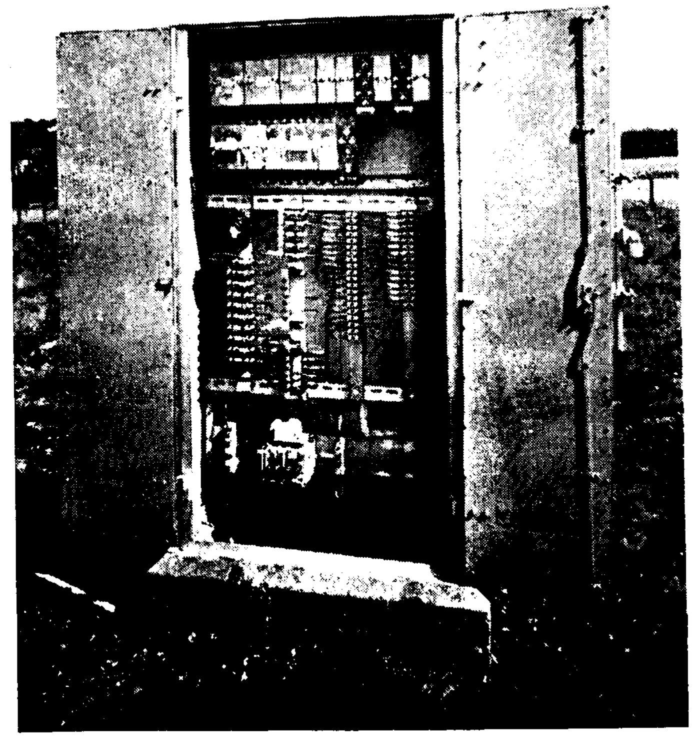
Several ways have been used for labelling wire terminations. One method is to fix an engraved label against the terminal block or fuse at the junction point between inside and outside wiring or to paint the designation on a wooden strip. If the wire has to be disconnected during alterations or other work, it has to be specially labelled. For this reason some railways use a sleeve, with the wire designation stamped on it, slipped over the wire and this seems to be the safest method.

CONNECTIONS BETWEEN SIGNALLING AND INTERLOCKING RELAYS

The Underground's extension and modernisation programme, which began in 1923, brought with it a large number of new signal boxes and although power level frames were in vogue at that time, the interior arrangements of the signal boxes, particularly with regard to the relays and wiring, were entirely different to their predecessors. Access to the bottom portion of the older power frames was obtained by removing the side, back or front panels. The connections to the lever contacts and lever locks were not easily accessable and illumination was supplied by means of an inspection lamp. The wiring between the lever frame and the cabinet containing the relays was run in wooden trunking.

The floor of the upper portion of the new signal cabins had a rectangular opening constructed in them which exactly fitted the area covered by the power frame. The relays were placed on open shelves, fixed to angle iron racks, and these were arranged around the opening in the relay room ceiling and signal box floor in the form of a square U. A steel platform ran the whole length of the opening, a few feet below the ceiling and access to this was obtained by a steel ladder. By this means the whole interior of the power frame could by inspected with great ease by the signal maintenance man mounting the ladder and standing on the platform. Fixed lights illuminated the interior of the power frame. The various relays being arranged around the floor opening considerably shortened the amount of wiring necessary. This was run on the open system being neatly treed and supported by aluminium hooks.

In modern signalling, relays have to accommodate many wires. If a relay becomes defective it has to be changed necessitating the removal of the wires and their correct replacement. The task is simplified if the wires are already labelled but the process is a

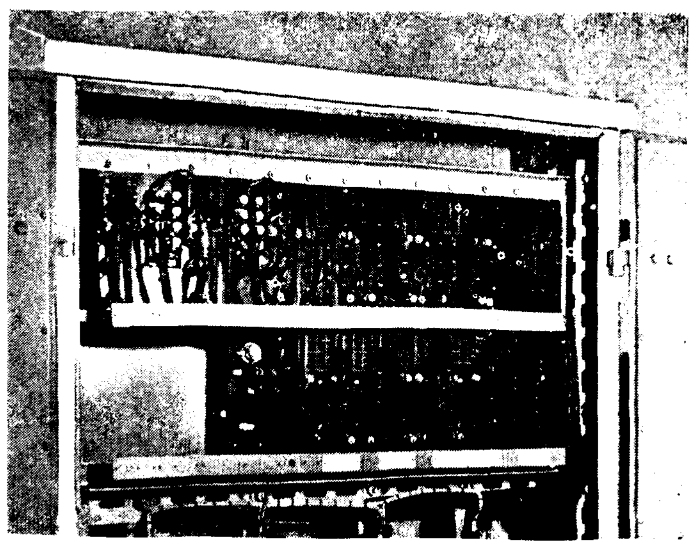


Steel location case showing terminals, fuses and plug in relays. (at top)

length one and great care and attention is essential. When the work is completed all the circuits affected have to be tested to ensure that wires have not become accidentally changed. A relay failure on a busy suburban section can cause severe dislocation of traffic and it has to be changed as quickly as possible. The maintenance personnel who have to change the relay are naturally all too conscious of the necessity for speed and it is this factor that could cause wires to be inadvertantly exchanged. The facility for testing all the circuits involved after the work is completely is not immediately available with trains running at close intervals. This very real problem led to the development of the detachable top relay. This relay has two tops, one permanently fixed to the relay case with its terminals connected to the contacts, coils, etc. The removable top has the terminals to which the outside wiring is secured. The two tops are clipped together by a special locking device which brings the underside of the terminals and the contact pieces leading to the interior of the relay together. Once the relay is connected up it is unnecessary to disconnect it again when it has to be changed. When a relay has to be changed, the locking device is opened and the terminal top is lifted off with the wires for the various circuits attached to it. Hooks are provided on the underside of the relay shelf immediately above and they support the terminal top while the relay is being changed. Not only does this mean that the changeover can be done very quickly but there is no likelihood of wires becoming crossed. To prevent the wrong type of relay being used in place of the one being removed, each relay has one or two sets of code pins. If a relay of another type, with different contact arrangements and characteristics is substituted, the terminal board cannot be fitted to it. A difficulty with the detachable top arises with the wiring. If this is run flat across the terminal top and treed where they leave the relay, some resistance is experienced when lifting up the top. Some railways attach the wires singly and vertically each one going through a hole in a guide board into the wire run over the relay.

PLUG IN APPARATUS

Another type of signal relay which has become very popular is the plug in type. These relays are plugged into a plugboard which has terminals at the back. The plugboards are mounted on verticle racks. Connections from the relay are run out through the base as springs which engage on contact strips on the side of wedges composed of insulating material on the plug base. Each relay is supported by two brass rods projecting from the plugboard and these act as guides. The relay is pushed right home and secured in position by two knurled nuts. A relay can be changed in a very short time and a dexterous man can do it in about 30



Rear view of upper portion of location case showing rear view of relay plugboards.

seconds. The wiring between the plugboard terminals is arranged in the same manner as the earlier type relays and the wiring from the relay rack is taken across to the cable terminal rack or control unit at suitable positions through overhead steel channels. Inadvertent use of the wrong type of relay is checked by coding pins as with the detachable top type.

In another type of plug in relay, the plugboard is not provided with terminals but with detachable terminal spades or contact pieces to which the connecting wires between relays are soldered. When it is necessary to remove a wire from a relay, the detachable terminal spade, which is locked in position at the back of the plugboard, is withdrawn by means of a special tool. If wiring alterations are necessary at any time, new wires can be run with the terminal spades already attached ready for exchanging or for insertion in new positions. The main feature of the detachable terminal spade in the relay plugboards is that disconnection points are available without the necessity for providing independent terminal boards for each relay. Special arrangements are also made to permit a Voltmeter or an ammeter to be connected in circuit without interfering with the operation of the relay in any way.

Plug in equipment is also used for outdoor apparatus. The plugboards are mounted on a framework fitted inside the location cases and the method of changing relays is exactly the same as in the signal box relay room. Quickly detachable plug coupler arrangements are also provided for the electrical movement and connections in searchlight signals.

PREWIRED APPARATUS

In order to reduce the amount of wiring required to be done at site, signal cabin relay racks and location cases for the main cable run can be prewired by the manufacturers or in the railway's signal shops. Not only does this save work out on the track but it permits the work to be done more neatly and accurately. The only wiring to be done outside is that of connecting the main cables to the location cases, the incoming cable to the fuse and terminal racks in the signal box relay room and the wiring between one relay rack and another or to the control unit.

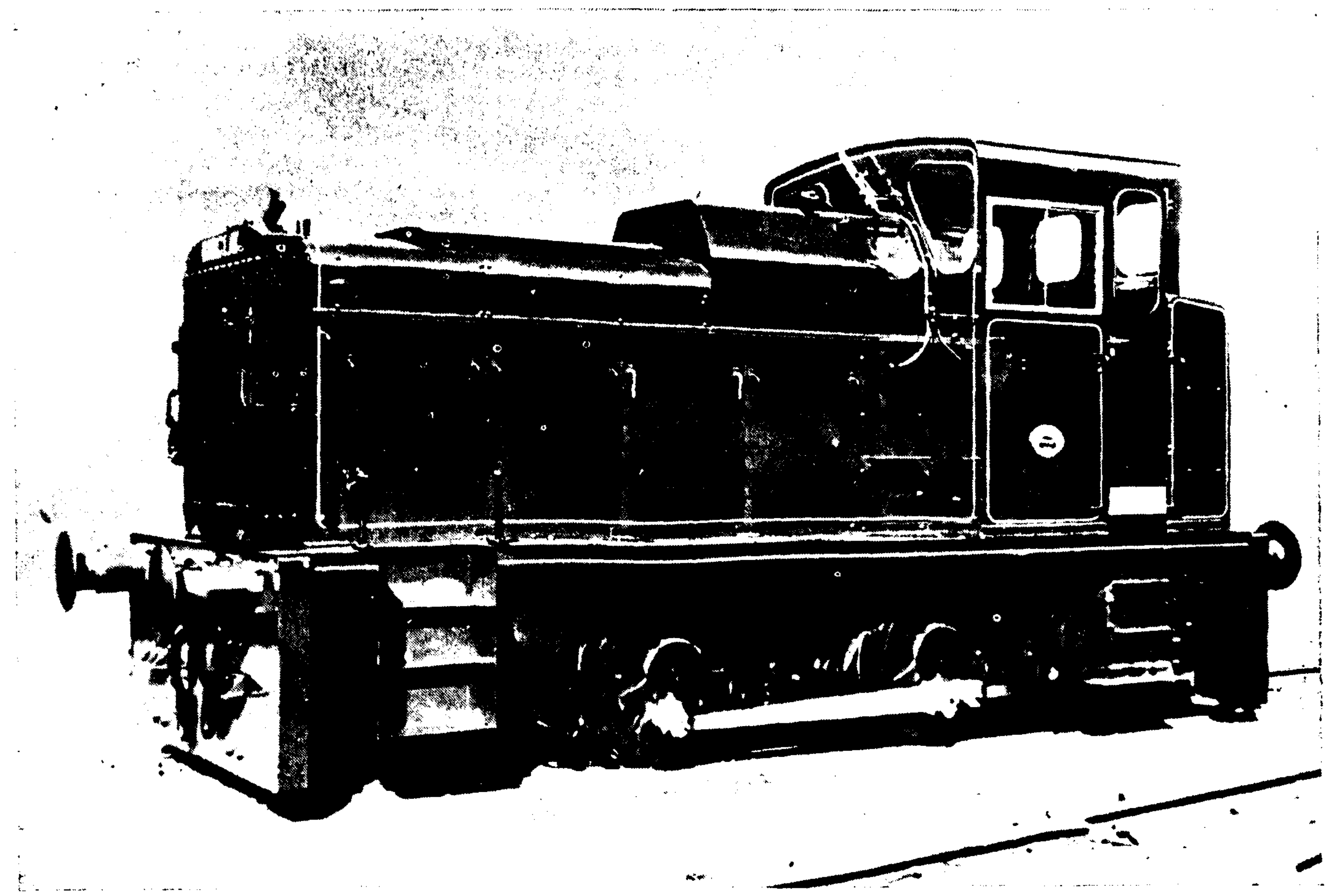
In new construction work now being carried out, both at home and abroad, and in work still in the planning stage, quickly detachable, plug in facilities will be required for almost all types of apparatus to be used. Whole units will be manufactured assembled and prewired in the workshops with the object of cutting down the amount of wiring on installation work to a very minimum.

A New Diesel Hydraulic Locomotive

THE diesel hydraulic locomotive is now well established and several types are in operation using hydraulic torque converters of various designs. A new type, the principal feature of which is its simplicity, has been introduced by Messrs. Andrew Barclay, Sons & Co. Ltd., of Kilmarnock, for whom, Parry & Co. Ltd. are Agents in India. This locomotive is fitted up with a British Twin Disc torque converter, the first to be applied to a locomotive in this country.

The locomotive is of the 0-4-0 type and is fitted with a National five cylinder diesel engine developing a maximum of 200 B. H. P. at 1500 r. p. m. The locomotive is intended for shunting duties and for this class of work, the most desirable characteristic is a high tractive effort for starting combined with a steady pull to minimise wheel slip and with the possibility of accelerating steadily up to a moderate speed.

Most diesel hydraulic transmissions have hither to embodied two or more converters or a converter and fluid coupling or a converter and change speed gearbox in order to provide a sufficient range of torque variation but the British Twin Disc three-stage torque converter is capable of giving a maximum range of 5 or 6 to 1 and can therefore be used as a single unit in a shunting locomotive The operation of the converter is entirely automatic, depending on the speeds of the input and output shafts. Actually the full range of 5 or 6 to 1 torque multiplication is not used as the efficiency is low when the multiplication is as high as this but part of the range is used giving a torque multiplication of approximately 4 to 1. This is equivalent to that obtainable from a normal 4-speed gearbox. This wide range is not obtained from any serious loss of efficiency, the efficiency of the converter being 70% at each end of this range and at its best speed the efficiency rises to a maximum of 82%. It will be observed that the tractive effort is perfectly smooth there being no breaks or steps in it such as in the graph of a change speed gear box. It is thus possible to fit the tractive effort of the locomotive exactly to that called for by the load and to utilise the full power of the engine at all times. This is not always possible with a change speed



gearbox as the tractive effort required by the conditions may not be exactly obtainable without adopting a lower gear and running the locomotive at a lower speed than might otherwise be obtainable. The smooth variation in the tractive effort of a hydraulic locomotive ensures that there is no jerking of the transmission or train such as occurs when changing gear on a diesel mechanical locomotive. This is of particular importance when working with loose coupled rolling stock. Compared with a two or three stage hydraulic transmission, there is no governor or arrangement of valves to control the change-over from one stage to the other. In addition to this, there is no free wheel.

The application of power when starting from rest is perfectly smooth and the locomotive can therefore be of the minimum weight to give the maximum tractive effort. The maximum tractive effort of this locomotive is 20,000 lbs. It is 18,000 lbs. at 2.4 m. p. h. and 4,500 lbs. at 9.6 m. p. h., this being the range of speed in which the efficiency of the converter is 70% or over. The weight of the locomotive is 31 tons giving an adhesion ratio of 3.5 to 1 with the 20,000 lbs. tractive effort. The locomotive will run up to a maximum speed of 11 m. p. h

The engine is of the National M4AA5 type having five cylinders 6″ bore by 8½″ stroke. It is set to develop a maximum of 200 B. H. P. at 1500 r. p. m. this being a 12-hour rating. It is of advance design and incorporates four-valve cylinder heads with controlled turbulence resulting in high thermal efficiency with good combustion at all loads. Solid injection into an open combustion chamber is used. Starting is by electric motor engaging with a toothed ring on the flywheel.

Electric lighting is provided on the locomotive consisting of head and tail lamps, a cab lamp, a lamp under the engine casing, two lamps over the instrument panel and a portable inspection lamp. These are supplied from the starting batteries which are of ample capacity.

The mechanical construction of the locomotive is extremely simple. The Twin Disc torque converter is rigidly mounted on the engine crankcase, in addition to which it is supported at the output end from one of the locomotive frame stays. From the output shaft of the torque converter the drive is taken by a propeller shaft with Layrub flexible couplings at each end and the drive is taken from these to the rail wheels by means of connecting and coupling rods. The reverse gear is of the bevel type consisting of a bevel pinion running between two crown wheels which are mounted on roller bearings on a cross shaft. Either of these crown wheels can be connected to the cross shaft by means of a multiple toothed clutch which slides between them on splines on the shaft. From this cross shaft the drive is taken by means of double reduction spur gears to the jackshaft. All shafts in the reverse and final drive unit including the jackshaft are mounted on roller bearings. The casing of the gearbox is of cast iron and is bolted to the frame by fitted bolts so that in addition to forming a rigid mounting for the jackshaft, it acts as an effective frame stay. It is possible to dismantle the gearbox and remove all shafts including the jackshaft without disconnecting the principal casting from the frames of the locomotive.

A friction clutch is embodied in the torque converter casing between the engine and the torque converter. This clutch is only fitted to provide a free engine when the locomotive is standing and to facilitate operation of the reverse gear. It is of the over-centre type and is therefore either fully engaged or disengaged. It is not used for taking up a load and the wear on it is consequently negligible. It must be engaged to connect the engine to the torque converter and must be disengaged momentarily to eliminate the drag torque of the converter to allow the reverse gear clutch to be moved. It is operated by a hand lever and requires very little effort. An interlock of a simple mechanical type is provided to prevent the reverse gear handle being moved unless the clutch is disengaged.

Another interlock, patented by Messrs. Barclay, is also provided to prevent the reverse gear handle being moved unless the locomotive is stationary. This is operated by the flow of oil circulating in the final drive gearbox. So long as the locomotive is moving, and consequently the coil is circulating, a plunger is held up to intercept a sector on the reversing handle shaft, so that it cannot be moved. When the locomotive stops and the oil flow ceases, this plunger recedes and the reverse gear handle can be moved, provided at the same time the clutch is disengaged.

The frames are exceptionally rigid being 1½″ thick and are built up with frame stays bolted to them with turned driven bolts. The engine and torque converter are mounted on a rigid sub-frame. The buffer beams are steel 6″ thick to provide the necessary weight for adhesion. The ballast weight is thus in its most effective position for absorbing shunting shocks. The locomotive was built for 4′ 8½″ gauge with a wheelbase of 6 ft. The wheels are 3′—2″ diameter. A sectional radiator of Messrs. Reliance Manufacturing Company's make is fitted at the front of the locomotive and contains separate sections for engine cooling water and lubricating oil. An auxiliary radiator is fitted in front of this to cool the fluid from the Twin Disc torque converter. A sheet steel casing is fitted over the engine with provision for ventilation at the top. A large fuel tank of 275 gallons capacity is fitted at the top of the casing, close to the cab so that it does not obstruct the driver's view. This fuel supply should be sufficient to keep the locomotive running for about four weeks if working on day shift work only. The cab is of welded construction with large windows giving the driver an excellent view all round. The side windows are of Beclawat type arrange to slide to open. The doors are divided, the top half, which is glazed, being arranged to open independently of the bottom half.

The driving controls consisting of throttle lever, clutch, brake lever and sanding levers are duplicated so that they can be operated from either side of the cab. The throttle, brake and reversing handle are conveniently grouped on a desk in front of the driver. An adjustable seat is provided for the driver at each side of the cab. A Clayton S12 type heater is fitted in the cab. It is operated from the engine cooling water system and the warm air is circulated by an electric fan.

The brakes are of the Westinghouse compressed air type, supplied from air compressors driven by Vee-belt from an extension shaft at the front of the engine. This extension shaft is drive through a flexible coupling and it carries also a pulley for the Vee-belt drive to the radiator fan. The compressed air for the brake system is also used to operate the reverse gear by means of diaphragm cylinders.

A gauge and instrument panel is fitted above the driver's desk and carries the following instruments.

Westinghouse Duplex air pressure gauge, gearbox air pressure gauge engine oil pressure gauge, gearbox oil pressure gauge, converter oil pressure gauge, engine oil temperature gauge, water temperature gauge, converter oil temperature gauge, tachometer, speedometer with mileage recorder, ammeter, lighting switches and starting button. A lock-type switch is also provided to prevent unauthorised starting of the engine. A fuel gauge is fitted in the end of the fuel tank and is visible above the instrument panel. A warning light is also fitted on the instrument panel to indicate when the temperature of the fluid in the torque converter is approaching the high limit.

The driving of the locomotive is simplicity itself. To start, after the engine is running, it is only necessary to engage the clutch and gradually ion the throttle. The engine will speed up and the torque converter will take up the load and it will start with perfect smoothness. If the throttle is fully opened, the speed will rise to the maximum which the power of the engine and the weight of the train will permit and the locomotive will run at this speed indefinitely without overheating of the torque converter, provided the load is within the maximum capacity of the locomotive. It should be noted that it is impossible to stall the engine by overloading the locomotive or by mishandling. The only controls which the driver needs to operate are the throttle, brake, reversign handle and clutch. As in all diesel locomotives, except the diesel electric type, it is necessary to bring the locomotives to a standstill before the reverse gear is changed. As explained above, a patented interlock is fitted to ensure that this is done.

It has been the aim of Andrew Barclay, Sons & Co. Ltd., to produce the simplest possible form of diesel shunting locomotive, both in construction and handling. This aim has been very successfully accomplished in this prototype locomotive, which has already undergone successful tests. It is the forerunner of a range of similar locomotives with powers up to 400 H. P. and the Company has already received orders for locomotives of 302 H. P. with British Twin Disc torque converters.

MANGANESE ORE

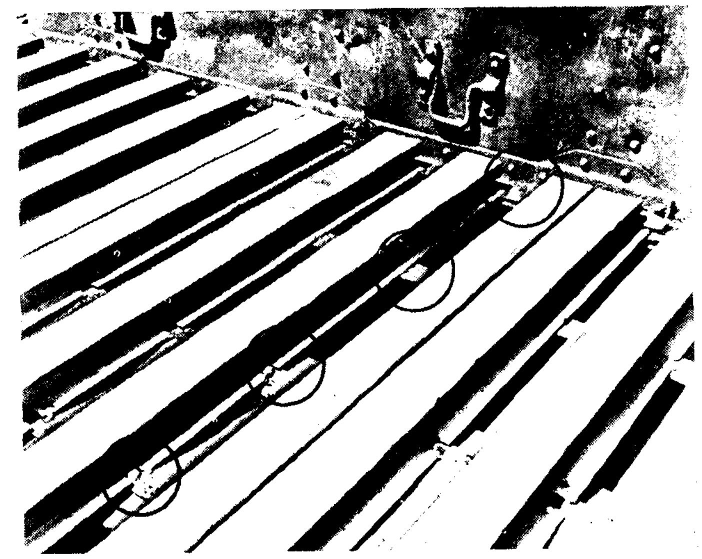
It is reported that shortage of railway wagons at some mine heads have seriously affected the export trade in Indian manganese ore in recent times. According to this report, the Madhya Pradesh Mineral Industry Association has, in a memorandum to the Union Minister for Commerce and Industry pointed out that unless immediate arrangements for wagons are made, the members of the Association may not be able to transport all the quota before the date of expiry i.e. June 30, 1958. The Association is further reported to have represented to the Government that "out of about 10.85 lakh tons of manganese ore for export registered with the Eastern Railway authorities the quota of State Trading Corporation alone amounts to 6 lakh tons".

Total imports of manganese ore in France during the month of August last totalled 67,999.6 tons compared with 54,237.8 tons in the preceding month out of which imports from India totalled 25,406.6 tons against 28,238.3 tons in the preceding month.

A Nailable Floor with a Backbone of Steel

By W. E. McFee.
Supervisor, Product Information Service, Armco Steel Corporation.
Middletown, Ohio

ARMCO freight car floor is a composite steel and wood flooring for gondola, box and flat cars. It is designed both for new construction and for replacement of worn-out wood or steel-plate floors in existing cars. The Armco floor consists of formed steel ribs and wood planks laid alternately. The steel ribs are hat-sections and their top surfaces form part of the floor. The heavy wood planks are nailing strips. They are supported by the flanges of the steel ribs and are fastened with bolts. The ribs themselves are welded to the underframe.

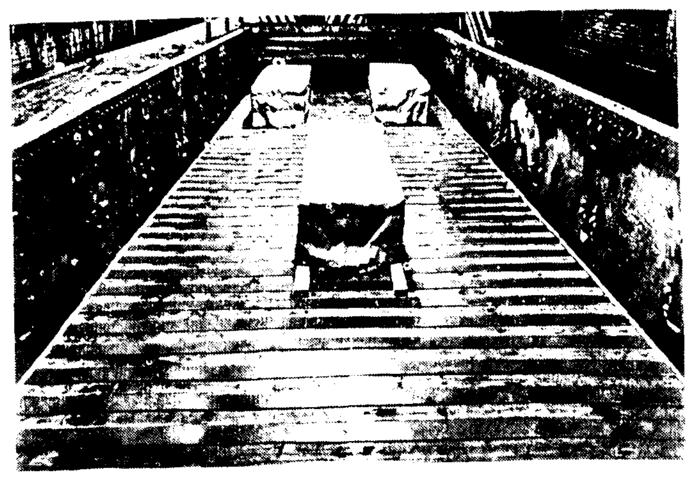


This is how Armco steel ribs strengthen the car frame. Circled welds are four of the ten points at which rib is welded to frame.

