THE ARIEL MOTOR CYCLE WORKS.

Interesting Production Methods Employed in a Factory Arranged for Large Outputs.

WITH a full production capacity of approximately 1,000 motor cycles and 2,500 cycles per week, the Ariel Works, Ltd., Selly Oak, Birmingham, provide constant employment for approximately 2,000 workers. The growth of the organisation has been rapid, particularly in recent years, this having been in no small measure due to a policy of producing motor cycles for overseas markets, in addition to those required to meet home demands. Additions from time to time have been made to the factory, and the total floor space now occupies an area of some 500,000 sq. ft.

Novelty in design has to some extent been responsible for the success of the Ariel motor cycle, which is claimed to be the first machine to employ a saddle tank. An innovation which created considerable interest at the Motor Cycle Show about a year ago is the four-cylinder air-cooled model. The engine of this machine is fitted with twin gear-coupled crankshafts mounted on large diameter ball bearings, the main coupling gears being enclosed in a separate oil-fed case within the main crank case. A single casting forms the four cylinders, and the detachable cylinder head has the exhaust passages and radial induction manifold integral with the casting.

In the layout of the works the flow system is employed for material and parts as far as is practicable. The works are arranged to permit the unloading of raw material at the stores situated at one end of the factory buildings, the stores being situated conveniently near the machine shops, through which the components pass on their way to the engine assembly benches, test houses, and finally to the assembly tracks for the building of the actual motor cycle. All the castings received in the raw material stores are produced in a foundry owned by the company, with the exception of the cylinder castings, which are bought from an outside firm.

The main machine shops, a section of one of which is shown in Fig. 1, occupy an almost central position in the works. Here the line system of operation is employed, castings and forgings being delivered at one end of the lines of machines, and being passed along from operation to operation until the work is completely machined. Most of the grinding is, however, carried out in a separate grinding shop adjoining the heat-treatment department. An orderly flow of material is obtained throughout the works and the machine shop equipment is for the most part up to date. Except in isolated instances, independent motor drive is not applied to machine tools, these being generally driven from overhead shafting. The castings dealt with are, of course, considerably lighter than those passing through the average automobile factory, so that mechanical handling means are not one of the main essentials in a works of this nature.

Grouped around the main machine shop are other departments where components are produced which will eventually pass through the machine shop. There is, for example, a press shop, where most of the pressings required are produced, a bar automatic shop, the grinding shop already mentioned, and the heat-treatment department. Here gas-fired furnaces are employed, these being principally of Richmond manufacture. The row of quenching tanks is served by means of an overhead runway, and a system of fans ensures that the shop is kept reasonably free from fumes.

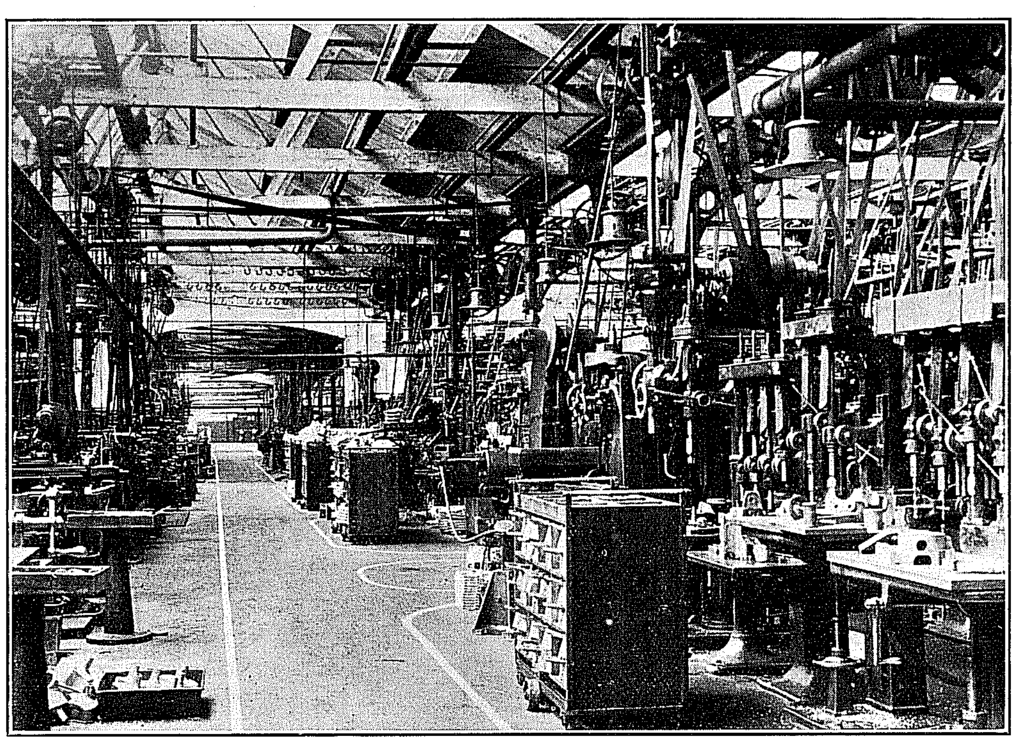


Fig. 1.
A section of one of the machine shops.

Drop stampings required in the construction of motor cycle frames are dealt with in a separate machine shop, a typical set-up in this section being shown in Fig. 5. The operation shown is that of milling opposite sides of a gear box bracket for the sloping cylinder type motor cycle. It will be noted that location is secured by means of one fixed and two adjustable cup-type locating pads, and the work is securely tightened by means of two locking screws. This operation is typical of many carried out in this section.

Parts received in a semi-finished state, such as exhaust tubes, silencers, petrol tanks, and so forth, which as a rule require to be plated before being passed through to the assembly section, are taken to what is known as the fitting department. Here they are placed in jigs which determine whether they will fit correctly into place during assembly without any further work or adjustments being carried out on them. Such a jig, which is employed in the examination of exhaust pipes, is shown in Fig. 2. It will be seen that a dummy cylinder head is mounted on columns and the exhaust pipes are mounted in position, the length being measured by hollow plungers in fixtures attached to the base plate. To ensure that the pipes are spaced at the correct width there is a swinging-type gauge, which is brought into position between them, and the pipes must also engage with a number of fixed stops which correspond to the fixing position on the finished product.

For testing saddle tanks a dummy-frame type of jig is employed to ensure that each tank when polished and plated will fit into position on its respective frame without any trouble of any kind.

There is a centrally placed tool room for serving the various machine shops, and here all the gauges and jigs required in manufacture are produced. Amongst the more interesting equipment may be mentioned an S.I.P. three-co-ordinate jig-boring machine.

Separating the machine shop for the framework components from the main machine shop makes it simple for machined stampings used in framework construction to be passed through to the frame-building section. The assembled frames are then passed direct to the main assembly tracks after enamelling. A typical jig employed in the assembly of frames is shown in Fig. 3. As is clearly shown, it embodies means for aligning the frame within definitely defined limits, there being plungers placed at suitable points for engaging with certain joints and sections of the frame. Small holes are drilled through the joints, and pegs are inserted, after which the frame is taken from the jig for the brazing operations. From the brazing shop the frames are taken to the cleaning and enamelling department.

The assembly shop for engines is situated between the machine shop and the main assembly tracks. During assembly the engines are mounted on small carriages which are arranged to run along on a track. As the engine is built up it is passed along the track, and when completed is removed and conveyed to the test house, the carriage being returned along to the starting end of the line by means of a track arranged underneath the main line.

A section of the engine test house is shown in Fig. 6. As a preliminary test each engine is run-in for a period of half an hour by means of an electric motor, after which it is run under its own power driving a fan. It is then passed over to the section shown, so that a test may be made as to the actual power capable of being developed. The engine, which is connected to a shaft running alongside by means of a chain, may either be driven by means of a motor connected to the shaft or run under its own power, in which case it drives a Heenan and Froude dynamometer arranged at the end of the line. The engine is geared down in the ratio of 2 : 1, so that the readings given on the dial are actually half the engine speed obtained. It will be seen that there is a system of air ducts which provides for cooling air to be blown on to the engine during test, so that the conditions approximate to those likely to be existing during actual service.

In this department there is also an interesting machine which is employed for testing complete motor cycles of new design. Each of the wheels of the cycle engages with a pulley housed in the floor of the shop, as shown in Fig. 7, there being cams of various dimensions bolted to the pulleys so that when the machine is being run it is subjected to a severe jolting process. As shown, the machine is secured to the test bed by means of a system of links fastened to the engine crank case, and the two pulleys are connected together by means of a cycle-type chain. The motor cycle runs under its own power and the top gear is engaged. In this manner the rear wheel of the cycle drives one of the pulleys, which in turn, by means of the chain, drives the front pulley to drive the front wheel of the motor cycle. Weights are applied at the saddle position, as shown, and air is blown to the cylinder by means of ducts, so that conditions generally are similar to those likely to be encountered during very rough service.

