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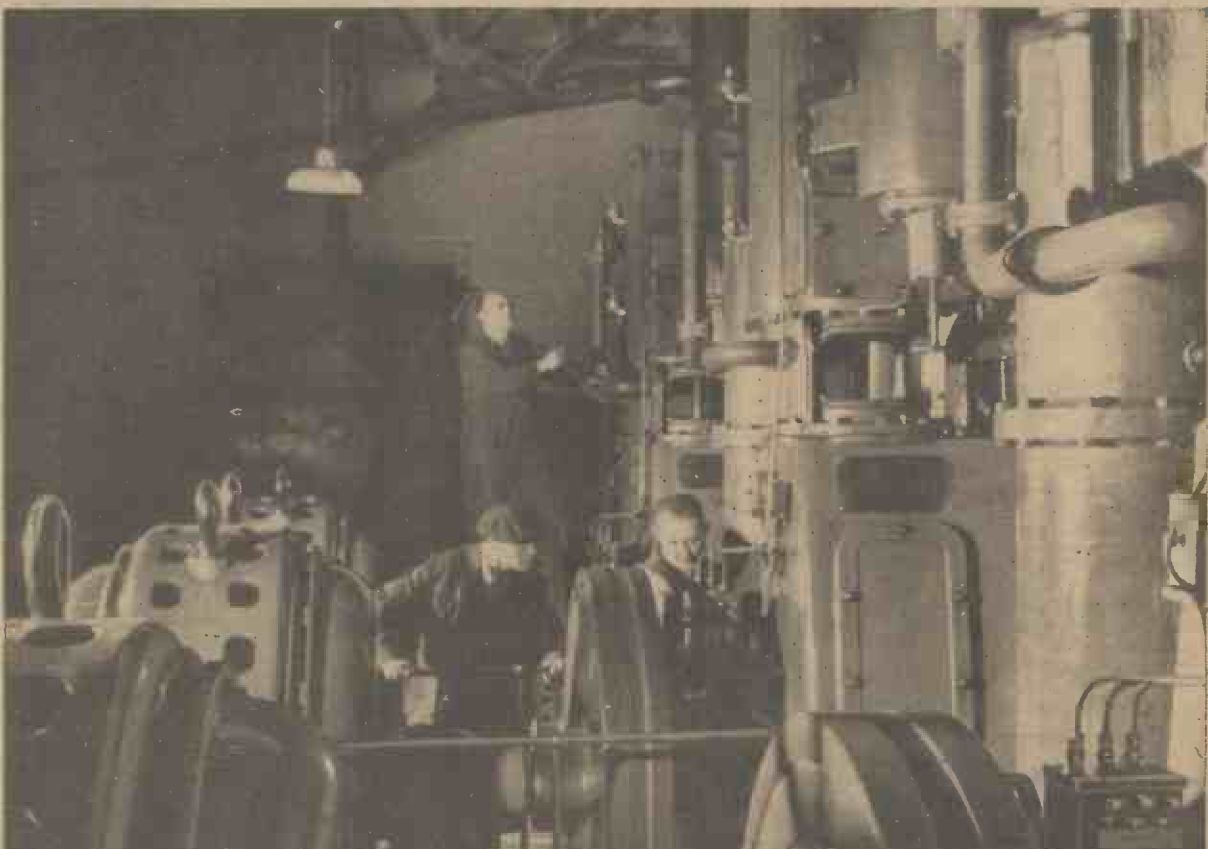


Rocket Propulsion

British Sounding Rocket Developments

By K. W. GATLAND

(*Continued from page 135, January issue*)

THE rocket projectile as a means of long range, high speed, transit is no recent idea. It was, in fact, the pioneer rocket engineer, Professor Oberth, who first set down the specifications for such a vessel, which he did as long ago as 1931.

It is of interest to note that the flight control and trajectory of Oberth's hypothetical rocket bear much resemblance to the methods originally adopted in the V2 rocket shell.

The ascent was arranged vertically in order to overcome the main drag effects of the atmosphere in the least time. Having maintained a direct path to an altitude of 30 miles, the vessel's course would be reset at a predetermined angle, and at the desired speed (the requisite angle and maximum velocity would vary with the distance to be covered) the motor "cut," allowing the balance of the journey to be made under momentum. The maximum height of the parabolic flight curve was calculated to be in the region of 100 miles.

