CLOUDS: THEIR CHARACTERISTICS AND FORMATION

AT a 'geophysical discussion' held at the Royal Astronomical Society on February 22, with Sir George Simpson in the chair, the subject was "Clouds".

The discussion was opened by Mr. C. J. P. Cave, who explained that he would illustrate the different types of clouds and then proceeded to show a magnificent series of cloud photographs. Some excellent examples of cirrus were shown, and Mr. Cave directed attention to the frequent occurrence of wisps which were curled upward, and thickened at the end, the direction of the wisps not usually lying along the length of the cloud band. He pointed out that while such formations are frequent in depressions, they may also occur in anticyclones.

He next showed some photographs of cirro-cumulus, in some of which were striking examples of polar bands. Such clouds are to be seen in nearly all parts of the world, and Mr. Cave showed photographs from the British Isles, the West Indies, and elsewhere. There followed some photographs of cumulus, mostly taken in the West Indies, but some examples also from mid-Atlantic and from the British Isles. These photographs generally illustrated the fact that cumulus very frequently tend to occur in long parallel lines, stretching occasionally for hundreds of miles, rather than as single wool-pack clouds with clear spaces between.

A further series of slides illustrated the sharp outline of the head of a rapidly growing cumulus cloud with the development of cirrus at the top and the formation of an anvil. In some of the later photographs of thunder clouds, Mr. Cave directed attention to the formation of stratus ahead of the main mass of cumulus, the stratus showing as a dark line against the bright side of the thunder cloud, and well below the level of the top of the latter. He then showed examples of the mammato-cumulus which occurs frequently at the level of the base of the cumulonimbus. He next went on to show examples of alto-cumulus castellatus, and showed how such clouds frequently led to thunder storms.

Mr. Cave ended his series of illustrations of natural clouds by showing first a photograph of altocumulus in the form of irregular and roughly parallel bands, following this by showing a negative print of a photograph of ripples in the sand at Hayling Island, upside down. He then showed the Hayling Island slide turned up the right way, when it became obvious what was the true nature of this photograph. The resemblance between the altocumulus cloud and the picture of sand ripples at Hayling Island when shown upside down was extremely close, and it would not have been difficult to convince oneself that the second photograph also represented a cloud.

Mr. Cave then showed some vapour trails from aircraft, many of them produced at so great a height that the aircraft producing them were invisible. He directed attention to the fact that optical phenomena such as halos and mock suns could be observed in these vapour trails very frequently, and he concluded by showing a slide of a mock sun surrounded by a 46° halo.

The slides which Mr. Cave showed were very much appreciated by his audience, who were particularly pleased by the demonstration of the resemblance between the altocumulus cloud and the ripple formation on the sandy shore.

Mr. D. R. Barber, of the Kodak Company, then demonstrated a film made at the Kodak Laboratories at Rochester, New York, which showed records of the whole sky from dawn to sunset. The recording unit is in two parts: the first a recording photometer consisting of a photo-cell mounted in an opalescent spherical diffuser, the output from which, after amplification, is used to operate a level recorder; the second a convex hemispherical mirror mounted with its axis vertical, having a small circular mirror slightly inclined a few feet above it. The light reflected by the mirror falls on the lens of a cine-camera mounted below and to one side of the hemispherical reflector. With this equipment, in which the camera is a standard Kodak instrument, single frames can be exposed at intervals varying from one second to one minute. When the film is projected at a normal rate, it is possible to show on the screen the changes in sky covering and the nature of cloud taking place in twelve hours within from half an hour to thirty seconds. The equipment was illustrated in the first reel of the film shown by Mr. Barber, and a number of films showing the cloud movement for whole days during the spring and summer of **1944** were shown, ending with a series of photographs taken by the light of a full moon.

The discussion was continued by Prof. D. Brunt. He said that although Mr. Cave's altocumulus photograph resembles in a very striking way the photograph of ripples formed in sand, it is possible that the mechanisms which produced the two were entirely different. He proceeded to illustrate the types of motion produced in unstable air in a small chamber having a metal base which could be heated electrically from below, and having a glass top, the motion of the air being shown by tobacco smoke. When the difference in temperature between the top and bottom of the chamber had passed a limit, which depended on the depth of the chamber, the motion which set in took the form of polygonal cells with descending motion in the centre and ascending motion at the outer margin. This required that the depth of the chamber should be at least 7 mm. With smaller depth it was impossible to form polygonal cells, and the unstable motion took the form of small circular cells with ascent in the middle. With the glass cover of the chamber sufficiently long to be capable of being moved across the top of the chamber, the air within the chamber undergoes a shear and the type of motion produced depends upon the rate of shear. When the shear is extremely small, the polygonal cells are simply distorted slightly in the down-wind direction. With slightly greater shear, the motion is in a series of long rolls transverse to the direction of motion of the top plate. With high rates of shear, the smoke takes the form of long rolls directed longitudinally down wind. All these forms of motion were illustrated by slides showing the actual motion photographed in the laboratory. Prof. Brunt then showed a photograph of altocumulus (due to Mr. Cave) in which there were two sets of rolls or waves at right angles to each other. He next showed a slide illustrating the occurrence of transverse and longitudinal rolls simultaneously in the chamber used in the laboratory, the condition being that the shear should be near the critical limit between the conditions producing transverse and longitudinal rolls. This slide, as was pointed out in showing it, illustrated the possibility of explaining rather complicated cloud forms as due to a combination of instability and shear. With reference to the formation of a single long roll of cumulus extending a great distance, Prof. Brunt showed a slide in which was depicted the illustration of a cold front with nose elevated above the ground, taken from a paper by the late M. A. Giblett. The ascent of the warm air over the nose of the on-coming wedge of cold air could in certain cases lead to the formation of cumulus at the nose of the wedge, and this explanation of single rolls had in fact been put forward by Mr. Giblett in the paper from which the picture was taken.