This test is applied over a period which may last as long as twenty-four hours, and afterwards the machine is taken to pieces and the various components tested for wear. The cams bolted to the driven pulleys may be varied so that testing conditions range from those encountered on

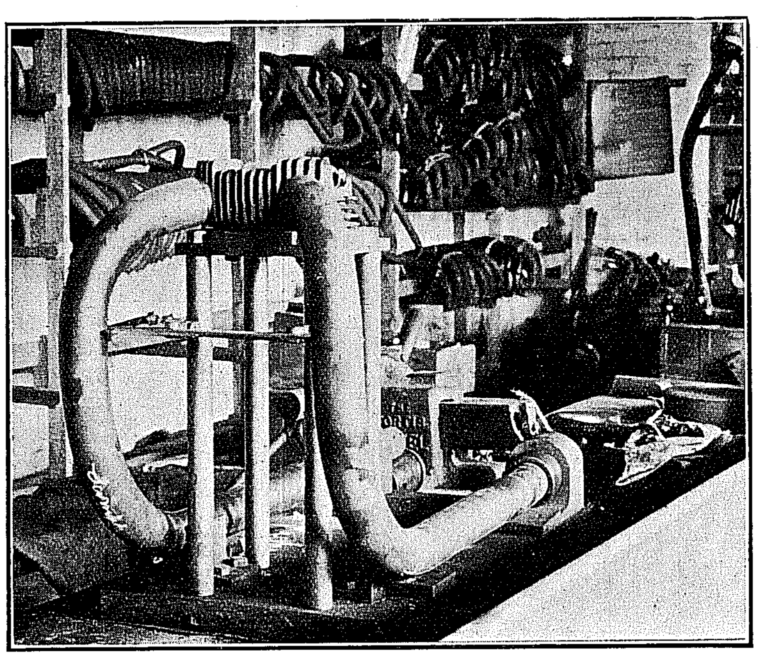


Fig. 2.
Exhaust pipe checking fixture.

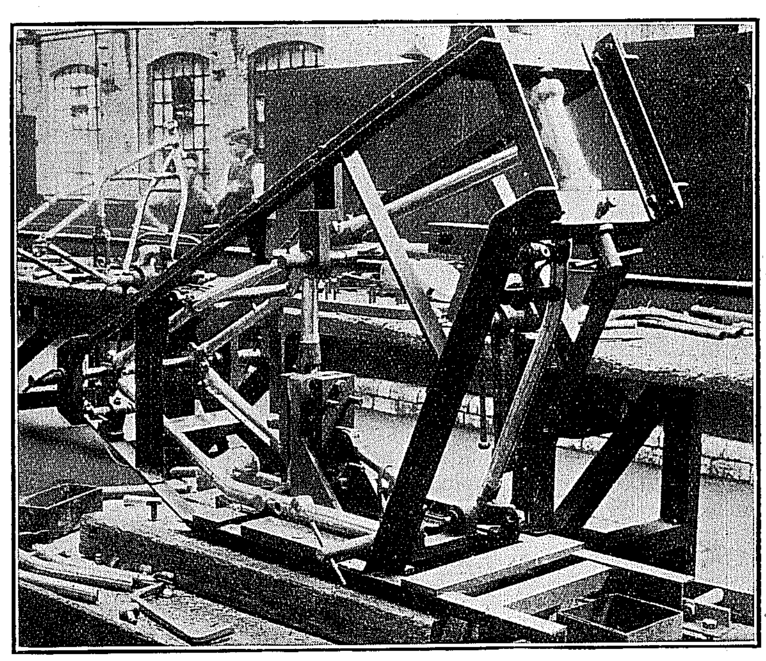


Fig. 3.
The frame assembly jig.

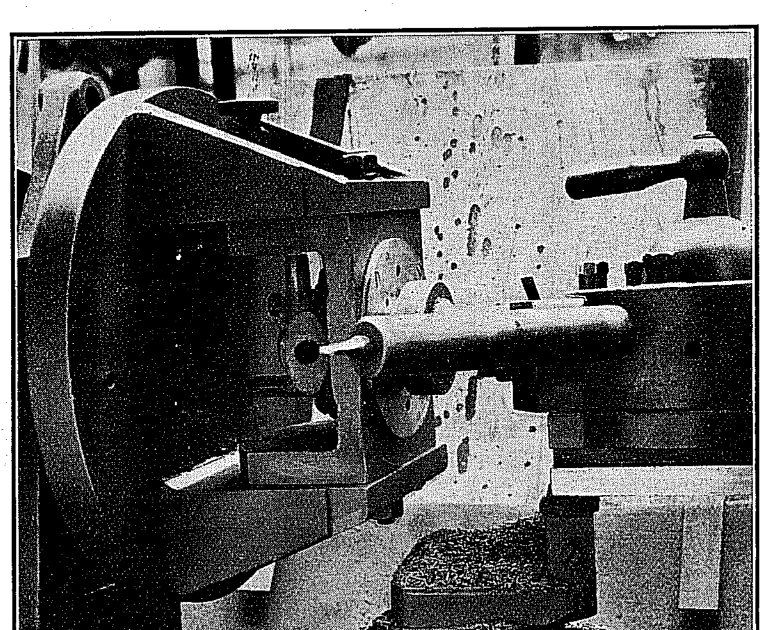


Fig. 4.
Milling the combustion chamber.

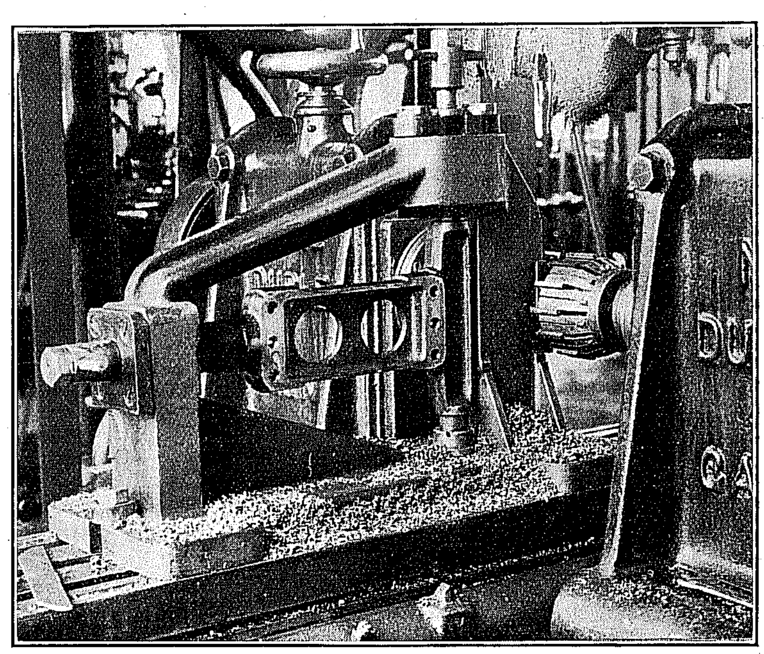
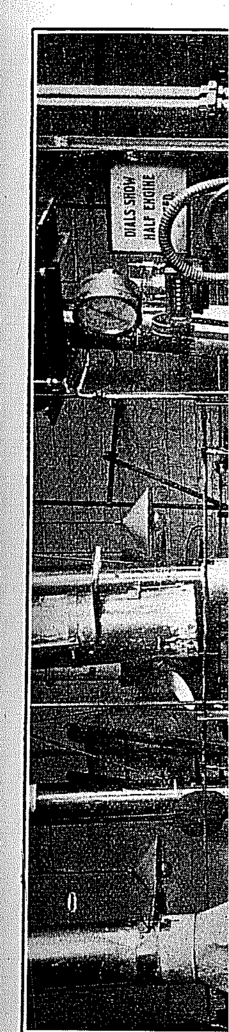


Fig. 5.
Milling a gear box bracket.



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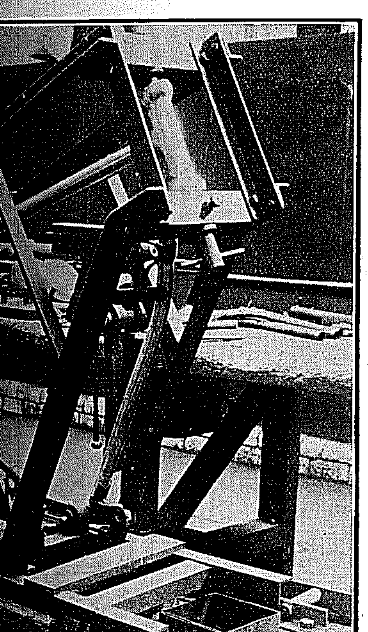

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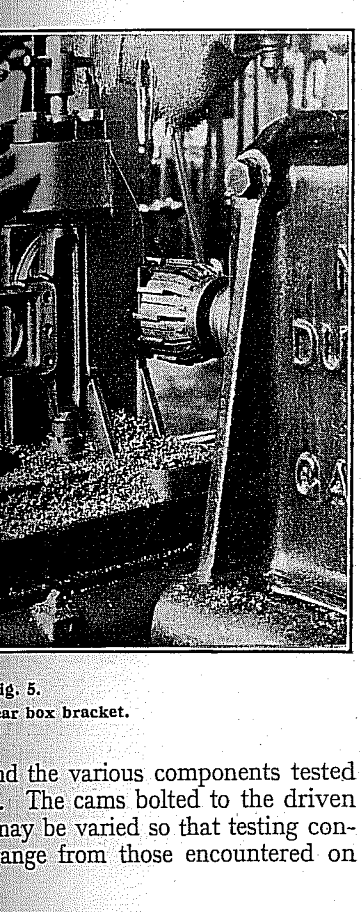

