Section 3

Light

Introduction

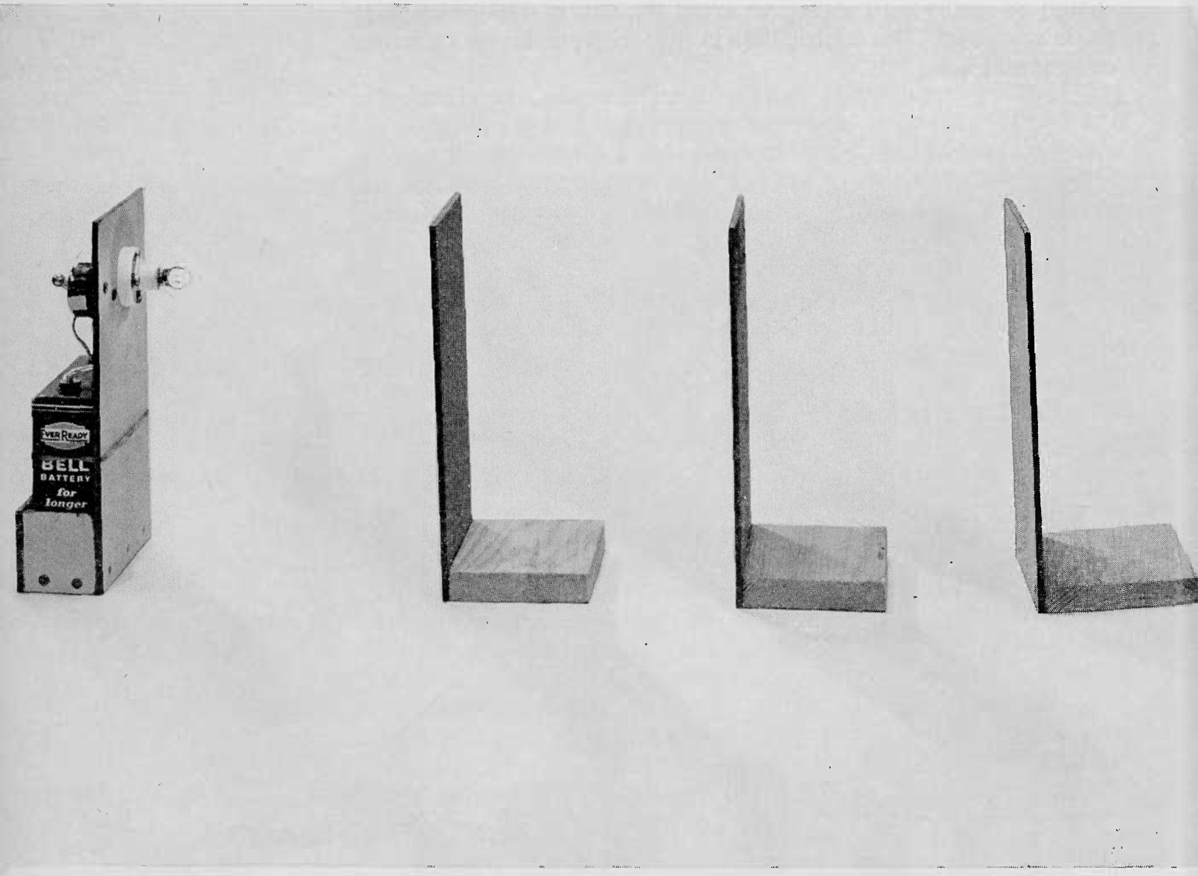
The study of light and its associated phenomena is fascinating to children and it is approachable from a variety of starting points. Enquiries into a wide range of living material frequently lead to practical investigations into this topic, which presents a whole series of intriguing problems. It is a flexible study: the teacher who wishes to direct will find that he can usually shape its course as he wants, according to the materials that he leaves out for the children's use. Furthermore, most of the experimentation can be carried out with simple, readily available odds and ends. As the work proceeds, and the children gain more experience and become older, its complexity, and the problems it poses in accuracy become of increasing importance. A certain basic minimum of equipment will be essential if fruitful work is to be done. The illustrations that follow will show some of the possibilities that this equipment offers. Some of it takes advantage of the fact that most schools possess film strip projectors which provide an excellent strong-light source. Dark boxes are easily constructed from unwanted cardboard containers or large tin ones. In either case, if suitably masked eye-pieces are fitted, a great deal of work can be done by the child in the surroundings of the ordinary classroom. Older children have been able to devise and construct boxes with sleeve attachments, so that lenses and mirrors can be handled within the darkened confines of a box. The apparatus illustrated here is largely concerned with the physical science of this subject. The bias is deliberate, as practical ways of illustrating the biological implications are already well known.

1. Sources of light

The question 'What is light?' may well arise when children are dealing with the subject. It is not easy to answer, though the relationship between light and heat can be tentatively posed by simple means. The sun is the primary source of light and heat in the solar system. Three aids to children's thinking about this difficult question are illustrated below. The holder for the candle is made from the top of a Polythene detergent container, cut away suitably. (This same material would also form an eye-piece for insertion into a dark box.) The spirit lamp in the background is a source of both light and heat. If an improvised one such as this is made, the joint between the metal tube which holds the wick and the screw-stopper of the bottle should be sealed with solder, to avoid the risk of vapour catching fire at this point. The electric bulb in the foreground is also a source of light and heat.

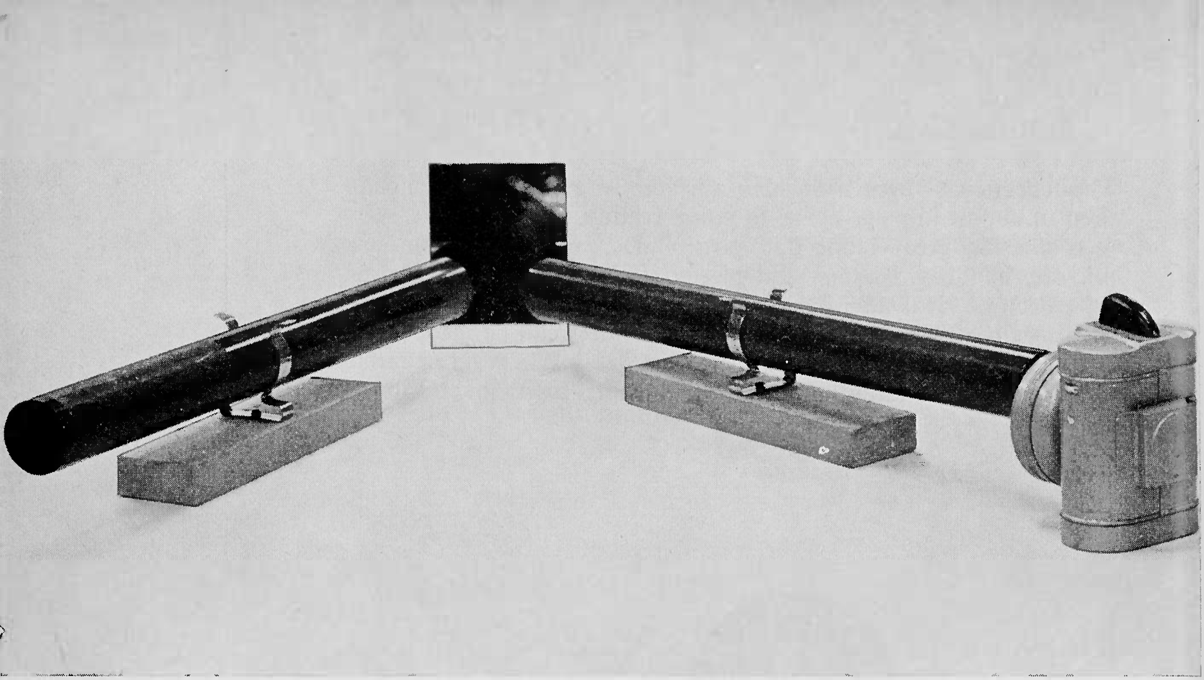
2. Path of light rays

The apparatus illustrated shows first a simple means of providing a light source. This is via a 4·5 V bell battery held suitably on the back of the base of the stand. A connection via a simple switch on the back goes to the lamp holder on the front of the apparatus. If a 3·5 V bulb is powered by the 4·5 V battery an intense light source is produced for use in an undarkened classroom. The sighting screens have $\frac{1}{8}$ in. holes drilled in them, on a level with the centre of the light source. Experiments can be done with this apparatus to investigate the path of the light from the source to an observer's eye.



3. Reflection A

The reflection of light from plain surfaces is something which children of almost any age come to study readily. It is a broad subject, offering great scope and possibilities. Discarded domestic mirrors, handbag mirrors, and pieces of bright metal are all useful reflectors. It is advisable to guard the edge of handbag mirrors with a strip of Sellotape. Useful mirror holders can be made from blocks of wood and Terry clips of suitable sizes. Whenever material is held firmly children will be better able to experiment with it exactly as they want.

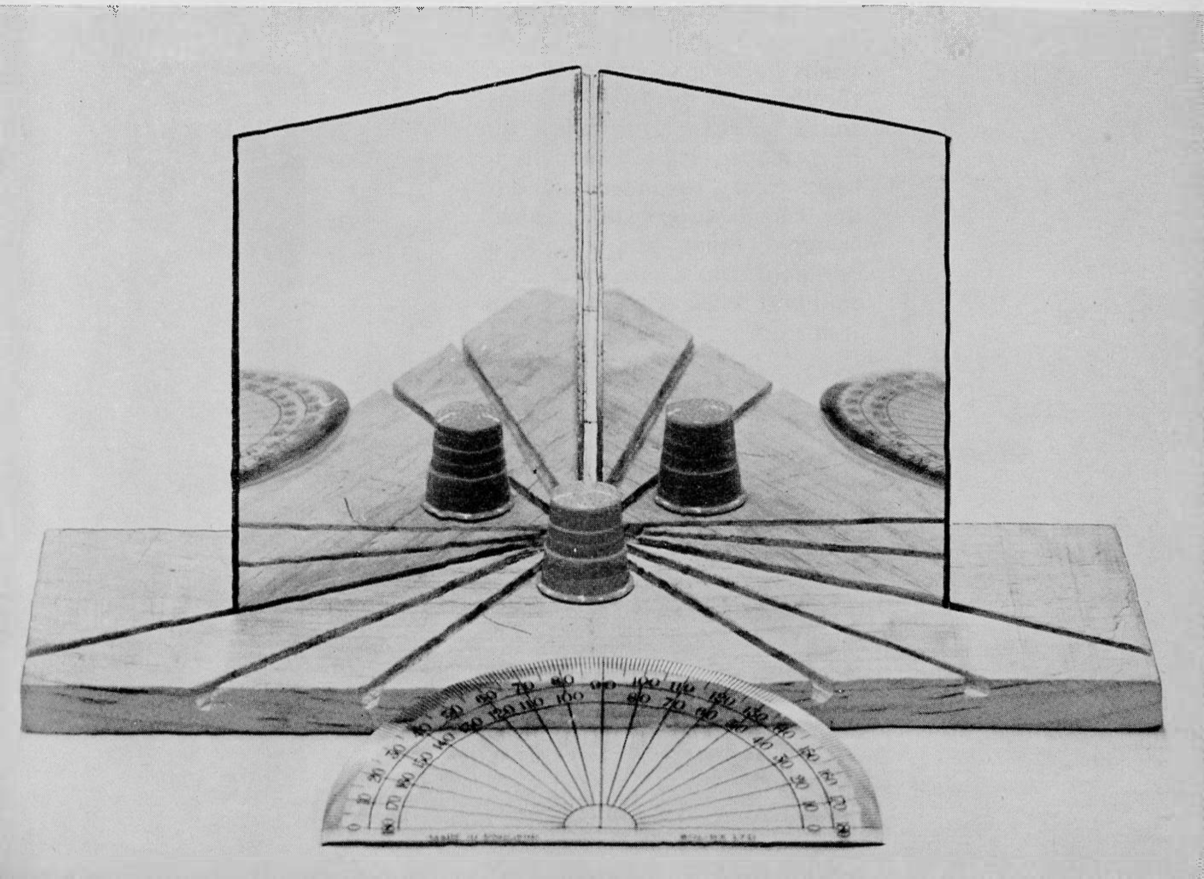


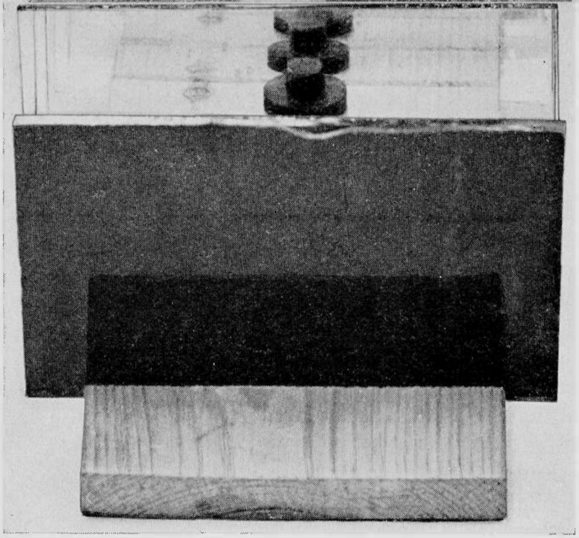
4. Reflection B

Children find it difficult to appreciate the concept of the point source of light. Their understanding is, of course, considerably helped by the provision of a light source. In this illustration a bicycle lamp is used. This has proved very satisfactory as suitable masks can be inserted to give light sources of various shapes and sizes as well as colours. Further, the battery is of sufficiently long life to give a useful period of work before its replacement is necessary. The Terry-clip holders are carrying plastic document tubes. These form an effective means for 'imprisoning' the light beams from the lamp in the direction of the mirror which is used here for reflection experiments.

5. Reflection C

Whilst more experienced children need to add precision to the work of discovery, this still springs best from a situation where they are free to experiment. However, the teacher can exert a valuable influence over the course of events, if the material itself suggests ways towards solving the problems. In this illustration, work on reflection has been taken several steps further. The baseboard has sawcuts at suitable angular intervals, and the child's manipulation of the hinged handbag mirrors will prompt him to use these. The protractor will provide a method of measuring the angular distances, and the idea of tabulating the results and building up some inferences will obviously follow. The baseboard can easily be reversed to provide a plain surface for the child to test the phenomena further with a completely free choice of angles. If mirrors are hinged with Sellotape as in this illustration a double layer should be used to make the hinge more durable and avoid having a sticky surface facing outwards.



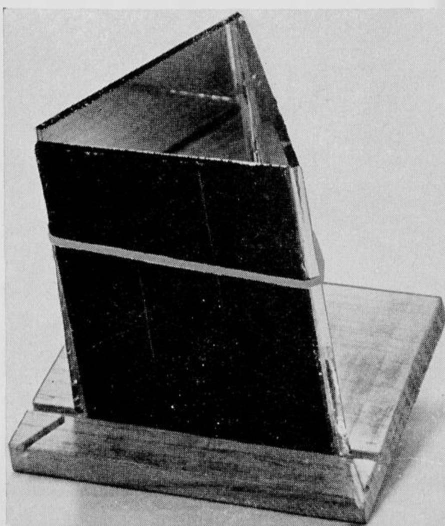


6. Reflection D

The phenomena produced by parallel mirrors has been explored with the simple apparatus shown on the left. Parallel sawcuts across a piece of wood will form inserts to take the mirrors. Children can study these phenomena and in time they may even begin to build up some idea of the concept of infinity. The equipment will provide only a rudimentary experience of it, and it certainly should not provide more than an experience at this stage.

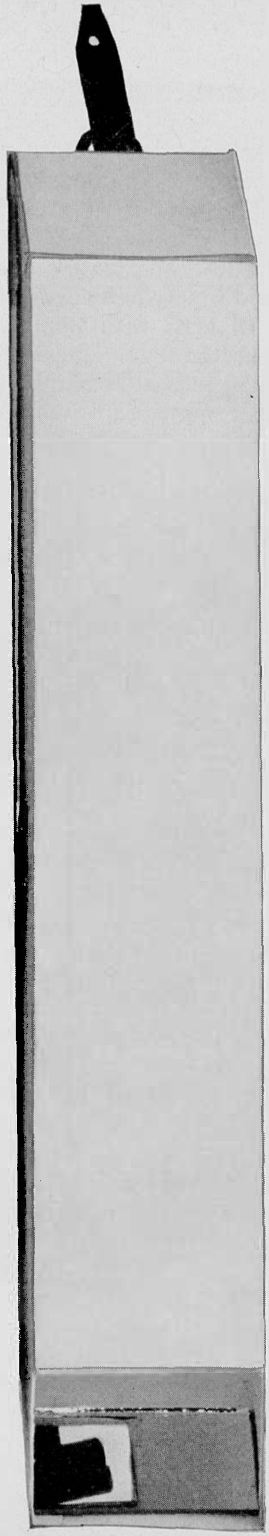
7. The kaleidoscope

Reflections from mirrors set at an angle pose many interesting problems for exploration and experiment. Again wooden baseboards with sawcuts at various angles are very helpful, and elastic bands will hold groups of mirrors together. In this way, as illustrated here, an arrangement can be made to enable children to begin to try to understand how the kaleidoscope works. Small coloured beads and pieces of coloured paper are useful as objects to place within the group of mirrors.



