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THE CALCULATING MACHINE

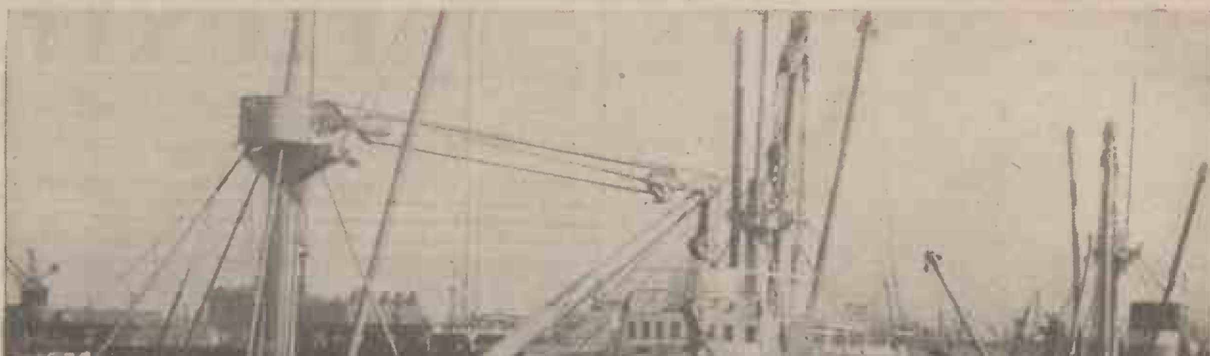
NEWNES

PRACTICAL MECHANICS

9D.

EDITOR: F. J. CAMM

JULY 1946



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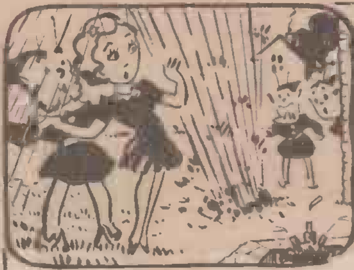

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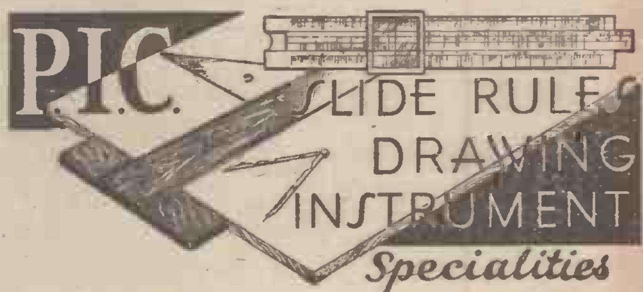

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PRACTICAL MECHANICS

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

Editor: F. J. CAMM

VOL. XIII JULY, 1946 No. 154

FAIR COMMENT—BY THE EDITOR

Time and Motion Study

FREDERICK WINSLOW TAYLOR did more than anyone in the history of industry to foster better understanding between labour and management, for it was he who first conceived the idea of time and motion study. After the industrial revolution when wheels took the place of hands and machines produced with automatic precision work superior in quality to that produced by hand, it was inevitable that labour itself should be geared in to the new methods, and that schemes should be produced to make labour lighter, with the resulting increase in output.

Taylor enunciated the need for time and motion study and gave his reasons for the opposition to it. "Why is it, in the face of the self-evident fact that maximum prosperity can exist only as the result of the determined effort of each workman to turn out each day his largest possible day's work, that the great majority of our men are deliberately doing just the opposite, and that even when the men have the best of intentions, their work is in most cases far from efficient?

There are three causes for this condition, which may briefly be summarised as:

First: The fallacy, which has from time immemorial been almost universal among workmen, that a material increase in the output of each man or each machine in the trade would result in the end in throwing a large number of men out of work.

Second: The defective systems of management which are in common use and which make it necessary for each workman to work slowly, in order that he may protect his own best interests.

Third: The inefficient rule-of-thumb methods, which are still almost universal in all trades, and in practising which our workmen waste a large part of their effort.

He goes on to say that craftsmen should realise that the one element more than any other which differentiates civilised from uncivilised countries—prosperous from poverty-stricken people—is that the average man in the one is five or six times as productive as the other. The workmen of England, perhaps the most virile nation in the world, he says, more than any other civilised country are deliberately restricting their output because they are possessed by the fallacy that it is against their best interests for each man to work as hard as he can.

Whether Taylor is right or wrong from his conclusions there can be no doubt that the new science of time and motion study has vastly contributed to the comfort of the worker and made his lot an easier one. It has been responsible for the introduction of devices to relieve him of the exertion of lifting heavy weights from the floor or the bench, and of performing unnecessary movements of body by introducing devices to place work components and tools at hand.

The new science has been responsible for the formation of the Institute of Industrial Technicians, whose object is to further the science of time and motion study.

Who *Made* the First Pedal Bicycle?

NO one has challenged the claim of Kirkpatrick Macmillan to have invented the prototype of the pedal-driven bicycle, and it is generally accepted that he evolved his design in the year 1839. As announced in *The Cyclist* supplement to this issue, a plaque has been unveiled on the Smithy at Courthill where, it is stated, Macmillan built his machine in that year. The Centenary Bicycle Club, whose members are chiefly manufacturers of bicycles, made a pilgrimage to the smithy for the unveiling ceremony, and adequate tribute was paid to the man who by accident, and purely for his own amusement, first applied pedals to the velocipede and operated the rear wheel by means of rods and cranks.

Shortly after this ceremony we were browsing through some old volumes of *The Hub*, which was one of the earliest cycling journals published by the proprietors of PRACTICAL MECHANICS, and we chanced upon an article in the issue dated April 23rd, 1898, which seems to cast doubt, since the article has never been challenged or refuted, upon Macmillan's claim to have *built* the machine which he designed. In the article to which we have referred appears an interview with Mr. A. Slade, then a resident of Twickenham, and in the course of the interview he stated that as a young man he lived in Somersetshire and earned his living as a mechanic. About the year 1840 he was working at a cabinet-maker's, and one of his mates told him that Macmillan, who was a travelling packman or "tallyman," wanted to get a new form of bicycle built. Macmillan's idea was to save himself the labour of carrying his pack about. Macmillan accordingly provided Slade with a drawing of his invention, and with the help of a coachmaker to make some of the iron work, it was finished, according to Mr. Slade, exactly as Macmillan drew it. The frame and pedal levers were made of ash and the wheels were made of lancewood. It was very heavy, and when Macmillan got it he found that he could not possibly carry his pack on it. Macmillan took it away and Mr. Slade never saw it again. Mr. Slade says that he made the bicycle when he was twenty-three years of age, and he was born in 1817, which would make the date of construction 1840—a year after Macmillan claimed to have invented it.

Like Dunlop, who had no idea of inventing a world-shattering invention when he invented the pneumatic tyre, Macmillan similarly had no idea that his invention was to give rise to the chain wheel and sprocket. For many years the invention was credited to Gavin Dalzell, but later researches which disclosed that Macmillan was actually fined for riding his pedal-driven velocipede (thus achieving fame as the first cyclist to be prosecuted), proved that Macmillan was undoubtedly the first inventor. There is now considerable doubt as to whether he was the first builder and we commend these notes to Mr. Gordon Irving who has written "The Devil on Wheels," which is a biography of the life of Kirkpatrick Macmillan and a history of his experiments, and also to the Centenary Club; for if an Englishman undoubtedly did build the first bicycle it is in the interests of historical accuracy that the construction should not be credited to the Smithy at Courthill. Additionally, if Macmillan was a journeyman, there seems to be a gap in Mr. Irving's biography which needs to be filled. As the book deals with consecutive phases in Macmillan's life and the story as printed seems quite cohesive, it would appear that memories are at fault or that the late Mr. A. Slade has made a mistake in the name. The matter should, however, be investigated and it should be possible to get into touch with the relatives of Mr. Slade, even as Mr. Irving has been able to trace acquaintances and relatives of Macmillan and so build up the material for his book. The matter cannot be allowed to remain in doubt in view of the disclosures we have now made.

The Model Engineer Exhibition

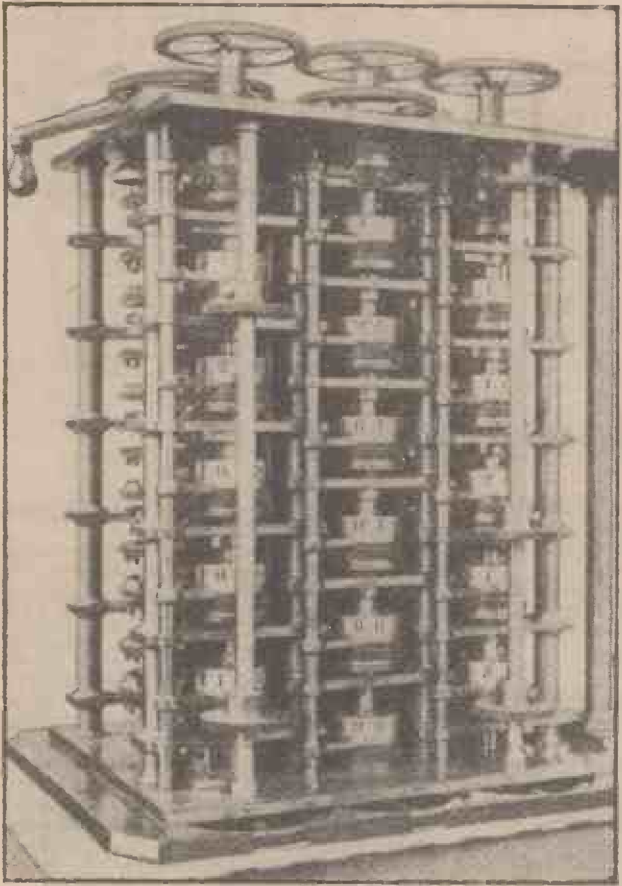
IT is a sign of the country's gradual return to normality that once again after a gap of over six years the Model Engineer Exhibition is to be held in August of this year at the Agricultural Hall. This journal will be represented, and all readers are cordially invited to call upon us there. We shall exhibit a full range of our technical books and periodicals, and we shall also show a number of interesting models. We expect to exhibit an accurate scale model of Macmillan's bicycle referred to in the preceding paragraph.

Indexes to Vol. XII "Practical Mechanics" are now available, price 10d. each (post free) from the Publishers, George Newnes, Ltd., Tower House, Southampton Street, Strand, London, W.C.2.

The Calculating Machine

Its History and Basic Principle

By F. W. COUSINS



Babbage's difference engine.

MAN'S hatred of the drudgery of calculation appears to have begun with time itself, for we find in early classic days the use of the dust board, a tray filled with damp sand which was scored by the fingers into squares and punched by the finger to facilitate counting. Pebbles called calculi were later used, and these when strung together formed a more permanent record, and a crude bead frame or abacus.

The origin of the abacus proper is lost in the mysteries of the Orient; it is thought to have come originally from the Semitic races, who were the great traders of the ancient world; or to be the outcome of Chinese numbering rods, explained in the works of Mei-wen-ting, and reputed to have been used in Korea from the earliest days.

The abacus is still used extensively in the East, and it has played an indelible part in the practical and commercial arithmetic of the ancient and mediæval worlds.

Napier's "Bones"

The first great advance toward an academic solution of the problem of rapid calculation came in the days when very few people indeed were able to use figures, and from a country more engrossed in religious dogmas than the advance of mathematical science. In the year 1617, John Napier, of Merchiston, explained his logarithms and numbering rods, now universally known as "Napier's Bones." To this Scotsman, who had spent periods of his education in Europe, must go the credit for the advances in science and mathematics which were to follow this gratuitous knowledge given to the art.

As a direct outcome of Napier's invention, Edmund Gunter plotted logarithmic values on a 2ft. rule and used a divider to transpose his measurements to add and subtract, and thus accomplish multiplication or division. Following this method of calculation, William Oughtred used two Gunter lines to construct sliding members of circular and linear form.

The first published description of a spiral and circular slide rule appeared in 1630, and this was written by Richard Delamain. Robert Bissaker and Seth Partridge followed this accomplishment with the first slide rule working between stocks, and this type of rule was advanced considerably by those able engineers Boulton and Watt, to aid calculation in steam engine design (1779). Mathematicians then had to wait until 1850 for the Mannheim type of rule, made by Tavernier-Gravet, and incorporating a cursor.

In the year 1666 Sir Samuel Morland had improved the numbering rods of Napier by using rotating drums instead of flat rods. Several of these machines were manufactured, but they were not machines in the strict sense of the word.

Pascal's Machine

Blaise Pascal, the noted French philosopher and mathematician, produced the first real calculating machine in 1642. This consisted of pin-wheel gearing, and numbered discs, but was very slow to operate.

A compact instrument in which the numbers were moved by a stylus, was introduced by Morland in 1666, and this was improved by the third Earl of Stanhope and Dr. Roth, to carry tens.

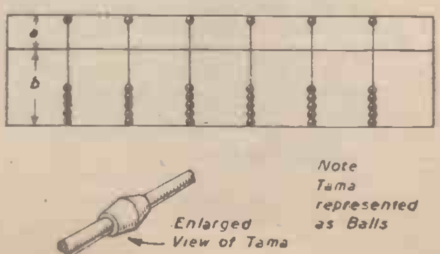


Fig. 1.—The Japanese Soraban.

It was a well-known fact that multiplication was really repeated addition, for example :—

$$6543 \times 434.$$
$$\{6543+6543+6543+6543\}+$$
$$\{65430+65430+65430\}+$$
$$\{654300+654300+654300+654300\}$$

This type of operation can be performed by all machines of the Blaise Pascal type, but the time required to operate is almost as long as that required for normal multiplication.

Rapidity in multiplication by the addition method was added to the art by Gottfried Wilhelm Leibniz,* a German mathematician and philosopher, who with his now famous Leibniz wheel was able to construct his first machine in 1694, and this remarkable instrument is preserved in the Royal Library at Hanover.†

During the 18th century many mathematicians, such as Lepine, Boistessandeau, Hahn, and Müller, made attempts to evolve a really satisfactory machine, but their chief difficulty lay in the high order of accuracy required in cutting the gear teeth.

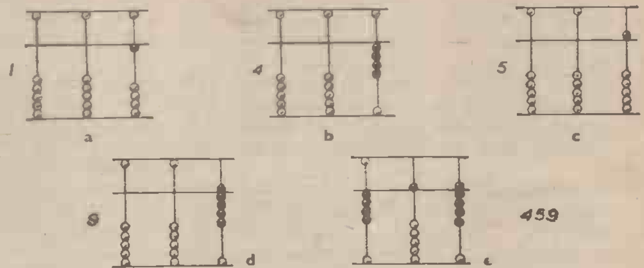


Fig. 2.—Stages in calculation with the Soraban.

Charles Xavier Thomas

In the year 1820 Charles Xavier Thomas, of Colmar, Alsace, demonstrated his distinct type of calculation machine which persists in type to this day, and must be considered the forerunner of the modern industry. The machine was in three parts, setting, counting and recording. It depended for its success in operation upon the masterly use of several "Leibniz" wheels.

The year 1878 saw the modern German industry born with the manufacture by Arthur Burkhardt of his Burkhardt Arithmometer. Similar machines which followed are known all over the globe under the trade names of Saxonia, Peerless, and Archimedes.

Frank Stephen Baldwin patented a machine in 1875 in which the "Liebniz" wheels were replaced by wheels from the periphery of which a variable number of teeth could be caused to protrude. Strange to relate, at the same time a Russian engineer, W. T. Odhner, designed and made a similar pin cam wheel, which was used to great success by the Grimme Natalis Company of Germany in their popular machine, the Brunsviga. The thin disc type "Odhner" wheel allowed for a compact machine and thus offered the designer a great advantage over the bulky drum type Liebniz wheel, which, up to this time, had enjoyed almost exclusive use.

* Spelt either Leibniz, Leibnitz or Lubeniecz.

† World War II may have altered the accuracy of this statement.

Key-driven Machine

The next great advance was the key-driven machine and the main development was undertaken in the United States of America. The Parmalee machine appeared in 1850 and in 1887 Dorr Eugene Felt patented his Comptometer.

During these years of development the first *direct* multiplication machine was in the embryo stage. Attempts to multiply directly and dispense with repeated addition had been made by E. D. Barbour and Ramon Verea without success. In 1887, however, Léon Bollée invented the tongued plate method for the representation in relief of the multiplication table, and in 1893 Otto Steiger patented his "Millionaire" machine, and it was marketed by Egli in 1899. This machine used the Bollée tongued plate multiplication table, and the machine has remained a popular and accurate means of rapid calculation.

Charles Babbage

Machines of a bolder and revolutionary nature were contemplated by that eminent mathematician, Charles Babbage, professor of Mathematics at Cambridge University. Working under Government financial assistance, he produced the plans for his Difference Engine and assisted in its actual engineering manufacture. It was, unfortunately, never completed. Babbage foresaw a new and in every way superior machine called his Analytical Engine, and this occupied his mind until his death in 1871. The object of the former machine was to calculate and print mathematical tables, and the Analytical Engine was to perform automatically a sequence of computations by punch card methods.

The Government of his day failed to realise his genius, and one cannot read the life of Charles Babbage without feeling keenly the tragedy of lost opportunities due to misunderstandings between this brilliant mechanician and the State.

In the compilation of statistics it is a necessity under modern conditions to have mechanical aid. In this field, mention must be made of machines such as the Hollerith range, using the Jacquard punched card, originally employed on the clever Jacquard looms.

This type of calculating machine has been used successfully to aid a compilation of statistics for the National Census, Customs and Excise work and the preparation of astronomical tables for the Nautical Almanac. Although the writer has no proof of the fact it seems likely that mechanisms of this type would be used to evaluate "demob" from the fighting Services according to the declared points allocation scheme.

Lord Kelvin's Machines

Lord Kelvin pioneered the next great advance. He united industrial science in this country with academic mathematics and was able to carry the art of mechanical computation far ahead of the ordinary arithmetical machines. He introduced machines for solving differential equations, and to effect harmonic analysis. His work was completed by such men as Dr. Vannevar Bush, Dr. Flemming, and Prof. D. R. Hartree. There are now in existence machines brought to perfection by these men which is a tribute to the foresight of Kelvin and his contemporaries.

Great strides have also been made in the field of mechanical computers, the mechanical brains which are used for such operations as gunfire control. This type of machine receives instantaneous values and delivers a continuous answer, and must therefore be considered as a distinct type of mathematical machine.

Principles of Design

The earliest instruments of calculation in the East were numbering rods ch'eou, and mention of them is found in the writings of the Han Dynasty, about A.D. 80.

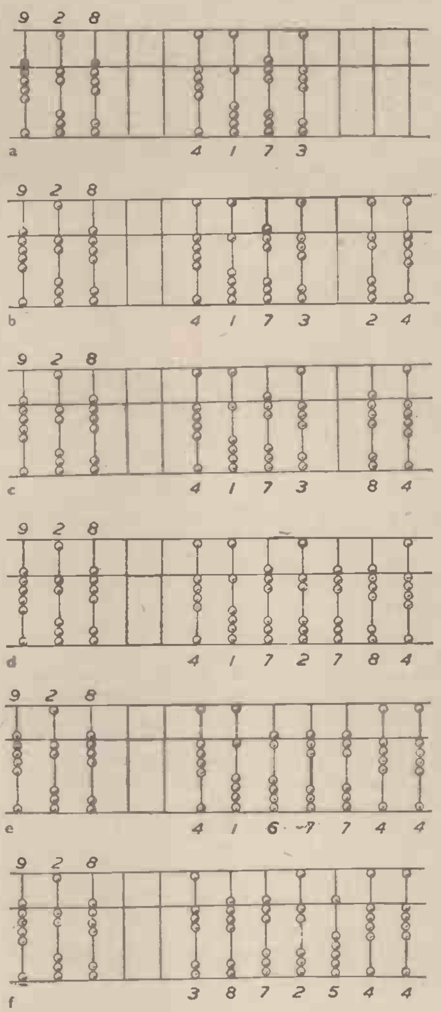
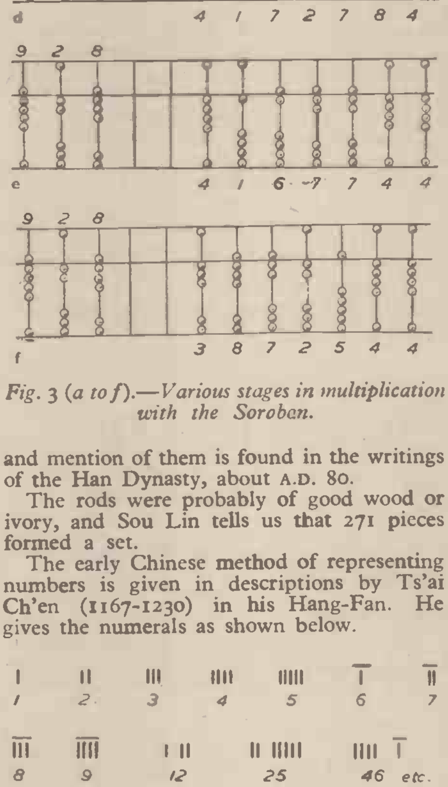


Fig. 3 (a to f).—Various stages in multiplication with the Soroban.

The rods were probably of good wood or ivory, and Sou Lin tells us that 271 pieces formed a set.

The early Chinese method of representing numbers is given in descriptions by Ts'ai Ch'en (1167-1230) in his Hang-Fan. He gives the numerals as shown below.



The great Mogul astronomer Kouo Sheou-kin, 1281, gives the No. 198617 in the following fashion  which is similar to the Japanese sangi.

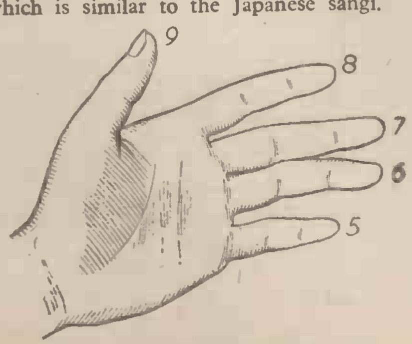


Fig. 4.—Using the hand as an abacus.

The Sangi Pieces are square prisms 5 cms. long and 7 mm. thick. The number 38057 would appear as follows when constructed with these pieces.

Eventually the Sangi pieces were dispensed with, and the lines placed on paper with the introduction of a zero.

38057 was then written 

The transition from ch'eou or rod calculation to the abacus came with the Ming Dynasty about 1384.

The Chinese Abacus is called the swan-pan (reckoning table), and it was the forerunner of the improved Japanese soroban with its sharp edge buttons in place of the balls used on the swan-pan.

The Japanese Soroban

A very detailed account of the Japanese abacus appears in "The Transactions of the Asiatic Society of Japan" (Vol. XIV, 1886), by Cargill G. Knott, D.Sc., F.R.S.E., Professor of Physics, Imperial University of Tokyo, and in the classic book "History of Japanese Mathematics," by Eugene Smith and Yoskio Mikami.

It is hoped that the following short description will show the versatility of the instrument.

The Soroban consists of vertical rods rigidly mounted in a frame with a horizontal bar arranged to divide the vertical rods into a short portion and a long portion, "a" and "b" respectively. Usually six tama or beads appear on each vertical rod, one bead on the short portion, five beads on the long portion. The beads are formed as double truncated cones, and the central ridge provides an easy register for the fingers during manipulation.

When the Soroban is prepared for use it appears as shown in Fig. 1. All the tama or beads at the outer boundaries.

If any one bead of a set of five be moved to the crossbar, it can represent, according to the rod chosen, 1, 10, 100, 1,000, or as desired by the operator.

If the single bead on the short rod is moved toward the crossbar it can, according to the position of the rod selected, read 5, 50, 500, 5,000 or again as desired by the operator.

Fig. 2 (a to e) below will clarify these remarks. A portion only of the whole Soroban is drawn.

We have then a mechanical model of the cypher system.

Suppose it was desired to multiply 4,173 by 928. Then on the Soroban one would proceed as follows:

Set the multiplier and multiplicand as shown in Fig. 3a, with free rods in between.

The beads in use are the only ones portrayed.

Proceeding to multiply 3×928, we have initially Fig. 3b. $3 \times 8 = 24$, and this is set three bars away (the same number of bars as numbers in the multiplier). Fig. 3c shows the next operation in the multiplication of 3×928, i.e. $3 \times 2 = 6$. Six beads have accordingly been added to the tens rod, and we have the number 84. Fig. 3d completes the first manipulation $3 \times 9 = 27$, and this is added, seven to the hundreds rod and two to the thousands rod. Before the two can be added, the Figure 3 of the number 4173 must be removed, it now being redundant.

Continuing in like fashion, 928 is multiplied by 7.

$7 \times 8 = 56$
$7 \times 2 = 14$
$7 \times 9 = 63$

These are added to give the result shown in Fig. 3e.

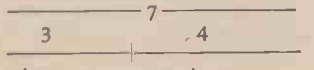
The operations for 1 and 4 are similarly carried out and the final answer 3872544 appears as in Fig. 3f.

Division on the Soroban is based on the division table known as the ku, ki, kó, or nine recurring method, which is learnt off by heart in a similar way that Western children learn their tables.

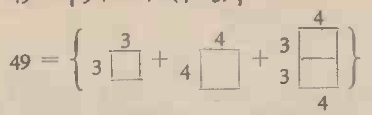
Square Root Extraction

Murai in his explanation of the Soroban shows a method for extracting the square root and cube root. In extracting the square root he divides half of the remainder by the part of the root already found. In treating the cube root he proceeds in analogous fashion, dividing a third of the remainder twice by the part of the root already found.

C. G. Knott explains that the extraction of the square root is called "kai-hei-ho, and requires a knowledge of the table of half squares (han-ku-ku). The basis appears to be the geometric theorem that if a straight line is divided into two parts, the square on the whole line is equal to the sum of the squares on the two parts, together with twice the rectangle contained by the parts.



$$49 = \{ 9+16+2(4\times3) \}$$

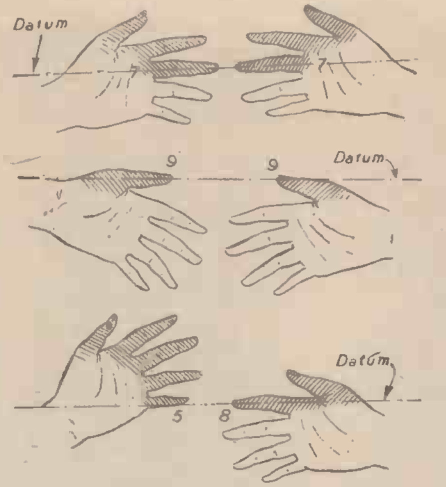


Expressed algebraicly, we say the square of a binomial is the sum of the squares of the two components together with twice their product.

$$(a+b)^2 = a^2+b^2+2ab$$

Thus the number 6889 can be divided into 6400+489 where 6400 is the highest power of 100 contained in the number which is a complete square.

$$6400+489 = 80^2+489.$$



Figs. 5 to 7.—Method of using the fingers for simple multiplication.

So that 80 is the first approximate value required.

Now, just as $(a+b)^2 = a^2+b^2+2ab$

$(80+3)^2 = 80^2+3^2+2(80\times3)$

But it can be shown that by halving the remainder 489 we may employ 80 itself as our trial divisor. In completing this step we must take $\frac{1}{2}(3)^2$, i.e., $\frac{1}{2}b^2$, and hence the importance of the table of $\frac{1}{2}$ squares.

An example step by step will clarify the method :

```
 8 |68|89| ..............(a)
      489  ..............(b)
83  244.5  ............(c)
      4.5  ..............(d)
     ----
      . .
```

In line (a) $8^2=64$ is subtracted from 68, leaving 4.

In line (b) halve the whole remainder 489—to give 244.5 in line (c).

Use 8 as a trial divisor of 24, and this gives 3. Subtract $3\times8=24$, leaving 4.5, and consider 83 as full divisor.

Subtract $\frac{1}{2}(3)^2$ from 4.5 (line (d)), which leaves zero.

Thus, 83 is the required square root.

Human Type of Abacus

It is interesting to consider at this point a human type of abacus believed to have been handed down by gipsy tribes. The fingers of the left and right hand are used to aid multiplication and reduce the number of tables committed to the memory.

The fingers of the two hands are allotted various numbers, as detailed in Fig. 4, the right hand being treated in similar fashion.

Multiplication of any simple numbers from 5 to 9 is then achieved by placing the fingers representing the numbers together. Fingers below the two used for the multiplication count 10 each. Fingers above the two used for multiplication and including those two fingers along with the thumbs, count one each, and the left hand quantity is multiplied with the right hand quantity. Figs. 5 to 7 explain the simple procedure.

To multiply 7×7.

Fingers below datum = 4 = 40.

Fingers above and on datum = 3 left, 3 right. $3\times3 = 9$.

$(40+9) = 49$

To multiply 9×9.

Fingers below datum = 8 = 80.

Fingers above and on datum = 1 left, 1 right = $1\times1 = 1$.

$(80+1) = 81$.

To multiply 8×5.

Fingers below datum = 3 = 30.

Fingers above and on datum = 5 left, 2 right = $(5\times2) = 10$.

$(30+10) = 40$

(To be continued)

An Electric Drive for a Gramophone

By K. SILLERS

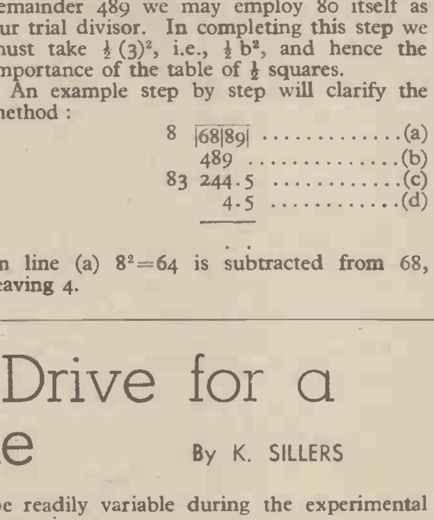
IN these days electric gramophone motors are almost impossible to obtain, but there are a certain number of cycle dynamos available ; some readers may even consider it worth while to rob their cycles of this adjunct for a good purpose.

Though it may not be generally realised, most dynamos can be used, with a bell transformer, as a synchronous motor. The speed of running is, of course, dependent upon the number of poles of the rotor and armature, which varies with different makes, but the writer has found the power just sufficient to drive a gramophone turntable, by friction drive on to the outer edge.

The gramophone motor was first partly dismantled, so that the turntable spindle was quite free of governor and gear train. Then a hole was cut at the back of the motor-board, and the dynamo mounted by its built-in spring swivel on to an angle bracket screwed under the board and insulated from vibration by thick rubber washers. The milled wheel of the dynamo projects through the hole and, surrounded by a soft rubber tyre, bears lightly on the turntable edge. The pressure must be the absolute minimum possible without slip, as the small margin of power available will not cope with much unnecessary friction. It was found necessary to weaken the built-in spring by means of a counter spring pulling the dynamo away. This may simply be an elastic band, as shown in the sketch, and the tension should be readily variable during the experimental mounting stage.

Rubber Tyre

The size of the rubber tyre will govern the final speed of the turntable. For the tyre a doorstop, about $1\frac{1}{4}$in. in diameter, was used, with the central hole enlarged to fit over the milled wheel, though with some dynamos it may be possible to remove the wheel and bolt on the rubber stop in its place. To avoid noise there must be no irregularity in the shape, and after the rubber has been carefully trimmed with a sharp, wet knife to the approximate size required the edge should be well smoothed by means of sandpaper held against it while the turntable is rotated by hand. A stroboscopic disc is almost indispensable for these final adjustments.



Method of using a converted cycle dynamo for driving a gramophone turntable.

The motor will start at synchronous speed at a mere flick of the turntable and stop at the touch of a finger. The current used is minute, and a small switch may be mounted, with the bell transformer, under the motor board.

In addition, a metal rectifier and change-over switch was also fitted so that the same transformer can be used as a trickle charger.

A LONG CYCLE

A NEW description of elongated cycle has been designed.

This is a pedal-driven wheeled vehicle, in which the force exerted on the pedals is transmitted through hydraulic pistons to a rotary hydraulic motor coupled by mechanical driving gear to the rear wheel or wheels of the vehicle.

The fluid used in the hydraulic transmission may be water, oil or mercury, and the transmission is preferably in two stages. The hydraulic motor of the first stage drives a shaft from which crank-operated plungers drive a secondary hydraulic motor coupled through a gear box with the driving shaft of the vehicle.

Fig. 73.—*The "Bat." This was the first and only missile of the war to incorporate a radar "self-directing" scanner.*

Rocket Propulsion

Anti-shipping Missiles : the "Baka" Suicide 'Plane : German Aircraft Developments

By K. W. GATLAND

(*Continued from page 320, June issue*)

ALTHOUGH it must be admitted that many of America's guided missiles were based on German research, the Germans by no means had the monopoly of ideas in this development.

The "Bat" (Fig. 73), one of the rocket powered missiles, produced in quantity and used effectively against Japanese shipping, was actually *self-directing*. It had the appearance of a miniature high-wing monoplane, and contained within its blunt nosing a radar target-seeking device against which evasive action by the enemy was useless.

