PROGRESS IN X-RAYS

NEWNES

PRACTICAL MECHANICS

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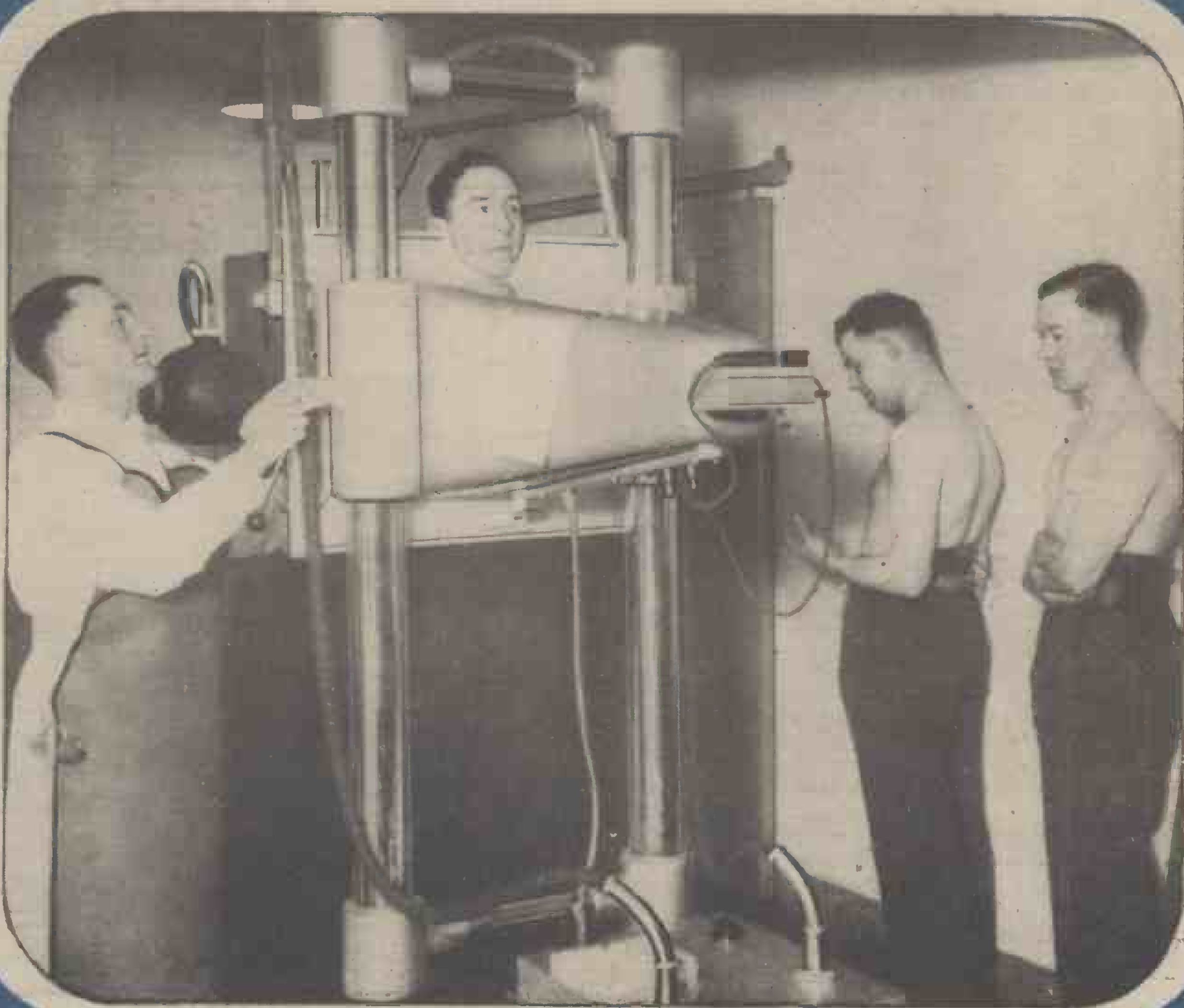
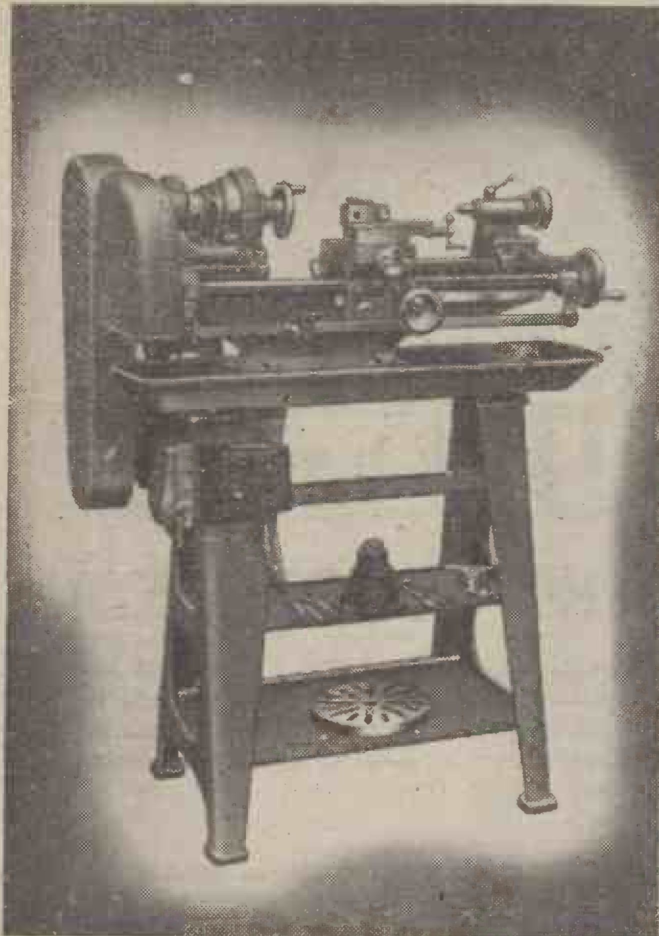
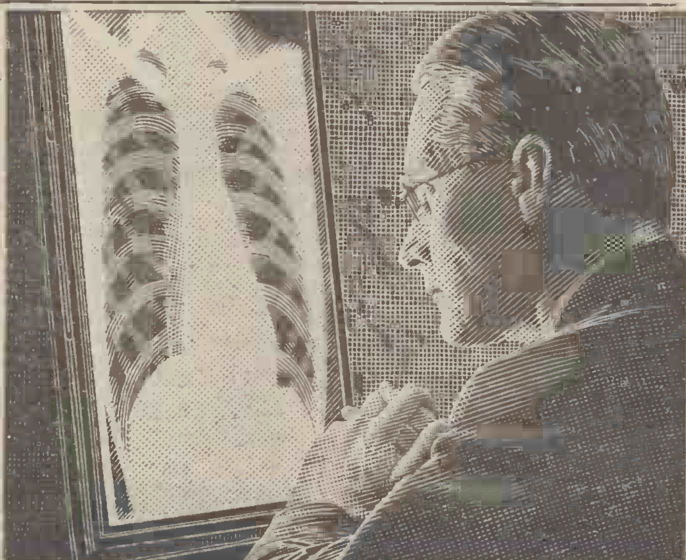
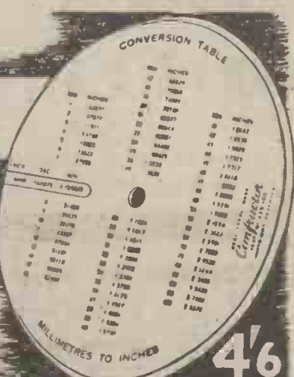
NOVEMBER 1944





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Owing to the paper shortage "The Cyclist," "Practical Motorist," and "Home Movies" are temporarily incorporated.

Editor : F. J. CAMM

VOL. XII NOVEMBER, 1944 No. 134

FAIR COMMENT——BY THE EDITOR

More Developments

CONTINUING our summary of war-time developments which are released for publication, we give this month details of a further batch.

The Hydrobal Instrument

The hydrobal, an instrument designed by Glenn Martin, is providing an accurate, rapid and comparatively simple means for determining proper loading on the Mars and other Martin flying boats. The functioning of the device, an automatic weight and balance indicator, is dependent on the well established facts that the distance from the keel to the water line of a boat's hull is proportional to its loaded weight, and that the angle at which the hull floats (trim angle) is related to the loaded centre of gravity.

Two standpipes with enclosed floats are installed in the hull, one each fore and aft. The difference in height of the floats indicates centre of gravity, and the average gives loaded weights. Readings are obtained quickly from a calibrated chart. Results of tests in a 25-mile wind and 2ft. wave were more accurate than those obtained with much more complex flight calculations.

The hydrobal requires no complicated adjustments or servicing, and may be prepared in kit form from service installation. Further developments, still in the laboratory stage, will permit direct recording of weight and centre of gravity without reference to charts and graphs. Further electric or pneumatic connections between the floats and indicating gauges may be used. These instruments are expected to have promising post-war applications.

Self-starting Aeroplane Tyre

A "self-starting" aeroplane tyre that will ease wear and tear of landing impact has been announced by B. F. Goodrich Co. When the landing gear is lowered, an arrangement of vanes, or fins, built into the side wall of the tyre, catches the air and sets the tyres rolling at high speed before they touch ground. The fins, made of rubber and fabric, spring back flush with the tyre's side on the "upper half" of each rotation of the wheel.

Automatic Radio-range Monitor

By instantly warning both the flyers and ground crews of a shift or fading in any radio course, a new automatic radio-range monitor, manufactured by Islip Radio Manufacturing Corporation, represents an important improvement towards airway safety. The monitor acts if any radio course shifts as little as three degrees from its normal setting and may be adjusted to operate all warning devices with a range course shift of less than one degree.

The course monitor receiver is located directly on the radio course 1200ft. from the radio-range station. Interlocking A and N signals transmitted by the range station are received continuously by the monitor. A shift in course is indicated by predominance of either A or N signal. If this should occur, the monitor receiver automatically transmits an electrical impulse to the airport's monitor board, which flashes a red light and sounds a siren to warn the ground crew. Simultaneously, the monitor dials the range transmitter, which instantly signals a warning at the end of each A-N cycle to all pilots. The same warning is given if the link circuit relay fails to interlock the A and N signals correctly or becomes locked, if the output of the radio-range station drops below a predetermined level, or if more than one-half of the range's station identification call is not being transmitted.

"Sonotest" Instrument

An electronic instrument called "Sonotest" is being used in ordnance plants to test shells for the 20 mm. automatic cannon. The device tells whether or not the shells are sound by the way they ring when dropped on an anvil. It is an elaboration of the shopkeeper's trick of tossing coins on the counter to see if they ring true. The shell is tested twice—first by dropping it on its base end, then on its side. The sound is picked up by a microphone and relayed through a hook-up of electronic tubes. The vibration frequency, or range of tone, is recorded, and duration of sound measured. If the shell meets requirements, a green light, or master indicator, flashes. The "Sonotest" inspects for such factors as loose rotating bands, loose base plates, cracks, deep cavities, and serious imperfections of threads. With a little preliminary training, a girl operator can test from 1,200 to 1,800 shells an hour.

Navigation Instrument

A new celestial navigation instrument for life-raft use provides a simple, rapid means for determining true north, sun time, latitude, great circle course and direction. It combines a miniature of the celestial sphere showing the exact location of 22 navigational stars with a world globe and all co-ordinates. The instrument, made entirely of Plexiglas, and weighing about 1lb., will float, and is said to be clearly visible even at night. Its use will eliminate need for a nautical almanac, sextant, compass, and the involved calculations required with such equipment.

Rotary Indexing Machine

Thermosetting plastics may be injection-moulded on a large scale continuous basis at Ford's River Rouge plant by a rotary indexing machine in which the three basic operations of injection moulding are perfectly synchronised. The unit, which was built by the Hydraulic Press Mfg. Co., measures exact amounts of the powdered raw material into an injection cylinder, where the plastic is gradually heated to a viscous state. The now viscous plastic is injected into an electrically heated injection mould under the tremendous pressure of 40,000lb., and the casting is cured at a temperature between 300 and 330 deg. and under a pressure of 10,000lb. While the casting is being cured, it is revolved on a turntable through 12 stations by the rotary indexer, key feature of the machine.

The new machine is said to have several advantages. Because exact quantities are injected, the castings are free of flash, resulting in a 10 per cent. reduction of waste and a 10 per cent. saving in labour formerly required to trim the flash. The continuous injection produces castings of greater tensile and dielectric strength. It effects an estimated 250 per cent. saving in curing time, attributed largely to higher mould pressure. The use of fewer dies permits a 25 per cent. saving in the cost of the cavities. According to technicians, it should be possible to employ a different mould in each of the 12 stations on the rotary indexer, provided the dies were in the same weight range. To make new parts, only the cavity, not the shoe, need be changed. Although the machine is still considered in the experimental stage, it has turned out hundreds of truck-engine coil cases, which are difficult to mould because of their odd shape.

Aircraft Ignition Distribution System

A supercharged aircraft ignition distribution system used by Northwest Airlines on the DC-3's is said to prevent most of the conditions causing the operational troubles frequently encountered in the ignition harness. The system supplies pure dry air to the ignition system at a pressure higher than that of the surrounding atmosphere, and provides a means for removing contaminated air before it can cause damage or misfiring.

The supercharged ignition harness consists of an engine-driven, oil-lubricated pump which supplies air through oil separators. The air passes through a dehydrating unit into the shielded distribution system. The flow of extremely dry air through the harness cools the insulation and so prolongs its life.

Progress in X-rays

The Advances Made in Apparatus and the Application of X-rays

By A. J. WALTON, F.S.R.

IT is not my intention to go into the physics and technicalities of this subject, but to enable the reader to understand more fully what he is reading it is necessary to touch on the fringe of physics occasionally.

It is surprising how many times during my 40 years' experience in hospitals, clinics, and even private practice, I have heard people remark, "What a wonderful invention X-rays were"; hence the short history.

X-rays, of course, were not invented; their discovery was quite accidental, like other epoch-making discoveries in science. Various scientists had, over a period of years before 1895, been experimenting on the passage of electricity through a rarefied tube. It had been found that, when two metal electrodes were sealed into the ends of a glass tube and connected to a source of electricity of sufficient potential outside the tube, certain changes took place if the gas pressure in the tube was reduced. Amongst other things it was noticed that a dark patch or space surrounded the cathode (the negative pole of the tube). It was eventually discovered that the dark space would, when the pressure was further reduced, fill the whole tube, and the walls of the tube would light up with a fluorescence (many have seen a green fluorescence of the X-ray tube in years gone by, but this was not X-rays). In 1869 it was discovered that the space within the tube contained rays which appeared to come from the negative end of the tube. These rays were, and are called to-day, cathode rays. The cathode rays are a stream of units of negative electricity.

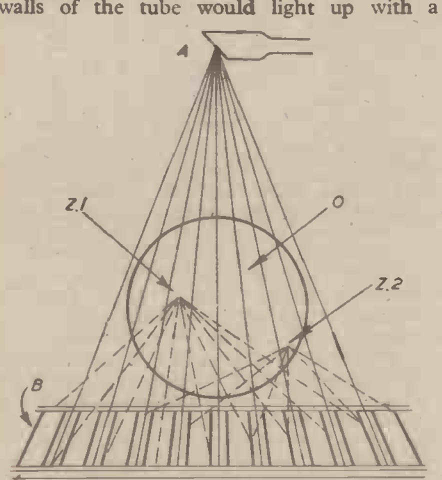


Fig. 2.—"Scatter" rays and moving grid.

Crookes' Tube

Sir William Crookes commenced his experiments in 1879. He demonstrated by means of a tube and a cross which could be raised and lowered, that the cathode stream leaves the cathode at right angles to its surface and flies in straight lines; when the cross was raised into the path of the stream of electrons, it cast a shadow on the fluorescence wall of the glass tube, thereby showing that the fluorescence was due to the glass walls being struck by the flying electrons (see Fig. 1).

The speed of the electrons varies from one-third to four-fifths of that of light, and is directly proportional to the electric tension which is applied to the tube. When the cathode is given the shape of a concave mirror, the stream of electrons converge to a focus. (This principle was eventually incorporated in the manufacture of X-ray tubes.) On striking an object like the cross mentioned above, or the glass wall of the tube, the electrons are stopped and their energy is converted. More than 90 per cent. is changed into heat, less than 1 per cent. being converted into X-rays. Other scientists were following the lead of Sir William Crookes, and Röntgen was led to his discovery by the work of Lenard.

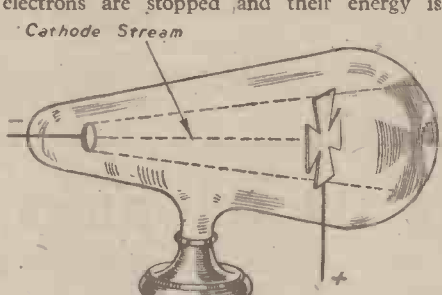


Fig. 1.—Diagram of a Crookes tube.

The discovery of X-rays, therefore, goes back to the invention of Crookes' tube.

Lenard missed priority over Röntgen, but only just missed it; he had observed when working with a Crookes tube that if a thin plate of aluminium were let into a little window cut in the tube, rays of some kind were able, more or less, to pass through the aluminium, but what they would do after that they could not discover.

Röntgen's Experiments

In April, 1895, Röntgen, during the course of search for invisible light rays, turned on a low pressure discharge tube which was completely enclosed in black paper, when a fluorescent screen which was lying in the vicinity of the tube showed marked fluorescence while the tube was in action; obviously some unknown radiation was at work, and Röntgen quickly realised that he was dealing with a new agent which he afterwards called X-rays. In this simple way one of the most important discoveries in physics was made, one which itself, together with other discoveries, has gone far to revolutionise our conception of matter, and which has developed new and invaluable aids to practical medicine.

On December 28th the same year Röntgen announced his discovery to the world. Amongst other things, he said: "The fluorescence of barium platino-cyanide (the fluorescent screen) is not the only recognisable effect of the X-rays. First, it may be mentioned that other bodies also fluoresce, as, for instance, calcium compounds." Also, "the fact that photographic dry plates have proved sensitive to X-rays is of special importance in many respects; it enables many phenomena to be recorded, thus making it easier to exclude deception, and, wherever possible, I have checked by means of a photographic exposure every more important visual observation on the fluorescent screen."

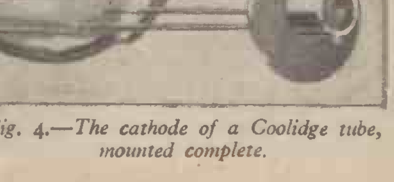


Fig. 4.—The cathode of a Coolidge tube, mounted complete.

How important these discoveries were. The fluorescent screen is to-day used for the examination of parts of the anatomy where such examination is more useful than by an X-ray photograph. The patient is placed between the X-ray tube and the screen, the required shadow being thrown on the screen. Calcium tungstate is used in the form of a screen called an intensifying screen in conjunction with films because it fluoresces (a means of converting X-ray energy into visible light) and allowing this light, rather than the X-rays themselves, to act on the sensitive emulsion of the film. The X-rays also act on the film, and in this way we cut down our exposures to about a tenth. This is of great importance, particularly in moving organs, and in accidents (shocked patients). Again, with regard to Röntgen's last remark mentioned above, the latest chest technique, called miniature radiography, is merely the taking a photograph on a small film of the chest as seen on the fluorescent screen. For a long time there was no definite knowledge regarding the nature of X-rays. It is now known that they have their own definite spectrum, and that they are a wave motion of the ether which can be measured; there is no question of deflection of the rays by refraction (prisms), nor, therefore, of the possibility of collecting than in a lens system, for X-rays are not refrangible, and pass in straight lines through matter; only a very small portion of the radiation undergoes deflection and the deflection is due to diffraction, an effect discovered by Von Lane when employing a crystal (crystals, with their absolutely uniform arrangement of

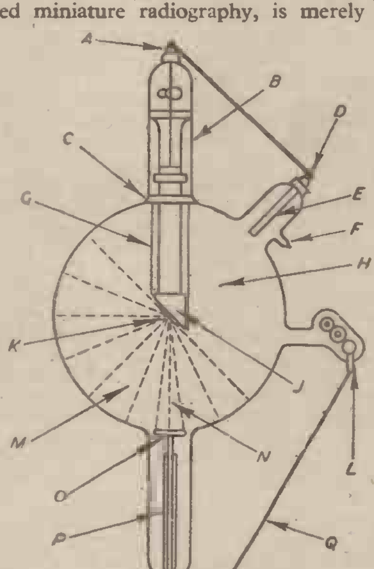


Fig. 3.—Diagram of an X-ray tube, showing the paths of the cathode stream impinging on the anticathode.

A—Anticathode terminal. B—Anticathode supporting tube. C—Junction of anticathode support and bulb. D—Anode terminal. E—Anode. F—Exhaust point. G—Glass mantle. H—Dark hemisphere. J—Anticathode. K—Target. L—Regulator tube. M—Active hemisphere. N—Cathode stream. O—Cathode. P—Cathode stem. Q—Regulating arm. R—Cathode terminal.

atoms, provide natural gratings, in which the distance between neighbouring planes is sufficiently small to cause interference in X-ray beams reflected from them).

X-ray Intensity

We can measure the intensity of X-rays. It can be done by more than one method, but that generally used is by ionisation of the air, but there are a variety of instruments for the purpose. The measurement of X-ray intensity is important when using them for therapeutic purposes. Apart from the action of X-rays on substances previously mentioned, they have a biological effect on human tissue, and when used in this way the application is called X-ray therapy. As most people know, X-ray treatment is used with great success in many diseases. The inestimable value of X-rays both in photography and therapy, depends on the amount of radiation which has been absorbed. With the normal picture of the hand, the flesh appears quite light because it is comparatively permeable; the bones are shown distinctly with all their detail, because the bone substance has absorbed more of the rays.

The penetrating power, or wavelength, of the ray depends upon the voltage applied to the X-ray tube; the higher voltage there is the shorter the wavelength and the more penetrating the rays. The high penetrating rays are called "*hard*" rays; the low voltage long wavelength rays are called "*soft*" rays, and in-between, "*medium*." The wavelength is inversely proportional to the voltage applied to the tube. The higher the voltage the greater the speed of the cathode stream and the greater the impact on collision with the positive terminal of the tube (called the anticathode); thus, the shorter the wavelength of the X-rays produced. In practice there is always a mixture of wavelength rays called heterogenous rays produced by the tube. The reason for this will not interest the reader, but from the X-ray worker's point of view, it is important because a system of filtering must be used, particularly when using them in therapy; for instance, if one is treating a deep-seated organ with penetrating rays, various metal filters must be used between the tube and the patient to absorb the less penetrating rays, otherwise they would be absorbed by the skin and more superficial tissues, with perhaps serious results. The composition of the beam is independent of the material with which the anticathode of the tube is made and depends only on the maximum, or peak, voltage applied to the tube. 30,000 volts produce "*soft*" rays; 200,000 volts produce "*hard*" rays.

Fig. 5.—A hot cathode tube used for the protection of X-ray workers. It operates in similar manner to the Coolidge tube.

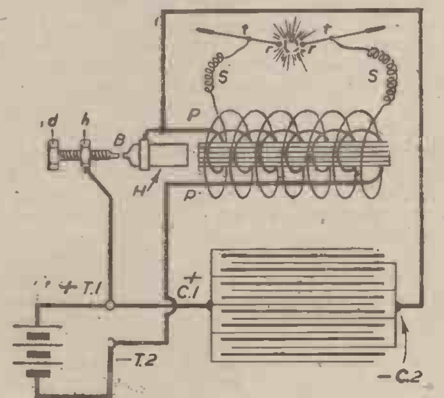


Fig. 8.—Circuit diagram of an induction coil.

A much higher voltage is being used in deep therapy, and when testing metal for imperfections, in fact, in America a million volt machine is used. Metals are tested both by the screen and, where necessary, films. When X-rays pass through matter, a part of the incident radiation is absorbed and transferred into either heat or chemical effects. Another part induces a ray which is generally known as "*scatter*." We get scatter from the glass walls of the tube, from the X-ray couch, from the tissues and bones of the patient, etc. The scatter of rays in the passage through matter depends on the thickness and density, scattered radiation having a slightly longer wavelength than the primary beam. The "*scatter*" rays tend to interfere with X-ray photography; they cause a blackening of the film and interfere with fine detail; we must therefore exclude them as much as possible, particularly when dealing with a corpulent patient. The means, the use of a cylinder diaphragm attached beneath the tube or a special moving grid depending on the nature of the work. The grid (see Fig. 2), A. anticathode; B. grid; P. film; O. patient; Z. scatter, is placed between the patient and the film. It consists of strips of lead alternated with strips of wax or wood. It is attached to a small oil motor which is released by means of a cord; the whole is built up into a frame with a carrier to take the film; the frame is usually attached to the table placed on rails and has free movement along the table. The lead strips cut off a small portion of the primary beam, but they absorb scattered rays. It is said that the first X-ray picture of a hand was taken in this country with a Crookes tube in 1896. Since then the importance of the material of which the anticathode is made has become more apparent. The bombardment of the anticathode by the cathode stream causes a considerable rise in temperature of the anticathode, therefore it must have a high melting point. Moreover it must have a high atomic weight and specific gravity so that it can arrest the cathode stream completely; hence the common use of tungsten.

No one in 1895 could have foreseen the enormous strides which have placed the benefits of Röntgen's discovery within reach of all, or have foretold that the simple apparatus in use then would, in 1944, be replaced by highly technical apparatus now used to excite the X-ray tube, or the great improvement in X-ray tubes. For a number of years the exciting apparatus was far in excess of the capacity of the best tubes, but now we have tubes which will take powerful electrical discharges with safety.

Scientists, apparatus manufacturers and their engineers, photographic experts, chemists and medical men (called radiologists), and the technician, the non-medical man called the radiographer, have all contributed to the great general improvement.

X-ray Apparatus

To produce X-rays we require two distinct pieces of apparatus. 1. The X-ray tube in which the high tension electric energy is converted into X-rays. 2. The transformer which converts the current from the *main* electric supply to high-tension current essential for passage through the X-ray tube to produce X-rays. The original X-ray tube (after the experimental period) and still in use for some purposes, is called the gas tube (see Fig. 3).

It is a sphere of glass into one end of which is sealed the anticathode; at the opposite end the cathode (already explained). The anticathode is a copper stem faced with platinum, but later with tungsten because, although its atomic weight is less, its melting point is higher. With increased output in apparatus this was important; it became necessary on account of this heat produced to disperse some of it by various means. A fin radiator was connected to the anticathode outside the tube or a water cooling device was used. The third terminal (connected to the anticathode) served for manufacturing purposes only. There was also a regulating device for stabilising the vacuum of the tube. In manufacture the tube has air pumped out until only a small residue remains. It is on this residue that the tube depends for the passage of electricity. These tubes are practically out of use to-day. They were used in conjunction with the transformer called the induction coil, the tube being dependent upon its gas content (which was not constant) for the production of X-rays, was unreliable, and a tube in which the production of the cathode stream, independent of the combination of gas tube and induction coil was overcome by replacement of both. If the tube is completely exhausted, or as completely as possible, no current will pass through the tube when both the electrodes are cold, but if the temperature of the negative electrode is raised to incandescence, electrons are given off and current will pass.

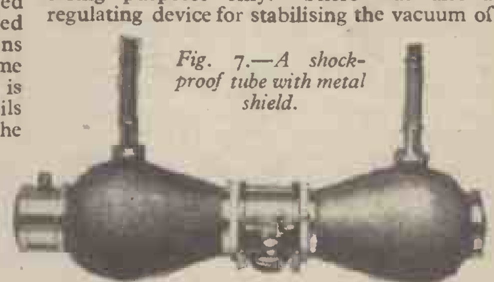


Fig. 7.—A shock-proof tube with metal shield.

Hot Cathode Tubes

Dr. D. D. Coolidge invented a tube on these lines named after him, and it is a hot cathode tube. This has been followed by other types of hot cathode tubes. The one which Dr. Coolidge devised is exhausted to

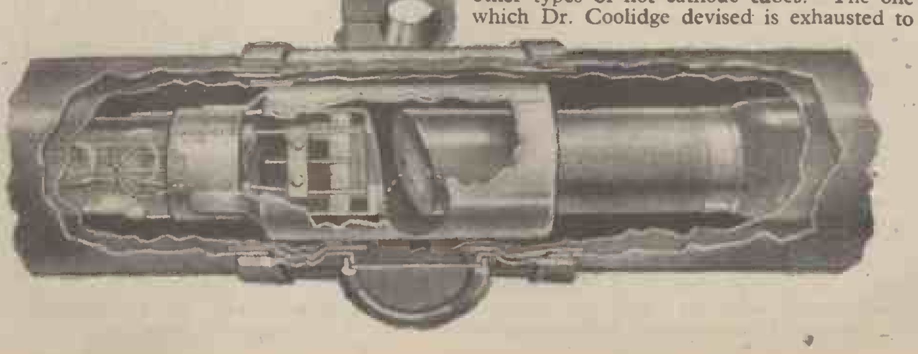


Fig. 6.—Cut-away diagram showing the interior of a hot cathode tube.

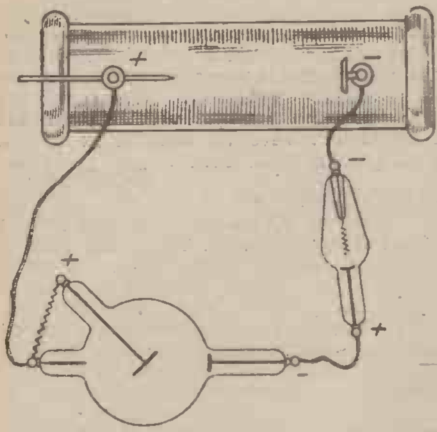


Fig. 9.—Showing the introduction of valves in the secondary circuit of an induction coil.

the highest possible vacuum. The anticathode is constructed of tungsten; the cathode, instead of an aluminium cup-shaped electrode, consists of a spiral of tungsten wire surrounded by a sleeve of molybdenum to focus the cathode stream (see Fig. 4).

The tungsten spiral is connected to an auxiliary source of electricity of 12 volts from accumulators, having a resistance, and anameter in the circuit for regulating the strength of current, the accumulators being insulated from earth. This current heats the spiral wire of the cathode, causing it to give off a negatively charged stream of electrons which are projected on to the anticathode, the amount of free electrons being regulated by the degree of heating of the tungsten spiral, and the speed of the stream of electrons is governed by the voltage applied to the tube by the secondary circuit of the transformer. The tube, therefore, has accurate adjustment, stability and extremely large output and the means of duplicating results. One of its advantages at the time of its invention was its great output for therapeutic work. It was a great stride. The disadvantage of accumulators in the auxiliary circuit can be appreciated when one considers the necessary charging, cleaning, etc. These were soon replaced by a transformer which stepped down the main voltage to 12 volts.

The tube required to be surrounded by very heavy protection. The next tube was a hot cathode tube, but it is more important for its protection. Everyone has heard of the dangers of X-rays, and the unfortunate ones who suffered and died from its effects, together with other dangers which were encountered in an X-ray department. There were four great dangers; they have practically been eliminated: 1. X-ray dermatitis, commonly called X-ray burns. 2. Electric shock. 3. A very bad blood condition due to ionised air in the X-ray department with little or no ventilation. 4. A blood condition to a lesser degree due to working many hours in small, dark developing rooms with no ventilation. All this was due to ignorance. X-ray burns were due to over-exposure to X-rays; first, because there was no protection whatever, and, second, even after the dangers were realised, through insufficient protection around the X-ray tube.

Protection for X-ray Workers

The tube called the "self protected" tube came into use. It protects the X-ray worker from the primary beam of rays (provided they are not facing the aperture through which the rays emerge) without other protection. It is a hot cathode tube; there is more than one make. The principle of action is similar to that of the Coolidge tube; it has its secondary source of electricity to heat the cathode (see Fig. 5).

It consists of a continuous glass cylinder instead of the sphere. Surrounding the central active zone is a protective lead shield, in which is an aperture for the emission of X-rays; thereby, the tube carries its own protection, and does away with the heavy lead protective boxes (see Fig. 6). This was followed by the tube used to-day called the "shock-proof" tube. This tube has a metal shield surrounding it, to which is attached cables which are heavily insulated, and also surrounded by a flexible metal shield (see Fig. 7).

The tube shield and the sheath surrounding the cables are inter-connected and then joined to the metal case surrounding the transformer, which, in turn, is connected to earth. That part of the apparatus, which is near the patient, is thereby electric-shock proof; even the cables may touch the patient without danger when the tube is running. This, together with its own protection, is a great advance. Another development of the tube is a tube with a "rotating anticathode."

