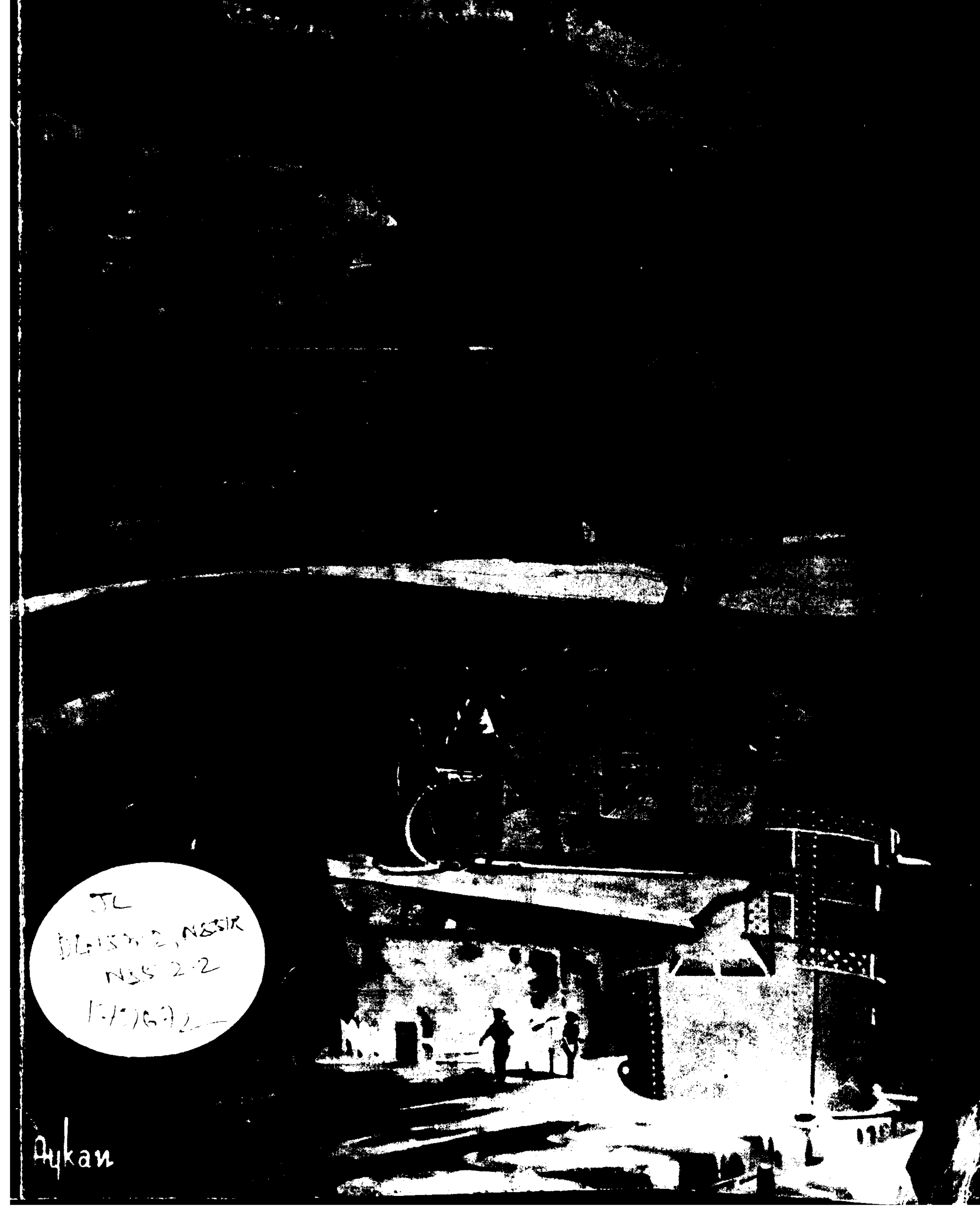
THE INDIAN RAILWAYS
WORKSHOP MAGAZINE



THE INDIAN RAILWAYS WORKSHOP MAGAZINE

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CONTENTS

ARCHDALE RADIAL DRILLING MACHINE FOR USE IN RAILWAY WORKSHOPS

The complete range of Archdale Radial Drilling Machines are used in considerable numbers in the Railway Workshops, but for the purpose of this article it has been decided to devote the attention to the Heavy Duty Radial Drilling machines with hydraulic pre-selection of speeds and feeds. These machines are built in eight sizes with a 5 ft., 7 ft., 8 ft., 9 ft., 10 ft., 11 ft. and 12 ft. radius.

Designed for heavy duty high speed drilling up to 3½" in mild steel, the machine has a wide range of speeds and feeds, for drilling, boring, reaming, facing and tapping operations. Both the speeds and feeds can be pre-selected whilst the machine is actually drilling which reduces to the minimum idle time between operations. The controls are conveniently placed low down on the saddle to relieve the operator of all arduous work when the arm is in the high position on the saddle.

The Machine is foolproof and cannot be damaged by incorrect use. Safety trips are provided to prevent over-traversing of the arm and the spindle. Moreover a special safety clutch stops the movement of the arm in either direction should any obstruction be encountered.

The speed and feed gears cannot be damaged by careless changing, as these changes are automatically effected. Clutches are provided to prevent overloading of the speed and feed drives. Should the motor which controls the locking mechanism be left running after the machine is fully locked, an electro-hydraulic locking device safeguards the locking mechanism against overload.

The machine is of the pillar-sleeve type, the sleeve being mounted on the pillar on ball and roller bearings. The sleeve is locked on the pillar by a conical ring, which moves in a vertical direction and thus prevents any displacement of the tool in the horizontal plane during locking.

The mechanism for locking the arm to the sleeve incorporates a long split bearing to obtain a secure lock. The locking or unlocking of the sleeve to the pillar and of the saddle on the arm is effected simultaneously by push-buttons in the centre of the transverse handwheel, controlling on electro-hydraulic motor.

The elevating arm is provided with a wide bearing face for supporting the saddle. A tensioned hardened steel strip on top of the guides on which the saddle traverses, minimises wear and maintains the original accuracy of traverse indefinitely. The arm is automatically locked to the sleeve upon release of the elevating switch lever on the saddle. This locking is independent of the simultaneous locking of the sleeve on the pillar and the saddle on the arm, and consequently the arm swings in the radial direction whilst it is locked to the sleeve. Vertical displacement of the tool during setting in the horizontal plane is eliminated and drilling with the arm unlocked is impossible.

When the elevating switch lever on the saddle is released the direction of rotation of the elevating screw is automatically reversed and the locking effected by a separate nut. The movement is automatically stopped when a full lock has been effected. Alternatively, when commencing to elevate the arm the special nut moves first, and unlocks the arm before the elevating nut comes into action. Should the elevating nut fail the arm will not drop as the special locking nut comes into operation and automatically locks the arm, which cannot then be lowered or raised until the elevating nut has been replaced by a new one.

The elevating nut is provided with an aperture to enable the wear of the thread to be checked.

The combined locking of the sleeve on the pillar and the saddle on the arm is effected by an electro-hydraulic device, which is fitted at the head of the column. The device is rapid in action, simple and free from trouble, and provides protection against over load.

Piping and consequently oil leaks are eliminated, as the oil pump piston motor and safety valves are carried in a totally enclosed housing. The locking or unlocking operates immediately the motor is started by the push-button control, the slightest pressure on the control button being sufficient to provide any degree of lock. Arrows on the base of the sleeve indicate the actual degree of lock and this is adjusted so that the sleeve can be locked on the pillar before the saddle on the arm, thereby permitting a slight movement of the saddle along the arm, whilst the radial movement is locked.

The required speeds and feeds are selected by turning two concentric direct reading dials on the saddle. The actual gear changes are not effective until the start and reverse lever is operated. This lever engages three actions in sequence :—

(1) The hydraulically operated gear change

(2) The delayed starting of rotation of the gears

(3) Engagement of the full drive

With this arrangement the pre-selected speed and feed is obtained whilst the motor is running, with ease and without clashing the gears.

By dialing 'O' the drilling spindle is set in neutral, and is free to be turned by hand for changing tools.

A multi-disc clutch is provided for smooth engagement and disengagement of the gears, to provide for sensitive control of the spindle, especially for tapping and rapid reverse. This clutch requires, no adjustment and is designed to pull smoothly and maintain its driving power under the severest test. A constant even pressure is compensated and distributed over the entire surface of the plates. When the clutch is disengaged the plates are separated by oil pressure and separately held on "Steps" so that opposite contact is eliminated.

Wide speed and feed ranges are provided, so that drilling, boring reaming, facing studding and tapping operations can be done. Fine boring as well as heavy drilling can be carried out and four automatic tapping feeds are available if required. The five feeds are available for boring work held in jigs and fixtures which is normally carried out on horizontal boring machines, a high degree of accuracy and surface finish being obtained. Particular care has been given to provide the low speeds frequently needed for boring. The twenty-two speeds and eighteen feeds available are as follows.

Speeds : 11, 14, 17, 22, 28, 35, 44, 55, 70, 90, 110, 140, 175, 220, 270, 350, 440, 560, 680, 880, 1100 and 1450 r. p. m.

Feeds : 8, 11, 14, 18, 25, 30, 36, 48, 62, 75, 100, 125, 160, 215, 270, 320, 425, 540 r. p. i. The Automatic tapping feeds are 8, 11, 14 and 18 r. p. i.

A precision depth trip is provided to ensure accurate drilling or facing of blind holes to the correct depth. The power feed is tripped by means of an integral dead stop which ensures a uniform accuracy of depth of hole without the necessity of other measuring devices. The required depth is set on a clearly graduated feed trip dial, which is provided with a micrometer screw the latter being adjusted after rapid setting of the dial.

The fine feed hand wheel is stationary when the power feed is in use. A lever adjacent to the fine feed handwheel engages either the hand or power feed.

Ease and rapidity of control are outstanding for a machine of this size. The controls are simple and few in number and are located close together on the lower face of the saddle. As the speeds and feeds are pre-selected whilst drilling is in progress, gear changing time is eliminated, and as spindle setting, reverse and gear change are effected without stopping the motor, no second control movement is necessary.

An Automatic brake quickly stops the spindle and prevents "Creeping". The free and easy action of all movable parts combined with the small area into which the controls are grouped, enables the operator to manipulate all movements of the machine from one convenient position which results in a remarkably high output rate without fatigue. All locks are obtained by finger-light pressure, and their ample rigidity is such as to ensure long tool life and also to safeguard against tool breakage. A tachometer is fitted which indicates the speed in use, and a circular scale enables the operator to find the appropriate speed and feed for different materials by direct reading.

In addition to a normal base plate the machine can be supplied with special bases to suit individual requirements. These include :—

(a) Small "Stub" base for operations where boilers or other bulky components have to be drilled, which can be accommodated in a pit adjacent to the base.

(b) Traverse base where it is necessary to drill large surfaces, the traverse of the machine on the slide is controlled from the saddle.

(c) Two-three or four-way bases to provide for continuous production whilst work is being drilled on the one base, other work may be set up or removed from the others.

The agents in India for James Archdale & Co. Ltd. are, Alfred Herbert (India) Ltd., Calcutta with branches at Bombay, Madras, Bangalore and Secunderabad.

AN ELECTRO-HYDRAULIC DROP HAMMER

By Obering W. Brauer, V.D.I.

ELECTRO-HYDRAULIC Drop Hammers were developed during the last War chiefly for use in the Aircraft Industry. They were principally engaged on sheet metal forming and shaping and had rather large table sizes. The maximum distance between the hammer legs was approx. 8' 2½" with a corresponding depth of 3' 11" and max. daylight of 5' 11". The tup weight of such a hammer was 4 tons.

Based on the experience thus gained an oil-hydraulic drop-hammer for die-forging was developed, see fig. 1. Its method of operation and control are quite different from sheet metal forming hammers. For the latter hammers relatively low speeds of 31½" to 39½" per second were sufficient and the drop height was comparatively small, and considerably less than required for drop-forging hammers, for which the speed must be much higher in order to allow for rapid blows.

Tup weight for tup weight the energy required for drop-forging is very much greater than for sheet forming and the demands made on a drop-hammer are considerably stronger.

The basic design principles of the electro-hydraulic hammer are similar to a steam or compressed-air drop stamp, i. e. the tup is lifted by the movement of a piston inside a cylinder and connected by a piston rod. In our case the pressure medium is oil. The diameter of the piston could, however, be kept much smaller by selecting a higher specific pressure and therefore the piston-rod itself could also be reduced to a minimum diameter.

The whole drive is mounted together in one enclosed unit containing the electric

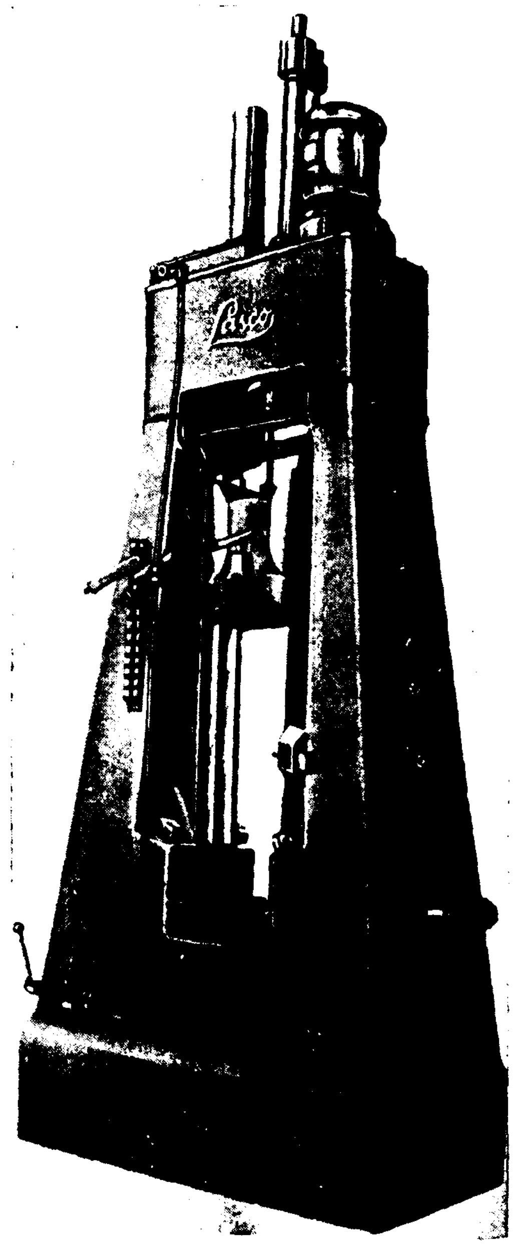


Fig. 1. Electro-oil-hydraulic Drop Forging Hammer with separate V V-guides.

motor and the direct-driven oil pump. The cylinder pipe, all valves and sleeves are

contained in one casting, see fig. 2. The design also permitted to do without all pipes and pipe connections, as it is a known fact that pipe connections do not stand up to the frequent shocks of a drop hammer. Only one aperture for the piston-rod exists in the top plate and all components are fitted from above so that the danger of leakages is completely eliminated. A simple but robust packing is provided for the emerging of the

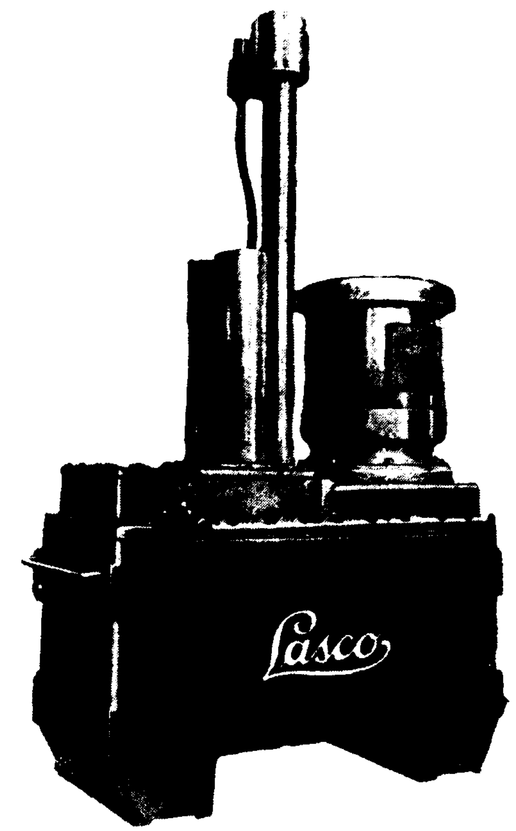


Fig. 2. Completely fitted hammer head.

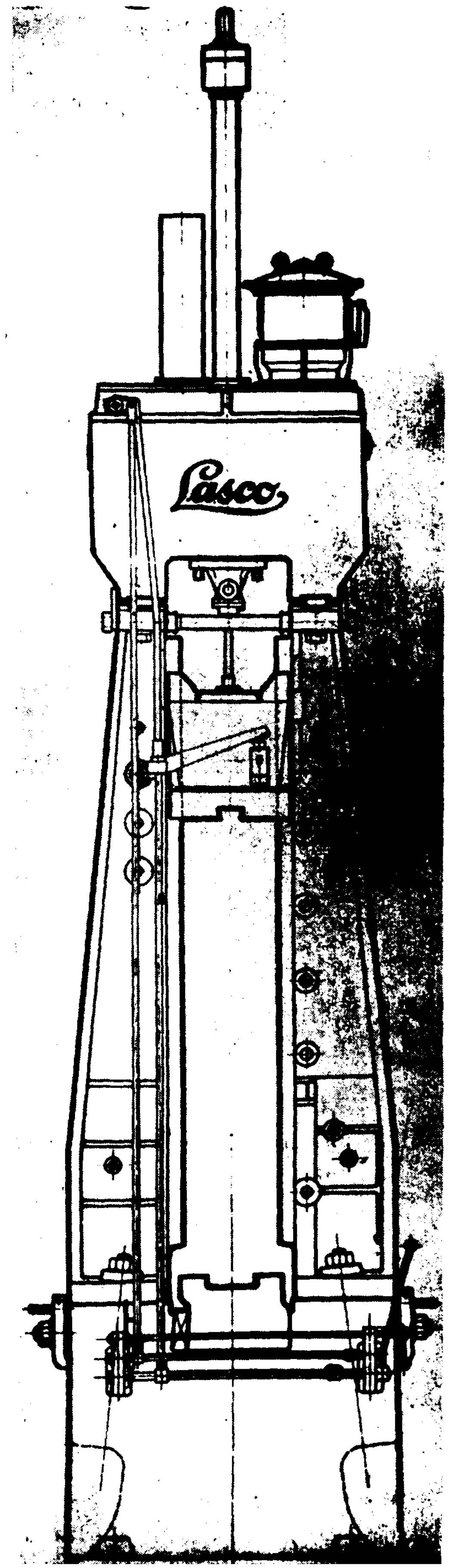
piston-rod and will last a very long time. In the unlikely event of a rod breaking, it can be replaced easily and quickly by a new rod without letting the oil run out. An actual test has shown that a piston-rod can be changed is less than 30 minutes from stopping the motor and starting up again.

A number of reasons existed to select an oil-hydraulic drive. One of the chief reasons was the exceptionally efficiency of the pump, which was specially designed for this application, rather than rely on existing proprietary pumps. Such pumps with infinitely variable delivery, and suitable for a large output at high pressures were too large to be fitted into the driving head and it is doubtful if they would have been reliable enough bearing in mind the rapidly changing and substantial variations in pressure.