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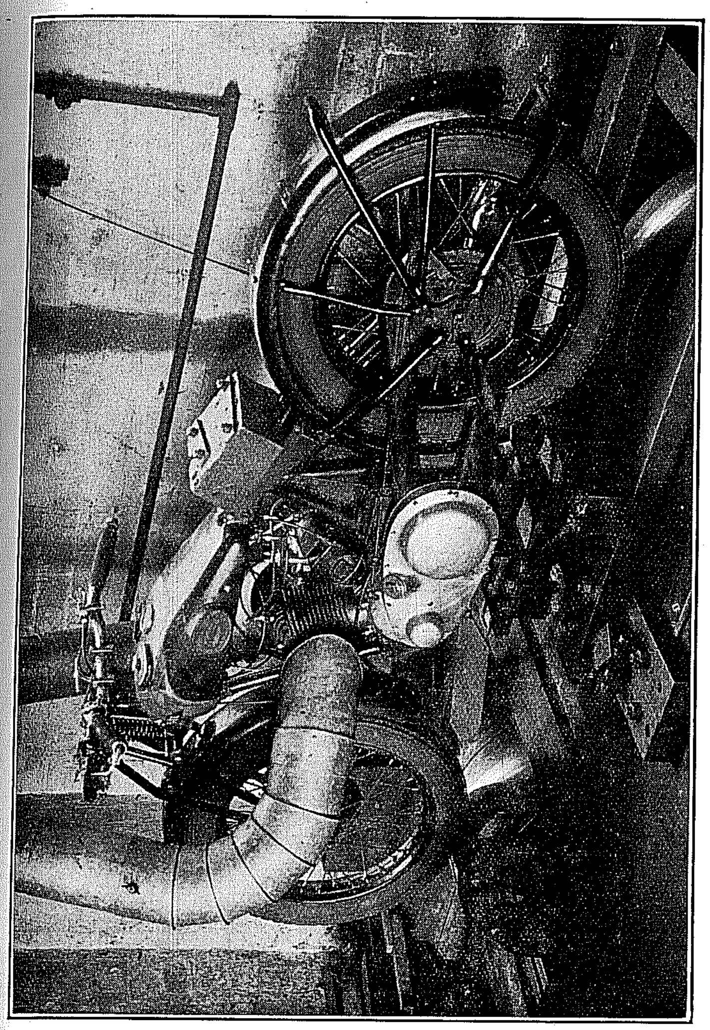

Fig. 7. Testing rig for completed motor cycles.

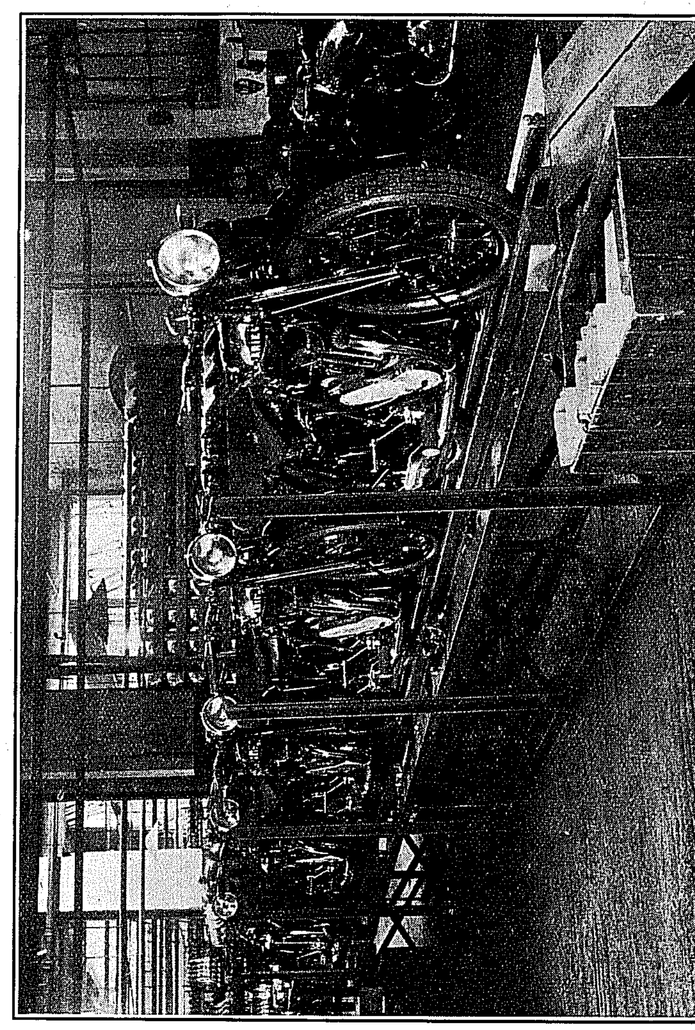

Fig. 9. Electrical equipment assembly line.

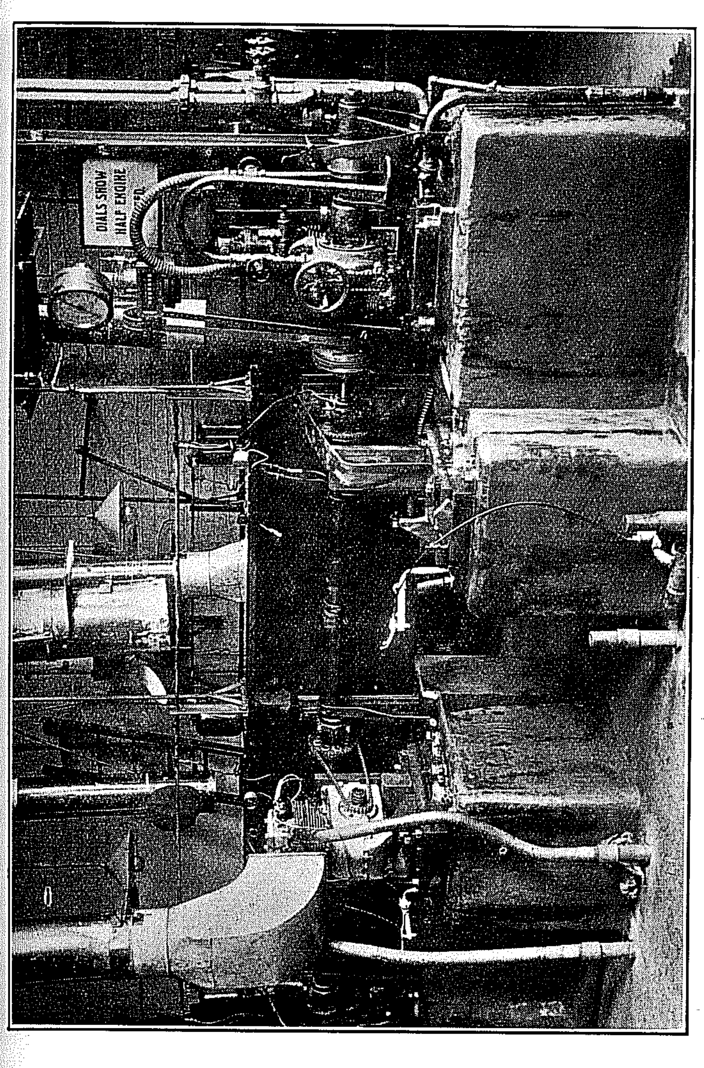

Fig. 6. A section of the engine test shop.

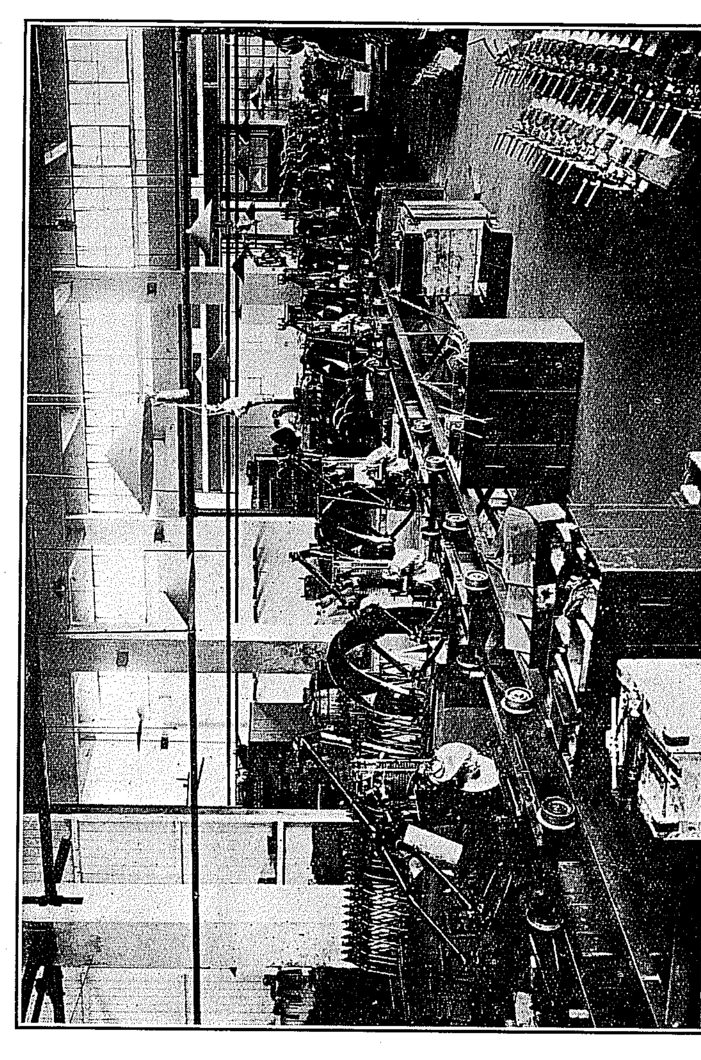

Fig. 8. One of the main assembly lines.

an ordinary road to those likely to be met during severe trials. In addition, the machine serves as a test for the durability of tyres, springs, and so forth.

