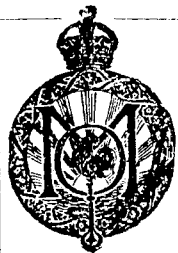


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Conference on Atmospheric Ozone

Oxford: September 9th—11th, 1936

The band of workers on the problems of atmospheric ozone is not large; it was nearly fully represented at last month's Ozone Conference,* attended by about 60 members, and this 60 included a

* The photograph reproduced on the opposite page was taken during the Conference. The names reading from left to right are:—Front row: Prof. V. Conrad, Austria; Mlle. Michel, France; Mme. Gauzit, France; Mme. Vassy, France; Mme. Prettre, France; Mme. Lijot, France; Mme. Chalonge, France; Mme. Cabannes, France; Dr. W. Gorczynski, Poland; Prof. E. van Everdingen, Holland; Mons. Ph. Wehrlé, France; Prof. L. Weickmann, Germany. Second row: Father P. Lejay, China; Mons. D. Chalonge, France; Dr. J. A. Fleming, United States; Prof. R. Ayres, Egypt; Dr. D. F. Martyn, Australia; Prof. S. K. Mitra, India; Prof. B. Gutenberg, United States; Prof. E. V. Appleton, Great Britain; Dr. Hoelper, Germany; Prof. Schmidt, Austria; Prof. J. Cabannes, France; Prof. J. Gauzit, France; Dr. C. L. Godske, Norway. Third row: Dr. Kohn, Great Britain; Dr. W. Morikofer, Switzerland; Dr. A. Ångström, Sweden; Dr. O. R. Wulf, United States; Dr. R. H. Weightman, United States; Dr. F. W. Paul Götz, Switzerland; Mons. Dedeant, France; Dr. C. L. Pekevis, United States; Mr. C. H. Collie, Great Britain; Dr. A. R. Meetham, Great Britain. Fourth row: Dr. G. M. B. Dobson, Great Britain; Dr. J. Bjerknes, Norway; Mons. E. Vassy, France; Mons. B. Lijot, France; Dr. Ratcliffe, Great Britain; Prof. R. Ladenburg, United States; Father L. Dumas, China; Prof. E. Stenz, Poland; Dr. H. D. Harradon, United States; Prof. J. Bartels, Germany; Prof. S. Chapman, Great Britain; Prof. F. A. Paneth, England. Fifth row: Capt. Heck, United States; Prof. M. Hessaby, Persia; Prof. Cario, Germany; Dr. T. W. Wormell, Great Britain; Dr. White, Great Britain; Mons. D. Barbier, France; Mr. F. J. Scrase, Great Britain; Dr. F. J. W. Whipple, Great Britain; Dr. E. H. Gowan, Canada; Mons. M. Prettre, France; Dr. R. Penndorf, Germany.

number of scientists whose interest in the subject is that of the onlooker. Yet 16 countries were represented and there were members from the United States, Canada, Australia, China, Egypt and Persia. It is remarkable too, that so many branches of science are interested in ozone—meteorologists, physicists, chemists, physical chemists, mathematicians (of course), biochemists and astronomers. The papers at this conference were of wide scientific interest and showed that considerable progress has been made since the last similar conference was held in Paris in 1929.

It is not hard to find the attraction of atmospheric ozone. The whole lot of it would form a layer only 2 or 3 mm. thick at N.T.P., and yet it absorbs 5–6 per cent of the total energy of sunlight. If it were not for this absorption, which is chiefly in the ultraviolet, we could never expose our skin to direct daylight; while astronomers, who learn many things from stellar spectra, would have much more work to do. Above the limits of sounding balloons our knowledge of temperatures is partly learned from ozone, and we believe the temperatures themselves depend on the presence of ozone. At these heights the geophysicists know more about the distribution of this comparatively rare gas than of oxygen and nitrogen. Meteorologists, in their turn, in their fundamental problem of explaining the weather, are confronted with the ozone, which far into the stratosphere behaves differently with different surface conditions of weather.