The lifting speed obtained by the oil-hydraulic drive is approx. 11' 6" per second. In view of this high speed special provision had to be made to store the oil temporarily during the process of acceleration instead of letting it blow off through safety valves. The lifting speed cannot be uniform over the whole stroke bearing in mind acceleration and deceleration. It reaches temporarily a speed which is considerably higher than calculated from the quantity of oil involved and piston area. This in turn has made it possible to avoid the chief disadvantage of all friction hammers, i. e. loss of energy during acceleration; on the contrary, it was possible to increase the speed of the tup and thereby the number of blows per minute.

The lifting speed of belt—or board hammers is normally limited, as too great a speed will cause excessive wear and heating up of the driving gear which will render the functioning of the hammer uneconomical. In the case of the oil-hydraulic hammer the opposite applies, in fact it is even necessary to brake the rapidly rising tup by means of an air column in the cylinder above the piston, as otherwise the tup could not be stopped quickly enough after the oil feed has been switched off. As an example, a tup rising at a speed of 11' 6" per second would require a distance of approx. 24½" to come to rest, ignoring friction of losses, which are very low in view of the comparatively large clearances between tup and guides at the top and the thorough lubrication of piston and piston rod. This air cushion above the piston acts also as an accelerator at the commencement of the

Right: *Fig. 3. A Board Drop Hammer converted into an electro-hydraulic Hammer.*



down stroke by gravity and increases the speed and energy of the blow.

Doubts were raised by experts that in view of the high dropping speed the oil could only leave the cylinder with great losses. Investigations were therefore made on the test bed at Coburg by the Investigating Branch Dept. Drop Forging, Hannover (Director Prof. Kienzle). The result was exceptionally favourable. The average impact speed was only 5% less than the theoretical maximum for a completely free drop. These 5% include the loss caused through friction between tup and guides. During these tests the top of the cylinder was left open in order to eliminate any possible assistance of the air cushion, above the piston.

In practice, the actual impact speed assisted by the air cushion is greater than pure gravity speed. This has been proved by actual experience in all cases where existing board or belt hammers were converted by the fitting of an oil-hydraulic driving head (see figs. 3 and 4). In these hammers anvil block and uprights remained unchanged. With identical drop height and tup weight a greater number of blows could be obtained together with a measurable increase of the strength of the blow so that the saving in stamping time amounted to 20% to 30% and even 50% in special cases.

A further reason for the high impact speed is the automatic reversing at the bottom of the stroke, without using stops or other mechanical means.

The movement of the tup is reversed merely by the oil which comes to a full stop, i. e. its flow is fully arrested, as soon as the tup strikes. Therefore, the reversing can never occur prematurely and no excessive stresses can be set up in the hydraulic control or in the piston rod or in the connection between tup and rod. The reversing takes place irrespective of the height of the dies. It is a very import factor in the contribution to the great reliability of this type of hammer that the operator has no possibility to influence the setting!

The time during which upper and lower die are in contact with each other is therefore extremely short, which is of greatest benefit for reduced die wear.

The ability to control a hammer accurately and quickly is of importance for its efficient use, and a "one-man one-lever" control is provided. In order to obtain a blow of maximum strength and maximum stroke the single foot-pedal is pressed down sharply and released. The tup will drop instantaneously and revert automatically to its top position against a ratchet lever which is adjustable.

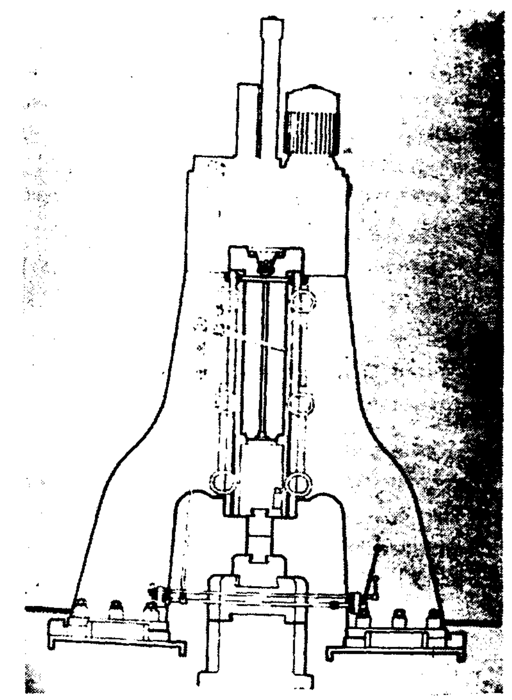


Fig. 4. A Steam Hammer converted into an electro-hydraulic Drop Hammer.

For short stroke blows the pedal is pressed down gently which causes the tup to drop slowly. The pedal can either be kept in the required position so that the tup will stop, or alternatively it can be kicked through where-upon the tup will accelerate rapidly, strike and return to starting position. If further short blows are wanted, the pedal can be operated again whilst the tup is lifting. This will cause the tup to drop again from any required position.

Furthermore, if a workpiece has to be cut off the bar after forging the tup need only be lifted a few inches and can drop again gently to separate the forging from the bar. In all cases the tup always returns immediately to its top position after the foot is taken off the pedal.

If a forging requires to be straightened after trimming it can be put back into the hammer die and the tup can be brought down slowly until it comes to rest on the forging without making a blow strong enough to cause a further small flash which may be difficult to remove subsequently except by grinding.

As the process of drop-forging is not everywhere the same and different demands are made on a hammer a different control can be supplied on request which is automatic, similar to the modern board-hammer. With this type of control the tup will move up and down rapidly and continuously as long as the operator keeps his foot on the lever. When the foot is removed the tup will return automatically to its top position and stay at rest until the pedal is pushed down again. The foot pedal need not be fixed but can be moved along the floor, being connected to the control mechanism by a flexible pipe.

The hydraulic control is very easy to operate and saves the hammer operator from fatigue. It also renders a second man unnecessary as the whole range of performance is within easy reach of one man alone.

An additional hand lever is provided which acts directly on the main control shaft and which will be useful for the careful and sensitive handling and adjusting of the tup when changing dies. The tup can thus be raised and lowered slowly and accurately for die-setting and additional outside lifting gear is not required.

DISCUSSION

The discussion which followed the lecture brought to light several interesting points which are briefly mentioned below and which could be supplemented subsequently.

The largest tup weight was stated as 50 cwt but can be increased to 5 tons and more.

Regarding the control lay-out it was pointed out that the first sheet metal forming hammers as used in the Aircraft Industry were provided with electric push-button control which was adjustable as to height, so that by merely pressing a button by hand or foot continuous blows could be given from any height.

The number of blows of oil-hydraulic hammers is very high due to the very great lifting speed and down-stroke acceleration through the air cushion. 40 to 60 blows over the full length of stroke have been obtained for larger hammers, whilst smaller hammers have given 80 to 110 short stroke blows/minute.

Energy consumption is low due to the very efficient working of the pumb which is between 0.8 and 0.85. A 20 cwt Hammer has a 22 kw motor but its actual energy requirements are only between 13 and 15 kw. The energy required by comparable hammer size driven by compressed air is considerably higher, by several multiples.

Another question raised the problem of impact speed, i. e. losses caused by the oil column. The favourable result could only be achieved by adopting a design which corresponded less to the principles of oil pressure control, but more to the principles of oil flow which apply to the high speeds which are obtained.

The question is existing hammers could be fitted with the oil-hydraulic drive could be answered in the affirmative. Figs. 4 and 5 show conversions of old-type drop-hammers.

The smallest tup weight for which hydraulic drive is economical is normally 16 cwt, although smaller hammers of 10 cwt capacity have been built.

PAKISTANI RAIL CONTRACT FOR SCOTTISH FIRM

The oldest Scottish firm of railway-wagon builders—R.Y. Pickering and Company, of Wishaw, Lanarkshrie—has received an order from Pakistan for the construction of 1,100 covered railway wagons, the total cost of which is £ 1,500,000.

Delivery of the wagons is to begin towards the end of 1956 and is expected to be completed about seven months later.

HERBERT MACHINE TOOLS FOR RAILWAY WORKSHOPS

THE Herbert organisation was established in the year 1889 at Coventry, England, and began with the manufacture of simple hand lathes and drilling machines. Later a considerable number of machines were made for the repetition production of cycle components.

Gradually the hand lathes were developed into capstan lathes and the ultimate adoption of travelling saddles and chasing attachments laid the foundation of the now famous Herbert No 4.

Most companies grow from the creative ideas of one man and the Herbert organisation is no exception. Throughout the past 60 years the company has enjoyed a continuous growth and development due to the creative genius and leadership of its founder Sir Alfred Herbert K. B. E. Today it is the largest machine-tool organisation in the world and includes four factories having a total floor area of 29 acres and employing over 5,700 workers.

The Herbert manufacturing programme covers an extremely wide range of machines which can be grouped as follows:—

Capstan Lathes, seven sizes for bar work up to 2" diameter, and chuck work up to 15½" swing.

Combination Turret Lathes, five sizes from 16" to 36" swing.

Hexagon Turret Lathes, two sizes, 2" and 3" bar capacity.

Carbitracer, for the copy turning of shafts up to 6" diameter and 48" in length.

Auto Lathes, four sizes from 8½" to 25" swing.

Vertical Milling Machines, three sizes, 48" × 16" × 23"; 62" × 29" × 28½"; 62" × 29" × 30½".

All-electric Drilling Machines for holes from the very smallest up to 1¼" diameter.

A comprehensive range of engineers small tools is made including Coventry Dieheads and Dies, Tangic Dieheads, Tangel & Tangar Dieheads, Coventry Chucks, Herbert Air-and Electric Chucks, Coventry Quick-change Drilling Chucks, Ground Thread Taps, Ground Thread Rolling Dies, Coventry Adjustable Reamers, Ardoloy-tipped Tools, Hypercut Lathe & Planer Tools and Coventry Gear Pumps and Fittings.

A further branch of the business is the manufacture of the Atritor-Dryer Pulveriser, a machine for drying and grinding in one operation, coal, clay, chalk, limestone, sewage sludge, gypsum and other sticky materials. The Atritor can be applied to the firing of boilers, metallurgical furnaces and kilns for cement and lime manufacture.

Alfred Herbert Ltd. have eight branch offices in Great Britain, associate companies in India, Australia, France, Italy and Argentina, and agents in forty-four other countries throughout the world.

They are also agents for the leading British, American and Continental machine-tool makers.

The Indian Company, Alfred Herbert (India) Ltd., is the finest organisation of its kind in the East. The head office is in Calcutta where spacious showrooms afford ample opportunity for visitors to see the latest types of Herbert and Factored machine tools. There are also branch offices in Bombay and Madras and a resident representative in Southern India.

In addition to acting as sole agents for the sale of Herbert products they represent many leading British and American machine-tool makers.

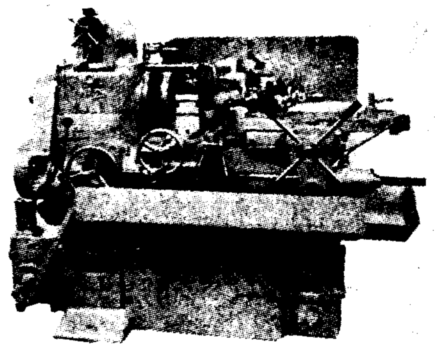


Fig. 1. Herbert No. 2D Capstan Lathe for bar work up to 1½" diameter and chuck work up to 9" swing.

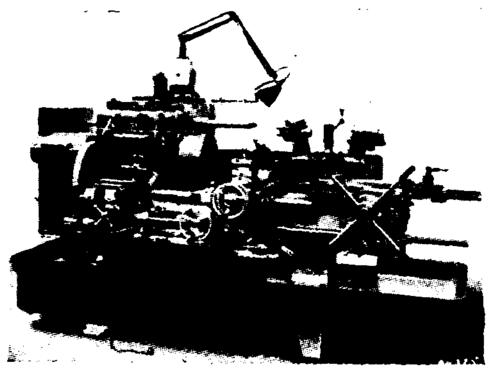


Fig. 2. Herbert No. 4 Senior Preoptive Capstan Lathe for bar work up to 2" dia. and chuck work up to 15½" swing. Power-operated speed changes are instantaneous and may be made while the tools are cutting.

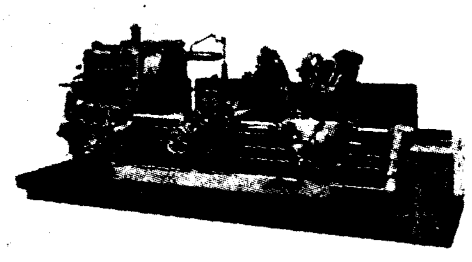


Fig. 3. Herbert No. 8 Preoptive Combination Turret Lathe for chuck work up to 20" swing. Fitted with independent feed shafts to saddle and turret slide.

Right: Fig. 6. Herbert No. 28A Vertical Milling Machine, a powerful machine for the heaviest classes of milling including negative rake carbide milling. Capacity: 62" x 29" x 30½"

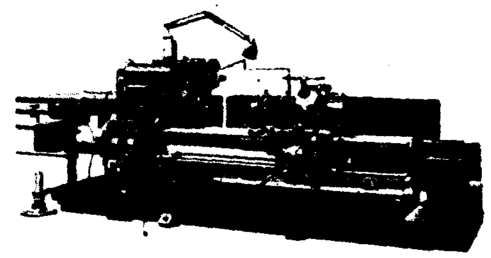


Fig. 4. Herbert No. 3 Hexagon Turret Lathe specially designed for bar work up to 3" diameter and 38" long. Preoptive headstock eliminates time lost due to frequent speed changing from high speeds for turning low speeds for threading.

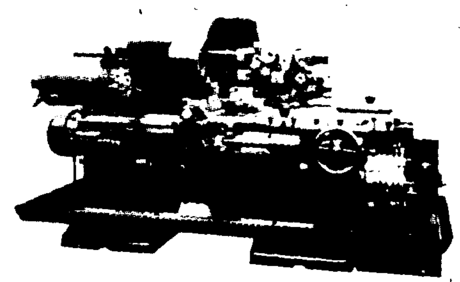
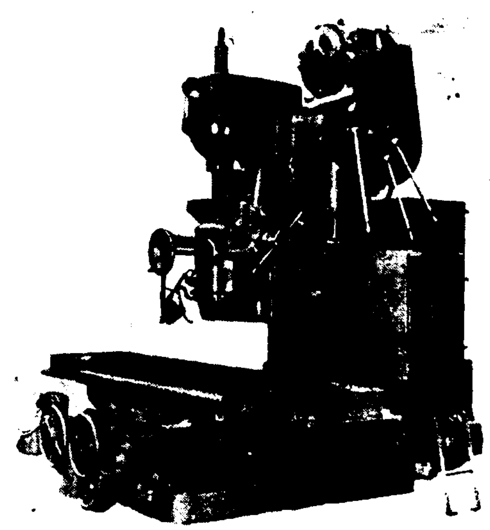


Fig. 5. Herbert No. 4 Auto Lathe, a high-speed automatic chucking machine for continuous high Production. Maximum swing: 16½" diameter.



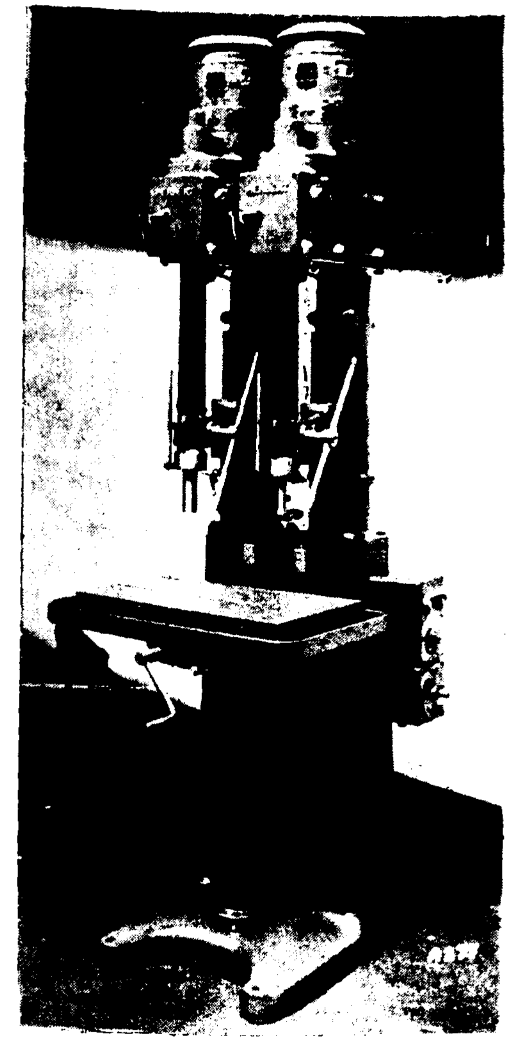


Fig. 7. Herbert Type C all-electric two-spindle drilling machine.

Unit construction of these machines enables a wide range of customers needs to be met simply by assembling various combinations of standard units to form a complete machine.

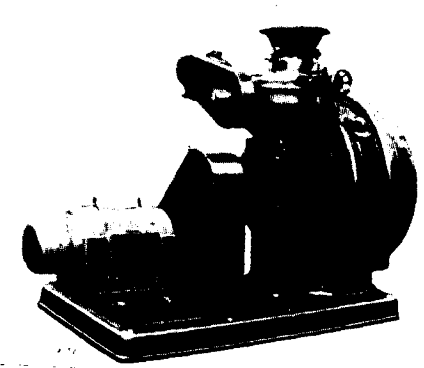


Fig. 9. Large numbers of Herbert Capstan Lathes are used in the brass shop of the British Railways works at Derby.

Fig. 10. Three Herbert Vertical Milling Machines installed in the Horwich works of British Railways.

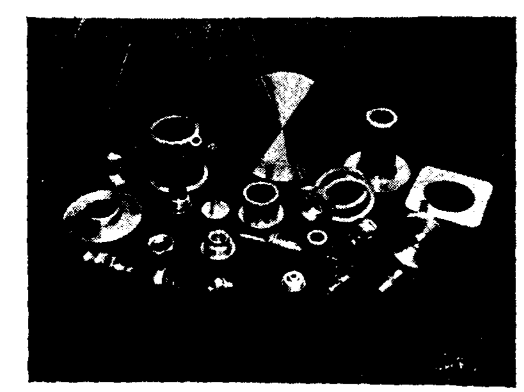


Fig. 11. Typical examples of the work dealt with on Herbert Capstan Lathes at the Derby works of British Railways.

Left: Fig. 8. Atritor Dryer-pulveriser. Grinds and dries in one operation, coal, clay, chalk, limestone, sewage sludge, gypsum and other sticky materials. Ideal for firing boilers and furnaces.

Workshop-trained production engineers and specialists in various machining operations are employed so that an efficient advisory service on all such problems can be given. Machines are offered complete with necessary tools and fixtures.

The territory covered by Alfred Herbert (India) Ltd. includes India, Ceylon, Burma, Siam, Federation of Malaya, Colony of Singapore, British North Borneo, Sarawak and Brunei.

When Herbert Capstan and Turret Lathes were first introduced over 60 years ago, railway engineers were the amongst the first to recognise their great advantages and have continued to install them as new and improved designs have been evolved. The following examples are typical of the work done on Herbert lathes installed in railway workshops throughout the world.

Fig. 12 shows a Herbert No. 2S Capstan Lathe set-up for machining fire-box fusible

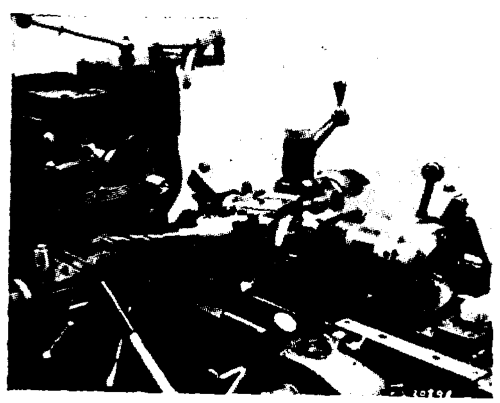


Fig. 12. Herbert No. 2S Capstan Lathe, set-up for machining fire-box fusible plugs from brass castings in a total time of 1 minute each.

plugs from brass castings in a total time of 1 minute each.

