

USE OF IONISING RADIATIONS FOR FOOD PRESERVATION

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THE search for new and improved methods of extending the storage life of food is a never-ending task for chemists, physicists and food technologists. Ever since it became known that radiation in the form of X-rays could destroy or inhibit the growth of cell tissue, experimental work has been going on in the use of radiation to kill the spoilage organisms in certain foods.

These experiments have met with varying degrees of success and the present position is encouraging, but the end of the road has not yet been reached.

In general, the radiation used is obtained from one or two sources; high speed electrons produced by electrical machines such as the Cockroft-Walton generator or the linear accelerator, or "gamma rays" (which are similar to X-rays) produced by radioactive isotopes.

Use of radiation doses sufficiently large to sterilise meat (that is to kill all the normal spoilage bacteria) often results in unacceptable changes in colour, odour or taste, and so later experimental work has concentrated on giving a much lower "pasteurising" dose which serves to extend the storage life by a factor of three to five without the ill effects of the higher dosage.

NUTRIENT VALUES COMPARED

Chemical tests show that the nutrient value of irradiated food is no less than that of similar food which has been preserved by a heat treatment, and, in fact, volunteers in the U.S.A. have lived on a complete diet of such food for short periods. Animals have been fed on irradiated foods for more than one generation and no effect has been found on longevity or reproduction.

Owing to the high level of radiation at the processing point, strict control of the personnel employed is necessary and the radiation source must be properly screened to prevent the escape of dangerous radiation. It is expected, therefore, that when radiation processing becomes a commercial possibility, food will be taken to large packaging and radiation processing centres rather than being treated in small factory units. There is no danger of residual radioactivity in the food.

Waste radioactive material from nuclear power stations has been used for some food irradiation work, but economically there are serious disadvantages to the use of the material. Although regarded as waste material at the reactor, these fission products are extremely

expensive to transport to the processing centre due to the heavy protective containers required. Another radioactive material, Cobalt 60, is also sometimes used for food irradiation. When these sources are used, the radiation given off continuously in all directions cannot be controlled except by removing the radioactive source from the vicinity of the processing line and placing it in a suitable "safe" place. Further, these sources produce radiation in the form of gamma rays which tends to pass through the product without being fully absorbed, and in order to receive the correct dose an extremely complicated handling system is required which passes the food on multilayer conveyor belts around the source.

Free electrons give the ideal method of irradiation provided that the beam used has sufficient energy to ensure effective dosage of the products from one, or both sides. The present form of food packaging in small units lends itself well to electron irradiation and the electrical machine, which can deliver a controlled, directional beam of electrons through the products, gives a much more efficient utilisation factor than the use of radioactive isotopes.

DIRECT AND INDIRECT ACCELERATORS

Electrical machines fall broadly into two classes—direct accelerators and indirect accelerators. The first type requires a very high electrical potential between an anode and cathode. Thus the energy level from machines of this sort is limited by insulation problems, and energies of three million electron volts in a simple machine represent the upper limit.

For the production of electrons above these energies indirect accelerators must be used. In this type of machine the necessary acceleration is obtained without the use of very high potentials. Where a large output of electrons at a high energy level is required the microwave linear accelerator is ideal. This machine uses radiofrequency waves to accelerate the electrons along a specially constructed waveguide.

Recent developments have produced reliable linear accelerators with a built-in safety system to protect both operator and machine in the event of incorrect operation. The machine can be mounted vertically over the conveyor belt for one-sided irradiation or horizontally with a device to split the electron beam for treatment on both sides of the product.

Further developments in valve technology have produced klystron valves which, when used to power a linear accelerator, will give many kilowatts of electron output at energies of 10 to 25 MeV.