The energy which can be applied to the tungsten surface of the anticathode is limited; there is a time when the stationary anticathode becomes damaged; its fine focus is spoiled, the focus being of great importance. The rotating anticathode overcomes this. By its rotation the surface on which the focus is formed is continually being changed; therefore, much heavier currents can be employed without injury to the metal. Therapy tubes of to-day employ the hot cathode system, but they are specially made to take heavy currents for much longer periods than the tubes used for diagnostic work. For X-ray photographs we need from 40 to 100 kilovolts (1,000 volts—1 kilovolt), and for therapeutic purposes from 120 to 200, or in some cases 400 kilovolts, are used. The amount of current we pass through the tube is measured in milliamperes, a milliampere being a thousandth part of an ampere. Both kilovolts and milliamperes vary according to the work we have in hand. The current passing through the tube must be unidirectional.

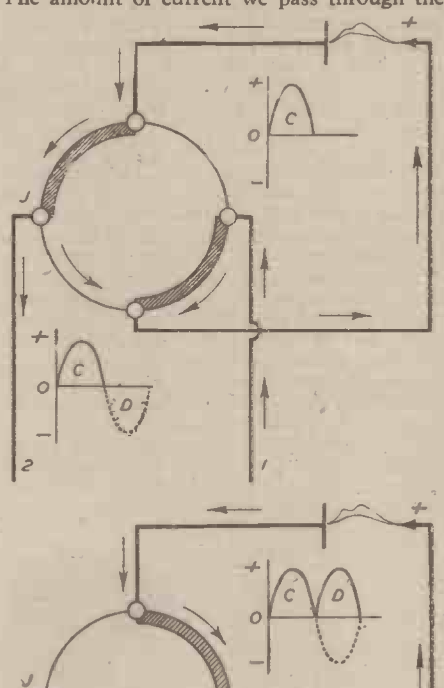


Fig. 11.—Diagrams illustrating the principle of a mechanical rectifier.

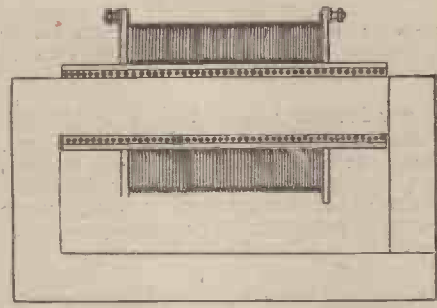


Fig. 10.—Section of a closed-core transformer.

The Induction Coil

The voltage from the electric supply is usually 250 volts. This may be transformed to the required voltage either by means of the induction coil or by the transformer. In the early days the induction coil was used and often not from the main supply of electricity, but with 12 volts in accumulators. One could almost write a book on the induction coil, but briefly the coil is made of a core, the primary and secondary windings, interrupter and condenser. The core is made of laminated iron around which is wound about 200 turns of thick copper wire, the two ends of which are, when in use, attached to the main supply. Around the primary wire is placed a thick insulating shield, generally ebonite and outside this are many turns (thousands) of very fine copper wire. These are the secondary windings, the ends of which are attached to the X-ray tube. The secondary is embedded in paraffin wax or oil. In the primary circuit there is an interrupter; the original was a hammer type working on the end of the coil and operated by magnetism (as in an electric bell). A condenser was placed across this interrupter to take away self-induced currents from the primary circuit, thus giving a cleaner interruption. The primary current induced a current in the secondary windings called the "*inverse*" current, but at the time of the interruption when the core gave up all its magnetic influence, a much greater current was induced in the secondary circuit; this current flowed in the opposite direction to the inverse current and was used for the production of X-rays. As we must not let the inverse current flow through the tube, it had to be suppressed; this was done by introducing one or more valve tubes in the circuit (see Figs. 8 and 9).

Closed-core Transformer

With the introduction of the hot cathode tube came the closed-core transformer (see Fig. 10).

This works from an alternating current which causes a rise and fall in the primary circuit, the interrupter being no longer required. By a closed core we mean a continuous ring or rectangle of laminated iron capable of being loaded with more magnetism. The whole primary and secondary windings plus core are placed in a tank of oil, the ends of the secondary being brought through the top to insulated supports, and finally to the X-ray tube. The oil acts as an insulator and also keeps the windings cool. Having currents of equal potential in the secondary circuit flowing in opposite directions, it is, when working with heavy currents, necessary to change this alternating current into a unidirectional one. Two methods are used: (1) mechanical rectifier (Fig. 11), and (2) valve tubes.

(To be continued)

The Centenary of Atoms

The Memory of John Dalton, the Famous Founder of Chemical Theory

A HUNDRED years ago—in July, 1844, to be precise—died at Manchester the celebrated Dr. John Dalton, the man to whom chemical science is probably more indebted for its foundations than it is to any other single individual.

Dalton was a man of outstanding chemical genius, a thinker who, in the dark days of chemical knowledge, presented the scientific world with a systematic scheme by means of which the then perplexing problem of chemical combination might, at least in part, be understood.

Such, in a nutshell, was the "Atomic Theory" of John Dalton. Intrinsically it was a towering generalisation which, so far as it goes, has had its essential truth confirmed over and over again by a century of chemical workers. The Atomic Theory is Dalton's monument; and it is a non-perishable memorial, too, for, despite the fact that modern science has proof that the atom is not the small hard, round, impenetrable particle which Dalton believed it to be, the Daltonian theory of atoms and their modes of combination still stands as stolidly as ever it did, its principles having almost instinctively been accepted by generations of chemists the world over.

Known to the Greeks

In consequence of the cursory view of the Atomic Theory which is given by many school textbooks, many of us are often inclined to regard John Dalton as the "inventor" of atoms. Nothing, however, could be further from the truth. The existence of tiny particles of matter seems to have been believed in by the very earliest of the world's thinkers. For example, Democritus and Leucippus, two Greek philosophers who flourished about the years B.C. 440-400, held that all material things are made up of minute round particles which are invisible and which cannot be destroyed. Moreover, it is remarkable to find these old Greeks actually postulating that their "ultimate particles" were in a state of perpetual motion, which fact is precisely what our modern experimental observations disclose to us.

Robert Boyle, the early chemical experimenter of the time of Charles II, the author of the famous "Boyle's law," and one of the founders of the Royal Society, dabbled in atoms, so to speak. So, also, did a few other chemical investigators who came in the century after him; but these people never managed to get to grips with the inner meaning of atoms. The subject was too difficult a one for them. They preferred to put it aside and to go on with their more interesting practical work of discovering new chemical reactions and fresh chemical compounds. It was an easier task, besides being far more spectacular.

Dr. John Dalton

College Tutor

The way in which Dalton first became interested in atoms is a rather curious one. When, in 1793, at the age of 27, he first went to Manchester as a mathematical tutor in a college which had then recently been established in that town, one of his abiding interests was the subject of meteorology, the study of weather science. He was led into chemistry through meteorology, for he endeavoured to find the reason for the various gaseous constituents of the earth's atmosphere all being intimately mixed together, despite their differences in density, just as liquids of varying specific gravity can be made to float one above the other in layers.

He then began to investigate the subject of gases and their make-up. He experimented with different gases. He weighed them as carefully as he could, determined their densities, tried to work out the inner relationships between different gases of a like nature and, in general, entered enthusiastically into experimental work upon some of the most fundamental and momentous of chemical problems.

Dalton has been criticised by some present-day people on account of the inaccuracy of his experimental results. They say that he devised his theories first and afterwards tried to confirm them by means of experiment. To the extent that Dalton used his scientific imagination, such a statement as the latter is true enough, a fact which surely points emphatically to the inner genius of this theorist. But as for Dalton's experimental work being inaccurate—well, how *could* the degree of accuracy of modern determinations possibly be obtained when experimenters like Dalton had to work with ink bottles as flasks, with bladders as gas-holders, with domestic crockery for chemical utensils and, indeed, with crudities of apparatus which would immediately be turned down by the youngest chemical student of our present day?

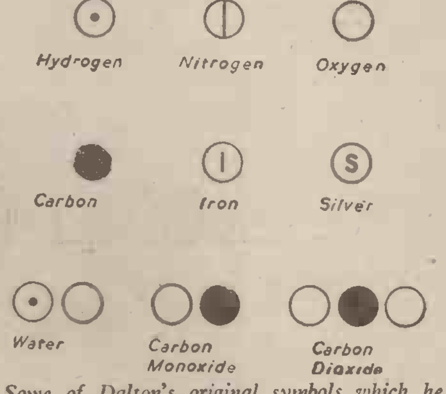
Yet, despite all those difficulties, Dalton triumphed, giving to the world his Atomic Theory, without which chemistry could not possibly have made its phenomenal progress.

A curious and a picturesque character was John Dalton, the gentle and amiable Quaker philosopher, of Manchester. He was the second of the three children of Joseph and Deborah Dalton, hard-working and frugal farmers who had a small area of land near the village of Eaglesfield, near Cockermouth, Cumberland. It was here that the future creator of the Atomic Theory was born on September 5th, 1766.

The Juvenile Schoolmaster

Brought up in the early tenets of the Society of Friends, John Dalton acquired a youthful seriousness and earnestness which made him different from other children. Although he only attended the village school at Eaglesfield for a few years, at the age of ten (when he ceased from regular school attendance) he was miles ahead of his fellow-pupils in scholastic attainments. And at the tender age of 12 years he started a

A "magic" lantern used by Dalton. It was illuminated by means of a single oil burner.



Some of Dalton's original symbols which he used to represent atoms and their components.

John Dalton's air pump. A crude apparatus made of brass and wood, yet it sufficed for the many momentous experiments on gases which its owner made.

school of his own in the district, but this venture had not the brilliant success which its optimistic originator intended it to have. For before very long the eldest and the biggest of the pupils began to fight the juvenile schoolmaster in the schoolyard, and as fighting was a matter which was morally opposed to Dalton's tenets he had to acknowledge the failure of his first independent venture.

Three years afterwards, at the age of 15, Dalton, in company with his elder brother, Jonathan, started a school in Kendal, an academy in which "youth will be instructed carefully in English, Latin, Greek, and French; also writing arithmetic, merchants' accounts and the mathematics." Again the venture was unsuccessful.

Migration to Manchester

At Kendal, Dalton struck up a lasting friendship with a blind man named Gough. It was largely through Gough's encouragement that Dalton ultimately proceeded to Manchester to take up his employment as a tutor there. Dalton made Manchester his home. He spent more than half a century there, living for the greater part of that time entirely by himself as a confirmed old bachelor in a house belonging to the Manchester Literary and Philosophical Society, of which body he was elected a Fellow in 1794.

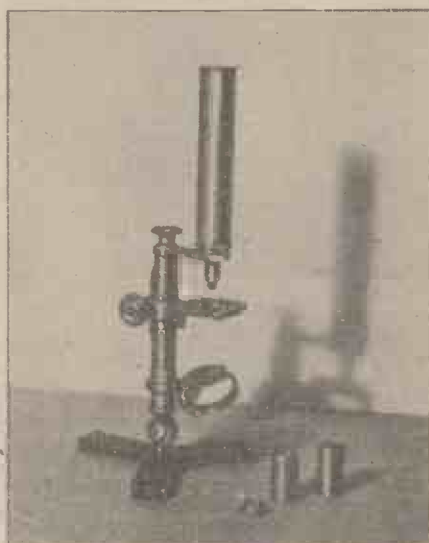
This gaunt Georgian building, now, alas, destroyed by enemy action, formed the birthplace of the Atomic Theory. In its front room, which Dalton converted into a modest laboratory, all his chemical and physical work was carried out, and all his multitudinous observations made. It is said that Dalton took no fewer than 200,000 weather and climatic observations during his lifetime, all of which he patiently recorded in his notebooks. His first book was written on the subject of Meteorology, and, as we have already noted, it was through this subject that he became interested so greatly in the fundamentals of chemistry.

Dalton first conceived the main atomic theory about the year 1802.

When meditating over the ways of chemical combination he had been strongly struck by the fact that gases stem to combine together in definite proportions, either by weight or by volume. He noted, for example, that the gas nitric oxide would combine with oxygen to form two other and entirely distinct gases. One of these new gases was a compound of nitric oxide with one volume of oxygen; the other was a compound of nitric oxide with two volumes of oxygen gas.

A non-mercurial thermometer used by Dalton. Made about 1800, it comprised one of the world's first metallic-strip thermometers.

Dalton perceived that it was never possible to obtain a gas of intermediate composition. Thus, no gas existed having the composition: nitric oxide 1 vol.; oxygen, 1½ vols.



John Dalton's microscope. Crude enough according to modern standards, yet it was "up to date" in Dalton's day.

Law of Definite Proportions

REASONING on these lines, Dalton crept forward from fact to fact. When his facts were lacking, he tried to devise experiments with the object of supplying them. Eventually, he formulated his "law of definite proportions," the great chemical generalisation which states that atoms combine with each other in definite proportions only. Methane gas (firedamp), for instance, is always the result of the combination of 1 atom of carbon with 4 atoms of hydrogen. In modern chemical parlance, it is ALWAYS CH_4—*never* CH_5, or CH_3, or CH_2, for example.

Dalton's conception of atoms was very similar to that of the old Greek thinkers. He imagined them to be something of the nature of miniature billiard balls, perfectly elastic, perfect indestructible, perfectly impenetrable, in fact perfect entities in almost every respect.

Dalton had no idea of what we now term "molecules." He talked about atoms of hydrogen and atoms of oxygen, but, when referring to what we should now term a "molecule" of water, he designated it a "combined atom."

"New System of Chemical Philosophy"

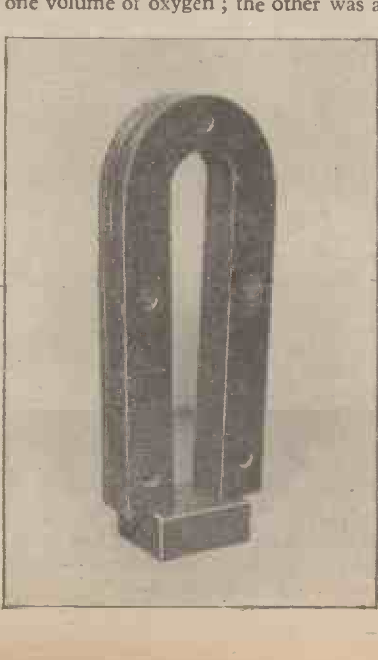
THE total number of chemical elements known in Dalton's time was just 23. When, in 1810, he published his "New System of Chemical Philosophy," in which he outlined and detailed his theory of atoms and their modes of chemical combination, he drew up a list of the then known elements. To designate each element he proposed to use a sort of alchemical symbol, a number of which are shown on this page. Curiously, Dalton never seems to have been struck by the far greater ease of denoting the various elements by their initial letters or by means of a system of agreed abbreviations, as we do at the present time. In fact, when such a rational system was, at a later date, introduced by Baron Berzelius, the Swedish chemist, Dalton was merely impatient of it.

Much of Dalton's experimental work at Manchester was devoted to determining the relative weights of the elements. Owing to imperfections of his methods, he got many of these relative weights wrong, which fact caused him to assign entirely wrong formulae to many chemical compounds. Nevertheless, he had hit upon the basic principle of what we now term the "Atomic weight" of an element, that is, its weight relative to the weight of a "standard" element, usually hydrogen, and in the "New System of Chemical Philosophy" Dalton was sufficiently confident of his new "philosophy" to publish a Table of Atomic Weights of Elements.

Colour Blindness

THE fact that John Dalton was colour-blind is well known. He seems to have been the first to study his constitutional defect scientifically.

It was only after some investigation that Dalton realised that his colour vision was abnormal. He could distinguish yellows and greens, but he had no real perception of blues, reds, purples and crimsons. They all appeared a uniform flat grey to him.



(Left) Dalton's original "magnet battery" — a number of horseshoe magnets screwed together in order to obtain greater magnetic power.

(Right) The original maximum and minimum thermometer used by Dalton in his meteorological work.

In the year 1794, before the Literary and Philosophical Society of Manchester, he read the world's first paper on colour-blindness, yet he was unable to solve its mystery.

Dalton never married. He was too unworldly for the ordinary concerns of life. There was the financial aspect of the question, also. He was never rich, for how can one become wealthy by teaching mathematics and chemistry for years and years at two shillings a lesson? That, however, was what Dalton did in order to augment his other slender resources.

Dalton was nothing if not mathematically methodical in his routine of existence. Laboratory duties and tutoring made up his daily life. Every Thursday afternoon he went to play a game of bowls at a nearby hostelry. Every year he went for a holiday in the Lake District.

Many Honours

THE publication and the eventual acceptance of his Theory of Chemical Atoms brought Dalton almost universal fame in the scientific world. Oxford University awarded him a doctorate degree, the Royal Society made him one of its Fellows, he obtained various Continental medals, and the British Government, in his later days, gave him a small pension.

Towards the end of his life he was troubled by several seizures which removed from him much of his mental alertness. Yet he still plodded on at his experimental investigations. Even his meteorology was continued. Indeed, Dalton's last meteorological observation was made on the evening before his death. Entered in Dalton's weather record under the date July 26th, 1844, and in his own handwriting, is the report "little rain this day."

It was the last of a series of observations which Dalton had kept up for more than half a century. On the morning of the following day—27th July—the great Master of Chemistry had passed away. At his funeral in Ardwick Cemetery, Manchester, the whole town observed a day of mourning.

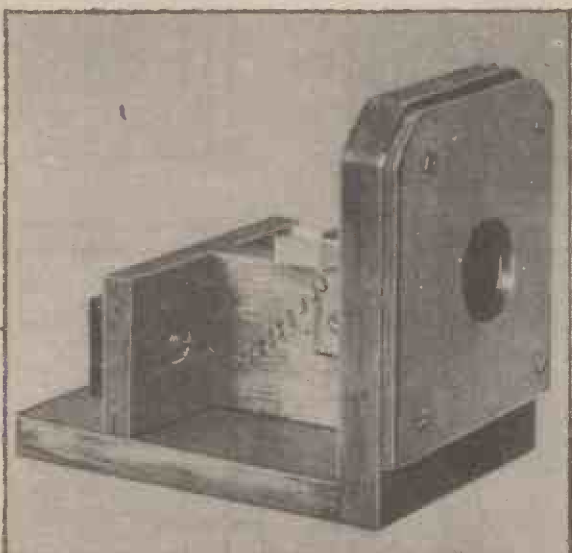
In his simple, gentle, and non-assertive way John Dalton had managed to obtain for himself an almost national reputation. The funeral crowds knew nothing—and undoubtedly cared much less—about his Atomic Theory, but, instinctively, those Mancunians of a century ago, and the many visitors to the town who mixed with them, recognised in John Dalton a man whose mark had been made not merely for their own age, but, rather, for many future ages to come.

An Easily-made Telephone

Built from Readily Available Material

By H. H. WARD

BASED on the original "Gallows" telephone made by Dr. Graham Bell, the instrument about to be described was designed as an instructional model to be made by senior schoolboys in their science room. For this reason the construction was kept well within the range of a few simple woodworking tools. Unlike the original model, the present one has a first-class cobalt chrome magnet, and therefore gives results which compare very favourably with the modern commercial article, provided the necessary adjustments are carried out with care and patience. As low-resistance telephone earpieces are now difficult to obtain, these home-made substitutes can be recommended to pre-service units, and others who are anxious to practise Morse signalling and telephony.



General view of the finished telephone.

If two 'phones of this type are connected together by means of a length of twin bell wire, speech can be transmitted from room to room, one instrument acting as a microphone whilst the other functions as the telephone, no battery being required. In order to transmit speech over greater distances, it will be necessary to use a carbon microphone and a battery of 1½ to 4½ volts. It will be seen that the type of microphone button which has a stem for securing it in position can be fitted into the present wooden stand in place of the magnet and coil assembly shown. The instrument has also been found useful as an extension to a Morse buzzer outfit, and is wired to the two terminals marked "line," which are usually found connected together by a small brass rod. Fig. 2 gives details of its construction.

Constructional Details

The sketch Fig. 1 shows the general layout of the device. Before commencing construction, it is advisable to obtain the magnet, as the size of this component affects the sizes of some of the others. The magnet chosen should be of the cobalt chrome type, and should take the form of either a round or square bar. The one used in the model illustrated was 2in. in length and ⅜in. by ¼in. in section, two such magnets being obtained from a reed loudspeaker unit of the type fitted to cheap pre-war radio sets. Round bar magnets, obtained from dealers in scientific supplies, were equally suitable, but a groove had to be cut along the top of piece No. 4 to prevent them from rolling when an adjustment was made. In Fig. 3 parts 1, 2 and 3 are fretsawn from 6mm. plywood, if obtainable; if not, plain non-plied wood will serve, but great care is required to avoid splitting when the screws are driven into it. When piece No. 2 is being cut, the hole for starting the fretsaw on the inside circle should be bored on the line itself, as the piece which comes out has to be glued to the rear of part No. 1 to form part 1A. If a lathe is available, the front of the instrument may be formed from two turnings from the solid, and the mouthpiece may be included, in place of building it up by layers as shown in the sketches.

The length of parts 4 and 5 are shown, but the height marked "X" must be such that the centre of the magnet chosen will come level with the centre of the diaphragm, whilst the thickness of the parts should be the same as the width of the magnet. The base (part 6) is ½in. thick and may be left rectangular or cut as shown by the dotted lines to form a grip for the fingers. Parts 1 and 1A are glued together, and when the glue is set a 1in. hole is bored through the centre, the bit being started from both sides to ensure a clean hole. The pieces numbered 2 and 3 are also glued together to form a rebated circular frame for the reception of the diaphragm (Fig. 2). If a diaphragm from a disused horn type speaker is available, the

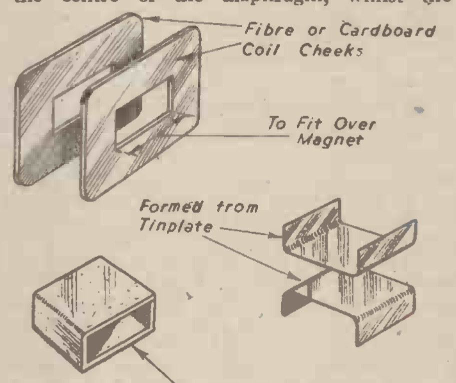


Fig. 4.—Details of coil former.

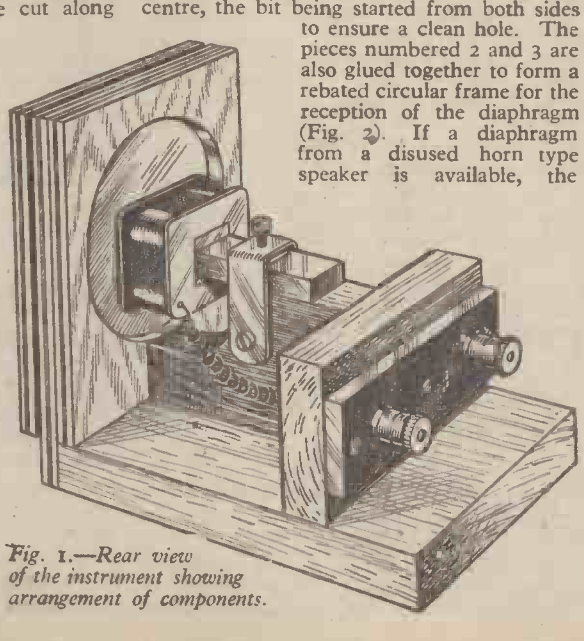


Fig. 1.—Rear view of the instrument showing arrangement of components.

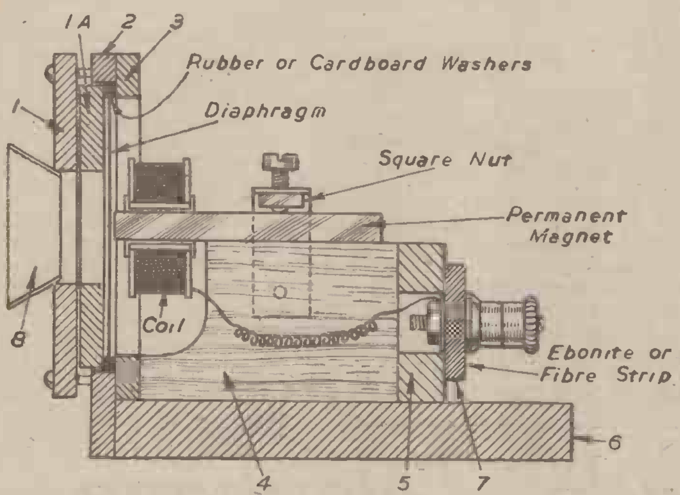
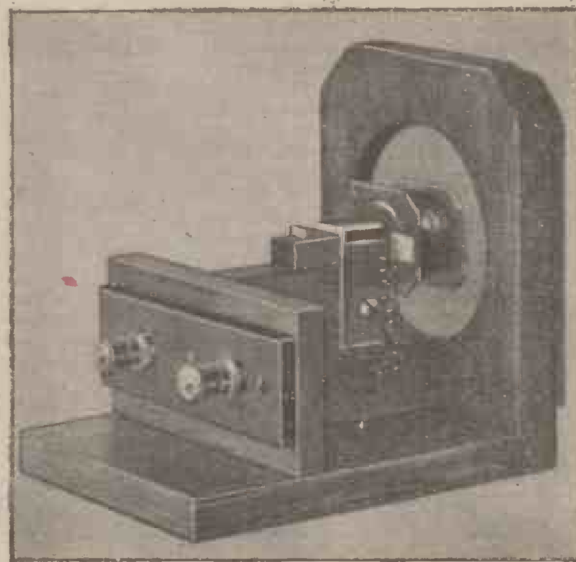


Fig. 2.—Sectional view, showing how the parts are fitted together.



Another view of finished instrument.

dimensions of these parts may be altered to make it fit, as the performance of the finished article depends to a large extent on the choice of the diaphragm. The various wooden parts should be assembled with good quality glue, and when this has set the joints may be reinforced with panel pins at judicious points, so that the device will not come apart if accidentally dropped whilst in use.

Coil Former and Winding

The details of the brass strap which secures the magnet are shown quite clearly in the sketches, and the exact size of screw used is not important. The details of the coil former (Fig. 4) should require no explanation beyond the fact that, when complete, the bobbin should leave a winding space approximately three-eighths of an inch wide by half an inch in depth. The bobbin should be wound full of 28-gauge enamelled or D.C.C. wire, but if this is not to hand, any gauge between 24 and 30 seems to suffice as the resistance is not critical. It is an advantage to have the leading-in and leading-out wire of thin flex or of a heavier gauge to avoid breakage.

If a mouthpiece is required, a circle of thin cardboard, cut as shown, may be coated with glue and wrapped round three times on itself to form a truncated cone, which in turn can be glued into the 1in. hole in the front of the instrument. When no commercial diaphragm is at hand, a circle cut from "commons" tinplate will suffice, although one made from "Taggers" tinplate is more sensitive, but not so easy to obtain. As a last resort, a disc from a dried milk or similar tin container will work provided that it is cut and flattened so that the finished product is free from buckles.

Magnet Adjustment

The working of the instrument depends upon the final adjustment of the magnet, which is undertaken as follows: A double piece of notepaper is placed against the diaphragm and the magnet is pushed forward and clamped in place. By pushing the diaphragm gently outward the paper is released and the gap between the diaphragm and the magnet examined. If the magnet has pulled the diaphragm into contact with itself, the process must be repeated with an extra thickness of paper each time, until the magnet is as close to the diaphragm as it can be without pulling it into actual contact. Obviously the exact distance cannot be specified owing to the differences in the strength of various magnets.

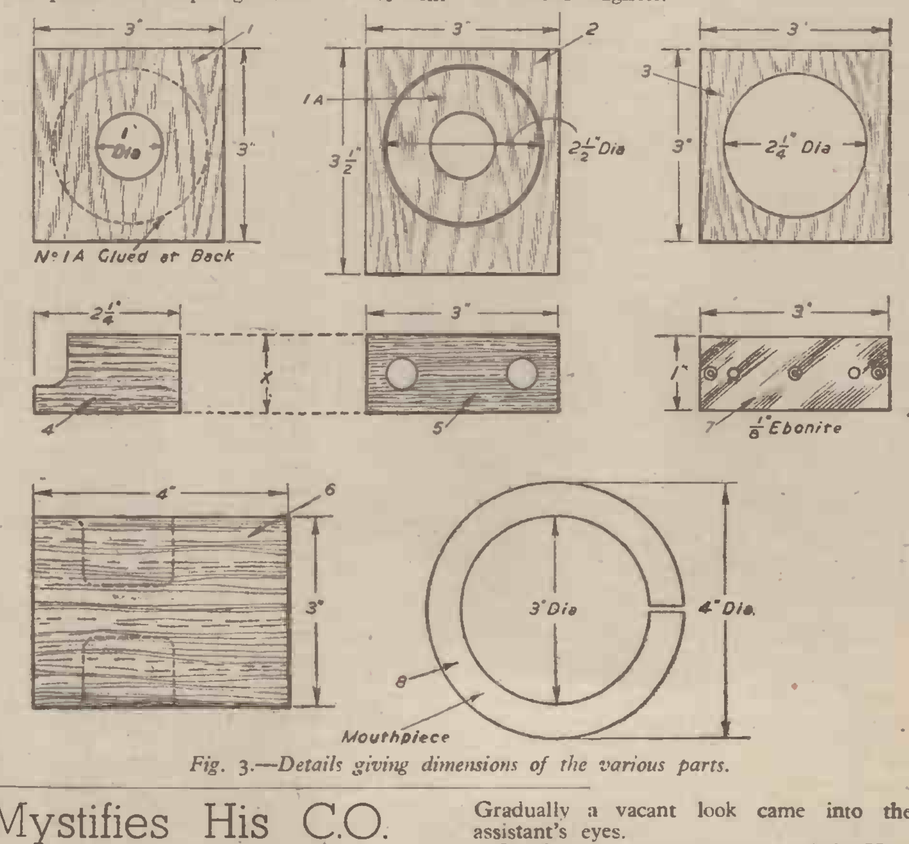


Fig. 3.—Details giving dimensions of the various parts.

The Ju-Ju Man Mystifies His C.O.

OFFICERS of the new West African Air Corps—the force that is replacing R.A.F. men in Africa by native airmen—used to scoff at Ju-Ju and jungle magic, but not now.

One night an airman of the Corps was robbed of a cigarette case containing his money. He asked his commanding officer if he could call in a Ju-Ju man to find the thief. Permission was granted.

The Ju-Ju man turned out to be another airman—a corps tailor. The scepticism of the British officers seemed to hurt his professional pride, and he offered to give a demonstration before he set out to find the thief.

The test was agreed, and while the man went into the bush to gather Ju-Ju twigs, a bag of money was hidden in a chest in the C.O.'s office, the Ju-Ju man had to find it.

The medicine man's only equipment was his twigs, and a small tin full of water. He called for an assistant, who stood with the twigs in both hands, arms held out rigidly to the front. The Ju-Ju man mumbled an incantation and sprinkled the man's hands and wrists from time to time with the water. Gradually a vacant look came into the assistant's eyes.

Slowly the two men went round the H.Q. buildings, the assistant beating the walls and floors with the twigs. At last they got to the C.O.'s office. At once the man began to beat frenziedly on the chest with the bunch of twigs. The medicine man told the C.O.: "Your money is in there, suh."

In the same way a kit-bag in a barrack hut was picked out, and the missing cigarette case found inside. The owner confessed to the theft.

The airman who was robbed had to pay the Ju-Ju man 16s. for his services, and the assistant received 5s. By tribal law money can be got back from the thief.

Rocket Propulsion

Improved "Mirak" and "Repulsor" Rockets

By K. W. GATLAND

(*Continued from page 22, October issue*)

ON July 2nd, 1930, the Verein für Raumschiffsfahrt E.V. engineers conducted preliminary trials of a new constant volume combustion chamber, designed by Professor Oberth, known as the "Kegelduse" (cone nozzle) type. Tested on a special proving stand, the motor recorded a thrust of approximately 16lb., constant for 90 seconds, operating at an estimated thermal efficiency of 6.3 per cent.; not a highly satisfactory result.

"Mirak" II—Development

Fortified by experience gained from the trials of its predecessor, the second Mirak (Fig. 10) remained essentially the same, improvements being in the provision of a valve within the liquid oxygen tank, designed to relieve excess pressure; and in the shape and make up of the combustion chamber. A ceramic liner was provided inside the combustion chamber as a precautionary measure aimed at the prevention of combustion heat effecting a too vigorous expansion of the liquid oxygen. The combustion chamber in this design was cylindrical and in order to gain a certain desired strength factor, a lining of steel was also provided on a copper alloy base.

An attempt to provide internal cooling of the combustion chamber was also made by the substitution of an alcohol-water mixture, in lieu of petrol, as fuel.

Despite the many improvements made, however, after a number of tests, "Mirak" II suffered the same fate as its former stable companion; the oxygen tank exploding due to the inadequate function of the relief valve.

"Mirak" III

Later in 1931, yet a third "Mirak" (Fig. 11) was produced at the Ratenflugplatz, and as with its immediate predecessor, several design modifications were embodied.

A considerably more efficient combustion chamber of a much improved internal shape was the main feature of the new design, which incorporated, in addition, a special cooling system; the motor being finned externally to provide a greater radiation surface. The complete unit, motor and coolant, was in this design mounted outside the liquid oxygen tank—positioned symmetrically below, about the rocket axis. The increased capacity oxygen tank fitted was provided with a pressure relief valve as before; designed to function at a pressure of 90lb. per square inch.