The aircraft chosen to operate the missile was the Naval PB4Y-2 Privateer, and priority modification was set in hand at Consolidated Aircraft to provide two special carriers, one beneath each wing.

A large number of Privateers equipped with "Bats" were ready before the final overthrow of Japan, and no time was lost in using them in action. The missiles were released, one at a time, from well outside the range of defensive fire, and were presumably directed to the vicinity of the target by radio-control. Instead, however, of depending upon the remote controller for final delivery, the "Bat" was able to search out its own target and to guide itself directly in to the vessel its sensitive radar "eye" had first located.

This 12ft. long missile was responsible for sinking many thousands of tons of shipping, being the only weapon of the war to be fitted with the radar-scanner "brain."

The Henschel 293

It was, of course, the Germans who first demonstrated the anti-shipping "glide-bomb." Their most successful missile in this class was undoubtedly the Henschel 293 (Fig. 74); it was, in fact, the first of all aerial missiles, being initially used against Allied shipping in the Bay of Biscay during the autumn of 1942. It later appeared in the Mediterranean, particularly near Anzio.

Certainly, the Hs. 293 was a unique weapon, coming as it did before the era of the "V" developments. In it were combined for the first time in any warcraft a bi-fuel rocket unit and a radio-controlling gear, the latter being operated by the crew of a parent aircraft.

The controlling aeroplane, usually a Dornier 217, remained out of range of defending fire, yet at a distance that permitted direct sighting of the target. A flare was fitted at the tail of the missile to assist the controller. Designed by Prof. H. Wagner, of Junkers, the Hs. 293 was about the same size as the American "Bat," 11ft. 8in. long and 9ft. 6in. in span. It had the appearance of a small mid-wing monoplane, with the tail-plane high on the rear fuselage and a single fin extending forwards along the centre-line.

A detonator projected from the nose, behind which was the 1,120lb. war-head. The radio directive gear was contained in the centre section, with the gyroscope, power generators and batteries at the rear. The propulsion unit was housed complete in an underslung nacelle.

The weapon weighed 1,730lb. when fully charged with 1,120lb. of propellant. It had a controlled range of 5½ miles and flew at a maximum speed of 375 m.p.h.

Propulsion was by the reaction of H_2O_2 and calcium or sodium permanganate in a modified version of the Walter 109-500 assisted take-off motor. In this system hydrogen peroxide and an aqueous solution of the permanganate are injected under pressure from air bottles into a single reaction chamber. The catalytic action of the permanganate decomposes the H_2O_2 to steam and oxygen at 480 to 500 degrees Centigrade, yielding an average thrust of 1,500lb. for twelve seconds.

There was also an alternative motor which burned gaseous oxygen and methonal.

The missiles scored a certain initial success until a satisfactory antidote was found in the development of a radio device for jamming the controlling signals.

Another Henschel development was the Hs. 294, an air-launched missile which entered the sea at approximately 275 m.p.h., to explode below the surface. It was guided to hit the water at 100 to 130ft. from the target vessel, shed its wings and motor, and penetrated beneath the ship, being detonated by a proximity fuse.

The "Baka" Suicide 'Plane

The "Baka" or Kamikaze 'planes were the Mikado's last desperate challenge to Allied sea-power in the Far Eastern waters. They were initially operated from the island of Okinawa against shipping in the Ryukya area, and several were found intact when the island was subsequently taken by U.S. forces.

A remarkably small 'plane to be piloted, the "Baka" was only 19ft. 10in. long. Its low aspect ratio wings were 16ft. 5in. in span, and the tail span 7ft. 1in.

The fuselage was well streamlined, and the pilot was accommodated about two-thirds from the nose. His cockpit embodied a clear-view hood, which appeared large in comparison with the rest of the machine, of all-metal construction, the body structure having a covering of thin gauge light alloy. In the nosing was a 1,200lb. charge of tri-nitro-anisol explosive, and behind the pilot three dry-fuel rocket units, which propelled the "Baka" in its final "death-dive" at a maximum speed of

This "Baka" 'plane was found on Yontan airfield, Okinawa. Its capture may have saved an Allied warship—certainly the life of a Jap.

630 miles per hour. Each unit weighed approximately 260lb., of which 97lb. comprised fuel and fired for about eight seconds. The maximum thrust developed by each propulsor was 1,760lb., and the jet velocity, therefore, a little more than 4,700ft. per second.

The all-wood, ply-covered wings were placed mid-depth of the fuselage, forward of the cabin, and the tail-plane was set high at the extreme rear, with square fins at the tips.

The "Baka" was equipped with a liberal array of instruments, comprising an air-speed indicator (served by a pitôt head, which protruded from the port wing), altimeter, compass, fore and aft level indicator, rocket ignition selector and ignition buttons, circuit test switch, and a base fuse arming handle.

The pilot was supplied with oxygen during his brief flight, and protection was afforded by two 5-16in. armour panels, one on the floor of the cockpit and the other at his back. Normal "stick" and foot controls worked the ailerons, elevators, and fin rudders.

It was a surprisingly well-built aeroplane considering the short period of its operation, and had a high-gloss finish. The colouring was dark green on the upper surfaces, light grey beneath.

The Betty 2-2, a development of the Betty 1-1, was the aircraft initially used to parent the "Baka." The standard version of this two-engined medium bomber was able to carry two torpedoes in lieu of bombs. It was powered by two Mitsubishi Kasei 21 air-cooled radials, each capable of 1,800 h.p. at sea-level, which gave the machine a top speed of about 330 m.p.h. and a maximum range of 2,700 miles. These figures naturally suffered slight reduction when the "Baka" was carried.

A special carrier was installed below the fuselage near the c.g. of the aircraft, which held the 'plane snugly above the depth of the lowered undercarriage, permitting normal take-off. The undercarriage and all services were fully operable, as also was the protective armament, three 7.7 mm. machine-guns and two 20 mm. cannon.

The cockpit projected into the bomb-bay, and the twin fins and rudders fitted alongside the bomber's fuselage. The Betty 2-2 was particularly ideal for the job, as bomb-bay doors were not normally fitted. Another bi-motor aircraft, the Peggy, was reported to be operating the "Baka" during the later stages of the war.

The Kamikaze Corps

The fanatics who kept the "Baka" 'planes hammering away at Allied carriers and capital ships from the early summer of 1944 were, of course, inspired to the "supreme sacrifice" by their peculiar religious cult. The Japanese had grown up to the philosophy that to commit suicide was to be assured of a place among the gods. Even their nursery stories reflected the apothesis: "The Forty Knights of Ronin" tells of a band of knights who set out to avenge the death of their leader, and, each having accomplished his particular deed of valour, rounded off the episode by committing "hari-kari" with the sanctified sword.

Large numbers of their warriors during the war died self-inflicted deaths rather than suffer the "disgrace" of capture; similarly, it was not uncommon for pilots of orthodox fighters to dive their 'planes headlong into Allied bombers in preference to returning unsuccessful.

The men of the Kamikaze Corps went to their deaths as a well-trained unit. Their initiation involved months of calm instruction in the handling of gliders, and they eventually flew in specially built "Baka" trainers which landed on skids. Few of the pilots were more than 20; the majority ended their lives at an earlier age, and there appears to have been no lack of volunteers.

Having completed their training and before being assigned to their missions, the pilots, their heads shaven, were consecrated in a priestly ceremony. This involved a kind of religious carnival in which the people joined, honouring their heroes with flowers as pilots and priests paraded through the streets of Tokyo.

Eventually the fateful day arrived, and, locked within their separate cockpits, with the emblem of their unit painted boldly on the nosings of their machines—a cherry

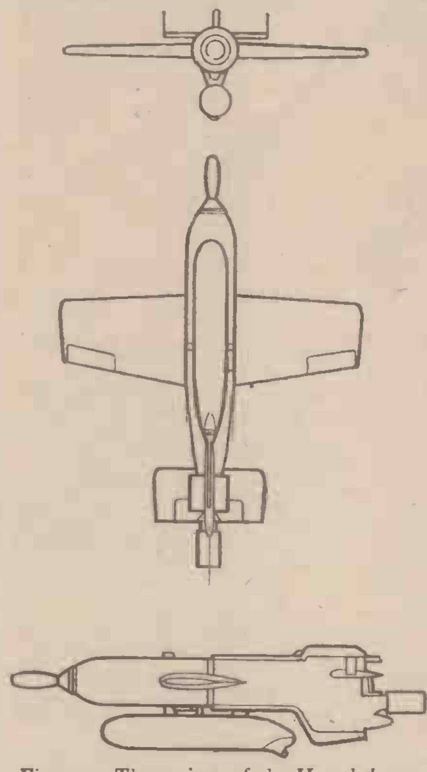


Fig. 74.—Three views of the Henschel 293, radio-controlled anti-shipping "glide-bomb." Its bi-fuel rocket unit was contained in a separate nacelle below the fuselage.

blossom, for instance, was the insignia of the Cherry Blossom Unit—the pilots were airborne on their last flight.

While the "Baka" and its parent 'plane were joined, the pilots were in radio contact, and it was the bomber pilot who decided upon the target and the time of release. Approaching the target area, the Kamikaze pilot was given his last instructions, and the 'plane cast loose from about 10,000ft.

The pilot did not use his rockets immediately, but glided in to his objective, bringing them into operation one at a time to increase speed for the final assault; then, weaving and diving to evade defensive "flak," he plunged headlong to his death.

Although the damage inflicted by suicide attacks was not as great as one might have expected, it is nevertheless true that a number of the "Baka" pilots succeeded in exploding their tiny aircraft on the decks of warships. The great majority, however, were either shot out of the air by the barrage of defensive fire or made to miss their targets completely, crashing harmlessly into the sea.

Whatever the outcome of the attack, the fate of the pilot was certain; the "Baka's" delicate fuses detonated on the water as easily as against the steel of a warship.

German Aircraft Developments

The turn of the air war in favour of the Allies brought an ending to heavy bomber production in Germany, and the entire industry was switched to the production of high-speed single and twin-engined interceptors. Only when the practicability of jet-propulsion was demonstrated did work again proceed with "heavies," and even then development was restricted to one or two firms. These aircraft were to have been operated from great heights, and in order to achieve bombing accuracy provision had been made in the original designs for guided missiles to be carried. The first of these new types to reach the prototype stage was the Junkers 287. This machine was said to have a range of 1,000 miles with a bomb load of 4 tons and a top speed in the region of 550 miles per hour.

Fighter Production

The production of fighters proceeded along the three distinct paths of power-plant development, (a) the conventional internal combustion engine, (b) the jet-propulsion unit, and (c) the bi-fuel rocket propulsor.

The most prominent in class (a) were, of course, the veteran Messerschmitt 109 and the Focke Wulf 190. At least three newer propeller fighters were in course of production.

In the jet-propulsion class were the Messerschmitt 262—the first jet machine to be used operationally—the Heinkel 162 or Volksjaeger (People's Fighter), the Arado 234, and a unique tail-less fighter designed by the Horton Brothers. A number of other jet interceptors were in project stage, while many prototypes of more advanced designs were still incomplete at the time of the surrender. Of particular interest is the fact that two of these projects were purely research aircraft intended to test various aerofoil sections and wing plan-forms at speeds in the region of $M = 1$. One of the research machines was designed for the fitment of alternate wings of 0 deg., 25 deg. and 35 deg. sweepback, and with these it was hoped to determine a degree of sweep-back optimum for flight both at high and low speeds. The other was to have been a twin-boom aircraft with the space between the booms utilised to test high-speed wing profiles.

Compressor-less Jet Interceptors

Another machine in class (b) was one projected by Lippish—undoubtedly the most unorthodox jet aircraft that has yet undergone serious investigation. A flying-wing in the very essence of the word, its design was based on the phenomenal top speed of 1,500 m.p.h., "g" effects being reduced by the pilot occupying a prone position. The wings were swept back sharply, the air to be taken in through a duct in the nosing.

It was intended to accelerate the 'plane into flight with dry-fuel rockets, and compression of the air was to have been entirely due to the ram effect of the high speed and not the result of rotary compressors. There was, of course, no turbine, and whereas most jet systems employ a liquid hydrocarbon to raise the air temperature, this was to have been accomplished in the Lippish machine by the use of carbon blocks, pre-heated to incandescence and rapidly loaded into the expansion chamber just prior to flight. The A.T.O. rockets having imparted the initial speed, the high velocity air-draught would ensure that the heat of the carbon was maintained in much the same way as bellows inflame a fire. The air was thereafter heated by the glowing carbons and the effluent ejected from the rear through a long, narrow slit in the trailing edge.

This system was said to be capable of maintaining a useful thrust for three-quarters of an hour, and in the closing months of the war the German technicians had suc-

A corner of a hangar at the Yokosuka Naval Air Station, Japan, where the Kamikaze pilots underwent their training. The machines in this picture are all trainer versions of the notorious "Baka," having ballast in place of H.E., and fitted with landing skids.

ceeded in the development of an improved motor in which the effective life of the heating substance had been almost doubled, simply by incorporating liquid fuel sprays above the carbons. The fuel tank was to be built within the single vertical fin.

Other compressor-less jet projects were fighters to be powered by liquid-fuelled propulsive ducts, including a high-speed helicoptor of unorthodox layout, which was to embody a duct unit in each tip of its three rotors.

All jet systems which depend upon induced ram pressure and are not resonant operating (e.g., as the Argus Rohr 014, propulsion unit of the "V1") are termed "athodyd"—the abbreviation of "aero-thermodynamical-duct." The simplest of all thermodynamic engines, the working portion is simply a venturi-shaped tube, having no moving parts and fitted solely with fuel burners and means of ignition. The duct contour is, of course, based on the performance desired of the motor.

Operation of the Athodyd

When the duct moves forward under the thrust of assisting rockets, air commences to ram into the intake at high pressure. The fuel burners, placed about a third from the intake, heat and expand the air, and the resultant high velocity gases are ejected from the rear as the reactive jet.

The greater the speed of the athodyd, the higher is its efficiency. Its possibilities for operating aircraft at sonic and supersonic speeds are enormous, and small test units have already been operated in America within these speed ranges.

In aircraft, however, its use will always be in conjunction with an auxiliary motor, and an integral rocket unit has already been tried by the Germans and found highly effective. A simple athodyd unit was employed with the rocket motor placed in the mouth of the duct, and it was found that a 50 per cent. increase in thrust was registered without actual burning of the fuel in the duct. This was largely cancelled, however, by the increased drag.

The rocket and duct combined were then tested for maximum thrust conditions, and the duct only for cruise purposes. This brought about a 100 per cent. increase in the cruising endurance over that of the bi-fuel rocket motor used in the Me. 163, and it was, in fact, proposed to replace the cruising unit on rocket powered fighters by a composite motor of this type. The development, however, arrived too late for operational use.

(To be continued)

Notes and News

Gun-fire Control

NOW that peace prevails, naturally we do not expect so many war inventions to be contrived. But military devices are not absolutely in short supply. Here is one relating to machines and particularly to gun-fire controlling mechanism.

The inventor points out that in the case of machine-guns mounted on aircraft, economy in the use of ammunition is desirable in view of the difficulty of carrying great quantities on aeroplanes. This is especially so when machine-guns of large calibre fire, for example, explosive shells. It is therefore sometimes desirable to employ short bursts of fire. But, owing to the rapidity of the fire of modern machine-guns, the number of rounds fired should be limited. This is not possible without some means for stopping the fire after the desired number of rounds have been fired.

The new invention has for its principal object the provision of mechanism for limiting to any desired value the number of rounds fired upon one continued depression of the firing button or trigger.

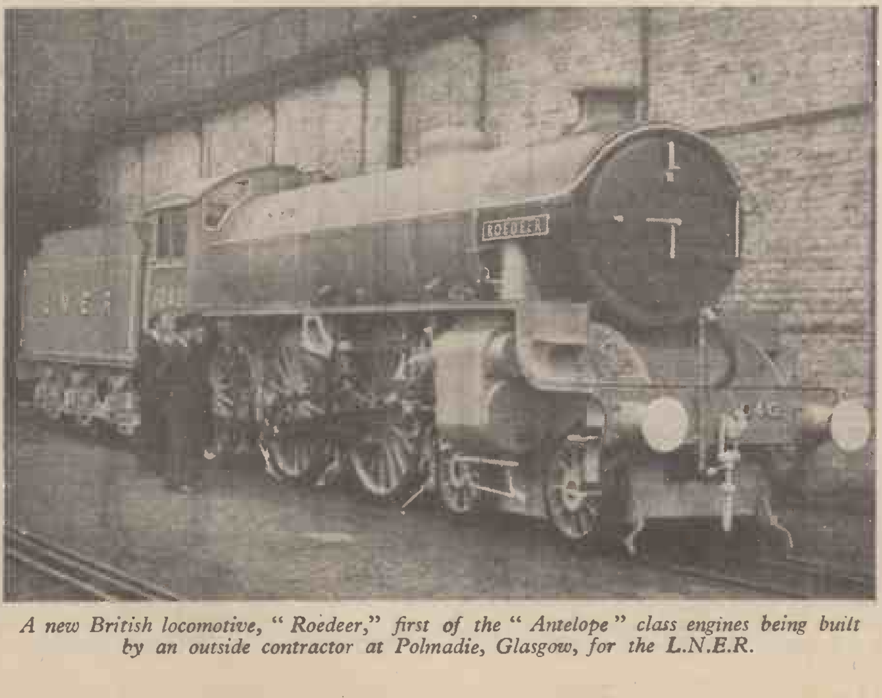
The device comprises electro-magnetic or electro-dynamic means for effecting directly, or through a relay, withdrawal of the gun sear, and an energising circuit for the electro-magnetic or electro-dynamic means, including a normally open firing switch, arranged to be closed by depression of the firing button. And there is a normally closed control switch arranged to be opened by a control member, when the latter has been moved forward a predetermined number of slips. This corresponds to the rounds fired by mechanism operated by the recoil of the gun or by the movement of a gun component during the firing cycle.

New High-speed Wind-tunnel

WITHOUT the modern wind-tunnel the task of the test pilot would be much more complicated and dangerous. At the Royal Aircraft Establishment at Farnborough, the new high-speed wind-tunnel is proving invaluable in testing aircraft models and component parts in varying atmospheric and wind conditions similar to those that might be experienced in any part of the world.

Work on the wind-tunnel was commenced in 1938, and over 1,000 tons of steel were used in its construction. The tunnel is 130ft. long and has a diameter of 37ft., while its 4,000-h.p. fan can produce a wind velocity of over 600 m.p.h. During tests a great heat is generated, and a brine circulation plant is used for cooling the shell of the wind-tunnel.

Full-size aircraft are not tested in the tunnel, but it is possible to use quarter-size models for making a close study of the characteristics of the airflow in relation to the aircraft's fuselage, nacelles, and controls.



A new British locomotive, "Roedeer," first of the "Antelope" class engines being built by an outside contractor at Polmadie, Glasgow, for the L.N.E.R.

An Experimental Sympiesometer

Constructional Details of an Easily-made Sensitive Instrument

By R. M. DAVIES and R. J. NORBURN

THE recent series of articles on meteorology in PRACTICAL MECHANICS lends additional interest to the following description of an unusual type of barometer based on Hooke's marine barometer, and invented by Adie, of Edinburgh, in 1818.

It is more sensitive than an ordinary mercury barometer and much less expensive, as glycerine or a light mineral oil, or even water may be used. The principle is really that of a gas barometer, the liquid acting almost entirely as an indicator.

The general appearance of the instrument may be seen from the photograph (Fig. 1); constructional details are given in Fig. 2. It consists essentially of a narrow glass tube about 15in. long with a bulb at the upper end, while the lower end is connected with a small cistern, as shown. The bulb, tube and cistern would be all in one in a properly made apparatus, but in this experimental model they consist of three separate pieces joined by rubber tubing. The larger the bulb, in relation to the tube, the greater the sensitivity. In this particular model the capacity of the bulb is 8 c.c. and the internal diameter of the tube 2.6 mm. Any small bulb or bottle may be used, providing it has a narrow neck so that the rubber tubing may make a good joint between it and the glass tube. The barrel of a 2oz. glass syringe was used for the cistern, as it has a suitable nozzle on which to fit the rubber tubing. It is essential that the joints should be airtight. This completes the instrument except for the scales which were made from strips of aluminium, but other materials such as brass or ivorine may, of course, be used. The whole apparatus is mounted on a board, and small strips of brass are convenient for this purpose.

The calibration of the instrument needs to be done fairly accurately and is, perhaps, the most interesting part of the construction. For practical purposes, the calculation may be simplified by disregarding minor factors, such as the vapour pressure of the liquid. Glycerine was used in the original design, but water was employed in this experimental model, and the calculations were made on that basis. The liquid is usually coloured, with red ink for instance, to make it more easily visible. Although the metric system is more convenient for calculation, the final figures were converted into inches for the actual graduation of the scale.

Assembling and Mounting

Determine the capacity of the bulb by measuring the quantity required to fill it up to the top of the neck. The capacity of the tube may be determined by filling completely with water and dividing the quantity by the length of the tube in centimetres. The apparatus may now be assembled and mounted. Make certain the glass tube abuts on the neck of the bulb, to avoid inaccuracy in subsequent measurements. Water is then poured into the cistern and made to run into the long tube by tilting and tapping as necessary, until it rises to 5 or 6in. below the bulb. The exact length from the neck of the bulb to the surface of the liquid is measured, and thus the total volume of air in bulb and tube determined. The height of the column of water above the surface in the cistern is also measured. The correct atmospheric pressure is read from a standard barometer, and the temperature of the room noted, as the starting point for the calculations.

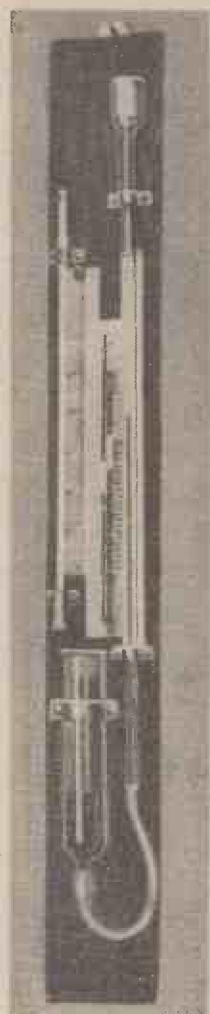


Fig. 1.—The completed instrument mounted on a baseboard.

Calculating Atmospheric Pressure

The method is perhaps best explained by taking the actual figures for the model illustrated.

Capacity of bulb = 8 c.c.

Capacity of tube per cm. length = 0.07 c.c.

Length of air in tube at start = 19.5 cm.

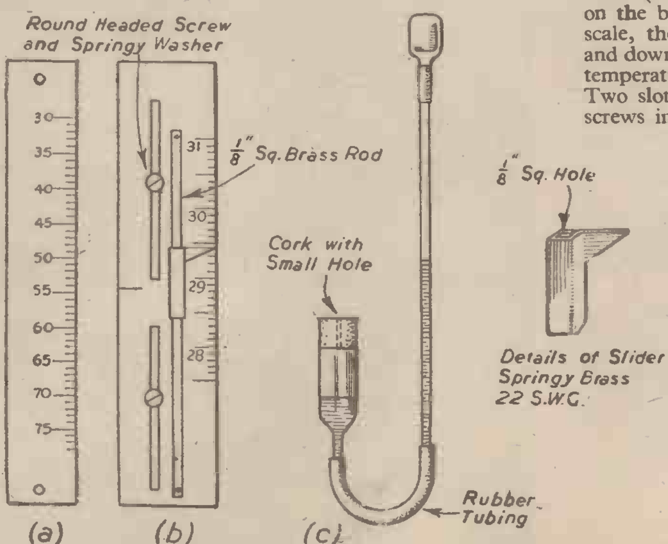
Height of water above surface in cistern = 23 cm., equivalent to 16.9 mm. of mercury.

Atmospheric pressure = 756.158 mm. (29.77in.).

Pressure of air in bulb was therefore 756.158 − 16.9 = 739.26 mm.

Volume of air was $8 + 19.5 \times .07 = 9.365$ c.c.

Pressure multiplied by volume of a gas is constant for a given mass of gas, therefore, 739.26×9.365 is constant.



(a) Temperature scale (Fixed). (b) Atmospheric scale (Sliding). (c) Details of bulbs and tubing.

Fig. 2.—The scales, tubing and slider.

Let atmospheric pressure rise to 781.56 mm. (30.77in.).

Water will rise in tube about 4 cm., therefore, new height of water will be 23 + 4 = 27 cm. (= 19.8 mm. of mercury).

New pressure of air will be 781.56 − 19.8 = 761.76 mm.

$$V_1 = \frac{PV}{P_1} = \frac{739.26 \times 9.365}{761.76} = 9.088 \text{ c.c.}$$

Original vol. = 9.365 c.c.
New vol. = 9.088 c.c.
Difference = .277 c.c. = 3.96 cm. length of tube.

Therefore, a rise in atmospheric pressure of 1in. produces a rise of water in the tube of 4 cm. (1.57in.) very nearly. Similarly, it will be found that a fall of 1in. gives a fall of 4 cm. in the sympiesometer tube. The scale must therefore be graduated with four lines each 1.57in. apart to give the usual reading of 28 to 31in. Each division should be subdivided into 10 equal parts equivalent to the usual tenths of an inch. (See Fig. 2(b)).

Temperature Scale

As the volume of a gas varies under changes of temperature, a second (temperature) scale is necessary. Charles's law states that the volume of a gas is directly proportional to its absolute temperature, that is, its centigrade temperature plus 273 deg.

The original temperature of the air was 14.4°C. = 287.4°A. What will be its volume at 8.8 deg. C.? The absolute temperature will be 281.8 deg.

$$\therefore \text{ new volume will be } \frac{9.365 \times 281.8}{287.4} = 9.183 \text{ c.c.}$$

Original vol. = 9.365 c.c.
New vol. = 9.183 c.c.
Difference = .182 c.c. = 2.6 cm. length of tube.

$$\text{At } 20°\text{C. the volume will be } \frac{9.365 \times 293}{287.4} = 9.546 \text{ c.c.}$$

Again the difference is .182 c.c. = 2.6 cm. length of tube. The temperatures chosen for calculation are 10 deg. apart on the Fahrenheit scale, generally used in this country, the scale is therefore graduated in tenths of an inch (.26 cm.) which will read as degrees Fahrenheit. (See Fig. 2 (a).) This scale is screwed on the baseboard at the side of the pressure scale, the latter being arranged to slide up and down to bring a fixed mark opposite to the temperature at the time of each observation. Two slots, in the aluminium, sliding on two screws in the baseboard is a convenient way of doing this. A pointer to slide up and down the pressure scale will indicate the last reading. An ordinary room thermometer should be attached to the board to give the temperature setting of the pressure scale.

To fix the temperature scale in the correct position, take careful note of the atmospheric pressure at the time, as observed on a standard barometer, and also the temperature. Move the sliding scale to indicate the barometric reading, and bring the correct temperature graduation opposite the fixed mark on the pressure scale. The temperature scale is then secured in position.

This type of instrument is not quite as accurate as a mercury barometer, but is surprisingly sensitive.

The Elements of Refrigeration—3

Electrolux Refrigerator : Compression-type Machines : Operating Troubles

By R. WINTER-EVANS

(Concluded from page 284, May issue)

AS mentioned previously, the Electrolux refrigerator unit operates on the absorption principle. It consists of a series of steel cylinders and tubes welded together to form a hermetically sealed unit. Fig. 17 shows the arrangement of the component parts and serves to illustrate the cycle of operations. The refrigerant employed is ammonia, the charge consisting of aqua ammonia, a mixture of water and ammonia, and hydrogen, and it is kept under sufficient pressure to ensure that the ammonia is liquid at room temperature. The pressure in the unit will vary as the room temperature rises and falls, but it is always uniform throughout the system. The working is as follows:—

Heat is applied to the boiler by means of a gas jet, or in some cases an oil flame. Ammonia vapour and a small quantity of water vapour is evolved, and this mixture passes through the vapour cooler to the water separator or rectifier. The water separator is baffled on the inner tube, and is cooled by the liquid ammonia on the outside, as a result of which the water vapour is condensed. This absorbs ammonia, and is drained back to the boiler as strong aqua.

The gaseous ammonia leaving the rectifier passes to the air-cooled condenser, where it is liquefied, before passing again through the water separator, this time on the outside. As previously noted, there is an exchange of heat here, as a result of which the water vapour is separated from the ammonia. From the water separator, the liquid ammonia goes on to the low temperature radiator, where evaporation takes place, and refrigeration is effected. Any ammonia vapour which is not condensed in the lower tubes of the condenser passes to the upper part, where, if the pressure is sufficiently great, it condenses and goes on to the high temperature radiator, where it evaporates into a mixture of ammonia and hydrogen gas fed from the low temperature radiator. In the process of evaporation an additional cooling effect is obtained.

Should the temperature be such that the pressure within the unit is not sufficient to bring about the liquefaction of the vapour in the condenser, some of the ammonia vapour passes into the pressure equalising vessel, displacing hydrogen into the radiator and absorbing systems. The effect of this displacement is to cause a rise in pressure in the unit. Then, as the temperature falls, the ammonia vapour in the pressure equalising vessel condenses, and the hydrogen previously displaced returns, reducing the pressure in the unit once again.

After the liquid ammonia has evaporated in the radiator system, the resulting vapour, mixed with hydrogen gas, passes through the gas heat exchanger to the bottom of the absorber In its passage through the gas heat exchanger, the gaseous mixture cools the hydrogen gas passing over the outside of the tubes to the radiator system, and thus increases the effective refrigeration. The mixture of hydrogen and ammonia vapour, passing upwards through the absorber, meets the weak liquor flowing downwards. The ammonia is absorbed by the weak liquor, and the resultant strong liquor flows down into the absorber vessel whilst the hydrogen passes upwards into the low temperature radiator once more, thus completing its cycle. The strong liquor goes on from the absorber through the liquid heat exchanger to the bottom of the boiler. From here it is lifted to the top by the thermo syphon to complete the ammonia cycle.

In passing through the liquid heat exchanger, the weak liquor from the base of the boiler is cooled by the strong aqua going to the top of the boiler, and it should be noted that this heat exchange materially improves the performance of the unit, as not only does it increase the temperature of the strong liquor, reducing the amount of outside heat to be supplied, but it also reduces the temperature of the weak liquor passing to the absorber, and facilitates absorption.

It will be seen that there are three distinct cycles to be considered in a machine of this type, the ammonia, the aqua-ammonia, and the hydrogen. The ammonia cycle takes place between the condenser, the radiator, the absorber and the boiler, the aqua cycle is confined to the boiler and the absorber, and the hydrogen cycle is between the radiator and the absorber. Within limits, the cooling effect obtained depends on the amount of heat energy supplied by the gas or oil burner, as there is a certain rate of heat input at which the working of the unit is most efficient, and at rates above and below this the coefficient of performance decreases. The selection of the correct size of jet for the calorific value of the fuel in use is therefore important.

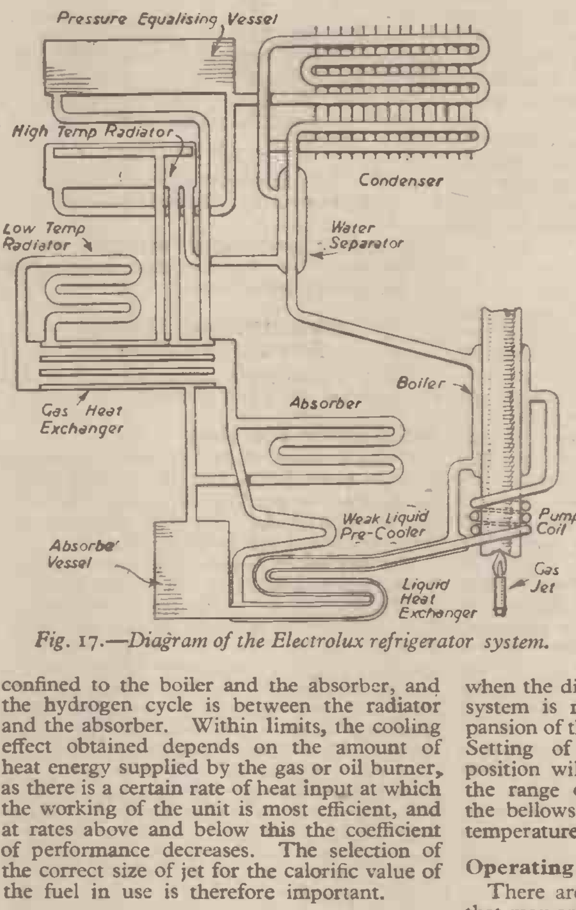


Fig. 17.—Diagram of the Electrolux refrigerator system.

Temperature Control

Non-automatic control consists of a gas governor to regulate the pressure at the gas jet, combined with a hand-operated needle valve to control the quantity of gas passing to the burner, and thus the heat input to the boiler.

Automatic control is effected by varying the heat input to the boiler to suit the load, regulation being thermostatically controlled, Fig. 18 showing the gas governor and thermostatic regulating valve of the Electrolux refrigerator.