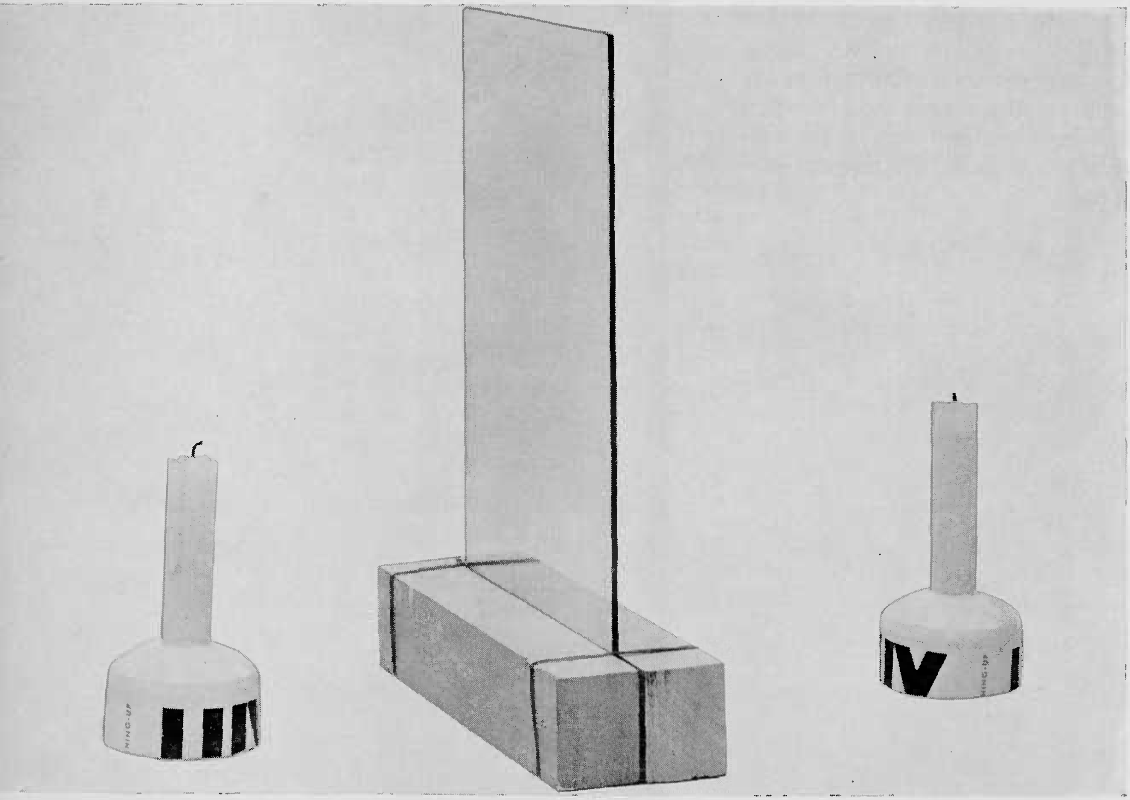
8. The periscope

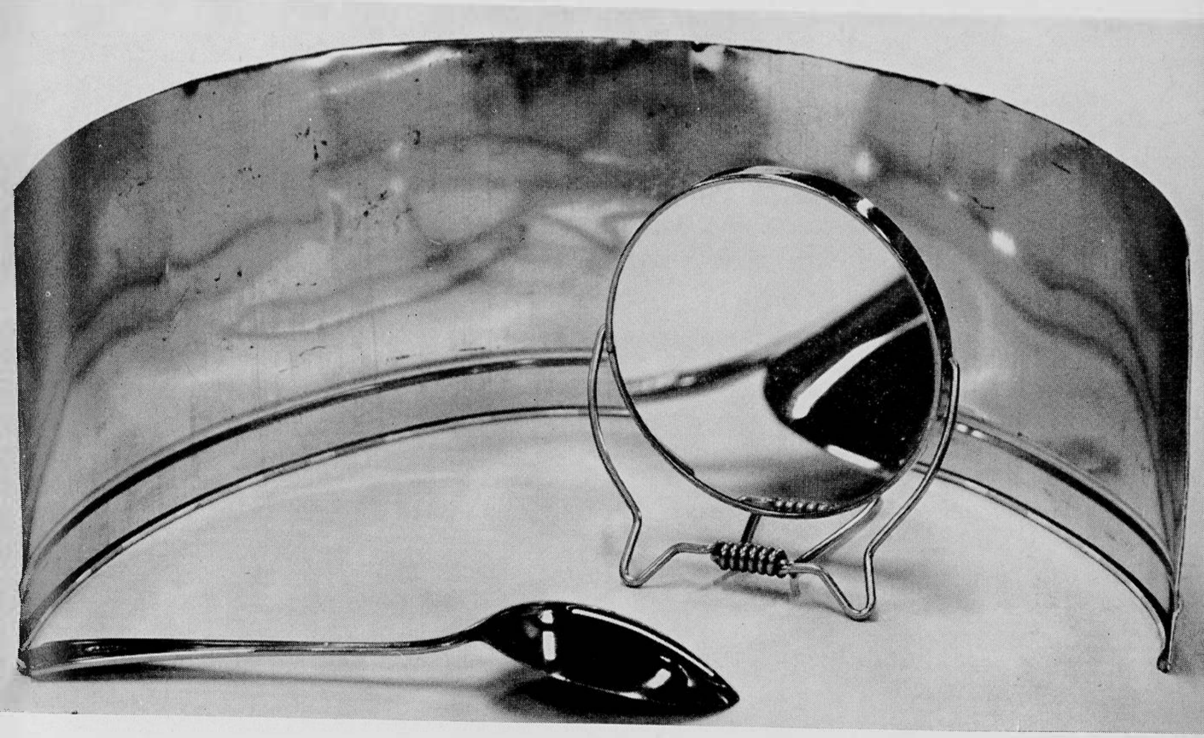
Children enjoy making periscopes. They benefit in every way if the means for this kind of construction is put at their disposal in as simple a form as possible. The periscope in the photograph is made basically of a wooden lath to which triangular pieces of balsa wood have been stuck. Two mirrors are then stuck to the balsa wood after the correct positions have been found. The whole piece of apparatus is finally enclosed in a box made from stiff card. A child derives much greater personal satisfaction as well as educational benefit when his apparatus not only works well but has a good finished appearance.



9. Reflection E

Simple means sometimes pose problems more dramatically than intricate pieces of apparatus. Often, a child is inspired to do a particular piece of investigation by materials set up in such a way that the child will take up the problem and make it his own. The photograph shows an example concerned with reflection. The two candles are held simply in holders cut from plastic detergent bottles. A large piece of glass with suitably guarded edges is held in place firmly between the 2 in. square-section pieces of wood of suitable length which in turn are clamped together firmly with thick rubber bands. Another merit of this kind of equipment is ease of storage.



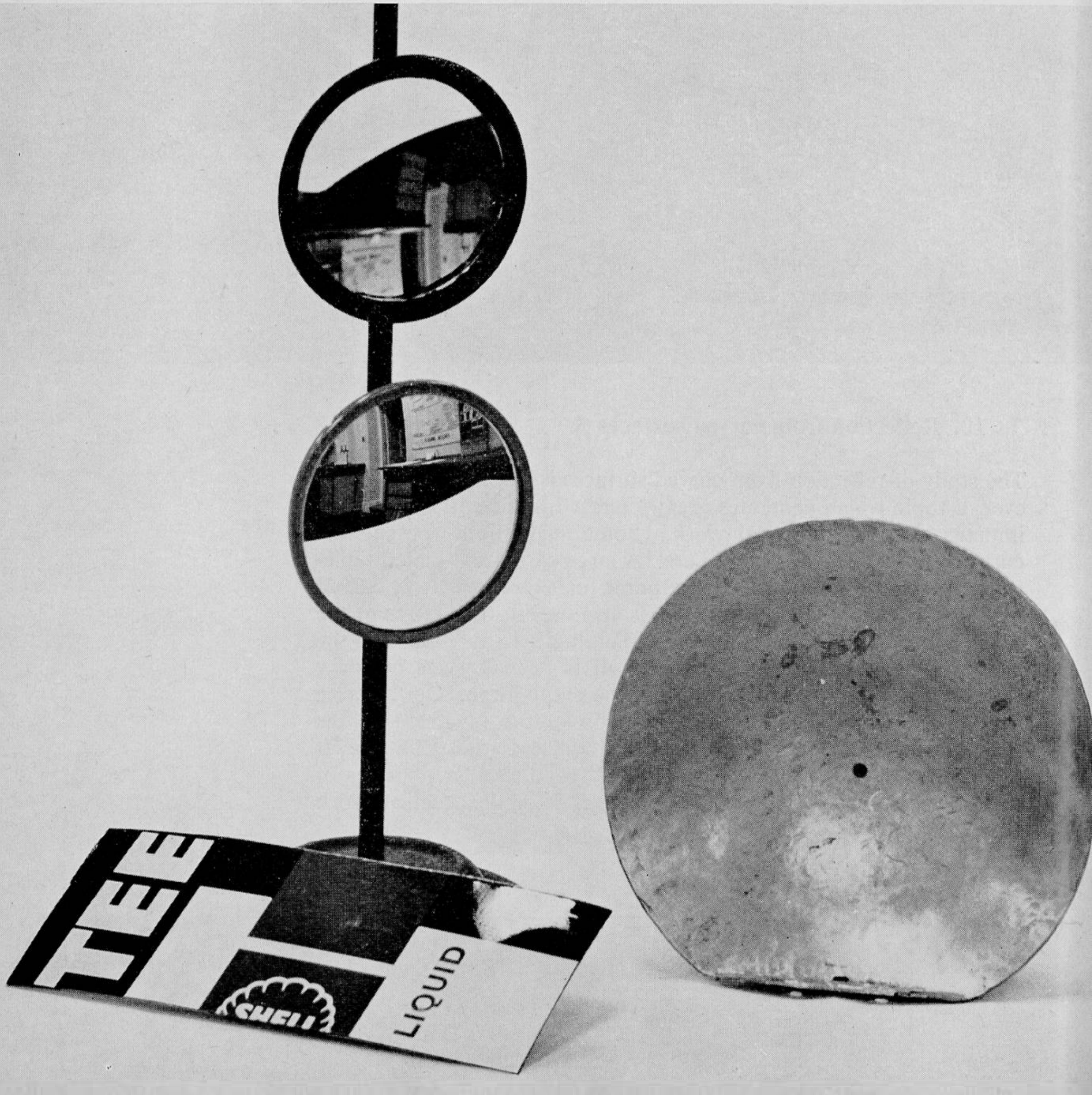


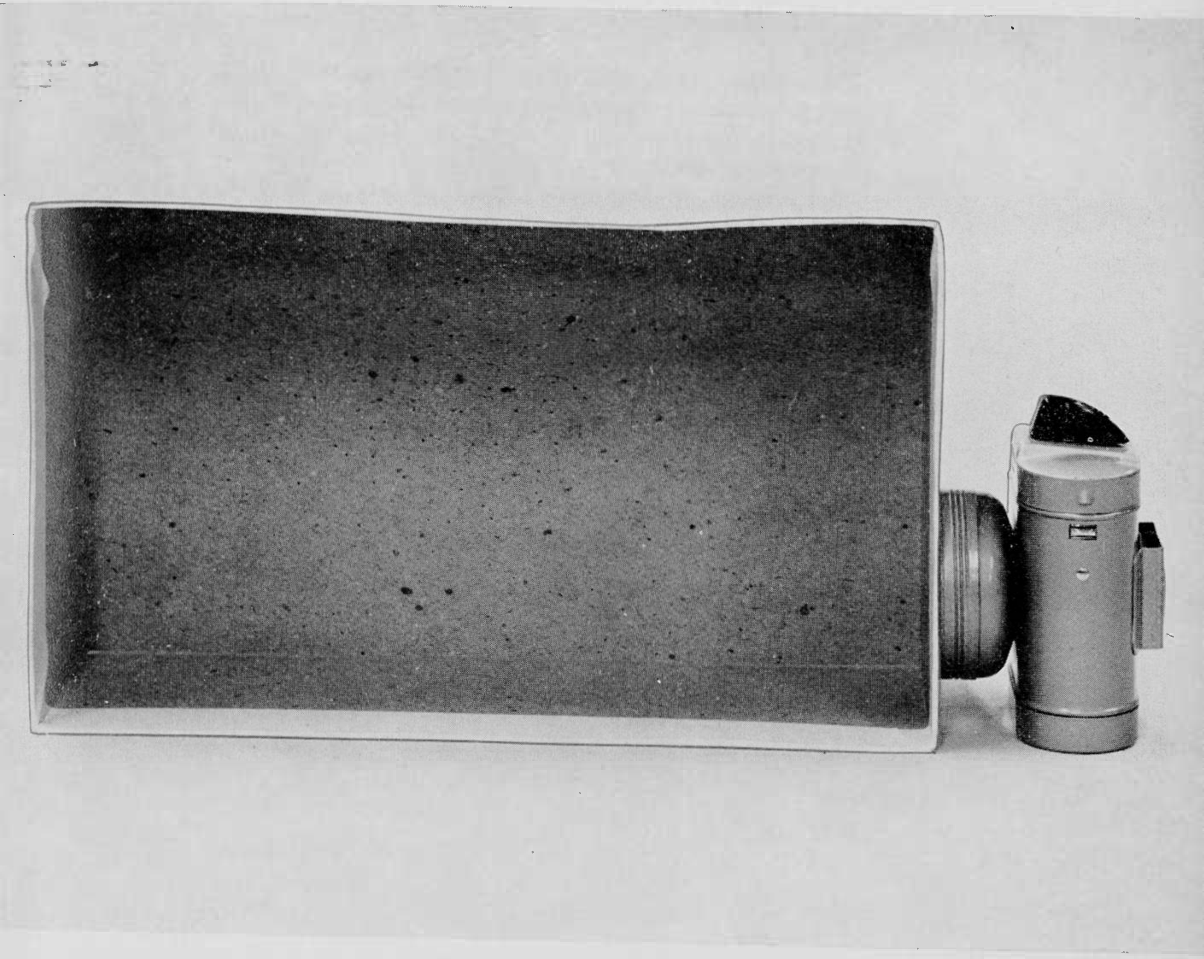
10. Reflection from curved surfaces A

The study of reflection from curved surfaces is not easy. It is, however, a topic which generates great interest for the child, and is an impetus to much practical work. Some suggestions for suitable curved surfaces are illustrated here. A large chromium-plated tablespoon forms an excellent starting point for experiment. A curved section cut from a round biscuit tin is also useful. The edges of the tin should be guarded with a layer of Sellotape, to avoid cutting the hands of the users. Most useful of all is probably the ordinary shaving mirror shown in the centre of the photograph. Quite young children have discovered the phenomenon of the inversion of the image and experimented to find the crucial points in this situation. It is wise and helpful if the teacher groups together related pieces of material, so that they are available to the child as the practical work proceeds.

11. Reflection from curved surfaces B

The study of reflection from curved surfaces may reach a point with older children where precision is important. In this case suitable mirrors can be ordered from suppliers and these can be used mounted on ordinary pieces of $\frac{1}{4}$ in. rod. The different effects of light diffusion that result from treating surfaces in various ways also provide a field for practical work. Sections from all kinds of solid substances are useful in this context.



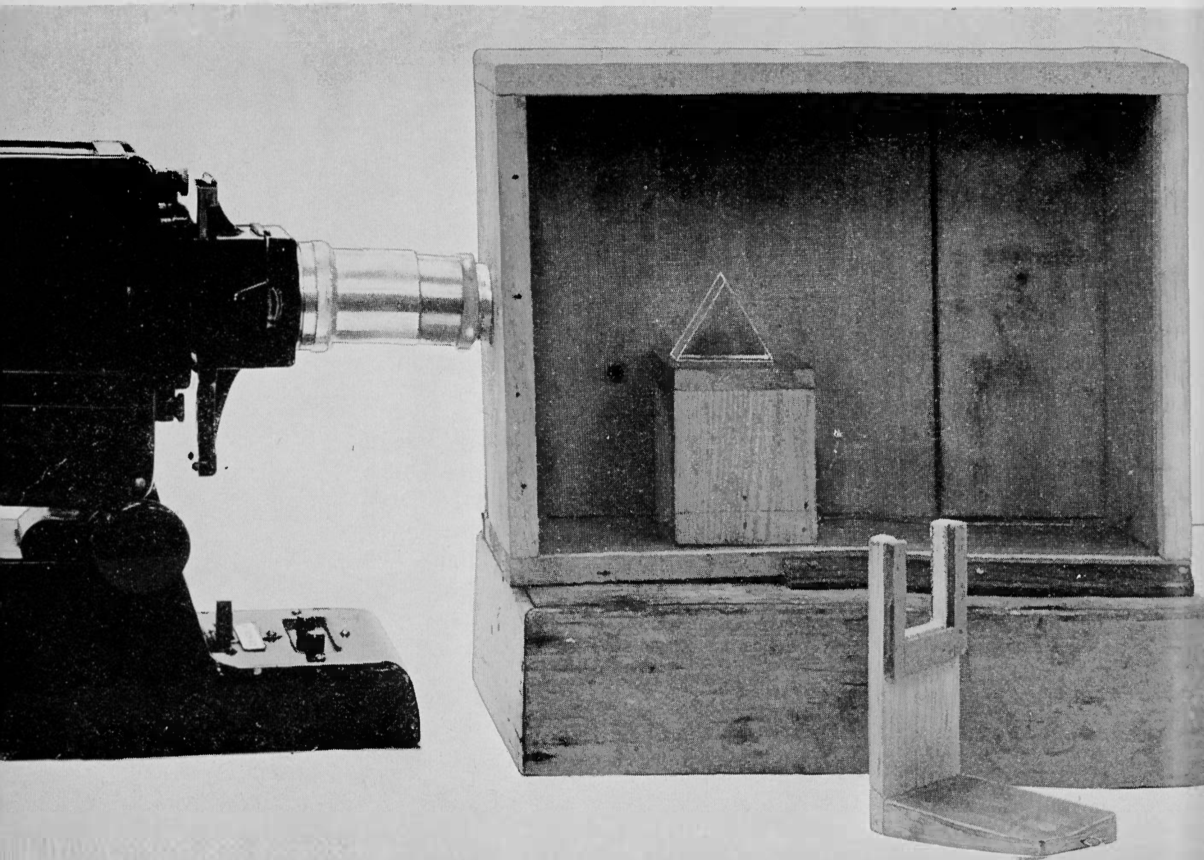


12. Dark box

A dark box is easily improvised from any container about the size of a shoe box. A suitable light source can be made by masking a cycle lamp. The masks can include pinholes, slits, and coloured filters. Observation holes should be small in size and fitted with paper tubes as eye-pieces to minimize interference by stray light. The dark box obviates the need for room darkening during some practical work on light and provides apparatus for individual use.

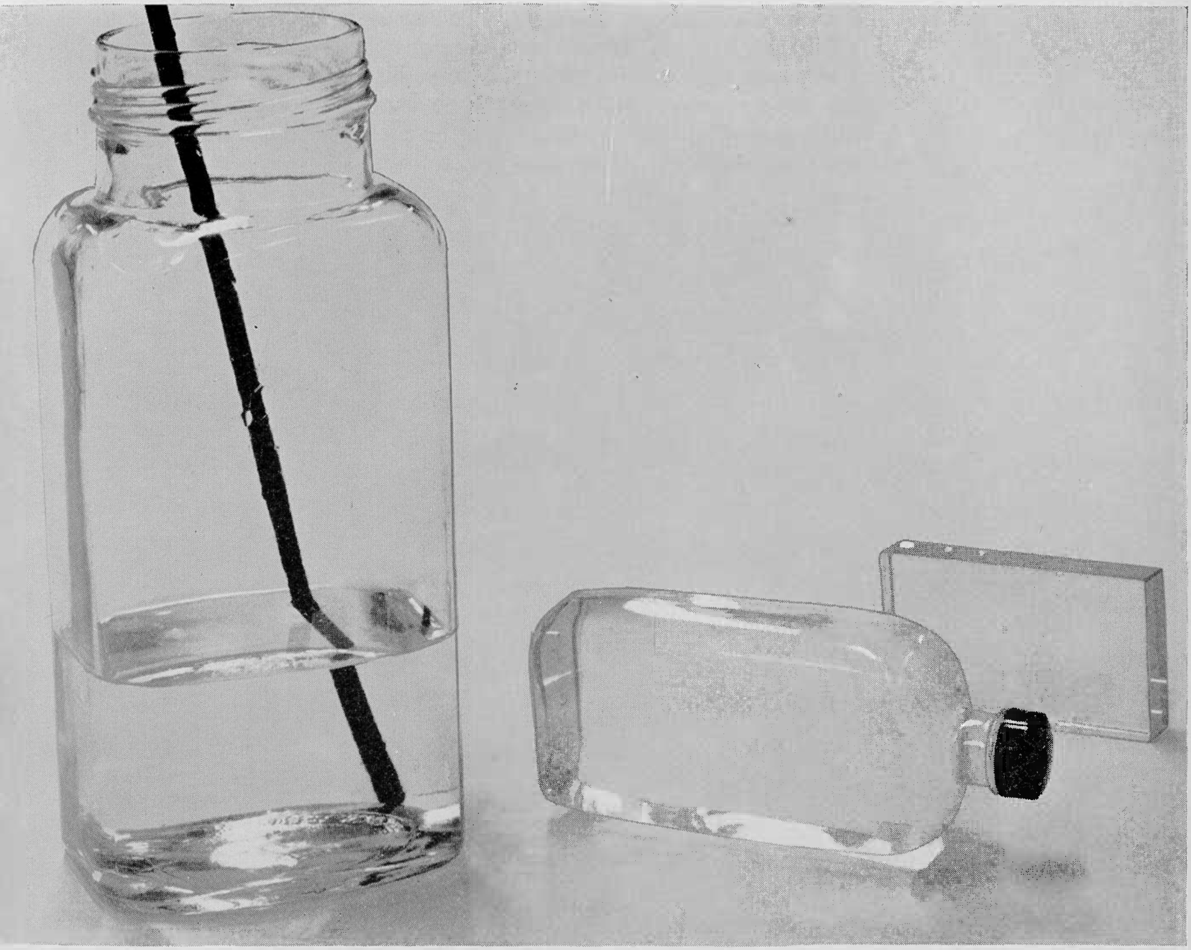
13. The smoke box

This illustration shows the use of an ordinary film strip projector as a light source. It is projecting a point source of light through a hole drilled in the side of a wooden box. The front of this has been covered with glass, and the back has a hinged section to provide a door through which pieces of apparatus may be inserted. A hole at the top of the box provides an opening through which smoke can be blown inside. Alternatively, corrugated paper soaked in saltpetre may be placed in the corner and left there to smoulder and so fill the box with smoke. When the projector is switched on the path of rays of light can be traced through the smoke. In the illustration, a prism is in use. The lens holder in the foreground will accommodate a lens of short focal length which can replace the prism for the purpose of illustrating the behaviour of light rays. This is rather a sophisticated piece of equipment, but many teachers have found it worth while for use with eleven- and twelve-year-old children, who have reached the stage when they want to refine their ideas. They can do this, both in discussion with their teacher, and by operating a special piece of apparatus.



