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PRACTICAL MECHANICS

JANUARY 1940

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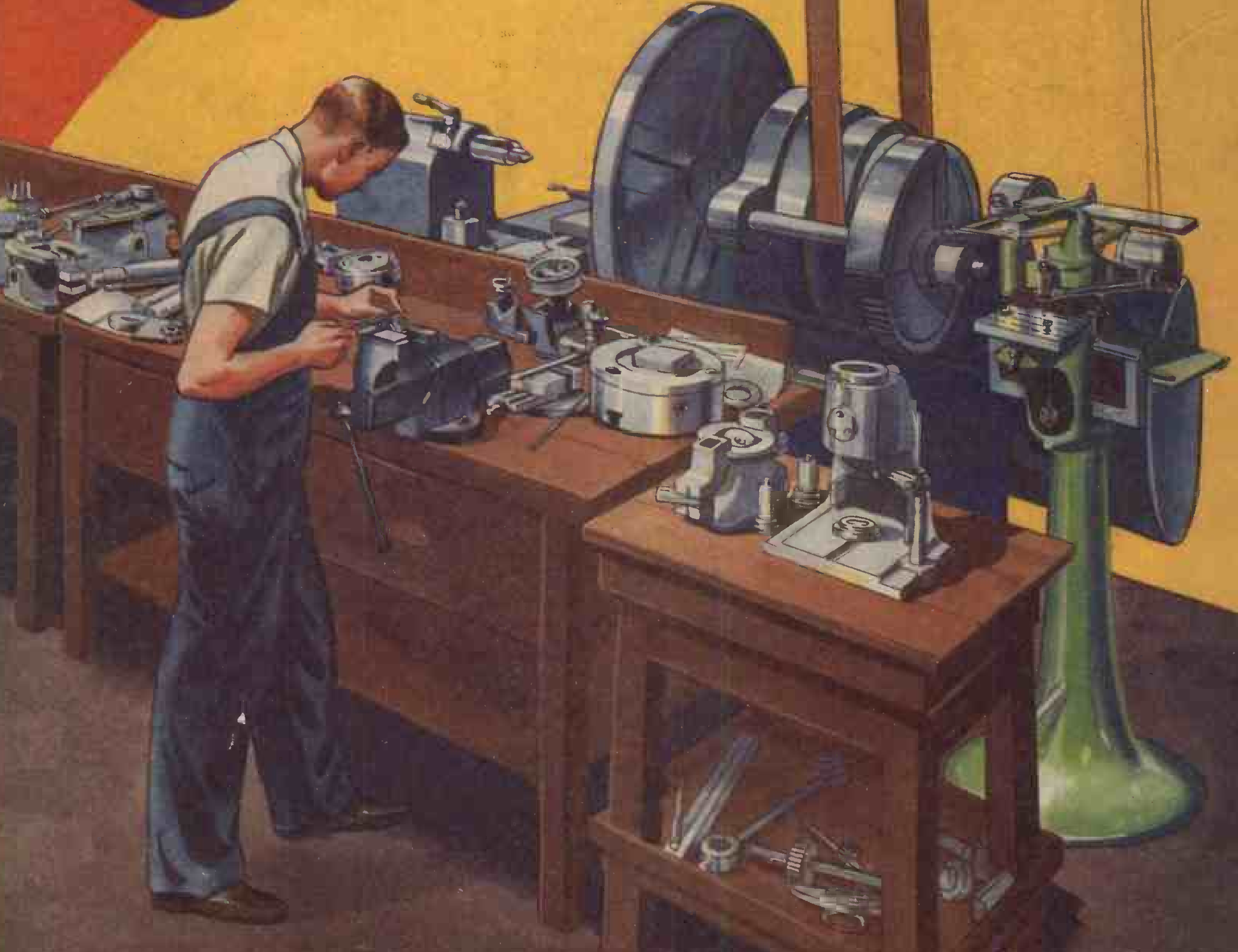

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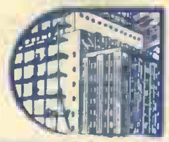

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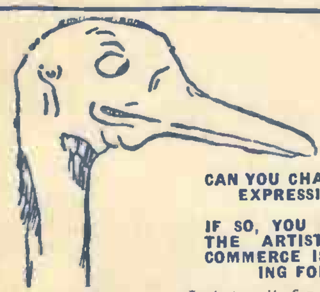

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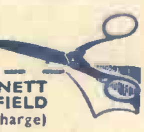

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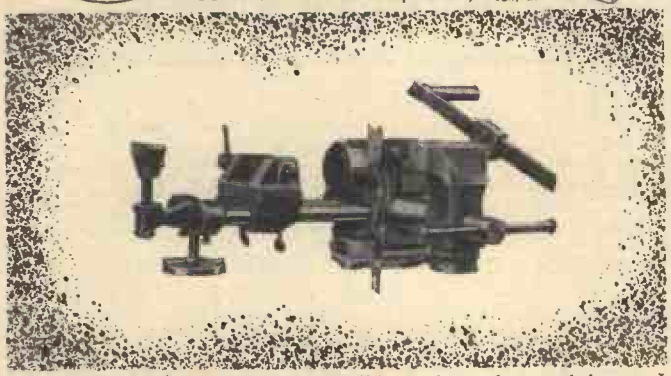

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PRACTICAL MECHANICS

Editor: F. J. CAMM

VOL. VII. JANUARY, 1940. No. 76.

FAIR COMMENT

By the Editor

Special Notice—Price Increase

READERS will notice that the price of PRACTICAL MECHANICS has been increased to 7d. as from this issue. The war has produced its inevitable consequences for publications of the character of PRACTICAL MECHANICS, and not the least are the higher costs and the lower advertisement revenues. On the cost side, paper alone has risen by over 60 per cent. since the outbreak of war and the possibilities are that prices will rise even further.

In facing this problem we had the alternatives of reducing the size and the number of pages of the journal or increasing its price. In deciding on the latter course we felt sure that our readers would prefer it to the alternative of a journal smaller in size and with fewer pages, for this would have meant sacrificing the services of contributors and artists and the many special features which our readers so much appreciate.

Our tens of thousands of loyal readers will, we are certain, appreciate our difficulties, and continue to give PRACTICAL MECHANICS their valued support and co-operation. They will, too, understand that the extra penny represents only a proportion of the increased costs we have to bear. Our readers, we are confident, will appreciate our intention, in spite of the difficulties of magazine production, to carry on throughout the war, and we express the hope that the war will mercifully be of short duration.

Clubs for Engineers

WHILST most other industries have clubs, it is somewhat surprising that hitherto the engineering trade has been without them. I now see that in some of the busy engineering districts engineers are forming local clubs where they meet for discussions on engineering problems and to listen to lectures. Many engineering firms are willing to supply lecturers and to hire out instructional films. This club movement seems to be growing and I suppose that inevitably there will be a parent organisation to link the various branches. In some of the industrial centres engineers have been having a flat time in the evenings owing to the black-out. The club movement provides them with a pleasant means of spending an evening and meeting others with kindred interests. It is a means, too, of gaining knowledge and experience.

The Model of the "Flying Scotsman"

I REGRET that it has not been found possible to commence the series of articles dealing with the 2½ in. gauge model of the "Flying Scotsman." These will, however, commence next month. The model has been built and the drawings are being prepared from the actual model. It has passed its steam tests with flying colours.

New Books

WE shall shortly be publishing from the offices of this journal the *Practical Wireless Short Wave Manual*—a complete treatise on the principles, design and construction of shortwave receivers for mains and battery operation. Another new book shortly to be published is *Watches—Repair and Adjustment*, which deals in a practical way with every branch of watch repair and tuning. We have recently published the seventh edition of the *Practical Wireless Encyclopedia* (formerly *The Wireless Constructor's Encyclopedia*). A new edition of *Model Boat Building* is in course of preparation and *Motor Car, Principles and Practice* is on the stocks for publication early in January. *More Miles Per Gallon*, which costs 1s. from the offices of this journal, is a volume which every motorist will appreciate in these times of petrol rationing. This book covers the whole subject of economical running, and deals with alternative fuels and methods of improving petrol consumption. We issue a catalogue of our technical books for engineers, mechanics, and electricians, and a copy will be sent free to any reader upon request. A list of the chapters of each book is included.

New Features

I MAKE my annual request for readers to let me know what subjects they would like to form the subject of future articles. Last year I received an excellent response to my appeal and was able to satisfy the requirements of a large number of readers.

I should welcome a postcard from you detailing articles which you feel would be of interest. I would, however, ask you to bear in mind that reference should be made to the indexes of past issues so that you do not suggest a subject which has already been treated. Indexes for most of the past volumes are available at 7d. each.

Our Companion Journals

READERS interested in motoring, wireless or cycling should remember that we issue from the offices of this journal the *Practical Motorist*, which is published at 3d. every Friday, and deals with all aspects of motoring and the motor car, especially from the owner's point of view; *The Cyclist*, every Wednesday at 3d.; and *Practical Wireless*—the only weekly wireless journal—at 3d. every Wednesday. Next month I hope to make an interesting announcement regarding another new journal which will appeal especially to engineers.

The Principles of the Electric

A Brief Description of Tonal Combinations of an

A Model A Console will give every satisfaction in a small church or auditorium or in the home. There is hardly a limit to the scope of music which can be played on this instrument

AN organ that is without pipes or wind may well indeed be called a new instrument. The Hammond Organ is not merely new; it represents in itself a revolution so far-reaching as to be quite incalculable.

Science and the laws of dynamics have been so harnessed to the inventor's will that he has created an instrument eminently suitable for the drawing-room; yet, when occasion demands, powerful enough to fill a cathedral with a tone of great sweetness. It is remarkably adaptable for installation purposes. The maximum floor space which it needs never exceeds four or five feet square.

The actual "furniture" of the instrument consists of but two pieces—the console and the power cabinet, which is connected to the console by a cable and can be placed in any convenient part of a room or building. The number of cabinets may be multiplied for large buildings, as required.

General Arrangement

Fig. 1 shows the various controls marked. The pre-set keys are at the left-hand end of each manual. The tremulant control is located just above the pre-set keys. Immediately over the upper manual are five groups of controls.

There are two groups of harmonic controls of nine draw-bars each, on the left-hand side; these operate on the upper manual. The two groups of nine harmonic controls on the right operate on the lower manual. Between these groups are two other harmonic controls; these operate on the pedals.

The Pre-set Keys, Models A and B Consoles

At the left end of each manual is an additional octave of reverse colour keys—that is, the naturals are black and the sharps white. These are the pre-set keys. Those to the left of the lower manual are associated with that manual, those above with the upper manual.

When a pre-set key is depressed it stays down. When a second key on the same manual is depressed the first key springs up and the second remains down. Up, the pre-set key is "off"—not functioning. Depressed, it is "on." Only one pre-set key should be depressed on the same manual at one time.

The key at the extreme left, C, is the cancel key, used only to clear the pre-set keys when two have been depressed by mistake.

The two pre-set keys at the extreme right, A-sharp and B, are really switch keys. When A-sharp is depressed the organ speaks with whatever tone colour is set up on the left one of the two harmonic controllers for that manual. When B is depressed the organ speaks according to the right-hand controller for that manual.

The intervening pre-set keys, C-sharp to A inclusive, are each associated with a different ready-mixed tone quality set up before the organ is installed. These keys correspond to the pistons on a pipe organ. They are generally useful tone qualities. The artist may, however, substitute any other pre-set quality he prefers for any or all of them by a simple method fully explained in the operating instructions.

The tone of the organ is changed from one quality to another while playing, merely by depressing another pre-set key.

The two manuals are really duplicates of each other, each having its own pre-set keys and two harmonic controllers.

It should be clear from the above that, before playing, the organist must first depress one of the pre-set keys associated with the manual on which he is about to play.

The Pre-set Pistons

On the Model E Console, small pistons (numbered 0 to 11) are employed, instead of the reverse colour keys. A label against each piston indicates the tone quality associated with it. The piston marked "O" is the cancel key and Nos. 10 and 11 are available for any tone qualities that may appeal to the organist by manipulation of the drawbars as explained on the opposite page.

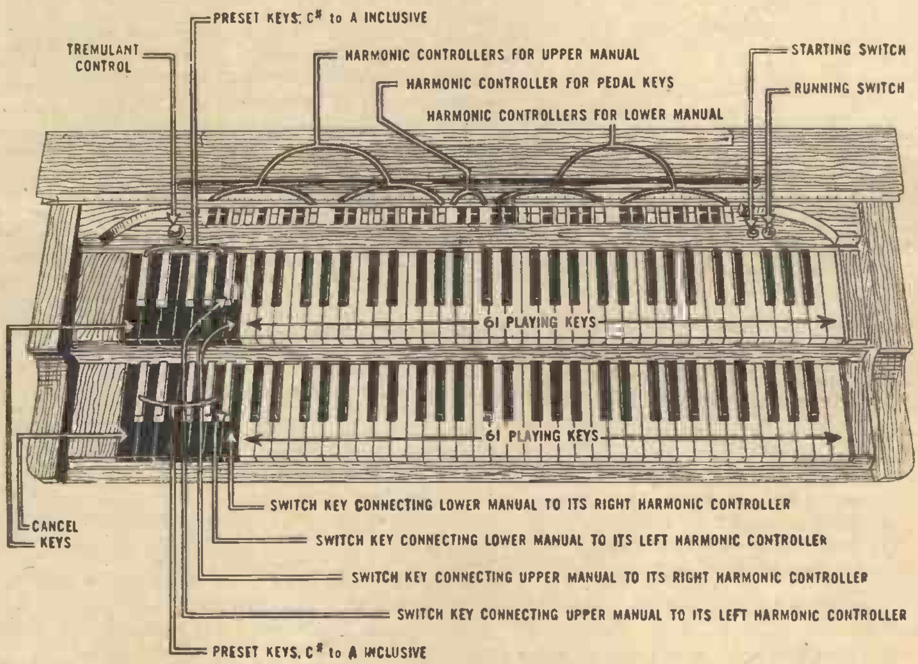


Fig. 1.—A plan of Console A model. The pre-set keys are at the left hand of each manual. The tremulant control is located just above the pre-set keys. Immediately above the upper manual are five groups of controls

Organ

the Electrical Principles and Ingenious Musical Instrument

Model E Console which can be termed a professional organist's instrument. Whilst being perfectly suitable for use—

—in the home or in the smallest or largest building, it is so equipped that every description of organ literature may be played on it

The Harmonic Controller

The Harmonic Controller is the device by which the artist is enabled to mix the fundamental and any or all of 8 different harmonics in various proportions. It consists of 9 drawbars. The third drawbar from the left controls the fundamental. Each of the other drawbars controls a separate harmonic as shown on the diagram. Each drawbar may be set at any one of 8 different positions. If pushed all the way in, against the console, the element it represents is not present in the mixture. It may be drawn out to 8 different positions. These are marked off on the drawbar and may be read by the artists. Each position represents a different degree of intensity of the element it controls. When drawn out to position 1, the element it represents will be present in the mixture with minimum intensity: when drawn out to position 2, with greater intensity, and so on, up to position 8.

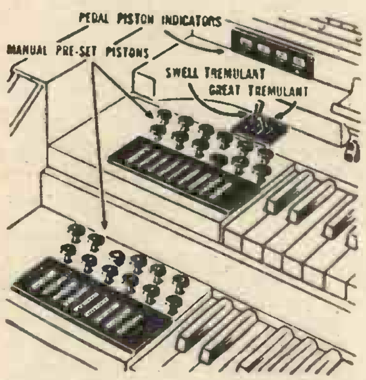


Fig. 2.—Model E Console showing the manual pre-set pistons, pedal piston indicators and tremulant levers

A tone colour is logged by noting the numerical position of the various drawbars. For instance, the tone set up in the diagram Fig. 3 is known as tone 23,6444,222. After a tone is so logged it may be made available again by setting up the harmonic controller to that number.

The Electrical Principle

When you pull out one drawbar of a controller and depress a playing key, a minute single alternating current generated in the console is carried through the cable to the power cabinet. Here it is amplified by the use of normal amplifying methods and caused to operate standard speaker cones and produce audible sound. The characteristics of the minute current generated are such that the sound produced at the speakers is a musical tone perfect in pitch and free from all overtones and harmonics. In other words, it is a pure fundamental tone.

To this the artist, by using the other drawbars, may add other pure tones which are selected harmonics of this fundamental and thus produce complex musical tones of a wide variety of qualities. The quality of a musical tone depends upon its harmonic content. This harmonic content is added to the fundamental by combining the proper minute electrical currents at the console through use of the controls provided.

The Generator

Let us now consider the generator, located in the console, and see how it produces the minute electrical currents which create the musical tones. Refer to Fig. 7. A metallic plate (the tone wheel) about the size of half a crown is arranged so that it will rotate in close proximity to a permanent magnet. About the permanent magnet is wound a coil. The illustration clearly shows this arrangement of plate, magnet and coil. This plate is not circular but has a number of high points equally spaced around its periphery, as shown. As it rotates it does not touch the permanent magnet, but these high points pass close to

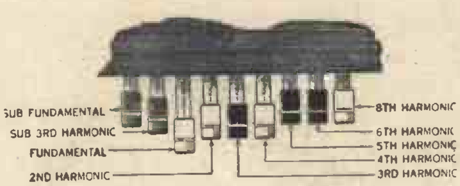


Fig. 3.—A harmonic controller. This is the device by which the artist is enabled to mix the fundamentals and any or all of eight different harmonics in various proportions

the magnet. Each time a high point passes the magnet it varies the magnetic field and induces a minute flow of current in the coil. Should the tone wheel be rotated at such a speed, for instance, that 439 high points pass the magnet each second, a minute alternating current of a frequency of 439 would be generated in the coil and flow in the circuit with which it is associated. Such a frequency of 439 when converted into sound would be "New Philharmonic" Pitch "A."

Now in the generator there are 91 such plates, all permanently geared together and driven by a constant-speed synchronous motor. Their speeds of rotation and the number of high points on each are so calculated that each disc produces one of the 91 frequencies necessary for the 91 pitches which are used in the fundamentals and harmonic overtones.

The General Electrical Operation

Ninety-one frequencies are thus continuously available at the generator. When a key is depressed it selects the proper frequency for the fundamental of the note it represents, together with the proper frequencies for eight harmonics of that note as set up on the harmonic controller or on a pre-set key. These frequencies then flow through the contacts made by the key, each to its proper drawbar, of the harmonic controller. The position of the drawbar (which is under the control of the artist) determines the intensity of each frequency. After leaving the harmonic controller these various frequencies are superimposed upon one another, or mixed, and flow as a single complex electrical wave to the preamplifier, also located in the console. From here the wave (amplified somewhat) flows through the connecting cable to the amplifiers located in the power cabinet, where it is further amplified and caused to operate the speakers.

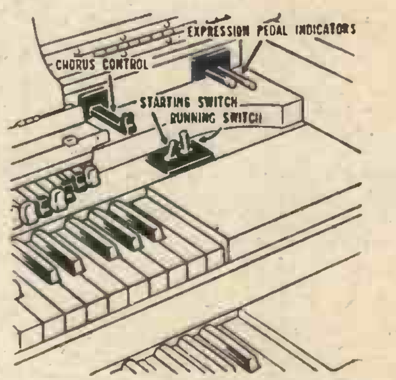


Fig. 4.—The expression pedal indicators, chorus control and starting and running switches

The swell pedal control is located between the pre-amplifier and the matching transformer Its operation varies the strength of the electric wave flowing to the pre-amplifier but does not change any of its other characteristics. Varying the strength of this wave varies the volume of the organ.

Notice that the operation is entirely electrical. No sound is created in the console—only electrical wave forms. The music first appears as sound at the power cabinet.

The above should serve to give an idea of the vast resources of the Hammond Organ. Within each tone family can be discovered an infinite variety of qualities from which the player can choose; he is not limited to relatively few in each family, but is enabled to create that special subtlety of tone-colour which he may want at a particular moment. It is this which makes the Hammond Organ the instrument upon which the artist-organist can best express his own individuality.

The Harmonic Controller for the Pedal Organ

Here the harmonic resources have been combined into only two harmonic controls. The fundamental 16 ft. pitch and second harmonic are associated with the left-hand control and produce the fundamental depth to the pedal. The third, fourth, fifth, sixth, and eighth harmonics are associated with the right-hand control to give higher harmonic quality variations. and a useful 8 ft. solo if used without the left-hand control.

While the possible number of pedal organ tone qualities is, of course, less than those available on the manuals, the player will find the volume quality and tonal depth ample to balance the manual combinations that are used.

The Toe Pistons

Situated to the left of the expression pedals of the Model E Console are four pistons which are placed in the correct position for easy manipulation for the toe.

The standard settings are:

1. FF—Adjustable from the back of the organ as are the 18 pre-sets.
2. MF—Swell and pedal.
3. Great to pedal
   (This piston is especially useful as it enables the organist to couple any of the whole range of tone qualities available on the manuals to the pedals in 8 ft. pitch; 16 ft. tone can be added by using the first pedal drawbar).
4. Adjustable. With this piston the two pedal drawbars are brought into action and are used in the manner described in the foregoing paragraph.

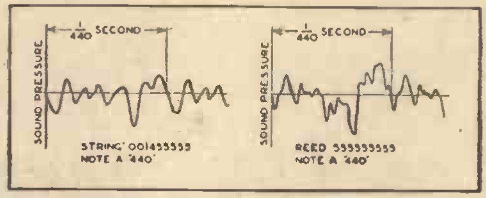


Fig. 5.—Graphs of the wave patterns of string and reed, pitch " A." The string quality is characterised by large upper harmonic development, and in the reed tone the upper harmonic development is very heavy

Electrically lighted indicators just above the manuals show which of the toe pistons is in action.

Fig. 6 illustrates the position of these toe pistons, the independent swell pedals and also the 32-note concave, radiating pedal clavier that is such an outstanding feature of the Model E.

The Tremulant

The organist can adjust the degree of tremulant to suit his own musical taste. When the knob is turned as far as possible to the left, the tremulant is entirely off. As it is turned to the right (clockwise direction) the degree of tremulant gradually increases until it reaches the maximum at the extreme right position. The white dot marker on the knob indicates at a glance the degree of tremulant present.

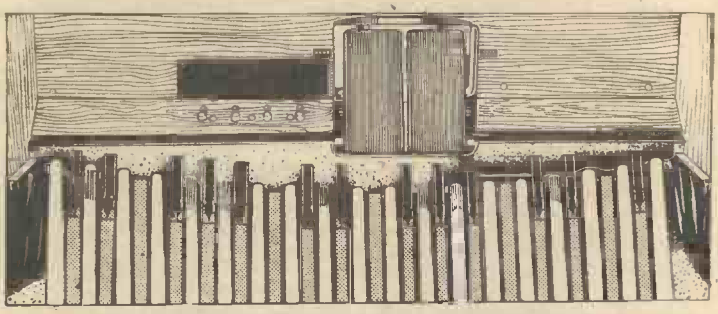


Fig. 6.—Showing the toe pistons, the independent swell pedal and also the 32-note concave, radiating pedals clavier that is such an outstanding feature of the Model E

The adjustable feature makes it possible to have a mild tremulant for flute qualities and a more vibrant one for string qualities. etc.

The Model E Console has separate tremulants for each manual. These tremulants are adjustable as to intensity or amplitude.

The Swell Pedal, Models A and B

The swell pedal, or expression pedal which is of the balanced type, is located in the customary position and with it the volume of the organ may be controlled over a wide range. It operates on the two manuals and pedal clavier equally; that is to say, once the manuals and pedals are balanced, they retain their relative balance over the entire swell peda range.

The dynamic range of the swell is stupendous. Technically, the power ratio of the swell pedal fully open to fully closed, is 50 decibels. In the most carefully constructed pipe organ swell shades, the power ratio seldom exceeds 15 decibels and is usually considerably less. The range of 50 decibels would correspond to approximately 32 points on a pipe organ, only a few of which are constructed with a range in excess of 12 points.

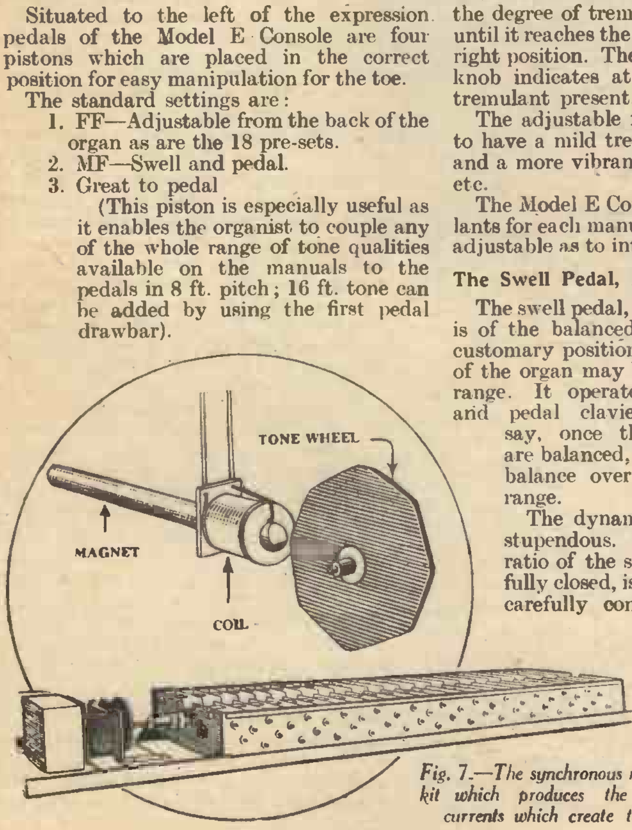


Fig. 7.—The synchronous motor and generator kit which produces the minute electrical currents which create the musical tones

The volume increase effected through the swell pedal is dynamically equivalent to a pipe organ crescendo build-up. One noticeable and very desirable difference is the absence of sudden tone quality changes characteristic of the build-up of the pipe organ to orchestral crescendos.

How to Make One Manual Louder than the Other (Models A and B)

Since the swell pedal operates equally on both manuals and on the pedals, this balance is maintained throughout the entire dynamic range of the swell unit. When it is desired to make one manual louder than the other, it is necessary only to select a tone colour which is softer than the one being used on the other manual, whether the softer tone colour be identical in character or different.

To select an identical but softer tone colour, it is necessary only to see that the harmonic controller for that manual is set with the drawbars in the same relationship to each other, but not pulled out so far. For example, tone number 23,6444,222 is of the same quality as 34,7555,333, but softer. You have simply pushed each drawbar in by one position.

This ability to make the same tone colour louder or softer on one manual than on the other is of great advantage musically. The swell pedal, operating equally on both manuals, changes the volume of both equally without destroying the balance between them.

The volume of the pedals can be controlled over quite a wide range by the use of the harmonic controls associated with the pedals, in addition to the volume change of the swell pedal.

The Swell Pedals, Model E

The Model E Console has the added advantage of independent swell pedals, each of which affects its respective manual over the wide dynamic range of which the Hammond Organ is noted. The pedal controlling the Great manual also controls the pedal clavier.

The position of each pedal at any time is clearly shown by indicators situated on the right, above the upper manual.

Hammond a " Straight " Organ

The chief difference between the Hammond and a pipe organ is that in the Hammond organ the player is able to control the precise amount of strength of each rank, which is obviously impossible with pipes, because a pipe must either be blown or left silent. To incorporate as many different sizes of pipes for each rank of the harmonic series as are necessary to control the tone quality by harmonic changes alone, would require so many pipes that the expense and difficulty of regulation and maintenance would make it impracticable.

New Methods of Camouflage Detection

Fig. 1.—*The observer of a reconnaissance plane using an aerial camera. The use of colour film is revolutionising the art of camouflage detection*

Cut Branches of Trees and Similar Devices Are No Longer Effective Camouflage Against the Reconnaissance Plane Equipped with the Latest Photographic Apparatus

AERIAL photography for reconnaissance purposes in war-time dates from the Great War of 1914-18, but subsequent developments have been so rapid as to make cameras and films of that time appear extremely primitive when compared with modern apparatus.

In the meantime the world has seen the introduction successively of super-sensitive panchromatic (colour corrected) film, infra-red photography, direct colour photography and television.

Photographing Objects Beyond Visual Range

Each of these developments in its turn has been applied to military uses by the leading powers. The latest development of which we learn is the use of aerial television by the Italian Air Force. At the moment this is admittedly rather in the nature of an experiment, but aerial photography using infra-red film has already proved its usefulness in recording objects many miles distant or concealed by mist or fog. Enemy ships at sea can be spotted by the infra-red camera when quite invisible to the photographer and sometimes as far as 50 miles away!

Penetrative Powers of Infra-Red Rays

There is one very definite "snag" with infra-red photography, however, and that is that the film is not very sensitive and, therefore, requires longer exposures than with ordinary film. One of the characteristics of this film is the paleness with which green foliage is recorded; but it also has certain peculiar penetrative properties which are probably not generally so well known. For instance, the rays apparently penetrate rayon or artificial silk but not real silk; which recalls the embarrassing experience of a young press photographer who took a snap of the ladies of a certain revue chorus. When the photo was submitted for publication it was noticed that the girls, with one exception, appeared in the print as though naked. The exception was provided by the only girl of the troupe who was wearing real silk.

Advantages of Colour Photography

For the detection of camouflage, however, infra-red photography takes second place to colour photograph and the results from the latter are such that the camouflage experts are being forced to devise new methods of concealment. The old dodge of covering gun emplacements with torn-off branches of trees and shrubs is no longer effective against aerial photography, since the change in colour of the leaves which occurs a few hours after the branches have been cut can be detected by the colour film now being used. In the last war very considerable use was made of cut foliage for concealing ground objects and such camouflage would remain effective for many days under ordinary observation, but with the aid of colour photography even the scorching of foliage by the blast from a concealed gun is easily discernable on the film.

Objects Identified Only by Their Colour

Aerial photography cuts out the human element in reconnaissance work by correcting and supplementing the memory of the observer. On the other hand until the advent of the colour camera successful observation and detection of military objectives was dependent on the perception of the observer himself, supplemented by monotone photographs. It was discovered, however, that the identification of an object might depend solely on its colour. This was proved by instances in which an object which had been apparent to the human eye, had appeared entirely absent from the negative of an ordinary black-and-white film taken at the same time.

As an example of the importance of colour in discerning objects, let us take the hypothetical case of two areas of contrasting colour adjacent to one another. If the depth of two of these areas be photographically the same, then a black and white photo will record the two colours by the same shade of grey. In other words they will appear as one area without division.

Colour in Terms of Black and White

It must be understood that colours which are photographically of the same tone may not necessarily be so visually; thus, for instance, a certain blue may be darker in tone than a red, but when photographed, especially with ordinary non-panchromatic film, the tone values may actually be reversed, the blue reproducing as a lighter shade than the red. With panchromatic film, on the other hand, the tone values are rendered approximately correctly.

The very fact that ordinary photography often tends to reduce contrasting colours to the same tone, might very well prove useful in detecting some forms of camouflage, particularly of the type which endeavours to break up the outline of the object by bands of contrasting colours such as that shown in Fig. 2. The reduction of the colours to half tones helps to clarify the outline. It is interesting to note that in the early stages of "dazzle painting" used by the British Navy, and which, incidentally, was introduced to deceive the enemy as regards the course and speed of a vessel and not to reduce its visibility, that the use of a large range of colours was used. This was discontinued, however, when it was discovered that the German submarines were having their periscopes equipped with colour filters which neutralised the effect of the colours and reduced them to a monotone. Thereafter, the colours employed were limited to black, white and blue, the dazzle properties of this combination being unaffected by the colour screens.

Colour Camera at High Altitudes

Apart from the fact that the permanent record of a reconnaissance flight provided by the colour camera has obvious advantages over a memorised visual record, the camera also surpasses the human eye in its power of detection and resolution of colours and small details. It is of particular advantage when flying at high altitudes when the human eye loses its power of discernment due to haze.

The colours of objects, which are easily recognisable at low altitudes, become increasingly difficult to detect as the plane rises, and at 12,000-14,000 feet the colours of objects commence to merge into a hazy blue. By the use of special correcting filters the colour camera can overcome this disadvantage to a very large extent; as an example, it is possible sufficiently to record the colours of cars in the street! Again aerial colour photographs show clearly the contrast in colour between the various types of vegetation—the green of young corn as distinct from the green of meadow grass, and the brown foliage of a dead tree in a living forest. By the use of multi-lens cameras large areas can be photographed at one shot and the films developed and pieced together at the base.

