their places, a molecule travelling through a distance equal to its diameter after something less than but approaching a hundred impacts.

Andrade has put forward a theory of liquid viscosity on the basis that the momentum is transmitted from layer to layer not, as in a gas, by the passage of molecules from one layer into the other, but by instantaneous association of the molecules when they touch, so that at any nearest approach two molecules share their momentum. On this basis a formula can be derived which gives the viscosity of a simple liquid at its melting point, and another which gives the temperature variation of the viscosity.

Molten metals are particularly suitable for experiments designed to throw light on this problem of viscosity, because they constitute liquids which consist of one kind of atom only, and they are not, in general, associated. The viscosity is conveniently measured by sealing up the molten metal in a sphere suspended in vacuo, and observing the damping of the torsional oscillations of the sphere about a vertical axis due to the enclosed liquid. The method has already been used for the alkali metals, and is being extended to other metals.

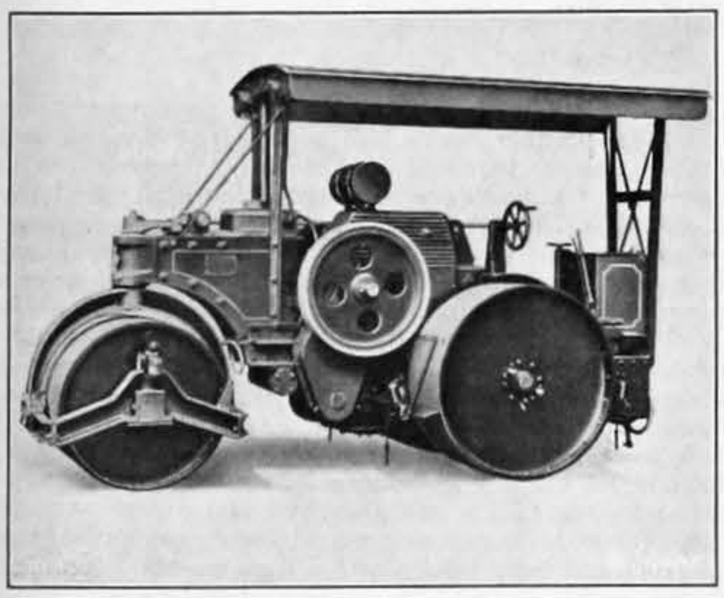
The flow of solids is perhaps at first sight even more troublesome theoretically than the flow of liquids, for single crystals of metals exhibit plastic flow under very small stresses, whereas a perfect crystal should, first, be strong, and, secondly, be brittle. Again, single crystals of metals show a very marked hardening with flow. The mechanical properties of metal crystals have been elucidated by the work of Polanyi, Schmid, G. I. Taylor, and others, and it is now known that the factor which initiates plastic flow is the shear stress in a certain crystal plane and in a certain crystal direction, which can be found by experiment, but there is no general rule, applicable to all crystals, which enables us to decide beforehand what the plane will be, whereas the direction is always the direction in which the atoms are packed most closely. The glide direction seems to be more significant and fundamental than the glide plane.

To explain how it is that metal crystals can flow at all, various workers have suggested, with different detail, that in the ordinary crystal places exist where the atoms are out of step for a small distance with their immediate neighbours, such regions being called "dislocations" by Taylor. It can be shown that quite a small shear stress will cause such a dislocation to run along, leaving the atoms in the region through which it passes advanced by one. The weakness and the flow of single crystals is explained along these lines. Other internal flaws have been involved to explain the time factor in the flow, and the hardening. It cannot be said that there is any fully satisfactory theory of the flow of single crystals of metals, but a good beginning has been made.

It is, of course, a far step from the single metal crystal to the poly-crystalline metal of industry, but we can see that any crystal boundary is likely to stop the propagation of a dislocation or glide in general, and so will make the metal less weak and less liable to flow. Industry cannot, of course, wait for theory, but the only really satisfactory way to approach the problem of the strength of metals is by way of the single crystal.

Oil Engine Driven Road Roller.

