accounted for by theoretical considerations Messrs. Shinjo and Watanabe endeavour to show that the constancy of angular momentum results from the hypothesis that the celestial bodies have evolved from primordial swarms of meteorites.

THE DESIGN OF OPTICAL MUNITIONS OF WAR.

IN a paper read before the Optical Society in January last,[1] Lt.-Col. A. C. Williams, the officer until lately in charge of the inspection of optical munitions at Woolwich, described in some detail the tests made by his department when inspecting the various optical instruments submitted by the manufacturers. The precedent thus set is a most useful one. It is common knowledge what an immense number of instruments were made and accepted, but it is not so generally known how stringent were some of the tests. Col. Williams makes no apology for the stringency of these tests, and in stating the conditions of service shows how different Army conditions are from those of civil life. They are indeed severe. "It must be remembered that Service instruments may be sent to any part of the world, and must remain serviceable when used in Arctic snows, Flanders mud, Mesopotamia heat and desert sandstorm, or after travelling in lorries for thousands of miles over bad roads. In some cases they are attached to guns, and have to withstand the shock of firing. It must also be remembered that they are not always used by men accustomed to handling delicate instruments, and that it is only on rare occasions that they can be sent to a workshop for repair." In addition to these considerations, that of weight is always present. As Mr. J. W. French in his interesting contribution to the discussion points out, it is easy to make an instrument to withstand severe shock tests if lightness is not of importance.

Interesting as is the description of the various tests made at Woolwich, the most interesting part of the paper is the glimpse given of the pre-war attitude of the Government Department to the scientific instrument maker.

Col. Williams assumes that the manufacturer by some uncanny instinct "should know what classes of instruments are required, and should submit to the authorities the highest class of designs of such instruments." The designs would then be considered by a committee of experts, who would criticise and decide on the most serviceable.

In the past the complaint of almost every manufacturer of scientific instruments has been the difficulty of learning what instruments were required by the Services and of obtaining detailed information of the particular problem. Secrecy was necessary during the war, but even then it was frequently insisted upon to an unnecessary extent. In times of peace it has the effect of holding back the development of new instruments. It is common knowledge how much Prof Cheshire did to bring together the manufacturer and the officers testing and using the instruments when made. In the future it is essential that the designs of the Service instruments should be jointly considered by a body of experts, manufacturers as well as officers, so that instruments are not built up in the haphazard way they were in days gone by. It is not necessary to trace the evolution of an instrument by its obsolete excrescences or unnecessary parts It is essential, however, that the fundamental parts should be accurate, within certain specified limits, and that the experts should decide on those limits.

The Government must also be prepared to pay liberally for the manufacture of first models. In the future, with the aid of the National Physical Laboratory, the Institute of Technical Optics, the British Optical Manufacturers' Association, and the British Scientific Instrument Research Association, the Government Departments should not find it difficult to obtain good and generous technical assistance.

ROBERT S. WHIPPLE.

[1] "The Design and Inspection of Certain Optical Munitions of War." By Lt.-Col. A. C. Williams, R.A. (Trans. Optical Soc., January, 1919.)

THE OUTLOOK OF METEOROLOGICAL SCIENCE.[1]

AT no period in the sixty-nine years of the society's existence has the president had a wider range of choice for the subject of his address than at the present moment; and certainly never has the richness of choice been more of an embarrassment than on this occasion. The notable and welcome increase in the number of fellows adds to the responsibility of the situation. Whether we look backward over the days of war, or forward to the future and all that it may have in store for those who are interested in the study of weather, there is more than enough to occupy the time which tradition has placed at my disposal.

Looking Backward—The Position before the War—The Investigation of the Upper Air.

Looking backward, we must take account of a promise of remarkable activity in all branches of meteorology. Even if there had been no war, the last five years would have been fruitful years in the development of the science. The progress of aerial navigation, already begun in 1914, promised unexampled opportunities in the comparatively new study of aerography, in addition to those which meteorologists had previously made for themselves.

The Shock of War and the Reaction.