Modern Methods of Camouflage

Parallel with the military research into improvements in colour photography are experiments being carried out on methods of camouflage. For instance, where the paint-brush fails to disguise an object it is made to resemble something else, thus an innocent-looking cottage or farmhouse may hide a powerful anti-aircraft gun and its crew. The cottage may not necessarily be a real

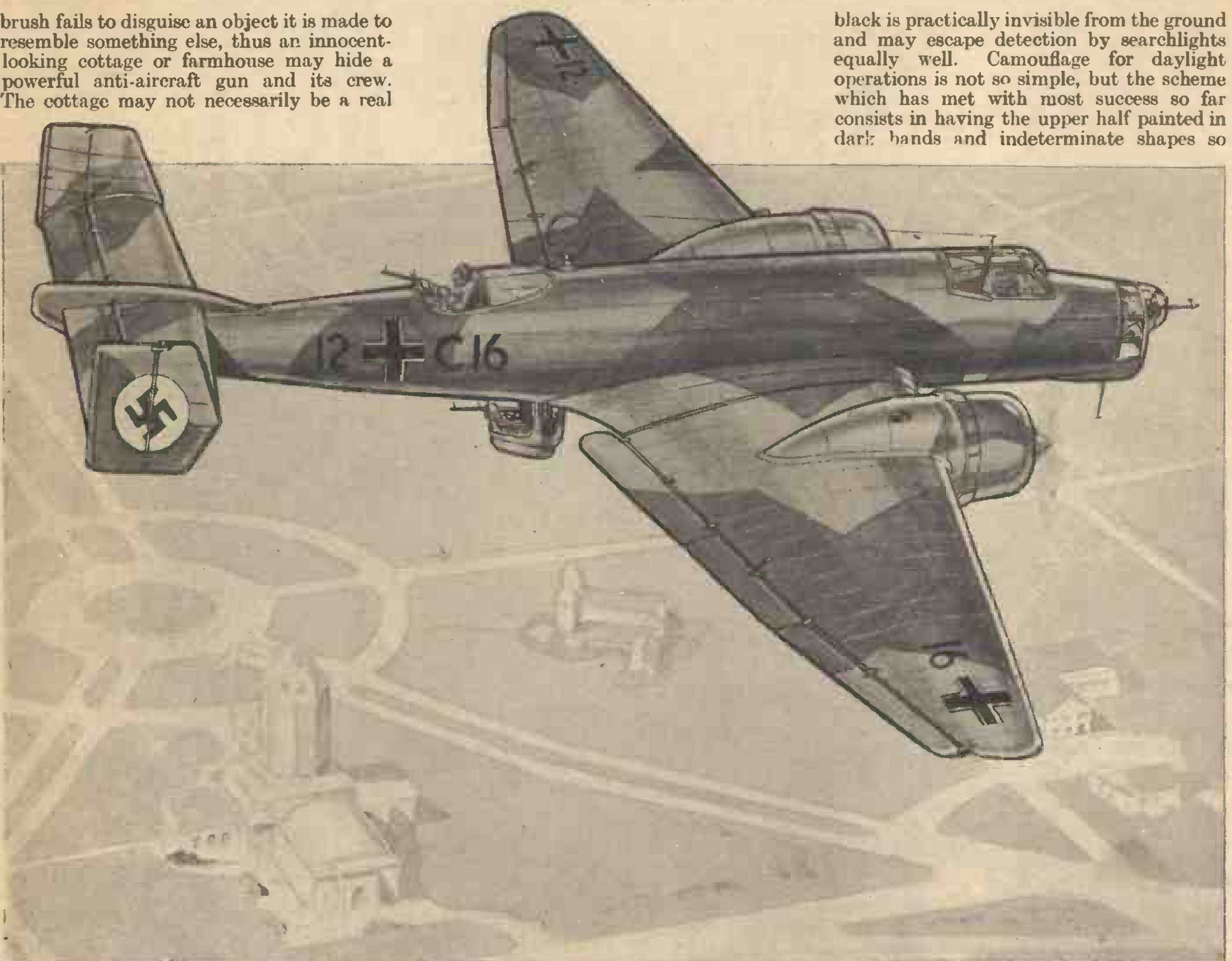


Fig. 2.—A typical example of a camouflaged aeroplane—a Junkers bomber. For daylight operations it is usual to paint the upper surfaces of a plane in dark colours, as depicted here, with the underside a light tone, so that when viewed from above or below the outline of the plane merges into the background. Night bombers have the under surface painted dull black

one but may be a specially constructed "set" built for the purpose. However, large-scale troop movements, batteries of large guns and such distinctive objects as airports and harbours are extremely difficult to conceal from the air. In the case of areas of easily recognisable shape such as aerodromes, attempts are made to alter their appearance by marking the field in such a way that it appears to be divided up into a number of smaller areas.

Disguising Bomber Planes

Aeroplanes themselves have also come in for their share of camouflage, thus a night bomber with the underside painted dull black is practically invisible from the ground and may escape detection by searchlights equally well. Camouflage for daylight operations is not so simple, but the scheme which has met with most success so far consists in having the upper half painted in dark bands and indeterminate shapes so as to merge into the general landscape when viewed from above, while the underside is coated with a light-coloured paint or alternatively is given a highly polished metallic finish, which although it does not minimise the risk of detection, serves to dazzle the man at the range finder so that it becomes difficult to determine the plane's altitude.

BOOKS worth READING

" SECOND YEAR ENGINEERING SCIENCE —MECHANICAL," by G. W. Bird, Wh.Ex., B.Sc., etc., revised by B. J. Tams, M.Sc.Tech., A.M.I.Mech.E. 246 pp., 230 illustrations. Pitman, 6s.

A SECOND edition of this well-prepared book has just been published, of which the first edition was published in 1934.

Since the first edition appeared a number of minor corrections have been made and a new chapter—Strength of Materials—has been added. The book was prepared to cover the Second Year National Certificate course, and various other courses of a similar nature. This it does in a praiseworthy manner, for the contents are not written in dry-as-dust form, as are those of far too many text books. Instead, the authors have added to the technical explanations descriptions and illustrations of the application of the technical points in practical engineering.

This will have an especial appeal to younger students, although very valuable to all readers. As a result of this form of treatment the book is a combination of a good text book and an interesting manual. It will commend itself to every student of the subject.

Especial reference should be made to the illustrations, both in line and half-tone, which are uniformly good.

" Silent Flight." By Ann C. Edmonds. Published by Country Life, Ltd. 84 pages. Price 5s. 0d. net.

YOUNG persons of either sex who enjoy outdoor life will find this entertaining book very interesting reading. The author, a well-known girl glider, has taught many R.A.F. pilots and leading commercial pilots the art of gliding. The book tells the story of how two young persons began their aerial knowledge by flying model aeroplanes and eventually progress to actual gliding and flying. Several fine illustrations are a feature of the book.

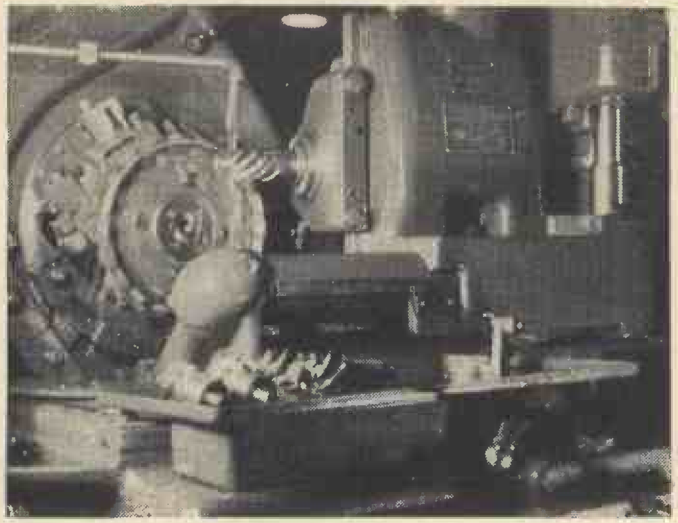
" The Mechanic's Repair Shop Manual." By Herbert J. Dyer. Published by Percival Marshall & Co., Ltd. 116 pages. Price 2s. 6d. net.

HERE is a book written by a practical fitter and turner for mechanics who run their own workshops, and their assistants. The practical wrinkles described are based on everyday repair-shop experience, and deal with repairs to ordinary engines, marine motors, and general mechanical repairs. The book is divided into fourteen chapters, covering, amongst other subjects: Removal of Studs and Screws; Drawing Off Flywheels; Lighting and Removing Valves; Piston Troubles; Re-Metalling Bearings; Boring Jobs; and Taking Up Slack Bushes. The book is illustrated with numerous line drawings.

The Second Article of a New Series

Workshop Practice

No. 2.—Gear Cutting and Grinding



Cutting a spiral bevel pinion with a Gleason machine in the factory of the Moss Gear Co. Ltd.

ONE method of cutting a series of teeth around the edge of a gear wheel blank is to make use of a simple rotary cutter driven at high speed by the spindle of a milling machine. The edge of the cutter can be shaped to give the correct tooth contour, according to the number of teeth on the gear wheel.

The first cutter in Fig. 1 would be suitable for producing a large gear wheel with approximately 135 teeth, while the second would be applicable for cutting a small pinion with only 12 or 13 teeth. Normally, a set of eight cutters for each pitch will cover all sizes of gears, but half sizes can be obtained if necessary by the use of special cutters. In use, the rotating cutter is moved across the face of the blank, which is rotated through the required amount after each cut.

Involute Gear Teeth

The fact that in the case of involute gear teeth the shape or profile of the teeth varies according to the number of teeth on the wheel, offers a simpler and more accurate method of producing the teeth as mentioned. On a small pinion having, say, 15 teeth, the curvature would be fairly pronounced, as shown in Fig. 2. On a larger wheel, the curvature of the teeth begins to disappear, until in the case of a rack, that is, a number of teeth arranged on a straight strip—the sides of the gear teeth would be straight.

From this it follows that a very simple method of producing the gear teeth is available. Fig. 3 shows that the cutter can take the form of a rack with straight-sided teeth. For accurate work the contour of the teeth of the master gear must be absolutely exact. This is considerably simplified at the outset, as it is a simple manufacturing proposition to produce straight-sided teeth. The simple design of the cutter is, in fact, the keynote of this system of gear generation, as it is termed.

During the process of genération the rack is moved forward so that it engages with the blank, which is rotated at the correct relative speed. If the blank were not of hard metal, the pressure of the rack would automatically generate correct involute teeth, as will be appreciated from the illustration. As the metal has to be cut, however, it is necessary to move the rack from side to side at the same time, so that its teeth will cut or " plane " corresponding teeth in the blank.

The Rotating Cutter

An alternative method of producing gear teeth is to make use of a grooved, cylindrical rotating cutter, known as a hob. Probably the most readily understood example is the hob shown in Fig. 4, which is used to produce the worm on a worm wheel. The hob, which in this case more or less resembles the worm with which the wheel is eventually intended to mesh, is gashed along its length so that cutting faces are formed. With the worm wheel and the hob rotating at suitable speeds the hob is slowly advanced, so that cutting takes place progressively until the required depth of thread is obtained. Sometimes separate hobs are used for the preliminary cutting and the finishing operation.

Making Bevel Gears

Bevel gears are, of course, widely used

The Methods by which Gear Wheels are Produced Depend not only on the Shape of the Teeth Themselves but also on Manufacturing Considerations

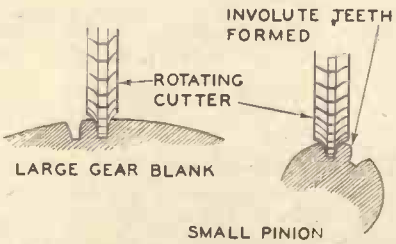


Fig. 1.—A simple method of cutting gear teeth by means of a rotating cutter with a tooth edge, carried on the arbor of a milling machine. Note the different shape of cutter when dealing with small and large wheels

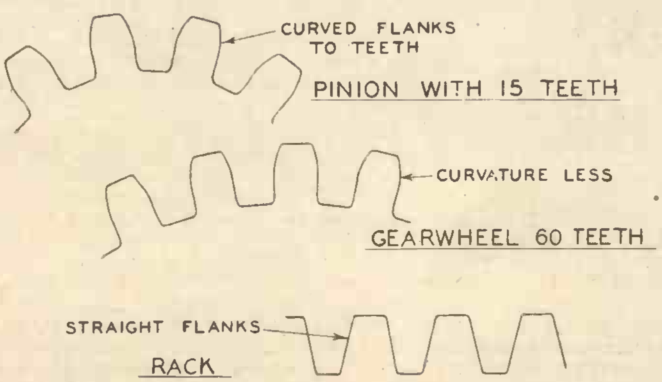


Fig. 2.—With the involute form of gear tooth, principally used, the flanks of the teeth become less curved as the size of the gear wheel increases, until they are straight in the case of a rack, or toothed strip

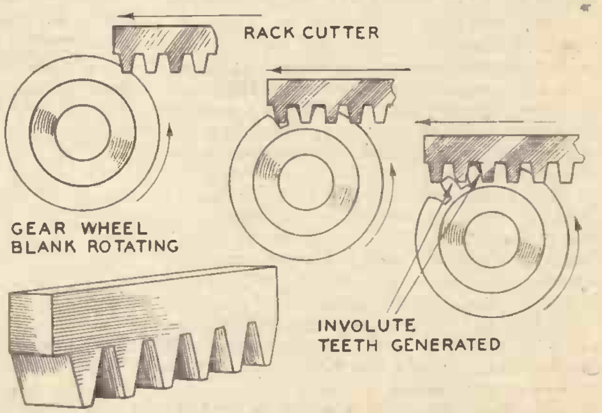


Fig. 3.—A simply cut straight-toothed rack can be made to cut correctly curved teeth in a circular blank. While the rack is moved forward into engagement with the rotating blank, it is given a simultaneous side-to-side cutting movement

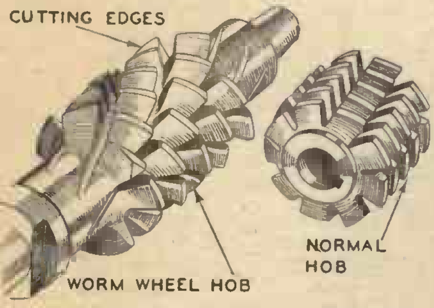


Fig. 4.—During the process of hobbing the cutters shown are rotated against the edge of the gear wheel blank, which is turned during the process so that teeth are cut

for back-axle drives, and for other applications, such as driving overhead camshafts. There are objections to the old-fashioned straight-toothed bevel gears, so that the spiral bevel is now almost universal.

There are three well-known methods of cutting spiral bevels. In the first place, the end-mill process can be used; the cutting tool is again driven by the spindle of a milling machine, and moves in a curved path, cutting curved flutes in the blank. This process, however, offers technical difficulties, and is normally limited to large-size bevels for industrial use, in which the pitches are coarse. Alternatively, straight-line bevel teeth may be planed at an angle. This, however, does not give correct results.

Double Helical Difficulties

Difficulty is sometimes experienced in the production of double-helical gears, in which the gear teeth are cut in the form of a shallow " V." To-day hobbing may be used, two hobs being required for right-hand and left-hand teeth respectively. It is impossible to hob a double-helical gear with continuous teeth across the blank, however, as the two halves of the helicals are separated by a gap which depends on the diameter of the hobs used.

As the size of the hob cannot be reduced beyond a certain point owing to technical difficulties, hobbed helical gears are often machined with staggered teeth in order to overcome this difficulty. Staggering of the teeth becomes almost imperative, in fact, if a narrow gear wheel is desired and the hobbing process is used. Continuous double helical gears, however, can be generated by using two rack cutters of the type already described, which generate accurate gear teeth, and move to and fro across the surface of the blank to the centre or apex of the teeth.

Under modern production conditions when single-helical or spur gears have often to be cut in compact clusters mounted, for instance, on a gearbox layshaft, and when internal teeth have to be formed at the same time, as in the case of the engaging dogs on synchromesh gearboxes, a universal high-speed gear-shaping machine is usually more suitable for mass production when gears cannot be produced by hobbing or other methods of milling.

The cutter of a gear-shaping machine for this type resembles a pinion, as will be seen from Fig. 5; this is very accurately made, and is frequently checked for truth. It is passed rapidly backward and forward across the face of the gear blank in order to cut the teeth. Modern gear-shaping machines enable as many as 600 strokes a minute to be made; in a typical instance, two complete turns of the gear blank are made while the teeth are being cut, the total time taken to cut all the gears on a layshaft cluster being just over an hour.

Gear Finishing

Surplus metal to the extent of approximately .002 in. is left on the flanks of the gear teeth to allow for finishing operations. Where the greatest possible silence of operation is required, the finishng of the gear teeth assumes considerable importance. One method is to make use of a specially designed gear-finishing machine. A machine of the type used in one well-known motor car works is illustrated in Fig. 6. The cutter resembles the gear itself, but has helical teeth which are slotted to their full depth. The teeth of the cutter, moreover, are ground to conform with the convexity of the gear teeth, and the tool is thus said to be of the enveloping generating type.

The gear is mounted on a mandrel and is raised against the cutter, which rotates it.

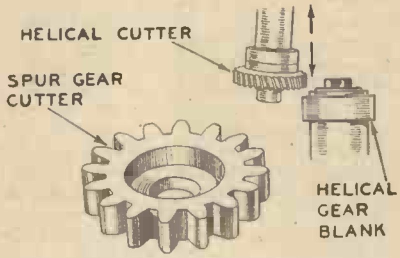


Fig. 5.—Gear shaping machines are widely used to-day. Various types of cutter similar to those shown are drawn backward and forward against the edge of the gear wheel blank, which is rotated during the process

The cutter, which is not parallel to the gear, but at a slight angle to it, runs at a speed of 600 r.p.m., reversing its direction of rotation at intervals of 10 seconds. After two runs in each direction the operation is completed and the cutter comes to rest.

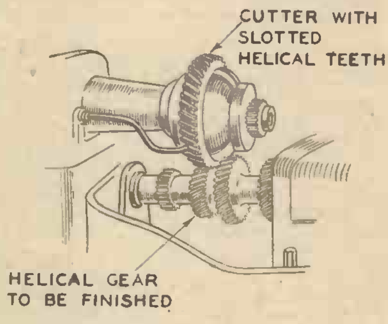


Fig. 6.—A cutter provided with grooved helical teeth rotates the gear wheel during the finishing operations. The cutter is not quite parallel to the wheel, so that a sliding and cutting action takes place between its teeth and those on the wheel

An alternative method of finishing the gears is to make use of a rack cutter of the type already described. The work is mounted on an arbor, which is held between centres, and is lowered into contact with the horizontal cutting rack. The fact that the gear wheel is at a slight angle to the rack results in a fine shaving cut on the teeth of the gear as the rack is moved lengthwise while in mesh with the gear wheel.

A more compact machine of a similar type is one in which a circular involute type of cutter is substituted for the rack. In this case the cutter axle is again at an angle to the work, so that a lengthwise sliding action takes place between the cutter and the gear teeth when they are rotated in mesh.

Heat Treatment

Before the final finishing of the gears takes place, the gear wheels are sent for hardening and heat treatment. As some slight distortion takes place, the wheels are often run in a lapping machine, as shown in Fig. 7. In some cases there are three lapping wheels, and in others only two; the wheels are of cast iron, and are coated with an abrasive compound. The gear wheel to be lapped is engaged with these wheels and is rotated at a speed of about 180 r.p.m. At the same time it is moved backwards and forward, or "stroked" at the rate of approximately 90 times per minute.

After lapping has continued for about 20 seconds the direction of rotation is automatically reversed, so that the gear wheel is lapped under both driving and over-running conditions.

The laps themselves are braked by hydraulic means in order to provide a drag on the teeth. As a rule, a cast iron lap requires renewal after about 8,000 or 10,000 gears have been dealt with.

Finishing is, alternatively, often carried out by grinding the gear wheels with the aid of rapidly rotating abrasive wheels, shaped to provide the correct tooth contour. Grinding wheels can, of course, be used for producing the gear teeth themselves. The thread on a worm, for instance, is produced on a machine in which the worm is simultaneously rotated and moved along its axis past an abrasive wheel, the edge of which has been trimmed to a section which will provide the required form of thread on the worm. The longitudinal motion of the machine table, in unison with the rotation of the work, provides the screw thread, in just the same manner as on a screw cutting lathe. A highly polished surface is subsequently obtained by running the worm with a wooden worm wheel to which an abrasive lapping compound has been applied.

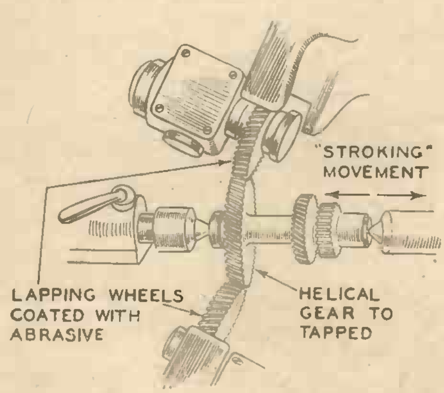


Fig. 7.—The final finishing is often carried out by lapping the gear wheel in conjunction with two or sometimes three cast iron wheels which are coated with an abrasive compound. An end-to-end movement of the gear wheel is usually provided in order to distribute the abrasive

A Turret Tool Holder for the Lathe

By Fitting a Turret-Head to the Slide Rest, Much Time and Labour can be Saved, Especially in Repetition Work Where Several Operations have to be Carried out on one Chuck Piece Fitting

WHERE repetition work is to be done in the lathe, and there are several operations on one chucked piece fitting, a turret-head to the slide-rest is a time and labour-saving device.

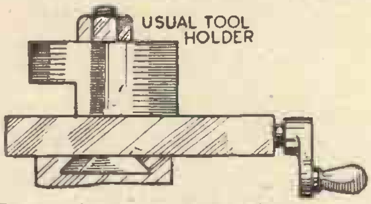


Fig. 1.—A conventional type of top-slide rest tool holder

In the accompanying illustrations are shown methods of applying such a head to an ordinary lathe.

In Fig. 1 is shown a conventional type of top-slide rest tool holder which has a tool holding block bolted down by a single stud and nut; the stud is a fixture in the top-slide. In the new arrangement this stud is replaced by a new one and a cast-iron block is cast from a simple wooden pattern of the same shape and size as the block, Fig. 2. It is bored centrally to fit the upstanding stud or a longer and larger stud if necessary.

Boring

For boring it is chucked in the three-jaw chuck and a drill is put through, fed along by the back headstock barrel, or by the back centre if no drill-holder is available to fit the barrel taper. In this case the drill is centred at the end to hold on to the back centre and a lathe dog or carrier with a piece of gas barrel driven on its shank depends between the lathe ways to prevent the drill turning. The arrangement is shown in Fig. 3.

The hole should be bored dead parallel. The block is then chucked on a mandrel between centres and faced flat each side and turned along its outside diameter. While on the mandrel a line is scribed all round it at a height which will bring the line into the axial line of the lathe centres. To get this line, fit the upstanding stud in the lathe top-slide in place of the tool post holding-down stud, and rotate the block by hand meanwhile pressing it up (by the top parallel slide) to a hardened and tempered cast steel pointer or scriber running dead true in the lathe three-jaw chuck. This will give the height for the centres of the holes drilled radially around the block to take the tools.

Divide this line around the block into four, five or six equal parts and with a $\frac{3}{16}$-in. drill running in the three-jaw chuck drill radial holes at each division. This is done by feeding the block up to the drill by the top-slide. Open these $\frac{3}{16}$-in. holes out to a size of hole which will be decided upon for our turret-head tools. The size will depend on the amount of room there is between the lathe head centre axial line and the top surface of the top-slide. These holes should go through the side of the block and terminate just clear of the central hole as shown in the sectional plan view, Fig. 4.

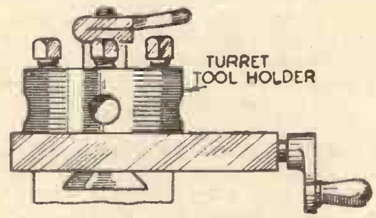


Fig. 2.—In this arrangement the bolting down stud is replaced by a new one and a cast iron pattern is cast from a simple wooden pattern of the same shape and size as the block

Drilling

Before drilling the holes in the centre marked ring round the block, chuck the block again on the mandrel on which it was turned and, with a scriber bolted in the tool post with its tempered point at lathe centre height, scribe lines horizontally (they will be vertical when the rig is in use) through each centre mark for the tool holes, to the top surface of the block (now standing vertical) without moving the block round and, with the scriber still in the tool post at the correct height, scribe horizontal lines across the face of the block from its periphery to the mandrel on which it is chucked. These lines will be, when the block is in its horizontal working position, dead above the axial lines of each of the holes for the tools. With the block still chucked on the mandrel scribe a circle on the top (now vertical) face of the block, at a distance $\frac{3}{4}$ in. from its outer edge. This circle will intersect the radial lines on the top of the block and, at each intersection will be drilled and tapped holes for the set screws which hold the tools in the holes in the turret block.

The size of these holes (like the size of the tool-holding holes), will depend on the size of our block and the clearance between the top surface of the top-slide and the axial line of the lathe centres. Hexagon or square-head set screws can be used, but they must have flat ends and must be case hardened at the ends which grip the tools.

Where we have an American type of lathe with a slotted pillar in a slot in the top-slide as shown in Fig. 4, we shall have to fit the centre stud in a manner differing from the arrangement shown in Fig. 2, for the English type of lathe. The method is shown in Fig. 4. A long central bolt with a square head to fit the slot is turned to fit the slot in the top-slide. It is screw-cut to take a flat hexagon nut which will hold it down on the top-slide vertically and in a fixed position in the middle of the slot in the slide.

The Turret

The turret cheese-shaped block will have its central hole recessed underneath to clear the hexagon nut and the cheese-shaped turret will bed down flat on the top of the top-slide. It will be held, when any of the tools are in working position, by a washer and a nut on the centre stud.

To avoid the necessity for using a spanner every time the capstan is turned to present a new tool to the work, a lever nut as shown in Fig. 5, can be used. It is made by forging over a piece of cast steel bar at one end so as to get double thickness for the length of thread and bending at an angle as shown. The bent-under part and the upward bend of the handle will enable the lever to clear the set screws on the top of the turret or a bush, $\frac{3}{4}$-in. thick, as shown, can be put on the holding-down lever nut to enable it more easily to clear the set-screws.

The turret can be used for tools for face or side work. Sometimes a combination of both will be used according to the class of work being undertaken.

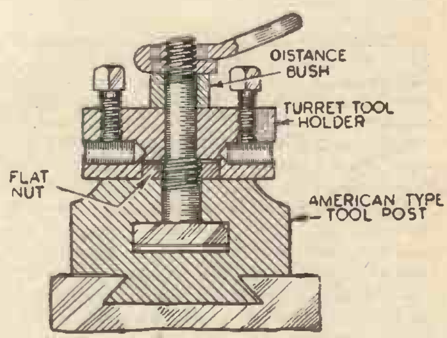


Fig. 4.—An American type of lathe with a slotted pillar in a slot in the top-slide

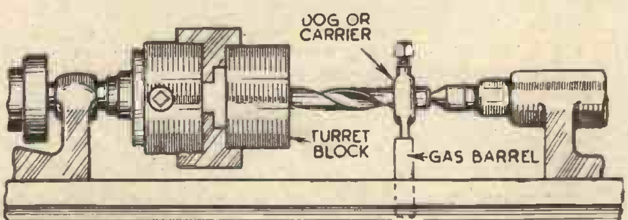


Fig. 3.—A piece of gas barrel driven on its shank depends between the lathe ways to prevent the drill turning

Fig. 5.—Details of the lever nut

Some Practical Electronic

By H. J. Barton

By Harnessing the Energy of the Electron and Making it do Improvements May be Effected in his Equipment if he

Fig. 1.—An interesting example of a really large-surfaced photo-electric cell such as was used some ten years ago

WITHIN the last few years it has been very apparent on all sides that the practical control of electrons has become an applied branch of engineering whose rate of development has outstripped even the wildest dreams of early pioneers. By harnessing the energy of the electron and making it do work, the physicist has shown the engineer that material improvements may be effected in his equipment if he studies the subject of electronics in its broadest sense. In an article of this length no attempt will be made to deal exhaustively with the many applications but rather to select a few of the most important, especially that section of the subject which makes use of secondary emission and electron optics. There is no "order of merit" for obviously that will vary according to which branch of engineering is most concerned, but there are certain fundamental principles common to all and these will be dealt with briefly in case readers may have forgotten them.

Processes Involved

The various forms of electron tubes in which the motion of electrons moving from one area to another is controlled by some specified method, are really energy convertors. The thermionic valve, photo-electric cell, electron camera, gas discharge lamp, X-ray tube, mercury arc rectifier, and so on are but a few examples of those in everyday use; devices which have really become so commonplace that they are often not recognised as electronic engineering equipment. In ordinary circumstances, when a current of electricity is made to flow, the electrons have their movement confined to fixed conductors, but under special conditions energy can be imparted to free them, and these free electrons then become capable of carrying out other work. Certain known substances when heated release electrons, photo-sensitive surfaces release electrons under the influence of light, electronic bombardment of a surface can cause secondary emission, ionisation produces free electrons from gases, and once set free it is necessary to exert an electrostatic or electro-magnetic control according to requirements.

Cell Limitations

One of the earliest forms of electronic energy convertors to be used scientifically was the photo-electric cell, and the engineering applications of this device have extended enormously. The incidence of light on a cathode enclosed in a glass container either evacuated or partly filled with gas according to the purpose to which it is to be applied, causes electrons (minute particles of negatively charged electricity) to be released from the surface and these are attracted towards and collected by an anode which has applied to it a positive potential with reference to the cathode. The degree of emission is dependent upon the quantity of light to which the cathode is exposed and this photo-electric principle has made possible many modern developments, particularly television. The limitations of this device are associated with its varying sensitivity according to the colour of the activating light and also its relative insensitiveness to small quantities of light, 30-50 microamps per lumen being an average figure. In the case of the former, continued research is being applied to develop types of surfaces which are applicable to the infra red or ultra violet ends of the spectrum, while certain forms of cæsium combinations have furnished a colour response which closely resembles that of the human eye and in this way, at least in so far as television is concerned, there is a better monochromatic rendering of coloured objects.

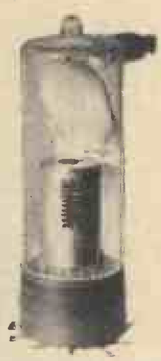
Sensitivity Improvements

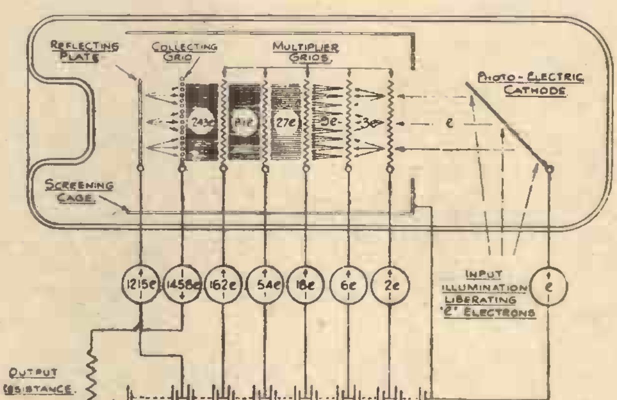
To obtain an increased output signal under certain light activation conditions, one of the first methods used was to increase the size of the cell. This was carried to very wide limits and as an example of what could be done in this connection reference can be made to Fig. 1 which illustrates a cell considerably over 1 ft. in diameter. Difficulties were still encountered, however, and it was the harnessing of the principles of secondary emission that brought about such a high gain in efficiency. In simple words, secondary emission merely implies the process which takes place when an electron stream is allowed to strike one or more metallic surfaces which have been specially prepared. Each electron is then capable of displacing from that surface secondary electrons varying in number from 1 to 10 and if this effect is made cumulative it is easy to see that the final current produced is increased enormously when compared with the magnitude of the initial electron stream.

These secondary emission multipliers can be made up in a variety of ways. In some cases the electrons are made to reciprocate between two parallel faces and at each impact secondary electrons are released which join the main stream and so ultimately builds up a large current which is passed to the output circuit. Successive impacts directed against separate surfaces produce the same cumulative result, while in yet another form the electrons are guided to pass through mesh grids where the secondary emission multiplication is of the order of three times per stage.

An Example

As an indication of this last named scheme being put into actual practice, reference can be made to Fig. 2 which shows an early form of a compact multiplier photo-electric cell. The individual multi-





Figs. 2 and 3.—(Left) An early form of multiplier photo-cell showing the cathode surface and multiplier cage. (Right) An explanatory diagram showing the stage by stage multiplication of electrons which result ultimately in a very large output signal

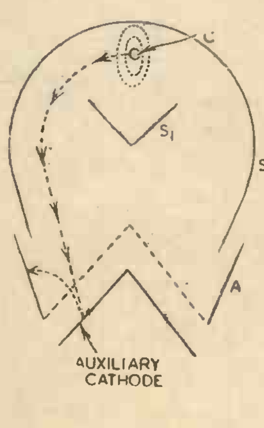


Fig. 4.—The electron stream path and electronic arrangement of a secondary emissive thermionic valve

Aspects of Engineering

Chapple, B.Sc., etc.

Work, the Physicist has Shown the Engineer that Material Studies the Subject of Electronics in its Broadest Sense

plier grid stages are accommodated in the tubular metal shield shown with its bar window at the base of the cell. In Fig. 3 is a simple explanatory diagram which traces quite clearly how with five multiplier grids and one reflecting plate a single primary electron becomes 1458 electrons flowing into the output circuit resistance. The potential applied to each stage is stepped up, and assuming that "e" electrons are released from the photo-electric cathode by the incidence of a beam of light, each grid stage produces a triple multiplication. After the fifth multiplier grid, each of which has a fine mesh texture, an accelerating voltage drives the stream through the wide meshed collecting grid so as to strike the reflecting plate, where the average multiplication is 6. The total electrons released by this final action are collected as shown and so cause a magnified current to flow through the output resistance.