WE illustrate herewith a new oil engine driven road roller, which has recently been placed on the market by Marshall, Sons and Co. (Successors), Ltd., of Britannia Ironworks, Gainsborough. It is one of a series of four machines with weights of 6, 7, 8, and 9 tons respectively, all of which can be supplied with Marshall single-cylinder two-stroke heavy oil engines with a bore of 6½in. and a stroke of 9in. having a designed output of 20 B.H.P. at 700 r.p.m., or, as shown in our engraving, with a Blackstone engine of the single-cylinder, four-stroke pattern, with a bore of 7¼in. and a stroke of 9½in., rated at 22 B.H.P. when running at 600 r.p.m. We have already described



OIL ENGINE DRIVEN ROAD ROLLER

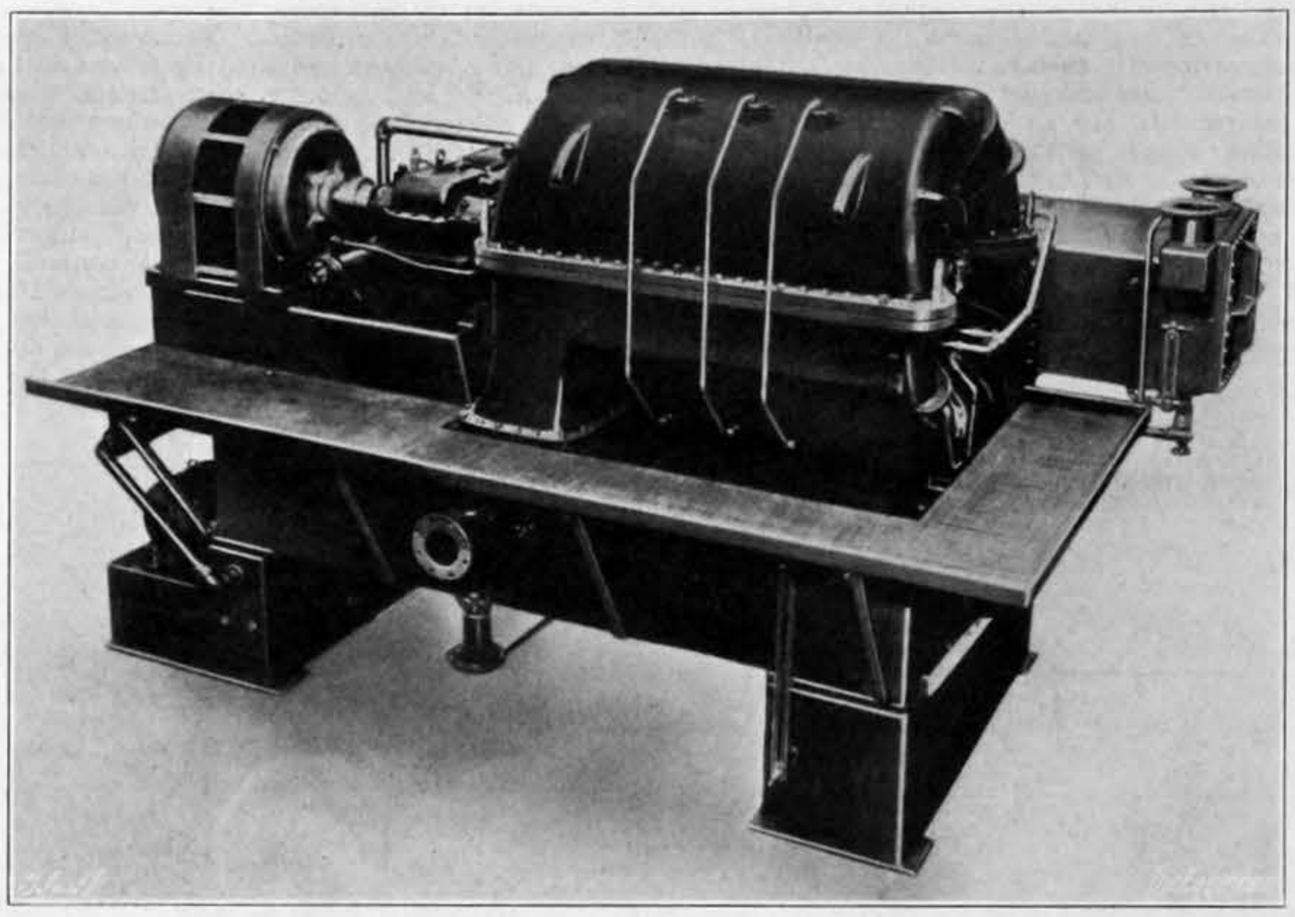
this type of engine, which is totally enclosed, with the upper part of the bed designed to form a cooling water hopper. Airless fuel injection is employed, the C.A.V.-Bosch type of fuel pump being employed. The engine is equipped with a governor control for the speed at all loads, and, in addition, there is a hand speed adjustment, giving a variation in speed over a wide range. The principal working parts are lubricated by a plunger type oil pump. For easy starting a decompression device is employed, which enables, the makers claim, the engine to be readily started by hand even when cold. The design of the roller follows closely the firm's standard practice adopted for their extensive range of steam, petrol engine, and oil engine driven machines. It incorporates a four-speed gear-box, giving in each direction road speeds of 1, 1½, 2¼, and 3½ miles per hour, which, along with the variation given by the hand speed control, provides a very wide range of rolling speeds. Both hand and foot brakes are provided. Other features in design include the fore-and-aft front fork, which is pivoted at its lower ends, also a special forecarriage with a taper roller bearing. The steering is effected by a hand wheel mounted upon a horizontal spindle which is connected through bevel gearing to a steel worm and segment. On the 6 and 7-ton rollers the driving rolls have mild steel rims with flanged steel side plates and detachable semi-steel bosses, with front rolls of similar design. For the larger 8 and 9-ton sizes, however, semi-steel centres are used with the bosses gun-metal bushed. The driver has a comfortable seat, before which the controls are grouped for convenient operation.