The gas governor consists of a diaphragm of oiled leather, fixed at the edges and weight loaded. This carries the gas valve which is moved on to or away from its seat with the movement of the diaphragm. If the gas pressure is excessive, the diaphragm deflects upwards, and partially or wholly closes the valve; if the pressure is reduced, the diaphragm deflects downwards under the influence of the loading weight and increases the supply of gas.

The thermostatic control consists of a bulb containing a freezing medium connected by a flexible tube to a metallic bellows operating a gas regulating valve. The bulb, which is not shown in the diagram, is attached to the radiator of the unit. As the temperature falls below the desired figure, the freezing medium in the bulb contracts, the bellows also contract, and the gas valve is moved towards its seat by the spring, cutting down the quantity of gas supplied, whilst, should the temperature rise too high, the bellows expand, and the valve is lifted off its seat, increasing the gas flow.

When the gas valve is hard down on its seat, of course, the flow of gas to the burner is cut off entirely, and the flame goes out. It is therefore necessary to arrange for a small by-pass to a pilot jet, in order that there may always be a flame available to relight the main jet after it has been extinguished, and the gas supply is restored. This pilot flame is not sufficient to operate the unit, however.

In order that the cabinet temperature may be readily adjusted by the user, the thermostat is provided with a dial which, when turned through one complete revolution, displaces the complete bellows system by an amount slightly greater than the full expansion or contraction of the bellows. Thus, when the indicator is turned to the limit marked "Maximum" the complete bellows is moved to such an extent that the valve remains open even when the bellows are fully contracted. Similarly, when the dial is turned to "zero" the bellows system is moved so that even the full expansion of the bellows will not open the valve. Setting of the dial at any intermediate position will bring the bellows system within the range of contraction and expansion of the bellows itself, and control of the cabinet temperature is obtained.

Operating Troubles

There are a number of operating troubles that may arise in domestic refrigerating units, independent of the make, but varying with the type, and the most common of these are briefly discussed below, together with their possible causes.

COMPRESSION TYPE REFRIGERATORS

The faulty operation of the compressor may be due to a fault in the electrical circuit, a mechanical defect, or to an excessive load on the compressor. On the electrical side, possible causes of trouble are an open, short, or earthed circuit, incorrect voltage, a burnt-out motor, and incorrect working of the motor protective device, and if the compressor will not run at all, the electrical circuit should be tested for these faults. An open circuit may be found by inserting a suitable test lamp in series with the apparatus; a short or earthed circuit may result in blowing of the line fuses, welding of the contacts of the control switch, or tripping of the motor protective device.

Stalling of the compressor may be caused by mechanical failure of a valve, excessive load, or sticking due to dirt. It may be found possible to free the machine by a slight jarring, but mechanical failure of a valve will, of course, necessitate its replacement. Stalling due to excessive load will probably occur during the initial running-in period after installation, or after the machine has been out of service for a time, and in this event the motor may trip out, and require restarting two or three times before a normal operating temperature is reached, after which it should continue to run correctly. Restricted air circulation to the condenser, faulty operation of the float valve, and the presence of non-condensable gases in the condenser are also possible causes of stalling. If the circulation of air to the condenser is restricted, the pressure and thus the load on the compressor will rise to a point where the motor trips out. The presence of non-condensable gases also produces an increase of pressure in the condenser, and has a similar effect. If the float valve fails to operate correctly, the return of refrigerant to the evaporator is restricted, the condenser pressure rises, and the compressor trips out.

If the control system itself is defective, the compressor may not cut in and out as the load requires, but may continue to run. This may be caused by welded switch contacts, weak bellows, or defects in the linkage.

Refrigeration Unsatisfactory

Symptoms of this condition, with the compressor running correctly, are partial or erratic refrigeration, or no refrigeration at all, incorrect cabinet temperature, unsatisfactory freezing of ice, high percentage running time, and high power consumption. Possible causes are no refrigerant in the machine, non-condensable gases in the condenser, leaky compressor valves, and defective float valves.

The presence of non-condensable gases has a similar effect to that of a float valve stuck closed. In this case the return of refrigerant to the evaporator is stopped, and the pressure in the condenser builds up until the compressor relief valve operates, when refrigeration ceases. Similarly, if the float valve sticks open, a large proportion of the fluid passing to the evaporator will be gaseous refrigerant, and little or no refrigeration will be effected.

In the event of trouble of this nature being experienced, the first step should be to purge the machine by opening the purge valve. If this does not correct the trouble, the float valve case should be tapped to free the float valve, which is probably stuck open or closed.

In the event of one or both of the compressor valves leaking, the cylinder will remain open to the high or low pressure side, or both, and the refrigerator will not operate correctly. This is probably caused by dirt or other foreign matter.

A further cause of partial or erratic refrigeration is a weak bellows system on the temperature control device, resulting from a leaky bellows, and its cure necessitating complete renewal of the bellows. High cabinet temperatures also result from restricted air circulation in the condenser or cabinet, heat leakage due to frequent opening of the cabinet door, excessive leakage at the door joints, excessive live load, or incorrect setting of the temperature controller, possibly through ignorance on the part of the user. Leaky bellows permit the evaporator temperature to rise higher than it normally would to close the switch contacts in order to start the compressor, and the cabinet temperature will be high.

Restricted air circulation in the cabinet itself may be caused by faulty arrangement of the items stored, and leads to local overheating in the cabinet, whilst restricted air circulation in the condenser reduces the effectiveness of the cooling, and the capacity of the unit.

Unduly low cabinet temperatures may occur as a result of incorrect adjustment of the temperature control, low ambient temperature, or faulty contact between the evaporator and the thermostat bulb.

Unsatisfactory ice-making will be caused by poor heat transfer from the ice trays to the evaporator, due to buckled or dented cans making poor contact with the cooling surface, or by frosting and snowing-up of the evaporator surface.

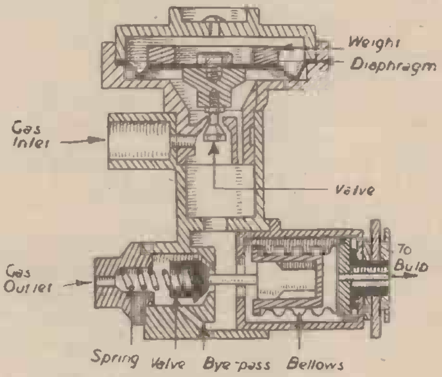


Fig. 18. Section of the Electrolux governor and thermostatic regulating valve.

ABSORPTION TYPE REFRIGERATORS

The following notes apply to the Electrolux Refrigerator described above.

Refrigerator Too Cold

Possible causes of this are abnormally low ambient temperature, incorrect setting of the temperature control, poor contact between the thermostat bulb and the radiator, and incorrectly-adjusted by-pass screw.

Trouble which is due to abnormal ambient temperature conditions will automatically correct itself as the room temperature varies, but it may be necessary to find an alternative position for the machine, where conditions are more suitable. Defective contact between the thermostat bulb and the cooling unit will result in the radiator temperature being depressed below normal before the gas is cut off. The remedy is apparent.

If the temperature control is set higher than is necessary for the prevailing ambient temperature, the temperature in the cabinet will be correspondingly low, but can be simply corrected by adjustment of the controller setting. When this is set to "Zero" the gas supply should be reduced by the by-pass quantity, sufficient only to maintain the flame, but not to operate the unit.

If the machine fails to shut off with the controller set at "Zero," the trouble may be due to the by-pass not shutting down the gas supply sufficiently. The screw may not be seating properly, or may be the wrong size for the calorific value of the gas in use. A thermostat which is out of adjustment is also a possible cause of the unit failing to shut off with the control set at "Zero," and in this event the thermostat must be changed.

Refrigerator Not Cold Enough

If the radiator temperature is correct, the trouble may be due to excessive leakage, excessive live load, restricted air circulation in the cabinet, incorrect setting of the temperature control, or to frostation. When the radiator temperature is high, possible causes of trouble are incorrect gas supply, restricted air circulation due to bad arrangement of the commodities in the cabinet, incorrect use of the temperature regulator, or incorrect application of heat. This last may be caused by the burner being out of centre with the boiler, or being too low, or to the flue baffle being wrongly located, or missing altogether. It should be remembered, as pointed out above, that the cooling effect is reduced by the application of too much as well as by too little heat, and the size of the jet and by-pass screw must be carefully chosen to suit the calorific value of the gas in use, and the gas pressure. Dirt may also cause too little heat to be applied.

No Refrigeration

Entire absence of refrigeration may be due to a stoppage in the gas line, a choked by-pass, too little or too much gas burning. Complete or partial stoppage of the gas may be due to condensation, to dirt lodged in the supply pipes, valves or cocks, or to the gas pressure being unduly high and causing the governor valve to shut. If the burner is extinguished a short time after starting up the trouble is probably due to a choked by-pass screw. This shuts off the supply to the burner completely when the unit is cut out by the thermostat, and it then cannot cut in again. Cleaning or replacement of the screw are the remedies.

Leaks

Detection of leaks from the system will depend on the refrigerant in use. Some may be found by smell, but there are other methods of discovering when and where a machine is leaking, and the following notes will serve as a brief guide.

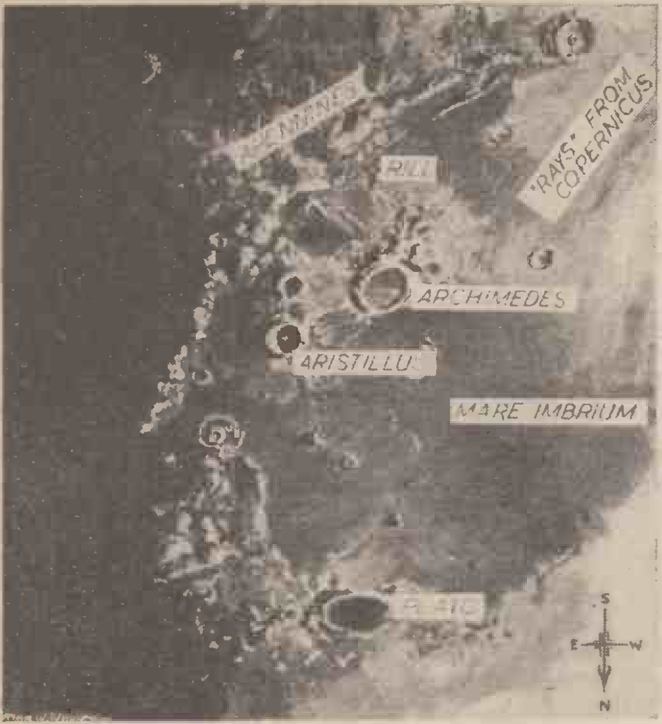
Ammonia.—Serious inconvenience will result if an ammonia system starts to leak, and ammonia unfortunately finds its way very readily through pipe joints. Special care in making these is therefore needed. Owing to its pungent odour, any leakage is readily detected, and it may be located by using a sulphur candle, as the products of combustion from the candle combine with the ammonia to produce grey fumes.

Carbon Dioxide.—This gas is odourless, and leaks are not, therefore, as readily detected as in the case of ammonia machines. Also the working pressures in carbon dioxide machines are much higher than in systems using other refrigerants, and the loss of working substance at glands is usually higher. However, owing to the harmless nature of carbon dioxide, leakage is attended by no more serious results than periodic renewal or making up of the charge. With the larger plants, it is common practice to keep a lighted candle on the floor, as any leakage of the refrigerant will extinguish this.

Sulphur Dioxide.—This refrigerant has a pungent, suffocating odour, and is very harmful to commodities. It is non-inflammable, and non-explosive. Leaks may easily be found by applying a solution of ammonia in water to the pipes and joints of the suspected areas. Dense white fumes are given off when the sulphur dioxide comes into contact with the ammonia.

Methyl Chloride.—The odour of methyl chloride is only appreciable when fairly large quantities are present, and a small leak is likely to pass undetected. It is common practice to introduce a powerful irritant into the gas in order to ensure that ample warning is given of any leak that may develop. Methyl chloride gives a greenish tinge to the flame of an alcohol lamp, and advantage may be taken of this fact in locating any leak.

The Moon's Surface



The Moon's surface in the region of Mare Imbrium.

A Short Survey of the History of Man's Progress in this Important Field of Research

By M. W. WHOLEY, G.I.Mech.E.

IT is almost certainly true that of all the objects which have excited the curiosity and sometimes worship of the human race in the past, the Moon is in the forefront. The Sun, it is true, has also had a huge share of wonder and worship, but it has forever appeared in the sky at a time when the practical considerations of everyday life excluded all thoughts and speculations as to its material nature, leaving most of the interested factions warring over its theistic aspects. Inability to stare at the Sun for long periods with the naked eye has also tended to force speculation into theistic channels by precluding any attempts at detailed observation of its surface. The Moon, on the other hand, has always been easy to look at and enough of its surface features have always been visible to the naked eye to excite speculation. Indeed, the fact that it was the most prominent object in the Heavens at night, when men's minds were relaxing, was sufficient to germinate ideas about it.

Conjectures as to its surface composition were many and fantastic. Cheese was seriously thought to be the main constituent by some people, and there was a belief that the surface of the Moon was crystalline in character, similar to glass; this mirror-like surface was thought to reflect the earth's features, a notion which received support from the fact that the Moon always keeps the same face to the earth. Colourful imaginations conjured up many celestial "pictures in the fire."

The Moon's surface became, in belief, the home of the familiar "Man in the Moon," who was replaced at various times and places by a lady, a goat, a donkey, a dog and numerous other illusions produced by mass-effect.

"Mountain-walled Plains"

The coming of the telescope dispelled this mass-effect of the surface markings to some extent, and even Galileo with his first primitive instruments charted the Moon, but although recognising the existence of the main features, he made some unhappy attempts at naming them—hence what is now called "Crater Copernicus" he called "Mount Etna," and described the Maria as "great and ancient spots." Further advancement of the telescope revealed the Moon's features as a scene of sublime desolation, the most striking aspect of which was the vast number of craters, so varied in size that several broad classes are now enumerated. They vary from about 150 miles in diameter to sizes beyond that which can be resolved by the most powerful modern instrument. Sizes ranging from 60 to 150 miles in diameter have been given the name of "Mountain-walled Plains"—a description enhanced by the fact that a human observer deposited in the centre of one of the larger craters of this type would be unable to see the crater walls which surrounded him because of the relatively sharp curvature of the Moon's surface, and again—a good-sized telescope shows that the apparently smooth floors of these "Mountain-walled Plains" exhibit numerous tiny craters or "craterlets." Plato, for example, is known to have at least 40 of these formations on its floor. "Tiny" is, of course, a relative term; thus the Great Meteor Crater in Arizona, which is about three miles in circumference, would be classed as a rather small "craterlet" if observed on the Moon. Sizes ranging from approximately 10 to 60 miles in diameter are known as "Mountain-ringed Plains" or "Ring Mountains" and a third type known as "Crater Rings" are about three to 10 miles in diameter. Still smaller formations of this kind comprise the type previously mentioned in connection with "Mountain-walled Plains"—the "craterlets."

Keplar noted the amazing similarity of these circular formations, and regarded them as pits excavated by supposed lunar inhabitants to shelter themselves from the long and intense action of the sun. Had he known the real size of the Moon and the enormous diameters of some of the craters, he would probably have thought twice about his hypothesis. Some authorities class the largest of the "Mountain-walled Plains" as small "Maria" (sing. "Mare"), a name given to vast dark areas which, as the name implies, were once thought to be seas, and flowery names like "Mare Serenitatis" (Sea of Serenity) were given to them. Subsequent investigation proved that the Moon totally lacked atmosphere and hence could not retain surface water.

Landing Places for Space Craft

Considering the surface of the Moon as a landing place for space craft, it will be interesting to examine the various aspects which would present themselves to an astronaut during the latter portion of his orbit.

The approach to the Moon would soon enable him to distinguish the larger craters and the more rugged of the mountain ranges, until, a few thousand miles above the surface, the scene would resolve itself into masses of pockmarks vastly blotched by the apparently smooth, dark expanses of the "Maria." He would notice the haphazard confusion of craters, peaks, rills and rifts. Approaching even closer, it would become apparent that the "Maria" were not as smooth as they would at first appear; in fact, there are numberless pits, so small as to merge in with the general surface so that they become visible only when extremely close observation is possible. At a point in the orbit where landing is to take place, the full effect of the starkly naked appearance of the rugged landscape would be observed—an effect one might expect to see if all the soil, vegetable growth and snow were to be stripped from the tableland of Tibet. We will assume that the ship is that of a scientific expedition. That being the case, the point chosen for landing would most probably be one from which short journeys in various directions would bring the scientists in contact with the most varied examples of lunar topography. Such a point on the visible side of the Moon is between the craters Aristillus and Archimedes and the southern arm of the Apennines. In such a position the expedition would have two distinct types of crater in Archimedes and Aristillus, together with a portion of the "Mare" surface, and an example of the peculiarly rugged type of mountain formation characteristic of the Moon. Light also may be shed on one of its many problems by visiting the "rill" or furrow which can be seen to run almost parallel to the Apennines at that part of the range. By examining this location a fairly general picture of the surface characteristics will be obtained.

Exfoliation

Assuming that the landing has taken place during the lunar day, the first effect on climbing down to the ground would be the amazing sense of lightness, as one would only be supporting a sixth of one's terrestrial weight. Probably the next things observed would be the intense shadows, the blinding glare from the ground, the utterly black sky with its coldly brilliant stars, and the intensely bright Sun exhibiting its prominences and its corona in all their full glory. All this because of the lack of atmosphere. The horizon would appear very close at hand because of the much greater curvature of the Moon. Smooth as did the "Mare" appear from the surface, it would now seem almost impassable. Where the ground was fairly flat it would most probably be a mixture of dust and gravel composed of light materials such as porous rock. Small pits and craters from a few inches in diameter to several feet would be abundant. This is evident from the way in which the sunlight is reflected at various angles and substantiated by recent experiments on the polarisation of reflected light from the Moon. Probably, as the scientist was standing there, a small puff of dust would remind him of the continuous shower of meteorites which rain, unchecked by atmosphere, on to the ashy surface, adding continuously to the mass of small pits already there; and also perhaps of his own vulnerability, considering that an average speed of a meteorite is somewhere in the region of 30 miles per second! Due to exfoliation, the rocks and boulders of the Moon are most probably crumbly, and rock surfaces may easily flake away under the pressure of our scientist's boot.

There is much evidence that these "plains" were once in the plastic state, and if the scientist were to strike away from the ship towards the foot of the Apennines, he is almost certain to come across numerous clefts along the margin of the "Mare," apparently caused by the shrinking of the surface crust as it cooled. The huge "rill," one of the several hundred to be found in various parts of the Moon, which is parallel to the Apeninnes, S.E. of the craters and the supposed expedition, is most probably formed in this way, helped, perhaps, by the raising of the adjacent mountains at the same geological age. This crack will now almost certainly be filled or partly filled by solidified lava. In places the lava "plug" may have been forced up above the surface during subsequent moon-quakes much as a plug of lava is sometimes forced from an old volcano—as happened in the early stages of the Krakatoa eruption. If this is the case, the ridge, which can be seen to follow the "rill" southward on its path alongside the Apennines, may indicate a continuation of the "rill" in the form of a sawback of lava. The appearance, then, of this ridge to our scientist would be the brown-black of a rock of the igneous type, probably a basalt.

Exfoliation by expansion and contraction due to changes in temperature from day to night conditions is likely to be small, because although the temperature change is extreme—from about 214 deg. F. at noon to −243 deg. F. at midnight—it takes place very slowly.

However, coupled with the flaking caused by the quick changes of temperature during eclipses of the Moon—on one observed occasion it fell from 160 deg. F. to −110 deg. F. in about an hour—an extensive system of talus slopes or rock slides is almost sure to be present on the flanks of the ridge and adjacent slopes of the Apennines. In fact, owing to the absence of all other types of erosion, the meteoric dust and flaky gravel will lie thickly wherever gravity allows. With not even sound waves to stir the deposits, the only disturbance other than exfoliation will be the occasional tiny tremor of an impinging meteor or meteorite. Meteor scars will be numerous even on the vertical sides of the rocks as dark burn marks where the flying fragments have liquifted under terrific generation of heat, or possibly as long scars of lighter colour than the parent rock.

Travelling Problems

Travelling on foot even with less gravity would be extremely difficult and, owing to the danger of becoming buried by the lightly balanced slopes of talus, impossible in some places. In fact, some form of light frame, akin to a snow shoe, would probably be needed to skirt such patches.

It is interesting to note that, if it is established that ecliptic changes of temperature are the chief cause of erosion on the Moon, then it follows that the visible side will be more rugged and dusty than the hemisphere which is away from us, because it is only the near side which is subjected to eclipse by the Earth, and thus the unseen side would be inflicted only by the day and night temperature changes.

On the rocky heights of the Apennines only the varying types of rocks will change the colour of the landscape. No soil formations of any type will be present, as soil depends on fluid erosion for its formation, and hence the passage of a climber would be characterised only by clouds of dust and slow falls of shale and rock slivers, which to an outside observer would appear to drop and settle with curious slowness. If the protective suit of the climber conducts, very slightly, big changes in temperature, such changes would be noted with surprising abruptness when passing from the sunlight into the shadow cast by a rock. This phenomenon has been measured by a vacuum thermocouple with subsidiary instruments, using the principle that the maximum energy of sunlight is in the visible spectrum and hence any infra-red emanation observed is an indication and measure of the surface temperature of the body in question. This proves that the surface of the Moon is extensively covered by an extremely non-conductive material, and laboratory tests suggest that the most likely material which obeys the observed thermo-dynamic and optical evidence collected is a mixture of porous rocks resembling pumice and pulverised rock. The low albedo or reflecting power of the Moon—about 7 per cent.—coupled with the evidence that its reflected light is yellowish and reddish compared with direct sunlight, generally suggests that dark brown rocks are most abundant in the crater formations and mountains. It follows that the dust must be of coarse structure because fine dust has a high albedo.

Meteor Crater, Arizona, U.S.A. Nearly a mile wide, this enormous crater was caused by the impact of a huge meteorite in prehistoric times.

Much of the porosity of the surface materials is probably due to small bubbles of subsurface gases which forced the molten materials upwards to form the extensive "Maria." Evidence that these were formed after most of the craters had come into existence is to be seen in the type of crater characterised by Archimedes. This crater formation is found on the outer limits of most of the "Maria" and by comparison with formations such as Aristillus, it intimates that they, too, were once normal but were subsequently filled by molten material up to the level of the surrounding "Maria" whose comparatively smooth and uninterrupted surfaces complete the evidence that most of the crater-creating phase was over at the time of the volcanic flooding.

Crevices, Crags and Shattered Rock

Following our scientist away from the rugged desolation of the Apennines, northward to the crater of Aristillus, we would find its approaches extremely difficult to surmount, being a hodge-podge of crevices, crags and shattered rock, much of it showing signs of subjection to great heat. Being of the school of meteoric origin of the craters, it is the writer's opinion that the evidence of lava *only in the crater rims* of most of the craters is direct evidence of such an origin, and that the "lava" is, in fact, not lava in a volcanic sense, but surface rocks liquified by the heat generated in meteoric impact.

Climbing the riven walls of the crater, it would be found that the slope of the wall was much steeper on the inside of the crater than the outside, and a comparison between the floor of the crater and the surface outside would show that the floor was much the lower. Furthermore, far out in the centre of the floor a group of sharp peaks, not quite so high as the walls, project themselves. Such are the characteristics of the majority of the craters. Such types as the "level floored craters," craters with no centre peaks, and a few others can be regarded as exceptions to the general rule. The number of the exceptions, it is true, is large, but then there are so many ways in which modifications to structure could have occurred *after* their formation in the early stages of the moulding of the lunar topography, that this objection is, in the main, neutralised.

The characteristic crater shape outlined above can be reproduced perfectly by firing a rifle *at any angle* into fairly soft mud, or by firing a shotgun at close range in the same way, so that the shots remain bunched together.

The crater floor would be found to be covered with shattered rock, some of it from fairly deep strata, and huge quantities of "rock flour" which is the probable cause of the local increase of albedo noted in some craters, and may be the key to the solution of the problem of the peculiar "rays" which emanate from some of the larger craters, Tycho in particular. It is observed that these "rays" cast no shadow, whatever the direction of the Sun's rays, and are unimpeded by crater or mountain in their radial path from their parent crater. From evidence at hand, the simplest explanation is that the "rays" are composed of "rock flour" mixed with somewhat coarser material, the mixture having been flung out of the impact centre in the same way a pile of flour is scattered when a marble is dropped upon it. The terrific impact and the low gravity explain the immense distances covered by these "rays." The rim of the crater Archimedes would have all the characteristics found in that of Aristillus, but its floor would have the appearance of a small "Mare."

Temperature Gradient

A survey of the lunar surface conditions would not be complete if mention were not made of the temperature gradient on the crust. It ranges from 214 deg. F. at the Moon zenith, nearest the Sun, to under −58 deg. F. at the terminator. A fairly constant temperature of −243 deg. F. is recorded on the night side. To obtain a more complete record of the temperature gradient on the sunlit side, imagine the Moon in its first or last quarter, when half the visible side of the Moon is sunlit, then divide the bright portion into six longitudinal sections of approximately the same width except for the first, which just slices off the Moon's bright zenith. Then the approximate temperatures on the surface of each of these sections thus formed, starting with the bright zenith and ending with that bounded by the terminator, are: 214 deg. F., 194 deg. F., 140 deg. F., 86 deg. F., 32 deg. F., and minus 58 deg. F.

So multitudinous and varied are the individual features of the Moon's surface that a full description of them could fill many volumes, and such a task is obviously not within the scope of this short survey, but in conclusion it may be of interest to mention a few of the more outstanding individual peculiarities. One interesting lunar formation is the "Straight Wall," some 70 miles in length, in the S.E. corner of Mare Nubium, north of Tycho. It is shown to be a cliff or wall 1,000 to 2,000 feet in height, its sheer face clearly due to its origin as a rock fault, where one edge has risen above the other. Similar faults on a much smaller scale are found, on Earth, to be the foci of earthquakes. Another phenomenon is the "crater pit," which differs from the "craterlet" by its lack of an elevated rim to the crater. It is very small compared with most formations, but is quite common on the Moon's surface. A system of these can be seen west of Crater Copernicus.

Peculiar Formations

We have already mentioned the queer "rays" which flare from many of the large craters, but it is interesting to consider an additional point. The presence of the "rays" attached to some craters and not to others, even though the structure of the crater may be the same but for that, can perhaps be explained by one Selenologist who has a theory that such craters can only be formed by *metallic* meteorites, and suggests that the bright "rays" are areas covered by tiny spheres of shining metal—metal that has been vaporised by the impact and condensed into millions of tiny spheres. A geologist has recently substantiated this theory by discovering millions of tiny iron pellets in the soil about a meteoric crater near Haviland, Kiowa, County Kansas, U.S.A. Analytical tests prove the pellets are composed of meteoric iron alloyed with nickel.

A final peculiar formation is found in the discovery of a dark spot near the Crater Aristachus while photographing with ultra violet light-sensitive plates. It was found that the patch did not appear on plates sensitive to orange light, and subsequent experiments led to a conclusion that this large dark spot was an extensive deposit of sulphur.

A short survey of the surface conditions of the Moon, such as this, can touch only on the main points of the subject, and many tomes would be needed to hold all the evidence and experimental results which have led to the numberless theories of the Moon's composition. It is true to say that confirmation of any one theory with scientific certainty will only be possible when the first expedition steps from its vessel on that enigmatical crust, and that time is not far distant!

The Helicopter—2

The Focke-Wulf FW.61 Machine

By L. H. HAYWARD

(*Continued from page 309, June issue*)

A model of a 14-passenger helicopter air bus intended to be used on local air services in the United States. The aircraft was designed by Raymond Loewy, in collaboration with Igor Sikorsky.

FIVE years of hard work, intensive research and the carrying out of countless experiments, coupled with thousands of mathematical calculations and the expenditure of large sums of money, brought due reward to the German, Professor Henrich Focke, when the helicopter that he designed captured all the world records for this type of aircraft in 1937.

Believing that the conventional type of aircraft suffered from the limitations that a large flat space was necessary for take-off and landing, and that it was unable to hover or fly very slowly—two requirements that have very considerable advantages in certain conditions of flight—Professor Focke interested himself in the direct lift, rotary wing type of aircraft. He aimed at providing a machine capable of taking off and landing vertically, hovering as required, flying in any direction, giving the maximum service for the minimum amount of attention, combining rigidity with lightness, being perfectly stable under all conditions of flight, and last, but not by any means least, the provision of such a machine that would be simple and easy to fly.

During 1932 Focke designed and built a model helicopter that was powered by a 0.7 horse power petrol engine installed in the nose of an orthodox type of aircraft fuselage. A structure extended outwards and upwards from each side of the fuselage and carried a three-bladed rotor assembly. The two rotors revolved in opposite directions to each other and thereby cancelled out the torque on the machine. The model was extensively used for experimental purposes, and although it usually turns out that a model and a full-size machine behave in rather different ways, it did prove that Focke's theory was sound.

The Focke-Wulf Company built a full-size machine that was ready for initial testing during the early part of 1936. To minimise the risk of damaging the machine through mechanical failures, and to obtain experimental data, a large number of "flights" were made while it was securely tethered to the ground. The first free flight was made on June 26th, 1936, by Herr Ewald Rohlfs, a Focke-Wulf test-pilot. In addition to covering the fuselage, many refinements and detail modifications were made to the machine during the next twelve months, and on June 25th-26th, 1937, this machine, flown by the same pilot, put up a performance that captured all the international helicopter records for Germany. A speed of 76 miles per hour was averaged over a distance of 12½ miles, the machine making a duration flight of 1 hour 20 minutes, and rising to a height of nearly 8,000ft. Exactly a year later, on June 20th, 1938, a distance of 143 miles was flown on a dead-straight course.

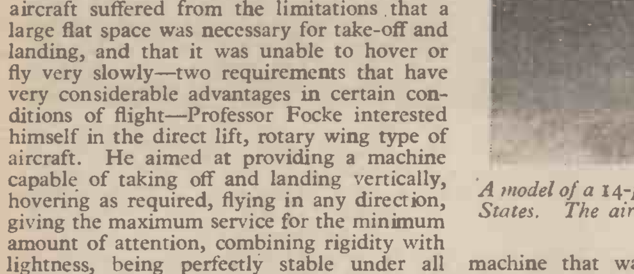


Fig. 4.—Focke's proposed passenger helicopter.

Indoor Flight

In 1938, Fraulein Hanna Reitsch, who was famous in Germany for her sailplane and glider flights, flew the Focke helicopter, now known as the FW.61, a distance of nearly 70 miles from Stendal to Berlin to demonstrate the machine in the Deutschlandhalle. A number of diehard technicians and government officials had expressed the opinion that the FW.61 could only hover when flying into a strong wind, so the Focke-Wulf company arranged that the machine should be flown indoors, where any assistance from the wind was an absolute impossibility. Although this is believed to be the first time a helicopter was successfully flown indoors under perfect control, the Royal Aeronautical Establishment at Farnborough had previously been experimenting with machines in the old balloon shed, and the Brennan and Isacco machines are reported to have made a number of indoor "hops," but, unfortunately, the greatest feature of these machines was their apparent lack of control.

Construction

A normal aeroplane fuselage of fabric covered welded steel tubes, with rigid bracing and carrying a fin and rudder at the tail, is used. A seven-cylinder, air-cooled, radial, Siemens' Bramo Sh.14A engine (without supercharging), and with a direct drive to the engine-cooling fan, is installed in the nose of the fuselage. The engine weighs approximately 300 lbs., has one inlet and one exhaust valve per cylinder, operates on the dry sump principle, and develops a maximum of 160 h.p. at 2,200 revolutions per minute.

Cooling Fan

In place of a normal airscrew a small fan is fitted on the front of the engine. This fan plays no part in the propulsion of the helicopter, and is fitted so that an adequate flow of cooling air is available for the engine when the machine is hovering, and the engine is operating at full throttle.

Tail Unit

The tail unit, which is constructed as an integral part of the fuselage, comprises a welded steel tube fin structure and a light alloy rudder, both of which are fabric covered. The tailplane, placed right at the top of the fin, is secured to the fuselage by external bracing struts. A control in the cockpit allows the pilot to adjust the incidence of the tailplane as required for any condition of flight.

Rotor Support Frames

A steel tube structure extends outwards and upwards from each side of the fuselage and carries a rotor assembly. In an attempt to reduce the drag on the rotor supporting structure, the steel struts of the first machine were faired with balsa, while on later machines the struts were faired with light alloy sheeting.