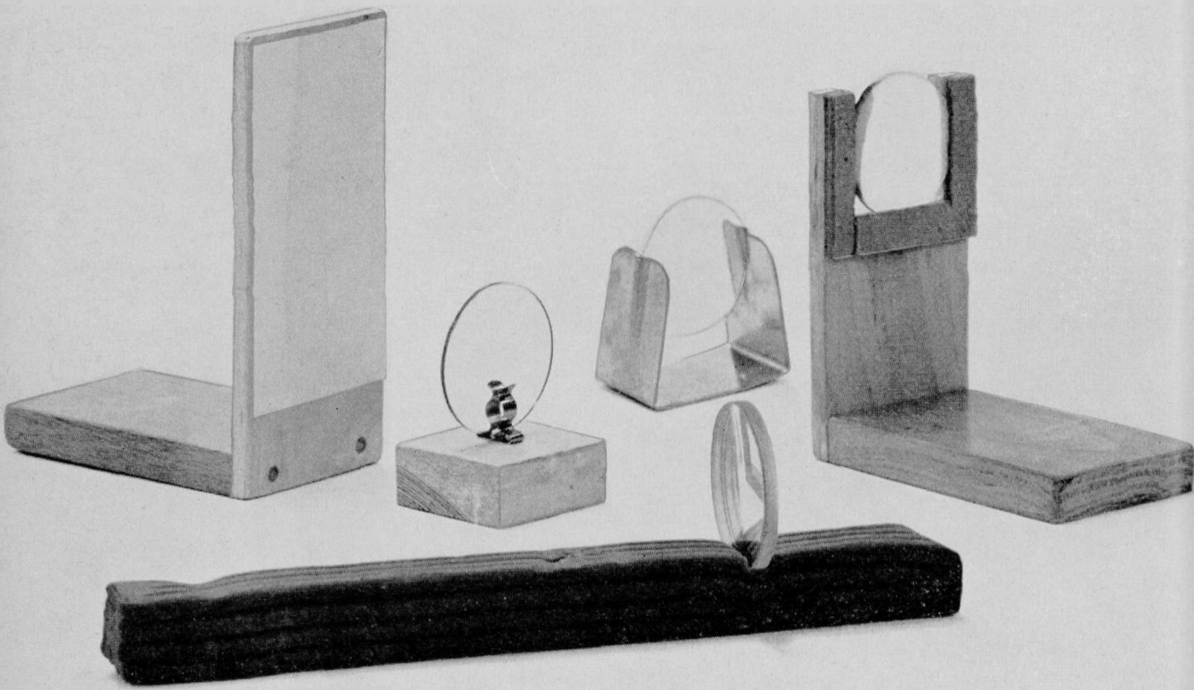
14. Refraction

There are several ways of helping children with the problem of refraction of light. This illustration shows some of them. The ruler placed in the large sweet jar containing water shows the phenomenon particularly well. A small medicine bottle full of water or a glass block can be used by individual children in a similar manner. Any of these means which highlight the phenomenon of refraction may open the way to much useful work.



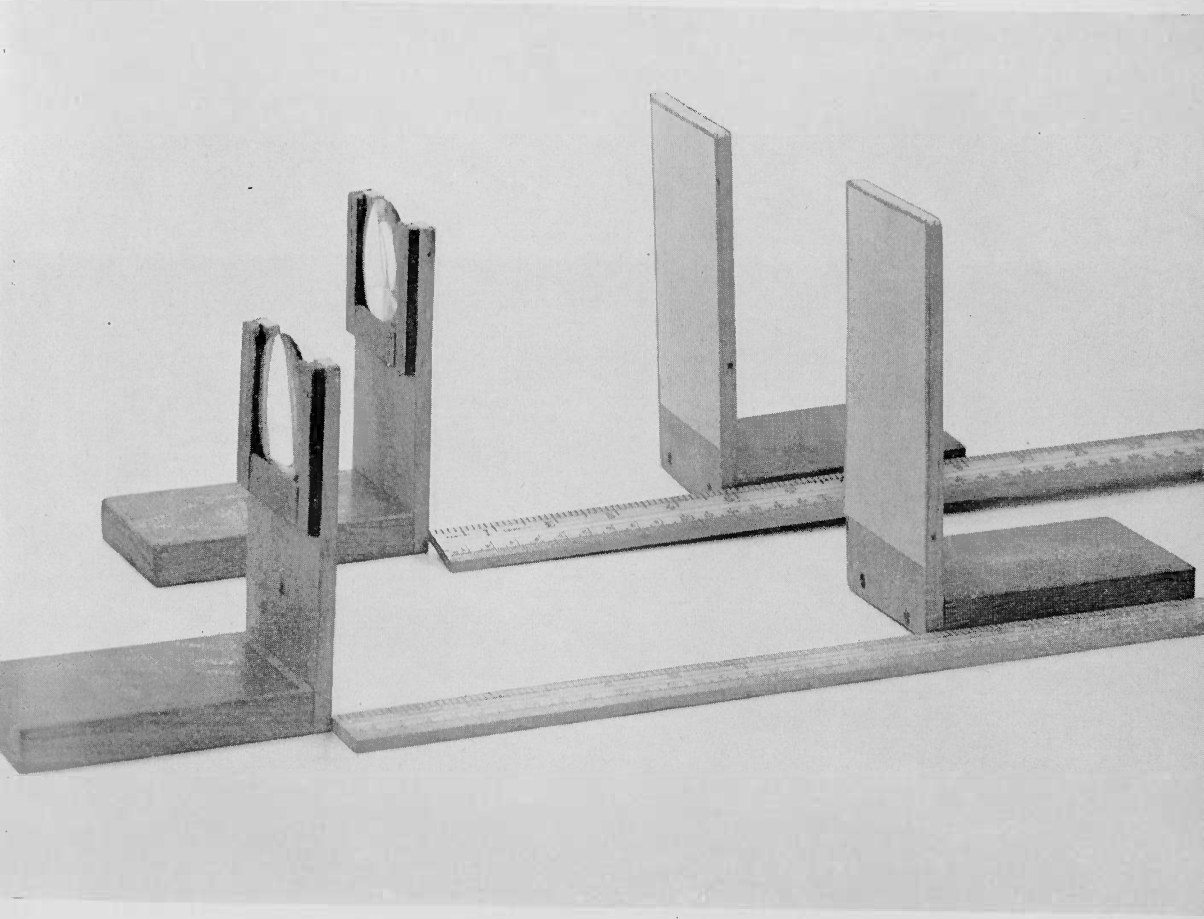
15. Lenses and lens holders

Standard 50 or 51 mm diameter lenses will be found to be the most useful for children's experiments. Focal lengths ranging from 10 cm to 30 cm in 5 cm intervals will provide a useful range. There will immediately be the problem of holding the lenses. Some suggestions for lens holders are shown in the photograph. In the foreground is a piece of Plasticine. This has the disadvantage of marking the lens each time it is used. Lenses of long focal length can be held in place with Terry clips, but these tend to obscure the centre of the lens. Lenses of short focal length will have curvatures which are difficult to maintain firmly in the clips. To the right of the picture is a satisfactory type of lens holder, the construction of which can be clearly seen. On the extreme left of the illustration there is a screen. This simple piece of equipment will be necessary for practical work with lenses. The metal lens holder in the background is a simple type which is cheap to purchase and easy to use.



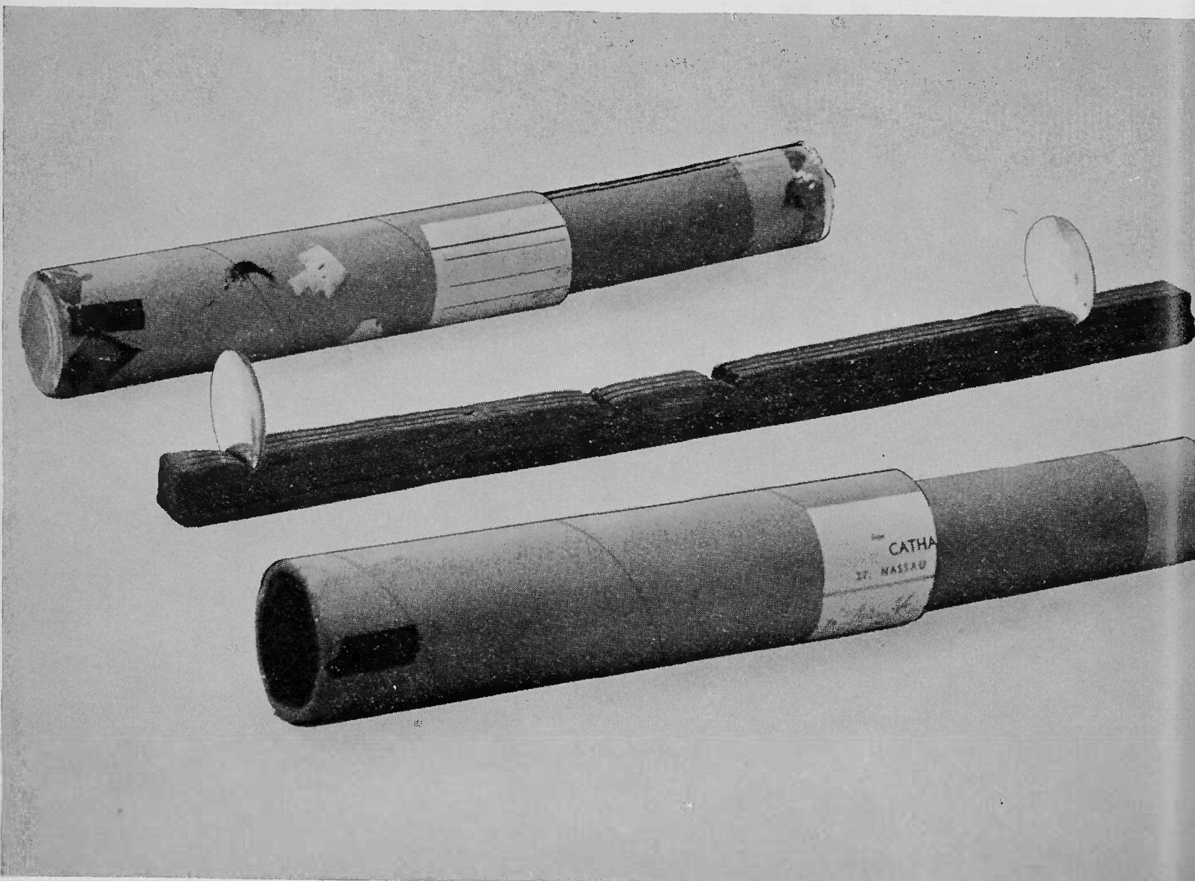
16. Lenses—focal lengths

This illustration shows lenses in use with screens. Problems of focal length soon show up when lenses of different curvatures are inserted into the holders. Here the teacher will direct the child towards a quantitative recording of results by providing rulers with the equipment. This whole area of work represents a more sophisticated phase and is therefore more suited to the child at the top of the junior school and in the lower forms of the secondary school, although the phenomena associated with lenses may well be appreciated by very much younger children.



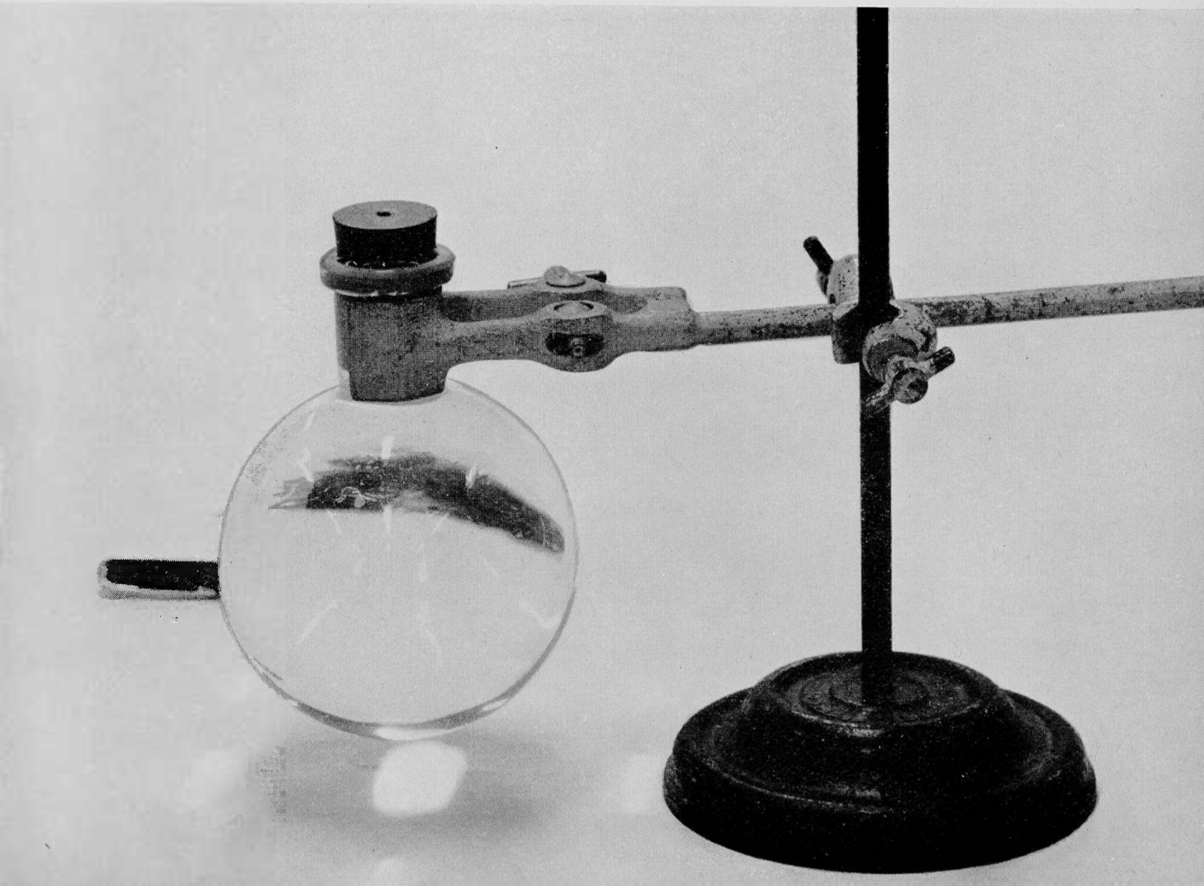
17. The telescope

Some of the stages in children's inventions of telescopes can be seen illustrated here. The first manipulations are tried out on Plasticine. This provides a long stretch of material which will hold lenses at different points, and also allows experimentation with lenses of different focal lengths. This is the most important part of the work, establishing the right relationships of the lenses for making a first rudimentary telescope. After this, the lenses can be fixed to cardboard tubes with Sellotape and a more traditional model made.



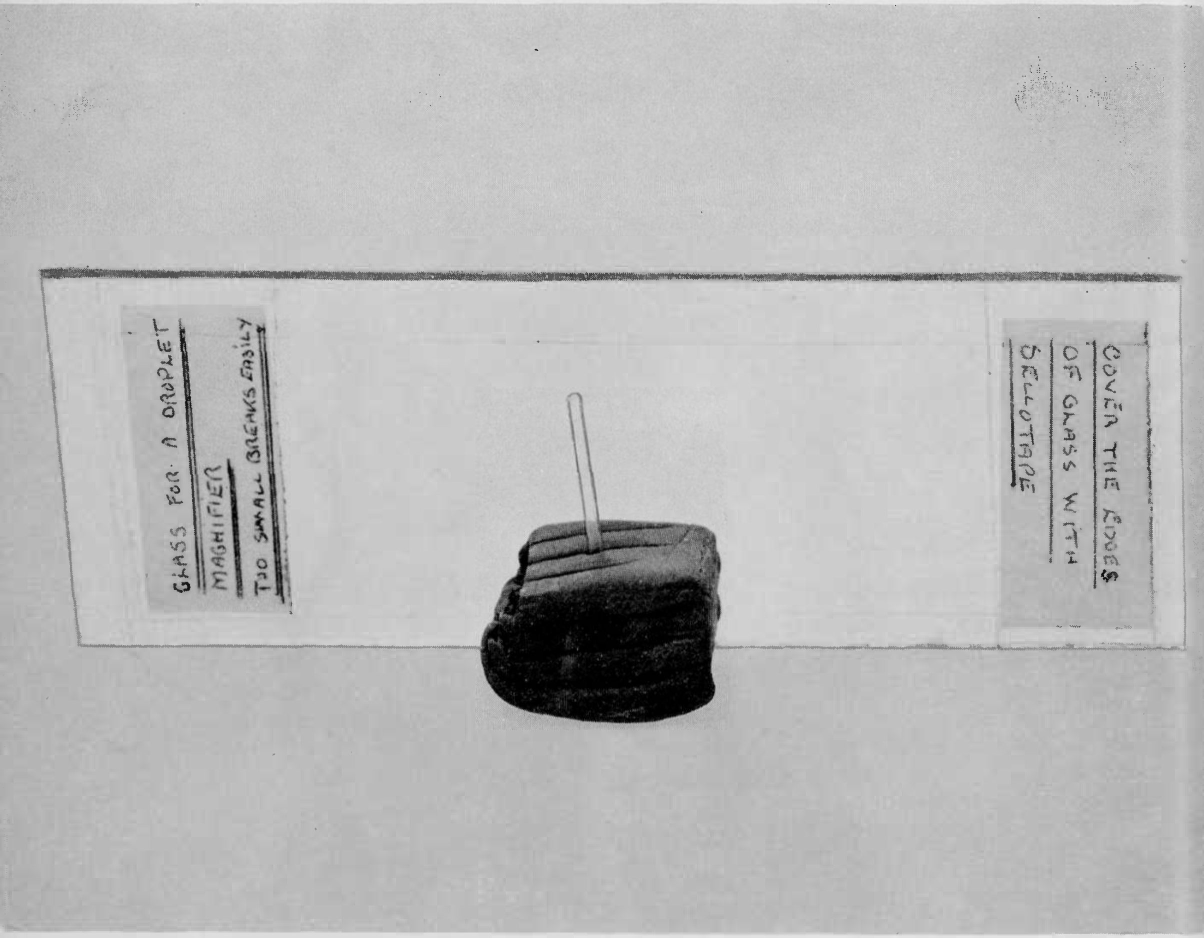
18. Droplet magnifier A

The significance of the water droplet as a lens was appreciated by early experimenters in the field of microscopy. A flask completely full of water will illustrate this phenomenon on a large scale. If the flask is supported somewhat in the manner of the one in the illustration the lens can be adjusted to produce a better definition. This work will obviously be related to the children's observations of goldfish bowls and the like. Its whole range links naturally with practical work done with lenses and leads to further investigations into the use of the droplet microscope.