Methods of Measurement.—A few years ago the process of measuring upper atmospheric ozone, by using its property of absorbing ultraviolet light from the sun, was extremely tedious and not very accurate. Today it is little more wearisome than reading a barometer. Dobson showed how measurements can be made in a few minutes with a photoelectric spectrophotometer even when the sky is completely overcast, and with a standard error under the worst conditions of less than 3 per cent. Gauzit has developed a simple visual spectroscope which uses the Chappuis absorption bands of ozone in the yellow. Chalonge and others have measured ozone at night with the light of stars and the moon, using the more classical methods of photographic photometry. Chemical methods, which should be very valuable and straightforward for measurements of ozone concentrations near the earth's surface, are still struggling against the handicaps of the very low concentrations which occur in nature. One other technique is being applied to measurement of ultraviolet light intensities—that of the photon counter. At present this method is in its infancy, but it may develop into one of great power.

Demonstrations of Apparatus.—It was hoped to arrange for a demonstration of various pieces of apparatus used by different workers. Unfortunately Customs and other difficulties interfered with this and the only apparatus shown was that of Gauzit for measuring the amount of ozone by visual methods, and the photoelectric instrument shown by Dobson.

Vertical Distribution of Ozone.—In 1929 very little was known of

the whereabouts of high concentrations of ozone in the upper atmosphere. There was some evidence which seemed to show that if atmospheric ozone existed in a fairly thin layer, its height above the surface would be about 50Km. With the help of photoelectric instruments measuring intensities of ultraviolet light from the zenith sky near sunset, the vertical distribution of ozone has now been roughly evaluated. The bulk of it lies between the surface and a height of 40Km., with maximum density between 20 and 30Km. The height of the centre of gravity of ozone, which can be evaluated with much greater accuracy, is 22Km. \pm 1Km. under all kinds of conditions in our part of the world. It should be emphasised that these results were deduced rather indirectly from observations at the earth's surface, but they have been strikingly confirmed by the Regeners, using the far more direct method of a spectroscopic camera attached to a sounding balloon. Discordant results are, however, reported from the recent United States stratosphere flight when similar methods to the Regeners were used. Ozone concentrations from sea level to 3Km. have also been determined in France and Switzerland by chemical and photometric methods.

The problem of the vertical distribution of ozone has been approached theoretically by Chapman, and by Wulf and Deming, but theoreticians are severely handicapped by lack of information about absorption coefficients and constants of reaction. With more information from the laboratory they might go very far. At present they can only say that the results of measurements of the vertical distribution are plausible.

Temperatures of the Upper Air.—At heights which are just out of reach of sounding balloons it is believed that temperatures increase very appreciably. If this is so, then some mechanism must be found whereby heat is taken up by the upper air from the radiation which passes it. Now oxygen molecules are known to absorb ultraviolet light, which splits them up into atoms. Where there are atoms and molecules of oxygen, ozone is formed, and ozone itself strongly absorbs some wave lengths of ultraviolet light in the process of disintegrating into oxygen. The radiant energy absorbed by oxygen and ozone degenerates into heat, and hence an atmosphere containing ozone should be warm. The Oxford conference devoted a full day to discussing this important matter of upper air temperatures.

Whipple showed that to account for the reflection of sound waves a negative lapse rate must exist at heights of about 35Km. This has been known for some time, but a possible new method of investigating upper air temperatures is being developed by Vassy, Barbier and Chalonge. It depends on the results of laboratory experiments which show that the absorption curve of ozone in the ultraviolet has an undulatory form if plotted as absorption against wave length, and that the amplitude of undulation is dependent on the temperature of the ozone. Comparison with absorption curves from upper atmospheric ozone will give the mean temperature of

the ozone traversed. It should be possible to arrange that ultraviolet light is used which undergoes its greatest absorption by ozone at heights above, say, 40Km. so that this new method may be used to measure temperatures at these heights. Appleton and Martyn discussed temperatures likely to be associated with the regions of the ionosphere, and showed evidence of very high temperatures at 250Km. and above. Eropkin suggested that oxygen at a height of 30Km. or more might be in the form of atomic oxygen, and that the abnormal propagation of sound could be explained in this way.