The trend of development points the way conclusively to the ultimate evolution of the rocket projectile. The orthodox aeroplane has already reached a reasonable limit of speed efficiency beyond which it is impracticable to proceed.

The operation of aircraft above the compressibility limit, as we have already seen, is a reasonable possibility, but only if the efficiency of the rocket engine, when working in atmosphere, can be substantially improved. It may be that this obstacle will be completely overcome by the development of the atomic reaction engine, and if so, then the many lesser problems associated in this development should be quickly solved.

It is only when the Sänger flight system is considered that the practicability of operating *chemically* powered rocket aircraft in the super-sonic range strikes feasible, and this obviously is merely an interim step leading ultimately to the true projectile craft.

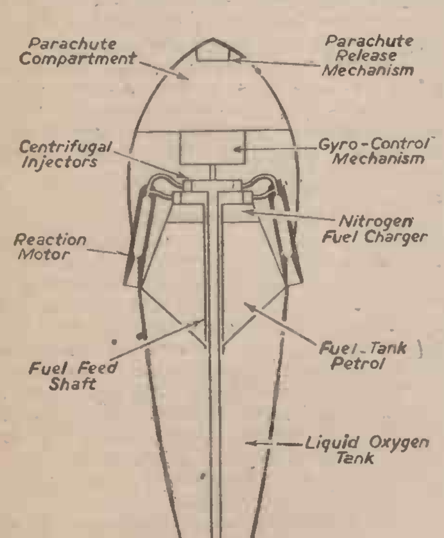


Fig. 51.—Diagrammatic layout of the original M.A.A. design for a sounding rocket (1939).

The Sounding Rocket

Apart from sea-rescue, *meteorological sounding* is another specialised peacetime use that the rocket is now serving. The war has been the means of accelerating this development, and already much important data has been accumulated in this way.

Prior to the rocket, all meteorological and specific soundings of the atmosphere had been made by (a) the small "pilot" sounding balloon, (b) the small radio-sounding balloon, (c) the manned balloon, and (d) the aeroplane. Each of these methods serves a distinct purpose. The first mentioned is simply a free balloon, which is sent aloft and its course followed by a ground observer using a theodolite. In this way the direction and strength of wind can be estimated; and there are also other purposes which these small balloons serve. An instrument called an "anathermoscope," for instance, can be carried, which is used for anticipating fog conditions. It consists of a delicate thermostat attached beneath the balloon, and when an abnormally warm layer of air is encountered at a certain height—the condition which normally precedes fog formation—the contacts close, and either effect the release of a paper parachute or light a signal lamp. The ground observers, with the aid of the theodolite, are then able to determine the height of the warm air layer, and also to calculate the time at which fog will begin to form.

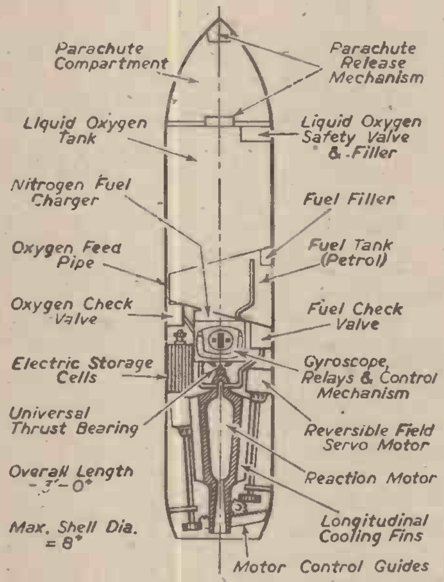


Fig. 52.—Diagram showing layout of the M.A.A. experimental sounding rocket (1941).

The radio-sounding balloon is, of course, more elaborate, and it is generally employed for high-altitude sounding. The instruments carried measure air pressure, temperature and humidity, and each are linked to a midget radio-transmitter, which emits continuous signals. These are picked up and recorded at a ground receiving station. The hydrogen-filled balloon, which is normally between 3ft. and 4ft. in diameter, bursts at an altitude of about 35,000ft., the instruments and radio descending by parachute.

