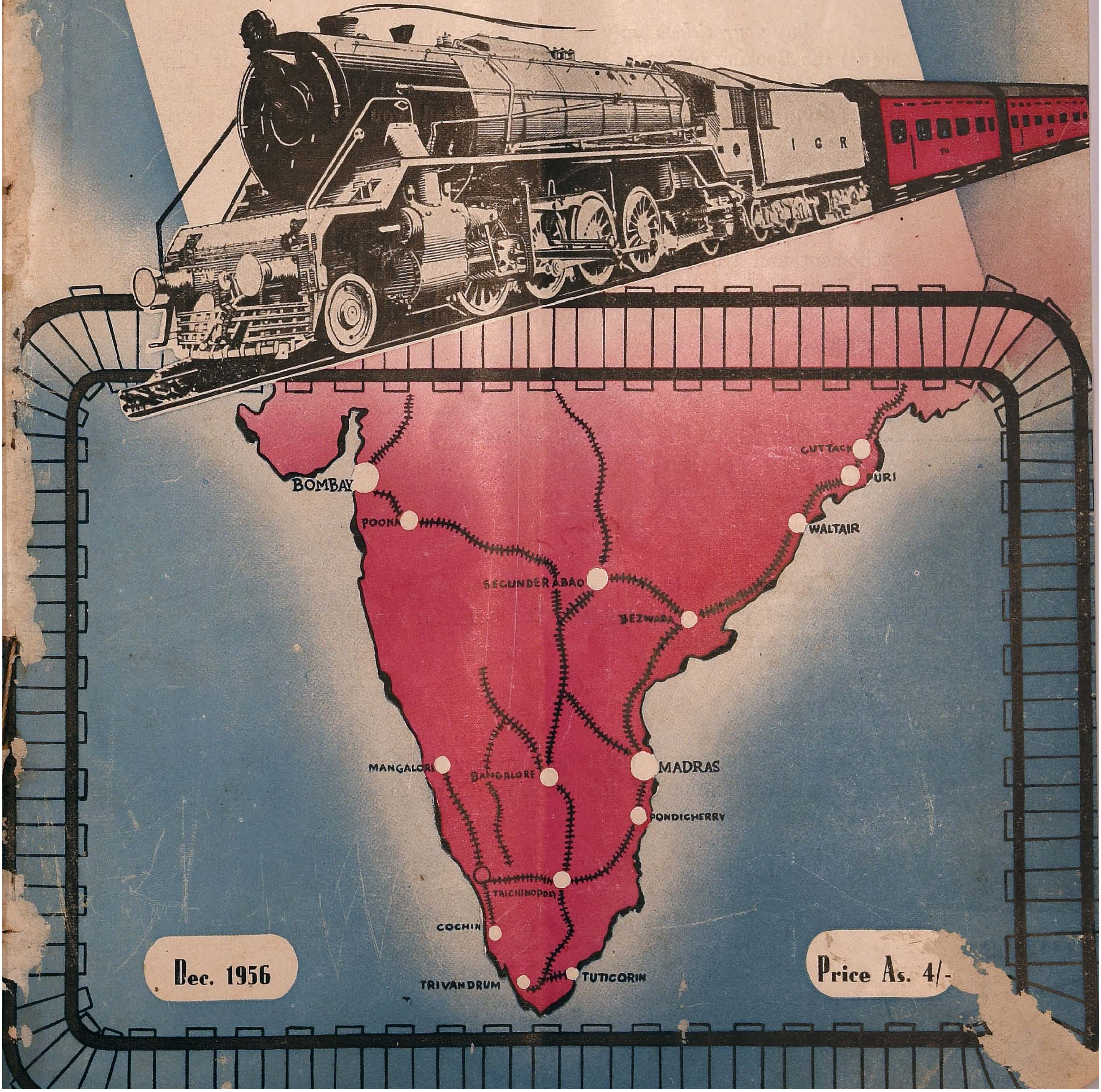
X'MAS NUMBER

SOUTHERN RAILWAYS *Magazine*



Dec. 1956

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(Inserted in the interests of Travelling Public)

Some Recent Developments in British Engineering

By F. M. Davies

Recent engineering developments in the United Kingdom are of particular interest in the light of the visit of the British mission to advise on further extension of Indian heavy engineering manufacturing capacity. This article describes some of these developments. EDITOR

A series of electronic devices which will automatically perform vital routine analyses in the laboratory has been developed in the United Kingdom. The first instrument to reach commercial production is a meter for the automatic determination of moisture.

Its electronic system is so arranged that it will also automatically carry out the titration of chemicals. This is the measurement of the amount of any given chemical on the basis of the quantity of it required to cause a chemical reaction with a standardized solution of another chemical. The reaction, or end-point, of such titration measurements is shown by the lighting-up of a pilot lamp.

The makers—Baird & Tatlock Ltd., London—claim that the results achieved are equal to good manual titration. Every instrument in the series is of a type normally found in the analytical laboratory, but all have been adapted to at least partial automation. The skilled operator is thus relieved for other work for at least some of the time he would otherwise have to spend on routine but highly skilled operations.

The firm claims that the instruments will also enable considerable laboratory analytical work to be done by an unskilled operator, since, in general, the more difficult part of the technique necessary has been made automatic through an electronic system of measurement and control.

This is but one example of recent engineering development in the United Kingdom. There are many others.

ANTI-ROLL FIN

Fishing fleets and users of other small craft, for instance, will be interested in a new type of anti-roll fin produced by Vosper Ltd., of Portsmouth. The firm claims that the fins give an 80 per cent. reduction in roll. They have already been installed in three vessels, and orders have been received for fins for a yacht of 250 tons and a vessels of 600 tons. As the fins have been designed for fitting and removal by a diver, they can be removed for inspection or maintenance without the need to enter drydock. Of low aspect ratio (small outreach), so that a saving of weight and space can be ensured, the fins are non-retractable.

A high-pressure hydraulic system, actuating small rams which work similarly to the undercarriage-retraction equipment of aircraft, operates the stabilizing fins. It is stated that the fitting of stabilizers to existing vessels need cause little rearrangement, and there would be no need to allocate a special compartment for the actuating gear.

Two new gas heaters, designed for use in industrial premises, are being produced by William Sugg Ltd., of London. The first, the Raymaster radiant heater, is for suspension from the ceiling; the second, the Halcyon convection model, may be fitted on a wall or behind it, with special ducting to the area to be heated.

The firm states that the Raymaster is particularly suited for lofty buildings, normal fixing height being between 9 ft. and 10 ft. from the floor, and no flue is required. In the convector model, the passage of air through the heating surfaces is aided by an electric fan.

CEMENT-HANDLING EQUIPMENT

Now in production is equipment for automatically transporting cement from the site where it is mixed to the point where it is to be used. Pneumatically operated, the equipment will transport the mixed cement 1000 ft. horizontally and more than 100 ft. vertically. It is claimed that it will convey up to 35 cu. yds. per hr. through a 6 in. pipeline.

The pressure cylinder, which will hold 17½ cu. ft. of cement, is located at the mixing point, and the cement poured into it through a hopper at the top. Compressed air, stored in an air receiver, is then admitted to the top of the cylinder through a valve, and the cement is forced through the pipeline. Regulation of the air pressure in the cylinder governs the cement's speed of travel.

At the delivery end of the pipeline, a discharge box separates the cement and the air, and a central baffle within it divides the flow of cement into two streams which are re-united before the final delivery. Velocity is thus arrested and the force of discharge reduced. Pipeline is supplied in sections 10 ft. long and 1 ft., 2 ft., 3 ft., and 5 ft. sections and bends are also available. Blaw Knox Ltd., London, manufactures the equipment.

FUME CABINET

For many years the danger of explosion from handling perchloric acid and the toxic effects of hydrofluoric acid have been predominant in the minds of chemists and laboratory assistants. As a result of considerable research into the effects of these and other aggressive chemicals on conventional wood and metal fume-cabinets, Turner & Brown Ltd., of Bolton, Lancashire, has produced the "Turbro" Cabinet, types 3 and 6.

The main structure of the cabinet is in BX Cobex rigid vinyl tube, reinforced with metal. Rigid ½ in. polyvinylchloride sheet is employed to form the side of the back panels. A stainless-steel tank (optional) can be incorporated to form the working level. The tank is insulated from the polyvinylchloride with glass wool; Bunsen burners and hotplates may, it is claimed, be used with complete safety.

A water feed irrigates the tank to a depth of ⅛ in. fumes from the cabinet are drawn through bottom extract ports to a fan, and in the case of perchloric acid the ducts may be sprayed with water to eliminate build-up and risk of explosion.

A totally enclosed fluorescent-light fitting and control gear is provided with the cabinets. The sliding sash is manufactured from transparent polyvinylchloride, adequately reinforced; the sash is raised and lowered by "Terylene" cords working on polyvinylchloride pulleys and counterbalanced by lead weights in a tubular polyvinylchloride housing.

PLASTIC JUNCTION-BOX

The General Electric Co. Ltd., London, has just produced for the British Army a plastic junction-box capable, it is claimed, of withstanding the roughest treatment and extreme climatic conditions in the field. The new box, which with the associated plugs is moulded from high-impact Bakelite material (X199), has been given extensive troop trials at Britain's School of Military Engineering, as well as field trials with the British Army in Germany. As a result, the box is to be put into quantity production for the Army. Permission has been given for commercial production also.

One of the tests to which the box was subjected was to be run over several times by a three-ton Army truck. The box was unharmed, and its electrical performance unimpaired. It was also found that it will stand up to snow, ice, sleet, and rain in the field, and that its performance is satisfactory in temperature conditions ranging from -60°F to +125°F.

The box, which has one 80-ampere outlet socket and three 13A outlet sockets, is capable of distributing 10kW of lighting load, sufficient for the dugouts and tents of a divisional headquarters in the field. The supply is normally taken from a 27.5kVA field generating set, the distribution panel of which carries socket outlets and plugs moulded from the same high-impact Bakelite material as the junction box.

These comprise altogether six 80A single-pole outlets and plugs, four neutral points and plugs, and two 13A standard-socket outlets.

An important feature of the design of the box and of the distribution panel is that a high-impact Bakelite cover is permanently chained to each outlet, and screwed over it when not in use. The plugs provided also carry a threaded protective sleeve which enables the engineer to screw the plug right home, rubber seals on the socket and plug ensuring a waterproof joint.

FLOW-LINE PRODUCTION

A British firm which, it is claimed, is one of the foremost manufacturers of specialized packaging materials in Europe recently opened a new factory in London in which flow-line methods of production have been applied. The firm — Venesta Ltd., London — States that this application represents a pioneering venture which sets new standards of production, quality, and hygiene in the collapsible-tube industry—an industry which in Britain alone is now producing 360,000,000 tubes a year.

Flow-line is a system of continuous production by means of which manual processes are virtually eliminated. Where, formerly, machines performing identical operations—extrusion, capping, and so on—were grouped in their respective sections, they are now incorporated individually in separate flow lines. In addition to other new equipment, the lay-out of the plant contains a number of machines designed and manufactured by the company's own development and engineering department.

Flow-line production has materially cut time and labour. A tube which formerly took 5 hrs. to produce can now be made in 20 min. Four operators now perform the work of eight.

When the problem of switching over to flow-line production was first approached, the primary difficulties encountered at the time were those of "transfer mechanisms"—that is, the movement of tubes from one process to the next. These problems were overcome by the firm's own technical development department. The flow line operates at 55 tubes per min.

HIGH-ALTITUDE BREATHING EQUIPMENT

Flight trials have been taking place of a prototype liquid-oxygen system for aircraft made by Normalair Ltd., of Yeovil, Somerset. The first such trials to be carried out in a British aircraft, they were organized by the firm as part of an extensive programme of flight testing, in Meteor and later in Canberra aircraft. This programme, sponsored by Britain's Ministry of Supply, has been designed to speed up the development of high-altitude breathing apparatus, and of cabin pressurization and air-conditioning units.

The performance of the liquid-oxygen system in the air is being observed by company technicians. Two important advantages, from the aircraft designer's point of view, stem from the fact that a given volume of liquid oxygen will provide over 800 times its own volume of gaseous oxygen. By storing the aircraft supply as a liquid in a liquid-oxygen converter, instead of as a gas in conventional storage cylinders, significant reductions can be made in installation weight and space occupied—a saving of 67 per cent. of the total weight and 81 per cent. of the total storage space.

The system flight-tested by Normalair employs a liquid-oxygen converter of 5 litres liquid capacity, giving a gaseous supply equivalent to that provided by six standard 750-litre storage cylinders. Converters of other sizes are being developed. The components of the system fall into two distinct groups, the only installational requirement being location of them such that the pipelines connecting them are as short as possible.

The first group, known collectively as the liquid-oxygen converter, has a diameter of 14 in. and an overall height of 9¼ in., and includes the liquid-oxygen container itself, an evaporating-coil, and various valves. It is neatly tucked away below a radio-equipment shelf in the Meteor being used for the trials.

The second group, comprising a contents gauge, a filler valve, and a build-up-and-vent valve, is mounted just behind the fuselage skin, in a position allowing the hose of a ground charging truck to be easily coupled up.

RADIOACTIVE RATEMETER

A battery-operated instrument designed for geological surveying, mapping, and prospecting for radioactive ores and for the examination of mine workings has been developed in conjunction with Britain's Atomic Energy Research Establishment. When the instrument is used in conjunction with the associated beta probe unit, assay work can be carried out in the field. The equipment, by Ericsson Telephones Ltd., of Beeston, Nottingham, is known as the "1368" Field Ratemeter.