The casting is gripped on its square end in a Herbert 6" Air Chuck fitted with special hard jaws. The sequence of operations is as follows:—

1. Start drill, form the 60° angle and turn 15/16" diameter with tools held in a combined toolholder.
2. Drill 27/64" diameter hole.
3. Face the end and form the 5/32" wide recess with tools held in the square turret.
4. Turn external taper with tool held in a special taper turning slide.
5. Thread taper using a Coventry 1½" Taper Threading Diehead (Thread Form is at 90° to the taper)
6. Tap ½" Whitworth Thread.

The tooling arrangement shown in Fig. 13 is for machining Stay and rivet bushes from

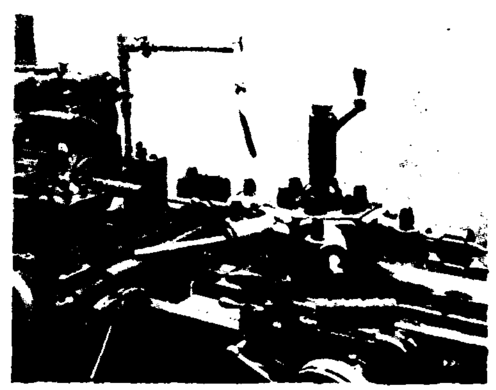


Fig. 13. Tooling arrangement on a Herbert No. 4 Senior Capstan Lathe for producing Stay & Rivet bushes from reeled mild-steel bar.

The total time per length of five bushes is 23 minutes.

reeled mild-steel bar. The machine is a Herbert No. 4 Senior Capstan Lathe fitted with a hand-operated dead length bar chuck and automatic bar feed.

1. Feed out the bar to the stop.
2. Start drill with a 13/16" diameter twist drill.
3. Drill, using a patent straight flute drill having an internal coolant supply.
4. Cone the mouth of the bore with a special coning reamer.

The component is then supported by a revolving centre while the following operations are performed from the saddle.

5. Form the five 1.3/16" diameter grooves with a grooving tool held in the rear tool post.
6. Form the five taper diameters using a form tool held on the first face of the square turret.
7. Chamfer the back and front of the taper diameters with a tool held on the second face of the square turret.
8. Chase the five taper threads using a chaser held in the square turret in conjunction with the taper turning attachment and the leader control.

The operation is completed by parting off the five bushes with a tool held on the fourth face of the square turret. The total time per length of five bushes is 23 minutes.

Fig. 14 shows a Herbert No. 2 Hexagon Turret Lathe used for machining Sling and Crown Stays from mild-steel hexagon bar,

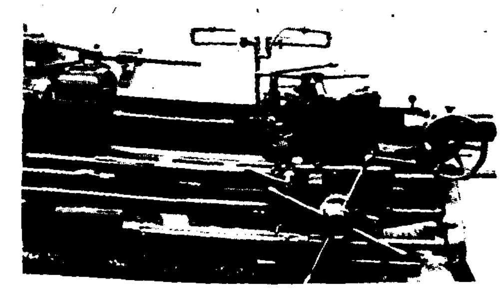


Fig. 14. Sling of Crown stays are machined from mild-steel hexagon bar on a Herbert No. 2 Hexagon Turret Lathe.

1¾" across flats, in two operations. The machine is equipped with a 2" capacity double-toggle bar chuck but for the second operation a Coventry 9" three-jaw chuck is required. This is fitted with a special adapter and gripped in the bar chuck.

1ST OPERATION

1. Feed out bar to an adjustable stop in a triple tool holder on the first turret face.
2. Centre end with a roller-steady centring tool held in the triple tool holder.
3. Start turn to 1.21/64" diameter using a step turning tool fitted with a dead centre.
4. Turn 1.21/64" diameter up to the head of the stay with a Chipstream Boxtool.
5. Dig in and turn the taper waist diameter, feeding away from the chuck with a special roller-steady taper turning tool.
6. Turn the parallel waist diameter, feeding away from the chuck with a roller-steady turning tool.
7. Break the corners of the hexagon bar at the back of the head with a parting-off tool, form a chamfer at the back of the head and complete the parting off. Both tools are held in a cut off slide on the second face of the turret.

2ND OPERATION

The component is gripped on the hexagon head in the Coventry chuck, previously mentioned.

1. Start turn the 1" thread diameter and form the end with a roller-steady ending tool held in the triple toolholder.
2. Turn the 1" thread diameter with a chipstream boxtool.
3. Turn the taper thread diameter and chamfer the hexagon head with a special roller-steady taper turning tool.

4. Cut the 11 T.P.I. taper thread and the 1"—11 T.P.I. parallel thread simultaneously, using 1½" taper threading diehead mounted in the bore of 2nd turret face and a 1½" CH Diehead held in the long stay attachment.

The total time taken was 9½ minutes for the first operation and 4¼" minutes for the second operation.

Fig. 15 shows an interesting method of producing piston valve head rings from an iron casting. The machine is a Herbert

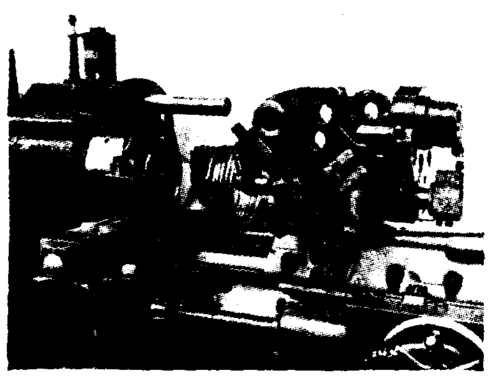


Fig. 15. Herbert No. 4 Auto Lathe, fitted with a Herbert 15" electrically-operated chuck, set up for producing piston valve head rings from an iron casting.

No. 4 Auto Lathe fitted with a Herbert 15" electrically-operated chuck, the sequence of operations being as follows :

1. Rough turn the 10" diameter and rough bore the 8¾" and 9" diameters.

2. Finish bore the 9" diameter and finish turn the 10" diameter.

3. Chamfer the inside corners of the rings and rough face the end using tools mounted on a slide facing toolholder operated by a pusher on the front cross slide.

3A At the same time as 3 finish the end face.

4. "Catcher" moves forward into the bore.

4A At the same time as (4) part-off the rings with tools held on the rear cross slide.

In this way six rings are produced for one cycle of the turret the total time taken including chucking being 16 minutes.

A good example of the use of Ardoloy Tools in the railway workshop is shown in Fig. 16.

Fig. 16. Machining a cast-steel bogie centre on a Herbert No. 28V Vertical Milling Machine.

The operation testifies to the rigidity of the machine on heavy work and the finish obtained, using Ardoloy-tipped cutters, is of a better standard than that of corresponding work machined with high-speed tools.

The machine is a Herbert No. 28V Vertical Milling Machine, the component a cast-steel bogie centre.

The overall size of this casting is 5' 4" × 4' 7" and it is necessary to reset the casting on the machine table for machining each surface.

Four surfaces are machined having a total area of 696 sq. ins. The stock removal on each surface is approximately 5/16" and despite its outsize in dimensions and weight the component was handled on this machine in characteristic style.

The operation testified to the rigidity of the machine on heavy work and the finish obtained using Ardoloy-tipped cutters is of a

(Continued on page 17)

The use of Mechanical Plant for Foundation Installation on Railway Electrification Projects

In every branch of British industry the constant objective is greater efficiency, particularly in those cases where the introduction of mechanical aids can assist in heavy manual labour. One sphere of operation in which there has been a great need for such aids is in the installation of foundations for railway electrification supporting structures.

Foundation work has always presented a problem to the Railway Electrification Engineer, due mainly to the fact that working space and track occupation periods are usually very restricted. In consequence the operation, close to the railway tracks, of standard types of mechanical plant, has been virtually impracticable, with the result that for many years the pick and shovel, powered by strong arms, have had no rivals.

Put very simply, the construction of track structure foundations consists of two operations—namely, removing earth to a certain depth, and replacing it with concrete. Nevertheless, without mechanical aids these two comparatively simply operations can become laborious and costly.

With a view to overcoming this important problem, and at the same time speeding up the rate of working, British Insulated Callender's Construction Company have designed special equipment, which is now being used for the first time on the contract for the electrification of the line between Shenfield, Chelmsford and Southend in Essex, on the Eastern Region of British Railways.

Previously, the holes for the foundations of overhead structures for electrification have been excavated by hand, concrete materials being dumped and mixed on site. The erection of the masts and grouting in have been separate operations which necessitated later visits to the site.

The equipment which is now being used makes it possible for all operations to be performed in sequence during one visit. A hole is bored in the ground by a mechanical auger, a temporary ground frame is placed over the hole and the mast is erected in the ground frame. Concrete, mixed on train, is then poured into the foundation hole and the sequence of operations is complete. In this way a construction unit will enter a section of line on which no work has hitherto been done and in four or five hours will leave, having completed all the foundations and erected all the masts on one side of one mile of track.

The construction unit consists of three separate parts—the first part contains the

(Continued from page 16)

better standard than that of corresponding work machined with high-speed tools.

The success of the Herbert organisation is largely due to the efficient service available both before and after sales.

Workshop-trained production engineers give advice on machines, tooling equipment and methods for the most economical production of any desired work.

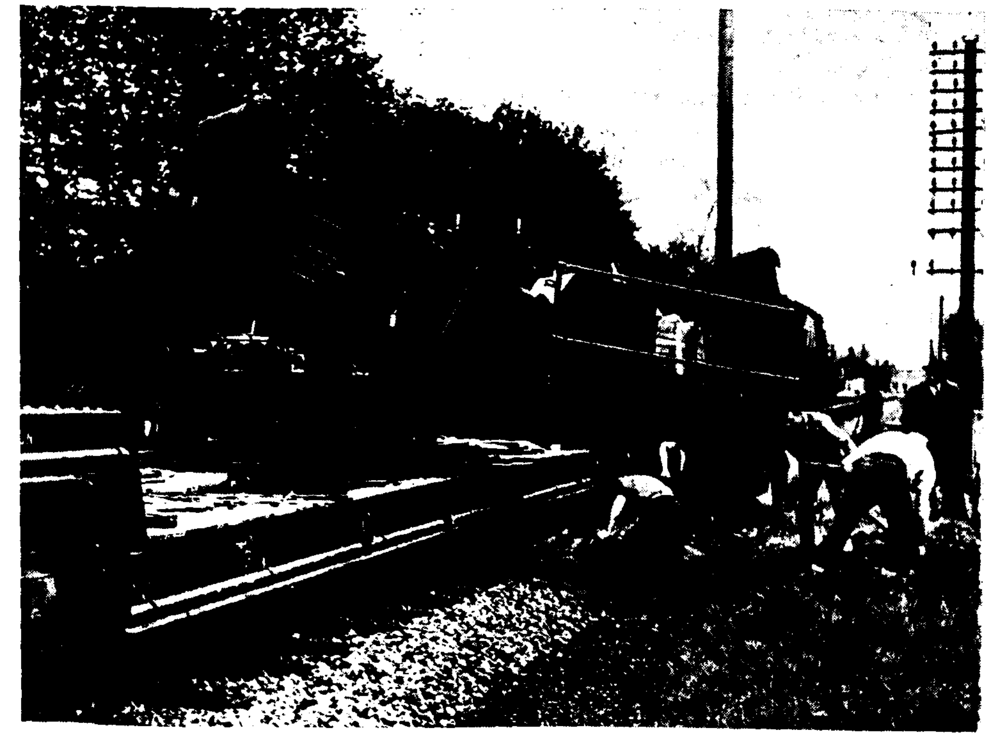
The most suitable machines are offered with all necessary tools and fixtures and reliable estimates of production are given.

Demonstrators attend customers works to give assistance and advice to operators and service engineers call periodically to ensure satisfactory results.

An efficient and prompt spare parts service is also available.

Mixing and placing unit pouring concrete round steel core former.

Concrete mixing and placing unit. General assembly. Cement and aggregate trucks fore and aft of concrete mixing and placing unit. Diesel electric power plant opposite second mast.



Auger operating at normal boring distance from rail.

earth-boring unit which proceeds to bore the holes as required, temporary ground frames being placed over the excavated holes. This is followed by the steel-work erection unit drawn by a self-propelled steam crane which lifts the masts into the excavations where they are held in the steel ground frames at their correct position and height. The third part is the concreting unit which fills the excavations.

The earth-boring unit consists of a boring head driven by a diesel engine, all mounted on a railway wagon. The unit can be made to travel along its own truck, to rotate about its axis, to traverse in an across-track direction, to be raised or lowered and to be adjusted to the vertical for any cant of track. In this way the unit can be quickly and accurately positioned. Holes measuring from 2 ft. to 3 ft. 6 ins. in diameter can be bored and the maximum depth of bore is 12 ft These holes can be bored up to a distance of 13 ft. 6 ins. from the centre line of the track. As far as is known, no other augering unit has embodied all these features.

The concreting unit, also mounted on a railway wagon, is made up of two electrically-driven mixers, each embodying a weigh batcher. Between the mixers is a specially designed placer unit which is electro-hydraulically operated. A telescopic jib enables the concrete, which is taken from each mixer in turn, to be placed in the hole. Power for driving the concreting unit is obtained from a diesel-electric set mounted on another wagon. This same wagon carries pumps for delivering water to the mixers and a rotary compressor for operating concrete vibrators and other tools.

The successful operation of this new equipment can only be obtained by close co-operation with the Railway authorities, and careful planning of site activities. Results to date indicate that the work is proceeding smoothly, at a considerably higher rate, and more economically than ever before.

SPECIAL PLANING MACHINES FOR RAILS

THE use of rails with a high manganese content of about 12%—14% is greatly increasing, owing to their superior wearing qualities, which easily offset the greater first cost, as compared to standard rails. However, the machining of this class of steel is a difficult problem and the Railways and commercial manufacturers of points, crossings and switches have had to look to the machine tool makers to provide machines with rigidity and power considerably in excess of the capabilities of the machines at present is use for dealing with normal steels.

Two machines recently produced by the Scottish Machine Tool Corporation, Ltd. of Glasgow, Scotland, as part of their well-known range of LOUDON Planing Machines, may be of interest as illustrating the present trends in the construction of these machines.

Fig. 1 illustrates one of a batch of 4'—wide × 26'—table length machines recently sent to a Railway system abroad for use in their Permanent Way Workshops. These machines have a Ward-Leonard motor-generator type of drive, the actual machine driving motor

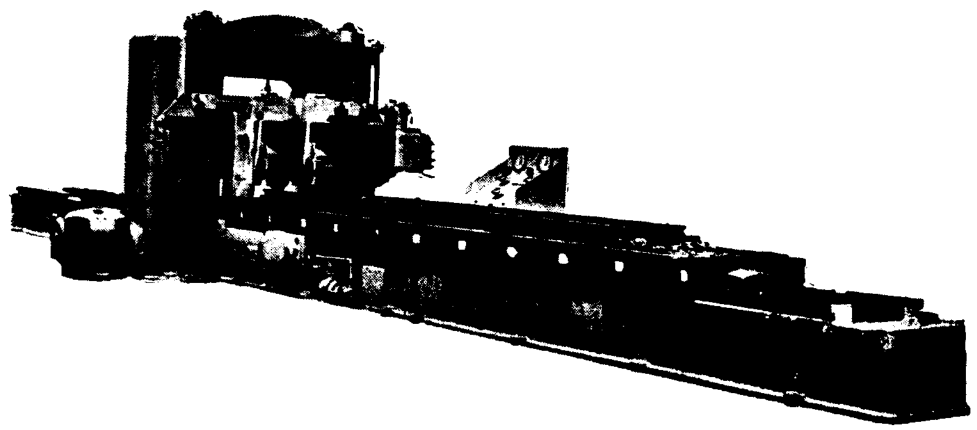


Fig. 1

being rated at 75 h.p. and the a.c. motor for the generator and exciter at about 15% above this figure. This arrangement gives a speed range of from 27.5 to 220 feet per minute, with return speeds up to 220 f.p.m., whilst a change gear is provided, giving a further range of cutting speeds from 12 to 96 f.p.m. with a corresponding return speed of up to 96 f.p.m. Electronic feed gear is used allowing infinitely variable feeds of 1/64" to 1/2" for the cross feed and 1/100" to 1/3" for the down feed.

The table of the machine is intended to take two rails abreast and a detachable canting table is supplied 18' — long × 3' — wide. It is capable of a maximum taper of 1 in 32.

This length of machine is for switch work, although by the use of fixtures a great variety of operations is possible. However, where points and crossings will predominate, the planer is made with 12' — stroke. In this case, the canting table is 7' — long and has a maximum taper of 1 in 4.

The great power and rigidity of this model will enable it to give a fine output, but for certain depots where it is required to accommodate four rails abreast, a 5' 4" wide machine is indicated with 100 h.p. driving motor.

Another type of machine, as recently supplied to one of the leading steel makers

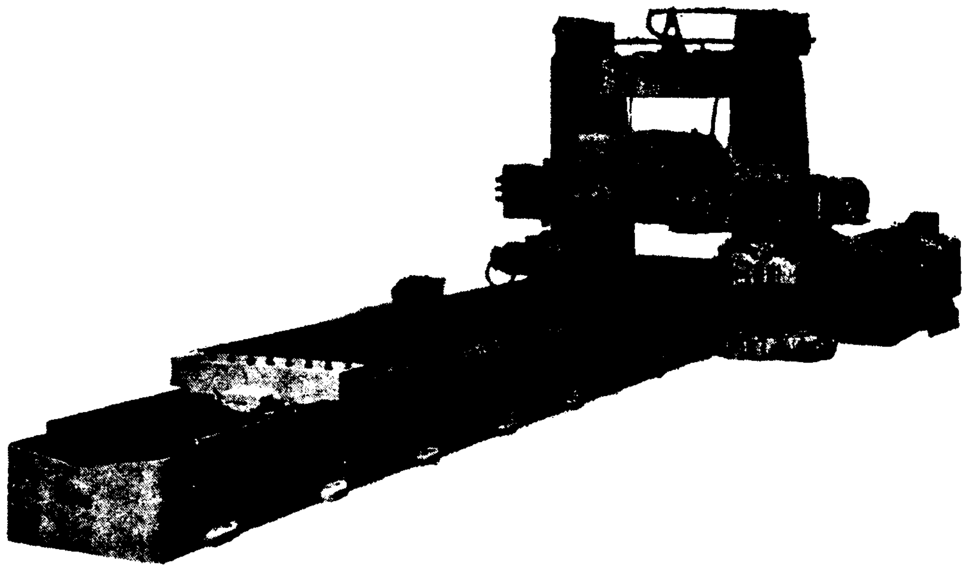


Fig. 2.

in the United Kingdom is shown in Fig. 2, this being 5′—wide x 4′ 9″ high and having a stroke of 24″. The table is of the tandem type so that for short work it may be used in two halves, one carrying the work in progress, whilst the other half is being loaded. The driving motor is 60 h. p. giving a speed range of 8 to 108 f. p. m. Although primarily intended for planing rails, the design of the machine makes it suitable for a wide variety of normal planing work, this being the reason for the fitting of side tool boxes on each of the uprights.

As before, it will be noted that great care has been taken with all parts of the machine to allow very adequate strength and rigidity, without which the successful machining of high manganese rails is quite impracticable.

BRITISH LOCOMOTIVE FOR MYSORE STEEL WORKS

A repeat order for a works locomotive for the Mysore Iron and Steel Works has been received by a British firm. The new engine is of the 2-8-2 type, and is designed for a 2 ft.—gauge light railway.