The feed system, too, was improved; a second tank, containing compressed nitrogen, being fitted in lieu of the carbon-dioxide pressure "charger" previously employed. A reversion to petrol as fuel was also made.

This third model, when subsequently tested, proved highly successful in operation, responding perfectly in every way, without exploding.

The "Repulsor" Rockets

After the tests of "Mirak" III were completed, the Society engineers continued with their development work, building several more rockets rather more ambitious both as regards design and size. These rockets were termed "Repulsors"; the first of the type, constructed in the spring of 1931, being designed by engineer Klaus Riedel, essentially for the purpose of free flight test.

The rocket motor of "Repulsor" I consisted of a combustion chamber, distinctly similar to the one employed in the "Mirak" III; housed with in a water coolant jacket. This assembly formed the nosing shell. Below, and separated from the motor nosing, were fitted two thin tubular tanks, one containing petrol, with pressure charger, the other liquid oxygen.

Connecting the combustion chamber, and nosing, to the tanks were feed lines, the tanks being supported beneath by rigid metal struts. The all-up weight of this first rocket of the "Repulsor" series was 250lb.

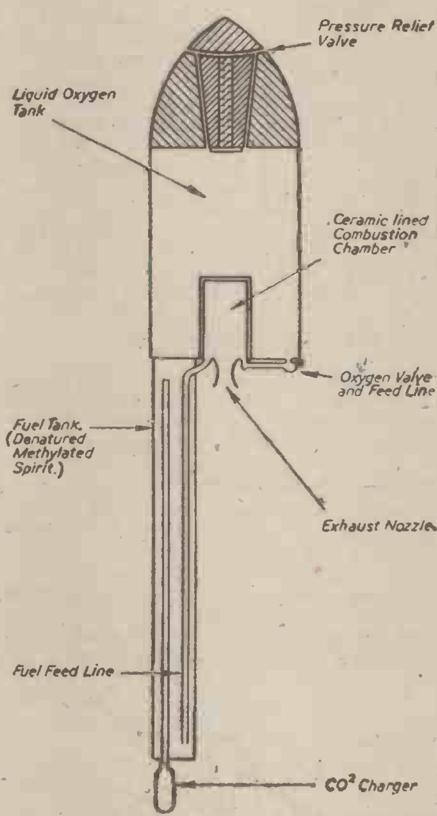


Fig. 10.—Sectional diagram of the "Mirak" II rocket.

After initial trials of its motor on the proving stand, "Repulsor" I was fired in free flight on May 14th, 1931. No parachute was provided for descent. Unfortunately, the rocket did not rise vertically, but took off slantwise, striking a small building during its path of flight. Nevertheless, the rocket rose to a height of nearly 200 feet, but was not sufficiently stable, and spun in the air, jettisoning most of the water from the cooling jacket, prior to its return to earth. Examination showed that a hole had been burnt through both the side of the combustion chamber and the outer casing of the water jacket.

A second "Repulsor" (Fig. 12) was built, and was ready for test by May 23rd. This particular model did not differ greatly from its predecessor, the only alteration being the elimination of the heavy support struts. Circular aluminium "hoops" were fitted in their stead, the tanks being supported solely by means of the rigidity of the feed lines. Again, no parachute was fitted.

When fired, "Repulsor" II climbed vertically to about 200 feet, before curving over, slowly losing altitude, and ending in the branches of a tree some 2,000 feet from the point of take-off. A further "Repulsor" was built before the end of the month, and this time a parachute provided to enable a safe return. The design was essentially the same as the former rocket, the only difference being that the tanks were located closer to the rocket axis, in an attempt to improve stability.

The third "Repulsor" was fired in June, and attained a height of over 15,000 feet. Unfortunately, the parachute was released too early in the flight—while the motor was still functioning, and was torn away. The rocket covered a distance of nearly 2,000 feet, in a well-stabilised flight, before hitting the ground as a complete wreck.

In all, more than 30 "Repulsor" type rockets were built, and most of their tests were recorded as highly satisfactory. Some of the later rockets were termed "one-stick Repulsors," and differed considerably from the early types, the main distinguishing feature being that both tanks were placed in line about the vertical axis. The first rocket of this type was free-flight tested in August, 1931, and attained an altitude of practically 33,000 feet; a parachute opening at the peak of trajectory, wafting the rocket gently back to the ground.

Rocket Motor Tests

While work on the "Repulsors" continued, another section of the Society concerned itself essentially with the development of the rocket motor combustion chamber. These investigations resulted in the construction of a number of highly efficient rocket motors of varied internal shapes, which were subjected to stringent test on the Society proving stands. Specially constructed reaction units of highly durable metals were thoroughly tested, and many of the special heat-resisting steels and alloys produced up to that time were quickly disposed of as practical combustion chamber materials. A number of rocket motors, constructed of materials considered to be highly satisfactory for the purpose, literally disintegrated into a mass of white hot sparks, after being on test for merely a few seconds. Others, fired for their respective runs, were so severely scarred internally that they had to be discarded as useless for further experiment. Nevertheless, several successful rocket motors were produced during 1931, most of these being constructed of aluminium. By the end of 1933, over 500 individual ground tests had been satisfactorily concluded at the Ratenflugplatz. Six large Oberth designed rockets were also built during this period, but did not prove so efficient (relatively) as the third "Mirak," and "Repulsor" types, although on occasions thrust values of over 450 lb. were recorded during tests.

End of the Verein für Raumschiffsfahrt E.V.

At one time, during the peak of its career in 1929, the Verein für Raumschiffsfahrt E.V. had a total of nearly 2,000 members on record. However, by 1933, the Society's numerical strength was considerably changed, only 200 members remaining. Due to the consequent depletion of funds, publication of "Die

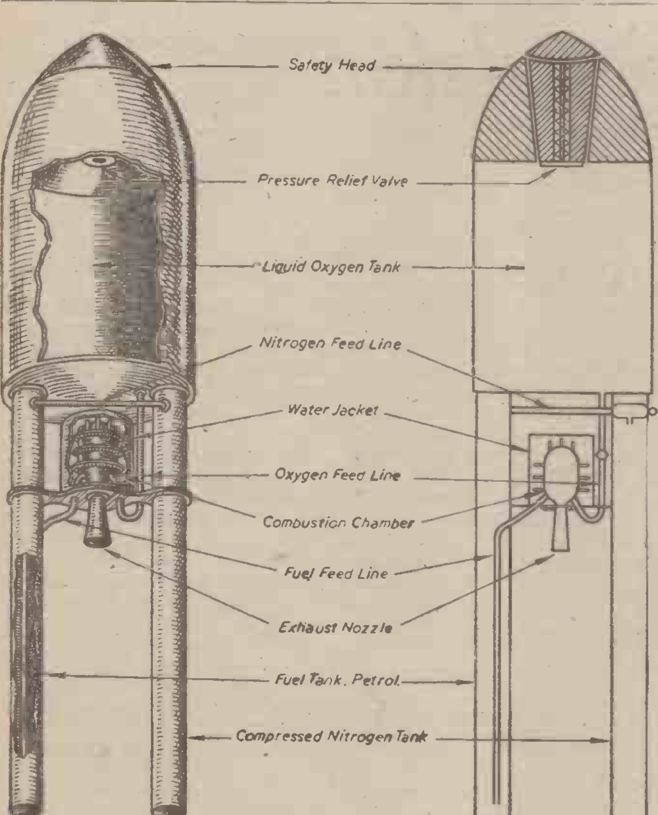


Fig. 11.—*Exterior and sectional diagram of the " Mirak " III rocket.*

Rakete," the Society journal, was indefinitely suspended early in 1933. Towards the end of the year, the position had grown considerably worse and the Society was facing the prospect of disruption.

Not only were troubles restricted to lack of funds; prominent members were accused of using the Society for personal gain, and there were also questions of extravagance.

While this dispute was at its height, Willy Ley (one time vice-president of the Society), together with a number of his associates whose interests in the development of the rocket were less superficial than the rest, disassociated themselves completely from the Verein für Raumschiffsfahrt E.V. A short time after, the Society was dissolved.

The German Interplanetary Society

Ley's idea was to form another research group around the nucleus of rocket enthusiasts which remained, in order that the work of years should not fade with the name of his former Society, and with the aid of another German organisation, the E.V. Fortschrittliche Verkehrstechnik (Society for the Progress of Traffic Technique), a Society interested in all forms of propulsion, success in this direction was achieved. A proposal was put to Dr. Otto Steinitz, the founder of that Society, to the effect that the Ley group should amalgamate with the E.V. Fortschrittliche Verkehrstechnik, with the view to establish the projected coalition as the German Interplanetary Society. This proposal was readily accepted by the Steinitz organisation, which at that time was also in precarious straits with regard to funds. Thus substantially augmented numerically, the new Society grew slowly but steadily in strength, and by the spring of 1934 the total membership had risen to about 200. Regular publication of the Society journal, "Das Neue Fahrzeug," was also possible by the increased income, which although adequately sufficient to satisfy this problem, was not, however, large enough to finance practical experimentation. Nor was this the worst of their problems; the rise of National Socialism throughout Germany did not make the problem of maintaining the Society an any too easy proposition, and complications with the military authorities soon arose, making the prospect of further progressive research virtually impossible.

In 1935, Willy Ley, together with H. Scharfer, another engineer of the Verein für Raumschiffsfahrt E.V., and other fellow countrymen quick to size up the situation, quitted the German scene, travelling to the U.S.A. There Ley continued his researches; but mention of this more current work will be made in a subsequent article.

On the other side, Hermann Oberth, von Opel, and many others prominent in German rocket development, remained in Germany, getting caught up in the Nazi ideals. (Unofficial reports have indicated that the German long-range rocket weapon, "V-2," is an Oberth creation.)

In this way, free German research came to an end, later rocket development being catered for by special Government departments under a cloak of extreme secrecy.

An Austrian Research Society

Another European rocket society, the Oesterreichische Gesellschaft für Raketentechnik (the Austria Society for Rocket Technique) was formed on August 16th, 1930, in Vienna. Investigations were concerned largely with theoretical research of the problems connected with interplanetary communications; engineer G. von Pirquet, the Society's vice-president, featuring prominently in this work. A similar fate as that which befell the German Society, however, brought about disruption of this group but a few years after its formation.

Fig. 12.—*Diagram of the " Repulsor " II rocket.*

The American Interplanetary Society

In the spring of 1931, a year after the formation of the American Interplanetary Society, the president, G. E. Pendray, travelled to Germany and visited the Ratenflugplatz. There he witnessed a number of tests of the "Repulsor" type rockets, and gained much valuable experience, both concerning the design and construction of liquid fuelled rockets, and also of the organisation of the Society itself.

Upon his return to New York, Pendray set about a policy of reorganisation, combining ideas of his own society with those of the German group, and finally succeeded in the establishment of an experimental programme to cover the development of a series of liquid fuelled rocket units.

As might be expected, the first rockets constructed by the Society engineers were not highly original in design, but incorporated many features proved by the German "Repulsors." A great deal of acutal test experience was required before technical improvement became a practical possibility, but within a relatively short space of time the Society successfully constructed and proved as highly satisfactory, a number of rockets embodying many original design innovations.

A.I.S. Experimental Rockets Nos. 1 and 2

The first rocket, Experimental Rocket No. 1, fuelled by petrol with liquid oxygen, was tested in November, 1931. For the purpose of this, and subsequent tests, the Society engineers constructed a small proving stand.

During the initial firing, however, an accident occurred in which parts of the combustion system were damaged. In view of the mishap, the Society's first rocket was not put to further test. Instead, a number of components, which included the motor and tanks, were used in the construction of Experimental Rocket No. 2, the design and building of which occupied the Society for a year and a half. After a number of proving stand trials, the rocket was finally fired in free flight on May 14th, 1933.

The rocket was fired out over the sea from the Society's proving ground at Staten Island, New York, and exploded upon reaching a height of approximately 250 feet. An examination of the wreckage found that the liquid oxygen tank had burst, despite the fact that a relief valve was fitted—the direct cause being the heat from the combustion chamber had effected an excessive expansion of the contents.

Instruments for Motor-cars and Aircraft

(Continued from page 409 September issue)

Oxygen Instruments, the Voltmeter, and the Gyroscope

By J. MARTIN

IT is common knowledge that oxygen in sufficient quantity is necessary to support the human life. At normal altitudes this oxygen is present in sufficient quantities to do so, but at great heights, from approximately 10,000 feet upwards, owing to the rarefied atmosphere, the oxygen content of the air is insufficient. To make up for this deficiency, oxygen is supplied by artificial means, and this is done by a number of containers, containing oxygen at high pressure, being fitted in the aircraft. The amount required for any particular aircraft has been carefully calculated according to the number of crew, length of journey, etc., and an ample margin for safety is provided. At various positions in the aircraft there are plug connections attached by pipe line to the source of supply. Indicators are provided at the pilot's cockpit, the bomb-aimer's position, the rear gunner's turret, etc., to show the amount of oxygen in the containers and also for adjustment to be made to the flow of oxygen according to the height, e.g., the greater the height the greater the flow.

The containers are spun from seamless steel, and oxygen is carried in them at a pressure of approximately 1,800lb. per sq. in. In the neck of each bottle is a valve, and all the bottles are connected to one main supply pipe line, and from this pipe line the connections are made to the various points required.

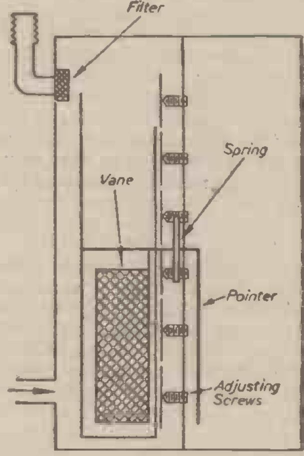


Fig. 21.—Oxygen delivery indicator.

It is obvious that oxygen cannot be breathed at the above pressure, and so it passes through a regulator which reduces it to a constant low pressure of approximately 35lb. per sq. inch.

After passing through the regulator, the oxygen passes to a delivery indicator (Fig. 21). This is marked off in 5,000 foot intervals, and according to the height at which the aircraft is flying the flow is adjusted. It is essential that all oxygen tubing should be thoroughly cleaned with petrol and dried with warm air. In no case whatsoever must any oil or grease be permitted to come into contact with any part of the system, e.g., for tight valves, etc., as this will cause a violent explosion.

The Oxygen Regulator

This is a very ingenious instrument and operates in the following manner, as seen form the illustration, Fig. 22. Oxygen at high pressure enters the regulator through a filter. Some of the gas is led off to a supply indicator, which is a simple gauge of the Bourdon type described earlier in this series, and operates in the same manner, the dial being calibrated in fractions of cylinder contents, e.g., $\frac{1}{8}$—$\frac{1}{4}$, etc. Another passage from the filter leads to the reducing valve, and in this chamber is a safety valve adjusted to blow off if the pressure builds up above 100lb. per sq. inch. The operation of the reducing chamber is as indicated in Fig. 23. Oxygen flows through the filter past the valve into the chamber, where it builds up to a pressure of 35lb. If the pressure increases above this then the diaphragm presses against the tension of the spring A, causing it, the diaphragm, to move away from the L-shaped lever. Spring B comes into play, moving the lever, and since the valve is attached to the lever, it closes, reducing the supply of oxygen. The oxygen in the chamber is led off through a small pipe line to the delivery indicator. This supply is controlled by the control knob, as in Fig. 23. As the pressure is reduced in the reduction chamber, spring A forces the diaphragm back again against the tension of spring B; this moves the L-shaped lever in the opposite direction, causing the valve to open and admit more oxygen.

The Delivery Indicator

This instrument is necessary in order that each member of the crew in the aircraft may adjust his supply to the correct amount required at the altitude at which the aircraft is flying. The instrument is a moving vane type, i.e., it consists of a circular disc cut in a series of vanes. These vanes control the supply of oxygen, being adjustable by a screw set behind each vane. On passing through the vanes, the oxygen impinges on a large vane attached to the pointer spindle. The greater the flow of oxygen required for greater heights, the greater the pressure on the vane, therefore greater movement of the vane. The pointer, being attached to the spindle, will move farther round the indicator dial, which is calibrated in 5,000 of feet. The pointer moves against the tension of a torque spring, which returns the pointer to zero, as the flow of oxygen decreases.

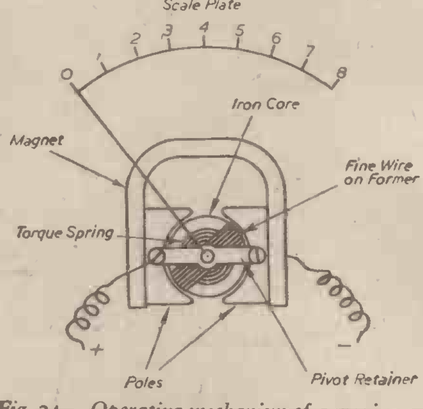
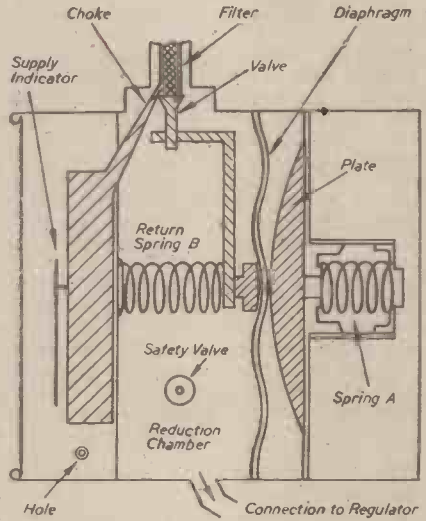


Fig. 24.—Operating mechanism of a moving-coil voltmeter.



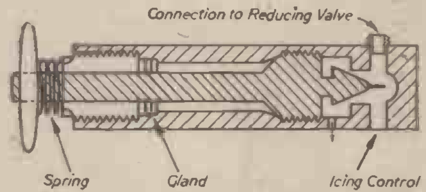


Fig. 22 (below).—Section of oxygen regulator. Fig. 23 (above).—Diagram of oxygen reducing valve.

From the delivery indicator the oxygen is fed directly to the masks of the crew.

The Voltmeter

A voltmeter is installed in the aircraft or automobile, on a panel, to indicate the voltage of the supply. The supply may be a generator for the main supply, or an accumulator, or both. The generator is driven off the engine and maintains a constant voltage. The voltmeter may indicate the voltage of the supply when charging, or voltage in the accumulator when the aircraft is stationary. Several voltmeters may be included in the main circuit, plus subsidiary meters, as in the wireless equipment, etc.

The voltmeter (Fig. 24) is a moving-coil instrument, and works on the following principle:

> If a conductor carrying current is placed between two magnets of different polarity, the lines of force emanating from the conductor will reinforce those of the magnets. In the magnets the magnet flux or lines of force will flow from N. to S. The lines of force in the conductor, if a wire, will flow radially around the wire. The result is that at one position the two lines will form a strong force, whereas immediately opposite there will exist a weak force; this will cause the wire to move. The development of force on a conductor carrying a current is called "the Motor Principle." When the coil has rotated through 90 deg. there no longer exists a rotational force, and the coil comes to rest. By changing the direction of the current, the coil can be made to continue throughout the 360 deg. as with the simple motor, but for the purpose of constructing a moving-coil meter the movement through 90 deg. is quite sufficient.

In the instrument is incorporated a permanent magnet, and between the two faces is inserted a uniform radial magnet in the form of a small soft iron core. Surrounding the soft iron core, but quite free from it, is an aluminium former. This former carries the coil wrapped around it, the coil consisting of many turns of fine copper wire. The wound former is suspended on jewelled bearings.

When the current flows through the coil a magnetic field is established, and this interacts with the uniform radial field, and by a law known as Fleming's Left Hand Rule, rotation can be deduced.

Now, since the field of the permanent magnet is uniform, the angle of rotation depends entirely upon the field due to current, therefore the angle of rotation is directly proportional to the current carried in the coil.

A spring is attached to the coil former, and the spring becomes wound up the torque of the spring opposing the torque of the coil. The greater the current the greater is the torque of the coil, and the greater the angle of rotation. When the electrical torque due to the coil is equal to the resisting torque of the springs, then rotation will cease.

The indicator needle is attached to the spindle fitted to the coil former.

The angle of rotation is directly proportional to the value of the current. If the current is doubled then deflection is doubled. In consequence a uniform scale is fitted. Since I equals $\frac{V}{R}$, the angle of rotation is proportional to the voltage, therefore a moving coil can be used as a voltmeter. A voltmeter is inserted in the circuit in parallel, that is to say across the circuit. When the current is nil the plane of the coil is parallel to the permanent field and the pointer is at zero. The "eddy currents" in the soft iron core reinforce the torque springs for the purpose of preventing oscillation of the pointer. This is known as damping, and results in the pointer coming to rest very quickly. The resistance of a voltmeter is high, and this means that the amount of current flowing will be low.

The Moving-coil Ammeter

This is essentially the same in construction as the moving-coil voltmeter, but included in the circuit is a "shunt," fitted in parallel. This is necessary in view of the fact that the fine wire can only carry very small currents without the danger of burning out, and in consequence strips of very low resistance alloy are inserted to carry off the greater proportion of the current. Thus the instrument carries a fraction of the main current, but is calibrated to register the main current. The ammeter is joined in series with the supply at any convenient point.

The Gyroscope

In these days of modern aircraft, involving considerable distances over unknown territory at night and over vast expanses of ocean, it has been found necessary to incorporate more accurate navigation instruments than were used in days gone by. Aircraft navigation has developed into a science as accurate as that of seaborne navigation. Hit or miss methods are useless to a Sunderland pilot detailed to pick up a convoy hundreds of miles at sea in thick weather. And so, in order that more accurate indication shall be given to pilots concerning the bearing of the aircraft, and the actual flying position, such instruments as the Directional Gyroscope, the Artificial Horizon, and the Turn and Bank Indicator have been invented. The actuating principle of all of these three instruments is the gyroscope.

The Principle of the Gyroscope

A gyroscope is briefly as follows: A statically balanced flywheel or rotor, of some heavy material, for instance, brass, turning about an axis. This axis is pivoted in a ring, and this ring in turn is pivoted in another ring. So we have two rings, pivoted at right angles to one another, with the rotor in the centre. This instrument is exactly similar to the familiar toy of one's childhood, and is a further adaptation of a spinning top.

The main property of the gyroscope is that with the rotor revolving at high speed it will tend to maintain its axis of spin, whatever the position of the gyro. And, if a force be applied to the inner ring of the gyro, the outer ring will tend to veer or turn, and if a force be applied to the outer ring, the inner ring will tilt. This is known as precession. For whatever torque is applied to either ring the other will tend to precess in a definite direction according to the direction in which the torque is applied (a torque, simply described, is a turning force).

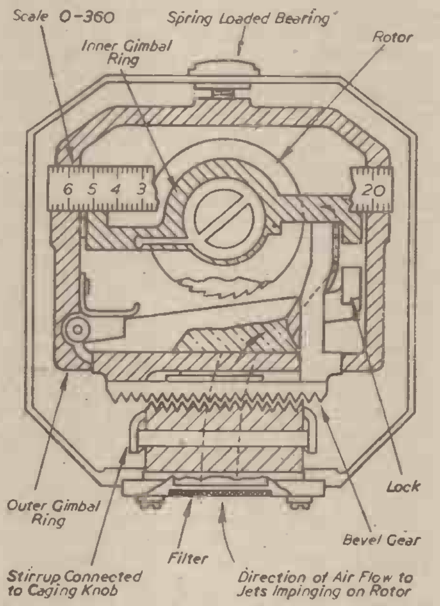


Fig. 25.—Sectional diagram of a directional gyroscope.

The Directional Gyroscope

It is obvious that the magnetic compass, whilst being very sensitive to any deviation of the aircraft from its set course, the degrees on the card or ring are set so close together that a slight deviation, say of one or two degrees, is not immediately apparent, and on a long flight this can result in the pilot being some miles off his course. Therefore the directional gyroscope or indicator was designed to show immediately any such slight deviation, when set to the course on which the aircraft is heading (Fig. 25).

The rotor of the gyroscope in this instrument has its axis of spin horizontal, and its plane of spin vertical. The rotor is propelled by air. The outer ring carries a bearing card, which is marked in degrees similar to the magnetic compass. The whole is housed in a light alloy case, which is air-tight with the exception of the union feed to the line, also the filters. The indicator is viewed through a shaded glass.

Action

The action of this instrument in a turn or on any deviation from the set course is as follows: The gyroscope will tend to maintain its plane of spin and keep the rings, or gimbal system, steady. The aircraft and instrument casing will move around this gimbal system. It will be seen that any relative movement between this bearing card and the casing can immediately be viewed through the glass window. Owing to the imperfect balance of this gyroscope, and due to the earth's rotation, it is necessary to reset this instrument from the magnetic compass at frequent intervals. This resetting is carried out by means of a knob situated on the front of the instrument, below the glass window, and which, when compressed, will bring into play a series of gears, thereby permitting the gimbal system to be turned gimbal.

The Artificial Horizon

This is a highly important instrument, for it provides the pilot with a clear indication of the aircraft's relative position to the earth whilst flying at night, or in bad weather. It shows whether he is flying straight and level, and the position of the horizon relative to the aircraft (Fig. 26).

It consists of a rotor and gimbal system, the plane of spin of this rotor being horizontal. The inner ring is pivoted athwartships, that is, on an imaginary line running through the main 'plane from tip to tip. The outer ring is pivoted horizontally fore and aft, and a pin protrudes from the inner ring through the outer ring and engages with the horizon bar assembly through a slot. The outer ring carries a "sky" plate and a "bank" pointer. The horizon bar assembly is also pivoted on this, the balance being maintained by lead weights placed at the opposite end to the horizon bar assembly. On the dial is engraved the form of an aircraft.

Action

On the aircraft diving, the outer ring, being pivoted fore and aft, moves with the case. The rotor case, or inner ring, remains upright due to the rotation of the gyroscope. Thus, as the relative distance between the inner and outer ring increases, so the horizon bar moves above the model aeroplane, thus providing an indication of a dive to the pilot.

When the aircraft "rolls," the case and scale move round the "bank" pointer, which remains still owing to the action of the gyroscope. Therefore the difference indi-

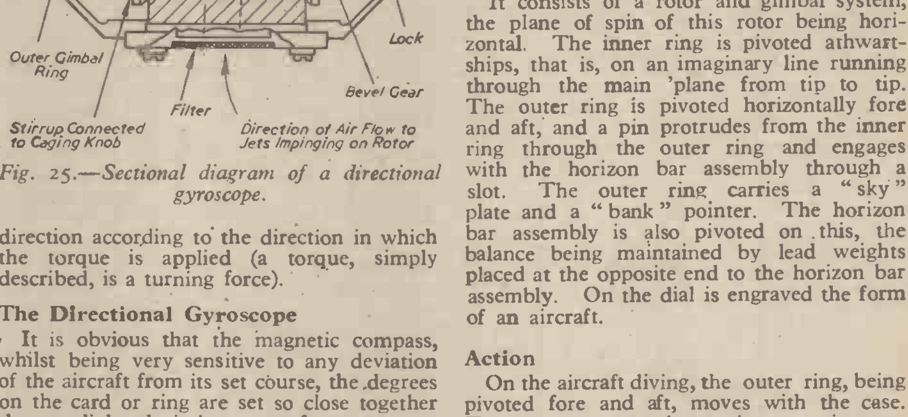


Fig. 26.—The mechanism of the artificial horizon.

cated, in degrees, on the scale is the amount of which the aircraft has "rolled."

Turn and Bank Indicator

This instrument consists of two separate units contained in the same case, and each working independently of the other. The turning mechanism is controlled by gyroscope, whilst the side slip depends upon centrifugal force and gravity for operation.

The "side slip" mechanism consists of a pendulous weight which is freely pivoted in a wedge-shaped box, and pivoted on the same shaft is an arm from the top end of which protrudes a pin. The forked end of a pointer engages with this pin. This forked method of pivoting ensures the pointer moves in the direction of the roll. When the aircraft "rolls" weight continues to define the vertical position owing to the action of gravity. But in doing so causes relative movement between the pointer and the dial.

Gyroscopic Mechanism

This consists of a rotor pivoted athwartships, and vertical, inside a single gimbal ring, which is pivoted fore and aft and horizontal.

The turning pointer is connected directly to the inner ring, the case of the instrument forming the outer ring. A small spring connects the inner ring with the casing.

Torques and Precessions

When the aircraft turns a torque is applied to the case, which causes the inner ring to precess and move the pointer across the scale. In doing this it increases the tension of the spring. When this tension has built up sufficiently to be equal and opposite to the torque caused by the aircraft turning, the inner ring becomes stationary, and the pointer will indicate a definite rate of turn. When the aircraft ceases to turn, this turning torque subsides, leaving only the spring tension. The torque which this spring is applying to the inner ring, now becomes operative and tries to precess the outer ring. But as this is impossible, for this represents the case fixed to the aircraft, the outer ring applies a back torque, which precesses the inner ring back to its original position and so returning the pointer to zero. To prevent the pointer from vibrating excessively a damping device is fitted. This consists of a quadrant firmly attached to the inner ring, which, through a pinion and crankshaft, drives a small piston within a cylinder. The action of the pinion opposing the air within acts as a buffer and so damps any oscillation.

It will be understood that both of these mechanical devices, in the same case, become operative simultaneously.

Rotors and the Means of Propulsion

It is obvious that some means of propulsion of the rotor is necessary, and the method involved is quite simple. An accurately balanced wheel has eliptical or square-cut buckets or grooves cut around the periphery. One or two air jets direct air which impinges on the buckets (Figs. 25 and 26). This air is supplied as follows: A suction pump is driven directly from the engine and is connected to the union of each instrument by a pipe line. As stated earlier, the cases of these instruments are airtight, with the exception of the filters. The pump, by withdrawing air from the case of each instrument, creates a difference in pressure between that of air inside the case and the air outside. Air flows from high to low pressure, and since air has been withdrawn from the case, the pressure in it is less than the air pressure outside. The air, in an endeavour to equalise the pressure, flows through the filter, which is directly connected to the jets, impinging on the rotors. Since the nozzles of the jets are very fine and the difference in pressure is high, it is obvious that the air flows through these jets with great force. The force of the air flow is sufficient to cause the rotors of the directional indicator and artificial horizon to revolve at 10,000 to 12,000 r.p.m., and the turn and bank at a somewhat lesser speed.

In order that the partial vacuum in the case be maintained constant, and therefore the rate of flow of air through the jets constant, a valve known as the suction relief valve is fitted in the pipe line. This consists simply of a spring-loaded disc in a metal case. In normal operation this disc closes off the pipe line from atmosphere, and the spring is of such strength that whilst the reduced air pressure in the system is equal to that required to support a column of mercury, 4½ins. high, the valve remains closed. If the suction pump builds up the partial vacuum greater than the equivalent of the figure mentioned, the valve lifts. This is due to the fact that the difference in pressure outside and inside the system has increased to such an extent so as to allow the air pressure outside to overcome the tension of the spring. The references to "pressure" are at all times referring to the reverse of "suction."

Since, with increased engine revolutions, the pump will give increased suction, the requirement of the valve is to keep the partial vacuum in the instruments constant, at the above-mentioned figure of 4½in. of hg.

(To be continued)

Modifying Car Dynamos and Starters—2

Tests on the Original Machine After Cleaning Up

By D. E. BARBER

(Continued from page 25, October issue)

IT is now assumed that the reader has in his possession a suitable automobile machine, preferably a dynamo or dynamotor, which has been thoroughly cleaned and reassembled exactly in its original form. If a starter motor is to be modified there is little that can be done in the way of simple preliminary testing so that the remarks in this article can only be taken as applying to dynamos and dynamotors. The purpose of these preliminary tests is to provide operating data of the machine in question in order that new windings or other relevant alterations can be predetermined with fair accuracy. In this way, blind guesses and "shots in the dark" can be largely eliminated. To simplify ultimate analysis, preliminary tests should always be carried out with the machine generating, irrespective of whether the final machine is to run as a motor or generator.

Apparatus Required

The apparatus called for is fairly simple and can usually be borrowed if not already to hand. As a tachometer is invariably beyond the reach of the average amateur, all the tests suggested can be done at a constant speed which should be as near as possible to the speed at which the machine is finally to operate. Where the modified machine is to be a dynamo, the test drive may well be taken from the same prime mover as will eventually be used.

Only three meters are required; a voltmeter having several ranges is advisable, in addition to two ammeters, one having a range of about 5 or 10 amps, and the other about 20 amps. A good D.C. supply should be available, and for this, two 12-volt car batteries are suggested. Finally, two variable resistances are required and these can be made up at home as follows: Obtain two glass or stone jars of the pickle jar variety, and having a capacity of at least a gallon. In the bottom of each, a lead, brass, or copper sinker should be placed connected to which is a length of heavily insulated, waterproof cable forming one lead-in to the resistance. A wooden strip across the top of the jar carries a metal rod which passes through a hole in the strip and into the jar. The position of this rod can be varied in a vertical direction, and a piece of springy brass pressing against it serves to retain it in position and also provides electrical connection. Fig. 6 will make clear the construction. The jar should be three parts filled with water and sufficient washing soda dissolved in it to provide the necessary conductivity required. The less soda that is added, the higher will be the resistance of the unit. If it is found to get too hot whilst in operation, the jar can be placed in a second vessel containing cold water. Having considered the apparatus, a few tests can now be mentioned.