The instrument is particle counter which incorporates a junction-type transistor and four Geiger-Muller tubes. The counter rate is shown on a 50-microampere indicating-meter calibrated in milli-Rontgens per hr. Five ranges available in the instrument cover count rates of 0 to 25 milli-Rontgens per hr. An accuracy of either 10 per cent. or 2 per cent. can be chosen by operating a selector switch, and the speed of response of the instrument depends on the accuracy chosen.

The power supplies are all derived from three 1.5V torch cells, and a stabilizer ensures that the instrument is not affected by changes in battery voltage between 3V and 4.5V. The beta probe unit obtains its power supplies from the Ratemeter through a 6 ft. cable. It is used for making assays of radioactive ores, and for the detailed examination of rock facings and mine workings which are inaccessible to the Ratemeter operator.

The total weight of the equipment is 28 lb., which includes the Ratemeter, probe unit, with extension handle, headphones, sample holders, filling-funnel for assay work, tools, spare parts, and canvas haversack, the complete supply being contained in a light-weight-alloy suitcase. The Ratemeter itself weighs 8½ lb.

WIRE ROPE TERMINALS

A new form of terminal, designed as an attachment to wire ropes of any known specification, has been produced by the Tulloch Construction Co. Ltd., of Sutton, Surrey. Known as the Tulcon Terminals, they consist of compact assemblies of three simple units which, when assembled, form a terminal locking the wire rope to the assembly, thus forming a connection which cannot come apart. The assembly comprises a sleeve, to accommodate a given size and diameter of wire rope; a plug, which is inserted to separate and hold the strands of wire rope; and a terminal which can be made to suit any given application.

The sleeve and the terminal are made of forged alloy steel, and the insert of shell cast gunmetal. The complete assembly, therefore, provides a strong terminal designed to exceed the strength of the wire rope to which it is attached. The advantages of simplicity, strength, speed of assembly, and economy are claimed by the firm. The terminals can be fitted by unskilled labour using a hammer, spanners, and vice. They will withstand hammering, vibration, or other industrial hazards. An inspection hole is provided in each terminal to ensure that the attachment is secure. Standard ranges offered at present range from $\frac{1}{8}$ in. to 1 in.

NOVEL GLASS-WORKING MACHINE

Capable of producing a very wide range of laboratory glass-ware, a laboratory glass-working machine has been perfected in Britain. The laboratory glass-blower usually employs simple hand tools and relies upon a high degree of manual skill to form glass into the complex forms needed in the laboratory. The problem of speeding up such work and making it more economical was studied by the British Coal Utilization Research Association.

Tests have shown that a prototype machine, designed and built at the association's laboratories, is more versatile than the conventional glass-working lathe, and can deal with all but the larger and heavier work in either soft or hard glasses. It is so designed that a semi-skilled operator can handle specialized work which would otherwise take the time of a more skilled glass-blower.

As it was realized that the machine could have many applications outside the association's own laboratories, commercial production was decided upon. Edwards High Vacuum Ltd., of Crawley, Sussex, working closely with the association, has developed and is now manufacturing a production model.

DIESEL-ELECTRIC SHUNTING LOCO

A Diesel-electric shunting locomotive of new design, for heavy use, has been developed by the Yorkshire Engine Co. Ltd., Sheffield. It is being made in two models, one of 200 hp. the other of 400 hp. The machines are fitted with Rolls-Royce Diesel engines and British Thomson-Houston transmission equipment, and they are complementary to each other in that the power equipment of the larger model duplicates that of the 200 hp. model.

The larger model has a weight of 48 tons and a wheelbase of 11 ft. Its starting tractive effort is 30,000 lb., and at a continuous rating speed of 8 mph. has a tractive effort of 13,100 lb. Maximum permissible speed is 23 mph.

Two sets of power equipment are arranged, one on each side of the central driver's cab, and they are linked to one set of controls for multiple working. Should one power set break down—or for light-duty working—the locomotive can be worked effectively on the other set.

The 200 hp. model of the new design are built in 0–6–0 and 0–4–0 types, weighing 30 tons. They have a maximum tractive effort of 18,000 lb. and a continuous tractive effort of 7,400 lb. at 7 mph.

FOR PRODUCTION OF SCREWS

New equipment for automatically feeding screws to the head of a portable driving tool is being produced under the trade name Pneuma-Serve. It is operated from the normal factory compressed-air supply at a pressure between 70 to 90 lb. per sq. in. The device consists of a hopper holding a supply of screws (enough for 5 hrs. to 8 hrs. operating), with an elevator and magazine where they are selected individually and delivered to a cut-off plate or shuttle.

Compressed-air feeds the screws from the shuttle to the portable driving-head through a tough plastic tube. The driving-head may be attached to any standard power driver. If an air driver is used an armoured plastic tube is coupled alongside the feed tube, or flexible cable if an electric driver is preferred. A third line, connecting the head to the hopper, is a signal tube which synchronizes the operation of the hopper with that of the driving-head. The driving-head is fully mobile up to 20 ft. from the hopper and can operate at any angle.

The machine can be produced to drive screws of large variety up to $1\frac{1}{4}$ in. maximum length. Advantages claimed for the tool are that screws can be driven four times faster than by conventional methods; and that it eliminates handling of screws, reduces wastage and operator fatigue. Manufacturers are Guest, Keen & Nettlefolds (Midlands) Ltd., Screw Division, of Birmingham.

RETRACTABLE MAST

An interesting development by Mitchell Engineering Ltd., of London, is a mast which consists mainly of a three-sided articulated chain wound flat on to a drum when not in use. An electric motor operating through a gear reduction unit unrolls the links from the drum and, as the links travel through curved guides, the two outer sections swing inwards and join together to form a rigid triangular mast.

The mast can be raised vertically at 15 ft. per minute to a maximum height of 50 ft. The over all dimensions of the complete unit with the mast retracted are: width–5 ft. 2 in.; length–8 ft. 10 in.; height–7 ft. 6 in.; weight–2½ tons. The mast dispenses with time-wasting erection tackle, such as ladders and scaffolding, and has many uses, both indoors and outdoors, where men have to work aloft up to heights of 50 ft.

It can be used for the following purposes: repair and maintenance of street lights and overhead power systems; cleaning of walls, roofs and skylights; the inspection and servicing of aircraft and hangars; work on ships' hulls in drydock; fire-fighting towers; television and motion camera towers.

TOOLBIT HOLDER

It is essential, if maximum value is to be obtained from the ground surface of a toolbit, that a really flat surface is provided upon which it can rest. A British firm—James Neill and Company (Sheffield) Ltd., of Sheffield—claims that this is achieved in its Eclipse model, by providing a carefully machined groove with relieved corners. This grove, being open, is easy to keep clean and free of swarf and provides the accessibility necessary for accurate positioning of the tool.

An effective means of securing the toolbit is also necessary and with this holder a clamp-plate of patented design provides both downwards and sideways pressure so that the toolbit is clamped rigidly between the angle of the groove and the angle of the clamp.

BARIUM TITANATE TRANSDUCERS

The Research Laboratories of the General Electric Company Ltd., London, have developed miniature barium titanate accelerometers and strain gauges which are proving extremely useful in the field of vibration testing. They are said to have many advantages over previous methods of vibration testing and measurement, are inexpensive, reliable and simple to operate. Their small size enables them to be used in a variety of circumstances where it would be impossible to use more bulky equipment and they are extremely sensitive and will work efficiently over a relatively wide range of temperatures and vibration frequencies.

The two new devices are Type E Barium Titanate Accelerometer and the Barium Titanate Vibration Strain Gauge. The former can detect and measure shocks over a wide range of operating conditions. It is effective at any temperature between −50°C and +100°C. If this temperature is exceeded the piezo-electric properties can be restored by repolarization.

The Vibrations Strain Gauge was originally developed for measurements of blade vibrations on rotating turbine wheels, but it has many other applications to similar problems. It is 2,000 to 3,000 times as sensitive to alternating strain as a typical wire resistance strain gauge, the firm claims.

COIL WINDER

A coil winder has been developed, the principal feature of which is its ability to accommodate 12 reels each of 6 in. diameter with a winding range of from 20 to 46 steel wire gauge. The machine has a travers from $\frac{1}{16}$ in. to 6 in. with a maximum effective winding length of 18½ in. An automatic cut-out operates in the event of wire breakages. The maximum coil diameter is 4¾ in. and the minimum ⅝ in.

In changing from one gauge wire to another, the operator or setter can see the required setting from a small dial. The coil winder is driven by a 1.25 bhp. alternating-current motor with electric clutch control ensuring smooth acceleration in speed from 0 to 2,500 revolutions per minute. It has a predetermined electric revolution counter with a Warner electric brake on a mandrel headstock to ensure accurate control and prevent over-running. The device has been developed by Westool Ltd., County Durham.

GEARED POWER PRESSES

Another British firm has developed 100-ton geared power presses for use with its special tooling. The machine takes tooling up to 36 in. left to right by 13 in. front to back by 23 in. shut height. The ram moves on four precision ground pillars which guides as close as possible to the tool and ensure accuracy of ram travel throughout its 8 in. stroke and 9 in. adjustment.

The press has an air cushion enclosed in the ram which operates a top pressure pad in the tooling. A positive bottom knock-out is driven directly from the crankshaft so as to eject the component during the upstroke of the press for mechanical or air unloading, and to return the ejector pad leaving the die clear for component location as the press stops at the top of the stroke.

HOW TO RESERVE ACCOMMODATION

Unless you reserve your berth (I and II Class) or Seat (3rd Class long distance) in advance, you may not be sure of getting accommodation on the train you wish to travel by.

Application should be made to the Station Master of your starting station at least 3 days in advance specifying the date and train by which you intend travelling and the tickets must be bought in advance. The reservation fee leviable is 8 Annas per seat or berth.

Reservation by I and II Class from intermediate stations by Express trains can also be made similarly, but reservation ticket can be issued only after getting an advice from the Reservation Centre that the reservation has been made.

Tickets will be issued only if accommodation is available.

If the reserved seats or berths are not occupied at least 5 minutes before the booked departure of the train the reservation will be cancelled and the seat or berth given away to another.

Reservation fee is not refundable.

III Class seats are also reservable on Express and certain other important trains for long distance passengers from the train-starting stations on payment of a reservation fee of 4 Annas per seat.

Do not occupy a berth or seat reserved for another, as you are liable to be displaced at the last moment.

If you find another person occupying the berth or seat reserved for you and if he will not vacate it on demand, report it to the Guard or Station Master. They will help you.

(Inserted in the interests of Travelling Public)

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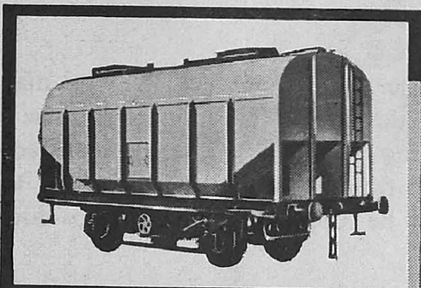
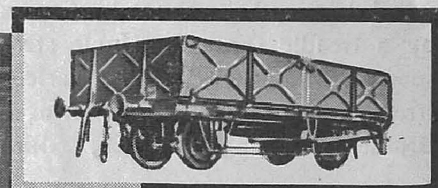


20-ton capacity Bulk Grain Van to the order of British Railways.



F.J.S. Low-sided Open type Wagon as used by Queensland Government Railways, Australia.

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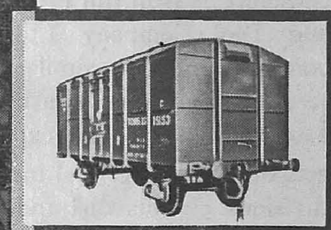
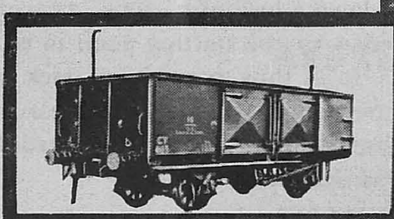
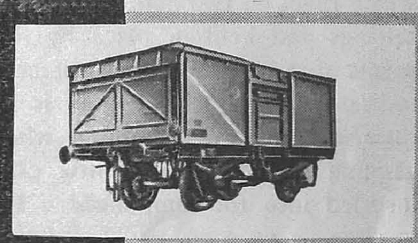


Broad gauge covered Wagon type C.R. as used by Indian Railways.



22-ton G.Y. type Wagon as used by Victoria Government Railways, Australia.



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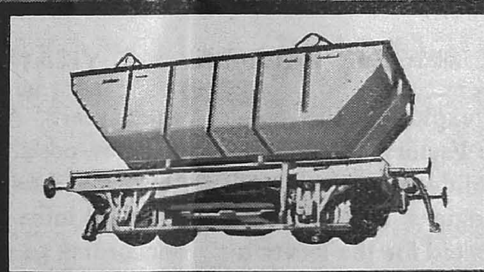

V. J. M. Hopper type Wagon with Drop Bottom Door as used by Queensland Government Railways, Australia.

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The reciprocating weight of the ram and tooling are fully balanced by air cylinders, and the action of the connecting rod is taken through a large section plunger which is separately guided so that tilting forces cannot be transmitted. The press frame is of extremely strong, rigid construction. The drive from a 10 hp. high-torque motor is transmitted to the flywheel through a variable-speed drive and the clutch is of radial key design operated by a treadle through a single stroke mechanism. The speed of the press can be varied between 25 and 50 strokes per minute. The firm concerned is Turner Brothers (Birmingham) Ltd., of Birmingham.

NEW COMPARATOR

A new comparator for checking internally threaded components is in full production by the Coventry Gauge and Tool Company Ltd., of Coventry. Simple in construction, it is similar in principle to an expanding screw plug gauge, consisting of two master threaded gauging segments, the expansion or contraction of which actuates a sensitive dial indicator graduated in 0.0001 in. divisions This dial indicator shows the relationships of the part being measured to a master setting ring.