Four similar locomotives were supplied to the Mysore Iron and Steel Works by the British firm in 1947.

BERKEFELD FILTERS FOR RAILWAYS

A supply of pure water is essential on long cross-country train journeys, and an interesting filter has now been placed on the market which surmounts the difficulties usually encountered in providing portable water in such circumstances.

For railway use in particular the Berkefeld filter is ideal. It is made of stoneware and is available for use where no mains or tank pressure is available, being manufactured in six sizes varying from 1½ gallons to 7 gallons capacity, and weighing from 19 lbs. (8. 6 kilos) to 56 lbs. (25.2 kilos).

The filtering medium is in the form of hollow candles of various sizes made of Kieselguhr, an infusorial or silicious earth which on account of its enormous porosity, is an ideal filtering medium, but owing to the absence of any pressure the filtration although perfect, is somewhat slow being at the rate of about one pint for each candle per hour.

As the standard candles required boiling at frequent intervals in order to restore their sterilising ability, the manufacturers have carried out intensive research and experimental work with the object of eliminating this process. As a result they have recently introduced an entirely new design of self-sterilising candle, the 'Sterasyl' candle. This is a great advance on former types of Kieselguhr candle for it not only acts as an efficient filter but sterilises as it filters, thus providing a complete safeguard against water-borne contamination. Germs are both trapped and destroyed on the exterior surface of the candle, and filtered water can be stored and will remain pure for lengthy periods. The candles too will last for a long time without renewal and for cleaning purposes all that is necessary is to wash them occasionally with a soft brush in clean water

Pattern "B" Stoneware Filter.

to remove superficial dirt. No soap or detergent should be used.

As these filters are of course subject to a considerable amount of friction they have a smaller lid than usual which is designed to minimise the vibration. In addition, an inner lining is made with special anti-vibration lugs and a rubber washer is also provided to fit under the flange to prevent this vibrating against the outer case.

Another useful pattern filter for railway use is their type 'S.F.' which can be connected to a low pressure overhead tank yielding about 10 gallons (45 litres) per hour and weighing 20 lbs. (9 kilos).

Further details may be obtained from Berkefeld Filters and Water Softeners Ltd., Sardinia House, Kingsway, London. England.

Editorial Notice

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

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

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

All published contributions are paid for at our usual rates.

Editor

BRUSH BAGNALL DIESEL ELECTRIC LOCOMOTIVES

THE locomotive is of the type designated AIA—AIA, the superstructure being mounted on two bogies, each bogie having three axles of which the two outer axles are motored whilst the centre axle is for carrying purposes only.

The locomotive superstructure has a driving cab at each end mounted behind a short, streamlined, nose end compartment. The power unit with its auxiliary equipment and control gear is mounted in the main body of the locomotive. A partition separates the engine from the generator and control equipment, and unobstructed walk-ways are provided on both sides of the power unit.

Both driving cabs are fitted with a driver's position and controls on the left-hand side of the cab with an assistant driver's position on the right-hand side of the cab. All instruments essential to the driver are mounted on a panel in front of the driver and his assistant. Unobstructed vision for both men is provided by large driving windows, fitted with pneumatically operated windscreen wipers. A powerful headlamp is fitted into the nose at each end of the locomotive.

Immediately behind No. 1 cab is the main radiator ducting carrying the radiator fan motor and runner. Air is drawn through the radiator panels, which are mounted vertically on either side of the locomotive, and after passing through the twin branches of the

ducting is ejected upwards through a grille in the roof.

Access to the main body of the locomotive is provided by doors in the cab bulkheads. At No. 1 end, the centre walk-way through the radiator ducting branches on either side of the diesel engine; the generous loading gauge of the Ceylon Railways allowing sufficient space between engine and locomotive sides for the withdrawal of the engine pistons and connecting rods from the sides of the crankcase.

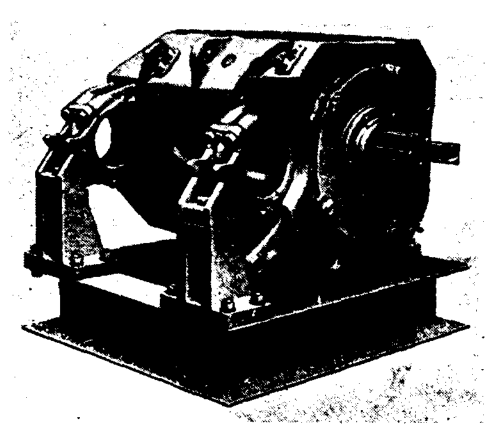
Doors are provided in the partition separating the engine and generator compartments and the walk-ways continue on either side of the main and auxiliary generators, exhausters, compressor and control equipment cubicle. Doors in No. 2 cab bulkhead give access into No. 2 driving cab.

The nose end compartments in front of each driving cab contain a traction motor

A section of the Brush Electrical Machine Test Department.

The Locomotive Driving Cab.

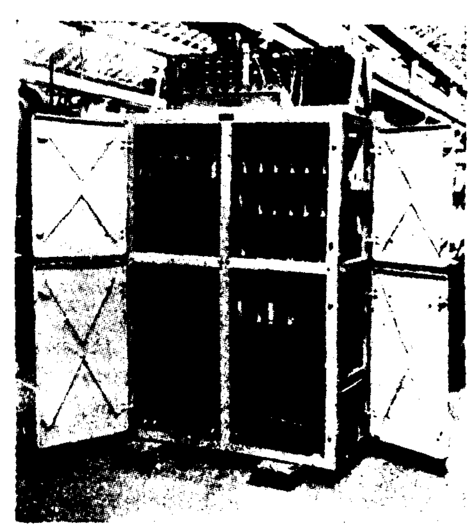
Locomotive Bogie without Motors.



Brush Traction Motor.

Locomotive Bogie with Motors fitted.

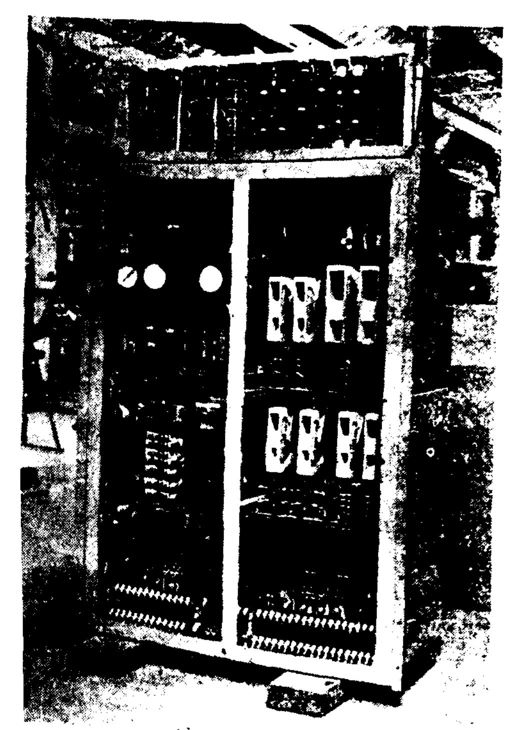
Mirrlees-Brush Diesel Electric Power Unit.



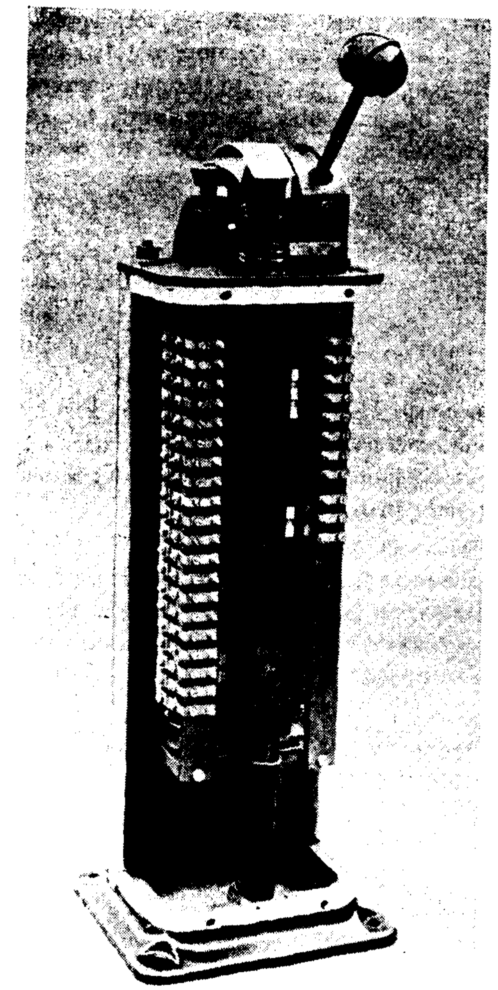
Main Control Cubicle (Rear view)

Fitting Locomotive Side Panels.

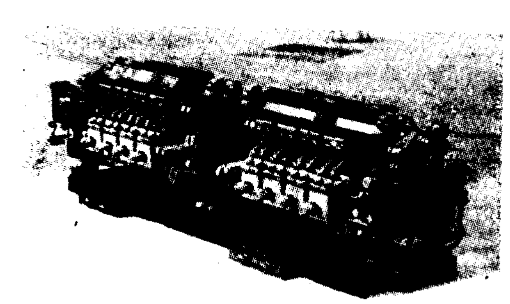
Part of Brush-Bagnall Locomotive Erection Department.



Main Control Cubicle (Front view)



Main Controller.



Reverser Unit.

blower, electrically driven, which supplies filtered air to the two traction motors in the bogie beneath. Access to the nose compartment is by removable panels inside the cab and by hinged louvre panels on the outside of the locomotive nose.

All auxiliaries are electrically driven with the exception of the engine cooling water circulating pump, which is belt driven from the free end of the crankshaft, and the engine lubricating oil pumps, which are gear driven from the crankshaft. Power for the auxiliary machines is taken from the auxiliary generator, which is mounted on an extension of the main generator shaft.

The main fuel tank and batteries are slung beneath the locomotive between the bogies. A separate fuel service tank is mounted in the roof of the locomotive.

Due to the bad weather conditions encountered in Ceylon, which include tropical rain and heavily corrosive salt atmosphere, special care has been taken to make all ventilating and air inlet louvres water-proof and anti-corrosive materials have been used throughout the construction of the locomotive.

DIESEL ENGINE

The locomotive is powered by a Mirrlees, Bickerton and Day, Vee-type 12 cylinder, turbo-charged four-stroke oil engine, with a rating of 1,254 B.H.P. at 850 r.p.m. under normal temperature and altitude conditions.

Under site conditions in Ceylon, the engine develops 1,000 H.P. at 850 r.p.m.

The bedplate is of welded construction, and carries the crankshaft bearings. The cylinder housing and upper part of the crankcase are also of fabricated construction and the complete crankcase assembly is solidly bolted to the bedplate. The cylinders themselves are of the " wet " type.

The crankshaft is of solid forged steel and is supported by main bearings of steel, white metal lined. The pistons are of light alloy fitted with compression and scraper rings. The piston pins are of the floating type. The connecting rods are of steel " H " section and carry marine type large end bearings consisting of steel-backed white metal shells.

The twin camshafts are mounted in the cylinder housing and are driven by spur gears from the flywheel end of the crankshaft. They are located on the outer sides of the two banks of cylinders, and operate the valve and fuel pumps through roller ended push rods and tappets.

The engine is force-lubricated from gear type lubricating oil pumps, and a shutdown device is incorporated which automatically stops the engine when the oil pressure falls below a certain point, or when the engine speed exceeds a certain limit.

The engine cooling water is circulated by a water pump, belt-driven from the forward end of the crankshaft.

The engine and generator, which are bolted together to form a single unit, are mounted on three pedestals carrying Silentbloc bushes, thus eliminating any possible distortion of the locomotive underframe being transmitted to the diesel engine.

ENGINE AUXILIARIES

The engine is started by motoring the main generator from starting batteries slung beneath the underframe. Starting connections cannot be made until the sufficient oil pressure has been built up in the diesel engine by an electrically driven priming pump.

Fuel oil is delivered to the engine fuel rail under pressure by an electrically driven fuel transfer pump. In the event of failure of this pump, fuel is supplied from a service tank under gravity feed. A semi-rotary fuel transfer pump is provided for filling the service tank from the main fuel tank.

Suitable radiators are supplied for the diesel engine oil and water cooling circuits.

The radiator fan which draws air through the radiators and expels it through the roof, is driven by an electric motor fed from the auxiliary generator.

ELECTRICAL EQUIPMENT

The main generator is directly coupled to the diesel engine and provides power to the four traction motors, which are axle hung on the outer axles of the two bogies. The motors may be connected in series-parallel, full-parallel, or arranged so that an initial connection in series-parallel is re-grouped automatically to full-parallel.

Control of the locomotive is effected by varying the excitation of the main generator and the speed of the diesel engine. Current for the field excitation of the main generator, auxiliary machines, battery charging and operation of the control equipment is supplied from the auxiliary generator which is overhung from the main generator.

The main control cubicle is mounted in the generator compartment and is provided with doors giving full access to all equipment mounted in the cubicle. The cubicle is dust-proof, and special care has been given to the design of the control equipment to make it suitable for the arduous conditions of railway working.

The locomotives are arranged for multiple unit operation by which means two locomotives are coupled electrically as well as mechanically and operated together by a driver in the leading locomotive.

A single handle on the Master Controller enables the driver to select Engine Starting, Forward and Reverse positions and all running notches.

Commencing Locomotive Erection.

Lead acid batteries of 192 ampere-hour capacity are provided for starting the main power unit and for supplying the necessary auxiliary power when the diesel engine is not running.

The driving axles are fitted with tubes for the axle suspension of the traction motors, the nose of each traction motor being suspended by a flexible link from the centre transom.

The traction motors are fitted with roller bearings for both the armature and suspension bearings. The drive from the motors to the axles is taken through single reduction gearing; a pinion on the armature shaft meshing with a resilient gear wheel on the road axle.

BRAKE EQUIPMENT

The locomotive is fitted with twin Westinghouse reciprocating exhausters, electrically driven, to provide vacuum for the train brakes. The locomotive itself is braked by compressed air brakes, four brake cylinders being fitted to each bogie and operating clasp brakes on all wheels. A Westinghouse compressor provides compressed air for the locomotive brakes, and also for the control and other auxiliary equipment.

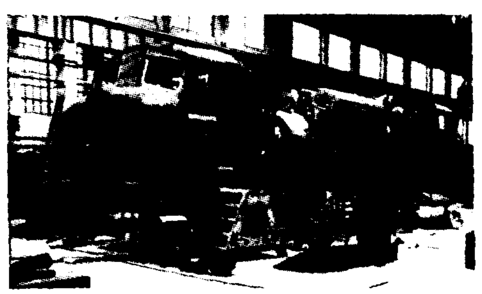
The driver's brake controls consist of a vacuum brake valve which operates the train brakes and automatically operates the locomotive brakes through a proportional valve. This valve ensures that the locomotive air braking is applied in direct proportion to the vacuum braking on the train. A separate brake valve is supplied which gives independent braking on the locomotive when required.

A hand brake for the locomotive is also provided in each driving cab.

CONSTRUCTIONAL DETAILS

Underframe

The underframe is constructed of four main rolled steel "I" sections, which are reduced in depth over the bogies by means of flame cutting and welding along the neutral axis, in order to provide clearance for the bogies between underframe and rail head.



Locomotive Assembly in progress.

The two outer main members terminate at the bogie centre cross members, to which they are welded, but the inner main longitudinals continue and are welded integral with the fabricated drag box.

Cross members, which are riveted to the main longitudinals at various points along the underframe, carry channel section sole-bars and an unbroken deck of steel plate covers the underframe skeleton.

SUPERSTRUCTURE

The superstructure is constructed in sections comprising the two cab ends, two sides, and three roof sections.

All the superstructure is constructed of 14 gauge steel sheet welded to frameworks of angle and top hat section.

Entrance doors to the locomotive are provided on each side of both driving cabs. Top hatches in the roof section permit easy access to the cylinder heads of the diesel engine, and the roof itself is easily removable for major overhauls or complete removal of the power unit.

Port-hole type windows are provided in the sides of the engine and generator compartments, and full drop windows are provided in the cab doors and side windows.

BOGIES

The bogies are constructed from box type side frames of welded construction joined by a heavy fabricated steel centre transom, and by two channel members as headstocks.

The weight of the locomotive is carried on the centre bolsters of the bogies. Each bolster rests on eight nests of coil springs carried on two spring planks, one on each side of the centre carrier axle of each bogie. The spring planks in turn are suspended by swing links from the bogie side frames.

The leaf springs for the axles are carried internally in the hollow side frames, suitable openings being provided for inspection and withdrawal, whilst the coil springs are situated below the bogie frames.

Roller bearing axle boxes are fitted in manganese steel horn guides, which are replaceable.

Electro-pneumatic sanding gear, operated from a foot pedal in the driving cabs, is provided for the outer axles of each bogie.

PRINCIPAL DATA

Locomotive Details

Locomotive Weight	87 tons
Track Gauge	5' 6"
Maximum Height	13' 3½"
Maximum Width	10' 3⅞"
Length over Buffers	50' 9"
Bogie Wheel Base	10' 6"
Bogie Centres	27' 0"
Minimum Curve Negotiable	5 chains
Clearance from Gearcase to Rail Head	4½"
Capacity of Fuel Tank—main	775 gallons
—service	75 gallons
Wheel diameter—motored	3' 7"
—carrier	3' 0"

Locomotive Performance

Maximum speed	55 m.p.h.
Starting Tractive Effort (26% Adhesion)	33,700 lbs.
Tractive Effort (1 hour rating)	30,000 lbs. at 9.2 m.p.h.
Tractive Effort (continuous)	24,600 lbs. at 11.7 m.p.h.
Estimated Range with Full Fuel Tanks	750 miles

Diesel Engine Details

Maker	Mirrlees, Bickerton & Day
Type	JS12VT
Output at Sea level and normal temperature and Humidity conditions	1,254 H. P. at 850 r. p. m.
Developed continuous Power at Site	1,000 H. P. at 850 r. p. m.
Bore	9¾"
Stroke	10½"
Number of Cylinders	12
Superchargers	Two, Napier type TS200/1
Exhaust Temperature (Cylinder outlet full load)	750°F./850°F.
Lubricating oil pressure	30 lbs./sq. inch.

Electrical Equipment Details

Main Generator	Brush Electrical Engineering Co. Ltd.
Continuous Rating	850 r.p.m. 652 kW. 630 V. 1,035A. 850 r.p.m. 652 kW. 750V. 870A.
Auxiliary Generator	Brush Electrical Engineering Co. Ltd.
Continuous Rating	850 r.p.m. 35kW., 110V. 318A.
Traction Motors	Brush Electrical Engineering Co. Ltd.
Number per Locomotive	4
Continuous Rating	196 H.P. 315V. 517.5A.
1 Hour Rating	226 H.P. 315V. 610A.
Gear Ratio	82 : 16
Radiator Fan Motor	Brush Electrical Engineering Co. Ltd.
Continuous Rating	110V. 3.1 H.P. /12.6 H.P. 32/115A. 600/960 r.p.m.
Traction Motor Blower Motors	Brush Electrical Engineering Co. Ltd.
Continuous Rating	110V. 5 H.P. 1980 r.p.m.
Exhauster Motors	Brush Electrical Engineering Co. Ltd.
Continuous Rating	110V. 3/6.05 H.P. 29/55A. 600/1,115 r.p.m.
Compressor Motor	Westinghouse Brake & Signal Co. Ltd.

