WEATHER BALLOON ASCENTS

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Is this effort justified? Whatever may be the scientific interest to scientists themselves, is there good reason to suppose that the information will be useful? It is believed that there is. The economic value of good weather forecasts for aviation, agriculture, industry, and the general public, although difficult to estimate, can contribute a marginal percentage of national income. In recent years new methods in forecasting based on the classical principles of fluid dynamics, requiring heavy calculations with electronic computing machines, have come forward. These methods demand the information provided only by upper air observations, and the issue cannot be sidestepped. Either we progress scientifically or accept the present unsatisfactory position.

But there are problems as yet almost untouched. Variations in weather from year to year occur quite unpredictably and introduce in many directions—in agriculture, in industry, in fuel supplies, and in water measured with nothing more than a stop watch to time the disappearance of the balloon: a simple but highly effective method not yet obsolescent although electronic methods are becoming available.

The second type is the large load-carrying balloon, weighing some 500 grammes, ascending at about 1,000ft. a minute and reaching 50,000ft. regularly. Still larger but manageable balloons will reach about 100,000ft., but this seems at present to be near the practical ceiling for balloon work. The difficulty is to obtain an envelope which is both sufficiently light and sufficiently strong. At 100,000ft. the ambient pressure is only about 1 per cent. of that near the ground, and, if the balloon is to retain its buoyancy, it must expand to about 100 times its surface volume; if it does not expand, the hydrogen is under excess pressure and so is comparatively dense; if it is not strong, it bursts. Non-elastic envelopes, incompletely inflated at launching and arranged to valve gas when full, run into other tion, not in the carrier wave frequency itself, which is measured by a cathode ray oscillograph at the ground.

One further development of major importance must be mentioned; it is one where Britain was first in the field and where we are still ahead of most other countries—the use of radar for wind finding. With a suitable reflector carried by the balloon, radar will permit its position in space to be determined continuously and the wind calculated from the drift. By this means a major problem was solved: to determine the winds in the frequent conditions when the balloon passes through clouds and can no longer be followed visually.

These advances do not exhaust the resources of the electronic experts but merely inspire them to more elaborate devices. At the present time we are in the development stages of producing a completely automatic radar-sonde in this country, automatic both in following the flight of the balloon by radar and in recording at the ground station the upper wind, temperature, pressure, and humidity; whether or not it can be produced sufficiently economically to become a routine equipment for general use remains to be seen.

Space prohibits our discussing these problems of instrumentation and communication in more detail, but it would be wrong to give the impression that there is nothing more to it than there is, say, in producing an ordinary radio set. The precision of measurement required is stringent, every individual

Radar aerials are seen in use at Kew Observatory to follow a radio-sonde balloon of the standard Meteorological Office type.

Preparing to launch a radio-sonde balloon from an ocean weather ship.

resources—an element of gambling which is enormously expensive. These seasonal anomalies are not at all understood because we have established no adequate physical theory of the general circulation of the atmosphere on which to work. Nature has certainly presented a complex problem, but, given the data provided by world studies of the upper air and by other means, the science of physics may be expected to clear up the problem of seasonal weather forecasting one way or the other—not necessarily by providing good predictions, but certainly by showing clearly what standard of prediction is practicable.

Forecasting, for short or long periods, is of course far from being the only practical application of weather knowledge of the upper air, but it has a special feature in that its problems arise fresh from day to day; they are never solved for all time and the requirement for upper air data will be permanent.

With this very incomplete comment on the physical problems of weather and climate we pass on to say something of the techniques of balloon sounding, introduced towards the end of the last century by Teisserenc de Bort in France, and by Assman and by Hergesell in Germany. Pioneer work in this country is associated particularly with W. H. Dines in the early years of the century. The hydrogen-filled rubber balloon of moderate size is a remarkably convenient lifting agent; it is easily handled and readily filled from commercial cylinders, will ascend at a convenient speed, and attain a meteorologically useful height. There is a range of these balloons used for different purposes.

First we have the simple pilot balloon, weighing a few grammes, inflating at ground pressure to a diameter of about two feet, ascending at about 500ft. a minute, carrying no load, and attaining heights of 10,000ft. to 30,000ft. Followed visually by theodolite, it allows the wind speed and direction to be computed by simple trigonometry. Cloud heights, so important for aircraft, can be difficulties and the ceiling remains not far above 100,000ft.

The instrumentation carried is, for normal weather sounding, a barometer, usually an aneroid capsule, a thermometer of the bimetallic strip or resistance type, and a humidity measuring device (hygrometer), usually strands of hair or a strip of gold-beater's skin. In the early days of balloon sounding, autographic records could be obtained only when the instrument was recovered, largely by chance (encouraged with a small reward to the finder) after descending at some place many miles away. Some quite astounding discoveries were made in this way, and it was Teisserenc de Bort who 50 years ago first announced, to a sceptical scientific world, that above a height of some 10 kilometres the temperature of the air no longer decreased with height but remained sensibly constant: the stratosphere had been discovered.

With the advent of radio and the growth of electronics, it became no longer necessary to recover the instrument; the radio-sonde was introduced. This was in the years before the Second World War, the pioneering work being mainly in France, Finland, Russia, Germany, Switzerland, Belgium, and the United States, with Britain lagging a few years behind. A wide variety of systems was introduced, depending on a variety of radio devices but using for the most part basically the same meteorological instruments as had been used in the older meteorographs. The essential thing was to transmit a radio signal characterized by the meteorological readings, and there is no end to the possibilities. In the French system the signal is pulsed by intermittent contacts, and the different quantities, pressure, &c., are indicated by pulse counting. The whole instrument weighs about 2 kilogrammes. In the Swiss system the control is chronometric; the Finnish instrument depends on the variation of the capacity of condensers and the variation in the frequency of the signal (near 25 Mc/s), while in Britain it is the variation in the frequency of modula- sonde must be calibrated before use, and the errors due to solar radiation and lag and to electronic complications must be assessed and removed or allowed for. The variety of types in use complicates the issue and there is still much to be done if world records are to be made consistent.

And finally, what about these much publicized American balloons? These are described in the literature as large plastic (polyethylene) balloons some 70ft. in diameter and 130ft. in length, the so-called "skyhooks," which, inflated with helium (a safety measure), can carry a pay load of 80lb. to a height of 100,000ft. Perhaps there are even larger ones now in use. Naturally such an equipment is prohibitively expensive for regular world-wide use, but as a research tool it opens up new possibilities with more elaborate and heavier instruments and, if desired, more powerful radio transmitters. By arranging the load the balloons may be made to float at a constant level and in this way they have been tracked across the United States and beyond. Recently they have been released over Europe but little is yet published about the results. It is common knowledge that meteorological information from enemy country is valuable in war time and anyone may speculate on possible motives in this research. It is sufficient for the meteorologist to recognize that here we have a method which may provide data about the world's upper atmosphere not obtainable hitherto. Experiments with large constant-height balloons have also been made in this country mainly for studies of cosmic radiation, and extensible latex and neoprene balloons have been successfully floated to drift at 100,000ft. with a load of some seven pounds; 120,000ft. is thought to be possible. The materials are not, however, so far very reliable and premature bursts are common.

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