apparatus, of which a few examples only can be mentioned. The Lecher wires (Prof. Whiddington) will illuminate the conception of wave-length, and apparatus by Dr. Smith-Rose demonstrates the rectifying property on which crystal detectors depend. The determination of absolute frequency by Mr. D. W. Dye's recently perfected oscillograph system is also a feature in this section of the Exhibition. The cathode-ray oscillograph is caused to give a circular trace by means of crossed fields controlled through a valve by a standard tuning-fork, the ray completing the trace once per vibration of the fork. By the superimposition of a supplementary pair of crossed fields at high frequency the circular trace is transformed into a closed series of loops when the frequency is a harmonic of the fork frequency, and can be calculated from that and the number of loops. In this way standardised high frequencies can be obtained. The same apparatus is used to give wave form by transforming the circle into a long ellipse, and adding to the deflecting field which gives the minor diameters a further deflecting field proportional to the high frequency voltage. If the eccentricity of the ellipse be sufficient, the time base is substantially rectilinear and uniform. Direction finding is demonstrated by Dr. Smith-Rose, the currents produced in a rotatable coil by a neighbouring oscillator being read off from a galvanometer. Possibly if a pointer were fixed to the coil with its tip moving over a set of equidistant straight lines forming a scale, the galvanometer reading could be adjusted to give directly the sine of the inclination of the coil to the wave front, as indicated by the tip of the pointer. The General Electric Company illustrates in a striking way the problem of uneven filament-heating. In a diode valve the filament heating current is an A.C. from the source that supplies the anode volts, but the phase of the filament current can be varied. The brightest point on the filament is seen to move along the latter as the phase alters. The longest electromagnetic wave-lengths are represented by some experiments on audio-frequency currents.

Amongst the geophysical apparatus must be mentioned a working installation of the new Milne-Shaw seismograph, which employs an optical lever and Foucault-current damping. This instrument is exceedingly sensitive, giving a magnification of 500, and can even indicate the tilt of a coast due to tidal load. Records of the Japanese earthquake of September 1923 are exhibited.

The biological exhibits include all those which proved most attractive last year together with some additions, amongst which may be mentioned Prof. Groom's cultures of various species of fungus causing dry-rot in timber. Prof. Harris shows an apparatus for measuring the oxygen pressure of fresh blood, the blood and a comparison solution being contained in two quartz bottles which can be exposed to light containing ultra-violet radiation. It is shown that exposure to light promotes the absorption of oxygen and so alters the equilibrium point between the oxygen in the blood sample and that in the air above it. Dr. E. H. J. Schuster shows a respiration pump by means of which a detached organ or a headless trunk can be kept alive for some hours. In connexion with physiological demonstrations it is perhaps well to remind the public that with a few rare exceptions British biologists have been humane men who have recognised the imperative duty of using anaesthetics in experiments on living animals. In the physiological section is also classified an apparatus for measuring the compressional elasticity of films of fatty substances on water. The water surface is swept clean and the film is compressed by means of a measured force applied to a floating strip. The films are found to be monomolecular. The method has been used for estimating very small amounts of fat.

An attractive innovation is a miniature kinematographic projector by Kodak for which a number of scientific films have been obtained, including some high-speed films taken with the Heape and Grylls machine.

The Exhibition as a whole is an admirably conceived attempt to instruct the public as to the methods and aims of science, and is entitled to the support of all who have the interests of scientific prestige at heart. In conducting their unscientific friends through the series of demonstrations provided they will themselves derive no small profit and enjoyment. C. W. H.

Problems of the Rhone Delta.[1]

By R. D. Oldham, F.R.S.

III.