Auxiliary Equipment Details

Compressor	Westinghouse Brake & Signal Co. Ltd.
Working Pressure	85/100 lbs./sq. inch
Exhausters	Westinghouse Brake & Signal Co. Ltd.
Type	4-cylinder reciprocating (4V110)
Normal Speed	600 r. p. m.
" Release " speed	1,115 r. p. m.
Batteries	D. P. Battery Co. Ltd.
Number of Cells	48
Capacity	192 amp.-hours @ 5-hour rate
Traction Motor Blower	Sturtevant
Output	2,940 cu. ft. per min. 2,170 r. p. m.
Radiators	Serck Radiators Limited
Axle Box Bearings	The Skefko Ball Bearing Co. Ltd.

PRODUCTION IN RAILWAY WORKSHOPS

By U. A. Kamath

SUMMARY OF PAPER

THIS paper deals mainly with the Production Organization in Golden Rock Shops with a few notes on "how to secure increased productivity in Railway Workshops." Only production of components for stock is dealt with and not out-turn of Rolling Stock after shopping.

The major responsibility of the Production Engineer is to maintain the stock position of Rolling Stock components and in order to indicate broadly the extent of work involved salient points about Golden Rock Workshops are next mentioned. A general outline of the duties of a Workshop Production Organization are given followed by a brief description of the duties of the various constituent units comprising the Production Organization at Golden Rock whereas a detailed enumeration of their duties is given as an Appendix.

From here onwards, the paper deals with the important question of increased Productivity in Railway Workshops and details how it can be secured by improved component design improved production methods, improved labour utilization, improved management and by specialisation amongst the various Workshops of the Zonal Railway. The paper ends with a plea to restore the pre-eminent position enjoyed by Railway Workshops in the heavy Engineering Industry of India through resource, vigour and initiative.

INTRODUCTION

The integration of Indian Railways, which has recently been completed, is expected to lead to greater efficiency alround. From the point of view of Workshop management, the integration has immediately resulted in a greater awareness of the organisation and methods adopted in other Workshops. On the Southern Railway for example, the results obtained from Workshops located at various corners of South India have come to be constantly compared and assessed, principles of organisation in vogue at one Workshop found to yield better results have been applied at other points thus leading to a gain in efficiency. These trends are to be welcomed. It is hoped that this brief paper will lead to serious thought being bestowed on this all important subject and increased awareness alround.

MAJOR FUNCTION OF A PRODUCTION ORGANISATION

Indian Railways had in 1952, 8439 locomotives, 21,296 Coaches and 204,630 Wagons operating on its extensive network. The maintenance of the large number of locomotives, carriages and wagons (i. e.) Rolling Stock in brief in a thoroughly safe condition to operate at present day speeds with absolute reliability is the major responsibility of the Chief Mechanical Engineers of the six Railway Systems. This is a highly onerous responsibility in which Workshops play a very vital role. Rolling Stock of all types are " Shopped " at periodic intervals based on mileage earned or time spent on line. The maintenance of the required out-turn of " Shopped " rolling stock is the primary responsibility of the Works Manager. To maintain this out-turn, a large number of spare parts of various descriptions, sizes and materials have to be stocked so that they can be drawn and used when necessary instead of waiting on the parts to be manufactured. Bulk production of spare parts to a definite programme to meet the requirements not only of Workshop consumption to maintain shop out-turn but also to assist the outlaying Running Sheds and Train Examining Stations to keep the rolling stock on the run and earn rupees is the major responsibility of the Production Engineer.

GOLDEN ROCK WORKSHOPS

The Railway Workshops at Golden Rock are one of the most modern in India built in the year 1928 to the design of a firm of London Consulting Engineers. They cover an area of 200 acres of which 24 acres are roofed and are split up into eighteen smaller shops of which 14 are exclusively for the Mechanical Department. The following rolling stock are maintained.

	B. G.	*M. G.*
Locomotives	201	405
Coaches	908	2371
Wagons (as 4 wheelers)	2930	7315

Amongst Locomotives only, there are 10 BG and 13 MG types. The rolling stock in general are of so many different designs and age groups that the total number of fittings in use on them run into the 20,000 mark. The parts vary in weight from ounces to hundred of pounds. Of this number, a total of approximately 8,000 components are manufactured in Shops for stocking purposes since they are generally items of constant demand. For many others, the consumption is not sufficient to necessitate stocking and therefore are manufactured as and when necessary. The productive capacity of the Workshops allotted for stock production has to be made use of to manufacture the stocked components as and when called for by the Stores Department so that at any one time the number of stocked items out of stock may be as low as possible. Most of the production is of the batch type which keep the machines engaged on similar work for an average of 2 or 3 shifts at a time except for items such as water space stays, piston rings and piston valve rings which are under continuous production. In all the so called production shops, both production and repair operations are carried out side by side. Machine Operators are likely to be transferred from repair to production jobs or vice versa, the supervisory staff have to supervise both these distinct types of work. While such a set up has been the result of growth from olden times and may be inevitable, it cannot be denied that to maintain the atmosphere of production these two functions should be bifurcated as far as is practically possible.

GENERAL OUTLINE OF DUTIES OF A PRODUCTION ORGANIZATION

The activities of the production organization has an important bearing on the productivity attained by the workshop by ensuring that the available manpower, tools, manufacturing facilities and materials are used in the most efficient manner and to the fullest extent. This it does by not only assuming responsibility for the actual planning of operations involved in production but also for carrying out the work as per planning. The separate kinds of effort involved in manufacturing activity, such as taking material from place to place at the right moment, providing drawings and instructions for processing material, issuing important directives to the correct personnel and inspecting the finished product all according to a prearranged schedule are all controlled by the production organization by the design of appropriate machines and tools, specifying time, quality and output standards, determination of manufacturing processes and preparation of drawings and bills of materials. Having dealt in a general way with what a production Organisation should do, let us take a look at the production Organisation at Golden Rock Shops in greater detail.

PRODUCTION ORGANISATION AT GOLDEN ROCK— CONSTITUENT UNITS

The constituent units of the Production Organisation at Golden Rock are :—

(a) The Planning Office under Chief Planner.

(b) The Jig & Tool Drawing Office under Chief D'man.

(c) The Inspection Department under Chief Inspector.

(d) The Production Control Section under a Head Clerk.

(e) The Production Shops (Foundry, Tool Room, Forge & Smithy, Saw Mill, Machine & Welding Shop) under their respective Foremen. Their basic responsibility is to produce fittings for ultimate consumption by the other shops. Some of the consuming shops also undertake work of a production nature but the quantum of such work is small and is undertaken only to make the fullest use of available equipment and labour.

The production Organisation was introduced and built up over a period of years starting from 1930. Until June 1951 the Mechanical Engineer (Planning) as the Production Engineer was then called, was not responsible for the actual production of stock components in shops. Thus while the

Mechanical Engineer (Planning) initiated all the primary steps relating to production, their execution on the shop floor was the responsibility of another Officer. This division of responsibility can result in inefficient planning or jig and tool design getting perpetuated. This defect was rectified in 1951 by giving the Production Engineer control over the Production Control Section and the Production Shops so far as the work therein related to Stock production.

PLANNING OFFICE

The Planning Office is the most important part of the Production Organization. It is staffed by over 33 Planners and it will, be worthwhile to put down here certain salient points. Every aspect of work undertaken in the Workshops is covered-stock manufacture, jig and tool manufacture, modifications to locomotives, carriages and wagons, manufacture of materials for outstations and other departments and new carriage construction. The Section dealing with stock manufacture, is the most important section since it deals with as many as 8500 stock items. Planning cards are maintained for every one of these items detailing the type and quantity of raw material to be used, operations to be performed, in what sequence and in what shops and estimated time required. The sequence of operations takes into account the available facilities and best production practice. Particulars of load resulting from stock manufacture are maintained with a view to determine whether any particular section of the Workshops is getting overloaded, to facilitate redistribution of load where found necessary and for compilation of the annual machinery programmes. Before modifications to Rolling Stock can be carried out on the shop floor, considerable amount of spade work is necessary all of which is done in the Planning Office. Components have to be manufactured and got ready in sufficient quantities, detailed instructions have to be issued, completion watched and CME and the districts advised. Similarly all spade work necessary for the construction of passenger coaches which is a normal feature of Railway Workshop operation in India is also dealt with. Arrangements for cutting of timber have to be put in hand and the Stores department advised of the fittings required to be obtained by purchase. Manufacture of the numerous components which are within the capacity of the Workshops to manufacture has to be planned for economical manufacture. Whenever special jobs such as erection of wagons and construction of brake vans are undertaken, preparation of estimates and staff and tool requirements are investigated and finalised. The Golden Rock Shops has been privileged recently to receive a bulk order for 250 Metre Guage brake vans to be constructed for the various Indian Metre Guage systems. The planning work involved was considerable.

JIG & TOOL DRAWING OFFICE

Efficient and economical utilisation of expensive machine tools is not possible without an efficient jig and tool drawing Office. This factor assumes considerable importance in a Works which has over 372 machine tools. The major portion of the work dealt with is jig and tool design which is an interesting and absorbing work requiring not only considerable experience of machine design but also of workshop practice. Fortunately at GOC, this branch has been nurtured carefully during last 20 years with the result that it is in a position to deal with jig and tool designs not only for normal maintenance work but also for special works. A case in point of the latter category is the jig and tool design work required for the construction of M. G. Brake Vans. A total of 226 Jigs and Tools made up of Drop Stamp dies (17), forging machine blocks (12), punching and blanking tools (22), pressing tools (28), drilling jigs (114) and welding fixtures (2) were designed to facilitate economical production of the various brake van components. Other duties handled include answering all querries pertaining to material specification of grinding wheels and electrodes, distribution of Rolling Stock, drawings to the Works and incorporation of alterations in the CNE's drawings.

INSPECTION DEPARTMENT

Locomotive Components are inspected immediately after stripping and also after repairs prior to despatch to Erecting shop. Planning for manufacture of non-stocked locomotive components is also undertaken. All carriages and wagons after periodical overhaul are inspected to ensure that no repair is omitted, that rolling stock is safe in all respects and all passenger conveniences are provided. In addition, Inspectors are posted in Foundry, Forge & Smithy and Machine Shops to check the out-turn of stock and non-stocked components. Except in Foundry where the Inspectors check and ensure that the pattern is correct in all respects, the Inspectors only check the quality of finish and dimensional accuracy of components prior to despatch to Stores. No interim stage inspection is in existence. All repairable stock fittings are sent into the Returned Serviceable Stores (RSS) where they are tallied. Recoupment of stock of these fittings in the Stores is effected after making fullest use of available repairable fittings in RSS. The Inspector attached to the RSS plans for the repair of stock fittings just as the Planning Office does for new manufacture. He is in a position not only to divert repair operations to shops which have the capacity but also introduce new and up-to-date repair procedures.

PRODUCTION CONTROL SECTION

Let us now see what happens when a work order for a stock item is released on the Shops. The work order requisition is checked by the Stock Planner and passed on to the Production Control Section where operation planning sheets, based on the Unit Planning Cards, are typed and distributed to all the shops responsible for its production along with the material indent. On the Shop floor, job cards are made out which follow the job from start to finish, on the reverse of which all labour expended is booked for Costing purposes. All work relating to release of orders on Shops, writing out material indents, expediting of orders wherever necessary, determination of priorities, progressing of the work and maintaining statistics of stock order out-turn is performed by this Section. The question of improving the office control over the progressing of stock orders through the Shops is under consideration and is being implemented. The Railway Workshops have two distinct consumers—the Shops and the Running Sheds whose demands have to be considered and supplies effected without delay to either. In the Shops, stock production work is as far as possible segregated under separate Chargemen and they have no repair work to do. In the Machine Shop, the machines for stock work are separately marked off, load boards being maintained to facilitate loading taking the urgency of the order into consideration.

HOW TO SECURE INCREASED PRODUCTIVITY?

A question likely to be asked is "Every Railway Workshop of standing has a production organisation but how can increased productivity be secured?" That is a very pertinent question. The efficiency of a Workshop is dependent on several factors such as productivity of raw materials, fuel, machines, fined equipment and labour. It has to produce more at a cheaper rate and better quality. It is my earnest opinion that productivity in Railway Workshops can be increased by:—

1. Improved component design.
2. Improved production methods.
3. Improved labour utilisation.
4. Improved management.

IMPROVED COMPONENT DESIGN

Many of the part drawings now in use were made in the prewar era. They morely indicated functional requirements without indicating or taking into consideration the manufacturing processes to be employed. During and since the War new fabrication methods such as welding, use of press brakes, stud and resistance, butt welding have been developed and extensively employed not only to increase production but to reduce dependence on skilled manpower which is in short supply. It is therefore necessary that components should be redesigned and tolerances specified so as to make for ease in production while maintaining the required performance and quality. The drawing offices should keep abreast of the latest fabrication techniques and while re-designing take into consideration the problems of the Workshop man, the tools and facilities at his disposal or that should be placed at his disposal. The design of the new RAIL Coaches has revolutionised Railway Coach designs in India and it is hoped that the latest fabrication methods employed on it will quickly find their way into Railway Workshops as well. Constant co-ordination between the Workshops and the Headquarter Office should be maintained so that available Workshop capacity in any machine group is not outstripped and to take remedial measures where necessary. The position should be re-assessed at specific intervals, extra plant ordered where necessary and training schemes introduced to provide the additional skilled labour in the wanted categories.

IMPROVED PRODUCTION METHODS

This heading will include use of improved plant and equipment such as jigs and tools, better factory layout, work simplification and improved internal transport. These factors are mostly affected by the activities of the design, production engineering, motion study and similar functional service departments. While Railway Workshops have a Production department, these do not usually provide experts in motion study, material handling and work simplification. These three aspects have, in recent years, been developed extensively to help workshop management to effect considerable economies. Material handling in our Workshops is taken to mean the provision of overhead cranes, installation of some pneumatic hoists and provision of a few transport trucks. Efficient material handling will reduce indirect labour and overhead costs and avoid skilled operator fatigue leaving them with more energy to do their skilled duties thereby giving a fillings to production. A thorough study of the material handling problems in every shop for every skilled man by experts is called for.

IMPROVED LABOUR UTILISATION

Many of the factors influencing labour utilisation are under the control of management. These are :—

1. Avoidance of plant breakdowns.
2. Provision of materials to labour for processing without any delay.
3. Reduction of scrap due to defecting planning.
4. Use of inexperienced or partly trained labour.
5. Reducing variety and increasing quantity on order i.e. Specialisation.

Plant maintenance is the responsibility of the plant department. Use of inexperienced labour is all too common nowadays. There are no proper or effective labour training programmes. In the West, training of Operatives receives considerable attention both from the Industry and the Government Authorities. The Railways being a large scale employer of skilled labour must initiate these programmes and the personnel departments should take a hand in the matter and assist the drive for increased production. Maintenance of regular material supplies should be ensured by the supervisors on the floor of the shop.

SPECIALISATION

With only 6 Railway Groups operating in India at the present time and such group having more than 3 large Workshop. Indian Railways will have to go in for " Specialisation " which means the devoting of particular productive resources exclusively to the manufacture of a narrow range of product. While the limitations imposed by Railway working may not permit this policy being carried out extensively, any advance in this direction is worth achieving. Standardisation of components on non IRS Rolling Stock, concentration of manufacturing facilities for components of one class of engine or wagon in one workshop instead of in several, separation of locomotive repair and carriage and wagon repair wherever they exist conjointly are directions in which progress can be achieved on a long range basis. Before the integration, the manufacture of the entire requirements of say Brake truss beams for wagon and coaching stock for one Railway would probably not have justified the provision of butt welding and other facilities required for their fabrication on a mass production basis. After the integration however, installation of the necessary modern plant at one of the several Workshops in the integrated system may be economically justified. One more aspect which may be mentioned in passing is a development of recent origin. Since 1947, Railway procurement policy has tended to give a fillip to local manufacturers who can be expected to tool up for mass production of components such as bolts, rivets, washers, cotters, hinges etc for which bulk and constantly recurring orders are placed. Not only will the product be available at a cheaper rate but also uneconomic manufacture inside Railway Workshops can be given up.

IMPROVED MANAGEMENT

The effectiveness of management is measured by its ability to increase productivity at less cost and is achieved not by technical superiority but by its ability to make the fullest use of available men and machines. In fact quality of management has a direct bearing as factory efficiency. It is a quality which needs not only experience but close study. Schools for management have been opened in the West especially U S.A. with a view to impart knowledge about administration so that skill in administration is acquired more quickly and completely. If a School of this nature is opened in India for Railway Mechanical Engineers it will be a step forward in the direction of increased productivity.

Another factor by which management ensures success of the business maintains efficiency is by strict budget control. Monthly comparisons are made of actual performance against budget allowance. Various statistics and problems are analysed by the Accountants to show where waste is occurring. Cost accounting as a tool in the hands of management is a most potent tool. Steps are already being taken to adopt uniform costing systems in all Railway Workshops where they differ from the standard so that costs of manufactured items as between Workshops may be compared. Again supervisors should be considered as part of the management. They should be properly trained and his rights and privileges secured. He should be kept well informed and cost figures of shop operation should be supplied to him for corrective action. Changes and modifications to be carried out in his section should be done only after fully consulting him so that he may not feel he was being " by passed ". Under the rules operating at present, these conditions are not always fulfilled with the result efficiency on the shop floor suffers to some extent.

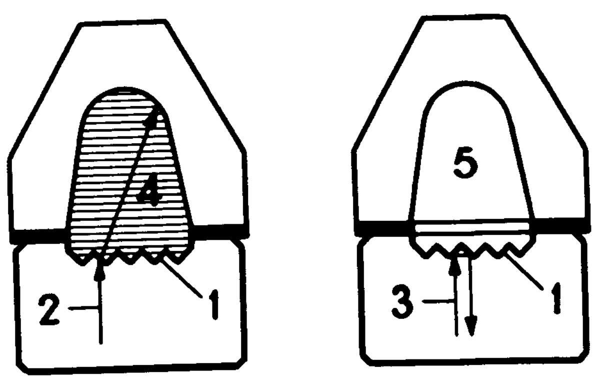
All these years, the Railway Workshops have remained in the forefront in the heavy

(Continued on page 40)

KLINGER GAUGES

FOR many years, Klinger Water Level Gauges and fittings have been standard items of railway equipment throughout the world. The Reflex type of level-gauge has largely superseded the older type using glass tubes, although the latter is still widely used.

The Reflex Level Indicator was originally invented by Richard Klinger in Vienna at the latter end of the last century. It was designed to replace glass tubes which were proving to be inadequate in their resistance to the corrosive action of boiler waters and to the rising steam pressures and temperatures. The underlying principle of the reflex gauge may be readily understood with only the most elementary knowledge of optics. The Klinger Reflex Glass is provided with right



angled grooves (1) on the liquid side. Rays of light falling on the glass (2) and (3) are totally absorbed in the zone of the liquid (4) and totally reflected in the zone of the gas, air or steam (5). Thus, the liquid zone appears black and the vapour zone appears silvery, with a most distinctive interface between the two.

The glasses are made from the highest quality of heat resisting and water resisting borosilicate glass. The glasses are moulded and toughened and the grooves are moulded in the glass below the level of the joint face, so that the latter may be reground, if necessary, without breaking the protective skin on the glass.

The construction of a Reflex gauge is illustrated elsewhere in this article from which it will be seen that the tightening screws G in the wedge piece F press on to the back of the centre piece E and hold it tightly against the reflex glass C, the whole being enclosed in a strong body, A. A Klingerit joint D makes a steam tight seal between the reflex glass C and the centre piece E and a soft asbestos washer B acts as a cushion between the front of the glass and the body A. The wedge piece F which carries the tightening screws G is easily removed from the body by sliding it along about one inch and then lifting it out.