The gauging segments are mounted on two members which pivot on two hardened steel balls housed in conical settings and held in place by tension springs. Movements of the segments are directly recorded on the dial indicator. The comparator is operated by pressing together the two members, which in turn bring the gauging segments sufficiently close to each other to be inserted into the component. The spring-loaded members are then gently released and the segments engage with the thread, at the same time actuating the indicator. Constancy of pressure against the threads is thereby ensured, and makes experience unnecessary in judging an acceptable fit when conventional gauging methods are employed.

An eccentric contact pin actuates the dial indicator and enables the zero to be adjusted to the most convenient reading position. The normal range of the comparator is from $\frac{3}{8}$ in. to 1 in. diameter, but special segments can be supplied for fine threads down to $\frac{1}{4}$ in. diameter.

MULTI-PURPOSE STRADDLE CARRIER

Recently seen in London was a straddle carrier which, since it obviates the need for cranes and overhead gantries, can be put to a number of uses. The size of the loads which it can handle with ease can be judged from the fact that an average saloon car finds ample parking space under the huge vehicle.

An indication of the speed at which the carrier can operate was seen in tests which demonstrated that it could pick up from ground level, transport a distance of 220 yds. and set down a load of $7\frac{1}{2}$ tons, 23 ft. in length, and return unladen to the starting point in an inclusive time of 80 sec. It is thus possible to pick up at the rate of 300 tons per hour and move the loads a distance of 220 yds. Manufacturers are British Straddle Carrier Company Ltd., of London.

DIESEL ENGINE FACTORY AT VISAKHAPATNAM

The Government of India were exploring the possibilities of starting a Diesel Engine Factory at Visakhapatnam. The factory would be mainly concerned with the manufacture of marine diesel engines and for that reason, Visakhapatnam would be selected for the location of the factory. The project, to be run by the State, would cost them about three to five crores of rupees.

* * *

KORBA PROJECT

Production of coal in a pilot quarry in the Korba Project in Madhya Pradesh was expected to begin early next year. As a result of the drilling so far carried out it was possible to plan for opening of three open cast mines and one underground mine. Work on the underground mine was expected to be started very soon and according to present expectations coal would be touched in April 1957. Work on the other two open cast mines would also be taken in hand in a few months when the machinery, indented for, would arrive. A team of Russian experts had just arrived in the country to study the Project Report prepared by an Indian team for coal mining in the Korba region. The team would advise generally on the mining methods to be adopted for the speedy and economic working of the mines and the type of machinery to be used.

EX-RAILWAYMAN AVERTS ACCIDENT

Towards the close of the monsoon this year, as a result of heavy rains between Multapi and Chichonda stations on the Itarsi–Nagpur Section of the Central Railway, a slip occurred in the Railway embankment. As a result of the slip, the rails were left hanging without any support for a distance of 16 feet.

Fagoo Kashiram, one of the local residents, who was some 12 years ago in Railway service, observing this slip, ran to the nearest level crossing gate and informed the gateman of the impending danger. The latter stopped an approaching goods train in time, thus averting what might have been a serious accident.

This ex-Gangman of the Railway has been granted a reward of Rs 100/- by the General Manager for the good work he has done. He has also been offered re-employment as a gangman on the Central Railway subject to his being willing to accept this job and to his being found medically fit.

* * *

INCREASED RAIL MOVEMENT OF CEMENT

Reports have appeared in a section of the Press alleging failure on the part of railway authorities to provide sufficient wagons for carrying cement. These reports are at variance with actual facts.

Movement of cement has been given very high priority, and such movements from various factories are programmed in advance to ensure expeditious clearance.

Between April 1 and September 20, 1956, a total of 69,830 wagons were loaded with cement on the broad gauge system, as against 61,918 wagons during the corresponding period of last year. Similarly, on the metre gauge system, more wagons were loaded during this period in the current year than during the corresponding period of last year. The demands are being met satisfactorily and without delay, except when on account of breaches or accidents, movements have to be regulated.

Suggestions have in some cases been made that cement factories might generally arrange loading of wagons on Sundays and other holidays also. If this is done, the position would improve still further.

The Machine-Tool Industry in Britain

By A Technical Correspondent

The visit of a British mission to advise India on further extension of heavy engineering manufacturing capacity focusses attention on some of the latest developments in the British machine-tool industry described in the article below.—*Editor*

AUTOMATIC CONTROL SYSTEMS

THE word automation has been used so loosely that it is sometimes difficult to distinguish between the various mechanical, hydraulic, and electronic techniques which are generally included under that heading and which are increasingly becoming important features of machine-tool design and application.

Some authorities regard automation simply as the use of automatic handling methods, as in transfer machines where the work is held in a mobile fixture and passed from one operating position to another. More usefully perhaps, automation might be defined as the use of power to control power, as when electronic or servo devices are employed to govern the motion of a machine-tool cutter with respect to a workpiece.

Essentially, however, it is a group of techniques which serve to reduce the man-hours necessary for making any product or component, and is, therefore, as old as engineering itself.

Since the inter-tool handling aspect is not inherent in the actual tool, this article will deal with only those techniques which can be built into the machine. These may be divided into four main categories:

Control systems, by means of which drawings can be translated into finished workpieces with the minimum of human interference;

Programme units which permit a given sequence of operation to be performed at a number of predetermined machine settings;

Mechanisms which automatically feed and discharge the workpieces to and from the tool; and

Profiling and copying devices.

Much time is required in machining for such non-productive operations as setting up, loading, gauging, and checking, and it is here that these techniques can be of most value. Moreover, whereas automation is often thought to be only relevant to products required in large quantities, the first of these categories applies especially to small-number production. There are also various combinations and mutations of the four techniques: in a sense, electronic control systems in the first category combine the advantages of programming and profiling plus ease and economy of tooling, while automatic lathes employ, in effect, both a simple programme and mechanical means of feeding the workpieces. A number of typical systems and machines which illustrate these principles are described in this article.

ELECTRONIC CONTROL

The Ferranti System.—Where it is necessary to machine components in small numbers with considerable accuracy, as in the aircraft, tooling, and other industries, the use of human skill in conjunction with expensive tools, jigs, and fixtures has long been considered the only practical approach.

However, with the advent of electronic techniques it may be possible to abandon such costly methods, since with their aid the whole process can be reduced to the preparation of a drawing and planning sheet, and the operation of an instrument resembling a typewriter.

In the Ferranti system, the essential elements are as follows: an electronic digital computer capable of

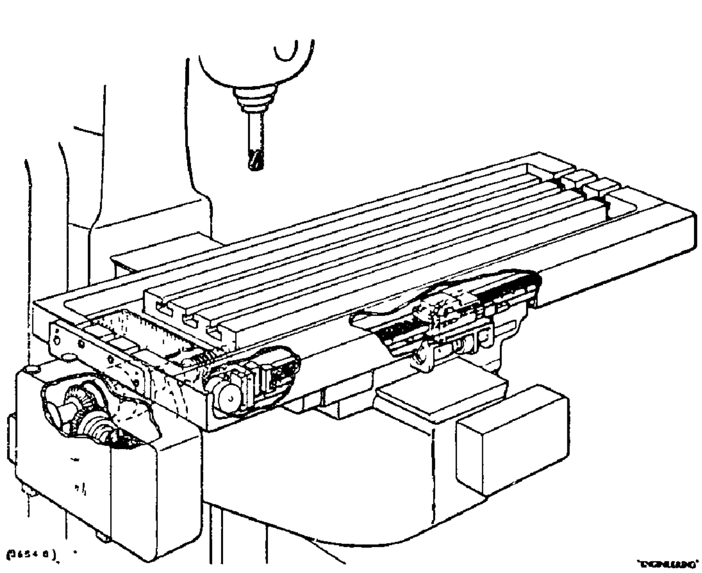


Fig. 1 Drive unit and measuring equipment associated with one slide of milling machine (Ferranti).

providing a service to a large number of machines; a control unit associated with the machine tool and its servo-motors; high-performance servo-mechanisms utilizing the measuring system as feedback; and an electro-optical method of measurement employing a long diffraction grating and having an inherent accuracy superior to that of the machine tool with which it is used; these items can be seen in Fig. 1.

There are five principal stages in the operation. First a drawing is prepared, preferably dimensioned in a form suitable for the system; a typical example appears in Fig. 2.

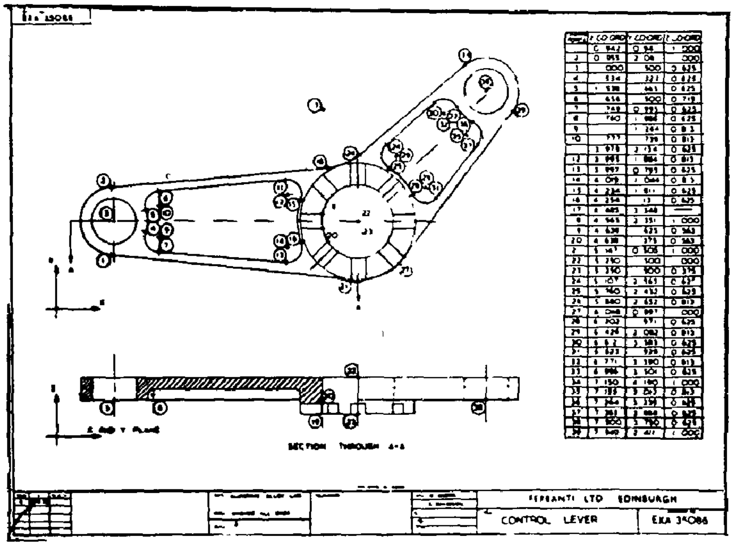


Fig. 2. Method of detailing drawing for use with Ferranti system, showing origin and co-ordinates.

From this a planning sheet is prepared, and the information it records is then transferred to punched paper tape by means of a machine having keys like a typewriter. This serves as input to the computer which prepares a magnetic control tape.

Finally, the tape is used in the control equipment to determine the continuous movements of each axis of the machine tool. It is claimed that, with high spindle speeds and excluding tool changes, once the magnetic tape has reached the control equipment a component can be made in 7 min. which would formerly have taken a skilled operator 12 hrs.

The basic element in the measuring system is a long diffraction grating marked at right angles to its length with a precisely known number of lines, and fixed to the table of the machine tools. When the grating is superimposed on another shorter grating slightly inclined to it, a Moire fringe pattern is produced which travels across the gratings as they are moved relative to one another.

The dark bands are detected by photo-sensitive elements which convert the light intensities into signals of equivalent intensity. These wave-forms serve to form a digital measuring system of two pulses per grating line, and to provide means of effecting a feedback control through servo-motors of the table movement.

There is, of course, one long grating for each axis of motion. Gratings currently in use are marked with up to 5,000 lines per inch, giving measurements to an accuracy of 0.0001 in.

The servo-motors are three-phase 400-cycles-per-sec. induction motors delivering 0.5 b.h.p. at 10,000 r.p.m. and fed by high-performance magnetic amplifiers. A magnetic drum brake is fitted to lock the slides when the motors are de-energized; the brake also operates as an emergency stop if the machining tolerances are exceeded or when the limits of travel of the slides are reached.

Each motor drives through a backlash-loaded gearbox. The reduction trained is designed to offer minimum inertia loading to the servo-motor. Lubrication is by oil mist, with the cast gearbox casing forming a sump.

The reduction ratio of the standard gearbox gives an output shaft speed of 120 r.p.m. at peak motor power. This shaft is arranged to drive in three alternative planes to allow for variation of machine geometry, and a self-aligning, torque-limiting coupling is fitted to safeguard the gearbox from overload. A typical lay-out of gearbox and measuring system on one slide of a vertical milling machine is shown in Fig. 1.

In preparing the drawing and the planning sheet, the basic consideration is the co-ordinate nature of the control system. Thus an origin must be given, as indicated in Fig. 2, and co-ordinates of all change points must be shown. It should be noted that for a curve its nature should be stated, whether circle, ellipse, parabola, or hyperbola and the pole of the curve indicated.

Finally, the basic machining information must be recorded, such as feeds and speeds. Once the planning sheet has been completed, no more skilled operations are required, and after the data have been encoded cutting can proceed. It has been found that the overall saving in time can be in excess of 5-to-1, while the only limitation on precision is that entailed by the machine tool.

The E. M. I. System.—Another control system employing electronic techniques is the E.M.I. system. This is believed to be of almost universal application, and has already been successfully applied to four types

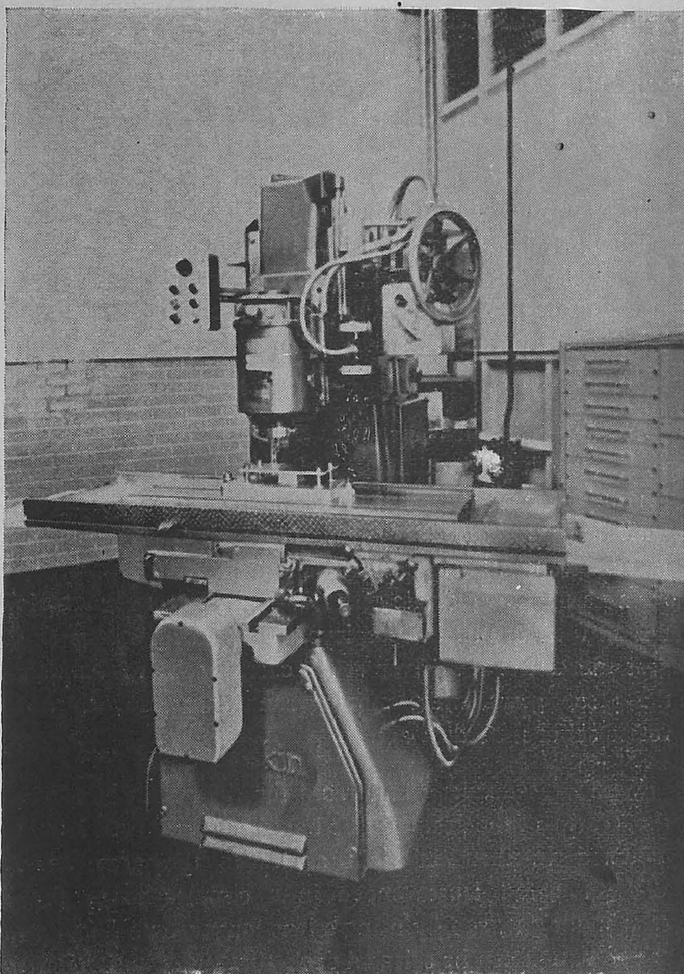


Fig. 3. E.M.I. electronic control system: control unit on right.

of machine tool: the Cincinnati Hydrotel, the Cincinnati No. 3 Vertical Miller, a high-precision copy miller made by Research Engineers Ltd., and a Wadkin high-speed vertical miller. The Wadkin machine is shown in Figs. 3 and 4. Fig. 3 shows the adapted high-speed miller with, on the right, the control unit; and Fig. 4 shows a detail of the table control mechanism.