From the theoretical point of view Gowan has recalculated temperature distributions in the light of modern results about the vertical distribution of ozone. His results depend very much on what percentage of water vapour he assumes to be present, and little information is available about this. However, under all reasonable assumptions he arrives at high temperatures such as Whipple, Dobson and Lindemann require. Ladenburg dealt with the absorption of energy by oxygen.

Horizontal Distribution of Ozone, and Weather Conditions.—Chalonge and Tönsberg brought forward results of measurements of ozone in polar regions both in summer and winter. They confirmed the great correlation of ozone with surface weather conditions. Lejay in Shanghai found that ozone was not high in cyclonic weather, as it is in Europe. Using statistical methods, Meetham showed that in Europe ozone was very highly correlated with potential temperature, entropy, and air density at heights of 15–18Km. above the ground. He further showed that although there is undoubtedly high correlation between surface weather conditions and total ozone content, this is not so high as between surface weather conditions and height of tropopause. He put forward the suggestion that the variations of ozone and potential temperature at 18Km. which are found in association with cyclones might be explained by considering the effect of air of the stratosphere sinking into a depression of the tropopause. In considering this qualitatively, however, he was compelled to assume a vertical circulation of the stratospheric air in association with depressions, and geophysicists are dubious about any assumption of vertical circulation in the stratosphere.

General Papers.—Götz gave a résumé of 10 years' measurements of ozone in Switzerland, in consideration of a possible 11 year cycle of variation of ozone. He showed that there might be an 11 year cycle, but there was also a possibility of a real variation in ultraviolet intensities emitted by the sun. Vassy discussed laboratory technique in handling ozone. V. H. Regener described the technique of automatic spectrographic apparatus used by himself and Professor Regener with sounding balloons, and his efforts to obtain solar spectrophotographs in the far ultraviolet. Much interest was aroused by his ultraviolet light filter, which employed a new principle depending on the variation of the refractive index of paraffin with wave length.

Programme of Future Research.—During the conference Dobson reported on the new survey of ozone in north-west Europe which it is hoped to inaugurate. The following are his own words :—

“ The possible aid which ozone observations might give to weather forecasting, makes it very desirable that the subject should be thoroughly explored. Since a suitable instrument for routine observations of ozone is now available, a programme has been drawn up which would require daily observations at some fifteen stations suitably placed in Europe. It is suggested that daily observations should be continued for about two years in the first instance. The programme has received the general approval of the International Meteorological Organization (the Conference of Directors) but it rests with the individual meteorological services to carry out the work. It was suggested that the cost of the instruments should be met by the various countries in which the instruments were used. I have personally been in touch with all the meteorological services concerned, and the countries where observations are most required are willing to co-operate by having observations made if they can be provided with the necessary instruments. The majority are also willing to meet the cost of at least one of the instruments required for use there. Unfortunately the cost of the instruments is high (approximately £400 each), and the money for six instruments is still required in order to make the research a success.

The sort of question which it is hoped will be answered by this research (and can only be answered by such co-operative work) is :—

(1) How does the distribution of ozone round a depression vary with the state of occlusion of the depression ?

(2) How is the distribution related to the speed and direction of movement of the depression ?

If, for instance, it is found that the distribution of ozone is related to the direction of movement of a depression in some definite way, then a knowledge of the ozone distribution must be of great value to the weather forecaster, and while the cost of the investigation is necessarily high, such results would abundantly repay the outlay. At the present time there is some danger that full value of this work may not be obtained owing to lack of money for all the instruments required.”