The single row of tightening screws down the back of the gauge ensures that an absolutely even pressure is applied to the whole of the joint between the glass and the centre piece, as it is impossible to tighten one side more than the other. The deep box-like section of the body A prevents distortion and risk of broken glasses. The gauge can be quickly and easily dismantled when it is desired to fit a new glass.

This design has been arrived at after many years experience of former types and incorporates many notable features. Each assembly is built up from four different units, viz.: (i) the reflex gauge, (ii) two identical shut-off

(Continued from page 39)

engineering industry. Unfortunately that pre-eminent position is lost to us to-day. We have fallen back a few steps and are no longer the acknowledged leaders. Unless Workshop problems are tackled with resource, vigour and initiative, the leadership will not become ours. We shall continue to be second rate men. Let us strive to do better.

cock assemblies, (iii) two identical stuffing-box heads, and (iv) the drain cock.

It will be noted that the drain cock is immediately below the reflex gauge so that there is a direct blow through the gauge when the drain cock is open. (This is necessary because of the general railway practice of blowing through without closing the shut off cocks). Corrugations at the top inside face of the centre piece deflect the steam on to the surface of the glass when blowing through so as to obtain the maximum cleaning effect, should the water be unusually dirty. Cleaning plugs permit the passage of brushes or rods to ensure that all ports are clear. The gauge, together with the two stuffing-boxes, may be removed without disturbing the shut-off cocks.

Many users of Klinger Reflex Gauges fit a brass plate to the front of the gauge body indicating minimum water levels to be maintained, (a) on the level (b) on a down gradient, and (c) on an up-gradient.

The spares required for a Klinger Reflex Gauge assembly are:

(i) Packing Sleeves for Cocks, size "AB.18"

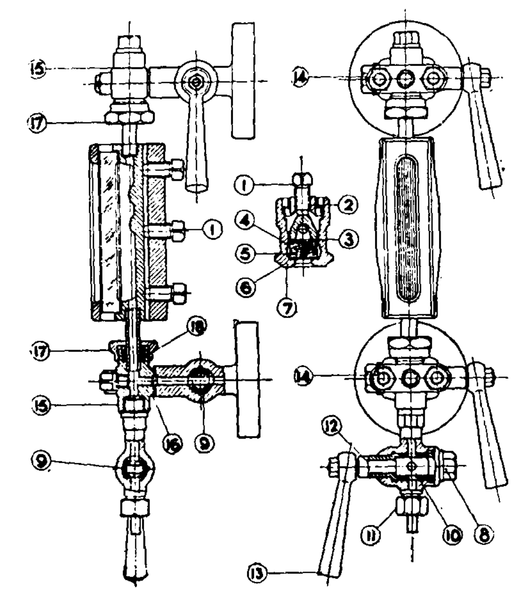
(ii) Plugs for Cocks, size "AB.18"

(iii) Packing Rings for Stuffing-Boxes, Type "KU", 16 mm.

(iv) Reflex Glasses, Type "A" (Each glass is packed complete with asbestos washer and Klingerit joint.)

The gauge illustrated is supplied in either bronze (type KB-DR) or forged steel (type K-DR), in the following sizes:

Sizes	Distance between centres on boilers	Length of gauge Body	Visible Length of Glass	Actual Length of Glass
III	11" –12"	$7\frac{1}{16}$"	$5\frac{5}{8}$"	$6\frac{1}{2}$"
IV	12" –13"	8"	$6\frac{5}{8}$"	$7\frac{1}{2}$"
V	13" –$14\frac{1}{2}$"	$9\frac{1}{4}$"	$7\frac{3}{4}$"	$8\frac{5}{8}$"
VI	$14\frac{1}{2}$"–16"	$10\frac{3}{8}$"	9"	$9\frac{13}{16}$"



Type "KB-DR"

1. Tightening Screws	*10. Plug*
2. Wedge Piece	*11. Union Nut*
3. Centre Piece	*12. Neck Bush*
4. Klingerit Joint	*13. Cock Handle*
5. Reflex Glass	*14. Stuffing-Box Head Nuts*
6. Asbestos Joint	*15. Stuffing-Box Head*
7. Body	*16. Klingerit Washers*
8. Tightening Nut	*17. Gland Nuts*
9. Packing Sleeve	*18. Packing Ring*

SERVICE AND MAINTENANCE

Maintenance — To obtain the maximum of service from this level indicator the following points MUST be observed. When it is under steam for the first time the tightening screws (1) along the back of the reflex gauge should be followed up firmly and evenly. This ensures that the Klingerit Joint between the reflex glass (5) and the centre piece (3) is properly compressed.

The packing rings in the top and bottom stuffing-box heads should be followed up by means of the gland nuts (17). The tightening nuts (8) on each of the shut-off cocks and the drain cock should also be followed up in order to compress the packing sleeve tightly around the plug.

ALL WATER GAUGES SHOULD BE BLOWN THROUGH AT REGULAR INTERVALS TO PREVENT THEM BECOMING CHOKED. Both the steam- and water-end cocks should be blown through separately.

To Repack a Cock first remove the tightening nut (8), take off cock handle (13) and drive out plug (10). The neck bush (12) can then be pushed out together with the packing sleeve (9). Having cleaned the various parts, re-assemble as follows: Replace neck bush (12) and drive in new packing sleeve, taking care that its ridge exactly enters the groove in the cock body. Push in the plug (10) and replace cock handle (13) and nut. Finally screw in tightening nut (8) and tighten it up until the packing can be felt to grip the plug closely. This nut must be followed up again when the cock is first under steam.

N. B. Do not attempt to remove old packing sleeve unless you have a new one to put in its place. The plug can be removed for inspection without disturbing the packing sleeve in the cock body.

To remove Reflex Gauge from cocks, disconnect drain pipe by union nut (11) and then unscrew the four stuffing-box head nuts (14). The gauge together with the stuffing-box heads (15) can then be removed from the cock bodies. If required, the stuffing-box heads can then be drawn off the end tubes of the reflex gauge. When replacing, see that the two Klingerit washers (16) are first inserted in the recess in each cock body. If the reflex gauge has a corrugated centre-piece, it should be replaced with the corrugations at the top, as shown in the section illustrated.

To fit a new Gauge Glass loosen the tightening screws (1) at back of gauge. The wedge piece (2) should then be slid along about an inch and lifted out. It will then be possible to remove the gauge front (7) together with the glass (5) from the centre piece (3). Clear away all traces of the old joint from the gauge, and replace new glass as follows: Place the ribbed side of the glass against the centre-piece (3), taking care to see that the Klingerit Joint (4) is properly in place between them. Replace gauge front (7) with soft asbestos joint (6) properly in position between it and the front of the glass. Slide wedge piece (2) into place and tighten up screws (1) evenly and alternately. Cut away the centre of the soft asbestos joint from the front of the gauge with a sharp penknife. Follow up tightening screws (1) again firmly when the gauge is first under steam.

To Repack stuffing-Boxes undo nuts (14) and remove reflex gauge together with stuffing-box heads. Draw the stuffing-box heads off the gauge tubes and then undo gland nuts (17) and take out the old packing ring (18). Insert new Klingerit "KU" 16 mm. packing rings and re-assemble gauge. Tighten up the gland nuts (17) firmly again when the gauge is first under steam.

A CORRECTION

The article entitled "Stockton And Darlington Railway 1825" published in our November (Annual) Number was contributed by Mr. U. A. Kamath.

ELEMENTS OF WELDING METALLURGY

By P. K. V. Challam

METALLURGY is indeed such a vast subject, that it is impossible even to enunciate the broad principles within the scope of this article, but as an elementary knowledge of metallurgy is very essential to all classes of Welding Technicians, Supervisors etc., an attempt is made here to enumerate the salient features of the various metals which the welder is called upon to work with, either in the field of welding, cutting or other allied techniques and processes.

To attempt to apply certain welding and cutting or other allied processes to a given metal without sufficient knowledge of the characteristics of such a metal, is rightly described in certain quarters as attempting to cure a disease without diagnosing it. From this point of view the rather low degree of metallurgical knowledge present in the average welder of today is both inexcusable and deplorable. The sponsors of the welding industry are therefore right in laying stress on the basic education which they are endeavouring to impart to the welding personnel through Demonstration shops and welding schools, where the beginner learns the subject in a proper way, and others belonging to a higher strata widen their existing knowledge to the advantage of themselves and the Welding industry in general.

Metallurgy has been defined as the art of working metals or the art of separating metals from the Ores, whereas Metalography may be defined as the study of the structure of metals. As Iron and steel form the major portion of the metals that present themselves to the welder, Ferrous Metallurgy has been dealt within the following pages in wider detail than non-ferrous metallurgy.

Before proceeding further with this subject, it is thought advisable to enter a brief description of the production of iron and steel. The scope of the article does not, however, allow more than a general survey of the production of iron and steel. For a detailed study of the subject the reader is referred to the vast number of books available on the subject. An attempt is made in the following pages to give the story of the transformation of iron ore into Pig Iron, Cast Iron, Steel etc. in a way that an average welder will understand it.

IRON ORE

Iron ore exists in Nature all over the world in the following forms:

1. Hematite
2. Limonite
3. Magnetite
4. Siderite
5. Pyrite

In India Hematite occurs in very large quantities (approximately 3,000 million tons) in the district of Manbhum (Bihar), Mayurbanj, Bonai and Keonjhar (Orissa), as also in Mysore. The principal Iron and steel Companies in India Messrs. Tata & Iron Steel Co. Ltd., The Indian Iron & Steel Co. Ltd., and The Mysore Iron & Steel Co. Ltd. use this type of ore for the production of iron and steel.

The Iron content of Hematite is 70% theoretically, but as much as approximately 60% of iron is obtained from this type of ore by the Iron and Steel Processing Companies in India.

The Principal Raw Materials required by the Iron and Steel Industry are:

We have pleasure in announcing to all our Readers and Advertisers that we are bringing out a special supplement entitled "Evolution of Machine Tools in RAILWAY WORKSHOPS" along with our MAY Number. Machine Tool Manufacturers are requested to send in their technical articles or write-ups on or before 10th May, 1956, along with suitable illustrations.

Editor.

1. Good quality Iron Ore
2. Fuel (Coking Coal)
3. Flux (Lime Stone or Dolomite)
4. Refractory materials
   (Fire-clay, Quartz Magnesite etc.)

As far as the Ore is concerned, India is fortunate in having the biggest and high grade deposit which can be mined at a cost lower than any existing in the world.

India's Coking Coal deposits do not enjoy the same abundance and quality as Iron Ore. Owing to their larger ash content, more coke is used per ton of ore smelted. An idea of the coke requirements of a Blast Furnace is given below :

To produce one ton of Pig Iron, the required quantities of Coke and Iron Ore are as follows :

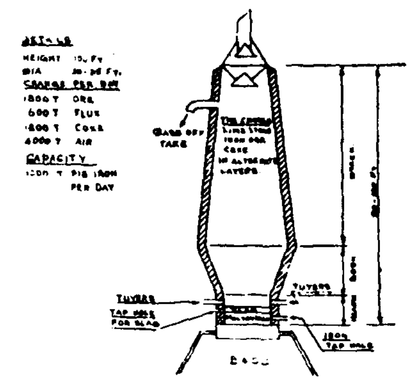
1 Ton of coke (from 1.1/3 ton of coking coal) 1½ Tons of Iron Ore.

FLUX

The position of Fluxes, i. e., Lime stone and Dolomite is the same as that of Coking Coal ; the quality of these materials is not very good, but moderately good fluxing materials being available near the processing plants at very cheap rates, the cost element of fluxing materials in the Pig Iron produced is not higher than that in any other part of the world.

With regard to the Refractory materials, no difficulty is experienced and sufficient production of quality Fire Bricks is carried on in Ranikunj, near Calcutta, which is close to the steel processing plants.

With the availability of these Raw Materials in abundance, India is able to produce Pig Iron cheaper than any manufacturer in the World, and has registered herself as an exporter of Pig Iron to Japan etc.



PRODUCTION OF PIG IRON

From the raw materials described above Pig Iron is produced from the Iron Ore in what is called a Blast Furnace (see diagram below). The charge containing the correct proportions of the raw materials is lowered into the stack by means of cup and Cone as per illustration given below.

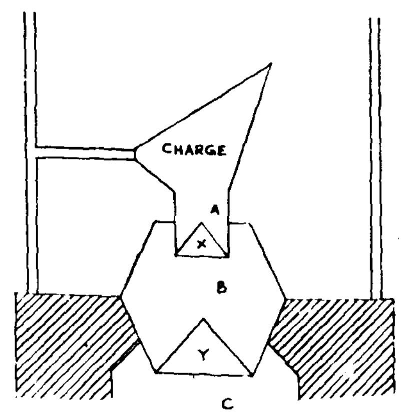


Fig. 1. Charging detail in a Blast Furnace.

X and Y are the Cones in the charging device. The lowering of these cones one by one lets the charge by gravitation from A to B and B to C. When Cone X is lowered, the cone Y is as shown in the diagram and when cone Y is lowered, the cone X has already been moved into position, so that by this arrangement, the Blast Furnace gases have no chances of being wasted through the lowering of the cones.

In the Blast Furnace, the coke is ignited at the bottom and it burns under forced

draft. As it burns away, ore and lime stone are converted into liquid iron and slag. The materials move downwards by gravity and the stack is kept filled by fresh charges admitted through the cone device already mentioned.

The process of heating inside the blast furnace is aided by the admission, through the tuyers, of hot air preheated in stoves to approximately 700 degrees Centigrade. The Pig Iron is tapped at intervals at the point marked in Fig. 1 for casting into pig iron blocks. The slag which floats at the top of the molten metal in the crucible is tapped at a higher level, and is either thrown off or utilised in various other ways.

The hot gases from the furnace are not wasted. A part is led into a battery of stoves, usually four per Blast Furnace and burnt there to heat the incoming air from the Blowing Machine, the capacity of which is roughly 1,00,000 C. ft. of air per minute.

The surplus gases from the furnace is utilised in the following ways :

25% for heating the blast
15% for driving the Blowing Engine
60% for generation of power and other uses.

Where a blast furnace is in operation, large quantities of water are required for :

1. Cooling Furnace parts subjected to intense heat.
2. For feeting the Boilers
3. For cleaning the furnace gases before they are led into the stoves.

Summarising the requirements of a blast furnace, we have the following list of items :

1. A Blast Furnace
2. Hauling mechanism for charging the furnace
3. Air Compressor-Blowers to produce the blast
4. Stoves for heating the blast
5. Facilities for pumping large quantities of water
6. Power generating plant.

The first stage of producing pig iron from iron ore having been discussed, we now proceed to the production of cast iron and steel.

CAST IRON

Cast Iron and Steel (which latter is described later) form the major portion of the metals that present themselves to the welder, and it is imperative that the welder and those connected with welding, understand the characteristics of these two categories of iron and steel.

Cast Iron is obtained by the melting of pig iron and scrap iron together with a small quantity of fluxing materials. The melting is done in a Cupola (see diagram below).

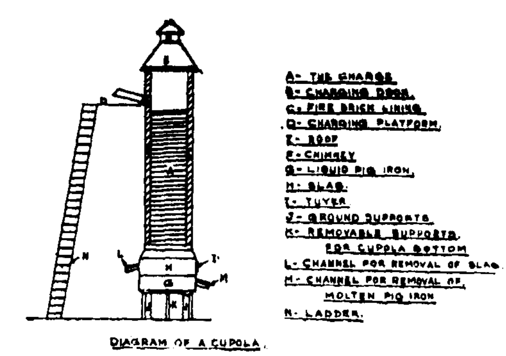


Fig. 2.

The process is roughly as follows :

The bottom portion of the fire-brick lined Cupola is first charged with coke up to about 1/3rd over a layer of wood and other cumbustible materials about 10 to 12" from the bottom. This charge of coke is called the Bed Coke. The bed coke is then lit from the bottom opening of the cupola and the coke is allowed to burn by natural draught. This goes on for about 2 to 3 hours when the pig iron and the coke and scrap iron are charged into the cupola in alternate layers after closing the bottom with a thick iron plate. At this time the Blowing machine is started and air is let into the cupola by means of tuyers located around the cupola. This inlet of air increases the temperature inside the cupola and the melting takes place (usually within 15 minutes from the time the charge is made and air let in) until liquid iron is formed at the bottom of the cupola. This is tapped off at intervals and carried in clay and mud lined buckets to the moulds. At intervals the slag which floats on the molten metal is also removed through an opening which is at a higher level than that for the tapping of the metal.

In the moulds the molten pig iron transforms itself into various forms of cast iron articles. The place where the cupola functions and casting takes place is called the Foundry.

Some times the pig iron is melted in a crucible but the crucible casting is invariably limited to non-ferrous castings, such as brass, aluminium etc.

STEEL

Both Steel and Cast Iron belong to Iron-Carbon alloy group. The iron-carbon alloy called Steel is by far the most important of ferrous metals. The word ferrous is derived from the LATIN word "Ferrum" for iron as distinguished from the non-ferrous group, i. e., Copper and its alloys, Aluminium etc.

It is impossible to say what course our civilization would have taken if steel were not discovered. Without steel there would not have been the great ocean liners, Railway tracks, Locomotives, Automobiles, modern steel structured buildings and various other implements on which humanity depends. In fact, the progress of the world would have been negligible without the members of the Iron and Steel family. It is therefore right to say that Iron and Steel are the life of the humanity and part of it.

It would be advantageous at this juncture to deal briefly with the characteristics of various categories of iron and steel. Chart on page 49 gives a schematic representation of the various forms of iron and steel.

WROUGHT IRON

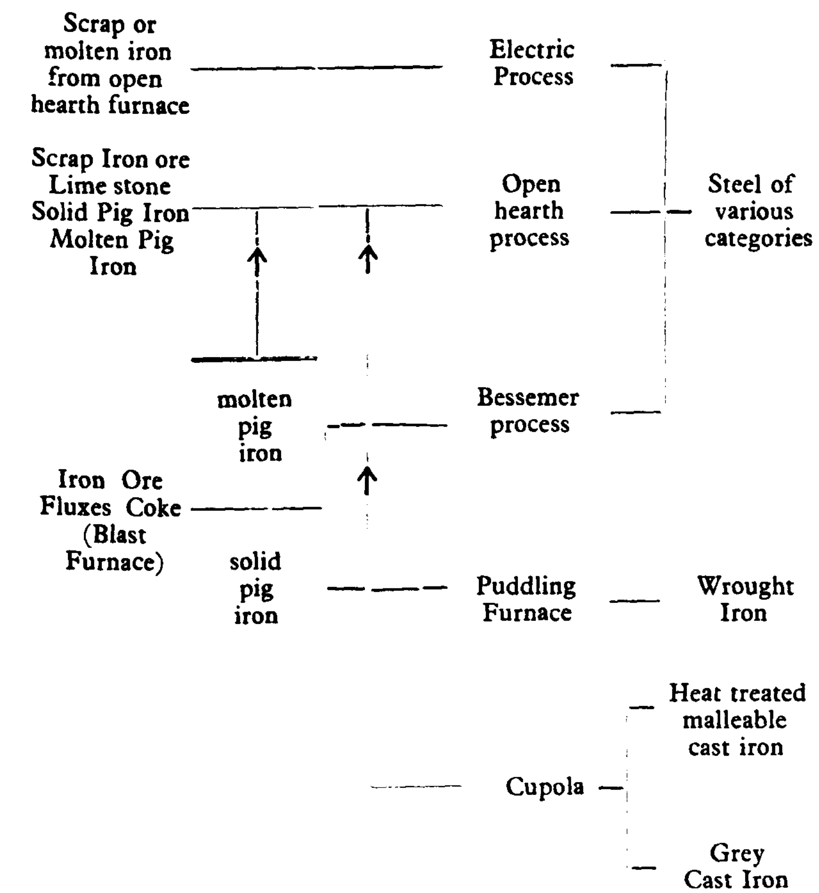
Wrought Iron is a ferrous metal composed of almost pure iron and iron silicate commonly known as slag. Wrought iron is made in a Puddling Furnace from Pig Iron and, but for the slag inclusion, is very similar to pure iron. This is the purest form of iron available. Some examples of the uses of wrought iron are: Crane hooks, bolts, water pipes etc. Owing to the slag inclusion it is resistant to corrosion, oxidation or rusting.