Above the main assembly department are two other floors, the first of which houses the automatic enamelling plant, whilst the second houses the wheel assembly section. The enamelling plant, which was supplied by the Carrier Engineering Co., functions automatically, the various parts being dipped into baths of enamel and slung from an overhead conveyor which passes them through a drying oven.

Air in the drying oven is heated by means of a number of gas-fired units, and the speed of the conveyor is such that the work emerges at the unloading end completely dry. It is then slung from a further conveyor and returned to the starting end again so that the second coat of enamel may be applied. Frames, mudguards, and so forth, are sent from this department direct to the main assembly department, whilst rims and hubs for wheels are taken up to the second floor, where wheel assembly is carried out.

The wheels are built up in accordance with conventional practice, and on completion are placed in a chute, down which they are guided to the ground floor, where they arrive at a position conveniently adjoining the main assembly tracks. In order that the wheels shall not drop directly down to the ground floor with results that might well be disastrous, there are a number of pegs in the chute, these being arranged in staggered order on opposite sides. In this manner the wheel is constantly passed from side to side of the chute, and, the motion being constantly arrested, the speed at which the work is lowered to the ground floor is comparatively slow.

Attached to the main assembly department is a separate store, at which saddles, lighting sets, and so forth, are received. There are two main assembly lines, one for the 600 c.c. and 500 c.c. capacity machines, whilst the other is for the 300 c.c. capacity models. One of the assembly lines is shown in Fig. 8. It will be seen that the frame is bolted to a four-wheel bogey which is progressed along the track by hand. The main frame is first bolted to the bogey, after which the engine and gear box are assembled. Next come the rear wheel and front wheel, and the work is passed along for the addition of silencers, saddles, controls, and so forth.

There is a separate line for the mounting of lighting sets, this being shown in Fig. 9. In this case the completed machine runs on its own wheels between two guide bars, and a wooden clamp is arranged to press down on to the saddle to keep the machine rigidly in position whilst the lighting equipment is being assembled. From the assembly tracks the completed machines are passed into a shop where the tanks are filled with petrol. The oil tanks are filled and grease is applied where necessary, and the machines are then tuned up and subjected to a road test.

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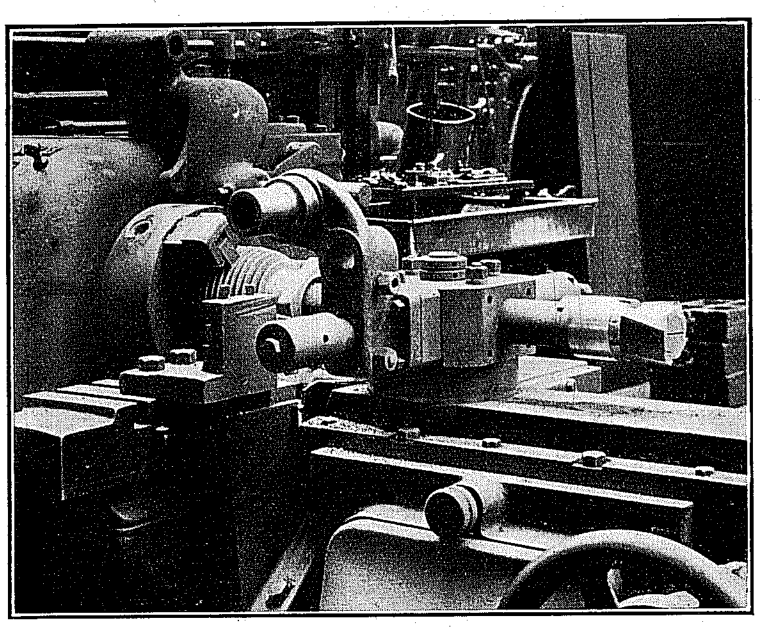

Fig. 10.
First operation on a cylinder casting.

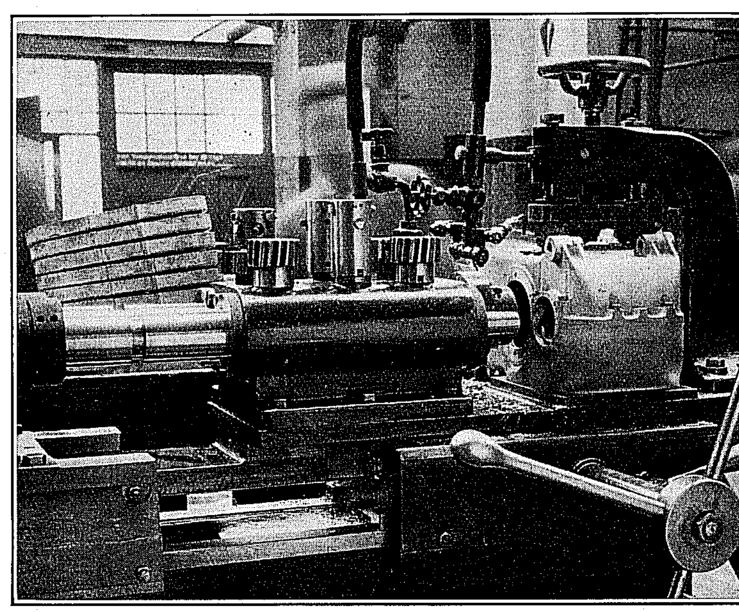

Fig. 11.
Two-spindle boring machine and cutters.

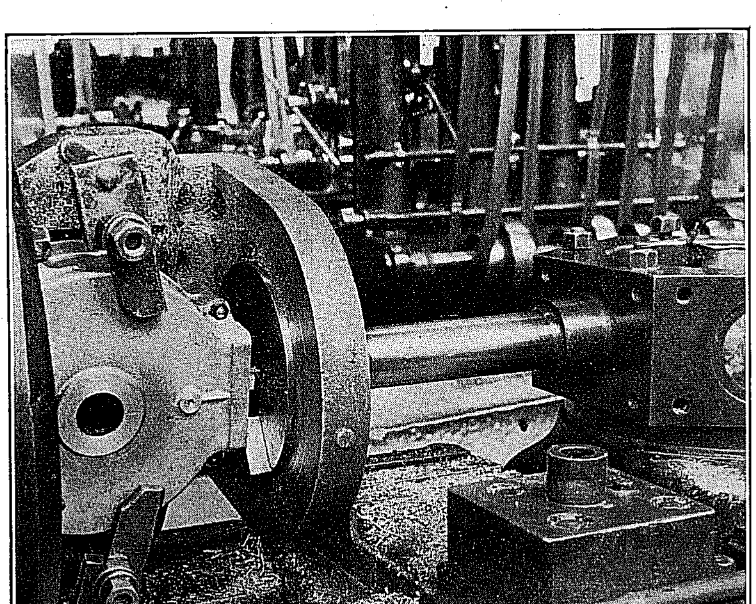

Fig. 12.
Boring and facing a crank case.

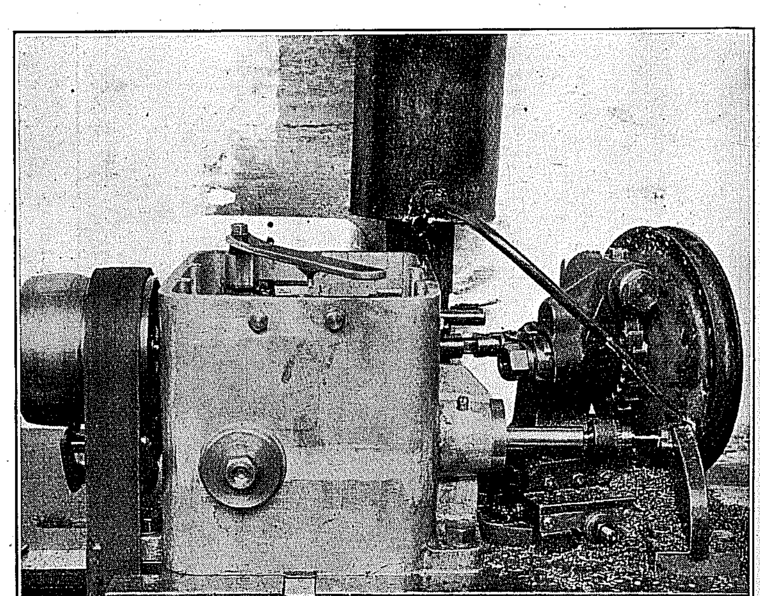

Fig. 13.
Automatic drilling machine for spoke rims.