Thus the outbreak of war found the various meteorological agencies actively employed upon their own projects for the world's enlightenment, and its first effect was to paralyse a good deal of their activity. It cut our wireless communications, hampered our telegraphic reports, put shipping out of bounds, claimed our active workers and their possible substitutes for services that wore a uniform, and altered the whole balance of the complicated machinery which had been elaborated for our contribution to the world's stock of knowledge of the atmosphere.

The whirligig of time has brought its revenges. We are no longer allowed to regard the weather as a subject of curious inquiry that can be ignored in time of war. It has been borne in upon us that weather has its influence on the production, preservation, and transport of food; that it has a bearing upon the health of the community; that floods and droughts, sunshine and storm, such trivial circumstances as low clouds and fog, have their effect upon operations of offence and defence; and we have learned in the school of experience that aerial navigation may be attended with danger to others beside the navigators.

The Call for more General Knowledge of Meteorological Methods and Results.

The quickened interest in the study of weather for all purposes has expressed itself in the creation of a number of special establishments for the Naval Air

[1] From an address on "Meteorology: The Society and its Fellows," delivered before the Royal Meteorological Society on January 15 by Sir Napier Shaw, F.R.S., president of the society.

Service, for the Navy itself, for the Army, and for the Royal Air Force.

Throughout the whole course of the war we were constantly reminded that what was standing in the way of an effective use of past experiences of weather in all parts of the world was a lack of general knowledge of the common methods of meteorological study and of the principles deduced by their aid. Until this position is secured, every letter in reply to a simple inquiry must be prefaced with an explanation of what you mean by an isotherm, an isobar, the exposure of an anemometer, and even the difference between the points of the mariner's compass and the geographical orientation, and every popular lecture must begin, and generally has to end, with a recitation of rudimentary ideas.

The Preliminary Training Required for a Professional Career.

Here, perhaps, it is desirable to make it clear that the practice of the science of meteorology includes the process of observing, of the first part; the compilation and summarising, in maps or otherwise, of the facts of weather, of the second part; the application of meteorological principles, which includes the forecasting of future weather, of the third part; and the development of the science of meteorology, of the fourth part. Any one of the first three may be pursued according to recognised canons of procedure with satisfactory results; every one of them is indispensable, and history is my witness that all three of them may be pursued simultaneously without any effective recognition of the fourth part, which forms our only avenue to the comprehension of the secrets of the sequence of weather.

In the present position of meteorological science there are two extremes of opinion: either to think the penetration into the secrets of the subject to be so difficult that we must be content to forgo the attempt and deal with what we have, or to think it so easy that only observations are required and the training of our brains is of no account. Both these extremes ought to be avoided. Brains without observations are certainly of no avail at all; and observations, however numerous and however widely distributed, will not at this stage of meteorological science exonerate us from the use of highly trained intelligence.

If trained intelligence is to be devoted to the important questions which fall within the scope of meteorology, there must be money to pay for it at the rates which prevail in the professions with which meteorology must in practice compete.

The Society: Its Relation to the General Meteorological Organisation.

What, then, is the relation of the society to such a future? If I may venture to define it, I would say that the society, as representing all the many-sided interests of meteorological study, may fairly claim the right and duty of fostering, or even of creating, the atmosphere which is necessary for the successful development which is now required.

One of the urgent questions for the future is a new home for its meetings and for its invaluable library. Its journal has enriched the literature of the science with contributions of many different kinds. That, again, is capable of development with great advantage, and in one respect the need for development is extremely urgent. Meteorology is a co-operative science in the progress of which all nations share. Its literature, all told, is probably larger and more diversified in character than that of other sciences. When we take into account the diversity of language and of form, I suppose that there is no meteorologist who can follow for himself without the aid of many colleagues the progress of the science in different parts of the world; and that makes it all the more necessary for the fellows of the society to come to the assistance of each other by providing an effective survey and summary of the work that is being done.

If meteorology is to be put upon a proper footing to discharge its multifarious duties to the public, due provision must be made for the collection of observations to give a proper survey of the rainfall and other aspects of weather for all public purposes.