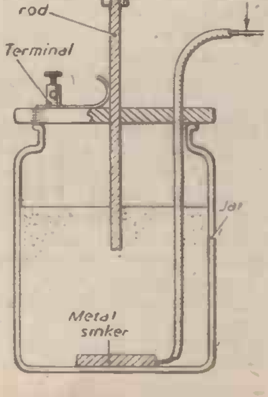
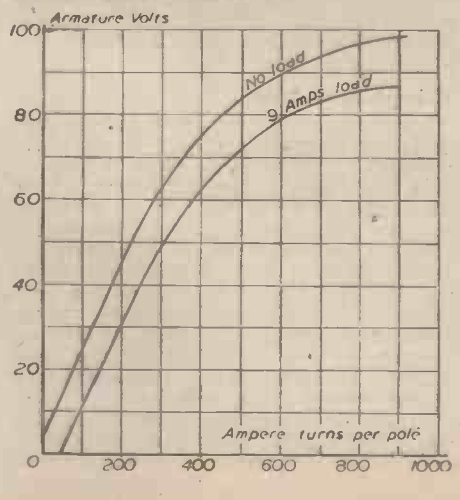


Fig. 6 (left) Section of a variable liquid resistance.

Fig. 7 (right) Typical saturation curves.



Checking the Brush Neutral

Generally speaking, the third brush will never be required, so that this can be removed at the outset if fitted. One of the main essentials when doing brush tests, is that a good bedding has been given to the brushes, and this should be done using a piece of fine glass-paper passed under the brush surface and drawn in the direction of rotation of the commutator.

The next item should be the setting of the brush position, and this should be done immediately after building up the machine, before the poles have been magnetised again. With the machine turning over very slowly, a current of 5 or 10 amps should be passed through the armature, and the voltage across the armature measured. The speed should then be increased to normal and the same current passed through the armature, the voltage again being measured. The brushes should be moved until a position is found where this voltage is the same as the reading obtained at the very low speed. Between each movement of the brushes, the machine should be run for a few minutes to allow the brushes to settle down in their new position. The position obtained by this test will be the correct neutral position.

Saturation Curves

The function of a saturation curve is to show graphically the variation of armature voltage against field excitation. Two such curves are usually taken, the first with the armature on open circuit, and the second with the armature loaded up to its full current value. Fig. 7 shows two such curves obtained on a four-pole generator running at 3,000 r.p.m. with a neutral brush setting. The falling off in voltage due to the load current can be clearly seen. It will also be observed that the excitation has been plotted on an ampere-turn base since this will be found most useful when deciding on a new winding. This form of plotting necessitates a knowledge of the number of turns on the field coils being used for the test, and it will be found that by stripping off the tape from one of the coils, thus exposing the wires, a reasonably accurate estimate of the turns can be made ; this may be done before commencing, or after completing the tests.

The procedure when taking a saturation curve is as follows: Run the machine at normal speed and arrange to excite the field winding from the D.C. supply through a variable resistance and ammeter. A voltmeter should be connected across the armature terminals which, in the case of a no-load saturation curve, should be disconnected from the load resistance. Starting from zero field amps, take a series of readings, increasing the excitation in small increments and recording the armature voltage for each value of field amps. Values of excitation up to about 7 amps will give good curves for normal car dynamos and by multiplying by the field coil turns, a value of field ampere-turns per pole will be obtained for each point. These may then be plotted against the corresponding armature voltage readings.

The only difference in procedure when taking a load saturation curve is that a variable resistance should be connected across the armature. For each point taken this resistance will have to be adjusted to maintain the load amps at the value required for the rest. Fig. 8b and c show the two circuits required. To avoid overheating, the higher values of field current should not be maintained for long periods.

Temperature Tests

Temperature tests are useful because they enable a good approximation of the maximum permissible loading to be made. Thus, if it is found that a certain machine, during its preliminary tests, will give an output of say, 300 watts, then it will be fairly reasonable to suppose that, unless the efficiency is greatly reduced, the final modified machine will also give 300 watts for about the same degree of heating, the ventilation system remaining unaltered. A further use for temperature tests lies in the fact that they offer a means of comparing the relative efficiency of two or more cooling schemes.

Broadly speaking, these tests consist of a run at full load for a specified time, usually until the temperatures have reached a steady value. The machine can then be shut down and, using thermometers, measurements made of the temperature rises of the various parts, such as the commutator, core, and field windings. During the run, measurements of the yoke, bearings, air inlet and air outlet temperatures are made at regular intervals so that their rate of rise can be observed.

For preliminary temperature tests, the circuit of Fig. 8c will be found the most useful, although for the final tests after

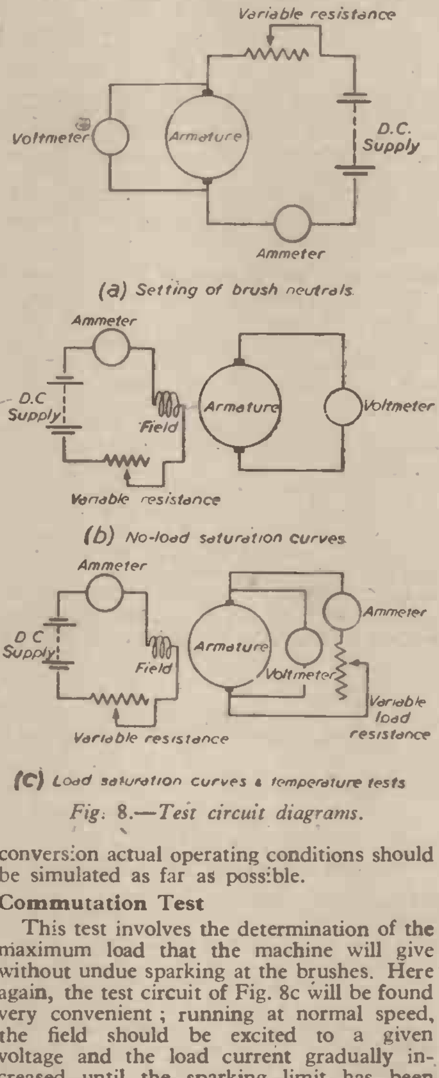


Fig. 8.—Test circuit diagrams.

conversion actual operating conditions should be simulated as far as possible.

Commutation Test

This test involves the determination of the maximum load that the machine will give without undue sparking at the brushes. Here again, the test circuit of Fig. 8c will be found very convenient ; running at normal speed, the field should be excited to a given voltage and the load current gradually increased until the sparking limit has been reached. As a rule these machines cannot be expected to work all the time with commutation absolutely "black" so that a little sparking is permissible so long as it is not allowed to become excessive. Although not theoretically correct, it will generally be found that the sparking limit is reached as a result of the "watts being commutated." Thus if, during the preliminary test, the commutation limit was reached with the machine generating, say, 30 volts 10 amps, the same machine when rewound to generate, say, 60 volts would stand a load current of up to about 5 amps before bad sparking commenced.

What the Test Results Mean

Having run over the main tests which can be carried out on the machine before modification, it is now proposed to consider briefly the meaning of the results obtained in order that they can be seen in their true relationship with the proposed alterations. To assist in this matter, an example will be made of the machine, the saturation curves of which are drawn in Fig. 7. Assume that it is required that this machine is to be modified to operate as a self-exciting generator, driven by an engine running at a speed of 3,000 r.p.m., and that the voltage is to be 120, the output being as high as possible.

In the first case a no-load saturation curve should be taken ; a glance at this shows that saturation of the machine commences at about 75 volts, denoted by the start of the "knee" of the curve. Obviously then, it is not economical in ampere-turns to go higher than this, that is, about 400 amp-turns. The next step is to find how many watts the machine will generate and this involves a series of temperature tests all carried out with a fixed field excitation of 400 amp-turns but with different values of load current for each test. The idea is to find the highest current that can be taken from the armature without exceeding the prescribed temperature limits. In the case in question the heat runs showed that 9 amps was the maximum value and that at this current, and with 400 amp-turns excitation, the armature voltage was 62 ; in other words, $9 \times 62 = 558$ watts, represented the total permissible output.

Once this value has been ascertained, the requirements of the new windings can be visualised. Thus, in the example, since the new voltage is to be increased from 62 to 120, the armature current will be reduced in the same proportion and will be found to be 4.65 amps. As the modified machine is to be self-exciting, a percentage of this current will be taken up by the field, so that probably only 4 amps will be finally available for useful output. From a sparking point of view, the preliminary tests showed that commutation was quite good at 9 amps 62 volts, so that it would be reasonable to suppose that the new design would be satisfactory at 4 amps 120 volts.

The voltage generated by an armature is proportional to the number of conductors it contains, other factors being equal, so that the number of conductors in the new winding should be increased in proportion to the voltage increase. As the specimen dynamo had 336 conductors, the new winding would require $\frac{336 \times 120}{62} = 650$ wires in all. As the load current is reduced from 9 amps to 4.65 amps, the section of the conductors may be reduced in this proportion so that although the original conductor used was No. 19 S.W.G. the modified winding calls for only No. 22 S.W.G. which has approximately half the sectional area. It will have already been understood by the reader that before the data for the new winding can be fixed, complete details of the original winding must be obtained. This entails stripping the armature completely and counting the turns on the coils, at the same time making a very accurate sketch of the connections of the coils and commutator bars.

Operation as Motors

Although the foregoing notes refer mainly to dynamos, it is not difficult to line up the test results to cover motor operation. It should be remembered that the losses occurring in a motor must be supplied from the line electrically in the form of increased voltage or current. The preliminary tests can still be carried out with the machine generating, but due allowance should be made for these losses. Thus, the sample machine which generated 9 amps at 62 volts would probably develop a little over $\frac{1}{2}$ h.p. and would require an input of perhaps 9 amps at 80 volts. This follows from the fact that 1 h.p. is equivalent to 746 watts, and assumes that the motor efficiency would be between 50 and 60 per cent. The same proportions would hold for the new higher voltage winding so that this would operate at about 4 amps 150 volts. For the same excitation of 400 amp-turns, the motor would run at about the same speed as did the generator, that is 3,000 r.p.m.

(*To be continued.*)

Masters of Mechanics—99

Sir William Herschel

Astronomer, Mechanic, Musician, and Pioneer of Telescope Construction

THE term "astronomical engineering" has not yet entered into common phraseology. Probably it never will do so. Yet there is no doubting the fact that, for many years, the building of observatories, and the making of big telescopes has been a specialised task of the true engineer in addition to that of the fine instrument-maker. Indeed, modern telescope-making, as exemplified by the present-day giant American instruments, calls for the highest degree of engineering ingenuity and precision, for it is only by harnessing the skill of the constructional engineer that the astronomer can hope to bring into being the mammoth telescopes and other instruments which fulfil his needs—and ambitions.

Like all other departments of applied engineering science, telescope design and construction has followed an evolutionary trend ever since its inception. With the truly engrossing narrative of giant telescope development we can have no association during this present article, for our concern at the moment is to view the life activities of a very remarkable individual who, more than a century and a half ago, first began the design and construction of what were then regarded as super-scale observatory telescopes.

The fact that this constructional pioneer was, at the beginning of his astronomical career, neither a trained mechanic nor an experienced engineer, but that he had, up to that time, actually made his living as a professional musician renders his constructional feats all the more amazing to us, particularly as, in addition to these activities, he found the time to devote himself long and earnestly to celestial observation, and, as an eventual result, to become one of the world's most famous astronomical discoverers.

William Herschel, for such was the name of this "second Galileo," as he has been called, was born at Hanover, Germany, on November 15th, 1738. He was christened Friedrich Wilhelm, but, in after life, he dropped his first name, and, on coming to England, became plain "William." His father was a band musician in the Hanoverian army.

An amateur's refracting telescope containing an object glass of 3in. diameter. Such instruments are often designated "table telescopes."

Seven Years' War

The times were stormy. Not long afterwards the Seven Years' War broke out. It was a conflict in which Prussia, military-minded then, even as now, opposed Austria, Russia and France. William Herschel, his brother and his father left Hanover and came to England, landing at Chatham in 1756. But, after a few months, the band was ordered back to Hanover owing to the French threat to Germany.

Sir William Herschel (1738-1822)

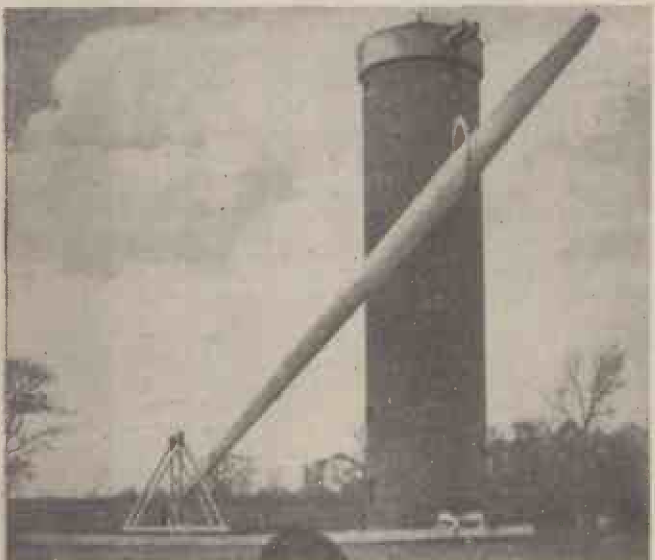
Young William Herschel, joined by his brother Jacob, eventually left Hamburg for England with the intention of making a living as musicians. Jacob Herschel quickly gave up the hard struggle and returned to Hanover, but William remained in this country, and ultimately obtained one by one appointments as organist at Leeds, Halifax and other towns, until, at last, in 1766, he was given the post of organist of the Octagon Chapel at Bath. This post he held for 16 years. As a music teacher there he was fairly successful. His sister, Caroline Lucretia Herschel, came over from Germany to keep his house in Bath, and from this time onwards Herschel, having his sister to look after him, settled down to a jog-trot life, the material rewards which were, in those days, but meagre and slender.

Then something happened which revolutionised Herschel's life (and that of his sister), and set the pair on a scientific career from which they never afterwards receded. He happened to read one of the popular treatises on astronomy of the day, and, about the same time, to obtain a glimpse of the heavens through a small telescope belonging to one of his associates in Bath. The experience was sufficient to twist Herschel's mind completely away from his professional subject of music and to focus it squarely upon the science of astronomy, then very much in its evolutionary stage.

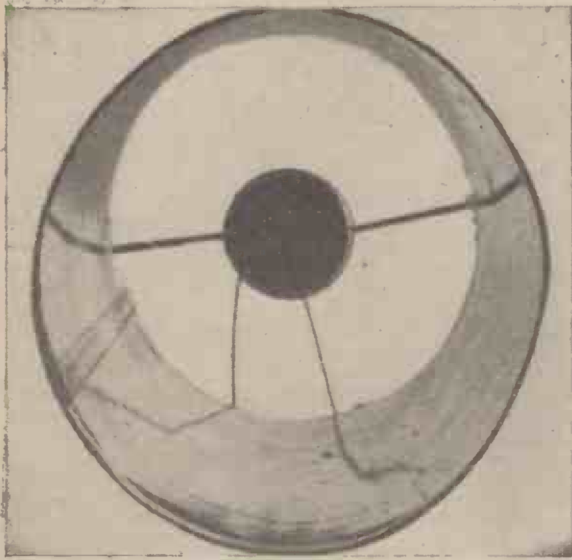
A Telescope of His Own

Herschel's reaction was at once to endeavour to procure for himself a large telescope for his own use. Inquiries in London revealed to him the fact that the price of such an instrument was far beyond his means, and this news determined him on making his own telescope. Obtaining as much practical information as he could from the few treatises on optics which were then available, Herschel forthwith proceeded to the task of making a telescope for himself. At first he had many failures resulting from his complete lack of practical experience of mechanics and other constructional work. At last success crowned his efforts, and in 1774 he had the satisfaction of surveying the heavens through a 5ft. Newtonian reflecting telescope of his own design and manufacture.

For the sake of the reader who is not at present very familiar with astronomical matters, it should, perhaps, here be explained that telescopes divide themselves up into two main classes, to wit, the *refracting* type of telescope and the *reflecting* variety. The refracting telescope is built upon the principle of the small "table telescope," which is common in our day. It comprises a barrel with an object glass (or light-collecting lens) at one end and an eyepiece at the other. The reflecting telescope embodies a *speculum*, or mirror, of very accurately ground and polished curvature. This replaces the object glass of the refracting telescope, and the observer looks at the reflected images of the celestial bodies through an eyepiece focused on the mirror. Both refracting and reflecting telescopes



A large refracting telescope of about the year 1848, the exact type and location of the instrument being unknown. It was probably a wealthy amateur's telescope.



A portion of a telescope attachment containing a sensitive thermocouple for infra-red ray detection.

have their own advantages and disadvantages, and both types of instrument have come down to us unchanged in principle from Herschel's day.

On March 1st, 1774, Herschel made the first entry in his astronomical journal which he kept to the end of his life. It consisted of a record of his observation of the rings of the planet Saturn.

For the ensuing eight years Herschel combined the two very opposite professions of musician and astronomer, to say nothing of proceeding with his career as a telescope maker. In his astronomical work and telescope making he had his sister to help him, for she was as interested in the work as he was. After the success of his first small reflecting telescope he made others, each of an increased size and power.

After being engaged with his musical teaching for sometimes as many as 15 or 16 hours out of 24, Herschel would devote the remainder of his waking hours to the patient grinding of lenses and mirrors, and to the design and calculation of his improved telescopes.

Soon he began to limit his musical engagements. That resulted in loss of income. But, not in the least deterred by this factor, the musician-telescope enthusiast delved more and more deeply into his mechanical and optical activities. His ambition was to make a telescope which was bigger and more powerful than any which had been previously known.

Mirror Grinding

The amount of labour and the degree of determination which he devoted to this matter was almost incredible. He found, for example, that with the crude mechanical means at his disposal it was impossible to grind accurately telescope mirrors having focal lengths greater than about 6ft. The only way in which he could impart the exact curvature to mirrors larger than these was to do the whole of the job entirely by hand. It was rather a hit-and-miss method. Many mirrors had to be made and tested before a perfect one was obtained. So delicate was the operation of mirror grinding and polishing that during its final stages a single rub in the wrong direction would completely ruin the perfection of the mirror, and thereby render it more or less useless for accurate observation.

Herschel's mirrors were formed out of an alloy of tin and copper (afterwards known as "speculum metal"). He brought the construction of these mirrors to such a fine art that they gave degrees of optical resolution which had been previously considered impossible. He also increased the magnifying power of his eyepieces, thereby developing the capacity of his telescopes very greatly.

The New Planet

During the period of his constructional activities, Herschel's fame as an astronomer gradually increased until eventually it blossomed forth into world renown. On March 13th, 1781, Herschel, training his latest telescope on to a favourable part of the heavens, noted a small and hitherto unknown star which he took to be a new comet. The Astronomer-Royal confirmed Herschel's conclusion. However, after the supposed comet had been observed for some little time it became clear that it was no mere comet at all but a veritable new planet, the first new planet to be discovered in the whole of astronomical history.

Herschel's proposal was to call his new planet *Georgium Sidus* (i.e., the Georgian Star) after the reigning monarch of England, George III, but this proposal was not favoured by Continental astronomers. After being given the name of its discoverer, *Herschel*, for a number of years, the new planet was eventually named *Uranus* (from the Greek, "ouranos," the heavens). Uranus is about nineteen times the size of the earth, but its distance from the sun (1,800,000,000 miles) is so great that until the time of Herschel's telescopes it had never been recognised as a planet.

In the following year (1782), George III granted William Herschel a pension of £300 per annum, thus leaving him free to give up his musical activities and to devote himself to the design and construction of telescopes and to the advancement of astronomical science generally.

"Never," exclaimed Sir William Watson, a contemporary politician, "did monarch buy honour so cheap!"

"Royal Astronomer"

With the pension of £300 per annum came the appointment of "Royal Astronomer." Assuming this title, Herschel, together with his sister, took up residence in a large house on Datchet Common, near Windsor, where he constructed a 20 ft. telescope. But the Datchet house was a damp one. It nearly gave Herschel pneumonia, so that, after a short stay at Clay Hall, near Windsor, he removed permanently to Slough which thereafter was destined, in the words of one French philosopher, to become one of the "shrines" of astronomical science.

It was at Slough that William Herschel for many years swept the skies with his telescopes, each time making fresh discoveries. "If it had not been for the intervention of a cloudy or a moonlit night," wrote his sister Caroline, "I know not when he or I either would have got any sleep."

In the daytime, too, Herschel's activities were endless. He was now employing a small army of workmen and millwrights to aid in the construction of his ever bigger telescopes, and to prepare for a "super" telescope which he proposed to make.

40ft. Telescope

This was a 40ft. instrument, the building of which would necessitate a special Government grant. At the instance of the Royal Society (of which Herschel was a member) this grant—amounting to £2,000—was forthcoming, and the construction of the giant instrument was at once commenced. A couple of years later, another £2,000 was added to the grant, together with £200 extra per annum for the upkeep of the telescope.

The making of this once-famous telescope occupied four years. Caroline Herschel, in her wonderful narrative of her brother's multifarious activities, records that:

> "there is not one screw-bolt about the whole apparatus but what was fixed under the immediate eye of my brother. I have seen him lie stretched out many an hour in the burning sun across the top beam, while the ironwork for the various motions was being fixed. At one time, no less than twenty-four men (twelve and twelve relieving each other) kept polishing day and night, my brother, of course, never leaving them all the while, taking his food without allowing himself time to sit down to table."

The new telescope was more than successful. Its immediate result was the detection of two satellites or moons of the planet Uranus and the discovery of two new satellites of Saturn. In every way, it was a spectacular instrument. Its tube was nearly 40ft. long and 5ft. in diameter. It was made of iron, the observer being seated in a movable chair at the upper end of the tube from which, by means of an eyepiece, he observed the astronomical image in the mirror at the lower end of the tube. The mirror had a uniform thickness of 3½in. and weighed 2,118lb. It was made from a copper-tin alloy.

A view of a spiral nebula as seen through a modern 60 ft. reflecting telescope.

With the many astronomical discoveries which Herschel made during his career this present narration obviously cannot deal, for here we are mainly concerned with Herschel's activities as a mechanic rather than as an astronomer.

A "World's" Wonder

The 40ft. telescope proved to be the climax of Herschel's constructive career. After that, he settled down to an easier life and to what became, with him, the "routine" of stellar discovery.

For a time, the Herschel telescope at Slough was a world's wonder. Important people came from far and near to inspect it.

But, before long, its constructor having shown the way, the instrument was superseded by others still more powerful. Owing, no doubt, to Herschel's lack of earlier training as an engineer and mechanic, the Slough elescope was somewhat awkward and difficult to manipulate, despite its effectiveness in actual use. Moreover, the speculum or mirror which had been so carefully polished, lost its pristine lustre within a couple of years. The telescope remained standing during Herschel's lifetime, although the astronomer himself seldom used it. Not until 17 years after Herschel's death was it taken down, and, even then, it remained for many years in a horizontal position before it was ultimately destroyed.

The latter years of Herschel's lifetime were comfortable ones. He married a rich widow, a procedure which removed any vestige of financial want. He received a knighthood, and he lived to see his only son, afterwards Sir John Herschel, rise to a position of fame in the scientific world. His death took place at the age of 83 on August 25th, 1822, and he was buried in the Church of St. Lawrence at Upton.

Discoverer of the Infra-red

Herschel is seldom accorded the honour of being the discoverer of infra-red rays. Yet it is to him that such an honour must go.

In order to compare the heating effects of coloured rays of light, William Herschel placed sensitive thermometers in different portions of a spectrum band of light. He noticed that the heating powers of the rays continually increased as one descended the spectrum from blue to red. What was of still more importance, he observed that the thermometer showed its highest registration when it was placed just outside the red band of the spectrum, proving that invisible rays of great heating powers were present at that area.

It was in these circumstances that knowledge of the infra-red was given to the scientific world.

The New Spitfire Mark XIV

THE Vickers-Armstrongs, Limited (Supermarine) Spitfire F. Mark XIV is a single seat low-wing monoplane fighter with single fin and rudder and elliptical wings. It has a Rolls-Royce Griffon 65 engine, driving a five-bladed Rotol constant speed propeller. The Griffon 65 engine, which develops a horse-power of over 2,000, is of 12-cylinder type, pressure-cooled, with a two-speed supercharger. The Spitfire F. Mark XIV has a retractable tail wheel. The armament may consist of four 20 mm. cannon or two 20 mm. cannon and two .5 in. machine guns, or two 20 mm. cannon and four .303 machine guns. A bomb carrier for either a 250lb. or 500lb. bomb can be fixed under the fuselage in the drop tank fittings. The Spitfire F. Mark XIV may be described as "faster than any other Spitfire in service," and referred to as being in operation in the north-western European theatre, and that it has been in action against flying bombs.

Griffon 65 Engine

A single stage supercharged Griffon engine has been operating in the Spitfire XII with great success as a low-altitude fighter, and now a Griffon engine with a mechanically driven two-stage two-speed supercharger and intercooler has been introduced in the Spitfire XIV. Its performance is outstanding both in speed and climb at all altitudes from sea-level to 40,000ft., and the aircraft retains all the fighting manœuvrability and control for which the Supermarine Spitfire is renowned.

Use of the five-bladed propeller in the Spitfire XIV arises from demands for greater efficiency at all altitudes. With the introduction of the two-stage supercharger which maintains the engine power at higher rated altitudes, combined with higher top speeds, four-bladed variable pitch propellers have been found essential, since diameter is limited by the need for ground clearance.

With the increased powers of the modern aero engine, a further stage was reached where the four-bladed propeller became "underbladed" and could not efficiently absorb the power at altitude. For the same reason the climb and cruising performance suffered.

The new Spitfire banking above the clouds.

The Spitfire Mark XIV in the air, showing the underside of fuselage and main plane.

The new Spitfire has the following dimensions :

Span—36ft. 10in.
Length—32ft. 7¾in.
Height (tail up, one blade vertical)—11ft. 7½in.
Wing area—248.5 sq. ft.
Weight—about 8,000lb.

The Torsionmeter

Particulars of its Construction and Use in Taking Horsepower Measurements of Machinery

By G. W. McARD

VARIOUS methods are employed for determining the horsepower generated by different units, each naturally being that found most suitable for the purpose. The absorption brake, for example, is generally used for testing the output of the I.C. motor; so far as rail power units are concerned, the dynamometer car placed between the prime mover and the train enables the maximum power available for haulage to be found. On turbines and marine power generators the horsepower is generally calculated by using the readings taken from the torsionmeter, an instrument that enables the power to be found from the twist which occurs as the result causes a minute rotation torque, the manufacturers normally testing by this means the power output of every equipment supplied. This instrument, incidentally, can be employed to indicate the power transmitted through line shafting between any two points, and where the power absorbed in driving any individual machine or batch of machines is in question a torsionmeter will usually solve the problem.

When a twisting load is applied to a shaft, whether through a crank, pulley, gearwheel, rotor or other means, the torsion which occurs as the result causes a minute rotation of the shaft at the section which receives the drive, relative to another section in a plane at a known distance from the first, and on the input side. Fig. 1 illustrates this more clearly, the amount of the angular rotation depending on the power input, the sectional area of the shaft, and the grade of steel used. Goodman gives the following formula for the h.p. transmitted by any shaft:

$$\text{H.P.} = \frac{2\pi \text{PrN}}{12 \times 33{,}000} = \frac{\text{PrN}}{63{,}025}$$

where P is the load in pounds applied at a radius of "r" inches from the centre of the shaft, and N is the number of revolutions made per minute. Assuming a certain power transmission, it is obvious that the twist of one shaft will be greater than that of another with a higher modulus, given similar grades of steel; likewise for different steels but similar shaft dimensions and power input, the shaft formed from the inferior quality of steel will twist to a greater degree than the shaft made of the higher grade material.

Hopkinson-Thring Instrument

A torsionmeter that has given excellent service is the Hopkinson-Thring Optical Instrument, shown diagrammatically in Fig. 2, the torsionmeter, mounted on a shaft, being illustrated in Fig. 3 and the scale box in Fig. 4. The principle of the apparatus is a differential one, and consists in the observation of the twist between two adjacent points on the shaft by means of two beams of light projected on to a scale from a fixed and a movable mirror. The beam projected on the scale by the fixed mirror is taken as the zero point, whilst the beam projected by the movable mirror indicates the amount of torque in the shaft. Both mirrors rotate with the shaft, and even at moderate speeds the reflections appear as continuous lines of light across the scale, no difficulty whatever being experienced in taking the readings.

From Fig. 2 it will be observed that a collar R is clamped to the shaft whose torque has to be measured, and this collar carries a flange bearing on which the sleeve T, also clamped rigidly to the shaft at the end remote from the collar, is free to rotate. It will be appreciated that any twist set up in the shaft by the power transmitted will cause a relative rotation of sleeve and collar, and this movement is rendered visible by one or more systems of torque mirrors which are mounted between the two flanges, the mirrors reflecting one or more beams

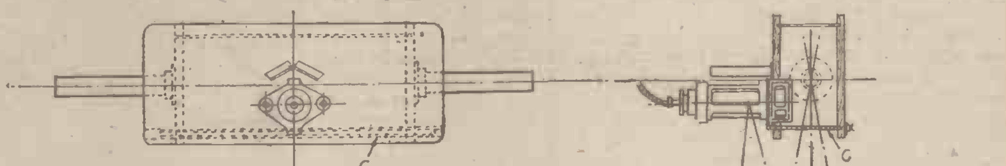
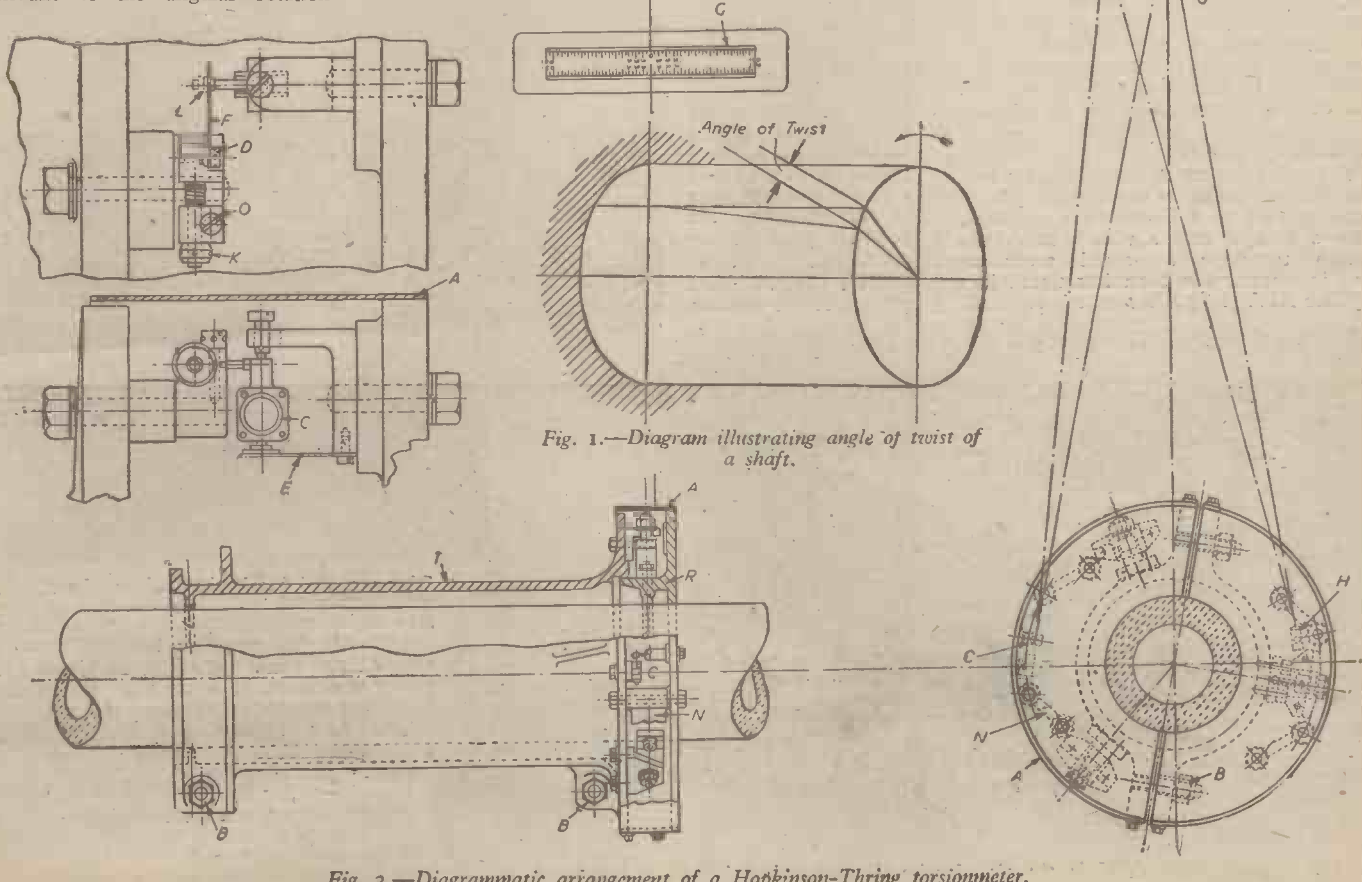



Fig. 1.—Diagram illustrating angle of twist of a shaft.