A normal specification of wrought iron would be:

C ..	0.04
P ..	0.09
S ..	0.02
Mn ..	0.05
Si ..	0.08
Slag ..	1.5

In some specimens, however, the slag content is as much as 3%. The slag content in wrought iron is evenly distributed in the form of threads along the line of rolling.

An important point to be remembered with wrought iron is the fact that wrought iron melts at a higher temperature than most of the ferrous metals. With other ferrous metals, suitable for welding, the welding temperature is indicated by the fluxed or greasy surface. With Wrought Iron, however, this indication only shows that the fluxing action of the slag content is taking place, and this temperature being below the fusion



Schematic Representation of the manufacture Cast Iron and Steel.

temperature of the base metal, welding at this temperature should not be proceeded with. Heating should be continued till the fusion of the base metal is achieved.

CAST IRON & STEEL

As already pointed out, both Cast Iron and Steel are members of the Iron-Carbon alloy group and the percentage of carbon in any given alloy determines whether it is steel or cast iron. The following table gives the percentages of carbon present in the different Iron-Carbon alloys:

Type of Iron-Carbon Alloy		*Percentage of Carbon*
Wrought Iron	..	0.04
Mild Steel	..	0.25
Medium Carbon steel	..	0.25 to 0.45
High Carbon steel	..	0.45 to 1.5
Cast Iron	..	2.5 to 4.5

Iron carbon alloys of 1.5 to 2.5 carbon content are not in wide use, and it will be seen from the above table that Iron-Carbon alloys with carbon contents ranging from 2.5, place themselves within the category of Cast Iron. As a matter of fact, the dividing limit between steel and cast iron has been recognised as 1.7% carbon.

ROLL OF CARBON IN IRON-CARBON ALLOYS

Here it will be advantageous to enter into a brief discussion of the role of carbon in iron-carbon alloys. It has already been pointed out that iron of 100% purity, not being available, wrought iron should be considered as a close second. The addition of the alloying element carbon in these alloys increases the hardness and strength of the alloy up to a certain limit, which can be taken as 1% carbon content. Between 1 & 1.5% Carbon content, the alloy increases in hardness but diminishes somewhat in strength. As will be seen from the table given above, up to this limit, i.e., 1.5%, the alloy is classified as high carbon steel, the use of which is limited to tools and other instruments which are required to be very hard.

Iron carbon alloys with a carbon content of 2.5% and over are classified as cast iron, the qualities of which are:

1. Good castability
2. Moderate strength and hardness
3. Low Ductility.

The Engineering Industry, however, uses low and medium carbon steel to a very great extent. For different jobs, Iron carbon alloys of various carbon contents are selected. A diagram showing the alloys with different carbon contents and examples of their uses, appears on right side.

The melting points of the various categories of iron-carbon alloys are given below:

	Category of Iron-carbon alloy	*Melting point*
1.	Pure Iron	1530 deg. C.
2.	Cast Iron	1235 „
3.	Malleable Iron	1235 „
4.	Wrought Iron	1593 „
5.	Hard Steel (.4/.7%C)	1371 „
6.	Low Carbon Mild Steel	1482 „
7.	Mn. Steel	1343 „
8.	3½% Ni. Steel	1427 „
9.	Cast Steel	1343 „
10.	Stainless Steel	1490 „

The procedure for the welding of each type of cast iron and steel is not discussed here, as this is being dealt with in the article to be continued.

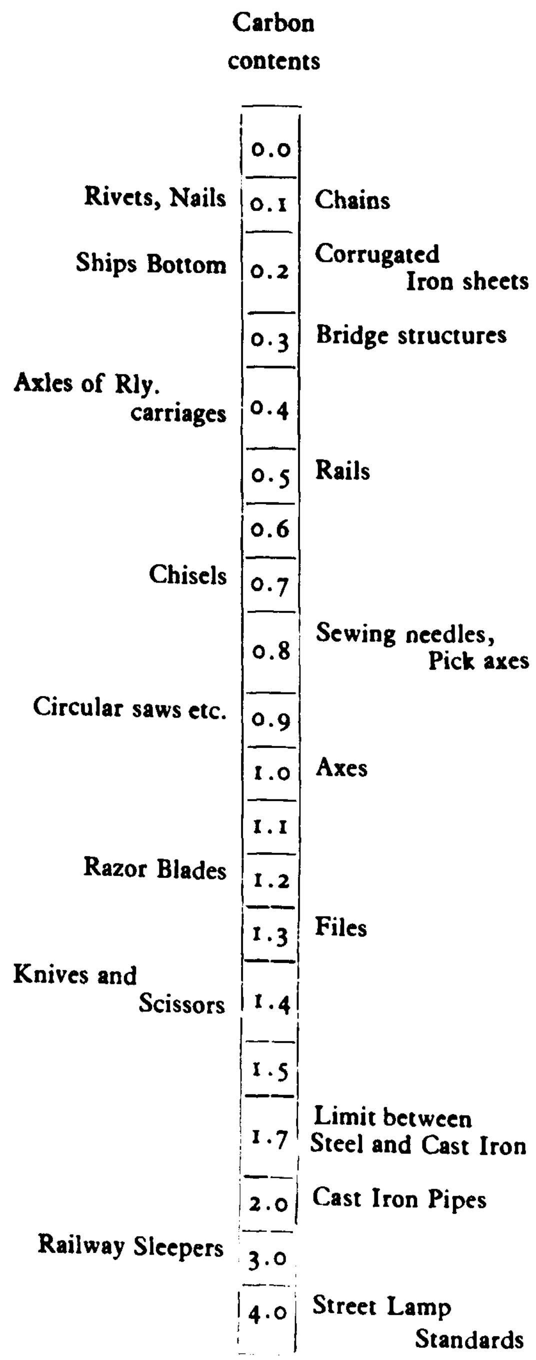


Diagram showing the various Iron-Carbon alloys and Examples of their uses.

ALLOY STEELS

Various alloying elements are added to steel in addition to carbon, to achieve various properties and these are discussed here briefly.

MANGANESE STEEL

Ordinarily, steels containing about 0.4% manganese and steels with 1% manganese are extremely hard and wear resisting. Steels of manganese content between 1% and 7% are extremely brittle, and there is no way of removing this brittleness, but when the quantity of Manganese is increased to the region of 12 to 14%, we get a manganese steel which when heated to near melting point and rapidly quenched, will give a material possessing the ductility of steel and retaining all the hardness of the material not subjected to heat treatment. Manganese steel is selected for jobs where extreme hardness is required such as rock crushing equipment, Railway crossings etc.

STAINLESS STEEL

This is an alloy of steel containing about 18% Chromium and 8% Nickel, and the rest iron, and is generally known as 18/8 Stainless steel. Stainless steels have been classed into the following different groups:

Stainless iron

An alloy of chromium and nickel and iron or chromium or iron with a carbon content of 0.15%.

Ferritic Stainless Steel

This is a stainless iron containing about 18% chromium and a low carbon content.

Martensitic Stainless Steel

In this alloy the principal alloying element is chromium only; used for cutting knives, surgical instruments, etc. and is very resistant to corrosion.

Austenitic Stainless Steel

This is the usual stainless steel of the 18/8 variety (staybrite etc.) very resistant to corrosion, and is used for chemical, food and industrial equipment. To prevent weld decay after welding, heat treatment between 950 deg. C. to 1150 deg. C. is recommended.

TUNGSTEN STEEL

This alloy usually contains 5 to 15% Tungsten and up to 1.8% carbon. The alloying element of Tungsten renders the metal self hardening. This is used for high speed metal cutting tools.

VANADIUM STEEL

This is an alloy containing .2 to .25% Vanadium, the properties of which are, increase in tensile strength and elasticity. The Vanadium in the alloy also acts as a fatigue resistant. Examples of uses are Springs, Axles and parts subjected to vibration and high stresses.

MOLYBDENUM STEEL

This is very similar to Tungsten steel, but contains .15% to .25% Molybdenum which tends to increase the hardness and endurance limits of the steel. It also increases the corrosion resistant quality in stainless steels. Examples of uses are, crank shafts of motor cars etc.

NICKEL STEEL

When Nickel is added as an alloying element, it gives the metal strength, toughness and resistance to abrasion. These alloys usually contain 4% Nickel and .45% carbon. The alloys are very suitable for heat treatment; examples of uses are Armour Plates, Rails etc.

Injurious Effects of certain elements present in steel.

PHOSPHORUS

The occurrence of this element in steel makes it brittle. It is generally present in percentages of .03 to .04. The Phosphorus content makes the metal liable to cracks when cold worked, and is supposed to produce what is called " Cold Shortness ".

SULPHUR

Unlike phosphorus, sulphur produces " hot shortness ", i.e., liability to crack when hot. The safe percentage limit is the same as for phosphorus.

Before going to non-ferrous metallurgy, we will briefly describe the different process of steel manufacture.

Production of steel by Bessemer Convertor

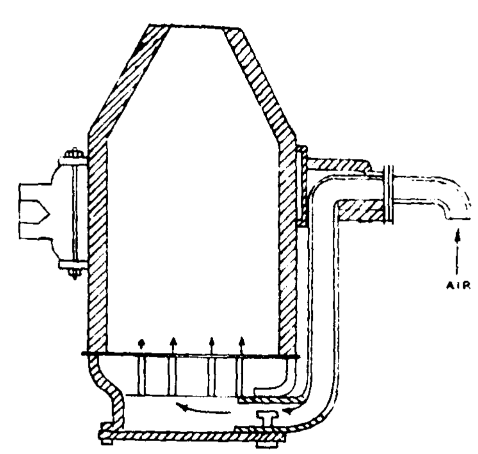
This process consists of the oxidation of the impurities of molten pig iron through the agency of cold air blown under a high pressure in small stream through a shallow bath of molten iron contained in a vessel called the convertor as per diagram appearing below. This convertor has been provided with holes at the bottom for letting in air.

The molten pig iron is transferred to this convertor after tilting the convertor into a horizontal position, so that the molten metal may not run into the tuyers at the bottom. The blast of cold air at the rate of 30,000 Cu. ft. per minute at 30/35 lbs. per sq. in. pressure is let in. The convertor can now be brought into its original vertical position, the powerful blast keeping the molten metal from running down the tuyers. The blast is continued for about ten minutes, by which time almost all the impurities are eliminated by oxidation. The convertor is again brought into the horizontal position and the steel tapped off after re-carburising the same to the extent required.

The process of conversionin a Bessemer Convertor results in the metal being deprived of its carbon content beyond the desired limit and the process of re-carburising by the addition of carbon in the form of coke is very necessary. Side by side with this re-carburisation, some de-oxidising elements are also added in the shape of ferro-manganese, ferro-silicon, aluminium etc. with the result that the remaining gases in the metal are eliminated. The finished steel of the proper composition is then cast into ingots, then reheated and rolled into the required shapes.

Production of Steel by the Open Hearth process

This process of producing steel differs from the Bessemer Convertor process in that the de-carburising of the molten pig iron is achieved by the addition of iron ore. The process also uses the sensible heat of the outgoing products of combustion to preheat the fuel and the incoming air, thus obtaining the very high temperature required in steel making. In a Bessemer convertor the heat of the bath is maintained by the purifying and de-carburising reactions going on, but in an open hearth process, external heat is supplied, as also the incoming air and the fuel are preheated.



SECTIONAL DRAWING OF A BESSEMER CONVERTOR

In the basic open hearth process, the charge of the furnace consists of :

1. Solid and Liquid pig iron
2. Scrap
3. Iron Ore
4. Lime Stone

and the order of the charge is :

1. Plate scrap or if this is not available, then Lime stone.
2. Iron Ore
3. Scrap
4. Solid pig iron
5. Molten pig iron from mixtures obtained from Blast Furnace.

The charge consisting of the first four items, takes about 2 to 3 hours to become molten, and at this stage, molten pig iron is added.

It is found some times that the carbon is being eliminated too fast, i. e., even before phosphorus is eliminated, so that sufficient quantity of pig iron is added, whereas if the carbon is being eliminated at a lower rate, iron ore is added. When the process of decarburising is complete, the metal is tapped.

After tapping, recarburising and deoxidising elements are added in the ladle, as this process cannot be achieved in the furnace.

When alloy steels are desired, the necessary alloying elements are also added in the ladle, where the elements are easily oxidised. In the case of alloying elements which are not easily deoxidised, these are added in furnace towards the end of the heat. The comperative features of the Bessemer and Open Hearth processes are given below :

Bessemer Process	Open Hearth Process
1. The process starts from the stage of molten pig iron obtained from the blast furnace.	1. The process is a complete one starting from the ore stage, although scrap, solid pig iron and molten pig iron are added during the process.
2. The heat of the bath is maintained by the purification or decarburising process going on in the bath.	2. The charge of ore, scrap and solid pig is heated by an independent outside source, i. e., fuel gas, assisted by hot air. The fuel is also preheated by the sensible heat of the outgoing furnace gases.
3. The composition of the pig iron should have a high P/content for the reaction to yield the required temperature to be maintained in the convertor. In this case P is not entirely eliminated, which results in a low quality steel.	3. The process of purification in the bath being slow, better quality steel results.
	4. In the open hearth process the pig iron phosphorus may be in the region of 1% only and its elimination is therefore more complete than in the Bessemer steel.

(Continued on page 54)

ELECTRICAL EQUIPMENT OF 1,500v D.C. ROLLING STOCK

UP to the present all railway electrification in India has been at 1,500v D.C., with overhead contact line, and now totals 244 route-miles. Therefore, although 3,000v has been selected for the Calcutta project, the former system will continue to be of importance in the development of electric traction on the Indian railways. At the present time railway administrations are studying closely the advantages of motor coach trains compared with those formed of steam type stock hauled by electric locomotives, and it is likely that motor coach sets with multiple-unit control will be used increasingly for long-distance passenger services. Where modern amenities are desired, such as air-conditioning, restaurant and buffet services and fluorescent lighting, the motor coach train is well placed because these electrical loads can be supplied conveniently without incurring the additional tractive resistance involved by the axle-driven generators in ordinary passenger vehicles designed originally for steam haulage.

Electrical manufacturers have reduced the size and weight of their equipment in step with the trend towards weight reduction by the use of light alloys in coach-building practice. At the same time improvements have been made in performance, in ease of maintenance, and in various directions which make travel by electric train attractive to the public.

Control systems have been developed so as to provide smoother acceleration. In this respect it is interesting to compare the first 1,500v D.C. passenger stock in Great Britain with equipment which went into service this year, and which is generally similar to that recently ordered for new electrification extensions on British Railways. The first British passenger vehicles for the 1,500v D.C. system were provided with traction equipment by The General Electric Co. Ltd., and had series/parallel control with ten resistance notches. In the latest G. E. C. stock this number has been increased to 14, and the setting of the accelerating relay is reduced automatically during parallel running to avoid heavy current peaks. The change of setting is effected by a bias coil energised during series running through interlock contacts on the parallel contactor, which are closed when the latter is "out". Its effect when in circuit is to oppose the ampere-turns of the accelerating relay series coil so that the relay drops at a higher motor current. In parallel the bias is removed so that the motor current must fall to a lower value before the relay is released and the next section of starting resistance is short-circuited.

In some circumstances it is necessary to give the driver control of the relay setting so that he can maintain approximately the same rate of acceleration with different train formations. This requirement arose in the Estoril Railway (Portugal) motor coaches equipped by the G. E. C., where at times one coach may haul three trailers, or operate independently, although the normal formations are one motor coach and two trailers, or two motor coaches and four trailers. The conditions are met by providing two "forward" positions of the reverser handle, in one of which a bias coil is brought into circuit.

The method of transition between series and parallel grouping of the traction motors also affects the smoothness of acceleration. It is desirable to minimise the reduction of tractive effort during the changeover. Early practice was to open-circuit the motors completely. Later this gave way to shunt transition (used in the first G. E. C. 1,500v D. C. equipments) in which two motors are short-circuited but the others continue to provide tractive effort. The system now favoured for motor coach stock is bridge transition, shown schematically in fig. 1. Connection X (fig. 1a) is made on the full series notch, the starting resistances then being disconnected from the supply. In the transition step the resistances are reconnected as shown in fig. 1b, the circuit then taking the form of a balanced bridge, with connection X carrying a relatively low current. This connection can therefore be broken, leaving the motors in parallel with all resistance in circuit. Tractive effort from the motors is maintained throughout the re-grouping and there is only one transition step between full series and first parallel, instead of three as in the shunt method.

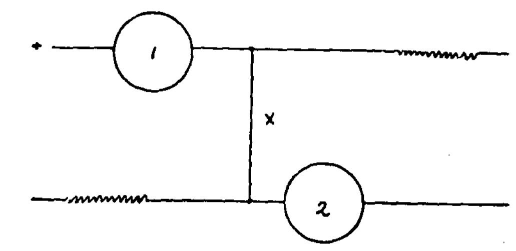


Fig. 1a. Motors in full series.

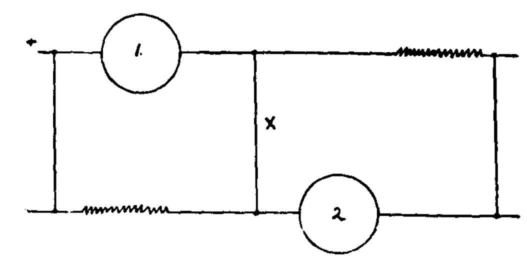


Fig. 1b. Bridge Transition Circuit. Breaking connection leaves motors in parallel.

It is general today to introduce a weak field step in parallel so that a higher balancing speed can be obtained when stops are fairly widely spaced. The accelerating relay setting for parallel notching might give rise to a current peak on going into weak field, and it

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(Continued from page 53)

Manufacture of Steel by the Electric Furnace

The Electric furnace, using Electricity as the source of heat to melt the charge, is used for:

1. Producing steel from steel scrap or molten metal from the open hearth.
2. For super refining of steel obtained in the open hearth process.

Here, the furnace, is charged with scrap steel and an arc is struck between the charge and a set of carbon or graphite electrodes, which are manually operated in the initial stages and switched on to automatic control after the arc has become steady.

During the process, ore, Mill Scale and lime are added as oxidising elements. The carbon and Phosphorus contents are deoxidised and a slag is formed on top. After this, slag is removed and lime, coke dust and flour-spar are added to make a second slag which is called the Carbide Slag. When this slag has been formed and taken to a stage where it yields Acetylene when contacted with water, it is to be assumed that the molten bath has been completely deoxidised as also desulphurised.

At this stage, the additions consisting of ferr-silicon and other alloying elements are made gradually without unduly affecting the temperature of the bath. The Steel is then tapped.

By whatever method the steel is produced, it is ultimately poured into ingot moulds and such ingots devoid of any defects are then hot worked into various items of bars, rounds, flats etc.