The Future Responsibility for the Public Memory.

So far there is very little difference of opinion, but when we take the next step and inquire with whom should rest the duty of supplying the necessary observations, the unanimity may be less marked. We are all agreed that it is a matter of national importance, and the necessary cost should be borne by national funds. Now national funds are of two kinds, some derived from Imperial taxation and others from local taxation. In either case the money comes ultimately out of the same pockets, and to me it appears clear that the proper division of responsibility in this case is that the local authorities should contribute the necessary local observations, while the central authority should provide for the organisation of the observations, the co-ordination of the results, and the distribution of the information. Such an arrangement is at the same time the most economical and the most efficient. If the nation wants to know what the weather has been doing at Magna-Parva, it seems natural that it should apply to the local authority of Magna-Parva for the information, because the events of which a record is required occurred within the jurisdiction of the local authority. That the events should be allowed to pass unrecorded, because somebody has not been sent from somewhere else to record them, approaches the limit of absurdity.

A full weather-station of the Meteorological Office now includes a barograph, a thermograph, and a hygrograph. The instruments are easily procured, and, except in an atmosphere like that of London, they are very durable. But such instruments are scientific only if scrupulous attention is paid to setting, checking, and timing—duties which require even more skill and care than the daily readings of standard instruments. A new survey of the meteorology of the country on the basis of self-recording instruments is not unworthy of your attention. They require for their interpretation the accompaniment of the nephoscope and the camera. And, in passing, let me say that the camera obscura which Capt. Cave introduced at South Farnborough seems to me to have possibilities as an instrument of meteorological observation which are in many ways unrivalled.

Other Opportunities of Co-operation.

But observing and experimenting are only one side of meteorological activity, and dealing with observations that have been made requires quite as much scientific skill and daring as devising and making the original observations. From the recollections of my correspondence at the Meteorological Office, I feel sure that there are a considerable number of people with scientific aspirations in this country who regard the Meteorological Office as a collection of leisured clerks waiting to be moved to do something by the fortunate originators of bright ideas who flourish most outside, but, so to speak, within striking distance of, Government institutions. I do not think I do some of my correspondents injustice if I say that the gist of the correspondence is that if they supply the ideas in the way of the design for an instrument or some

original observations in the crude form the Office can do the rest. I can assure them that I have never known the staff of the Office to be at a standstill for lack of ideas to carry out, and from the freedom of this chair I will be bold enough to say that there are worse services to meteorology than helping to carry out the ideas of the Meteorological Office.

The Fellow as a Centre of Local Influence.

And outside the immediate sphere of the society there is much that is necessary to create an atmosphere favourable for the development of the science. We want people to know that meteorology is not exclusively forecasting. No doubt the view into the unknown future is, as Prof. Schuster said in his address to the British Association in 1915, the lure of scientific research, but the long way that has to be travelled in order to make sure of it rewards us with many side-views of common human interest. The discovery of the separation of the atmosphere into troposphere and stratosphere surely belongs to the great achievements of the human intellect, and the meteorological exploration of the globe is worth reciting. So I picture to myself a meteorologist, even in a part of the kingdom or the Empire so remote that he cannot share the privileges of our monthly meetings, who would be a centre of knowledge of the weather without aspiring to a reputation for foretelling the fortunes of his neighbour's hay or anticipating the prospects of a smooth passage.

RECENT IRON-ORE DEVELOPMENTS IN THE UNITED KINGDOM.[1]

WHILST the basis of the prosperity of a country is admittedly agriculture, its industrial growth is founded on mineral resources, and its participation in the world's markets is chiefly dependent on the extent to which these raw materials can be applied to home manufactures.

It is true that the first historical reference to this country mentions the export of tin from Cornwall, and that Great Britain's production and export of copper in the early part of the nineteenth century were the largest in the world; but for its modern industrial pre-eminence it is indebted to its coal and ironstone.