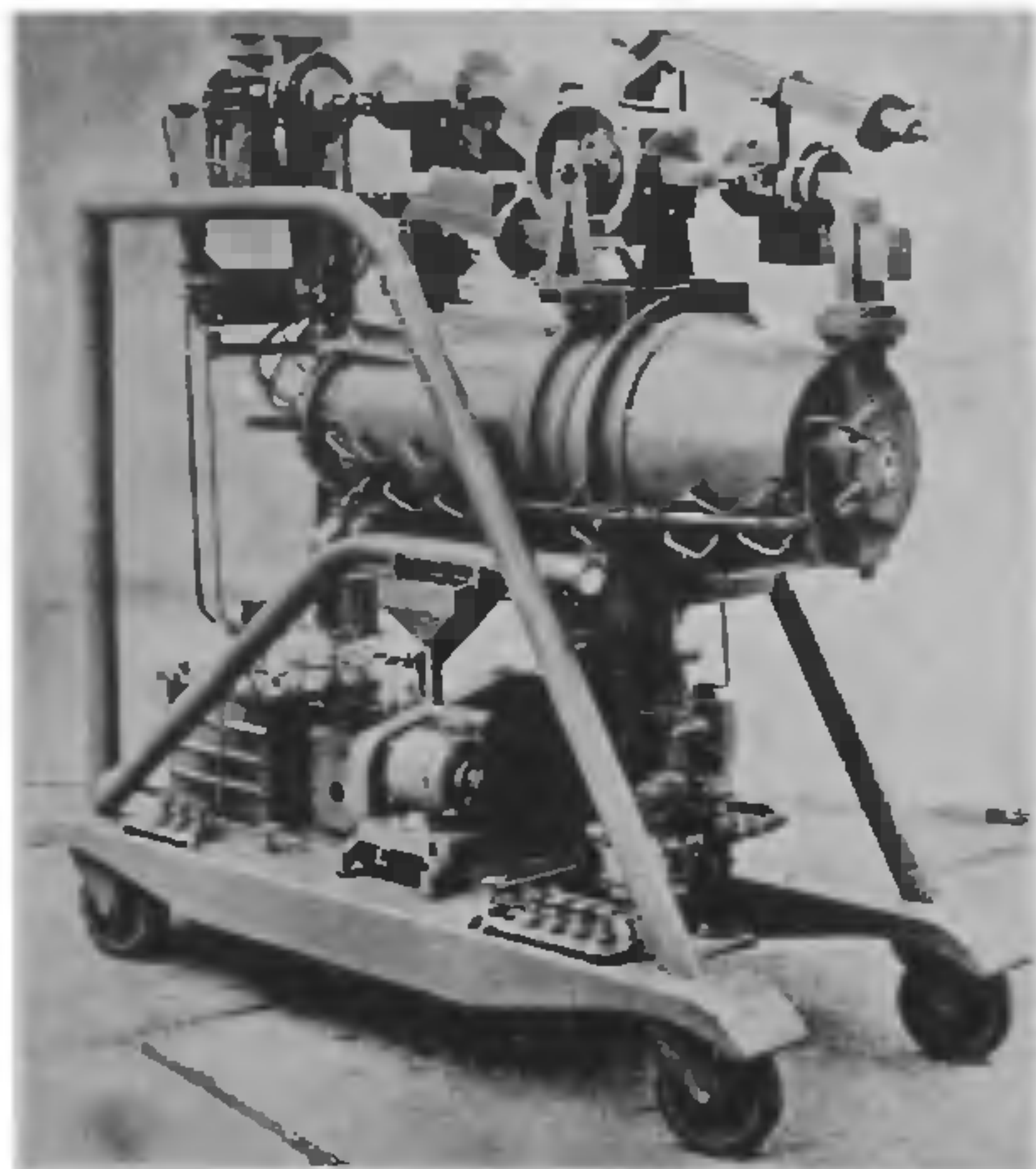


FIG. 1. The Mullard 4.3 MeV Travelling Wave Accelerator.

To assess the output and energy required to treat a given volume of product the following factors have to be assessed:—

1. *Thickness of Product.*—Electron penetration into unit density material is approximately half a centimetre per MeV so that to irradiate from one side a package 10 centimetres thick would require an electron energy in excess of 20 MeV. If the product were irradiated from both sides, an energy of only 12 MeV would be required.

2. *Utilisation Factor.*—This factor deals with the most efficient use of the electron beam. Electrons leave the machine in a narrow beam through a thin metal window, and in order to cover a conveyor belt, need to be scanned over the belt to achieve a uniform dose distribution in the product. A typical utilisation factor for flat packaged food products could be as high as 70% using double sided irradiation.

3. *Dose.*—This represents the amount of radiation necessary to achieve the desired result and is measured using a unit known as the "rad". This is defined as the dose corresponding to the absorption of 100 ergs per gram of irradiated material. In practice, doses used are measured in terms of millions of rads (the megarad) and as an example the pasteurisation of food requires a dose of about 0.1 to 0.5 megarads.

Combining these factors it is possible to calculate the amount of food which can be processed in a given time by any machine.