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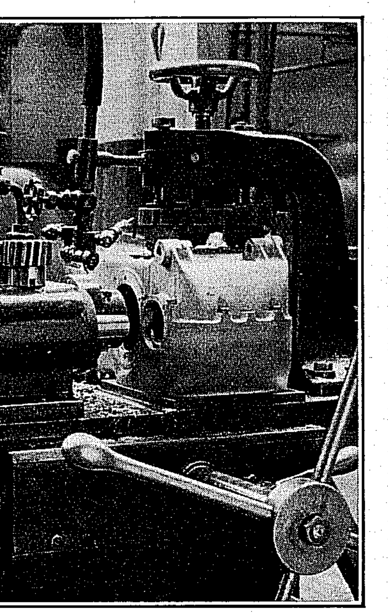

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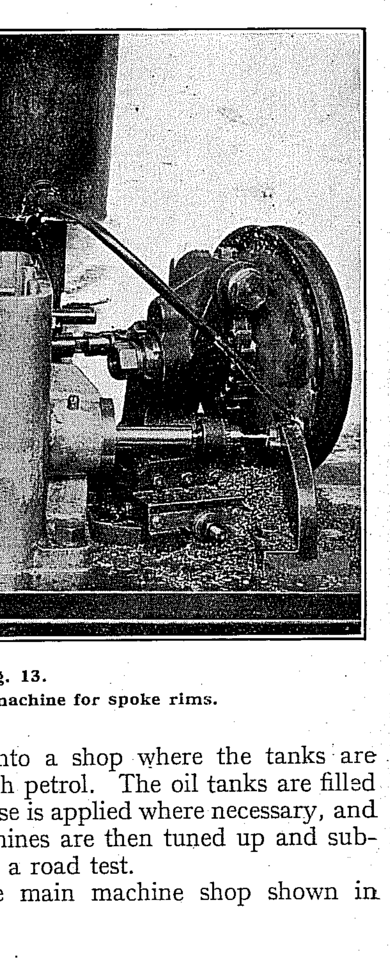

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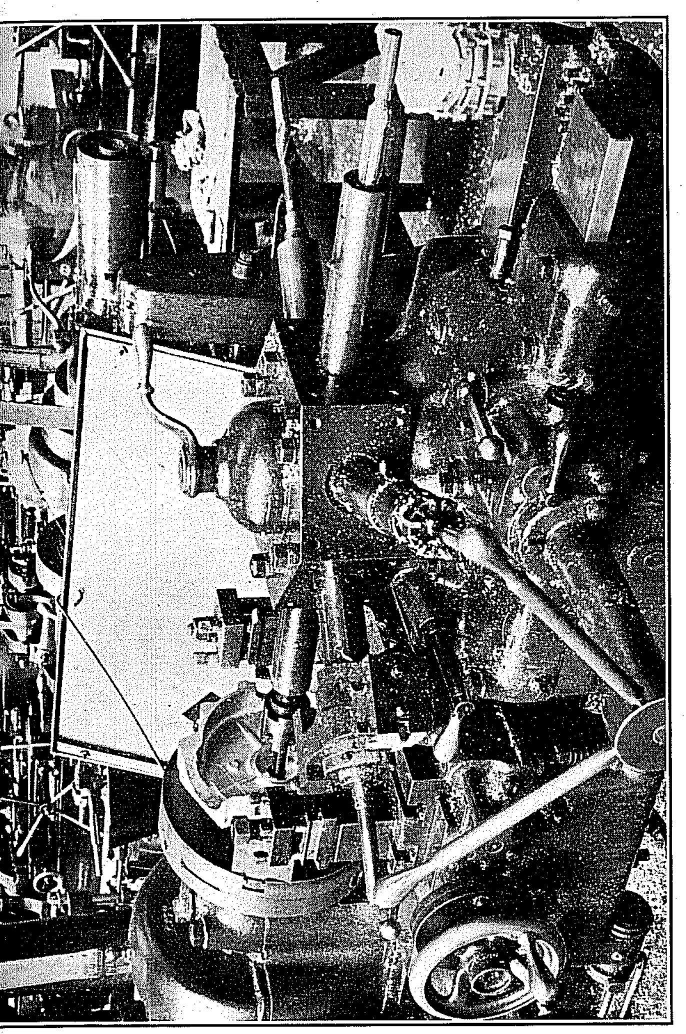

Fig. 15. First operation on one type of crank case.

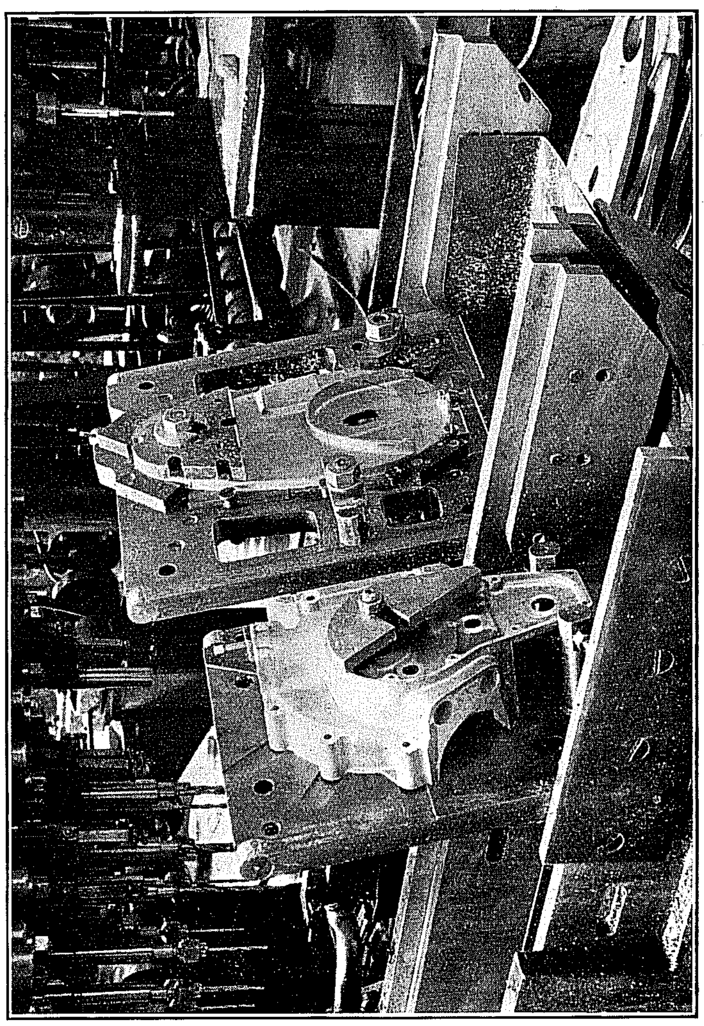

Fig. 17. The drilling jigs in the loading position.

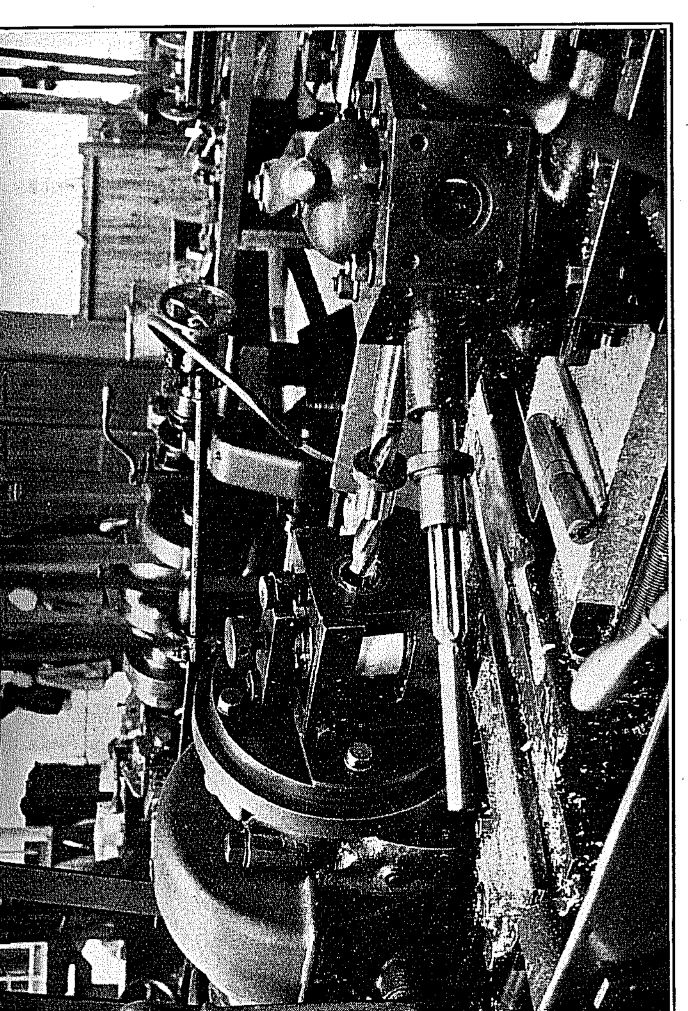

Fig. 14. Drilling and reaming the gudgeon pin bore.