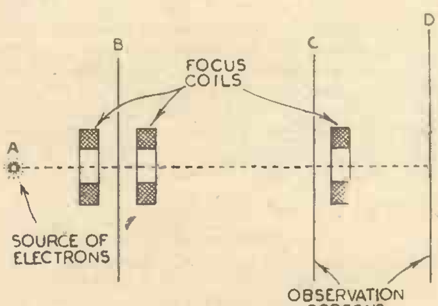


Fig. 7.—A simplified optical arrangement of a modern electron microscope

All the different forms of secondary emissive multipliers have found application in various types of modern electronic equipment and many important advantages accrue when compared with the previous orthodox methods of valve amplifiers. Among these mention can be made of the absence of microphony, extreme stability over long periods of time, a greatly improved signal to noise ratio, and the maintenance of high gains over a very wide frequency range (up to more than 10 megacycles, if required).

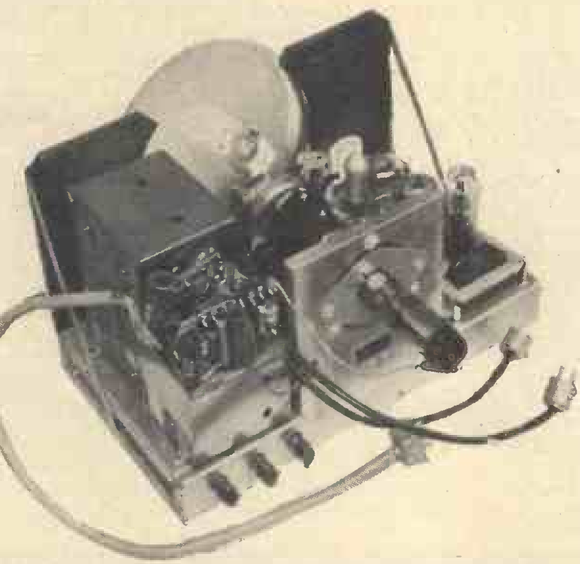


Fig. 6.—The marked improvement on the design in Fig. 5 brought about by using one diode and three secondary emission valves

Thermionic Valves and Secondary Emission

For a long time it was found impossible to harness this important principle of secondary emission in a direct manner with thermionic valves, but now even this difficulty has been overcome and there are now on the market valves which give very high mutual conductances by making a distinct departure from ordinary valve practice. The original TSE4 Philips Mullard valve now superseded by the EE50 is a case in point. Shorn of all the intricate constructional details, the method of operation becomes quite simple as can be seen by referring to Fig. 4. Electrons are emitted from the valve cathode C, are controlled or modulated by the first grid and after passing through the auxiliary grid are made to follow the dotted path shown, by the combined action of the two screens S1 and S2. These electrons pass through an open meshed anode, strike the auxiliary cathode which has been made secondary emissive, and the resulting amplified electron stream is collected by the anode A, which is really a continuation of the open meshed anode.

By this single stage of multiplication the effective gain is three and it might well be asked if this improvement in valve technique can be put to practical advantage. The answer is in the affirmative as can be proved by referring to Figs. 5 and 6 which illustrates a two year advance in television

Fig. 5.—The vision chassis of this set occupies the whole width of the middle shelf and embodies eight valves

receiving design. The vision chassis occupying the whole width of the cabinet on the middle shelf of Fig. 5 used six high gain pentode valves, a diode and triode, while the sensitivity was of the order of $\frac{1}{4}$ millivolt and a band width of approximately 2 megacycles. While this design and layout gave good results, a reference to Fig. 6 shows the marked change brought about by the use of secondary emission valves of the TSE4 class. The whole unit comprises time base generator on the extreme right, cathode-ray tube with deflecting and focusing system in the centre, and vision chassis on the left. The last named chassis is far more compact than its Fig. 5 predecessor, uses only three secondary emission valves and a diode, and provides increased gain and band width, higher stability and improved sensitivity. This single example will serve to show how quickly an electronic advance is incorporated in commercial equipment to the advantage of designer and purchaser alike.

An Electron Microscope

The principle of operation of an ordinary optical microscope is no doubt familiar to most readers but in practice, since light is used, there is a limit to the degree of

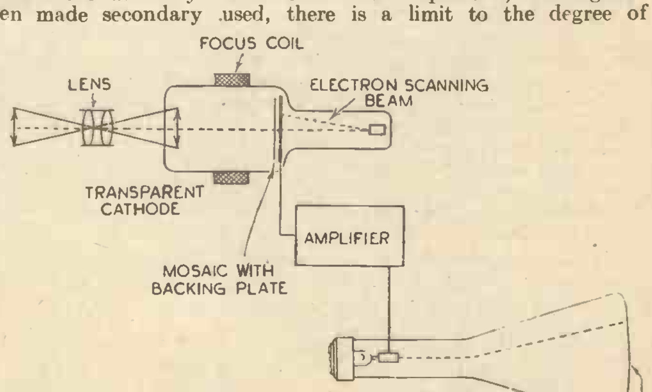


Fig. 8.—A pictorial example of the application of electronics to produce a scientific instrument

magnification which can be achieved for investigation purposes. It is for this reason that the subject of electronics has come to the fore within the last two or three years and it has been established that magnifications up to at least 100,000 times have been achieved, which of course is far in excess of anything undertaken optically. The bare details of such a device are shown in Fig. 7. On the left at the point A is a cathode providing a source of electrons and these are accelerated towards and focused down to a minute point on the slide carrier B. The object undergoing observation, often some form of extremely minute bacteria—is held in place on this slide by a very thin collodion film and the image is produced initially on the observation screen shown at C. This can be either a fluorescent screen or photographic plate as desired, but if further magnification is required then the final observation is undertaken at D. A combination of electron lenses provided by electrostatic and electro-magnetic means in conjunction with extremely high voltages (these sometimes reach 100,000 volts) makes this device an instrument of immense value for bacteriological investigation, and equipment has been built both on the continent and in the United States using these electronic principles.

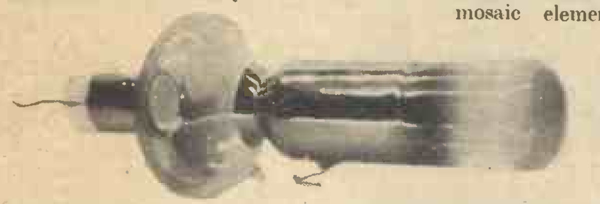


Fig. 9.—An actual example of an image-convertor tube using an opaque concave shaped cathode

Other Electronic Instruments

In a much simpler form the same idea is used for investigating the cathode emission of a cathode-ray tube. It is just a case of producing an enlarged image of the cathode surface on the fluorescent screen and for this purpose an electro-magnetic tube has a positive potential applied to the modulator electrode—something of the order of 200 volts depending on the voltage normally used for the anode itself. The modulator and anode used in this way provide an electrostatic lens system and if this is used in conjunction with the focusing coil, which is of course and electro-magnetic lens, by careful adjustment a greatly enlarged image of the cathode surface is seen on the fluorescent screen. The variation of emission over the cathode may then be studied and the necessary steps taken to improve this so that the tube when used for ordinary commercial purposes will give a much better performance.

Yet another scientific electronic instrument which has been used successfully is shown in elementary form in Fig. 8. Here the object to be examined is optically focused on to an electron tube having a transparent photo-sensitive cathode. This produces an electron image such that the electron density at every point is directly proportional to the light and shade of the optical picture distributed over the whole surface. This electron image is then attracted towards and focused on to a mosaic element screen which can be scanned by a beam of electrons to produce signal currents on a backing gauze. These are amplified and passed to the modulator electrode of a standard cathode-ray tube and by using the usual focusing and deflecting system a magnified and bright visible image of the original object is seen on the tube's fluorescent screen.

Image Convertor Tubes

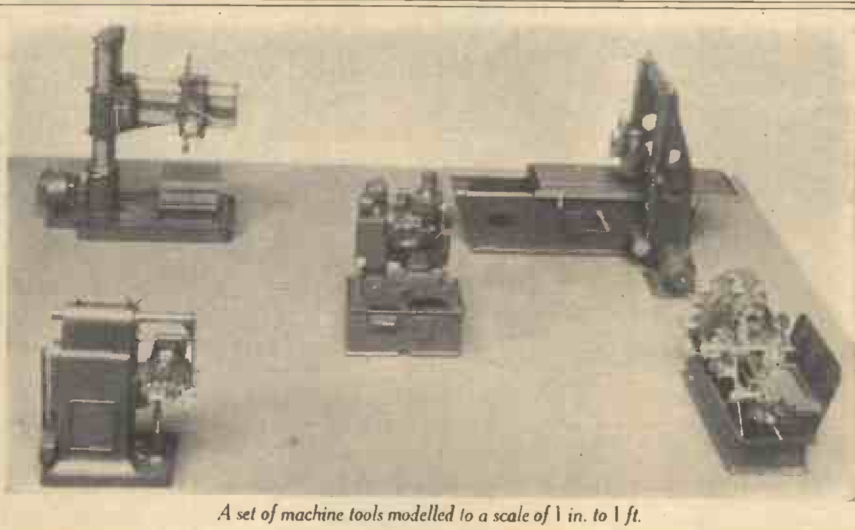
Another useful piece of apparatus which is based entirely on the principles of electron optics is the image-convertor tube which has its most important application in the infra red end of the spectrum. A small practical example of this device is illustrated in Fig. 9 and in the spherical glass section will be seen a disc cathode. This is provided with a uniform coating of photo-electric material, while the surface is made slightly concave to prevent any form of pin cushion distortion in the final observed picture. The picture undergoing observation is optically projected through the thin glass spherical wall on to the opaque photo sensitive surface. This produces the familiar form of electron image as was the case of the device described for Fig. 8 and by means of the metallised coating, to which is applied a positive potential and a cylindrical focusing coil placed round the neck of the tube, a bright visible image appears on the fluorescent coating applied internally to the glass wall at the right hand end of the tube. No scanning is necessary, the device being a straightforward convertor of an optical image into a visible electron image which can be magnified and observed section by section by adjusting the current passing through the focusing coil. If the photo-sensitive surface is made responsive to infra red rays, then an apparently invisible optical image projected on to this surface becomes completely visible on the tube's fluorescent screen as a sharp, bright picture. This infra red ray investigation is important when, say, living bacteria need to be examined which would be damaged if subjected to visible light rays and its value in the medical world has already been made manifest.

A somewhat similar tube but capable of providing a larger picture and using a transparent cathode in lieu of an opaque one is shown in Fig. 10. On the right is the optical projector apparatus and at the end of the tube neck is the transparent photo-electric cathode on to which the picture to be observed is focused. A large solenoidal coil provides the electro-magnetic electron lens and this in conjunction with the high potential anode connected to the terminal on the conical section of the tube is all the equipment required for this ingenious but relatively simple piece of electronic apparatus.

Fig. 10.—An image-convertor tube with a transparent cathode set up for scientific examination

Tools in Miniature

Modern machine tools have a special interest in these days of mass-production on work of national importance—munitions, aircraft components, guns, gauges and other engineering products. Here is an attractive set of machine tools modelled to a scale of 1 inch to 1 foot and built specially to order. The model represents a workshop fitted up in the modern style with electric power transmission for each individual model. Each of these machines was hand-made to scale and several were working replicas of their prototypes. They were constructed mainly from brass and brass castings and of the models illustrated the bed planing machine and the capstan lathe were working models, driven from a shaft as with the "real thing." Among other models you will recognise are the radial drilling machine, Drummond gear cutter and milling machine.



A set of machine tools modelled to a scale of 1 in. to 1 ft.

TOOLMAKING AND TOOL DESIGN—6.

The Principles and Methods of Making Press Tools, Jigs, Gauges and Fixtures

By W. H. DELLER

ALTHOUGH what has been written so far on the subject of drilling jigs by no means exhausts the subject, the writer is of the opinion that sufficient has been said to enable the reader to have an accurate outline of the principles of design suitable for handling work of a general character.

Each individual job will, of course, be considered on its merits from the point of the actual design of the jig, and once the elementary requirements are fully understood the designing offers abundant opportunities in many cases for the inclusion of "snappy" ideas where warranted. This being so, simplicity should be the keynote, however, and the jig should not emerge as a device bristling with "clever" parts costly to make and no more efficient than something a lot simpler.

Fixtures

The term jig is one that is often erroneously applied to a fixture. As stated earlier a fixture is purely and simply a work-holding device not equipped with cutter guides. When intended for use on a machine-tool table or lathe face-plate the base of the fixture is provided with a key, or keys, or a circular register so that it can be accurately disposed on the machine without prior indication or measurement, therefore the fixture is merely bolted down each time it is used.

Fixtures are also employed for certain assembly operations, but in these circumstances the point just mentioned does not apply.

Various types of work where fixtures may be profitably employed for the purpose of carrying out the operations indicated are illustrated in Figs. 30 to 35. That shown in Fig. 30 is a turning job which has been machined at a previous operation consisting of turning a male register and facing the flange at the bottom. The next operation calling for a fixture is that of turning and screwing the male thread, facing the flange and undercutting the thread. The requirements are, that the faces of the flanges shall lie at 90 degrees with each other and that the centre of the screwed nose shall be at a pre-determined distance from the face of the bottom flange. In passing, mention is made of the fact that the same type of fixture which will be described would suffice if the angle between the faces is other than that mentioned. Where this is so, it follows that the portion of the fixture on which the work is mounted will lie at an acute angle in relation to the surface of the face plate.

Previous Articles in this Series appeared in Nos, 61, 63, 64, 65 and 67

Milled Work

Examples of simple milling operations are seen in Figs. 31 and 32. The first one would be milled with a gang of three cutters from the solid. The domed portion is "formed"

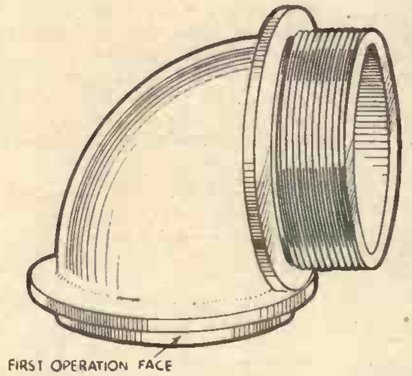
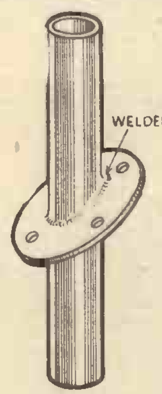
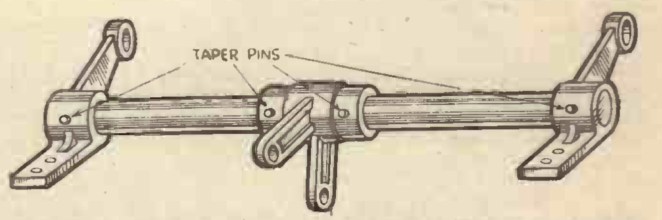


Fig. 30.—A turning job which has been machined at a previous operation

in the turning operation. In the second example the parts are turned from square bar material, the slot is then milled at one operation and the radius at the end of the fork at another. Both of these examples should be held by the shank while the



Figs. 34 and 35 (Left).—An assembly job and (right) An assembly job of a different type



operations were being performed and dealt with singly or in gangs of six or more at one pass of the cutters.

A broaching job is seen in Fig. 33. Here the requirements are that the splines are correctly positioned in relation to the hole in the small boss. In this instance the broaching would be done after the boring, facing and drilling operations, the lever being positioned in relation to the broach teeth by means of a peg or pin passing through the hole in the smaller boss.

The assembly job illustrated in Fig. 34 consists of a flange attached to a tube by means of welding. Here the washer would be held in correct relationship with the ends of the tube and at the desired angle while being "tacked" at several points. The welding operation proper would be completed with the work removed from the fixture. This practice should not be taken as a general rule for other types of work might require to be more rigidly held than is necessary in this instance. Where this occurs allowance has to be made in the clamping arrangements for expansion and subsequent contraction.

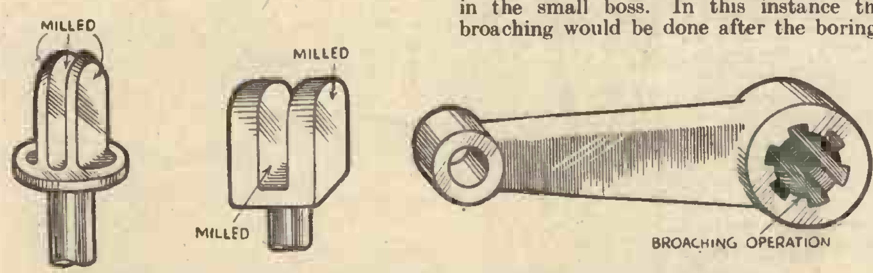
Assembly Fixtures

Many light assembly jobs are greatly expedited by the employment of fixtures which are thus beneficial even where close accuracy of the finished product is comparatively unimportant, but where close accuracy is demanded the use of a fixture for the purpose is practically a necessity.

Jobs of this nature may consist of the assembly of several pressings by means of rivets or spot welding. Smaller parts of the same nature might be joined together by eyelets or hollow rivets. Holes in parts thus joined would for ease of manipulation be relatively large in relation to the diameter of the rivet or other means of fixing. Therefore no reliance could be placed on the use of the rivets for the purpose of initially lining up the several components. An assembly job of a different type is shown in Fig. 35. Here the end brackets are attached to the shaft or tube by means of taper pins and the bell-crank lever in the centre is free to rotate between a pair of collars similarly fixed. The essential features of this assembly are that the feet of the brackets shall lie in one plane at a distance apart to correctly maintain the requisite centre distance between the fixing holes. Equally important is the disposition of the lever. Therefore even if the assembly consists of placing the parts in position and taper reaming the holes, the brackets require to be fixed down in their correct positions and the lever also placed, before so doing and driving home the pins. It is only by taking these precautions even with so simple a job that constant results will be obtainable.

Handling Milling

Reverting to the question of milling, the type of work shown in Fig. 31 presents no difficulty as in this particular example the surfaces to be formed are lying in one plane. In the second example, however, the track of the machining is in two directions at right angles with each other. This means



Figs. 31 to 33 (Left to Right).—Two examples of simple milling operations and a broaching job either locating from the slot, or from the square sides, to bring the work into correct relation with the concave cutter which forms the radius.

Where the milling operation consists of forming a square, or other head of similar balanced section, such as may be formed by a pair of cutters, the point to be decided if gang milling is to be adopted, is whether the work shall be partially rotated mechanically between each pass of the cutters to bring about the desired result, or to otherwise achieve the purpose by re-locating the parts after the completion of each cut. The partial rotation of each part, arranged in line, simultaneously will invariably mean the incorporation of gearing for the purpose. This point, coupled with the fact that collett type of work-holders would most likely then be necessary, leads to the conclusion that such a scheme will be one that will be costly to produce, but this will not prove a disadvantage where the outlay can be spread over a considerable quantity of parts. It might be that the fixture would prove, with the provision of different sized shank-adapters or collets, suitable for the production of a range of similar parts. In this case the expense would be also warranted. An alternative arrangement is to have a fixture that is capable of being indexed about a base and upon which the components are arranged in such a manner, on the rotatable portion, of course, as to permit their being machined in several lines at once by means of a gang of suitably spaced cutters. After one pass of the cutters the fixture is swung round to bring the unmachined portions in line with the cutters. This is a scheme which is much simpler to carry out, but is one which, for obvious reasons, is unsuited for parts having long "shanked" portions below the milled surfaces.

Items having tapped holes in them could naturally be handled in a similar manner by the provision of suitable mounting adapters.

While dealing with this class of milled work mention should be made of the fact that there is a special horizontal type of milling machine that was developed for machining parts of a "special headed bolt" nature. The milling is carried out on the continuous principle and the fixture employed is really a portion of the machine. Briefly, the work pieces, held by the shanks, are passed through the cutters by a rotary motion imparted to the fixture. After the work has passed the cutters it drops from the fixtures and fresh work is inserted as the empty "stations" reach the loading position. A rough picture of how this is done can be obtained by imagining the fixture as a pair of bevel wheels mounted side by side with their teeth facing. The axes of the gear shafts are arranged at such an angle as to bring the tops of the teeth together more or less at the point nearest to the cutters. The work is fed between the teeth at the "open" side and is carried round to the cutters by which time it is gripped in rolling contact with the flanks of the teeth. After the cutters are passed, the receding teeth of the gears will permit the work to fall out down a chute. Actually, specially contoured plates are used in substitution for the gears. It will at once be apparent that slots thus produced will not be "flat bottomed" but will be concave to the extent of the radius from the centre of the fixture to the face of the cutter. This fact is one that does not prove objectionable on many classes of work.

THIS MONTH IN THE WORLD OF

SCIENCE AND INVENTION

Steered by Television "Eye"

MR. U. A. SANABRIA, a Chicago scientist, chief of staff of the American Television Institute, has supplied to the U.S. War Department plans for an aerial torpedo steered with a television "eye."

A television transmitter is enclosed in the nose of the machine which televises the scene below the torpedo to a screen in the controlling plane. This formidable machine is described as "so explosive that it could destroy even a large battleship." The inventor states that the torpedo is a small streamlined aeroplane controlled by a large aeroplane from as far away as 100 miles.

World's Biggest Water Main

WHAT is stated to be the largest water main in the world has just been completed in Southern California. It is 242 miles long and big enough to drive a car through most of the way. The system will supply thirteen cities with 1,000,000,000 gallons of water a day.

New Torpedo Boat

A NEW torpedo boat capable of cruising at 22 knots for more than 1,000 miles and safe from both mines and torpedos was recently described by Mr. Hubert Scott-Paine, the speedboat designer.

More than £200,000 has been spent in research and construction of the boat and it has been presented to the British Navy. The boat has a draught of only 3 ft., and can carry a crew of eight. It has a top speed of 40 knots and carries four 18 in. torpedoes.

New Road Lighting

A NEW type of neon light is being tried out in Poplar which is invisible from the air. It shows a blue light to drivers when on their right side of the road, and a red light if they swerve to the offside.

Collapsible Dinghies

AIRCRAFT patrolling the North Sea are fitted with special equipment for safeguarding the crew in the event of the plane having to make a forced landing in the sea. It consists of a collapsible rubber dinghy which is carried in such a position on the plane that it can easily float free after being automatically inflated from a cylinder of compressed gas. The releasing mechanism is actuated by sea water flowing into an inlet pipe as soon as the plane alights on the water. In this way the crew have a means of keeping afloat until they are picked up.

New Steerable Parachute

ANYONE who has ever jumped out of a plane and taken the bumps of Terra Firma as his parachute dragged him over the rough spots will appreciate this new steerable parachute which is shown on this page, being demonstrated by Raymond Morders of Lancaster, PA., U.S.A. Air, instead of spilling out around the edges as in regulation parachutes, flows out two vents in the rear of the parachute. The operator may swing around by pulling a shroud line and closing one of the vents.

A Kerb Detector

BECAUSE he was continually scraping his wings and tyres on the kerb, a watchmaker of Rochester, New York, has invented a device which lights a tiny red lamp on the instrument board when the car gets too close to any object. The most important part of the device is a delicate coiled spring which closes an electric circuit and lights the lamp when the car edges towards the kerb.

Mechanical Bird-Man

A Continental inventor has produced a flying machine that can be strapped to the body. It is powered by a two-cylinder engine and is controlled by two hand levers. The feet are placed on a special framework and the machine has a foot-controlled rudder.

The parachutist holding out his hand for a left turn

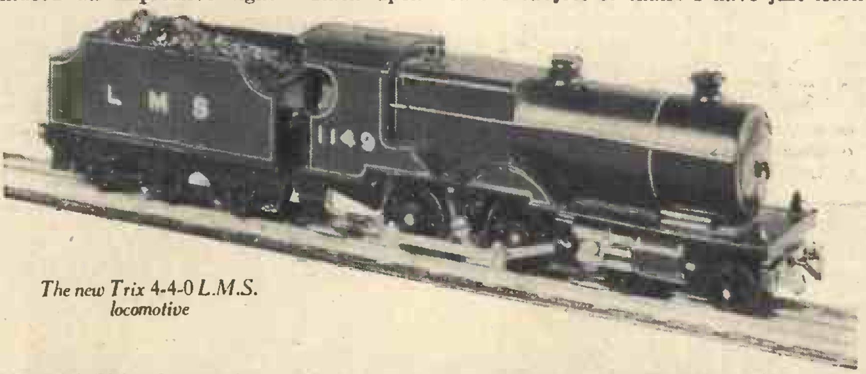
"MOTILUS" PEEPS INTO THE MODEL WORLD

Well, Model Fans, this Month we Celebrate the Anniversary of "Motilus" who joined us in January Last Year. Despite the Black-Out our Model Fan, with his Camera and his Torch, has been Prowling About, and has Found out that Though Shops in London and the Provinces may Look Dead from the Outside in Black-Out Time, INSIDE they are Hives of Industry!

A salesman explaining the merits of a model road tractor

Trix Railway

A HAPPY New Year to you, readers, and here's hoping you are all keeping your spirits up! Your model spy has not only visited shops in London and the provinces, with their cheerful Christmas displays, but has also been conducted round factories devoted to model making. He had the opportunity of seeing units of the Trix railway being produced in bulk and it was indeed an impressive sight. Rack upon rack of Trix locomotive casings—goods locos, passenger locos and accurate little scale model trains—drying in all their pristine glory in the special "ovens" for this purpose. Huge power presses blanking and piercing the small units for rails, wagons, tenders, coaches—the finished units, hundreds at a time, being assembled neatly—as for instance the bogie and wheels on a truck—the mechanism in an engine! It all appeared most efficient to me and I thought of the lucky boys these holidays who would be running them round their tracks. While I was there I saw the new 4-4-0 L.M.S. and L.N.E.R. locomotives in an advanced stage of construction and the illustration shows you the finished L.M.S. locomotive. A smart little job don't you think? And not expensive—two guineas!



The new Trix 4-4-0 L.M.S. locomotive

Permanent Way

Many model enthusiasts I know use many hours of their Christmas holidays in re-arranging or adding to their track. The laying of permanent way is quite often a job the model engineer likes to do himself, but for an exhibition layout it is a task for a scale track worker. My picture shows one laying a left-hand turnout in scale model permanent way with scale spacing of sleepers and keyed chairs—and by the way while on the subject of chairs I have just learnt that Basset-Lowke are now making a new slide-on chair with cast key at the same price, 1s. 4d. per hundred, as their die-cast keyless chair. They have also introduced a slightly heavier pattern with the cast key, and chemically coloured at 1s. 9d. per 100. I examined samples of these new chairs and they are a good fit on the standard section steel rail.

Laying a left-hand turn out on scale model permanent way

Road Tractor

My tour of London's toy shops has shown me that despite the loss of population to provincial centres they did a brisk festive season trade, also that working models were still in the front rank of popular hobbies. Here I caught a technical salesman explaining the merits of a road tractor—actually a brother model to that described by Mr. F. J. Camm not so long ago in these pages, while high upon a special stand was a 7¼-inch gauge "Royal Scot," and looking at this first-class engineering job so accurately modelled, I felt a twinge of jealousy at the person or persons unknown who would own this monster model on their garden railway. When I become a wealthy magnate(!)—hope springs eternal you know—that is the gauge I'll go in for—just large enough to haul twenty persons and with a good run for a quarter mile of track and 40 ft. radius curves.

Repairing Models

I'm afraid if the present state of my railway is anything to go by, it will soon require the services of a model hospital. I am initiating a young nephew into the mysteries of gauge "O" locomotives, but he is unfortunately at the stage of pouring sand in the mechanism! Model railway dealers take into account such imps of mischief and practically every one has a repair department. Some firms like Bassett-Lowke, Ltd., undertake repairs on every type and make of locomotive whether clockwork, electric or steam, low or high pressure. Others like Messrs. Trix, Ltd., have a specialised service for dealing with their own repairs. The man in charge of a repair department seems to me to need varied and unique knowledge of the idiosyncrasies of small models, and like a doctor, must

A model torpedo boat destroyer

know where to look for the trouble, but—and here he differs from the physician—he can often reach down a spare part from the shelf to replace a broken or damaged limb. Testing tracks are an essential part of the "model hospital" where after overhaul the patient can be put through his paces and then officially discharged! Those readers who have models they prize and who cannot carry out their own repairs should not trust them to some local garage or a friend who is a good mechanic. Like a motor car or a radio set they need specialised repair and should be sent to a firm of repute. My picture shows a Bassett-Lowke craftsman resetting the valves of a steam Mogul locomotive.

Models of Rooms

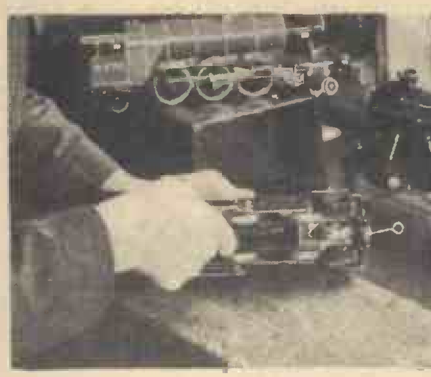
When gazing at the interiors of those exquisite models of rooms you sometimes see at exhibitions, I have often been struck with the realism of the work on the ceilings, and the other day a friend of mine asked me how this work was done. Well, here is the secret. The ceiling is placed upside down and worked upon and completed in this position before it becomes a fixture the right way up. What a joy it would be to

Modelling a room interior

decorators and designers to-day if they could get at their work in this way instead of the back-aching job of doing the work *in situ*. There is no need to give politicians this idea. They have already turned Europe upside down!

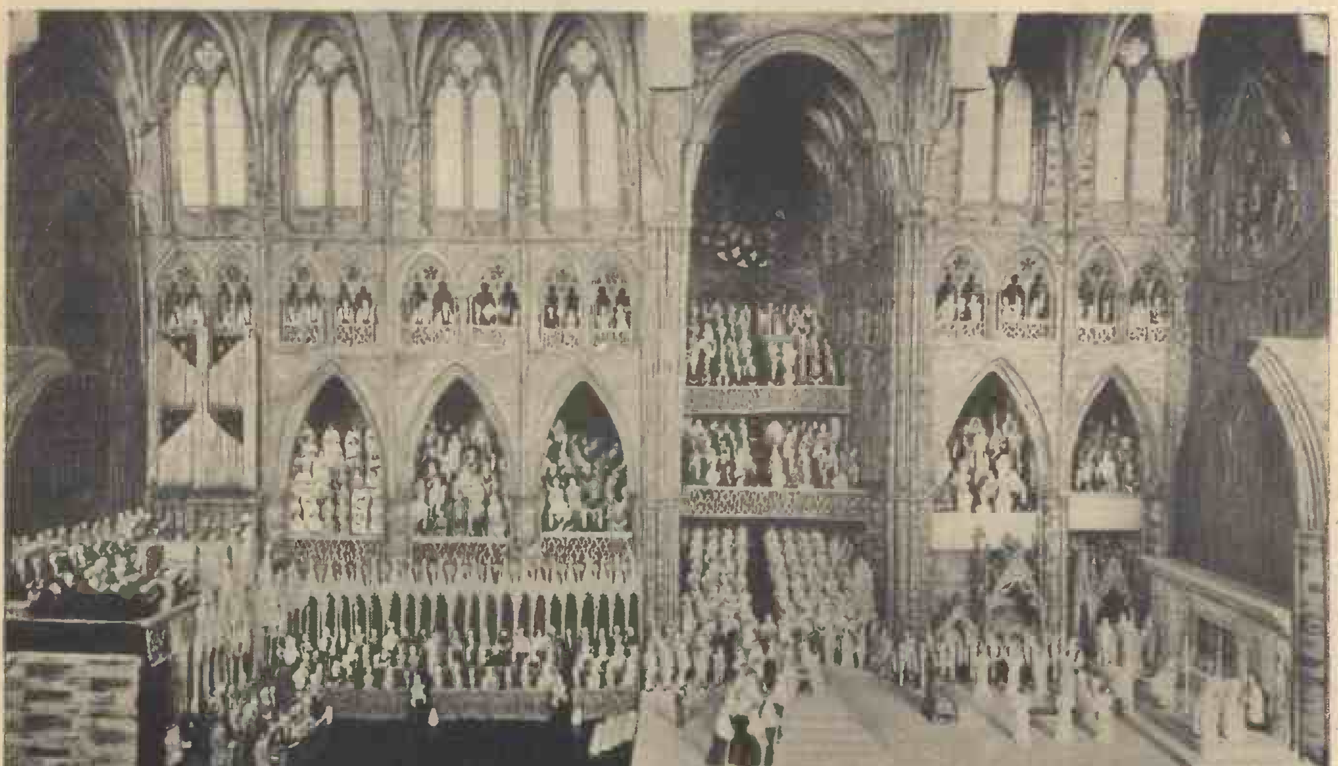
Torpedo Boat Destroyer

Particularly topical at the moment is the new set of parts brought out for making a model torpedo boat destroyer. The length of the boat is 30 in., the decks are roughly cut to shape, the motor and stern tube are fitted and the hull is bored to take the



Resetting the valves of a steam mogul locomotive

rudder. Among fittings included are rudder, anchors, QF guns, ventilators, bollards, fairleads, mast, davits, lifeboats, torpedo tube, as well as steering wheel and standard and the smart little engine room telegraph. These varied fittings can be disposed about the decks at the discretion of the owner, who can also, if he is keen on trying out her paces, experiment with her electric propulsion. The motor can be wired in various ways with flash lamp batteries. For instance, he can obtain a longer run by series winding, or a slightly higher speed by parallel wiring, though in this case he must beware of overloading the motor, which is only constructed to take 4 to 6 volts. The set of parts is not expensive at 50s.