The cheap manufacture of iron and steel in this country has in the past been greatly aided by the providential dispensation that the ironstone was so closely associated in Nature with the fuel required to smelt it that the factor of transportation was practically eliminated

But the gradual exhaustion of the richer blackbands and clay-ironstones of the Carboniferous formation, and the introduction of the acid Bessemer process of steel manufacture, which requires a pure ore free from phosphorus and sulphur, made it necessary to find other sources of iron-ore supply. For many years the United Kingdom has been dependent for 30 per cent. of the iron-ore used in its blast furnaces on foreign countries. Foreign ore plays even a bigger *rôle* than at first sight appears, since it contains 50 per cent. of iron as against an average of 30 per cent. for home ores. The importation of hæmatite, rich in iron and low in phosphorus, from Spain and the Mediterranean has built up the big iron industries that are engaged in the manufacture of steel by the acid process in South Wales, on the North-West Coast, on the North-East Coast, and in Scotland, where the ports of Cardiff, Port Talbot, Whitehaven, Barrow, Middlesbrough, Newcastle, and the Clyde, situated in close proximity to an ample supply of labour, enable foreign ore and native coal to be easily assembled and cheaply handled.

But it was found to have its drawbacks when the war broke out; and the scarcity of ship-tonnage, which resulted from the activity of the enemy submarines, raised the cost of imported ore from about 20*s*. (at which best Bilbao ore ruled in British ports in 1914) to an actual price of more than 6*l*. per ton, although (under the cloak of Government subsidies) it figured at a lower level. At one period of the war the supply from these sources threatened to be cut off altogether.

To meet this situation an increased development of the Jurassic ironstones of this country was decided on. These ironstones, although abundant and cheaply worked, are what the ironmasters term "lean"—that is to say, they are low in iron, averaging only 28 per cent. of that metal. Moreover, they have a high phosphorus- and sulphur-content, and for the most part are rather siliceous.

The increased production of the domestic phosphoric ores brought about by the war raised many difficult problems. In the first place, it necessitated a different metallurgical treatment. This involved the substitution of basic-lined steel furnaces for those of the acid type, with consequent increased supplies of suitable refractory materials. It also involved large additional supplies of fuel for smelting, and of limestone for fluxing the ore in the blast-furnaces.

Especial difficulties arose with regard to magnesite and magnesite bricks. Prior to the outbreak of the war the magnesite-brick industry was almost wholly in the hands of the Austrians. Possessing in their own country extensive deposits of magnesite peculiarly suited for brick-making, they devoted both skill and money to the perfecting of their products, with the result that before the war they commanded practically the entire custom of the steel trade of this country. To make up for the loss of the Austrian material, arrangements were made by the Ministry of Munitions for the manufacture in this country of magnesite bricks, and the raw material was obtained from Eubœa, in Greece, and from Salem, in Madras.

To furnish the required dolomite and limestone, new quarries were opened up in this country.

With regard to labour a fresh supply had to be found, not only to work the new quarries of ironstone, limestone, dolomite, etc., but also to build the railways required to open them up, to erect extensions to existing plant, to man the new works, to reline furnaces, etc., and this in face of the incessant and urgent calls of the Army to fill the gaps in the fighting line.

Considerable use was made of prisoner labour. The difficulty with prisoners was to induce them to work. On account of the Army regulations, work could be compelled neither by force nor by a reduction of rations The difficulty was overcome by the introduction of piece-rates, but only to a limited extent, as there was no outlet for surplus earnings in the canteens, food supplies having been cut down on account of the general food shortage. On the average, the efficiency of prisoner labour was about 50 per cent. of that of British labour.

The shortage of quarrymen led to active steps being taken in responsible quarters to supplement and to increase the efficiency of the manual labour at the quarries by the provision of mechanical appliances for stripping, breaking, and loading the ironstone.

In these open workings the output per man employed varies with the thickness of the ironstone-bed, the amount of cover to be removed, the use made of mechanical appliances, and the condition of the weather. The weather materially affects the output, especially where hand-labour is concerned. From

[1] Abstract of a lecture delivered at the Royal School of Mines on May 27 by Dr. F. H. Hatch.