Rotors

Three fabric covered plywood blades built up on a tubular steel spar and hinged to a rotor hub are laterally disposed in the same plane and supported by the steel structure on each side of the fuselage. The rotors, which are driven through shafting from the engine, are 23ft. in diameter and revolve in opposite directions to each other. The angle of attack is dependent upon the speed of rotation. The manufacture and assembly of the rotor blades is a very highly skilled job. It is essential that all of the blades are exactly the same weight and made in exactly the same way. To ensure that the blades balance perfectly, the component parts that go to build up a complete assembly are all balanced against each other. The blades are hinged at the roots so that they are able to flap up and down. A predetermined amount of flapping is allowed by fitting stops on the blades that operate in conjunction with stops in the rotor hub. The stops allow the centrifugal, lifting and bending forces on the blades to be balanced out to produce what is commonly known as the coning angle. The same hinge also permits a small amount of sideways movement or drag on the blades to take into account the different forces acting on the retreating and advancing blades. An elastic type of damper is fitted at the roots of each blade in an attempt to equalise the distribution of centrifugal force. It should be remembered that when the helicopter is hovering the revolving blades meet the air with the same velocity all round, but if the machine is moving in any direction the air velocities will change rapidly over the blades. It is for this reason, and to prevent aerodynamic roughness and/or mechanical vibrations being transmitted to the aircraft, that the flapping and dragging hinge and the centrifugal dampers have been developed. Using two rotors revolving in opposite directions eliminates torque reaction, and the tendency of the aircraft to swing in one direction.

Directional Control

Directional control is obtained by increasing the pitch of the blades in one rotor, and at the same time decreasing the pitch of the blades in the other rotor. This action results in an unequal torque force being set up and the helicopter will turn in the direction of the rotor transmitting the greater torque. If the machine is required to turn in the opposite direction the pitch of the rotor blades is adjusted for the required condition of flight. As well as being rotatable as a whole, the blades are mounted so that they may be individually turned about their own axis during their rotation. The lift force is controlled as a whole by a change in the angle of incidence of the blades, and articulation, that is, flapping and dragging, varies the lift force at each point of the disc swept by the rotating blades. The lift forces on the blades are balanced by the centrifugal force holding the blades in an extended position, and the angle at which the blades cone is dependent upon the equalisation of the centrifugal and lift forces. Forward flight is obtained by continuously changing the pitch of the blades during rotation. This is done through a control known as the cyclic pitch control, and produces forces which are similar to the forces obtained by tilting the rotor hub.

A great advantage of the side by side twin rotor arrangement over the superimposed twin rotor is that each rotor assembly is revolving in undisturbed air, and the only parts of the helicopter affected by the columns of air which are being forced down by the rotors are the open steel structures on each side of the fuselage. The pilot's cockpit is entirely clear of the slipstream from the rotors.

A new helicopter, the PV3, which will carry 12 passengers or the equivalent in cargo, has been constructed in Pennsylvania for the U.S. Navy. The machine is 48ft. long, 13ft. high, and has a rotor at each end. It can land within a 100ft. circle, and can be adapted for either land or water landing and take-offs. In the illustration the aircraft is taking off from the Navy Yard Airport for a test flight.

Engine Transmission

A gear box driven by a friction type of clutch transmits the engine power through long shafts to the rotor hubs. A normal type of aircraft control column and rudder bar is used to obtain the various control movements required. An emergency device is provided so that the rotors are allowed to become free of the engine drive and autorotate in the event of engine failure, and a forced landing being necessary, or if the engine revolutions fall below a predetermined number per minute. For take-off the engine is warmed up, the clutch is carefully engaged and the rotor drive slowly gathers speed as the throttle is progressively opened up to allow the engine to develop its maximum number of revolutions per minute so that the helicopter will rise vertically into the air.

Undercarriage

To ensure a certain degree of stability on the ground, the FW.61 is fitted with a very wide track undercarriage. A tubular steel structure secured to each side of the fuselage, just in front of the pilot's cockpit, carries a spring type shock absorber leg and a special light alloy wheel which has a very small tyre. A third wheel is fitted to a structure extending from the nose of the aircraft and prevents the machine nosing over during take-off or landing.

A single seat open cockpit houses all the controls necessary, and in addition to the usual aircraft instruments a rotor tachometer and a special airspeed indicator are installed. The pilot's seat is adjustable for height.

Performance

The all-up weight of the FW.61 is in the region of 2,200 lb. and it is capable of a maximum speed of 90 miles per hour when streamlined fairings are fitted to all the struts. Without the fairings the maximum speed is approximately 76 miles per hour. The initial rate of climb is 720 feet per minute, and the normal ceiling approximately 8,500 feet. The machine can hover at will, take off and land without any run, and turn through 360 deg. on a vertical axis in just over two seconds.

Developments

It is interesting to note that Professor Focke proposed building a large twin fuselage, four-bladed twin rotor, passenger carrying helicopter in 1938. This machine is illustrated in Fig. 4. Each rotor was to be independently driven by its own power unit, but to ensure that both rotors revolved at the same speed, Focke proposed to synchronise the two engines by hydraulic or electrical coupling. The machine was to have been an amphibian, and a large diameter, fully retractable wheel was to have been fitted in each fuselage. The two fuselages were to have been connected together by streamlined or airfoil section structures. How far this machine was developed is not known.

Conclusion

In the author's opinion the use of two side by side rotors does not give a satisfactory increase in efficiency over that of the single rotor system to justify the increase in weight, higher drag resistance and complication of mechanical drives and controls. The chief feature of the side by side twin rotor layout is the automatic balancing out of torque reaction so that there is no direct absorption of engine power for this purpose.

SPRAY PAINTING

2.—Constructional Details of Two Spray Guns

(Continued from page 323, June issue.)

OF the two spray guns described in the present article, the injector type, shown in Fig. 13, is best for small work or the delicate application of paint, while the syphon type, Fig. 20, is used for covering large areas quickly, as it lays a coat of paint as fast as a man can swing his arm. With the injector type as little as a single spoonful of paint can be handled at a time for colouring the wheels of toy trucks, for tinting bric-a-brac, touching up woodwork, laying in backgrounds and shading showcard work, besides many other jobs of daily occurrence. However, a larger paint-container is needed for the syphon-type gun; this is a glass jar that screws into a lid attached to the gun. A spray gun works on the principle of an air blast creating a vacuum to draw in a supply of paint, which is mixed with the air stream and blown out in the form of a fine mist. Small changes in adjustment will give wide variations in performance; it frequently takes considerable experimenting to get correct atomising with a given air pressure and density of paint. The syphon gun always works best when there is a slight air pressure in the jar. The lid must fit airtight, and the packing nut must not leak. To get pressure in the jar hold your finger over the nozzle and pull the trigger momentarily. Air will bubble up through the paint in the jar, and upon testing it will be found that the paint sprays farther and finer than otherwise. If the pressure goes down before the jar is empty repeat the operation, but be careful not to build up too much pressure or the jar may break. The injector works on the same principle, only gravity pulls with the vacuum instead of against it. Even so, it is always advisable to dilute paint with thinner before using it. Thinned paint breaks up into finer mist and is less inclined to "bounce" when it strikes a surface. Always clean your gun when you have finished using it for the day. Take it apart and dip in varnish-remover. The guns illustrated and described in this article are designed to come apart easily and quickly. After cleaning in varnish-remover rinse the parts in warm water and, when dry, reassemble. When removing the needle from the syphon gun always unscrew the entire sleeve gland. Disturbing the packing means extra work.

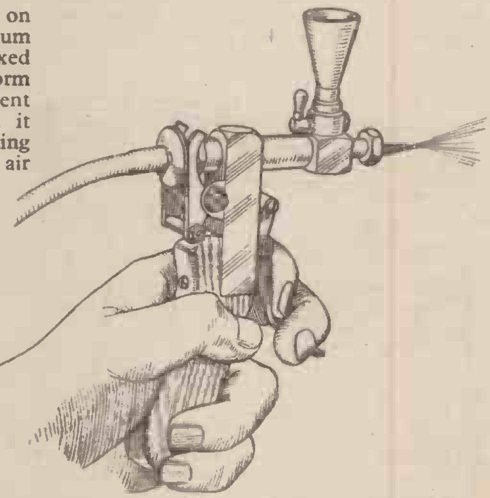


Fig. 13.—*The injector-type of spray gun suitable for small work.*

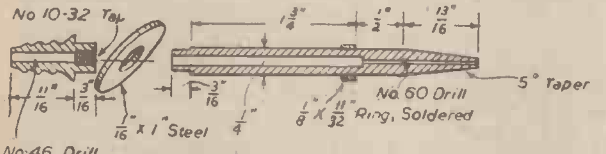


Fig. 14 *(above).—Section of air jet.*

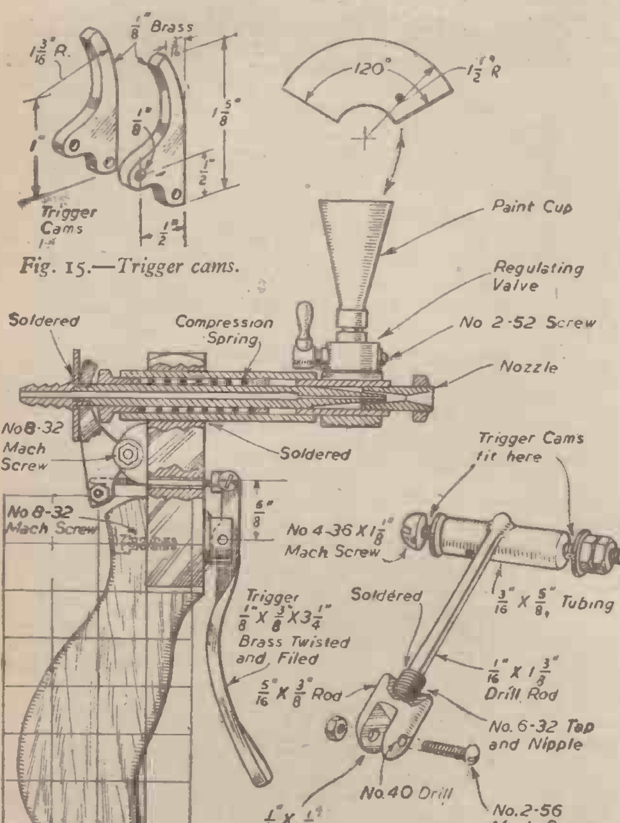


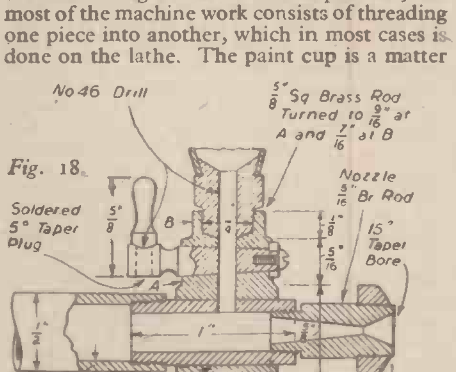
Fig. 15.—*Trigger cams.*

Fig. 16.—*Part sectional view of the injector-type spray gun.*

Fig. 17.—*Trigger-cam operating rod.*

Injector Gun

In making the parts for these guns the machine work is done within close limits so that the parts will fit perfectly. While the injector gun (Figs. 13 to 19 inclusive) has more parts than the syphon gun, its construction is much simpler as there is no needle, no packing gland, and only one joint which must fit perfectly. Also, it is easier to operate as there are no critical adjustments which must be mastered first. The nozzle (Fig. 18) and the air jet (Fig. 14) are both ground to fit. Silicon-carbide dust mixed in oil is used for this purpose, and the work must be done carefully. A good job makes it possible to spray paint in a line so fine that you can write your name on the wall. Stock rod and tubing are used as far as possible, and most of the machine work consists of threading one piece into another, which in most cases is done on the lathe. The paint cup is a matter



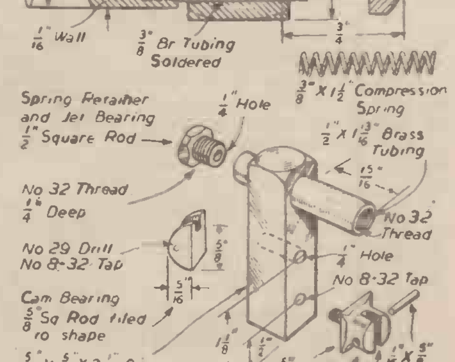


Fig. 18.—*Section of nozzle.*

Fig. 19.—*Details of barrel holder and trigger bearing.*

of personal preference. It may be large or small, open or closed, a glass jar, or a metal cone. Production workers, who use their guns all day long, and frequently change from one colour to another, prefer a metal cone because it is easy to empty and refill.

To get perfect and delicate control, a two-finger trigger is used (Fig. 16). The air jet requires a movement of $\frac{3}{16}$in., and a cam-and-lever arrangement (Figs. 15, 16 and 17) steps this up to ½in. at the end of the trigger, making possible a vernier adjustment of the spray. The pistol grip is another matter of personal preference. The size and shape should conform to the hand of the user. The hand should close around the grip naturally with the butt nestled in the palm. To get a good fit, a number of handles are cut from softwood, after which the most satisfactory one is duplicated in hardwood.

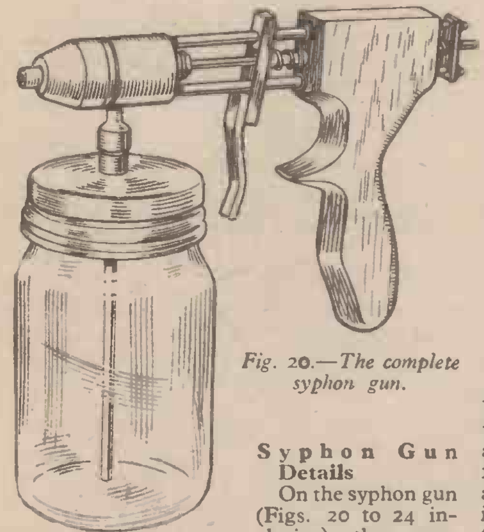
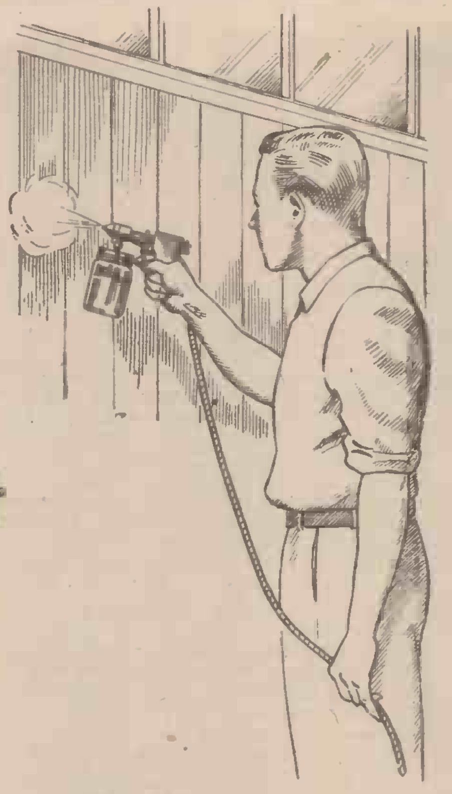


Fig. 20.—The complete syphon gun.



The syphon gun in operation.

Syphon Gun Details

On the syphon gun (Figs. 20 to 24 inclusive), the spray head (Fig. 21) is turned first. All other parts are fitted on to it. Securely mounted in a four-jaw chuck, the head is turned to size, bored and counterbored, then threaded. Small and deep internal threading is done best with a hand tap used while the work is mounted in the lathe, but the external and larger internal threads are cut on the lathe with the tools held in the slide-rest. A well-cut thread can be made airtight. The secret is to take a very thin shaving toward the last, and when the two parts will just barely mesh apply oil and "coax" them together to remove the burrs and high-spots until the threads slide easily. When using machine tools in combination with taps and dies, always make sure that both have the same cutting angle. Professional spray-gun makers grind special tools for their work. An attractive type of knurling is possible without a knurling tool. With the threading tool, a series of V-grooves 3/64in. apart are cut in the cap, after which the tool is turned 90 deg. in the holder, the indexing gauge locked, and the sharp point ploughed across the grooves like a shaper. As only light cuts can be made in this way, the carriage may have to be advanced five or six times to make the cut as deep as the V-grooves. With sixty index divisions, the perimeter is divided into sixty neat and sharp-edged rows of squares.

Wooden Grip and Trigger

Parts to be united permanently are soldered. All details of construction and assembling can be obtained from Figs. 21, 22, 23 and 24. A wooden grip (Fig. 23) is easy on the hands, and if well waxed allows paint to be removed from it without difficulty. The trigger is assembled and fastened permanently in place. When the gun is dismantled for cleaning, the handle is removed and the needle is simply withdrawn until the point is clear. On a large job it is advisable to pour your paint into a number of identical pint jars all of which will fit the lid on the gun, so that they can be used in succession without filling them until all have been used. To make an airtight joint, paper washers and packing may be needed. That which usually comes in a commercial food-container lid is satisfactory.

[By courtesy of POPULAR MECHANICS *Press, Chicago.*]

(To be continued)

SURGEONS' INSTRUMENTS

THE sterilisation of instruments used in the practice of medicine is an essential part of surgery.

An inventor who has conceived an improved method of sterilising instruments remarks that heat has a number of disadvantages. Among others are the adverse effect of the heat and water on the instrument, the requirement of special equipment for sterilisation and particularly the difficulty of excluding contamination after sterilisation and until use.

The disadvantages of heat sterilisation are especially pronounced when applied to hypodermic units, that is units enabling pharmaceuticals to be promptly and efficiently administered by injection directly from sterile original containers.

The object of the invention is to provide surgical instruments ready for use without preliminary sterilisation.

The device comprises the application to at least the operative surfaces of the instruments of a film of a composition containing a solution of a sterilising agent in a non-volatile liquid.

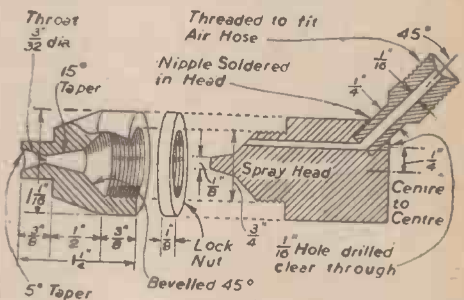


Fig. 21.—Sectional details of nozzle and spray head.

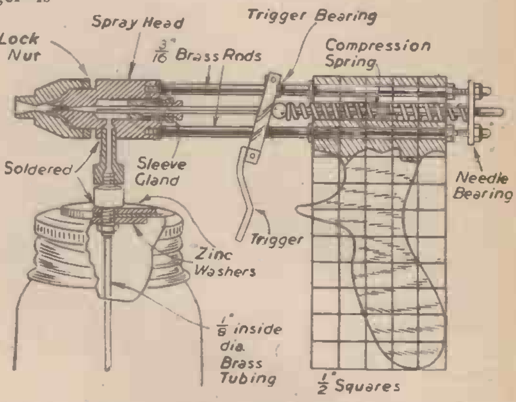


Fig. 23.—Details of the syphon gun and wooden grip.

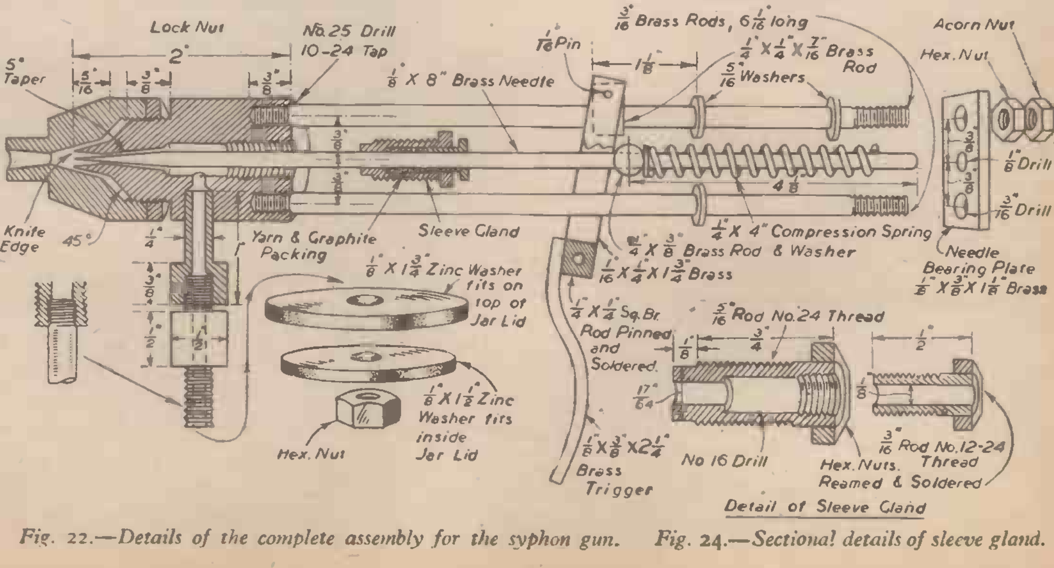


Fig. 22.—Details of the complete assembly for the syphon gun. *Fig. 24.—Sectional details of sleeve gland.*

Science Notes

A Few Facts About Everyday Things

By Prof. A. M. LOW

Beautiful Eyes

I HAVE some very interesting things to write about this time. Because I have been sitting in the train opposite a most beautiful lady. I so wanted to tell her that the colour of her blue eyes was due to the absorption of various parts of the spectrum of which daylight is made. Surely she would have been interested to know that blue is one of the short wavelengths, and that it approached the violet which is so useful when one wants to take a photograph? Not at all like the heat waves from a gas stove.

For some queer reason it is considered essential in all the best novels to say that somebody's eyes turned black or green as their emotions varied. This is, of course, just nonsense, because an eye out of its surroundings is not a pretty thing, and if this lady had had colouring matter round the pupil through which the light passed to the photographic camera or retina at the back resembling violets in springtime, the effect would have been really ugly. Nasty little red streaks would be terribly out of place.

A much more romantic thing to have said would have been that an empty sardine tin upset in a puddle of dirty water reminded me of her eyes. Now, wait a minute. I am quite serious. When the thin film of oil spreads over the water it interferes with light vibrations and if the film is thin enough it will absorb all of them so that it looks black. If it is not quite so thin, nothing in the world could surpass the blue irridescent violet which you can see in any puddle when a leaking motor-car crankcase has passed by.

I shall not tell you what happened, but it did occur to me that thought is an electrical process giving rise to etherial oscillation, and I begin to wonder how long it will be before thoughts are capable of reception by some apparatus. It would be a blessing if we could pick up ideas in this way without the vulgar preliminaries of handshaking and lip-wagging which oscillate the air to produce speech. Noise is a vulgar thing which we should never inflict on other people any more than unwanted touch or smell.

I will admit that some regular noises which become sound can be quite pleasant. No doubt it is due to the manner in which we obtained our meals millions of years ago when we existed in protoplasmic form on the seashore. Rhythm of the tides fed us, and from that dim period we have been creatures of rhythm which breathe by habit at the same speed, absorb light at a definite speed and have hearts which beat like some form of savage music. That was long before the days when men wore a moustache to filter insects as they drank from a stream!

Watch It Bend

I SUPPOSE you know that when a butterfly sits on a bridge it bends? I mean the bridge, not the butterfly, although no doubt it is mutual. There is a kind of measuring balance so delicate that if it is attached to a 4in. deal plank about 3ft. long and a halfpenny is placed at one end, the instrument will indicate that the wood has been bent very considerably.

Apparatus to increase the sensitivity of your own perception is very important in science. One interesting example is called a thermopile, an arrangement of different metals such as antimony and bismuth in contact and connected to a delicate apparatus for detecting electric current. Heat causes a current to flow. Many years ago Professor Boys concluded that if the planet Jupiter was as hot as boiling water it would be possible to measure its temperature by a thermopile of this character. These little machines are so delicate that it is easy to detect the heat of a candle one mile away, and I am told, although I was not present at the time, that it has measured the heat of a girl's cheek when she blushed. It might be difficult to make this experiment nowadays, not because thermopiles are hard to make but because blushes. . . . I will leave the rest to your imagination.

Nothing is Strong

I EXPECT you know in these days of atomic destruction that all substances, if you had microscopic seeing eyes, would seem to be more or less hollow. Electrons and atoms buzzing round interminably, buzzing quicker when the material is hot, slowing down at freezing, and looking most queer in the case of substances like wood. There is far more space than wood in a piece of wood. Keen enough eyes would show you a plank of oak looking like the Milky Way.

It is this idea that is being extended in the search for strong and better materials, and it is true to say not only that a spider's web is far stronger than most man-made steels, but that if we knew how to imitate the strength of ultra-microscopic particles of steel which live, as it were, inside the harder metal, it would not be impossible to make it quite 20 times stronger. I seriously believe that in a few centuries' time the size of things used to-day will seem ludicrous to the children of that era.

We use thick girders because we do not know how to make them strong when they are thin. We use thick motor-car tyres because we have not yet learned how to make a steel like skin, flexible and with a thousandth part of the weight now so necessary.

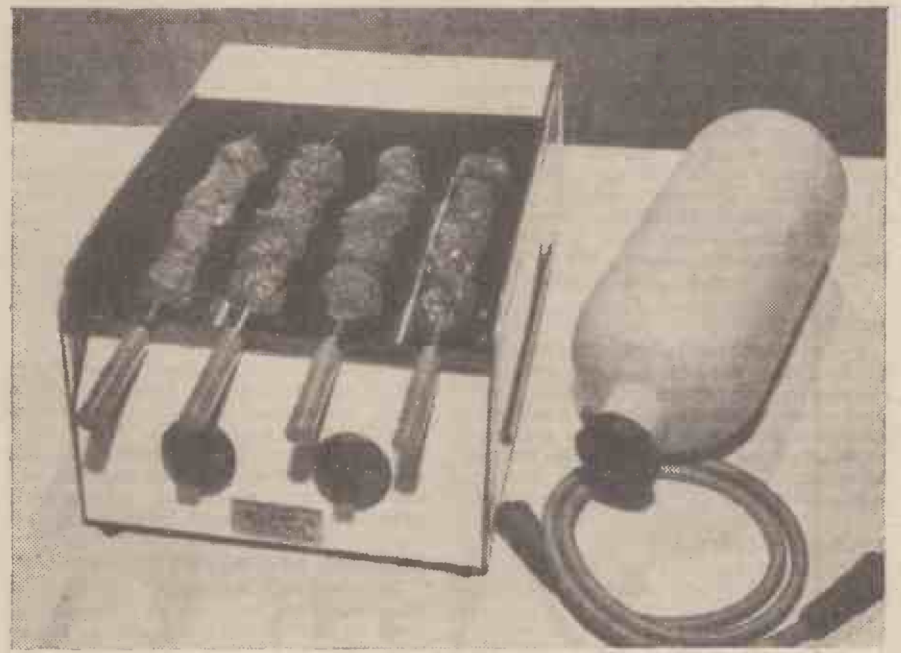
If wheels could only be made much thinner, road springing would be far better and the wheel would bounce on the road, following its contour, while you sat lazily and happily in the back.

This point of size reminds me of an amusing question once put to some students. "Tell me, gentlemen," said my friend, "what would you first notice if you woke up and found everything in the world 20 times the normal size?" The answer, of course, is *absolutely nothing*, because if everything was bigger you would have nothing with which to make your relative comparison!

Winning the High Jump

THE subject of weight is rather interesting, for it is, of course, due to the earth's attraction. Now, in addition to the earth attracting things to it, the earth is also attracted to the things. Drop a stone and the stone falls to the ground, but do not forget that the ground also moves towards the stone. I will admit the movement is very small. Many things in this world are small. If I thump on the table in London it rattles the teacups in Australia, but so slightly that neither you nor I would notice.

To come back to earth, our happy world is revolving exceedingly fast, and there is a tendency for everything to be thrown off exactly as in the joywheel. But for gravity we would fly away like the ball in roulette. Now the lines of the equator being longer than a smaller line nearer to the poles are clearly moving faster, just as the rim of a wheel travels quicker than the hub. So anyone standing on the equator is being thrown away against the force of gravity more strongly than another man in Alaska. It is probably true that if you want to break the high jump record, other things being equal, it would be better to attempt this feat on the equator. One pound of tea weighed on a spring balance varies all over the earth, but no one has yet thought of setting up a chain of stores round the equator to make good use of such a business-like state of affairs.



Camping in the country or on the beach is made easy with this new griller which may be used portably with bottled gas. Manufactured in the United States the appliance was shown at a recent exhibition in New York.

British Civil Aircraft

Leading Particulars and Manufacturers

The Shetland Flying Boat on a test flight.

AEROCAR

Twin-engined monoplane in three versions. The Major and Junior can carry six passengers, the Minor five. Cruising speeds: Major, 141 m.p.h.; Minor, 118 m.p.h.; Junior, 110.5 m.p.h. Ranges: Major, 668 mls.; Minor, 832 mls.; Junior, 771 mls. Engines: Major, Blackburn Cirrus Major, or de Havilland Gipsy Major; Minor and Junior, Blackburn Cirrus Minor II. *Portsmouth Aviation, Ltd.*

AEROVAN

Twin-engined monoplane designed for use as freighter, 6-10 passenger carrier, air ambulance, air operating theatre, flying showroom or caravan. Carries a payload of 2,000lb. a distance of 450 mls. at 109 m.p.h. Freight hold has 530 cu. ft. capacity. Engines: Blackburn Cirrus Major, or de Havilland Gipsy Major. *Miles Aircraft, Ltd.*

AMBASSADOR

High-speed twin-engined monoplane for passenger and freight transport. Maximum seating capacity, 40. Range: 1,000 mls. with 36 passengers; 2,000 mls. with 24 passengers. Cruising speeds: 180-280 m.p.h. Engines: Two Bristol Centaurus air-cooled, sleeve-valve radial engines of 2,540 c.v. *Airspeed, Ltd.*

AVRO XIX

Twin-engined monoplane. Feeder-service type. Normal passenger accommodation, six. For short-stage routes seating can be increased to nine. Cruising speed range: 120-186 m.p.h. Range: 334-570 mls., according to number of passengers. Engines: Two Armstrong Siddeley Cheetah air-cooled radial engines. *A. V. Roe & Co., Ltd.*

BRABAZON I

Eight-engined monoplane airliner. Designed for North Atlantic air services. Day and night accommodation for 80 passengers. Cruising speed: 250 m.p.h. Range: 5,000 mls. Engines: Eight Bristol Centaurus sleeve-valve air-cooled radial engines, paired, and driving six-bladed contra-rotating propellers. *The Bristol Aeroplane Co., Ltd.*

BRISTOL FREIGHTER

Twin-engined monoplane. Designed for the transport of heavy cargo. Payload varies from 10,120lb. over 1,060 mls. to 11,720lb. for a range of 500 mls. Cruising speeds: 150-180 m.p.h. Engines: Two Bristol Hercules 131 air-cooled engines rated at 1,675 BHP ENG. *The Bristol Aeroplane Co., Ltd.*

CONCORDIA

Twin-engined monoplane for feeder-services. Standard accommodation: 10. Max. cruising speed: 212 m.p.h. Most economical cruising speed: 130.5 m.p.h. Max. range at 130.5 m.p.h.: 1,200 mls. Engines: Two Alvis Leonides air-cooled radial engines. *Cunliffe-Owen Aircraft, Ltd.*

DOVE

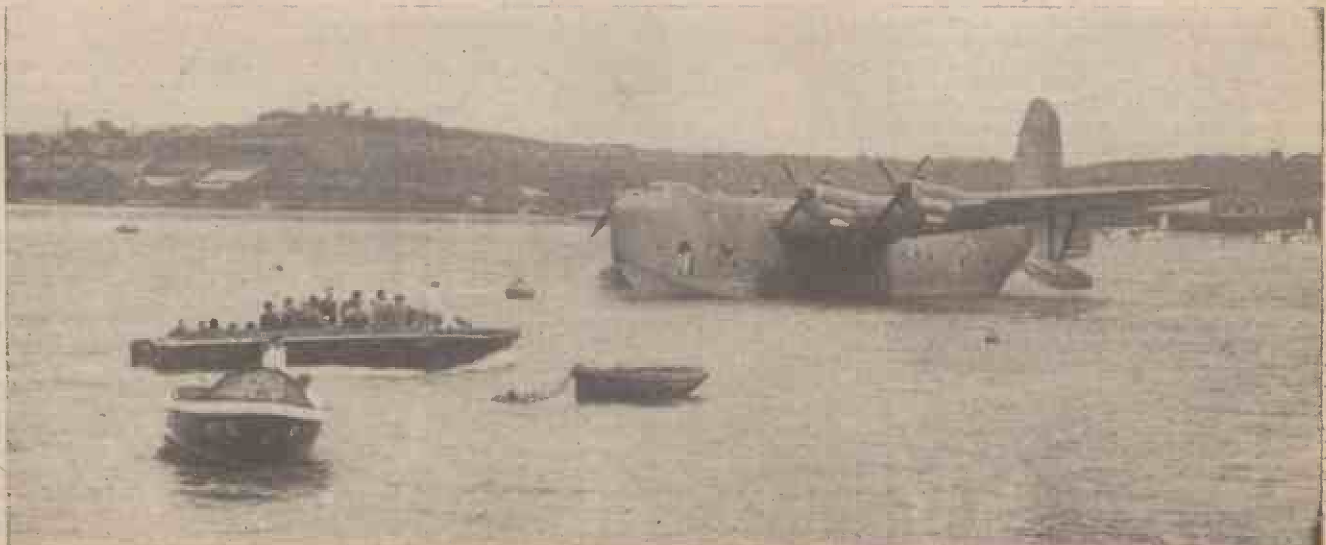
Twin-engined feeder-service monoplane for passenger or freight transport. Standard version carries eight passengers. For short-stage routes number can be increased to 11. Cruising speeds: 150-170 m.p.h., according to height. Range with full tanks: 1,242 mls. Engines: Two de Havilland Gipsy Queen 71 engines each giving 330 BHP/ENG., and driving reversible-pitch propellers. *The de Havilland Aircraft Co., Ltd.*

HALIFAX C.VIII

Four-engined passenger, freight and mail transport. Max. load (at all-up weight of 65,000lb.): 12,000lb. (max.). Range with maximum load: 1,810 mls. Range with 10,000lb. payload: 2,146 mls. Economical cruising speed: 200 m.p.h. at 10,000ft. Engines: Four Bristol Hercules sleeve-valve engines of 1,675 BHP/ENG. *Handley Page, Ltd.*

HERMES

Four-engined airliner and freighter. Standard accommodation: 34 passengers. Other versions carry 20 and 50 passengers. Range with 12,290lb. (max.) payload at 192 m.p.h. at 10,000ft.: 2,000 mls. Max. range with 8,900lb. payload: 3,000 mls. at 20,000ft. Freighter version carries 18,800lb. payload a distance of over 1,740 mls. Engines: Four Bristol Hercules 100 sleeve-valve, air-cooled engines of 1,675 BHP/ENG. *Handley Page, Ltd.*



Another view of the four-engined Shetland Flying Boat, showing her at anchor.