THE eastern branch of the Rhone has undergone changes, as extensive and remarkable as those of the western, though differing in character. In the early centuries of our era the mouth of the river is put, in the maritime itinerary of the Antonines, at 16 Roman miles from the port of Fossæ Marianæ, and from thence it was 30 miles by river to Arles. These distances fix the mouth of the river close by the present termination of the Vieux Rhône, or main channel during the seventeenth century, and this identification is borne out by the finding, in 1883, of an old boundary pillar with a Latin inscription, regarded as fifth or sixth century, which appears to show that it was set up near to the mouth of the Rhone. The place where it was found lies 3 km. west of the old river channel and 2 km. inland from the sea-face of the delta, and, whatever may be the exact age of this inscription, it must date from before the subsidence in the Dark Ages.

This subsidence brought about great changes; a large part of the seaward portion of the delta was submerged, leaving numerous islands of various sizes, the memory of which is partially preserved in local place names, and the mouth of the river proper receded to near, but not up to, the town of Arles.

When light again begins to dawn on the history of this region we find, in the description, by Roger de Hoveden, of the voyage of an English fleet along the coast in 1190, a statement that they passed an island called Odur, at the mouth of the Rhone, going up which river brings one to the fine city of Arles le Blanc. The identification of this Odur is certain; it is known at the present day as the Roque de Dour, or more simply La

[1] Continued from p. 19.

Roque, a low hill of about 25 feet high, rising from the alluvium of the delta, just west of the entrance to the Étang de Galéjon. In the form of Odor or Dor it appears on all the portolan maps, being given equal prominence with other more conspicuous towns, ports or landmarks, and evidently owed this prominence to its importance as marking the entry to the main channel leading to Arles. On a flat, low-lying coast, often indistinguishable in hazy weather, even so small a hill would form an important landmark.

The course of this channel can still be traced; it was up the Étang de Galéjon, and then westwards along the general course of an old river channel, known as the Bras Mort, to the neighbourhood of the village of Passon, on the banks of the Rhone. Along this line there is a strip of low-lying modern alluvium, bordered on both sides by higher ground, part of the old land surface of the Roman period. The Bras Mort was practicable for small boats, at any rate during part of the year, until it was artificially closed in 1642, but long before that it had ceased to be navigable by ships. The channel was, however, still in use at the beginning of the fifteenth century, and is described in a portolan, or book of sailing directions, printed at Venice in 1490, evidently from old manuscripts works of similar character, dating from the early part of the century.

The advance of the mouth of the river and successive closing of alternative channels of access to the town and port of Arles can be traced in the records of that city. From the commencement of the Middle Ages it claimed, and exercised, a control over the navigation of the Rhone, and, for the purpose of this control, maintained an armed and fortified post for the double purpose of levying tolls on the shipping and excluding undesirable, or piratical, intruders. The latter purpose made it desirable that the post should be as distant as possible from Arles itself; the former compelled it to be situated so near that the traffic had to pass it, that is to say, above the highest point where there was an alternative channel to the open sea. The earliest of these fortified posts or towers of which there is record was the Tour de Malusclat; the exact position of this has not been identified, but the name remains as that of a village, and it must have been on the western bank of the river a couple of miles or so above Passon, the place where the old channel from the Galéjon joined what is now the main stream of the Rhone. The date of construction of this tower is not known, but, about the middle of the fifteenth century, the advance of the mouth of the river having reached the neighbourhood of Passon, the channel leading to the Étang de Galéjon, and the Roque de Dour, became blocked by the alluvial deposits of the river, thereby closing what had been the principal channel of access. This made the situation of Tour de Malusclat no longer suitable, and, in 1469, the Council of Arles decided that it should be demolished and a new tower built farther down the channel.

The site of this new tower, afterwards known as the Tour de Belvar or Bolovard, has been identified, in the lands of the Grand Peloux, close to the left bank of the present channel, and nearly opposite where the Bras de Fer channel takes off from the river. It was not, as has been stated in some modern works, built on the actual sea-face of the delta, for maps of the seventeenth century, and records of law suits and grants of land in the thirteenth, show that there was land to the southwards, but the site was chosen because it lay at the junction of two alternative channels of access, and was the site, farthest from the city of Arles, at which the whole traffic of the river could be controlled by a single post. It remained in function for more than a century, during which the principal channel led southwards,