A magnificent model of the Coronation assembly of our present King

A SMALL STEAM BOILER

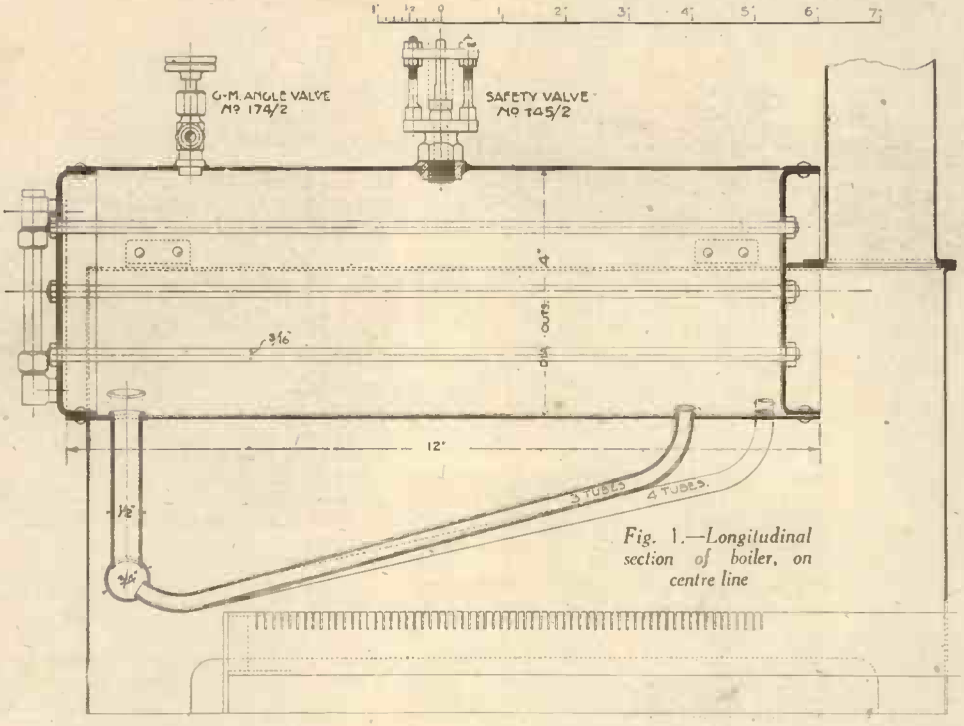


Fig. 1.—Longitudinal section of boiler, on centre line

The Steam Generator Described Below will be Found Suitable for Driving the Steam Engine Described in the November Issue

By E. W. Twining

THE article published in our November issue concerned an original design for a single-acting horizontal model steam engine, but, unless such a model is required to be kept solely for spectacular reasons, in a showcase or as a table ornament, alone it is of no practical use. In order to complete it and to drive it, a boiler, or, to give it its proper name, a steam generator is required.

As the engine was intended to be an example of model-making suitable for the beginner, I think it desirable that the making of the boiler should be a job which is also well within his capacity. To this end I have made both the design and construction as simple, or nearly as simple, as they could well be, consistent with good and quick steaming capabilities.

A plain cylindrical shell or drum boiler with a fire beneath it would perhaps be somewhat easier to make, but it would be more uneconomical in fuel and certainly would not generate steam at the rate called for by the engine. By the way, I should state that the boiler which I have shown in the drawings illustrating the present article is intended to drive the larger of the two engines, i.e. the one having the 2 in. by 1½ in. cylinder.

Small Engine

For the small engine a smaller barrel tube of, say, 2½ in. diameter by about 8 in. long can be used, with three or perhaps four simple water tubes. These tubes can each enter the boiler shell at both ends, being brought down to a lower level at the front and sloping gradually up towards the chimney end. Other details such as the dimensions of the casing, the chimney, the gas, or alternatively methylated spirit burners, will all be in proportion.

The type of boiler here dealt with follows somewhat on the lines of the famous Babcock and Willcox steam generators; at any rate as regards general proportions and external appearance. To make the resemblance complete, however, the rectangular casing ought to be of brick or something which could be made to look like brickwork. Internally the combination of a shell with large "downcomer" tubes and angularly placed water tubes constitutes a type of model boiler originally designed by Mr. Smithies, a well-known model maker, nearly 40 years ago. It was primarily intended for locomotives, and for simplicity, thermal efficiency and quick steaming qualities has never been beaten.

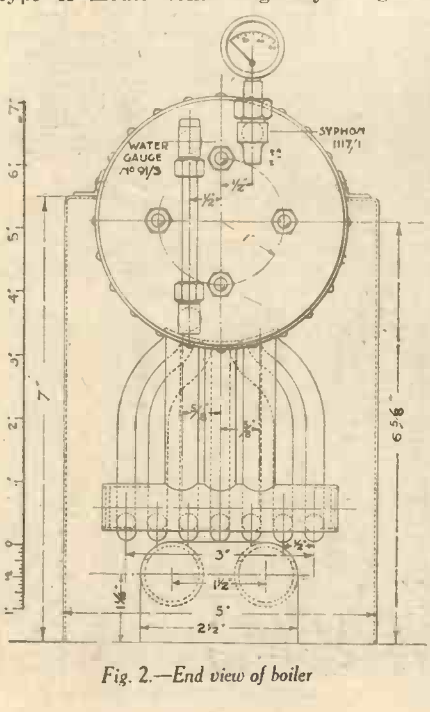


Fig. 2.—End view of boiler

In Fig. 1 is shown a longitudinal section on the centre-line. Fig. 2 an elevation of what I, for convenience, call the front end, and Fig. 3 a plan of the shell and water tubes as viewed from underneath. In Fig. 2 the front plate of the casing is supposed to be removed in order to show the downcomer pipes and cross drum from which the water tubes issue.

Main Barrel

The main barrel should be made from a piece of seamless copper tubing 4 in. in diameter and 12 in. long, having a thickness of not less than $\frac{1}{16}$ inch bare, that is to say about No. 18 gauge. If it should be a full $\frac{1}{16}$ in. it will not matter, but, as we are not going to work at a high pressure, No. 18 will be quite strong enough. If, when buying the tube, one or both ends are not cut off square, the supplier should be asked to give you a sufficient margin over and above the 12 in. to enable you to square the ends.

The flanged end plates, since they will be flat, may very well be a little thicker, say $\frac{1}{16}$ in. full or No. 16 gauge. In cutting these end plates circular allow at least ½ in. for flanging. This flanging is done by beating the metal over the edge of a circular thick plate of steel, a circular cast iron block or a piece of very hard wood. Obviously iron is best and the simplest way to obtain what is necessary will be to turn a wooden pattern and get a casting made at an iron foundry. The pattern can be in any suitable wood; several pieces of plywood to make up a thickness of about ¾ in. will be best of all possible materials. To the back of this a small cube of wood should be glued and nailed, say about 1¼ in. square. This will result in the casting in a boss by which the plate can be held in the vice whilst flanging.

The Four Stays

The outside of each copper plate should be marked out with compasses and a second circle scribed for the lines of the four stays which will pass through the boiler. The inner circle on each plate is divided on its circumference equally into four, centre dotted and drilled $\frac{3}{16}$ in. holes. The two plates had better, perhaps, be clamped together for drilling, both at one time. Cut

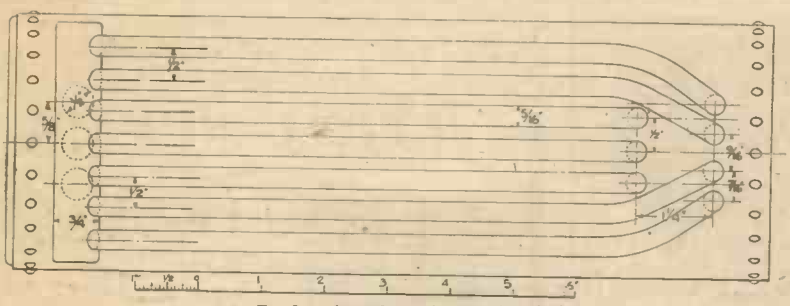


Fig. 3.—An underneath view of the boiler

the two plates circular and then thoroughly anneal by bringing them to a dull red heat and plunging in water.

Now lay one of them truly and centrally on the cast iron flanging block and mark through on to the iron the four holes. Centre dot and drill the iron with the same $\frac{3}{16}$ in. drill. It is now possible, by using four model bolts $\frac{3}{16}$ in. diameter, to clamp one of the plates securely to the iron. Before doing this, however, it will be necessary to check up the diameter of the iron casting so as to ensure that after the plate is flanged it will exactly fit the interior of the boiler barrel tube.

The best thing to do, to make quite certain of this, will be to turn the wooden pattern to a diameter of about $\frac{3}{32}$ in. larger than the inside diameter of the barrel and this amount will allow both for shrinkage of the casting and the machining or filing of the edge.

Obviously the exact diameter will be equal to that of the inside of the barrel less twice the thickness of the plate.

Flanging

Having got the casting right, bolt up one of the plates and commence flanging. Begin by tapping down all round, a little at a time, using a fairly light flat mallet. Assuming that the casting and plate are held in the vice in a horizontal position the blows should be delivered with a dragging action downwards and rather towards the outer edges of the plate.

As the flanging proceeds there will be a tendency for the edges to buckle and the metal to harden. Should it be found that it is becoming stubborn the plate should be removed and re-annealed, after which it will be found more ductile and flanging can probably then be completed.

When both ends are finished the flanges should be cleaned bright with emery cloth and tinned with solder. The inside of the barrel should also be tinned for a distance of $\frac{3}{8}$ in. inwards from the ends. The flanged plate which is to be the front of the boiler can now be drilled and have the collars of the fittings—the water gauge and pressure gauge syphon—soldered in place, and at this stage it may be as well to do the same on the top of the barrel with the safety valve and wheel valve collars. Then insert the plate in the barrel and tack it in two or three places with a large soldering iron.

Riveting the Plate

This plate has now to be riveted. Divide up the circumference as shown in Fig. 2, drill all the holes, clearance size, for $\frac{3}{32}$ in. copper snap-head rivets. These are inserted from the inside held up by a square bar of iron clamped in the vice to form a "dolly," cut off with pliers, if necessary, to the required length and closed over with the ball end of a ball-pane hammer. Each rivet head should be finished off neatly by a cup shaped "snap." This, the front, end of the boiler can be completed by sweating with solder, but it will be best to do this with the large copper soldering iron in combination with a blowpipe. The latter should only be used to assist in raising the temperature of the joint, letting the iron, well supplied with solder follow behind the blowpipe flame. If Baker's fluid is used as a flux well clean the inside of the boiler with soda water before the other end is inserted. This other end will be dealt with exactly as the first.

A great many writers advocate and most skilled model makers adopt brazing or silver-soldering as a means of securing and making joints in boilers such as this, and if it were necessary to work our engine with high pressure steam I would advise this method; but I consider that silver soldering in a boiler of this diameter and thickness of plate is a job somewhat beyond the young beginner's abilities and perhaps beyond his means. It will be obvious that far greater heat is required, silver-solder is expensive and a considerable amount of it would be needed for the whole boiler.

Water Tube Assembly

When we come to the water tube assembly, however, silver soldering could very well be adopted but I do not think it within the scope of this article to tell how such soldering is done.

Many years ago I built a locomotive with a Smithies type boiler, nearly as large as the one we are now dealing with, and every joint including those in the water tubes were soft soldered. I never had the slightest trouble with it. Being always careful never to let water disappear out of the gauge glass I never had a particle of solder melt. If the reader leaves a good heavy fillet of solder at every tube joint they will have plenty of strength.

It will be best to drill, bend and joint the whole of the tubes and down-comer pipes as a separate unit and then insert it in the boiler barrel before the end plates are put in; this will give an opportunity of slightly expanding the tubes and beading them over inside of the shell and at the same time will allow free passage for the holding-up iron, or "dolly," when riveting. The soldering of the water tubes can be done with the iron alone if it is a large one and thoroughly hot. The general arrangement and all bends of the water tubes are shown in Figs. 1 and 3.

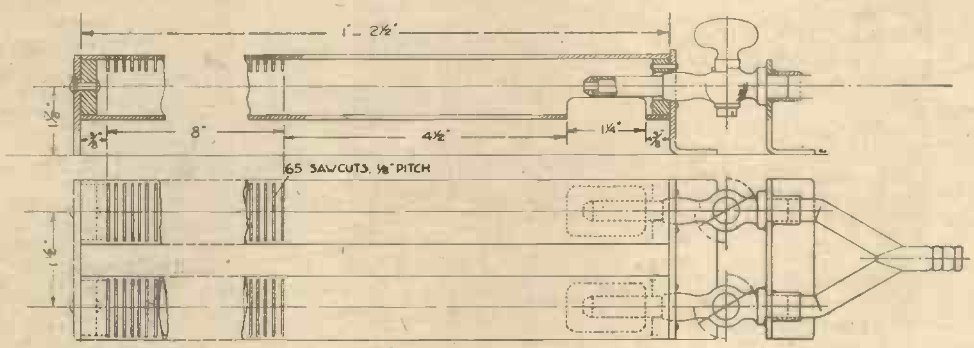


Fig. 4.—Details of the gas burners

The four longitudinal stays are of $\frac{3}{16}$ in. brass rod, screwed at the ends and fitted with nuts. After insertion, and the nuts screwed up, each stay end and its nut are soldered over. The casing enclosing the flames of the firing burners and supporting the boiler is made from any suitable sheet iron jointed where necessary at the corners by bending a flange over and riveting.

The chimney can be of any height which may be found convenient but should be not much less than 12 ins. It can be rolled from sheet metal riveted and flanged at the bottom or made from a length of brass or copper tubing with a separate ring of angle brass riveted at the base.

The adding of the water gauge, pressure gauge, steam wheel-valve and safety valve will complete the boiler. These fittings are all of Bassett-Lowke's make and the code numbers shown on the drawings against each item have been taken from the catalogue of Bassett-Lowke Ltd. The reader will therefore have

(*Continued on page* 191)

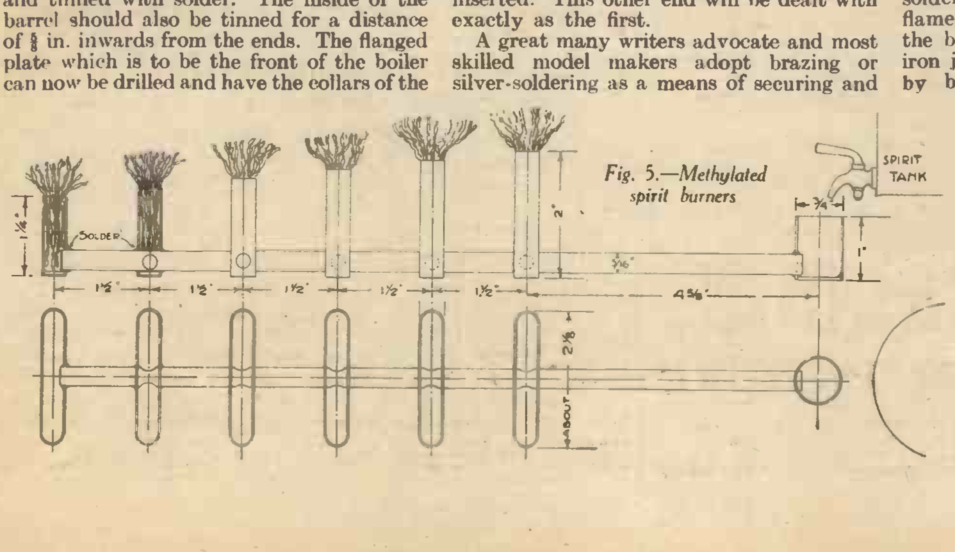


Fig. 5.—Methylated spirit burners

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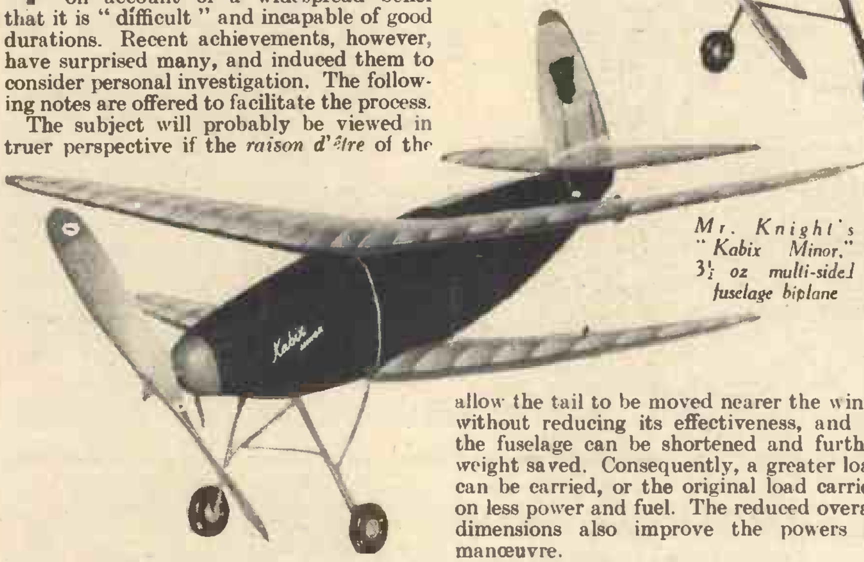
Designing Model Biplanes

A Fascinating Type of Model which has been Neglected in the Belief that it is "Difficult" and Incapable of Duration

Mr. Knight's "Kittihawk" 5 oz. cabin biplane

THE biplane is a fascinating type o model, but it has been sadly neglected on account of a widespread belief that it is "difficult" and incapable of good durations. Recent achievements, however, have surprised many, and induced them to consider personal investigation. The following notes are offered to facilitate the process.

The subject will probably be viewed in truer perspective if the *raison d'être* of the full-scale biplane is first explained. By dividing the required lifting-surface into two wings, and joining them with struts and wires, the efficiency is reduced somewhat, chiefly owing to the increased drag of the extra junction of wing and fuselage. But lighter spars can be used than would be needed to prevent a monoplane wing from flexing. The reduced span and chord allow the tail to be moved nearer the wings without reducing its effectiveness, and so the fuselage can be shortened and further weight saved. Consequently, a greater load can be carried, or the original load carried on less power and fuel. The reduced overall dimensions also improve the powers of manœuvre.



Mr. Knight's "Kabix Minor," 3½ oz multi-sided fuselage biplane

Rubber-Driven Models

These advantages do not apply to the rubber-driven model. Bracing-wires would soon come adrift in the rough-and-tumble of pilotless flying, and without them any appreciable thinning of the spars would result in flimsiness. The fuselage cannot be shortened without shortening the rubber-skein and reducing the duration. As for manœuvrability, this is of no value to the modeller.

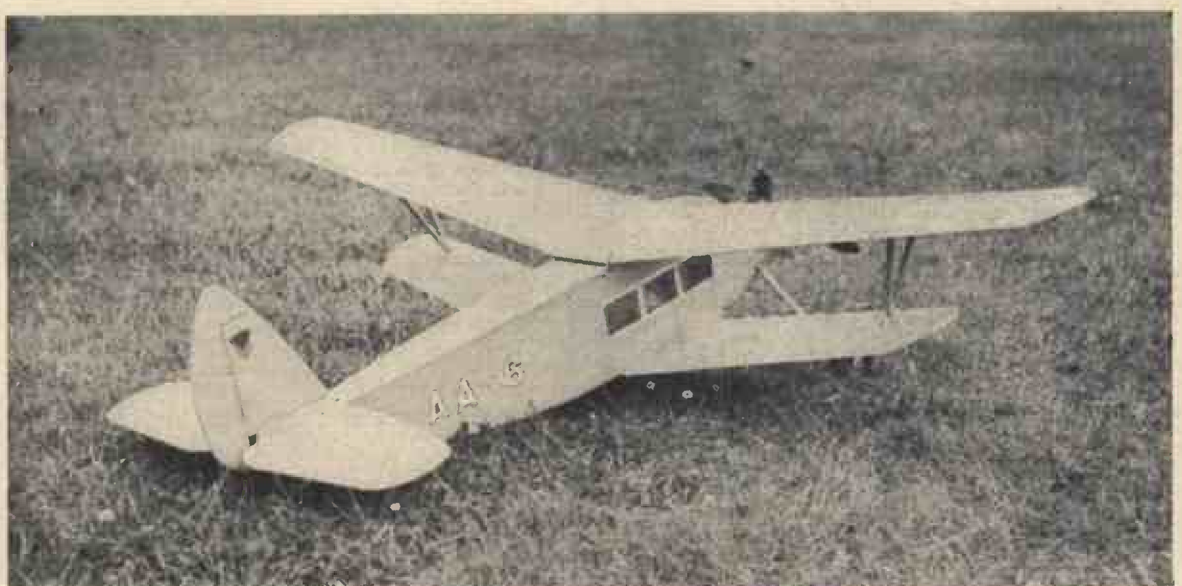
Biplane lay-out, in fact, offers no advantages to the modeller. On the contrary, extra work and care are involved, while the performance tends to be reduced through the extra drag steepening the glide. The sole inducements are the attractive appearance, and—to those who feel that way!—the satisfaction of tackling something out of the commonplace.

But while a biplane model is handicapped when flown in competition with monoplanes, it has shown its ability to soar in thermals, and a biplane holds the British seaplane record of 6 minutes 54 seconds!

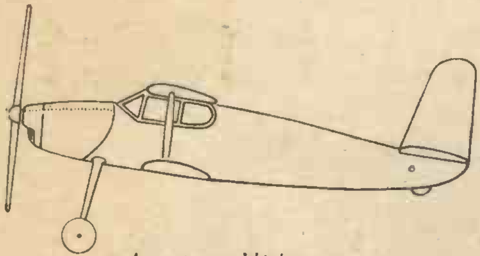
Lay-Out Variations

Numerous variations in lay-out are open to the designer. For instance, the wings can be equal in span, or unequal. (When the area of one is more than twice that of the other, the machine is termed a sesquiplane, and is not eligible for biplane contests.) The upper wing can be mounted directly over the lower, or ahead, or behind. Certain features are helpful, and others detrimental. The scale-modeller may have no choice, but the free-lance designer can select those features which benefit model stability and performance.

By way of example, centre-section struts, supporting the upper-wing above the fuselage, are likely to come off badly



A petrol-engined biplane (9 c.c. "Brown Junior") by Messrs. J. and W. Worden, of The Model Aircraft Club



An unstaggered biplane

(literally !), and it is better to deepen the fuselage sufficiently to fill the gap between the planes, so that the upper plane can rest upon it, and the lower against the lower longerons. If the gap is less than the root chord there may be interference between the air-flow under one wing and above the other.

Cantilever wings, independent of strutting, are an excellent feature. But interplane struts improve the appearance. In the case of Mr. M. R. Knight's "Kabix Minor" each strut plugs into a celluloid tube in the lower plane, and touches the upper plane without actual connection, thus avoiding damage in heavy landings. Another method is adopted in "Kittihawk," each strut consisting of a balsa-faired paper tube, through which passes a rubber-band linking small hooks on upper and lower planes. A hooked wire is employed to thread the band through the tube.

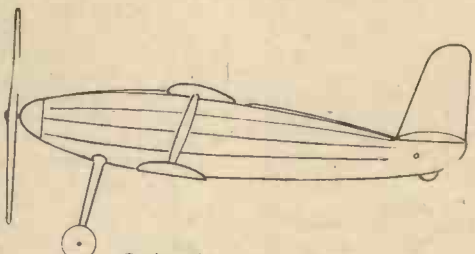
Ideally, the wing-area should be about one-quarter more than for a monoplane, to compensate for reduced efficiency, and the span of at any rate one wing must be sufficient to deal satisfactorily with torque. When the wing-area is restricted by rule, as with Wakefield models, the biplane is handicapped, for one is not making the best use of the permissible area by dividing it into two parts.

F.A.I. rules limit the tail-plane area to 33 per cent. of the wing-area. Despite the greater wing-area of the biplane, the writer has never found it necessary to use a larger tail-plane than for the equivalent monoplane, probably owing to the greater proportionate length of the model fuselage.

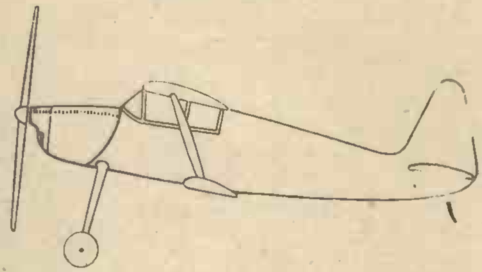
"Backward Stagger"

As to line-up, place the Centre of Gravity midway between the assumed Centre of Pressure of the two planes (33-40 per cent. across the chord), and place the thrust-line on the Centre of Resistance, the approximate position of which can be ascertained by drawing a front elevation and connecting the wing extremities by diagonals, as depicted in the accompanying diagram.

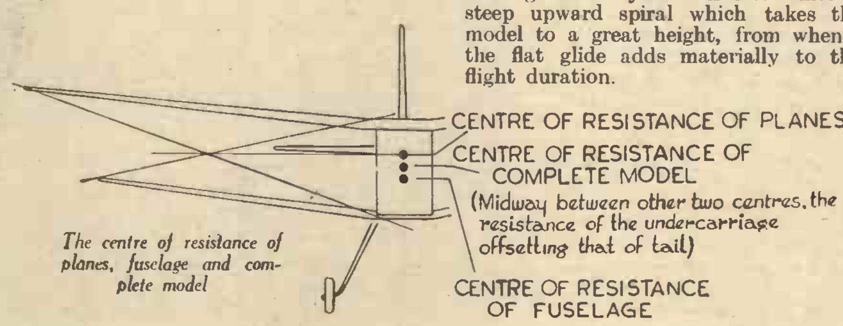
Other line-up items vary according to the type of biplane. It is interesting to note that Mr. F. Rogerson's model with negative or backward stagger (upper plane leading-edge behind lower leading-edge), which won the Canadian Wakefield Cup in 1935, had both wings set at 2 degrees positive to the thrust-line, and the tail-plane parallel with and above the thrust. The upper plane has about 6 degrees of dihedral, and the lower plane none. A slight increase in lower plane incidence, and 2 degrees or more of dihedral might prove advantageous.



Backward or negative stagger



Forward or positive stagger



The centre of resistance of planes, fuselage and complete model

"Unstaggered" Line-Up

When no stagger is employed, mount both wings at 3-3½ degrees positive to the thrust-line, and the tail-plane at about 1-1½ degrees positive. Any stalling tendency can then usually be eradicated by increasing the lower plane incidence. Difference in upper and lower plane incidence is termed "decalage." Use 6 degrees of dihedral on the upper plane, and about 8 degrees on the lower.

"Slot" Line-Up !

When there is an appreciable amount of forward or positive stagger (upper leading-edge ahead of lower leading-edge), the upper plane should have the greater incidence, say 4 degrees to the lower plane's 2 degrees. The lower plane then helps to stabilise the model, and the tail-plane area can be reduced. The upper wing can be given 8 degrees of dihedral, and the lower plane 6 degrees or even less.

Mr. S. R. Crow, who for long held the biplane record with this type, contends that it lends itself to a duration equal to that of the monoplane, or even better. His method is to rely chiefly for lift on a large upper wing of high-lift section, and to use ample power. A tail of lifting-section is mounted parallel with and slightly below the thrust-line. The model is trimmed to turn against the torque, and to have so flat a glide that it tends to stall on power. By the stagger acting as a species of Handley-Page slot (so Mr. Crow suggests) the stalling tendency is converted into a steep upward spiral which takes the model to a great height, from whence the flat glide adds materially to the flight duration.

Skybirds in Wartime

A New Ship Series o Waterline Scale Models

MANY readers will be interested to know that Skybird modelling is more popular than ever, despite the war; in fact, the war has given added interest to this most suitable and appropriate indoor hobby of solid Scale Model Aeroplane construction. What could be more interesting than to occupy both mind and hands assembling and painting models of Britain's air fighters—the "Spitfires," "Hurricanes," "Blenheims," etc.

Skybirds are known to many thousands of keen modellers, and the Skybird League founded some seven years ago has played a very important part in making the youth of this country air-minded. Many hundreds of the League members are now serving their country with credit in the R.A.F. Many letters and personal calls are received at League headquarters from enthusiastic members who have switched from modelling to the real thing. League headquarters report an influx of new members and regret that owing to the need for economy, and the censorship of our information relating to Service machines, the publication of the monthly *Skybird Bulletin* has been temporarily suspended. For the information of modellers, we are pleased to announce that all being well, the seventh annual rally and model competition will take place as usual on or about Easter next. Now is the time to prepare those prize-winning models (newcomers will have their chance now that the past winners are on active service). Particulars of the competition and the models eligible can be had from Skybird League Headquarters, 3 Aldermanbury Avenue, London, E.C.2.

Waterline Models

Ship model enthusiasts will welcome the new ship series of cast Water-Line Scale Models advertised in this issue. These models are marketed at very moderate prices by the manufacturers of the famous Skybird Aeroplane models, and can be relied upon for correctness of detail.

There is a special set of 11 models comprising battleships, cruisers, aircraft carrier and destroyers, scale 150 feet-1 inch, price 4s. There is also a very comprehensive range of practically every ship of the British Navy—scale 100 feet-1 inch.

The prices range from 3d. each in the smaller type submarine, patrol boats, etc., up to 3s. each for battleships and aircraft carriers, and the *Ark Royal* is still with this Fleet. Send stamps 1½d. for price list to A. J. Holladay & Co., Ltd., 3 Aldermanbury Avenue, London, E.C.2.

Blacking Out the Light

By "Handyman"

The Ideal Black-out Scheme is one which is Easy to Erect at Dusk and as Simple to Remove in the Morning

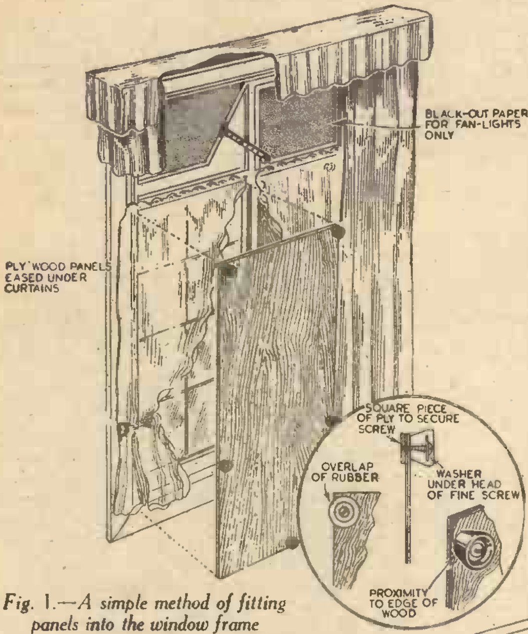


Fig. 1.—A simple method of fitting panels into the window frame

THE hurried black-out measures adopted by many when the war first started, necessitating the free use of drawing pins and sticky paper, must have taken toll of the wood and paint work, whilst unless suitable frames have been made for erecting black-out paper, both ventilation and light have of necessity been restricted during the daytime.

It can be said that the ideal black-out scheme would be one which is easy to erect at dusk and remove in the morning.

Various methods suggest themselves with a little careful thought, and the following notes may help those who find that their schemes have either the above objections or expense is of primary importance.

The writer's method of fitting panels into each window frame without marring the woodwork with screws, etc., comprises simply the location of rubber cabinet feet fitted close to the edge of the plywood panels so that there is provided a fair amount of overlap, as shown in Fig. 1.

The Panels

Now, as each panel is cut accurately to the size of the window frame, the overlap of each rubber will bind against the framework as the panel is worked into position.

Owing to the amount of side pressure on these rubbers it will be necessary for washers to be included under the heads of the fixing screws, to prevent the rubbers tearing themselves free over the heads of the screws after considerable use.

To facilitate erection and removal, handles can be fitted to the panels.

Where possible, the panels should be fitted so that they do not interfere with any existing curtain fitments, and by treating each window frame independently, it should be possible in the majority of instances to ease each panel under the casement curtains (see Fig. 1).

For opening type windows, it is only necessary to cut the plywood at the points where the casement catches are located, but although the wood should be cut sufficiently to allow each panel to be eased into position behind the catches, care will need to be taken to see that not too large a cut-out is made.

In such instances where this cannot be prevented, a strip of cardboard temporarily fitted over the hole will suffice. A leather, felt, or cardboard flap permanently fixed to the panel at these points would, however, be the best plan.

Fan-Light Windows

Fan-light windows should be treated separately, using either wood panels as in the above instances, or simply black-out paper fitted in the manner illustrated in Fig. 1.