LANCASTRIAN

Four-engined airliner. Accommodation: 9-11 passengers. Max. payload: 7,850lb. Max. range at 239 m.p.h.: 3,940 mls. Rate of climb at sea level: 740ft./min. Engines: Four Rolls-Royce Merlin engines of 1,600 BHP/ENG. *A. V. Roe & Co., Ltd.*

MARATHON

Four-engined feeder-service passenger and freight carrier. Normal passenger accommodation: 14. Still-air range with 3,525lb. payload: 500 mls. Economical cruising speed: 175 m.p.h. Engines: Four de Havilland Gipsy Queen in-line engines, each giving 330 BHP/ENG. for take-off. *Miles Aircraft, Ltd.*

MERCURY

Single-engined monoplane. Two-four seater. Cruising speed at 6,400ft.: 172.5 m.p.h. Max. range: 490 mls. Engine: de Havilland Gipsy-Major III, Blackburn Cirrus-Major III, Gipsy-Major IIIS (with constant-speed propeller), Gipsy-Major IC or V. *Miles Aircraft, Ltd.*

MERGANSER

Twin-engined aircraft. Accommodation: Five passengers and pilot. Disposable load: 2,300lb. Max. speed at 5,000ft.: 193.5 m.p.h. Economical cruising speed at 8,000ft.: 170 m.p.h. Range (normal): 750 mls.; max., 835 mls. Engines: Two de Havilland Gipsy Queen Series 50 engines of 295 BHP/ENG. *Percival Aircraft, Ltd.*

MESSENGER

Two-four seat aircraft. Single-engined. Max. speed at all-up weight of 2,425lb.: 115 m.p.h. Cruising speed: 100 m.p.h. at 2,000ft. Range (normal): 250 mls. With extra fuel: 500 mls. Engine: de Havilland Gipsy Major IC, III or V, or Blackburn Cirrus Major III. *Miles Aircraft, Ltd.*

OXFORD

Twin-engined monoplane for feeder-service. Disposable load: 2,660lb. Max. speed at sea level: 169 m.p.h.; at 5,000ft., 183 m.p.h.; at 8,000ft., 192 m.p.h. Cruising speed at 5,000ft.: 165.5 m.p.h.; at 10,000ft., 164 m.p.h. Engines: Two Armstrong Siddeley Cheetah air-cooled radial engines. *Airspeed, Ltd.*

The Avro Lancastrian 'plane in flight.

PROCTOR V

Single-engined aircraft. Four seater. Disposal load, 1,155lb. Max. speed at sea level: 156.5 m.p.h. Max. cruising speed at sea level: 148 m.p.h. Economical cruising speed at 3,000ft.: 140 m.p.h. Range: 490 mls. Engine: de Havilland Gipsy Six air-cooled engine of 206 BHP/ENG. *Percival Aircraft, Ltd.*

SANDRINGHAM

Four-engined flying-boat airliner. Accommodation (standard): 24 day passengers, 16 night. Max. speed at sea level (at 56,000lb. all-up weight): 220 m.p.h. Max. speed at 9,000ft.: 193.5 m.p.h. Range (at 56,000lb. all-up weight, including 8,200lb. payload): 1,570 mls. Engines: Four Bristol Pegasus 32 air-cooled radial engines of 1,025 BHP/ENG. *Short Brothers (Rochester and Bedford), Ltd.*

SHETLAND

Four-engined flying-boat airliner. Payload and range at 8,000ft.: 7,700lb. over 4,650 mls. at 184 m.p.h.; 22,000lb. over 3,000 mls. at 185 m.p.h. Max. speed at 4,000ft.: 267 m.p.h. Engines: Four Bristol Centaurus air-cooled sleeve-valve engines each giving 2,500 BHP/ENG. for take-off. *Short Brothers (Rochester and Bedford), Ltd., and Saunders Roe, Ltd.*

SOLENT

Four-engined flying-boat airliner. Passenger accommodation: max. 36. With 24 passengers and 1,895lb. freight, a range of 2,260 mls. is attainable at altitude of 5,000ft. Over shorter range 24 passengers and 14,600lb. freight can be carried. Engines: Four Bristol Hercules air-cooled engines. *Short Brothers (Rochester and Bedford), Ltd.*

TUDOR I

Four-engined trans-Atlantic airliner. Day and night accommodation for 12 passengers. Max. range/payload: 4,330lb. for 4,000 mls. at 245 m.p.h. at 25,000ft. Max. payload: 6,010lb. for 3,000 mls. at 241 m.p.h. Engines: Four Rolls-Royce Merlins. *A. V. Roe & Co., Ltd.*

TUDOR II

Four-engined airliner. Standard version, 49 passengers; other various, 60- and 22-seaters. Cruising speed: 215 m.p.h. at 10,000ft. For 2,000 mls. at 25,000ft. and 250 m.p.h. the payload is 11,100lb. *A. V. Roe & Co., Ltd.*

VIKING

Twin-engined feeder-service airliner. Standard plan: 27 passengers. "De Luxe" version: 21 or 24. Disposal load: 10,000lb. For a range of 1,000 mls. the aircraft will carry payload of 6,370lb., at 10,000ft. Cruising speed: 240 m.p.h. Engines: Two Bristol Hercules 130 sleeve-valve air-cooled engines of 1,675 BHP. *Vickers-Armstrong, Ltd.*

WAYFARER

Passenger version of the Bristol Freighter. Standard accommodation, 34 seats; maximum, 40. Can carry 9,560lb. payload a distance of 500 mls.; 7,700lb. a distance of 1,000 mls., cruising at 180 m.p.h. at 10,000ft. Max. range: 1,300 mls. Engines: Two Bristol Hercules sleeve-valve air-cooled radial engines of 1,675 BHP. *The Bristol Aeroplane Co., Ltd.*

YORK

Four-engined airliner and freight transport. Standard accommodation: 14-16 passengers. As freighter, max. range with 6,240lb. payload, 3,000 mls. Cruising speed at 10,000ft.: 204 m.p.h. Max. range: 3,170 mls. with 5,240lb. payload at 204 m.p.h. at 10,000ft. Engines: Four Rolls-Royce Merlins. *A. V. Roe & Co., Ltd.*

The Tudor II, four-engined air-liner, on the production line.

The Story of Radar—8

Radiolocation in the Army: Elsie and the Searchlights: Radar in the Royal Navy

(*Continued from page* 292, *May issue.*)

When the first peacetime spring cruise of the Home Fleet took place recently, it was the first time that radar has ever been on manœuvres in peacetime. The illustration shows part of the radar apparatus on one of the warships.

ON the night of June 20th, 1940, the first heavy raid against the South coast was in progress; searchlights were weaving their complicated patterns in the sky —without much success; and three young scientists of the Ministry of Supply stood on the coast, listening to the drone of German 'planes and watching the ineffectual manœuvres of the lights. They resolved then and there that something should be done about it. Fortunately they were in a position to do something about it; they were already engaged in research work on the one-metre band; and they discussed and argued the possibilities of adapting their work to the solution of the problem of searchlight control. They evolved a clear plan; and within a fortnight of starting, the first model—held together by "string and sealing wax"—was ready; and it worked. Admittedly it was far from anything even approaching a final design; but it demonstrated that a solution along those lines was possible. The most prominent feature of the new equipment was a long bamboo rod, mounted above the searchlight projector and rotating to trace out the surface of a cone, which was the aerial system; other bits of radio gear were festooned round the projector. The bamboo rod was abandoned in later models and a group of four stationary aerials used instead.

Elsie—the name arose inevitably from the elision of S.L.C. (Searchlight Control)—was born. Or rather reborn; an earlier Elsie had been conceived in 1937, but the knowledge and technique of that time had not been adequate to save her life, and she died.

The news of the success of the "string and sealing wax" model spread rapidly, and shortly reached the ears of Mr. Churchill himself; with characteristic decision, he ordered that twenty-four of these devices were to be built immediately *and installed* "by the next moon-phase"—in other words, in rather less than four weeks. All available effort and materials were pressed into service; and thanks to the intense exertions of everybody concerned, the equipments were delivered on time, and, what is even more remarkable the majority of them worked. Another weapon was available in the battle against the enemy.

How Elsie Works

Fundamental to the design of Elsie is the fact that it was made in the form of units which could be easily attached to the existing searchlight projectors. Various models or "Marks" were made round the same basic units, the most important being those employed on the 90 cm. and 150 cm. projectors. A small transmitter working in the 1½ metre band sends out short period pulses of radio-frequency energy at a rate of 1,500 to 2,500 pulses a second.

These pulses are radiated from an ingenious aerial system designed by Yagi—one of the few original contributions made by Japan—and when reflected back from an aircraft are received on another Yagi aerial system. They are then amplified a million times or so, detected, and appear as inverted V breaks on the timebase of a cathode-ray tube. This enables the operator to discriminate between targets of different ranges, and also to estimate the range of the required target on a scale fixed to the front of the tube itself.

The receiving aerial system consists of four Yagi aerials, with wire mesh reflectors, arranged at the four corners of a square, one above, one below, and one each side of the projector barrel. The connections from the aerials to the receiver pass into a "phasing ring" over which a wiper arm is continuously rotating; the arrangement is such that the position of maximum pickup of the aerials is not directly forward, but is slightly displaced, and sweeps out the surface of a cone, in synchronism with the movement of the moving contact on the phasing ring. Thus "split" which has already been mentioned, is achieved, and the bearing is found by comparing the strengths of the signal when the beam is switched to the left and right: when the two signals are of equal strength the equipment is on bearing. Elevation is similarly found by comparing signal strength when the beam is switched up and down.

The angle operators see on their tubes a spot which, when they are on target, is central and well-defined; as they move off target, so does the spot move off centre, to the left or right in the case of the bearing tube, and up or down on the elevation tube, and at the same time becomes less well focused. The target which they are to follow is chosen for them by a third operator who has the usual horizontal timebase with inverted V breaks showing targets. On to the one he selects he brings a small bright "strobe" patch by means of a handwheel, and this chosen signal is the only one passed to the angle operators.

The Maggies

Two further equipments based on Elsie are worthy of mention here. Elsie herself did not measure range accurately; there was no need to; either the target was in the beam or it wasn't. However, if the equipment were divorced from the searchlight and an accurate ranging unit added, a handy and light equipment suitable for use with H.A.A. guns would be the result.

This was done, and the equipment was named "Maggie"; and a few were installed in places too small to accommodate a real G.L.

From this another equipment was built up, small, light, and self-contained, for which the Army clamoured as a substitute for G.L. in assault landings before G.L. itself could be deployed.

"Baby Maggie" was turned out in a tremendous hurry, and sent proudly into battle on the Italian beachheads.

Both Maggies are now obsolete; they have done their jobs and are superseded by newer and better equipments; but they should not be forgotten, for, with all their faults—and as always with equipments so hurriedly produced, they were many—they provided the means of doing a difficult job when nothing else was available.

The Later Elsie

It was realised that the use of wavelengths as long as 1½ metres presented insuperable difficulties in connection with the angular accuracy obtainable and the avoidance of unwanted ground reflections, particularly at low elevations. So, as in many other radar applications, centimetre waves were used, and an equipment was produced, more accurate, more reliable, and smaller than the earlier models.

"Autofollow" has made the latest Elsies uncannily accurate in following a target, however it twists and dives in an endeavour to escape from the beam. No better example of this uncanny accuracy could be cited than the fact that searchlights, though not normally regarded as lethal weapons were responsible on at least two occasions in N.W. Europe for bringing down—*unaided*—an enemy 'plane; the pilot, flying low, was on each occasion so disconcerted by the sudden intense illumination that he dived into the channel.

Coastal Defence

The story of coastal radar is somewhat confusing to the newcomer; all three Services have their particular interests in the coasts, and their stories are closely interwoven one with another. Furthermore, the Services have in this connection enthusiastically borrowed and modified and adapted each other's equipments to their own particular needs. The truly Army part of the story to-day is the control of coastal artillery batteries by means of radar; but in the early days the Army was actively concerned also with the broader question of the early warning of the advent of enemy shipping.

The story really starts on April 10th, 1935, when the Air Defence Committee were assured that it should be possible to locate ships at 20 miles range by the as yet undeveloped art of radiolocation; but even though Coast Defence may have been conceived in 1935, it wasn't born until 1939. Early in that year the War Office group at Bawdsey produced an experimental set with several remarkable features. First, it operated at about 1½ metres; and, although work on this wavelength had been in progress for some time, the building of an equipment incorporating the new technique was still a somewhat courageous undertaking. Secondly, it achieved a narrower beam than had ever been obtained before, though at the price—inevitable at all but centimetre wavelengths—of an impressively large aerial array. Thirdly, it incorporated the "strobe" principle already explained in the section devoted to G.L., and was undisputably one of the very first equipments to make use of this. Fourthly, it used the "split" system, also explained with reference to G.L. Mk. 3. It is impossible to overestimate the importance of this principle, simple and even obvious though it may appear in retrospect. Until the system of switching the beam from side to side was invented—and it was invented for this new coast set—no accurate measurement of angle, either bearing or elevation, was possible. The astonishing accuracies of G.L. Mk. 3 and its Canadian and American relatives can reasonably be said to derive from that one flash of inspiration.

So far as the determination of the accurate bearing of ships was concerned, the equipment was an immediate and spectacular success. It was installed on the Bawdsey cliffs and rapidly became a "show-piece" for visiting officials. These would be encouraged to lay the set electrically on to the "Butter Boat"—a grey thousand-tonner of commendably regular habits that plied between Esbjerg and Harwich—and then to look through the sighting tube provided to confirm that it was, in fact, looking straight at the target.

The way was clear for a real Coast Artillery set. But, before this work continued, other considerations intervened. The Air Ministry at once realised that a set which could locate a ship with such consummate ease would as easily locate a low-flying aircraft; and it has been told elsewhere how the C.H. chain, admirable though it was in all other respects, would be blind to the low-flyer. It was unanimously agreed that this aspect must be dealt with first; and so the set was handed over to the Air Ministry and became the first "C.H.L."

Meanwhile, the control of the coastal guns had not been forgotten; and by the autumn of 1940 three experimental models of the first "C.A." (Coast Artillery) set had been built. It had the transmitter of C.H.L., the aerials of C.D./C.H.L., and a new display system; the most striking feature of the latter being its spiral timebase, which was, as it were, "coiled" on the screen of the cathode-ray tube, making possible, with such a long timebase, a greater degree of accuracy. It passed its trials with flying colours, and the designs were passed over to a commercial organisation for manufacture.

That first precursor of the C.H.L. had other offspring. During those early days at Bawdsey it was decided to investigate whether the set would detect submarines when they surfaced (radar cannot detect anything *below* the surface of water, as the waves are absorbed very rapidly by the water; the energy is converted into heat, and there is no future in warming up microscopic portions of the sea). It did, with great success (the submarine that acted as "guinea-pig" for the trial got bombed for its pains, which was unfortunate); and this led to the installation of some very early models of a "C.D." set in the Orkney and Shetland Islands which gave valuable service.

Scientists had wondered whether it would be possible to "see" on the radar set, the actual splash of a shell hitting the water. After all, a pillar of water should reflect radio waves, so why not? It was tried; during the summer of 1939, the splash of a 9.2 inch coast artillery shell was detected and located by the radar set.

This opened up entirely new possibilities. The ship could now be located with great accuracy, and the guns told where to fire. But suppose the guns miscalculated slightly? After all, the accuracy of a radar set was already greater than the accuracy to which a gun could aim; this provided a chance of telling the gun control officer where precisely the shell had landed in relation to the target, so that he could make corrections for the next shot. So began the "fall-of-shoot" work, carried out by both Army and Navy. The details of the present equipment cannot yet be released; but it can be stated confidently that they have an accuracy and precision so great that no improvement need be expected, or desired, for a very long time to come.

By means of radar the fog menace is banished from the sea. Fixed to the bridge deck of a ship is the "scanner"—a circular revolving reflector which sends out a continuous beam.

We cannot close this section without some reference to the concrete achievements of C.A. radar. The application of radar fire-control came to its full fruition in 1944, when German ships, large and small, were sunk with devastating efficiency. The Dover defences ended their war in a blaze of glory when, on the last night of the German evacuation of Boulogne, they sank 11 ships out of 18 in the two convoys that tried to run the Straits, at a range of nearly 20 miles, and without being able to see one of them. Only radar control could have produced such deadly precision at so great a range.

The Future of Army Radar

The work of designing new radar equipments, and of adapting radar to new roles within the Army, goes on. As a particular example of the remarkable powers of radar, it can be divulged that by adaptation of the most modern equipments it ultimately proved practicable to follow the flight of a V2 rocket projectile.

Many of the new developments are very much on the secret list, and may not ever be adumbrated. But it may be said that design generally is concentrating on lightness, compactness and mobility, so as to be suitable for the ever-greater mobility of the modern army; and that the newer equipments are as fully at home in the arctic regions or the tropics as they are in England. Such developments obviously point to a more offensive role for radar, and its full potentialities are even yet not realised; but we may be certain that the post-war Army will not neglect the new powers that radar has conferred upon it.

Radar in the Royal Navy

As in the other Services, the Navy put aircraft detection first among its radar requirements.

From the start, the Navy was able to make a most important contribution to inter-Service radar developments by producing the special valves required for the pulsed transmissions on the power of which the range of detection depended.

H.M. Signal School, Portsmouth, was requested to assist the Air Ministry investigators in July, 1935, and undertook to make the silica valves required for the work proceeding at Orfordness. The silica valve was a Naval W/T development which had gone a long way towards solving the problem presented by heat dissipation in high-powered valves.

The Aerial Problem

Naval development of radar differed from shore development in that it was profoundly concerned with aerial design. Small rotating aerials producing a narrow directional beam which could search through 360 deg. were essential. This involved mechanical considerations and extra weight. Electrical requirements postulated dipole aerials (half as long as the wavelength employed) and the longer waves around twelve to thirteen metres gave most promise from the point of view of transmitting and receiving valve technique. On the other hand, such considerations as a ship's stability and wind resistance placed a very definite limit on the size and weight of aerial that could be mounted at her masthead. Thus, Naval research naturally tended to concentrate on the ultra-short wavelengths where success would permit the use of small aerials, with narrow beams, and which would also improve low cover and the much-needed detection of surface vessels.

With this object in view, the Signal School scientists were set to work on the ultra-short (centimetric) wavelength technique, which seemed a possible though not promising approach to the problem. At the same time the possibilities of having to use longer (metric) waves was not neglected.

At the end of 1937 it was decided to concentrate on a set operating on the longest wave for which it was deemed practicable to erect a rotatable dipole aerial system at a ship's masthead. One mast was to carry the transmitting aerial and the other the receiving aerial, their rotations being synchronised. Two development models were produced by the summer of 1938, the first being fitted in H.M.S. *Rodney* and the second in H.M.S. *Sheffield*.

First Radar Trials in Warships

Results of naval radar's maiden voyage were most encouraging, and valuable experience was gained from these sea trials, not only in aircraft detection but also in the location of surface vessels.

The development model was redesigned, and by June, 1939, the first of a series of sets with three times the power of the original, had been made in Signal School workshop. The remarkable increase in power was due to an improved transmitting valve with a new type of filament becoming available in time for inclusion in the set.

This forerunner of hundreds of air warning sets of the same type was fitted in H.M.S. *Curlew* in August, 1939. *Curlew* left Chatham in September, 1939, and it is interesting to note that before war broke out we thus had in commission a ship equipped with a complete air warning set of a design which has won especial honours for its reliability. A few of those sets are still on active service.

Progress in Decimetric and Metric Wavelength Technique

Scientific effort was now being concentrated on the shortest wavelength in the decimetric waveband on which adequate power could be generated, using valves of conventional design. At the same time an improved air warning set, using a slightly shorter metric wavelength than its predecessor and of even greater power, was being developed. This set incorporated an accurate gunnery ranging panel and great improvement in bearing accuracy was also obtained by the addition of beam switching, the principle of which is described elsewhere. A ranging panel adapted from Army equipment has also been added to the original set.

Small Ship Radar

Meanwhile there was a pressing requirement to fit destroyers, corvettes and light craft with some form of "R.D.F." An officer of the Fleet Air Arm working on the adaptation of R.A.F. airborne radar for Fleet Air Arm work, was testing a set in a Walrus amphibious aircraft on a slipway at Lee-on-Solent, when he found that it could detect shipping in the Solent at a useful range. Proposals followed to adapt this set for use in destroyers. This was done, using fixed aerials, the resulting assembly of struts and aerial rods resembling a giant box kite at the masthead. The display took the form of horizontal echo deflections on a vertical trace. When equal echo deflections appeared on either side of the trace, the target was dead ahead of the ship. Unless, therefore, course was altered until the echo deflections were equal, target bearings could be estimated only approximately from the inequalities of echo on the port and starboard sides of the trace; i.e., if the echo deflection on the port side of the trace was bigger than that on the starboard side, the target lay to port and *vice versa*.

These considerations and the prevalence of back echoes from objects astern, called for a high standard of skill from the R.D.F. operators in interpreting the "picture" on the cathode-ray tube of this Type 286M.

Transmission and reception with a common aerial which could be rotated by means of a Bowden wire control, converted 286M into 286P, which in turn with a more powerful but not very successful transmitter became 286 PQ. The real answer to this requirement for combined air and surface warning in small ships came in 1942 with an all-naval design which, due to its high "power-size ratio" and compact design, was known as the "suitcase set." It must be pointed out that none of these small ship sets had given or was expected to give an entirely satisfactory answer to the problem of U-boat detection.

Radar Rangefinding

Using the valves available at that time, the team working on the decimetric band were, by the end of 1939, in a position to undertake a new Admiralty requirement, namely an "R.D.F." rangefinder for A.A. armament.

Batteries of naval guns require a central control and sighting position. This is known as a director. Directors control pom-poms, heavier anti-aircraft guns and the main surface armament of big guns, six-inch and upwards. Accurate range is required for all guns, and had been obtained to date by optical rangefinders mounted in the directors. The possibility of "R.D.F." ranges being more accurate than those obtained by optical methods had been realised early on during trials of the first air warning sets, but when ranging panels were added it became clear that apart from the inability to deal with more than one target at a time, this set's primary function of detecting aircraft had become so important as to make tactically unsound any interruption of this work for ranging purposes. The priority requirement was "R.D.F." range for the A.A. armament, because in addition to the impracticability of applying optical rangefinding to a large number of high velocity targets, there was an added difficulty in the case of pom-pom armament, due to the small director being an inadequate mounting for an optical rangefinder of adequate base length.

New Era in Naval Gunnery

Experiments at Southsea showed that the decimetric team's work had made practicable R.D.F. rangefinding, using aerial arrays which could be mounted on all types of director, and that the accuracy of the fire thus controlled would be limited only by the precision with which the guns could be made to throw their projectiles. Naval gunnery was entering on a new era.

Within a little over four months of the request for an A.A. R.D.F. rangefinder having been stated, the required set was being produced—no mean achievement.

Meanwhile an experimental set to control the fire of the sixteen-inch guns of H.M.S. *Nelson* had been fitted with an aerial array on her main armament director. Results on test were good; too good, in fact, because they were actually better than normal. The first production model of the new main armament fire control set for ranging on surface targets was fitted in H.M.S. *Birmingham* and other cruiser and battleship fittings quickly followed.

Radar "Shadows" the "Bismarck"

In addition to providing accurate range, which enabled the guns to be given the correct elevation to hit their target, it was evident that with the addition of beam switching, R.D.F. fire control sets would be able to give accurate directional bearing of targets. The main armament set could even carry out a searching sweep in conditions of bad or nil visibility and enable the guns to open fire on an unseen target of which preliminary warning might have been given by the big air warning set with its masthead aerials. The surface warning set was yet to come. Meanwhile, the gunnery surface ranging set was doing its best to fill the gap, and H.M.S. *Suffolk* successfully picked up and shadowed the *Bismarck* with it in 1941.

The first post-war trip of the Golden Arrow, the famous Continental train took place recently. The "Canterbury," the cross-channel steamer on the service, which has a fine war record, has been reconditioned for the service from Dover to Calais. Our illustration shows the radar screen on the "Canterbury" which is the first ship on the Continental service to be fitted with Radar.

Developing the A.A. Gunnery Sets

Two types of A.A. gunnery sets were developed, one for use with pom-poms and the other to control guns fitted for both surface or A.A. fire—H/A (High Angle), L/A (Low Angle) armament, which had a medium-sized director. The prototype model of these sets was fitted in a Hunt Class destroyer, H.M.S. *Southdown*, in September, 1940.

The original display panel containing the cathode-ray tube designed for these first gunnery sets, had a mechanically-driven pointer, which moved across the range scale when a handle was turned. By keeping this pointer aligned with the target's echo on the tube, the operator automatically transmitted range and the speed at which the target was opening or closing to the guns.

(*To be concluded.*)

Atomic Power and Industry

By SIR GRAHAM CUNNINGHAM, K.B.E.

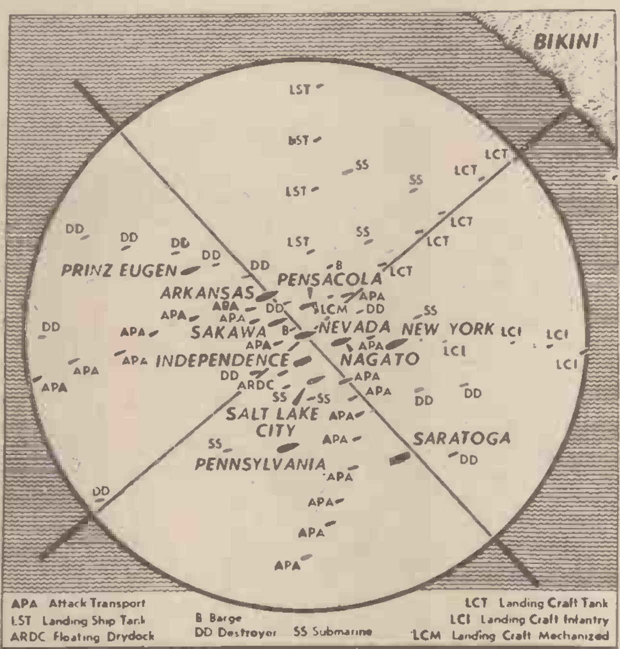
SIR GRAHAM CUNNINGHAM, K.B.E., has recently been released from his war-time work at the Ministry of Supply, where he was Chief Executive and Controller General of Munitions Production. Although this position brought him in touch with research on all military matters, including atomic energy, this article gives his opinion on its industrial possibilities without any reference to knowledge which he obtained in an official position.

THE subject of atomic energy seems to have produced two schools of thought to-day; some people are filled with a dread of its potentialities as a destructive force, but others are thinking of it in the terms of its constructive use in more peaceful directions.

If properly handled, can atomic power make life easier for all of us? The excitement that has surrounded the announcement of this recent discovery has perhaps naturally induced a number of writers to lose their sense of proportion and let their imaginations run beyond the limits of reality. There are many restrictions on atomic power which make its general application so remote as to be termed impossible. For example, it is known that atomic energy can be derived only from one or two known minerals of the higher atomic weight, such as uranium or thorium. It cannot, for instance, be obtained from clay. Secondly, we must also remember that quite apart from the expense and many difficulties of obtaining a substance which will enable us to obtain nuclear energy from these minerals, the substance from which nuclear energy is ultimately derived must necessarily be radio active. It is this feature of radio activity that enables the scientists to split the atom and thus set up a chain of atomic disturbances which result in fission. Owing, therefore, to the radio active substances that must be handled in order to create nuclear fission, all the precautions involved in the protection of personnel in the handling of a radio active substance have to be taken during the preparation of the raw material which is the source of the energy. This at once limits the use of atomic energy for any ordinary domestic purposes. One can only conceive atomic energy being used centrally to create heat and that heat converted into power, for example, electricity, which in turn can be transmitted by the normal means for domestic use. In other words, one need never expect to see small furnaces giving off nuclear energy installed in a block of flats in order to run the lifts, nor under the bonnet of a motor-car in order to give power to propel us along the roads. It is remotely conceivable that nuclear energy can be so contained and controlled as to be used in a large vessel needing mobility, as, for example, a big Atlantic liner.

Principle of the Atomic Bomb

There seems to be a lot of confusion in people's minds as to what an atomic bomb does. It is thought that it creates an explosion, and that the explosion of an atomic bomb is particularly big compared to the explosion of a normal high explosive bomb, and that, therefore, it is only a matter of regulating size in order to harness power. That, of course, is not so at all. The nuclear fission, which is the name given to the release of enormous quantities of energy by the splitting of the atom, is something quite different from a detonation or an explosion. These latter are really different forms of combustion. When we speak of combustion, we associate it generally with a flame and regard it as something burning, the most common form being coal in a fire. What is really happening is the very slow chemical change by the absorption of oxygen from the air of chemicals of one sort which are being converted into chemicals of another sort. The rate of change and the consequent creation of energy in the form of heat is largely the difference between combustion, explosion and detonation. An explosion usually arises when a material is in a confined space and by ignition is rapidly changed into materials of another kind, giving off gases in large quantities and, at the same time, generating heat. Owing to the rapid expansion of the gases, damage is caused to the surrounding static materials approximate to the centre of the explosion. A detonation is something which is similar to an explosion in as much as there is a chemical change of the material detonated, but a confined space is not essential, the time for conversion is far shorter and the expansion of gases and the heat generated are considerably greater. Now a fission is not a chemical change, it is a physical change. The formula H_2O indicates the chemical structure of a molecule of water. If we split that up into two atoms of hydrogen and one of oxygen a chemical change takes place, and the result is that we have no water but some hydrogen and some oxygen. When atomic energy is created by a nuclear fission, it is not a change of a chemical nature from one form of known chemical to another that takes place, but the breaking up of the atoms which when linked together form the molecules, which in turn give us the mineral which is its constituent body. The atom can be conceived somewhat like a sun with the planets going round it, but instead of the sun and the planets we have a central body called the nucleus, surrounded by electrons, and it is the splitting up of this central body which creates nuclear energy. Although the atom is very minute, the energy created by splitting is vast. When, therefore, an enormous quantity of atoms is split simultaneously, the heat given off is something which hitherto has been almost unbelievable on this earth. Indeed, it has been calculated that the energy given off by the conversion of mass into energy is equivalent to the amount of the mass involved multiplied by the square of the velocity of light. As the velocity of light is 186,000 miles per second, it can be seen at once what colossal figures are involved. Indeed, as is stated in the excellent account of the development of methods of using atomic energy recently published by the Stationery Office, 1 kilogram (just over 2lb.) of matter, if converted entirely into energy, would give 25 billion kilowatt hours of the energy. This is said to be equal to the energy that would be generated by the total electric power industry of the United States, as at 1939, running for approximately two months. In comparison with this let us turn back to combustion. If we burn 1 kilogram of coal, the amount of kilowatt hours of heat energy would be only 8.5.



This chart is based on information released by joint Army-Navy Task Force, indicating approximate disposition of ships off shore of Bikini Atoll in the Pacific for the atomic bomb test. The centre of the target area is about 6,000 yards from the Bikini shore. Battleships included are the "Nevada," "Pennsylvania," "Arkansas," "New York," former Japanese battleships "Nagato" and "Sakawa" and the former German heavy cruiser "Prinz Eugen," along with the cruisers "Pensacola" and "Salt Lake City" and carriers "Independence" and "Saratoga."

The Atomic Furnace

It is hours of heat energy that are wanted from the disintegration of the atom, and the problem is how to get that energy at an even rate over a continuous period of time in such a way that it can be utilised in place of the normal known methods of fuel combustion, in order to generate power in the form of electricity, steam and the like.