STRENGTH FOR BOX CAR LOADS

Today, there is an increasing use of fork lift trucks for loading and unloading palletized freight in box cars. Wheel loads from lift trucks of 10,000 pounds (20,000 pound axle loads) are common. When a single box car floor plank 1-3/4 inches thick is called upon to resist such a concentrated load, the result is often a break-through. The hat section Armco steel rib has several times the strength of the wood plank under comparable loading.

When there is a concentrated load on the wood nailing strip, the load is transferred to a pair of steel ribs through their flanges. Consequently there is no point of weakness in the Armco freight car floor.



Three weatherproofed lifts of steel sheets in an old gondola car with new Armco floor. Note skids nailed to floor planks. This method of loading is ideal for quick unloading with crane.

Damage is often caused to open car floors from dropped loads and the impact of clamshell buckets when unloading aggregates. Wood plank floors cannot withstand it; plate floors become deformed and unsuited for many types of lading.

Wood planks in gondola and flat car floors are usually 2—3/8 inches thick by 5—1/2 inches wide. The corresponding Armco steel rib is several times as strong as the wood plank and can take a more severe beating longer.

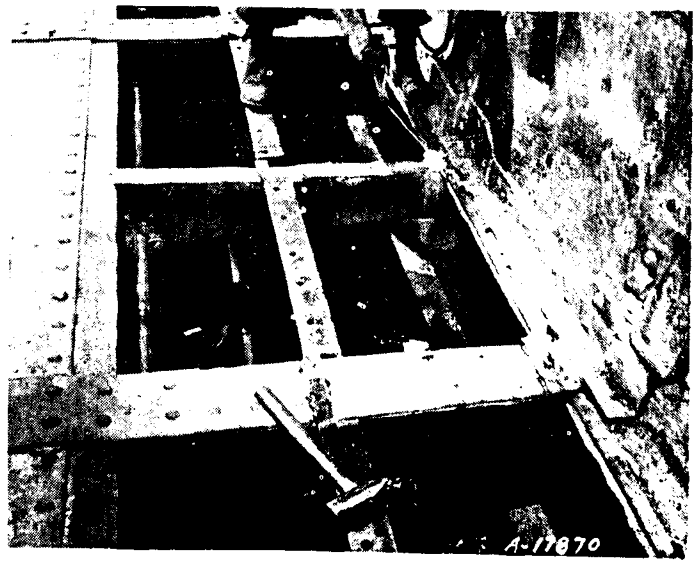
Steel plate floors in gondola cars are good for bulk lading, but plates have little beam strength and become bellied even from normal service. The steel ribs of the Armco floor are designed strong enough to remain flat under most service loads

Concentrated loads and impacts shorten the life of floors. Each plank in a wood floor must serve as a beam Standard wood floor planks do not have the

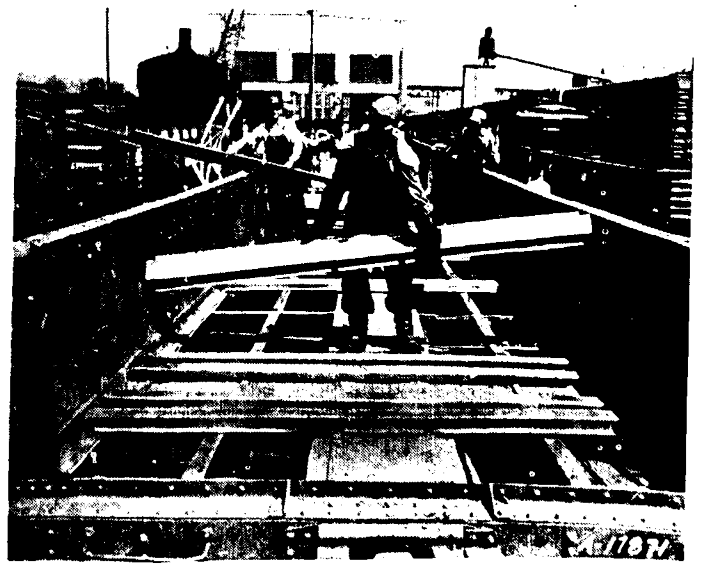
Steel plate floors become bellied, perforated and unsuitable for even bulk loads.

Stripping gondola car floor by cutting out old plate between sills and crossbearers in order to install the stringers. It is unnecessary to remove bolster or center sill cover plate.

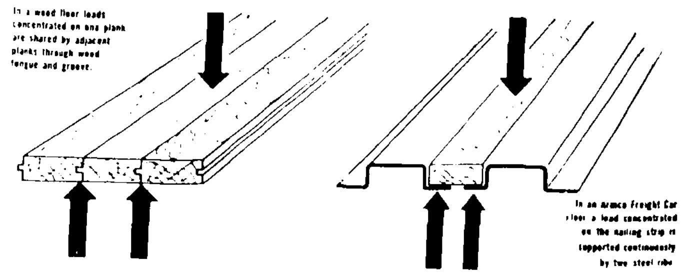
necessary beam strength. The Armco hat-section rib has the strength that is needed. It gives the best-known



Welding fillers to side sill of old car. Note installation of stringers made of old 5-inch bulb angles riveted to cross-bearers.



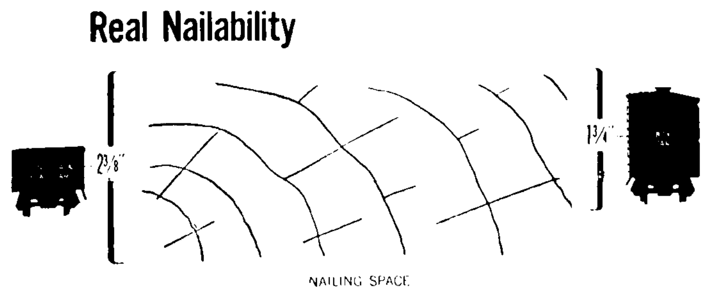
Unloading Armco ribs directly from car by conveyor and laying preparatory to spacing. Note ribs in foreground coped to clear center sill rivets.



combination of beam strength and floor surface per pound of steel.

EXCELLENT NAILABILITY

Here are actual-size cross-sections of the nailing strips used in Armco freight car floors. The 1-3/4 inch thickness



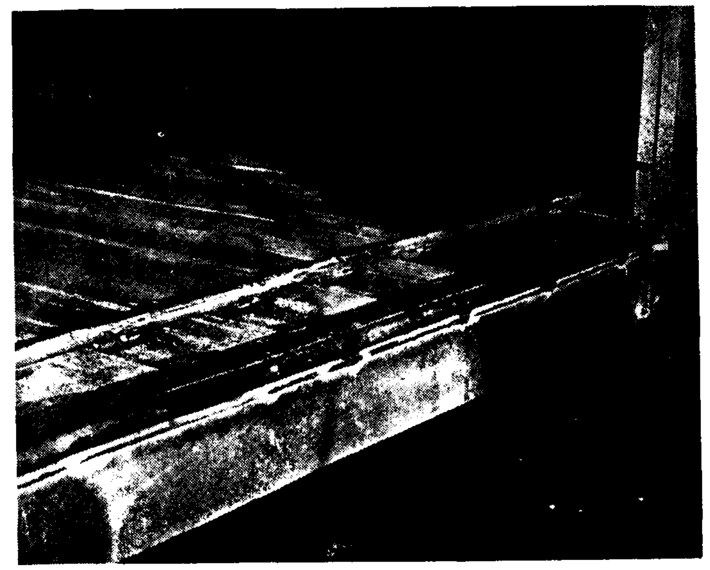
is for box cars, the 2-3/8 inch for gondola and flat cars. These nailing strips are spaced alternately with the steel ribs the full length of the car, except over bolsters or crossbearers where bolting is impractical. Here Armco standard steel planks or special ribs, designed to fit the car underframe, are fastened by welding.

Spacing ribs with template. The one shown is half the length of the car, of welded construction and made to clear special ribs over bolster.

The sturdy wood planks permit easy fastening of skids and bracing and provide the floor with real nailability.

A MULTI-PURPOSE FLOOR

The Armco floor will handle bulk—or unit-lading equally well. This eliminates the problem of selecting a car by floor type. It saves time and money for both the railroad and the shipper in switching empty cars.



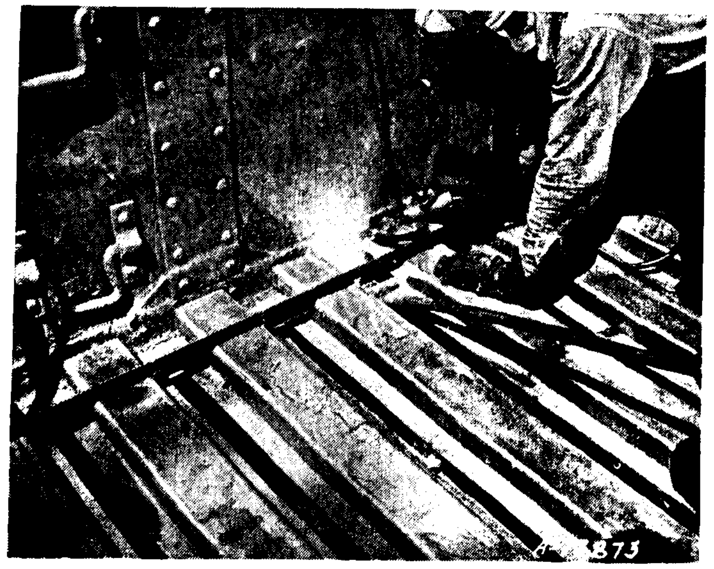
Template of welded pipe used for spacing box car ribs.

In this new box car installation steel ribs are being centered before welding to provide sealing space at car sides.

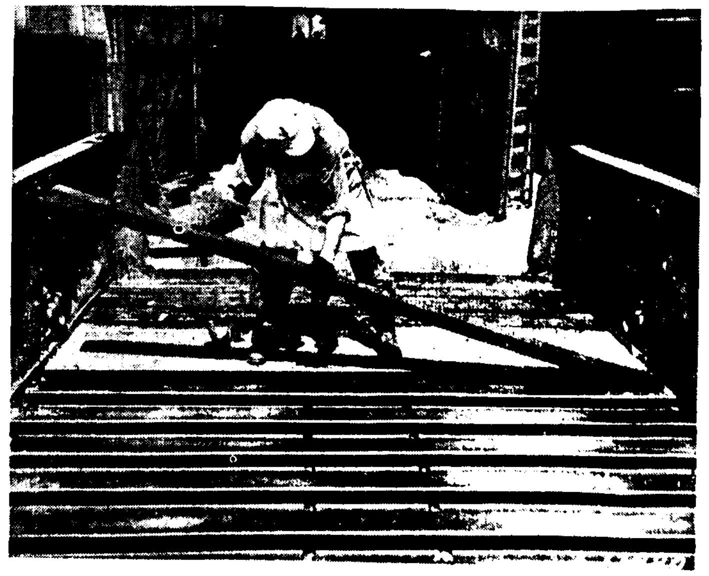
This is of particular importance in the case of gondola cars. The same car that brings bulk loads into a plant can carry away the manufactured product. Armco freight car flooring is made for fastening bracing and skids in the proper way—with nails. There is no invitation to weld fasteners to plate floor or burn holes for bolts.

RIBS REINFORCE CAR UNDERFRAME

The Armco ribs not only bear the weight of the shipment but reinforce the car frame. Each individual rib is welded to the frame in at least ten places.

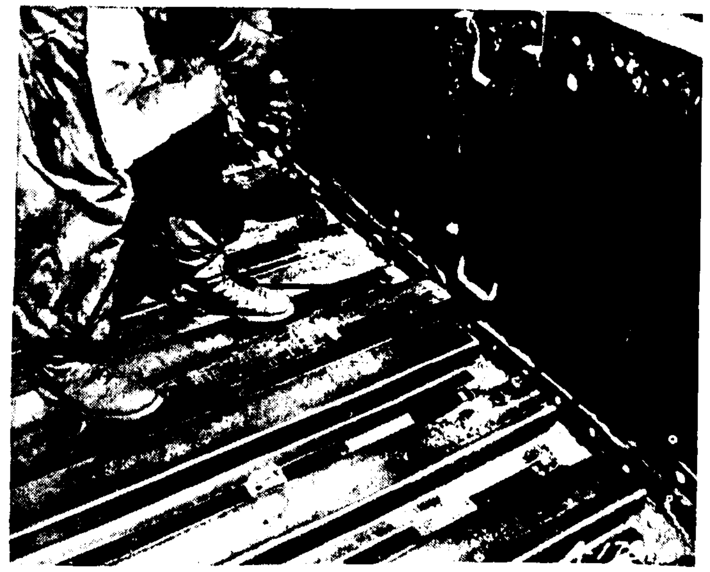


Tack welding Armco ribs while spaced with template. Note special pinch bar for holding ribs tightly to side sill while welding.



Laying treated wood planks between spray-painted ribs.

Welding special ribs over bolster.



Centering wood planks with pinch bar. Note chalk marks on steel ribs and car sides to locate bolt holes.

Welds are made on both sides of the ribs, two at center sill and two each at stringers and side sill angles. Resistance of the car underframe to twisting and racking is increased greatly by this strong welded lattice.

A SOUND INVESTMENT

The life of an ordinary wood-plank floor is limited to an average or about five years. The Armco floor will last much longer. It's steel ribs should be good for the life of the car.

The wood nailing strips are not required to resist concentrated loading or heavy impact. That is the function of the steel ribs. The wood planks wear chiefly from abrasion, and from this they are partly protected by the top section of the steel ribs.

This protection of the wood plank from mechanical damage is favorable to the use of wood preservatives. They will extend plank life.

Drilling planks to match existing bolt holes.

Armco freight car floors help create satisfied shippers, reduce costly claims for damage and loss. The danger of heavy concentrated loads breaking through a weakened car floor and causing a serious accident is eliminated.

Armco freight car flooring will also reduce shopping time and consequent loss of revenue from out-of order cars.

DESIGN DETAILS

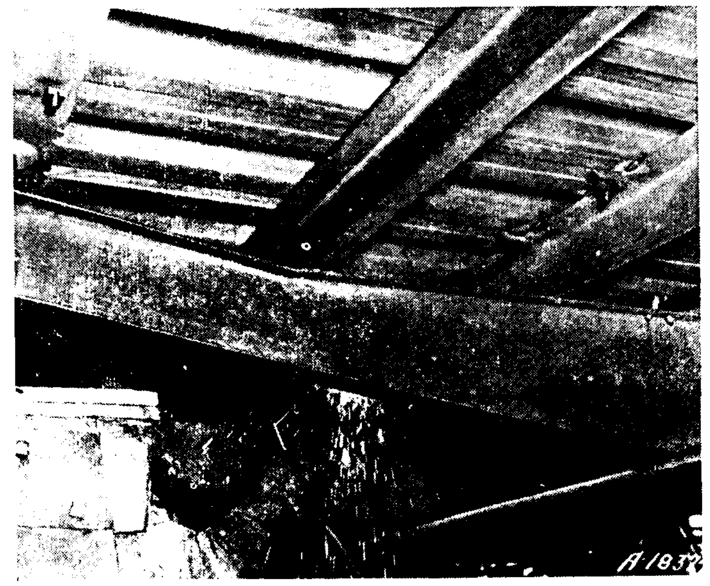
Sketch 1

Sketch 1 gives dimensions of standard gondola car ribs and planks. Method of bolting wood plank to side sills and stringers shown at left is used when existing bolt holes match wood planks. At center is bolt with floor clip, another method of fastening wood plank. At right is an Armco steel plank used over bolsters and cross-bearers where it is not practical to bolt wood planks.

Sketch 2

This drawing shows how steel ribs are welded to side sills, stringers and center sill. The arrangement shown to left of center line is used in older cars. Here, a steel filler strip is welded to the center sill and the steel ribs in turn are welded to the filler strip.

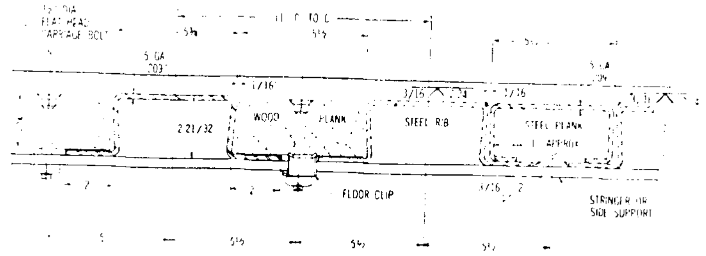
Drawing indicates how wood planks are fastened by bolts through side sills and stringers as previously shown in Sketch 1.



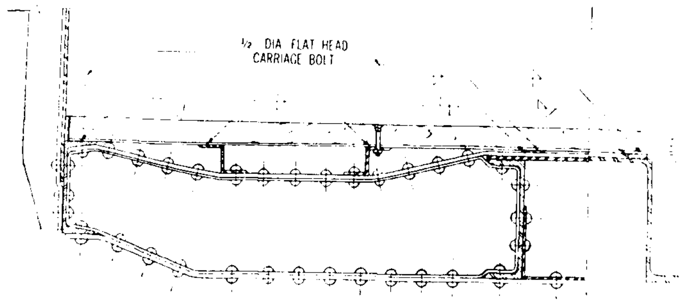
This box car installation uses floor clips similar to type shown in Sketch 1, to fasten wood planks to steel ribs and stringers.

Pouring car cement after inserting galvanized closure strip and filling crevice with sawdust.

The arrangement to the right of centerline of car shows the half-section of center sill used in newer cars.



Sketch 1



Sketch 2

Sketch 3

Sketch 3 shows special ribs supplied for use over gondola cars bolsters. Note how floor level is maintained and rivet heads avoided. Armco supplies these ribs made to measure for your cars and ready for installation.

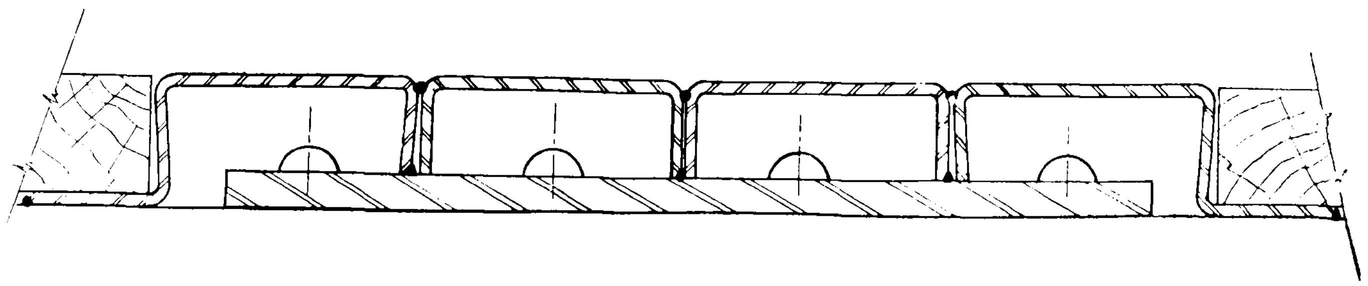
Sketches 4-A and 4-B

(4—A) Two single flange ribs with one short leg to fit cross-bearer cover plate used in one gondola car installation.

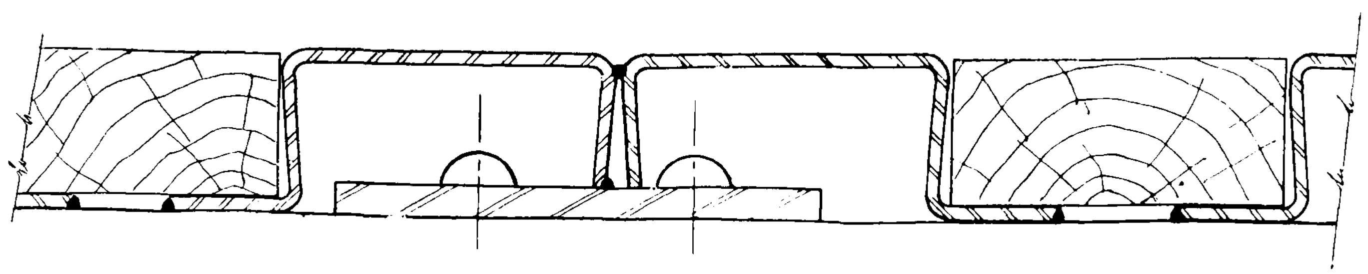
(4—B) Channel shaped rib in another gondola car installation. Design by Armco engineers from drawings of car.

Sketch 5

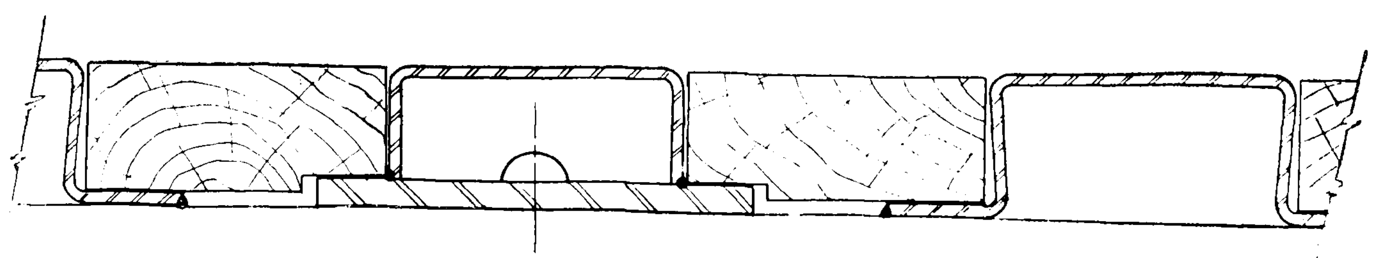
To seal sills, space between floor and side sill angle is filled with car cement. Sketch at lefts shows seal for box car with wood filler strip and grain strip. The rib is supplied with the closure welded in place. Detail at right shows sill seal for gondola car. The sheet metal closure strip is laid against the edge of the floor before the car cement is applied.



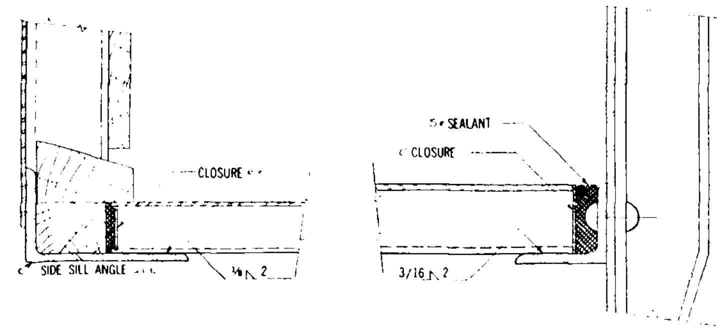
Sketch 3



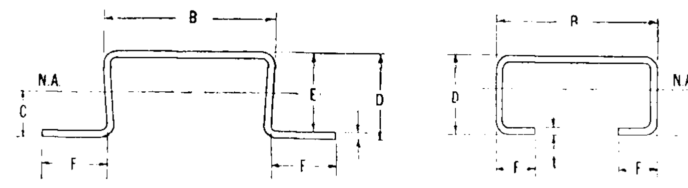
Sketch 4-A



Sketch 4-B



Sketch 5



Sketch 6

(DIMENSIONS & PROPERTIES)

Sketch 6 and Table

Here are the cross-sectional dimensions and structural properties of standard Armco steel ribs and planks. Lengths are supplied to suit requirements. Armco engineers will design any special or modified ribs needed.

	t in.	*B* in.	*D* in.	*E* in.	*F* in.	*I* in.^{4}	*S* in.^{3}	*C* in.	*Weight lbs. per 1 in. ft.*
Ribs for Gondola and Flat Cars	.209	5-3/8	2-21/32	2-15/32	2	3.21	2.26	1.42	9.83
Plank* for Gondola Flat Cars	.209	5-1/2	2-15/32	—	1-5/32	1.94	1.25	1.55	8.10
Ribs for Box Cars	.135	4-1/2	1-15/16	1-13/16	2	1.02	1.03	.99	5.47
Plank* for Box Cars	.135	5-1/2	1-13/16	—	1-3/32	.66	.56	1.18	4.82

*Steel planks are for use over bolsters or other cross members when wood planks cannot be bolted at these points.
I = Moment of Inertia
S = Section Modulus (I/c)
C = Distance from extreme outer surface to neutral axis

GENERAL COMMENTS ON DESIGN

1. When replacing worn-out wood floors, the car underframe requires few or no changes. When applying the Armco floor to gondola cars with worn-out steel plate floors, stringers must sometimes be installed between cross-bearers. This requires stripping of the old plate floor with cutting torch. In many cases, depending on car design, filler strips or shims must be welded to center sill, and occasionally to side sill angles, to provide a level foundation for the new floor.