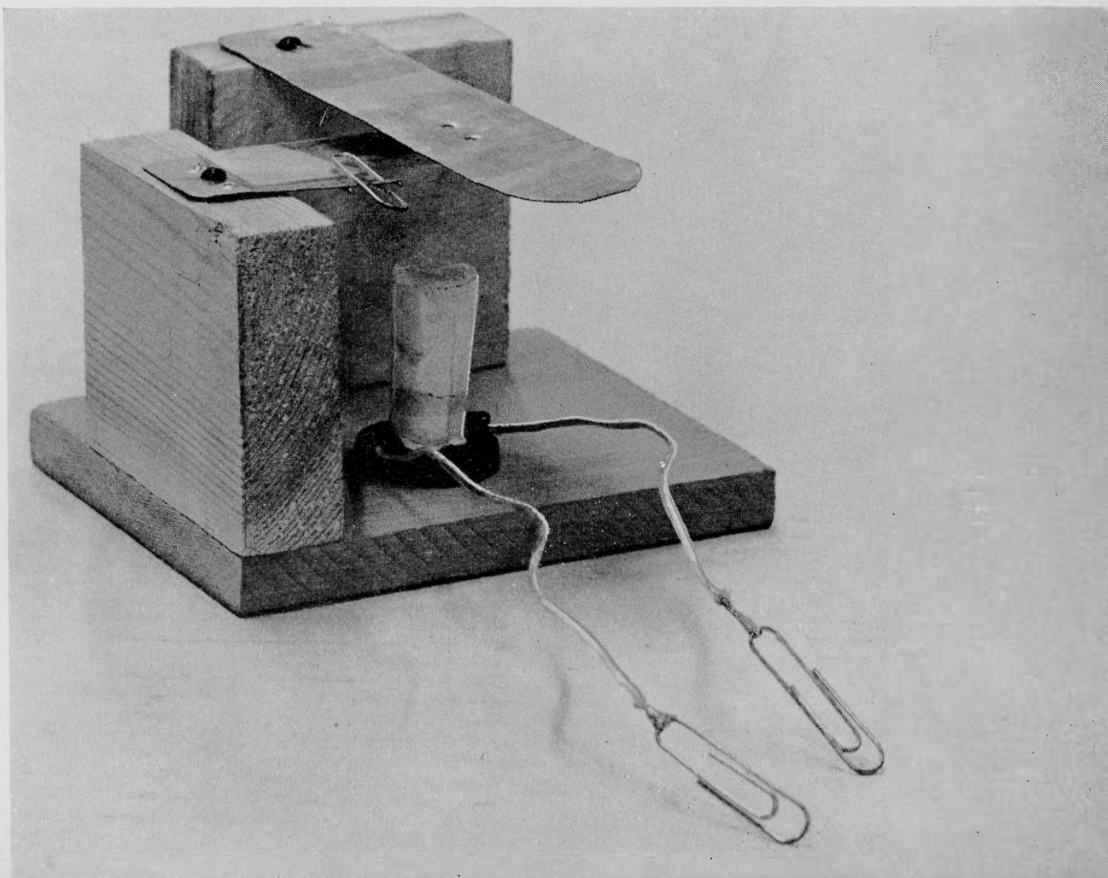
19. Droplet magnifier B

The first investigations into the use of droplets as lenses can be undertaken with plain pieces of glass, suitably protected at the edges with Sellotape, and scrupulously cleaned. If the surfaces are perfectly free from grease, bold droplets can be obtained and these can be used as magnifiers. In the photograph a glass bead made by a teacher is shown. This can be used in place of a water droplet in the microscope which is illustrated in example 20.



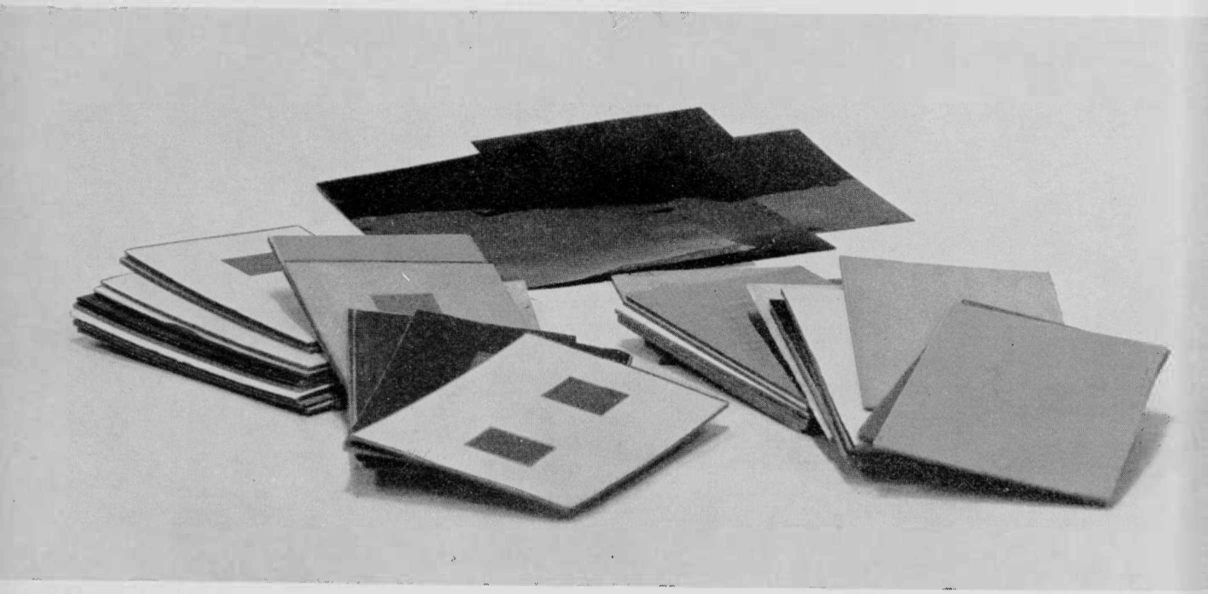
20. Droplet magnifier C

The basic construction of the droplet microscope can be seen in the illustration. The distance between the two blocks of wood which support the two metal pieces should not exceed $\frac{3}{8}$ in. The lower piece of metal is cut away suitably to accommodate an ordinary microscope slide. This is held in place with a paper clip. The upper strip of metal, which must be scrupulously cleaned and free from grease, including the grease from hands, is drilled with a $\frac{1}{16}$ in. hole. This piece of metal takes the droplet. The lamp provides a light directly beneath the specimen examined. The shade is made from a tube of cartridge paper covered with a piece of thin greaseproof paper. This keeps down the intensity of the light and diffuses it suitably. When the object is placed on the slide and the position is adjusted approximately under the droplet, focusing is achieved by moving the upper strip gently up and down until the best position is obtained. Obviously, this microscope gives crude results, but it will serve to provide children with a starting point to a whole range of work which opens up naturally from this kind of approach.



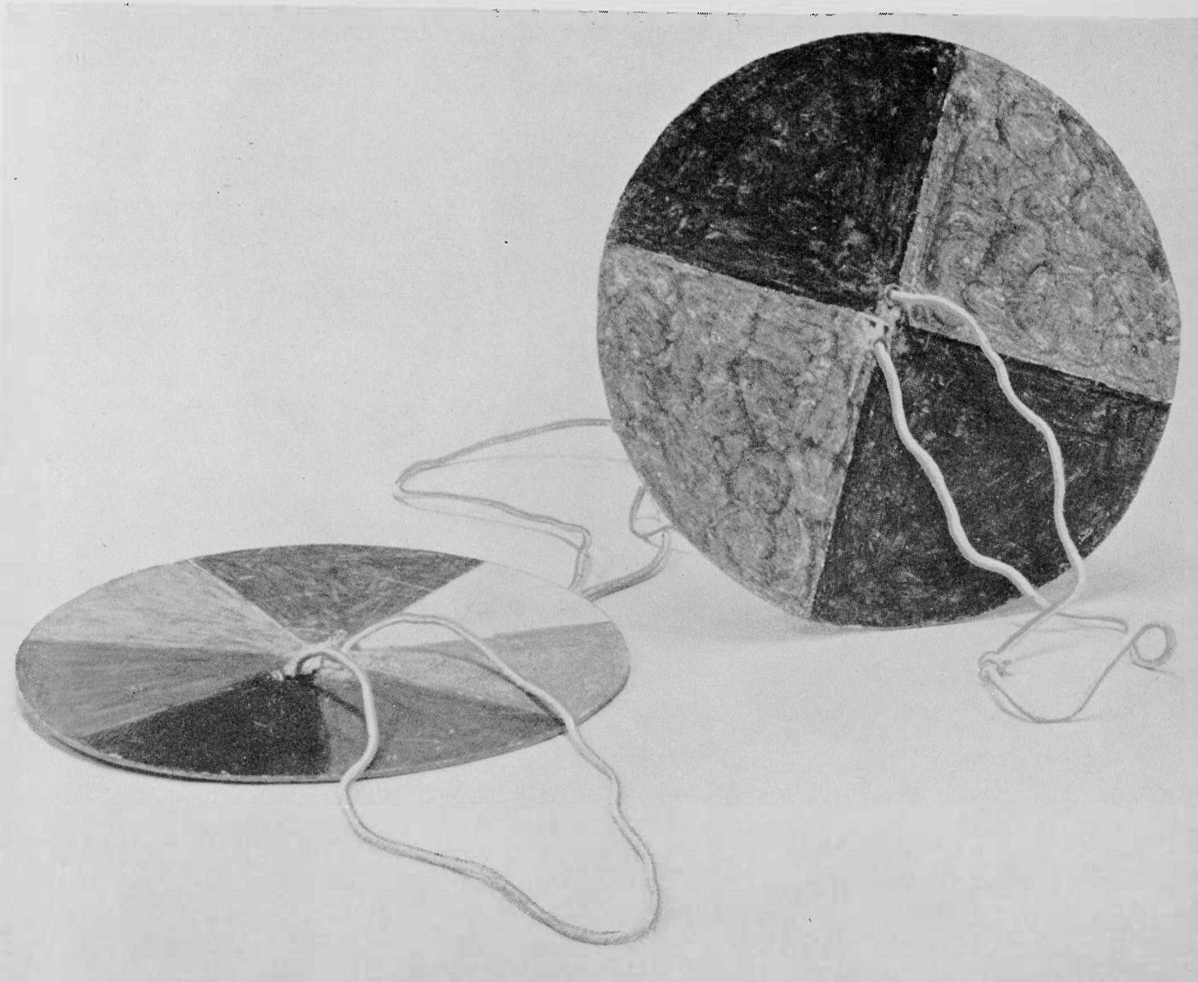
21. Light and colour A

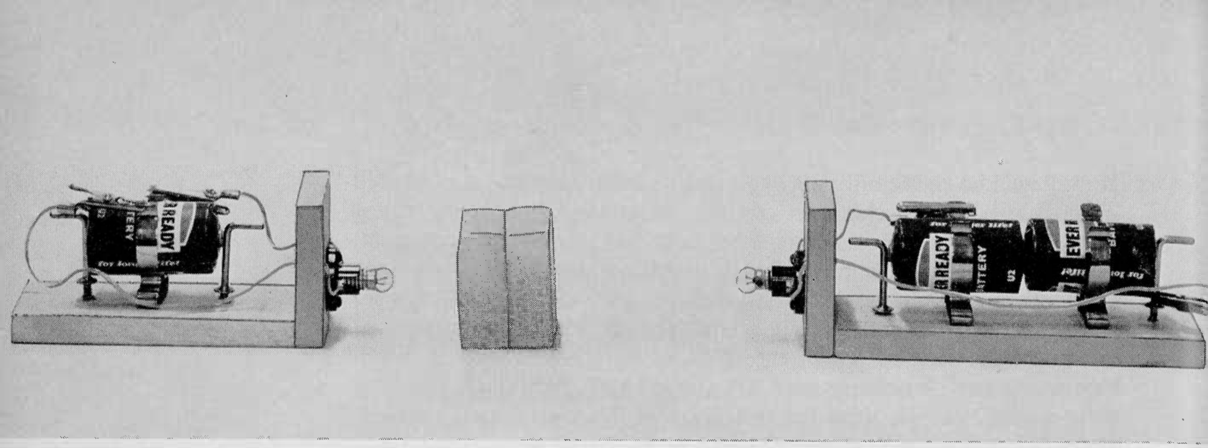
Children have a ready interest in the topic of light and colour. Sets of the primary colour filters in gelatine can be obtained quite cheaply if teachers are content to have theatre quality gelatines. These are quite adequate for classroom purposes. If a set of coloured cards is produced by sticking squares of gum-backed paper in each of the normal colours to cardboard, work can easily be undertaken. Children will need a great deal of freedom to experiment. They may find it hard at first to appreciate the difference between pure colour and pigment. However, as their skill increases it may be worth while producing an identical set of coloured cards, but each bearing two control colours, a red and a blue. Children can then look at these through their gelatines, and see for themselves the effects that are produced with these multi-coloured surfaces. They may well next go on to viewing coloured illustrations through gelatines. If a darkroom is available coloured slides can be made for insertion into the film strip projector, thus producing a strong source of coloured light. The extent to which the subject is followed and exploited in this way will greatly depend upon the children's inventiveness.



22. Light and colour B

It may well be that children's experiments with light and colour will often be verging on the limit of their understanding. Nevertheless this should not deter teachers from allowing them to experiment. Colour discs will pose many problems which will go far, nevertheless, to heighten their interest in the subject. Two simple colour discs are shown in the photograph. Children can make a variety of these and the best scope for intervention by the teacher will lie in suggesting useful colours, and encouraging the children to view their results not only with the unaided eye but also through colour filters.





23. Simple photometer

A simple photometer by means of which children can compare the intensity of light sources can be made from blocks of paraffin. The Irish physicist, Joly, inspired the apparatus in the upper photograph, adapted in this case as follows: the two 1 in. thick by 2 in. square blocks of paraffin wax have a sheet of polished aluminium cooking foil sandwiched between them. If the blocks of wax are warmed before the aluminium is placed between them they will adhere to it quite firmly. A simple method of introducing the comparisons is shown by the two light sources in the picture. In one case a 2·5 V lamp is powered by a single battery, and in the other an identical lamp is powered by two cells. The intensities of the light are compared by using the photometer.

24. Pinhole camera

Sooner or later, older children who become interested in a study of light will meet the phenomenon of the pinhole camera. The lower picture shows a method of constructing a simple one. Basically, it consists of two large tins. From one tin the top has been removed, and from the other both top and bottom. A small hole is pierced in the bottom of the first one, and a focusing screen is made to fit inside the other like a sleeve. The screen can be moved to and fro until the best position is obtained. The possibilities for study in this piece of apparatus are quite great. Just how far children will take them will depend both upon their readiness to carry their experiments further and their ability to deal with them. Many ten-and eleven-year-olds are ready to come to grips with the fascinations that photography provides, and this piece of apparatus may well be an entry to a whole range of studies of this kind.

Section 4

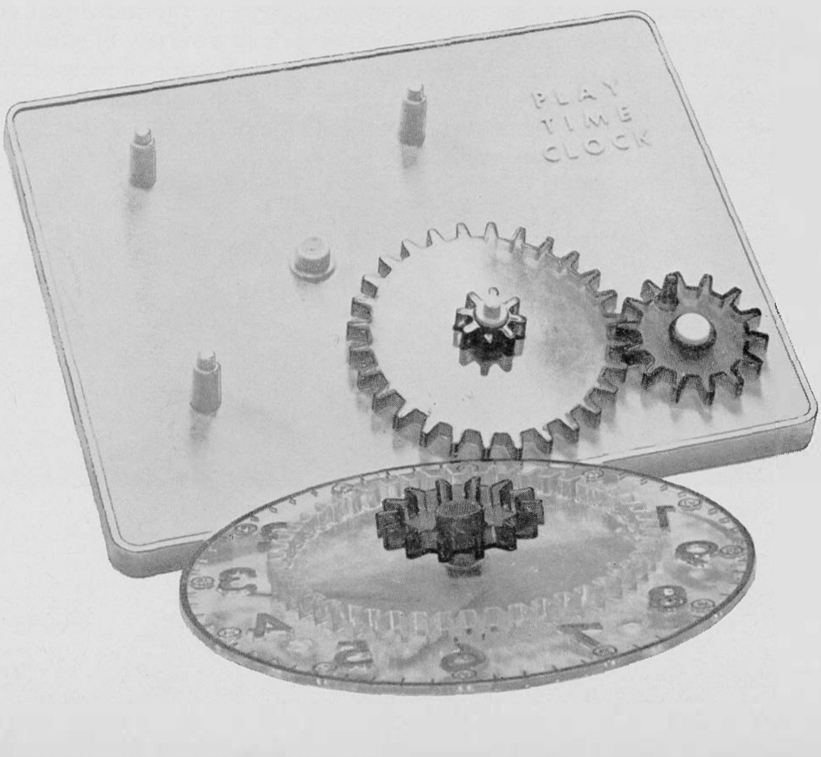
Machines

Introduction

Machines are an essential part of the child's environment in the twentieth century, whether he is in town or country. They are a stimulating and provocative part, and it is little wonder that children react with sharp curiosity and interest. However, although in imagination children feel they have understanding of machines and control over them, in practice this often comes slowly. Most machinery is complex and hides its essential features behind the outer frame of its skilfully designed unit. But there are some basic principles common to most pieces of machinery. These can form a worthwhile field for a considerable amount of practical work. Investigations may start from any point of interest on the part of the child, and the teacher can help by preparing in simple form a situation roughly parallel to one which has caught the child's attention. Repeated experiences can help the child to understand the function and purposes of machinery. Thus, plenty of practical work with a plank and a brick to form a seesaw can help his thinking about levers. The law of the lever first makes itself known through experience, but to realize it intellectually a child may need the wise intervention of his teacher. After this sort of experience, the reduction of the situation to a small scale can go ahead with all sorts of applications. Some of the interest in this subject can be used in a narrower sense by the teacher by provoking reactions from the children to individual pieces of simple machinery at suitable working points in the classroom. The section which follows endeavours to illustrate some of the simple pieces of apparatus which can evolve from and lead to a study of machines. It merely scratches the surface of this very broad subject, which, perhaps more than any other, has a universal appeal to all the age groups which form the five to thirteen range.