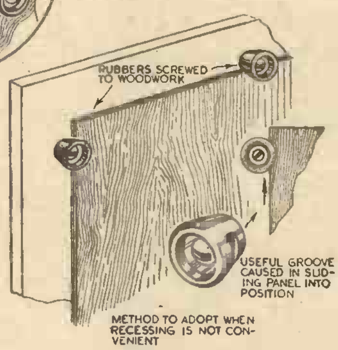


Fig. 2.—Grooves cut into rubbers as shown make an ideal method for holding the panels in place

Fig. 3.—Another method of holding the panels in position. To prevent them from looking unsightly the panels can be covered with wallpaper to match the walls of the room

So far one has seen how the frames can be fitted without using hooks or screws in the woodwork, but in instances where say, in the case of the hall door, or where a number of small panels would prove troublesome, exception to this need not prove unsightly and little damage need result to the paintwork where occasional screws are used.

In this case, the rubbers are fixed with long thin screws and washers directly to the wood, and positioned so that the panel may be either slid or pressed into position; this is shown in Fig. 2.

An alternative way to erect panels easily and quickly, is to make up a number of plywood strips at the ends of which, and so that they overlap, rubbers are fixed, thus each strip, cut a trifle larger than the framework into which it is to be fitted, will now be held in position by the bowed strip binding in the frame as illustrated in Fig. 3. Now with regard to incidental light precautions and fitments. Fig. 4 illustrates a rather novel front door lock illuminating scheme. In this arrangement, it will be seen that a "pea" bulb is neatly concealed and protected under half a small tin lid fitted just above the lock.

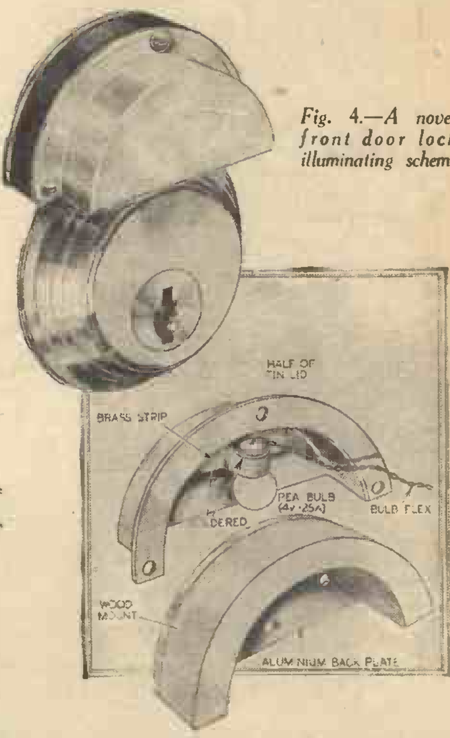


Fig. 4.—A novel front door lock illuminating scheme

Novel Switching Arrangement

The construction needs little enlargement here, and the rather interesting method of switching by the letter box flap will be easily followed on referring to the wiring diagram given in Fig. 5.

A separate switch behind the door makes it possible for the circuit to be put out of commission during the day, to preserve, as far as possible, the life of the pocket lamp battery. The tin cover could be painted to match the door.

The pea bulb is soldered permanently to the inside of the tin by a thin brass strip which could be obtained from one contact of an old torch battery. The fine wires pass through a small neat hole drilled in the door.

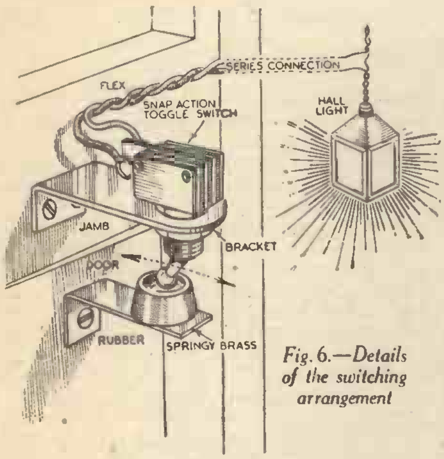


Fig. 6.—Details of the switching arrangement

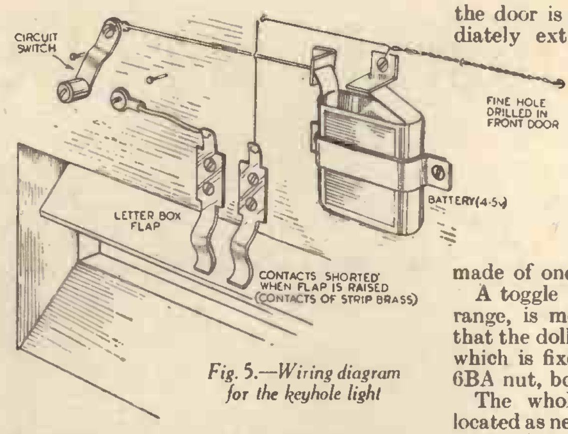


Fig. 5.—Wiring diagram for the keyhole light

Another wise plan is to fix a switch over the front door on the inside, so that when the door is opened, the hall light is immediately extinguished before open to any extent.

A snap-action switch should be used and good quality flex neatly cleated along the door frame.

The illustration Fig. 6 shows the essential details of a suitable switching arrangement and it will be noticed that here again good use is made of one of the cabinet rubbers.

A toggle switch, chosen from the Bulgin range, is mounted on a strong bracket so that the dolly is semi-recessed in the rubber, which is fixed to the springy bracket by a 6BA nut, bolt, and washers.

The whole fitment should be suitably located as near to the corner—on the opening side—of the door as is possible, so that before the door is clear of the jamb, the switch is operated. Both the resilience of the rubber mounting strip, and the binding of the rubber, ensures a minimum of wear with a surprisingly light action free of any fouling.

Adapting a Small Camera

A Pistol Grip and Trigger for Small Cameras

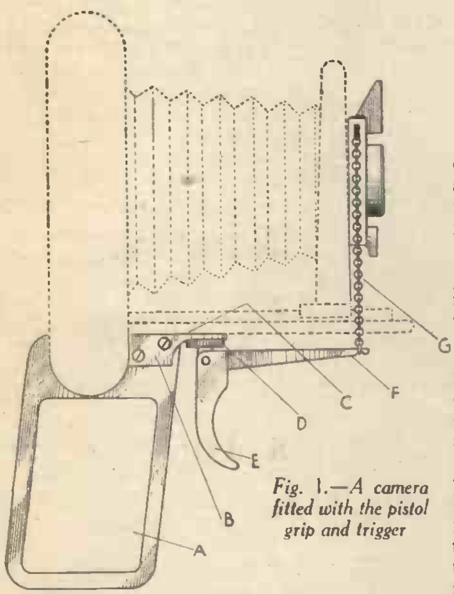


Fig. 1.—A camera fitted with the pistol grip and trigger

WHEN a small folding camera is used for taking quick snaps, difficulty is often experienced in handling the trigger release effectively. This is, in pocket cameras, invariably an integral part of the lens mounting, and the conditions are very similar to those which would pertain if the trigger of a revolver or a rifle were fixed on the side of the foresight. The camera trigger in its usual position is reasonably satisfactory when the back of the camera is held hard against the body fairly low down, but used against the cheek or the forehead it becomes awkward and nearly impossible to operate without moving the body of the camera. For this reason alone, the grip and trigger described here has proved exceptionally satisfactory. The grip enables a firm hold to be made on the camera, which is not possible in the ordinary way, owing to the irregular shape of the camera body, whilst the trigger is situated in the right place, contortions of the wrist and fingers are absent, and, used with the curling forefinger, no unsteadiness results.

General Arrangement

Fig. 1, shows the general arrangement. The grip or butt "A," is fashioned from a solid piece of hard wood, sandpapered and enamelled black. Corrugations may be scored in the wood for a good gripping surface, but it will be found that this is hardly necessary.

The actual dimensions are not given, because these will vary with different makes of camera and also the size of one's hand, but a piece of wood 5-in. long and $1\frac{1}{4}$ in. x $2\frac{1}{4}$ in., will be a reasonable basis for a large hand. The wood is shaped to fit the film chamber tightly as some support is obtained thereby, and the top should be just clear of the underside of the platform. The shaped brass bracket "B" shown in detail in Fig. 2, which is secured by the two screws to the butt, holds the device to the camera by a stud. The bracket should be made from $\frac{3}{32}$-in. or $\frac{1}{8}$-in. brass sheet and is made to fit flush in the wood of the butt, both on top and down the sides. If the tubular nuts cannot be obtained or made, ordinary screws with thin nuts used on the left-hand side of the butt or wood screws are just as effective. In the last case, the holes in the bracket should be staggered to avoid the points of the screws meeting.

The Trigger

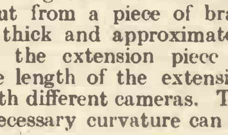
The stud "C" Fig. 1, and in detail in Fig. 3, fits into the tripod socket, usually tapped $\frac{1}{4}$-whitworth, but may be a metric size, and carries a round milled nut "D" and also forms the fulcrum for the trigger. The trigger "E," details in Fig. 4, is made in two pieces, the extension "F" being soldered into the slot across the top of the trigger, which also fits the tongue on the stud. The trigger can be cut from a piece of brass $\frac{1}{2}$-in. wide, $\frac{1}{4}$-in. thick and approximately $1\frac{3}{8}$-in. long, and the extension piece of $\frac{3}{64}$-in. brass. The length of the extension piece will vary with different cameras. The length and the necessary curvature can be obtained in this way.

Adjusting the Triggers

Pull out the camera to its middle distance according to the meter scale on the platform, and drill a hole through the platform directly below the trigger release lever. The length of the arm can then be measured from this hole. The connection between the two triggers is made with a short length of fine chain. This chain is hooked on to the release lever and passed down through the hole drilled in the platform and then hooked on the trigger extension. The strength of the spring in the shutter has been found in the four cameras which have been so fitted, to be sufficient to return the trigger to its forward position, but if a very light loaded shutter is used, a short piece of watch spring screwed to the butt behind the trigger will be all that is required.

The grip can be easily taken off the camera for carrying purposes, by releasing the chain, the lock-nut and unscrewing the stud

Fig. 3.—Right. details of the stud



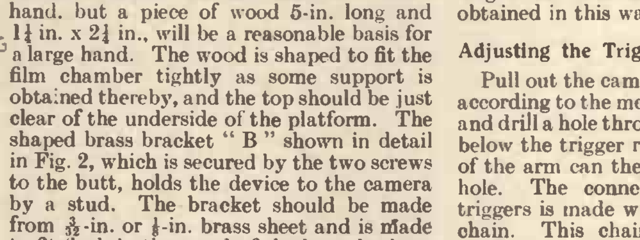


Fig. 4.—How the trigger is made

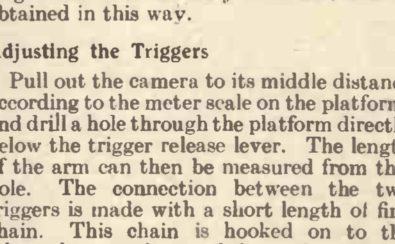


Fig. 2.—The shaped brass bracket

Chemistry for Beginners

No. 10.—Nitrogen and some of its simple Compounds. Easily-performed Experiments which can be carried out in any Home Workshop

NITROGEN is usually termed an "inert" element, for the reason that when in the uncombined state, nitrogen gas enters only with difficulty into the majority of chemical reactions.

Yet, if we choose to regard the element nitrogen in another light, we are at once struck by the fact that nitrogen is anything but an inert element. There are literally thousands of compounds in the constitution of which nitrogen plays an exceedingly important role. Nitrogen, for instance, imparts to many dyestuffs their colouring properties. It gives to a multitude of compounds their characteristic odours—good and bad—whilst, again, it confers upon another host of compounds which we call "drugs" the peculiar physiological effects which render them so valuable to us. And lastly, nitrogen is an indispensable constituent of all explosives. There is no useful explosive which does not contain nitrogen. Indeed, we may regard the sudden detonation of an explosive compound as a practically instantaneous liberation of nitrogen atoms, with the consequent release of enormous quantities of energy.

Explosive Compounds

In explosive compounds, the constituent nitrogen atoms show a great antipathy to existing harmoniously side by side. They are like quarrelsome people who are always trying to separate and who fly off at a tangent on the least possible pretext. And when they do so, they invariably manage to disrupt completely the "house" or chemical molecule in which they have been existing. This sudden disruption we call an explosion and, unfortunately, we are all only too well aware at the present day of the highly disintegrating and shattering effects of this molecular commotion.

In this article, we cannot, of course, deal with nitrogen in its explosive or other complex compounds. We must confine ourselves to experiments on pure nitrogen, which is, of course, a colourless, invisible and inodourous gas, and, also, to the preparation of some of the simpler, yet none the less interesting nitrogen compounds.

Nitrogen is a very abundant gas. It constitutes four-fifths of the total volume of the earth's atmosphere. Thus, in a roomful of air, practically four-fifths consists of pure nitrogen, whose main function is to act as a dilutant of the oxygen.

Nitrogen is so called because it is a constituent of "nitre" or potassium nitrate (saltpetre), the word itself meaning "nitre-producer." The French call nitrogen *azote*, meaning "without life," because the gas is incapable of supporting respiration or combustion, and the Germans term it *Stickstoff*, or "suffocating stuff."

Preparing Nitrogen

It is not difficult to prepare a quantity of nitrogen in the laboratory. All we require is a shallow basin of water and an inverted bell jar or even a glass jam jar, the latter being inverted under the water as shown in the illustration. Within the inverted jar is placed a small amount of red phosphorous which is contained in some receptacle which raises it out of contact with the water. The jar is raised, a light is applied to the phosphorous and the jar is then quickly replaced over it. The phosphorous burns with a yellow flame, emitting white clouds of phosphorous oxides. After a little time, the flame of the phosphorous will go out, indicating that the oxygen within the inverted jar has all been used up. At this stage, the remaining gas within the jar consists of nitrogen.

In this test tube are nitric acid and scrap copper. Nitric oxide gas is liberated, and this, issuing from the end of the glass tube, combines with oxygen of the air, giving rise to reddish fumes of nitrogen peroxide

Nitrogen prepared in this manner from atmospheric air is never quite pure. For one thing, the burning phosphorous invariably becomes extinguished before the last traces of oxygen have been used up, whilst, again, the "nitrogen" within the jar will contain a trace of carbon dioxide and about one per cent. of argon and the other "inert gases of the atmosphere." Still, however, for many purposes, nitrogen prepared in the above manner is pure enough.

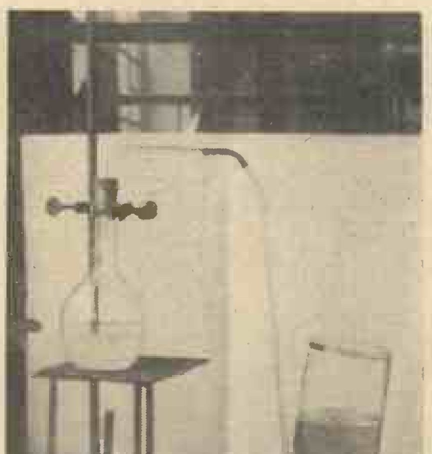
Absolutely pure nitrogen, the so-called "chemical nitrogen," is best prepared by heating in a flask fitted with a delivery tube dipping under water (see illustration) a concentrated solution of ammonium nitrate, or, better still, a mixture of equal volumes of concentrated solutions of ammonium chloride (sal ammoniac) and sodium (or potassium) nitrite.

$$NH_4NO_2 \rightarrow 2H_2O + N_2$$

Ammonium nitrite Water Nitrogen

Nitrogen, as we have already read, is a colourless, odourless gas, which is a non-supporter of life and combustion. Perhaps, however, the latter statement should be qualified, for nitrogen gas *will* admit of a certain type of combustion in that when some metals (notably magnesium, titanium, calcium and lithium) are heated in nitrogen

Practical Experiments for the Home Worker



Making pure nitrogen by heating a strong solution of ammonium nitrite. The gas is collected over water

gas, they "burn" in the gas, forming, not "oxides," but *nitrides*. Thus, when magnesium is heated in nitrogen gas it forms magnesium nitride, Mg_3N_2, a white, solid not unlike magnesium oxide.

Lighter Than Air

Nitrogen is somewhat lighter than air, its specific gravity being 0.973 (air = 1). Hence, when a jar of nitrogen is turned upwards, the nitrogen slowly rises out of the vessel.

Under the influence of the electric spark and the electric flame arc, nitrogen will not only combine directly with oxygen, forming the various oxides of nitrogen (which can be converted into nitric acid), but it can also be made to combine with hydrogen, forming ammonia.

These reactions, which, unfortunately, cannot be imitated on the small scale in the laboratory, are exceedingly important ones, since they underlie the modern industrial processes of "fixation of atmospheric nitrogen" whereby the nitrogen of the air is utilised for the production of nitric acid and ammonia, these latter compounds forming the basis of explosive, fertiliser and other essential chemical manufacture.

By heating calcium carbide in nitrogen gas we obtain a compound called calcium cyanamide, $CaCN_2$, which, under the name of "nitrolim," is used as a fertiliser. Thus:—

CaC_2	+	N_2 =
Calcium Carbide		Nitrogen
$CaCN_2$	+	C
Calcium cyanamide		Carbon

In order to make this calcium cyanamide, the calcium carbide must be heated to white heat.

Calcium cyanamide, $CaCN_2$, besides acting as a fertiliser, can also be used for generating ammonia. This is effected by passing a current of super-heated steam over the calcium cyanamide, whereby calcium carbonate (chalk) is formed and ammonia gas produced:—

$CaCN_2$	+	$3H_2O$ =
Calcium cyanamide		Water
$CaCO_3$	+	$2NH_3$
Calcium carbonate		Ammonia

Ammonia

Ammonia, of course, is one of the simplest yet one of the most important compounds of nitrogen. Many of us are apt to think that the "liquor ammonia" which we buy at the pharmacist's is pure ammonia. Actually, however, this is not the case, for ammonia itself is a gas which is extremely soluble in water. It is, therefore, the water solution of ammonia gas which is usually known as "liquor ammonia" or just "ammonia."

Water will dissolve (at 0° C.) more than eleven hundred times its volume of ammonia gas, and when the resulting solution is heated, the ammonia gas is given off. Thus a very simple way of making a quantity of ammonia gas consists in warming some of the "liquor ammonia" or "liquid ammonia" of the pharmacist. This solution, when at its strongest, has a specific gravity of 0.882 (at 15° C.) and contains 35 per cent. by weight of ammonia gas.

Ammonia gas is commonly prepared in the laboratory by heating any of the ammonium salts, as, for instance, ammonium chloride (sal ammoniac) or ammonium sulphate, with slaked lime or with caustic potash or caustic soda. Ammonia gas is abundantly disengaged, and, if required, it may be dried by passing it over quicklime, but NOT over calcium chloride (which is the more usual gas-drying agent in the laboratory) since the gas forms a compound with calcium chloride.

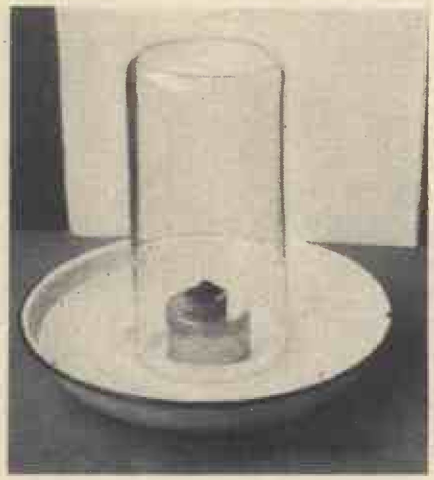
Owing to its extreme solubility in water, ammonia gas cannot be collected over water. If, however, a solution of ammonia is required, the ammonia gas should be led into the water by means of a funnel, as shown in the illustration. If this precaution is not taken and the gas is passed into the water by means of an ordinary glass tube, the absorption of the ammonia by the water will probably be so violent that the water will ascend the glass tube and be sucked into the flask. Using, however, the simple apparatus shown in the photograph, considerable quantities of ammonia solution may readily be made in the home laboratory.

Ammonia Gas

The suffocating, pungent-smelling properties of ammonia are well known. Both ammonia gas and its solution in water are highly alkaline. Mixed with acids, the solution forms salts. Thus, when ammonia solution and dilute hydrochloric acid are mixed, ammonium chloride is formed (in solution).

Many metals, such as magnesium and calcium, when heated in dry ammonia gas, give rise to *nitrides*, just as they do when heated in pure nitrogen gas.

Under ordinary conditions, ammonia gas is incombustible. If, however, the air be heated or the quantity of oxygen increased, ammonia gas can be made to burn with a characteristic yellow-brown colour. This flame is best seen by bubbling a stream of oxygen through a quantity of ammonia solution which is being warmed in a flask. The gas issuing from the delivery tube of the flask will burn with the yellow-brown colour characteristic of combusting ammonia. If, again, a stream of ammonia gas

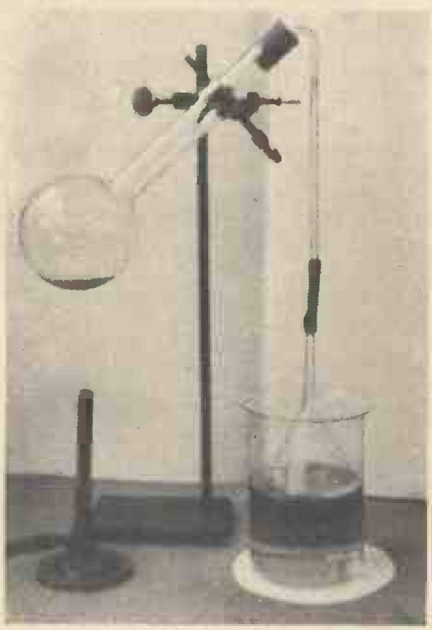


A glass jar inverted over a quantity of red phosphorus supported over a basin of water. When the phosphorus is ignited, it abstracts the oxygen from the enclosed air in the jar, leaving nitrogen

is directed into the air-hole of an ordinary bunsen burner through which coal gas is flowing, the flame of the burning coal gas will be coloured brown-yellow and will expand considerably.

When dry ammonia gas is passed over sodium heated in a tube, a compound known as sodamide, $NaNH_2$, is formed.

As we have already seen, nitrogen and oxygen can be caused to combine together



Preparing a solution of ammonia gas. A strong solution of sal ammoniac mixed with lime or caustic soda is heated in the flask, and the ammonia gas is abosrbed into water by passing it through the inverted funnel. This funnel is a necessary protection against the possibility of the water rushing back up the delivery tube into the heated flask and so breaking it

directly by means of the electric spark. Usually, however, the oxides of nitrogen, of which there are at least five, are prepared by roundabout methods.

"Laughing Gas"

The first of the oxides of nitrogen is nitrous oxide, N_2O, popularly known as "laughing gas," because, in a few cases, this gas, when breathed, has been known to cause great excitement on the part of the inhaler of the gas. This is the anaesthetic gas which is so much used at the present day by dentists for causing momentary unconsciousness. It has a sweet, rather sickly smell and it is best made on the small scale by heating dry ammonium nitrate. Since the ammonium nitrate, even when gently warmed, often gives rise to much crackling and slight semi-explosions, it is best not to heat this salt in a glass flask, but to employ instead for the heating an enclosed metal vessel. The nitrous oxide evolved can be collected over *hot* water, but not over cold water, for it is substantially soluble in the latter liquid. In its properties, it behaves very much like oxygen, many strongly burning objects, when thrust into a jar of the gas, still continuing to burn with great brilliancy.

Another interesting oxide of nitrogen is nitric oxide, NO, which is best made by acting upon copper with nitric acid.

Nitric oxide is a pungent-smelling colourless gas. When brought into contact with air, however, it combines with the oxygen of the latter, giving nitrogen peroxide, NO_2, which is a reddish gas.

Thus, in the experiment illustrated in the photograph on the previous page, a quantity of copper turnings contained in a test tube is acted upon by nitric acid. The test tube is provided with a cork through which passes a short length of glass tubing. Nitric oxide is generated within the test tube, and this gas remains invisible. On issuing from the end of the glass tube, however, it immediately combines with the oxygen of the air, giving rise to brown or reddish-brown fumes of nitrogen peroxide:—

2NO	+	O_2	=	$2NO_2$
Nitrid oxide		Oxygen		Nitrogen peroxide

In a similar manner, nitric oxide combines directly with chlorine to form nitrosyl chloride, NOCl:—

2NO	+	Cl_2	=	2NOCl
Nitric oxide		Chlorine		Nitrosyl chlorid

An Orange-Yellow Liquid

Nitrosyl chloride is an orange-coloured, pungent-smelling gas which, when passed through a U-tube immersed in a mixture of ice and salt or a similar freezing mixture, condenses to an orange-yellow liquid which boils at a temperature of about −8° C. If nitrosyl chloride is passed into water, it is decomposed into nitrous acid and hydrochloric acid.

Nitrosyl chloride may also be prepared by gently heating a mixture of 1 part concentrated nitric acid and 3 parts concentrated hydrochloric acid. In this instance, chlorine is produced in addition to the nitrosyl chloride, but when the mixed gases are passed through a tube immersed in a freezing mixture, the nitrosyl chloride condenses readily, while the chlorine passes on.

By acting upon silver fluoride with nitrosyl chloride, a rare gas, nitrosyl fluoride, NOF, is produced. The properties, however, of nitrosyl fluoride have been little studied.

Nitrogen peroxide, NO_2, may be used to prepare an interesting compound known as copper nitroxyl. In order to make this compound, all we need do is to pass a slow

(*Continued on page* 179)

Our Busy Inventors

By "Dynamo"

Steed for the Stage

THE zoological record of the pantomime includes more than one cleverly impersonated animal. Examples of this fact are Dick Whittington's cat, the mascot of a Lord Mayor of London, and the ass of Ali Baba, the panniers of which became jewel cases. The artificial horse has frequently cavorted on the boards.

This fictitious steed usually necessitates the employment of two men. According to an invention which has just been patented in the United States, the amount of labour required in connection with a property quadruped will be reduced 50 per cent. The beast in question consists of a skeleton body, which is carried on the back of the actor, who adopts a stooping posture. A flexible covering represents the hide of the animal. The front legs are artificial but the performer uses his natural walking apparatus as the hind legs. Consequently, his part may have a kick in it.

Birds and Black

THE Minister of Agriculture urges us to cultivate every square yard of soil available. But, though we dig Mother Earth in the ribs with a spade and tickle her with a hoe, she will not laugh in a harvest unless we defend the seed sown from those tiny air-raiders—the birds.

An application has been made to patent in this country a method of rendering seeds unattractive to feathered thieves. For this purpose crude tar has been used in the past; but it is affirmed that this expedient is liable to injure the seeds or to cause delay in their germination. The new invention is based upon the belief that the winged marauders are not enamoured of seeds treated with carbon blacks. The process therefore comprises the treatment of seeds with substances such as lamp black, gas black or acetylene black, or a liquid composition containing a proportion of carbon black. It is stated that this method has not been found to harm or hinder the seeds in any way.

Deep black seems to be the pet aversion of the birds. How they must detest the black-out!

Buried Treasure

IN these days of bombs and bandits an effective depository will make for the security of money and valuables and therefore for one's peace of mind. There is a parable of an unfaithful steward who buried his talent. It is possible now to follow his example but with a legitimate motive. I am informed that, at low cost, one may install vertically in the ground a home safe which is operated only by compressed air and which has a set of three keys. Presumably such a safe could be constructed in a manner that would defy incendiary bombs and present a powerful obstacle even to the expert cracksman.

Mechanical Sherlock Holmes

THE X-ray apparatus is eminently useful in detecting the position of foreign substances. But it is costly and somewhat cumbersome. A British patent has been applied for to protect a device which will not only find, but will also remove, metal particles from human bodies and those of animals. The invention includes a source of comparatively weak electric current, an indicator and a scissors-like arrangement.

A cynic may suggest that, in the days when gold was in circulation, in the case of a man swallowing a sovereign, such an appliance would have been unnecessary. The Chancellor of the Exchequer would have got it out of him!

Anti-Butting Halter

THE mad bull which runs amuck may now at least suffer some inconvenience. There has been contrived an anti-butting device for farm animals. The invention comprises an appliance of halter-like form, one loop of which encircles the head of the animal, while another loop surrounds its neck. The halter contains an electric battery, so that, when the animal butts, it receives a shock. Though this is not enough to electrocute the creature, it is sufficient to cause the beast an unpleasant sensation, if it be too pushing with its horns. The device can be applied to a cow or a goat as well as to a bull. A mild electric shock would train the animal to check its impulse to place folk on the horns of a dilemma. It would doubtless be effective in modifying a bull-fight.

Motor Boots

A YUGO-SLAVIAN doctor has thought out a contrivance for helping people who literally wish to go the pace. He has devised an accelerating apparatus for the feet, which is described as "the motorisation of walking by means of motor-driven roller-boots."

The idea of the invention consists in connecting the drive shaft of a small motor —carried in a satchel on the back—to two flexible shafts connected to the rear axles of the roller-boots. Thereby the power of the motor is transmitted to them and the boots are thus set in motion. Started with the left hand by means of a control wire, after a few gliding steps, the motor attains full speed.

The information on this page is specially supplied to "Practical Mechanics" by Messrs. Hughes & Young (Est. 1829), Patent Agents of 9 Warwick Court, High Holborn, London, W.C.1, who will be pleased to send readers mentioning this paper, free of charge, a copy of their handbook, "How to Patent an Invention."

Mercury's Rival

THE motor boots, also by means of the control wire, can be brought to a standstill. In an emergency a halt may be caused in the same manner as when one is skating on ice. The motorised pedestrian, in a moment, can become an ordinary walker and *vice versa*. It should be mentioned that between the motor and the back of the pedestrian there is an asbestos plate to keep the heat of the motor from the body. All the wheels are fitted with pneumatic rubber tyres.

Should one become fatigued after walking a long time with the roller boots, if desired they can be combined with a seat mounted on a wheel having a movable steering control. This rest wheel, when not in use, is carried folded up hanging on the outside of the satchel.

Verily, these motor boots will qualify their possessor to rival Mercury, the messenger of the gods, whose feet were equipped with wings.

Shirt with Zip Fasteners

THE evolution of male underwear during the present century has not been characterised by much variation. The average shirt is still planned to be put on in a manner calculated to ruffle the hair, although the American design, which is donned like a coat, is not unknown on this side of the Herring Pond.

I note that the British Patent Office has received an application to protect a shirt of a new pattern. The usual frontal opening is superseded by an aperture in each shoulder. This is opened and closed by means of a Zipp fastener. If wished, buttons can be permanently sewn down the front of the shirt, in order to imitate the customary opening. It will be appreciated that, with a shirt of this description, the studs can be inserted prior to dressing. This will avoid the risk of dirtying or crumpling the immaculate garment. Incidentally, it will prevent the wearer from becoming what is vulgarly termed "shirty."

To Stop "Laddering"

THE ladder is considered by the superstitious as a source of ill luck. Misfortune and the ladder are certainly associated in the case of silk stockings. As far as their hose are concerned, the ladies may indeed have a run of bad luck.

Yet another process for checking runs in knitted wear has made its *début*. It relates to goods composed wholly or in part of what are known as thermoplastic yarns. According to the complicated verbiage of the abridged American specification, it includes the step of applying heat at areas to form overlapping staggered spaced characters, through the medium of which contiguous filaments of the knitted wear are put in partial solution and coalesced thereby, forming a discontinuous band of untreated and treated areas at spaced points in the knitted wear.

If, without concentrated attention, we cannot unravel the procedure of this process, we trust that, as a result of its application, ladders in stockings will not, like Charley's Aunt, be still running.

Auxiliary Church Seats

A COLLAPSIBLE pew seat has been patented in the United States. This provides auxiliary seats in church when the congregation overflows the normal sittings. Adjustable seats at the ends of pews in the aisles are familiar but the new device, in the case of each seat, furnishes kneeling accommodation for the worshipper sitting immediately behind.

It is hoped that this supplement to the pew will not collapse at the wrong moment. In the Middle Ages certain monks occupied seats which they propped up with their legs. Consequently, if, through weakness of the flesh, they slumbered during the sermon, they soon found themselves on the floor of the sacred edifice.

Ideal Raincoat

FOR a new process recently developed it is claimed that it enables textile fabrics of all kinds easily to be made waterproof and stainless. The fabrics are rolled through vats containing a synthetic solution, derived from coke, limestone and salt. The coating may be crystal clear, white, translucent or any colour, and the fabrics can be printed over the coating. It is further asserted that the fabrics remain odourless, washable and pliable in all sorts of weather. Strength to the material is added by the coating but very little bulk. Lately, I am told, there appeared a man's raincoat made of this fabric, which weighed less than six ounces. It is affirmed that this coat can be folded and enclosed in an envelope small enough to be carried in a pocket. Such a paragon of a raincoat should qualify one cheerily to face that mildest form of adversity—the passing shower.

Dogs in War Time

NOW that the hounds of war have been unleashed, it has been a problem to know what to do with our canine friends. In an air raid the dog might prove to be an encumbrance. Barred from a public air raid shelter his position and that of his owner would not be enviable.

To ensure the safety of her Pekinese dogs and puppies, one lady, residing in a suburb of London, has had built an enormous wire spring erection like a mattress to cover the abode of her pets. She has sufficient faith in this construction to believe that at least incendiary bombs would bounce therefrom. And there is something to be said for stout chain netting as a protection against shrapnel. Like sand, it does not present rigid resistance which may cause an impact to be disastrous.