2. Armco steel ribs and planks are usually supplied in hot-rolled open-hearth steel. Copper-bearing steel will be used if specified.

3. Welding symbols in Sketches 1 and 5 indicate location of fillet welds, their size, length and spacing.

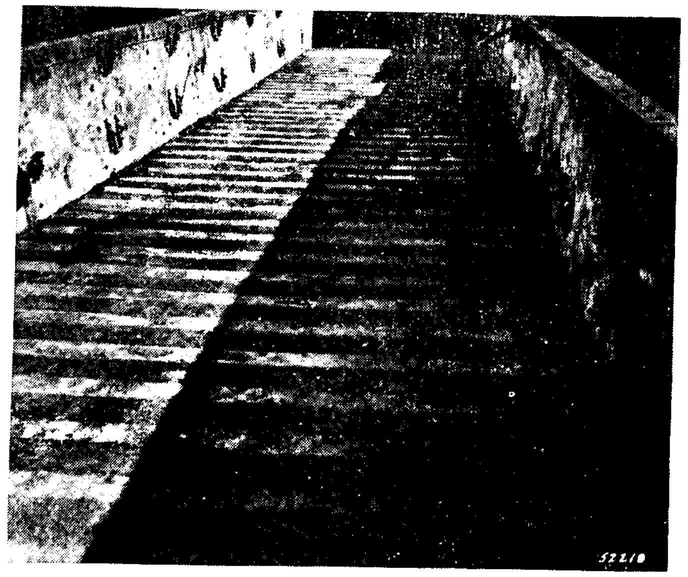
4. All welding required in installing the Armco freight car floor can be performed downhand (from above).

5. Dimensions of steel ribs and planks shown on sketches are for gondola cars. Standard ribs and planks for box cars are thinner and lighter. For dimensions see Table of Dimensions and Properties.

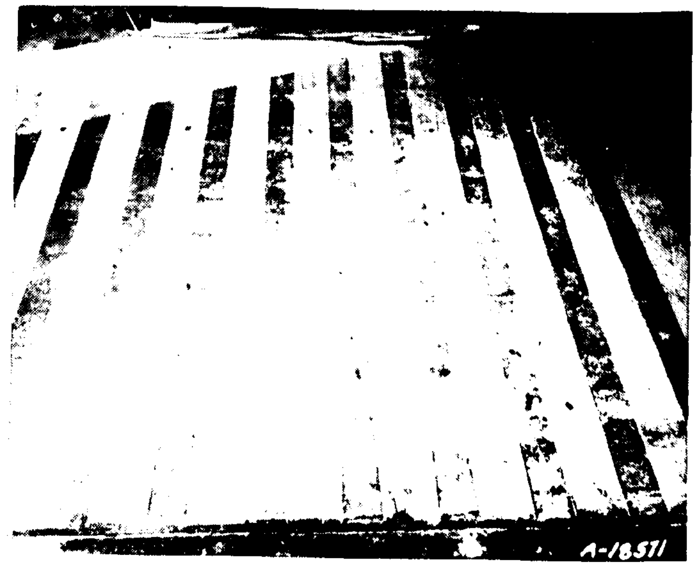
6. Where it is necessary to clear rivet heads in cross members, ribs will be supplied coped (holes punched for clearance) or part of the flange and leg may be omitted as shown in Sketches 3, 4—A and 4—B.

7. In drop-end gondola cars, the last one or two flooring members at both ends of car can be wood planks to more easily accommodate the hinges for the drop-ends.

8. Clips and bolts shown in sketches are representative and satisfactory types. Others may be used at the discretion of the railroad or car builder.



The proof of the pudding. This is the Armco freight car floor shown in photo 1 after 3 years of hard service.



An Armco box car floor after two years of service.

HOW TO INSTALL ARMCO FLOORS

Here is the general procedure for the installation of Armco freight car flooring :

1. When replacing a worn-out floor, the old one must first be removed. Then, if necessary, top surfaces of side sill angles, stringers and center sill are levelled to permit steel ribs to make full contact at all supports. This is done by welding steel filler strips to those surfaces low in elevation to bring them into line. Location and dimensions of these fillers is determined in advance from blueprints of car frame to eliminate on-the-job figuring.

2. Lay all ribs required for car in correct relative position. Make sure that any special or coped ribs are at the points for which they are designed.

3. Tack welding the first steel ribs at bolster or other point at which precise location is required. Then work toward center and both ends of car using templates to space ribs.

4. While spaced accurately by templates, weld ribs wherever they make solid contact with side sills, stringers and center sill.

5. If necessary, jack up stringers so that they meet the bottom surfaces of the rib flanges before welding. In old cars ends of steel ribs may have to be forced down to bear against side sill angles.

6. After finish-welding ribs, lay any steel planks that may be required, as over bolster, and weld in place.

7. Spray- paint ribs and steel planks. While this is not essential it is quite desirable.

8. Lay wood planks in place between ribs, and center so that equal space is left at sides of car for closure strip and seal.

9. Drill planks for bolts. Location of existing holes in side sill angles can be marked with chalk on side of car and ribs.

10. When required, set sheet metal closure strip at sills and use filler and black car cement to seal sides of car.

The S.N.C.F. (French Railways) will help to equip the Indian Railroads

BEFORE leaving for India after a two and a half months stay in Europe, Mr. Karnail Singh, one of the principal directors of the Indian railways, met Mr. Louis Armand, president of the S. N. C. F., and talked about extending the recent agreement on large scale technical assistance by the S. N. C. F. in electrifying with a single-phase system (25,000 volts, 50 cycles) 1,000 kilometres of main line in the Calcutta region.

The S. N. C. F. is being helped by the Sofrerail Engineering Company, which was created and is presided over by Mr. Armand Porchez, for the spreading French railroad technique abroad.

The electrification of the suburban lines around Calcutta, and then, during the Second Indian Plan, of the 2,000 kilometres of main line around Madras and Bombay, can be done with the same technique. In addition, India has ordered 50 electric locomotives from a group of European builders, including Belgian, Swiss and French. Forty percent of this order, amounting to a total of 4 milliard francs, will be done by French builders.

Mr. Karnail Singh said, about the agreement which was just reached, " It is much more than a simple technical agreement. French engineers have acted as pioneers in the use of alternating current, it is true, but the collaboration established must be infused with the French railwayman's spirit which has produced such noteworthy results, particularly under the direction of Mr. Louis Armand ".

" The French engineers who have gone to India have already prepared this cooperation. It is only one aspect among many others, of the rewarding agreements between the French and Indian governments ".

* * *

HIGH VOLTAGE A. C. TRACTION FOR RAILWAYS

Mr. M. N. Chakravarti, General Manager of the Central Railway, Bombay said that a high-level team of engineers, led by a technical member of the Railway Board, which visited France and other European countries recently had come to the conclusion that electric traction on the 25,000 volts alternating single phase current would be eminently suitable for India.

Mr. Chakravarti said the system was working faultlessly on railways in France and the Government had accepted the recommendations of the team of experts and had decided to increase the mileage for electrification under the second five-year plan from 816 to about 1,300, raising the cost to about Rs. 111 crores.

The General Manager of the Central Railway was presiding over a photographic exhibition and screening of films highlighting the achievements of the French railways held by the French Trade Commissioner in Bombay.

Discussing the future of electric traction in India, Mr. Chakravarti said in the field of modern motive power on the heavy traffic lines in India, the choice fell more on electric than on diesel traction. The advantage of electric power was the great potential India possessed for generating hydro-electric power at low cost. The main disadvantages of diesel power was that it made vital sections of the railway almost solely dependent on imported fuel for operation. It was for this reason that sections carrying the heaviest volume of traffic would have to be operated by electric traction, he said.

Mr. Chakravarti said the French Government had readily agreed to assist India in regard to electrification of sections of the railways and some French experts were already in the country. A three-member French team led by Mr. Nouvion came to India last year entirely at the cost of the French Government to advise the Indian Railways, he said.

In the post-war period, Mr. Chakravarti said, 3000 volts D. C. had been initially adopted as the standard as it was more economical than the 1,500 volts D. C. system at present in vogue in Madras and Bombay regions. In the meanwhile, high voltage single phase alternating current traction was developed and its economies both in respect of first cost as well as in respect of maintenance and operation costs established its superiority over the 3,000 volts D. C. system.

How do DSB's MY-locomotives pay off?

By E. Risbjerg Thomsen

SINCE the time when, in 1954, the first four big Diesel electric locomotives of type MY were put into operation, these locomotives have formed a remarkable feature of Danish railway traction and they will do so, to an even greater extent, once the further 22 locos now on order have been delivered in 1956.

MY 1101—1104, which have been in service for well over a year, have now covered a total distance of more than one million kilometres - a rather impressive performance—and thanks to their achievements, remarkable improvements were able to be made on main line trains on important runs, such as the »Nord-Express» and the »Nordpilen». In June and July 1955 only, the locomotives ran more than 180,000 km.

When the next 22 locomotives are delivered, they will be put into service on the main lines on Sjalland, Falster, Fyn and Jylland, to haul DSB's biggest and most important trains. They will improve running times and transportation speed in a way not experienced by DSB for many years.

What is expected from new locomotives is however, not only a higher train speed—although this in itself presents economic advantages and renders railways more competitive, compared with other means of transportation—but also a direct saving due to replacement of locomotives of older and less appropriate types.

DSB calculated, from the beginning, that essential savings would be rendered possible by the MY locomotives, and this was one of the reasons for their purchase. But it was, of course, necessary to exercise a certain caution and to obtain sufficient experience before an opinion could be formed as to the actual size of the savings.

The question of the operating economy of the new locomotives was considered so important that it was decided to keep a detailed account of their expenses in operation. Thus a special account was drawn up in the 2nd District and at the Central repair shops at Aarhus for all expenses arising from the operation and maintenance of the four MY-locomotives, in comparison with the corresponding expenses for four steam locomotives litra E.

The experience gained with regard to operating economy is considered of great importance not only by DSB but also by the other European railways, the MY 1101—1104 being the first big diesel locomotives of American type built in Europe and running on European lines. So the results obtained are followed up with interest by the railway's common research organisation, O. R. E. (Office de Recherches et d'Essais) in Utrecht.

A summary of the expenses over the period June 15th, 1954, until June 30th, 1955, has been made up in the 2nd District, and is given below. In this summary the expenses for the four MY-locomotives which have covered a distance of 873,493 train kilometres during this time are compared with those for 4 E-locomotives which over the same period covered 471,751 train kilometres.

Expenses for 4 MY-locomotives (Nos. 1101—1104), compared with 4 E-locomotives (Nos. 964, 969, 991 and 992) over the period June 15th, 1954, to June 30th, 1955.

	MY-locos	E-locos
Locomotive performances		
Train kilometres, total	873493	471751
Gross ton km in 1000, total	384746	142814
Train km per loco per year	209638	113220
Gross ton km in 1000, per loco per year	92339	34275
Average train weight in tons	440	303

Expenses in Danish Crs. per 1000 ton km

Fuel oil and coal (including train heating)	1.67	6.80
Lubricating oil	0.06	0.07
Water	0.01	0.20
Locomotive personnel	0.71	1.99
Attendance	0.13	0.30
Maintenance	0.19	0.75
Total	2.77	10.11

Expenses in D. Crs. per train km

Fuel oil and coal (including train heating)	0.74	2.06
Lubricating oil	0.03	0.02
Water	0.00	0.06
Locomotive personnel	0.31	0.60
Attendance	0.05	0.09
Maintenance	0.09	0.23
Total	1.22	3.06

The MY-locomotives, having a higher output than the E-locomotives, have naturally been used for trains requiring a greater tractive effort as for instance the Nordexpress (Northern Express) which in the past was occasionally pulled by two steam locomotives but is now hauled by one MY-locomotive, with shorter running-time than before. The MY-locomotives have also been used for express freight trains between Fredericia and Aarhus, on which it has been possible to increase the number of cars, thus saving special trains and consequently coal and locomotive and train personnel. The summary also shows that the average train weight for the MY-locomotives has been 440 t, against 303 t for the E-locomotives.

The use of these figures as a basis for the comparison should not be considered unfair towards the steam locomotives. The annual distance covered by the E-locomotives corresponds roughly to the average number of kilometres they were running before the MY-locomotives were put into service; whilst the distance covered by the MY-locomotives must necessarily be greater, there being no time lost for cleaning of fire-boxes, re-filling coal etc. And it is a fact that the MY-locomotives haul 440 ton trains faster than the E-locomotives pull trains of 303 tons.

The aggregate performance of the MY-locomotives, expressed in 1000 gross ton km (i. e. work corresponding to transporting 1000 tons over a distance of one kilometre) has been fixed for the period to which the summary refers, at 384,746 whilst the corresponding figure for the E-locomotives is 142,814; and if the actual transport work performed is to be taken as a basis for an examination of the economic advantages, these figures provide a starting off point.

It appears from a comparison of the expenses for the Diesel locomotives and the Steam locomotives respectively, during the time to which the survey refers, that the savings per 1000 gross ton km amount to 7.34 Crowns. i. e. 7.34 × 384,764 = 2.82 million Crs. which means about 678,000 Crs. per year per locomotive.

In proportion to thepurchasing-price of the MY 1101—1104, which was about 1,8 million Crowns apiece, this represents an exceptionally high annual saving, corresponding to about a 38% return on the investment, and DSB could scarcely find any other kind of investment yielding such a good return. It is of special importance that the essential part of these savings is made on imported fuel and thus represents a saving of foreign currency as well.

Now the questions arise whether the economic advantages obtained with the Diesel locomotives—i. e. quite new locomotives—during the first year of service can be studied in comparison with the costs of Steam locomotives which, although in the very best state of repair, have an average age of 24 years ; and also whether equal advantages can be expected in the following years, as the Diesel locomotives themselves get older.

To answer these questions it is necessary to examine the various items of the aggregate account and to investigate in the first place how the most important item in the budget, the fuel costs, are likely to develop.

Here, matters stand as follows. Experience gained in the United States, where a great number of the same type of locomotives have been running for a large number of years, shows, that the fuel consumption of the Diesel locomotives does not increase with their growing age, provided the maintenance schedule is conscientiously adhered to. Such a schedule has been established by DSB and is based partly on their own experience from many years of operating Diesel electric rolling stock, partly on the experience gained in the United States. Also in the case of DSB's other Diesel electric rolling stock, such as for instance in the »Lyn» trains, it has been proved that the fuel oil consumption has hardly changed during the 20 years of operation. If, thus, the fuel oil consumption can be expected to remain unchanged, the decisive factor, when estimating the future fuel economy of Diesel electric locomotives compared with Steam locomotives, will be the development of the prices of fuel oil and coal.

Since it is getting more and more difficult to obtain suitable coal for locomotives, the day is probably not far off, when the demand of the railways for coal will be met with difficulty and prices for coal will increase accordingly. No corresponding price increases are, however, anticipated for fuel oil for Diesel locomotives. On the contrary, a certain decline in prices has been noticed lately. Moreover, with new types of additives appearing in quick succession on the market, it will be possible to use oils of cheaper qualities. Tests with oils of such qualities are now being carried out in the United States ; and DSB have also, for the best part of a year, made tests with railcars fueled with an admixture of cheap oil and an additive. So far these tests have given quite satisfactory results.

Furthermore it must be kept in mind that coal prices are influenced by the rising freight rates to a far greater extent than are the prices of fuel oil. As a matter of fact, coal prices have today reached such a level that, if we base our calculation on the prices expected to be valid for coal and oils during the next budget-year, the profit realized from lower fuel costs for the MY-locomotives over the period June 15, 1954, to June 30, 1955, will rise from about Crs. 474,000 for each locomotive, to about Crs. 620,000, for the same performance, which will increase the total of the savings to about Crs. 824,000. per locomotive per year.

In respect to the other items in the account, it should be noted that, apart from the general price development, most of the expenses should remain unchanged.

As to the item »Locomotive personnel», the MY-locomotives will always be cheaper, being handled by one man only, whilst two men are required for the operation of a Steam locomotive. Neither will there be any change with regard to the costs of attendance which must invariably be higher for Steam locomotives, with fire-boxes to be cleaned and attended.

There remains, thus, the question of the maintenance costs. It can be asked whether comparison between the new Diesel locomotives and the 24 years old Steam locomotives does not give a somewhat distorted picture, and whether conditions may not change after the Diesel locomotives have been operating for some years.

To answer these questions the maintenance work carried out over the period covered by the account will have to be examined.

The four Steam locomotives have been submitted to 3 minor repairs (turning of wheels, inspection of controls, brakes, etc.) in the Central repair shops at Aarhus, at a cost of about Crs. 20,000. each, and

this can be said to be a reasonable allotment of this type of maintenance work in proportion to the number of kilometres covered. No major repairs have been carried out (essential work on boiler, fire-box etc. is due every 4th and 5th year), and there are thus actually no major repairs included in the maintenance costs.

All of the MY-locomotives were inspected after 75,000 and 150,000 kilometres running, and the wheels of all 4 locomotives were turned. But neither in this case are any major repairs of engine, electric equipment etc. included.

Well then, what do these major repairs imply ?

DSB cannot, from their own experience, form an opinion, whether the maintenance costs will increase, once more extensive maintenance work comes into the picture, such as inspection of Diesel engine and main generator, etc. This work should be carried out after 1.8 million kilometres running—corresponding to about 9 years' operation and in order to compare these expenses for the MY-and the Steam locomotives it is necessary to turn to information obtainable from other quarters.

Already before the MY-locomotives were put into operation a very careful calculation had been made as to the maintenance costs arising over a longer period. This calculation was based upon the very extensive experience gained in the United States with the same type of locomotives (the prices of material and labour having been altered to fit conditions in Denmark).

The difference arrived at by these calculations between the maintenance costs for MY-locomotives and Steam locomotives, has proved to correspond quite closely to the difference in the costs per kilometre actually obtained for the period June 15, 1954 to June 30, 1955.

There is no reason to doubt the reliability of the calculations, since all experience hitherto gained with the MY-locomotives in Denmark has confirmed that the maintenance periods etc. should be the same here under our conditions as in the United States. The same improvements have been introduced into the locomotives as into the latest models in the United States, resulting in longer life of the various parts. It is thus also possible to have a part repaired so as to be equal to a new one, without any increase of maintenance or operation costs after the repair. Summing up, it can therefore be said that the same amount of savings can be expected with regard to the maintenance costs of the MY-locomotives in the years to come as is indicated in the present account. Besides, deviations in the maintenance accounts have, as a matter of fact only a minor influence over the total result.

Assuming, therefore, that the 4 Diesel locomotives are run on the same schedule as for the period of the account, the saving effected by them can be expected to remain on a par with the saving effected over that period, i. e. about Crs. 678,000.—per locomotive per year. In fact the result will become still more advantageous as the prices of coal rise. In view of all this it is not surprising that further locomotives of the same type were ordered within so short of time of the first locomotives having been put into operation.

Another factor in this decision was the fact that a large number of Steam locomotives—the P-locomotives —required extensive repairs in order to be kept in service. It was not considered expedient to spend considerable amounts on these locomotives. The Danish State Railways therefore welcomed the decision of the authorities to appropriate means for the purchase of—besides the two MY-locomotives 1201—1202 already on order with A/S Frichs, Aarhus—a further 20 MY-locomotives Nos. 1105—1124, of the same type as the first four, but with a still higher output, namely 1750 HP instead of 1500 HP. (These statements of output are in accordance with American practice : According to general European norms the output of the new MY-locomotives will be more than 2000 HP.) The main contractor for the new locomotives is Nydqvist & Holm AB, Trollhattan, with the Danish firms A/S Frichs, Thomas B. Thrige and A/S Titan as subcontractors. The Diesel engines and some other vital parts are supplied by General Motors, USA.

When setting out the economic results arrived at with MY 1101—1104 it is natural to make some reflections with regard to the savings that can be expected, once all new Diesel locomotives now on order are in service on DSB's lines.

It has to be made clear at once that the remainder can hardly be expected to offer the same economic advantages as the first four. MY 1101—1104 were, of course, used for trains for which the existing means of traction were insufficient and where conditions were therefore favourable for realizing the best possible profit.

However, when preparing a schedule for the use of the new locomotives, every possible care is taken in order to arrive at the most favourable combination between the utilization of the Diesel and the Steam locomotives. These endeavours will naturally be continued as new locomotives are put into service; they will be used not only for very fast trains but also for all trains where their great tractive effort can be fully utilized.

The fact that the locomotives are equally suitable for different kinds of trains, greatly facilitates the establishment of rotating schedules. The design of the locomotives enables them to pull express trains with a train load of up to 500 tons at the same speed as the „Lyn„-trains, whilst at the same time they can be used for the heaviest freight trains. Moreover, they combine speed and tractive effort when large express freight trains are to be hauled. This makes it possible to arrange transport in an economic manner, scheduling a locomotive for a return train soon after its arrival at a terminal. Since no time need be lost through cleaning of fireboxes and other work required for Steam locomotives, the locomotives can do service throughout the 24 hours without any appreciable interruptions. The plans already made out for the use of the MY-locomotives on the main lines of the 2nd District (Fyn and Jylland) show that the 12 MY-locomotives which will be in service there after the delivery of all MY-locomotives now on order will do the work of 18 Steam locomotives, and it can be expected that the Diesel locomotives in this District will run an average mileage of 220,000 km each per year.

If the locomotives are adequately utilized according to this plan, it can further be expected that they will replace still more Steam locomotives; they will haul larger trains than the locomotives previously used, without increasing transport time, and will thus make extra trains unnecessary.

Thus, it appears that these new locomotives can actually be expected to do no less mileage service than MY 1101—1104, and it can further be expected that the average train weight pulled will approach the train weight hauled by the first locomotives.

Of course it is not possible to foretell exactly how transport work calculated in 1000 ton km covered, will be transferred from Steam to Diesel operation and how Steam and Diesel economy will compare after the transfers.

As already mentioned it can hardly be assumed that the new locomotives will save the same amount of transport work as the first four, the size and speed of freight trains especially being limited by local conditions. To arrive at a cautious estimate of the savings attainable with the new locomotives, it will therefore be best to start from the mileage they are planned to cover.

As mentioned before, this mileage has already been fixed, and, working on the experience gained from MY 1101—1104 as well as on the probable prices of coal and oil during the budget year to come, the following savings per kilometre can be forecast for the 16 Diesel locomotives in the 2nd District:

Fuel	1.78	Danish Crs.
Lubricating Oil	0.01	,, ,,
Water	0.06	,, ,,
Locomotive personnel	0.29	,, ,,
Attendance	0.04	,, ,,
Maintenance	0.14	,, ,,
Total saving per km	2.30	,, ,,

The total savings per locomotive per year can thus be expected to be $2.30 \times 220{,}000$ = about Crs. 500,000. A corresponding result can be expected for the new locomotives to be introduced in the 1st District. Compared with the price of the locomotives now on order, i. e. 1.5 million Crs. each, the economic result of the purchase of the MY-locomotives shows savings, amounting to 33% return per year on the capital invested. This also is a satisfactory investment.

It has already been pointed out that the above calculation is based on a cautious estimate. In the first place, the savings are calculated on a mileage basis, which does not fully reflect the extent to which the new locomotives can be expected to take over transport work.

Secondly, a fair amount of long-term savings can be anticipated, when more Diesel locomotives are doing service and the number of workshops and facilities required for Steam locomotives can be decreased (the periods between visits to the running sheds being much longer for Diesel locomotives than for Steam locomotives). This circumstance has not been considered at all in the calculations, neither has consideration been paid to the fact that with the MY-locomotives it will be possible to do the same work with fewer but heavier trains and thus to save not only locomotive personnel but also train personnel and achieve several other economies as well.

The experience gained with MY 1101—1104 has shown that extremely good use can be made of the potentialities of the new locomotives, resulting in great overall saving, the speeding up of transport of passengers and goods and the consequent increase of DSB's capacity to compete with other means of transport. All efforts will now be concentrated on obtaining the same good results with the new locomotives when they are put into service.

RAILWAY SIGNALLING CIRCUITS

By B. K. Cooper

Methods Adopted for Steam and Electric Lines

SIGNALLING, in its widest sense, of the control of train movements, was the first sphere of railway working to benefit from electrical apparatus. Originally, this was in the form of the electric telegraph, for as early as 1837 Cooke and Wheatstone demonstrated the use of telegraphy for communicating between Euston Station and the top of the Camden incline, up which trains at that time were hauled by a steam winding engine. In 1844 the telegraph was installed on the Norwich and Yarmouth Railway, two years after Cooke had published a pamphlet urging the importance of a telegraph system in ensuring safe working over single lines.

In later years the railway telegraph developed in two forms, one being the ordinary Morse single-needle telegraph and the other a specialised instrument for "offering" and "accepting" trains from signal box to signal box by a code of bell signals, and for giving a visual indication of whether a section of line was clear or occupied.