The scientists know, and have known for some time, that this nuclear energy can be obtained in a somewhat controlled form. The speed of disintegration of a chain of atoms can be slowed down and to some extent regulated, but to do this in the form of a furnace from which energy can be harnessed for industrial purposes is at present a problem on which immense work will have to be spent, and all one can do is to speculate on the consequences. One aspect which will have to be taken into account is whether the creation of such a furnace, with all the attendant cost of producing the raw material and the risks involved in dealing with a radio active substance, will give energy at a cheaper price than the present known methods of procuring coal or oil, and by means of combustion obtain the energy required. It is quite conceivable that an atomic furnace could be created which would last for such a long period of time that its original heavy cost need only be amortised over generations. This might be useful if there were signs of a world shortage of coal and/or oil by the drying

(Continued on page 367)

THE WORLD OF MODELS

Housing is Home Priority Number One, and This Month Our Contributor Shows Readers Models of Various Types and Styles of Houses that are Being Built for Local Authorities in Various Parts of the Country

By "MOTILUS"

Courtesy of the "Daily Herald."

The Minister of Health (the Rt. Hon. Aneurin Bevan) studies one of the "true-to-scale" models on opening day at the "Daily Herald" Modern Homes Exhibition.

HOUSING exhibitions were an annual feature of pre-war London, especially the one organised by the *Daily Mail*, which drew thousands of visitors from all over the British Isles—for everyone takes an interest in the home and the latest ideas for making life there more comfortable and housework easier and more congenial.

The outbreak of hostilities brought to a sudden stop exhibitions of every kind, but since the war has been won many smaller exhibitions have been held in different parts of the country in which housing and town planning have figured prominently. The Exhibitions Department of the *Daily Herald*, however, is the first organisation to stage exhibitions in London dealing purely with post-war homes and housing equipment.

Their first venture—the *Daily Herald* Post-war Homes Exhibition, held at Dorland Hall, in the spring and summer of 1945—was, perforce, something in the nature of a forecast, but it was popular, and encouraged the department to proceed with this year's effort —the *Daily Herald* Modern Homes Exhibition.

Opened on March 26th at the Dorland Hall in Lower Regent Street by the Minister of Health (the Rt. Hon. Aneurin Bevan) the Modern Homes Exhibition has, in the two months of its duration, attracted enormous crowds. By means of the exhibits of the Ministry of Health, Ministry of Supply, the Board of Trade and the London County Council the story of a *planned* attack on the housing shortage has been told.

Six Model Houses

For instance, the six models in the Hall of Houses (which the visitor first entered) aimed to give as wide a picture as is possible of the type of homes which local authorities are building in different parts of Britain. Four of them (the Braithwaite, the Orlit, the Airey and the Type A.1) were of the permanent prefabricated kind, while the remaining two (the L.C.C. house and the Lane Fox) were of the traditional brick design.

As the visitor walked on he or she saw full-size kitchens for solid fuel, electricity and gas, pottery, china, the latest plans for Utility furniture and fabrics, while the "Quiz" kitchen and "Make do and mend" display were particularly useful to young people about to set up a home. One section

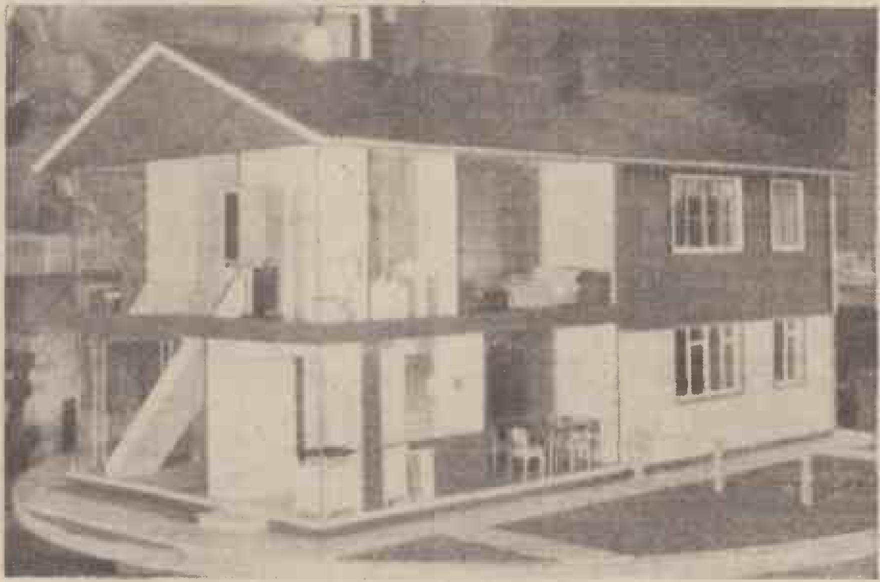


Fig. 2.—The B.I.S.F. house of British Iron and Steel Federation. One inch to the foot model by Bassett-Lowke, Ltd.

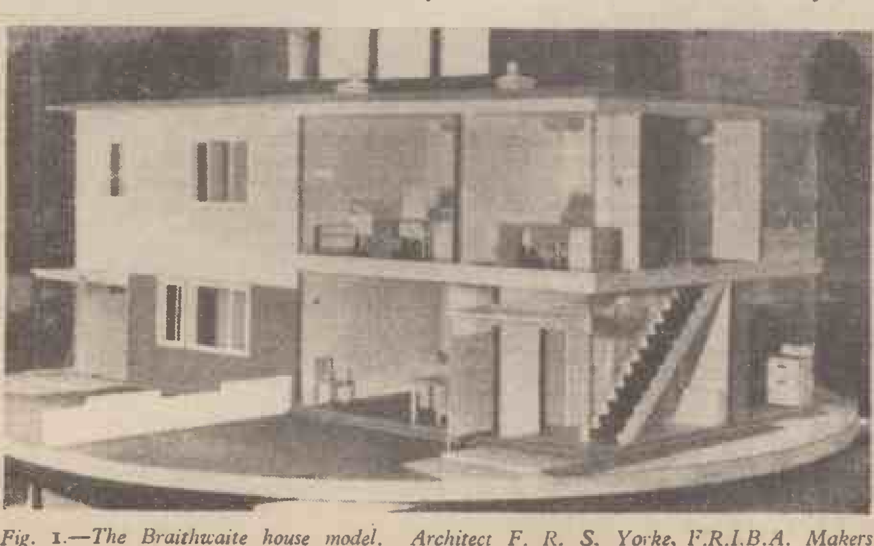


Fig. 1.—The Braithwaite house model. Architect F. R. S. Yorke, F.R.I.B.A. Makers Braithwaite & Co. (Engineers), Ltd., London.

of the first floor dealt with aluminium in the home, from Basildon New Period furniture, in impressed aluminium finished with a delicately tinted plastic, to the domestic utensils more usually associated with this serviceable metal. A particularly interesting item on the ground floor was the "A.S.U." house engine. All-purpose service is no misnomer for the unit, for it contained the entire mechanical and service equipment for an up-to-date five- to seven-room house. Its single coal-electric heat unit warms the rooms, cooks, and supplies ample hot water for at least six persons.

The six housing models certainly comprised the most attractive section of the exhibition from the model-maker's point of view. Each type was represented firstly by a perspective diorama showing the house in its external surroundings—how it would appear erected on a normal housing estate. Alongside, the true-to-scale model of one pair of houses revolved slowly on a 5ft. diameter turntable, so that the onlooker could see every aspect of the dwelling.

Fig. 3.—The Lane Fox house of Lane Fox & Co., Ltd.—a permanent brick-built type. Model, one inch to the foot.

Each model was so constructed that one of the houses showed all external detail, and was finished to indicate the material of which it was built, that is brick, concrete or steel. The second house, with transparent walls, showed all interior detail, including suggested colour schemes for the walls and the type of furnishing planned.

Our illustrations show close-ups of four of the models exhibited. The furnishing and colour schemes of the Braithwaite house (Fig. 1) were under the able direction of Mr. F. R. S. Yorke. The whole project was carried out with panelled walls in delicate pastel shades with furniture in light sycamore. The restrained use of chromium-plated bedsteads blended well with the general design, and the kitchen contained modern fitments and appliances.

Mr. Bronek Katz was responsible for the fitting out of the model Type A.1 house of British Iron and Steel Federation (Fig. 2) and his suggestions for modern furnishings of various designs were followed faithfully. The furniture was of mahogany and sycamore.

Steel Exterior

The finishing of the steel exterior of this house was very attractive, with a porch finished in different colours: The architect of the prototype is Mr. Frederick Gibberd, F.R.I.B.A., A.M.T.P.I., and this particular experimental Type "A" house has been thoroughly tested by scientific research bodies and proved to be warmer, drier and quieter than houses of conventional construction.

The Lane Fox house (Fig. 3), a traditionally brick-built type, appears (in model form, of course!) exactly as a number now being erected for the Borough of Sunderland. In this type the newer forms of Utility furniture were used in all rooms, and the pleasing layout of the house will, I think, do much to dispel the idea that this method of furnishing is only a wartime expedient.

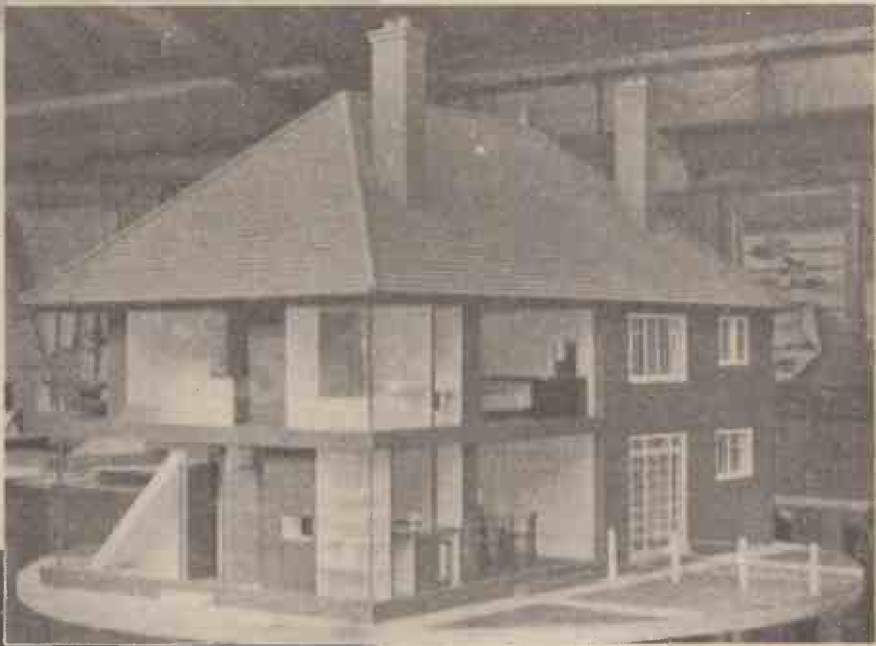


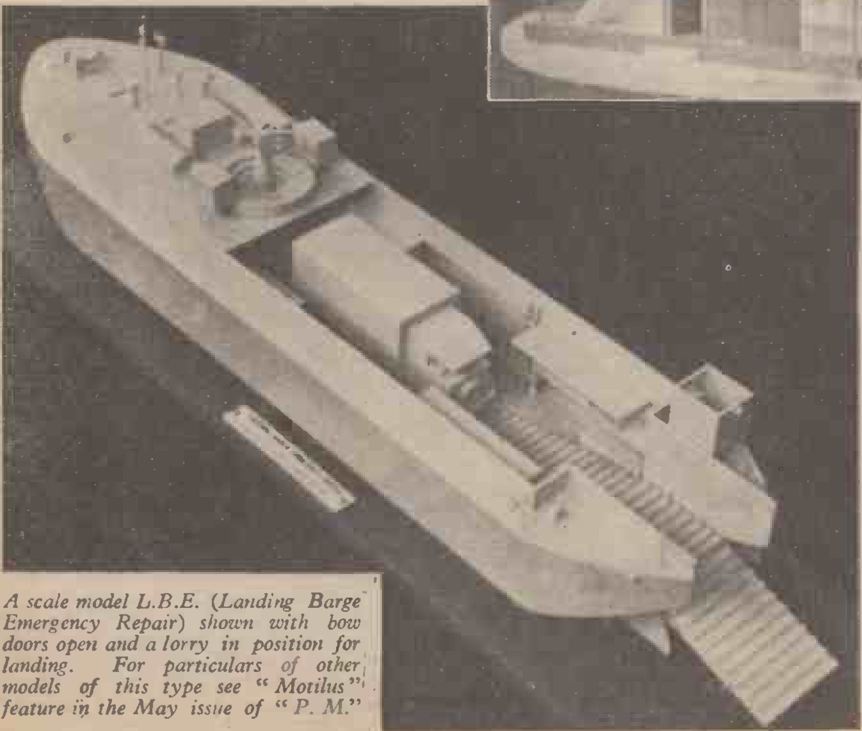
Fig. 4.—A model of one of the L.C.C. post-war housing types. It is the P.5, suitable for the larger family.

Carried out in light oak and mahogany, the appearance of the furniture was clean-cut and homely.

Last to be described is the L.C.C. dwelling, also built in brick, with a hip tiled roof, which definitely improves the look of the house (Fig. 4). The house type modelled is the P.5, one of the L.C.C. post-war designs catering for the larger family, and the furniture scheme makes use of pre-war as well as Utility items, which merge well together in the main design. Houses of this type will comprise 15 per cent. of the Loughton and Hainault communities.

Interior Fitments

All the true-to-scale pairs of houses were made to the same scale of 1in. to the foot, which allows the model craftsman to show quite fine detail in the interior fitments. Such small accessories as books, clocks, pots of bulbs—even the *Radio Times*—were there in miniature, while the bedspreads and cushions gave the rooms a look of "home"!



A scale model L.B.E. (Landing Barge Emergency Repair) shown with bow doors open and a lorry in position for landing. For particulars of other models of this type see "Motilus" feature in the May issue of "P. M."

Inventions of Interest

By "Dynamo"

Aircraft Security

ACCIDENTS will happen in the best regulated transport on terra-firma. When man ascends to the empyrean, he expects the chance of catastrophe to increase. But, in spite of this likelihood, crashes are rarer than one's anticipation has forecast.

There has hove in sight an invention designed to improve protective means for aircraft. This is especially concerned with a method for functioning automatically in the emergency of a crash landing. The chief danger in such an event is, of course, fire. For instance, contact between inflammable substances and the heated parts of smashed engines affords a very considerable fire risk.

The originator of the improvements in question, reviewing previous fire-fighting equipment, mentions that such equipment has been installed at various points on 'planes and under both manual and automatic control. For example, by operating an appropriate switch, the pilot has been enabled to bring into action an extinguisher at any one of the engine stations which may happen to be involved, or likely to be involved, in a fire.

In addition, an automatic switch worked by an inertia device has been supplied. By this means, upon the occurrence of a crash landing, the inertia device was projected forcibly and operated the switch. This closed the circuit of the fire-fighting or extinguishing means at all points. As a consequence, all the fire-fighting devices were simultaneously put into action.

Fighting the Flames

THE inventor avers that an inertia-operated switch requires to be set with caution, because it must not be brought into action, for example, by a bumpy landing or ordinary shocks incidental to rough flights or aerobatics.

With such a setting it is possible that, in the case of a "pancake" or shockless landing on soft earth, the switch may fail to be operated. In such a contingency and, if the automatic switch be not operated and the pilot is injured, there is a grave risk that a fire may break out and get a rapid hold on the aircraft.

The main object of the improvements is to provide a reliable automatic safety device and one irrespective of the character of the landing.

According to this invention there is furnished a crash detector comprising an outer electrode, such as a coil electrode. There is also an inner electrode such as a straight red electrode, surrounded by the outer electrode. A frangible enclosure normally protects the electrodes. This enclosure is so devised that, in the case of a crash, it will break and cause or permit contact between the electrodes.

On any aeroplane there would ordinarily be a number of these detectors fitted at different points, for instance, at the nose of the fuselage and at suitable points on the wings or at engine stations. Bombers would have a large number of detectors fitted and distributed, so that all vulnerable points would be covered.

Ear-stalking

A THRESHING machine has been devised which may interest the Minister of Agriculture. Its characteristic is the fact that it threshes out the grain from the ear before the stalk is cut from the ground.

The machine comprises a carriage upon which one or more pairs of beater members are rotatably mounted. These are arranged to provide a gap between them for the reception of the ears of grain. There are gathering members projecting forwardly of the beater members so as to provide a tapering space. The stalks of the crop are gathered together and guided into the space between the beater members. Means are supplied for rotating these members. As a consequence, those parts which first engage the crop are moved upwardly. And a casing surrounding the beater members is arranged to catch the grain separated from the ears.

Ever-ready Tea

A TEA infuser, which has emanated from the brain of a Pole, has been submitted to the British Patent Office.

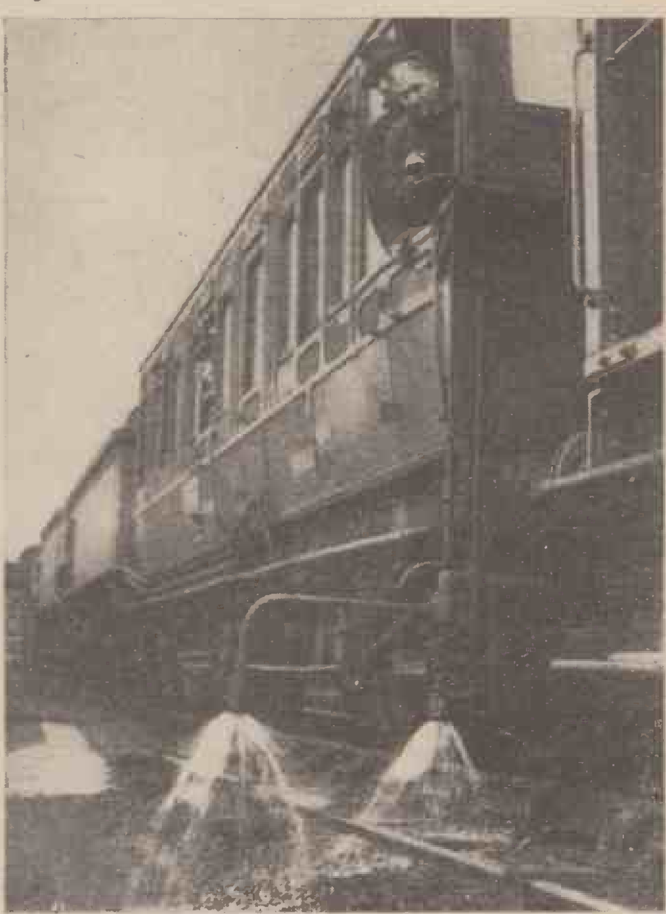
The principal aim of this device is to furnish an apparatus whereby tea of excellent quality may be prepared readily in large quantities and maintained in good condition during a long period of time.

It is asserted that this infuser would be advantageous for use in restaurants and milk bars. But the inventor affirms that its principle is equally applicable in the case of the ordinary domestic household. And he adds that a small sized apparatus would provide the equivalent of freshly made tea on tap throughout the day.

The new tea infuser comprises an inner vessel having an aperture in the bottom open to a pipe extending above the contemplated level of the tea. There is a second pipe enclosing the first pipe and sealed at the upper end and provided with perforations at the lower end.

A removable perforated container for the tea encircles the pipes and rests on the bottom of the inner vessel. In addition, a closed outer vessel is arranged to enclose the inner vessel and to contain water and means for heating the same.

The information on this page is specially supplied to "Practical Mechanics" by Messrs. Hughes & Young, Patent Agents, of 7, Stone Buildings, Lincoln's Inn, London, W.C.2, who will be pleased to send free to readers mentioning this paper a copy of their handbook, "How to Patent an Invention."



The L.M.S. Railway is now using a special "weed-killer" train for spraying a trail of poison along the entire L.M.S. system from Wick to Shoeburyness, and across Britain to Holyhead. The "weed-killer" train sprays on an average 70 miles of track a day. If left unattended, many of the tracks would become covered with weeds, but these are eliminated by the poison spray. The illustration shows the spray train in action in the Midlands.

Folding Vehicle

A COLLAPSIBLE vehicle is the subject of an application for a patent in this country.

To collapse the vehicle it is not necessary to detach individual parts and to keep them separately. Also the individual parts do not require to be loosened.

By this means, due to the inter-engagement of all parts, the frames and any wheels mounted on these frames remain parallel to each other and also parallel to a vertical plane passing through the pivots of the pairs of cross-members in any relative position of the load-supporting surfaces. Consequently, the vehicle occupies a very small space.

An advantage of particular importance is derived from the fact that, by means of one manipulation, the vehicle can be adapted to a variety of uses either as a sledge or as a wheeled vehicle, for pulling or for pushing, as a trailer, or as a litter, by adjusting the load-supporting surface in the manner required.

Parachute Harness

THE parachute is destined to play an important part in the future conquest of the air.

Harness has been designed which it is maintained surpasses that in use up to the present time.

The new equipment comprises an adjustable belt or girdle characterised by the fact that the movable end of the belt can be folded, turned under itself and fixed in a variety of positions of adjustment with the aid of means operable from the exterior.

Letters from Readers

Cutting Glazed Tiles

SIR,—Regarding your reply, *re* cutting glazed tiles, in the Queries and Enquiries section of the May issue of PRACTICAL MECHANICS, I have had experience in cutting a number of these tiles with complete success with an ordinary wheel glass cutter, and the information may be of interest to other readers.

A line is scored on the glazed side of the tile in exactly the same way as would be done on a piece of glass, and then, with the tile resting on a table or bench, with the scored line over the edge, a firm downwards pressure will break the tile quite cleanly. I found that less pressure seemed required if the tile was first soaked in water. Curves are easily worked by means of a pair of ordinary flat-nosed pliers, the tile being nibbled away a little at a time by gripping with the tip of the pliers.—J. RABE (Harrow).

SIR—In the May issue of PRACTICAL MECHANICS I note a request for an easy way in which to cut tiles.

The use of a carborundum tipped saw is excellent when it comes to circular cuts, but during any tile laying I have done straight cuts lead by a big majority, and I find there is nothing to beat an ordinary glass cutter (an old one will do). Simply mark the surface of the tile, as you would a piece of glass, and give a smart tap on the underside with a strip of wood, hammer shaft, etc. This will give a clean break which seldom requires dressing.—J. T. PRIOR (Motherwell).

Hand-cleansers

SIR,—In the February issue of PRACTICAL MECHANICS we note you refer to our hand-cleanser under the Queries and Enquiries section. Actually, you give a composition and then refer to our product as being of a similar type: I would like to make it clear that the composition quoted is nothing like our product.—A. C. PEPPER (for Alexander Duckham and Co., Ltd.).

Vitreosil Muffle Furnace

SIR,—In reference to the answer given to a correspondent in your May issue, in which you recommend the use of a Vitreosil muffle for the construction of an electric furnace to operate at 1,000 deg. C., may we mention that we also manufacture fused alumnia cement C60, which is recommended for securing and insulating the nickel-chromium alloy heating elements on Vitreosil furnaces, and it is applied according to the directions given in the data sheet given below.

Refractory Cement No. "C" 40, coarse;
"C" 60, fine.

The cement is suitable for securing and covering base metal electric heating elements on Vitreosil or similar apparatus. Temperature at which the cement hardens is approximately 1,000 deg. C., and can be used successfully up to a temperature of 1,600 deg C.

1. The cement should be mixed to stiff mud consistency and then applied with a small paint brush to the previously wetted surface. We have found that painting the cement on in this manner is better than using a spatula or small trowel; with a brush the cement can be dabbed into any crevices below the resistor, e.g., where the resistor is passing over a surface concavity.

2. The cement should be thoroughly dried out before the resistor is made hot. This can be done by passing a low alternating current through the resistor, provided the current is sufficiently low to ensure that the resistor merely becomes warm. Direct current should not be used, because the electrical endosmose effect occurs, resulting in most of the water being driven to the negative end of the winding. This makes the cement sloppy at that end, and there is also the objection that any products of electrolysis will tend to collect there, with the possibility of future failure of the winding in that area.

3. One pound of number 40 and number 60 material has a coverage of 40 sq. in. for a layer thickness of 3/16in.

4. Depending on the thickness of the wire or ribbon the layer thickness can be reduced for plain tubes because in such cases the resistor can be brought into close contact with the tube. For muffles, however, the layer thickness will usually have to be increased in parts, because the "flat" surfaces of muffles are generally viewed from the outside, and the taut resistor stands off these surfaces, thus requiring a greater thickness of cement for adequate covering.—G. E. STEPHENSON (The Thermal Syndicate, Ltd., Wallsend).

Ethyl Silicate

SIR,—We were interested to read the inquiry concerning ethyl silicate from Mr. W. A. Munro, of Beddington, and your reply which appeared in the May issue of your journal.

In addition to the uses which you mention, we suggest that it might be of interest to your readers to know that the main use for ethyl silicate at the present time is as a binder in the preparation of moulds for precision castings by what is known as the Lost Wax, or Investment Moulding Process. This process is particularly useful for obtaining accurate castings with an excellent finish from special alloys which will withstand high temperatures, and are difficult to machine.

We should also like to comment on the price which is quoted in your reply: in 1 gallon lots the price is 40s. per gallon, i.e., about 4s. per lb. The prices for smaller quantities are naturally somewhat higher, but if larger quantities are bought it is, of course, possible to quote a lower price.—K. PIERCY (for Albright and Wilson, Ltd., Park Lane, London, W.1).

Is Manual Flight Possible?

SIR,—In answer to Mr. J. Stephenson's letter (PRACTICAL MECHANICS, June, 1946). Yes. I think I can say I have a fair knowledge of modern gliders, and I fancy they are rather like the modern motor-cycle, somewhat over-developed. These are simply motor-cars on two wheels. To my mind the autocycle is the true motor-cycle. It conveys its passenger to his or her destination at a reasonable speed.

To have a framework of wood and linen weighing 300lb. to carry a passenger weighing 140lb. is not a compliment to modern intelligence and design. I have no doubt that it would be possible to put a small engine in such an aircraft, and then it becomes—what? A light aeroplane!

A look round the aeronautical section at the Kensington Science Museum shows how light gliders could be made. I think the original Lilienthal glider (the monoplane) weighed 8¾lb. (it's a long time ago since I read of his experiments, so I may be wrong).

The trend right throughout the history of aviation is to increase size and H.P. Therefore, the everlasting cycle has been set up. Proof of this is right before us. More size, therefore weight, so more H.P., *or* more speed, more H.P., so more weight.

I think, if the matter were taken in hand by a large firm, such a machine as I have in mind would not weigh more than 15-20lb. and cost about £25. After a little while I think that that figure could be reduced considerably.—"ORNITHOPTERIST" (West Kensington).

Model Engineer Exhibition

THE Twenty-first Model Engineer Exhibition, directed by Messrs. Percival Marshall & Co., Ltd., the Society of Model and Experimental Engineers, and the Society of Model Aeronautical Engineers, will be held at the New Royal Horticultural Hall, Vincent Square, Westminster, London, S.W.1, from August 22nd to August 31st, 1946. Among the interesting things to be seen at the show will be a Passenger-carrying Track, Aircraft in Flight, Working Models of all types and Club and Trade Stands.

There will also be a fine display of all kinds of Engineering Models, including Locomotives, Rolling Stock and Railway Accessories, Ship Models, Power Boats, I.C. Engines, and all types of Aircraft.

We shall be there.

Our Cover Subject

THE illustration on the front cover this month gives a general view of the Gladstone Docks, Liverpool, showing locomotives being loaded on to the *Empire Wallace*. Thirty British-made locomotives and tenders, each weighing a total of 104 tons, were recently loaded on this ship. The engines were part of an order of 120 for Yugoslavia, and were being shipped to Trieste under the auspices of UNRRA. The cost of each of the engines and tenders is approximately £16,000, and they were all made at the Vulcan Foundry, Newton-le-Willows.

ATOMIC POWER

(*Continued from page* 363)

up of oil wells or the extraction of all the coal. That is not likely to happen in our or our grandchildren's generation so there is time enough for the scientists to develop an atomic furnace. Where the great use of an atomic furnace might be found would be in parts of the world which are particularly difficult of aceess but where, if power were available, mineral wealth would be developed. As an example, suppose in the centre of Australia a most valuable mineral deposit of some kind were found, it is conceivable that by the erection of an atomic furnace there electricity, steam and other sources of power could be supplied through the heat given off from the atomic furnace. The mineral could then be readily procured whereas, at the present time, the cost of conveyance of fuel to the area might make the procurement of the mineral an impossibility.

Let us remember, therefore, that domestic refrigerators and carpet sweepers are not likely in our time, or in any time, to derive their energy from the splitting of the atom in our domestic abodes. If the energy given off by this physical change in the structure of the atom is harnessed at all, its use is likely to be only in immense power stations serving the whole country.

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.

Glazes for Pottery

CAN you please give me a formula for a glaze for home-made pottery, together with baking instructions? A blue and a brown glaze are desired. Also, can you recommend any book on home pottery making?—G. W. Kerr (Newton Abbot).

GLAZES are usually formulated with (a) a ground glaze and (b) a colouring agent, the complete glaze being made by mixing together 6 parts of ground (or white) glaze and 1 part of colouring agent. A formula for the ground or white glaze is the following:

White lead, 13 parts.
Feldspar, 20 parts.
Zinc oxide, 3 parts
Plaster of paris, 1 part.
Flint glass, 13 parts.
China clay, 3 parts.
Paris white, 1 part.

The following formula is for a blue colouring agent:

Aluminium oxide, 20 parts.
Zinc oxide, 8 parts.
Cobalt oxide, 4 parts.

whilst the formula below gives a brown colouring agent:

Iron chromate, 30 parts.
Manganese dioxide, 20 parts.
Zinc oxide, 12 parts
Tin oxide, 4 parts.

All these glaze preparations should be ground to the utmost degree of fineness and fired at about 1,200 degs. C., this temperature being attained gradually. Slow cooling after firing is also advised in order to avoid "crazing" of the glaze.

We think the following books should appeal to you if you can still obtain them through a good bookseller such as, for instance, Messrs. W. & G. Foyle, Ltd., Charing Cross Road, London, W.C.2. In each case, the pre-war price is indicated after the title of the work.

C. F. Binns: The Potter's Craft. A Practical Guide for the Studio and the Workshop (14s. 6d.).
H. & D. Wren: Handcraft Pottery for Workshop and School (12s. 6d.).
Noke and Plant: Pottery (3s.).
C. F. Binns: Manual of Practical Potting (17s. 6d.).

Induction-type Motor

I HAVE purchased a small electric motor, ¼ h.p., 220-230v. 1-phase, 50 cycle, 1,420 r.p.m. When I connect it direct to a plug, however, I find it starts with a severe jerk and sparking. Does this mean that I require a starter and, if so, could you please tell me if it is possible to make one?—A. Young (Glasgow).

APPARENTLY your machine is an induction-type of motor, and has no commutator. Such motors are usually started by switching them direct on to the full line voltage and, provided the motor does not overheat when running, we do not consider that a starter should be necessary. At the same time, the starting current of such motors is often rather high, and it would be an advantage to connect the motor to the mains through a double-pole switch, or even a single-pole tumbler switch, rather than by simply inserting the plug. We are not quite clear whether the sparking occurs at the plug or in the motor. In the latter case it is probably due to the operation of a centrifugal switch in switching out the starting winding—quite a usual feature.

Duplicator Ink

CAN you furnish me with the formula for making duplicator ink (Gestetner-type machine), and method of preparation?—J. M. Wormald (Brighton).

DUPLICATOR and stamp pad inks are all made up on an aniline dye basis, such as:

Aniline dye	3 parts.
Water	10 "
Rectified spirit	15 "
Glycerine	70 "

Mix the water and the glycerine. Dissolve the dye in the spirit and then add the resulting solution to the water-glycerine mixture. Any kind of spirit-soluble dye may be used. Examples are: Methylene Blue, Clayton Yellow, Eosin, Fast Acid Scarlet, Brilliant Green, Bismarck Green, Methyl Violet, Alkali Blue, Spirit Black.

To test the ink, spread it on a piece of cloth and apply a clean rubber stamp to the ink-saturated cloth. When the impression of the inked rubber stamp is transferred to smooth paper the impression should be clear and distinct. If the colour runs at the edges, there is too much glycerine in the ink; if the impression is too weak the ink is probably too thick, and should be diluted with more glycerine or glycerine-water mixture. The actual intensity of the colour may, of course, be controlled by increasing or decreasing the strength of the dye solution.

Electric Soldering Iron; Choking Coil

(1) Can you supply me with particulars of winding, etc., to be used for making a 40-watt electric soldering iron for small household jobs? It would be operated from the domestic mains, viz. 200-250 volts A.C., single phase, 50 cycles.

(2) I desire to make a choking coil to operate from the same mains, in conjunction with a heating element of 500 watts.

Would you please forward particulars of winding, insulation, dimensions and type of iron to be used for the adjustable core?—W. H. Grieve (Newcastle-on-Tyne).