Mr. C. S. Durst then described some data which had been prepared by Dr. A. H. Goldie, but who was unable to attend the meeting. It has been shown by Dr. Cwilong at Oxford that in clean air ice crystals will only form when the temperature is between $-35°$ and $-45°$ C. In polluted air ice crystals form at a higher temperature. Dr. Goldie has found that, over Salisbury Plain, cirrus cloud forms in air at temperatures below $-25°$ to $-28°$ C., but over Lerwick similar clouds were not formed until the temperature was below $-32°$ C. It is inferred that the atmosphere over Salisbury Plain, being more polluted than that at Lerwick, accounts for the difference in the conditions in which cirrus clouds form in the two localities.

Mr. A. W. Brewer discussed the question of the formation of vapour trails from aircraft, pointing out that an aircraft engine burns fuel at a very rapid rate, every pound of petrol used yielding about 1·4 lb. of water. The exhaust gases both raise the temperature of air and raise its humidity. Which of the two factors will predominate will depend on the temperature, and Mr. Brewer stated that at ground-level condensation trails will be produced if saturated air below $-23°$ C. is present, while at 20,000 ft. the temperature must be below $-43°$ C. if trails are to form. It is found that in practice the temperature of the air must be about 4° C. lower than those mentioned before trails can form, and Mr. Brewer showed some of the results obtained during flights which confirm this. Persistent trails require a saturated atmosphere, and low temperatures and super-saturation may occur together at the tropopause, thus explaining the frequency of the occurrence of vapour trails at about this level. At a greater height within the stratosphere the humidity falls off rapidly, so an aircraft can avoid making trails by climbing to a high level above the tropopause. Mr. Brewer went on to point out that the persistence of a trail requires super-saturated air. Now super-saturation with respect to water is not found in the atmosphere, though at temperatures below freezing point the air may be super-saturated relative to ice. Thus condensation trails will only persist at temperatures below freezing point.

Prof. G. M. B. Dobson then spoke of the work of Dr. Cwilong and described how this work has shown that at low temperatures, round about $-40°$ C., water vapour condenses directly into ice-crystals without passing through the liquid phase. When air below $-40°$ C. is expanded to about double its original volume, ice crystals can easily be formed, and this is a likely explanation of the formation of cirrus cloud. If water drops are formed at a higher temperature than this, they may persist without freezing down to a temperature as low as $-40°$ C. Thus altocumulus at great heights is not surprising.

Sir George Simpson then directed attention to a paper by Findeisen published shortly before the outbreak of war and dealing with the formation of cumulus. This writer suggested that such clouds grow until their top freezes, giving ice crystals which spread downward until a level is reached where the temperature is 0° C. Sir George pointed out that this would also explain certain measurements of electric fields inside clouds, which he found to descend at about the rate at which he computed the snow would fall.

Mr. D. J. Schove directed attention to the importance of cloud observation as an adjunct to forecasting. He pointed out that when there is a horizontal gradient of temperature in the atmosphere, cumulus clouds take the form of long lines along the isotherms. When there is a horizontal gradient of temperature in the atmosphere, the rate of change of wind with height is a vector directed along the isotherms. The cumulus clouds which form in these circumstances, and to which Mr. Schove directed attention, thus belong to the class of longitudinal rolls mentioned earlier in the discussion.

ECOLOGY OF THE EELWORM CYST

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WHEN cysts of the potato-root eelworm, *Heterodera rostochiensis* Wollenweber, are stimulated with potato-root excretion, larvæ begin to emerge from the cyst after a delay of some days : the number emerging per day increases steadily, reaches a maximum, and then declines, even though fresh root excretion is continually supplied ; finally larvæ no longer emerge. The reduction in the number of larvæ emerging, per day, is connected, to some extent, with the reduction of the number of embryonated eggs as the experiment proceeds, but its cessation is not due to their exhaustion ; cysts from which larvæ no longer emerge still contain large numbers of eggs, and larvæ will again emerge if the cysts are re-stimulated after an interval. This phenomenon is probably of considerable importance to the eelworm ; all the larvæ contained in a cyst will not emerge in a single season, and the attack on the host plants will tend to be damped. The mechanism by which it is brought about, however, has received little attention. Hitherto it has been thought to be due to some difference in the state of development of the eggs inside the cyst ; but as it is shown by cysts which are some years old, and as an interval of a few weeks between the first and subsequent stimulation is sufficient to cause many more larvæ to emerge, this theory is inadequate. Experiments with punctured cysts now show that such a theory is untenable and that the cessation of emergence is due to factors operating within the cyst *as a unit.*

One experiment involved eighteen groups of twenty-five cysts, each treated for other purposes, in a different fashion ; a small hole, however, was made with a needle in five out of each group of twenty-five cysts. All the groups were then stimulated with potato-root excretion in the usual way, using a single cyst technique[1], emerging larvæ being counted until emergence had practically ceased. As the nature of the different treatments is irrelevant from the present point of view, the effect of puncturing, in each group, has been demonstrated by expressing the number of emerging larvæ, per punctured cyst, as a percentage of the emergence per normal cyst ; these results are