To-day the mention of electricity in railway signalling usually suggests the use of colour-light signals and power-operated points, but electrical safeguards associated with mechanical signalling and the operation of the signal box telegraph instruments are of much earlier origin than the first power schemes. Their modern developments are still to be seen on many miles of main and branch lines.

ELECTRIC LOCKS

The principle of the block system of railway signalling, in which the line is divided into block sections and only one train is normally admitted to a section at a time, is generally familiar. An electric lock on the signal lever giving admission to a section, released only by receiving "line clear" from the box ahead, is one of the methods of ensuring compliance with the rules of block working. A further step is necessary in this electrical safeguard, however, for when the signal has been pulled "off" (i.e. to show "line clear") and restored to "on" (danger) after the train has passed, it must be locked again until the signalman ahead has sent "line clear" for a second train.

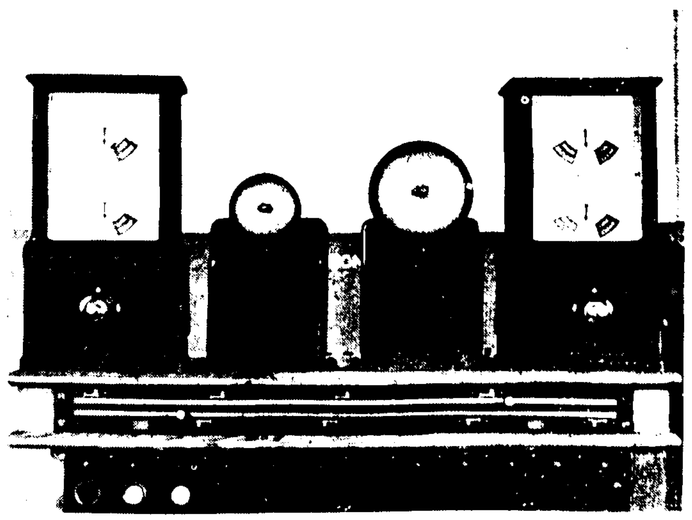


Fig 1. Block telegraph instruments and bells

Block telegraph instruments and bells of the type used for exchanging messages between signal boxes are shown in Fig. 1. In the type illustrated the bell code is transmitted by operating a plunger, the head of which can be seen on the front of the case. It is concentric with a commutator handle which is turned to right or left to change the indicating pointer from its central "line closed" position so as to show "line clear" or "train on line." The instruments are connected by a three-wire circuit and energised by 10 V batteries.

Considering two successive signal boxes, A and B: when the signalman at B is able to accept a train from A he operates the commutator handle of his block telegraph instrument to set it, and A's also at "line clear." A circuit by which this action can be made to unlock signal 1 is shown in Fig. 3.

The circuit which energises A's block telegraph instrument to "line clear" also energises the relay LC, causing its contact to change over and make a circuit through the coil of the lock on the lever for signal 1. When this lever is pulled, contacts A, which may be controlled by the signal operating rod, are opened and the release relay is de-energised. The feed to the lever lock coil is therefore broken at contact 2, so that the lock is no longer held released and will drop back into

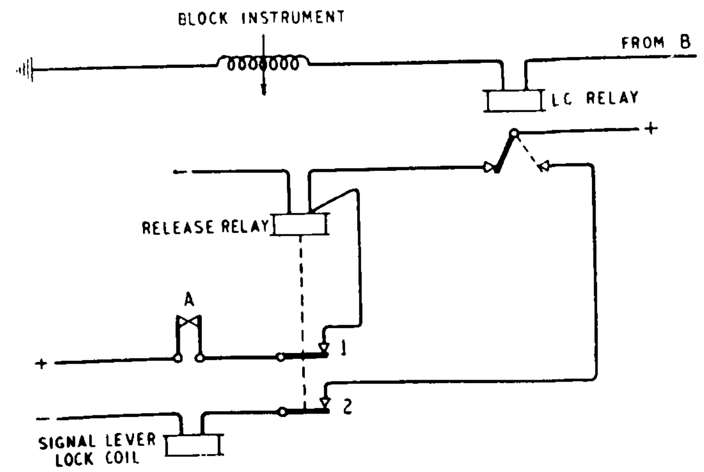


Fig. 3.—Locking circuit for signal lever controlling entry to a block section

position as soon as the lever is returned to the "danger" position. In this condition the feed to the release relay is still broken at contact 1. The release relay cannot be re-energised to prepare the circuit for unlocking the signal lever until the LC relay has been returned to normal by B restoring his block instrument to "line closed", as a preliminary to sending the next "line clear".

In B box, when "train entering section" is received by bell signal from A, the signalman sets the block instrument at "train on line", the indication being repeated at A. This action energises and releases a lock on B's signal 2 and enables him to pull it "off." The block instrument is now locked at "train on line" and remains so until the train has passed out of the section. Consequently, B cannot again give "line clear" to A until the section is unoccupied.

One method of proving that a train has passed a given point—in this case the end of the section—is a rail treadle. The type of treadle illustrated in Fig. 4 operates by the flexure of the rails under the weight of a train causing mercury to be pumped into a float chamber so that contacts attached to the top face of the float are operated. In this way a circuit can be made to the coil of the lock on the block instrument commutator handle.

RELAY INTERLOCKING

When electrical methods were applied to the actual

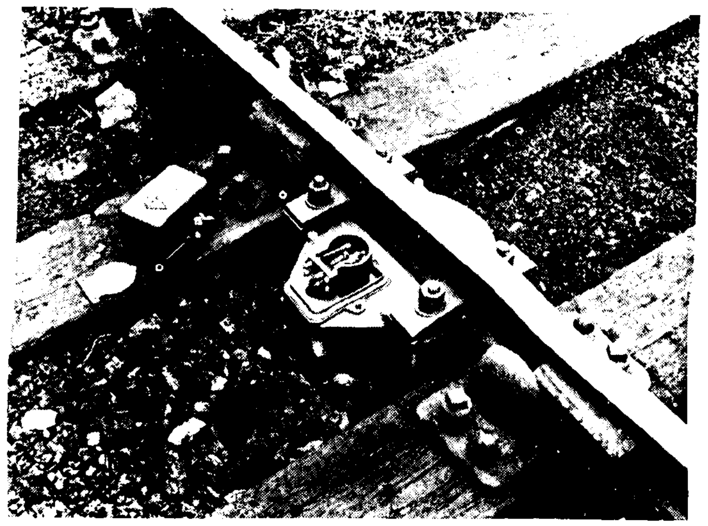


Fig. 4. Mercury type treadle attached to rail, with cover removed to show contacts operated by the passage of trains

operation of signals and points, it was no longer necessary to provide the large levers required to give the necessary purchase with mechanical working. Consequently, miniature levers controlling electrical contacts were used. Electric locks of the type described already were applied to the levers, but often the interlocking between levers which controls the sequence in which they can be operated remained mechanical. An example would be the interlocking of the levers controlling signals 2A and 2 in Fig. 2 to ensure that the distant (or warning) signal 2A could not be pulled "off" before the "stop" signal 2. Eventually the use of electrical controls for interlocking as well resulted in the replacement of levers by key switches of various types and the application of relays to produce the effects of interlocking. This principle is known as relay interlocking. No physical locks are required on the key switches because the relays prevent dangerous conditions being created in the event of incorrect operation.

A separate key switch may be provided for each function, such as the control of signals and of points, but it was a logical step forward to make a single relay set the points and then clear the signal for a particular route. Schemes based on this principle are known as route relay interlockings, and are the usual form of new power signalling to-day.

Fig. 5 shows the elements of route relay interlocking. A and B are key switches, shown in the "normal" position in which the signals are at "danger" and the points are set for the straight-through route (route B). In this condition the N coil of the signal relay is energised and both coils of the point relay are de-energised, although its contacts remain latched in the position to which they were last operated.

If a train is to be signalled to route A, the A switch is turned. Although this breaks the feed to the N coil of the signal relay, contacts *1 and 2 remain latched in. Consequently a circuit is made* to the R coil of the point relay, causing the points to be reversed (i. e. set for the diverging route). Energisation of the R coil also closes contact 3, so that a feed is made to the R coil of the signal relay. This clears the signal for route A and simultaneously unlatches contacts 1 and 2. It will be seen that even if switch B is now inadvertently operated there will be no feed to the point relay N coil and consequently the points cannot be changed. Similarly, the signal for the straight-through route cannot be cleared, for the energisation of the point relay R coil has released contact 4.

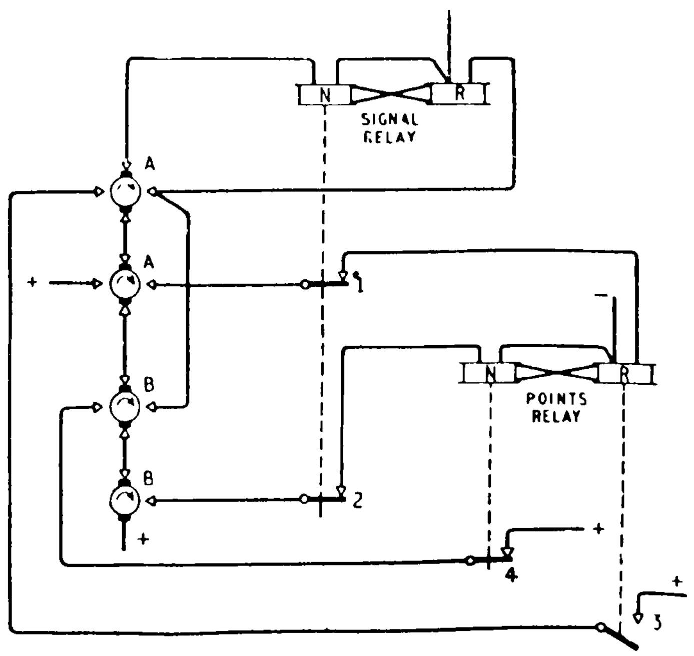


Fig. 5.—Elements of route relay interlocking

The form taken by the control switches and their arrangement in the signal box have several variations. A separate key may be provided for setting up each route, or a single key in conjunction with a selector may control two or more routes. An alternative arrangement is for a separate key to be allotted to the beginning and the end of a route, both having to be operated in order to set it up. The keys may be located on a diagram of the tracks in positions corresponding to those of the actual signals and points they control (Fig. 6), or on a desk in front of the diagram.

In practice many control circuits additional to the simple ones described in the above example are involved in relay interlocking. Some of these are track circuits which detect the presence of trains and prevent premature clearing of signals or changing of points. Electric point machines, having thrown the points, bolt them in position, and detector contacts associated with the bolts ensure that the circuits controlling the signal are not completed until the bolt is home.

The track circuit takes various forms and has an extremely wide range of functions which it exercises through multi-contact relays. In addition to its safety controls when signals and points are operated by signalmen, it is the basis of automatic signalling in which, over long distances, signals are controlled, and the requirements of the block system maintained, by the passage of the trains themselves. In the simple d. c. case on steam-worked lines, the track-circuited sections of line are isolated electrically by means of insulated rail joints from their neighbours. A battery is connected across the rails at one end of the track circuit and a relay at the other end. When no train is present the relay is energised, but when a train enters the track circuit its wheels and axles shunt the relay coil and cause its contacts to be released. One application would be to use a track circuit instead of a treadle of the type described earlier in connection with electrical safeguards in mechanical signalling. Release of the relay by the passage of a train could then be made to unlock a block telegraph instrument from "train-on-line" and so enable a second train to be accepted.

On d. c. electrified lines where the running rails are used as traction current return conductors, simple track-circuit systems of the type just described need modification so that the apparatus will be immune from the effect of the return current from the trains. Recent examples of modifications for this purpose have been seen on the Chelmsford and Southend extensions of the British Railways, Eastern Region, 1,500 V d. c. electrification in the London area, where a.c. track circuits have been substituted for d. c.

AUTO-IMPEDANCE BONDS

If only one rail is needed for the traction current, it can serve as a common traction and track circuit return conductor. The track circuits are then formed by the insertion of insulated joints in the second rail and are known as single-rail track circuits. Where both rails are needed for the traction return, as on

Fig. 6. Route relay interlocking control panels at Liverpool Street Station signal box.

densely-occupied or steeply-graded sections of line, means must be provided for the d. c. to by-pass the insulated rail joints necessary for defining the a. c. track circuits. A method of effecting this by the use of auto-impedance bonds is shown in Fig. 7.

Referring to the figure, it will be seen that the d. c. flows in opposite directions through each half of the bond windings so that the magnetic fluxes cancel each other and the impedance presented to changing current is zero. On the other hand, the bonds present their normal impedance to the track-circuit a. c.

In the typical arrangement shown, T is a 1 : 1 transformer and the feed capacitor C_1 is adjusted so that the voltage across the rails is between 3 and 9 V, this low value being necessary to ensure that the relay is not shunted by leakage through damp sleepers or ballast. R is known as a two-element relay, being held operated by a state of balance between the torques of two coils, a condition obtained by adjustment of the phasing capacitor C_2. Shunting of the track by a train disturbs the equilibrium and causes the relay to be released.

Where lines already equipped with power signalling suitable for use in conjunction with d. c. traction are to be converted for industrial frequency a. c., the choice of track-circuit frequency will demand a sufficient difference between the signalling and traction frequencies for reliable discrimination. This may be achieved by generating and distributing a special signalling supply at 83.3 c/s. New signalling schemes for industrial-frequency lines where there is no risk of extraneous

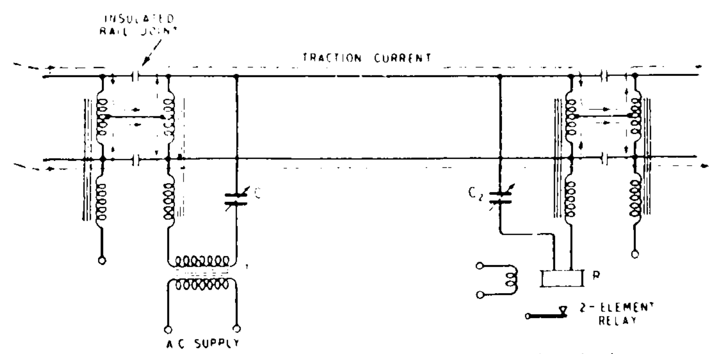


Fig. 1 Double-rail a.c. track circuit with auto-impedance bonds

interference from direct current are likely to be d. c., but a. c. at 83.3 c/s might be adopted where such a risk exists.

A contract awarded in February to the Siemens and General Electric Railway Signal Co., Ltd., was the first to be announced since the 50 c/s traction system was adopted by British Railways, for signalling modifications arising out of it. On the lines concerned, from Colchester to Clacton and Walton, single-rail d. c. track circuits and protection of d. c. signalling apparatus by series inductances will be suitable for the most part, but two-rail track circuits and a special frequency will be required on routes such as Liverpool Street to Chelmsford and Southend-on-Sea. Here the 50 c/s signalling circuits installed recently for immunity from d. c. traction current interference will have to be adapted for immunity from a future traction supply at their present frequency. In addition, before the change-over to industrial-frequency traction takes place, the modified circuits will be required to operate for a time in conjunction with the existing 1,500 V d. c. supply and not be affected by it.

The natural desire to use the industrial supply for all purposes has led in France to the development of an alternative method with valve oscillators generating a frequency of 1,000 c/s. The oscillators are fed through transformers from the 50 c/s mains and incorporate a grid-blocking circuit which breaks up the output into wave trains of 13 millisec duration, followed by interruptions of 37 millisec. Consequently the basic 1,000 c/s frequency carries a 20 c/s coding. In this way additional security is gained from interference with the signalling circuits by harmonics of the traction frequency, a point of particular importance when rectifier locomotives and motor coaches are used. Amplifiers are used at the relay ends of the circuits to ensure satisfactory holding of the relays in spite of the attenuation of the track-circuit frequency in the rails on long sections.

POWER SUPPLIES

It was shown at the beginning of this article that electrical circuits and apparatus are widely used in many circumstances other than those of complete power signalling schemes. While at one time primary batteries were a common source of supply for items such as block instruments, lever locks and isolated colour-light signals (often installed between existing semaphore signals to break up long sections and so help to keep the traffic moving), it is general to-day to use secondary battery and trickle-charging equipment, operating on a normal single-phase supply. Individual batteries, located as close as possible to their associated apparatus, are installed for working signals and points remote from a signal box. Supplies for lever locks, block instruments and nearby outdoor equipment are located in the signal box itself. Colour-light signal lamps are operated at 12 V or 24 V as this enables a short, sturdy filament to be used and makes it easier for the optical system to concentrate the light into a long-range beam. Often the lamps are two-filament types so that, if the main filament fails, a second, lower-rated filament maintains the signal in operation at reduced brilliance—a fact which would be noted by passing drivers and reported. It is now becoming more usual on British Railways to provide two single-filament lamps of the same rating and to bring the second into operation automatically by a relay in case of failure, a warning being given simultaneously in the signal box.

Point machines installed for convenience of long-distance control are often operated from a local 30 V supply, but in complete power interlocking schemes they generally work at 110 V d. c. Where it is inconvenient or impracticable to install trickle-charging equipment and a local battery at points too far from a signal box for mechanical operation, hand-operated generators are often used overseas and to some extent in this country. Although operation of the points is slower than when a battery or mains supply is available, hand generators may save the expense of providing additional signal boxes and staff. Existing semaphore signals may be modified for electric working by means of signal machines comprising a d. c. motor and a reduction gear train for driving the signal arm spindle direct or, if the machine is to be mounted at the bottom of the post, through rodding.

In large colour-light signalling installations to-day power is generally taken direct from the mains and every effort is made to obtain supplies from two sources with the largest possible measure of independence. One of these would be a normal and the other a standby supply, generally with automatic change-over in the event of either failing. It is now becoming increasingly common to provide in addition a standby diesel-alternator set with automatic starting arrangements.

At the signal box to which the power is fed, duplicate transformers are installed to provide a 110 V supply for control circuits, point machines and colour-light signals, the colour-light lamps being connected to local step-down transformers. In the larger installations it is usual for several signal boxes and other places to need a power supply, and the method preferred is to install duplicate step-up transformers feeding a ring main or duplicate cables. A distribution voltage of 650 V is chosen when possible in the interests of economy in the size of cabling.

The extension of power signalling, a major item in the expenditure of £100 million allotted to signalling and telecommunications generally in the British Railways' modernisation programme of 1955, increases the concern of the signal engineer with supply and distribution questions. As in the field of traction, therefore, there is taking place a progressive overlapping of interests between the railway specialist and the general power engineer. The applications of electricity in railway signalling are so numerous and varied that a single article can do no more than prepare the way for further study of a subject of growing interest to many sections of the industry.

Acknowledgment is made to the Siemens and General Electric Railway Signal Co., Ltd., for assistance in the preparation of this article and supplying illustrations.

IMPORT OF STEEL ITEMS FROM JAPAN

A Japanese steel mill is reported to have signed a contract for the export to India of 9,500 tons of steel plates and 4,300 tons of steel rail which constitute a part of the 560,000 tons of steel products being sought by the Indian Government for the railways. Negotiations reportedly are under way between some Japanese companies and the Government of India for the supply of 120,000 tons of steel products for rolling stock. Besides, a Japanese trading firm is reported to have accepted a contract for the supply of 11,000 tons of steel plate to India.

CASTING TITANIUM

By John Ham and Roger Veneklasen
Metallurgical Department, National Research Corp., Cambridge, Mass.

FOR the last ten years the Research Division of National Research Corp., Cambridge, Mass., has carried on metallurgical research and development work with emphasis on vacuum melting and casting and on processing of many of the newer and more refractory metals.

During this same period, the Equipment Division of National Research has designed, built and sold many vacuum and other special metallurgical furnaces. For the past two years, many of its research efforts have been directed to the development of techniques and equipment for melting, handling and casting of titanium.

Although the corporation is still working with a relatively small experimental furnace, sound castings of titanium and titanium alloys of intricate shape with a finish equivalent to that of good sand castings can now be made. The casting process involves the use of a vacuum and inert atmosphere arc melting furnace and a special, but relatively inexpensive, method of making the molds. This process is covered by patent applications.

The Titanium Casting Process—The corporation's process is simple and requires few steps or procedures not generally practiced in foundries manufacturing stainless steel and alloy castings :

I. Preparation of the pattern and the mold flask.

a. As is customary, the pattern is made to a size based on experience on shrinkage factors of the metal and mold.

b. The mold is made by mixing a powdered refractory with a liquid binder and pouring the resulting slurry over the pattern. This slurry solidifies on the pattern, thus forming one half of the mold. The other portion of the mold is prepared in a similar manner.

c. A low-temperature bakeout followed by a high-temperature firing produces a strong cohesive mold.

d. During the above steps the mold is given a special treatment which enables the finished mold to withstand the action of molten titanium.

e. The mold is assembled with the necessary gates, risers and pour blocks and held together by suitable clamps or jigs.

II. Premelting operations.

a. The mold, at room temperature, is placed in the furnace and titanium sponge or scrap is loaded into the crucible.

b. The furnace is sealed from the atmosphere and is evacuated to a low pressure ; i. e. 1–10 microns, or 0.001–0.01 mm. of mercury.

c. Argon is admitted to the furnace to give a suitable pressure for the melting and casting phase of the process.

III. Melting and Casting.

a. Power is applied to the electrode, starting the arc, and melting of the titanium in the crucible is begun.

b. When a suitable quantity of metal has been melted, as observed through an observation window, the power is cut off and the electrode moved out of the path of the molten stream.

c. The melt is poured into the gate of the mold, placed below and directly in line with the pouring lip of the crucible.

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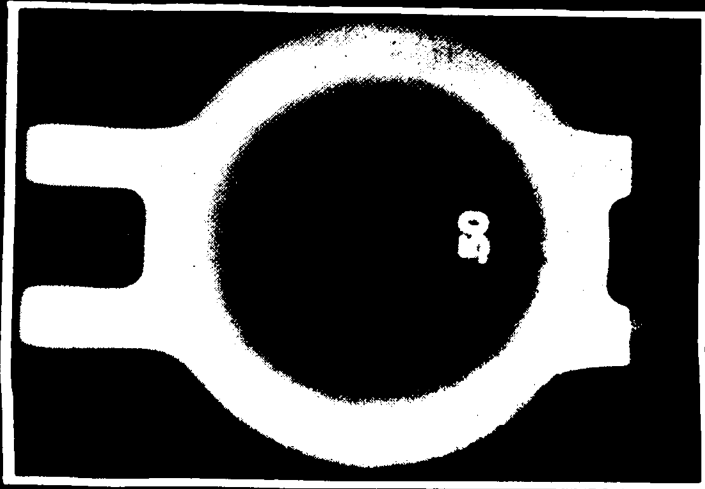
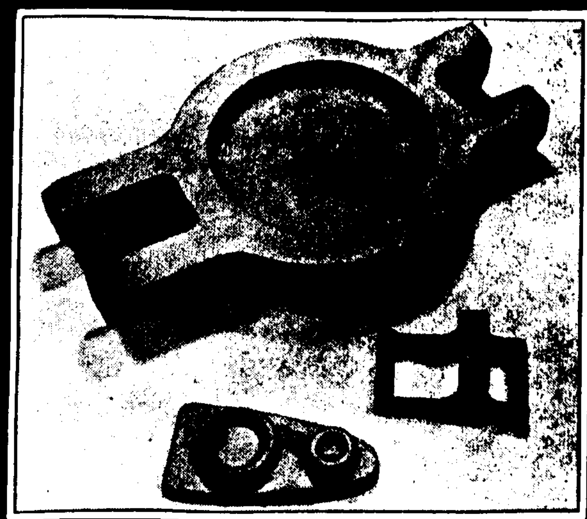


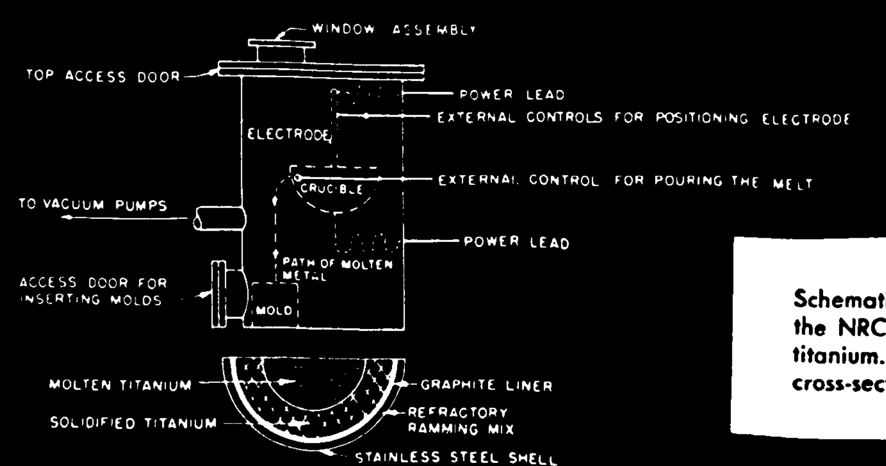
Radiograph of cover plate similar to one shown below

These titanium castings are shown at about 40 per cent of their actual size. The largest casting is a cover plate that was made for the U. S. Army Ordnance Corps



Physical and Chemical Tests on Castings of Titanium and Titanium Alloys

	Pure Titanium	4% Cr–2% Mo Alloy
Hardness, Rockwell A	60–63	65.5
Charpy impact, at room temp., ft-lb	11	8.4
Tensile strength, psi........	Not available	129,000
Chemical analysis, %. wgt. :		
Oxygen	0 1 -0.2	0.3
Nitrogen	0.03	0.03–0.05
Carbon	0 08–0.15	0.1 –0.15



Schematic representation of the NRC furnace for casting titanium. Crucible shown in cross-sectional view below

d. The mold is cooled in the furnace under argon or vacuum for one half to one hour, giving the titanium in the mold and crucible sufficient time to solidify and cool below the temperature at which it reacts with atmospheric contaminants.