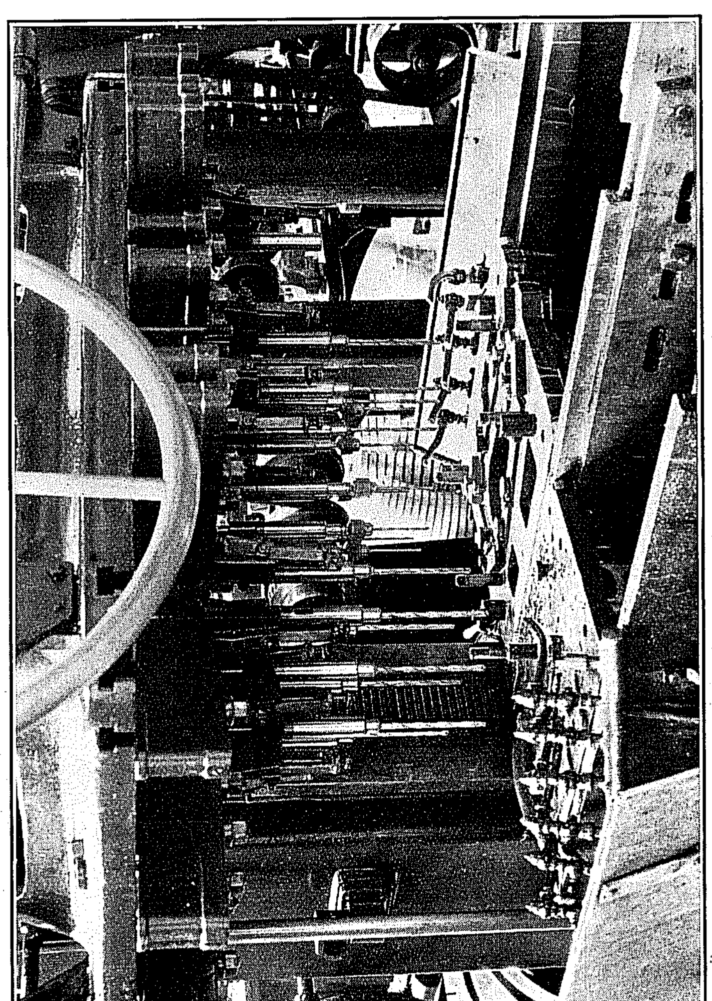

Fig. 16. An interesting multi-drilling arrangement.

Fig. 1 some interesting operations are carried out in the machining of the various components. The first operation in connection with the machining of a light alloy piston consists of rough turning the skirt. For this process the work is located on an expanding mandrel on a capstan lathe and

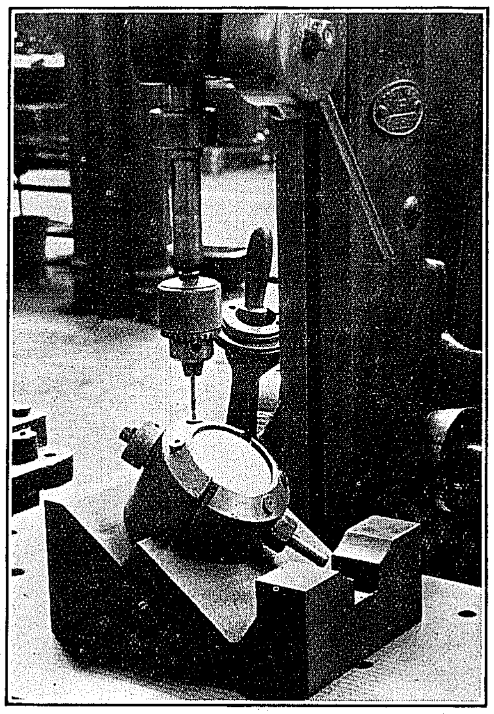

Fig. 18.
Drilling the oil holes.

two tools are arranged so that one follows the other when the automatic traverse is engaged.

The next operation consists of turning the recess and register in the skirt, this being also performed by means of a capstan lathe. In this instance the work is located in a hollow chuck from the previously turned outside diameter and the end of the skirt is faced by means of a tool carried by the saddle, whilst the boring tools are carried by the turret. This is an important operation, as the skirt register forms the location for all the turning, grinding, and drilling operations which follow.

Fig. 14 shows the set-up employed for drilling the gudgeon pin bore. It will be seen that in this case the work is located in a box-type jig carried on the face plate of a capstan lathe. Location is effected from the skirt register and a quick-acting clamp is fitted for holding the work securely in position. Drills and reamers are brought into operation as required, the drills being piloted in a bush at the front of the jig, whilst the reamers are piloted both at the front and the rear. A plug gauge is employed for testing the bore for size.

The next process consists of turning the skirt, turning the piston ring grooves, facing the end, and reducing the diameter of the work over the ring section. A B.S.A. hydraulically operated piston-turning lathe is employed for this operation, the set-up being shown in Fig. 20. The work is located from the skirt register, a pin is inserted through the gudgeon pin bore, and, when a lever is actuated, hydraulic motion causes the pin to be pulled back to keep the work securely in position. The cycle of operations is entirely automatic, all that the operator is required to do being to operate a lever to set the chuck revolving and engage the feeds.

After drilling the various oil holes, the placement of which varies in accordance with the particular size of piston being operated upon, the skirt is ground by means of a Landis grinding machine. An interesting point in connection with this operation is that the work is ground with an ovality of 0·01in., this being secured through the medium of a cam mounted in the head of the machine. The work is pulled back on to a register, as in the case of the previous turning operation, and the work is sized to a vernier scale. The next process consists of drilling the gudgeon pin oil holes, the set-up being shown in Fig. 18. It will be seen that the work is held in a hollow-type split jig, a plug being passed through the gudgeon pin hole to secure the assembly in position. The assembly of piston and jig may be swung round in the angular base plate to present the various drilling bushes to the tool.

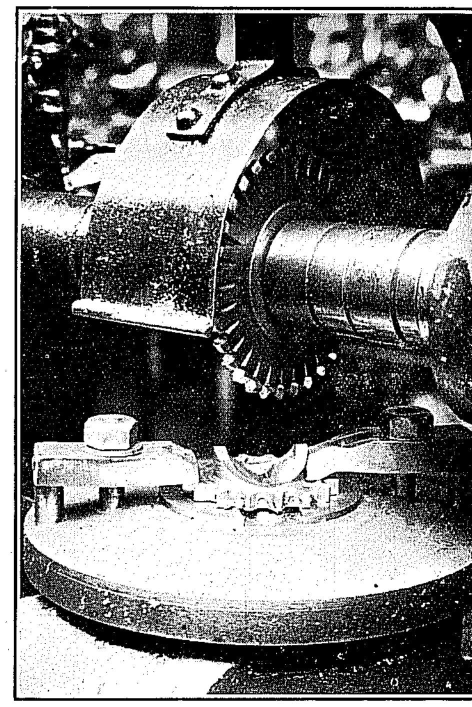

Fig. 19.
Milling cam profile on sprocket.

After the various minor operations have been performed the work is passed to the checking table. One of the principal tests carried out here is to see whether the gudgeon pin is exactly at 90 deg. to the axis of the work. For this process the skirt register is located on a spigot on a ground face plate, and a plug that is approximately 3in. longer than the diameter of the piston is inserted through the gudgeon pin bore. A dial gauge is held in a suitable fixture, and is arranged to

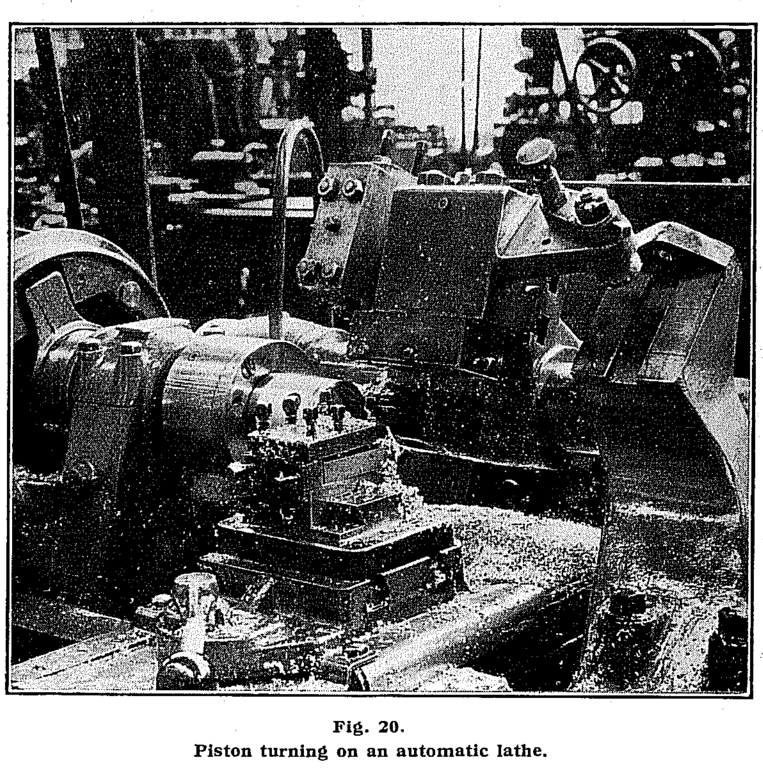

Fig. 20.
Piston turning on an automatic lathe.