Fig. 2.—Diagrammatic arrangement of a Hopkinson-Thring torsionmeter.

Fig. 3.—Torsionmeter mounted complete on a shaft.

of light, projected from a lamp, across to a scale suitably prepared on ground glass. Each system of torque mirrors consists of a mounting, pivoted top and bottom on one or other of the flanges, in which two mirrors are arranged back to back. This mounting is provided with an arm (see the large scale view in Fig. 2), the end of which is connected by a flat spring to an adjustable stop on the other flange, and any relative movement of the two flanges will rotate the torque mirror, causing the beam of light to move on the scale, the deflection registered being directly proportional to the torque applied to the shaft. If, therefore, the rigidity of the material and the number of r.p.m. are known, the h.p. transmitted can be arrived at easily.

With the arrangement described, a reflection is received from each of the two mirrors provided at every half revolution of the shaft, but where the torque varies during each revolution, as it does on all reciprocating engines, a second system of mirrors can be arranged at right angles to those already provided, to enable four readings per revolution to be taken ; if a second scale be introduced, eight readings can be taken per revolution, thus enabling more precise h.p. reckonings to be plotted.

Electrically-indicating Torsionmeter

Although the optical torsionmeter just described is still doing useful service, and even preferred in certain quarters, it has been superseded to a large extent by models operated more or less electrically. One of these, while still controlled by the torsional rotation of a plane of the shaft relative to another plane distant, possibly 4 or 5ft., indicates the torsion set up by utilising the angle of twist to alter the air gap of a small differential transformer, this alteration being measured by a suitable electrical device which caters equally well for the varying torque of the reciprocating engine as for the more uniform torque of the turbine. One of these is illustrated in Figs. 5 (the torsionmeter), 6 (the indicator) and 7 (the complete arrangement), and as in the instrument already described, the h.p. is obtained from the reading of the indicator multiplied by the r.p.m., and divided by a constant which is determined either by a calibration of the shaft and meter together, by means of a static torque on the shaft, or by calculations in which the leading dimensions and characteristics of the instrument and the modulus of rigidity of the shaft are accounted for.

In Figs. 5 and 7 the brush gear which conveys the current to and from the rotating instrument is clearly visible, and a big advantage in this design lies in the fact that the indicator can be situated at whatever point is most convenient and accessible for taking the readings, without in any way affecting the accuracy of the results. From Fig. 7 it will be seen that the portion of the instrument which is mounted on the shaft comprises two cylindrical units AA, these being secured to the shaft at A and A_2 respectively. In order to ensure that they are secured square to the shaft, a series of steel strips "B" link tightly the two cylinders internally, the adjacent flanges C and D then being correct axially until the shaft is loaded torsionally, when one rotates slightly relative to the other. This movement, as already stated, is employed to alter the air gaps of the differential transformer "E" which is situated between the flanges. A glance at Fig. 8 shows more clearly what will occur when this movement takes place, the cores F and F_1 being set, under zero loading, with equal air gaps between the cores and the H-shaped iron piece G.

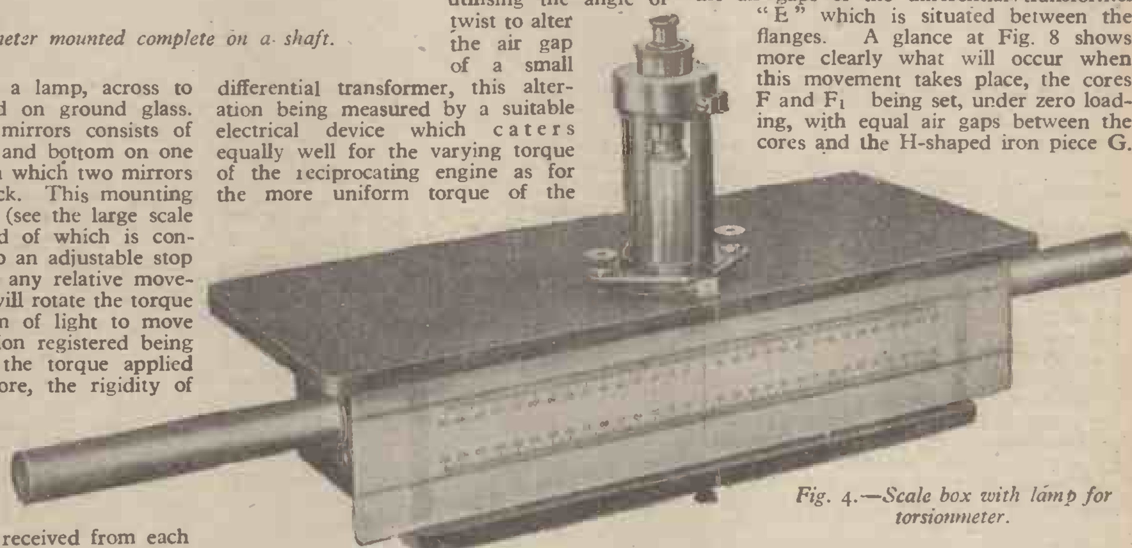


Fig. 4.—Scale box with lamp for torsionmeter.

A differential transformer having precisely similar characteristics is built into the indicator (Fig. 6), the air gaps in this unit being

Fig. 5.—An electrically-indicating torsionmeter in position on a shaft.

Fig. 6.—Exterior view of indicator.

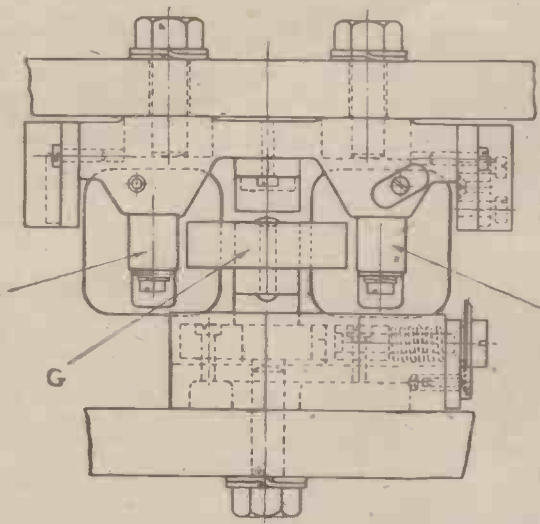


Fig. 8.—Arrangement of indicator and transformer on shaft.

altered by the operation of a screw micrometer, the latter having an indicating drum to register the screw's movement.

Operation

The operation of the layout is as follows: Primary coils on the cores of both transformers are excited in series by current—taken from ship's mains or shop circuit, as the case may be—interrupted by a motor interrupter "J" situated in the indicator, Fig. 9, the interrupted current producing an alternating EMF. in the secondary coils of the transformers. The latter are connected in opposition to each other, from which it follows that if the two sets of air gaps of each transformer are equal, no current will flow in the secondary circuit. This is the condition when the shaft is free from any torsional load. A second interrupter "K," operated by the same motor, cuts out one-half phase of the secondary current, and a small D.C. galvanometer "L" indicates when current is flowing.

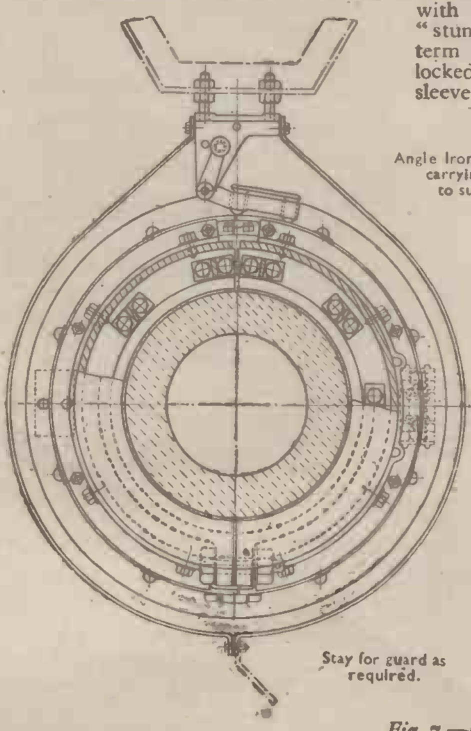
When the shaft is transmitting the drive, the air gaps of the transformer on the shaft will vary, and the EMF. of one secondary coil will be reduced, the other being increased, thus permitting a flow of current which moves the galvanometer pointer off the zero position. If by means of the micrometer screw already referred to the air gaps of the transformer in the indicator are changed to oppose an equal and opposite EMF. to that given by the shaft transformer, current will cease to flow, as will be apparent by the galvanometer pointer returning to zero. The two transformers being alike, it is obvious that the alteration which has been made in the air gaps of the transformer in the indicator must be the same as that which was set up on the shaft transformer, and is therefore a measure of the twist produced in the shaft. This movement of the micrometer screw, as indicated on the drum provided, by means of a constant obtained either from a torsional callibration or by calculation, can express the torque producing the twist, and this, in conjunction with the r.p.m., will yield the shaft horsepower. The apparatus is of so sensitive a nature that alterations of torque can be measured with an accuracy of ± 0.25 per cent.

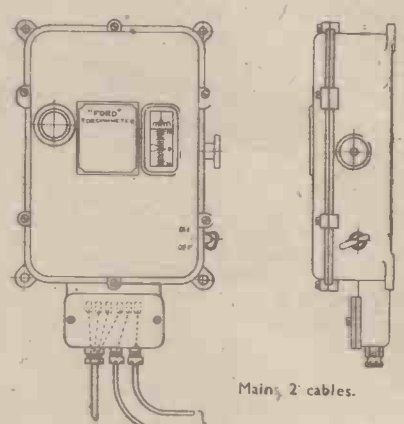
Direct-vision Torsionmeter

A third type of instrument is the Denny-Edgecombe Direct-vision Torsionmeter, which is a straight mechanical instrument giving readings by an unusual optical arrangement. The general scheme is shown in Figs. 10 and 11. In this design the usual sleeve S_1 is carried co-axially on the shaft, one end (that on the observer's right hand in Fig. 10) being secured to the shaft, while the opposite end is free to rotate in spigot and socket relation with a second short sleeve—or "stump" S_2 as the makers term it—the latter being also locked to the shaft. The long sleeve and also the stump are each provided with radial arms, one of the arms on the stump carrying a motion-multiplying gearbox M with scale and index finger. This gearing connects with the radial arm of the sleeve by means of a stout balanced link, so that any relative angular movement of the radial arms is indicated in a magnified measure by the movement of the index finger over the scale.

In an earlier design of this instrument, in order to facilitate the reading of the index finger on the scale, the finger was arranged to move a contact over the face of a rheostat, so varying the resistance of an electric circuit in such a manner that the pointer of an indicating instrument included in the circuit deflected correspondingly with the index finger of the gearbox M. This involved the provision of an electrical supply, a specially devised ammeter to serve as an indicator, slip rings on the torsionmeter with, of course, the necessary brushes, and a rheostat device operated by the index finger of the motion magnifying gearbox.

By the employment of a novel optical device it has become possible to eliminate the whole of this electrical apparatus, and to read the position of the index finger on its scale during rotation. To this end the stump carries a disc D, which supports a lens L in axial register with the index finger and scale of the gearbox. The whole is enclosed by a stationary housing H suitably attached to the ship's structure, while in the end face of the casing several inspection openings are provided. On looking through any one of these apertures the index finger





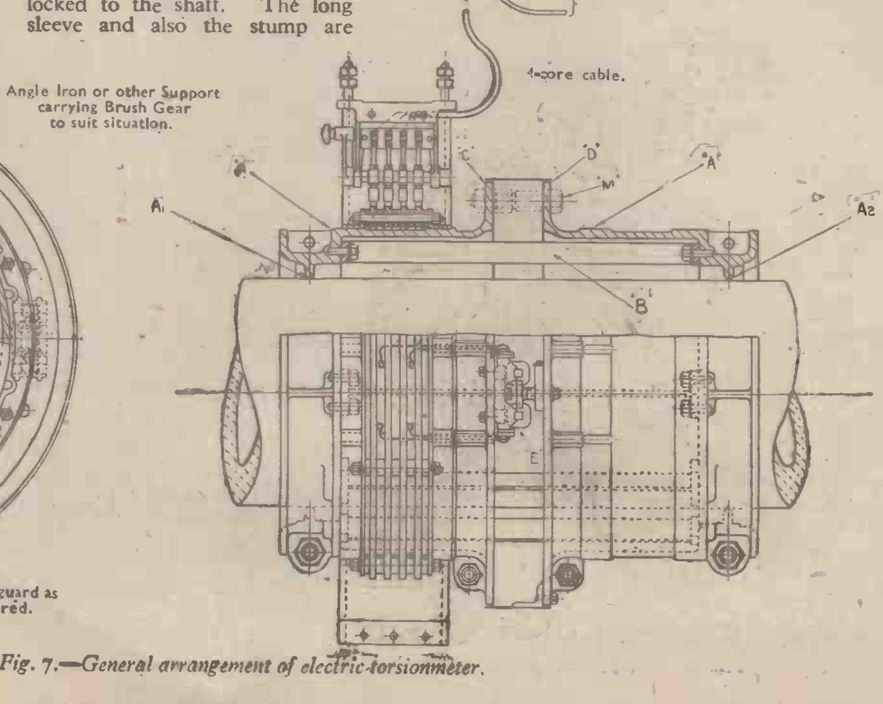


Fig. 7.—General arrangement of electric torsionmeter.

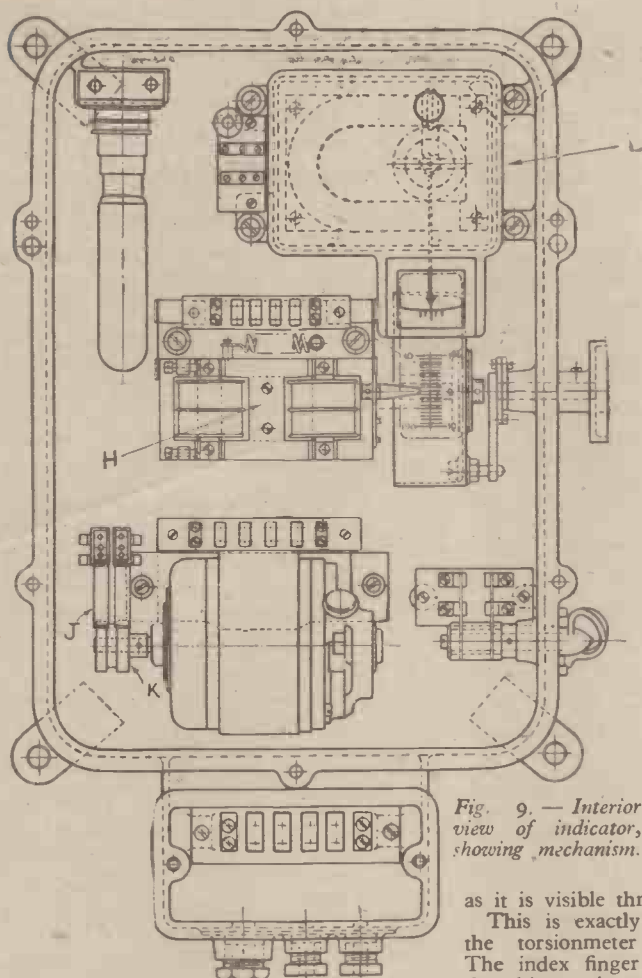


Fig. 9. — *Interior view of indicator, showing mechanism.*

is seen to be stationary, and its position in relation to the scale is easily observed at all speeds, notwithstanding the fact that the impression made on the observer's eye is not continuous.

Optical Principle

In the above scheme a simple yet novel optical principle is employed, which ought to be touched upon briefly at this stage. Fig. 12 shows an observer sighting a coin or washer down a piece of tubing (solely employed to confine his line of vision to a definite direction) whose bore is practically equal to the size of the object. Between the lower end of the tube and the coin is a reading glass mounted on a frame which also supports the coin, the frame with glass and coin being capable of lateral displacement relative to the sighting tube, and, therefore, across the line of vision. So long as any portion of the glass remains under the bore of the tube, however, the coin will appear to the observer to be centrally disposed; in other words, if the object be seen by an observer through a magnifying lens located at its focal length from the object, and if the object and lens move together across the line of sight of the observer, the object will appear to be stationary so long as it is visible through the lens.

This is exactly what occurs in the torsionmeter under review. The index finger and scale form the object. At a suitable distance from the scale a collimating lens is housed. Once during each revolution the lens and object traverse the observer's line of vision as described above, the object itself appearing to be static during the whole transit period. To assist in reading the scale, which, incidentally, is suitably illuminated, the vision is sharpened by the insertion of a slot diaphragm between the lens component, the slot being radial to the centre of the shaft.

The writer expresses his thanks to Messrs. Siemens, Brothers & Co., Ltd., for the privilege of using their illustrations for Figs. 1 to 9 inclusive, and to Messrs. Kelvin Bottomley & Baird, Ltd., for Figs. 10, 11 and 12.

Fig. 12.—*View illustrating optical principle of torsionmeter.*

Progress in Jet-propelled Aircraft

IT is reported that Allied aircraft in the European theatre have been in action on several occasions with German jet-propelled fighters. The appearance of these aircraft had been expected, and their design and operational characteristics appear to follow closely the estimates which had been formed of them. In spite of their high speed and rate of climb, they have shown themselves to possess poor manœuvrability, and our aircraft have had satisfactory exchanges with them in the engagements that have occurred.

It must, however, be expected that increased numbers of jet-propelled aircraft will appear in service.

Meanwhile, we are able to report that the development of British and American jet-propelled aircraft has made considerable progress since the beginning of the year.

Details of these aircraft and their engines still remain secret, but research scientists, aircraft technicians and workers in both Britain and America may take pride in their work. British aircraft of this type have already been employed with success against the flying bombs.

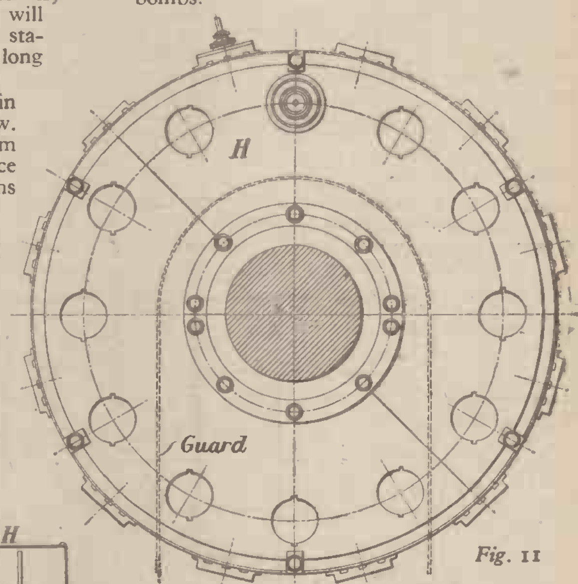


Fig. 11

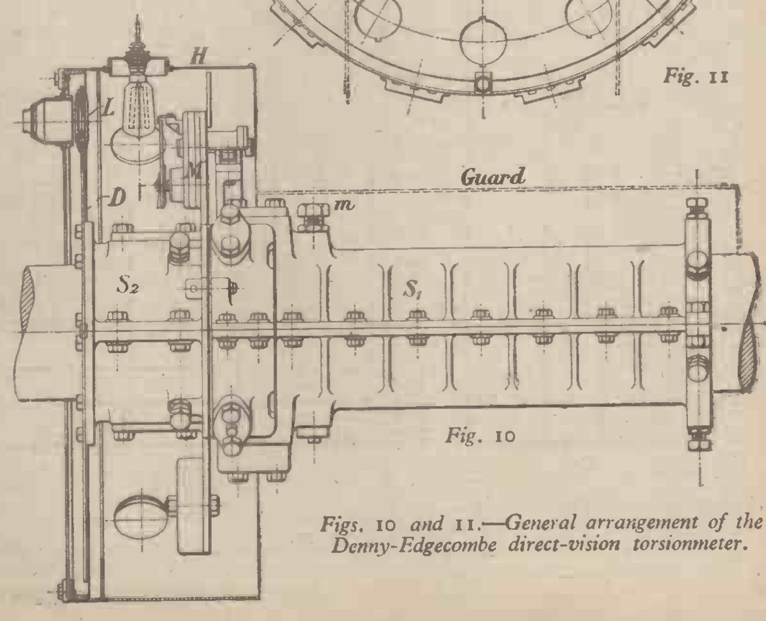


Fig. 10

Figs. 10 *and* 11.—*General arrangement of the Denny-Edgecombe direct-vision torsionmeter.*

Sound-film Recording and Reproduction

Questions and Answers

By DONALD W. ALDOUS, M.Inst.E.

FOLLOWING the publication of an article dealing with sound-on-film amplifier designs (October, 1943, issue), with particular reference to practical circuits for use by sub-standard "talkie" enthusiasts, the author received a considerable number of queries from readers seeking further information on various points mentioned in the article, as well as many inquiries on general sound-film matters. These letters have been answered directly, but in view of the widespread interest in this subject to-day, a selection of the more important questions, with expanded and illustrated answers, is given below for the benefit of other amateur workers in this field.

Q. *"What is the 'Donner effect' in sound-film recording?"*

A. The so-called "Donner effect" is the German term (derived from *donner*, meaning thunder), given to a form of non-linear distortion in sound-tracks recorded by the variable-area method. It is a photographic rectification effect, and is due to the uneven filling-in of valleys and cutting-off of peaks of high-frequency waveforms. The effect is a function of gamma and density of negative and positive, and by correctly determining these factors, minimum distortion may be obtained.

Q. *"I recently came across the term 'shredded wheat' in an article; can you tell me its meaning?"*

A. It is a colloquial term applied to film which has been damaged by running off the sprocket wheels in a projector or camera!

Q. *"Regarding amplifier noise: what are 'Johnson noise' and the 'Schottky effect'? Are these different names for the same phenomenon?"*

A. Briefly, "Johnson noise" is due to thermal agitation of electrons in a grid circuit, and the "Schottky effect" is valve noise caused by the arrival of electrons, emitted by the cathode, in finite groups at the anode. These are not different names for one and the same phenomenon, although both are of a similar fundamental nature, and show themselves as a high-pitched rushing sound or the so-called "background noise" in reproduction. The former name is after J. B. Johnson, of America, who first referred to its existence and measured its magnitude. It limits the possible amplification.

W. Schottky first indicated the source of noise arising from the electron stream within a thermionic valve, due to a fluctuation in the anode current stream, and so it is sometimes referred to as the "Schottky effect." It is also known by the German designation "schrotteffekt," but is more often called the "shot effect," because of the similarity to small shot (electrons) pattering at random on the target (anode). Under normal working conditions in a valve, the thermal agitation voltage on the grid is usually sufficient to swamp the "shot effect." The sound energy is equally distributed over the frequency spectrum so that reducing the top cut-off frequency of a system from, say, 10,000 c/s to 5,000 c/s halves the background noise energy, as reproduced. This explains why the noise sounds "toppy," because with a 10,000 c/s cut-off 90 per cent. of the noise energy is above 1,000 c/s.

Q. *"In some circuit diagrams for sound-film amplifiers a variable photo-cell voltage control is shown, e.g., in Fig. 6 of your article in October, 1943,* PRACTICAL MECHANICS. *Surely the p.e.c. should operate only at a certain specified voltage, and can a voltmeter be used to determine this correct voltage?"*

A. The advantage of the p.e.c. voltage control is that, although many photo-cells work nominally at 90 volts, the manufacturer's instructions with each cell should be followed, and a variable control is useful in obtaining the required figure. For example, Osram (G.E.C.) photo-cells are marked by the makers with the exact voltage at which the cell has been found to give optimum output.

In practice, most photo-cells operate at their best at a voltage just below that which produces a blue-glow in the tube, sometimes loosely termed "flash-over." No damage to most photo-cells will be caused by this blue-glow effect, provided it is only momentary and it must not be permitted to continue for any length of time. Although some p.e.c. manufacturers advise against the following method of checking and fixing the cell voltage, it will be found to be the simplest and most convenient way. First increase the potentiometer setting very gradually until a faint bluish haze is seen in the cell, when the cathode is illuminated with the full normal scanning-beam. This glow indicates ionisation, and with most photo-cells produces noisy and distorted sounds in the loudspeaker. Now slowly turn back the potentiometer control until the glow just vanishes,

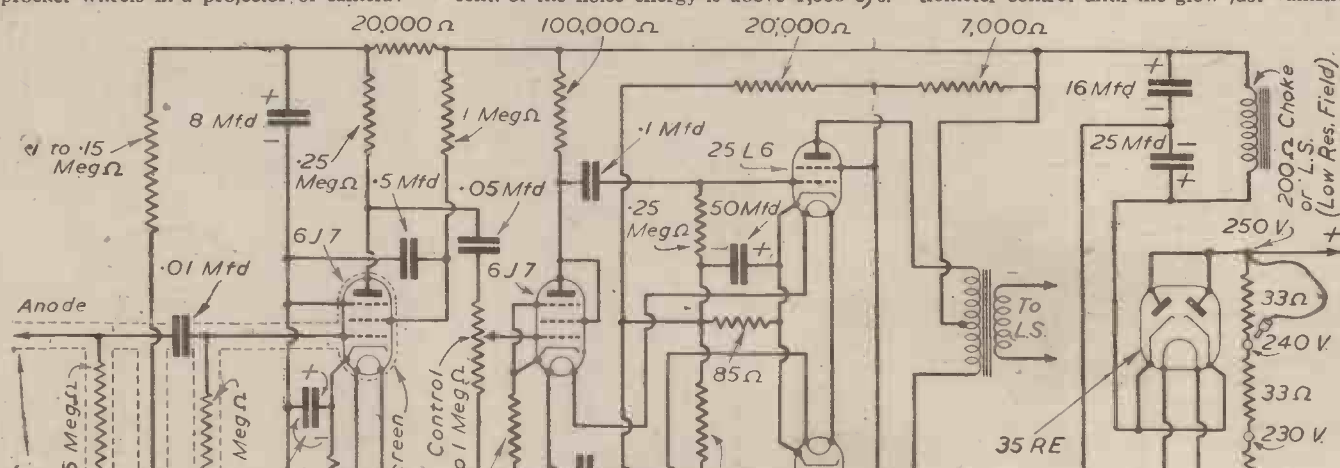


Fig. 1.—Complete circuit diagram for A.C./D.C. sound-film amplifier, giving approximately 10 watts output. The 200 ohms choke should be of as high inductance as possible, and capable of handling 100 mAs. Electrolytic condensers are indicated by the usual plus sign on the positive side. Condenser working voltages should be 400, except, of course, the biasing electrolytics.

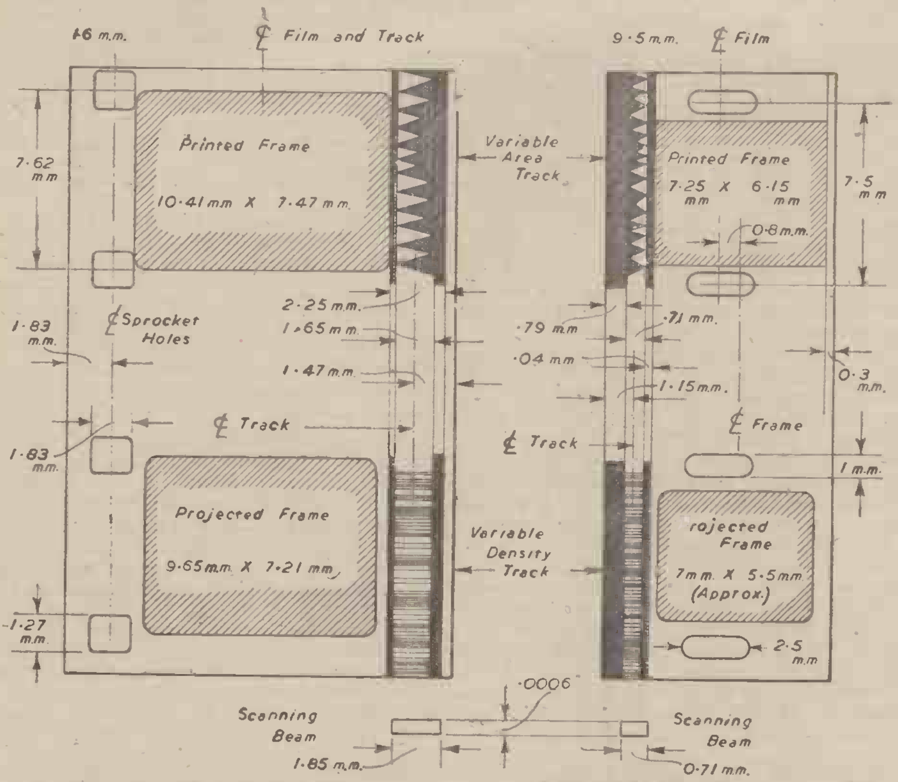


Fig. 2.—16 mm. and 9.5 mm. sound-film dimensions. The variable-area (width) track illustrated is of the simple unilateral type. In both standards the picture is upside-down.

and this is the point of optimum sensitivity, and may be regarded as a satisfactory working voltage. It will provide the maximum stable output from a given scanning-beam.

To obtain precise figures for such voltages, the only voltmeter that could be used is a valve-voltmeter, but an approximation may be made by calculating the ratio of the "upper" (fixed) and "lower" (variable) sections of the potentiometer circuit, and applying this proportion to the H.T. value, which can, of course, be read accurately with an ordinary high-resistance voltmeter. For instance, if the 0.5 megohm potentiometer (linear-law type) was at its mid-position, and 300 volts H.T. were employed, the proportion of this applied to the cell would be in the same ratio as 0.25 megohm to the total of 1 megohm, i.e., one quarter, or 75 volts. This figure would have to be slightly reduced to allow for the photo-cell current, which, however, is minute.

If only 200 volts H.T. were available, it would probably be necessary to use only a 0.25 megohm fixed resistor (and not the 0.5 megohm resistor in the original circuit), as some photo-cells run at considerably higher polarising voltages than 75 to 90, reaching in some specimens as much as 130 volts. Of course, the 2 megohm p.e.c. "load" resistor should not be altered because of the lower H.T. voltage.

Q. *"To save space and weight of mains-transformer I would like to use a 'universal' amplifier in my sound-film equipment. Can you suggest a suitable design?"*

A. A compact AC./DC. amplifier, with a careful lay-out and construction, is useful for sound-film work, and a suitable circuit (8-10-watt output, when used in conjunction with a high-wattage exciter) is shown in Fig. 1. Variable photo-cell voltage control (as mentioned in the previous question) can be incorporated when coupling the cell to the first valve (6J7), or the cell can be coupled direct to the two points indicated in the diagram, which circuit provides a fixed polarising voltage. Ample ventilation is needed for the power resistor, which preferably should be a vitreous wire-wound type, and not a length of "line-cord resistor." A permanent-magnet loudspeaker can be used, with 200 ohm choke smoothing, as shown in Fig. 1, or a mains-energised loudspeaker (with a low-resistance field, i.e., not more than 500 ohms) can be substituted in place of this choke. It must be remembered that, under certain mains supply conditions, the chassis of this type of amplifier may be "live," and so it should be properly protected by wooden or other insulating material. Earthing must be done *only* through a 0.01 to 0.05 mfd. (V. working) condenser.

Q. *"What is the meaning of S.M.P.E. and D.I.N. standards, and is there any difference between them?"*

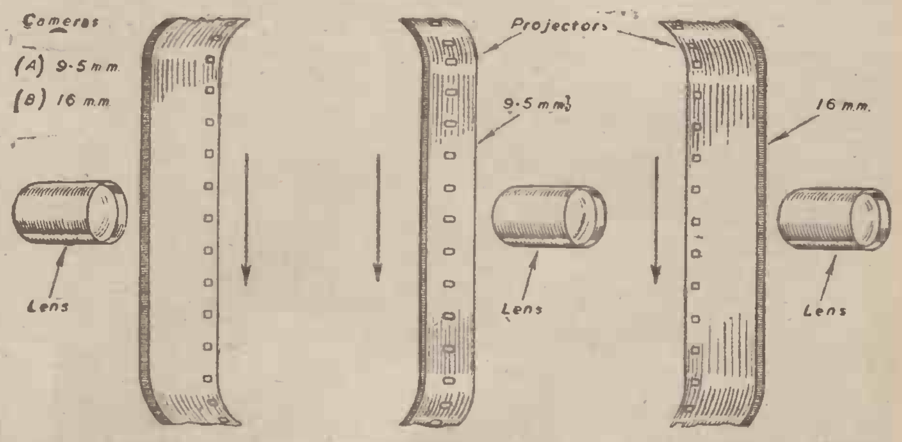
A. Sound-film in the 16 mm. gauge has sprocket holes down one edge of the film only (see Fig. 2), as the space normally occupied (in 16 mm. silent film) by the second set of perforations is used to accommodate the sound-track. In the American Society of Motion Picture Engineers' standard (S.M.P.E.) the sprocket holes are along the right-hand side of the film, when viewed from the rear of the projector, and in the Deutschen Industrie Normen standard (D.I.N.) they are on the left-hand side, as seen from the rear of the projector.