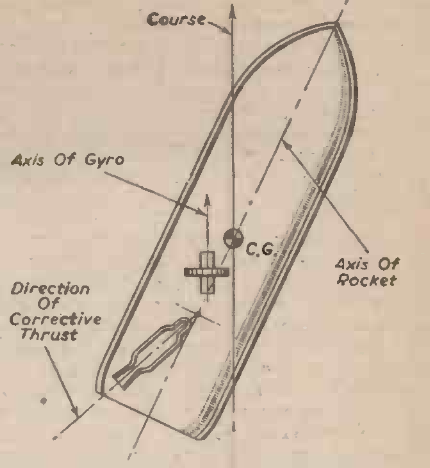


Fig. 53.—Principle of the gyroscopic corrective control adopted in the M.A.A. sounding rocket (Fig. 52).

More specific soundings, of course, require different instruments, and some balloons are used which carry aloft light glass containers which return with samples of air taken from the stratosphere. Since certain of these balloons are capable of reaching heights of 20 miles and more, their importance is very great indeed.

Manned Balloons

The manned balloons, as employed by Professor Piccard and Capt. Orville Anderson, although not capable of altitudes as great as the free-sounding balloon, are, too, very valuable, particularly since the varying conditions through which they travel can actually be *experienced*. The apparatus they are able to carry is, of course, heavier and more varied, and the fresh knowledge that is gleaned from these flights invariably has an immediate bearing on many fields of science. The study of the radio-reflective, Heaviside and Appleton Layers, and the effects of natural electronic emissions is, for instance, of immense value in radio technique; but this is only one example of how the results of high altitude sounding can be applied in the practical sense.

Finally, there is the aeroplane, and it is this method that is employed for most routine soundings of the lower atmosphere for the purpose of computing the day-by-day weather forecasts. For several years past Gloster "Gauntlet" meteorological aircraft have been used for this purpose. A recording instrument, termed the "psychrometer," is attached to one of the inter-plane struts, and this, too, automatically registers the pressure, temperature and humidity.

Although the rocket should ultimately prove of great use as a meteorological instrument, its principal work will undoubtedly be in the sounding of extreme altitudes where the atmospheric pressure is too low for the balloon to penetrate.

The greatest height reached previous to the rocket was by a small sounding balloon released by Russian experimenters, which carried its instruments to a height of 25 miles. This may not be strictly true, however, as calculations show that the shells from "Big Bertha" may have reached as high as 34 miles.

The rocket will enable soundings to the limits of the atmosphere and into space itself. In this connection, the adaptation of the V2 projectile as a sounding rocket has already been suggested, and it will be remembered that the calculations for the modified version gave a maximum altitude attainable of 500 miles. Since the practical extent of the atmosphere is in the region of 200 miles, it is clear that in this development we have a means of sounding adequate for all scientific purposes.

From the experience gained in the development, handling and performance of the V2, the design and construction of sounding rockets of high reliability are certain, and, of course, these could be fitted with radio-transmitting gear in much the same way as the radio-sounding balloon. The example given of converting the V-shell for this purpose is primarily intended as evidence of what can be accomplished with a mechanism that has been proved and is available to-day. There is obviously much scope for the specific development of sounding rockets, and no doubt these will range from light meteorological types to the larger models which will ultimately be used to probe the fringe of atmosphere in search for proofs of the many controversial theories that exist, principally about the cosmic ray and other electronic phenomena. Whether or not the remaining V-rockets that are available will be converted for these latter purposes is yet to be seen. There seems no reason why they shouldn't be so employed. The cost of conversion and fuelling would indeed be cheap exchange for the invaluable data they would provide.

A brief account of sounding rocket developments in the U.S.A. has already been given (*Practical Mechanics*, June, 1945, pp. 315-6), and apart from the investigations of the American Rocket Society and Professor Goddard there is little evidence of any other pre-war research.

In Britain, too, work in this direction has been slow, and, again, it is the rocket societies that have provided the most detailed account. The initial investigations of sounding rockets are due to the Manchester Astronautical Association, whose work in this connection was started in January, 1941.

The investigation began with a mathematical survey in which the characteristics and performance of a hypothetical sounding rocket were calculated. This occupied the association for several months, and from the experience gained the design of an actual rocket was next attempted.

M.A.A. Sounding Rocket Developments

The first scheme produced was for an oxy-petrol rocket stabilised by axial rotation (Fig. 51), and from the diagram it will be seen that the design provides for nose-drive, the propellent feed being arranged in similar manner to that adopted in the M.A.A. centrifugal injector.