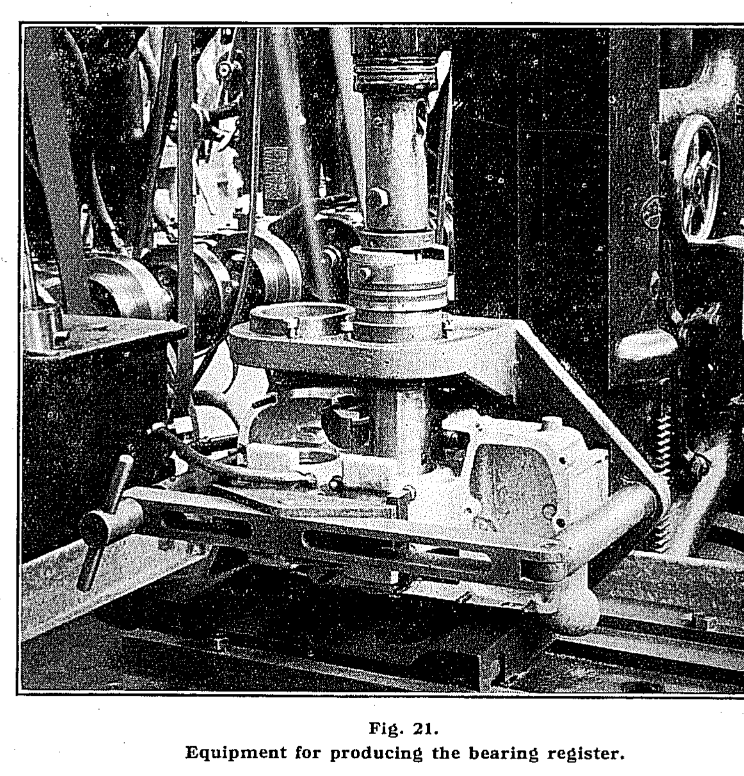

Fig. 21.
Equipment for producing the bearing register.

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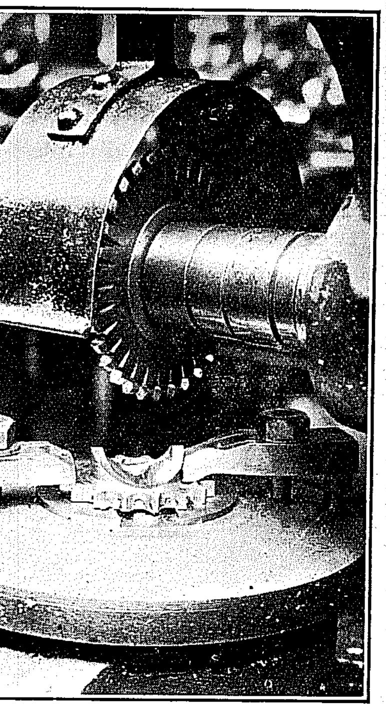

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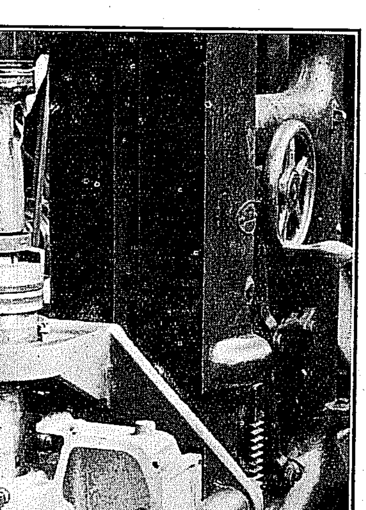

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touch the periphery of the plug at one side of the work. The assembly is then revolved so that the opposite end of the plug comes into contact with the gauge, and any alteration in the position of the dial from the first reading is carefully noted.

There are, of course, several different designs of engine being produced. The designs of the casings for the single-cylinder engines are, however, somewhat similar, so that some of the operations performed on them are almost identical. The first operation on the crank case for the vertical single-cylinder engine is shown in Fig. 15. This consists of boring the main shaft hole and ball race housing and turning the main flange and spigot. The saddle of the machine carries two tools for facing, whilst the turret carries six further tools for boring the holes and producing the spigot on the flange. All the tools are piloted in a bush carried in the spindle of the machine, and for producing the spigot a double fly cutter is employed.

The facing operation, which is effected in two cuts, is carried out by bringing the saddle up to an indicator, so that the correct depth of flange from the bearing face is secured. Turning the back face for bolting to the primary chain cover forms the next operation, and during this process the work is, of course, located on the previously turned spigot.

Figs. 16 and 17 show the equipment for drilling the various flange holes in a crank case casting, which is mounted in the nearer of the two jigs seen on the machine. Two slides are carried by the 36-spindle Natco drilling machine, each of these carrying a sliding jig. On one jig are drilled the pin holes on the outer edge of the primary chain cover, whilst on the nearer jig are drilled the eight bolt holes in the crank case. The jigs slide on rollers, and when pulled to the front of the slides may be inverted, as shown in Fig. 17, for loading and unloading the work. The crank case is located on the main spigot, simple clamping means being provided, as shown, whilst the primary chain cover is located by means of adjustable stop pieces. Coolant is conveyed to each drill point and push-button control is provided.

Fig. 12 shows the operation of boring the cylinder register and facing the cylinder flange. The work is located on the main shaft bore and the timing gear face so that the cylinder face is dead square with the timing gear face flange. In front of the jig carried on the face plate of the turret lathe is a pilot bush for housing the boring bar. Two tool bars are carried by the turret, these being indexed 180 deg. as required. The first provides for rough boring and rough facing, whilst finish boring, finish facing, and turning the bevel are effected by means of the second.

Drilling two holes for the bushes for the tappet rod guides and four holding-down bolt holes forms the next process, after which the stud holes for holding down the cylinder are tapped. The work is located from the main bore in a jig, and the action of a cam forces up the plug on which the main bore is located so that the flange is pressed up against a spigot on the underside of the drilling jig.

Fig. 11 shows a two-spindle horizontal boring machine employed for dealing with the main bearings of four-cylinder crank cases. In this case the work is located from two dowel holes drilled on the underside of the casing, and the work is clamped in position by the operation of a hand wheel. Various cutters are mounted on the spindles for dealing with the different diameters of the bearings as necessary. Cutting the ball bearing register is an interesting process, and is effected by means of the equipment shown in Fig. 21. It will be seen that a single-spindle vertical boring machine is employed and that the jig used is capable of being indexed laterally. In this way, after one bore has been dealt with, the work may be indexed so that the second hole is in line with the axis of the boring bar.

A feature of the boring tool is that the cutters are arranged to expand when the bar has been fed to the correct depth. The boring bar is fed downwards until a collar engages with the stop. This indicates that the cutter of the cutting tools is in the correct position for starting. A U-type washer is then removed from the spindle so that the bar may be fed in farther, and by wedge action the tools are expanded radially to cut the recess. The purpose of the U-type washer is to prevent the cutters from feeding out before the tool is in the correct position and perhaps spoiling the work. As in the case of the previous operation the work is located on two dowels in holes bored in the base of the casting. A swingover-type clamp of the floating type is employed to give quick operation.

The first process carried out on chain wheel stampings consists of turning off the flash during which operation the work is located in a suitable jig. The work is then placed in the chuck of a turret lathe for boring, facing, and recessing one side of the chain face, after which a Blanchard surface grinder is employed for grinding the flat face to the necessary width. Three blanks are then mounted in position on an adapter for the turning of the outside diameter and producing the correct tooth radius, after which twelve wheels are mounted together on a Barber Colman hobbing machine for the production of the teeth.

Fig. 23 shows the first operation carried out on a hub. The pressings for these components are bought from an outside source, and the operation shown consists of machining the main bore and facing the back of the hub centre flange on a turret lathe. As will be seen from the illustration, the tools are piloted, and a back-facing tool is employed for the operation of facing the flange at the rear.

The axle tubes are mounted in position on a hydraulic press, they being ground to within 0·0015 to 0.002in. of the bore of the hub. They are then spot-welded into position. The tube is reamed to size for the Timken roller race, and from the reamed hole the work is turned on the top diameter of the drum, and the spoke ring is faced to receive the chain wheel. The work is then turned inside to the correct brake-shoe diameter.

Fig. 13 shows an interesting automatic drilling machine for spoke rims, which was designed and manufactured by the firm. It is driven by fast and loose

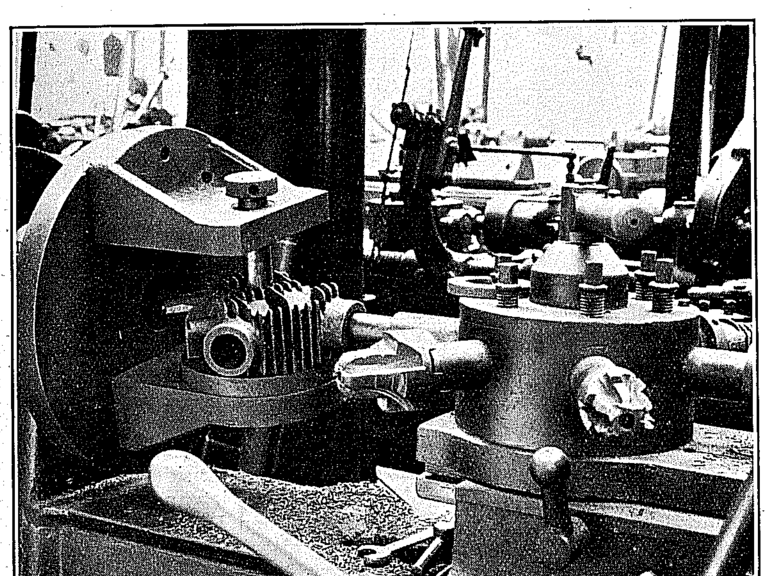


Fig. 22.
Machining the inlet and exhaust pipe connections.