1. Gears A

The illustration shows a clock made in plastic material for use by infant children. In simplified form it begins to expose some of the problems of the arrangement of gears in a clock. The more closely a child ėxamines it, the more questions also begin to emerge about the relationship between the sizes of gear wheels, their number of teeth, their diameters, changes in direction of rotation, changes in speed, and changes in linkage. Thus, it illustrates the versatility of this sort of equipment, because older children are looking at some of these problems and it has a valuable part to play with them too.

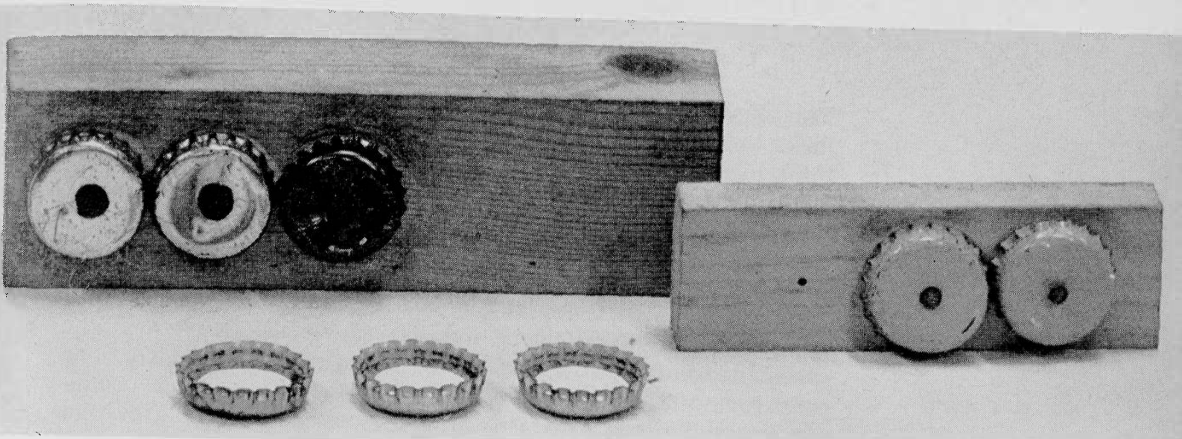


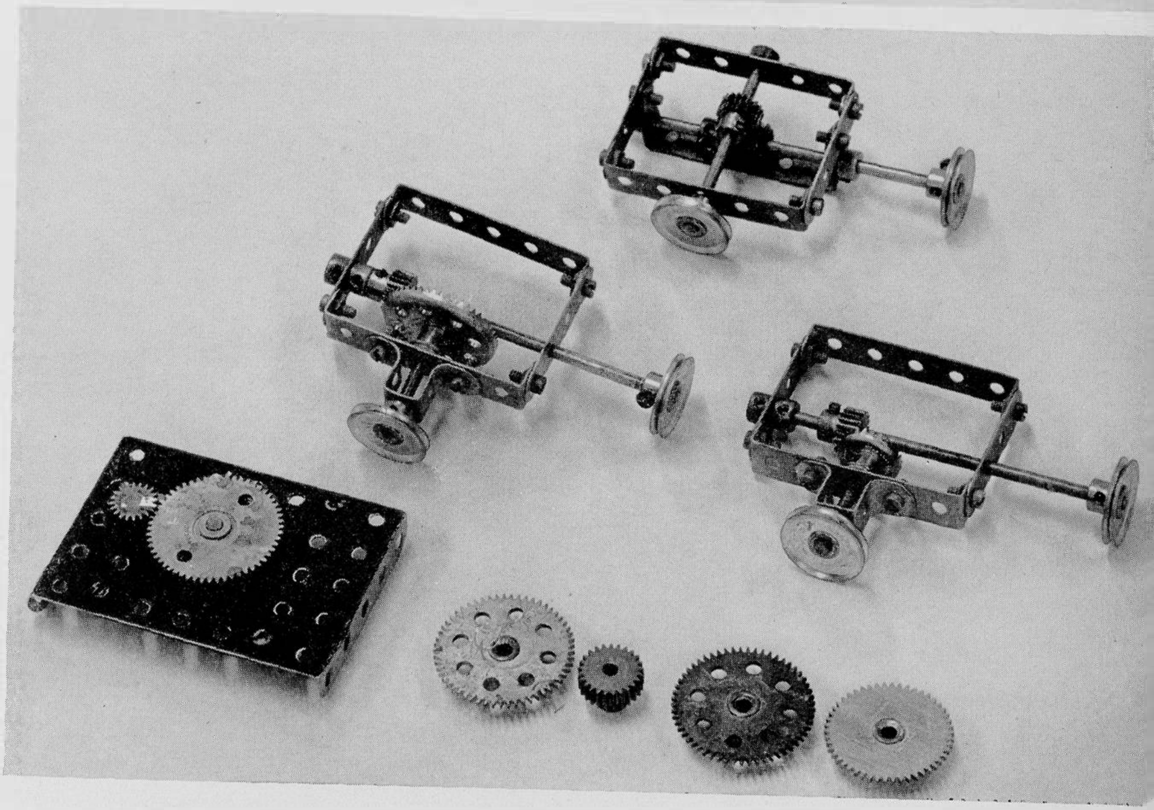
2. Gears B

This illustration shows a starting point for investigating the workings of gears, still nearer the simple beginnings which form a helpful springboard to more complex thinking. These simple devices show up the intermeshing of the teeth in gear wheels and the changes in the direction of rotation as gears are added to the train. Children can make similar arrangements with circular cardboard cheese boxes with their edges covered with corrugated card, but making these is less easy than using bottle caps as shown.

3. Gears C

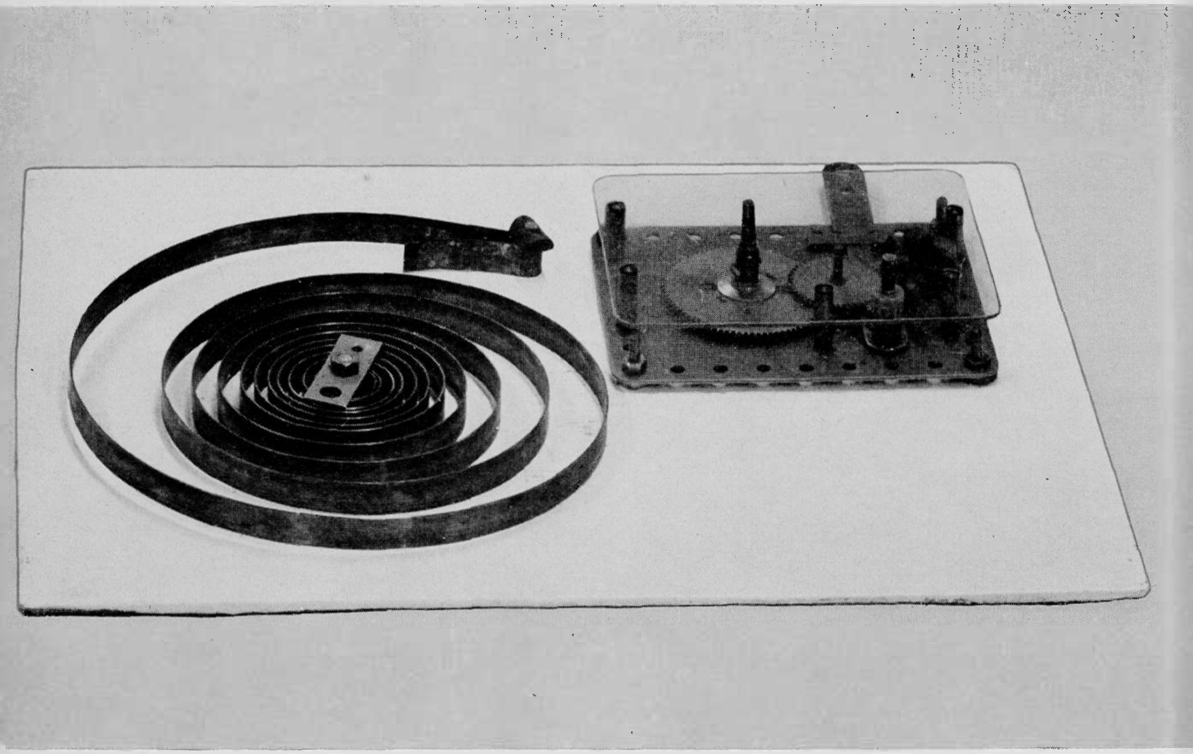
When children have had various opportunities to experiment with simple gear relationships—perhaps by the workings of a clockwork toy or trying to dismantle an old clock, or even playing with a bicycle bell—they may be prepared for a more exacting look at gear mechanisms. Meccano gear wheels as shown in the illustration provide a basis for investigating gear relationships, ranging from the very simple to the quite complex. Variations in speed, direction of rotation, as well as the design of the individual gear wheels can all be easily studied, and these in a variety of situations. The simple frames illustrated give scope for work ranging from a simple examination of the situation to quite complex operations involving some elementary measurements of the physical effects of different gear arrangements.





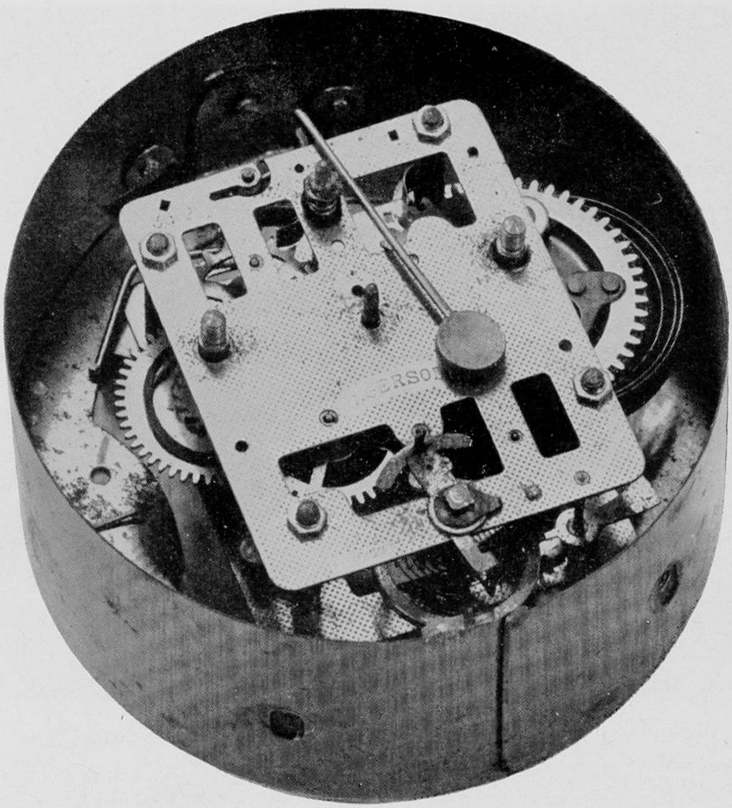
4. Gears D

This illustration shows the kind of adaptation that it is useful to make to a piece of equipment, to help older children who want to think logically about an application of their previous experiments. Here, a simple Meccano clockwork motor has been adapted by removing the spring and the top face-plate, and replacing the face-plate by an identical one made from a piece of Perspex. This device shows up well the functions of the gears. It permits a simple manipulation of them so that the working of the reverse mechanism can be seen, and in addition poses questions about the function of the spring, its source of energy, and how energy is transmitted from one point to another in the mechanism. The concept of energy is a difficult one and at this stage it is probably best not to take it beyond the practical situation.



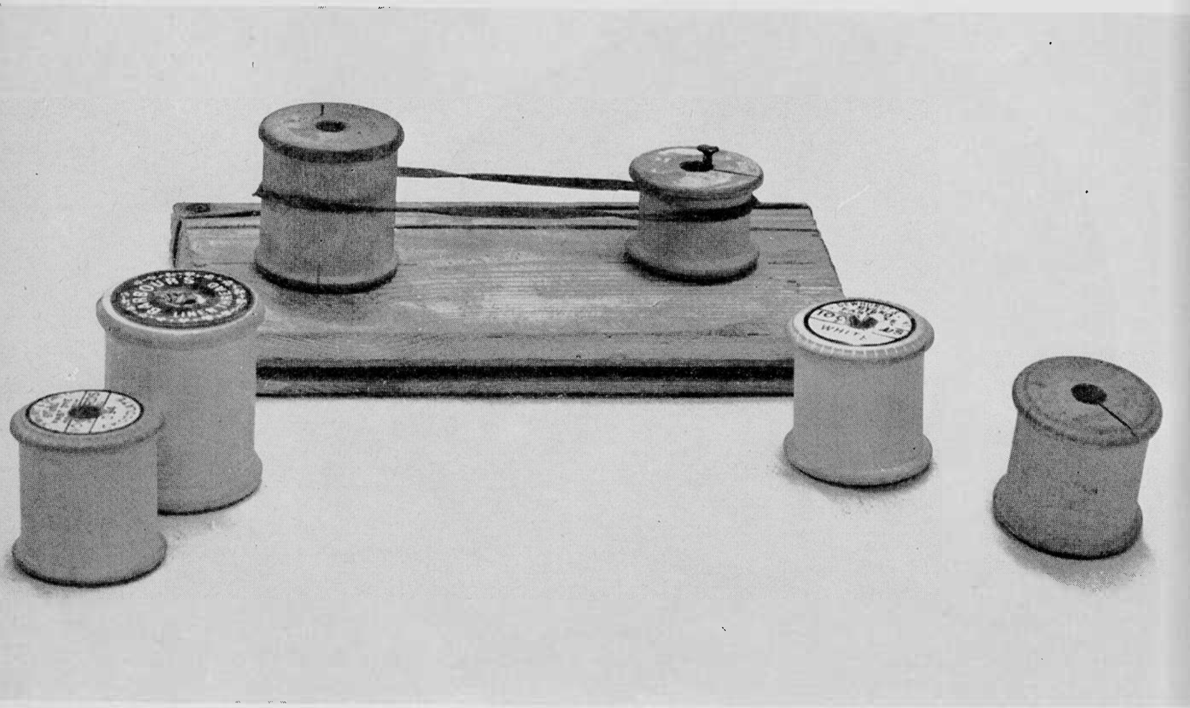
5. Gears E

A discarded alarm clock is a familiar piece of household equipment which finds its way into many schools. The infant will play happily with it, turning the hands, listening to the gong and the tick, and so on. The younger child in the junior school may begin to use this same object with an imaginative understanding of its workings rather than any real appreciation. It is usually not until the top of the junior school that the functions of any of the complex parts become really apparent. However, at all the stages there are possibilities for the child to begin to develop his understanding through manipulation and for the oldest juniors to isolate separate components and gauge something of their functions. The time spent in dismantling complex machines is by no means wasted, as it provides the teacher with an almost never-ending series of opportunities for posing questions, and for the child to form conclusions about the concrete components.



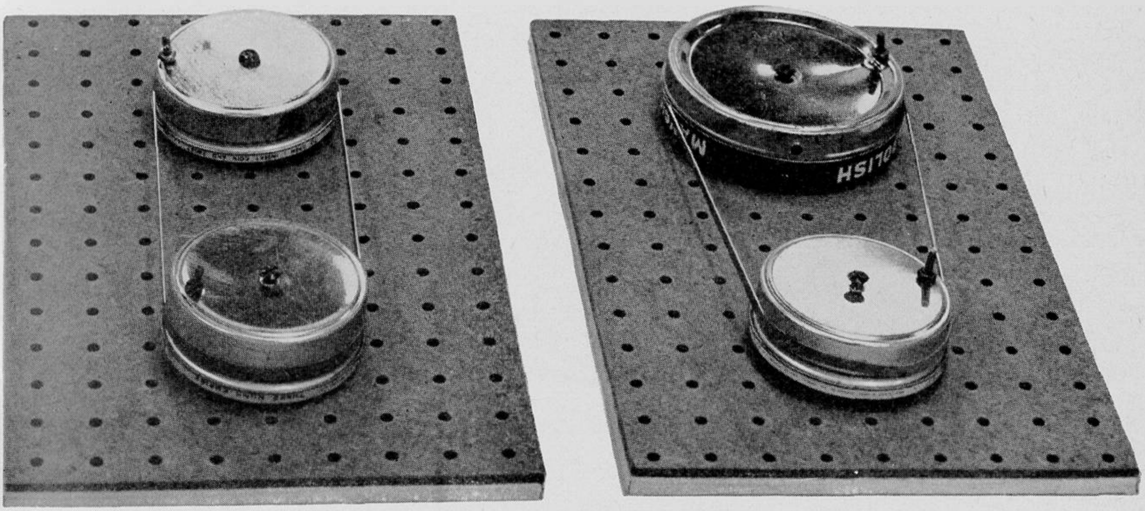
6. Belt drives A

In many machines a central problem is the transmission of power. This will have been met with if gears have been studied. Otherwise, it may well be that the child's first acquaintance with it will be through the belt drive. The illustration shows some simple means for studying some of the aspects of the problem involved here. Basically, the apparatus is a piece of wood with two nails inserted which form spindles for the reels. There should be some reels of different diameters and some of the same. These can be manipulated so as to work out some of the relationships involved in this mechanism. It may well be enough simply to let the child use the apparatus to appreciate the fact of the belt drive, and leave it at that. But it also provides the opportunity for the teacher to pose questions concerning the mechanism, the relationship between direction of rotation and the primary drive, the relationship between the sizes of components, how to achieve the reverse drive, the relationship between the drive and the driven, and so on.



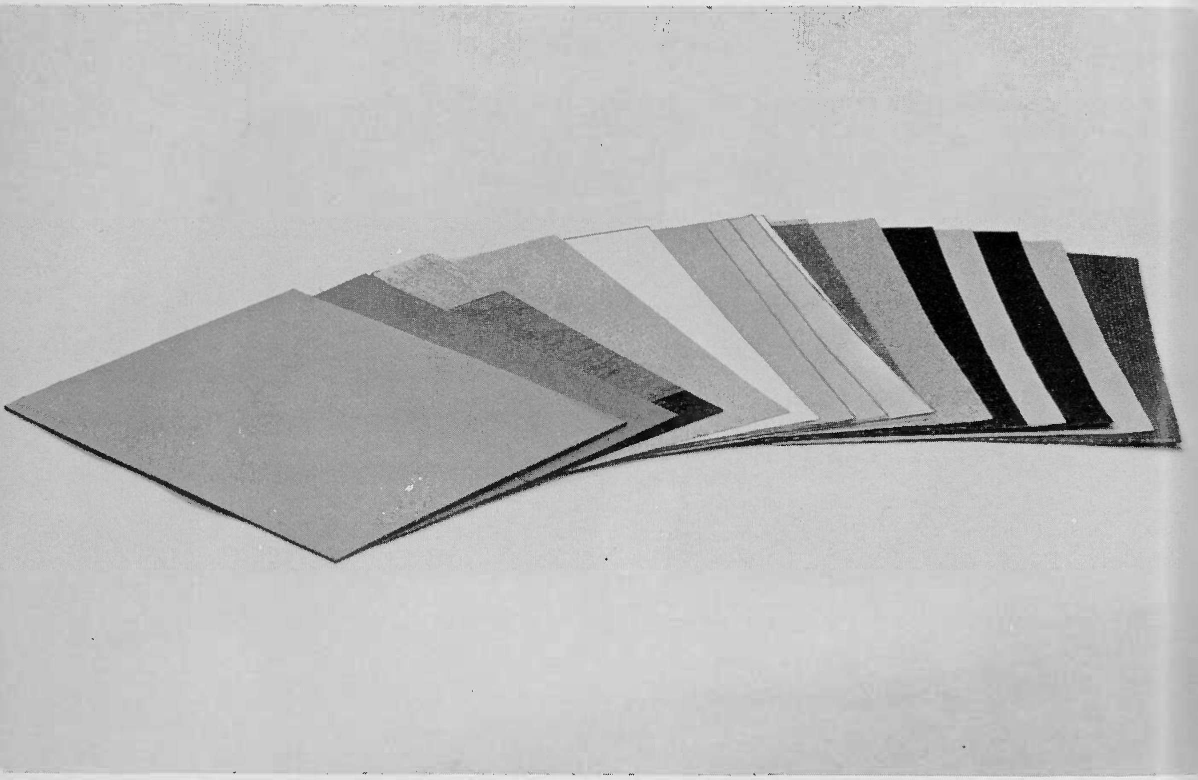
7. Belt drives B

A variation on the apparatus shown in the previous illustration is shown here. The pegboard makes a base upon which the tins which form the drums of the drive mechanism can be mounted. The spindles are formed by nuts and bolts pushed through the holes in the pegboard. Quite complex variations in mechanism can be built up on this simple basis. Drives on identical drums are shown on the left, and on the right a drive between drums of different sizes. With a good supply of tins and a fairly large baseboard children can build up most elaborate drive mechanisms and will be able to work out some of the facts concerning them. Interconnections by way of belt drives can easily be made by using elastic bands of various sizes, widths, and strengths.