Obviously there is an important difference in those standards, and how the discrepancy arose is a complicated story. Briefly, in 1932 certain standards for 16 mm. sound-film were laid down by the S.M.P.E. in the U.S.A. However, a British projector manufacturer and the German Siemens-Halske firm had introduced 16 mm. sound projectors in which the film was turned round from back to front to produce the standard subsequently agreed to be known as D.I.N., following a discussion by British and German projector designers in 1933. Thus the two standards were in widespread use at the same time, but the D.I.N. standard did not drive the S.M.P.E. standard from the British market, and, in fact, this confusion seriously retarded the use of 16 mm. sound-films in this country. In 1936, following arbitration, the S.M.P.E. standard was finally accepted as the only standard for educational purposes, and is now universal.

Of course, many D.I.N. standard sound-films are still in existence, and it is possible to use both types of film on one projector by the addition of a large prism (or even a mirror), which must be fitted in front of the projection lens in order to reverse the titles, when the film is being projected of the opposite standard for which the machine was originally designed. When this method is adopted it is necessary to place the projector at right angles to the screen instead of the normal "facing" direction.

Q. *"Precise figures for the dimensions of 9.5 mm. and 16 mm. sound-tracks, size of picture-gate, scanning-slit measurements, etc., do not seem to be readily available. Information on these dimensions, etc., would be very helpful, particularly to experimenters wishing to convert silent projectors to sound."*

A. It is not easy to offer accurate information, and precise dimensions, for sub-standard sound-films, as not every projector



9.5. mm. : Emulsion towards lens. Sound-track opposite to 16 mm.
16 mm. : Emulsion towards lens. Sound-track as shown.

Amateur Films : Emulsion to lens for reversal stock (refocus sound-head). Away from lens for negative position. Stock only.

Library Films : Emulsion away from lens. Sound-track "outside," as shown.

Fig. 3.—Sub-standard sound-film emulsion conventions, showing correct orientation in cameras and projectors.

manufacturer has rigidly observed the official standards, and there is often a diversity of opinion on such matters as: (a) the "thickness" or "height" of the scanning-beam, and (b) the exact width of the 16 mm. sound-track, arising from the fact that there are three important dimensions, viz., printed width, scanned width, and modulation width.

However, a chart has been prepared (Fig. 2) giving all the known dimensions, in most instances, to the nearest hundredth of a millimetre. It is customary to give these figures in fractional thousandths of an inch, but for the average amateur worker it has been found that these metric figures are more convenient. They will serve as a practical guide in the construction of a sound-head.

Of course, "working" dimensions to the nearest tenth of a millimetre (e.g., the 9.5 mm. printed frame, 7.25 mm. by 6.15 mm., becomes 7.3 mm. by 6.2 mm.), can be substituted for the more accurate dimensions shown in Fig. 2, if one wishes to employ only the naked eye in reading a fine engraved rule, or with the aid of vernier callipers rather than a micrometer.

Fig. 3 illustrates correct orientation of 9.5 mm. and 16 mm. sound-films (S.M.P.E. standard) in cameras and projectors. The following relevant facts will also be found to be useful: Normal speed of 16 mm. sound-film, 36ft. per minute. Length of sound-track scanned in one second, 7.1in. (9.5 mm.) and 7.2in. (16 mm.). Number of frames per foot in 16 mm. sound-film is 40 and in 9.5 mm. $40\frac{2}{3}$, which small difference should be noted when, say, making sound-sockets. 16 mm. and 9.5 mm. sound is $25\frac{1}{2}$ frames ahead of the corresponding picture, or approximately $7\frac{1}{2}$in. of film. (Actually there is a small tolerance, so that two to three frames on either side of the exact position is rarely detectable aurally as being slightly out of synchronism.) Manufacturers' tolerance in total film width is minus 0.002in., plus zero.

Q. *"I have been told that a film worker in America has successfully recorded sound on 8 mm. cine-film. Is this true?"*

A. Yes, Louis Borchert, an amateur film enthusiast, of Maryland, U.S.A., after seven years of abortive efforts, has certainly put a sound-track on the edge of 8 mm. film, but the technique is still in the experimental stage, and reports on the reproduced quality say it is barely above the intelligible level. He has sold his process to a leading American firm of camera manufacturers, so developments may be forthcoming.

Q. *"What is meant by a 'single-system' recorder? Is this the type of equipment employed professionally?"*

A. "Single-system" simply means that both picture and sound-track are initially recorded on a single length of film in a combined sound-picture camera. Its advantages are compactness and portability of the equipment, as well as automatic synchronism, but its chief disadvantage is when the completed film has to be edited. (An interesting example of this type of apparatus, designed for amateur use, was the R.C.A. 16-mm. sound camera, available in this country before the war at about £100.) This equipment is used to some extent for newsreel work, but hardly ever nowadays in the professional studios.

Q. *"I recently heard a projectionist use the word 'azimuth.' What does it mean?"*

A. This is the term used to indicate the squareness of the scanning-slit in relation to the sound-track. This optical adjustment has to be carefully performed, or generally a loss of treble response will result.

Q. *"What is the difference between 'wow' and 'flutter'?"*

A. A fundamental requirement of all sound-film equipment is that the film medium must be propelled at an absolutely constant speed past the scanning point. Any marked departure from this criterion, whether in recording, re-recording, or reproduction, will produce "wow" or "flutter," which can be defined respectively as slow-speed variations made audible as pitch (frequency) variations, and speed variations too rapid to be heard as individual pitch variations, but responsible for harsh, discordant sound caused by the production of sum-and-difference tones.

Robot Bomb Secrets

IT can now be stated that the flying bomb was designed to hit the ground with the engine running. The cutting out of the engine just before the dive, which gave such effective warning of imminent danger, was never intended by the designer. This feature, which probably saved hundreds of people's lives by enabling them to take shelter at the last minute was, in fact, completely accidental.

These conclusions have been reached by British aeronautical scientists who, since June, have been investigating the secrets of the robot bomb at the Ministry of Aircraft Production Experimental Station.

The engine is much cheaper to produce than an ordinary engine, but it consumes fuel at about eight times the rate. The bomb is aimed entirely by pre-setting the automatic pilot which corrects any deviations from the course.

In the nose is a "windmill," with two blades each nearly 6in. long, which determines the distance to be travelled. It revolves under air pressure and the revolutions are counted by an electrical counter operating from a contact on the shaft.

The counter is set so that after a definite distance the bomb is pushed over into a steep dive by locking the controls and putting down small tabs under the tail plane.

Approximately 3 per cent. were fitted with a minute radio transmitter and short trailing aerial. The transmitter was switched on automatically in flight and sent out a continuous stream of radio signals which could be picked up by two enemy receiving stations. In that way the Germans hoped to be able to plot the course of the bomb after being launched,

(Above) A close-up of a flying bomb showing the grill which incorporates the petrol injection jets. On the left is one of the spherical air bottles.

(Left) One of the flying bombs which was shot down over Southern England. Fighter pilots from a nearby airfield are examining the wreckage to discover its vulnerable parts. The tail is in the foreground.

Colour Photography—1

A Brief Résumé of Its History and Development

By JOHN J. CURTIS, A.R.P.S.

EVEN the best and most expert of us amateur photographers have experienced disappointment when viewing our monochrome prints from some of our most perfect negatives of scenes and landscapes; we used every possible care to secure accurate exposure and correct development, and as black-and-white prints they were all that could be desired. The gradation was good and the composition was satisfactory, but there was something lacking, and, after considering all the details, we are obliged to admit the fact that when we made those exposures we were influenced and attracted by the colouring in the scene; we failed to visualise how it would look when all the colours and tints were cut out.

We should reduce the number of such disappointments if we adopted the simple plan of many of our early photographic pictorialists to carry a piece of smoked glass in order to view each landscape or other subject as a black-and-white scene. How often have we expressed a wish to reproduce a scene exactly as we see it with all that harmony of colour with which nature has painted it, and how frequently have our friends suggested the same thought when looking at our results?

Why is it that colour appeals so much to everyone?

Colour gives life; do away with it and everything becomes drab and uninteresting, and so it is only natural that human beings are attracted and influenced by it. I am sure that Wedgwood, Fox-Talbot, Daguerre and all the early pioneers, when they were making experiments to produce sun pictures, had the desire and hoped that sooner or later they would strike a means whereby colour could be reproduced in the silver image, and there is no doubt that much scientific thought was given in order to solve the very difficult and many-sided problems connected with colour work. It was actually between thirty and forty years before any practical solution was found, and this seems to prove that "the way was long and full of traps and pitfalls" before anything really definite was accomplished, as you will understand from the following brief history of the progress that has been made and which extends over a period of seventy years.

In giving an historical résumé of the progress and developments which have occurred we may be able to indicate how the best brains have tackled the difficulties, also to give details of their work in a way which will help you to gain some knowledge of the fundamentals of the various branches or processes required before a colour transparency can be made; but it is necessary before taking up colour work to understand something of the highly technical character underlying it all; it is not such a simple subject as would appear, and you are therefore advised to read some of the books which have been written by men who have made a scientific study of it.

Clerk Maxwell

It was in 1861 that Clerk Maxwell evolved the theory that the whole of the spectrum colours could be produced by three primary colours or by a mixture of them. In 1868 a French scientist, du Hauron, made use of this idea using the three primaries—red, green and blue—to reproduce photographically not only these three, but also the intermediate colours. His success would appear to have started the principles of colour photography as we know it to-day.

Before going farther with the history let us consider this three-colour theory so as to get a little idea of its whys and wherefores. Most of you know that white light is produced by a mixture of the violet, blue, green, yellow, orange and red rays of the spectrum; if the violet and blue are cut out an effect of yellow is obtained; if green is eliminated from the spectrum, then magenta is formed, and if red is extracted the remaining colours will produce a blue-green. To put this in the simple language of the printer, it becomes:

Minus violet and blue = yellow.
Minus green = magenta.
Minus red = blue-green.

Suppose now we make three different negatives of the same coloured subject, one taken through a blue-violet filter, the second through a green, and the third through an orange filter, we shall have a record of the primary components of the subject. If we proceeded to make prints from each of these negatives by means of the carbon or similar process, we should lay down the one from the blue-violet first, then superimpose that from the green, and finally that from the orange filter; the result will prove to be a combination of the colours of the original. It may not be possible for you to make this experiment, but if you will examine through a magnifying glass a coloured illustration in a magazine you will find that it is composed of dots; some yellow, some magenta and others blue.

Further Advances

We must now skip over a few years during which some little progress was made, but the greatest help was when plates were produced that were sensitive to red and green rays and were more rapid. It was then possible to develop three-colour work, and towards the end of last century Professor Joly and an American named McDonnough, about the same time, struck a new way of applying the three-colour theory; they ruled glass plates with very fine red, green and blue transparent lines. These plates were used in contact with panchromatic plates; when an exposure was made on a colour subject, a monochrome negative resulted, and from this a positive transparency was produced which was, after being dried, placed in contact with another of the ruled plates, and when viewed by transmitted light proved a very fine example of a coloured transparency. The cost of making the screens prevented this process reaching popularity, but it has never been lost, for it has been adapted and improved by other workers.

A great sensation was caused in 1907, when the Lumiere Autochrome plate appeared, a very advanced adaptation of the three primary colour theory, making it possible for a photograph in colours to be taken with any plate camera. The Autochrome plate was coated with a colour screen consisting of fine starch grains dyed to the primary colours and carefully scattered on to the carrier base so as to be properly proportioned in the distribution of the colours. The processing of these plates was somewhat complicated, though very interesting to the studious or careful worker; after development the image had to be reversed to obtain a positive, and when this was completed and the plate dried the result was a perfect representation of the coloured subject. To appreciate the full value of the Autochrome it must be remembered that the colour screen of the three essential colours was embodied in the emulsion of the plate and remained a fixture for both the taking and viewing.

The Thames Plate

The next on the list was the Thames plate, with a separate screen plate ruled with fine lines so that the colours appeared as minute squares; this had to be used in contact with a colour sensitive plate when the exposure was made and then a transparency or positive produced from the negative. The positive was then very carefully brought into register with another of the screens and bound as when finishing a lantern slide. The new "separate" method had a very favourable feature: it enabled as many transparencies as desired to be made from the original negative, whereas the "combined" idea of the Lumiere Autochrome plate, by virtue of the screen being embodied in the plate, restricted it to the one only.

An improvement in these plates was made when the Paget Co. took over the Thames process. They were able to produce screens of greater transparency, thus enabling more rapid exposure. This improvement was further extended when it came on the market as the Duplex, and later still as the Finlay.

In 1923 the German firm of Agfa produced a plate of the "combined" type, but, instead of the dyed starch grains and the filling of the interstices with a black powder as adopted by the makers of the Autochrome plates, they used gum granules and no filling.

In 1932 the Autochrome Co. gave us a coloured film, and later they were producing the Lumicolour Roll Film. In two years this was followed by the Agfacolor Roll Films and Film Packs, and about this time the Dufay and the Kodacolor Films appeared, both of which are a great advance in what we term colour photography, enabling all serious amateurs to indulge in this most absorbing branch of our hobby.

This brief account is sufficient to show that the reproduction of colour by means of the camera has been studied by some of our best experts in this department of science, extending over many years and requiring large money for experimenting and the laying down of suitable plant. It is a big subject having huge possibilities, and not the least of these is the fact that it will permit us to take our landscapes and other scenes as our eyes see them and not as the camera used to record them in black-and-white.

(To be continued.)

THE WORLD OF MODELS

By "MOTILUS"

The Fascination of "Tinycraft"

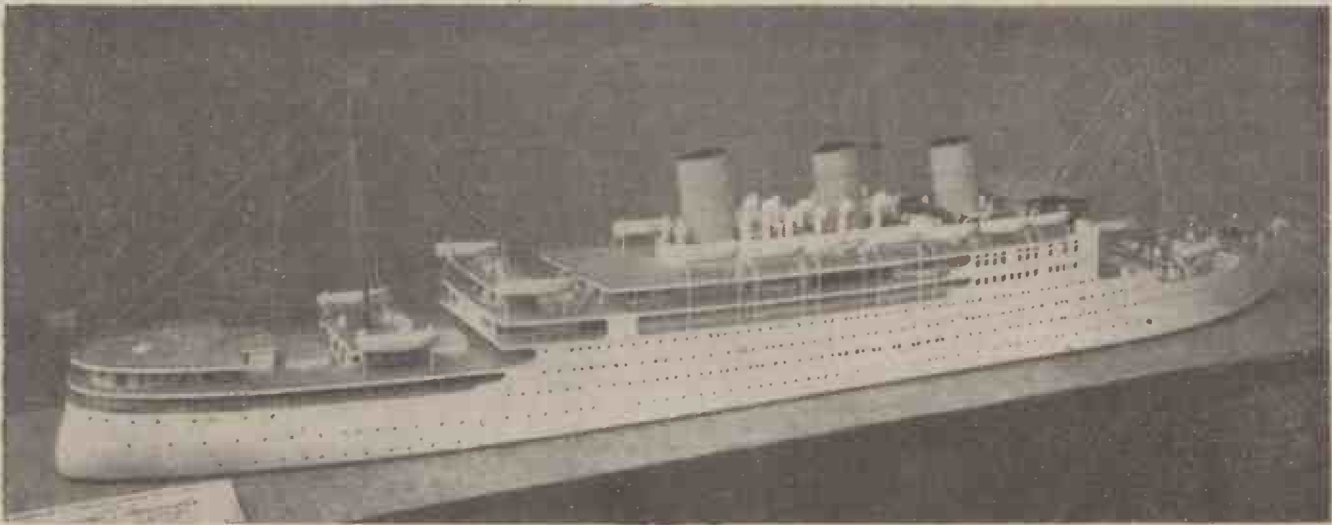


Fig. 1.—Waterline model approximately 5ft. long of the P. & O. liner "Strathaird." This model was made to send to America to familiarise the American travelling public with the fine steamers used by this company on their various services, particularly that to India.

It is not known who made the first waterline model, but as far as the British public is concerned I believe the first real display of this type of model ship was on view at the United Services Exhibition held in the year 1913 at Earl's Court, London, when the whole of the then World Navies were featured in the form of miniature waterline vessels. Each individual warship was built to the scale of 100ft. to one inch or 1/1200th actual size.

What is the precise meaning of the term "waterline model"? It indicates that the model in question shows all that is to be seen of a ship when it is afloat, the part of the hull below water being left to the imagination of the onlooker.

This is really a more natural method of showing a ship to the average person, who is not interested in the hull lines, the shape of the rudder or the style and pitch of the propellers.

The purchaser of a house, when looking at a model, does not expect to see the foundations that are in the earth, although they are of major importance to the architect and the builder.

So it is to-day with the voyager (or should I say would-be voyager waiting for the war to end!).

Most models of ancient ships in museums are full-hull models, and this is probably because in earlier days the model was used as a guide to the owners when discussing any problem connected with ship design. In fact, it was part of the contract when a ship was being built that the shipbuilders should supply the customer—the ship-owner—with a ¼in. to the foot full-hull model of the ship, and this model was generally displayed in a prominent position in the offices of the shipping company.

Just prior to the outbreak of war the full-hull model was losing ground to the modern idea of the waterline model, in the offices of shipping companies and touring agencies. It became generally recognised that this was how the voyager preferred to see the ship he was expecting to travel in, apart from the undeniable fact that the waterline type of model is less expensive than the full-hull vessel.

Fig. 4.—Great Lakes steamer, with stern wheel drive, scale 25ft. to 1in.

Waterline Models of P. and O. Liner

An example of this type of publicity model is shown in Fig. 1—a commercial model made for publicity purposes of the Peninsular and Oriental Line "Strathaird"—approximately 20,000 tons with turbo-electric drive. The model is ⅛th scale and is made in exhibition finish, showing all deck fittings made in gunmetal and brass and painted in their true colours. The decks are lined and polished and the model fully rigged, and the bridge details, such as binnacles, compass, etc., are visible through the side windows of the chart house.

To return to the small waterline model, which craftsmen and connoisseur alike find so fascinating; this became of vital use in the 1914 war, when waterline models of

Fig. 3.—An example of wartime miniature ship modelling—the "King George V," 50 ft. to 1in.

warships were used both by ourselves and the enemy for identifying ships at sea.

Between the Great War and the present world struggle waterline models of the Mercantile Marine were developed, and many a great passenger liner at sea carried a selection of "Tinycraft" models aboard her to be sold as souvenirs. And nostalgic voyagers would often bring home to their "bric-à-brac" cupboards an essential reminder of their trip in the form of the tiny model ship in the place of honour there.

Models for Identification Purposes

During the present war waterline models have been utilised not only for identification purposes at sea, but also from the air. It has also been necessary to familiarise fighting men of land, sea and air with the new types of landing craft and surface vessels for amphibious operations, and before D-Day models of the various types of landing craft were made, and other new war craft which would be novelties to the most seasoned seaman.

Fig. 6.—The World's Ocean Giants. The perfection of Tinycraft depicted by a representative set of the finest pre-war ships in the world's mercantile marine, compared with Christopher Columbus' famous sailing ship, "Santa Maria," pioneer of Western Ocean crossings.

Fig. 5.—Great Lakes grain carrier, scale 50ft. to 1in.

The making of waterline models is a phase of model making that the war has failed to check, in fact, quite the opposite has occurred. The material required is small. Practically no metal is required for their construction, and their painting in wartime colours presents no difficulties to the novice. This hobby has been further developed in wartime by the War Savings Committee of London, who issue quite a big series of drawings with working instructions on how to build all types of wartime vehicles and weapons, aeroplanes, tanks and warships. As I have mentioned before in these pages displays of models made from such drawings have been a feature at the various war-savings weeks.

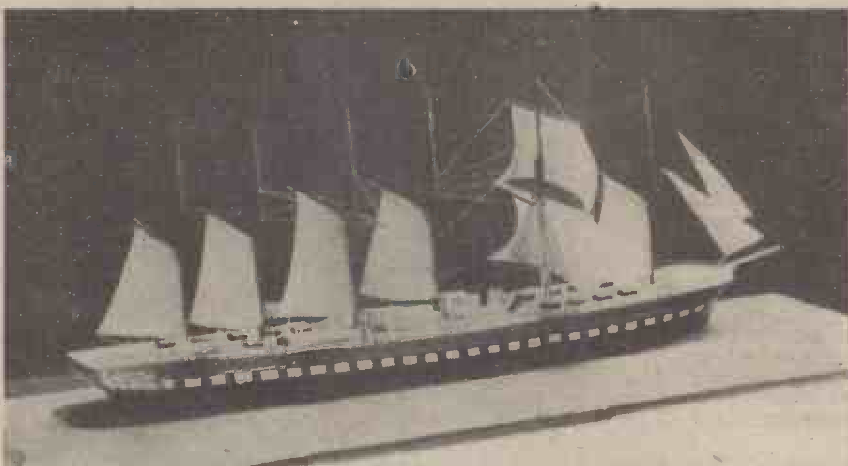


Fig. 2.—50ft. to 1in. model of the "Great Britain," a historical model, which, in peacetime, was available as a set of finished parts.

Let us hope it will not be long before the firms who provided sets of parts cut out and ready for assembly will be able to do so again. Certain firms, I notice, are already providing a limited number of finished parts, made from scraps of the best quality wood obtainable in wartime.

Made from Finished Parts

The model "Great Britain," illustrated in Fig. 2, was built up from a set of finished parts available in peacetime, a very interesting piece of craftsmanship for the modeller who is also an historian. The painting of the hull and the rigging and setting of the sails call for ingenuity and an artistic touch.

Fig. 3 shows a good example of warship modelling of this war—a model King George V, scaled at 50ft. to the inch. Other examples of special model war work are to be seen in Figs. 4 and 5, the first of a Canadian Great Lakes steamer, a familiar sight, with its stern wheel drive, on the Great Lakes of N. America, the second a Great Lakes grain carrier. Both these models measure 10½ins. long, the first built to a scale of 25ft. to the inch, and the second to a scale of 50ft. to the inch. They are two of a special series of models made for a Canadian exhibition sponsored by the Ministry of Information.

Miniature Models of Pre-War Liners

Last of our illustrations shows a group of the world's famous pre-war ships, by Bassett-Lowke, Ltd., excellent examples of the amount of detail that can be obtained with the scale of 100ft. to 1in. Reading from right to left they are the famous Cunarder "Mauretania," which held the Blue Riband of the Atlantic for nearly a quarter of a century, the Italian liner "Rex," which held the record for a short period, the North German Lloyd "Bremen," which wrested the Blue Riband from the "Mauretania," and held it until beaten by the French liner, "Normandie." Last of the large ships is the Cunard-White Star "Queen Mary," which at the outbreak of war was in possession of the Blue Riband. After the war when the "Queen Elizabeth" officially enters the Western Ocean passenger service, we may expect this latest of British liners to become the new record breaker. On the extreme left of the picture is to be seen the "Santa Maria" ship of Christopher Columbus (pioneer of Western Ocean crossings!) made to the same scale as the other models shown in Fig. 6.

Transport Aircraft's Thirty Thousand Miles

A TRANSPORT Command aircraft recently completed a tour which suggests the big possibilities for post-war commercial flying.

In 30,000 miles, accomplished in 175 flying hours, the aircraft, a Hudson, made more than 80 take-offs and landings, visited 24 countries, flew in temperatures varying from 12 degrees below freezing point to tropical heat, and suffered only one defect—the tread on the tail wheel-tyre wore thin.

The trip was made as a routine duty tour —Staff Officers visiting Transport Command and other stations and staging posts, over certain routes of the Command.

It began in Britain, went by way of Gibraltar, Malta, and North Africa to Egypt, thence via Iraq and the Persian Gulf to Karachi, India, down through India to Ceylon, back through India and then westwards, to Southern Arabia, and afterwards by way of Aden, Eritrea, the Sudan, Kenya, and Rhodesia, to South Africa.

The return journey was made back through Africa, across to Lagos, and via Rabat, Sale and Gibraltar to Britain.

"We were 175 hours flying altogether," reported the Captain of the Hudson on his return, "and we never had a moment's anxiety. Our passengers on this trip were engaged in tying up communications over what is just a part of the Command. Everything went like clockwork. Everywhere we landed, the facilities for servicing the aircraft and looking after the crew and passengers were organised and working smoothly."

Inventions of Interest

By "Dynamo"

Anti-frost Pipe Guard

TO safeguard pipes against frost is the aim of an invention for which a patent in this country has been applied.

The device has a vent capable of being sealed. The sealing means includes a cap securing a destructible washer disc or diaphragm which will yield when subject to excessive pressure. And the characteristic feature of the invention is that the vent comprises an off-set pipe, and that the sealing cap clamps the washer in position and has a small outlet or leakage aperture.

Escape Hatch for 'Planes

IN an emergency the crew of an aeroplane naturally desire to bail out easily and expeditiously. I note that recent applications to the British Patent Office include two relating to an escape hatch for aircraft.

The construction in one case comprises a hatch panel secured to the body of a 'plane by a releasable fastening at one edge and a hooked engagement at the opposite edge. The arrangement is such that the above-mentioned fastening can be quickly released from within the cockpit by operating a single member. This edge of the hatch can then be pushed or is sucked outwardly. The hatch pivots outwardly about the edge where the hook fastening is provided. The engagement at that edge is self-releasing.

The object of the other invention is identical with that already described. In this instance it is specified that the means of escape is devised for use with hatches or panels of various sizes or shapes. Consequently it can be standardised.

This second device includes a loose panel retained in position over an aperture by separable pin-and-slot connections in combination with a releasing lever operable upon the panel, the fulcrum being a fixed part of the aircraft. By means of this lever the panel may be shifted longitudinally to release the pin-and-slot connections, thereby allowing of its being unshipped and jettisoned.

Cheap Sandals

A SOUTH AFRICAN has conceived the idea of utilising fabric-reinforced rubber sheet material, such as disused vehicle tyre casings. This once-upon-a-time waste substance he converts into footwear, particularly sandals.

One of the objects of the inventor has been to furnish a cheap, serviceable type of footwear intended especially for natives.

The sandal is made from a single blank of fabric-reinforced rubber sheet material of the thickness of the sole. The blank is cut and shaped in such a manner that the middle portion constitutes the sole. The two opposing side portions, after at least a part of their rubber covering has been stripped, are bent upwards and inwardly over the sole portion to form the upper.

Refined Sawdust

ALTHOUGH after the war the pre-fabricated house will be very much in evidence, dwellings consisting of more or less conventional materials will still continue to be erected.

The inventors of an improved block or slab for building purposes point out that it has already been proposed to make blocks from mixtures of sawdust and Portland cement, in order to produce a material possessing strength and lightness in weight which can be sawn and nailed.

However, it appears, as the result of wetting and drying, this material is apt to alter its dimensions. In addition, when untreated sawdust is used, the setting and hardening of the cement are deleteriously affected. The amount of this deterioration depends on the kind of sawdust employed.

It is stated that sawdust is variable even when it emanates from one source.

The inventors in question affirm that by experiment they have discovered that the injurious effects on the setting and hardening of the cement are due to a number of substances in the nature of tannins in the wood, which vary in different species.

The new invention consists in a special treatment of the sawdust. The sawdust is first boiled in water and then allowed to drain. Next it is washed with water, which process removes some of the tannins. Afterwards the sawdust is boiled in a solution of a salt which precipitates the residue of available tannins not removed by the previous treatment.

Two American scientists demonstrate the method of operating a new high-powered electron microscope with which they photographed greatly magnified views of the action of penicillin and sulphur drugs upon disease-producing germs. The new microscope has enabled American scientists to discover heads and tails on minute creatures only a quarter of a millionth of an inch in length and so small that 1,000 of them can be assembled on the point of a pin.

Granary Thieves

AMONG the enemies within our gates, both in time of war and peace, is the persistent insect pest. This dangerous parasite, if not destroyed, will levy heavy toll upon our grain.

An inventor who has specially directed his attention to this subject, affirms that it has already been established that the pest in question can be controlled by exposing grain to low concentrations of the vapour of metallic mercury.

It appears, however, that the carrying out of this operation on a practical scale is confronted with the difficulty of manipulating metallic mercury in the circumstances.

The object of an invention which has recently been submitted to the British Patent Office is to overcome this obstacle. The new method is to use a porous brick in which finely divided metallic mercury is uniformly distributed. Such bricks can be inserted in the sides of storage hoppers and grain elevators. And they continue to emit a high concentration of mercury vapour for a considerable period.

Portable Projector

FOR cinematographic displays in halls and rooms a portable collapsible projectile equipment is a great convenience. Such an outfit is the subject of an accepted application to the British Patent Office.

The screen, when collapsed, is housed in a long box, from which it can be made to extend upwardly. This box is provided with one or more pairs of transverse slots. One slot of each pair is in the front wall of the box; the other is in the rear wall. Through the slots forward and rearward projection is effected.

Carving Dish

AN inventor has catered for the man who carves the joint at the dinner table. This inventor points out that, when the savoury sirloin is carved on the customary type of dish, the depth to which the roast beef may be cut is limited by the height of the dish's rim. Consequently, he has devised a dish which will permit the joint to be carved right down to the bottom.

His device is described in dignified phraseology as a carving dish having a central raised plateau surrounded by a shallow channelled rim, of which the peripheral edge is approximately level with, or only slightly above, the surface of the plateau. The outer edge of the latter is formed with a low upstanding beading. A well is contained in the rim channel, and a series of grooves in the plateau surface converge towards a notch in the beading leading to the well.

QUERIES and ENQUIRIES

A stamped addressed envelope, three penny stamps, and the query coupon from the current issue, which appears on back of cover, must be enclosed with every letter containing a query. Every query and drawing which is sent must bear the name and address of the reader. Send your queries to the Editor, PRACTICAL MECHANICS, Geo. Newnes, Ltd., Tower House, Southampton Street, Strand, London, W.C.2.

Modelling Wax

COULD you please inform me if there is a material suitable for taking a mould of a person's foot, and from this mould make a plaster cast with either plaster of paris reinforced with hair, or any other substance ?

I have tried to use paraffin-wax but have had no success. Would the modelling wax as used by dentists be suitable, if so could you supply me with information where to obtain same ?—G. Whittlesey (Peterborough).

ONE of the various grades of dental moulding waxes would suit your purpose admirably, but these compound waxes are rather expensive and their sale is more or less controlled. If possible, you should order a quantity through your local dentist, since some of the dental supply firms will not sell outside the dental profession. However, there is no harm in your making inquiries for such material. Suitable firms to try are :

Associated (Dental) Products, Ltd., Kemdent Works, Ealing, London, W.13.

Amalgamated Dental Co., Ltd., 5, Broad Street, London, W.1.

Dental Mfg. Co., Ltd., Brock House, Great Portland Street, London, W.1.

Glasgow Dental Depot, Ltd., 36, Renfield Street, Glasgow, C.2.

If you are unable to procure any of the above material, you can make a somewhat similar compound fairly easily by means of either of the following formulæ :

Wax Softening at 55 deg. C.	
Carnauba wax	5 parts (by weight)
Beeswax	40 „
Copal	15 „
Ozokerite (M.P. 58/60 deg. C.)	10 „
Soft Paraffin (M.P. 40/42 deg. C.)	30 „
Higher Melting-Point Wax Compounds	
Paraffin Wax	75 parts (by weight)
Japan Wax	10 „
Beeswax	15 „

The various waxes mentioned above are obtainable fairly freely from any firm of chemical and laboratory supplies, as, for example, Messrs. Harrington Bros., Ltd., 4, Oliver's Yard, 53A, City Road, Finsbury, London, E.C.1.

Split-phase Winding

I HAVE a ¼ h.p. 230 v. A.C. motor with a split-phase starting winding. Would it be possible for me to remove the centrifugal switch in the start winding and incorporate a suitable condenser in series, so making it capacity starting ? Would it be possible to include a condenser also in the running winding and what should be the value of both condensers ? I do not wish to have the start winding rewound.—N. Hastie (Hayes).

IT is doubtful if there would be much gain in connecting a static condenser in series with the present starting winding. In addition the centrifugal or other starting switch would still be required to cut out the starting winding in order to avoid overheating, as at present. It is not possible to give you details of a suitable condenser to give best results when used in this way as details of the motor design are unknown. If you wish to experiment you could try connecting a condenser of about 8 mfd. capacity in series with the starting winding during starting. There would be no worth while benefit in connecting a static condenser in circuit with the running winding.