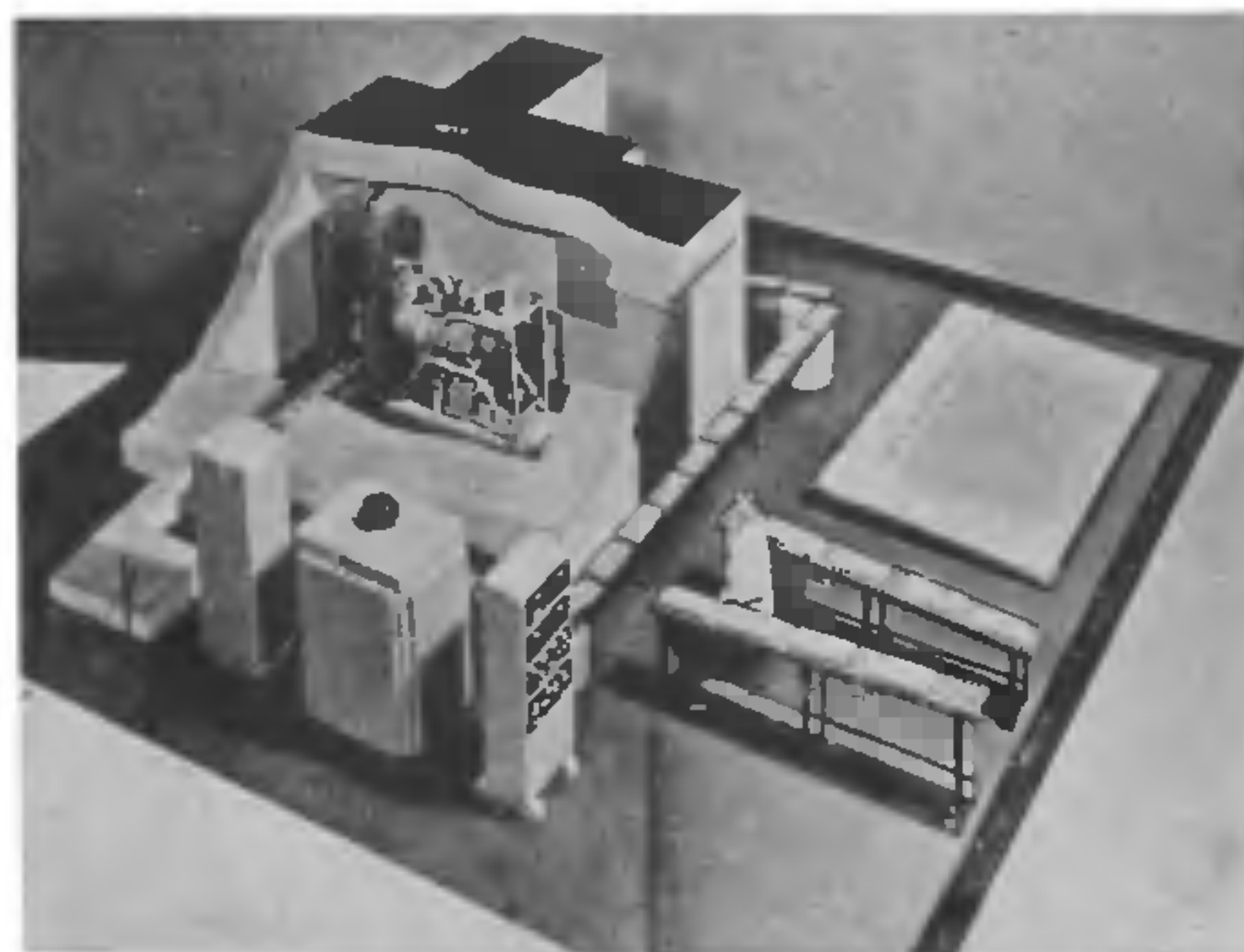


FIG. 2. The Mullard Accelerator being used to irradiate packaged foods.

Scientists working on food irradiation throughout Europe are now co-operating to combine the results of their work. Information is also fully available on the much wider programme in the United States so that the many problems still remaining should be solved more quickly.

FIRST APPLICATIONS OF PROCESS

Three specific uses of radiation in food processing have proved extremely successful* and it is likely that these will be the first commercial applications of the process.