Although experience to date has been based upon use of split molds, there is no apparent reason why this process cannot use investment casting techniques.

Castings Produced—The small furnace now in operation at National Research can produce castings weighing 4 or 5 pounds. Only the melting capacity of this furnace limits the production of larger castings, and it is believed that good castings weighing as much as 100 pounds can be produced by the process in larger furnaces. The finish of the castings is equivalent to that of good sand castings. The castings have a high degree of soundness. Physical and chemical properties of titanium and titanium alloy castings produced are shown on page 42.

Equipment Required—The combination vacuum and inert atmosphere arc furnace is the essential piece of equipment not ordinarily found in the foundry. Such a furnace consists essentially of a skull-melting type crucible contained within a chamber which can be evacuated by means of vacuum pumps to pressures as low as 1 micron. The titanium scrap or sponge in the crucible is melted by an arc with external controls provided for positioning the arc electrode and for pouring the molten titanium from the crucible into the mold.

The titanium is contained within a graphite crucible backed up by refractory ramming mix, all contained within a stainless steel shell. By limiting the melting of the titanium to a center pool, carbon pickup from the graphite shell is minimized and can be maintained below 0.15—0.20 per cent in the finished cast shape.

National Research Corp. offers a 10-pound titanium skull-melting arc-type furnace, similar to the one used for the development of this process by its research division. It also is prepared to build larger furnace equipped with three arc electrodes from which titanium castings weighing as much as 25 or 30 pounds can be produced.

SELECTION OF MOTORS

By Sunil Chandra Banerjee, G.I.Mech.E.(Lond.), A.M.I.E.(India)

THE growing industries of the present age are demanding more machineries and consequently more prime-movers. With the advent of electricity, the general practice nowadays is to use electric motors as the main kind of prime-movers in the factories. The latent chemical energy of coal has been transformed into heat for the generation of steam in boilers driving turbines in power station. The devastating powers of flooding rivers have been harnessed for moving the blades of gigantic water turbines. The tremendous heat of the erupting volcanoes has been utilised in the generation steam and electricity. The radiant energy of the sun has been employed in the generation of steam in solar boilers, and even, the tremendous energy liberated by the nuclear fission is applied in the generation of heat and power. Thus we find the different methods for the production of power, but we find in each case that the ultimate form of the conveyable energy is electricity the power which turns the spindle of the motors, which means the wheels of the industry. The recent developments in the Science of factory organisation have taught us two important factors in planning the layout of the factories—flexibility and compactness. These factors, accompanied by the factor of efficiency, are rapidly dispensing with the use of long line shafts and beltings for the transmission of motion and power, and today we find most machines fitted with independent driving motors. Modern researches in speed, feed, cut etc., have developed the working of different machines suitable for the particular work and so the demand for the correct type of driving motor is very great, and today a manufacturer of a machine faces the very difficult problem of selecting the correct motor for driving his machine. Various factors are required to be considered while selecting motors for the machines. The selection of motors is broadly classified on the following heads :

(1) POWER SUPPLY—Although both D. C. and A. C. are expected in factories, it may be uneconomical for small factories to have mains for both the systems. The selection of motors for the supply of electricity depends on the following characteristics :—

(a) D. C. Voltage (b) Voltage, phase and frequency of the A.C. supply. These factors have a great effect on the output, speed and the size of the motor.

(2) POWER RATES—This factor directly deals with the cost of energy and should be considered very carefully before the motor is selected. The motor should not be over sized, but there should be provisions for a little over loading. The selection of motors with this basis depends upon :— (a) *Cost of energy,* (b) *Effect of power factor* and (c) *Factor of demand.* The question of power factor involves the installation of static condensers in the circuit or the selection of synchronous motors in the circuit having too much inductance. The factor of demand determines the quantity of power demanded in each circuit, when the load is maximum, and the sizes of the motor and the controlling gears are to be designed accordingly.

(3) VOLTAGE REGULATION—Voltage regulation has a great effect on the performances of electrical machineries. In fact the speed of a motor has a direct relationship with the applied voltage. In the case of machines operating under precisioned controlled speed and feed, the driving speed of the prime-mover plays a very important effect on the performance of the machine, and then the factor of voltage regulation should be considered very carefully. This factor depends upon the following :—

(a) *Starting current limitations*—This factor depends on both the distributing circuit and the motor itself. The inertia of the machine must be considered very carefully as too heavy a starting torque means a heavy starting current

(b) *Allowable current pulsations*—This factor is essential in the case of wound rotor motors and specially the synchronous motors.

(c) *Continuity of power*—The use of synchronous motors in a circuit, where there are too many power failure, is very difficult to operate easily, because every time the circuit goes out of phase or out of continuity the motor has got to be started again.

(d) *Short circuit current*—The safety devices in the motor should be carefully designed so as to take the short circuit currents ; and the motors when run idle with a short circuit must be within the limits

(e) *Voltage surges*—Surging of voltage means increase of pressure with the consequent increase in speed, increase in heat loss etc. The safety devices should be designed very carefully and machines with low revolutions should be provided with governors or other speed controlling arrangements.

(4) DRIVEN MACHINES—The requirements of the driven machine are equally important in making the final selection of motors. The torque, speed, cycle of operation, frequency etc., of the machines are determined to suit the requirements, and the prime-movers should be designed accordingly. This factor depends on the following characteristics :

(a) *Mechanical arrangements*—It means whether the motor is horizontal, vertical or tilting, and the general construction is made accordingly. The type of body, the shape of the base, the shape and size of shafts, the type of feeding leads etc., all depend on this factor.

(b) *Stationary or portable*—This factor controls the weight and shape of the motor. A portable motor should not be unnecessarily heavy. Special materials should be used to reduce the weight. Provisions must be kept easy handling of the motor. A portable motor should have simple controlling arrangements. Care should be taken to insulate the motor properly. Stationary motors should have strong bodies and well designed control gears.

(c) *Method of connecting motor.*—The method of connecting the motor should be determined before considering the shafting of the motor. It should be ascertained whether the coupling is direct, or through clutches, or built in, or it is a geared one. It must be ascertained whether there is a belt, rope or chain drive. Flexible couplings, friction clutches and belt drives are suitable where the motor is subjected to serious shock loads. In case of belt or chain drives the further bearing of the motor should be provided with compensating cones so as to take up the wear due to eccentric drives.

(d) *Space*—The question of space is very important in selecting motors. Big motor cannot be fitted very small and compact machines. The type of motor is also determined from this factor. The quality of materials, the quality of efficiency etc., are all determined by this factor.

(e) *Speed*—The rated speed at which the motor is expected to work determines the mechanical construction and the armature conductors. This factor also determines the field windings. If the motor is expected to have a variable speed, the tappings or resistances are to be determined accordingly. In any case it is to be seen that the protective device is fitted in the motor.

(f) *Control*—The controlling gear of a motor is equally important as the motor itself. The motor must be provided with devices to regulate the speed within the desired limits. The motor must be fitted with no-volt and over-load relays. In crane or other hoisting motor there must be provisions for magnetic and mechanical clutches and brakes. Starter for synchronous motors should be perfectly adjusted. In the case of phase wound motors, the motors should have simple starters. In any case, complications should be avoided as it needs operating skill. Squirrel cage motors are very simple in working particularly where frequent stop and start are necessary.

(g) *Reversing*—D. C. motors can be reversed by altering the relative connections of the field and armature ; and A. C. motors can be reversed by altering the relative connections of two phases. But the reversing accessories become a bit complicated in the case of heavy duty motors. In such cases however, it is best to have mechanical reversing gears. In some cases e. g., cranes, stark planers, traction motors, earth borers etc., the motors must be fitted with electric speed reversing arrangements. While installing speed reversing connections in motors, it must be seen that automatic circuit breaker is operative while the motor is reversed otherwise the back e. m. f. will be a source of danger.

(h) *Rated horse-power*—Before selecting the size of the motor the maximum horse-power of the driven machine, the R. M. S. value of the absorbing power and the peak load under maximum operating load of the machine must be considered. Careful consideration of these factors makes the selection quite upto the requirements. It must be remembered carefully that the total demand of power should not exceed the limit. Hence if the demand exceeds the limit, the distribution of load on the different machines should be reorganised as to put the factor of power within the desired limits.

(i) *Torques*—Torque is one of the most important factor which governs the design of the motor. Now. the amount of torque required by a machine can be classified as follows:

(i) *Starting torque*:—This torque is actually the greatest as it has to overcome the friction and the inertia. The motor therefore takes a heavy current which is much greater than the rated current. This rush of heavy starting current necessitates the installation of carefully designed starters.

(ii) *Running torque*: Running torque is the rated torque and is usually $\frac{3}{4}$th the torque under full designed torque of the motor.

(iii) Pulsations and moment of inertia of the rotary parts. Pulsations of the load have a direct effect on the torque demanded, but if the rotors of the motor have sufficient moment of inertia as to store the required amount of kinetic energy a steady speed is maintained by the motor. Too much moment of inertia has a detrimental effect on the fine control of speed feed and braking of the motor.

(j) *Thrust and pull-in* If the motor is connected with the machine by a belt drive, the factor of thrust is to be considered very carefully, and the motor should be fitted with suitable bearings. Commutator motors should have compensating devices for misalignments. Squirrel cage motors are free from electrical difficulties in such a case. In D. C. motors the armature has a pull towards the middle of the field. This factor tends to balance the factor of thrust. In the case of vertical motors the pulling-in forces should be balanced carefully, otherwise there are chances of the armature getting hot due to rapid cycles of magnetic reactions.

(k) *Frequency of starting and declaration time*—Frequency of starting is a common factor in machines like lathes, drills etc. The rotors should be carefully designed as to avoid shocks as far as practicable. Declaration time plays an important part on the speed of work in machine tools like turret lathes, capstans etc

(l) *Operating schedule*—Machines are usually worked as per pre-planned schedules. This schedule is intended to speed up production, to eliminate interference and to minimise idle hours. But the overall efficiency of a machine is governed by the idle hours. For this reason the prime-movers should preferably be of heavy duty so as to keep pace with the schedule of the machines efficiently.

(5) POSITION—The position of the motor means the surroundings of the motors and their influences on same. This factor depends upon:—(i) ambient temperature which affects insulation and lubrication, (ii) altitude, which affects the temperature and lubrication, (iii) moisture, which has a detrimental effect on the general insulation, commutation etc., (iv) dist, which harms the commutators, magnetic flux and bearings, (v) corrosive atmosphere, which affects the materials of the motor, (vi) explosive dust or gas which have a direct effect on the safety of the motor, (vii) effect of noise which has a direct effect in the surrounding locality. A warning sound makes the operator drowsy, (viii) codes and ordinances, the construction and design of the motor must be free from the intrecacies of codes and ordinances. The motors should be constructed accordingly.

It is very difficult to bring out a compromise between all the above factors in the selection of motors. The following illustrations, however, will make the points more clear:—

(a) *Air compressor* These machines require a constant speed with pulsation torques. In the case of the reciprocating compressors smaller powers squirrel cage type motors are suitable for A. C. operation and compound wound motors are suitable for D. C. operation. For heavy reciprocating compressors the motor should be low speed synchronous motors for A. C. operation and low speed engine type motor for D. C. operation.

For rotary compressors and low H. P. Blowers squirrel cage motors are suitable for A. C. operation and constant speed motors are suitable for D. C. operation. Heavy H. P. Blowers or rotary compressors

require similar motors as were found in the case of heavy reciprocating compressors.

(b) *Conveyers* Conveyers work with steady controllable speeds. Squirrel cage motors are suitable in A. C. operation and compound wound motors are suitable in D. C. operation.

(c) *Cranes*—The machineries of a crane requires high torques, controllable speeds and reversing arrangements. Specially designed crane or hoist type motors or wound rotor motors are employed in A. C. operation, and series wound motors are employed in D. C. operations.

(d) *Fans*—Fans require constant power and speed. Squirrel cage class A motors are recommended for A. C. operation and constant speed or shunt wound motors are recommended for D. C. operation. For high H. P. fans high speed synchronous motor is recommended for A. C. operation. Split phase A. C. motors can be used for small fans installed in single phase A. C. circuits.

(e) *Hoists*—Hoists require drives similar to the cranes, but the velocity ratio of the combination being smaller, require less powerful motors. Squirrel cage motors are suitable for hoists of small lifting loads, and wound rotor motors are suitable for heavy hoists in A. C. operation. Series wound or special hoist motors are suitable in D. C. operation.

(f) *Machine tools*—There are numerous types of machine tools; but according to the nature of speed, feed, torque and frequency of stoppings most of the machine tools can be grouped under the following machines:—

(i) *Bolt manufacturing and forging machine group*—These machines require constant speed and well designed fly-wheels. Squirrel cage class D motors and phase wound rotor motors (for heavy services) are suitable for A. C. operation. Compound wound motors, and constant speed motors are suitable for D. C. operation.

(ii) *Boring or turning mill group*—All the types of boring machines, large wheel lathes, vertical surfacing machines etc., can be grouped under this heading. These machines require large power input at a constant speed. Squirrel cage A motors, single speed motors, and in special cases multi-speed motor can be used in A. C. operation. Shunt wound and constant speed motors are suitable for D. C. operation.

(iii) *Buffing and polishing machine group*--These machines require high spindle speed at low power input. Squirrel cage class A motors are suitable for A. C. circuits and shunt wound motors are suitable for D. C. circuits.

(iv) *Drilling machine group*—These machines require constant torque at a comparatively high revolution. Squirrel cage class A motors are suitable for small machines and phase wound rotor motors are suitable for large radial type drilling machines in A. C. circuits. Constant speed or adjustable speed motors are suitable for small machines and shunt wound motors are suitable for large machines in D. C. circuits.

(v) *Gear cutting machine group*—All the types of gear cutting machines e. g., gear shapers, gear generators, gear hobbers etc., can be classified in this group. These machines require constant speed and torque. Squirrel cage class A motors and single speed motors are suitable for A. C. operation; and shunt wound or constant speed motors are suitable for D. C. operation.

(vi) *Grinding machine group*—The various types of grinding and fettling machines can be grouped under this heading. These machines require high driving speed with very little torque. Squirrel cage class A motors are suitable for A. C. operation; and shunt wound motors are suitable for D. C. operation.

(vii) *Hammers group*—Hammers require pulsating load. Squirrel cage class D or wound rotor motors are suitable for A. C. operation; and, compound motors are suitable for D. C. operation.

(viii) *Lathe group*—Lathes require a variety of speed and torque even there are trains of speed gears fitted in the machine. Squirrel cage class A motors or multi-speed motors are useful in A. C. operation; and series wound motors are suitable for D. C. operation.

(ix) *Milling and shaping machine group*—The operating conditions of these machines and the lathe are similar as regards the speed, torque and frequency of stoppages are concerned. The types of motors suitable for these machines are therefore similar to those for lathes.

(x) *Planer group*—The various types of table planers of the horizontal and vertical designs, edge planers, grooving machines, etc., can be classified in this group. These machines require high working torques and reversing arrangements. Squirrel cage class A motors, multi-speed type motors with electrical reversing arrangements are suitable for A. C. operation, and series wound or compound wound motors are suitable for D. C. operation. In most cases the machines are operated by D. C. motors and automatic switchgeared converters are used.

(xi) *Punching and shearing machine group*—All the varieties of shearing, punching, cropping, pressing machines can be classified in this group. These machines are provided with massive fly-wheels because such machines require periodic heavy thrusts. Squirrel cage class D. motors and wound rotor motors are suitable for A. C. operation; and compound wound motors are suitable for D.C. operation.

(xii) *Rolling Mill group*—All the varieties of rolling, bending and straightening machines can be classified in this group. These machines require very heavy torques at variable speeds. Wound rotor motors are suitable for A. C. operation; and compound wound motors or shunt wound motors are suitable for D. C. operation.

(xiii) *Sawing machine group*—Sawing machines require high speed. Squirrel cage class A motors are suitable for A. C. operation; and shunt wound motors are suitable for D. C. operation.

(g) *Centrifugal pumps*—Centrifugal pumps require constant speed and constant torque. Squirrel cage class A motors are suitable for A. C. operation and shunt wound motors are suitable for D. C. operation.

(h) *Refrigerating machines*—These machines require low speed and high torque. Squirrel cage class C motors are suitable for small machines and low speed synchronous motors are suitable for heavy machines in A. C. operation. Shunt wound motors are suitable in D. C. operation.

(i) *Air-pumps*—These machines run at a high speed. Squirrel cage class A motors are suitable for A. C. operation and compound wound motors are suitable for D. C. operation.

From the above illustrations it can be seen that the selection of motors is to be made after carefully considering the different operating characteristics of the driving motors and the driven machines. The characteristics of the different types of motors mentioned in above can be found in any standard text book on electrical engineering. The surroundings of the motors must be considered carefully. In an atmosphere containing corrosive furnaces the motor body should be of the encasing type. The bearings which cannot be attended very easily should preferably be grease lubricated. Motors under pulsating torques should have spring washers fitted at the foundation bolts. In this way, after having a careful consideration of the different aspects of the problem one can select the appropriate type of motors needed.

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WESTERN RAILWAY MOVES ITS "TALLEST" CONSIGNMENT

The "tallest" consignments ever moved on the Western Railway, and some of the tallest moved on the entire Indian railway system, were recently transported from Bombay to the Punjab for the Bhakra power project.

The consignments consisted of 56 sections scroll casings intended for the 150,000 H. P. Francis type turbines for the Bhakra power house.

The Railway had to move the giant consignments, some of them 14′ 3″ tall, on special wagons.

NOHAB - GM Locomotive to the Norwegian State Railways

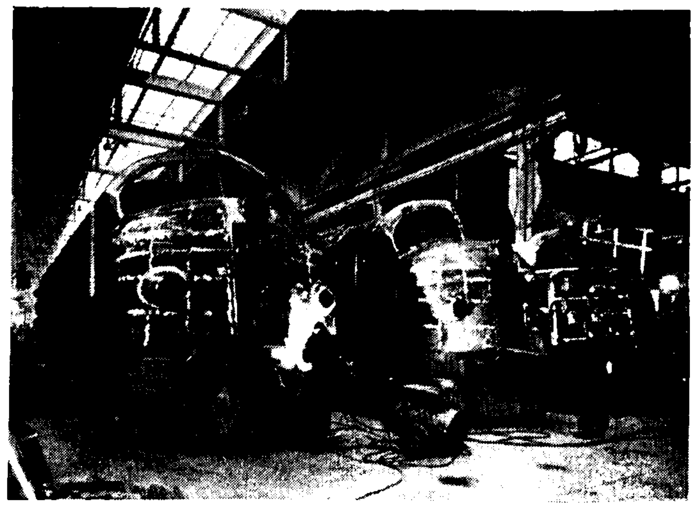
IN connection with a ceremony on April 25, outside the workshops of Nydqvist & Holm Aktiebolag (NOHAB), Trollhattan, Sweden, the first in a series of diesel electric NOHAB-GM locomotives was delivered to the Norwegian State Railways, represented by a delegation with Director General H. E. Stokke at the head of it.

As this delivery constitutes the beginning of the dieselization of a whole district of the Norwegian State Railways, the so called Nordlandsbanen, the President and representatives of the Storting (the Norwegian parliament), members of the Ministry of Communications, representatives for the Ministry of Finance and the Ministry of Commerce had assembled. Representatives for the press in Oslo and Trondheim as well as Norsk Telegrambyra and Norsk Rikskringkasting had also been invited.

After the delivery a tour around the NOHAB works was made where among other things the manufacture of the locomotives could be followed in detail.

The locomotive now delivered by NOHAB is a Streamlined bogie locomotive with 3 driving axles in each bogie. It is equipped with one driver's cab in each end and is arranged for single operator drive.

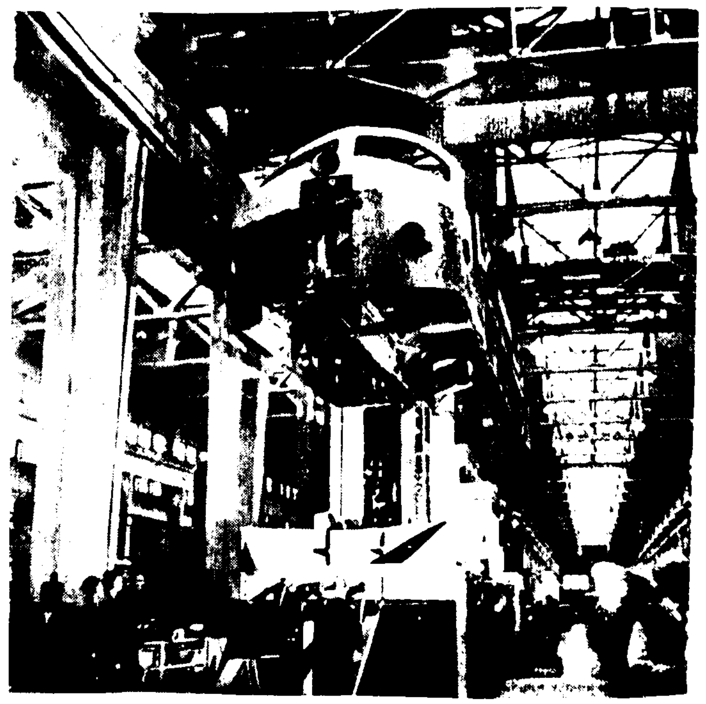
Together with the underframe, the body of the locomotive constitutes the supporting construction. Both the underframe and the car body are all-welded.



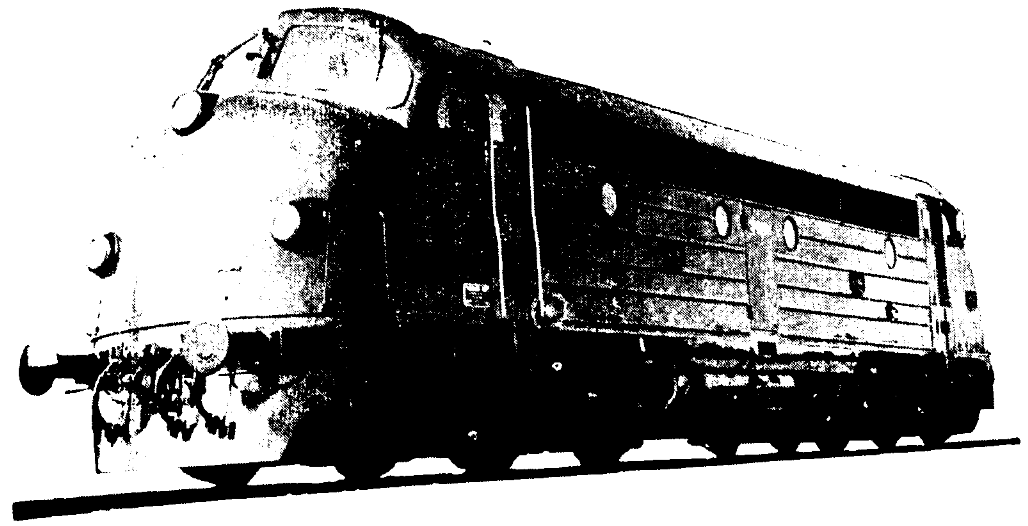
Manufacturing diesel-electric locomotives in NOHAB'S Workshops.

The bogies are made according to the so called flexicoil principle with the axles displaceable in the journal boxes, which gives the locomotive an extremely smooth and even running.

NOHAB-GM locomotives are made in the rational way — in series



Placing the locomotive body on the bogie of a NOHAB-GM diesel-electric locomotive.



Diesel-electric locomotive of the NOHAB-GM type delivered by NOHAB to the Norwegian State Railways.

The driving machinery consists of one V-shaped 1900 HP 16 cylinder 2-cycle diesel engine, manufactured by General Motors, USA. The power transmission is electric and consists of a generator direct driven from the diesel engine, regulation equipment, and D. C. motors, which by gears transmits the tractive power to the driving wheels.