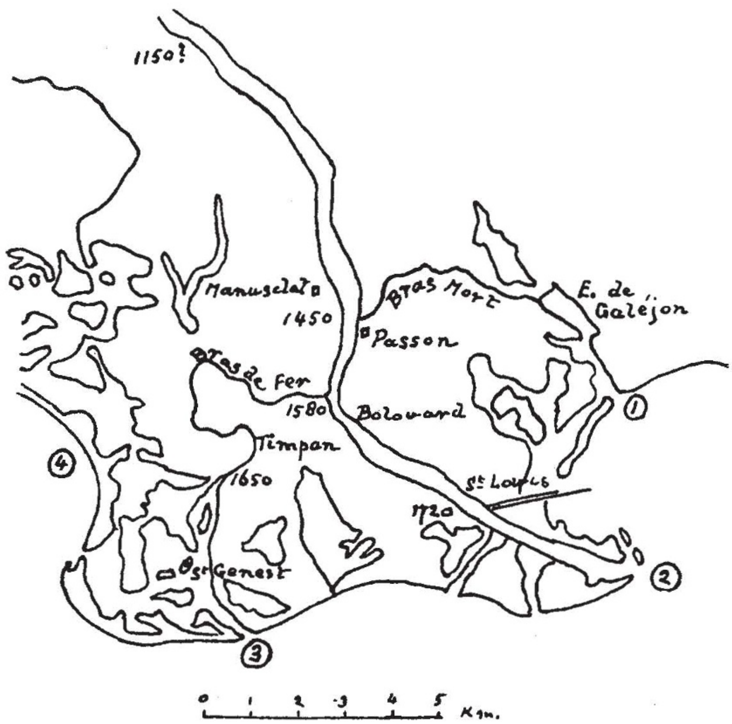

FIG. 4.—Lower course and mouth of the Rhone, showing position of the successive towers, approximate position of the mouth of the river at the dates indicated, and main channels of navigation. (1) Up to about 1450. (2) Until 1585 and again from 1720 to the present day. (3) From about 1585 to 1720. (4) Alternative channel, finally blocked about 1650.

much along the general course of the existing river channel. By 1587 the mouth of the river proper had advanced to this place, and the river, instead of continuing along the direct channel, broke away to the westwards, to follow the general course of the Bras de Fer.

The Tour de Bolovard was thus left stranded and, after a while, sold and demolished, all but the foundations, which still remain. Meanwhile, a new tower had been built, in 1607, known as the Tour de Tampan, on the banks of the Vieux Rhône, and about 8 km. inland from the present coast-line. Here, again, the tower was not built on the sea-face, for old maps show that a group of islands, separated by channels, extended out to very near the existing sea-face of the delta; the site was evidently selected because, in addition to the channel afterwards followed by the river, there was another navigable channel, called the Rajeirol, which led, from a little below the tower, into the Golfe de Beauduc.

In course of time the river mouth passed this channel and blocked it up, so the Tour de Tampan was abandoned and a new one, the Tour de St. Genest, was built, in 1656, on what was evidently an island of the old land surface of Roman times, and not far from the spot where the boundary stone with Latin inscription was discovered in 1883.

This tower, at last, lay close to the sea-face of the delta; the most advanced outpost of the old land was not much more than a mile to the southwards, and, when the river extended past this point, it no longer ended in a sheltered inlet, but in the open sea. The formation of an extension of the delta, by the silt brought down the river, began, and a difficult and dangerous bar developed, the hindrance to navigation becoming more acute as the river mouth was pushed farther out into the open sea. Many schemes and proposals for remedying this were considered, during the latter half of the seventeenth century, but none had been initiated when, in 1711, the river broke away along the line of the old navigable channel, past the site of the Tour de Bolovard, to enter the sea close by the place where, in 1737, the Tour St. Louis was built, close to the sea-face of the land, as it then stood. Since then there has been no further change in the channels farther up-stream, and the whole river is so firmly controlled by protective embankments that none is likely to occur.