Root vegetables, such as potatoes, deteriorate in storage by the production of sprouts which take nutriment from the tubers and make them useless as food. A small dose of radiation will prevent potatoes from sprouting and the keeping time can be extended up to fifteen months.

Certain foods are liable to contain specific undesirable organisms such as *trichinella spiralis* in pork and *salmonellæ* in frozen or dried egg. Both of these organisms are responsible for serious food poisoning and it has been found that comparatively low doses of radiation can destroy them without damage to the product itself.

Grain is attacked by insects during storage and again it has been found that beetles and grain weevils are destroyed by small doses of radiation, but at present the problem of treating grain in very large quantities has not been solved.

The outlook for radiation processing of food is very promising but much work remains to be done. No irradiated food will be available to the public until an exhaustive series of tests

has proved that the food is safe for general consumption and its nutritive value has not been impaired. Legislation in the U.K. which already protects the public from the use of dangerous preservatives, assures that radiation, which is regarded legally as a preservative, will not be used until all the resources of analytical chemis-

try, biochemistry, pathology and histobiology have approved a long series of tests on such food. When these are satisfied, radiation processing may solve one of the most serious problems of mankind—that of assuring an adequate food supply at all seasons.—(Courtesy: *British Information Service*.)

NATIONAL PHYSICAL LABORATORY (ENGLAND), ANNUAL REPORT FOR 1960*

PIONEERING research in a number of important branches of physics is reported in the National Physical Laboratory's report for 1960. They include work on ultra-high pressures, physics of high polymers, autonomies, and noise measurements and control.

A combination of pressures up to 100,000 atmospheres and high temperatures can cause profound and permanent changes in the properties of certain substances. Using an ultra-high pressure apparatus built at NPL to a modified American design, the Basic Physics Division has carried out studies of the effect of pressure on the resistivity of semiconductors, and produced coesite, a dense form of silica, and some very small artificial diamonds.

Polymers are widely used as plastics, synthetic rubbers and fibres and it is of great practical importance to discover the relationship between the structure of their long chain molecules and their electrical and mechanical properties. Work has continued during the year on measuring the dielectric properties and the low frequency dynamic properties of polymers.

Control of complicated industrial processes, such as the distillation column in an oil refinery, may be optimised by special computers permanently attached to plants and "learning" as the inputs and demands change. The first steps have been taken, with encouraging results, towards the building of an exceptionally fast analogue computer of such a kind. The high speed computer group is working on the development of the planar cryotron as a computing component. This gives promise of higher speeds, greater reliability, and smaller size for computers of the future. The division is also working on the mechanical translation of scientific Russian into English, automatic retrieval in libraries and automatic reading of both printed and hand-written numerals.

Subjective tests on motor vehicle noise are being made in the Applied Physics Division in collaboration with the Ministry of Transport, aimed at designing an instrument which will give a physical measurement of subjectively assessed noise for a wide range of vehicles. With

the help of 1,300 Open Day visitors, an experiment on the unpleasantness of disagreeable noises was carried out last year to find out whether unpleasantness can be used as a criterion of judgment and if there is uniformity of judgment between different people.

Most of the work of the Aerodynamics Division consists of fundamental research in fluid dynamics needed by the aircraft industry. Hypersonic flow now forms a large part of this, and research has also continued on swept-back, slender and delta wings.

A crucial experiment in the Light Division was the attempt to measure light as a "visually weighted" radiation. This is radiation which has been passed through a filter transmitting, at every wavelength, a fraction proportional to the sensitivity of the eye at that wavelength. First results were very encouraging and aroused considerable interest. Further researches in this field may lead to an absolute radiometric method to the measurement of light. A small research group has been formed to study lasers, which are new powerful sources of nearly monochromatic light obtained by stimulating emission in fluorescent crystals. The aim will be to find out what factors control the light output and to build experimental lasers for pulse and continuous operation, which can be used in new applications. The new programme of the re-organized High Temperature Materials Laboratory will include a greater concentration on new materials of very high melting point.

Work in ferrous metallurgy by the Metallurgy Division, using the electron microscope, continues to make progress, and will have many industrial applications. During the year proposals for some new research programmes have arisen. They include a research development programme on high speed digital computers, a proposal for a research reactor, to be sited at Teddington, and one for a Van de Graaff electrostatic generator.

* *Report of the National Physical Laboratory for 1960*, published for D.S.I.R. by H.M.S.O., Price 9 s. 6 d., by post 10 s. 2 d.