The E.M.I. system, which also employs a computer and servo-mechanisms to control the feeds, enables the machine tool to cut two or three dimensional shapes without the use of templates or other patterns, and has the advantages of a copying machine, with the added benefit that short runs can be performed as economically as longer runs. It is, therefore, suitable for production of master cams, templates, and prototype parts.

In principle, the action of the electronic control system is to direct the tool in a smooth path through a number of points specified by the designer and designated by co-ordinates. In the machine shown, these points are spaced approximately $\frac{3}{8}$ in apart along the profile, but larger-point spacings are permissible, depending upon the accuracy required and the complexity of the part.

The points, which can be specified in rectangular or polar co-ordinates according to convenience, are listed in the form of a table of dimensions and recorded on perforated tape in a decimal binary code. The tape is then fed into the control unit, where analogue circuits perform a parabolic interpolation and deduce from the relatively small number of "marker" points in the table the large amount of subsidiary information required in order to cause the machine to cut a smooth profile through the specified points. No elaborate external computer is, therefore, required.

The system makes use of position control, whereby each dimension encoded on the tape is measured separately from the same datum point on the machine tool. Cumulative errors are thus eliminated.

The cut is both true and smooth, and requires no subsequent blending or hand-finishing. An important feature of the E.M.I. system is that an additional unit can be supplied, if required, to provide compensation for cutter diameter wear, thus allowing re-sharpened cutters to be used without the preparation of new tape.

The Wadkin machine has been modified by the attachment of servo-motors to the longitudinal and transverse feeds in place of the normal hand feeds, and a third motor for raising and lowering the head. This is controlled by an extra set of information punched on the paper tape, and gives the system the additional facility of cutting pockets within the profile specified for the workpiece. The electronic control system is designed to operate over the standard range of cutting speeds of the machine, which is a high-speed tool for fast cutting and routing of light alloys. Accuracy is achieved by taking position control measurements from the recirculating ball nut leadscrews. The accuracy of the information supplied by the control unit is greater than 0.001 in on dimensions of up to 100 in. The system has been designed by E.M.I. Electronics Ltd., Hayes, Middlesex.

PROGRAMME SYSTEMS

Somewhat simpler than the continuously controlled electronic machines are those which can perform a given sequence of different operations in accordance with a fixed programme without repeated setting up. In other words, the co-ordinate position of the cutting tool is set for each operation without intercession of the operator.

Such machines may be controlled by punched cards, metal tapes, paper tapes, film strip, and possibly other means. Though they are intended primarily for quantity

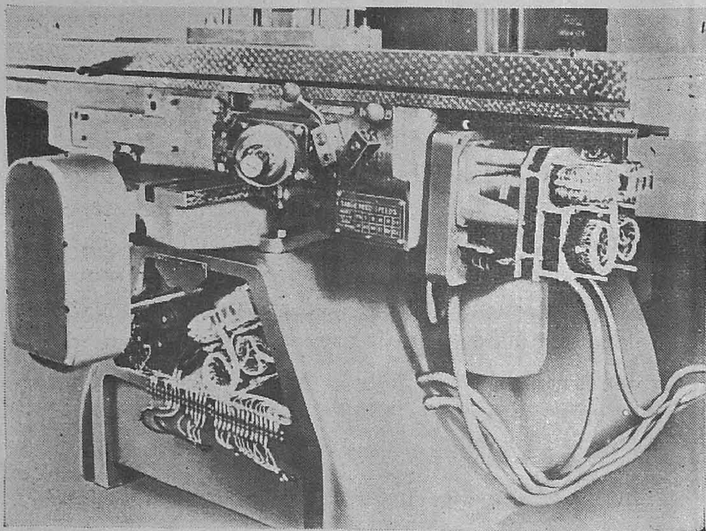


Fig. 4. Detail of E.M.I. system as applied to Wadkin miller.

manufacture, they may often be suitable, too, for small-number or prototype production.

Matrix Jig Borer.—Although the "Matrix" No. 150 jig boring machine is not strictly a programme-controlled units, it is in fact a step in the evolution of a jig borer with automatic positioning. It makes use of an electronic linear measuring system for locating the table and extensive pushbutton controls, and has been developed by the Coventry Gauge and Tool Co. Ltd, in conjunction with the Mullard Research Laboratories. Settings can be made in both directions to within 0.0001 in.

The internal standards of length in the Matrix No. 150 take the form of steel buttress scales, each consisting of a solid steel bar into which is accurately cut a sawtooth form of 0.1 in pitch. A step, machined lengthwise, reveals the form consisting of upright and sloping edges, and the maximum adjacent pitch error is 0.00002 in.

The scale is rugged and durable, being machined from a single piece of material; it also has the same coefficient of expansion as the rest of the machine. Interpolation between the 0.1 in steps of the master scale is accomplished optically.

A glass scale a little over 2 in. long carries upwards of 1,000 alternate opaque and transparent bars, equally spaced. These are scanned by a moving line of light, and the projected image reduced optically by a factor of 20 so that 1,000 bars fit exactly between adjacent vertical edges of the buttress scale.

As the table is driven, the bars are counted as they emerge from behind a vertical edge by means of photomultiplier tubes and an electronic counter. The number counted is subtracted electronically from the required number, and the error displayed on a row of dial lamps. When the error is reduced to zero, the central lamp lights and the table is clamped by operating a pushbutton.

The opaque and transparent bars on the glass interpolating scale are scanned four times per second by a line of light produced by a specially designed scanning mechanism, known as a flying line scanner. The light originates from a line filament prefocus car headlamp bulb.

A condensing lens provides a beam of parallel light wide enough to illuminate the glass scale over its entire length. The scale is, however, shielded from the light, which can only reach it through one of four glass-rod lenses mounted in the centres of four planet gears which form part of an epicyclic gear train. The scanner makes use of the fact that in an epicyclic gear train, if the sun gear and carrier are driven at the correct relative speeds, the plane gears, while moving round the sun, do not rotate about their own axes.

With large-diameter ball races for the planet bearings the centre of the gears can be bored out and rod lenses mounted in them at right angles to the gear axes. While the rod lenses move in a circular path, they remain upright, and by using a lens longer than $\frac{3}{8}$ in., an arc of motion can be selected such that the 2 in. by $\frac{3}{8}$ in. scale is fully scanned from end to end.

The equipment, which embodies many additional refinements including pushbutton control of table speed and magnetic clutches, is shown in Fig. 5. The last three digits of the desired table position in 0.0001 in. units are set up on dials of the electronic console on the left, while indication of position is given by a row of lamps above these dials; pushbuttons for controlling machine functions are on the panel in front of the table.

FEEDING AND CHECKING

The grinding process is also capable of automatic operation and may be used to illustrate not only the presetting of work cycles but also the automatic feeding and checking of workpieces.

Scrivener Automatic Systems.—Among the most comprehensive ranges both of workpiece feed and sizing devices and of controlled-cycle centreless grinding machines are those developed by Arthur Scrivener Ltd., Birmingham. To feed workpieces delivered at random into a grinding machine correctly positioned with the large end first, a vibratory hopper has been designed, from which the items pass down an inclined chute to a

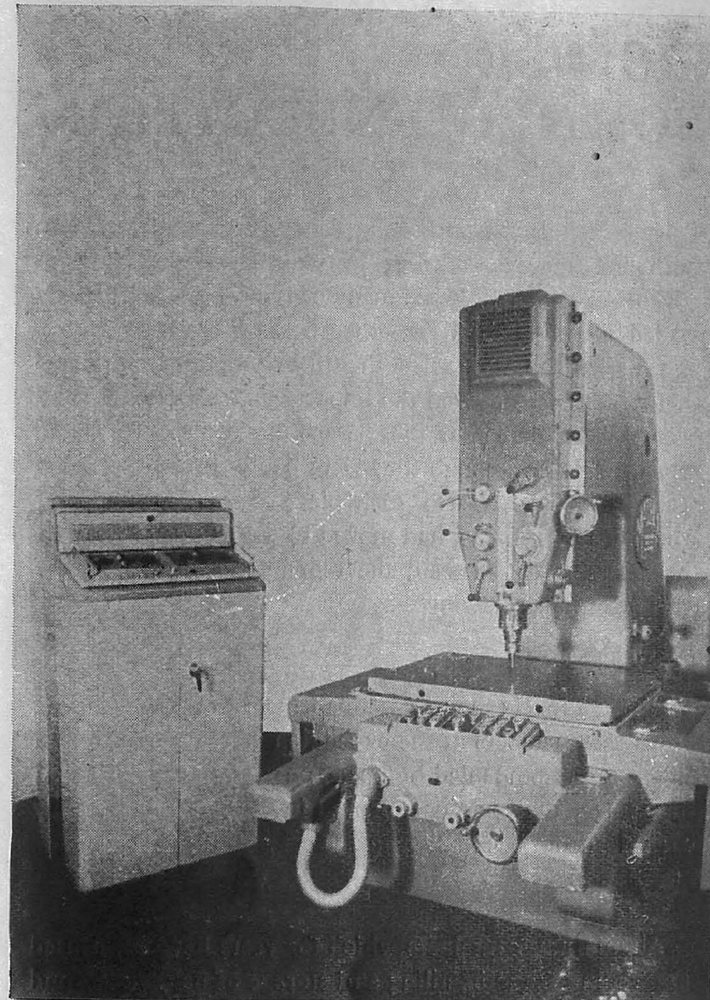


Fig. 5. Matrix No. 150 jig borer fitted with electronic linear measuring system developed by Mullard Research Laboratories. Table position set by dials on console (left) and indicated by lights above dials. Pushbutton controls on front of table (Coventry Gauge and Tool Co. Ltd.)

hook stop. The first piece is then gripped by spring-loaded transfer fingers, which contact the large-end diameter and, under the action of a rack and pinion, swing the piece over on to the plate. The piece is then released, ground, and ejected. Scriveners are also demonstrating a push-feed mechanism, a roller-type throughfeed unit, and an automatic overhead loader.

An item which can be used to effect continuous automatic control of size on throughfeed centreless work is the Scrivener micro-sizer. It is a device enabling the control wheel of a grinder to be advanced by a pre-determined distance varying from 0.0001 in. to 0.0005 in., and, when used in conjunction with pneumatic ring gauging, provides compensation for wheel wear and so permits continuous operation. Another unit, known as a synchronous timing device enables the final dwell or "sparking-out" period to be adjusted from zero to 10 sec.

This is a heavy piece with two opposing tapers and two parallel diameters, so that the considerable difference in size between the large and small diameters would involve opening the wheels more than lin on release to achieve a continuous throughput. The idle time would thus be unsatisfactorily long.

In the arrangement illustrated, the pieces are loaded on to the sloping magazine A, the bottom end of which is in line with the tubular guide B. At the commencement of the grinding cycle, the lowest piece is fed along this tube by the pusher rod C, which advances it a distance of some 16 in. to bring it into a position exactly over the formed workplate D.

As the push-feed rod retracts, a pair of vertical lifting arms are raised; their upward movement is effected by the sliding cams E operating through the rack and pinion E1 and E2 on the outer of the two co-axial shafts. The simultaneous partial rotation of the tubular guide B, which places the workpiece in the V-pieces of the lifting arms, is obtained from a similar cam F, operating through its own rack and pinion F1 and F2, and the chain wheel and sprocket drive on the inner shaft at the rear of the grinding wheel.

When the piece has been lowered on to the workplate, the controlled-cycle movement of the machine comes into operation: the control wheel (not shown) advances the piece on to the grinding wheel and withdraws after grinding has been completed.

On the commencement of the next cycle, the finish-ground piece is lifted back into the tube in the reverse manner to that previously described, so that the incoming piece pushes the finished component to the discharge end of the tube where, in a production line, a suitable multi-jet air-gauging station could conveniently be located.

PROFILING

Already a large number of profiling or copying systems are well known, but it may be worth noting here some recent additions in this field.

Webster and Bennett Profiling Mill :— A 48 in. single Series DH vertical boring and turning mill with built-in electronic profiling equipment is offered by Webster and Bennett Ltd., of Foleshill, Coventry.

The direction of profiling and the feed is set. After initiation of a profile cycle the stylus (shown concentric

(Continued on page 16)

ALUMINIUM CONTAINERS USED ON BORNEO EXPEDITION

Standard aluminium containers such as are in regular use for the handling of food-stuffs in the country have recently proved entirely dependable, and virtually indispensable, under the gruelling conditions of an expedition into one of the hitherto unexplored regions of Borneo. They are of a range of general-purpose one-piece stacking containers made by Pressoturn Limited, the ones chosen being of 70 lb capacity, deep-drawn from 16 SWG Noral M57S sheet produced by Northern Aluminium Company Limited and made airtight and watertight by lids of the same material sealed with a rubber gasket and locked in position with clip fasteners.

