have been obtained since February 1953, and monthly summaries of the data are published in the *Journal of Scientific and Industrial Research*. At present, Ahmedabad is one of the three stations in India at which round-the-clock observations of the ionosphere are being made.

Besides the main regions, E, F_1 and F_2, of the ionosphere, two intermediate layers between E and F_1 have been found to be regularly recorded, and these are being studied. A comparative study is also being made of the critical frequencies and heights of F_2 reflexion at different latitudes in India, and also the effect of magnetic storms and solar flares on the F_2 region. In addition, the true heights and thicknesses of the F_1 and F_2 regions, and the total electron content in a vertical column of the atmosphere up to the height of maximum electron density, are being examined. A radio pulse transmitter, aerials and recording receiver have been built for studying winds in the ionosphere on the lines of Mitra's method.

PERMANENT MAGNET ASSOCIATION

CENTRAL RESEARCH LABORATORY

THE research activities of the Permanent Magnet Association were conducted for many years by co-operative investigations carried out in the works laboratories of its members. The technical collaboration so fostered has many advantages and such work still continues; but in 1941 centralized research, more removed from the distractions of production problems, was commenced with the equipment housed temporarily in the Physics Department of the University of Sheffield, by courtesy of the University authorities.

In 1946 it became possible to proceed with the building of the first story of a laboratory in Brown Street, Sheffield. This building, opened in 1946, gave facilities for pilot manufacture and heat treatment of magnet castings. Physical, chemical and metallographic laboratories were included, and also a workshop for apparatus and instrument construction.

The original plans have recently been completed by the addition of a second story, and on November 8 representatives of the technical Press, of local industrial concerns and of scientific establishments were invited to view the laboratories and to see some of the work now in progress. The new story includes a heat-treatment laboratory, a library and conference room and also gives additional office and storage space. These extensions, in conjunction with the re-arrangement of the older laboratories, now give a rationalized lay-out of the various sections.

The laboratory is approved by the Department of Scientific and Industrial Research but is not grant-aided, being supported wholly by the manufacturing firms who are members of the Association. The director is not only responsible for the work of the Central Laboratory, but also keeps in close touch with the research activities in the laboratories of the members, thus promoting the continuation of that technical collaboration which has been found fruitful throughout the history of the Association. In these circumstances it would be invidious to distinguish between the technical progress of the Central Research Laboratory and of the Association as a whole.

The principal activity of the Laboratory lies in the development of new permanent-magnet materials and the improvement of the properties and of the economy of processing of the existing alloys. The high energy ($BH_{max.}$) of modern magnet alloys is only obtainable by the use of large percentages of expensive metals, and so the achievement of maximum properties with minimum consumption of alloy is a constant objective. In 1945 it was possible to introduce 'Alcomax II' with average $BH_{max.}$ 4·5 megagauss-oersted and coercivity 575 oersted. Work on a wide range of additions to the basic alloy led in 1948 to the discovery of the beneficial effects of niobium in small amounts. There followed the introduction of 'Alcomax III' with $BH_{max.}$ 5·0 megagauss-oersted, coercivity 670 oersted, and of 'Alcomax IV' with $BH_{max.}$ 4·5 megagauss-oersted, coercivity 750 oersted. Shortly afterwards it was predicted on theoretical grounds that similar anisotropic alloys with a common crystal axis instead of random orientation should have markedly improved properties. Considerable experimental work led in 1952 to laboratory production of 'Columax', with remanence 13,000–14,000 gauss, $BH_{max.}$ more than 8·5 megagauss-oersted, and coercivity 750–850 oersted. The production of the structure necessary for such properties requires that the solidification of the alloy should take place progressively from one face of the casting. A mould which is chilled on one face and heated on other faces to temperatures approaching the solidus temperature of the alloy is necessary. The study of the thermal conditions for a completely columnar structure and of practical means of obtaining columnar castings is an important part of the current work. The maximum properties obtained in the laboratory cannot yet be realized in quantity production, although marked improvement on random crystal material is possible.

The metallography of 'Alcomax' alloys is not fully understood, but the diagnosis of faults in composition or heat treatment by microscopic observation of the incipient development of two-phase structures has been of practical utility. Some remarkable macroscopic structures can be seen by the polishing and etching of 'Columax' specimens, which demonstrate well the effect of crystal orientation on the reflexion of light from an etched surface.

High-energy permanent magnets of complex composition have led to secondary problems. Magnets tend to smaller and smaller sizes, and the measurement of the normal *B–H* curve criteria on small pieces has required the development of modified apparatus and methods. New methods of chemical analysis have been necessary for alloys of increasing complexity. Electrolytic separation and the use of absorptiometric and chromatographic techniques have been found necessary. Here also the collaboration with works laboratories has been valuable, and the analytical methods standardized by the Association have been approved and published by the British Standards Institution.

With the support of the Electrical Research Association, investigations are proceeding on the stability of magnetization under extremes of temperature. Very little knowledge existed until recently on the effect of sub-zero temperatures, although there is now a definite practical interest down to −70° C. The nickel–aluminium magnet alloys are very resistant to demagnetization by heating, and so the observation in 'Alcomax' magnets of losses of magnetization to the extent of 1–4 per cent due to

cooling to about $-70°$ C. was surprising. It has been found that the coercivity of 'Alcomax' after normal heat treatment decreases reversibly with decreasing temperature between $0°$ and $-180°$ C., but that this change can be reduced by modifications to the heat treatment. Any stabilization or ageing process which brings the working values of B and H for the magnet within the main hysteresis loop also eliminates the loss due to cooling.