Plastic Rubber Compound

I HAVE several rubber tyres (outer covers) with holes in them, where they have been gashed with flints, etc. Is it possible to make a stopping of putty-like consistency to fill them with ? I have several pieces of scrap rubber ; could this be softened in any way to plug the holes ? Could you also tell me where to obtain the solvent ?—J. F. Carr (Horley).

IT is a very difficult job for the ordinary amateur to prepare a really satisfactory rubber solution or a plastic rubber compound. The great trouble is that ordinary scrap rubber is semi-vulcanised, and that this is, under ordinary conditions, not readily soluble. The works method of obtaining plastic masses from scrap rubber is to powder or finely shred the scrap rubber and then to place it, along with a small proportion (say 10 per cent.) of raw rubber in a kneading machine along with a suitable quantity of rubber "solvent." The machine is then operated for 24 hours or more, during which time the scrap rubber is kneaded and ground up with the raw rubber and the solvent until eventually a plastic mass (not a true solution) is obtained.

If, by any means, you can devise a method along these lines, you have a reasonable prospect of success.

"Solvents" for scrap rubber are, petrol, turpentine, carbon disulphide, carbon tetrachloride, naphtha, chloroform and benzine, but the scrap rubber will not dissolve if it is merely left in contact with any of these liquids. It needs to be continually ground and kneaded into the liquid, and for such a purpose special plant is usually necessary.

If, however, you can, by some means, get the scrap rubber down to a plastic mass you could easily incorporate a little "filler," such as asbestos powder" into it in order to provide a serviceable stopping. But the whole business is far more difficult than you think, so much so, that if you decide to carry out experiments in this direction, be prepared for disappointments.

The solvents above mentioned can all be obtained (petrol, at present, excepted), from any firm of laboratory suppliers and chemical manufacturers, such as Messrs. Harrington Brothers, Ltd., 4, Oliver's Yard, 53a, City Road, Finsbury, London, E.C.1, or Messrs. A. Boake, Roberts & Co., Ltd. (Temporary address), "Ellerslie," Buckhurst Hill, Essex.

Windings for a Dynamotor

I HAVE a Lucas A900R car dynamo which has had its wiring connections disconnected. I intend reconstructing it without the third "regulator" brush by connecting one end of the field coils direct to the case.

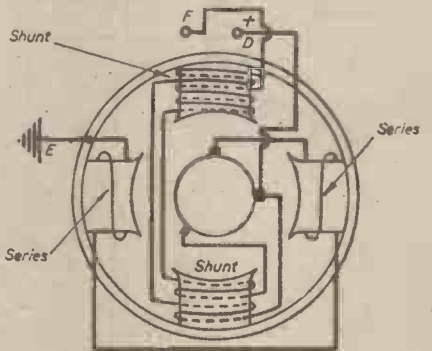


Diagram of windings for a dynamotor.

There appears to be two different types of field coil, similar ones being opposite one another. The larger pair seem to be connected in series and to consist of copper strip. The smaller ones have two wires connecting them together. From one coil two more wires come out and from the other only one wire.

Could you please give me a circuit diagram showing the connections for the field coils ?—M. D. Whitehead (Sheffield).

THE Lucas machine is actually a dynamotor, the series field windings having the most effect when used as a motor, while the shunt field windings predominate when used as a dynamo. The series field coils, of course, are those wound with the strip, while the two shunt coils actually have a double winding each, and are connected up as shown in the accompanying illustration, one winding being fed from the third brush, and the other winding from the main brushes. If, therefore, you wish to dispense with the third brush you could remove the connection from this brush and connect to the positive terminal. The series field coils will have little effect when used as a dynamo. If desired, you could replace these coils with fine wire shunt coils, connected in parallel with the other shunt coils, in which case the voltage output of the dynamo at a given speed would be increased.

"Catalin" and Formaldehyde

I WISH to obtain some information concerning the material "Catalin." Is carbolic acid cheaper to purchase or to manufacture ? What is formaldehyde, and in what ratio are they mixed ?—T. Dowling (Cork City).

(1) "CATALIN" is a proprietary product, manufactured and marketed by the Catalin Corporation, Inc., of America. It is a type of bakelite, and is manufactured by the controlled chemical interaction of phenol (carbolic acid) and formaldehyde (formalin). The material is then cast into sheets, rods, tubes, etc. The above company also makes a speciality of producing special castings to any design in this material. Fundamentally, however, it is but little different from ordinary bakelite.

(2) Carbolic acid (phenol) is obtained from coal tar, although it can be made synthetically from benzine. Hence, in order to manufacture this material yourself you would, at least, have to equip yourself with a coal tar distillation plant, together with the special purifying apparatus necessary for the extraction of phenol or carbolic acid. Thus, in your case, we imagine, the only possible way would be for you to purchase your carbolic acid either by means of import from England, or through a chemical manufacturing firm, such as Messrs. Harrington Bros., Ltd., of Cork.

Formaldehyde is the simplest member of a very active family of chemical compounds known as "aldehydes." It is really a gas which may be condensed to a liquid boiling at —21 deg. C. The formaldehyde or formalin of commerce is merely a solution of this gas in water. This solution, besides being a disinfectant and preservative, is highly active in a chemical sense. Thus, for example, it interacts with carbolic acid, forming the various bakelite resins.

You must not imagine that resins of the bakelite or "Catalin" type are produced from carbolic acid and formalin merely by mixing these two ingredients. In a test tube you can make a little resin by heating together equal parts of formalin and carbolic acid with the addition of a small piece of caustic soda, and, in this way, you will get a sticky, yellow resin. But to do this sort of thing on a large scale demands the highest chemical skill and experience. Hence, if you are thinking of going in for the manufacture of synthetic resins of the bakelite type, give up the idea at once. Besides, these resins are patented in every country, and you might find yourself in serious circumstances if you were found infringing the very stringent patent laws in connection with these chemical processes.

If you want to know more about formalin and carbolic acid refer to any textbook of elementary organic chemistry, where you will find these substances fully described.

Vacuum Cleaner Motor

I SHOULD be obliged if you would provide a winding specification for a "Goblin Junior" vacuum cleaner motor armature, details of which I give below. This motor has been rewound since it left the makers, and I have reason to believe that it is now incorrectly wound, and I hesitate to copy the present windings.

Length of armature, 1¼in. ; diameter of armature, 1¾ in. ; No. of poles, 11 ; No. of commutator bars, 33.

The motor is the usual two-brush series wound type, 250 volt A.C.-D.C.—A. G. Haynes (Harrow).

IT is difficult to give an exact winding specification for the armature without having details of the field winding. We suggest, however, that you wind the armature with 11 coils, each having 240 turns of 39 s.w.g. single silk-covered enamelled wire, tappings being brought out at the 80th and the 160th turn. The coil pitch should be from slots 1 to 6. Placing the armature so that slots 1 and 6 are equi-distant from the centre of one pole face number the commutator segments which then lie under the nearest brush, Nos. 2 and 3. The start of the coil in slots 1 and 6 should be connected to No. 1 segment, the first loop or tapping being connected to segment 2, second loop to segment 3, and finish of the coil to segment 4. Connect the start of the coil in slots 2 and 7 to segment 4, first loop to segment 5, and so on round the armature. The coils should be arranged so that one side of each coil is in the bottom of a slot and the other side at the top of the other slot.

Water Power

I HAVE a water spring giving 2,000 to 3,000 gallons daily into a tank situated 25ft. vertically over a roadway, of which I am owner. I am anxious to tap this reservoir for motive power. I am told I would obtain 2 h.p. for four hours by inserting a 3in. pipe at bottom of tank and taking to roadway to give a 25ft. head, and inserting a 1in. nozzle at the bottom of pipe, to direct nozzle on to a Pelton wheel direct coupled to a dynamo of 32 volts or 50 volts to charge house lighting accumulators.

I should like to have your observations as to the feasibility of the project.

I should also like to obtain the name of any firm marketing Pelton wheels.—P. J. Horgan Carbury).

THE available water supply cannot generate 2 h.p. for more than a few minutes per day, no matter what type of hydraulic installation is used.

The work done by 3,000 gallons of water (the daily supply) descending through 25ft. is

$$3{,}000 \times 10 \times 25 = 750{,}000 \text{ ft. lb.}$$

which is equivalent to 2 h.p. for

$$\frac{750{,}000}{2 \times 33{,}000} = 11.4 \text{ minutes.}$$

Allowing for losses in pipe, turbine or Pelton wheel, and electrical equipment, the period would probably be found to be about six minutes per day.

Small water turbines are made by Stuart-Turner, Ltd., Henley-on-Thames.

Air Compression Details

COULD you provide me with constructional details of an air compressor giving up to 100lb. per sq. in. suitable for paint spraying, to be operated by a ¼ h.p. electric motor? Main details required are single or double cylinder, material for pistons, size of flywheel, and stroke and bore. Unit to be small and portable.—A. Bloomer (Atherstone).

WITH the expenditure of ¼ h.p. about 0.3 cu. ft. of free air could be compressed per minute from atmospheric pressure to a gauge pressure of 100lb. per sq. in.

The following figures assume that the compressor would be direct coupled to a motor running at 1,500 r.p.m. Two-stage compression is recommended, with single acting cylinders 1in. stroke.

Diameter of l.p. cylinder, 0.875in.
Diameter of h.p. cylinder, 0.625in.
The cranks should be set at 180 deg.

The cylinders and pistons should be made from cast iron. The cylinder heads should preferably be detachable so that by insertion or removal of shims the compression ratios can be altered.

The design should be such as to minimise clearance volume. For the initial trial the striking clearance between piston and cylinder cover should be about 0.010in., but trial may show that this has to be increased to enable the motor to run the compressor.

The discharge pipe should be provided with a by-pass to atmosphere, so that the set may be started up and allowed to attain full speed before the compression load is put on.

The motor armature will probably provide all the flywheel effect required, but a steel disc 4in. diameter, ½in. thick would make the running smoother.

Centrifugal Air Blowers

IS it possible to produce a vane type (or, alternatively, a centrifugal type) supercharger capable of delivering approximately 100 cu. ft. of air per minute at 100lb. per sq. in. pressure? If so, what are the approximate overall dimensions (including inlet and outlet bores), the h.p. required to operate it, the r.p.m. required, and any other relevant details?

Please state the details outlined in second above for an output of 100 cu. ft. air per minute at (a) 90lb. sq. in.; (b) 75lb. sq. in.; (c) 60lb. sq. in.; (d) 45lb. sq. in.?

Can you recommend a book on supercharging from the construction of superchargers' point of view?—R. Wakefield (Longlevens).

OWING to the low density of air at or near atmosphere pressure, extremely high rotational speeds are necessary to produce any appreciable rise in pressure. As a rough guide it may be mentioned that the pressure gain in lb. per sq. in. cannot exceed the figure obtained by dividing the peripheral speed in f.p.m. by 20,000 and squaring the quotient. Thus, for a peripheral speed of 30,000 f.p.m. the pressure rise cannot exceed 2.25lb. per sq. in.

For such a rise as 100lb. per sq. in. many stages (about 50) would be required, and so the scheme is more complicated and less efficient than one based on compression by piston.

We know of no book that gives details of the methods of design of superchargers.

Power for Traction

CAN you give me the necessary formula for calculating the horse-power required to drive a four-wheeled vehicle on a level road, and also up inclined roads, assuming normal road surfaces and ordinary pneumatic tyres, and also given the weight of the vehicle.

How does one calculate the power required for acceleration?

I should be much obliged, also, if you could tell me if there is any simple way of measuring the b.h.p. of a petrol-driven vehicle during actual running conditions.—S. White (Barnet).

THE resistance to motion of a pneumatic-tyred vehicle on normal road surfaces is the sum of:

(a) Total weight (lb.) divided by 20.
(b) Total weight (lb.) divided by the gradient factor (e.g. 15 for a gradient of 1 in 15).
(c) Frontal area (sq. ft.) multiplied by

$$\left(\frac{\text{Speed (f.s.)}}{25}\right)^2$$

(d) Total weight (lb.) multiplied by acceleration in feet per second per second and divided by 32.2.

The horse-power required is the sum of (a), (b), (c) and (d) multiplied by the speed in feet per second and divided by 550.

The quantities (a) and (c) are approximate since they depend on variables (type of road surface, type of body of vehicle) not considered in detail here.

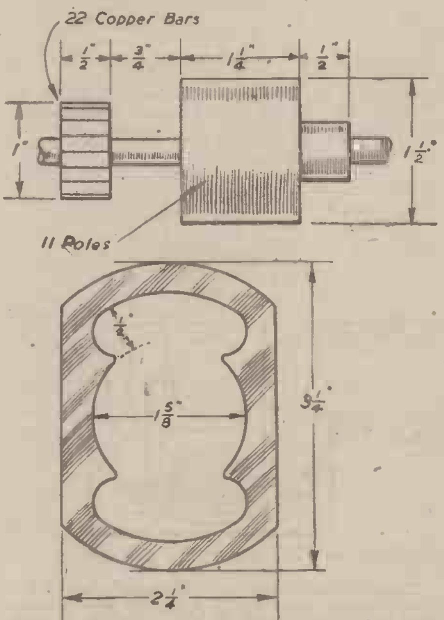
Determination of b.h.p. of the engine in service is not practicable except by calculation on the basis of the formula given above.

Rewinding a Motor Armature

I HAVE a vacuum-cleaner motor which I intend to rewind. All the original windings have been removed. The armature and field poles are as in sketch below.

Could you please supply me with information for rewinding for 230 v. A.C.?—C. H. Radford (Birmingham).

WE suggest you wind each field coil with 320 turns of 32 S.W.G. enamelled wire, the two coils being connected in series so as to create poles of opposite magnetic polarity, and in series with the armature.



Armature and field poles of a vacuum-cleaner motor.

The armature can have 11 coils, each with 240 turns of 39 s.w.g. single silk-covered enamelled wire, a loop being brought out from the centre of each coil for connecting to the commutator. The coil pitch will be from armature slots 1 to 6. Placing the armature so that slots 1 and 6 are equidistant from the centre of one pole, face number the commutator segment which then lies under the nearest brush, No. 2. Connect the start of the coil in slots 1 and 6 to commutator segment 1, the loop to segment 2, and the finish of the coil to segment 3. Connect the start of the coil in slots 2 and 7 to segment 3, the loop to segment 4 and so on.

Lateral Vibration of Rotating Bodies

CAN you help me with the following query? The centrifuges used in laundries, engineering firms, etc., for removing liquids from solids appear to operate without excessive vibration although no attempt is made to balance dynamically the rotating basket and contents.

What is the method of suspending the basket in order to obtain this steady running? Does any unbalanced body when rotated at high speed revolve round its true centre of gravity if free to take up this position? What is meant by the critical speed of a rotating body and what determines this speed?—E. J. Ross (Southall).

THE lateral support given to a rotatable body by the shaft and bearings on which it is carried always has some degree of elasticity. Consequently the body is capable of executing lateral vibrations after having once been deflected from its equilibrium position. The natural frequency of such vibrations is determined by the mass of the body and the stiffness of the support.

If the body is not completely balanced—i.e., if its centre of gravity is not on the axis of rotation—a centrifugal force is set up when it rotates and the changing direction of this force sets up and maintains a lateral vibration. The magnitude of this vibration depends on (a) the magnitude of the centrifugal force, and (b) the relation between the frequency of alternation of the centrifugal force (i.e., the speed of the shaft) and the frequency of natural lateral vibration.

As speed rises the magnitude of vibration increases, until when the speed of the shaft becomes equal to the frequency of natural vibration the amplitude of vibration becomes very great. If there were no restraining influences it would tend to become infinite.

As speed rises above this figure the amplitude of vibration diminishes, until at very high speed the amplitude of vibration is such that the centre of gravity of the body lies on the axis of rotation and there is no centrifugal force exerted on shaft or bearings at all.

If, therefore, a rotating assembly is carried in a support that is so flexible laterally as to make the frequency of natural vibration much lower than the speed of the shaft, then the assembly tends to rotate about its centre of gravity and there is no vibration in the sense that the bearings are subjected to no vibratory load.

In an arrangement of this sort there is a moment during the starting up of the assembly when the speed is equal to the natural frequency and severe vibration tends to appear, but at higher speeds this dies out and smooth running is obtained.

In practice the lateral flexibility is obtained by supporting the bearings by springs and providing stops to prevent overloading of the springs during the short period of heavy vibration in starting up and shutting down.

Electric Clock Motor

I HAVE constructed an electric clock on the lines of the one described in "Practical Mechanics" some months ago, but have utilised a standard alarm clock gearing (with the addition of a 50-1 worm drive), and have designed a much smaller motor to suit. It is a complete success, and I venture to say that it is far more simple to construct than the clock described. However, this induction motor was so simple to construct, that I am prompted to ask:

Is it possible to make it self-starting and if so, how? (I understand that Smiths' clocks are made so.)

What would be the approximate dimensions and winding for a similar motor of about ¼ h.p.?

Can any book or books be obtained describing the making of such motors?—A. J. Anderson (Parkstone).

THE clock described would need to be completely redesigned to make it self-starting. A self-starting clock could be made with a stator which had a number of adjacent poles of opposite magnetic polarity, i.e., the stator projections or poles would have alternate polarity. The rotor could have half its poles or projections spaced so they were in line with the stator poles when the other half of the rotor poles were midway between the stator poles. The rotor should be of steel and permanently magnetised. When the A.C. current is switched on to the stator the rotor would then oscillate until the oscillations exceed the pole pitch after which rotation would commence.

The synchronous clock motor is essentially a slow speed machine and is, therefore, relatively large for a given power output. We do not advise this construction being used for ¼ h.p. For such a power output you could use a series type of motor or a squirrel cage induction motor for A.C. supply. If it is essential for the motor to run at synchronous speed you could use a wound stator fed with A.C. and a permanently magnetised rotor or a rotor winding supplied with D.C. through slip rings; or you could use a rotor winding fed with A.C. and a permanently magnetised field system or field system fed with D.C. Such a motor would not be self starting.

The book "Practical Design of Small Motors and Transformers," by E. Molloy (Geo. Newnes, Ltd.), deals with the construction of small motors.

Toughness of Steel

CAN you inform me which is the tougher steel, black mild steel strip or bright mild steel strip? Which would bend first under the same pressure, and why should one be stronger than the other?—J. Hall (Nottingham).

BRIGHT mild steel strip is usually cold rolled, and the additional mechanical working it receives as compared with black strip improves the structure of the steel, and consequently the mechanical properties. Bright strip will, therefore, not bend so quickly as black under identical pressure, being tougher, and will also have a higher tensile strength. We suggest you read "The Mechanical Working of Steel" and "The Structure of Steel," by Gregory and Simons for a detailed explanation of this point and others of similar character.

Transformer Windings

COULD you please advise me regarding windings necessary for constructing a transformer to supply 20 volts at approximately 40 amps. from 230 volt A.C. mains.

Could you also tell me where I would be likely to obtain the required stampings?—A. G. L. Brown (Cambridge).

WE suggest you use a laminated core built up to 4 sq. in. in cross section. For the primary winding you could use 430 turns of 17 s.w.g. d.c.c. wire, and for the secondary 37 turns of d.c.c. conductor having a cross sectional area of 0.026 sq. in. You may be able to obtain suitable stampings from Joseph Sankey & Sons, Ltd., of Bilston, Staffs.

THE Cyclist

Editor: F. J. CAMM

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Comments of the Month. By F. J. C.

Can the Breach be Healed?

THERE is still no sign of peace in the dispute created by the N.C.U. and the R.T.T.C. over the question of the B.L.R.C., and the matter is not being helped by the vast number of cycling critics who are offering solutions to heal the breach. Some of these critics are new to the sport of cycling, and whilst they allow their own pens to sling mud from behind a fence they pompously accuse others of doing so and, condescendingly and with a dignified air, make vapid and vacuous appeals to give the impression of a pontifical interest in the "game."

If their misguided efforts, sometimes lacking in tact, have had any effect at all it has been to widen the breach, not to close it. We see no particular reason why the B.L.R.C. should need to give way either to the N.C.U. or the R.T.T.C. These latter two bodies conduct two totally different forms of cycle racing, and each are opposed to one another on questions of policy.

The N.C.U. eschewed all forms of road racing, including time trials. Many years ago it passed a resolution to that effect, owing to the attitude of the police towards cycling at that time. They not only refused to have anything to do with time trials *per se*, but they threw attempts at records overboard at the same time.

To-day the N.C.U. exists to control a few hundred riders interested in track racing, to whom they issue licences. As a result the Road Records Association came into being and so did the Road Racing Council, which has been superseded by the R.T.C. It is thus obvious that the R.R.A., the R.T.T.C., and the N.C.U. have nothing in common except the adversity which makes strange bedfellows.

Two of those bodies have been formed as a result of opposition to the N.C.U., and it is curious to note that those two bodies now side with the N.C.U. against a third body, the B.L.R.C., which wishes to run its own form of sport, non-competitive with the others and which has broken away from the N.C.U. as they did years ago.

The National Cyclists' Union has not changed its policy with the changing times, and neither has the R.R.A. All those years ago the N.C.U. tabled its famous resolution quoted in our last issue forbidding its members to partake in time trials and forbidding also its officials to act in any capacity whatever in them. It has seen the growth of time trials, but the resolution remains.

If the breach is to be healed the move must come from the N.C.U. and the R.T.T.C., which have everything to lose and nothing to gain from its continuance. The B.L.R.C., on the other hand, has nothing to gain and nothing to lose from the attitude of the N.C.U. It is running a form of sport which is wanted, as is very evident from the attendances which far transcend anything which the N.C.U. can produce at Herne Hill or the Paddington tracks.

Dangerous Competitor!

THERE perhaps is the rub. The N.C.U. *fears* this new form of sport as a dangerous competitor which will rob track racing of its few remaining protagonists. It is fear which is promoting N.C.U. opposition, and so-called concern for safety on the roads. As far as the R.R.A. is concerned, it is an unimportant body operating entirely as a domestic tribunal, and is not a national body in the correct sense. Its opposition can be ignored for it is a body without power, and without very much voice. However, an attempt has been made by one who has been long associated with the sport to find some common platform on which the disputants could meet, and it has been suggested that a *vis-à-vis* committee should be formed to discuss the matter. The following is the reply jointly made by the Secretaries of the N.C.U. and the R.T.T.C.

Broken Rules

"YOUR letter of the 23rd September addressed to the N.C.U. and R.T.T.C. has been received. We think it is necessary to make the position clear to you.

"A number of people have broken our rules and promoted massed-start racing on the public highway to the danger of the sport. These people have been suspended, and our action has been overwhelmingly backed by the membership of our bodies. The Government have more than once expressed their strong disapproval of massed-start cycle racing on public roads, and this has been confirmed as recently as August 2nd in the Parliamentary question and answer of which you will be aware. *It is only by making it quite clear that we disassociate ourselves completely from such racing* that we have been able to speak on behalf of cyclists generally and preserve the reputable forms of cycling sport from interference. If further threats to the rights of cyclists are to be met and countered it is more than ever necessary that this policy should be continued. [*Our italics. Apparently one has only to dissociate oneself from any particular policy to be able to speak on behalf of cyclists.*—ED.]

"Last November, with a view to minimising the dangers to the sport and at the same time giving the massed-start riders an opportunity of coming back and thus putting an end to the disturbance which they had caused, both the N.C.U. and R.T.T.C. offered an amnesty to them. This was ignored, and the massed-start riders have persisted in their dangerous activities throughout this season, in defiance of the expressed views of the Government. This amnesty was withdrawn on February 17th, but the ordinary machinery still exists for any suspended persons to make application for reinstatement. Any such application would be fully considered; but we have no power to vary the procedure.

"The foregoing is the position at present, and we cannot see that there is anything to be gained by sending representatives to offer the same information verbally.

"We would remind you that constitutional measures exist whereby members of clubs affiliated to the N.C.U. and R.T.T.C. can bring forward proposals through their clubs for consideration by Centre and District Councils as the case may be. This machinery is a safeguard to the democratic structure of both the N.C.U. and R.T.T.C., and the general membership would quite rightly refuse to allow us to recognise small unrepresentative groups of club members who suggested the consideration of proposals by means other than those provided in the rules."

In the forefront of this letter observe that it is not the question of safety on the roads which is placed first, but the trivial matter that "a number of people have broken our rules."

The reference to "democratic structure" of the N.C.U. and the R.T.T.C. is really laughable in view of known facts. Their constitution does not differ to any great extent from the constitution of the C.T.C., which is certainly not a democratic body. The C.T.C. has rules, but the members have little power to get them altered. If that is democracy perhaps someone will define dictatorship.

We agree with the letter in its expression of view that it would be a waste of time for the bodies to meet. In view of the methods which have been adopted in the endeavour to get massed-start racing suppressed, such a meeting would only result in further mud slinging and exacerbation, and it is therefore wise to avoid it.

Stratford St. Mary, Suffolk.

Crouch Hill Man Decorated
FLIGHT LIEUT. R. L. LASHAM, Crouch Hill C.C., has been decorated with the Distinguished Fying Cross.

Club Losses
TOM SMITH, Glasgow Regent C.C., and Donald Brown, Kilmarnock Goldberry C.C., have both been killed in action.

Good News
AFTER a lapse of almost three years it is now authoritatively stated that G. H. Burgess (Bronte Wheelers) is a prisoner of war in Japanese hands. He was reported missing following the sinking of the *Repulse*.

Level Crossings
THERE are 4,360 railway level crossings in this country; figures are authentic, but no estimate is given of the time lost by cyclists who encounter them!

Earnshaw's New Role
"SHAKE" EARNSHAW, noted pre-war record breaker, is now serving with the Royal Air Force.

A Proud Record
FLYING OFFICER ERIC LEE, former hon. treasurer of the Manchester Eagle C.C., has been awarded the Distinguished Flying Cross after taking part in over 80 operational flights.

Audrey Allis, well-known club cyclist.

Outstanding Ride
NELLIE SPYRE, Sheffield Central C.C., rode 213 miles 1,030 yards to win the Broad Oak 12-hour time trial for women.

Barnet Man's New Role
R. C. MILLER, former Barnet C.C. stalwart, is now a Flying Officer in the Royal Air Force.

Coming of Age
BEDFORDSHIRE Road Club this year celebrates its twenty-first birthday.

Cycling's Northern Outpost
THURSO Social C.C., the most northerly of cycling clubs, is again operative. Serving men in Caithness and Sutherland are invited to participate in its activities.

Barnesbury C.C. Loss
BARNESBURY C.C. mourn the loss of Jack Gaul who has been killed in action in France.

Finsbury Park News
A. EDRUPT, Finsbury Park C.C. social secretary, has married Miss J. Holly.

12-Hour Champion
A. E. G. DERBYSHIRE, Calleva C.C., is reigning 12-hour National Champion by virtue of his winning ride of 233⅜ miles in the Manchester D.C. event.

Douglas Man Missing
LAWSON MILLER, Douglas C.C., is posted as "missing." He was serving as an air-gunner in the Royal Air Force.

One-armed Man's Win
RON BROWN, Calleva C.C., known as the "one-armed wonder," won the South Western "12" with 235⅜ miles; his second consecutive win in this event.

Southgate C.C. Loss
SUB.-LIEUT. ALFRED CHAS. ELLIS, (Fleet Air Arm) formerly reported "missing," is now known to have lost his life while on active service.

Killed in France
TOM GERRARD, Liverpool Century Road Club, has been killed in action in France.

Some Cycling!
W. S. D. WALLACE, a Stirling postman, claims to have cycled no fewer than 320,000 miles during his 41 years' service.

Appreciated
WHILE serving with a Parachute unit well behind the lines in France, Sergeant C. F. Valentine (Southgate C.C.) received among his weekly mail a copy of his club's magazine.

Growing Strength
THERE are over 188 members in the Central Mediterranean C.C.; another of the many Forces' clubs.

Manchester Revival?
THERE is a possibility of a revival of the famous Manchester Wheelers track meeting next year. An ambitious programme of road time trials has also been planned. A. J. Bradbury is the president-elect.

Versatile Jack Seath
JACK SEATH, Vegetarian C.C., is at home on road and grass track. A prolific winner of road time trials, he rounded off a very successful season by winning an 880 yards grass championship in Kent.

Ridley C.C. News
ARTHUR LONG, Ridley C.C., is in Corsica and his clubmate, Larry Phillpotts, is with the R.A.F. in Italy.

W. H. Chappell Commissioned
W. H. CHAPPELL, pre-war hon-secretary of the Western Counties R.R.A. and Western T.T.A., has been commissioned in the R.A.F.

American's Interest
LT. F. E. HIGGINBOTTOM, U.S.A. Tactical Air Force, has joined the Cambridge Town and County C.C. and has participated in some time-trials. He is a Thunderbolt pilot.

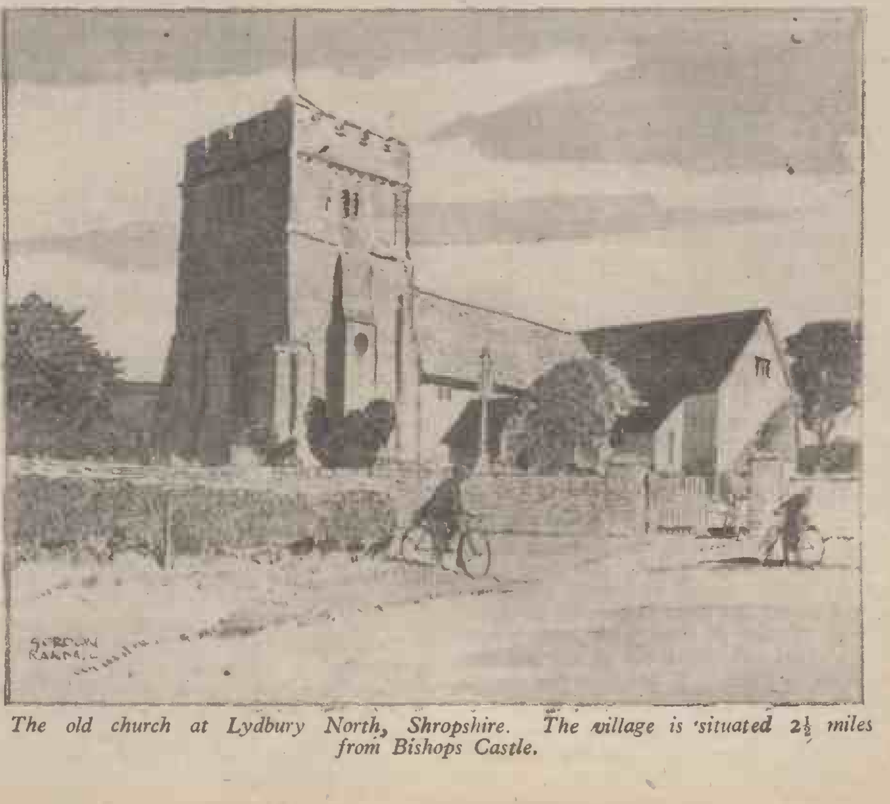
Wedding Bells
E. WATTS, Hemel Hempstead C.C., has married Miss Joan Parrock, herself a keen cyclist.

Anfield Loss
LIEUT. B. H. BAND, D.S.C., of the Royal Navy, a member of the Anfield Club, has lost his life as the result of enemy action at sea. He was in the submarine service.

Club Revived
THE Norfolk Road Club has been revived.

The Hat Trick
COURSE, club and personal records were broken by Harold Gibson, Achilles Velo C.C., when he clocked 2-8-10 in his club's open "50."

Meeting Abroad
BATTERY SERGEANT-MAJOR J. McLAREN, King's Lynn C.C., met two members of the Wisbech Wheelers in Cairo.



The old church at Lydbury North, Shropshire. The village is situated 2½ miles from Bishops Castle.

Around the Wheelworld

By ICARUS

About Criticisms

FOR criticisms to be of value they should be made by those whose knowledge and long experience qualify them to speak with authority. In the field of cycling we have many critics who have not that qualification, and whose "criticisms" only confuse the issue. The controversy in the cycling world is not being helped by those who, comparatively new to the movement, can know little, if anything, of its history, nor of the pros and cons of the disputes; yet they wax oracular in their "powerful" articles and evince an almost avuncular interest in the welfare of cyclists, believing that, as they have to write about cyclists, the cyclist must always be right, that they must utter no word of criticism of them, and that anyone who dares to see both sides of the question is an anti-cyclist.

These alleged critics endeavour to cover in a quagmire of tangled verbiage their abysmal lack of knowledge of the subject, and endeavour to court the goodwill of cyclists by nauseating praise; when they do faintly endeavour to criticise, they praise with faint damns. We all know the type of contributor who plays for safety by praising things which quite rightly ought to be severely criticised.

Their particular pose is that they are acting as judicial and impartial arbiters, and aloof their way with impertinent sanguinity past an array of inexorable facts. If any personal note has been imported into the various cycling disputes which have been going on for almost 50 years, it is because some of the so-called leaders have resorted to personalities. If you compare the writings of some of these critics you will perceive that during the years they cross from one side to the other with the stealth of a sleek cat crossing a very muddy street.