(1) For the heating element of the soldering iron you could use 10ft. 6in. of 46 s.w.g. Brightray resistance wire, as supplied by Messrs. Henry Wiggin & Co., Ltd., of Grosvenor House, Park Lane, W.1.

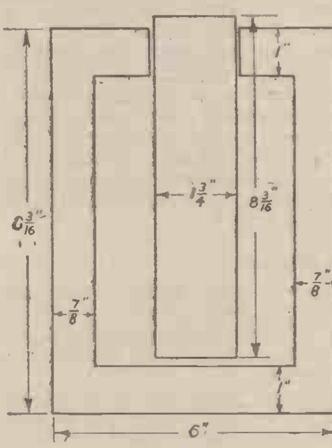


Diagram of a choking coil for operation on 200-250 volts A.C. (W. H. Grieve).

The wire could be wound on a mica-covered rod, the wound coil being surrounded with a thin layer of mica; the whole being made a good fit in the copper bit.

(2) The core of the choke coil could be built of Stalloy stampings about 0.014in. thick to the dimensions given in the diagram. The laminations should be lightly insulated on one side and riveted together. The centre limb or plunger should be arranged to slide in an insulated former, the latter being wound with 800 turns of 16 s.w.g. enamelled wire with a thin layer of paper between each of the wire layers.

Canvas Dressing

HAVING purchased a canvas-covered canoe, could you please advise me on the best rubber paint for the rubberised canvas skin, or any other good preservative?—D. Richards (Seaton).

YOU can give the canvas a dressing on its outer side with a solution of 1 part of medium-hard bitumen dissolved in 8 parts of solvent naptha, paraffin or petrol, but you would, we think, be better advised to apply a good bituminous paint such as that manufactured by the Wailes Dove Bitumastic, Ltd., Collingwood Buildings, Newcastle-on-Tyne. This paint can be had in a variety of colours in addition to black.

You can, also, we believe, obtain similar preparations from Durastic Bituminous Products, Ltd., 23, College Hill, London, E.C.4, but we are unable to say whether these preparations are obtainable in small quantities.

"Terrazzo" Floors

WILL you please inform me what mixture is used for terrazzo floors? Also, where can I buy moulding sand for metal castings of copper and aluminium, and their alloys?—J. M. Reilly (Port Talbot).

THE term "terrazzo" is given to numerous types of floors, some of which should definitely not be included under this category. Usually, the type of floor to which you refer consists of coloured mineral fragments embedded in a softer matrix or medium such as asphalt mastic, cement or some plastic composition. After laying, the surface is usually subjected to some grinding process whereby the mineral fragments are laid bare and exhibit a decorative appearance. Anything of a coloured mineral nature can be used for the terrazzo pieces. Coloured rock fragments, coloured grits, brick fragments, coloured cement chippings, all these and similar materials can be used.

Moulding sands can be obtained from Messrs. H. Pritchard & Sons, Ltd., 40, New Road, South Lambeth, London, S.W.8, or from Messrs. J. E. Garbett & Co., Ltd., 39, Union Passage, Birmingham.

Rewinding Field Coils of Gramo. Motor

I HAVE a Collaro induction gramo. motor, 200-260 volts, 25-40 cycles. I have unwound one of the four field coils, and it consists of 940 turns 34 s.w.g. enamelled wire.

I wish to rewind coils for 200-240 v., 50 cycles. What are the alterations necessary to do this, please?—W. Pennell (Bridgend).

THE speed of an induction motor depends on the number of poles for which the stator is wound and on the frequency of the supply. Speed being practically proportional to the supply frequency divided by the number of stator poles. We suggest each field pole be wound with 750 turns of 32 s.w.g. enamelled wire. The speed of the motor will be increased with the increase of frequency.

Cementing Optical Glass

I WISH to cement two or more pieces of optical glass together and leave them clear and free from any optical distortion. Can you please give me the formula for the cement used for this purpose? Can you also tell me if the preparation would be suitable for cementing tinted gelatine between glass? I require this information in order to try to make some photographic colour filters.—A. Wood (Hull).

CANADA balsam is the material which is used professionally for cementing glass and other materials. It is a colourless, transparent resin which is (with some difficulty) soluble in benzene, xylene, chloroform and other liquids. It can be purchased ready made up in solution form, and we would advise you to purchase it in this state rather than in its dry, undissolved condition. You can obtain small amounts of Canada balsam dissolved either in chloroform or xylene from Messrs. Flatters and Garnet, Ltd., Oxford Road, Manchester, 13, or from any laboratory furnishing supply house. Either of these solutions is satisfactory for cementing optical glass.

The procedure is to "wet" each contacting surface thoroughly with the balsam solution and then to bring them into firm contact, taking very great care to exclude dust and air bubbles. No attempt must be made to dry the balsam cement by means of heat. On the contrary, the glass work must be light clipped and then put away in a room of normal temperature for about a month, after which time the balsam will have set hard and will be perfectly transparent.

If anything goes wrong with the working of the process, drop the entire work into a bath of benzene or xylene. This will dissolve away the balsam, and the work, after cleaning, will then be ready for restarting.

Canada balsam solutions are perfectly suitable for cementing gelatine films between glass. In fact, this is the professional mode of cementing, but the working details are kept more or less secret.

Resistance Welding

I INTEND shortly to start manufacturing cabinets, glass houses and furniture from steel angles, flats and T-bars. I know how to weld by arc, but I think resistance welding would be more suitable for the light steel I intend using.

Could you give me the following particulars, please ?
Voltage for resistance welding whether A.C. or D.C. and where I could get a welding machine suitable for the proposed work. Would you recommend a book on welding, resistance or otherwise ? The current available is 230 volts A.C. —P. Daly (Glasgow).

ALTERNATING current is usually employed for resistance welding, this being obtained through the medium of a step-down transformer which is normally built into the welder. A very high current is required for spot welding, usually between 100,000 and 200,000 amps per square inch. For steel up to 16 s.w.g. tips of about 3/16in. diameter could be employed, with ¼in. tips for metal of 10 s.w.g. up to ¼in. thick. Thus for sheets or strips up to 3/16in. thick a current of 2,500 to 5,000 amps could be used; with 5,000 to 10,000 amps for ¼in. sheet or strip.

The secondary voltage required from the transformer will depend very largely on the length of arms carrying the welding tips, which again will be determined by the nature of the work undertaken. The actual voltage needed across the weld would probably be 3 to 4 volts at the most, but to allow for the length of the arms we would suggest a welder of about 10 kW. for 16 s.w.g. metal, 20 kW. for 3/16in. metal, and 30 kW. for ¼in. metal.

Electric resistance welders are manufactured by British Insulated Cables, Ltd., of Prescot, Lancs; The Atlas Engineering Co., Ltd., of 3, St. James's Square, London, S.W.1; British Federal Welder and Machine Co., Ltd., of Dudley, Worcs.

The books "Welding and Metal Cutting" (7/6) and "The Welding Engineers' Pocket Book" (6/-) (George Newnes, Ltd.), would no doubt be helpful to you.

Colouring Lantern Slides

COULD you inform me how to paint lantern slides the same way as the M.O.I. slides, the whites of which are so clear ? Also, is there any book on the subject ?—S. Taylor (Rossendale).

LANTERN slides are hand-coloured in several ways. The modern method is to use concentrated solutions of aniline dyes in spirit, using very little of the dye solution and working with a fine brush.

The older method is to employ oil colours, using the special oil medium supplied with them. A third method (particularly for painting designs on to plain glass) is to employ dyed celluloid solutions. All these materials and requisites can be obtained from either Messrs. Flatters and Garnet, Ltd., Oxford Road, Manchester, 13, or Messrs. J. Chapman, Ltd., Albert Square, Manchester.

There are no special books on the colouring of lantern slides, although this subject is generally treated in photographic dictionaries and general textbooks, a list of which you will be able to obtain on application to Messrs. Wallace Heaton, Ltd., New Bond Street, London, W.1.

"The Book of the Lantern," by T. C. Hepworth, a work which has long been out of print, but which may be obtained second-hand (inquire of Messrs. W. and G. Foyle, Ltd., Charing Cross Road, London, W.C.2), contains a great deal of practical information on the colouring of lantern slides.

Waterproofing Fabric

PLEASE inform me of a home method of waterproofing linen or cotton cloth which would give a finish suitable for wearing apparel, for example, cycling cape or leggings.—A. E. Trimen (Belfast).

IT is a very difficult task to make a good job of waterproofing fabric for wearing purposes, particularly when a trade finish is desired. Indeed, many of the trade fabrics are produced by secret processes which cannot be imitated.

However, the waterproofing process which you require is the following, which method, however, we give you without any guarantee of its success:

Choose, if possible, unbleached calico for the basic fabric and rub well into this a mixture of 10 parts (by volume) raw linseed oil and 1 or 1½ parts of liquid drier. A little yellow ochre mixed with the oil will produce the familiar yellow colour of many waterproofed fabrics, but, of course, any other pigment can be used for colouring purposes.

Some recipes recommend that various proportions of soap jelly and of beeswax should be incorporated with the oil, but it is best to eschew such materials.

Lay the oil on the fabric sparingly and hang the material up in a warm room to dry. When dry, give it another coating, and proceed in this manner three or four times. At the last coating a little beeswax may be added to the mixture and the fabric should be run through rollers.

The material takes about a fortnight to dry out after each application of oil. It is highly important that this drying should be most thorough, otherwise the greater the number of successive oil-dressings the stickier the fabric will become. The whole process, indeed, under home working conditions at least, is one which calls for much time and patience, and even then professional results are seldom obtained. That is why all such methods seldom give any real satisfaction, although, of course, they may be perfectly efficient for the effective waterproofing of rough fabrics which are not intended for the purpose of being employed for wearing apparel.

Sand and Cement Tiles

I WISH to make some red sand and cement roof tiles. Could you tell me the mixing proportions of sand, cement and colouring; the name of the colouring; and also where the same can be obtained ?—A. G. Musselwhite (Dagenham).

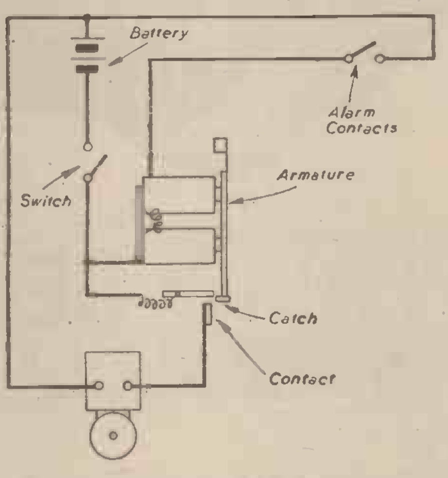
USE a "mix" comprising 1 part of Portland cement, 3 parts of sand and 1 part of red oxide.

The red oxide is merely a nature oxide of iron and it can be obtained normally from most large paint stores and colour merchants. At the present time, however, this particular colour is in short supply and big demand. Hence it is very difficult to obtain, particularly by those outside the "trade." The Golden Valley Oxide & Colour Co., Ltd., Wick, Bristol, and also, British Colour & Mining, Ltd., Coleford, Gloucestershire, are both manufacturers of red oxides, but it is very doubtful whether you would be able to obtain such material from them in relatively small quantities.

Burglar Alarm

I SHALL be obliged if you will give me particulars of a simple form of closed circuit burglar alarm. I do not wish to incur much expense in obtaining relays, etc., and it is also essential that the current consumed shall be as small as possible. It is also important, of course, that once the circuit is broken, reclosing it will not stop the alarm.—J. Matham (London, S.E.).

WE suggest you construct a small relay from the electromagnet of an ordinary trembler bell. Each coil could be wound as full as possible of 36 s.w.g. enamelled wire and connected in series with a battery, switch, and the alarm contacts. It may be necessary to mount the armature on a lighter spring than normal. The armature should have a small stud or catch fitted at the end as shown in the diagram. A brass contact strip about ¼in. by ¼in. by 1in. long with a light flexible lead could be hinged to rest against the armature stud. The relay is set by raising the brass contact strip and pushing the armature to the poles. Should the primary circuit be interrupted the armature will be released and the contact strip will fall by gravity, this being arranged to make contact with the fixed contact to complete the secondary bell circuit.



Circuit diagram for a simple burglar alarm (J. Matham).

Ignition Coil Details

COULD you please explain the principle of the ignition coil as fitted to most modern cars ?
I know that there is a primary and secondary winding and a soft iron core, and by making and breaking the primary circuit a high tension voltage is induced with a drop in amperage.
What I wish to know is how the high tension voltage is induced into the secondary winding.—P. Hudson (Bawtry).

AS you may be aware the primary coil wound round the iron core is fed from the battery through the contact breaker. As a result the core is magnetised during the period that the contacts are closed, the primary and core then acting in the same way as an electromagnet. In a given core the strength of magnetism will be proportional to the number of ampere turns in the primary coil. This coil is wound with a comparatively small number of turns of fairly heavy wire, so that an appreciable current passes through the coil. When the contacts open at the predetermined times, as governed by the position of the pistons in the engine cylinders, the primary circuit is interrupted and the current cut off, so the core magnetism then falls to zero.

It is a fundamental fact that a voltage is induced in any circuit which is linked with a changing magnetic flux. The value of the induced voltage is proportional to the number of turns of conductor linked with the changing flux, and to the rate at which the flux changes. The direction or polarity of the induced voltage depends on whether the magnetic flux is increasing or decreasing. This principle is applied in a dynamo in which the field windings create a practically constant magnetic flux through which the armature coils are rotated. Thus the strength of flux linked with each armature coil varies and is reversed, as the coil rotates on its axis.

In an ignition coil the changing magnetic flux induces a voltage in the primary coil, but this is a secondary consideration so far as ignition is concerned. The secondary coil, which is also wound on the core, is subject to the changing magnetic flux when the contacts are opened and therefore a voltage is induced in this coil. The voltage per turn of the winding will be greater if a strong flux falls to zero in a given time than if a weaker flux falls to zero in the same time, and will be greater if the time in which a given flux falls to zero is reduced.

The primary circuit is designed to create a strong magnetic flux and to reduce this flux to zero in a very short time after the contacts open, so the voltage induced per turn is high. The secondary coil has a large number of turns so its total voltage is high. The secondary current is determined by the resistance of the secondary winding and plug gap, etc., and is low.

Mounting Micro-slide Objects

CAN you please give me any information as to proper methods for preparing and mounting specimens on microscope slides ? Also, I understand that certain things need to be "stained" to render them visible under the microscope. What are these stains and how are they applied ? Are there any books dealing with this subject ?—H. Read (Rochester).

IN order to give you all the information which you need regarding the preparation and mounting of micro-slide objects we should have to write a very substantial book on the subject! Hence, we can only hope to give you an outline reply, and advise you to study any available books on the subject.

There are very many methods of mounting microscope objects. The precise method depends upon the nature and size of the object, its thickness, the manner in which it is desired to mount it (i.e., either as a transparent or as an opaque object) and the degree of permanency which is required of the finished slide.

Generally microscope objects are mounted "transparent." For this purpose they are cut very thinly by means of a microtome, or else they are treated in certain chemical solutions to render them clear and transparent. Sometimes, also, as you mention, the preparations are dyed, either wholly or partially, in one or more different colours, ordinary aniline dyes being employed for this purpose.

Then comes the actual work of mounting and sealing up the prepared objects on the microscope slides. The preparations may be mounted "dry," being secured to the glass by means of a spit of cement, or, alternatively, they may be mounted in a preservative fluid, of which there are many different kinds. Finally, the objects are covered with a "cover glass" which has then to be "ringed" around with a sealing solution.

All this manipulative work demands great skill, a great amount of patience and much practice. That it can be acquired by anybody sufficiently interested is a definite fact, but, at your present stage, you cannot hope to mount microscope objects successfully without having acquired this necessary knowledge and practice.

Unfortunately, most of the books on microscope preparation and mounting have gone out of print. You might obtain some volumes second-hand from Messrs. W. G. Foyle, Ltd., Charing Cross Road, London, W.C.2, but, in your case, we think the better plan would be for you to write to Messrs. Flatters & Garnet, Ltd., Microscopists, Oxford Road, Manchester, 13, and request a list of available books on amateur microscope object mounting; also a list of their mounting requisites and apparatus. In this way, by dealing with specialists in the subject, you would be taking the first steps towards practical success in this very difficult yet exceedingly fascinating branch of scientific manipulative work.

Leadless Glaze

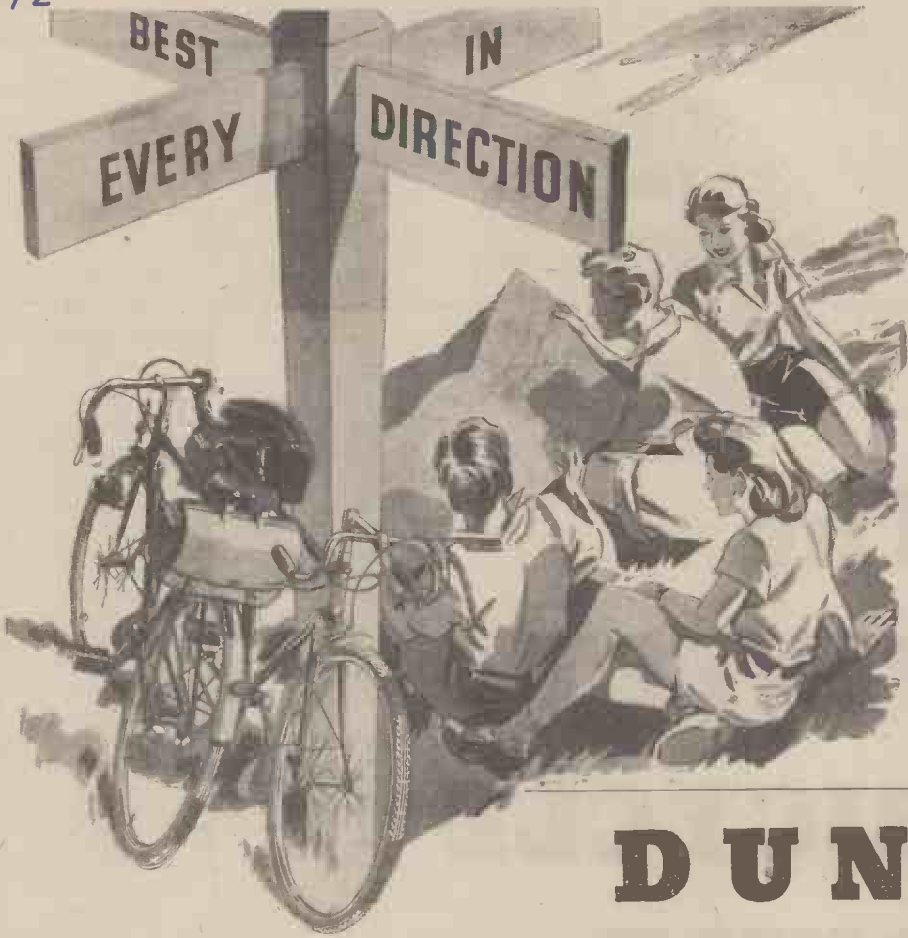
WILL you please give me some information on leadless glaze with a melting point of about 1,000 deg. centigrade, also the composition of same ?—B. Welch (Elland).

THERE is no leadless glaze which will melt satisfactorily at 1,000 deg. C. The following, however, is a fairly soft pottery glaze which will flow around 1,200 deg. C.:

(All parts by weight).

Feldspar	20 parts
Zinc oxide	4 „
Plaster of paris	1 „
Flint glass	13 „
Paris white	1¼ „
Common soda	1 „
Borax	4 „

The ingredients must be finely ground and intimately mixed before firing.



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THE Cyclist
Editor: F. J. CAMM

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Comments of the Month By F. J. C.

The Centenary Memorial

WHEN Kirkpatrick Macmillan first applied rods, cranks and pedals to the rear wheel of a boneshaker in 1839, it is true to say that he builded better than he knew. We have no doubt that he was unaware of the importance of his device. He produced a machine which he could pedal along the roads for his own amusement. It is also true to say that his invention was never of very great value in the form in which he produced it, for the bicycle as as we know it to-day differs vastly from his direct rear-driver. The chain, at that time, had not been invented and Macmillan made use of well-known principles, for there is little if anything original in driving a wheel by means of rods and cranks. Although he was the first actually to apply this mechanism to a two-wheeled vehicle the same system had been in use on beam engines and other forms of motive power for many years before Macmillan was born.

To him, therefore, really belongs the credit of first propelling a two-wheeled vehicle, then known as a boneshaker or velocipede, by a means other than that of alternately paddling the feet on the ground. It is just as well that we should set this thing in its correct perspective for there is always a tendency to ascribe great genius to people who do not fall within that category.

For many years the credit for having first applied pedals to a bicycle was accorded to one Gavin Dalzell, and it was due to the efforts of Mr. J. Johnstone of the Glasgow Cycling Club that the credit was rightly established, for Mr. Dalzell's son on April 16th, 1892, admitted in a letter to Mr. Johnstone that, as a result of the inquiries he had made into the question of the earliest inventor of the bicycle or "geared" dandy horse, he had no hesitation in frankly admitting that Kirkpatrick Macmillan made his machine long before Gavin Dalzell produced his.

Consulting our files of *English Mechanic and Mirror of Science*, for June 11th, 1869 (we notice that Mr. Gordon Irving in his book, entitled "The Devil on Wheels," merely refers the reader to the issue of that journal, dated June, 1869; the journal was a weekly not a monthly and he may care to note the exact date of the issue for his second edition), there is an illustration of "The improved Kilmarnock velocipede," which exactly resembles Macmillan's machine. It cost £7 and weighed 58lb. It was fitted with a brake, gun-metal bearings, and the connecting rods were made also to suit a long or short leg. The user could attain a speed of from 8 to 12 miles an hour.

Macmillan's machine had a 32in. front wheel, a 42½in. rear wheel, 48in. wheel base, 64in. cranks, whilst the treadle stroke could be increased by the levers to 17.6in. A replica of the machine was in the Science Museum, at Kensington, but at the moment of going to press it still reposes in its wartime hide-out.

Recently, as announced in a previous issue, a centenary memorial tablet was unveiled by Sir Harold Bowden, at the Courthill Smithy, Keir, where Macmillan built his first machine. The memorial was provided by the National Committee on Cycling and it reads, "1939. The Centenary of the Bicycle. The National Committee on Cycling honours the memory of Kirkpatrick Macmillan, the Inventor of the Bicycle. He builded better than he knew." (There is a doubt as to whether Macmillan actually *built* his machine. See page 341 of this issue.)

At the ceremony were a large number of Macmillan's descendants—grand nieces, grand nephews, great grand nieces and great grand nephews. The youngest of them, Marion Callander, aged four, is a great-great-great grand niece. The unveiling ceremony was in the hands of the Centenary Club which was formed in 1939 largely as a result of the efforts of the editor of this journal who was then also the editor of the trade paper *Bicycling News* (wherein the suggestion for a centenary club was first mooted). This club was formed to commemorate the centenary of the invention of the bicycle and it represents the cycle industry of the Midlands which has sprung out of Macmillan's invention. Its members are all industrialists and the club is said to be the wealthiest group of cyclists in the world, representing a capital of £15,000,000.

The memorial was ready for unveiling in 1939, which was the centenary year of the invention, but the war deferred the event. Sir Hugh Gladstone, Lord Lieutenant of the County of Dumfries, introduced Sir Harold Bowden, who drew attention to the fact that it is now 107 years since Macmillan built his first machine. Macmillan was born in 1813, two years before the battle of Waterloo. The development of the industry from the year 1890, following the invention of the pneumatic tyre, can be realised by recalling that before the war there were 17 million cyclists in Germany, seven million in Japan, five million in Italy, 12 million in the United Kingdom, 10 millions each in France and the U.S.A., four million in Holland, three million in Sweden, two millions each in Czechoslovakia, Denmark and Belgium, one and a half millions each in India and Australia, one million each in the Argentine, Austria, the Dutch East Indies, Poland, Russia and Switzerland, half a million in Hungary and Spain, 300,000 in Finland, half a million in Portugal, Norway, Egypt, China and Jugoslavia and a further two million in other British countries. There are thus about 70,000,000 bicycles in use at the present moment and, as Sir Harold Bowden said, the Courthill Smithy can fairly claim as its own this mighty family, now being ridden by white and black and yellow folk all over the world.

The bicycle gave birth to the motor-cycle, the motor-car and the aeroplane, but it is the bicycle, by general consent, which has made the world a happier place in which to live, for the great thing about cycling is that you can enjoy it through all the chapters of life, almost from babyhood until the end of the road.

After the unveiling the party went to Keir Church for a short memorial service, and we quote a few words from the address of Rev. W. Fulton: "It may seem a far cry, as time goes, from Ezekiel's vision of Jehovah's chariot wheels to the intensified concepts of speed and ubiquity familiar to our day. But the theme of his vision remains the same throughout the ages. Man's restless urge to subdue the inertia of his mortal loss; his struggle to control, to neutralise, to outlive the tedium of space and time—to transform the powers that terrify into creatures of his will—the story is one of the progressive revelations of the secrets of God's mysterious universe, as where and when man is able to receive it. . . . To-day we gather from all parts of Britain to do homage to the genius of Macmillan, who a century ago toiled at his forge at Courthill. . . . His first crude efforts evoked only the ridicule of contemporaries. . . . He realised his dream, he put a living spirit in the wheels. From that hour we date the rise of a vast industry which has brought the joy of pleasant travel for work or play to every land under the sun."

As a centenary memorial and record of the life of Macmillan there has recently been published a book, previously referred to, entitled "The Devil on Wheels," by Gordon Irving. It accurately records all of the facts as far as they are known concerning the life of Macmillan. There is a tendency here and there to enter the realm of imaginative writing and to adduce things to Macmillan's credit for which there is not any documentary evidence. Also, there are one or two anachronisms which doubtless the author will rectify in later editions. All the same, this 2s. 6d. book of 75 pages should be purchased by everyone interested in the history of the bicycle. It is published by Robert Dinwiddie and Co., Ltd., Dumfries, Scotland.

Canadian Comment on British Goods

AT the annual meeting of the Canadian Bicycle and Sports Goods Dealers' Association, the president made the following significant statement:

"Many items which we imported from Britain simply faded out of the picture and we were forced to design tools to make in Canada those items which were no longer procurable. Handlebar tops, seat posts, chainwheels, cranks, fork blades, malleable castings were some of the parts we had to manufacture; previously, on many of these items we had merely placed an order, with no worry as to delivery date. You can readily realise that it was a great deal more expensive to manufacture these separate items than to buy them from a manufacturer who specialised in these various components. The average manufacturer struggled along to the best of his ability, absorbing these costs and, to use a slang phrase, 'taking it on the chin.' With war work, the various component parts that we manufactured ourselves were limited to the

(*Continued on page 75*)

PARAGRAMS

Pot and Kettle

"WE wonder whether you are still fit to be on the road in these busy days, in view of your age," said the chairman of Northampton Divisional Magistrates Court when a 77-year-old motorist was convicted of careless driving. The chairman, who also drives a car, is 80 years old. The defendant said he had been driving a car since Easter, 1914, and had been a cyclist for 58 years.

How to Frighten Lions!

ANYONE with a bicycle—and a bell—is a match for a lion any day, so it would seem. In Northern Rhodesia a lion which had killed a native woman ran away when another native rode up to it on his bicycle, ringing the bell wildly. Another cyclist, confronted by four lions out in the wild, made all four of them beat a quick retreat by ringing his bell.

Why there are Accidents

"WE have no great trouble from speeding. It is sheer bad driving on the part of people who have not driven for about seven years," said the Chief Constable of Leicestershire, at a meeting of the local Accident Prevention Council. He said the county accident figures for the past four months were higher than those for the corresponding period of 1945, and he viewed his monthly accident figures with horror.

No Scholar

"I'M no scholar. I don't know half the streets in Rugby," said a Rugby cyclist when he appeared before the local magistrates charged with riding in the wrong direction along a one-way street. He added that he was 44 years old and could not read, so the "No Entry" sign meant nothing to him.

Child Cyclists

A LINCOLNSHIRE policeman, speaking on road safety in his district, said that the local schoolchildren knew their kerb drill backwards, but when they were cycling things were very different. Out of 32 cycles examined, he said he found 28 unfit for the road, and the police-instructor on road safety made a habit of showing the worst-kept cycle to the schoolchildren as an example of how a cycle should not be kept.

The Right Spirit

AT Spanhoe airfield in Northamptonshire there is a park of ex-R.A.F. vehicles sufficient to provide over 70 vehicles of varying types for each of the 250 airmen on the station. But they ignore the lure of motoring, and have just formed their own cycling club.

Change for the Better

CONCRETE static water-tanks which during the war were installed down the centre of Charles Street, Leicester, are now being replaced by traffic islands, with flower-beds and shrubs. The Lord Mayor, commenting on the scheme at the meeting of Leicester Highways Committee, said: "Charles Street is a highly efficient street, but rather dreary, and we felt something must be done to brighten it up."

No Parking

AN old bicycle was found the other day roped to the 90ft. spire of St. John's College, Cambridge. It remained there for several hours until workmen were able to get it down from its airborne parking place.

Economy

AT the present time, the painting of the white lines on Northamptonshire roads costs some £4,700 a year. If the painting is done in accordance with the latest suggestions of the Ministry of Transport, the work will cost £18,000.

Children's Cycle Check

THE police at King's Lynn, Norfolk, are to carry out regular inspections of the cycles used by local schoolchildren, and certificates of road-worthiness will be issued by the Town Council.

Road Planning

A COMMITTEE to study the subject of the design and layout of roads was appointed by the Minister of Transport in April, 1943. The committee has now issued its report, and a few of the recommendations are briefly as follows: On important and heavily trafficked routes there should be separate tracks for vehicles, cycles, and pedestrians. In large towns, buses should be diverted from the central area. Where there is a substantial volume of through traffic, provision should be made for a by-pass, or the provision of an outer-ring road.

Dealing with sub-surface or elevated roads, the report states that these may be justified in heavily built-up areas.

Dangerous Safety-first

REFERRING to the "amazing posters" displayed at Wellingborough, Northants, as part of a Road Safety Drive, a member of the Northamptonshire County Council said: "The posters attract the eye of the motorist to such an extent that they bring an accident almost into the realms of certainty."

Road Discipline for Children

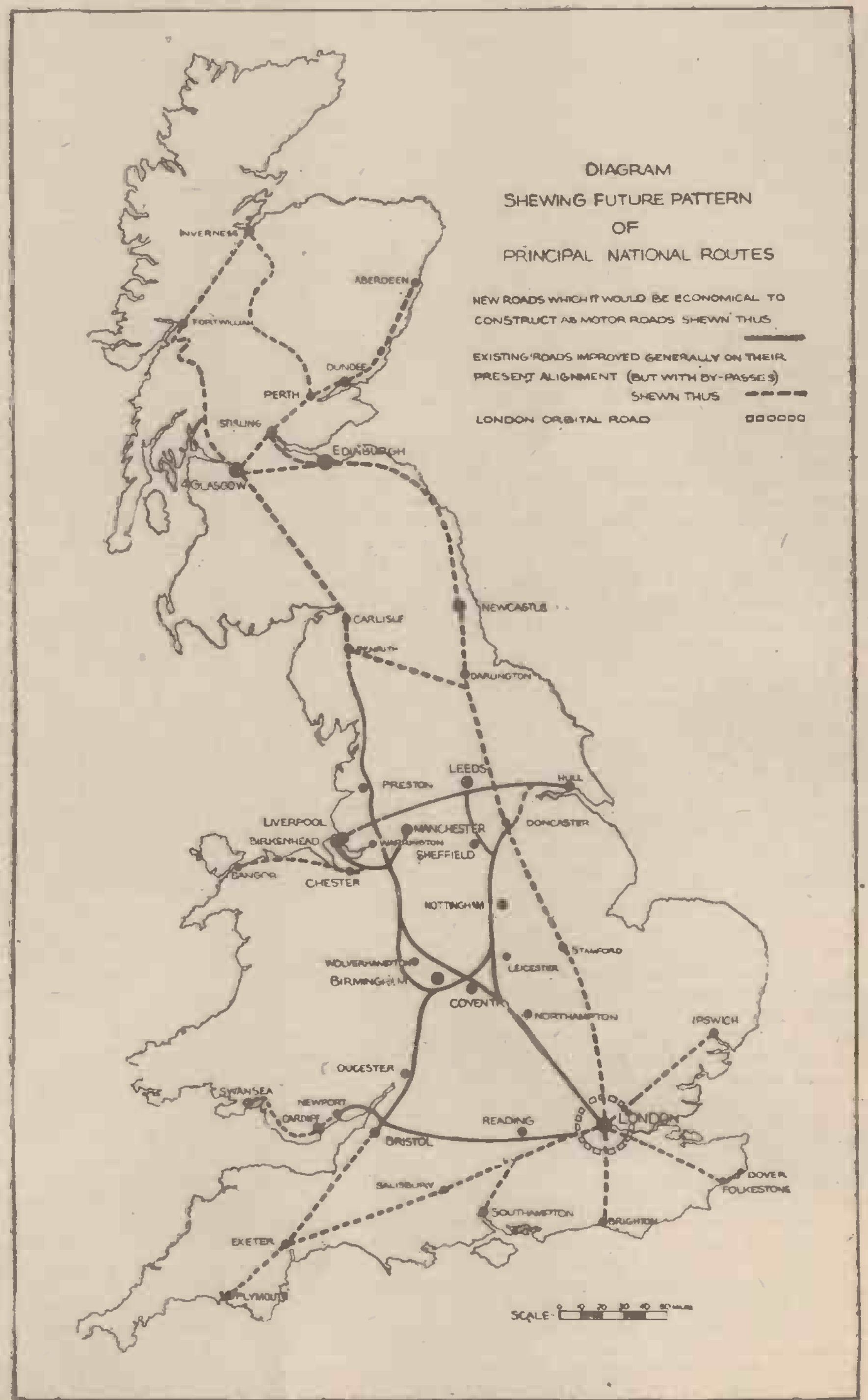
AT the opening of Melton Mowbray's Safety First Week Exhibition, the Director of Education for Leicestershire said it was proposed to make strict rules regarding the use of cycles by schoolchildren. He said: "We are going to insist that no child under seven cycles to school and that before a child of any age rides to and from school it must be examined in the Highway Code." He added that no child would be allowed to put a cycle in the school shed without having a written permit, and the consent of the parents.