Hysteresis motors are coming into general use as components of gyro and servo systems. The rotors of these motors require a hysteretic material of the permanent magnet type; but the operating conditions are not well defined and there have been few measurements made with non-saturating magnetic fields or of rotating rather than alternating hysteresis. It has become customary to use for these rotors one of the magnet steels, frequently in a metallurgical condition other than fully hardened. A large programme of measurements is in hand to provide a body of design data for this application and to check the optimum magnetic and metallurgical conditions for maximum utilization of material.

Fundamental physical research on high-coercivity materials has always occupied an important place in the work of the Central Research Laboratory of the Association. Measurements of magnetostriction and of anisotropy coefficients on 'Alcomax' alloys and their interpretation in the light of current ferromagnetic theory have been the basis of a series of published papers. This work, in conjunction with work elsewhere by X-ray and electron diffraction techniques and the electron microscope, has led to a better understanding of the origin of the preferred-domain orientation and high coercivity which is the basis of the nickel–aluminium–cobalt–iron alloys used for high-energy permanent magnets.

CHEMISTRY OF MUSCLE CONTRACTION

Contraction of Muscle without Fission of Adenosine Triphosphate or Creatine Phosphate

AS Hill[1] has pointed out, it still remains to be proved that adenosine triphosphate is the immediate source of energy in the contracting muscle. The analytical methods now available for determining the individual phosphate fractions of animal tissues have made it possible to re-examine directly the relation between contraction and breakdown of adenosine triphosphate. Experiments are here reported which suggest that muscle can in fact do work under certain well-defined conditions without the decomposition of an energetically equivalent amount of adenosine triphosphate or creatine phosphate.

The crucial experiments were carried out on a slow muscle, the rectus abdominis of the frog, *Rana temporaria*, at $0°$ C. A slow muscle and a low temperature were chosen in order to reduce the rate of chemical processes. Pairs of muscles from the same animal were used in each experiment. One, left and right alternately, was stimulated while the second served as control. Otherwise both were treated in the same way. The muscles were stimulated either electrically, or by immersion in isotonic 0·765 |per cent potassium chloride solution, or by immersion in 0·5 per cent caffeine–Ringer solution. The work done during contraction was calculated from the kymographic record[2]. After the attainment of contraction, the muscle and the control were quickly placed in liquid nitrogen. No contraction occurred in the controls on freezing as the muscles were thin and cold.

To determine the phosphate fractions, the frozen tissue was ground in a cold mortar and trichloroacetic acid solution was added to the frozen muscle powder. The mixture was allowed to melt at $0°$ C. and centrifuged. Creatine phosphate was determined in the supernatant according to Eggleton and Eggleton[3]. Two more samples were chromatographed on paper by a modification[2] of the methods of Eggleston and Hems[4] and Krebs and Hems[5] for the determination of the following six fractions : (a) creatine phosphate, (b) inorganic phosphate, (c) adenosine triphosphate, (d) adenosine diphosphate, (e) an 'unknown' fraction ('Dritte Fraktion' of Fleckenstein and Janke[6]), and (f) the total acid-soluble organic phosphate minus creatine phosphate. Recovery of added creatine phosphate, adenosine tri- or di-phosphate was quantitative[7]. The fractions $c + d + e$ form about two-thirds of f. The techniques are described in full elsewhere[2,6,8].

In the case of the potassium contracture, no significant change of adenosine tri- or di-phosphate occurred at $0°$ C. or $20°$ C., but the amounts of creatine phosphate decreased (Table 1). These findings are in agreement with the assumption that adenosine triphosphate decomposes but is almost at once regenerated by the transfer of phosphate from creatine phosphate to adenosine diphosphate. They are not in agreement with Bendall's[9] view that the

Table 1. CHANGES IN PHOSPHATE-CONTAINING COMPOUNDS AS A RESULT OF A SINGLE CONTRACTION AT $0°$ C. CAUSED BY IMMERSION FOR 45 SEC. IN 0·765 PER CENT POTASSIUM CHLORIDE SOLUTION

(All phosphorus estimations on each sample were carried out in duplicate and comparisons were made between the left and right side of the rectus abdominis from the same frog (*Rana temporaria*). The mean difference was obtained from the differences between the test and control of each pair of experiments. The muscles were cut off the support and frozen in liquid nitrogen. For further details see ref. 6). The absolute amounts and ratios of the various fractions vary with the time of year, so the controls in Tables 1–4 are not directly comparable with each other

Notes		a Creatine phosphate (μmol./gm.)	$(a + b)$ Creatine phosphate + the inorganic phosphorus (μmol. P/gm.)	Fraction c Adenosine triphosphate (μmol./gm.)	d Adenosine diphosphate (μmol./gm.)	e An unknown fraction ('Dritte', ref. 6) (μmol. P/gm.)	Work done by the muscle (gm. cm./gm.)
8 pairs	Test		18·5	1·80	1·44	2·10	136 ± 8
	Control		18·0	1·85	1·53	2·59	
4 pairs	Test	5·99					81 ± 5
	Control	7·44					
Mean difference		− 1·45	− 0·5	− 0·05	− 0·09	− 0·49	
Standard error of mean difference		± 0·25	± 0·5	± 0·02	± 0·08	± 0·16	