The Oxford University Expedition to Borneo 1955-56, which has now returned from its exploration of the Usun Apau Plateau in Sarawak, chose these containers because of their lightness and robustness, their hygienic properties, and the protection they give against dampness and attack by insects. One hundred were required for use in transporting food, equipment and biological and zoological specimens.

Together with other equipment, some of the containers were borne up the Rejang River, and over the Pelagus rapids, in 60 ft-long canoes fitted with 25 h.p. outboard motors. Saving in weight was an obvious advantage especially since many of the porters were fully loaded carrying food for other bearing essential stores. In the air-drop of supplies the fifty aluminium containers that were used survived the impact very successfully and even when some of the parachutes failed to open, remained intact though they were badly distorted. In a second air-drop, which took place three months later when the expedition had moved to the northern side of the Usun Apau Plateau, the remaining containers were dropped with equal success.

Altogether six months were spent in the field, during which the members of the expedition were continually on the move accompanied by porters carrying supplies. At this stage, the containers proved invaluable being easily carried on the back.

Aluminium containers which for years have been used in Britain for the handling and storage of fish, meat and other foods, met the demands, not always conventional, of use in one of the jungles of the East.

(Continued from page 15)

with the tracer head) moves in towards the template. When the stylus contacts the template the output signal from the head, via the analyser, calls for a further increase in generator output and hence movement of the appropriate motorized slide.

When the stylus deflection reaches a pre-determined figure, a relay is energized and the output of the other generator causes the appropriate motorized slide to move the stylus, hence the tool, tangential to the given profile.

At this point, under profiling conditions, the complex signal from the head is analysed and split into two electrical signals equivalent to the mechanical displacements in the two axes. (It may be noted that the complex signal from the head represents the amplitude and direction of deflection of the stylus from its initially deflected position.)

These two signals are compared with a reference. The two resultant signals provide the control signals for adjusting the cross and vertical slides according to the change in output from the tracer head. As the tracer head is rigidly coupled to the vertical slide carrying the tool, a faithfully reproduction of the template profile is produced on the work.

B.T.H. Tracing Head.—The British Thomson-Houston Co. Ltd., of Rugby, have designed a wide range of electronic control equipment. It includes the automatic tracing head for machine tools. This unit and its associated equipment offers complete three-dimensional tracing with automatic control of any combination of three motions.—"*Engineering*", London.

MANUFACTURE OF ELECTRIC TOOLS IN INDIA

AN INDO-BRITISH VENTURE

Greatly increased industrial output, if it is not to sacrifice quality in the process of acceleration, calls for an abundant supply of performance-proved tools. Regular availability of better and more dependable tools is a very important factor in our rapidly expanding economy with special emphasis on industrialisation.

The Indian industry would therefore welcome the news that an Indo-British venture has launched a scheme for the manufacture of electric tools in India, and that the production has already commenced. The collaborators on this project are the *Wolf Electric Tools Ltd.*, London and *Rallis India Ltd.*, Bombay.

This Indo-British venture, the first of its kind in India will go a long way in ensuring adequate supplies of electric tools. And the close collaboration of the participating firms, both of which are well established, and the frequent exchange of technical experts will ensure that the Indian-made Wolf tools would be of the same high quality as those made in England.

An interesting feature of this venture is that a substantial portion of indigeneous materials is being used in the manufacture of Wolf electric tools in India.

* * *

MORE RESERVATION FACILITIES ON CENTRAL RAILWAY

As a convenience to those travelling by 306 Up Poona-Bombay Additional Express train from Poona, a certain number of Second Class seats is being reserved at Poona station in accordance with the rules in force: Arrangements have also been made for reservation of Second Class seats at Bombay V. T. in the Bombay-Lucknow bogies on 1 Down Punjab Mail and 3 Down Pathankot Express.

MR. H. F. AKEHURST OF BICC

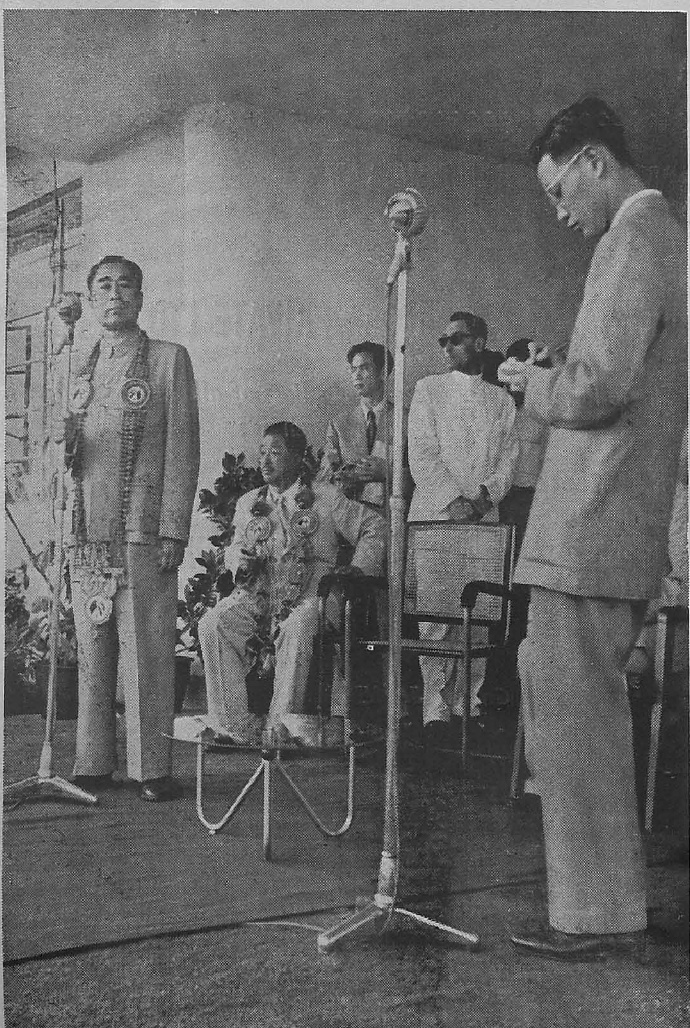
Mr. H. F. Akehurst, B. Sc., A. M. I. E. E., who has been appointed to the Board of British Insulated Callender's Cables Limited to hold the executive position of Director (Overseas Operations) was educated at Oundle School and Leeds University.

He joined the former Callender's Cable and Construction Company Limited in 1930, and proceeded immediately to India where he served for 17 years. During this period he was engaged on both Sales and Contracts work, and was employed for a considerable period on the Uhl River Hydro-Electric contract. In 1947 he became Joint Manager for India, and in the following year returned to London on his appointment as Joint Export Manager.

A new appointment in 1953 made him responsible for the BICC Overseas Factories Organization and in January 1955 he became on Overseas Manager of the Company. He is also Deputy Chairman of BIC (Export) Limited.

Mr. Akehurst's appointment to the BICC Board which takes effect from the 1st January, 1957, is an indication of the great growth in recent years of the Company's activities overseas as a result of which it was considered essential to concentrate responsibility for all overseas operations in one Executive Director. In addition, he will be responsible for the co-ordination of all BICC interests in subsidiary and associated companies located overseas.

Besides his long period of Indian service Mr. Akehurst has travelled widely in all parts of the World, and in recent years has made frequent business tours to Canada, U. S. A., South Africa, the Rhodesias, Australia and New Zealand, as well as Portugal and Spain.



Sri K. Sadagopan, Chief Administrative Officer, explaining with the aid of photographs and charts, the origin, development and structure of the factory to H. E. Mr. Chou-en-Lai.

LEFT: *H. E. Mr. Chou-en-Lai, Prime Minister of China, at the conclusion of his visit to the Integral Coach Factory, addressing the workers.*

Rubber as a Stress-carrying Material and Some Design Considerations

By S. W. Marsh, A.M.I.Loco.E.

INTRODUCTION

RUBBER as a stress-carrying material is being increasingly used in the engineering industry at the present time, and many designers find that problems which once could only be solved by the use of relatively complicated mechanical devices can now be overcome more simply by using rubber. This paper is intended to give some indication of the mechanical properties of rubber, its behaviour under stress and, what is just as important, some of its shortcomings. It is not intended to refer more than is necessary to the compoundings of rubber as this is the sphere of the chemist more than of the engineer. It is a subject in itself and its many aspects are dealt with fairly thoroughly in the literature already available.

Until a comparatively short time ago the use of rubber in engineering applications was rather restricted, and it was only prior to and during the last war that a real attempt was made to use to full advantage the properties peculiar to rubber. The development of methods for the bonding of rubber to metal opened up entirely new fields and made possible the use of rubber in hitherto unknown capacities. The provision of standardized specifications for rubber is still far from being satisfactory, and, while the engineer would undoubtedly welcome any move to bring rubber into line with other constructional materials, it is uncertain when this will be achieved.

STANDARDIZATION

There is, however, an attempt on the part of some rubber manufacturers to cut down the number of mixings in their own Works and to standardize on a number of qualities for specific applications. So far little on a national scale has been done, although a measure of standardization has been achieved by the Admiralty and certain other Government departments working in conjunction with official rubber committees, for example, T.G. 25A. A number of the larger engineering companies are now trying to safeguard themselves against variations in supplies by laying down a number of physical tests to which rubber mouldings and bonded units must conform. These normally specify minimum tensile strength, minimum elongation under a given load, maximum compression set or recovery under given conditions, and in certain cases where the rubber is to be in contact with oil or other swelling agents the maximum permissible increase in volume for time of immersion at a fixed temperature. These tests may be based on the United States standards as laid down in the American Society for Testing Materials Proceedings, or on those specified by the British Standards Institution. It is desirable, however, for the rubber chemist to be able to compound his materials to suit individual applications as an engineer may meet with a set of conditions outside the normal and it is of undoubted advantage to be able to make the material meet the conditions rather than have to try and alter the conditions to suit available materials.

There are other factors which make the standardization of rubber qualities a difficult problem. For some reason or reasons which would appear to defy logical explanation a rubber mix of identical constituents, compounded and cured under apparently the same conditions in two different factories, sometimes shows considerable variations in the physical characteristics of the vulcanized product. Conversely, to produce rubber mixes with the same physical properties from the Works of different manufacturers it may be necessary to vary details of

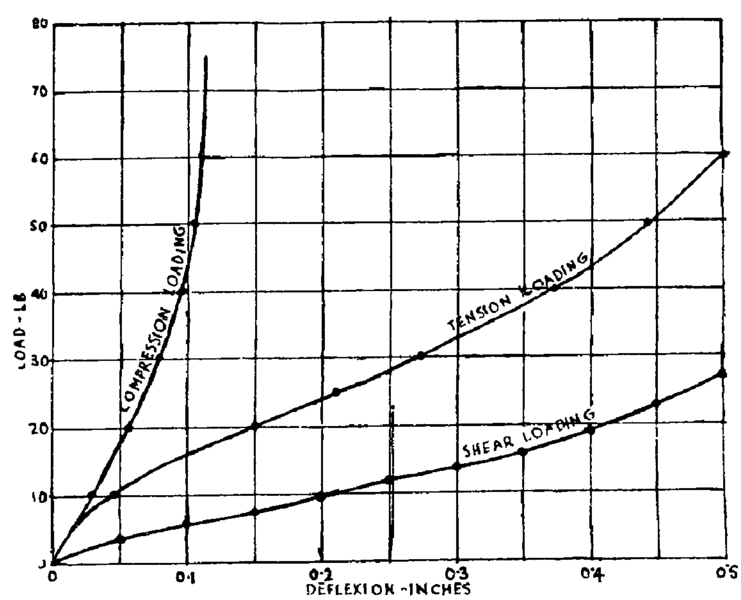


Fig. 1—Typical stress/strain curves for rubber.

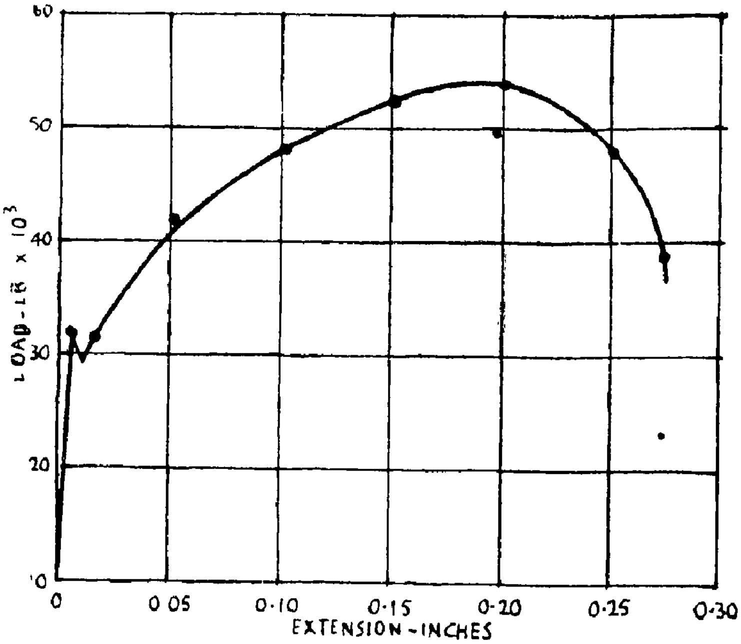


Fig. 2.—Typical stress/strain curve for steel.

compounding; in the same way the modulus values for rubbers of a given hardness may vary between one manufacturer and another. The question of relationship between hardness and modulus is more fully dealt with in a later section of this paper.