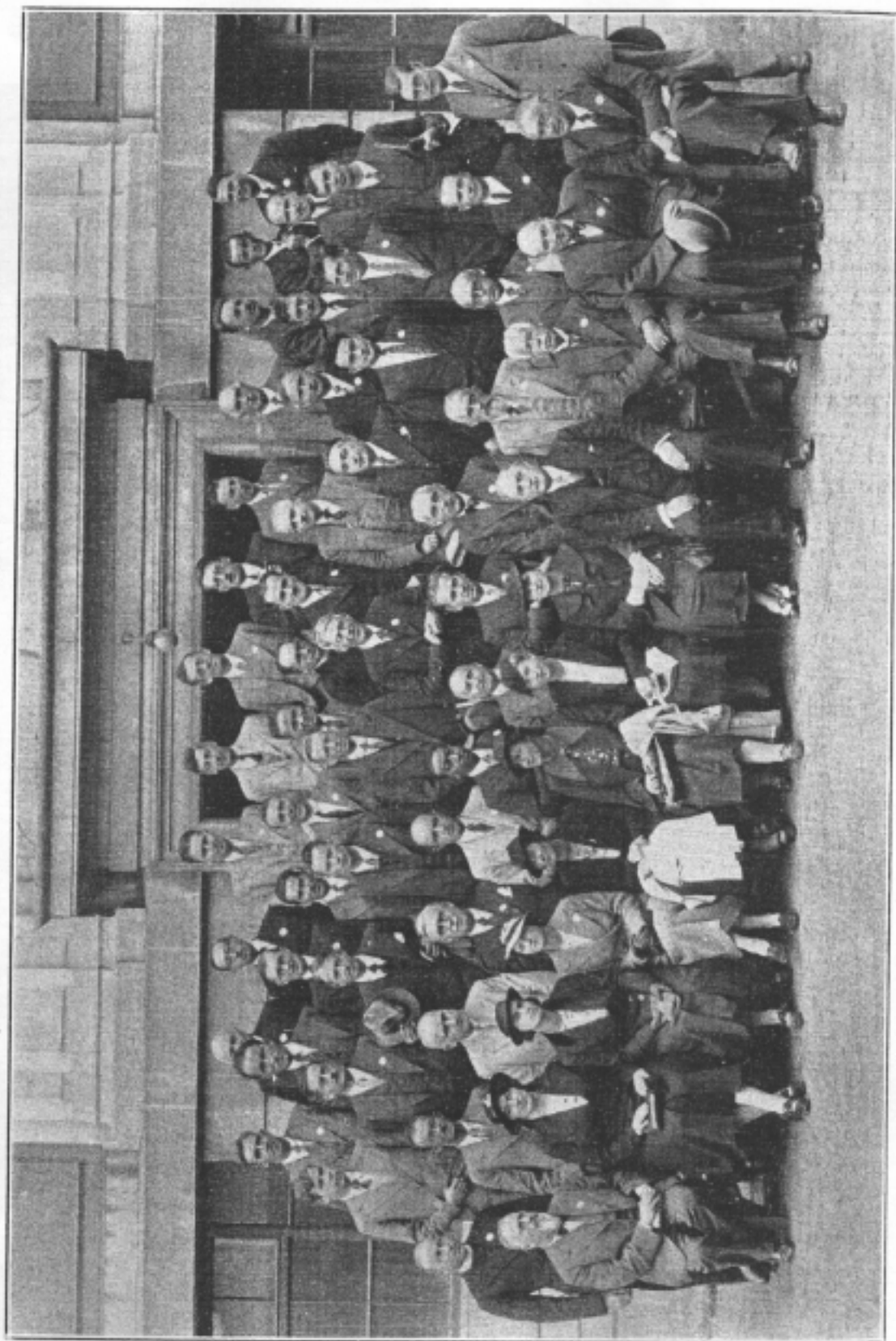
In the subsequent discussion the Conference showed considerable enthusiasm and decided to publish a motion expressing their view that such a survey would give valuable results.

The conference concluded with a vote of thanks to Dr. G. M. B. Dobson, who organised it in such a way that it will have been a great help to all who are engaged in studying the problem of ozone.

Papers and discussions of the conference are to be published by the Royal Meteorological Society as an extra number of the Quarterly Journal.

A. R. MEETHAM.

facing p. 201]



CONFERENCE ON ATMOSPHERIC OZONE, OXFORD, SEPTEMBER 9TH-11TH, 1956