in Cleveland. During the years 1922 and 1923, many trials were made under various conditions which could be controlled and with many modifications of the arrangements of parts of the apparatus. An arrangement of prisms and mirrors was made so that the source of light could be placed outside the observing room, and a further complication of mirrors was tried for observing the fringes from a stationary telescope. Methods of photographic registration by means of a motion picture camera were tried. Various sources of light were employed, including sunlight and the electric arc. Finally, an arrangement was perfected for making observations with an astronomical telescope having an objective of five inches aperture and a magnification of fifty diameters. The source of light adopted was a large acetylene lamp of the kind commonly used for automobile headlights. An extended series of experiments was made to determine the influence of inequality of temperature and of radiant heat, and various insulating covers were provided for the base of the interferometer and for the light path. These experiments proved that under the conditions of actual observation, the periodic displacement could not possibly be produced by temperature effects. An extended investigation in the laboratory demonstrated that the full-period effect mentioned in the preliminary report on the Mount Wilson observations is a necessary geometrical result of the adjustment of mirrors when fringes of finite width are used, and that the effect vanishes only for fringes of infinite width, as is presumed in the simple theory of the experiment.

In July 1924 the interferometer was taken again to Mount Wilson and mounted on a new site where the temperature conditions were more favourable than those of 1921. The interferometer house was also mounted with a different orientation. Again the observations showed a definite positive effect corresponding to the observations previously made at Mount Wilson. The observations on Mount Wilson were resumed in March 1925, and continued until about the middle of April, during which time 1600 measures of the drift were made. Again many variations in detail of arrangement of parts and in methods of observing were made without in any way altering the result. Throughout the latter epoch of observations the conditions were exceptionally good. The observations of April 1925 give results almost identical with those of April 1921, notwithstanding that the interferometer had been rebuilt and that a different system of illumination and different methods of observation were employed, and that it was mounted on a new site in a house differently oriented.

The interferometer readings being plotted, give directly by harmonic analysis the azimuth and magnitude of the ether-drift. There are no corrections of any kind to be applied to the observed values. In the work so far, every reading of the drift made at Mount Wilson has been included at its full value; no observation has been omitted because it seemed to be poor, and no "weights" have been applied to reduce the influence on the result, since no assumption has been made as to the expected result. It may be added that while the readings are being made, neither the observer nor the recorder can form the slightest idea as to whether any periodicity is present, much less as to the direction or amount of such periodicity.

The ether-drift experiments at Mount Wilson during the last four years, 1921 to 1925, consisting of about 5000 single measures of the drift, lead to the conclusion that there is a positive displacement of the interference fringes, such as would be produced by a relative motion of the earth and the ether at this Observatory, of approximately ten kilometres per second, being about one-third of the orbital velocity of the earth. By comparison with the earlier Cleveland observations, this suggests a partial drag of the ether by the earth, which decreases with altitude. A more extended account of these observations is given in the Proceedings of the National Academy of Sciences for June 1925.

Dr. Ludwik Silberstein, in his letter to Nature of May 23, has pointed out that these results, indicating a partial drag of the ether by the earth, "are easily explicable by means of the Stokes' ether concept, as modified by Planck and Lorentz," as discussed in a paper by Silberstein in the *Philosophical Magazine* for February 1920.

The final test of these observations is whether they lead to a rational and wholly consistent indication of a constant motion of the solar system in space, combined with the orbital motion of the earth and the daily rotation on its axis. There is a specific relation for a given latitude between the observed azimuth of drift and the sidereal time of observation. Observations at different sidereal times should show different azimuths, and all observations at the same sidereal time should show the same azimuth for a given epoch. It is believed that a reconsideration of the Cleveland observations, from this point of view, will show that they are in accordance with this presumption, and will lead to the conclusion that the Michelson-Morley experiment does not and probably never has given a true zero result. A complete calculation of the observations, now in progress, together with further experiments to be made in the immediate future, should give definite indications regarding the absolute motion of the solar system in space.

The Science Exhibition at Wembley.

THE Science Exhibition arranged by a Committee of the Royal Society in the Government Pavilion at Wembley represents a great advance on the similar exhibition held last year, particularly as regards the section devoted to physics. The space available has been considerably extended and the equipment of the demonstration benches is much more adequate. Perhaps the most striking advance, however, is the admirably systematic manner in which it is now possible to present the exhibits, for these have been arranged on an underlying plan which gives unity to the whole and converts a collection of miscellaneous experiments into an orderly sequence of demonstrations, which are not only striking in themselves but also calculated to give visitors a very fair impression of the nature of modern physics and the scope of the problems to which it addresses itself. The key to this part of the exhibition is to be found in an enormous chart, some 24 ft. long, showing the wave-lengths of electromagnetic radiation as a continuous series according to a logarithmic scale, the general nature of the radiation and the methods by which it is detected and generated being shown against each range of wave-lengths. This chart itself, which covers 60 octaves, is of considerable interest, particularly as regards the regions of overlap. For example, it has in recent years become possible to generate and detect radiation the wave-length of which is a few tenths of a millimetre both by thermal and by electromagnetic methods. It is a remarkable fact that it is now possible to use a scale of wave-lengths as a guide to a very representative series of physical experiments: it emphasises the change which has taken place in the orientation of scientific thought since the days when matter was everything and energy had not been defined, for now energy is paramount and matter is mentioned as an afterthought.