A parachute is provided at the nose, and a gyroscope supported immediately beneath for the purpose of maintaining stability. The motor assembly, below, comprises four concentric feed combustion units equally disposed around the circumference and axially inclined to impart the required spin. The petrol and oxygen are fed from their tanks through tubular shafts which extend from the feed unit. It will be observed that the oxygen line is fitted within the petrol shaft, the petrol being fed around it.

The performance calculations show that it would be necessary for the rocket to be 8ft. in length, and the maximum shell diameter 3ft. 9in. As this appeared unreasonable for the height that the rocket could be expected to reach—the performance estimation gave a figure approaching 40,000ft.—the entire design was scrapped and work commenced on another rocket.

The second scheme (Fig. 52) differs in several respects from the original. Its chief difference is that stability is not effected by spinning, but through the offsetting of a

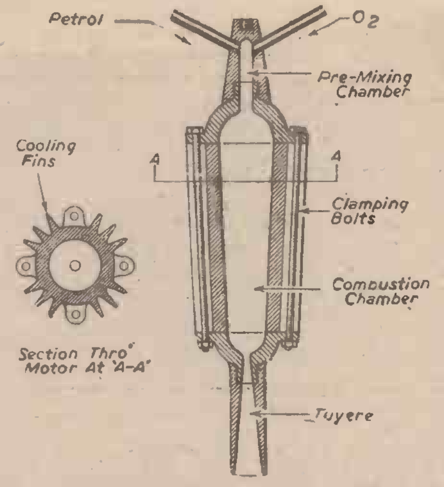


Fig. 54.—Rocket motor No. 4—developed to power the M.A.A. sounding rocket, as shown in Fig. 52.

single rocket motor, which is regulated by gyroscopically controlled electric motors.

The gyro-control is so designed to function immediately the rocket deviates from its true path, and at once alters the direction of thrust to oppose the deviation, thereby returning it to the original path of flight.

To achieve this movement, the motor is pivoted at the "head" on a universal thrust bearing, and at the nozzle end, held in place by a system of slides and ratchets. This ensures easy movement of the motor in any direction around the central pivot to apply thrust at angles ranging to 15 degrees from the normal thrust line. The method of control is apparent from the diagram (Fig. 53), reversible field electric motors being used to actuate the rocket chamber.

No motive power is provided in the rocket for functioning the gyroscope, since the

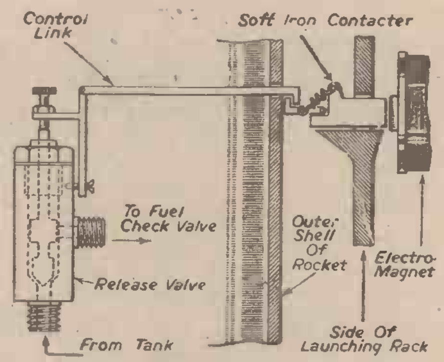


Fig. 55.—Part-sectional diagram of a remotely controlled propellent feed mechanism.

period of powered flight is only a matter of 43 seconds. It is considered, therefore, that a ground motor would suffice to build up the desired rotational velocity, allowing the inertia of the gyro to maintain control during the time of thrust.

The Rocket Motor

The driving motor (Fig. 54) was designed for construction in a light aluminium alloy, being internally sprayed in order to obtain a thin coating of steel as protection against the high combustion temperatures. The chamber is built in five sections: mixing chamber, "head" portion, central portion, "throat" portion, and nozzle. This facilitates replacement should any one of the components "burn-out," or become otherwise damaged during testing. It also enables varying sizes and shapes of chamber section to be tried as well as different nozzles.

The outer sides of the chamber portion are ribbed by longitudinal fins.

Cooling of the motor is arranged by the induction of air from inlets flush to the skin, and the air is introduced by means of the negative pressure caused by the rush of the exhaust gases, thus effecting a swift cooling flow past the reaction motor.

The liquid oxygen and petrol are contained in duraluminium pressure tanks, and these are designed to allow, as far as possible, unrestricted flow to the motor.

The feeding of the liquid oxygen is a simple matter, because of its low temperature of liquefaction and the ease with which it vaporises. The method is the same as that employed in the early German experiments. The "Mirak" rockets, it will be recalled, relied upon the self-feed characteristic of liquid oxygen, as did also many other types developed by the Verin fur Raumschiffart. The only difficulties then were: (a) the liability of the tanks to explode under the considerable pressures developed, and (b) the inconsistency of the feeding pressure. In the M.A.A. design these problems are overcome to a large extent by the provision of high pressure tanks, and the use of check valves in the feed lines to stabilise the rate of flow to the rocket motor. An emergency relief valve is fitted to the oxygen tank, but it is not anticipated that pressure would be developed to the critical point within the period from fuelling to flight.