The principle technical data are :

Max. speed	105 km/h.
Max. tractive effort	25 tons
Length over buffers	18600 mm.
Total wheelbase	14300 ,,
Bogie wheelbase	4000 ,,
Wheel diameter	1015 ,,
Weight in working order	98 tons

NSB (the Norwegian State Railways) have much experience of this type of locomotive. A NOHAB-GM locomotive of this type has since some years been in service in the Trondheim district. In spite of the difficult service conditions, very good results have been obtained.

According to an agreement in 1950 between NOHAB and General Motors (GM), USA, about the manufacture of diesel electric locomotives, NOHAB were secured diesel engines and electric equipment of GM's well-known make. NOHAB could at the same time benefit by all the operation results which the world's greatest manufacturer of diesel locomotives had acquired from the manufacture of more than 18,000 such locomotives. Locomotives of this type, supplied by NOHAB, are today rolling also on the railways in Denmark and Sweden. In Belgium 40 locomotives have been built to NOHAB's designs.

After NOHAB's works had been shown, dinner was had at the Town Hotel, whereupon the guests went back to Oslo by special train, hauled by the NOHAB GM locomotive delivered to NSB.

RAILWAY ELECTRIFICATION IN INDIA — TALKS WITH FRENCH ENGINEERS

Discussions have concluded in New Delhi between officers of the Railway Board and a party of five French electrical engineers who are here to advise the Indian Railways on electrification projects on the Eastern and South-Eastern Railways.

The five engineers have been deputed by the French National Railways in pursuance of an agreement signed last month between the Government of India and the French National Railways under which the French National Railways will act as technical associates in respect of railway electrification programmes in India during the second Plan period.

The five French engineers, top men in their respective lines, are : Mr. Vaubourdolle, Head of the Construction Department for Electrification Schemes; Mr. Walter, Head of the Overhead, Signal & Tele-communication Department; Mr. Nouvion, Head of the Electric Rolling Stock Department; Mr. Jaquet, Supply and Installation Expert; and Mr. Jacquemin, Mechanical Engineer.

The second Five Year Plan provides for the electrification of 1,373 route miles of the Indian railway system.

Rolling-in Retaining Rings in Railway-Truck & Locomotive Wheels

By A. C. Bhattacharya, I.M.I.R.E.

THE present development of traffic regarding rail borne vehicles requires high class fit for tyres and their fastening on the centres.

In early railway days the wheel pairs had axles forged from puddled steel, wheel hubs of cast iron and wheel centres of teak. The tyres were of puddled steel rolled into bars of the required section. These were cut into suitable lengths and then bent round and welded together at the ends. After this the tyres and hubs were assembled to the wheel centres, to which they were secured with heavy bolts.

Although wheel centres of teak gradually fell into disuse the securing of tyres to wheel centres by means of bolts continued for a considerable time.

In course of years, parallel with the advance made in engineering technique, this type of fastening was abandoned to give place to ring fastening, the practice which is in vogue to-day.

The most common method of tyre fastening, is however the Gibson or Glut ring fastening, which is not only simple and cheap but also very effective. This ring when fastened to the tyre is as one unit and is recommended for use on wheels working under normal conditions.

The ring consists of a specially rolled section of mild steel, which is bent between rolls into rings of the required diameter, the ends abutting but not joined. The ring is sprung into position, the dovetail portion

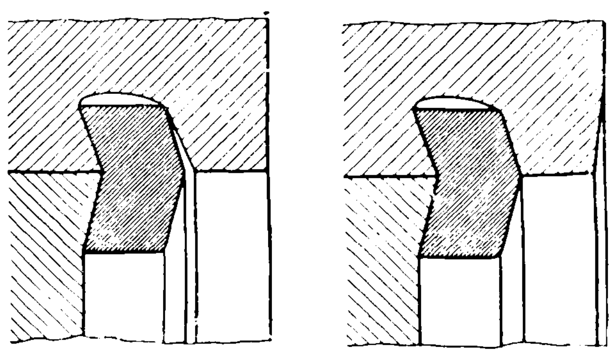


Fig. 1. Cross section of the tyre and wheel centre showing the ring before and after the rolling operation.

entering under the lip of the tyre, and the other lip into the groove in the wheel centre. The arrangement in cross section is depicted in FIG : 1.

The lip of the tyre is then hammered or rolled down until the ring is firmly gripped, and the tyre secured against lateral movements, and also separation in the event of fracture. When removal of the tyre for replacement purpose, becomes necessary, the lip of the tyre holding the ring is first turned off, the ring removed, and the tyre then heated and removed in the usual way.

ROLLING VS HAMMERING

Between the hammering and rolling down of ring, the latter is largely favoured and has now become the standard practice in view of the following advantages :—

(i) Silence Working.

(ii) No costly foundation and no transmission of vibration to machines or building located nearby.

(iii) Ability to deal with wheels either separately or with axles fitted.

(iv) The process is gradual and uniform without subjecting the tyres to sudden pressures.

(v) Ease of control with increased speed of work.

Consistent with this popular demand, the machine tool builders of to-day are turning out only the tyre lip rolling machine which has been made standard in their range of manufacture.

A typical example of one of these machines is described hereunder touching upon its salient features. In describing this machine, it by no means follows that the particular machine, which is being put forward, is the only suitable example of its kind.

ROLLING-IN MACHINE

The machine as made by BECHE & GROHS G. M. B. H. and depicted in FIG : 2, is suitable for rolling-in retaining rings in wheels and wheel sets of

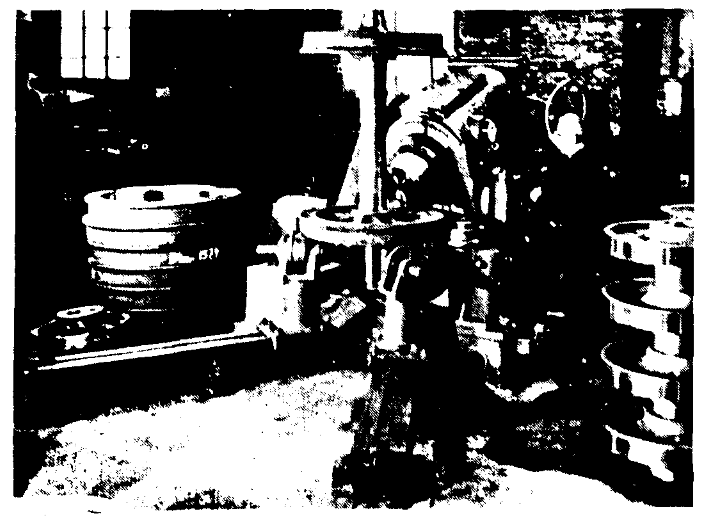


Fig. 2. Beche (German Make) Machine for Rolling-in Retaining Rings.

1 ft. 8 in. to 8 ft. 2 in. diameter on tread. The rolling effect is produced by means of a pressure pump which works at high pressure and is driven by an eccentric disc mounted on the fly-wheel shaft. The pump is fed with oil from the reflux container through the filter, and it forces the oil into the press cylinder mounted on the rear side of the upper part of the machine housing, as long as the no-load valve is closed. The quantity delivered can be controlled from zero to the maximum valve, by means of control lever.

The machine housing consists of two separate parts, the free-following counter roller being carried in the fixed lower part by means of its axle. The upper part of the housing in swingable about a swinging pin and moved backwards and forwards. The arrangement is such that wheel sets of the narrowest wheel base, as well as wheel sets with cranked axles, with toothed rims, etc., can be rolled without any auxiliary equipment.

The rollers in this machine are arranged in such a way that the pressure roller and the counter-roller form conical surfaces, whereby the apices of the cones lie approximately in line with the axle of the wheel set. This produces an almost true rolling motion between the tyre and the rollers, and the sliding movement between the surfaces is reduced to a minimum. The arrangement is illustrated in FIG : 3.

The rollers are driven by a machine cut worm gear, running in oil bath formed in the frame of the machine. The two shafts are geared together and

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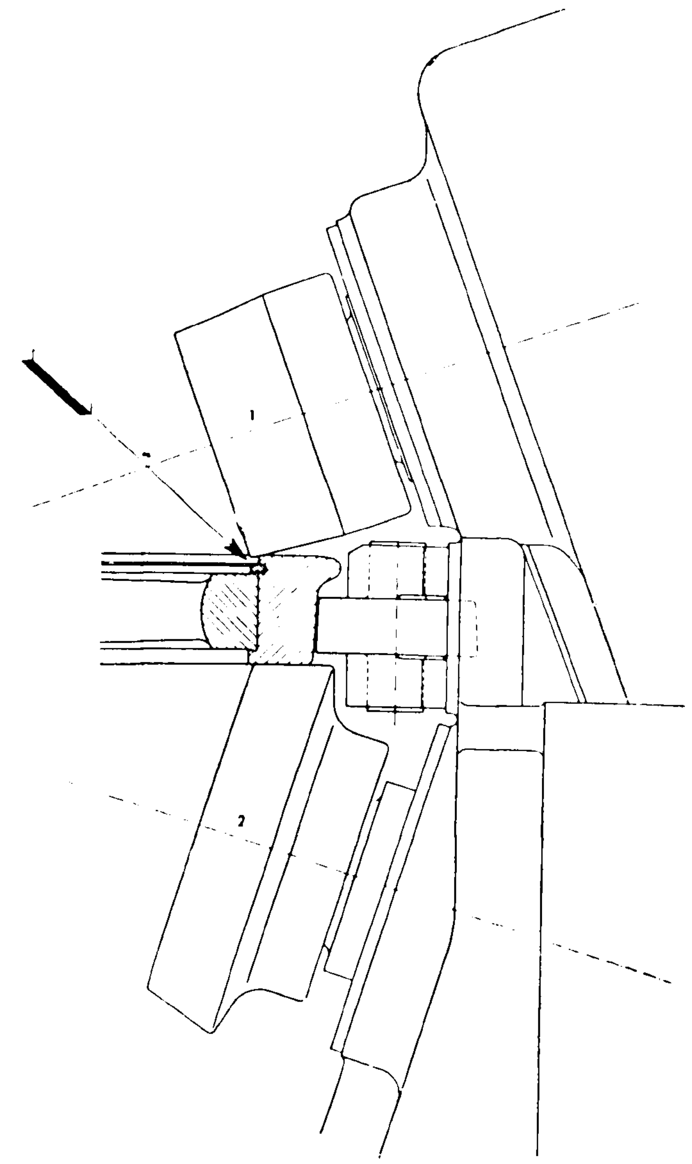


Fig. 3. The arrangement of the Rollers and the Steady Roller.

driven by means of spur wheels coupling the top pressing roll and giving same even driving with the bottom roll. The suspension of all driven parts is effected by means of roller bearings and that of other parts by plain bearings.

ROLLING OPERATION

After the machine is started up, the upper part of the housing is swung back to the required extent by turning the hand crank provided for applying and withdrawing the pressure roller to and from the tyre. The mounting of the wheel set is done in such a way that it rests against the steady roller. The roller crutch mountings together with the supporting rollers are then adjusted so

Development of Commercial Vacuum Furnaces for Melting Metals and Alloys

By James H. Moore

Director, Metallurgical Department, National Research Corp., Cambridge, Mass
(Now General Manager, Vacuum Metals Corp.)

RESEARCH Metallurgists recognized at least a half-century ago the usefulness of vacuum melting for the production of small quantities of high-purity, carefully controlled metals and alloys. W.C. Arsem pointed out to the Electro-chemical Society in 1906 that vacuum melting would purify metals by volatilizing impurities and by favoring reactions with gaseous products, and that exact compositions could be retained by avoiding oxidation.

The Arsem-type furnace was for many years the standard tool for carrying out all sorts of metallurgical reduction and refining reactions in a vacuum, although it was adapted only to melting and solidification without pouring. Arsem recognized the desirability of being able to cast *in vacuo*, but apparently never worked out the furnace design to permit it.

Prior to World War I, an Arsem furnace which could be evacuated to a pressure equivalent to 0.5 mm. of Hg * by a Guericke mechanical pump, was used by the late T. D. Yensen in his early work with the iron-silicon alloys to make 500 to 600-g. melts. While this could melt with some degree of success, it had disadvantages which led to a departure from the graphite resistor originally used as a heating element. Many early experiments were made with externally heated tube furnaces, but the quartz tubes usually collapsed when the temperature got into the melting range of the metals of most interest. The use of an evacuated quartz tube

(Continued from page 53)

that a free space of about 25/32" to 1.3/16" still remains between the tyre and the flanges of the supporting rollers. The supporting mounting is then advanced so that its guide roller comes in contact with the tyre. After they have been adjusted the roller crutch mountings and the supporting mounting are screwed tightly to the side plate.

With no-load valve opened, the upper part of the housing is then swung out so far to the front by means of a hand crank until the pressure roller rests on the tyre. The no-load valve is then closed and the pump control lever pulled back so that the pressure pump starts working. The wheel is carried along by the pressure roller, which is now pressed on to the tyre. When the rolling of the wheel is completed, the pressure is released by opening the no-load valve and the pressure roller is swung back by means of the hand crank.

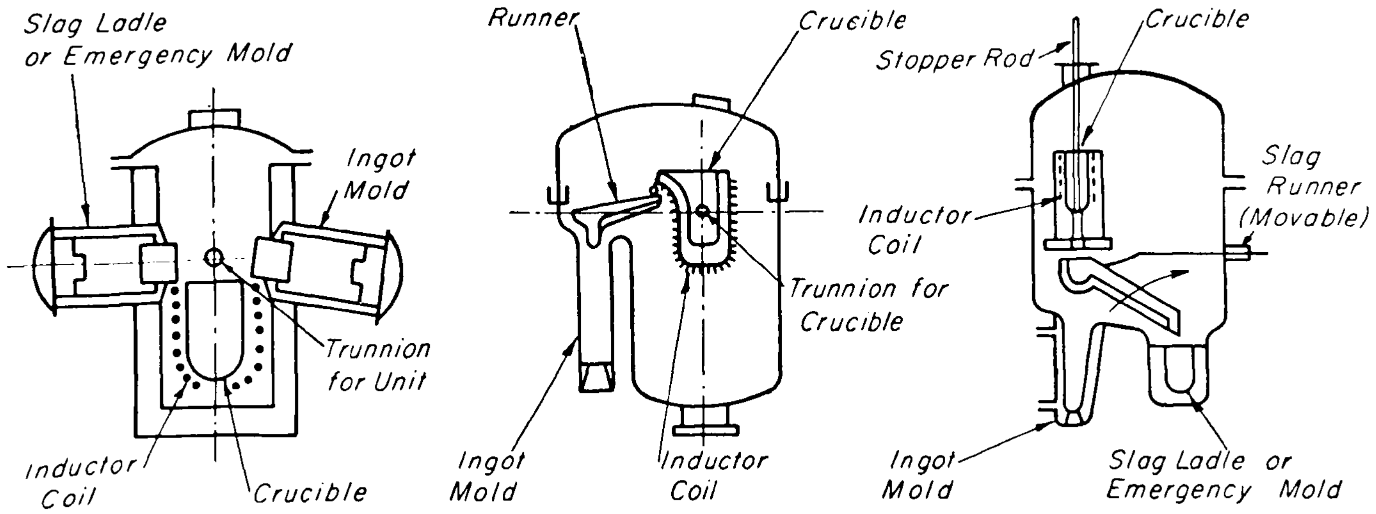
The machine is fitted with the pressure gauge showing the pressure per square inch.

With a tyre material having a strength of 45—50 tons per square inch. and a machine having 25 tons as the maximum pressing effect at the rolling point, the rolling of 43" dia on tread wheel takes about 4 to 5 minutes for punching the ring tightly in place. Three rolling periods are generally made with the tyre; the first with a load of 5 tons applied on the roller, the second with a load of 15 tons and the third with a load of 25 tons. The reason for starting the first revolution with a pressure of 5 tons is to avoid too high pressure on to the upper roll by the edge of the tyre which is yet sharp.

Where the strength of the rail tyres are harder say about 70 tons per square inch, as in the case of EMU stock, machines having a capacity of 55 tons, are employed, as a lower pressure at the rolling spot, in such cases, is considered insufficient. As regards rolling times, which are dependent on the strength of the material of which the tyres are made, the times, which are dependent on the strength of the material of which the tyres are made, the times taken with the higher capacity machine are approximately 2 minutes for a tyre of 43" dia and made up of 50 tons tyre steel and 4 minutes for a tyre of the same tread diameter but made from steel having a tensile strength of approximately 70 tons per square inch.

*1 atmosphere = 760 mm. Hg.

Fig. 1—Sketches of the Three Basic Types of Heraeus Vacuum Melting Furnaces—Tilting Unit, Tilting Crucible for Lip Pouring, Stationary Crucible for Teeming



Reprinted from September, October 1953 METAL PROGRESS

containing a crucible heated by a co-axial high-frequency induction coil around the tube was one solution to this problem; the walls of the vacuum chamber in this design remained cool. An advanced example of such a device has been described in *Metal Progress* for September 1947 ("Vacuum Melting and Casting of Beryllium", by A. R. Kaufmann and E. Gordon). In this furnace the melting crucible had a stoppered hole in its bottom through which the melt flowed to an ingot mold directly beneath.

Another school of thought led to the bell-jar type of unit in which the induction coil was placed within the vacuum chamber. This design, coming after World War I, was coincident with the beginning of the development of high-vacuum pumps. In the furnace designed by Brace and Ziegler of the Westinghouse staff and described by them in *Transactions*, A.I.M.E., Vol. 78, 1928, p. 544, a pressure of less than a micron of mercury (0.001 mm. or about a millionth of an atmosphere) was said to be attainable with mercury condensation pumps.

While this development of induction heated experimental furnaces was progressing in this country, Wilhelm Rohn began the activity in Germany which led to the first commercial vacuum melting. During World War I, he began experimenting with the preparation of nickel-chromium alloys in vacuum to replace the scarce platinum-base thermocouple alloys. By 1923, the field appeared sufficiently promising to warrant the founding of a new firm, Heræus Vacuumschmelze, as a subsidiary of W. C. Heræus, and production units were constructed. The first were heated by low-frequency induction and were made with capacities as high as 8000 lb. These were later discarded in favor of high-frequency induction units. Of the three basic designs of the latter, shown in Fig 1, all had both the induction coil and the mold or molds in vacuum. The major design difference was in the method of pouring. In the first, the whole tank tilted; in the second, the crucible alone was tilted within the chamber; and in the third, a bottom-tapped crucible was employed. Present operations of vacuum-schmelze A. G. (now part of Siemens-Halske), utilize primarily the first and third types of furnace.

While this German development took the vacuum melting operation out of the laboratories into the plant it did not improve the technique with respect to the pressure range which could be obtained. Mechanical pumps were used, with a blank-off pressure of about 100 microns (0.1 mm. Hg), but the actual furnace operations were in the range of 5 to 10 mm. Hg. In this country, it has been noted that the period between world wars saw the use of the high-vacuum condensation pump to obtain lower pressures in the Brace and Ziegler unit. With the design of the first oil diffusion pump by Burch in 1929, and the subsequent multi-stage types of oil vapor pumps, an improvement in pressure of several orders of magnitude became possible. The demands in World War II for large low-pressure operations in several fields, especially in the separation of uranium isotopes by electromagnetic means, gave considerable impetus to this development. During the war, the metallurgical department of National Research Corp., manufacturers of high vacuum equipment, also began to devote considerable attention to vacuum melting and casting equipment and processing techniques.

Our first furnaces, capable of melts of 15 to 300 lb., had 10,000-cycle, 200-volt induction coils within metallic tanks. These tanks held bottom-tapped crucibles which discharged into water-cooled copper molds attached to the furnace tank. Tapping was by stopper rod, operated through a seal. A 300-lb. furnace used for melting copper has been described in an article by Stauffer, Fox and DePietro in *Industrial and Engineering Chemistry*,

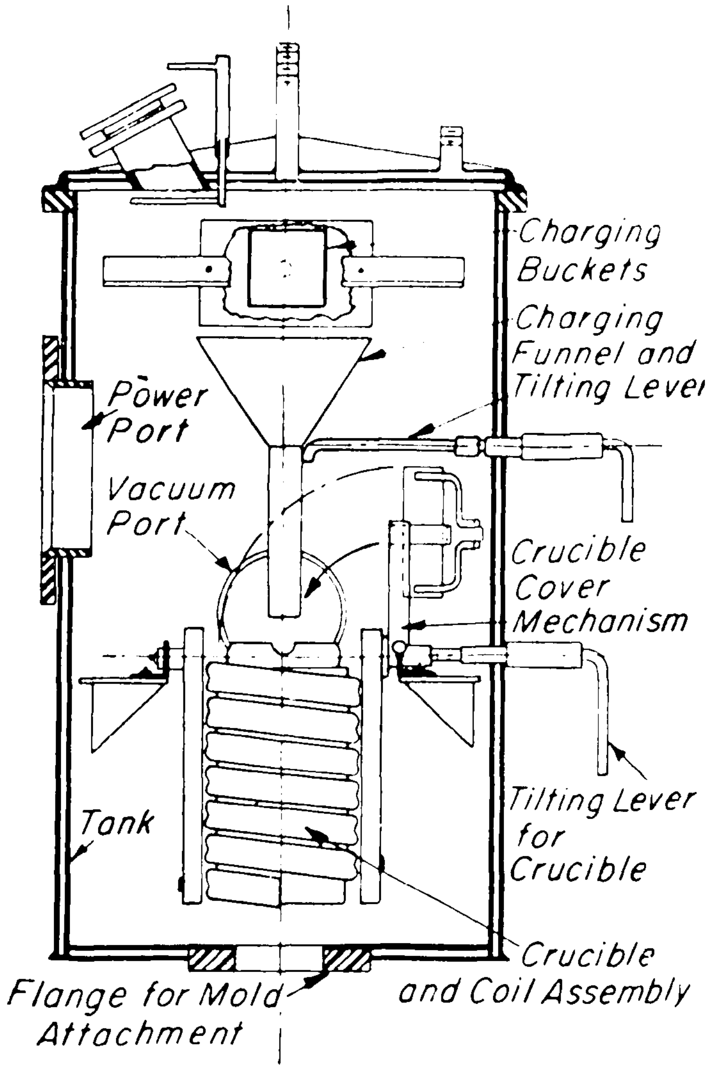


Fig. 2. Early Unit for Tilt Pouring Into Mold Attached to Bottom of Tank

Vol. 40, 1948, p. 820. For producing electronic grade copper and certain non-ferrous metals and alloys, equipment of this design is still in use, but it is unsatisfactory for steels, high-temperature alloys and many non-ferrous alloys. Difficulties were introduced by failure of refractories oxide crucibles and stopper rods—caused by softening, erosion and reaction. Tilt-pouring techniques were needed.

The first National Research Corp. unit employing tilt pouring is shown schematically in Fig. 2. A coil assembly which can be up-ended holds a crucible which in turn has a removable cover. A mechanism is provided for making additions consisting of a funnel and several small buckets, remote controlled. At the bottom of the main tank is a mold flange to which can be attached either a water-cooled copper mold, or a mold tank which could hold an ingot mold or a shaped mold. A 10,000-cycle, 200-volt, 30-kw. motor-generator furnished the power. This unit has been successfully used for a wide variety of metals and alloys, at first for 15-lb. and later for 30-lb. melts. Both ingots and precision castings were produced for research purposes.

It became evident from experience with such batch-type melting furnaces up to 100 lb. in size, that semi-continuous operation would be necessary if vacuum melting could be properly exploited on a commercial scale. As techniques for vacuum refining progressed, this new type of unit was formulated.

The first unit to be designed and patented (U.S. Patent No. 2,625,-719) expressly for the commercial production of metals and alloys at National Research Corp. is illustrated in Fig. 3. Charging and discharging locks were incorporated so that a melt could be tilt-poured into an ingot mold or a shape mold, the mold chamber locked off, and the crucible reloaded through the charging lock. The latter was designed to handle the widest variety of materials, such as compressed trimmings, electrolytic flake, powder, pellets or massive scrap. Thus, the next melt-down starts in the hot crucible while the preceding ingot is being removed. This not only greatly reduced the furnace cycle by eliminating the long cooling of the hot crucible assembly before opening to recharge, but was also beneficial to the life of refractories.