PHYSICAL PROPERTIES

Before discussing the general physical properties of rubber compounds it might be as well at this point to make clear a matter which, while it may seem elementary, does not seem to be fully appreciated by a surprisingly large number of engineers. Rubber in its raw state has little physical strength, is more plastic than elastic and is very sensitive to changes in temperature. Compounding ingredients are added, primarily to bring about vulcanization, to increase elasticity, to augment tensile strength, to increase resistance to abrasion, and so on. Vulcanization is brought about by the application of heat to rubber compounds containing proportions of sulphur, organic accelerators and other specific ingredients, all of which play their part in the vulcanizing reaction.

For the production of moulded natural rubber, synthetic rubber or bonded parts, the elastomer is usually contained in mild steel dies or moulds which are closed under hydraulic pressure and heat applied by means of steam-heated plattens, which are an integral part of the vulcanizing press.

The time and temperature of vulcanization, or cure, have to be carefully adjusted to the volume and reactivity of the particular rubber mixing being handled. Vulcanizing conditions govern to a large extent the ultimate physical properties of the vulcanizate, and close control is, therefore, of great importance.

Rubber, in its physical behaviour differs very much from the more orthodox engineering materials. This can, perhaps, be most clearly demonstrated by reference to a typical stress/strain curve for rubber and comparing it with a corresponding curve for steel—see Figs. 1 and 2. It will be noted first of all that rubber has no yield point in the accepted sense of the word. It will be seen, too, that nowhere does the curve become a straight line and that the modulus, to all intents and purposes, varies continuously with the applied stress. At the lower end of the curve, however, up to approximately 25 per cent. deflexion on the original dimensions, the modulus is fairly constant, and in the great majority of practical applications, fortunately, deflexions do not exceed this figure. Modulus curves for rubber qualities stressed in shear, tension and compression are shown on Figs. 3*a*, 3*b* and 3*c*. The rubber qualities are the same as those giving the stress/strain curves shown on Fig. 2. Average modulus values for good quality rubbers, such as would be used as dynamic applications, are given in Table I.

TABLE I

AVERAGE MODULUS VALUES FOR GOOD QUALITY RUBBERS

Rubber quality	*Shore hardness*	*Average modulus values in lb. per sq. in.*	
		Compression modulus	*Shear modulus*
A.D.4	38/42	270–280	80–85
A.D.16	50/54	365–385	105–115
A.D.24	58/63	540–560	125–140
A.D.30	67/71	740–760	185–195
A.D.36	77/81	1,000–1,300	270–290
D.Q.6	56/60	450/470	100–110

The term modulus, of course, refers to " Young's Modulus of Elasticity " and not to the " modulus " often used by the rubber chemist to denote the load required to stretch a piece of rubber of known section to a given percentage of its original dimensions, for example, 600 lb. at 300 per cent. This latter term is in common use in the rubber industry and may prove to be very misleading to the uninitiated.

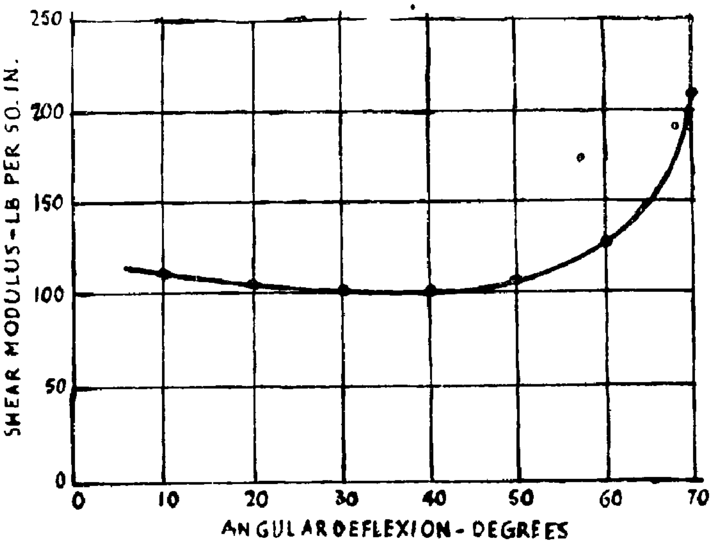


Fig. 3a.—Modulus curve—Shear.

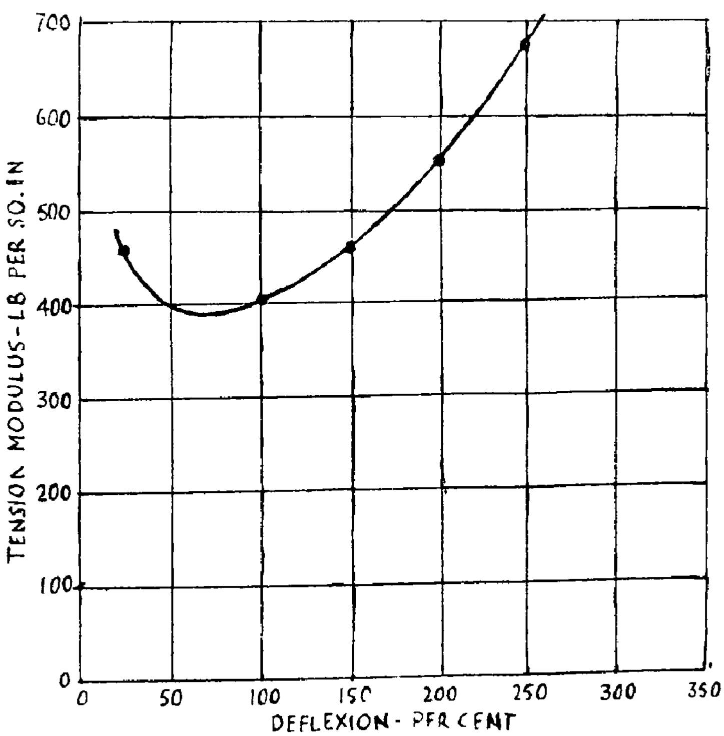


Fig. 3b.—Modulus curve—Tension.

HARDNESS MEASUREMENT

Rubber qualities are often specified in terms of their hardness value. There are a number of different hardness measuring instruments in use, but the most common in this country are the "Shore Durometer" and the "B.S.I. Hardness Tester." The "Shore Durometer" is probably the most widely used but suffers from the disadvantage that it is rather inaccurate and difficult to calibrate satisfactorily. In the hands of an inexperienced operator very misleading results can be obtained. The "B.S.I." instrument, on the other hand, operating on the dead weight principle, is more accurate and its use in Britain is becoming increasingly common. A hand-type "B.S.I." instrument is also available. While hardness may influence to some extent the general physical properties of a rubber, it is important to realize that there is no direct relationship between "hardness" and other properties, such as "modulus." The modulus of any specific rubber is entirely dependent on the compounding of the mix and two rubbers of the same hardness may have entirely different modulus values. This is demonstrated in Fig. 4, where the stress/strain curves for four rubber mixes, having the same hardness values but different moduli, are shown.

Curve "A" shows the stress/strain curve for a rubber compounded to give high resilience. This mix has a relatively high content of raw rubber to the other compounding ingredients.

Curves "B1" and "B2" show stress/strain curves for rubbers compounded to show high tensile strength, and maximum resistance to abrasion. This type of mix has a lower content of rubber than that for curve "A" but has a higher content of reinforcing carbon blacks. These curves demonstrate too that the modulus can vary even in compounds destined for similar applications. Curve "C" is that of a rubber compounded on a low cost basis. Its tensile strength is not high and it has a low hydrocarbon content consisting mainly of reclaimed rubber diluted with inert fillers.

USES OF RUBBER

In designing a rubber unit which is to function under conditions of stress, the following points have to be considered :—

(a) Before any consideration can be given to the use of rubber, the condition of service must be considered, such factors as temperature to which the unit will be subjected and the likelihood of the rubber being in contact with oils, etc., etc.

(b) Space available for the fitting of a unit and consideration as to whether sufficient rubber can be employed to carry the loads, under permissible conditions.

(c) Whether to use the rubber in compression or shear or both.

(d) Stress changes likely to occur from dynamic loading.

(e) Ease of moulding and mould design generally.

Rubber is best used as a stress-carrying medium either in a unit made on the "pre-stressed rubber

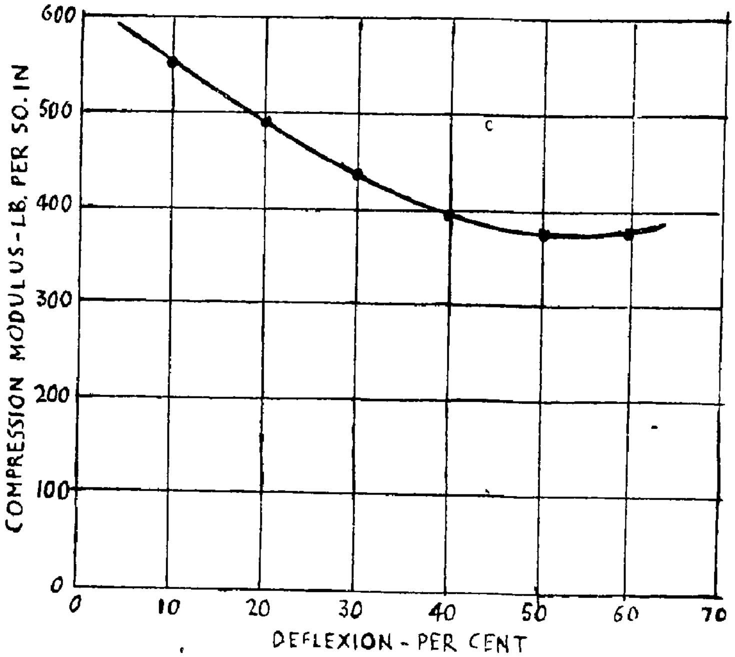


Fig. 3c.—Modulus curve—Compression.

principle" or in a component of "Bonded" type. A unit using "pre-stressed rubber" is typified in the "Silentbloc" bush. It comprises inner and outer metal sleeves with the rubber in a stretched condition between them. The rubber component is moulded in the form of a bush, and when assembled between the sleeves is considerably extended in its original dimensions. The rubber is held in position by the frictional resistance between the rubber and the metal parts and it is found that if the outer sleeve is removed the rubber rolls back to its original dimensions, as moulded. The accompanying diagram (Fig. 5) shows a "Silentbloc" rubber in its free moulded condition alongside an assembly containing the same rubber unit Anti-vibration mountings for carrying machinery and other equipment are made on the same principle, but the design of assemblies using rubber in this way is restricted to the basic form of construction described above.

In a bonded unit the rubber is firmly anchored to the metal parts, and the design is not subject to the same restrictions imposed on the pre-stressed form of construction. A variety of bonding techniques may be used, including brass plating the metal parts, or using proprietory bonding cements. There is a wide divergency of opinion as to which is the better method, but practical experience of both methods seems to indicate that for most engineering units where high bond stresses are likely to be encountered the brass plating method gives superior results. The bond obtained in this way is non-thermoplastic. It will be well perhaps to point out here that the bond between the rubber and the metal takes place during the vulcanization process.

Very careful process control is necessary when rubber is to be bonded to metal; under commercial operating conditions bonds having a strength of 1,000 lb. per sq. in. in tension can be obtained, while an average value of 700 to 800 lb. per sq. in. on test can be relied upon.

When using bonded units the most common method of carrying load is by placing the rubber either in compression or in shear. Rubber functioning in tension is seldom employed in general engineering practice and is confined to a few specialized applications of theoretical rather than practical value.

There are two different schools of thought on the use of rubber in compression and shear. It is claimed for rubber used under conditions of shear, that greater deflexions can be obtained than with rubber used in compression. Against this, however, a greater area of rubber for a given load must be used as the unit loadings which can be carried by rubber in shear are much lower than those allowable with rubber in compression. It was claimed for rubber used in shear that sound isolation of machinery could be achieved much more effectively, but it has been shown that equally effective noise reduction can be obtained with well-designed compression mountings.

There is little doubt that the use of rubber in compression offers many advantages. Used in this way, much higher loadings can be supported for a given effective area of rubber. Another point in favour of the compression unit is, that in the possible event of bond failure the unit can usually continue to function, whereas in shear mounting the bond has to be relied on completely, and any failure would mean complete breakdown of the unit. While present-day rubber-to-metal bonds have reached a very high degree of consistency there may be a doubt at the back of the engineer's mind, particularly when failure means stoppage of production equipment. Safety devices can, of course, be incorporated in the design, but they usually complicate matters and increase cost. The same remarks which apply to units used in shear apply when the rubber is used under conditions of pure torsion.

The unit loading which can be applied to a rubber section functioning in compression, shear or torsion depends, to a large extent, on the nature of the application, where there is likely to be variation in stress in the rubber, or whether it will be subject to stress variations over a wide range.

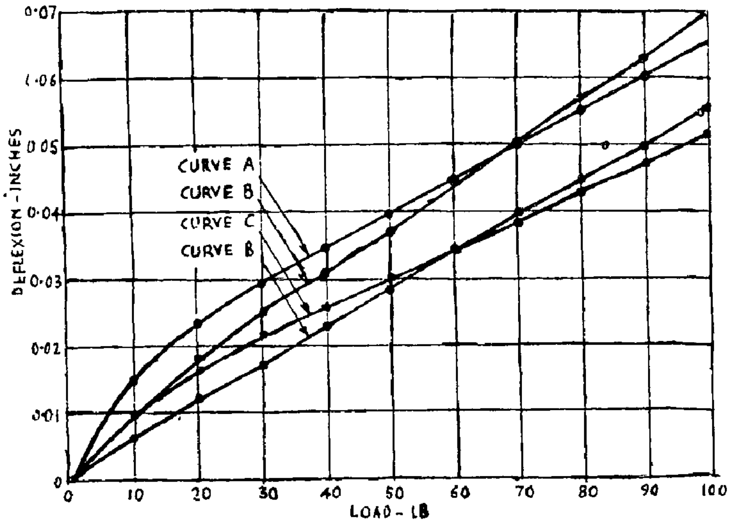


Fig. 4. Stress/strain curves for four different rubber mixes.