By the way, a dog-breeder within my ken sent eight dogs from the alleged London danger zone to somewhere in Scotland, in order that they might be safe from aerial warfare. The suburb of London in which they lived has, up to the moment of writing, been completely immune, whereas a number of air raids with bombs falling not far away have occurred in the neighbourhood to which the canine evacuees were dispatched. Such is the irony of fate !

A Novel Camera Sight

Fitting a Head and Cross Wire Sight to a Hand Camera

THE standard view finder fitted to most hand cameras is a practically useless fitment for the speed worker. It is only good enough if there is time to study the picture carefully and then only gives an approximate idea of the position of the image which will later appear on the film. It is rarely accurate, because being so small, only giving a picture about 1/50 of the size of the actual image, exact adjustment is nearly impossible. Further, no adjustment is made to balance any alteration in the focal adjustment of the lens, and although the register may be good at 50 feet the error at five feet may be large. Further, the picture being so small, small objects at a distance become too tiny to observe. Thus an aeroplane at 200 feet cannot be observed with any certainty in the view finder. Then the oblong pieces of wire fitted to cameras and called direct vision finders, although an undoubted improvement, are again not too accurate, they only giving the area of the picture and its approximate position.

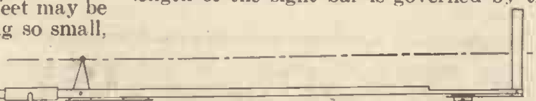
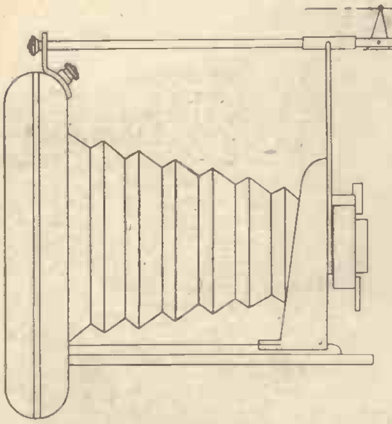



Fig. 1.—The general arrangement of the sighting device

Moving Objects

In order to get shots of birds on the wing, or an aeroplane diving, or in fact any fast moving object, another system of focusing the camera on the object and keeping it there, rock steady and central on the film is necessary. The bead and cross wire sight, used on aircraft guns, was tried out, at first by twisting pieces of wire on the camera, and in taking some shots of moving objects. These proved promising so a well finished device was then made. The sight does not indicate the size of the picture, but ensures that the object is in the centre of the screen. Very little additions have to be made to the camera and the sight is easily assembled or dismantled from the camera for transport.

The Sight Bar

Fig. 1 shows the general arrangement. Two fixings are required, one at the back of the camera and the other at the front. The front fitting is a sliding one to allow for focusing adjustment of the camera. The length of the sight bar is governed by the angle of the lens, but should be as long as possible without coming into the field of the lens. The bar is made from 3/16 in. x 3/16 in. brass bar, and is secured to the back bracket with a terminal nut, run on a piece of 6BA studding tapped into the end of the bar. The back bracket, shown in detail in Fig. 2 is made of 1/16 mild steel and is secured to the body of the camera with a terminal nut, on a short screw tapped into the body of the camera with the head of the screw inside. The bracket is slotted from the top and is graduated on the front face to register with a scratch line on the side of the sight bar.

The Front Bracket

The front bracket, the design of which will have to vary considerably with each camera, is fitted either with screws tapped into the carriage front or gripped behind the shutter casing. The top of the bracket carries a square sleeve, made to be an accurate sliding fit on the sight bar and is soldered to it. The back sight is shown in detail in Fig. 3. The sight bar is slotted so that the back sight can be folded down out of the way when not required. The back sight can be of thin mild steel sheet pivoted and shaped as shown, the spring underneath the bar, held by the screw tapped into the bar, holding it either up or down securely, by pressure on the flats. The bead can be a small ball of brass or a tiny black glass bead, fitted on a spike filled at the tip of the vane. The front sight consists of a brass ring or a piece of tube soldered to the foot which is arranged with two flats to press against the spring as in the case of the back sight. The actual cross wires can be made in several ways. They can be of 47 or 48 SWG enamelled wire soldered across the diameter of the ring, or very fine scratches made across a piece of clear celluloid and filled with Indian ink, or spider's web thread laid down on a disc of glass.

Adjusting the Sight

Having made all the pieces, fit them to the camera and adjust the sight in the following way. Remove the back of the camera and place a piece of grained glass on which are drawn fine pencil lines from corner to corner, into the back. Set up the camera on a steady base and place a candle or a pocket lamp at a measured distance from the camera. Move the camera until the image is at the intersection of the lines on the grained glass. Then adjust the sight without moving the camera to get the bead at the intersection of the cross wires in the front sight and dead in line with the object. Mark off the sight adjustment on the back bracket, and proceed to the next distance. If you require practice try shooting at a tennis ball thrown into the air.

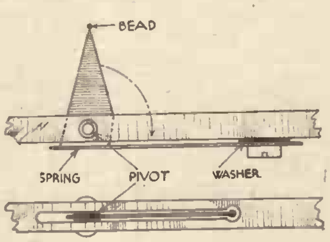
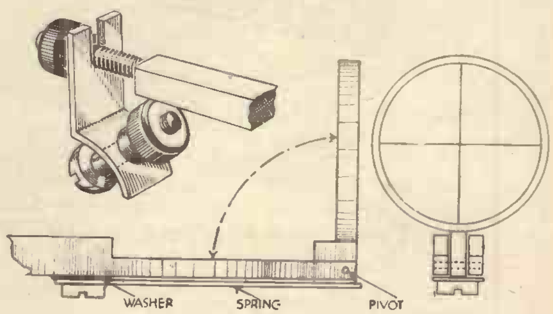


Fig. 3.—Details of the back sight



Figs. 2 and 4 (above).—The back bracket. (Right) The front sight

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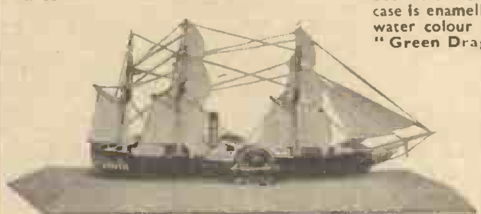

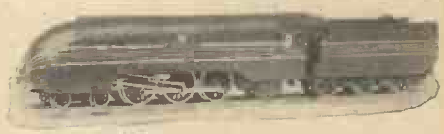

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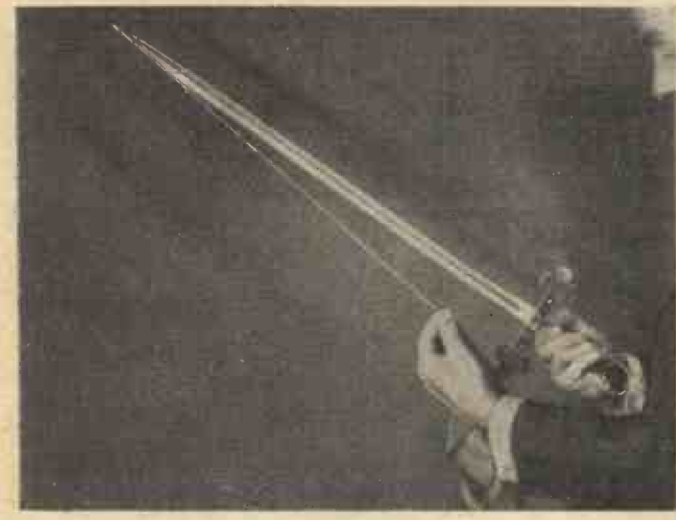


Fig. 1. (left)—Sword for catching a handkerchief. The blade is hollow and an elastic cord running through it brings the handkerchief out of the hilt to the point. Fig. 7 (right).—Pistol with tube for vanishing various objects. Note how the secret container is palmed out

Weapons For Wizards

Ingenious Devices that help to make the Conjurer's Armoury Baffling and Surprising

THE sword illustrated in Fig. 1 would not be of much use against an enemy. But for providing the conjuror with a silk handkerchief whenever he wants it, it is perfect. A pass in the air and the handkerchief appears on the tip of the sword.

The blade of the sword is hollow. A length of strong cord elastic is attached to the hilt just inside the hollow blade. It passes along inside the blade and out at the point, where it terminates in a small pointed hook. The hilt of the sword can be removed when the elastic wears out, so that a new piece can be inserted. There is slight tension on the elastic and this keeps the hook normally drawn up against the tip of the sword. To prepare the weapon for use, a silk handkerchief is impaled on the hook and the elastic is drawn down until the handkerchief can be concealed in the hand holding the sword. The performer presents to the audience only the side of the sword where the elastic is not visible. A sweeping handkerchief is released and flies to the point, appearing to be caught on the sword.

An Improvement

Fig. 2 shows an improvement to allow the sword to be picked up at any time during the show without the necessity of going off-stage to get the handkerchief ready in the hand. This consists of a tube attached to the hilt of the sword and fitted with a cap. The cap is hinged and held down by means of a small catch. The handkerchief, attached to the elastic, is tucked into the tube, the cap closed and the catch fastened. In this state the sword may be freely handled and the handkerchief can be released at the right moment by pressure of the thumb on the catch.

By Norman Hunter
(The Well-known Conjurer of "Maskelyne's Mysteries")
Further Articles on the Secrets of Conjuring will appear Regularly and Exclusively in this Journal

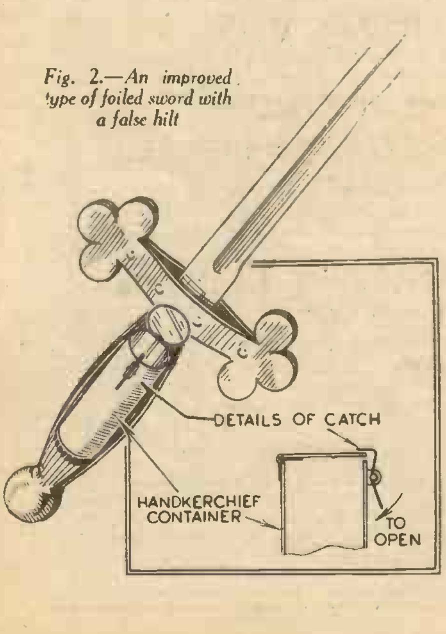


Fig. 2.—An improved type of foiled sword with a false hilt

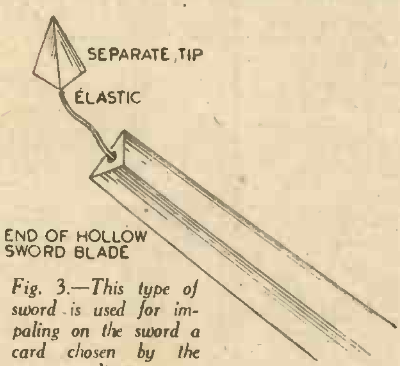


Fig. 3.—This type of sword is used for impaling on the sword a card chosen by the audience

The sword shown in Figs. 3 & 4 is adapted for quite a different purpose though the principle is similar. Here, the trick consists of impaling on the sword, a chosen card, when the whole pack is thrown into the air.

The blade is hollow as before and is fitted with elastic which, however, in this case terminates in a metal tip which fits on the end of the blade. The blade is triangular in section and the tip is cut off. The elastic emerges from the cut-off point, and is fastened to the loose tip as shown. To the hilt of the sword is attached a kind of frame large enough to hold a card. The card has a slit cut in the centre through which the tip of the sword is passed. The elastic is then stretched and the card inserted into the frame. It is an easy fit and needs pressure of the thumb to retain it, or a small catch may be fitted if desired. A card, duplicate of that on the sword, is forced by one of the methods already described in this series. The card is shuffled back into the pack, which is given to a spectator. The sword is then brought forward and the performer stands in a fencing attitude with his right side turned towards the audience. In this position the hand holding the sword completely screens the card holder on the hilt. The spectator is

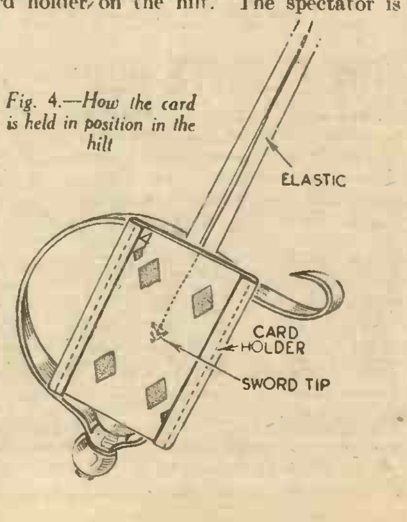


Fig. 4.—How the card is held in position in the hilt

asked to spread out the cards in a fan and throw them well up into the air. As they scatter in a shower a lunge is made into their midst, the card is released and flies to the tip of the sword, where it appears to have been caught from the falling pasteboards.

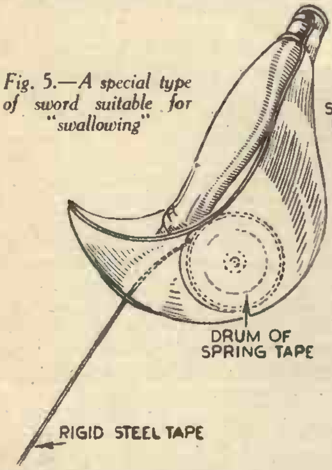


Fig. 5.—A special type of sword suitable for "swallowing"

Catching Three Cards

Three cards instead of one may be caught with this sword by making in the second and third cards triangular holes of successively larger dimensions. The three cards are fitted together in the same way as the single card. When released the cards fly to the point of the sword, one will settle down about half-way along the blade and the other will slide almost to the hilt, owing to the different-sized holes made in them.

Sword swallowing, though outside the range of ordinary conjuring tricks, can be effectively imitated with the special sword shown in Fig. 5. The blade in this case is of thin spring steel, exactly the same as the steel tape measures which can be rolled into a coil and yet will remain rigid when pulled out. A sword of this type is quite a simple job to make. First a hilt is constructed of wood with a metal guard. Within the guard the container of the steel tape is fitted so that the metal strip can be drawn out through a slit in the proper position. With the blade pulled out to a suitable length the sword appears quite rigid yet it can be apparently swallowed with ease by gripping the tip between the teeth and gently pressing the hilt down. The blade winds up in the hilt and conveys the impression of passing down the throat. It is then withdrawn by reversing the action.

Catching Oranges

Fig. 6 shows a sword for catching oranges from the air. A metal arm is pivoted midway along the blade so that it can lie along the blade either towards the point or towards the hilt. A spring is fitted which keeps the arm normally resting towards the point, but a catch is fitted to the hilt by means of which the arm may be held back in its reverse position. An orange is impaled on the end of the arm and the arm is held back against the hilt. Under cover of a slashing movement the catch is released, the arm springs rapidly over, bringing the orange to the point of the sword. If it is desired to produce several oranges, the arm is again swung back under pretence of removing the orange and an already palmed orange is brought into view in place of the one attached to the arm. This palmed orange is openly placed on a plate and the sword can then be used to catch another, and so on.

Magical Pistols

Now we come to magical pistols. The device illustrated in Fig. 7 is an old, but still very useful attachment to a pistol for the purpose of apparently shooting them at some given target. It consists of a metal tube fitting snugly on to the muzzle of the pistol. To the tube is attached a metal funnel and fitting loosely in the mouth of the funnel is a metal cup. The complete thing is shown in section in Fig. 8. With the cup in position, the inside of which, as well as the inside of the funnel, is painted dead black, the pistol is brought forward and the article to be vanished is wrapped in paper or in a handkerchief and tucked into the funnel. The conjuror then transfers the pistol from his left hand to his right, the right hand taking it by the mouth of the funnel, while the left hand moves some object into position or else guides a volunteer assistant to where he is to stand to fire the pistol. The pistol is then taken back again by the butt and the right hand palms out the loose cup by gripping the protruding edge, as shown in Fig. 7. The palmed cup can then be passed off for the contents to be placed in whatever apparatus it is eventually to be found while the pistol can be harmlessly discharged and the funnel shown to be empty.

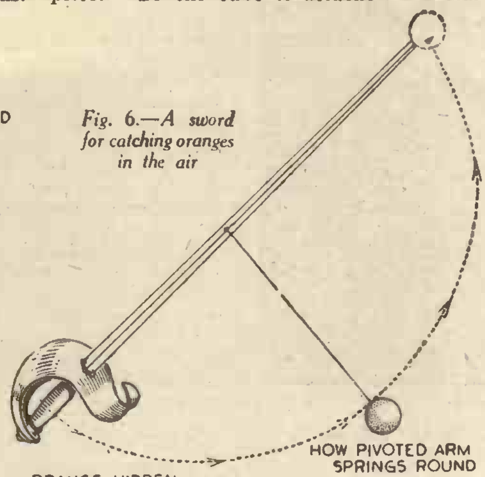


Fig. 6.—A sword for catching oranges in the air

Vanishing a Watch

A very subtle vanish of, say, a watch, can be managed by the use of this pistol funnel as follows. A handkerchief is gathered up by the corners and tucked into the funnel, the loose cup being inserted on top of it. A borrowed watch is wrapped in a duplicate handkerchief and tucked into the funnel, really going into the cup. The watch and handkerchief are then palmed out and disposed of ready for the finish of the trick. After the pistol has been fired, the duplicate handkerchief is withdrawn and shaken out, proving that apparently the discharge of the pistol has shot the watch off to its destination, but left the handkerchief behind. By borrowing a white linen handkerchief in which to wrap the watch and having another white linen handkerchief, torn and with burned edges previously packed into the funnel, a good deal of fun can be had at the expense of the owner of the handkerchief. One white handkerchief is nearly enough like another for the purpose of the illusion and the performer can say, "Well, we can see what's happened to the handkerchief, but the fate of the watch remains a mystery. Still, judging by this," holding up the damaged handkerchief, "I don't think we need worry that there is much of the watch left to trouble about."

A Variation

For visibly vanishing a watch from the end of a pistol, a device something like the orange-catching sword, but working the reverse way, is used. The pistol has a spring arm, pivoted part way down the barrel. There is a clip on the free end and this end is held against the muzzle by a catch which is released when the trigger is pressed and the arm swings round, bring the free end against the butt and out of sight of the audience behind the hand of the performer. The watch is attached to the arm by slipping the loop of the watch into the clip.

A pistol for visibly vanishing a handkerchief can be constructed in various ways. Fig. 9 shows details of a simple method which can be attached to an ordinary cap pistol. The pistol in this case is of the automatic type and the attachment consists of a length of tube soldered along the barrel on the side which it is intended to keep away from the audience when using the weapon. In this tube is a spring roller, operating in much the same way as a roller blind. There is a wide slot in the outer tubing and a sharp hook is fixed to the spring roller. The handkerchief to be

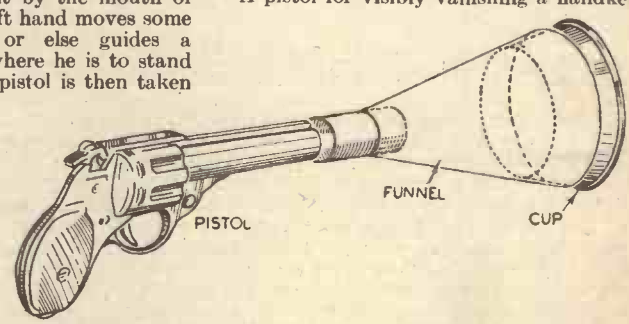


Fig. 8.—An attachment to a pistol for the purpose of apparently shooting oranges at some given target

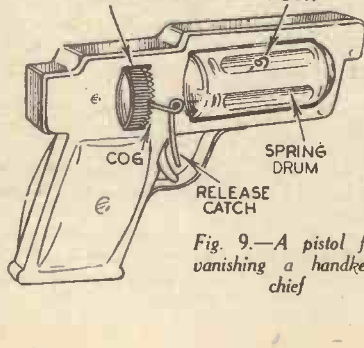


Fig. 9.—A pistol for vanishing a handkerchief

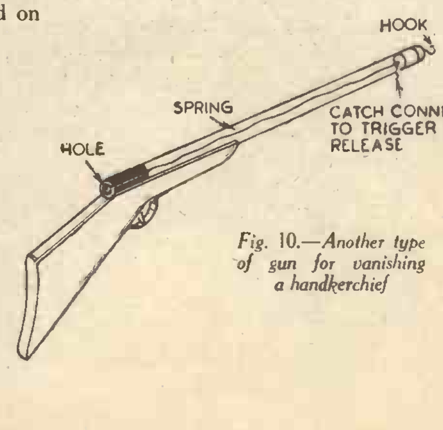


Fig. 10.—Another type of gun for vanishing a handkerchief

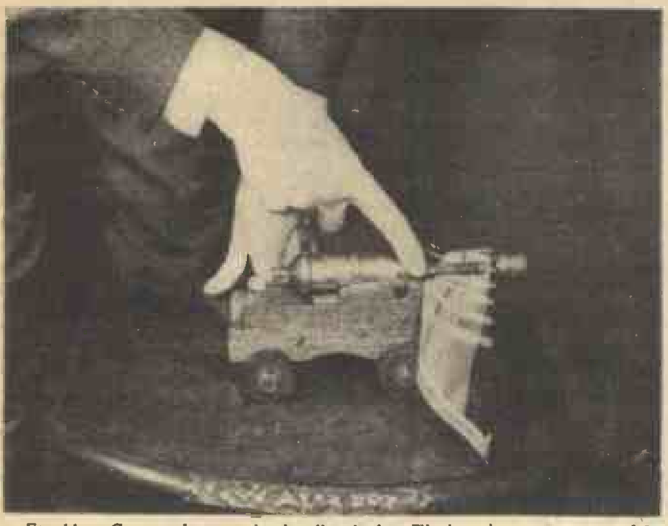


Fig. 11.—Cannon that vanishes handkerchiefs. The barrel contains a powerful spring which winds up the silk

vanished is draped over the pistol and the centre secretly engaged in the hook. When the spring is released the silk is rapidly wound up inside the tube by the spring roller.

The Release

The release is connected to the trigger as shown in Fig. 9. At the butt end of the tube is a thumb wheel for winding the spring and attached to this is a cog. A piece of wire bent to form a lever is pivoted to the pistol so that it engages the cog and stops the spring unwinding. The other end of the wire is soldered to the trigger. When the pistol is fired, the movement of the trigger not only explodes the cap. but also releases the spring and so causes the handkerchief to vanish.

A gun on a slighty different principle is shown in Fig. 10. Here there is a powerful expansion spring in the barrel, to the end of which is fixed a metal plug with a hook to engage the handkerchief. The spring is extended by pushing a metal rod through the breech of the gun and a catch holds the spring extended at the muzzle. This catch is connected to the trigger so that firing the gun also releases the spring and performs the vanish. The gun. having a long barrel, can be used for the disappearance of a fairly large silk handkerchief.

A card may be vanished by means of a pistol similar to the automatic pistol for vanishing a handkerchief. In this case the slot in the tube covering the spring roller is on top, and is slightly longer than the width of a card. A slot in the spring roller engages the edge of the card which is thus fixed upright on the barrel and is rapidly rolled round the spring roller when the trigger is pressed.

Miniature Cannon

Somewhat on the same lines is the miniature cannon, shown in Fig. 11. Here the spring roller is actually inside the barrel of the cannon and instead of a hook being used to attach the handkerchief, there is a hinged bar which closes across the handkerchief. When the cannon is fired the spring roller inside the barrel rapidly winds the handkerchief out of sight.

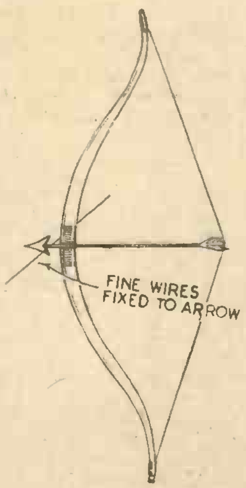
Another cannon. to cause the disappearance of a number of borrowed articles, has an inner lining to the barrel. This inner lining is closed at the breech end and slides easily within the barrel. The breech of the gun proper is either hinged or made to slide back. The articles to be vanished are dropped into the barrel while the latter is moved to a vertical position. In this condition the breech is opened secretly, the movement being concealed by the sides of the gun carriage, and the inner lining drops through into an open well in the table. The barrel with breech closed is then levelled. a little flash powder is put into the muzzle and fired, after which the barrel may be shown empty and duplicates of the vanished articles produced from whatever apparatus it has previously been decided to aim them at.

Bow and Arrow

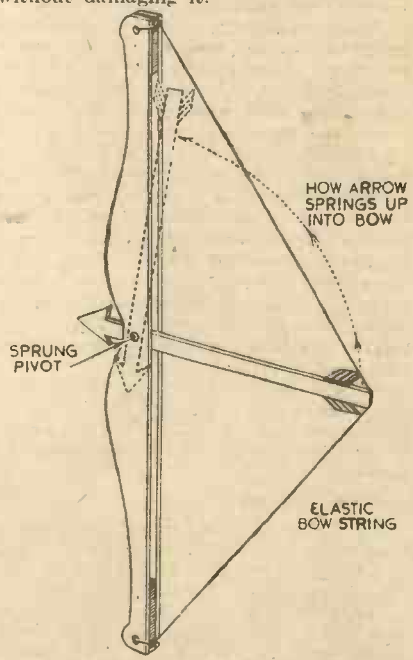
Finally, here are two more primitive weapons adapted to conjuring needs. The bow and arrow.

Fig. 12 shows a bow with an arrow fitted with fine wires at each side. With this weapon the conjurer can let fly the arrow behind his back and cut a strip of paper held some distance away. His aim need be only approximate since the wires projecting from the arrow will tear the paper if the arrow goes wide.

Fig. 13 is a bow that vanishes its arrow. The arrow is permanently attached to the bow, being pivoted as shown between two shaped pieces of plywood which form the bow. The bow with arrow in position for letting fly is either brought on or picked up from a table near the rear of the stage. The bowstring is of cord elastic and this stretches instead of the bow itself providing the spring. When the arrow is released, it flies up into the bow by the action of a small spring. The trick is completed by the appearance of a duplicate arrow in the target. This duplicate arrow is hinged by its point to the gold (or bulls eye) and rests in a slot running across the target. When the release is pulled the arrow springs out at right angles and appears to be sticking into the target. The two pieces of apparatus can be used with a sheet of glass between performer and target, the arrow apparently passing through the glass without damaging it.



Figs. 12 and 13.—(Left) A bow and arrow fitted with a fine wire. (Right) A bow that vanishes its arrow. When the arrow is released it flys up into the bow as shown



CHEMISTRY FOR BEGINNERS

(*Continued from page 172*)

stream of nitrogen peroxide over finely-divided metallic copper (prepared by the reduction of copper oxide in a stream of hydrogen). The finely-divided copper rapidly absorbs the nitrogen peroxide. forming a brown compound, which is copper nitroxyl, Cu_2NO_2.

Copper Nitroxyl

Now. when this copper nitroxyl is heated, it is decomposed into metallic copper and nitrogen peroxide. Thus, if we enclose a quantity of copper nitroxyl in one limb of a bent glass tube and seal both ends of the tube, the copper nitroxyl, when heated, will generate nitrogen peroxide within the tube, which, under the influence of its own internal pressure will condense to a liquid in the other limb of the tube.

Similar nitroxyls can be made with the metals iron, cobalt and nickel when in the finely-divided state.

Incidentally, liquid nitrogen peroxide may also be prepared by heating dry lead nitrate and by passing the evolved gas through a U-tube cooled in a freezing mixture.

Nitrogen peroxide must always be kept in the dry condition, for it is decomposed by water into a mixture of nitric and nitrous acids.

The necessity of taking elementary precautions when experimenting with ammonia gas is self-evident. In much the same way, the other gaseous oxides of nitrogen should not be breathed in any amount, since they are more or less poisonous. For this reason, therefore, it is recommended that all such experiments by prepared either out of doors, or in a well-ventilated outhouse, or in a room whose door and window are allowed to remain open, thus setting up a current of air and enabling the room to remain continuously ventilated.

A Winch for Gliders

The Winch Described can be Firmly Held to the Ground with one Foot, Leaving One Hand Free to Manœuvre it, or to Play the Line

THE F.A.I. method of launching gliders necessitates the use of a winch, and the winch described here will be found suitable for launching any model glider, and the drum is fully capable of taking the 655 ft. of tow line, without any danger of it becoming entangled.

When launching gliders, it is necessary to have a winch which is very strong and can be easily manœuvred.

Because of this, the winch which can be held in one hand and wound with the other is very difficult to handle even when only a small glider is being flown.

It is far easier to have a winch of the type described here, which can be firmly held to the ground with one foot, leaving one hand free to manœuvre the winch, or to play the line.

First Operations

Obtain a piece of hard wood, approximately 1⅛ in. x ⅝ in. and round off the edges.

Then bend a piece of flat mild steel strip approximately ⅛ in. x ⅝ in. to the shape shown, and drill two ¼ in. dia. holes at A and B.

Drill two ¼ in. dia. holes through the piece of hard wood, as shown on the drawing, and file off any rough edges which are to be found.

Buy a winder geared approximately 8-1.

A grinder without the grinding wheel, which can be purchased from any hardware store is most suitable.

Then cut a circular piece of wood 4 in. in dia. and ½ in. thick, and slightly round the edges. Two thin plywood sides approximately 8 in. dia. should then be cut. Cement or nail these on each side of the centre block, and make sure that there are no rough edges which could damage the thread.

Drill a $\frac{5}{16}$-in. dia. hole through the centre of the drum.

The Drum

Fit the drum on to the spindle of the winder and then tighten up the nut on the threaded end of the spindle. A washer should be fitted between the nut and the drum. A second nut should then be fitted and tightened up to prevent the first nut from slipping.

The metal foot rest can now be fitted to the wooden shaft by slipping two ¼-in. bolts through the holes as shown, and tightening the two nuts on the outside. The winder can be firmly screwed on to the shaft at the height most convenient to the flyer. It is very helpful if the top of the shaft is shaped into a handle which can be easily gripped.

When using the winch, the flyer should put one foot in the metal foot rest and grasp the top of the shaft with one hand.

The other hand is used for turning the handle of the winder.

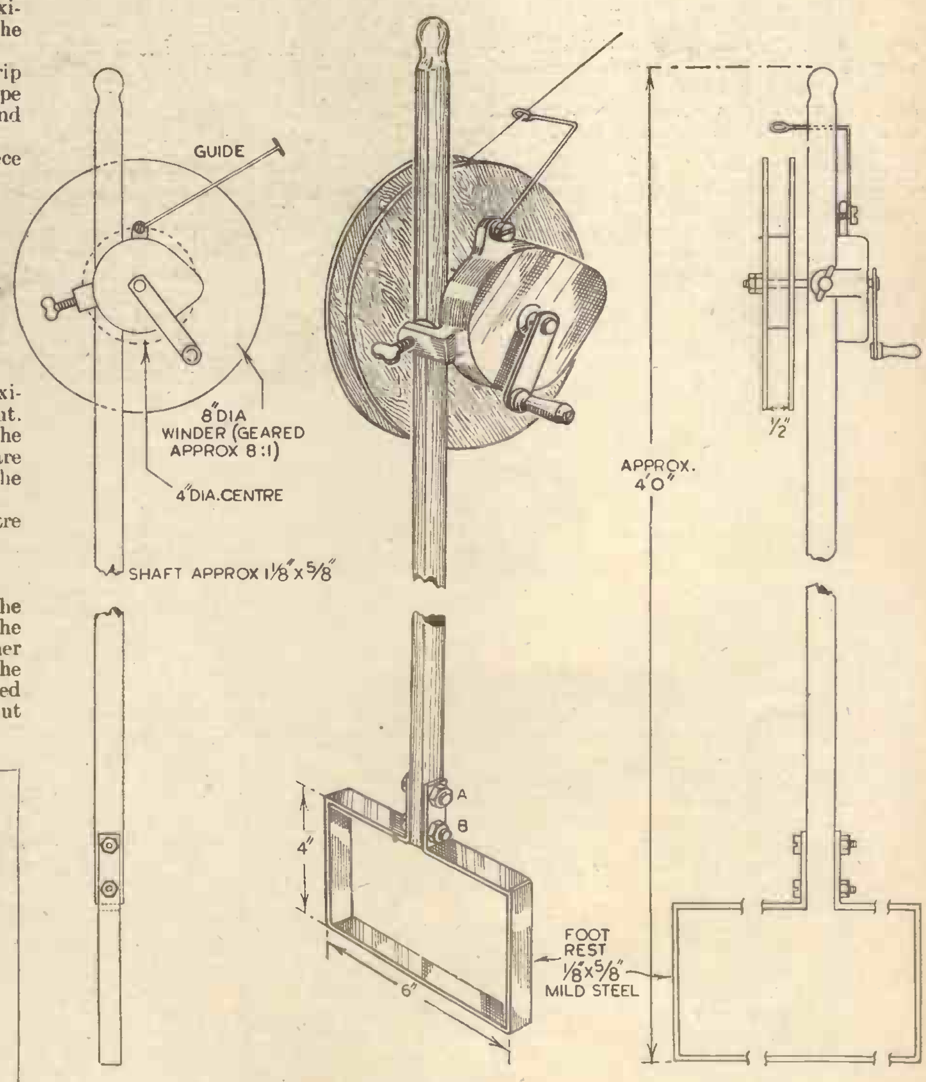
As the glider gains height, the shaft can be slowly tilted backwards, and should the glider go to the right or left, the winch can easily be turned in the same direction without having to stop winding in the line.

