reviewed by Professor V. E. Suomi (University of Wisconsin). The daily use of nephanalyses obtained from satellite photographs is already taken for granted, and the shape of things to come was presented in the form of hemispheric pressure-level contour charts derived entirely from satellite data.

E. R. Reiter (Colorado State University) presented some new results obtained from the GHOST project, in which balloons floating at approximately constant heights are tracked for periods of the order of months, providing information about the wind fields at various heights. These have already revealed some interesting differences between the northern and the southern hemispheres in the relationship between the Eulerian and Lagrangian spectra of atmospheric motions.

Considering smaller-scale motions, K. A. Browning (Meteorological Office) described the use of Doppler radar to determine the mesoscale structure of frontal systems. He described a particular example of a cold front in which the vertical motions were concentrated within a belt only 2 km wide, with a maximum updraught exceeding 8 m per second.

Meanwhile, considerable progress is being made in the development of numerical models of the atmosphere. Professor J. Smagorinsky (ESSA and Princeton University) reviewed their contribution towards understanding the global circulation, while J. D. Stackpole (US Weather Bureau) described the use of numerical models in operational medium-range forecasting. These two papers illustrated the difference in emphasis between the two aspects of numerical simulation.

In the closing session of the conference, Professor B. Bolin (University of Stockholm) set out the current position with regard to the planning and implementation of GARP (Global Atmospheric Research Programme). The enthusiasm expressed from the floor during the ensuing discussion left no doubt about the optimism that a fuller understanding of the Earth's atmosphere will come from this massive programme of data acquisition and research.

Regarding the conference as a medium of education, it is a pity that more speakers are not aware that progress has been made in this field as well as their own. In particular, the potential of visual aids was not always realized; the film illustrating laboratory models of the atmosphere given by R. Hide (Meteorological Office), the animated pressure charts presented by W. M. Washington (NCAR), and the use of slides to demonstrate the role of the tropics in the general circulation by D. H. Johnson (Meteorological Office) all pointed the way to what can be done.

COMMUNICATIONS SATELLITES

## Direct Broadcast TV

A CALCULATION of the capacity of a synchronous satellite system to provide individual television broadcasts for neighbouring countries has been carried out by A. K. Jefferis and P. C. Gilbert of the British Post Office (*Proc. IEE*, **116**, 1501; 1969). Their chief conclusion is that it should be feasible for synchronous satellites to be operated at a frequency of about 12,000 MHz in such a way as to provide up to four television programmes to each of some thirty countries in the same continent without intolerable interference. The notion is that ground reception would be based on community antennae, and the calculations have been carried out with the design of a direct-broadcasting system for Europe in mind. Jefferis and Gilbert conclude that such a service could be provided by something like eight satellites in neighbouring slots in the geostationary orbit.

It is, of course, acknowledged that the first applications of direct broadcasting of television from satellites are likely to involve the widespread diffusion of a single group of programmes, possibly on several channels. There is, however, a possibility that nations might wish to replace existing ground-based broadcasting systems by devices based on satellites, and this is the problem that Jefferis and Gilbert have tackled.

They assume that there will be something like 500 MHz of bandwidth available for their broadcasting system, and that interference will have to be kept outside a protection ratio of about 40 dB for a community reception system. Much of the argument depends on the ease with which it would be possible to pack together the radiation patterns from individual satellites in such a way that broadcasts on narrowly separated frequencies are not beamed at neighbouring regions. In these circumstances, it seems that the transmitter power needed at the satellite would range from 2·5 W for a beam covering only a circle of 315 km diameter to about 160 watts for a beam covering a region 2,500 km across.

COSMOLOGY

## An Evolving Universe

from a Correspondent

AMONG the many problems confronting astrophysicists who are trying to find a satisfactory theory of quasars, the peculiar nature of their red-shifts is outstanding. An understanding of these may be the key to determining the other properties of quasars. Sufficient quasars have now been discovered for reasonable accuracy to be expected when standard statistical methods are used to investigate the distribution of properties common to all members of the group, and M. J. Rees, writing in the latest issue of *Astrophysical Letters* (**4**, 61; 1969), finds that the initially surprising lack of known quasars with red-shifts above 2·4 may indicate that the gas lying between galaxies was less highly ionized in the distant past. The even more striking implication of this work is that this effect can only arise in an evolving universe with the quasars at cosmological distances, so that two vitally important pieces of knowledge are interlinked.

The argument used by Rees, a member of the Institute of Theoretical Astronomy in Cambridge, depends on the observation that although more than 150 quasars have been discovered, none of these has a red-shift in its spectrum greater than 2·4, and the red-shifts close to 2 seem to be particularly favoured, suggesting at first sight that the density of quasars was greatest during the cosmological epoch corresponding to this red-shift. Even though the more distant quasars will appear fainter, there should still be about ten quasars visible with red-shifts in the range 2·4 to 3·0, unless no quasars existed at such early epochs or some absorption mechanism has reduced the radiation from them below the minimum level detectable now. Rees favours the latter view, and shows that there would