Reference to Fig. 3 will show the major components of this type of furnace. The crucible is charged by a retractable bucket through the charging lock and valve. Heat for melting is furnished by a 3000-cycle, 400-volt induction coil. The crucible may be poured at the

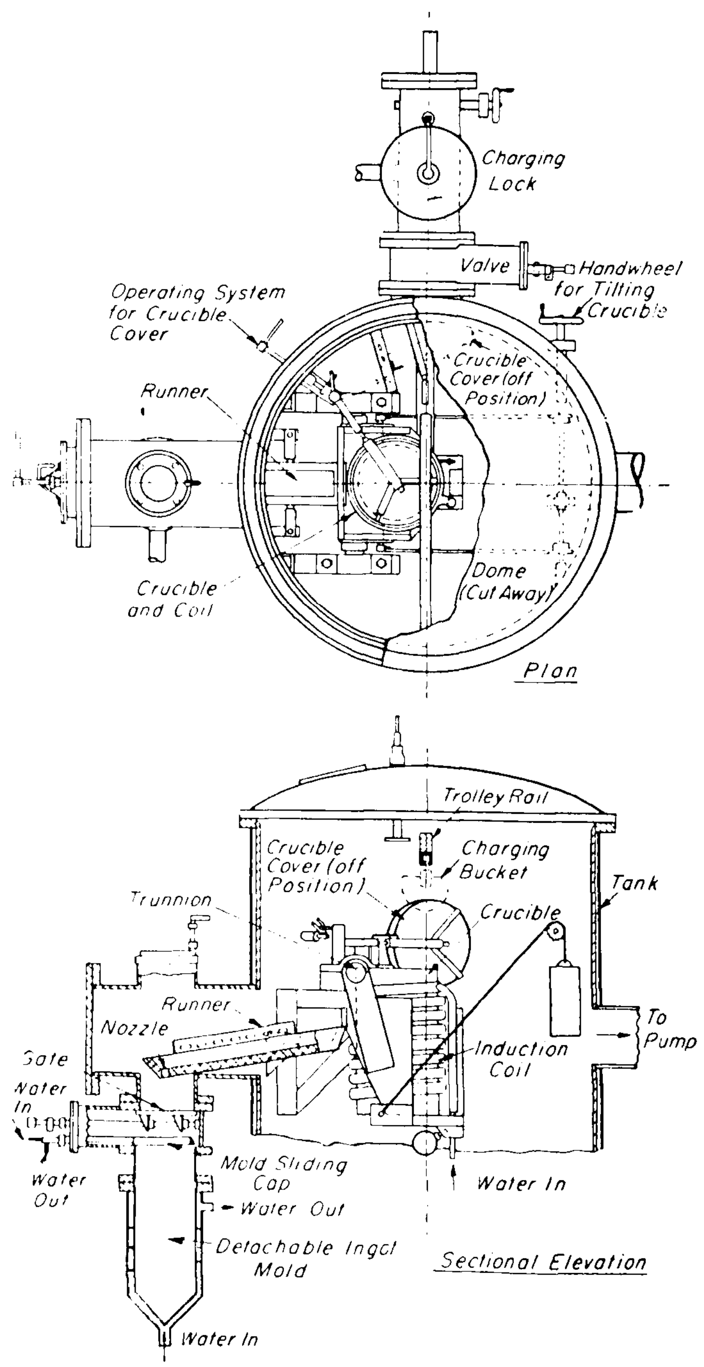


Fig. 3 General Assembly of National Research Corp. Unit for Semi-Continuous Melting in Vacuum.

conclusion of the refining cycle into the runner which has a controlled orifice or nozzle over the mold. After pouring, the mold and ingot are locked from the main chamber by the gate just below the pouring nozzle and the ingot may be removed by venting the mold chamber. By the proper design and operation of all locking components one can operate with essentially no effect of

(Continued on page 58)

Some Aspects of Vacuum-Melted Metal

By J. H. Moore

Director, Metallurgical Department, National Research Corp., Cambridge, Mass.
(Now General Manager, Vacuum Metals Corp.)

THERE are probably four basic effects of the reduction in atmospheric pressure over a molten metal which are being utilized in commercial vacuum melting. These are (*a*) simple protection against reaction with atmospheric gases, (*b*) dissociation of certain gas-metal compounds, (*c*) minimizing the amount of dissolved gas, and (*d*) acceleration of bath reactions which have gaseous products.

The usual vacuum refining treatment of a metal or alloy does not exploit just one of these effects, but two or more—although one of them may predominate. In the production of beryllium copper, for instance, while the simple protective action is instrumental in decreasing the beryllium loss from 10% to practically nothing, the more effective refining of the bath at low pressure gives a dividend in a completely effective content of alloy, undiminished by gas-metal compounds. Likewise, in such alloys as the nickel-base, age hardenable, high-temperature alloys, a major benefit is the avoidance of excessive loss of reactive hardening elements through oxidation. Particularly this is true when remelting scrap.

Utilization of the second advantage cited above—dissociation of oxides, nitrides, hydrides and certain other compounds such as sulphides—has limited possibility. If the common alloy bases, copper, nickel, cobalt, iron and aluminum are considered, it is evident that oxygen can be removed by dissociation of the contaminating oxides only from copper, nickel and possibly cobalt. The dissociation pressures of the oxide of iron and aluminum are much too low for practical vacuums to have any effect. All of the nitrides and hydrides of these metals can, however, be dissociated and the gases pumped off.

Considering those gases which do not form stable gas-metal compounds at the pressure in the furnace the amount of gas in solution may be reduced. A equilibrium, a direct relationship exists between the amount of gas left in solution and the partial pressure of the gas over the melt. For oxygen, nitrogen and hydrogen, this solubility is proportional to the square root of the pressure. The dissolved gas content of a melt will thus decrease under continued pumping and approach this equilibrium relationship. Figure 1 shows this effect for nickel. In the same way, any element which is gaseous under the temperature and pressure existing within the furnace will be vaporized from the melt. Thus, in all the common metals, such elements as lead, zinc, bismuth, antimony, tellurium and selenium are decreased by vaporization.

This reduction in content of nitrogen, hydrogen and the elements with high vapor pressure is a function of all the vacuum melting practices, but is particularly important for copper and nickel alloys for use in electronic tubes.

Because most raw materials available in quantity and at low price are rather impure, particularly with

(*Continued from page 57*)

charging or discharging on the pressure within the melting chamber.

The operating pressure range of the furnace is from about one micron to one atmosphere, with the usual end point for a low-pressure refining cycle at from one to ten microns. A three-stage pumping system provides high capacity throughout this range of pressures.

Much information about refining techniques has been gained from operating this type of furnace for several years. The evolution of improved commercial equipment has continued. In the plant of Vacuum Metals Corp. (a subsidiary of National Research Corp.), for example, one of the furnaces is capable of producing 1000-lb. ingots of copper alloys and 600-lb. ingots of steels and high-temperature alloys. Others produce melts of approximately 50, 100, and 300 lb. for metals other than the light alloys.

Ingots from these furnaces are fabricated into a variety of products for sale to industry. Much of the present output is going into pilot production lots in various applications. A subsequent article will describe the characteristics of some of the improved metals and alloys so manufactured.

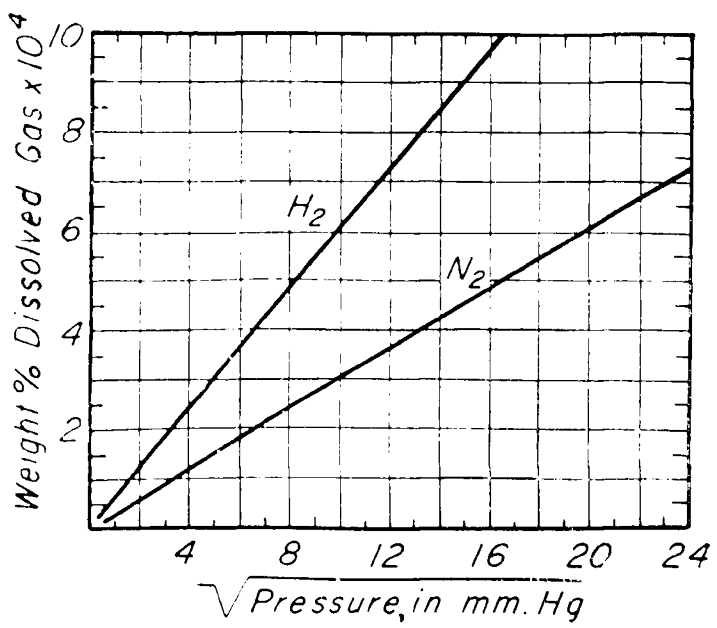


Fig. 1. Effect of Pressure on the Amount of Hydrogen and Nitrogen which is soluble in Nickel at 2875°F. (1580°C.)

respect to oxygen, the effect of vacuum on certain refining reactions can be very important. The best example is probably the reaction of carbon and oxygen in solution to form carbon monoxide. Since pumping is continually removing the product, the reaction is forced almost to its end. In practice, a problem is posed by the necessity for a close carbon-oxygen balance at melt-down to minimize both elements at the end point. If the oxide crucible is at all reactive, an added complication is introduced namely re-oxidation by reaction between bath and crucible.

Figure 3 illustrates the reduction of nitrogen and hydrogen in high-purity iron during vacuum treatment. The reduction in carbon by the CO reaction may be seen, as well as a corresponding decrease in oxygen content—to a certain point. The complicating re-oxidation by the magnesia crucible is also evident. The actual data in this plot correspond only to a certain size of experimental melt and definite set of conditions, but they may be considered as representative of the general case. A careful study of the kinetics of such reactions has been necessary in the development of vacuum refining practices.

It has been noted previously that, in the melting and casting of most materials, most if not all of the four effects listed are important. For example, in the production of an alloy steel or high-temperature alloy low in carbon, the first stage of refining may call for the reduction of carbon and oxygen in the base melt by a controlled reaction, with simultaneous elimination of hydrogen, nitrogen, sulphur and phosphorus. The addition of reactive components can then be made without losing substantial amounts by reaction with oxygen in the melt. Further purification can be performed, particularly with respect to nitrogen and hydrogen, prior to tapping, and the vacuum protects the metal from contamination and losses through atmospheric reaction, both during final soak and teeming. The resulting ingot can then possess the five advantages of (*a*) soundness because of lack of gas evolution, (*b*) extreme cleanliness due to elimination of inclusions, (*c*) low content of gas in solution, (*d*) completely effective alloying by elimination of gas-metal compounds, and (*e*) controlled total alloy content by eliminating losses to oxides and nitrides during melting.

PROPERTIES OF VACUUM-REFINED METALS

When metals and alloys are produced with such characteristics as just mentioned, technological properties may be pronouncedly changed, and an increasing flow of data on such matters is coming from work at National Research Corp. and several other laboratories.

A prime reason for eliminating gas porosity in the ingot is, of course, to avoid surface defects such as blisters during the fabrication of sheet and strip. Gas-free metal is probably of greater importance in the production of shape castings, since there is no subsequent working to weld up internal cavities, and surface blemishes or internal porosity are usually irreparable.

Our experience indicates that the most frequent cause for gas evolution during solidification is not the simple

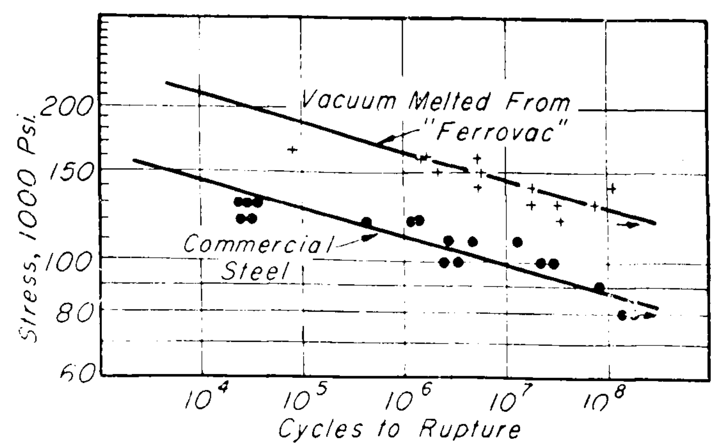


Fig. 2. Vacuum Melted (Inclusion-Free) 52100 has markedly better endurance than Commercial Alloy Steel of same analysis.

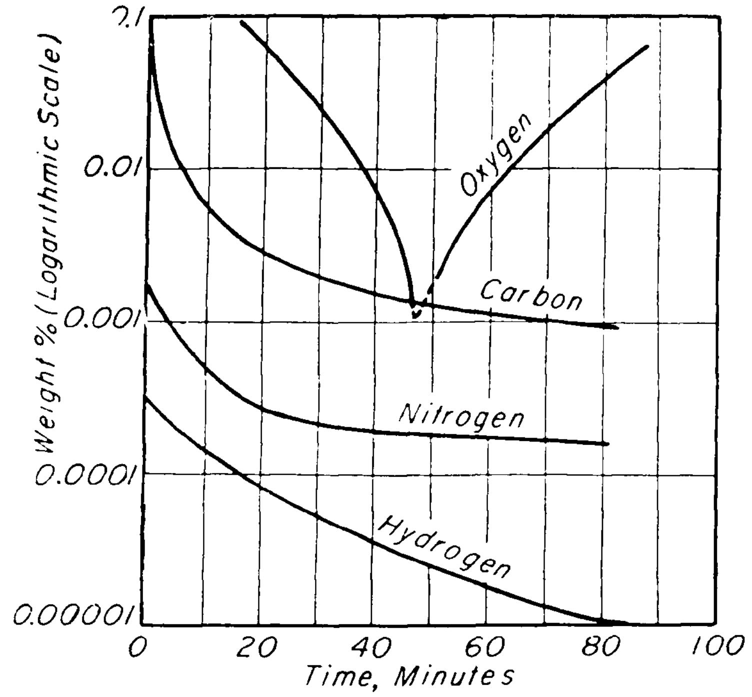


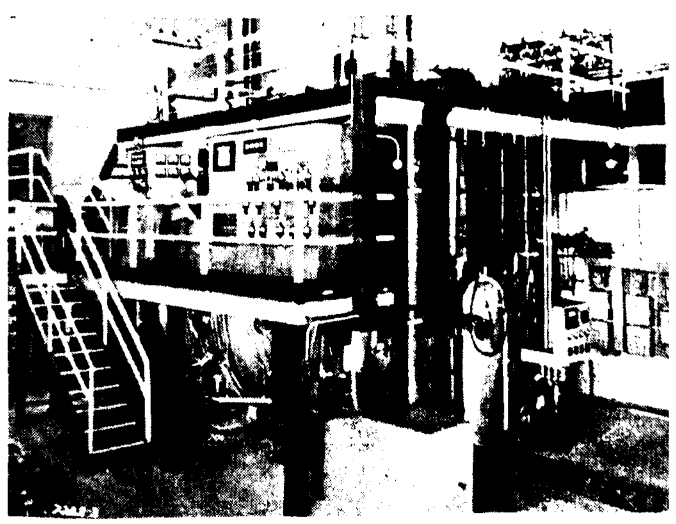
Fig. 3. Experimental Curves for Degassing during Vacuum Melting of Iron in a Magnesia Crucible.

decrease in solubility of a dissolved gas, but this effect combined with a reaction such as that of dissolved carbon and oxygen or of hydrogen and oxygen. In ordinary practice both reactions are inhibited by a strong deoxidation of the melt just before pouring. However, this is not always desirable—for example, in pouring castings of high-purity copper—where the presence of a strong deoxidizer in solution would be detrimental to electrical conductivity. Vacuum-melted copper can be cast to 100% I. A. C. S. conductivity and be completely sound as well.

The high degree of cleanliness obtainable in vacuum melting by avoiding slag inclusions and deoxidizers is of considerable interest. Certain alloys which are drawn to very fine wire can be fabricated with much less difficulty. Surface quality is greatly benefited; there are no inclusions to cause pitting, scratching, and consequent dulling of the finish or increase in coefficient of friction. A considerable improvement in rotating-beam fatigue life of high-carbon chromium steel is attributed to an increase in cleanliness which eliminated many subsurface as well as surface stress-raisers. The present author has compared the fatigue behavior of commercial 52100 ball-bearing steel to metal of the same analysis prepared in a vacuum furnace. Result were summarized in "Improvement in Fatigue Behavio of 52100 Steel by Vacuum Melting", *Iron Age*, Apri 2, 1953, from which Fig. 2 is copied. Marked improve ment in transverse fatigue properties of 4340 steel ha also been reported.

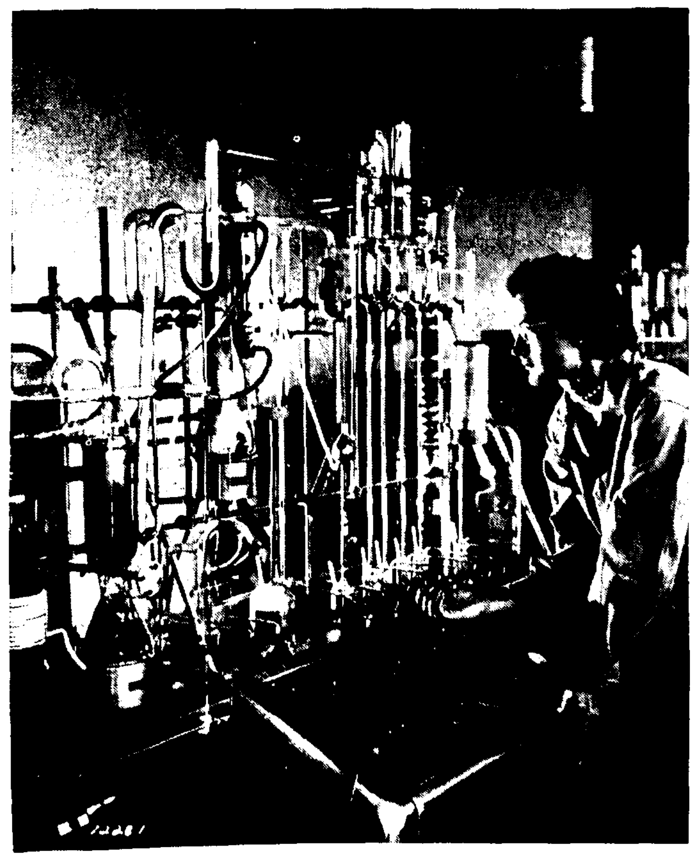
Very low gas content in solution at solidification ha been shown to have important effects on metalli properties, although the mechanism is not completel clear in all cases. The work of J. Hochmann on 25% chromium-irons* and of W. O. Binder and H. R Spendelow† on plain chromium steels, for instance, ha shown clearly that it is the amounts of carbon, nitroge and oxygen that determine the ductility of chromium irons, high in chromium, although there was som disagreement as to the relative importance of oxygen The effect on impact strength of decreasing the conten of these impurities in the 25% Cr alloy is very marked a value of about 100 ft.-lb. being characteristic of th vacuum-melted steel, as compared with 0 to 8 ft.-lb. fo the commercial product.

Recent tests under the direction of Prof. N. J. Grant at Massachusetts Institute of Technology have show that a very low total of carbon plus nitrogen has decided effect on the creep-rupture behavior of 18— stainless steel. An analogous steel, vacuum melted b National Research Corp., containing 0.006% tota



The World's Largest High-Vacuum Induction Melting Furnace built by the NRC Equipment Division for Vacuun Metals Corporation.

* *Revue de Metallurgie*, Vol. 48, 1951, p. 734.
† *Transactions* of the **ASM**, Vol. 43, 1951, p. 759.
‡ *Transactions* of the **ASM**, Vol. 45, 1953, p. 105.



Vacuum Fusion Unit for analysis of the Gas Contents of Reactor Materials.

$C+N_2$, exhibited decidedly better creep resistance, rupture strength and ductility at 2375 F. (1300 C.) than commercial "extra low-carbon Type 304 stainless", thus:

	Vacuum Melted 304	Commercial ELC 304
100-hr. rupture stress	18,000 psi.	13,500 psi.
1000-hr. rupture stress	14,800 psi.	9,000 psi.
Reduction in area	42 to 75%	20 to 39%

Similarly, in work done under the author's supervision at National Research Corp. (not heretofore published), a decided effect of nitrogen content on the rupture strength of high-purity iron has been found:

50-Hr. Rupture Stress	0.009 N_2	0.0001 N_2
At 800 F.	10,200 psi.	16,000 psi.
At 900 F.	6,800	12,000

Minimizing the gas content in materials used in vacuum tubes has been found to give such improved characteristics that they are now being so made in Germany. It has been particularly beneficial in decreasing leakage of glass-to-metal seals, and in the rapid degasification of tubes.

If a portion of a reactive alloying element can be tied up as inert oxides or nitrides, the effect can be particularly important in the age hardening alloys such as beryllium-copper, chromium-copper and the nickel-base series containing titanium and aluminium as hardeners. The proper use of vacuum melting greatly decreases the amount of alloying element tied up in this manner, thus increasing the uniformity of the alloy's response to heat treatment.

The advantage of closely controlled alloy content is being pursued particularly in electronic alloys such as those for cathodes. The emission characteristics of the oxide-coated cathodes appear to be quite dependent on very small amounts of alloying elements or impurities. Vacuum melting gives the necessary degree of control and is used for this reason in German production, and to a small extent in American. Expansion alloys and magnetic alloys are other types in which composition, control, usually critical for proper performance, is being improved by vacuum melting.

The principal metals and alloys now being vacuum melted in this country or in Germany are electronic tube materials, sealing alloys, magnetic alloys, steels for high fatigue and impact strength, and expansion alloys.

In Germany, the production of such vacuum-melted metals is about 16 tons per month. No estimate can be made of the capacity of American facilities, since most of them are either classified or used in research; they are operated by the electrical industry, the Atomic Energy Commission, and by certain specialists in industry. Our plant alone can make about 60 tons a month of a material like electronic copper, and 15 tons a month of steel or high-temperature alloy. The products require a sizable price premium, largely because of the small volume and large diversity of products. However, as an alloy becomes established as a standard product and gets into tonnage production, the prospects of cutting this premium to a fraction of the present level are excellent.

Diesel Railcar for Swedish State Railways

Compiled by AB Svenska Jarnvagsverkstaderna.
Linkoping, Sweden

A QUARTER of a century has now passed since the Swedish State Railways began to prepare the light, fast railcars as a replacement for trains hauled by steam locomotives on non-electrified lines.

These first railcars made an aluminium-covered superstructure of wood on an underframe of steel, the design being taken from road buses of that time.

But already in the years before world war II, a number of collision-proof all steel diesel railcars could be taken in service, the war, however, causing an interruption in the dieselization programme. After the war all the steam trains on the non-electrified lines have been replaced by diesel railcars, very often coupled together to train units, in which way great advantages have been gained both from operating and economical points of view. Among these advantages, in comparison with trains driven by steam or diesel locomotives, should be mentioned superior traction dynamics as well as the fact that the multiple-unit diesel train offers the great economy of flexibility. The superior traction dynamics comes from a better adhesion relation, i. e. a larger part of the total weight of the train lays on the traction wheels and, furthermore, the diesel railcar can generally be designed to have a greater effect per ton of train weight, meaning that the diesel railcar train can accelerate faster and get a higher average speed than the train driven by a locomotive.

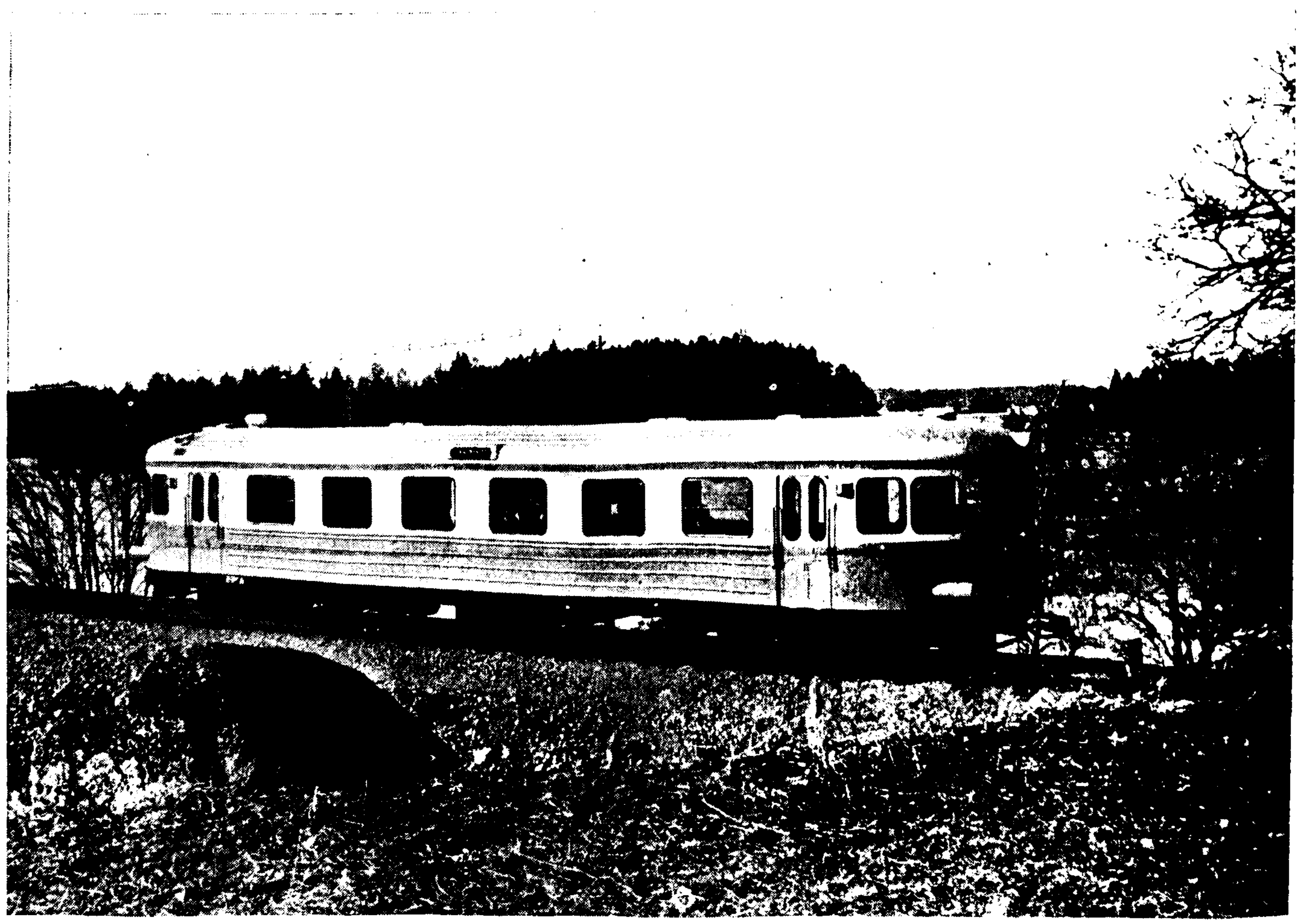


Fig. 1. Diesel railcars for Swedish State Railways.