Fitting a Guide

It is very helpful to fit a guide, for the thread, to the winder as shown. This should be bent from 16 s.w.g. or 14 s.w.g. Any thinner wire will have a great tendency to sway about, and will be of little use. Make sure that there is no chance of the thread becoming entangled or damaged on the guide. This winder is easy to make and is very simple to operate.

The best method of fixing the thread to the drum, is to pierce a small hole in one side of the drum, pass the end of the thread through it and securely knot it on the outside.

This obviates any chance of the thread slipping when the line is fully extended.



Constructional details of the winch for launching model gliders

MASTERS OF MECHANICS

No. 52—THE WONDERFUL DOCTOR

The True Story of Roger Bacon, First of the English Scientists

SOME three centuries ago there was translated into English a book entitled "The Famous Historie of Fryer Bacon," in which Roger Bacon, the famous Franciscan friar, was credited with having been capable of all sorts of black magic.

In the "Famous Historie" we read how Bacon was able to summon strange and beautiful music from nowhere, and how, at his mere bidding, a table could become covered with the richest and choicest wines and fruits of the world. Here, also, we read the absurd story concerning "Friar Bacon's Head," a brazon head which Roger Bacon was supposed to have constructed and which was capable of speech.

And finally, in this supposed History, Bacon is made to end his death in a cell after having made a bonfire of all his magical writings and having duly committed the secrets of his Art to the flames. "His grave," the "Famous Historie" concludes, "he digged with his own nayles, and he was laied there when he dyed."

Man of Mystery

Now, unfortunately, all this tissue of nonsense has had its effect upon the historical, or, rather, upon the quasi-historical character of Roger Bacon, so much so that even nowadays he is commonly invested with quite an unnecessary amount of mystery and glamour as if he had constituted a sort of scientific Robin Hood or Friar Tuck.

It is only within comparatively recent times that the truth concerning Bacon has been ferreted out, mainly by means of a careful study of those writings of his which have managed to survive the passing of time. Such studies show us that, far from being a charlatan, or a would-be common practitioner of so-called "black magic," Bacon stands out in the annals of British science as almost a second Archimedes, and certainly as the first English scientist and experimenter of whom we have any record or positive knowledge.

Roger Bacon, the Franciscan friar, was born near Ilchester, in Somersetshire, in the year 1210 according to some authorities and in 1214 according to others. He seems to have come from a very wealthy family who sacrificed most of their fortunes on behalf of King Henry III in his struggle with the Barons from 1258 to 1262. Roger grew up to be a studious youth, and, after beginning his studies at home at the age of thirteen years, he proceeded to the University of Oxford, where he came under the tuition of Edmund Rich (afterwards Archbishop of Canterbury), and also became acquainted with another of Rich's pupils, one Robert Grosseteste, who subsequently became Bishop of Lincoln.

Incidentally, it was this latter individual who was originally connected with the fabulous story of the Speaking Head, the legend becoming attached to Roger Bacon at a later date.

The Clergy

We have now to bring to mind the fact that in the days of Roger Bacon there was no science at all worth speaking of in the whole of Europe, let alone in England. All knowledge was in the hands of the clergy,

Typical of the crude mechanical contrivances improved by Roger Bacon is the old English waterwheel, a device which still has its uses

who, as perhaps was only to be expected from the manner of their lives, fastened it down to the study of theology and of the old Greek and Roman philosophies. True it is that there had flourished before the time of Bacon the renowned St. Thomas Aquinas (1125-74), one of the greatest and most brilliant intellects which the world has ever seen. But Aquinas gave his life over to the formulation of a comprehensive system of Theology and Philosophy, which, however excellent it may be, did not, in any sense, attack the many practical problems which were waiting to be investigated in the domain of what we now term "Natural Philosophy."

Nevertheless, at this time, the ancient "scientific" culture of the old Greeks began slowly to spread throughout Europe, chiefly as a result of the writing of several Arabian thinkers, and for the development of this scientific spirit of learning in England almost in the very middle of the "Dark Ages" we are indebted to a small group of Franciscan Friars who were mainly led by the previously mentioned Robert Grosseteste, afterwards Bishop of Lincoln.

It was this little coterie which Roger Bacon joined after he entered the Franciscan Order at Oxford. He had then studied at the great University of Paris, and, returning to Oxford in 1250, he seems almost immediately to have launched upon a twenty-years career of experimental investigation, for he tells us that during that period he expended upon books and instruments no less than two thousand pounds, the bulk of which was subscribed by influential friends.

A Career of Experiment

Bacon, in setting off upon a career of experiment, went directly counter to the prevailing notions of his day. Right up to the dawn of the New Learning and the birth of the Scientific Era, it had been held that if it was not exactly morally wrong to perform experiments, it was certainly totally unnecessary to do so, for all the knowledge attainable about the natural order of things around us was contained in the writings of the Greek philosophers, notably those of Aristotle. Thus if in those days you wanted to know how many teeth an adult horse normally had, you endeavoured to look up the problem in Aristotle. You would never, unless you were almost hopelessly degraded, refer the problem to an actual inspection of the horse's mouth.

Incredible as it seems in our present age, it was this slavish devotion to Aristotle and the other ancient philosophers which succeeded in delaying the oncoming of experimental Science for many long centuries.

Gradually, however, the urge to experiment, the ambition to find out at first hand some of the essential facts concerning things around us succeeded in overcoming the prevailing servitude to the works of the Greek philosophers, and from this growing desire for experiment came into existence the first fundamentals of modern Science.

That Bacon was England's first experimental scientist there seems to be no doubt. In many ways, also, he was one of the first martyrs of Science, for, although he was not actively persecuted by the Church authorities of his day, he at least fell foul of them for a time and incurred their active displeasure.

"Natural Science"

Perhaps Bacon treated his fellow clergy, or wrote about them, with a greater amount of candour than of tact. He spoke so freely on the prevailing ignorance of the time and he became so enthusiastic in his devotion to what we call nowadays "Natural Science" that he found himself inhibited from lecturing to his students at Oxford. Later, in 1257, he was, by command of the General of the Franciscan Order, sent to the Paris House of the Franciscans and there he remained under very close intellectual surveillance for some ten years

Perhaps Friar Bacon would have stayed at Paris for the remainder of his life had it not been for the fact that one Guy de Foulques, an ecclesiastic whom Bacon knew and who was unusually broadminded became Pope in 1265, taking the title of Clement IV. Knowing the new Pope's philosophical inclinations, Bacon sent a petition to him from Paris, offering to write down his own system of natural philosophy for the benefit of the world. In the following year, Clement IV wrote to his "beloved Son, Friar Roger named Bacon, of the Order of Friars Minor," and invited him to compose the projected works, which, within another eighteen months, were forthcoming under the titles of "Opus Magnus," "Opus Minus," and "Opus Tertius," the latter being a sort of recapitulation of the two former "Works."

These works, in 1268, gained for Bacon permission to return to Oxford, which he did immediately. Settled once again in Oxford, the Friar commenced an encyclopaedic work, a "Compendium of the Study of Philosophy," which was published in 1271. But this, again, did not please the Oxford clerics. Moreoever, his friend and protector, Pope Clement IV, died, and soon after Roger Bacon was charged with dabbling in the occult and magical arts. His writings were condemned, and he was once more taken to Paris. Here again, despite the fact that he was now 64 years of age, he was again more or less confined to the Paris House of his Order, and, this time, the confinement lasted for fourteen years. Nothing daunted, however, Friar Bacon occupied this long period in further studies and in the composition of books on a wide range of subjects.

Waterwheels

When eventually he was allowed to return to his beloved Oxford in 1292, Bacon was now an old. although by no means a broken man. Returning finally to Oxford, he wrote a "Compendium of Theology." His last days seem to have been spent in complete tranquillity, and peace, and he died at the age of 79 on the 11th of June, 1294. He was buried in the Church of the Franciscans at Oxford, but all traces of his last resting place have long since disappeared.

Bacon's contributions to early science and mechanics are many. He appears to have been an authority on waterwheels and windmills and on various types of machinery, although never, so far as we can ascertain, did he hit even dimly upon the idea of the steam engine.

Scientific Prophecy

Yet in his various writings, Roger Bacon shows an amazing trait for scientific prophecy. Read. for instance, the following passage from one of his earliest treatises, "On the Marvellous Power of Art and Nature":

"First, by the figurations of art, there may be made instruments of navigation without men to row them, as great ships to brook the sea, only with one man to steer them, and they shall sail far more swiftly than if they were full of men : also chariots that shall move with unspeakable force without any living creature to stir them. Likewise, an instrument may be made to fly withall if one sit in the midst of the instrument and do turn an engine by which the wings, being artificially composed, may beat the air after the manner of a flying bird."

Most people remember Friar Bacon for his supposed invention of gunpowder. It would seem that Bacon actually made gunpowder and gave sundry demonstrations of its exploding force (which, no doubt, by no means tended to disprove his claim of having nothing to do with the "Black Arts"). The more, however, we go into the circumstances of Roger Bacon and gunpowder, the more we become impressed with the idea that he was not the actual creator or inventor of this material. It would appear that he obtained the basic idea of employing a mixture of nitre, sulphur and charcoal from some old Arabian alchemical work.

Gunpowder

But Bacon made the best of his work on gunpowder, and, as was the wont of his times, hid the information concerning it in a great mass of wordy writing. He says :

"From Salt Petre and other ingredients we are able to make a fire that shall burn at what distance we please. Sounds like thunder, and corruscations, may be formed in the air, and even with greater horror than those which happen naturally; for a little matter, properly dispersed, about the bigness of a man's thumb, makes a dreadful noise and occasions a prodigious corruscation, and this is done in several ways; by which a city, or an army may be destroyed after the manner of Gideon's Stratagem, who, having broke the pitchers and lamps and the fire issuing out with an inexpressible noise, killed an infinite number of Midianites."

Bacon's 'little matter, properly dispersed," has indeed in subsequent history carried out the promise of this first investigator of the powers of explosive substances.

Optics

Of the subject of Optics (which he called "Perspective") Bacon had a considerable knowledge. It is on the cards that he invented and actually used a crude type of magic lantern or optical projector years before it was first introduced in the seventeenth century by Kircher, of Rome. Although Bacon did not invent the telescope. he did construct several types of magnifying glasses. It has been conjectured, also, that he had much to do with the introduction of spectacles, for these nowadays often indispensable aids to vision certainly first became used in his time.

Although Bacon was not exactly a mathematician, his knowledge of mechanics enabled him to devise many simple types of instruments and tools which were wholly unknown in his time. He dabbled in alchemy, but, so far as we can see, he produced nothing worth while as a result of his chemical efforts.

Bacon's Claim

Probably Bacon's greatest claim to being the "First of the English Scientists" rests not upon the few scientific inventions or improvements which he brought about, but upon his instigating in our country the true spirit of scientific investigation. And this claim still stands in spite of the fact that for a couple of centuries after Bacon's death Science in England remained very much at a standstill.

Roger Bacon undoubtedly lived before his time. His classification of the sciences into "perspective (optics), astronomy, the science of weights, alchemy, agriculture and medicine" was undoubtedly a bold and a revolutionary one. So also was Friar Bacon's conception of the elements of national prosperity and success—"a fertile soil, busy workshops and easy conveyance for men and commodities from one place to another," a dictum which remains true despite its six centuries of age.

The "Wonderful Doctor"

When Roger Bacon died, his fellow clerics and his pupils referred to him as the "Doctor Mirabilis," the "Wonderful Doctor," and such he undoubtedly was in his lifetime. Now that the spurious aura of fanciful mystery and deceit has been stripped away from the life-history of Friar Bacon, we see him as one of the long line of great Englishmen, a scientific and a mechanistic pioneer, and, curiously enough, a strange forerunner of another English scientific thinker, Sir Francis Bacon, who was born in London more than three and a half centuries after the decease of the "Doctor Mirabilis."

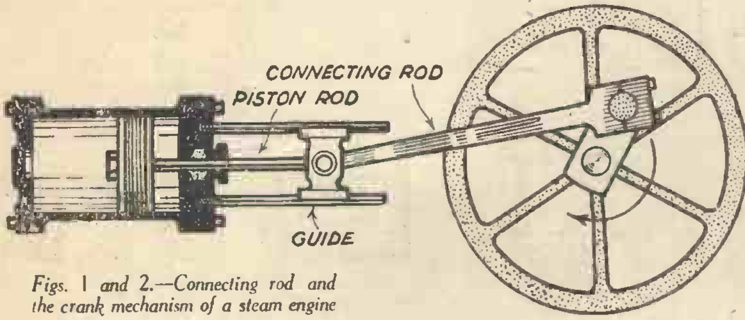
Both these Bacons adopted a similar and a fundamental attitude to scientific research, but if number and weight of works is any real measure of a man's true calibre, the older Bacon, who remained throughout his life a brown-habited friar of the Franciscan Order, was by far the superior of the two.

NEW MODEL AIRCRAFT BOOKS

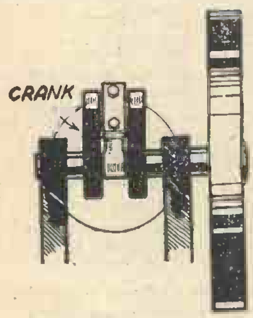
TWO new handbooks dealing with model aircraft are to hand from the Harborough Publishing Co., Ltd., Allen House, Newarke Street, Leicester. The first of these "The Design of Wakefield Models," by S. B. Stubbs, is a 48-page volume costing 1s. 3d. It is a treatise on the design and the factors affecting the design of the type of model specified for the Wakefield Contest. All of the necessary formulae and factors are given, and there is a generous supply of illustrations to luminate the text. A small improvement could have been made by giving titles to the chapters. That is not a criticism, but a suggestion. The second volume is entitled "An A.B.C. of Model Aircraft Construction." It is written by C. S. Rushbrooke, and costs 2s. 6d. There are 104 pages of most interesting matter and illustrations dealing with such subjects as the selection of your first model, materials and how to use them, why aeroplanes fly, tools, preparation for building, wings, fins, undercarriages, fittings, soldering, covering, propellers, etc.

Transmission

An Analysis of Some of the Better-known Devices for Transmitting the Drive from the Source of Power to Work



Figs. 1 and 2.—Connecting rod and the crank mechanism of a steam engine



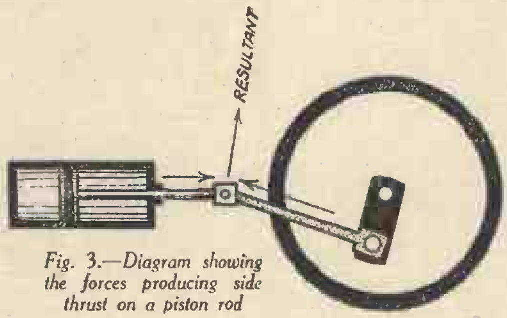


Fig. 3.—Diagram showing the forces producing side thrust on a piston rod

WHATEVER the source of energy utilised for the performance of mechanical work, whether it be steam, electricity, internal combustion or anything else, some mechanics is usually needed to convert that power into the form necessary for the particular type of work in hand. For instance, in the case of the ordinary steam engine the power is supplied in a reciprocating form, that is, by a piston which moves backwards and forwards, whereas it is usually required in a rotary form. The necessary conversion is therefore carried out by means of a connecting rod and crank.

Connecting Rod and Cranks Systems

An illustration of the steam engine system of connecting rod and crank is given in Fig. 1. The fact that steam is fed to both the top and bottom of the piston alternately necessitates the use of a rod known as the piston rod, which operates through a steam-tight gland in the end of the cylinder and transmits the power from the piston to the connecting rod. The piston rod is really a necessary evil, for it does nothing in itself to convert the direction of the piston's motion. It is employed merely to convey the motion of the piston to the little end of the connecting rod, without allowing the escape of useful steam from the cylinder. Its external end slides between two guides. Of course, without these guides it would tend to warp or bend with each thrust of the piston. the greatest strain being when the crank is roughly at right angles to the axis of the cylinder. Fig. 3 shows how the force of the piston and resistance of the connecting rod resolve themselves into this side thrust on the end of the piston rod, thus necessitating the use of guides.

In the internal combustion engine, as employed in motor cars, motor cycles and model planes and speed boats, the driving force is confined to the top of the piston, therefore the use of piston rod and guide rods, etc., is entirely dispensed with. Fig. 4 shows how the little end of the connecting rod is pivoted directly inside the hollow piston.

This form of transmission can be made extremely difficult especially if the main bearings of the crankshaft and the big end of the connecting rod are carried on ball or roller bearings. It suffers, however, from that one disadvantage associated with all reciprocating systems, due to the weight of the reciprocating parts. This weight not only reduces the speed of acceleration and deceleration, but tends to produce vibration. Even with the weight of the piston and connecting rod most carefully balanced by means of counterweights incorporated in the cranks or flywheels, vibration is likely to manifest itself at high speeds. Sometimes vibration "periods" occur. For example, an engine will run quite smoothly up to a certain number of revolutions per minute, say 3,000, and will then vibrate badly up to say 3,500 r.p.m.

Above this speed however, it will again run smoothly. This phenomenon is often due to the "natural" frequency of the whole unit coinciding with the frequency of the reciprocations of the engine at that certain speed. It is analogous with the classic example of the troop of soldiers marching in step across a suspension bridge and by reason of the rhythmic beat of their feet coinciding with the natural period or frequency of the bridge, causing it to oscillate violently in harmony with each step.

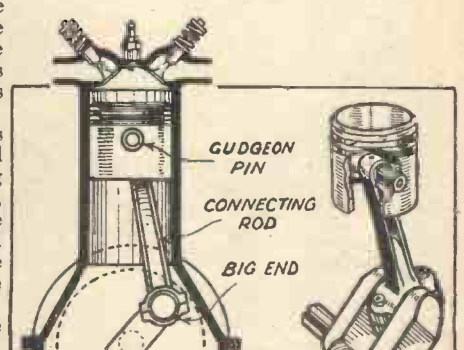


Fig. 4.—Connecting rod and crank assembly of an automobile engine

Weight of Reciprocating Parts

The need for making the piston and connecting rod as light as possible becomes very apparent if you consider that quite a usual speed for an internal combustion engine is 5,000 r.p.m. and that this speed means about 167 upward and downward movements of the piston per second. In other words, the piston is started and stopped 334 times per second. If you look at Fig. 4 you will see the reason for this. At the instant depicted the piston is moving downward. When half way down it will be moving at its greatest speed, but this speed will decrease rapidly until it reaches the bottom of its stroke, when for an infinitely short time it will remain stationary. It will then start on its upward journey until it reaches half-way when it will once more decelerate until it stops at the top of its stroke. It then starts on the next downward stroke, and so on. Thus you see, the piston actually accelerates twice and decelerates twice in the course of one revolution of the crank. Obviously, if the piston and the connecting rod are very heavy, the inertia to be overcome in alternately accelerating and decelerating something like 300 times per second will be

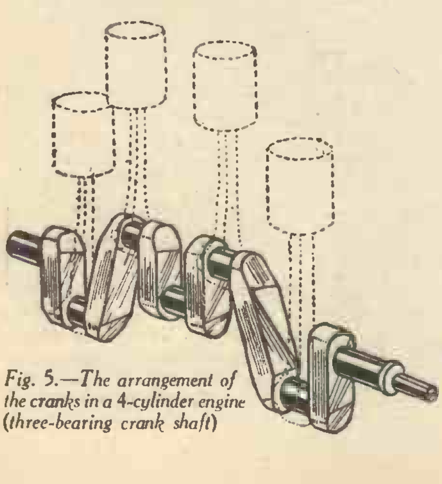


Fig. 5.—The arrangement of the cranks in a 4-cylinder engine (three-bearing crank shaft)

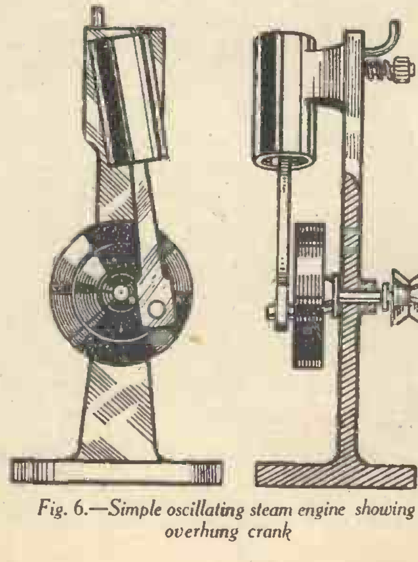
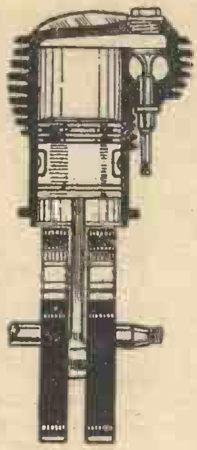


Fig. 6.—Simple oscillating steam engine showing overhung crank

# of Mechanical Power

enormous. It speaks well for the skill of modern metallurgists that alloys are available for piston and connecting rod construction which are light enough and strong enough to permit of speeds up to 10,000 r.p.m.

The design of cranks is by no means uniform, and various types are employed in different mechanisms. In some cases the crank is built up as in Fig. 2, in others it may be a solid forging such as the crankshaft of an automobile engine as shown in Fig. 5, or again crank and flywheel may be combined as in Fig. 6. This last arrangement is commonly used for small model steam engines of the oscillating cylinder type, while Fig. 7 shows a motor cycle engine in which the big end of the connecting rod bears on a crank pin joining the two flywheels.



(Right.) Fig. 7.—Twin fly-wheels which also form the crank in a motor cycle engine

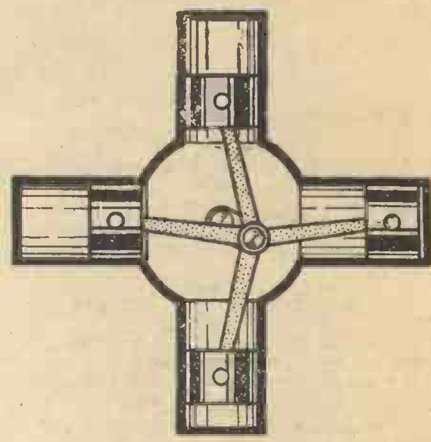


Fig. 8.—Principle of radial and rotary type engines

The Eccentric Belt Cam

A piece of apparatus which is closely allied to these crank devices is the eccentric cam. Builders of model steam engines and locomotives will be quite familiar with this. It is illustrated in Fig. 12 and is usually used to carry out a reversal of the action performed by the connecting rod and crank, that is, it converts rotary motion into reciprocating motion. In the steam engine it is used to impart a backward and forward motion to the valve gear by utilising the rotation of the crankshaft. Keyed or otherwise fixed to the crankshaft C is a circular disc or cam E. This, as its name implies, is mounted eccentrically on the shaft so that as the shaft revolves the centre of the disc traces out a circular path round the shaft. A metal strap S encircles the eccentric, which is able to rotate freely inside the strap. As this strap is an integral part of the eccentric rod R, the rotation of the eccentric causes the rod to adopt a crank-like action and so push the rod V backwards and forwards. This latter rod operates the valve. The dotted lines in Fig. 12 show various positions of the eccentric and rod in the course of a revolution of the crank.

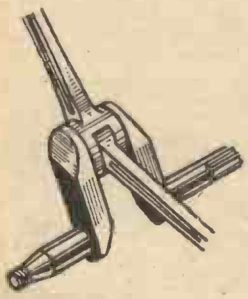


Fig. 9.—Method of mounting two connecting rods on one crank when the cylinders are in line

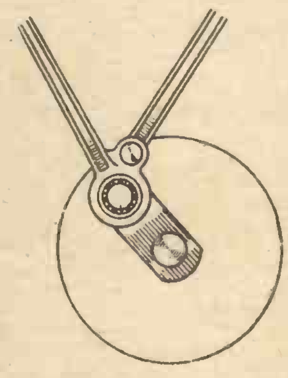


Fig. 10.—An alternative method

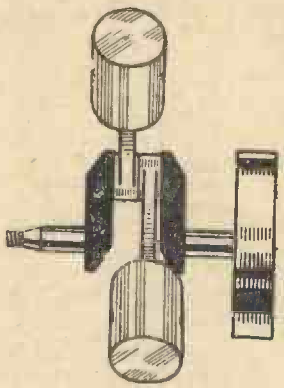


Fig. 11.—To mount the connecting rods side by side the cylinder must be off-set

In aero engine design, where multi-cylinder power units are the rule, some very elaborate connecting rod and crank assembles are to be found. Fig. 8 shows the principle of the radial and rotary types of engine. Here several connecting rods operate on the one crank, and some ingenious methods are employed to accommodate the big ends of the various connecting rods. A simple example of how more than one big end can be accommodated on one crank, when the cylinders are in line, is shown in Fig. 9. This is the usual arrangement adopted with a "V" type twin-cylinder engine. A stirrup shaped big end is used for one of the connecting rods. An alternative method is shown in Fig. 10. Of course, where it is not necessary to have the cylinders in line, the big ends may be placed side by side as in Fig. 11. However, in the design of radial and rotary engines with perhaps fourteen or eighteen cylinders, the problem is not quite so simple. Usually an elaboration of the method shown in Fig. 10 is employed.

The circular belt cam of the steam engine is but one of circular cam devices usual for converting circular motion into reciprocating motion and vice versa. The cams used to operate valve gear of automobiles are either pear-shaped or else squarish, as in Fig. 13. The object of a cam is to open and close its associated valve at the appropriate times during the explosion cycle. The ideal to be aimed at is the sudden opening of the valve to its full open position at just the right instant; the retention of it in this position for a certain period, during which time the gases are entering or escaping from the cylinder; and then its instant closing. The "square" cam conforms to these requirements. For about 180 degrees of its movement its contour is circular, and while this part passes under the tappet T the valve remains closed by reason of the valve spring S.

However, as soon as the "hump" of the cam arrives in the second drawing in Fig. 13 the tappet is suddenly pushed upward and opens the valve. This then remains open during the passage of the "hump" of the cam, after which the valve is instantly closed again by the force of the spring. Needless to say, with a "square" cam the whole mechanism is inclined to wear more rapidly than when a pear-shaped one is used, owing to the fact that a very strong valve spring is needed to induce the tappet to follow the violent contour of the cam, especially when it is rotating at speed. With wear the valve gear becomes noisy as well as losing its efficiency. For this reason cams of the pear-shaped type are usually employed for the engines of touring cars. O

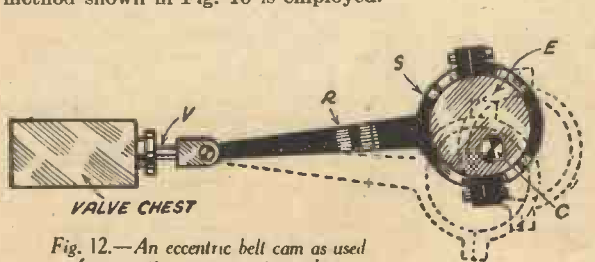
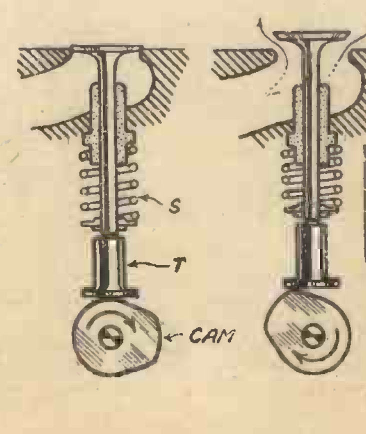


Fig. 12.—An eccentric belt cam as used for operating steam engine valves



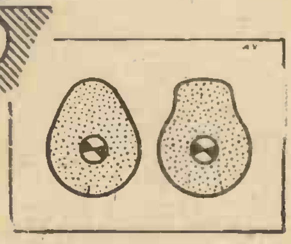


Fig. 13.—Internal combustion engine valve gear, using cams for converting rotary into reciprocating motion

course, with pear cams the valves do not open and close quite as rapidly as efficiency demands, but they are quieter in operation and wear better.

Other Cam Mechanisms

Some interesting, though less well known, cam devices are shown in Figs. 14-17. The first one is a face cam mounted on the end of a rotating vertical shaft. In the example shown, two separate cam contours are incorporated on the face of the one disc at the head of the shaft. Bearing on these two cams are two rockers pivoted at A and B respectively, and each is fitted with tiny rollers to reduce friction. As the shaft and cams rotate, so the two rockers move up and down, thus converting rotary into reciprocating motion.

The heart cam and the drum cam shown in Figs. 15 and 16 respectively are both of the positive motion type, no springs being required to make the reciprocating element follow the contour of the cam. They are both designed to convery rotary motion into irregular reciprocating motion.

The device shown in Fig. 17 is somewhat similar to that eccentric belt cam of Fig. 12. It employs a circular eccentric cam, but thus dispenses altogether with a connecting rod. The circular motion of the cam shaft is converted into an irregular backward and forward motion by the rotation of the cam within the rectangular shaped yoke.

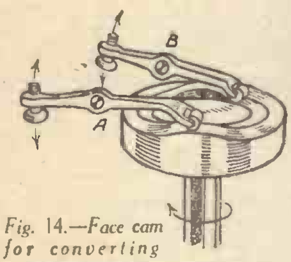


Fig. 14.—Face cam for converting rotary into reciprocating motion

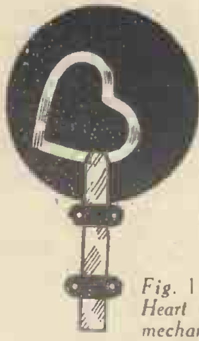


Fig. 15.—Heart cam mechanism

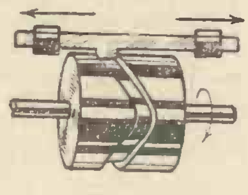


Fig. 16.—Drum cam for converting rotary motion into irregular reciprocating motion

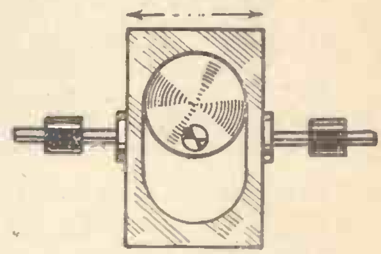


Fig. 17.—Another cam device

The Swash Plate Device

A device which is very similar to a face cam is illustrated in Fig. 18. It is known as a swash plate, and consists of a circular metal disc mounted concentrically on a shaft, but tilted at an angle to its axis. It is sometimes used for operating the valve gear of certain steam engines where the valve chest is mounted on the top of the cylinders and the valve works parallel with the axis of the crankshaft. This is illustrated in Fig. 18. As the crankshaft rotates, so the swash plate rocks from side to side and oscillates the lever. The upper end of this lever is attached to the valve spindle by a simple link mechanism which conveys a reciprocating motion to the spindle.

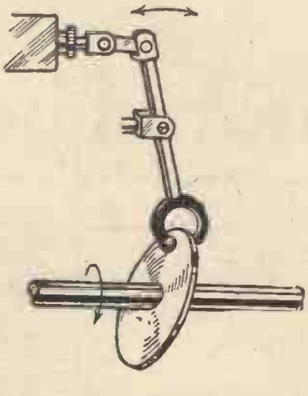


Fig. 18.—Swash plate for operating steam engine valve gear

A description of the various types of gears, clutches, ratchets and other mechanisms associated with the transmission of mechanical power will be dealt with in a later article.

The swash plate has also been used in place of a crank in both internal combustion engines and various pump devices. In these mechanisms a number of vertical cylinders are arranged in circular formation with their connecting rods bearing on the surface of a swash plate whose axis is parallel with that of the cylinders. Compared with the orthodox crank, this arrangement is somewhat inferior, as considerable friction is introduced at the contact of the connecting rods with the swash plate.

NEW INVENTIONS

To Keep the Head On

MOST people who have occasion to use a brush or broom, have experienced the nuisance of the head coming off the handle. An inventor, impressed with the fact that previous attempts to ensure an indissoluble union have been futile, has set himself the task of nullifying this tendency to divorce. The common mode of attachment consists in driving a nail through the brush head and the handle. It appears that the hole in the brush head is usually too shallow, causing the nail to have only a precarious hold on the handle.

To remedy this defect, the inventor in question has combined in a brush head and handle two screws. One of these screws has a hole bored through its head. This is screwed into the head of the brush approximately parallel to the handle. The second screw is inserted through the hole in the first screw and screwed into the handle at right angles to its longitudinal axis. The results should be that the head and handle live together happily for ever after.

Roundabouts

THE evolution of the roundabout from the primitive merry-go-round to the latest gorgeous development, has shown many variations. To heighten the enjoyment derived from this rotating source of amusement, by providing means giving novel sensations, is the declared object of a recent invention of the roundabout type. The new excitement is obtained by two roundabouts revolving in juxtaposition. As a consequence, the enchanted passengers on one will receive the impression that they are rushing to an inevitable collision with the delighted riders on the other. It is stated that the best effect is produced by by rotating the two roundabouts in opposite directions. The sequel is a thrilling circular tour.