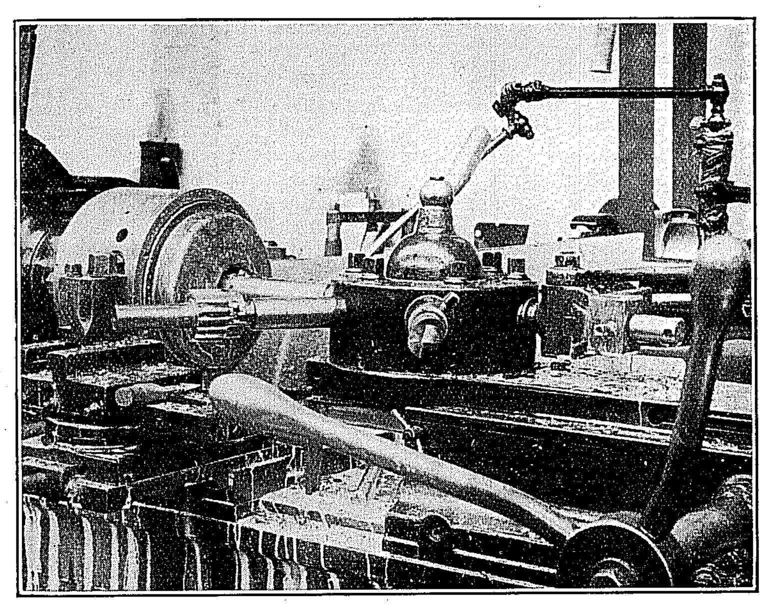


Fig. 23.
Preliminary operation on hub pressing.

pulleys, the spindles being mounted on ball bearings. From the main spindle a train of gears drive a worm, which in turn drives a vertical worm wheel. This has a cam on the upper surface for the purpose of operating the indexing mechanism, while on the underside of the worm wheel is a further cam which operates the feed-and-return traverse of the drill. Indexing is by pawl and ratchet, and a spring-loaded plunger engages depressions to ensure that the holes are correctly spaced. The work is, of course, mounted at an angle to the drill, so that the indexing mechanism is worked through a system of universal joints. A lever is fitted for bringing the machine into operation, and an interesting point lies in the fact that when the belt is slipped to stop the machine, a pad of felt is brought up against one of the main-drive gears to bring the machine quickly to a standstill.

Fig. 10 shows the first operation on one type of cylinder which is carried out by means of a Herbert turret lathe. There is a system of swivelling blocks in the chuck jaws to allow for any irregularity in the casting. This operation provides for roughing the bore, finish-reaming the bore, rough-turning the foot flange, and forming the bevel. The next process consists of turning the back of the foot flange, this being performed by means of a centre lathe. A turret lathe provides for turning and facing the spigot for the cylinder head in a third operation. The various holes are drilled in the cylinder by means of a box-type turn-over jig which is passed along a line of gang-drilling machines and turned as required.

The first operation of turning the cylinder head flange of one type of cylinder head is carried out on a lathe, the work being set up in a chuck provided with two fixed and two adjustable blocks which locate with bolt bosses. For holding the work in position a ball centre is provided, this being pressed into the combustion space, and the work being set to the first fin. The gasket face is turned by means of a tool on the saddle, after the work has been adjusted for position. In another type of head, where the system of employing a ball centre is not practicable, the work is secured to the face plate by means of a number of clamps and a system of adjustable stops.

Fig. 4 shows the set-up for roughing and finishing the dome. An angular box jig is employed, as shown, this being capable of being swivelled round for the drilling and reaming of the valve guide holes and forming the pear-shaped ports. In the position shown, the work is in position for dealing with the combustion chamber. It is swivelled to one angle for dealing with the inlet port, and to another for the exhaust port, a spring-loaded plunger being fitted to secure the correct angular location.

During the operation of boring, facing, and turning the inlet and exhaust pipe connections of an overhead-valve-type cylinder head, the set-up shown in Fig. 22 is employed. Location is secured by means of a spigot on a plate, the plate being capable of being indexed to give the correct angle to the bores. The various tools are carried in the turret as shown.

For producing the cam profiles of sprocket wheels the set-up shown in Fig. 19 is employed. The work is located on a shaped plug, a hole in the wheel engaging with a dowel in the face plate, and two clamps are brought into position to hold the work securely in position. By a system of cams and gears the face plate revolves and approaches and recedes from the milling cutter to produce the necessary cam profile.

PISTON-RING LEAKAGE.

Some Interesting Tests with Various Ring Sections.

TWO methods of testing piston rings for leakage have been practised at the plant of the American Hammered Piston Ring Co., one a static test and the other conducted under working conditions. The two methods used are described in the following abstract from a paper presented by A. Preston Petre to the Society of Automotive Engineers. Results of both types of test on piston rings of different designs are given in Table 1.

The static type of test is conducted in a head-down cylinder in which the piston is inserted and prevented from blowing out at the upper end by an air-tight hood and push rod. Compressed air is introduced below the piston head through an inlet provided with gauges and an equalising valve which prevents inaccuracies in the tests from fluctuation in the line pressure. The test is controlled entirely through a single hand lever, which admits the compressed air, operates the timer and releases the pressure.

Leakage is measured by means of a low reading petrol gauge which is connected to the hood and records the loss in cubic feet. In the tests recorded in Table 1, air was admitted to the cylinder at a pressure of 80 lb. per sq. in. for two 15-minute periods, and the amounts of air which the rings permitted to pass were recorded and averaged. All rings tested had the same end clearance and were lapped to a perfect bearing in the cylinder. No lubricant was used during the tests. The total diametral clearance between the piston and the cylinder was 0.010in.

Tests under working conditions.

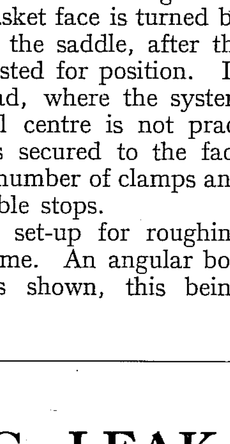
A Bauers 5 h.p. single-cylinder marine engine having a bore of 5in. and a stroke of 7in. was used for the working tests. The piston is fitted with two ¼in. compression rings and one oil control ring, all of the individually cast type, hammered for tension, inspected for diameter and flatness, and subjected to a light test for roundness. The average of Rockwell hardness tests on various rings ranged from 96 to 102.5 on the B scale. The tests were conducted to measure the leakage of the cylinder compression through the joints and piston rings of various designs. No effort was made to record other characteristics of engine performance, though conditions were held constant for each test.

The crank case was sealed and connected through a tube and check valve to a petrol

TABLE I.

RESULTS OF LEAKAGE TESTS OF PISTON-RINGS.

	Cubic Feet per Minute.	
	Static	Running.
Straight	2·00	0·55
Angle	2·13	0·53
Step	1·50	0·50
Step Seal	0·70	0·40
Step Seal (Reversed)	0·90	0·43
Plain, Double	2·16	0·46
Two-Piece Compressor	—	0·44
Three-Piece Compressor	1·06	0·30
Inner Seal	2·60	0·36
Inner Seal (Reversed)	1·33	0·45
Two-Piece Seal	1·17	0·36
Two-Piece Seal (Reversed)	2·56	0·41



gauge of standard design to determine the leakage loss in cubic feet per minute. The engine was started cold and run for 2 hours without load at 250 r.p.m. At the end of this time the engine speed was raised to 400 r.p.m., a brake load equivalent to 4 h.p. was applied for 10 minutes and the leakage carefully noted. After this the piston was removed and the rings were lapped to a perfect seat, without, however, being removed from the piston, and thus avoiding the possibility of distortion in springing them over the piston.

After lapping, the same tests were repeated and the results compared. In each case the absolute leakage was less on the final test than on the preliminary test, but the two tests checked in regard to relative leakage of the various designs. The figures given for these tests in Table 1 are the averages from the preliminary and final tests.

It must be noted that the running test results recorded in Table 1 are applicable only to low speed and are merely comparative. The time interval for leakage and the speed at which a ring fails to function must be given serious consideration for engines of higher compression and higher speed.

Two single-cylinder Diesel engines were used in a most interesting piston ring test which was carried out in Scotland. One of the engines was running and was connected through a pipe to the combustion chamber of another engine of the same size, in which the piston was blocked at top dead centre. Indicators were installed at various points, one in the working cylinder and others behind each ring and between each two rings of the blocked piston. The maximum pressure recorded in the cylinder and the average pressures at the other points, in pounds per square inch, were as follows:—

Cylinder pressure	580
Behind first ring	440
Between first and second	115
Behind second ring	115
Between second and third ..	55
Behind third ring	45

Audible blow-by to the crank case of an engine is almost always due to fitting the top ring too tightly in its groove. It should always be allowed enough side clearance to function, in view of its difficult position in relation to pressure, temperature and lack of lubrication.