Air Conditioning at the New Alhambra Theatre.

IN the design and construction of modern public buildings, theatres, stores, offices, &c., increased consideration is being given to the incorporation of air-conditioning equipment in order that the occupants may enjoy clean, comfortable, and healthy atmospheric conditions, regardless of the prevailing exterior weather. The new theatre now being built on the site of the old Alhambra in Leicester-square by Odeon Theatres, Ltd., will be equipped with air-conditioning plant by Vacuum Refrigeration, Ltd., of 39 to 45, Finsbury-square, London, E.C.2. The plant is designed to give a constant dry bulb temperature inside the building of 68 deg. Fah., with 57 per cent. relative humidity, when the outside shade temperatures vary between 80 deg. and 30 deg. Fah. Should the outside summer shade temperature at any time exceed 80 deg. Fah., a corresponding increase will be provided in the theatre, so that the difference between the inside and outside dry bulb temperatures will not be more than 12 deg. Fah., otherwise patrons would experience discomfort owing to the wide divergence. The percentage of humidity will, however, remain unaltered. The new theatre will accommodate some 2300 persons, and in designing the equipment it has been necessary to take into consideration the amount of heat and humidity liberated by so many people. Each occupant will be supplied with 1200 cubic feet of fresh air per hour. The heat gains make it essential for refrigeration to be incorporated in the service in order that excess moisture may be condensed out of the air.

The rotary water vapour refrigerating plant illustrated comprises a centrifugal water vapour extractor and compressor (of similar construction to a normal turbine blower), which may be driven by an electric motor operating through a speed increasing gear or by the direct application of a steam turbine, a flash type water evaporator, a surface vapour condenser, a dry vacuum pump for air extraction, and a cold water extraction and delivery pump arranged integral with the flash evaporator. The action of the surface condenser and dry vacuum pump will provide an absolute pressure in the evaporator of about 1½in. to 2in., depending on the temperature and quantity of the condenser water available. The action of the rotary vapour compressor further decreases the absolute pressure in the evaporator to some predetermined value, at which the temperature of the water to be cooled is obtained. In addition to this duty, the vapour compressor extracts and compresses the water vapour to the pressure existing in the condenser to which it is passed, the condensate then being returned to the evaporator feed. Since the vapour volume varies largely with a slight difference in temperature, the plant automatically regulates itself and practically floats on the load. The Alhambra plant is designed to eliminate 2,400,000 B.Th.U. per hour, which is equivalent to the melting of 200 tons of ice per twenty-four hours at 32 deg. Fah., the compressor being operated at full load by a 185 H.P. electric motor. This is equivalent to 0·925 H.P. per ton of refrigerating duty, which figure is claimed to show an advantage when compared with other methods of refrigeration. The chilled water leaves the evaporator at a temperature of 45 deg. Fah., and is circulated to the spray washing plant at the rate of 800 gallons per minute. The whole of the air admitted to the theatre will be thoroughly washed, cleansed, and dehumidified by a spray type air washer. Before entering the auditorium the air will be suitably heated, as conditions may demand, and the relative humidity adjusted. The complete plant will deliver 1½ tons per minute of correctly conditioned air to the theatre. The air extracted will be conveyed by ducts situated under the balcony steppings and stalls seats, and also through the proscenium arch and stage extracts. In total, it will constitute some 75 per cent. of the air admitted, the balance of 25 per cent. being used to maintain a slight pressure inside the auditorium, thus preventing cold draughts from entering in winter.