Bearing in mind the general scheme indicated by the chart, the visitor is conducted along a series of excellently appointed benches designed to illustrate the properties of the various types of radiation, beginning with the shortest. He is first introduced to the atom, as the source of gamma radiation, and this is represented by some new models in addition to apparatus which will be familiar to physicists. On the ceiling the relative distances of the electrons and nucleus in a neon atom are shown by means of coloured lamps, and further models, for which Prof. W. L. Bragg and Mr. D. R. Hartree are to be responsible, are awaited with interest. Another striking exhibit connected with atomic structure is an apparatus from the Clarendon Laboratory in which a single particle at a time, emitted by polonium, is made to break down the resistance of a small spark gap, the resulting current being made audible by means of amplifiers and a loud speaker. The properties of gamma rays are illustrated by a projection electroscope contributed by Dr. E. A. Owen, the rate of discharge being varied by placing various screens in the path of gamma rays emitted by radium.

Amongst the experiments connected with X-ray apparatus may be noted a very fine demonstration due to Mr. F. D. Edwards of the electric discharge through air at gradually decreasing pressure in a tube 4 ft. 6 in. long. The large scale of the apparatus makes these always beautiful effects very striking, and the rise in resistance of the tube at the highest and lowest pressures is indicated by sparks across a 10-inch alternative gap. A less familiar demonstration is afforded by de la Rive's apparatus, in which a luminous arc passes from an electrode at the top of a discharge tube to a ring electrode at the bottom, the core of an electromagnet being located in the axis of the ring. The arc is seen to rotate in one direction or the other according to the polarity imparted to the electromagnet. Dr. G. W. C. Kaye contributes a soft X-ray apparatus with which visitors can study the transparency of various substances by the aid of a fluorescent screen, and there are exhibits illustrating the application of X-rays to crystal structure. Bridging the gap between X-rays and ordinary ultra-violet light we have the Schumann X-rays, produced by the impact of electrons the velocity of which is measured by some hundred volts, and detected by their photo-electric effect on the insulated electrode of an electrometer. It was in this region that the "death-ray" was alleged to lie.

The ultra-violet range is illustrated by several demonstrations of which the most intriguing is perhaps one due to Sir Herbert Jackson, in which mixed visible and ultra-violet rays from a condensed aluminium spark are focussed by a quartz lens on a screen which fluoresces to ultra-violet rays of wave-length 1850 or 1860 Å.U. The visible rays are found to be focussed at about 2 ft. from the lens and the ultra-violet of the above wave-lengths at about 8 inches, so that by moving the screen it is possible to find two differently coloured focal regions. Mr. Guild contributes a visible spectrum projected by means of a calcite prism. The existence of radiation beyond the visible spectrum is shown by means of a thermopile at one end and a zinc sulphide screen at the other, and the effect of interposing various colour filters is shown by a comparison of the filtered spectrum with a patch of otherwise white light which has passed through the filter. Dr. Curtis shows that on increasing an electric discharge through nitrogen by shunting the break of the induction coil with a condenser, the disruption of the nitrogen molecules changes a band spectrum into a line spectrum, and a similar contrast is obtained by Prof. Fowler by means of a flame arc containing calcium fluoride, the band spectrum due to the fluoride being accompanied by a line spectrum due to the dissociated elements. Prof. Horton and Dr. Ann Davies illustrate the nature of light emission with an apparatus for showing excitation potentials, and there are photoelectric cells in action contributed by the Clarendon Laboratory and Mr. T. H. Harrison. Interference phenomena in the visible range are represented by a Michelson interferometer (Mr. Twyman), Lippmann colour-photographs (Mr. Gamble), diffraction gratings from the National Physical Laboratory (Mr. J. S. Clark), and a demonstration due to Prof. Rankine of the projection of an image of a luminous object by means of a spherical bicycle ball in place of a lens. Each point in the object throws a circular shadow of the ball having a white spot at its centre, and the aggregate of white spots forms the required image. Photographs can be reproduced by this method. Polarisation apparatus is shown by Prof. Cheshire.

For the infra-red region Mr. Twyman has a spectrometer with a rock-salt prism which can be turned by a micrometer screw so as to traverse the spectrum across a thermopile. The spectrum from 5,000 to 100,000 Å.U. can be explored in this way, and a Bunsen burner is shown to emit strongly in the neighbourhood of 44,000 Å.U. A caesium photo-electric cell, which is sensitive to infra-red rays, is contributed by the Clarendon Laboratory, an ebonite screen serving to filter out the visible light. The transition to wireless wave-lengths is afforded by Mr. F. E. Smith's demonstration of the production and heating effects of very short Hertzian waves, and by Sir William Bragg's example of Lindman's apparatus for rotating the plane of polarisation of such waves by means of an arrangement of metal spirals, the action being similar to that of quartz and other crystals which are optically active in the visible region.

The interest of the non-scientific visitor, for whose benefit the Exhibition is primarily intended, will no doubt be specially caught by the display of wireless 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.