Guerilla Warfare

HUNTINGDON schoolboys seem to have caught a craze for pea-shooters. Their most attractive targets appear to be passing cyclists, and one accident has already occurred. Probably the best remedy would be for every cyclist in the town to add a pliant stick to his equipment, and use it with a will on any of these marksmen caught adding to the dangers of the roads.

Dangerous Driving

WHEN a motorist was sentenced to nine months' imprisonment at Leicestershire Assizes for dangerous driving, and was disqualified for two years from holding a driving licence, it was stated that he ran into a cyclist and flung him 20 to 30 yards away, where he was knocked unconscious. The motorist then went on for some two miles with the cycle wedged on the front of his car and dragging along the road. On the outskirts of Leicester the driver stopped, removed the cycle and threw it over a fence.



Map showing suggested new motor roads as recommended by the committee appointed by the Minister of Transport.

Around the Wheelworld

By ICARUS

National Tricycle Meet

THE National Tricycle Meet, held last year at Meriden, the centre of England, was held this year in Shropshire on Whit Sunday. At this meet tricyclists from all over the country met for lunch and a club run through Shropshire lanes. The tricycle trophy was this year allocated to the Northern fifty.

B.L.R.C. 1946 Handbook

I HAVE received a copy of the well-produced B.L.R.C. Handbook for 1946. The Press Secretary, in a covering note, says: "Cycling sport in Britain has been pent up for fifty-five years . . . restrained by slavish tradition to Victorian ideas . . . road events promoted under rules imposing the utmost secrecy—private and confidential restrictions upon riders and officials alike; with the older cycling organisations stubbornly opposing any suggestion of change, a break out was inevitable. . . . The fact that the B.L.R.C. have been the honoured medium is accidental. Thanks to the B.L.R.C. the British public has for the past four years had cycling sport brought to its doorstep from Dover to Dundee. . . . They have turned out in their tens of thousands to witness it. . . . In the famous Brighton to Glasgow five-day race last August people lined the route in the latter stages. . . . For the first time in fifty-five years cycling sport has become news. The B.L.R.C. is solely responsible for this change. . . . The fact that the older organisations have had to wake up is all to the good. . . . The B.L.R.C. is the only cycling organisation in Britain with the constitutional powers to offer a completely comprehensive programme—road racing, circuit racing, Australian pursuit, track racing, time trials, team time trials, cross country, hill climbs, roller contests, with championships for seniors, ladies and juniors in all relevant events." Details of the B.L.R.C. programme are included in this 48-page handbook, which includes articles written by men of note possessing practical knowledge of their respective subjects. Every cyclist who wishes to keep his knowledge abreast of the times and to learn the B.L.R.C. case should obtain a copy of this handbook by sending 8d. to the Hon. Sec., 24, Disraeli Road, Ealing, W.5.

A view of Loch Lomond Youth Hostel at the official opening.

"Cycling Manual"

I HAVE received a copy of the 20th edition of the "Cycling Manual," published at 1s. 6d. It contains a great amount of information of use to every cyclist, tourist or sportsman. Copies are available from or through any newsagent.

Model of Macmillan's Bicycle

TO me has been delegated the task of scaling down the reproduction of Macmillan's bicycle, owned by the Science Museum. This machine is not the original but is probably a copy made about 1860. Compared with illustrations of Macmillan's machine in old cycling journals, it is none the less a faithful reproduction and I am well advanced with the drawings. By the time you read this they will have been completed and the model made. After inspecting the machine I had an intense desire to ride it. It is said that a speed of from 8 to 12 miles an hour could be attained, but I should think it would be a most uncomfortable ride even in these days of smooth roads, and it would certainly be noisy with its wooden carriage type wheels and iron tyres. It certainly is a blacksmith's job, and weighs 58 lbs. Readers will have an opportunity of building one of these models when the drawings are published in this journal.

The Largest Youth Hostel

BRITAIN'S largest Youth Hostel, formerly Auchendrennan Mansion House, on Loch Lomond, was recently opened by Mr. Tom Fraser, Joint Under-Secretary of State for Scotland. The hostel accommodates 500 visitors and is the gift of American Trade Unions, who donated a grant of £2,250. The work of clearing the house and grounds was carried out by volunteer working parties from the Glasgow district.

Death of C. J. Fox

WE regret to record the death as the result of a collision whilst taking part in a cycling event, of C. J. Fox, the noted Yorkshire cyclist who has done so much for the B.L.R.C. A full report and details of his career will appear in the next issue.

Cost to the Community of Road Accidents

AT the request of the Ministry of Transport, Professor J. Harry Jones, M.A., Professor of Economics and Head of the Economics and Commerce Department, University of Leeds, has estimated in terms of the national income the cost to the community of road accidents. His report is published to-day by H.M. Stationery Office, price 1s. 3d. net.

For the purpose of his calculation Professor Jones took the period 1935/38, and his estimate of the average annual cost to the community of road accidents during that period, at the price and income levels then prevailing, is approximately £60,000,000. If the same total number of similar accidents were to occur under present conditions, the total cost would be of the order of £100,000,000 per annum. For the period 1935/38 the cost of road accidents represented approximately 1.33 per cent. of the total national income.

It is interesting to note that, of the total cost, nine-tenths represented human injury. A small group of one-eighth of the total number of accidents (the most serious of all the accidents), accounted for nearly seven-eighths of the total annual cost to the community. As is to be expected, pedestrians, cyclists, and motor-cyclists were the road users most likely to suffer death and serious injury in road accidents.

The report incorporates, as an appendix, the Government Actuary's alternative estimate of £50,000,000, based upon a different method of procedure. This estimate compares with the £60,000,000 referred to above.

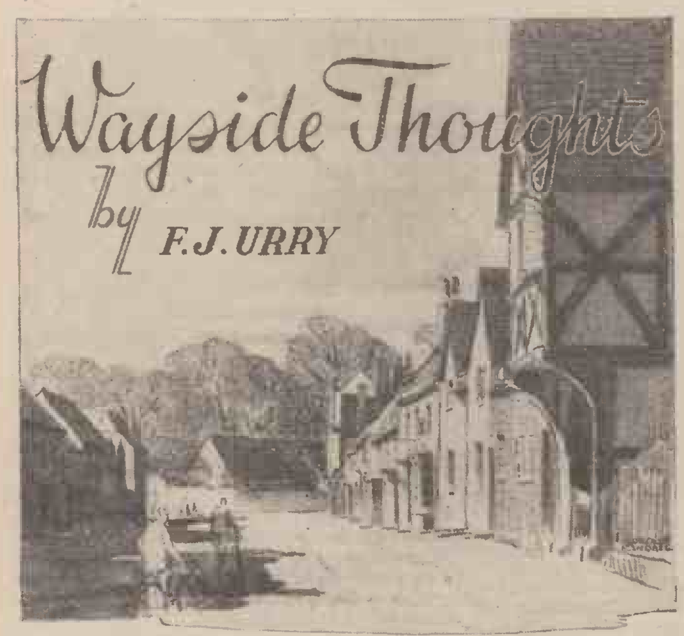
THE CENTENARY MEMORIAL

(*Continued from page* 73).

requirements of our own bicycle production. Taking as a comparison the British manufacturers of these lines, you will realise that we could not begin to equal their volume and there was not much opportunity to write off, on a volume basis, the enormous cost of tool dies. However, with British labour drawing the largest wages in the history of that country, and with a Labour Government to support them, we may be able to keep on manufacturing on a competitive basis these lines which we started to produce early in the war days; it may eventually turn out to be a blessing in disguise. Let us look at the question of imported bicycles. Bicycles have been imported from England finished in black, and with hand brakes. This type of bicycle was always less attractive to the buyer than the bicycle equipped with a coaster brake, yet the retail prices on these bicycles was $47.50. As stated previously, the cause of the high price on the English article is high labour costs, now protected by a Labour Government. This throws the export field open to Canadian manufacturers."

Wayside Thoughts

by F. J. URRY



Funny People

WHEN I was out at Easter I talked to numerous people along the road, some of whom (the caterers) I had known for years, and some total strangers who happened to be in the area I was occupying, and several of them had never been over those roads before. They were not all cyclists—these roamers on wheels—but some of them did possess the cyclists' reaction to beautiful scenes, and admitted our way of wandering the countryside, ever ready to drop a foot or lean over a gate and look, had much to commend it. But all of them were on common ground in thinking cycling was "hard work," and could not understand why I was riding when the little family car came along, and we agreed on a lunch spot some five miles farther on. It is most difficult to put the "easy riding" story over to such people, to make them realise that the air you enjoy, the food you eat and the visions of enchantment are the more ambrosial because you ride a bicycle, because your blood is stirred by the exercise, and your personal egotism is thereby complemented. I would rather people go in cars and see what they can from inside their closed perches than not go at all, but you and I know well enough who has the best of it when the perfect day comes to an end. How are we going to make people understand that our pastime—which is mechanical walking at its best—is not hard work; or perhaps it would be more true to say it is only as hard as you like to make it! It certainly need never be hard work under normal conditions if the urge to hurry—the modern fever which seems to affect so many people—is only kept in proper control. My contacts with the old catering friends along the roads were very comfortable, but they were not enthusiastic about the food controls. Yes, their jobs are not easy, and before we criticise we should consider the troubles of the times. You get better treated in return for sympathetic consideration.

Our Chance

THE Olympic Games are to be held in Great Britain in 1948. What is the cycling fraternity going to do about it? I am not asking that question in the political sense so much as on the matter of finance. It is obvious that if the sport of cycling is to hold its own with foreign competition then our representatives will have to be trained to meet the experts representing other nations. We have run our sport, and I hope we shall continue in that way, on good sound amateur lines; but it is an open secret that the word "amateur" has a much wider definition in some countries, and the fact has often been to the disadvantage of our fellows. I see no way of overcoming this handicap to our representatives except by the process of an early selection, when the fortunate ones can be granted an extended holiday for intensive training. That would mean expense, and the only way to meet the cost would be through the clubs, or through some central organisation given power to collect funds and disburse them to the selected riders on an agreed basis to cover their living costs while training, but not in the way of any kind of payment for prowess. Now, the clubs, broadly speaking, are too poor to find the amount required for such a purpose, and I doubt if any of the associations are in a much better position; so we are thrown back on to the trade if the bulk of the money is to be found to fulfil such a purpose. Whenever trade is mentioned in pure amateur circles people are inclined to shudder, for immediately the idea arises that some ulterior motive will be introduced. Why should it? I believe the industry as a whole has now got the right idea of amateur sport, and I feel if the right approach was made to it early, and on the right lines by the right authority, backed by all the sporting clubs of the country, the problem could be solved, and our fellows given the chance to show their mettle in competition with the world's best.

Shall We Take It?

ANNUALLY the cycle industry spends enormous sums on advertising, for which we, the riders, pay. As an individual I'm glad they do, because it is propaganda for the sport and pastime, in the joy and health of which I firmly believe. Cannot it spare a small percentage of this annual mighty sum for the purpose roughly indicated here? I think it would, provided that the scheme was run by intelligent men for the sole benefit of the purpose for which it was instituted; men of unimpeachable character with no axes to grind for any club or organisation. It is a tall order, but I do not think it is insuperable. It should be remembered in this connection that cycling plays a bigger part as a sport and pastime, and as distinct from utility riding, in these islands than in any country in the world. That is important, and in stressing it I want again to state that my personal opinion is that the game has a very long way to go yet before saturation point is approached. There is work here for someone to do, worthwhile work in the cause of cycling, and the most difficult part of it will be the selection of the personnel to take control. The rest is a matter of detail ending with a strict stewardship of distribution. The cycling world has been given a challenge, and a compliment, by the offer of the Olympic Games; are we going to accept both with all our joyous strength, and make the sport shine in the annals of 1948? We either ought to do that or decline the honour, for, in my view, there exists no half-way position; but to do the former we must have money—not an extravagant amount—but enough to see a complete team through a couple of months' proper preparation. By itself the sport and pastime is too impecunious to finance such scheme, but with the aid of the trade it would be easy and, I am sanguine enough to suggest, highly successful. Supposing motoring had such an opportunity to publicise itself through the prowess of selected amateur representatives, would it jump to the chance?

Sadly Needed

NOW that Sir Stafford Cripps has given a third concession on clothing coupons for women's coats, I wonder if he could be a bit more generous to us cyclists. We have had a raw deal on the coupon costs of capes and leggings, and even a third concession would be a great benefit to hundreds of thousands of riders. I know as a regular daily rider my waterproofs are never worn out in the true sense of that term, but are rotted and spoiled by the carriage in the bag, because so often they are wrapped up wet and tucked away; and I imagine that occurs to the macs of most daily cyclists. It is, of course, easy enough to say that capes and leggings should be properly dried out after every damp ride, but I wonder how often that ideal occurs in practice? I know it doesn't so far as I am concerned. So fair wear and tear of cycling waterproofs is not a habit among most of us, which is one reason why replacements are more frequently required than is the case, let us say, with overcoats. At this moment I am trying to keep a decent cape for my touring and week-end riding, by using an old one for daily service, and, if wanted, worn back to front. The old thing has become brittle with age, and is criss-crossed with patches all over the front, with the result that it is porous; but being a full-skirted article I can screw the back to front when I slip it on, and for a dozen miles it really is waterproof. But if I could buy a little more protection with fewer coupons I'm afraid I should fall for the easy way. And there must be thousands like me, just waiting for the chance of new equipment if only the coupons could be made to go farther. As a matter of fact I never used to buy macs, they were a kind of standard birthday present; but the coupon trouble bottled up that source of supply, and now that I have to find my own I take a little more care.

Lovely Bicycles

WHEN the labour is available and we can again obtain the right type of tyres, there will be some beautiful bicycles offered to a discriminating public. I say this with some knowledge, for I was recently invited to examine a collection specially made to high-class specification, the details and finishes of which were most attractive. There were included in their make-up many little improvements and simplicities calculated to appeal to men and women who really love the article which provides them with so much healthy pleasure, and there is no doubt about the welcome awaiting such goods once they are in the depots, and our desires can be satisfied. I believe the trade is really keen on improving the breed, and I admit, at one time, wondering if their object was to reduce us to standard for the purpose of cheaper mass production. But since seeing this collection I feel a good deal happier that we are going to be treated as customers who, knowing what they want, will be listened to and their personal specifications heeded. When will these models be available? There I could obtain no definite promise, only the vague suggestion that the next six months should see a big change for the better, and that everything depended on labour and supplies, which, generally speaking, are the same thing. To be quite candid I was cheered by the sight of these good bicycles, for they were the biggest bunch of high-class goods I have seen together since the Show of 1938, and eight years is a long while to wait for a sight of good stuff in staged form. It only goes to prove how eager some of us would be if a Cycle Show was held at the end of this year of grace—we should go in our thousands—but I am given to understand it will be 1947 before that occurs. So you see we—the cyclists and the cycle traders—are still being dragged at the heels of the motor industry—because they don't show in 1946, we shan't. Rather pitiful, I think, for a trade like ours.

Going With Circumspection

IT is many years since I rode over snowy roads at the beginning of March, but that way lay the choice on the first Sunday of the month, or stay at home. The air was quiet, but brisk, just trembling on the edge of freezing, and some of the corners and most of the hills were ice-patched and needed careful negotiation; for to tell the truth, I don't like sudden descents to earth, for such bumps may mean breakages, and I should hate to be divorced from my bicycle because—foolishly, as my folk would say—I had insisted on riding when road conditions were treacherous. However, nothing happened during my slow progress round the Warwickshire lanes, for I soon discovered that the secondaries provided much firmer steering way than the highways. So I went crunching over the inch or so of snow with circumspection, and got a little chilly in the process, for it was the kind of morning when the raw air seems to creep under your skin. Twice I stayed for a few minutes at farms I know to induce a little warmth into my feet, and then towards noon the glimmer of the sun transformed the day, and in a very few minutes the snow trickled into water, and dry patches began to appear on the road. Really, you know, our waterproof roads are rather marvellous in the manner in which they clear and dry out under the slightest encouragement. A few minutes later, after nineteen miles of quiet riding, I called on an old friend, toasted my toes at his fire, and slightly lowered his stock of rationed tea; and he, although knowing well my habits, quietly "told me off" for wandering round on such a morning of treacherous surfaces. But he also soothed the lecture by giving me a bag of beautiful apples, which, in turn, gave me a welcome home, and no more than a shake of the head for my supposed intransigence in the morning's adventure. But, I ask, what should I have done on a morning like that? There was no other game I could play, not even gardening, and I tell you—without a modicum of fresh air and a trifle of exercise a holiday seems to me to lack the very spirit of freedom. What a godsend a bicycle is to any restless individual, for even when the elements are unkind it can assist anyone to overcome the stagnation and ineptitude of a thoroughly idle Sunday.

We Don't Want Saturation

"THERE is no such thing as saturation point until every Hottentot is riding in a Rolls-Royce motor-car wearing a top hat," said Mr. George W. Lucas, past-president of the Motor Agents' Association. The cyclist's idea of paradise is rather different.

CYCLORAMA

By
H. W. ELEY

Historic STIRLING Bridge, (1400), Scotland.

The Cycling Dutchman

HE was ever a lover of the bicycle, and in happy pre-war days it was a wondrous sight to see the cyclists of Rotterdam, or Amsterdam, or other Dutch cities—the bike was the universal means of communication. I believe that many British firms are trying to meet the big demand for cycles from Holland . . . and there is, of course, also a big demand for tyres. The Dutchman will not get all he wants immediately, but his country represents a market we shall not neglect, and talking recently with a representative of a big British firm who has just returned from Holland after one of the "commercial surveys" which are so much the vogue now, he told me that Holland may be expected to make a quick recovery from the havoc and devastation of war; the Dutchman is a worker, a realist, and I do not think he will spend much time in idle regrets! "Coats off and go to it" is the motto in the country of bulb fields and dykes and windmills!

"Riding on Dunlop"

THIS phrase has a new significance as far as Herne Hill track is concerned, for recently there has been painted on the track a big bold "Dunlop"—and it must be one of the most striking and effective advertisements ever put out for the famous tyre. Actual painting of an advertisement on the track follows Continental practice, and possibly this is all part of the efforts which I know are going to be made to improve and brighten Herne Hill. I am all in favour of every action which tends to give colour and brightness to places, for so many of our streets, shops and sports centres are in need of renovation; shabbiness is, unfortunately, one of the inevitable aftermaths of war.

A Beautiful Wet Day

I CALL it beautiful deliberately, for there is something fascinating and extraordinarily pleasant about rain—particularly if you are wise enough to take out the bike and go for a ride into the country. And as I write I have been watching the rain fall steadily and soak into the dry earth—and I know that the sight will be a joyous one for many a farmer, for the land has been crying aloud for moisture. A happy bunch of cyclists passes my window—waterproof capes gleaming with raindrops and faces aglow with health. And what a joy, at the end of the morning run, to fetch up at some old inn, put on a pipe and drink a draught of good ale! And when the rain has ceased I know that the blackbirds will be on my lawn, in company with a dozen or more voracious starlings, to pull out the worms from the softened turf; and everything will smell very sweetly, and my rows of peas will at last begin to make some progress. Welcome to the rain!

The Cyclist and the Camera

I HAVE seen smiles on the faces of some of my camera-cycling friends this last few weeks, because of the greater ease of obtaining films. No two hobbies go better together than cycling and photography, and it has been a source of trial to many a rider that he has been unable to take pictures of some of the scenic gems along his routes. During the winter evenings I know of no more interesting pastime than looking through an album of pictures taken during cycling tours . . . bringing back the delights of spring and summer and awakening I know not what good memories of halts in little villages, of teas in ancient cottages or friendly chats by the wayside with all sorts of roadfarers — cyclists, walkers, motorists, and genuine "tramps." And now more shops have the essential films . . . and the hearts of many enthusiasts are glad!

A Day on the Farm

BY birth, by boyhood upbringing, I belong to Staffordshire, and I know of no English county which is more unjustly maligned. The ignorant think of it as a county of unrelieved smoke, grime and ugliness . . . and mention the Black Country and the Potteries in support of their verdict; they do not know of the green delights of the Trent Valley, of the glories of ancient Lichfield, of the unspoiled villages like Needwood, Hoar Cross, Dunstall, and Marchington. Quite recently I spent a day on a relative's farm on the Staffordshire borders . . . not far from Atherstone. And I came away convinced that the English farmer was still supreme, and that agriculture, if left to those who know and understand it, and have an inborn love of the land, will continue to thrive. I spent a full day on that farm . . . a general farm of some 100 acres. In the morning I helped to hoe a field of cabbages. In the afternoon I inspected a bean field, groomed a great bay cart-mare, and fed some ducklings. And about 4.30 I helped to bring in a herd of 16 good Shorthorns, and assisted with the milking. And I felt, as I worked and watched and listened, that unless one had a passion for work and a capacity for "keeping on," one should never be a farmer! Toil . . . without relaxation; work—without pausing; that is my impression of a farmer's day, and I do not forget that the week *is* a week . . . those cows have to be milked on Sundays and Bank Holidays! But what a free and grand life! I revelled in the work, and loved the smell of byre and stable. Hard work . . . yes; but *worthwhile* work! And my ride home in the dusk was good indeed . . . with the owls hooting in the spinney and the lights from farmhouses and cottages peeping out from the trees like glowworms. "Back to the Land" was an old slogan, but a wise one, and I ruminated a lot as I rode home of that dictum of old Jesse Collings: "For every man, three acres and a cow."

POLPERRO. CORNWALL.

Bullington Church. Sussex.

One of Englands smallest churches. A lonely little building surrounded by trees off the main road from West Dean to Alfriston. Only the chancel remains of the original building which was destroyed centuries ago by fire.

My Point of View

By "WAYFARER"

Much Wants More

HOW true it is that much wants more—especially in the case of a cyclist who, at the end of a day's ride, goes out for a walk; or, at the end of a fortnight's tour, feels smothered indoors; or, winter and summer alike, must have his bedroom window wide open. The consequential effects of cycling are quite important.

Shelter and Comfort

THE wind sat uncompromisingly in the north-east, its chilliness taking no heed of the fact that the month of May had arrived. A hole 20 miles long had to be bored in this crude blast in order that home might be regained, and I was quite unconcerned. My plans were made, and at the appointed hour I would move out to face the music. As temporary companions over tea there was a group of 15 to 20 young club cyclists, who were discussing their homeward journey, two of them being engrossed with maps. Above all the chatter about route possibilities the voice of the leader was heard: "We'll go main road"; and he folded up his map. To my mind, the choice was a poor one, for the main road in question is very busy, and is rather exposed. I wished the young folk joy of their choice, not feeling disposed to butt in and drench them with advice.

They made a start, aiming for their hearts' desire. My companion and I also set forth. By a lane route we reached and crossed a main highway. By a further series of lanes, complicated and curved, and sometimes deep-set between hedges, we crossed main roads Nos. 2 and 3. In the middle of the next lane-complex my friend and I parted company, his home lying in a direction different from mine. Proceeding alone, I ultimately re-crossed No. 3 main road, and so reached suburbia.

Here and there, of course, the north-easter "hurt" us, but we had so much shelter that we travelled in comfort and with a minimum of hindrance. We had chosen the better part—which was open to all—and, as an added reward, we saw practically no traffic.

Unforgotten Phrase

SOME well-remembered words, heard 22 years ago, come back to me vividly at this moment—the more vividly because the friend who was with me when they were uttered has just arrived home from India (where he has had to live and work for far too long a term) en route for a new job in Austria. My comrade and I were setting forth for our second Irish tour. We had boarded the Belfast packet in one of Liverpool's docks, and a while after the appointed hour (for the train from London was late) ropes had been untied, and the vessel was gradually warped towards the narrow exit, into the River Mersey. It was a slow process (and probably a tedious one for those who had to share it physically), but it proved to be engrossing and romantic in the extreme for the two cyclists who were setting forth to unlock the doors of the west of Ireland, and to enjoy the treasures there to be found.

So in the darkness of the night the vessel crept slowly forward, and then, at the appropriate moment, a voice from the quay cried out: "Let her have it, Captain Gill!" That was the dock-master's benediction; thus did he say "God speed!" to the ship and all who sailed therein. Instantly the wind freshened—or, at least, that was the effect of Captain Gill "letting her have it"—and we two sought shelter while we watched the Mersey lights slide by as the engines forced the vessel through the tumbled waters. Next morning we were in Ireland, and "Let her have it, Captain Gill!" was our joint slogan throughout the joyous days which followed. It is an unforgotten phrase, reminiscent of great delight—and certain weather trials. But, as ever, the pleasures of the tour predominate, and "the blue hills of Donegal," the eternal granduer of the 12 Pins of Connemara, the spacious glory of Galway Bay, the immensity of the River Shannon, and the magic of Killarney—these things are as unforgotten as the phrase itself.

The Way of Decency

IF I appear to give but qualified approval to a "Courtesy" scheme just launched by the Birmingham Accident Prevention Council, it is only because of my feeling that no special arrangements should be necessary to secure observance of the policy of doing unto others as you would be done by. That it *should* be necessary is a scathing commentary on present-day road manners. Moreover, I fear that those who rally to the scheme will be mainly the converted—that is to say, those who naturally act decently to all other road-users. (The originator of the scheme, for example, has driven motor-cars for 30 years without an accident—which just shows what you can do when you try.)

However, I wish "The Courtesy Club" every possible success. The sigh which members will display pledges them to courtesy at all times, and "Courtesy," be it noted, means good driving, the observance of pedestrian crossings, the discreet use of headlights, obedience to traffic signs, and so on. We are told that the subscription of 2s. 6d. "is designed to limit the membership to conscientious drivers who will observe the rules," and the ultimate extension of the club to include cyclists and pedestrians is contemplated.

"Utility" Bicycle

A FEW weeks ago I saw a real "utility" bicycle. It was being walked through suburbia by two men who were obviously house-decorators. Tied to it, on either side, was a pair of steps, and the other luggage consisted of those planks which are beloved of painters, together with buckets, cans of paint, brushes, and all the other junk of the decorating industry. With all this load the bicycle was, of course, unridable, but, in the absence of the much more usual hand-cart, it formed an admirable beast of burden—a veritable "utility" bicycle. I could not help recording the silent hope that, in its off-moments, the bicycle was used for more orthodox purposes, and thus gave pleasure to its owner as an instrument of joyous travel.

Jove Nodded

A CYCLING friend of great experience, and a notoriously careful rider, recently told me of an experience when, owing to his bad judgment, he very nearly came to a sticky end. The scene was a narrow suburban street carrying tramlines along the right-hand side. On his left, a few yards ahead, a motor-lorry was anchored. In the near distance, and approaching rapidly, was a heavily laden brewer's dray. The probability is that, in law, each of the moving parties had an equal right to the space available, and, unfortunately, each claimed it. (At sea, of course the equivalent of the brewer's dray would have given way to the equivalent of the bicycle.) When he realised that he had gone too far to retract my friend decided that he would have to stick to his course, though he had lurid visions of his face and body being plastered on the sides of the respective stationary and moving vehicles.

The drayman saw the imminent danger, and edged in farther to his left; the cyclist "kept a straight bat" and scraped through the narrow space without sustaining anything more serious than a fright. What the drayman said to the cyclist is not to be recorded here, but the cyclist admits that he was everything he was called. I gather from my friend that he considered his action in pressing forward—and in not doing the safe thing—was indeed a bad error of judgment, and I endorse the opinion. It was truly a case of Jove nodding, with an extremely lucky escape from disaster.

Propaganda Still Needed

THE need for hard-tyre propaganda continues. I was walking in a Surrey lane one day in company with my son-in-law when a cycling youth came along, riding practically on his rims. My companion, who is in the service of one of the big rubber companies, naturally believes in a paraphrase of there being "nothing like leather," and he called out a gratuitous but very fitting "Pump those tyres!"—an injunction which seemed to fall on deaf ears.

A few days later, at a Shropshire house of call, I was adding to the pressure of one of my tyres. A public schoolboy, standing by, demurred, saying: "But it's as hard as a brick already, sir!" Not quite, of course; and I took advantage of the opportunity to explain that really hard tyres make for comfort, speed, puncture-immunity, and longer tyre-life. Then I examined the tyres of the schoolboy's bicycle, to find, as I anticipated, that his preference was for just the reverse of the things at which I aimed.

The State of Perfection

IN the State of Perfection, which forms part of the Province of Utopia, matters are ordered better than in this country. All classes of road-user have been taught good behaviour, with the result that cyclists neither obstruct nor hold on to other traffic, motorists do not fail to show consideration to cyclists, and pedestrians make a point of looking where they are going, and of using the footpaths where such are provided. Incidentally, cyclists' mouth-organs have been abolished. Road sense—which is but another name for common sense—is highly developed. Nobody would ever dream of dropping bottles or leaving wheel scotches on the public road, and the person who accidentally broke a bottle would at once sweep up the debris and put it out of harm's way.

Halt signs are rigorously observed, and there is no "jumping" of automatic signals. Dogs are carefully controlled. Hob-nails, as used in the shoes of farm-hands, etc., are made of a material which dissolves when detached from its normal position. Roads are kept in good condition, the English system of "soleing and heeling" being unknown. An essential qualification for every Road Surveyor is that he is a cyclist; he is thus able to appreciate the need for curing any roughnesses occurring in the roads for which he is responsible. Roads are properly cambered, and regular inspections after rain are made, so that steps can be taken to avoid the facilities for free baths which motor vehicles would otherwise provide for all road-users.

Dazzle, of course, is unknown. Accidents are few and far between and continue to diminish, being due, now, solely to latent mechanical faults which it would be difficult to detect. Special courts for dealing with motorists, which it was designed to set up, have been rendered unnecessary, and the accident wards of many hospitals have been either reduced in size or entirely abolished. The majority of the Coroners have been pensioned off or directed by the State to other jobs, while police forces have been reduced. There is a pleasant spirit of comradeship on the road, and "After you, Claude!" is the favourite slogan.

The Lure

IN the case of many of us who have travelled far beyond the schoolboy age, what an appeal is still made by wayside notices such as "Farm House Teas" and "Home-made Cakes"! I, personally, am very conscious of the lure of such announcements, for which I frequently "fall"—sometimes with good results, and sometimes with results not so good. Nevertheless, the places which exhibit these announcements are worth trying. On the other hand, the enamel signs advertising "So-and-so's Cakes"—a big firm of London caterers—are no attraction when seen in the heart of the country.

Arithmetic

ON one of the days at Easter I lingered, for a while on a busy main road leading out of Birmingham, watching the boys and girls *en route* (in all probability) for Stratford-on-Avon. And, as I loitered there, a thought, previously voiced in these pages, came to me. It relates to the simplest of simple arithmetic—to, in fact, the twice-times table. Many of these young folk were obviously enjoying life, particularly as the wind was blowing them on their way. Equally obviously, lots of them were taking their first cycling trip of the new "season." How they revelled in the sunshine: how they enjoyed the jolly cycling exercise—and how easy it was: how lovely the country looked—wherever the eye turned lay beauty. It may be that a high proportion of these young folks did not realise that that helping wind was a very cold one, and that, when the time came for them to turn round and go home, it would "blow through them," making riding hard and at least a shade uncomfortable. It may be, also, that a lot of the boys and girls had forgotten their twice-times table. I hope that the process of remembering it, as the day wore on, was not too unpleasant for these folks. For 20 miles has a habit of turning into 40, and the helping wind of the morning is obstructive in the evening, and the hills down which you swept with ease on your outward journey have to be plodded up as you make for home. So, folks, don't forget your arithmetic!

Lofty Gearing

A YOUNG office colleague told me a day or two ago that he had changed over (for trial) to the fixed gear. He had at once arrived at the conclusion that he was too highly geared, and it transpired that he was riding an "85." To my way of thinking, his conclusion was eminently correct, and I had no hesitation in advising him to descend to something in the neighbourhood, and not in excess, of "65"—and to learn how to use his ankles. The day of 80-ish gears, when only one gear is used, has long since departed, so far as general cycling is concerned.

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