paratively brief report, and does not depreciate the efforts of the various contributors.

As outstanding features in the various reports, the following may be mentioned. Considerable space is devoted to the Bragg method of investigating crystals by means of X-rays, both by Dr. Dawson (general and physical chemistry) and by Mr. T. V. Barker (crystallography and mineralogy). An interesting discussion on phosphorescence is included in Prof. E. C. C. Baly's report (inorganic chemistry). Prof. J. C. Irvine contributes a very readable account of the year's researches on the aliphatic organic compounds, whilst homocyclic compounds are dealt with by Dr. F. L. Pyman, and heterocyclic compounds by Dr. A. W. Stewart. More than half of Prof. F. G. Hopkins's report (physiological chemistry) is devoted to the important subjects of "The Alkaline Reserve of the Body" and "Some Aspects of Nutrition." Dr. E. J. Russell writes on the year's agricultural chemistry in his customary lucid manner and emphasises the value of the present co-operation between farm and laboratory.

E. H.

LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

A Proof that any Transfinite Aggregate can be Well-ordered.

THE following sketch of a proof which seems to me to be not wholly unimportant is given here for certain reasons of priority. I hope that this short account is not unintelligible.

Hartogs's (*Math. Ann.*, lxxvi., 1915, 438–43) considerations may be generalised without difficulty to an investigation of the consequences of the existence of a least ordinal number which is greater than the ordinal types of all possible well-ordered series that can be constructed out of a given aggregate M. This consideration throws no light on whether or not any one of these series actually exhausts M, unless we assume that of two different cardinal numbers one is greater than the other. Instead of using Hartogs's method, I consider all those parts of M which can be well-ordered, well-order them in all possible ways, so that they form what may be called for shortness "chains of M" (so that the same part in different orders gives different "chains"), and imagine as put on one side all chains which are "segments," in Cantor's sense, of other chains of M.

At this point we must introduce a definition: Given a chain (K) of M, let us say that a class K′ of chains of M is a "class of direct continuations of K" if each member of K′ has K as a segment, and also, if L is any member of K′ of type λ, those members of K′ which are of type less than λ are segments of L. Such a class K′ evidently defines one chain and not a class of independent chains, such as Hartogs considers.

Now, in the above process of imagining, we do in fact have a remainder of chains which are not segments of others; for, if not, all chains of M would be segments of other chains of M, and then we could show indirectly that for any such chain K, any ordinal number γ, however great, and any class K′ of direct continuations of K, there is a segment of K′ of type γ. In fact, if there were not such a segment, there would be at least one definite example of each of γ, K, and K′, such that no segment of K′ is of type γ; and thence we can easily show that not every chain of M is a segment of others. But we can prove (*Phil. Mag.* (6), vii., 1904, 61–75) that there is no series which has segments of any ordinal number γ, however great. Thus there is at least one chain of M which is not a segment of some other. It is easy to prove that this chain exhausts M, and that there is a least type of those of chains that exhaust M. Thence, from the fact that the cardinal number of M is an Aleph, we can deduce Hartogs's theorem, determine the form of the limit that Hartogs was really trying to find, and prove Zermelo's (*Math. Ann.*, lix., 1904, 514–16; lxv., 1908, 107–28, 261–81) "principle of selection."

PHILIP E. B. JOURDAIN.

The Bourne, Basingbourne Road, Fleet, Hants, March 12.

Future Supplies of Laboratory Apparatus and Materials.

I HAVE been looking at my list of apparatus and materials which the chemical dealer tells me must wait until the war is over before they can be obtained from Germany. I regret to say the list is a formidable one; I had to add to it this week. Few in our generation will ever knowingly purchase goods made in Germany if they can be obtained from other countries. We feel that German goods must appear to be smeared with the blood of our relatives and countrymen. I take it that my position is much the same as obtains with the heads of other laboratories in the country. Surely, therefore, it is time our British manufacturers realised that it is not much use tinkering with laboratory glass and porcelain ware, if the thousand-and-one other forms of laboratory apparatus have to be purchased in Germany after the war. It seems reasonable to suppose that the orders for laboratory glass and porcelain ware are bound ultimately to accompany the orders for the other requisites.

X. Y. Z.

Long-range Guns.

BY a slip of the pen, double velocity was said, in my article in last week's NATURE (p. 65), to give double range, instead of fourfold.

At that rate, an increase of the velocity of our gun in 1887 would be required from 2400 to 6000 ft. per sec. to make the range grow from 12 miles to 75.

The rule is, of course, not exact except when air resistance is not taken into account. The 12-mile range would have been nearly trebled if it was not for the resistance of the air.

G. GREENHILL.

1 Staple Inn, W.C.1, March 30.

LONG-RANGE GUNS.

THE appearance of a gun with a range of something like seventy or eighty miles has naturally aroused considerable interest, and the question is often asked as to how such long ranges are attained. The answer is that if the shot is to travel far it must get outside the atmosphere, or rather to a height where the density of the air is very small, and that it must be started with such a velocity that in spite of the air resistance in the first part of its course, its remaining speed, after having reached the upper air, shall be sufficient for its further progress.