From this brief history it appears that the mouth of the Rhone, which was near Passon about the middle of the fifteenth century, had advanced to the present coast-line at the Vieux Rhône by the middle of the seventeenth, and early in the following century was at the coast-line of that time near the modern town of St. Louis. This advance of the mouth of the river does not, however, mean a growth of the delta by a depth of ten kilometres along a breadth of about twenty; this would mean an increase of nearly a square kilometre a year, fully five times the rate of growth of the delta during the last two centuries. It was, however, not from the open sea that the land was reclaimed, but from a number of shallow channels separating islands of old alluvium, thus reducing largely both the area and depth of the new deposits, and in this way the changes, which are known to have taken place, are not merely to be explained by subsidence of the land during the Dark Ages, but in themselves become evidence of the reality of the change of level, independently deduced from evidence of a wholly different character.

(*To be continued.*)

Two New Elements of the Manganese Group.

THE recent discovery of the two missing elements of the manganese group by Dr. Noddack and Fräulein Tacke of Berlin is of interest not only as an important step towards the completion of the periodic table but also on account of the methods used in the research. In these days no one branch of science can afford to stand aloof from the others, and perhaps it would be difficult to find a happier example of the way in which the various sciences can combine towards a successful result than this discovery of the eka-manganeses. Chemistry, physics and mineralogy have all played their parts, and the result is that the number of gaps between hydrogen and uranium in the periodic table has been reduced from five to three.

In the preliminary account of their work which has been published in *Die Naturwissenschaften* for June 26, p. 567, the authors give, in addition to the results of their investigations, the arguments on which their line of attack was based. In the first place, it was necessary to find some material in which the new elements might reasonably be expected to occur. A study of the neighbouring elements suggested two possible sources; the first that of the platinum ores, the second a mineral such as columbite. The platinum ores contain the elements chromium to copper, ruthenium to silver, osmium to gold, or, expressed in atomic numbers, 24 to 29, 44 to 47, and 76 to 79. Columbite, on the other hand, contains, among many other elements, those of atomic number 39 to 42 and 71 to 74. Here, therefore, were two minerals in either of which the missing elements 43 and 75 might well be found.

In endeavouring to form an estimate of the amounts of the elements 43 and 75 which might be present in these minerals, the authors employed an ingenious argument. The constitution of the earth's crust is now fairly well known, and it is possible to assign to the various elements numbers indicating the frequency of their occurrence. A study of these figures indicates that elements of odd atomic number are less common than those of even atomic number; in fact, an odd element is ten or twenty times less abundant than the succeeding even element. As ruthenium (44) and osmium (76) constitute about 2×10^{-12} and 2×10^{-11} of the earth's crust, it was deduced that the elements 43 and 75 would form about 10^{-13} and 10^{-12} of the earth's outer layer. As the frequency of occurrence of platinum is 10^{-9}, the amount of the elements 43 and 75 in the platinum ores should be from 10^{-3} to 10^{-4}, and as niobium, one of the chief constituents of columbite, forms 10^{-7} of the earth's surface, columbite was estimated to contain from 10^{-5} to 10^{-6} of the missing elements. In this way Drs. Noddack and Tacke obtained some idea of the extent to which the chemical processes of extraction would have to be carried if measurable quantities of the new substances were to be obtained.

It was a fairly straightforward matter to predict some of the chemical properties of the new elements from a consideration of their neighbours in the periodic table. Thus it appeared probable that both would form oxides X_2O_7, and that these oxides would readily sublime on account of the small difference of temperature between their melting- and boiling-points. Again, for example, it was argued that the eka-manganeses would resemble chromium in so far as no sulphides would be formed from aqueous solutions. These and other chemical properties were used in the chemical treatment of the ores.

Attention was first directed to the platinum ores as offering the highest chance of success. After preliminary chemical treatment, the residue of 80 gm. of a Russian ore was strongly heated alternately in oxygen and hydrogen. Among the deposits on the walls of the vessel was found a very small quantity of white microscopic needle crystals. These needles became dark in