The fuel is introduced in a similar manner through the pressure of an inert gas (nitrogen) acting directly on to its surface.

A parachute is housed in the nose of the rocket, and this is released by the action of a mechanism adjusted to function when the air pressure inside the lower shell is built up to a predetermined figure as the rocket falls back to the ground. Its descent would naturally be tail-first, because when the tanks are empty the weight is largely disposed at the rear. Should, however, the rocket descend nose first, due to accident, a small clockwork "timer" is also fitted to ensure that the return is made without damage.

General particulars of the design and the calculated performance figures are as follows: The total weight of the rocket is 50.0lb., of which 22.5lb. comprises fuel and 27.5 "payload." Its overall length is 35.0in., and the maximum shell diameter 8.0in.

The jet flow is estimated at 0.464lb./sec., and the jet reaction 53.280lb. Other items of interest are the reaction chamber pressure, 700lb./sq. in.; fuel tank pressure, 1,050lb./sq. in; jet velocity, 5,000ft./sec.; time of power, 43 sec., and the total height attainable 47,000ft. within 78 seconds.

Launching Procedure

As has already been mentioned, the controlling gyro must be run up to its designed rotational speed just prior to launching, and this is arranged through a flexible drive, the auxiliary motor being held at the side of the rocket. This is, however, but one of the operations which must be attended to in readiness for firing. Previously the fuel and oxygen tanks must be filled. The feed control valves must, of course, be closed during this time, but opened again just prior to ignition. The method adopted by the M.A.A. is shown in Fig. 55.

Finally, a last-minute check must be made to ensure that each of the three tanks—propellent and feed—are fully charged, and that the pressure in the oxygen tank has been developed to the degree required for self-feeding. The parachute release gear must not be overlooked, and only when all these checks have been made is the rocket ready for firing.

A motor to the design illustrated, but built entirely of steel, has been prepared for test, and it is proposed to make this the feature of a series of experiments soon to be carried out. It will not, of course, be possible to use liquid oxygen, as this would cause an infringement of the Explosives Act, and it is likely that compressed air will be employed instead.

Although it is not anticipated that the complete sounding rocket will be constructed, it is hoped that a further design, incorporating several of the characteristics of this model, will soon be ready as the result of a new investigation now proceeding under the auspices of the Combined British Astronautical Societies. The existing design was intended merely as a practical example on which could be based the development of larger and more useful sounding rockets. The dimensions of the preliminary model have been maintained at the lowest practicable limit, and in considerations of size it will be appreciated that its performance is highly credible.

IT is with regret that we record the death of Professor Robert Hutchins Goddard, who passed away recently in a U.S. hospital as the result of a throat operation.

As readers of this journal will already be aware, Goddard was the pioneer of modern rocket development. It was he who first conceived the "constant-volume" rocket system, which he successfully demonstrated in the world's first firing of a liquid-fuelled rocket at Auburn, Mass., on March 16th, 1926.

Many equally significant researches are due to him, both in previous and subsequent experiments. Readers will recall, for instance, the unique successively loading powder motor, which was one of Goddard's earliest achievements.

When war came to America, Goddard turned his capable hands to the military rocket, his work resulting in several of the highly-effective rocket weapons which contributed so large a part toward the eventual overthrow of the Axis.

Inventions of Interest

By "Dynamo"

Potato Peeler

AN inventor has been devoting his attention to an improved way of peeling potatoes. He points out that there has been a method of skinning this useful vegetable by subjecting it to a sudden blast of heat of an intensity sufficient to cause collection of free moisture or vapour beneath the skin. Disintegration and removal of the skin is then effected by a cooling treatment by means of jets of cold water or air or by mechanical friction, or both of these operations.

In prior proposals heat treatment has been carried out by using a current of hot air or gas derived from an oil or similar burner at a high temperature. This action produces the separation of the skin from the pulp, but it also dehydrates and coagulates the layer beneath the skin.

The aim of the new method is to retain the whole of the pulp in a completely raw state. This system is distinguished from its predecessors by heat treatment in a closed vessel with steam at only a moderate temperature. This lasts only a short period, sufficient to swell the tissues of the skin, but insufficient to cook any part of the pulp.