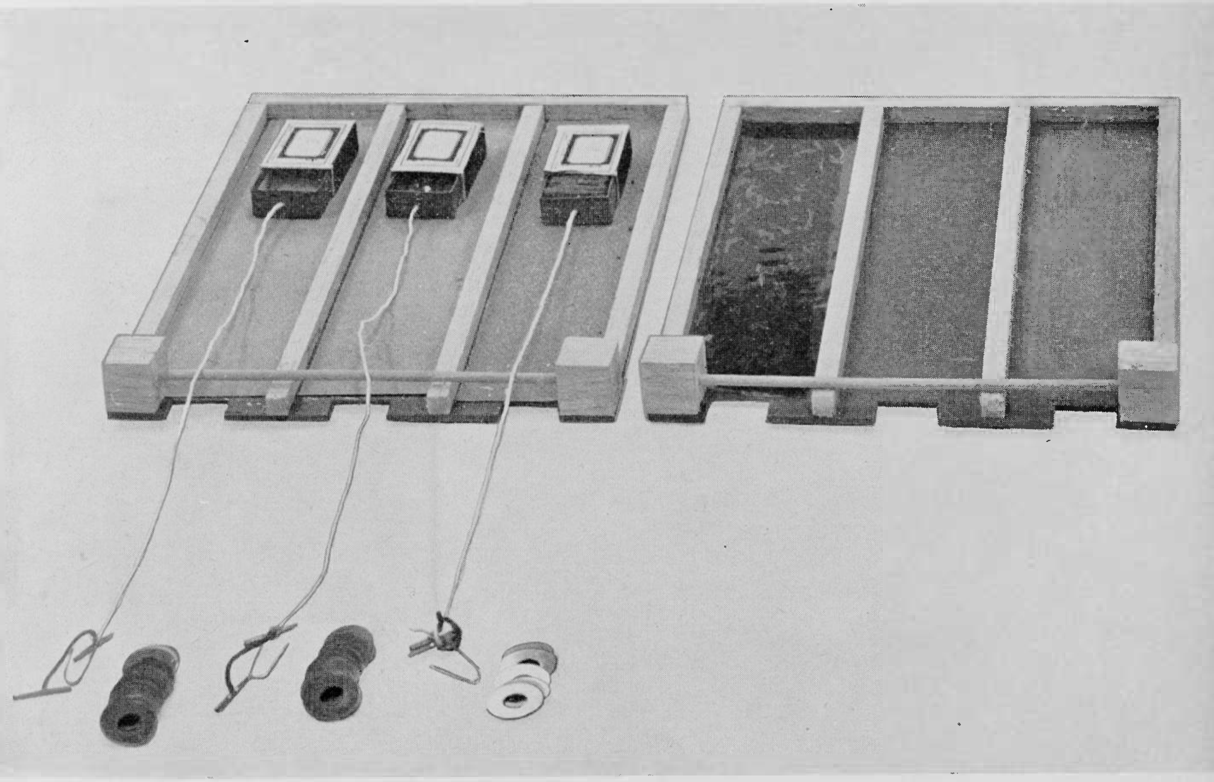
8. Surfaces A

Because children's tactile sense is well developed and they are able to feel surfaces with a discernment of which adults are not capable, they will perceive qualities by this method which are just as well worth pursuing as those they can see. The illustration is a reminder of the variety of types of surface which exist in the stock cupboard of most schools. There are pieces of paper of most of the common grades, as well as some sandpaper and emery paper. Included too are pieces of cardboard and two pieces of linoleum. Exploring the qualities of these materials alone can not only open up investigations along a path the teacher may have in mind, but will also reveal other qualities which are worth examination as the child approaches them in a genuine spirit of enquiry.



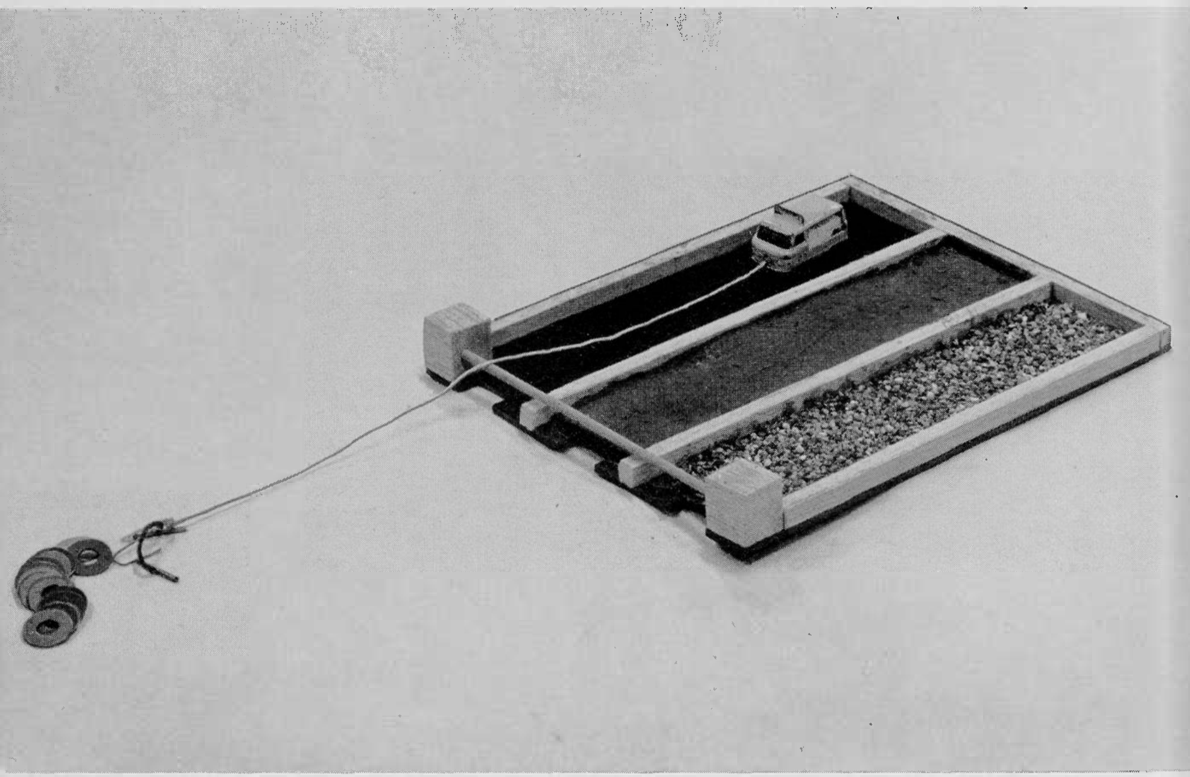
9. Surfaces B

This illustration shows a piece of apparatus devised for testing and recording information about one of the qualities of surfaces. It consists of a piece of hardboard as a base, with trackways separated by strips of balsa wood stuck to the hardboard, and with different surfaces applied to each trackway. In the lefthand set there are three grades of sandpaper stuck to the hardboard. On the righthand set there are a highly polished surface, one coated with Plasticine, and one very roughened. The test vehicles consist of matchboxes, one empty, one half-loaded with Plasticine, and one filled with Plasticine. The units of measurement are washers. This basic piece of apparatus can obviously be used to test the qualities of surfaces in many different ways.



10. Surfaces C

The basic situation illustrated in example 9 has been taken a step further in this illustration. Here an attempt has been made to reproduce road surfaces, and to test their effects upon the efficiency of a vehicle. This matchbox toy has deliberately been chosen because it is a scale model of a heavy vehicle, and the road surfaces have been similarly gauged to match real-life conditions. The lefthand surface represents a completely smooth tarmac road, the middle surface a damp mud road which was made from damp clay, and the righthand one a gravel-strewn mountain trackway. Similar units of measurement are used as in the previous experiments. This apparatus has yielded useful and interesting results in the class which designed it. There will obviously be many variations that schools will be able to make upon the same theme to suit their own work.

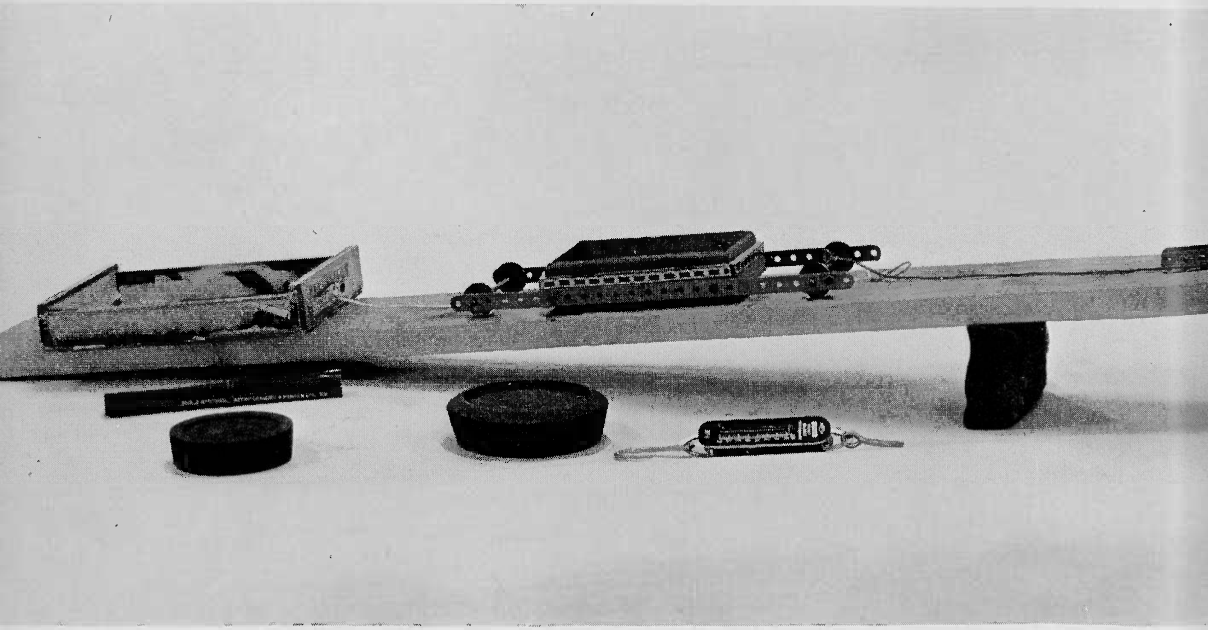


11. Surfaces D

No investigation into the problem of surfaces, friction, and machines would be complete without some experiments with ball bearing devices. The illustration below shows some simple means of initiating practical work. Large glass marbles on a saucer can be used effectively for helping children to see what is happening in these situations. Glass marbles, as shown, can be placed in a tin lid as a ball race, and another lid placed on the top. The child can stand on this and feel the effects of the ball race. If the marbles are taken out of the tins and these are placed together again and the child stands on them, quite a dramatic change will be noticed.

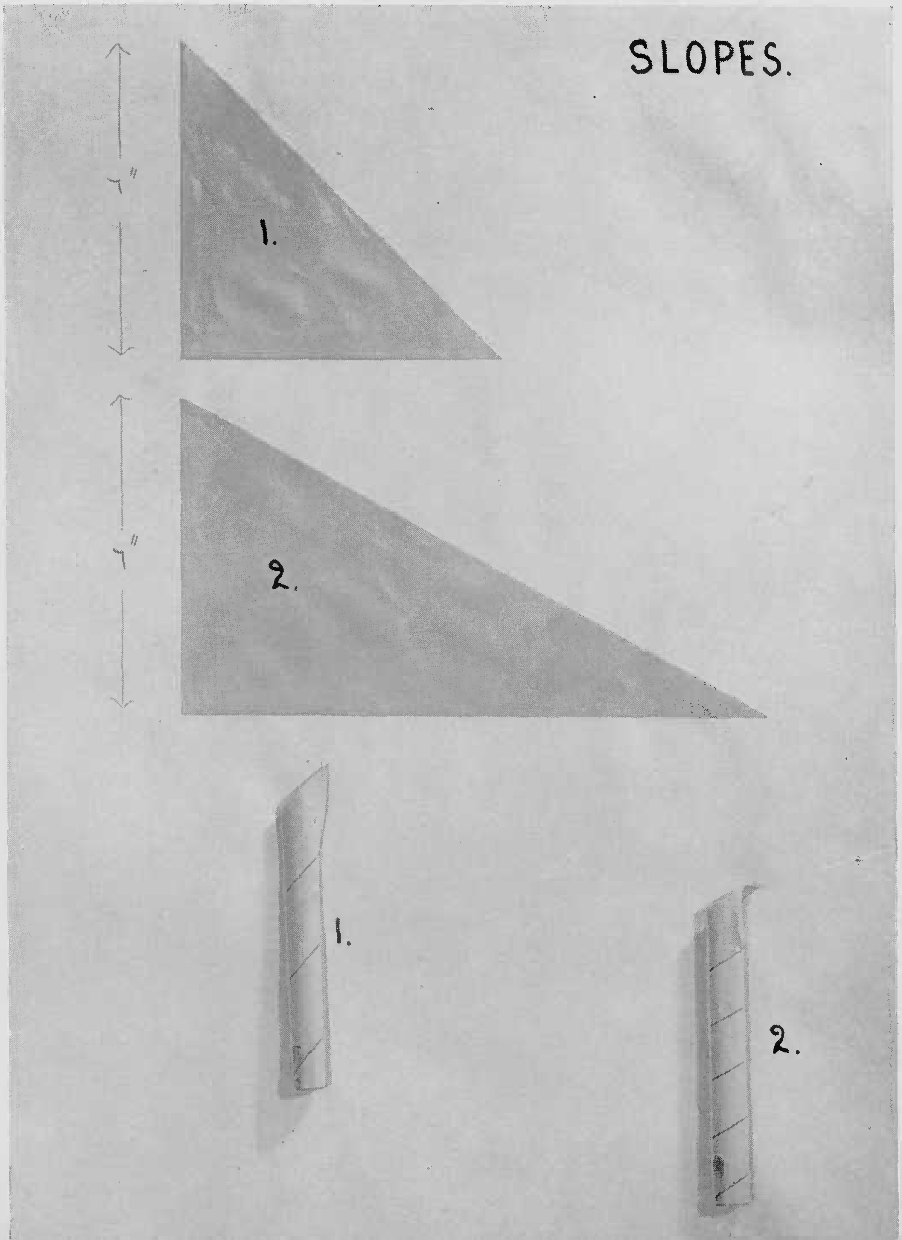
12. Slopes A

The miniaturized and quantitative studies of the inclined plane and the effects of surfaces rubbing against each other, and the effects of different loadings upon different surfaces, will exist in an unrelated vacuum unless they have been preceded by plenty of practical work involving the real thing. Children will need to experiment with planks and real loads so that the advantages of using simple mechanical devices will be appreciated by them in physical terms. When this sort of experience has been gained, it will be possible to understand some of the significances through a miniature representation of the situation. The photograph shows some of the simple apparatus which can be used to do this. The plank is a piece of floorboarding with a guide at one end made from two Meccano strips and a pulley wheel. The construction of the wheeled vehicle and that of the plain vehicle on the left are obvious. Both are made from empty cigar boxes. If weights are used for loads, it will be helpful to have simple multiples one of the other. Apparatus of this degree of crudity will only show trends, but this will be sufficient at this stage.



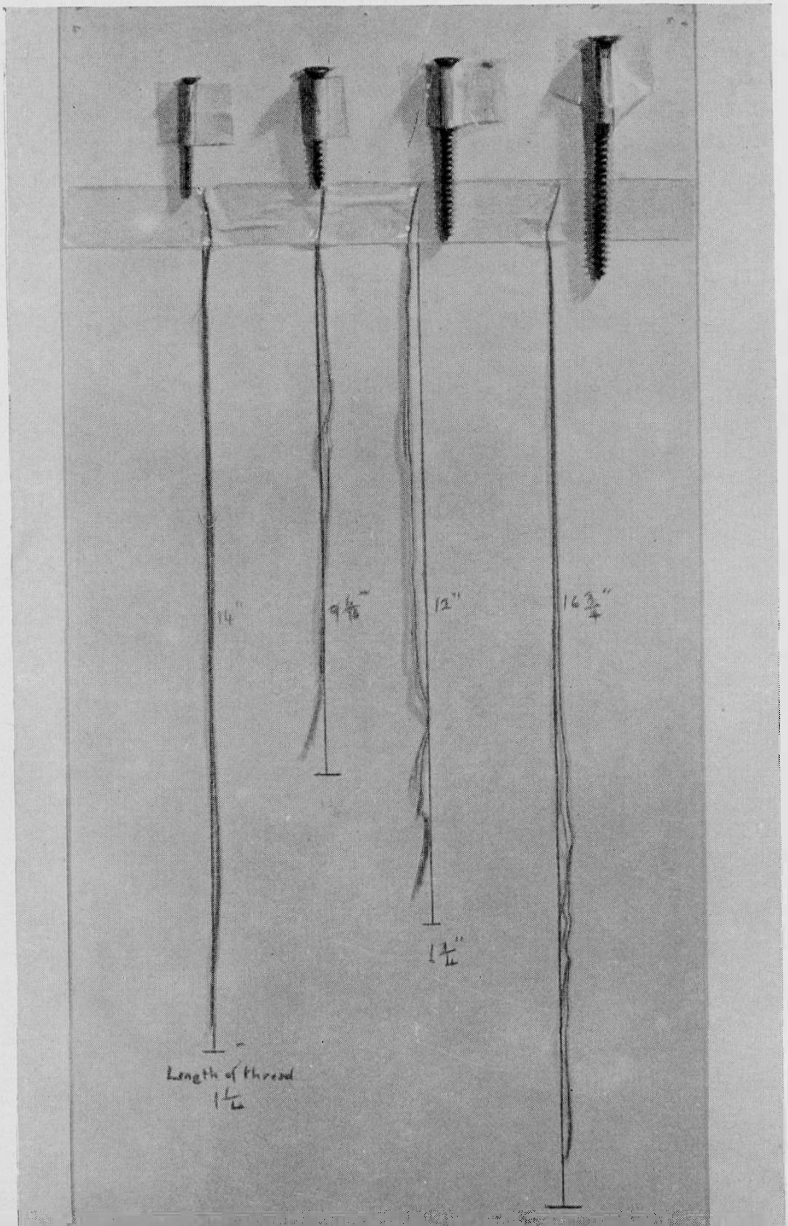
13. Slopes B

The significance of the screw thread as an application of the inclined plane is not always easily realized by children. The illustration shows a way of helping children to build up this appreciation. Obviously children can experiment with a variety of slopes to produce threads of different pitches.