The question of central control for the whole of this equipment required very careful consideration. The chief difficulty was to group all temperature indicators, motor starters, speed regulators, and pump controls about a convenient centre. Added to this was a further complication brought about by the necessity of arranging certain motors for sequence starting to comply with London County Council regulations. Other legislation also called for several motors to have their speed regulators coupled in order that speed variation should be simultaneous on the fans operated by the motors in question. Altogether the problem was most complex and intricate, as the conditions indicated partially precluded the use of remote operated contactor gear. A compromise was therefore effected whereby the fixed speed motors would

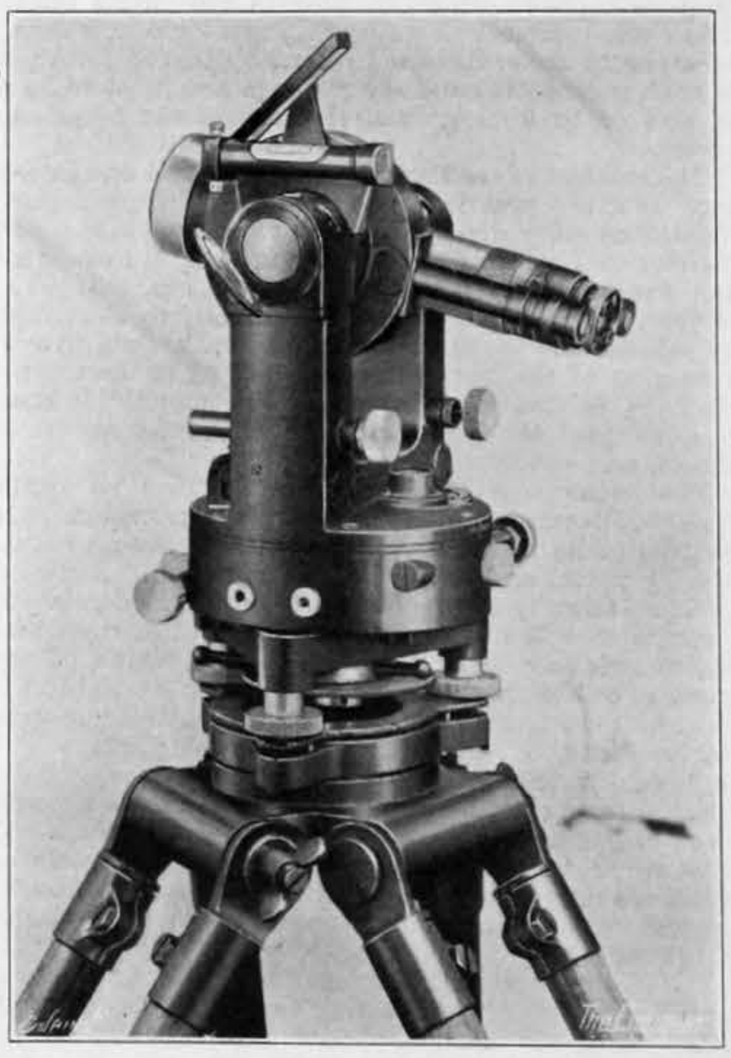


ROTARY WATER VAPOUR REFRIGERATION PLANT

employ contactor starters, situated adjacent to the motors, but controlled by push buttons from the main panel, the remaining variable-speed motors having their rotor leads brought back to the main panel in order that face plate starters and coupled speed regulators could be employed.

A New Theodolite.

WE were recently given the opportunity of inspecting a new theodolite at the London office of Cooke, Troughton and Simms, Ltd., of 15 and 17, Broadway, Westminster,



T 63 THEODOLITE

S.W.1. This instrument is known as the T 63 theodolite, and incorporates a number of new and interesting features in its design and construction. For a long time past the design of the theodolite appears to have been stabilised,