The potatoes are then suddenly cooled by means of a fluid at a low temperature. This causes contraction and disintegration of the skin and thus simplifies its removal by mechanical friction.

Adjustable Golf Club

AN application for a patent relating to golf clubs has been accepted by the British Patent Office. The inventor asserts that there have been several proposals concerning a universal golf club in which the angle of the striking face of the head may be adjusted infinitely or into one of a predetermined number of possible positions. Thus the player is enabled to strike his ball to various distances without having to carry a quantity of different clubs.

He affirms that previous ideas have not been entirely satisfactory. This was due to the difficulty of adjusting the head of the club, its unorthodox appearance and its inability to endure continuous use.

The inventor has aimed to devise a golf club head in which the angle of the striking face may be varied between predetermined limits and yet is of normal appearance.

The head is rotatable in order to vary the angle of the striking face by means of an element slidable on a keyway under the control of the rotatable element. The last-mentioned may be turned round by the hand of the player.

To describe the invention more particularly, an extension or stem is made fast to or integral with the club shaft at a suitable angle. It is provided with a key-way or spline. Along this is slidable an element having an external spiral thread or splines engaging corresponding keys or splines in a bore in the head. In this is a rotatable gear operable externally of the head and engaging cross teeth in the slidable member, so that rotation of the gear moves the slidable member along the spines, and the spiral splines, by engagement with those of the head of the club, cause the head to rotate.

In such an arrangement it is impossible to rotate the head except by manual rotation of the gear.

So robust is the construction that it will last for a very considerable period.

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

Pliable Toast Rack

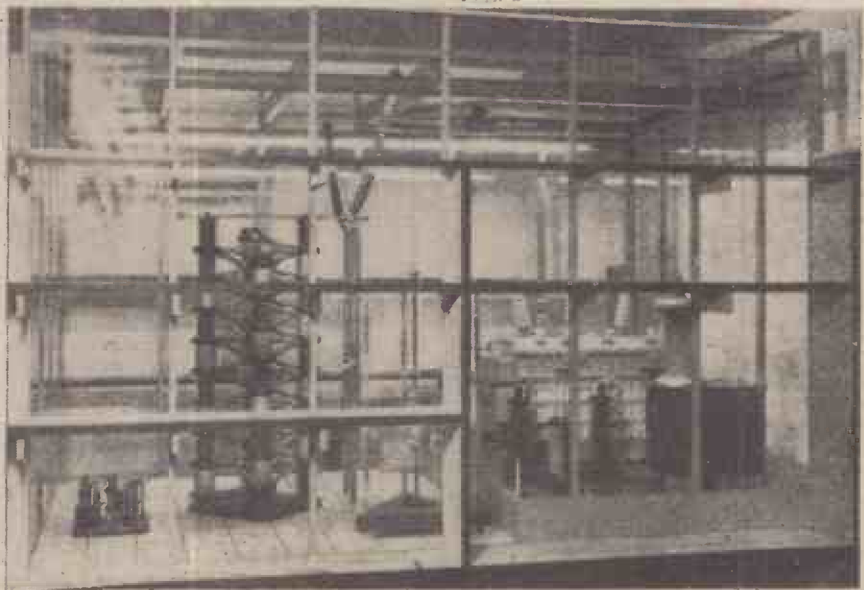
AN accommodating variation of that familiar object of the breakfast table, the toast rack, has made its advent.

As a rule the toast rack is constructed with fixed rigid partitions regularly spaced apart. Consequently, unless the bread is cut uniformly, some slices may be too thick to be fitted between the partitions, whilst others are so thin that they are in danger of falling out while the rack is moved; for example, when the toast is handed to a person at a table.

These disadvantages have been borne in mind by the inventor of this improved toast rack, and he has thought out a rack qualified to accommodate slices of toast of varying thickness which are held firmly when the rack is moved.

A further characteristic is the possibility of the removal of the partitions for the purpose of cleaning the rack. Yet another feature is an arrangement whereby it can be packed flat.

The device includes a base and a number of partitions, each of resilient construction or mounted resiliently on the base, so as to be capable of gripping the pieces of toast placed between the partitions.



A model of the high-voltage laboratory at The English Electric Company's Stafford works, showing a 132kV. grid transformer, and a 132kV. air-blast switch under test. An exhibit at the recent "War Activities" Exhibition.