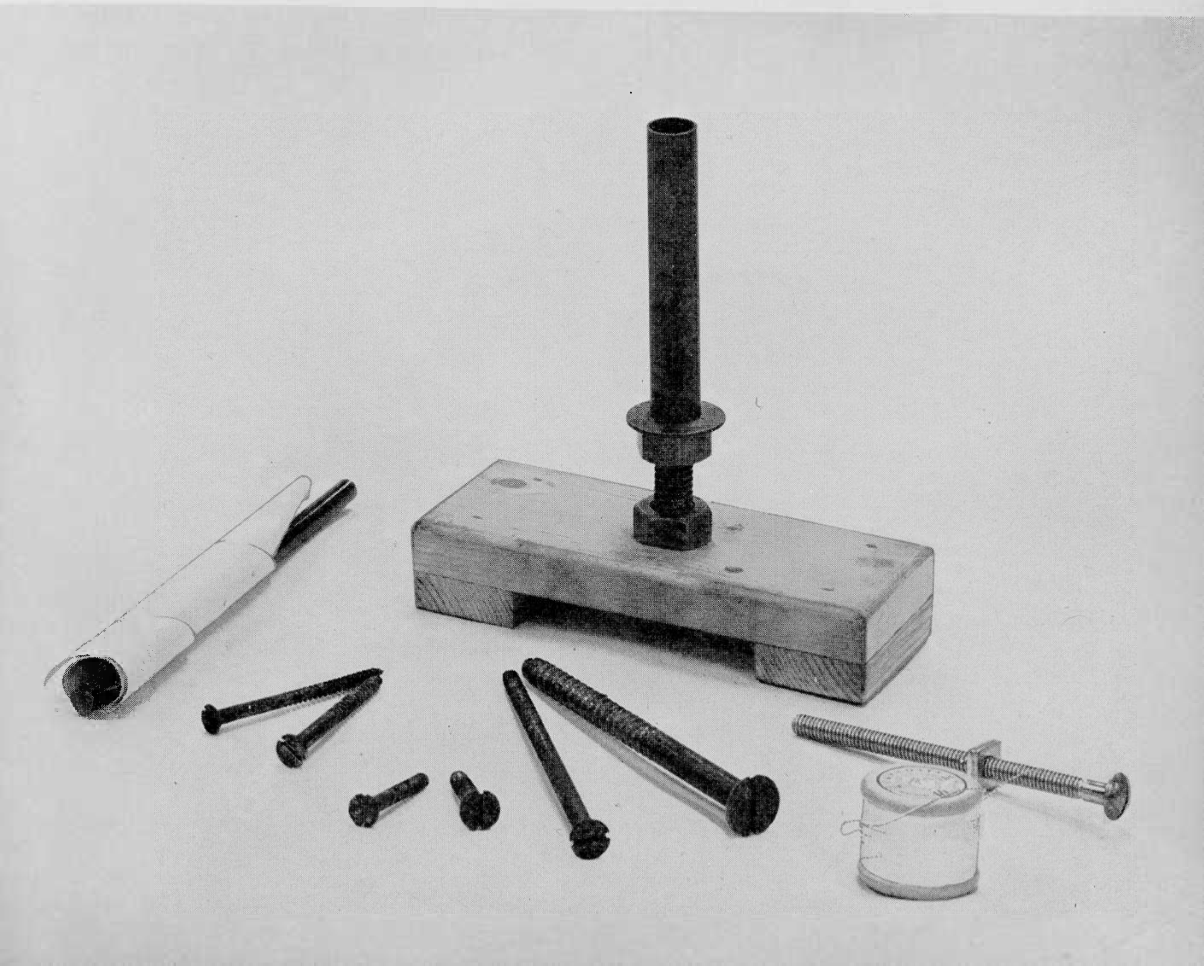
14. Slopes C

This illustration sums up the results of another way of investigating the pitch of threads on a screw, and the significance of these. A much wider range of screws than those shown in the picture would need to be used, including screws of the same length and with different pitches of thread, screws of the same gauge and with the same pitches of thread but different lengths, and so on.



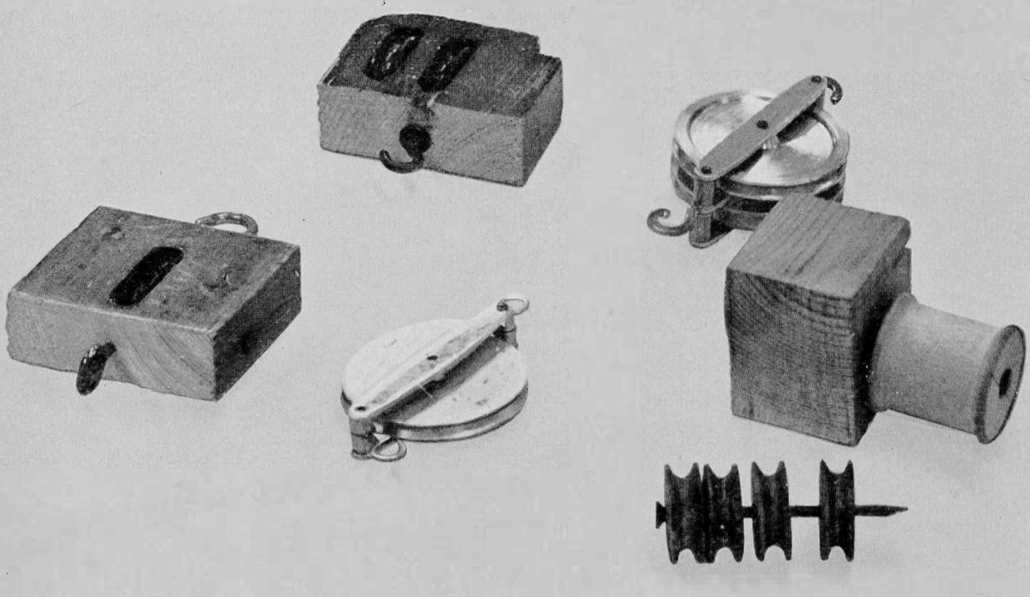
15. Slopes D

The illustration shows pieces of equipment which summarize some of the studies in the application of the inclined plane to the screw. A group of pairs of screws of identical length but different gauges and pitches of thread is in the central foreground. The length of the thread on the nut and bolt to the right of the picture proves quite startling when it is measured using the cotton placed near it. The application of the principle of the screw to a lifting device can be effectively investigated with the simple form of jack shown in the background. It is merely a nut and bolt of fine-pitched thread and about $\frac{3}{8}$ in. in diameter, attached to the wooden base and carrying a second nut with a washer above it and a piece of tubing to pass over this. Very heavy loads can be jacked up with this device using a spanner to turn the upper nut, which is the movable part of the jack in this case.



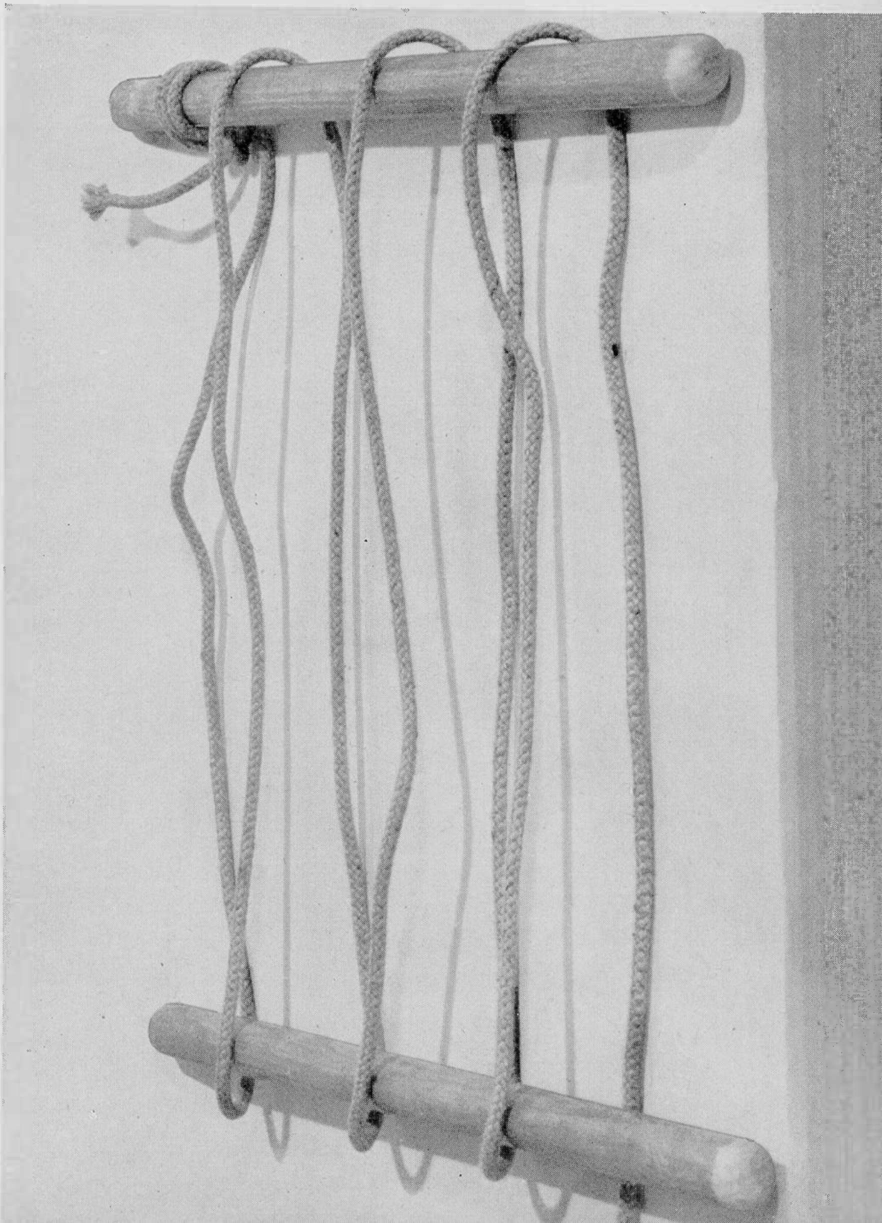
16. Pulleys A

The practical significance of the pulley is another subject which the child needs to approach by experiments on full scale apparatus. Most schools will have outdoor equipment designed for physical education. The frames form ideal supports for pulley devices of various kinds. Teachers should be sure that the ropes used for these experiments will take the strains that they propose to put upon them. When the child is ready for work on a smaller scale and it is done indoors, the first experiments can easily be undertaken with quite crude pulleys. The illustration shows some improvisations as well as two commercially made pulley blocks. The cotton reel and the nail are probably the most elementary types children will devise first. Pulley wheels from old Venetian blinds can easily be adapted for use in school. The wheels themselves are shown in the foreground, and a double and a single pulley block in the left of the photograph. Hooks and eyes placed at either end make the blocks all the more effective.



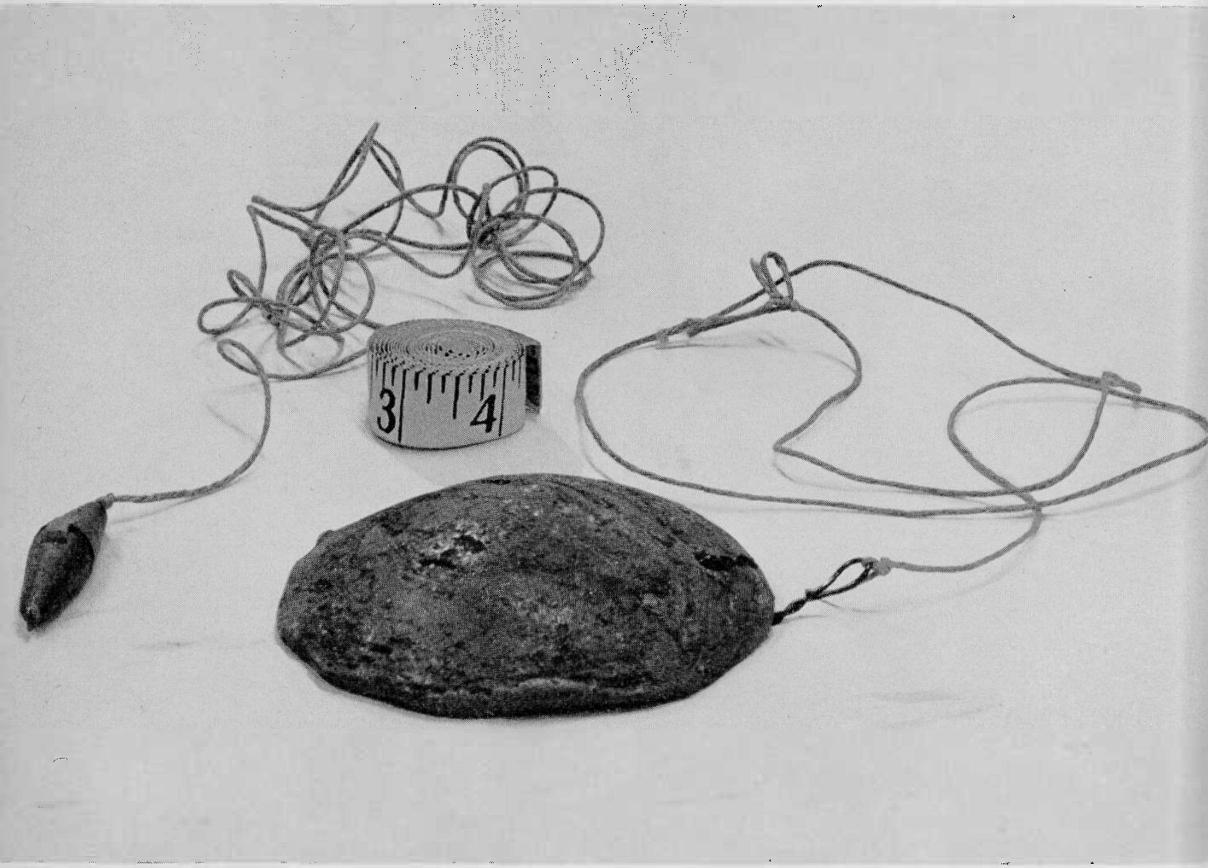
17. Pulleys B

It is not always easy for children to acquire an appreciation of the significance of the multiple pulley. This apparatus shows a method of helping them to come to it stage by stage. It consists of two highly polished ash poles with the rope laced between them suitably.



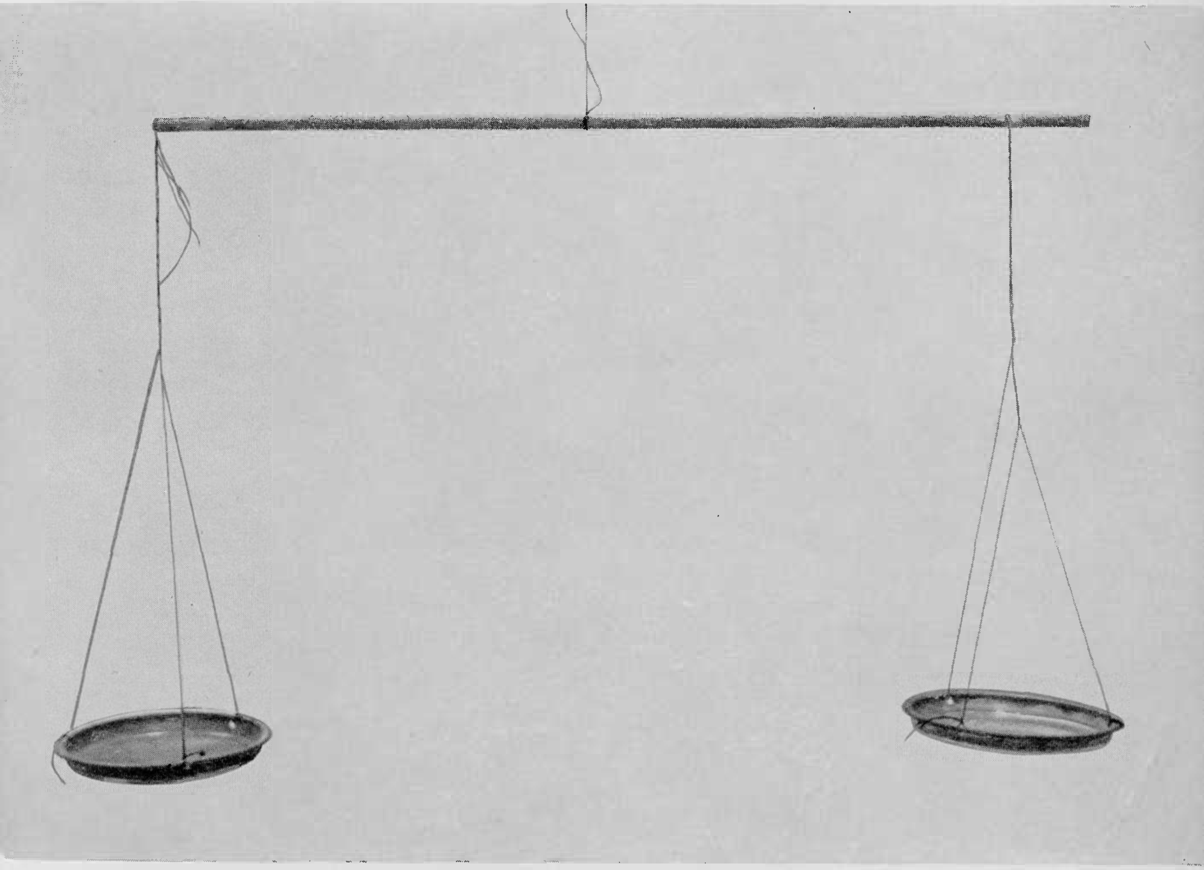
18. Pendula

The study of pendula forms a fascinating starting point for a great deal of work in science for children. This illustration serves as a reminder to teachers that they will need to provide only elementary material which will suggest in itself the contrasts between the effects of one set of conditions and another. If suitable measuring devices are available it is quite likely that children will make measurements of their own volition, and not as part of a required routine.