Using rubber in shear the maximum permissible stress consistent with reasonable life in service of the unit, is of the order of 55 to 60 lb. per sq. in. and where conditions are likely to be arduous calling for continuous flexing of the section 30 to 35 lb per sq. in. is a safer figure to work to. These figures may appear very low in relation to the ultimate strength of the rubber, but they are based on results obtained over a wide variety of applications. In some articles published in the United States of America higher stress figures are quoted for applications which are stated to have been thoroughly tested in service, but the author has not corroborated the figures quoted, and would feel apprehensive of any design based on them.

Using rubber in compression, however, stresses up to 500 lb. per sq. in. are permissible for normal applications, and loadings up to one ton per sq. in. can be dealt with as shock or momentary loads without fear of failure. Even higher stresses have been applied without apparent detrimental effect upon the rubber, but at loadings of over 500 lb. per sq. in. the effects of permanent set may become pronounced under continuously applied loads.

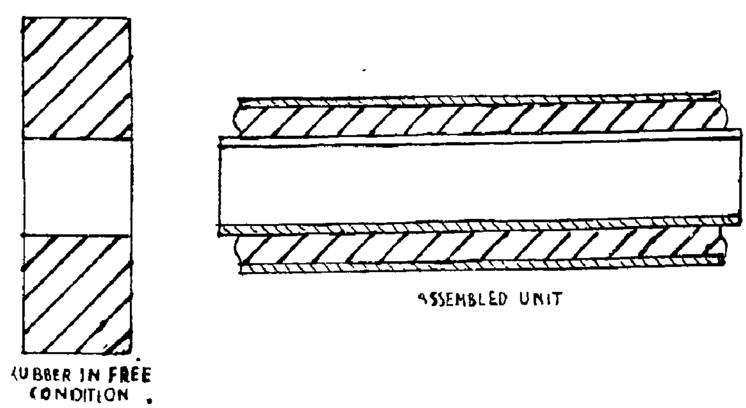


Fig. 5. A pre-stressed rubber component before and after assembly.

RUBBER BONDING

Fig. 6 shows a rubber-to-metal bonded sandwich subjected to a shear loading. For normal applications the value of "0" should not exceed 15° to 30° with a maximum value under shock conditions of 30°. The actual linear deflexion of one plate relative to the other can be obtained from the expression :—

$$d = t \tan 0 \text{ inches}$$

"t" being the thickness of the rubber section in inches.

The following formula gives the angular deflection for a given section and is reliable up to a value of $0 = 30°$. Over this figure the combined tension shear effect becomes more marked, and the formula becomes unreliable.

$$0 = \frac{57.3F}{AS} \text{deg.}$$

where 0 = angular deflexion in degrees.

„ A = cross-sectional area of the rubber in square inches.

„ S = shear modulus of the rubber in lb. per sq. in.

„ F = the applied load in pounds.

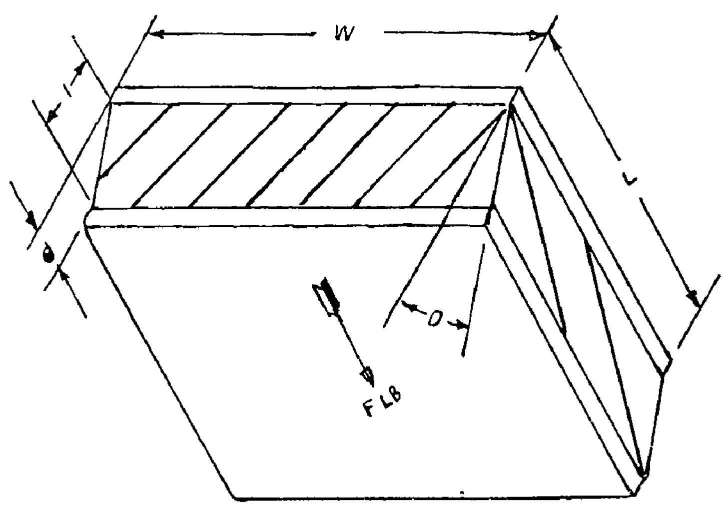


Fig. 6. Rubber-to-metal bonded sandwich.

Fig. 7 shows a circular bonded sandwich subjected to a torque loading, and here the value of "0" should not exceed 10° to 15°. This is to a certain extent controlled by the thickness of the rubber, and the angle B, between the two plates along the axis of the sandwich, should not exceed 30°. The formula for the value of "0" is in this case :—

$$0 = \frac{583Tl}{N(D^4 - d^4)} \text{ deg.}$$

where 0 = deflexion in degrees.

„ T = the applied torque in.-lb.

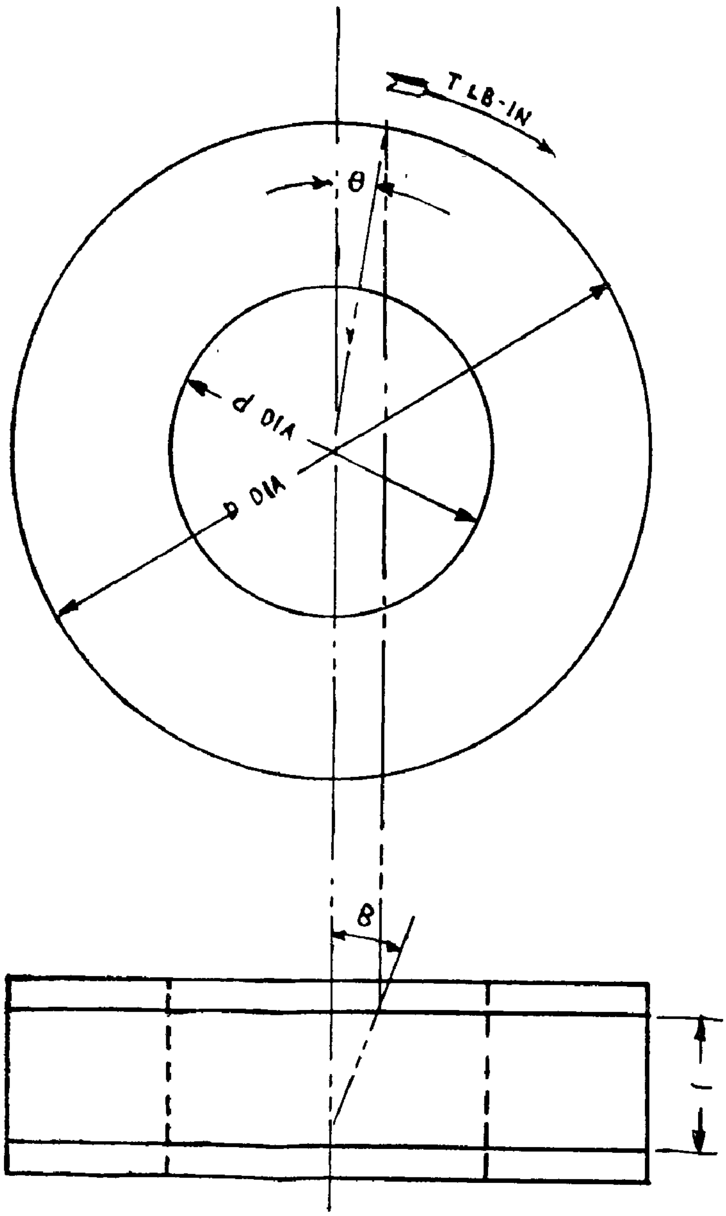


Fig. 7. Circular bonded sandwich.

where l = the thickness of the rubber section in inches.

„ N = the shear modulus in lb. per sq. in.

„ D = the outside diameter of the rubber in inches.

„ d = the inside diameter of the rubber in inches.

The torsional stiffness of the section is given by:—

$$C = \frac{\pi . N(D^4 - d^4)}{32l} \text{ in.-lb. per radian.}$$

where N = the shear modulus of the rubber.

„ D = outside diameter of section in inches.

„ d = inside diameter of section in inches.

„ l = thickness of section in inches.

„ C = torsional rigidity in in.-lb. per radian.

PERMISSIBLE DEFLEXION

The allowance deflexion of a rubber unit under compressive loading is rather more difficult to define, but is best expressed in terms of percentage deformation on original dimensions. In practice a deflexion of 15 to 20 per cent. maximum forms a good basis for calculation, though under shock conditions this figure can be exceeded. It will be remembered that earlier in the paper mention was made of the fact that above 25 per cent. deflexion the "modulus" value became more inconsistant; moreover, swelling of the rubber increases the effective area resisting the load. Both these factors combine to cause "hardening" of the rubber and result in a rapid increase in the slope of the load-deflexion curve.

The following formula gives a reasonably accurate forecast of deflexion up to 25 per cent.:—

$$d = \frac{Ft^2}{AEQ} \text{ inches.}$$

where d = deflexion in inches.

„ F = the applied load in pounds.

„ t = the free thickness of the rubber section.

„ A = the cross-sectional area of the rubber in square inches.

„ E = the compression modulus in lb. per. sq. in.

"Q" is an empirical value based on practical observation of results and might be termed a "shape" factor. Its value is:—

(a) For a rectangular sandwich, the length of the shortest side in inches.

(b) For a circular sandwich, the diameter in inches.

(c) For a circular sandwich with a hole at its centre, the difference between the outside and inside diameters in inches.

The ratio $Q : t$ should not exceed $5 : 1$.

Very careful consideration has to be given to the stress range over which the rubber is expected to work, as this has a considerable bearing on the life which can be expected from the unit. One condition under which rubber does not give satisfactory results is a combination of relatively high deflexion with rapid oscillatory motion, or again over a wide range of rapidly varying stresses. A rubber oscillated at speed with a high degree of deflexion tends to build up heat internally due to hysteresis losses in the rubber, and in extreme cases the heat build up may be so great that a blow-out will occur. This can best be explained by referring to some actual applications in which trouble has been experienced due to working under conditions similar to those outlined above.

APPLICATIONS

In the development of solid tyres for tracked fighting vehicles during the early part of the war, a great deal of trouble was experienced due to heat build up in the tyre. These vehicles were operating at tyre loadings and road speeds which were much higher, than anything

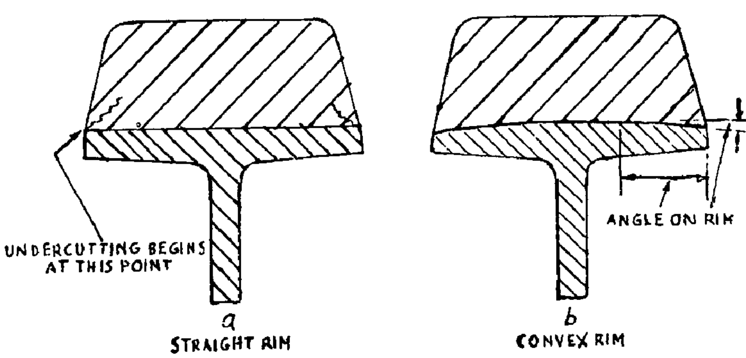


Fig. 8. Wheel rim design.

previously experienced on solid tyred vehicles. The difficulties experienced were eventually overcome to a large extent by the rubber chemists who produced improved tyre stocks having low hysteresis losses. It was also found that there was a maximum value for the load per inch width of tyre face which could not be exceeded with safety.

Another type of failure that was encountered fairly frequently was undercutting of the rubber tread under running conditions. Here failure commenced at the extreme edge of the wheel rim and developed rapidly into a cut running inwards and upwards towards the centre of the tyre. This was overcome by carrying out extensive experiments on the design of the wheel rim itself. The rim shape which gave the best results was found to be convex, and practically eliminated undercutting under controlled load conditions. The type of rim which gave undercutting and the convex rim are illustrated in Figs. 8*a* and *b*.

Another unit which failed due to rapid stress variation and high deflexion was the bonded shear mounting used on oscillation screens for coal cleaning. Here the screen was mounted at four points on rubber sandwich-type mountings and was oscillated on them. The top plate of the sandwich was attached to the screen and moved with it, while the bottom plate was attached to the supporting framework and remained stationary. On paper the stress in the rubber section was well within safe limits, as was the deflexion, but the life in service was found to be very short due to failures commencing close to the bonding surface. The failure in this case could have been overcome by increasing the thickness of the rubber section, thus decreasing the value of "0" the angle of deflexion, but this in turn rendered the screen unstable and produced a marked tendency for it to bounce when run up to operating speeds. It was found that when the screen was oscillated in a free unloaded condition, failure still occurred after only a very short period of running.

On the other hand, it has been found that a bush of the "Silentbloc" type, or a bush of similar design in which the rubber is bonded to the inner and outer sleeves, instead of being stretched into position, can give prolonged service life. A good example is the automobile spring shackle bush. Here the outer sleeve is held in the spring eye while the inner is anchored to the shackle pin, and due to spring movement the inner and outer move relative to one another rotationally. On oscillation tests it was found that there was little difference between the bonded bush and the bush using "pre-stressed" rubber, so far as performance was concerned. One type of bush was oscillated through an included angle of 30°, 15° each side of the neutral position, while carrying a radial load of 900 lb., which was equivalent to between 500 and 600 lb. per sq. in. on the projected area of the inner sleeve.

Bushes run under these conditions showed no signs of failure after many hours of continuous oscillation, equivalent to approximately 50,000 miles service in the road springs of a motor vehicle, and all the time they operated under extreme conditions of load and deflexion. In this instance the type of rubber used and the design of the rubber unit were important factors, as was the case with solid tyres. It was found that, to eliminate the same type of undercutting as was experienced with tyres, stress concentrations at the extreme edges of the bond had to be eliminated. This was done by relieving the stresses on the rubber at this point by modification to design as shown on Fig. 9. Figs. 10 and 11, Plate 1, and Figs. 12, 13, and 14 Plate 2, show four different causes of bond failure and may be of some interest.