(To be continued)

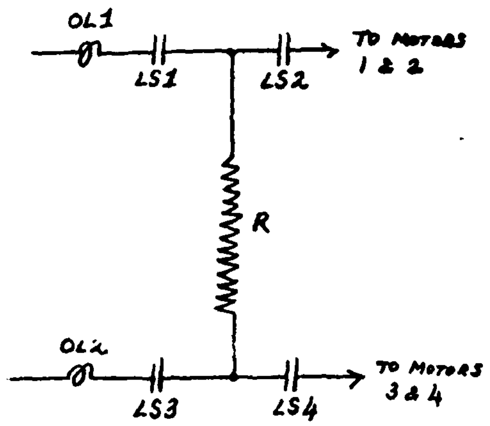
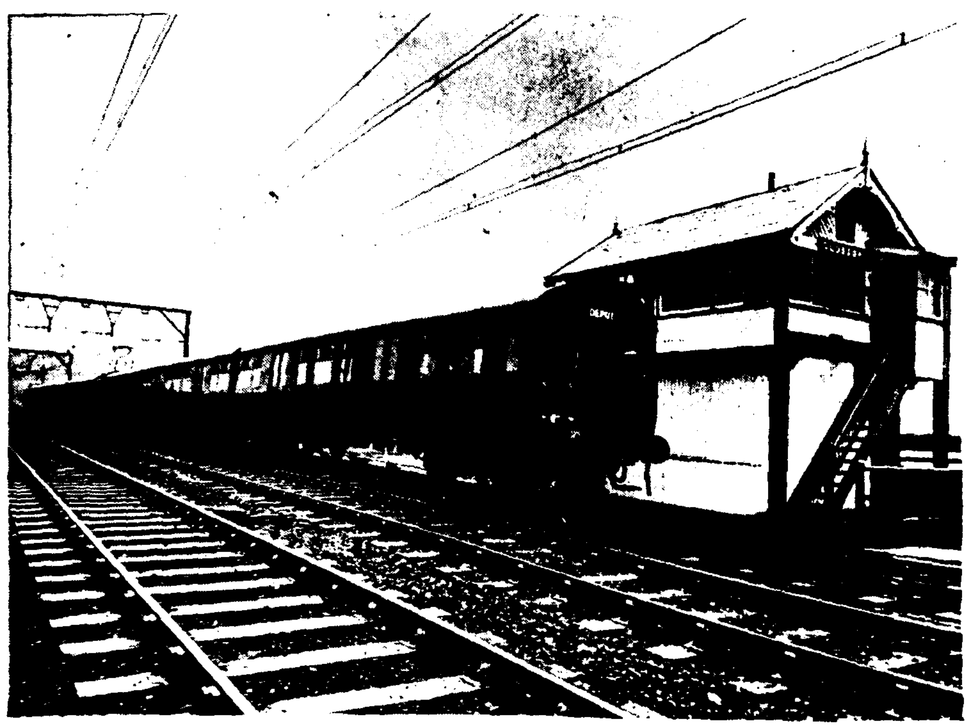


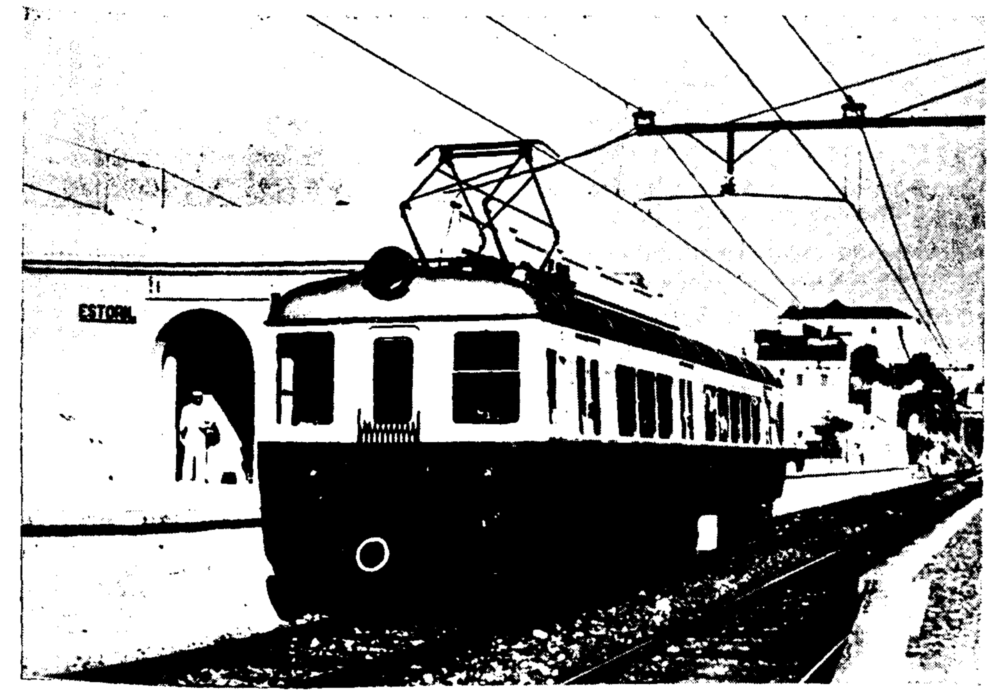
Fig. 2. Limiting Resistance Circuit for interrupting fault currents.

Assembling pantographs for 1,500v D.C. motor coaches at the Witton Works of The General Electric Co. Ltd.

(Photographs by courtesy of The General Electric Company Ltd.)



One of the new trains for the recent British Railways Manchester—Glossop electrification, for which the 1,500v D.C. traction equipment was supplied by The General Electric Co. Ltd.



A 1,500v D.C. motor coach of the 5 ft. 6 in. gauge Estoril Railway, Portugal, with G.E.C. traction equipment and mechanical parts by Cravens Ltd.

is therefore often the practice to provide a second relay with a lower setting to control the entry into this notch.

In protecting equipment against overloads, fault currents are now usually broken by the line switches acting in conjunction with a limiting resistance, rather than by means of a circuit-breaker. Fig. 2 shows a typical arrangement as it functions during parallel running. If overload relay OL1 operates due to a fault in the circuit of motors 1 and 2, line switches LS1 and LS4 open at once. LS4 isolates motors 3 and 4, while current to motors 1 and 3 now passes through the limiting resistance R. Line switches LS2 and LS3 then open to break the current. With this arrangement it is very rare for an equipment fault on the train to trip the substation circuit breakers.

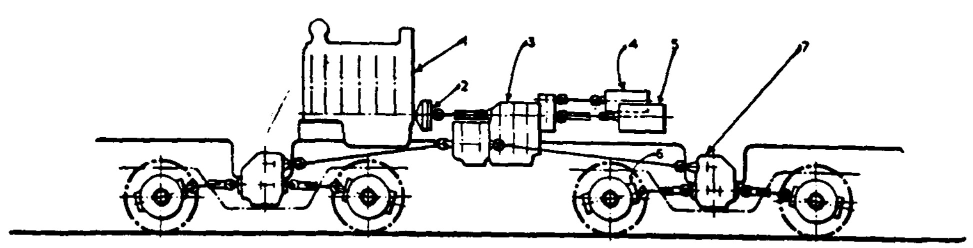
Hitherto in Great Britain 1,500v D. C. multiple-unit sets have been formed of a motor coach, trailer and driving trailer. The new stock for the forthcoming Southend and Chelmsford electrification however, for which the G. E. C. is supplying 32 traction equipments, will consist of four-coach sets with a driving trailer at each end and the motor coach next to one of the driving trailers, but with no driving compartments itself. When units are operating singly, therefore, not more than two vehicles will be propelled, thus fulfilling a British Railways requirement for the operation of trains in normal passenger service. At the same time the leading axles will be lightly loaded, a condition preferred by some civil engineers on the grounds that wear of track on curves is reduced.

COMPARATIVE STUDY OF DIESEL ELECTRIC AND OTHER DIESEL TYPE LOCOMOTIVES

A study was undertaken by locomotive and Traction Experts of General Electric Company to realistically evaluate the comparative performances of diesel-electric Locomotives and Torque-converter Locomotives, on the basis of basic theoretical principles, accepted engineering practices and experience accumulated over a period of time, derived from actual operation of the engines. This problem is discussed below :

A Torque-Converter may be defined simply as any mechanism that gains torque multiplication at the sacrifice of speed. The Hydraulic Torque-Converter is nothing new; it has been in use for more than 40 years. Invented by Dr. Herman Foettinger shortly after the turn of the century, its first application was as a speed reduction unit in ship propulsion. This was before the advent of high-speed helical gearing. The invention was exploited to a very limited extent until very recently, when economic factors rather than engineering need, made it more practical. New manufacturing techniques have reduced the cost of the different component parts making it more competitive with present day standards.

It is apparent that the application, not the device, is new and consequently no new principles are involved. We can thus see that the hydraulic torque converter locomotive is just another form of a mechanical locomotive and as such, has most of the same old disadvantages of a mechanical locomotive. The basic problem of any locomotive is distributing the power from a central source to the wheels. In reality, this problem has not



1. Diesel engine
2. Flexible coupling
3. Hydraulic transmission
4. Lighting and starting generator
5. Auxiliary generator for compressor motor
6. Bevel axle drive
7. Reduction and alternative-drive gearbox

Elements of power and transmission systems, German diesel-hydraulic locomotive

Fig. 1.

This design includes : *9—Cardan shafts, requiring :*
- *18 Universal joints*
- *6 Spline couplings*
- *18 Bearings (at a very minimum)*

3—Mechanical gear boxes
2—Auxiliary generators
4—Sets of bevel gears
1—Transmission which is comprised of either
- *3 hydraulic torque converters*
- *or 1 permanently filled converter and*
- *1 four-speed mechanical drive*

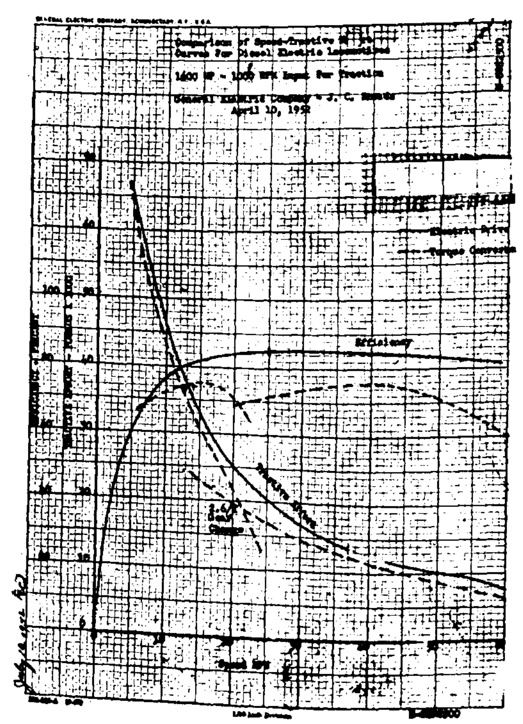
Manufacturer states "—drive to all four axles is achieved without a multiplicity of shafts and rods and without the result of a cumbersome locomotive design.

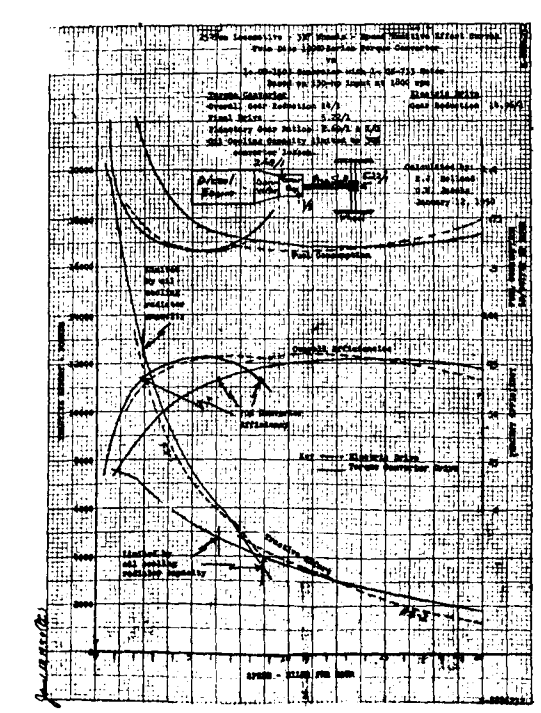
been simplified in the Hydraulic Torque-Converter Locomotive over mechanical locomotives. The complication of distributing power mechanically from a central source to the wheels is steel basically the major problem. An analogy may be drawn by considering an old machine shop with its maze of overhead shafts and tangle of belts which may be considered modern with the addition of a Torque Converter at the power source. In a similar manner, the gearing and shafting problem on a diesel hydraulic torque converter locomotive is not simplified. Figure 1 shows schematically one of the newest designs of a hydraulic mechanical locomotive.

There are applications where the hydraulic torque converter locomotive can perform an adequate job competitively. These cases are all low horsepower, rigid frame applications. However, as the locomotive size increases, as we get away from a rigid frame, as we get above a 4 to 1 speed range, the hydraulic torque converter becomes less and less attractive engineering wise. Each time a shaft changes direction, a gear unit has got to be interposed; each time lateral displacement of the power train is necessary, an additional gear unit must be added; each time flexibility is required to take care of vertical or lateral movement of the axle with respect to the locomotive platform, flexible couplings and splines must be added. All this is achieved at a loss of efficiency in operation and increased maintenance of the locomotive.

The Torque Converter is not reversible and therefore, a separate mechanical reverse gear is also necessary.

To meet the performance of the electric drive, a hydraulic torque converter locomotive needs a mechanical gear box and reverse gear. If a speed range in excess of 4 to 1 is required, some mechanism to enable shif-





ting under load is necessary. This usually takes the form of a planetary type gear unit with a complication of clutches and brakes. The torque converter unit along with associated mechanical gear boxes, propeller shafts, universal joints, bevel gears, clutches, brakes, hydraulic controls, oil coolers and similar equipment present quite a maintenance problem.

In a torque-converter drive, since neither the work nor the adjustment required allow the use of friction bearings, approximately 20 high precision gears and 50 roller bearings are required within the casing of each converter. Pressure lubrication must be used necessitating use of pumps, one for use when the vehicle is in motion, and one for use when it has been stopped with the engine running. In addition to the pumps, lot of piping is required which adds further complications. Any failure within the converter casing means pulling out a truck from the car and dismantling the whole casing. It would be required, for instance, that all bearings have a similar life to avoid all this work just for one failed bearing. A job of this nature takes several days, since the adjustments are very fine. On this point, the hydraulic transmission's disadvantage is great since, with electrical transmission systems, changing a traction motor is quite a simple operation and does not require pulling out the truck from the locomotive.

There is some maximum horsepower beyond which friction clutches are not practical. It is of little importance whether the clutches are in or out of some automatic shift mechanism ; they cannot transmit more than a limited amount of power. This weak link would be very costly in hydraulic mechanical locomotives.

Some means must be provided for cooling the fluid in the torque converter. The method which is more prominent is that of using a heat exchanger coupled to the radiator or utilizing a separate radiator. The use of the fuel tanks as a heat absorbing and radiating body has a very serious drawback in that the capacity is extremely limited when the fuel supply is low.

Leakage problems are experienced sometimes with hydraulic transmission when used in tropical climate where high ambient temperatures are common. Under such conditions the cooling system on the transmission has been found inadequate and the locomotives lose power to a considerable extent when the oil heats up.

Derailment Problems :

In diesel hydraulic locomotives there are cases where the engine is mounted on the platform. Use must then be made of telescopic shafts and cardan shafts, so as to reach the truck. In case of derailments, these shafts suffer damage and misalignment.

Though the initial cost of a torque converter locomotive may be less than a Diesel Electric, such factors as increased maintenance and operating costs and lack of flexibility of transmission should be taken into account and given due consideration.

A summary of the advantages and disadvantages of hydraulic torque converter-Gear Change and Electric Drive is given below :

Hydraulic Torque Converter-Locomotives

Advantages

1. Converter itself small and compact
2. Usual design of converter oil cooler enables high continuous adhesion.

Disadvantages

1. A new application for locomotive use.
2. Rail shock transmitted from axle to direct connected spline propeller shaft, universal joint, gear box, converter turbine and housing.
3. Three axles mean additional chains or side rods. Four axles either additional chains or rods or extra spline propeller shaft and associated gears. Increase in number of axles on rigid frame increases minimum radius of negotiable curves. Very complicated shafting when applied to swivel or articulated trucks.
4. High mechanical maintenance.
5. Mechanical reverse gears always necessary.
6. Either drive chain or splined propeller shaft and universal joint necessary.
7. Speed change clutch and brakes similar to Model 'T' Ford transmission necessary for gear changes.
8. Speed change, clutch and brakes are necessary for gear changes.
9. Oil cooling radiator necessary and larger fans needed for cooling both oil and water. This means reduction in power to converter, less space in engine room, more weight, extra piping and increased maintenance.
10. Electric or air starting motor necessary.
11. Maintenance of clutches, gears and brakes always difficult. Most problems the same as on straight mechanical locomotives.
12. Inspections are difficult and must be frequent. Oil level must be checked and all filters cleaned twice weekly. Clutch release, transmission bearings and accelerator controls must be checked and greased twice monthly. Auxiliary pumps and all fluid connections and controls must be checked once a month since overheating is a serious problem. The radiator must be cleaned at least once a month.

Electric Drive Locomotives

Advantages

1. Proven Dependability
2. Rail shock reduced since only traction motor mounted on axle. No mechanical connections between engine generator set and axles.
3. Readily adapted to any number of axles.
4. Low electrical maintenance and practically no mechanical maintenance.
5. No gears to shift, either forward or reverse.
6. No propeller shaft and universal joints to maintain.
7. No clutch and brake assembly to maintain and replace.
8. Readily adapted to swivel or articulated trucks.

9. Equipment is self-ventilated. Heat is disposed of at course. Generated heat is radiated by the coils and hot air is carried away by fans mounted on armature shaft.

10. Generator provided with starting winding to crank engine.

11. Easy to maintain.

12. Easy to inspect.

13. Can be provided with dynamic braking.

14. Easily capable of 10 to 1 speed range.

15. The speed of the diesel engine is independent of the locomotive speed so that the engine can be driven at its most economical speed for each output required, thus reducing wear and maintenance cost. Close engine governing enables best utilisation of engine output and the avoidance of critical speeds in the neighbourhood of service speeds. The tractive effort speed characteristic obtained with diesel electric locomotive enables the motive power unit to be used to full advantage.

16. Electric transmission eliminates interruption in the transmission of power when speed is changed. This eliminates the jerks in the movement of the train and road shocks to the engine.

17. Electric transmission permits practically all speeds between zero and maximum to be obtained smoothly which will allow the running of the vehicle to be better adapted to the profile of the line by using the total power of the engine.

18. It permits lower axle loading and most favourable arrangement of engine driving and carrying axles for good distribution of weight and running qualities.

19. Facility of simple and fool-proof remote and multiple control with uniform variation of the tractive effort to enable the train automatically adjusting to the engine output and train resistance and accelerating to the maximum speed in minimum time. When grades and curves are to be negotiated, no change of operation is necessary, the engine automatically developing maximum power without fear of overloading or stalling.

Disadvantages

1. Lower continuous adhesion (not a disadvantage for normal switching or ... service).

Two comparison curves have been drawn up, one for 1600-h.p. road service application and the other for small switching application. These curves are made with conservative estimates of gears and other mechanical losses. These curves provide a good comparison of the two types of transmission.

CHITTARANJAN'S 300TH LOCOMOTIVE PRODUCED

Chittaranjan's 300th locomotive has rolled off the assembly lines. In February this year Chittaranjan Locomotive Works completed the 200th locomotive, and the event was marked by the President, Dr.Rajendra Prasad, inaugurating the 200th engine. The Chittaranjan Locomotive Works were originally planned to turn out 120 locomotives per year. This target has already been exceeded. The output has increased rapidly from six locomotives per month in the early part of 1954 to ten per month from January to June 1955. Thereafter, a monthly production of eleven locomotives has been maintained. The Railway Board have accepted in principle to raise the annual target of production to [illegible] locomotives per year.

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