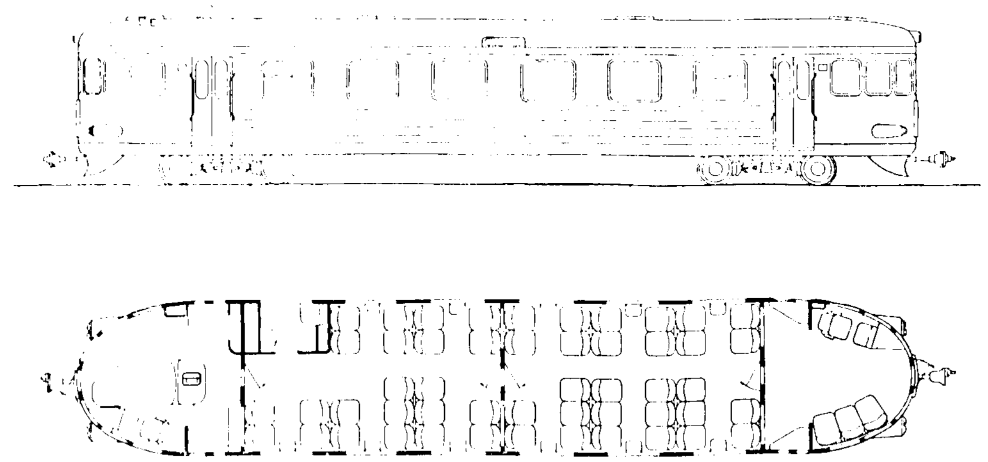


Fig. 2. Principle drawing of the railcar.

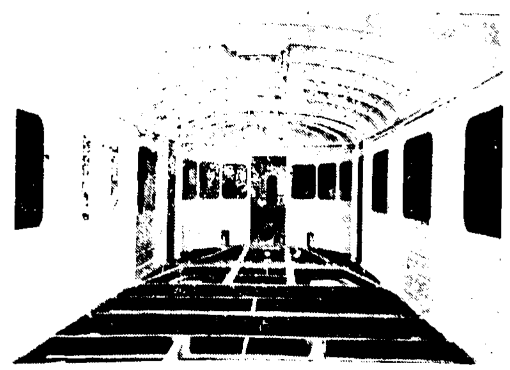


Fig. 3. Interior of steel body.

A great economy of flexibility is attained by the distribution of the traction force on several units and by the use of remote electric contacts, in which way the capacity of the diesel railcar train can easily be adjusted with regard to the varying requirements. This means a better use of men and material as well as savings as to fuel and maintenance.

In this connection perhaps ought to be mentioned the high importance of the modern easy and fast diesel engine with direct injection and with a supercharger, this type of engine being very much appropriate when designing railway equipment with small costs for operation and maintenance.

As the Swedish State Railways are carrying out a considerable programme for railcars, especially diesel-driven ones, the Swedish railway industry has acquired a very good experience in designing and building modern, light but collision-proof railway vehicles.

We think that our railway friends in India are nterested in a short description of the type of diesel

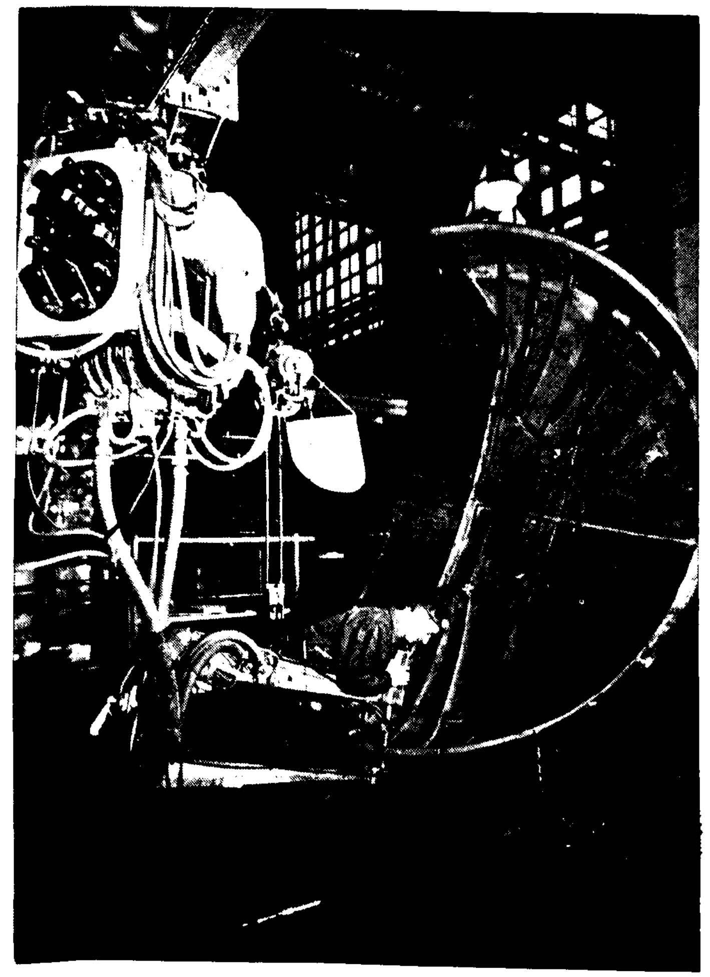


Fig. 4. Spot welding of end of roof.

railcar, a great number of which has been bought by the Swedish State Railways during the last five years and of which our company has hitherto delivered abt. 200 units.

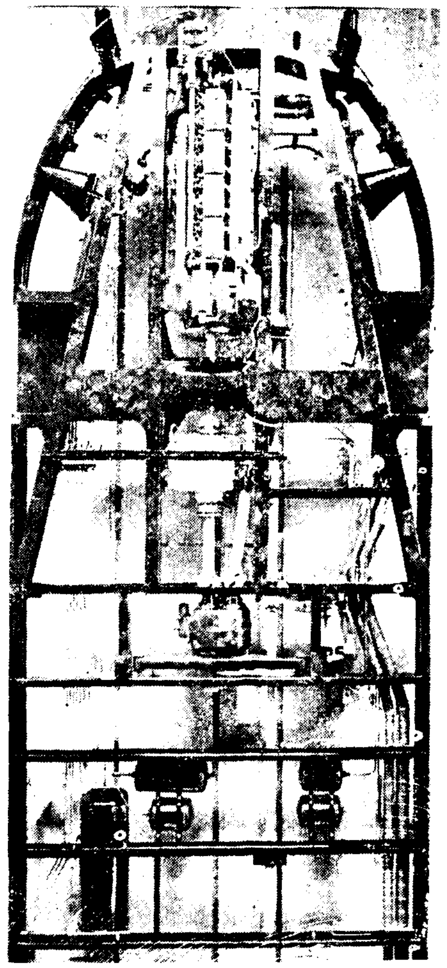


Fig. 5. View of the underframe with diesel engine and gear boxes

These cars have fully complied to the requirements of the State Railways, having made service in very different climatic conditions from a summer temperature of + 90 F to arctic climate north of the Pole circle, where the temperature in winter can sink to − 50 F.

This railcar is an exquisite achievement in the field of light-load traction. Meant for suburban and cross-country services, it has been designed for speeds as high as 72 m. p. h. 115 km/tim./, giving satisfactory service on all track conditions. In spite of high passenger capacity, the car is one of the lightest among the rolling stock of this size ever produced.

The outside view of the railcar is shown on figure 1, and figure 2 indicates the interior arrangements with one vestibule in each end of the car with driver's equipment and space for luggage. There are two passenger compartments.

Main data :

Track gauge	1.435 m.
Length over ends	16.55 m.
Breadth	3.1 m.
Height of car above rail	3.24 m.
Height of floor above rail	0.88 m.
Distance between bogie centres	10.7 m.
Distance between axles in bogies	2 m.
Weight in working order	17.4 ton.
Number of seats 2nd class	53
Engine	205 hk.
Number of traction axles	2
Maximum speed	115 km/h

Fig. 6 and 7. Interior of passenger compartment.

Fig. 8. Interior of toilet.

The sides, ends, roofing, and underframe of the steel body form a self-supporting unit in a light integral design. The underframe consists of pressed steel profiles joined together by arc welding. Sides, ends, and roofing are manufactured in complete units mainly by spot welding and strengthened by ribs and posts of z-profiles. The joining roof (walls and walls) underframe is made by means of riveting. The weight of the steel body is only 3.5 tons. The design of the steel framework can be seen on figure 3, 4, and 5.

The insides of the walls are clad with Formica boards or similar, and the roof of painted wall board. Space between the ceiling and roof, as well as between inside and outside walls is filled with Isoflex, a plastic material, or glass fibre panels for temperature insulation and for accoustic purposes. The floor is laid with linoleum or rubber mats on plastic glued ½" plywood resting on wooden beams on a steel underframe. Under the plywood there is a layer of Isoflex or glass fibre panels on a wallboard sheet.

The entrance doors, of an all pressed steel construction, are placed in each of the driver's cabs. They are of the folding type, automatically operated by door machines working on the compressed air system. The doors can be operated either from inside or from outside of the car and the driving gear provides control to prevent the opening of the doors when the car is in motion. The doors in the ends of the car are of the swinging type, turning outwards, and the doors between driver's cab and passengers compartment are turning to both sides.

All windows have double glass and the front windows are equipped with safety glass. In each passenger compartment there are two openable windows of the half-drop type. All the window panes are fastened by means of rubber profiles.

The seats are made of enamelled steel tubes and furnished with seats and backs of foam rubber, which are clad with specially made fabric. The cars are provided with other amenities for passengers such as tables, ashtrays, luggage racks, curtains, etc.

The toilet is fairly spacious, self-flushing and well equipped.

The interior of the car will be seen on figure 6, 7, 8, and 9.

The interior lighting of the passenger compartments is supplied by 1000 V 50 c/s cold cathode tubes mounted in two rows in the ceiling in shock proof mountings. Each end of the car is provided with one headlight of 50 watts and two sidelights of 50 watts each.

Fig. 9. Driver's cab.

The car is heated by hot air from the fan for the engine radiator. The air is thoroughly filtered. The driver's cab is additionally heated by aero-tempers in front of the driver's seat. In this way the car is well ventilated, but to increase this, the platforms and the passenger compartments are equipped with hand operated roof ventilators.

As stand-by, and for extra cold days, an oil burning heater is inserted in the water system.

Figure 10 shows the design of the bogies. They are all welded and equipped with resilient SAB wheels on SKF roller bearings, see figure 11. The axles are held parallel by long swing arms connected to the central bogie frame by rubber-bushes. The spring system consists of involute springs between the swing arms and the bogie-frame. The driving bogie has a differential gear box fitted to its central frame. The gear box is connected to the conical gears mounted directly on the wheel axles by universal driving shafts. The car body rests on rubber pads on side brackets attached to the central bogie frame. The rubber pads permits the car body to make lateral movements and the bogie to turn by passing curves. The traction and braking forces between the bogies and the underframe are transformed by a rubberbushed rod not shown on figure 10. The wheel diameter is 670 mm.

The brakes are electro-pneumatically operated and of a self-adjusted hydraulic type with one block per wheel. The car is further equipped with a mechanical handbrake for parking.

Traction power is supplied by a Swedish direct injected diesel engine, Scania Vabis 815, 8 cylinders supercharged to give 205 HP at 1750 RPM for railway service. The engine is rubber mounted direct to the underframe in one end.

The radiator is situated below the floor and the fan is driven by an auxiliary shaft from the diesel engine.

The transmission consists of a hydraulic coupling Daimler 18", a five speed epicyclic Wilson gearbox R 11 B, a reversing unit, the differential gear box

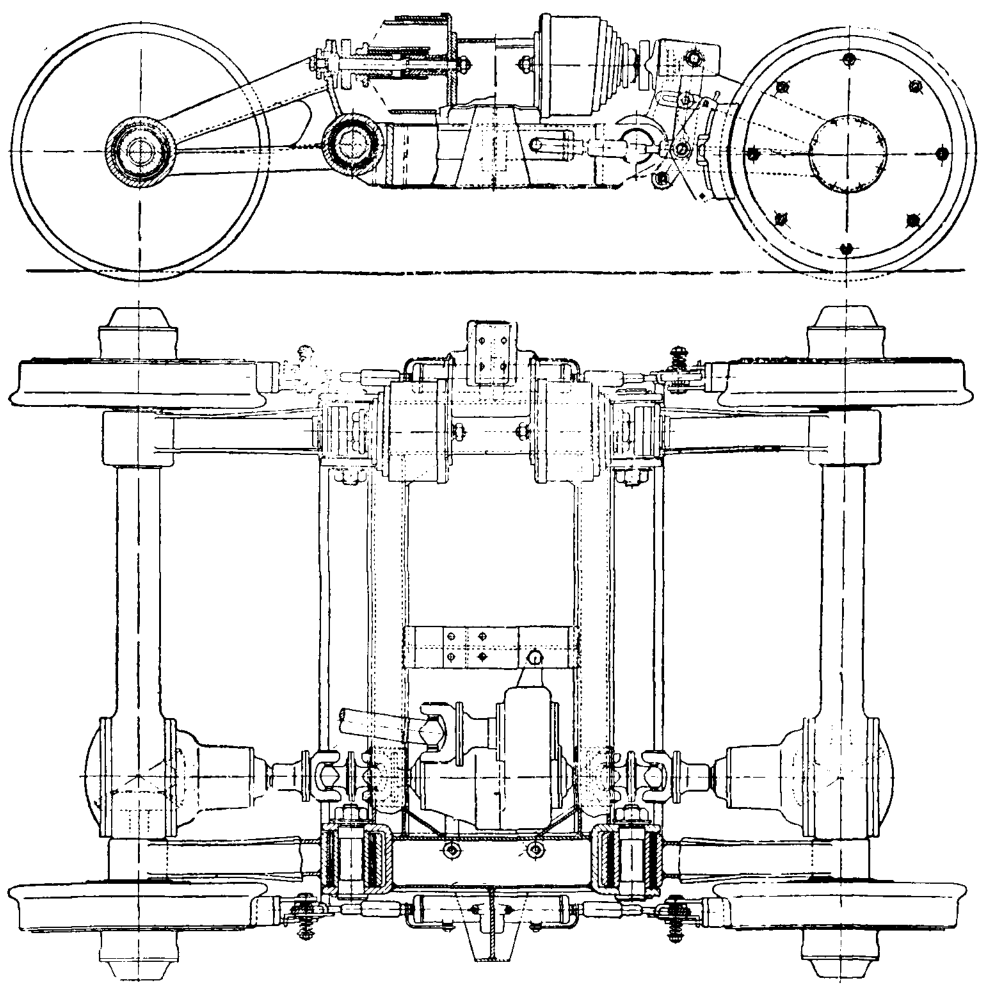


Fig 10. Principle drawings of driving bogie.

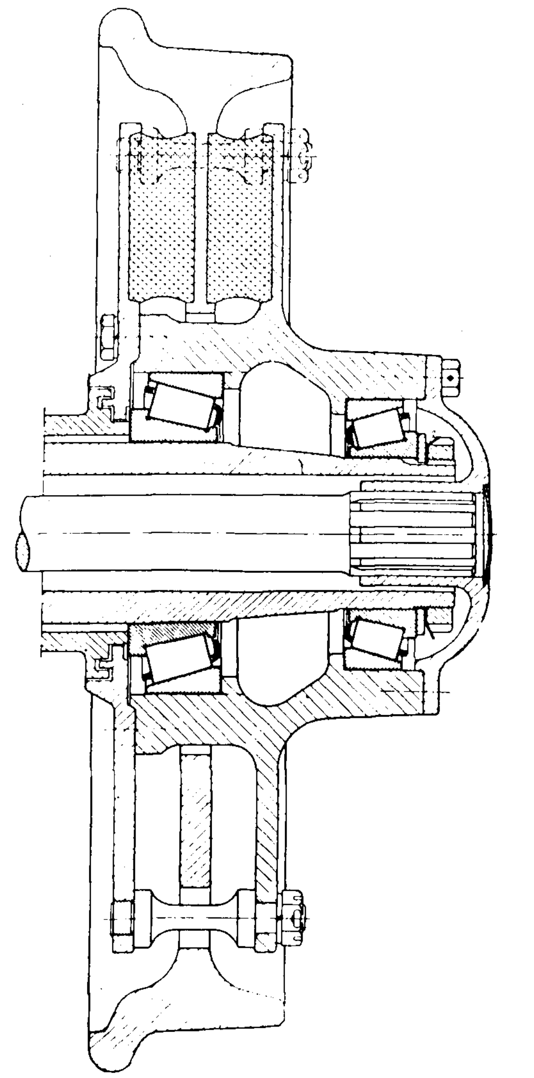


Fig. 11. SAB resilient wheel with SKF roller bearings.

mentioned above and the conical axle gears. See figure 5 and 10. The Wilson gear box and the reversing unit are operated by compressed air by means of E. P.-valves controlled from the driver's stands in both ends.

The air compressor Knorr V 70/155 is beltdriven from the engine. A 24 V 1600 W DC generator and an accumulator battery of 200 amp. hrs. capacity supplies power to the engine starter, lighting and signalling equipment, auxiliary heating fans sirens, sanding, door machines, electropneumatic control system etc. E. P.-valves, relays, switches etc. are easily accessible in the apparatus box in one of the driver's cabs as can be seen from figure 12.

The driver's controls are much simplified. The operations for accelerating, braking, and coasting are carried out by one handle, operating a master-controller of the drum type. The starting of the engine, gear changing, reversing, sanding, and blowing of the sirens

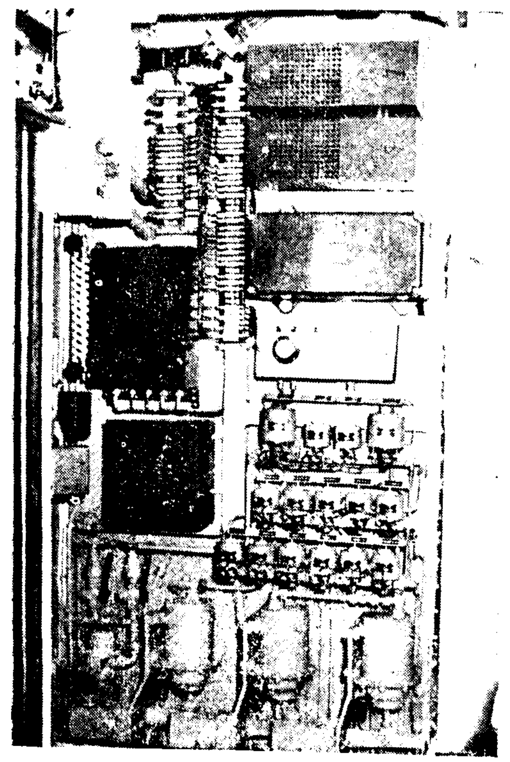


Fig. 12. Apparatus box in driver's cab.

can all be done through press-button switches situated on the driver's control-panel, which is further equipped with various indicator lamps and door locking switches. In view of the variations in the traffic intensities during the different hours of the day, the cars are so designed that any number up to 10 can be coupled together through automatic couplers and the whole train can be driven from any one of the very easily operated driver's controls.

The automatic couplers are of Scharfenberg type with built-in pneumatic connections. The car is in both ends provided with hand-operated junction boxes for control current.

The Swedish State Railways have also a great number of trailer cars in the same size as the engine cars, in multiple service generally coupled at a number corresponding to the proportions 3 : 2 or 2 : 1 between engine cars and trailer cars.

These trailer cars are arranged in the same way as the engine car described, i. e. with driver's cabs in both ends, or with half the car adapted to luggage space and with one driver's cab, or, finally, as combined luggage and post cars, without driver's cab.

The same type of cars, but with reduced breadth is used also on the narrow track lines with a track of 0,891 m.

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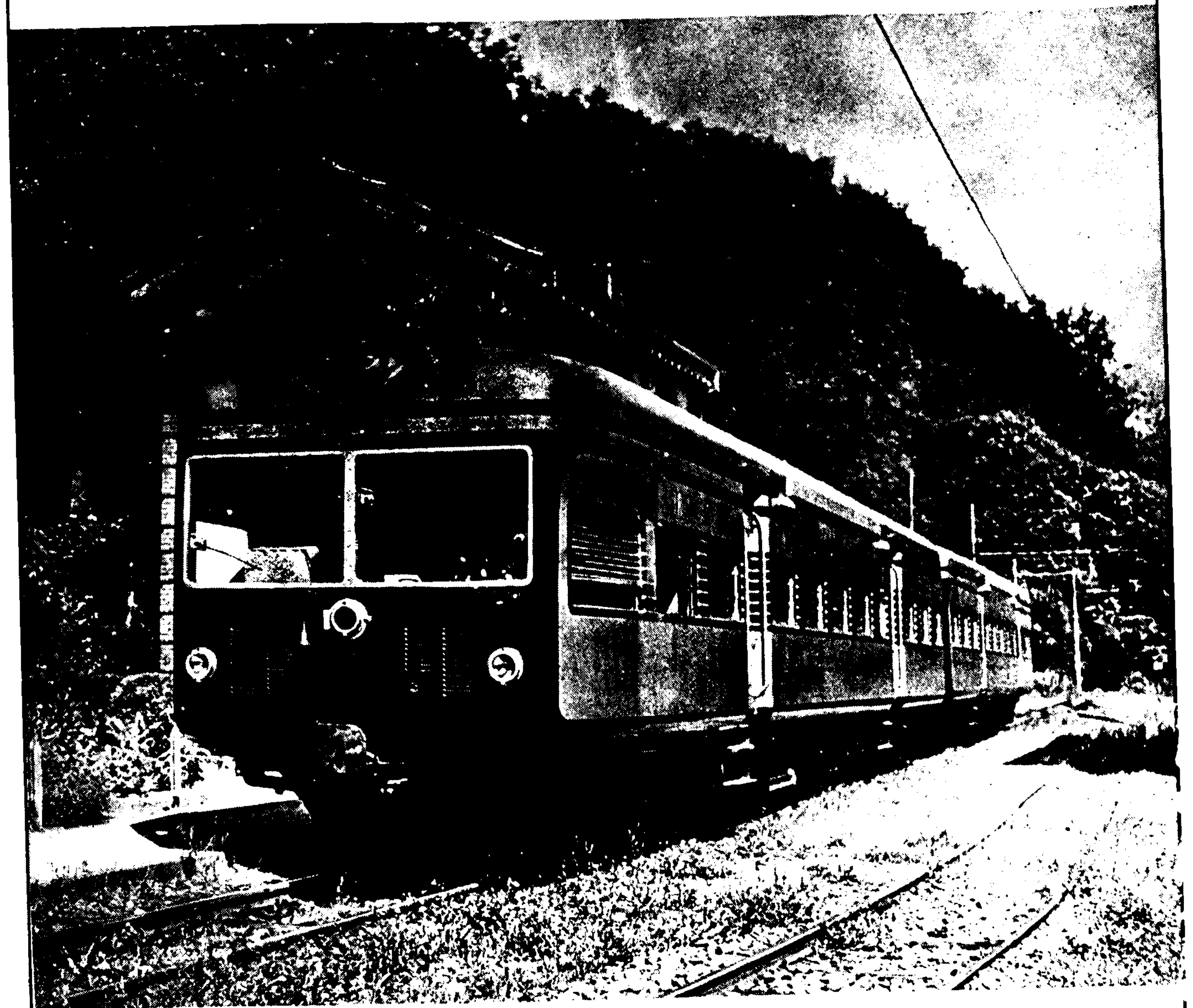

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