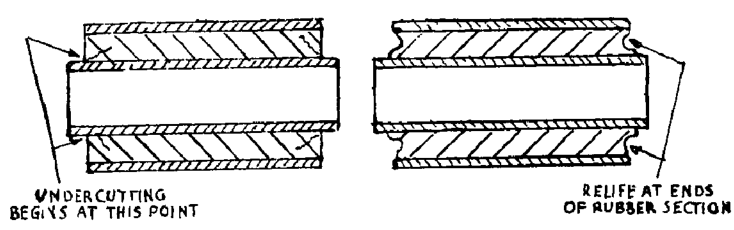


Fig. 9. Automobile spring shackle bush.

The fault in Fig. 10, Plate 1, was traced to porosity in the surface metal. Non-adhesion of the brass to the metal often accompanies this fault and is evident in the sample, although only to a small degree.

PLATE I

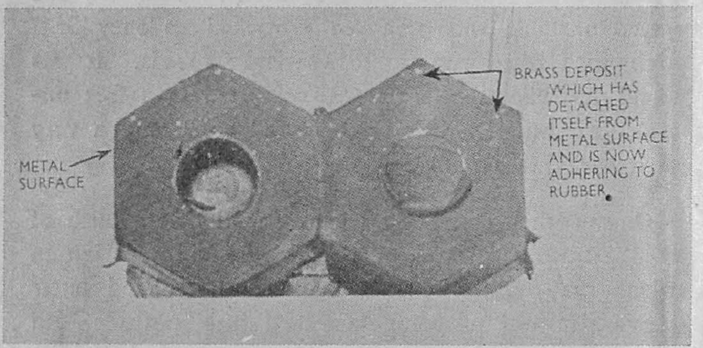


Fig. 10. Bonding Failure due to Porosity of the Metal Surface.

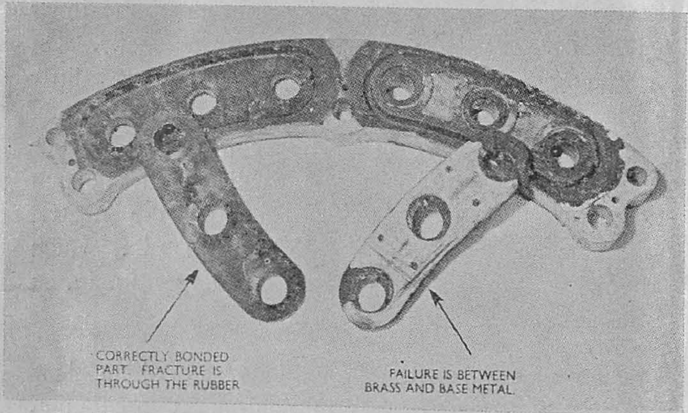


Fig. 11. An Example of Failure between Brass and Base Metal.

Fig. 11, Plate 1, illustrates a chronic case of loose brass. All the brass has come away on the rubber. Loose brass can arise, in addition to the case as shown in Fig. 10, Plate 1, when the metal surface has not been completely freed of grease, scale and other impurities or if the current density at which the article is plated is too high.

In Figs. 12 and 13, Plate 2, the brass has been deposited on a clean surface but is not of the correct composition. The rubber, therefore, has peeled away from the brass. Such a failure can also arise from a substandard cement being used or a cement which has not been properly applied.

In Fig. 14, Plate 2, failure has occurred between the cement and the rubber. This is usually due to the thin layer of cement curing before the large mass of rubber settles down and is vulcanized.

Another instance of a rubber component subjected to continuous oscillation under load is the anti-vibration mounting. These will give prolonged life in service, but here the oscillations, though sometimes rapid, are usually of small amplitude. It will be seen, therefore, that in any unit subjected to dynamic stresses, variation in direction and amount of deflexion should be kept to a minimum, and in no circumstances should exceed the values given earlier in this paper.

Neglecting the initial stress due to static loading, it has been found that rubber working over a stress range of from 20 lb. per sq. in. to 35 lb. per sq. in. will give an infinitely longer life in service than one working over a range of from 20 lb. per sq. in. to 50 lb. per sq. in. The dynamic modulus of rubber as with other materials differs from the static modulus and while it is impossible to give exact values, as the modulus varies with the speed and amplitude of vibration, an average value for dynamic modulus is from 2.5 to 3 times the value of the static modulus.

In the design of any rubber section, particularly in a bonded unit, there are a number of things which should be avoided as far as possible. Possibly the most important is the elimination of sharp corners at the edges of bonding areas, and all projecting lips on metal parts. It is at sharp corners and points of high local stress concentration that failures commence, and on projecting lips there is always a danger of the rubber doubling over when distorted under load and consequently cutting or tearing at these points. Wherever possible trapping of the rubber, when being compressed, should be avoided. It should be allowed to distort freely and take up its natural contours under load. Rubber is for all practical purposes incompressible and any tendency to trap the rubber and restrict its free movement will upset the calculated deflexion of the section. There are, of course, applications in which the incompressibility of rubber can be used to advantage. For example, a sealing strip or ring can be designed so as to give a small initial deflexion and can then be trapped in a channel section or other form of groove. To render the seal effective, however, the small initial deflexion is an essential feature, as otherwise very poor sealing qualities would result.

Another bad feature of design which can, in many cases, give trouble is the inclusion of acute angles in the rubber section. For example, a rectangular or triangular hole will tend to crease at the corners when the rubber is distorted, giving high concentrations of stress at these points which will in time cause the rubber to tear. As for as possible, smooth contours on internal or external surfaces should be aimed at.

PLATE 2

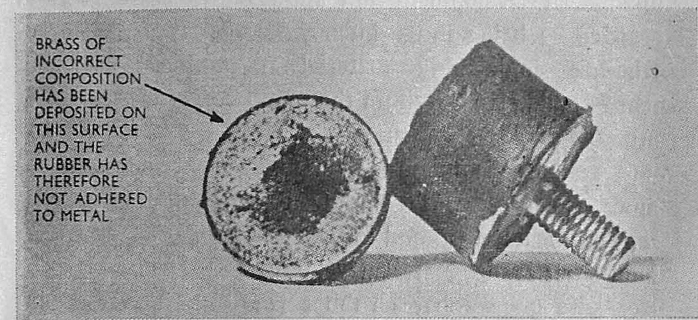


Fig. 12. Bonding Failure due to Incorrect Brass Composition.

Fig. 13. Another Example of Failure Caused by using Brass of Incorrect Composition.

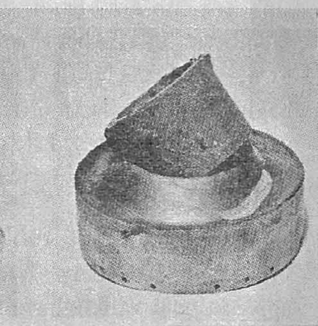


Fig. 14. Failure between Cement and Rubber.

In the design of bonded units, so far as ease of moulding is concerned, the primary object should be to concentrate on simplicity of form; complicated forms require complicated moulding equipment, and in very few cases are really complex shapes justified in the light of subsequent performance. Complicated contours, particularly on internal surfaces, may mean loose parts or inserts in the mould, and, not only do these increase the handling problems in the press shop and increase the likelihood of accidental damage, but they are expensive to produce. It should always be borne in mind that moulds have to be handled at temperatures around 300° F., and the operators wear heavy insulating gloves. These circumstances indicate why it is desirable to avoid complicated and intricate moulding equipment. Simple moulds, also, lend themselves more readily to mechanical methods of handling and stripping which in large quantity production has obvious economical advantages. The same remarks regarding complicated forms apply to metal parts which have to be accommodated in the mould. The fact that these have to be accurately made within specified tolerances on locating dimensions is a point which often does not seem to be fully appreciated by engineers. The greater the tolerances on the dimensions of the metal parts, the greater must be the clearances in the mould to receive them, and any gaps between the mould and the metal parts will fill with rubber during moulding. Accurately made metal parts greatly assist the rubber manufacturer and in the long run provide the engineer with a cleaner and cheaper finished article.

Where the rubber phase is concerned, it is advisable to maintain a uniformly thick section as far as is possible. In a unit which combines thick and thin sections there is a tendency for the rubber to be in different states of cure throughout. The thin section may be fully cured before the thick, or if the thick section is fully cured the thin may be heavily over-cured.

SYNTHETIC RUBBERS

So far no mention has been made of the various types of synthetic rubbers which are available to the engineer. Generally speaking these synthetic rubbers do not possess the load-carrying capacity of natural rubbers, especially under dynamic conditions. Certain types of synthetic rubbers on a basis of static tests have physical characteristics which compare very favourably with natural rubbers, but when subjected to dynamic stresses they do not stand up so well. They suffer from the defect of having a higher permanent set, and mountings made from synthetic rubber show under load a tendency to settle over a period of time. There is no doubt, however, that they form a useful and most essential addition to the range of rubbers available to the engineer. Their resistance to swelling in oils and their ability to retain their physical properties at higher temperatures are well in advance of what is obtained from natural rubber compounds. They are also most useful to the chemical engineer for lining tanks and other equipment, owing to their ability to withstand the action of a wide range of chemicals at relatively high temperatures for prolonged periods. Oil seals made in synthetic rubber can give long and satisfactory life.

APPLICATIONS CLASSIFIED

With regard to the wider application of rubber in engineering one can only generalize as space does not permit to go fully into every aspect. I would, however, like to mention one or two applications and in doing so suggest dividing them into the following classes :—

Rail Transport	Road Transport
Aircraft	General Engineering

Rail Transport. Papers and even books have been published dealing with the use of rubber in rail transport, the foremost of them being Sanders' Miscellany of Springs, Volume 1, which gives one complete chapter to rubber.

As is generally known, rubber springs for buffers, drawgear and auxiliary suspension have been used on the railways for many years and are still considered by many as the best means of shock absorption ; but rubber is now taking a more prominent place as a means of mounting auxiliary machines in the under-frame to insulate the body from vibrational shocks and, in the case of motor coaches, to mount instruments in the body, and for resilient gear wheels, also for mounting such machines as compressors, exhausters, dynamotors, M.G. sets, H.T. frames and alternators. Serious thought is now being given to the use of rubber in centre pivot and resilient road wheels.

Road Transport. Most engines are now mounted on rubber units. Rubber is also used, incorporated in spring bushes, front suspension bushes, suspension springs, propellor shafts, and in body mountings, amongst other projects. Rubber is now being tried out as a resilient element in clutch plates and in starter units.

Aircraft. Many complicated details are now made in rubber, or bonded rubber, such as engine mountings, instrument mountings, magneto couplings, starter couplings, radiator mountings, tank mountings, rudder buffers, air seals, oil seals, special rollers for supporting controls, snow guards, and so on.

General Engineering. The rubber industry is being called upon more and more every year to mount machines on rubber in order to damp out vibration and reduce noise. Mountings can be adapted or designed to function either in compression or shear, depending on the application, to deal with loads ranging from ounces to hundreds of tons.

Research is being carried out even now on the use of rubber for insulating buildings against shock impulses emanating from forging hammers and power presses.

Rubber has by no means reached anything like its full state of development and application and can still be regarded as being in its infancy compared to the more orthodox engineering materials. Continual development is taking place within the rubber industry and the outcome of these investigations should be more and more reliable compounds. Present-day rubbers as a known quantity are far in advance of those produced even ten years ago, and in another decade there is no doubt that even greater developments will have taken place. In some spheres rubber is already an accepted medium for the absorption of vibration particularly as regards the mounting of machinery and in the transmission of power from the power unit to its driven members. In others rubber is rapidly coming into its own, particularly in the textile industry, where it is beginning to replace other materials in the processing of yarns, with a marked degree of success and increase of efficiency over existing materials.

The designer of rubber units is faced with many problems of widely divergent nature not only in the applications which have to be dealt with but in estimating the performance of the rubber itself in service. When using rubber there are so many variables to contend with that it is often difficult to predict the performance of a given unit with any degree of accuracy. One has to reckon with a wide variety of compounds, the effect of permanent set, high—or low-temperature effects, and many other conditions all of which may affect the eventual service life of the rubber.

It is hoped that this paper will give engineers at least some indication of the basic principles of the application of rubber to engineering and some of the problems involved in the design of units.

ACKNOWLEDGEMENTS

The author would like to acknowledge the encouragement given by the Directors of the Andre Rubber Company in the preparation of this paper and their permission to present it.

A NEW INDUSTRY PROPOSED IN DURGAPUR

Messrs. Associated Cement Company Ltd., (Bombay), Vickers Ltd., (London) and Babcock and Wilcox Ltd., (London) announced that they had concluded arrangements for the formation of a company to be known as A. C. C.-Vickers-Babcock (Private) Ltd. The new company plans to build a heavy engineering works in the vicinity of Durgapur, West Bengal. The products to be manufactured would include cement-making machinery, mining machinery, large pumps, heavy gears, steam generating plant of all types, pressure vessels, cranes and mechanical handling equipment. The construction of the proposed works will commence as soon as Government of India's approval is obtained.

CLEANLINESS LEADS TO HEALTH AND HAPPINESS

Clean orderly habits contribute to general health and welfare and as such to happiness and prosperity; they are more important than medicines.

Cleanliness prevents disease; medicine only attempts to cure.

Cleanliness of the person, of the houses and colonies, reflects discipline in the individual and the community. Discipline is the foundation stone for progress of oneself and the country. Cleanliness is a good habit. It is also cheap.

All Railwaymen should set an example of cleanliness. This will help others and themselves.

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