At the surface of the earth and with ordinary projectile velocities (2000 to 3000 ft. per sec.) the resistance of the air is large compared with the weight of the shot, even for a 12-in. projectile, though, of course, this ratio decreases in the proportion of the area to the volume.

In the absence of air resistance, elementary dynamics show that if a projectile (or particle) is started upwards with an inclination of 45° the ranges would be as follows :—

Initial velocity	Range
1000 ft./sec.	11·6 miles
2000 „	47 „
3000 „	106 „
4000 „	188 „
5000 „	296 „

It is evident, therefore, that, if a gun is to carry seventy or eighty miles, the shot must attain a height where the air resistance is very small, with a remaining velocity of between 2000 and 3000 ft. per sec.

If the temperature of the air at all heights were constant, the air itself would extend to an infinite height, the pressure and density being connected to well-known laws. If, on the other hand, the temperature decreases adiabatically with the height (as is found to be the case, at any rate, up to 40,000 ft. or thereabouts), there is a finite limit of about seventeen miles above which no oxygen or nitrogen could exist. Above this height a projectile would experience no resistance, but even a few miles lower the resistance would be small compared with its weight.

By using graphic methods there is no difficulty in deducing the retardation which the shot undergoes in the earlier part of its flight, though these methods cannot be shown in full in this short article.

I have not computed the requisite initial velocity for a 9-in. shot (such as is said to have been used in the German gun), but it must be of the order of 5000 ft, per sec.

Data for air resistance up to this speed will be found in a paper read by me before the Royal Society on May 28, 1908.

To attain this speed a long bore would probably be more suitable than an extra-strong explosive; at least, this is what I found to be the case in my own experiments.

In the statement given above as to ranges *in vacuo* it has been assumed that the trajectory was parabolic. In reality, of course, it is part of a very long ellipse, the projectile, in fact, behaving as a satellite with an eccentric orbit of which the elements can be readily calculated.

A. MALLOCK.

CLOUD FORMATIONS AS OBSERVED FROM AEROPLANES.

THE recent development of aviation has provided a means of observing clouds which is much superior to any hitherto known. A modern aeroplane can reach the clouds in a very short time, and in many cases get above them. Observations of temperature can easily be obtained, and probably humidity observations would present no great difficulties. The "bumps" experienced also give some information as to the nature of the disturbance causing the formation of the clouds.

It is well known that the two most important processes which cause clouds to form are (1) the mixture of layers of air of high humidity and different potential temperature,[1] (2) adiabatic expansion due to upward movement.

The first process is the cause of most horizontal cloud-sheets, and the latter of the most typical cumulus clouds and also of rain-clouds. Many clouds of cumulus and strato-cumulus character are due to both processes combined.

It has not hitherto been clearly understood precisely how cloud-sheets a few thousand feet above the surface are formed. Observations from aeroplanes show that under these cloud-sheets there is always some vertical disturbance and a lapse-rate of temperature (*i.e.* a rate of decrease of temperature with height) which is little below the adiabatic rate for dry air, while above the clouds the air is undisturbed, and there is a marked rise of temperature for a few hundred or a thousand feet above the clouds. The disturbance within and below the clouds is not violent in the case of a horizontal cloud-sheet, and is of the same nature as the eddy motion discussed by Major Taylor[2] with reference to the fogs off the Newfoundland Banks. The disturbance is transmitted upwards from the earth's surface, and consists of a fairly regular distribution of eddies, which do not last long, the disturbed air soon mixing with the surrounding air. The effect of heating or cooling the air at the surface has been discussed by Major Taylor, but the type of cloud-sheet we are now considering is caused rather by the movement of a body of air over a wide stretch of sea where there is not much change of temperature. In the course of time the air up to the height of a few thousand feet is thoroughly mixed, with the result that the lapse-rate of temperature becomes adiabatic and the relative humidity increases with height; in many cases a cloud-sheet forms at the top of the disturbed layer of a thickness usually less than 1500 ft., often less than 500 ft. As the normal lapse-rate for the atmosphere generally is less than the adiabatic, there is an increase of temperature on passing from the disturbed to the undisturbed layer, which renders slow the further upward penetration of the eddy motion.

[1] Potential temperature is the temperature which a specimen of air would acquire if it were brought down, under adiabatic conditions, from the position it occupied to the earth's surface.

[2] See (1) "Report on the Work carried out by the S.S. *Scotia*, 1913," pp. 48–68 (London, 1914), and, also by Major Taylor, (2) "Eddy Motion in the Atmosphere" (*Phil. Trans.*, A Series, vol. ccxv. (1915), pp. 1–26) and (3) "The Formation of Fog and Mist" (*Quarterly Journal Roy. Met. Soc.* vol. xliii., No. 183, July, 1917).