Lather and Grit

FOR cleaning very dirty hands something more powerful than ordinary soap is required. The average lathering soap has the drawback that it will not remove the stains from the skin. On the other hand—in fact, on both hands—a sand-containing soap, which has the grit to rub out dirt, lacks lather.

To obviate these defects, an inventor has produced a soap tablet consisting of two parts, one of lathering soap and the other containing sand. The characteristic feature of this tablet is that the sand-containing part is located in a depression formed in one of the large sides of the lathering soap. Consequently, the former part has a border of lathering soap.

One advantage of this tablet is that, owing to the roughness caused by the presence of the sand, the soap is not so slippery as the average cake.

The villain in the melodramatic thriller who soaps the stairs would not find this particular soap effective for his nefarious purpose. And, though its obliterating power is almost omnipotent, I am afraid it would fail to remove the incriminating stains on Lady Macbeth and Bill Sikes.

To Salve an Aeroplane

IMMEDIATELY prior to the war, an application by a German citizen for a patent relating to aircraft was published by the British Patent Office. His invention concerns the movement or removal of damaged or disabled aeroplanes. If, whilst landing, an aeroplane breaks its undercarriage, or if it is fitted with a retractable undercarriage which cannot be moved because it is jammed, the plane is forced to land on its body. The salvage of the machine then presents difficulties, owing to the fact that damage may be caused to the framework.

To cope with the task of lifting an aeroplane in the aforementioned predicament, the inventor's idea is to raise the machine by means of inflatable receptacles of a pliable material. These are placed between the plane and the ground. The inflation exerts a lifting pressure directly upon, and over an extensive area of the surface of the structure. This invention is, in principle, a pneumatic jack.

A DICTIONARY OF

Metals and Their Alloys

(Continued from page 126 of last month's issue)

LIST OF ABBREVIATIONS

The following abbreviations are used throughout this Dictionary :

At. No.	Atomic Number
At. Wt.	Atomic Weight
M.P.	Melting Point
B.P.	Boiling Point
Sp. Grav.	Specific Gravity
Sp. Ht.	Specific Heat
Coef. Exp.	Coefficient of Expansion
Therm. Cond.	Thermal conductivity
Elec. Cond.	Electrical conductivity

Bismuth.—Metallic element. Chemical symbol, Bi; At. No. 83; At. Wt. 208; M.P. 269°C.; B.P. 1420°C.; Sp. Grav. 9.823; Sp. Ht. .0305; Coef. Exp. .00001333; Therm. Cond. (Silver—100) 1.8; Elec. Cond. at 0°C. (Mercury—1) .8676.

Chief ores: Bismuth Ochre, Bi_2O_3; Bismuth Glance, Bi_2S_3. It occurs mainly in the free metallic condition.

Metallic bismuth was known by the alchemists, but was frequently confused with antimony and/or zinc. The metal was, perhaps, first scientifically studied by an Englishman, J. H. Pott, in 1739. Its name is supposed to be derived from the German, *weissmuth*, white matter, in reference to its now well-known white carbonate.

Bismuth is a white, lustrous metal having a very faint reddish tinge. It is extremely brittle and is a poor conductor of heat and electricity. Alloys readily with other metals, and imparts to them the properties of hardness and low-temperature fusibility. Hence, it is used a good deal in the making of such alloys as Wood's metal, etc. "Fusible metals" of this type are used as safety plugs in steam boilers, in fire-alarm apparatus and in other devices. Bismuth alloys are also used for the making of metallic casts. Chemically, bismuth is fairly reactive, its best-known compound, bismuth carbonate, being a popular medicinal substance. In most of its properties, bismuth is similar to antimony.

The fracture begins at the surface of the metal

Bismuth Amalgam.—A thinly fluid amalgam prepared by adding mercury to molten bismuth. Almost any proportions of these two ingredients may be used. Bismuth amalgams, on account of their fluidity, are useful for filling very delicate moulds. Other amalgams are, also, rendered more fluid by adding to them a small proportion of a bismuth amalgam.

Bismuth amalgam is sometimes used for silvering glass globes and similar articles.

The amalgam will pass through chamois-leather like mercury. The drops, however, are pear-shaped and not perfectly globular as in the case of pure mercury.

Bismuth Bronze.—An alloy sometimes used for mirrors and lamp reflectors on account of the very high polish which it takes. Composition : copper, 52; nickel, 30; zinc, 12; lead, 5; bismuth, 1 parts.

Bismuth Purissimum.—Name sometimes given to refined bismuth metal of from 99.85 to 99.98% purity.

Black Antimony.—See **Yellow Antimony.**

Black Arsenic.—Also known as "beta" arsenic. Obtained by the slow condensation of arsenic vapour. It occurs as a black powder or a brittle, glassy-looking mass which, when heated to 360°C., passes into the ordinary "grey" or "metallic" arsenic.

Black Tin.—Strictly speaking, this is not a metal. It is the name given by miners to tinstone (tin ore) to distinguish it from tin metal which they called "White tin."

Blister Copper.—Name given to metallic copper after it has been roasted in a reverberatory furnace. It has then a blistered appearance.

Blister Steel.—A certain type of raw steel which has been cooled very slowly and which presents a warty or blistered appearance, the "blisters" having been formed by the efforts of gas to escape from within the metal.

Three stages in the growth of a fracture in a brass rod which has been subjected to intermittent stress

The fracture deepens

Block Tin.—Name given to ingots of cast tin. These are usually cast in granite moulds.

Blowhole.—An air-hole in a metallic casting.

Blue Gold.—(*a*) A gold-iron alloy containing from 25% to 33.3% of iron.

(*b*) A colloidal solution of gold prepared by reducing a solution of gold chloride with hydrazine hydrate. It possesses a bluish colour.

Blue Metal.—A name for impure copper obtained during the process of copper smelting. "Blue metal" contains from 55% to 66% of metallic copper mixed with copper and iron sulphides. It has a peculiar bluish colour.

Bob Brass.—See **Ferrule Brass.**

Bobierre's Metal.—This is ordinary brass consisting of 66 parts of copper and 34 parts of zinc. Introduced by M. Bobierre in the last century as a sheathing for ships.

Boroto Metal.—A tin-lead-antimony white-metal in which colloidal graphite is incorporated. Of American origin, it has a Brinell hardness of from 17-25, and is employed as a self-lubricating bearing metal.

Bottger's Amalgam.—An electric amalgam used in frictional machines, etc. Composition : zinc, 2: mercury, 1 parts.

Bottoms Copper.—The copper which has sunk to the bottom of the smelting furnace. It is the least pure of the mass of metal in the furnace and it usually contains tin, lead and antimony, and sometimes traces of silver and gold.

Bourbon Metal.—An alloy composed of equal parts of tin and aluminium. It solders readily.

Brass.—A generic name given to alloys of copper and zinc. Common brass (or cast brass) contains 2 parts of copper and 1 part of zinc.

Brass has been known from early ages. Its name is supposed to be derived from the Anglo-Saxon word *braes*—a fire-produced metal.

The various brasses are described under their individual names.

Brazing.—Soldering with a brass alloy.

Brazing Brass.—A brass alloy having a low zinc content. It possesses a red colour and is used for brazing purposes. Composition : copper, 86.75; zinc, 12; lead, 1.25 parts.

Brazing Metal.—This term is usually synonymous with brazing brass.

The fracture almost complete

Brazing Solder.—A variety of brass containing copper, 50%; zinc, 50%. Is usually cast in iron moulds having transverse and longitudinal ridges, so that the cake of brass can be broken up into small rectangular pieces. These pieces are then heated in a furnace and afterwards powdered in an iron mortar. The solder is used for uniting iron and brass.

Brearley Steel.—An original type of stainless steel discovered in 1913 by Mr. Harry Brearley, of Sheffield. It is a high chromium steel and it was first made available for cutlery purposes about the middle of 1914.

Brightray.—A nickel-chromium alloy of high corrosion resistance.

Brinell Hardness Test.—A standardised test of metal hardness. It is made by indenting the smooth surface of the metal under test by means of a hardened steel ball (usually 10 mm. in diameter) by subjecting it to a pressure or load of 300 kilograms for a soft metal and 3,000 kilograms for a hard metal. For very hard materials, a 2 mm. diameter diamond sphere is used.

By means of a lens, the diameter of the indentation in the metal surface is measured, and this is used as a means of calculating comparative hardness numbers—Brinell Hardness Number.

Bristol Brass.—This is the same as Prince's Metal, which see.

Britannia Metal.—This is, in reality, tin hardened with from 5 to 10% of antimony. It frequently contains a small amount of copper. Typical composition is: tin, 140; antimony, 8; copper, 3 parts. An increase in the amount of copper has the effect of colouring the metal.

The average M.P. of the above alloy is 250°C. It is much used as the base metal of plated goods of the ornamental type.

Brittleness.—A metal which easily breaks upon the application of a sudden shock or one which fractures readily when subjected to a hammering or compressing force is considered to be brittle. Metals are usually increased in brittleness by the presence of impurities within them. Thus, phosphorus in iron renders the metal brittle or "short."

Crystalline metals are usually brittle, because of the feeble degree of cohesion between their component crystals.

Distinguish carefully between brittleness and hardness of a metal. The two terms are by no means synonymous. Thus for example, Manganese steel is hard, but it is not brittle. Metallic tellurium is brittle but it is not hard.

"Brocade."—A type of bronze powder consisting of coarse metal flakes prepared from the waste of metal-leaf factories.

Bronze.—The name given to a large class of copper-zinc-tin alloys. Approximate limitating proportions of these constituents are: copper, 70-90%; zinc, 1-25%; tin, 1-18%.

Such bronzes are much used for making castings, coins, ornaments, etc.

Bronze has been known from very ancient times.

Bronze Powders.—These are used for coating metallic and non-metallic objects in order to impart to them a decorative appearance. They have the following average composition: copper, 64-83%; silver, 4.3-4.5%; tin, 8-8.7%. The lower grades of bronze powders contain up to 13% of zinc, which whitens them considerably.

Brown Gold.—An alloy containing 20 parts of gold, 4 parts of copper.

Buflokast.—An iron-silicon alloy of American origin. It is non-corrosive and is similar to Tantiron, which see.

C

Cadmium.—Metallic element. Chemical symbol, Cd.; At. No. 48; At. Wt. 112; M.P. 320.2°C.; B.P. 745°C.; Sp. Grav. 8.6603; Sp. Ht. .0548; Coef Exp. .00003323; Therm. Cond. (Silver—100) 20.06.; Elec. Cond. at 0°C. (Mercury—1) 13.46.

Occurrence: Mainly in zinc ores. Cadmium never occurs in Nature in the free state.

Cadmium was discovered by F. Stromeyer in 1817 in a specimen of zinc carbonate, the name "cadmium" being coined from the term *cadmia fossilis*, by which zinc ore was then known, the ancient Greeks having, during their civilisation, known zinc ore as "cadmeia."

Cadmium is a bluish-white metal, closely related to zinc on the one hand and to mercury on the other. It tarnishes superficially, and is fairly reactive chemically, one of its chief compounds, cadmium sulphide, CdS, being extensively employed in the paint industry as a golden-yellow pigment.

Cadmium metal is ductile, and can be rolled into sheets and drawn into wire. It has been used to some extent as a plating metal. Cadmium is also used in the making of fusible alloys and certain casting metals.

Cadmium Amalgam.—Amalgams of mercury and cadmium readily crystallise. They can be made in almost any proportions. They are tin or silver-white in colour and, when heated, become soft and can be kneaded. These amalgams are useful as metallic fillings and stoppings for a variety of purposes.

When mercury is completely saturated with cadmium, the resulting amalgam has the composition: mercury, 78.26%, cadmium, 21.74 parts. This amalgam is tin-white, crystalline, and, although it is somewhat brittle, it softens, like all cadmium amalgams, when heated, so much so that it can be kneaded like wax. This amalgam is sometimes used by dentists for filling teeth.

Cadmium Copper.—A copper - cadmium alloy containing either 0.5% or 1% of copper. Retains a maximum conductivity with an increased tensile strength, and hence is in demand for the manufacture of overhead electric lines, power cables, etc. It was first introduced in 1920 and has an approximately 50% greater tensile strength than ordinary hard-drawn copper wire.

Caesium.—Metallic element. Chemical symbol, Cs; At. No. 55; At. Wt. 133; M.P. 28.5°C.; 670°C.; Sp. Grav. 1.903; Sp. Ht. .0522; Coef. Exp. .000345.

Discovered by Robert Bunsen and G. Kirchhoff (1860) in certain spring water containing lithia. Given the name, caesium, from the Latin, *caesius*, sky-blue, in respect of the blue light emitted by its incandescent vapour.

Occurrence: in certain mineral waters containing lithia, sodium, etc. Also in some rare minerals.

Caesium is a silvery-white, ductile metal, which is soft enough to be cut with a knife, like cheese. It is the most electro-positive of metals. Exposed to air, it rapidly becomes covered with a film of oxide, and hence must be preserved below the surface of oil. Like sodium and potassium, it energetically decomposes water with the evolution of hydrogen gas and the production of caesium hydroxide. If placed in an atmosphere of dry oxygen, caesium will spontaneously take fire.

Within the last few years, caesium has come into prominence as a light-sensitive metal in the manufacture of photo-electric cells, "caesium cells" being particularly infra-red sensitive.

Calcium.—Metallic element. Chemical symbol, Ca; At. No. 20; At. Wt. 40; M.P. 780°C.; Sp. Grav. 1.52; Sp. Ht. .152; Elec. Cond. at 0°C. (Mercury = 1) 12.5.

Discovered in 1808 by H. Davy. Name derived from the Latin, *calx*, lime, since calcium is the constituent metal of lime and limestone. Occurrence: in limestone, chalk, marble, calcspar, $CaCO_3$.

A white, lustrous metal, having a slight yellow tinge. Has a strong affinity for oxygen, becoming coated with an oxide film when exposed to air. Decomposes water with evolution of hydrogen and formation of calcium hydroxide, $Ca(OH)_2$. In general properties, calcium closely resembles barium and strontium. When heated in nitrogen, forms calcium nitride, Ca_3N_2. Calcium metal is fairly soft and malleable. Usually preserved under oil or naphtha.

Calcium metal can be made to form alloys with aluminium, lead, antimony, sodium, potassium and zinc, as well as several amalgams with mercury, but neither the metal nor its alloys have any special uses.

Calcium Lead.—Lead containing a small percentage of metallic calcium to harden it.

Camelia Metal.—A white metal used for pivot bearings in machinery and for similar purposes. Composition: zinc, 10.2%; copper, 70.2%; tin, 4.25%; lead, 14.75%; iron, 0.55%.

"Carat" Gold.—The amount of gold in alloys is conventionally expressed in parts per 24, these parts being termed "carats." Thus pure gold is "24 carat gold," whilst a gold alloy containing 18 parts of gold and 6 parts of silver (or copper) constitutes "18-carat gold." Similarly, "9-carat gold" contains 9 parts of gold and 15 parts of other metal.

The word "carat" is supposed to be derived from the Greek, *keration*, signifying a bean or a seed used for weighing gold.

Carbon Bronze.—An anti-friction bearing metal containing a trace of carbon. Composition: copper, 75.47%; tin, 9.72%; lead, 14.57%; carbon, 0.1%.

Carbondale Silver.—A variety of nickel silver. Composition: copper, 66; nickel, 18; zinc, 16.

Carbon Steel.—Roughly speaking, steel is an intermediate material between cast iron and wrought iron, the latter being the purest form of iron commercially attainable.

Cast or pig iron contains about 3% of carbon. Wrought iron contains about 0.06% of carbon. Between these two limits comes "steel," a form of iron containing dissolved or alloyed carbon. "Carbon steel," therefore, is nothing more or less than "ordinary" steel, the word "carbon" being employed to distinguish the metal from the nowadays numerous "alloy" or "special" steels which contain other alloying metals in addition to carbon. "Carbon" steel, therefore, is the "old-fashioned" type of steel.

A "hard" carbon steel contains about 1% of carbon, whilst a "soft" steel of this type has a carbon content of about .1%.

(*To be continued*)

QUERIES and ENQUIRIES

Re-silvering a Mirror

CAN you tell me how to re-silver a looking glass?—A. L. (Bristol).

THERE are three general chemical methods of silvering glass. Of these the following, known as the Rochelle salt method, is the most readily worked for average purposes.

Make up the following solutions :—

Solution 1.

Silver nitrate	0.5 gram.	
Rochelle salt	0.7 ,,	Boil and
Water	250 ccs	filter.

Solution 2.

Silver nitrate	2.5 grams.
Water	25 ccs

To Solution 2 add strong ammonia drop by drop until the precipitate formed just dissolves. After this, add one or two drops of weak silver nitrate solution until the liquid just becomes cloudy again. Then dilute the solution with 250 ccs of water.

For use, the above two solutions (which should be freshly prepared) should be mixed in equal amounts and *instantly* poured over the surface of the glass. For this purpose, the latter should lie in a perfectly clean dish. Silvering will take place immediately and will be completed within about five minutes.

Before silvering, the glass should be very carefully cleaned, preferably by rubbing it over with nitric acid. It should then be well rinsed. Just before silvering it is advisable to immerse the glass in a strong solution of stannous chloride for a few minutes and, afterwards, to rinse the latter salt away.

Distilled water should be employed for making the solutions.

The whole secret of successful silvering is (*a*) thorough cleanliness of all vessels and solutions, (*b*) cleanliness of the glass surface, and (*c*) accurate making up of the solutions. If you have not engaged in this work previously, it would be advisable for you to perform a few experiments in glass silvering before embarking upon it for a serious purpose.

Repairing Bakelite

CAN bakelite be repaired so as to retain its insulating properties and if so how can this be achieved? Also, what is the voltage required to produce a spark of one centimetre?—L. D. (Carlow).

THE possibility of satisfactory repairs depends largely on the size of the article and the nature of the break. If the article has not become distorted or warped through the fracture and the edges are quite clean and close fitting apply a little of the cement sold as "Certofix" on both sides of the broken part, allow it to become tacky, and press together with a clamp until hard. "Bostick" is another useful cement, and rather a better insulator. Replying to another question, the voltage required to spark across a distance of one centimetre will depend upon the shape of the terminal points, the atmospheric pressure, and on the temperature. Between two insulated spheres of 20 mm. diameter at 25 degrees C. and 76 mm. barometric pressure, a discharge spark will take place across a distance of 4.2 millimetres with a potential difference of 10,000 volts between the spheres. At 20,000 volts the sparkover will cross a gap of 8.6 mm., and at 30,000 volts 13.7 millimetres. From these three points a curve can be plotted showing the probable behaviour for higher or lower pressures. Fuller particulars can be obtained from British Standard Specification No. 358 of 1929, obtainable from 28 Victoria Street, London, S.W.1.

Winding for Synchronous Clock Motor

I WISH to know how to decide on the number of turns and gauge of wire to use on a small synchronous multi-polar electric motor of sufficient power to drive a clock.

I have planned to use an iron disc rotor of 1 in. diam. and having 30 teeth. The coil would be $1\frac{1}{10}$ in. long and have its poles terminating in 8 teeth on each side. The current is A.C. 220 v. 50-60 cycles.—A. C. (Mullingar).

YOU omit to state what train of gears you are contemplating, but probably have realised that the clock would not keep time on frequencies of both 50 and 60 cycles, it must be designed definitely for one or the other. The 30-slot rotor of 1 in. diameter need not be more than $\frac{1}{8}$ in. thick, but should be built up of thin stampings, not from the solid. The same applies to the stator having eight slots on each pole face. If you intend this to be plugged in direct on a 220 volt circuit you must be prepared to wind the coil with extremely fine enamelled copper wire such as No. .45SWG, and if this is a first attempt at winding it cannot be recommended as it would tax the skill of quite an experienced winder. As an alternative it is suggested to run the clock from a bell transformer secondary, at say 12 volts, in which case a suitable winding would consist of 1 oz. of No. .38SWG enamel covered copper. Cotton coverings are quite inadmissible owing to the increased space factor they require. With enamel coverings 2.4 times as many turns as cotton covered wire of this gauge can be got into the same winding space.

Fireproofing Canvas

CAN you tell of a reliable solution for making canvas fireproof. Can paper also be made fireproof?—W. M. (Eltham, S.E.9).

IN two gallons of hot water dissolve approximately 1 lb. of alum. With a clean brush, spread this mixture (preferably hit) all over the canvas and on both sides so that it is thoroughly impregnated. When dry, rub the canvas over with a clean rag in order to remove any of the alum powder which may be adhering to its surface. The canvas will now be fireproof.

Another solution having the same effect is made by dissolving 10 parts of sodium tungstate in 100 parts of water.

Paper and other materials can be similarly fire-proofed by immersion in the above solutions.

Actually, the above "fire-proofed" materials will often smoulder slowly if they are ignited, but, usually, the smouldering area will not spread itself.

Running Motor on Reduced Voltage

I HAVE a Spartan refrigerator—compressor type—with a one-sixth h.p. motor. 1,440 r.p.m. 1.9 amps at 220 v. A.C.

I now want to run this off 240 A.C. mains. I take it that the coil resistance of the motor is 220/1.9 = 115 ohms. and that if I put a resistance of about 10 ohms in the lead from the wall plug to the motor it will reduce the voltage at the motor from 240 to 220.

How do I do this? I have some 24 gauge Eureka resistance wire, and I wound 10 ohms. on to a former, but the wire got very hot through overloading. What is the right wire, and how much shall I need?—N. L. (Middlesex).

IT is a little difficult to advise in the absence of further particulars as to the type of motor. If it is a series motor of the commutator type and you wish to dissipate the difference of voltage between 240 and 220, that is 20 volts, when the motor is taking its normal current of 1.9 amperes, all you need is a small additional resistance in circuit of 20/1.9 = 10.5 ohms. No. ·23SWG Eureka resistance wire will carry this current without excessive temperature rise, if freely ventilated, and has a resistance of 1.487 ohms. per yard, so that the length of wire required to give the required 20 volts drop would be 20/1.487 = $13\frac{1}{2}$ yards. approx. This should be wound on an insulated metal tube of about $1\frac{1}{2}$ in. diameter, mounted vertically and protected with a ventilated cover. If the motor is of the induction type, however, the proposed resistance may not be entirely satisfactory, since these motors take such a heavy starting current in order to develop normal torque that the additional resistance in circuit would cause an abnormal volt-drop at the terminals and probably prevent the motor from starting up. The impedance of the windings is mainly composed of inductance with a very low ohmic resistance, in this type of motor, hence your calculation of the motor resistance would not apply. If the suggested resistance does not enable the motor to start up the best alternative will be to put in a small auto-transformer input 240 volts output 220 volts, short-rated at 10 amperes, and continuously rated at 2 amperes.

Bengal Matches

COULD you kindly give me some information about the following :—

How Bengal matches are manufactured?

How enamelled show signs are manufactured?

How mechanical tin toys are coloured or painted?—P.O. (Co. Clare).

BY "Bengal Matches" we presume that you mean those which burn with a coloured flame, usually a red or a green flame. These matches contain the ordinary safety-match "mixture," i.e., the matches are tipped with a mixture containing potassium chlorate, potassium bichromate, red lead and antimony sulphide and they are inflamed by rubbing on a surface (usually the side of the matchbox) prepared with a mixture of red phosphorous, antimony sulphide and a little glue to act as a binding agent. The matches are "coloured" by adding to the match-head mixture a quantity of barium nitrate (which will colour the flame green) or strontium nitrate (which colours the flame red). Likewise, sodium nitrate would colour the flame orange, whilst traces of copper salts would import a blue-green colouration to it. The preparation of these matches is not without danger and should not be undertaken except upon a very small scale.

Enamelled show signs are nowadays manufactured in many different ways. Usually, however, the clean iron surface has spread upon it the glazing composition which is either printed on in the form of letters or designs or else laid on by hand. This glazing mixture, may, of course, be of any colour. Thus, for instance, a sign consisting of black lettering on a white background would have its black letters applied first, the surround subsequently being whitened. Finally, of course, the prepared sheet is "fired" for a definite time at a high temperature in a muffle furnace, wherein the glaze fuses and afterwards sets to a hard glassy film.

The mechanical toys which you refer to are usually hand coloured with ordinary enamel paints. If, for instance, you apply soap and water to any ordinary painted toy, the colours can usually be removed quite readily. Workers in the toy trades, particularly in foreign factories, become very adept at painting large numbers of these toys at a rapid rate.

Egg Tongs

I HAVE produced a pair of egg tongs, made of wire. The feature is the novel way in which the egg is picked up.

When the tongs are gently pressed into the egg, they automatically grip it and hold it securely.

A slight pressure on the sides of the tongs, releases the egg.

Do you think that the idea is fit subject for a patent. If not, can it be protected by some other means?—V. W. (Surrey).

THE improved device for handling eggs, if novel, appears to form fit subject matter for letters patent, but without further particulars or a sample of the invention, it is not possible to express a definite opinion. It may be that protection for the device could be obtained by registration as a design. The cost of registering a design is less expensive than a patent, but the protection given is not as broad as a patent.

In some cases it is possible to obtain both a patent and a registered design for a device, but all devices are not capable of registration as designs.

American Patents

IN a recent issue you state in one of the "Replies" that an American patent *MUST* be filed within 12 months of the English patent application.

Does this mean that a patent device which has proved to be successful, but only after 18 months exploitation here, cannot be patented at all in U.S.A. by its original British owner?—G. B. (Sunderland).

ACCORDING to the U.S. Patent Law an invention to be patentable must be novel. An invention is not considered novel (1) If it has been known or used by others in the U.S.A. before your invention or discovery thereof; (2) if it has been patented or described in any printed publication in the U.S.A. or in any foreign country before your invention or discovery thereof, or more than two years prior to the application for the patent; (3) if the invention has been in public use or on sale in the U.S.A. for more than two years prior to your application unless the same is proved to have been abandoned; (4) if an application for patent for the invention has been filed in a foreign country more than 12 months prior to the application in the U.S.

It may be taken as correct that unless an inventor applies for a U.S. patent within 12 months from the date of the application or the date of filing of his British patent application, on the supposition that such patent application is the first that is filed in any country for the same invention, then no patent will be granted on such a U.S. patent application.

It is, however, true that if it be possible to delay the sealing of the patent on the British application until after a U.S. patent has been issued on the late filing, i.e. after 12 months of a U.S. patent application, a U.S. patent will be granted on such application. In practice, however, this is hardly ever possible, since the sealing of the British patent can only be delayed for a definite time, which is almost certain to be exceeded before it is possible to obtain issuance of the U.S. patent.

It will thus be seen that the statement that a U.S. patent application must be filed within 12 months of the British patent application, is correct for all practical purposes.

Petrol Vapour Lamp

CAN you give me any constructional details of a petrol vapour lamp? I require one for use in a garage.—A. R. (Chesterfield).

A PETROL lamp works on the principle of an incandescent mantle being heated by the non-luminous flame produced by petrol vapour burning in a current of air. For this purpose, petrol from a suitable container is allowed to flow through a needle-valve or other suitable regulator to a specially devised burner over which is suspended an incandescent mantle of the usual type.

In order to start the lamp, it is necessary to heat the burner. This is effected by pouring a small quantity of methylated spirit in a cup-like channel former around the burner. When the spirit is ignited, it warms the burner and conduit thereto, with the result that the slowly flowing petrol is gasified and mixed with air in which condition it is combusted, thereby heating the mantle and so exciting it to a condition of incandescence.

We fear that you will find it a very difficult job to construct an incandescent petrol lamp for yourself and, if possible, we would suggest your purchasing a second-hand lamp of this type, since then you would not risk disappointment. If, however, you desire to try your hand at making these lamps (the majority of which, we believe, are subject to patent protection) your best plan will be to procure a suitable container for the petrol. This should have a filling orifice and cap at the top and a length of piping should lead out from it at the base. This piping (which must have in it some type of regulating valve) communicates with an upright iron tube having at its upper end a circular burner of the Bunsen type over which the mantle may be fitted and held securely. Around the pipe just below the burner, you will find it necessary to fit some type of race or channel in which to pour the methylated spirit necessary for the starting of the lamp.

Some petrol lamps operate under pressure which is generated by means of an auxiliary handpump fitted to the petrol container. The construction of these, however, is beyond most amateurs, unless, of course, an ordinary spirit stove of the "Primus" type is adapted for the purpose.

Firms manufacturing petrol lamps do not supply parts other than replacements. You might, however, try the following firms for supplies: Messrs. J. M. & D. Hunter, 41 Slaney Street, Birmingham; Messrs. Spencers (London), Ltd., 5 and 6 London Street, Paddington, London, W.2.; Messrs. M. Howlett & Co., Ltd., 140 Hockley Hill, Birmingham.

Designing a Solenoid

I WISH to construct a "Solenoid" similar to that used for gearchanging on the American "Caddillac" car some years ago, and capable of pulling or pushing a rod with a force of 10 lbs. Can you inform me if there is a "formula" for determining the size and length of wire required, and the necessary voltage and amperage of current. I want to use a car type battery if possible.

Is there any book covering the construction of Solenoids?—J. M. (York).

THE design of a solenoid to give a definite pull over a definite distance is a matter depending so much upon the space available that no general rules can be laid down. The tractive effort or pull when the fixed and movable iron cores are in actual contact is calculable from the formula:

$$\text{Pull in lbs.} = \frac{B^2 \times A^2 \text{ (in square inches)}}{72{,}134{,}000}$$

B being the induction or flux density in lines per sq. in., but this figure is very difficult to obtain in practice, as the magnetic leakage is a variable quantity and varies with every change in the length of the air gap between the cores. It is impossible to go into the matter fully in the space of a letter, but some assistance will no doubt be derived by studying the articles entitled "Electromagnetic Devices," by A. H. Avery, which appeared in *The Model Engineer* for April 23rd and 30th, 1936 and also May 7th and 21st of the same year. There is no publication dealing exclusively with Solenoids. You may be able to see a copy of Prof. S. P. Thompson's "The Electromagnet" at some technical library, but this has long been out of print.

A SMALL STEAM BOILER

(*Continued from page* 164)

no difficulty in choosing suitable fittings.

Working Pressure

The working pressure of our boiler is intended to be 30 lb. per square inch. Now I want to give the reader a method of setting the safety valve so that this pressure shall be determined before steam is raised in the boiler for the first time.

The aperture or diameter of the bore of the safety valve is ¼ in. (.25 in.). This figure squared and multiplied by .7854=.0491 square in., or for convenience we will call it .05 square in. Thirty pounds multiplied by .05 equals 1.5 lbs. which is the actual pressure of steam on the under side of the valve tending to lift it. Now all that it is necessary to do in pre-setting for this pressure is to insert a short piece of rod of steel, brass or wood up under the valve, letting it be a nice easy fit in the hole and projecting an inch or so. Hold the safety valve over a spring balance or scales. Press the whole body of the valve down on the scale by means of the rod and adjust the nuts until the valve is seen to just lift off its seat when the scales are reading exactly 1½ lbs. Then lock the nuts and the valve is set approximately if not with exactitude.

I have said that the boiler is finished, but it is recommended that the inside of the casing be lined with asbestos cardboard; this will prevent some loss of heat by radiation. The top of the boiler may very well be lagged, also with asbestos, and, for the sake of appearance, this should again be covered with thin sheet metal which may be painted and held down by brass bands.

Firing Arrangement

The last item to be dealt with is the firing arrangement. Gas will be found by far the most convenient fuel, and it may be that the reader will save himself some work by being able to find a gas ring of convenient size and shape; or it may be possible to adapt ready-made burners from a gas fire, the grill of a gas cooker or utilise the lower part of a Fletcher pattern soldering-iron-heater. Failing all these, burners can be made in accordance with the accompanying drawing Fig. 4., using iron tubing with saw-cuts made across it and stock pattern brass taps for the gas jets. The "Y" piece of pipe can be soft-soldered together.

If no gas is available methylated spirit is a simple alternative. Burners and lamp having asbestos wicks are shown in Fig. 5. The burners are made from 1½ in. diameter brass or copper tube flattened to oblong form. The boiler and engine may very well be mounted side by side upon a plywood base board which should be protected, underneath the boiler, by an iron plate screwed down over a thick piece of asbestos card.

The steam connection between the wheel-valve and the engine will be by $\frac{3}{16}$ in. diameter copper pipe and the exhaust from the slide valve cover-plate by ¼ in. pipe, which it will be advisable to take into the fire casing and bend in such a manner that it points upwards, centrally, at the base of the chimney, just as the blast pipe does in the smokebox of a locomotive.

It may be remarked that no provision is made for feeding the boiler with water. Actually I think that a pump is scarcely needed; for one filling through a funnel inserted in the safety valve hole, by unscrewing the valve, will be sufficient for a very long run of the engine; probably as long as is desired, but if a greater period than about an hour is wanted without cooling off the boiler and refilling then a hand pump can be mounted on the base-board, or a small pump be driven by an eccentric off the engine crankshaft. In either case a check valve will be needed on the boiler, and, all things considered, I do not think it will be worth while to provide a pump.

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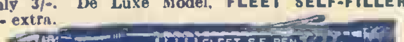

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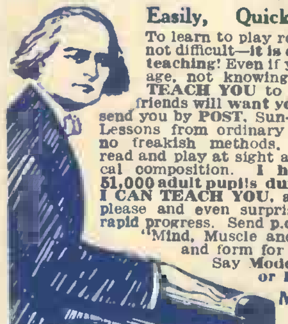

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