Roadfarers' Club—Pall Mall Address

THE Roadfarers' Club now have an office at 50, Pall Mall, S.W.1, telephone: Abbey 1597, to which correspondence should be addressed. The second annual meeting of this national representative and impartial body took place on October 25, when nearly 100 Fellows and members attended.

"What Shall I Join?"

MEMBERS of the Forces eagerly anticipating a return to civilian life when the war is over are wondering what post-war cycling conditions will be like in this country, and many of them wish to know which club they should join. So many of the old clubs have gone out of existence during the war for obvious reasons, and after the war many new clubs will be formed, that these inquirers should wait until the war is over before owning allegiance to any except a very well-established club. They should give a little time to investigating its past history, for it may be that it will be better to form a new club rather than be hamstrung to an existing club which has a history of spite and antagonism.

There are some clubs which I definitely cannot recommend. I am also asked whether there is any possibility of amalgamation between the various national bodies. All previous attempts to this end have failed. One national body is perfectly willing to amalgamate with another provided that other interprets amalgamation as absorption. Personally, I do not see the need for any but one national body, and the sort of body which I envisage is not at present in existence. I should like to see a body formed on really democratic lines, and whose committee obeys the wishes of its members.

I cannot advise any of my readers to join any club unless the members can take a hand in the conduct of it. I do not like clubs which are proprietorial, vending membership like a purveyor of hair oil, the sort of club which you can join if you are prepared to accept the unchanging policy laid down. That is not my idea of a properly conducted club, which should change its policy and its rules if necessary to meet changing times and changing conditions.

The allocation of delegates is another matter upon which I have decided views. A club should not be allowed to appoint, say, two delegates to national bodies, *irrespective of its membership*. The delegates should bear a strict relation to the number of members, say, one delegate for every 30 members, otherwise a one-man club has the same voting power as a club with a larger membership. Thus, the vote at a meeting of delegates does not reflect the real feeling of clubs as a whole. It does not give a majority verdict and it is possible for a majority of delegates at such a meeting to represent a minority vote.

While so many views have been expressed by one body and another on this problem or that, no one can state with certainty what cyclists do want, what they do agree with, and what they do not. Certainly neither the views of the C.T.C., the R.T.T.C., nor the N.C.U. represent real cycling opinion.

A.G.M.'s of the N.C.U.

MR. CHAMBERLIN, the secretary of the N.C.U., asks me to correct a misstatement in the memorandum on massed-start racing submitted to the Ministry of Transport and published in our previous issue. In the memorandum it was stated that the N.C.U. has not held an annual general meeting since the war. Mr. Chamberlin informs me that it has regularly held annual general meetings.

Sandpit Lane

IN response to representations made by the National Cyclists' Union, the Brentwood U.D.C. have agreed to erect a warning notice board in Sandpit Lane, running into Weald Road, Brentwood, Essex.

The Union has learned of several accidents to cyclists at this point, and the erection of the warning notice should prevent such occurrences in the future.

Road Accidents—August, 1944

CASUALTIES on the roads of Great Britain in August, 1944, resulting from road accidents, totalled 501 killed and 10,663 injured. The following table is an analysis of the number of persons killed according to the type of vehicle primarily involved:

Type of Vehicle.	*Number of Persons Killed.*
Service (British, Dominion, and Allied of the three Services)	163
Civil Defence and N.F.S.	9
Public Service and Hackney	75
Goods	98
Private Cars	30
Motor Cycles	25
Pedal Cycles	88
Others	13
Total	501

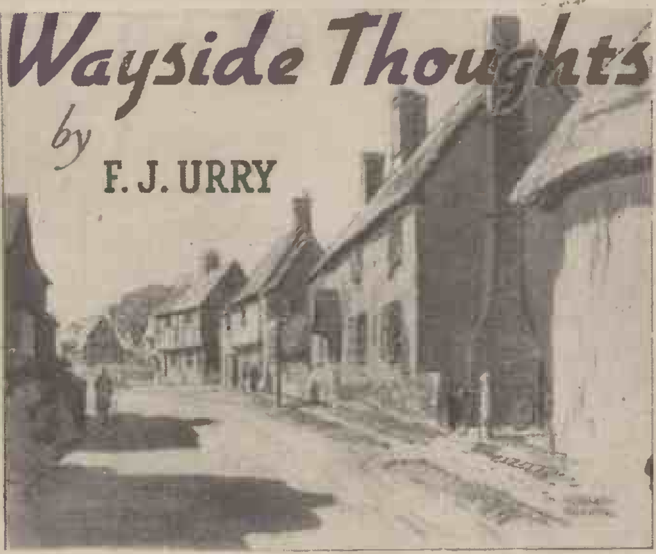
(The term "Vehicle primarily involved" means (i) where only one vehicle was concerned, that vehicle; and (ii) where more than one vehicle was concerned, the vehicle to which the accident appears to be primarily attributable. In either case it does not imply that the driver of the vehicle was culpable.)

R.T.T.C. on National Committee

IN response to the request from The Road Time Trials Council, the National Committee on Cycling have agreed to ask the Council to appoint a representative to the Committee, which is now made up of members of the British Cycle Manufacturers Union, the C.T.C., the National Association of Cycle Traders, the National Clarion Cycling Club, and the N.C.U.

The lovely old King's Head Inn at Rudgwick, Sussex, 6 miles N.W. of Horsham.

Wayside Thoughts
by
F. J. URRY



East Hagbourne, Berkshire.

Making Do

CONSIDERING the circumstances of the times, I have had a very good cycling year, with a couple of short touring holidays, and several good week-ends. True it is that arrangements for accommodation have been a trifle troublesome, and, even when completed, have not always been as happy as one would wish; but we all have to put up with difficulties these days, and I have found that a little sympathy with the trials of our catering friends is far more valuable than criticism of their imposed shortcomings. The fact is I have not gone short of a little holiday-making for lack of a little trying, and when people moan to me that they cannot "get away," I am afraid they are thinking in the terms of car travel or train transport, and have no use—in the holiday sense—for a bicycle. Take the August holiday week as an example. The works were closed that week, and three of my trade friends making bicycle accessories, suggested I joined them for an eight days' ride to Pembrokeshire, and, as I knew the country, would I guide them? We were not a young party; two of us had passed the sixty-mark and the others were on the fifty line border, and of the four three had been car men most of their lives. We managed by wire, to book up at three places for the home and return journeys, the last one being at Tenby for three nights, and actually we did not fare too badly with the addition of the rations we carried with us. And here is the remarkable thing: my three companions had never been south-west of Hereford, never seen the Brecons or the fine coast of Pembroke, or knew that rolling road beyond Carmarthen, mile-measured by the "Hobb's Point" stones, still *in situ*, that informed the weary mariner of the old days the distance he had still to walk before reaching his ship at Pembroke Docks. All the way from the Midlands that south-western road is a great cycling highway to-day, and it is good to have seen it once more, almost free of car traffic.

The New Country

ON that hot Saturday of the holiday we rode to Hereford with the comfortable aid of a north-east wind enjoying a change from its usual chill nature. Over the Malverns we went, and among the green and golden fields where the binder was busy and the farm lad waved to us from his elevated seat aboard the creaking wain. It is good to remember those hours now, and to think that another year will come, bringing its joys of release. But it was the next day that brought my friends into a new country, and they liked its outlines and its colouring. We crossed the Wye at Monnington (where, in its ancient churchyard, the grave of Owen Glyndwr is said to be), and, sweeping under the hills on the wings of that wind, we passed Hay and Three Cocks Junction, and in due time rose that glorious vision of the Brecons, nearly 3,000 feet of their elevation lying against that intensely blue sky. We did not fare very well for food that day (it was Sunday in Wales), but, with the aid of our small supply, we eked out, and finally raced a thunderstorm down the long drop into Llandovery, where all our food problems were solved at the North Western Hotel. For us Bank Holiday never seemed crowded; we had the roads almost to ourselves, and it was only in the villages and towns that the holiday spirit was in evidence. Those miles by the Towey to Carmarthen were glorious, and if we ambled along them in carefree fashion, with numerous rests and smokes by the wayside, who would blame us? This was a holiday, and our joy was to keep it such with no thought of the morrow. A country lunch in Carmarthen sent us near unto sleep over the St. Clears road, and it was there we left the hard highway to take the tumbled coastwise route to Tenby, and get into trouble for lateness at our berth.

The Best Woods

THAT coast road by way of Laugharne, Pendine, Amroth and Saundersfoot, rises and falls like the teeth of a gargantuan saw. We had to find tea somewhere, and when Brown's Hotel at Laugharne told me they had no bread, I promptly went into the village and persuaded a good dame to sell me a loaf, for the shops were all closed on this holiday. For very shame the hotel then had to do something for us, and if it was a poor show it at least saw us into Tenby, very late and very hungry, and only tardily welcome. But we overcame our sins of lateness by smiling politeness, and actually our stay in Tenby, if a little crowded, was sprinkled with good meals and that fortune, with the golden weather to back it, made the journey's end a happy one. My friends were duly impressed with Tenby (and actually it is one of the comeliest seaside places I know), and refused to leave it on the Tuesday, spending their time bathing and basking and enjoying —or taking—such refreshments as were available. I did manage to stir them out on the Wednesday when we went prowling round as much of the coast south of Milford Haven as the authorities would allow, and a very beautiful day we enjoyed, delving to Manobier, East Freshwater and Stackpole, and in the latter place discovering a lady who took pity on our hunger and cooked the ham and eggs that had been suspended from my saddle for four days, and 200 miles. It was the moment when the private larder helped to make up the joy of a gallant day. That afternoon we saw the sorrow that had overtaken Stackpole Woods and Bosherston Pools. The lumber camp is there, and the lovely beech trees are food for the circular saws; and those one-time mirrored lakes are now overgrown with reeds, over which echoes the strokes of the axe and the grunt of the tractor.

Both Ways

THAT evening we returned to Tenby over the Ridgeway road, and southward was the winking sea and the sheer cliffs, while to the north the blue distance was framed with the long outline of the Prescelly mountains beyond the land gaps of Milford Haven, a panorama in its peaceful loveliness as beautiful as anything I know. The next morning we started for home with a drift of rain to see us off, coming on the wings of a south-wester. What luck! to have the breeze both ways. The drift of damp ceased by Kilgetty, and the rest of that day was sunshine and soft helping winds. It was so easy one wanted to go on for ever, and no wonder we reached our excellent hotel at Llandovery in the early evening, and were regaled with Towey salmon, and all its proper dressings. My friends had never been over the Sugar Loaf Pass to Llanwtyd, so we decided to go that way, even though the night had been stormy and the morning was still grey and damp. But the rain petered in to mist in the first few miles up the valley, and the mist persisted, shutting out that canyon-like vision where the road and rail nearly meet at the summit of the pass, the road going over, and the rail through the shoulder of the hill. That was a pity, for 300 feet lower on the other side of the pass the sun greeted us with its misty gold dropping smoky columns through the clouds. We went by Llangammarch and Garth to Builth, the weather recovering its good temper with every mile, stayed for a moment to see the modest column raised near the village of Cilmery, to commemorate the spot were the last native Prince of Wales was killed by an English trooper in 1282 (so often missed by wanderers, because it is half hidden in a field), and found quite a good lunch in Builth to cap a beautiful morning's ride.

The Good Ending

I THINK that stretch of the Wye from Builth to Glasbury where its character is still full charged with the wild waywardness of the mountains, is the most beautiful of its long journey. We lingered along that road, sometimes sheltering from little summer storms, but more often sitting on the rocks and absorbing the glory of stream and forest and mountain around us. Glasbury would not give us tea, nor Clyro, so perforce we had to cross the bridge to Hay and make the best of a cafe that did not seem specially glad to serve us: then retracing over the bridge visited the fine old Inn of Rhydspense where we drank to its greater glory. Followed a quiet evening ride to Hereford, with the promise of more settled weather conditions in the orange glow of the sunset. And it was so, for the Saturday was gold and blue all the way. We crossed the Malverns over the Eastnor ridge, and that long run down to the Vale of Severn at Tewkesbury with a wind to back us, is now a memory to be cherished. The plums were ripe in Evesham Vale and we took our fill of the juicy fruit, had tea in Alcester, and came home with the lengthening shadows. Eight days of glorious freedom and 400 miles of joyous travel, and the cost £6 2s. 5d. each. The price just happened, for there was no attempt to keep the figure reasonable. Our roadside delays were one puncture, and one front wheel cone adjustment. And the reaction of my friends was to the effect that nobody had told them this south-western journey was so lovely and they were inclined to blame me for not informing them of the fact. Ah! these jolly old motorists turned cyclists, how much they have to discover of the beauty of this land over which they have passed too rapidly to understand its intimacies, or entirely missed an area because they were "not told."

A Desire

HOW I wish I could take many of my acquaintances a long and lovely ride of a like kind, without hurry or urgency, but with sufficient movement to keep active with cycling and inquisitive with the map. "Why can't we go here, and here?" was the constant query of my friends when I pointed to places on the map that gave the easy wanderer the beauties of vision. And the answer is you can't do it all in one journey, certainly not on a bicycle, and if you try to make it by car (when the car days return) then indubitably you will miss the freedom and the slow loveliness of riding, and the journey will descend to a parade of speed too great to be intimately observant. That is true, for I have proven it. If it were possible to accompany my doubting friends who say that cycling "is not for them," such a ride I verily believe would result in a surge of enthusiasm for the pastime that would astonish them beyond expression. It is the will to start, to get reasonably fit, to sit a saddle for an hour on end without quarrelling with its comfort, that is the initial difficulty to be overcome. They don't believe—such people—that it can be done and completely enjoyed—which is nonsense, as those few have discovered who have taken me at my word and entered a kind of demi-paradise of leisure with which to fill a holiday or an idle hour.

Not Too Old at 85

A FEW days after I arrived home a very old friend came to see if I could help him to find a cycle foot pump as he found tyre inflation a trifle tiring at his age. No wonder! for he is now in his 85th year and still riding from ten to twenty miles a day when the weather is good. This grand old cyclist was winning races in 1887, and cycling has been his main mode of travel since the earliest days of his youth. He sat and enjoyed a refresher as we talked of the old days, and an hour later pushed off home on his beloved bicycle, informing me as a parting shaft that it would be the last thing he should give up. Since then the foot pump has been delivered to him through the good offices of some trade friends of mine.

On the lovely Lee Downs, between Mortehoe and Ilfracombe, N. Devon.

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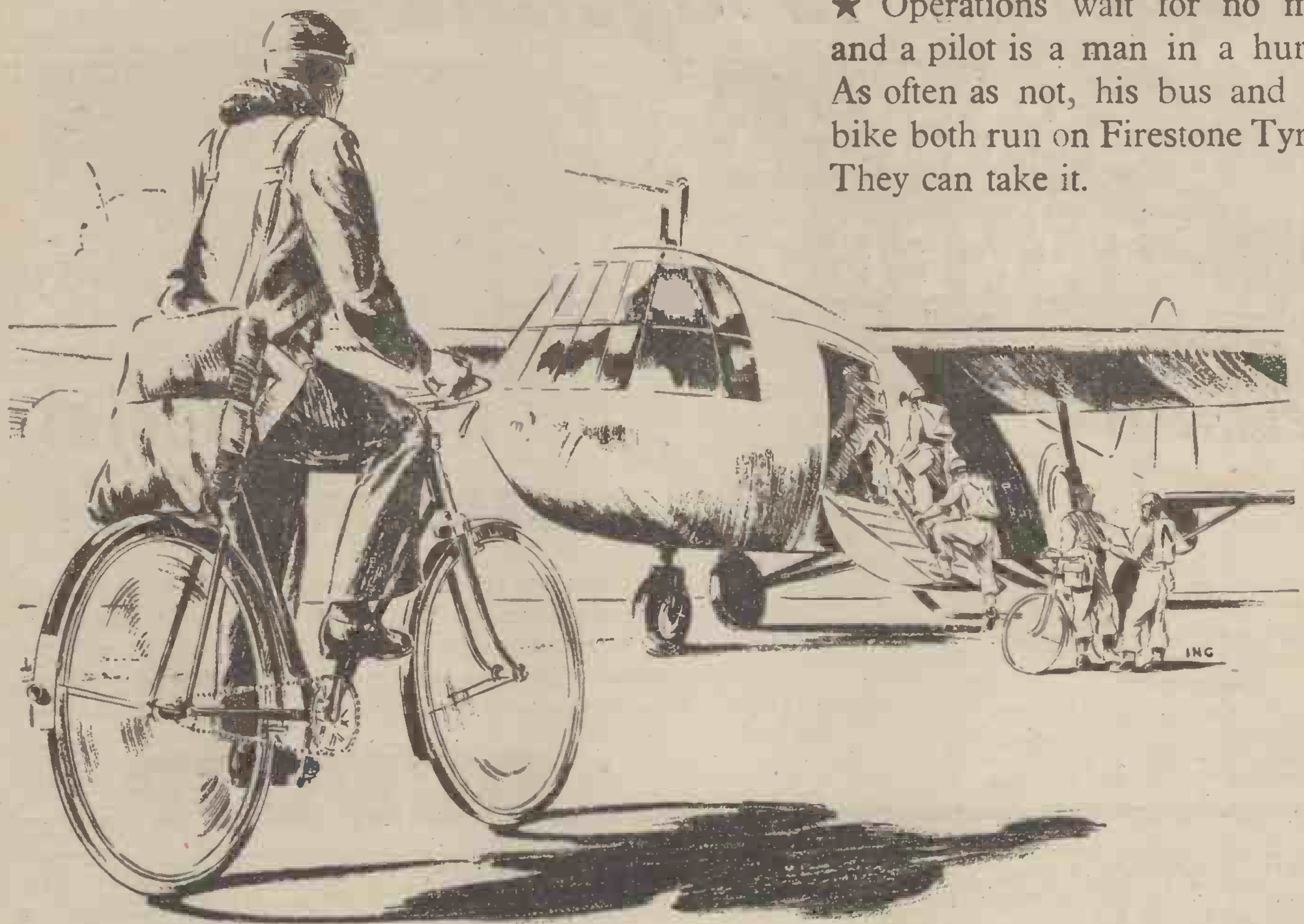

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CYCLORAMA

By H. W. ELEY

A pretty corner of Minster Lovell, Oxfordshire.

Cyclists and Nature

THERE has been much talk recently with cyclists about what they see on the roads, and what knowledge they acquire of the habits of birds and beasts of the fields. I am a little surprised at the small number of cyclists, apparently, who have any real and deep interest in natural history . . . whether it be in connection with wild flowers, butterflies and moths, or the wild animals still left to us; and yet what a wealth of interest there is in the wild life of the English countryside! What delightful hours one may spend if one has but a nodding acquaintance with the flora of our counties! One rider with whom I talked in a little Warwickshire inn confessed that he did not know the difference between a rook and a crow! Now, to anyone not at all interested in nature matters, that may seem a confession of no moment . . . but to the lover of the country, its ways and its wild life, it is a melancholy thing indeed! Why not, when cycling, keep an open eye for the many beauties with which our roads, lanes, and fields and hedgerows abound? Make a point of starting with a simple little specialisation: say, get a good pocket edition of a wild-flower book, and try to find out something about the blossoms which, even though summer is "getting on," are still bravely blooming in gay profusion.

Parsons and Cycling

THERE is nothing strange in a cycling parson . . . particularly in the country; how else would he get round his scattered parish? But most country parsons, I imagine, are *keen* cyclists—they do not, I find, regard their mounts as "utilities" enabling them to get around their parishes; the parsons I have in mind ride because they love cycling . . . just as their predecessors of the old days used to ride sturdy cobs. One aged cleric told me recently that he believed that cycling was one of the chief reasons for his longevity. He did say that maybe fresh air and the placidity of a tiny village parish had something to do with his robust health and his eighty-two years . . . but he evidently regarded the bike as the true lengthener of his days! I left him, mounting his somewhat aged bike, outside the lych-gate of his tiny church . . . and on that sunny morning, with the song of birds in my ears, and the peacefulness of green meadows before my eyes, I could have envied him his pleasant lot. . . .

Grey Derbyshire

ONLY grey, maybe, when compared with the sunnier south-lands; but, grey or not, I love the county where the Peak rises so majestically, and where one may revel in such diverse scenery as that provided by the soft, placid country around Sudbury, and the wild land of the Peak proper. Lately I was in Youlgrave, a grey little town not so far from Ashbourne, and I was entranced, as I always am, by the age-old Stone Circle . . . said by many to be more ancient than Stonehenge. I do not know whether it is Druidical in origin, but I do know that on a sunless day, with a chill wind, it can give one an eerie feeling and take one's mind back to the dim past, when, perchance, sacrifices were offered in the circle, and dread rites performed by the "wise men" of the day.

Carrying Children on Cycles

I HAVE never been vitally interested in this matter, because I never, personally, have to carry a kiddy on my machine. But there are plenty of folk who do, and who find that some convenient construction fitted to the bike means that a pleasant run into the country need not be missed because there are youngsters to cater for. Sitting in a little tea-shop the other day, I fell into conversation with a man about this subject, and he seemed to know the "law of the matter," for he quoted to me a section of the Road Traffic Act of 1934, under which it is apparently enacted that . . . "It shall not be lawful for more than one person to be carried on a road on a bicycle not propelled by mechanical power unless it is constructed or adapted for the carriage of more than one person." Now, I do not know whether there has ever been any official interpretation of "constructed or adapted," and possibly the whole matter is in a state of muddle. But there can be no doubt that the practice of carrying children on cycles is a growing one, and I think that in most cases parents show a due and proper appreciation of the necessity of safety and the comfort of the child carried. There are exceptions, and sometimes I see a "contraption" which I feel must be most uncomfortable for the kiddy, especially if long distances are covered.

Books for the Cycling Tourist

I DO not doubt that when the war is over there will be a huge demand for books on touring and kindred matters. Publishers have had a difficult time during these red years of war, and many a good manuscript received by them has had to "lie on the table" because of paper problems. We shall have a new generation of riders to cater for, and I hope we shall see a goodly number of guides and hand-books telling us of English roads and English inns, and the green and pleasant English scene.

Cycle Tyre Care is Simple

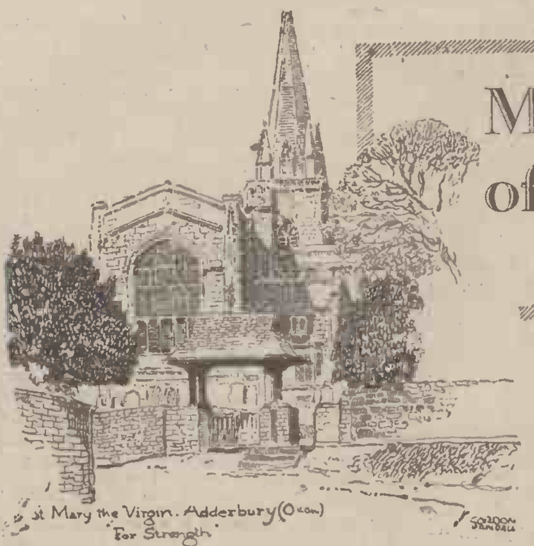
IT is right that during the war years, with raw rubber supplies as one of our major problems, the tyre manufacturers should have stressed, in season and out of season, the imperative need for tyre care. But talking to some cyclists the other day, I found that some of them seemed to think that a whole lot of "bother" was involved. Surely it is not so! I rather think that 90 per cent. of the secret of getting maximum mileage and service from cycle tyres lies in that little matter of proper inflation. "Pump 'em up *hard*"—and you have done almost everything that really matters; at least, that is my experience. Of course, it is wise to do as the motorist does, and pick out stones and flints from the cover. And it is essential, of course, to fit tubes correctly, and see that the valve is in good working order. But it all amounts to very little in the matter of time involved . . . and what a handsome dividend the little extra care and attention pays!

Rural London

SOME years ago someone wrote a book called "It isn't far from London," and in that book detailed the many rural spots which "modern progress" has left to us almost within sight and sound of the Metropolis. And it is amazing how much good green "country" there is within easy reach of Town. Lately, I have been riding around the lanes of Middlesex . . . that "dormitory" county which Mother London almost threatens to swallow up in her ever-growing expansion. A few minutes walk from a Tube station, and one may still see truly rural sights, and hear the authentic homely sounds of the countryside. It is but half an hour's journey from Baker Street to Northwood, and there, a week ago, I saw a hare loping across a meadow, heard the pleasant sound of a corn-cutting machine, and watched the merciful "despatch" of many bunnies which had taken refuge in the corn. And in the neighbouring woods I watched with pleasure the antics of the old English red squirrel . . . that lovable little creature which has been almost ousted from our woods and thickets by his American "cousin," the "grey." Yes! within sight of Charing Cross we may still find herds of cows, and see the shy hare dart from her "forme," and feel that Mother Nature clings to her strongholds with incredible tenacity.

Priority for Paint

TALKING with a cycle dealer the other day, he told me that one of his dearest wishes was to give his shop a coat of paint. Like thousands of other shops, it has just had to "manage" during the war, and it is looking a bit shabby and uninviting. My friend is looking forward to the day when it will be bright and alluring again; when his window will be full of goods to sell, and when he can feel that he is really in business. Well, I expect his wishes are echoed by hosts of dealers, not only in the cycle business. Our streets, our towns—they are all crying out for re-decoration.



My Point of View

BY "WAYFARER"

Mystery

I WAS wondering the other day how it came about that so many Italian ex-prisoners of war ("co-operators" I fancy they are called) manage to obtain the bicycles on which they career about the local countryside. Having regard to present-day shortages, this is a mystery to me, but the explanation may be that the machines are loaned by the men's employers.

Rehabilitated

ONE evening recently, when returning from a mid-week ride I heard a youngster playing at the roadside call out: "Look at that racer!" No other cyclist being in sight, I felt justified in believing that the "racer" in question was none other than myself. My lost prestige was at once restored to me (it is some years since I was singled out as a fast man), and I felt completely rehabilitated!

Sheer Bad Luck

I RECENTLY sustained a puncture which almost deserves the use of the word "unique," and which was a case of sheer bad luck. Leaning my bicycle against an ancient gate-post, I lay down under a tree for an after-lunch nap. When this was completed to my satisfaction, I took hold of my bicycle and started to move it from the gate-post, when my progress was arrested. I looked to see what was wrong and found to my horror that a bent nail, sticking out of the gate-post business-end first, about three inches from the ground, had just penetrated the side of my back tyre. An extremely unpleasant and unwelcome hissing sound told me the rest of the story, and I was not at all pleased to be the victim of an incident which, it must be admitted, is not likely to happen twice within the lifetime of any cyclist. My only consolation was that a bucket of water was *not* needed for the location of the puncture!

The Sands Are Running Out

THE war position at the moment (and it is bound to improve before these words see the light of day) leads one to say that the sands are running out, and that the "glorious hour" which was given to cyclists through the restriction of motoring is drawing to a close. We must count our blessings, remembering that the motorist's bad luck was our good fortune, for it gave back to cyclists travel conditions which the older inhabitants of the road never expected to see again. Apart from an occasional military convoy, we have had the highways very much to ourselves, and it has been truly delightful. The busiest of main roads, normally, has been almost a haven of peace. We have enjoyed the conditions of 40 years ago, plus grand road surfaces. In addition to counting our blessings, I suggest that there is one thing all wise cyclists should do—make the most of current conditions while they last. To paraphrase a well-known quotation, we shall not look upon their like again.

"Some" Present

ON my retirement from business at the end of March, 1938, my colleagues very kindly presented me with a first-class bicycle. I was asked what I would like to have, and it appeared to me that for one who is a cyclist first, last, and always, there could be no more suitable present. That machine took me away on the following day for a tour, and during the first year of my retirement I enjoyed a dozen such tours. Now, at the beginning of September, 1944, the cyclometer indicates that I have done 40,000 miles on that machine, which is my principal mount. It has taken me to many parts of England and Wales, to Scotland, and to Ireland, and it seems likely to give me super-service for, possibly, my remaining years as a cyclist. The bicycle has been a tremendous donor of joy—and a great withholder of trouble, for it has run perfectly. It has been my faithful companion in rain, snow, sunshine, wind: by day and by night: on good roads and bad roads: up hill and down dale.

I make bold to suggest that, in the whole history of the world, no more useful present was ever given to anybody. That bicycle, in the light of all that it has meant to me in the way of health and happiness, deserves to be characterised as "some" present. One of these days I shall again be retiring from commerce, to which I returned some 4½ years ago, and that bicycle will have greater use than ever. But how I wish somebody could give me 10 years of life, to eke out my own supply!

The Expected Happens

I NEVER see a brother cyclist holding on to the back of a motor lorry without fearing that the worst may occur. A sudden acceleration on the part of the driver, or some irregularity in the surface of the highway, or a piece of carelessness on the part of the cyclist, may result in the latter's equilibrium being upset, with fatal or non-fatal results. So, the other evening, I was not surprised to hear on the wireless that a cyclist being towed by a lorry had been killed and that witnesses of the accident were wanted. The expected had happened, and a totally unnecessary death, arising out of an action which is illegal, was the result. The price of this cheap power may turn out to be too high, and you may unwittingly hurt another cyclist while you are in the process of being towed. That's an important point.

A Right Start

ONE who is taking an active interest in the younger cyclists of the city in which he lives, and is conducting runs for their benefit (making it clear that neither their clothing, however unsuitable, nor their mounts, however ungainly, will be criticised—though advice on both points can be had for the asking), told me the other day that he was trying to give the youngsters a right start in at least two respects. He makes it clear to each party that "Halt" signs must always be observed, and that, as a general rule, the two-abreast method of riding should not be exceeded. An admirable policy!

MAJOR BROTHERTON

Death from wounds in Italy

MAJOR ERIC JOHN RODERICK BROTHERTON, only son of Mr. E. Brotherton, director of the Hercules Cycle Co., of Norwood House, Binswood Avenue, Leamington, has died from wounds, in Italy.

Major Brotherton went to Shrewsbury from the Lickey Hills Preparatory School. During his last year he was head of his house and was Matthews Exhibitioner, i.e., the best all-rounder of the year. He entered Balliol College, Oxford, as a scholar and came under the influence of Mr. Kenneth Bell, now associated with the Bishop of Coventry's work in this diocese.

Notes of a Highwayman

By LEONARD ELLIS

Post-war Planning

IT is inevitable that with the rapidly improving war conditions cyclists are already beginning to plan out their next year's tours. I expect that many will regret that the lifting of many restrictions and the obvious improvement in touring conditions should coincide with the fall of the year instead of the spring. The philosophical ones, however, will console themselves with the thought that there will be a longer period in which to perfect their plans. And what an orgy of map-searching and investigating will be indulged in during the not-so-dark period this winter. How many firesides will be adorned with anxious faces and fingers twiddling a map measurer. When the first signs of good weather appear in 1945 will there be a tremendous rush of tourists to all quarters of the British Isles like a flooded river bursting its banks? I saw in a paper quite recently that next year thirty million war-weary workers will make a rush for the resorts, and the powers-that-be are somewhat concerned to discover that even though holidays are staggered to the utmost, British resorts will be unable to cope with the avalanche. In fact the so-called resorts could not hold the anticipated numbers.

The Cyclists Score

HERE is where the cyclists score over travellers by other means. It seems fairly reasonable to suppose that by far the greatest numbers of cyclists will prefer to steer clear of the popular places. I have never gone deeply into this question and the only reason I can offer is that from the very beginning a cyclist's keynote is simplicity. His mode of travel is simple, his wants are few and simple. He begins his holiday from the moment he bestrides his bicycle. Unlike the others he does not have to wait until he has completed a tiring train journey which then lands him in a resort of artificial enjoyment. Whereas the train traveller seeks and finds no great enjoyment in the journey there and back, the cyclist begins to enjoy the very first minute. He comes therefore in time to appreciate the simple things of nature, such as the hedgerows, the birds, the brooks and the like. He realises very soon that these and not the tennis courts, the cinema and the immaculate flannels are the backbone of a holiday that will live in the memory.

The Prospect Ahead

THE cyclist at any rate will not be compelled to wait interminably in a railway station, or to jostle with the crowds on the promenade. You are more likely to find him plodding a lonely trek across a Welsh mountain pass, seated on a rock overlooking a sunlit Cornish cove, or wandering in deep and silent admiration along the banks of a turbulent little Derbyshire stream. What a wealth of unspoilt countryside to choose from. Three whole counties in the far south-west, Cornwall, Devon and Somerset, choc-a-bloc with beautiful spots far from the madding crowd. The cliffs along the southern Cornish coast, the lonely tracks across Dartmoor, Selworthy and the delightful villages of Devon and Somerset. North and South Wales, so different and so alluring. The Derbyshire Dales with their wealth of beauty and variety. The warm, mellow stone and earth of the Cotswolds; the rugged grandeur of the Pennine Chain and the Yorkshire Dales; the immense area of Scotland and the Lake District—all these are calling vociferously to the cyclist, all are there for the taking. After five weary years the prospect ahead almost seems to justify the war.

Selworthy, Somerset.

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