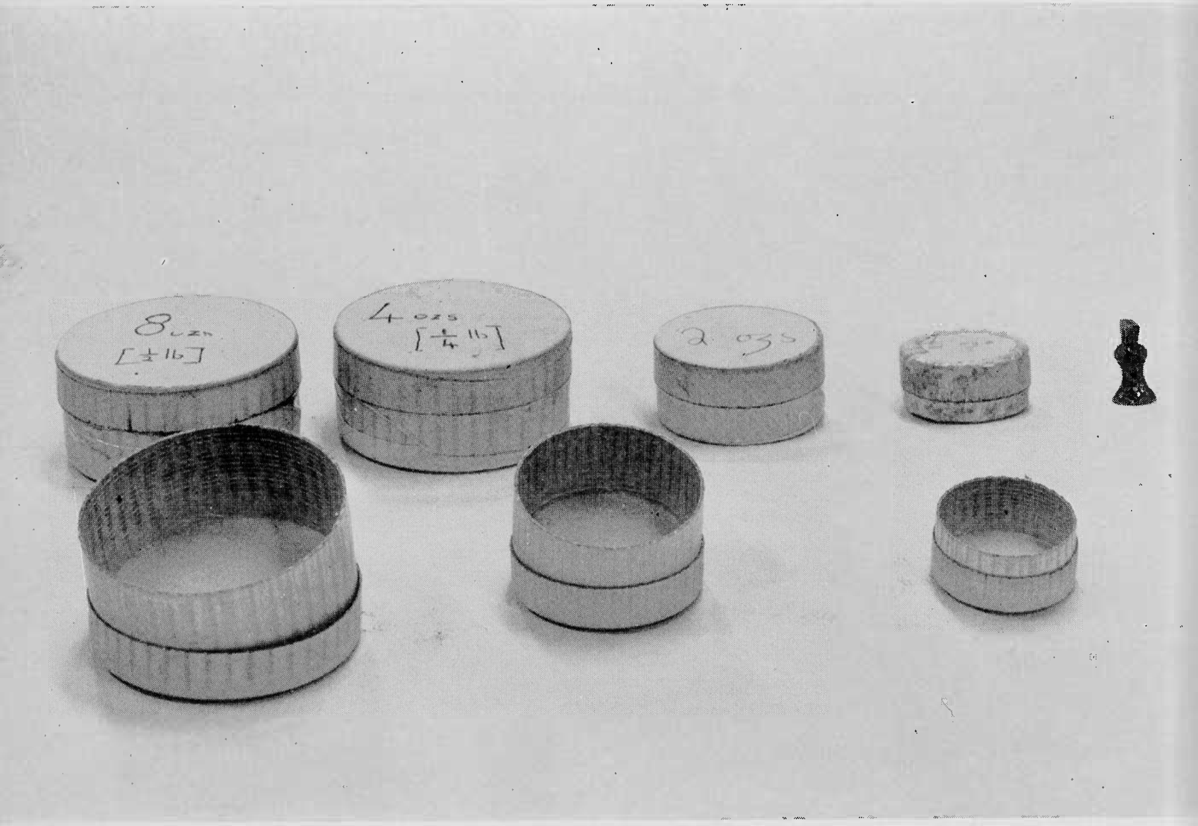
19. Simple balance A

In work in science, children are constantly faced with the need to weigh and measure. It is often a good thing to throw them back upon their own resources for inventing the means of making these measurements. The next few illustrations show some inventions in this direction. This photograph of the simple apothecary's balance has its inspiration from a section in a history book. Children made it with considerable patience and then faced the problem of producing a set of weights.



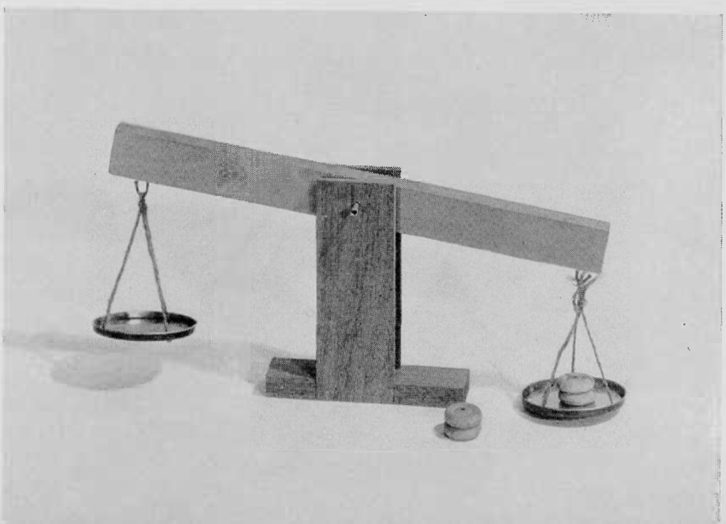
20. Simple balance B

This illustration shows one solution to the problem of producing a set of weights when only one weight of known denomination is available. In this instance, pill boxes have been filled with sand in suitably increasing quantities.



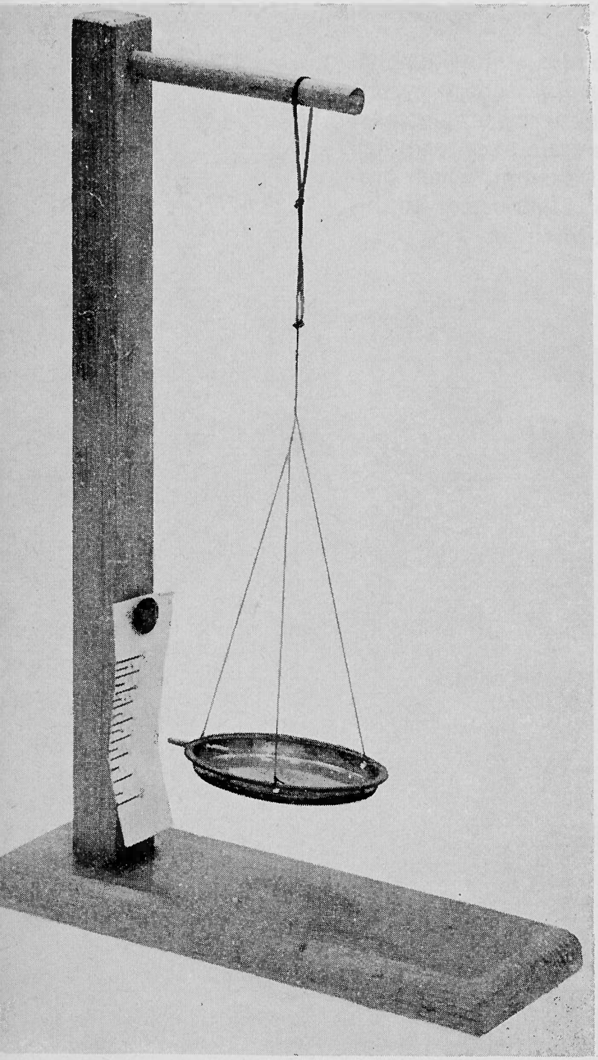
21. Simple balance C

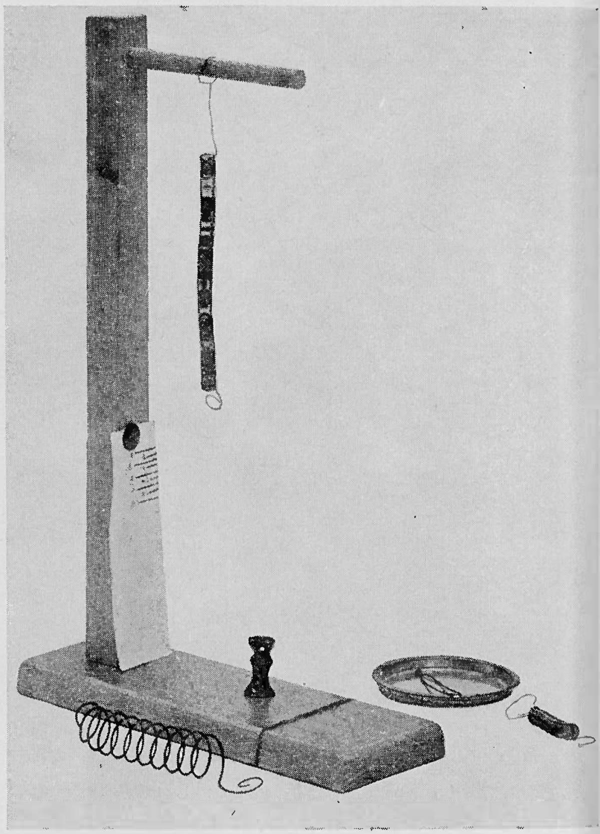
These two photographs show attempts to produce a more sophisticated version of the apothecary's balance. The upper one, however, shows only crude variations on the theme, by using a ruler as a beam. This was not really satisfactory as the scale pans easily fell off. The lower picture shows a more refined attempt, which produced a creditable balance when the spindle was lubricated. In this case, wooden wheels were used as units of measurement.



22. Spring balance A

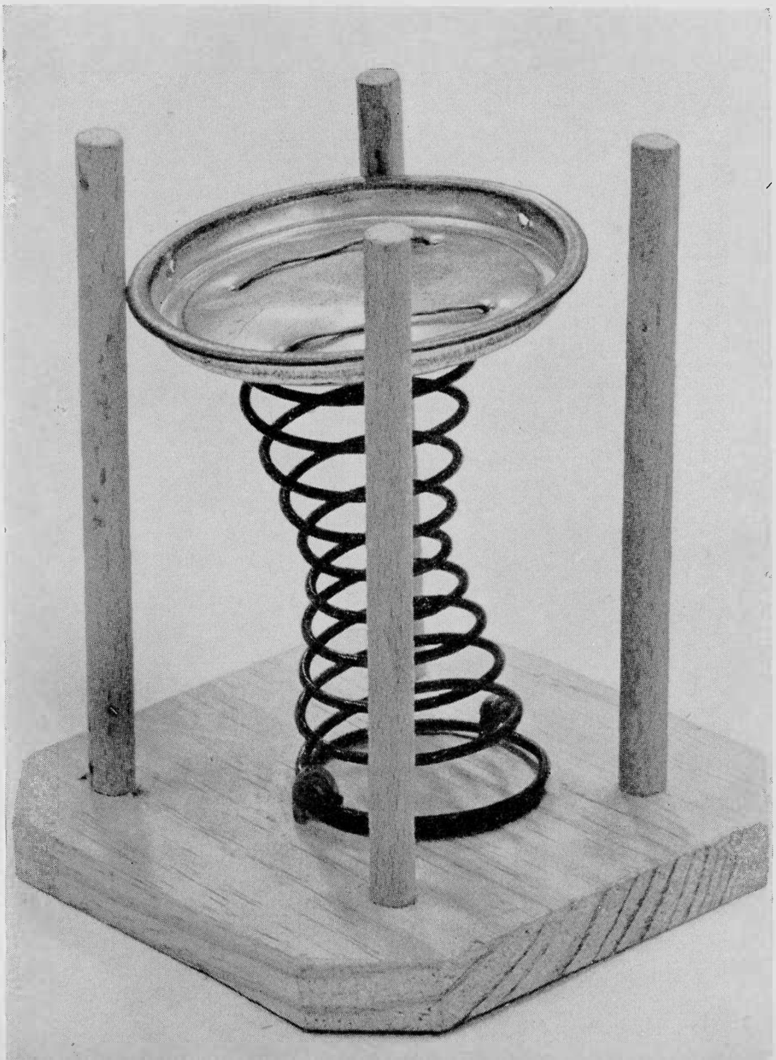
The illustrations show another approach to the measurement of weight. In the upper one, an elastic band is used against a scale calibrated from a series of known weights. In the lower, springs of different tensions have been used to produce scales of weights over different ranges of values. The calibrations were made on cards pinned to the upright. These cards were changed according to which spring was in use for a particular range of work.





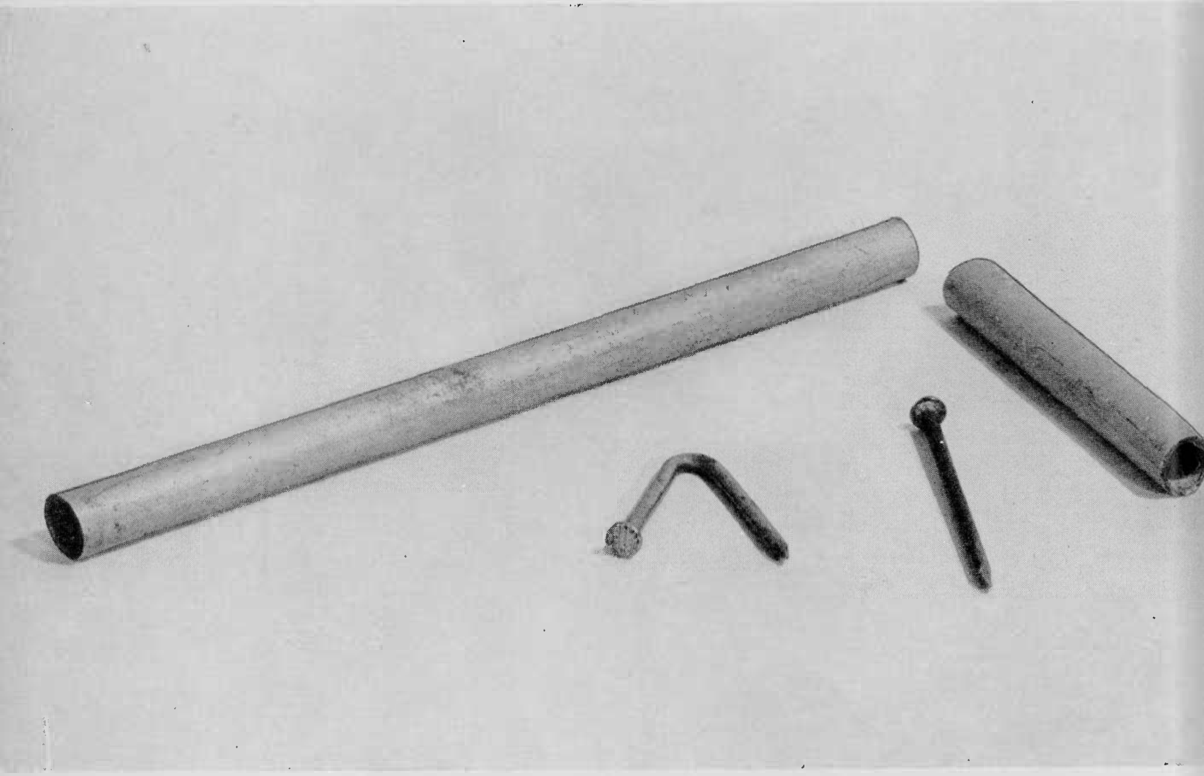
23. Spring balance B

Alternative methods for weighing heavier loads can be produced by using the design of depression balance illustrated here. The four upright supports on the wooden baseboard help to keep the load in place. A similar function can be served if the spring is placed in a tin and another tin of suitable size placed over it, providing a containing sleeve as the balance functions. With a suitable range of springs, these basic designs serve to deal with loads over a wide range of weights.



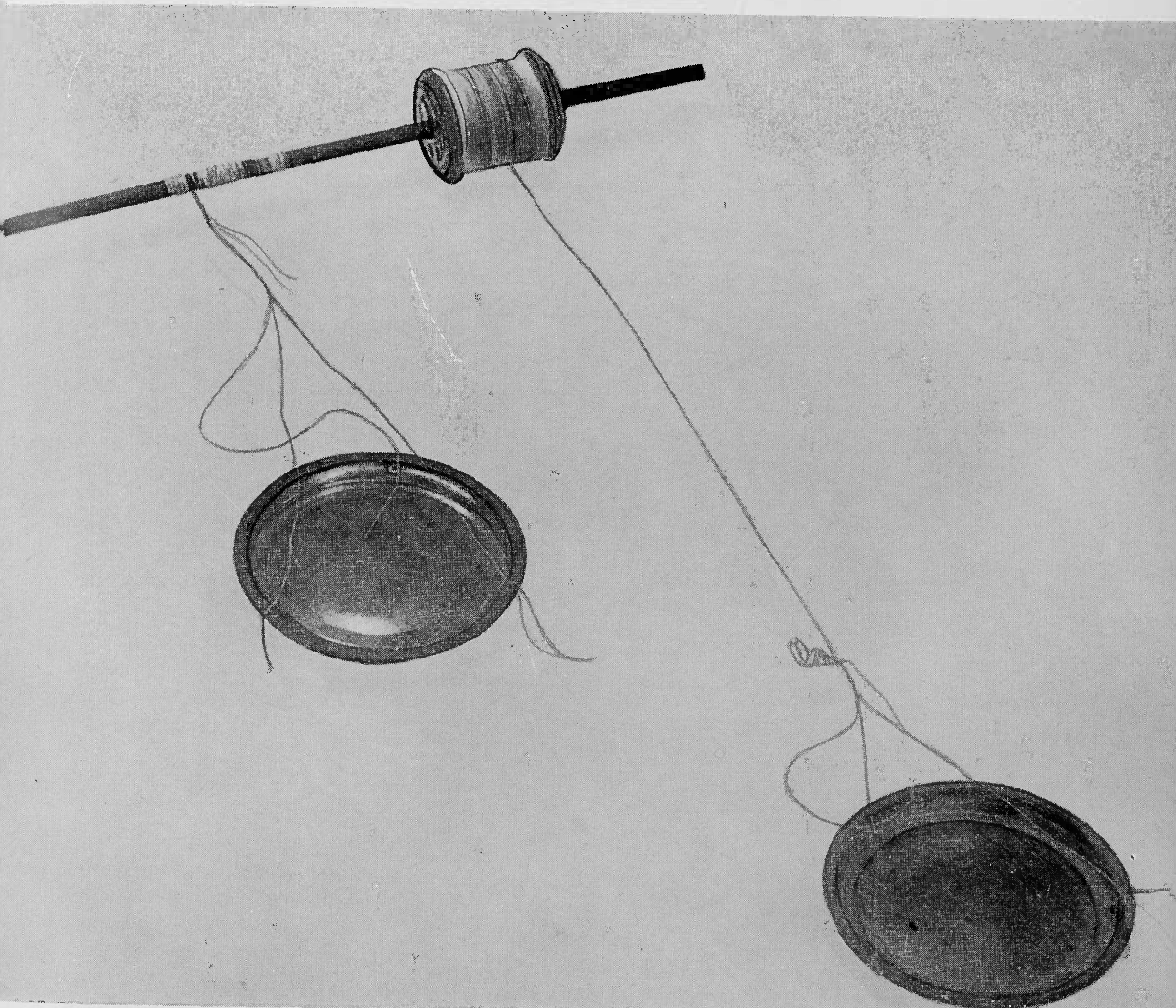
24. Levers

This illustration shows an interesting variation on the approach to physical experiences with levers. The two pieces of waterpipe have been cut so that one is about four times longer than the other, the smaller being about 4 in. long. The effect of different lengths of lever upon the child's ability to bend a 3 in. nail can quite dramatically be measured, as he endeavours to bend the nail with his hands placed at different points on the length of the longer lever. The value of arranging early physical experiences in this dramatic way is that they can be followed up effectively. Certainly, the amount of conversation resulting in questions that they produce presents the teacher with many opportunities to exploit.



25. Wheel and axle

The working of the wheel and axle is not easy for children to understand. This photograph gives some idea of an elementary piece of apparatus which can open the way both for experiments on the general principle and also some quantitative work.



26. Toys

Children have an interest in how things work and quite often this leads to the reproduction of a situation with equipment that they make themselves. This is not as unoriginal work as may be assumed, for quite often the improvisations required produce thinking of quite a high order. The children will rarely have available the specially made components of the manufactured goods, so they will need to search for and improvise substitutes. This illustration shows an interesting attempt to make the equivalent of one common toy, keeping both the fascination of its apparently mysterious movement and using simple means of producing this.