balloon observations, similar calculations are extended to conditions during the summer and in winds. This discussion of the heat balance is of particular value for a large number of meteorological problems.

During the latter part of the expedition, entirely new methods of observing amounts of precipitation and the formation of hoar frost were devised and successfully used; but lack of space forbids further reference to the fascinating results obtained. This short article must be closed by a reference to the last chapter in the work, entitled "The Circulation of the Air". For the first time the new ideas of the Bergen school of meteorologists have been applied to the interior of the polar regions. Depressions with their characteristic 'fronts' are recognised and their motion determined in so far as that is possible without synoptic charts. There appear to be two main permanent 'fronts' in the Arctic on which depressions form in the winter months—one in north-west Siberia, near to the Bering Straits, and the other between Spitsbergen and Norway. During the winter months the pressure distribution over the Arctic is found to be mainly anticyclonic, but the anticyclonic conditions are frequently destroyed by deep cyclones which form on these two fronts and progress eastwards and northwards into the centre of the polar basin. In the summer the general weather situation is of a more cyclonic character, but the actual disturbances are small and weak compared with the deep winter cyclones.

Development of the Modern Broadcast Receiving Valve

THE specification of most modern broadcasting receivers contains an imposing list of titles describing the various thermionic valves employed in the set. The simple terms, 'high-frequency amplifying', 'detector' and 'low-frequency amplifying', are now no longer sufficient to describe the type of valve and its function in a wireless receiver; and one is led to speculate whether those investigators who were responsible for the introduction of the terms 'diode' and 'triode,' about sixteen years ago, envisaged the possibility of the octode as a manufacturing proposition in 1934. In the presence of such attainments, it is useful to review the developments which have led to such a complicated valve. Such a review, with special reference to the technique of the manufacture of receiving valves on a mass-production basis, was made by Mr. S. R. Mullard in his chairman's address to the Wireless Section of the Institution of Electrical Engineers on November 7 last.

The thermionic valve, in both the two- and three-electrode forms, was in existence prior to 1914, and its early development was considerably accelerated by the demands of wireless communication during the War period. After this period, the main receiving valve available in Great Britain was the then well-known *R* type, comprising a cylindrical anode, spiral grid and a co-axial filament of pure tungsten. This valve was available for general purposes as a high- and low-frequency amplifier, a detector or as an oscillation generator. Judged by present-day standards, the valve was very inefficient and, incidentally, rather expensive. Its chief extravagance, as a valve to be used almost universally with batteries, was its filament, the function of which was to produce an electron emission of one or two milliamperes. The main improvements in this direction were the introduction in turn of the thoriated tungsten filament and the oxide-coated filament, which is in use in most modern receiving valves; the more recent development of the mains-operated valve has involved the necessity for electrically insulating the heater from the metal cathode carrying the oxide coating. The use of a heated wire coated with oxides of one or more alkaline earths, such as barium and strontium, is reminiscent of the early work on thermionic emission carried out by Elster and Geitel about fifty years ago.

Having placed the cathode in a fairly satisfactory position as an efficient source of electron emission, the valve designer has had to turn his attention to the provision of more than one grid and one anode in order to meet the requirements in the progress of receiving circuit technique. By means of lantern slides, Mr. Mullard illustrated the constructional development of the valve up to the octode of quite recent production. The desirability of keeping the overall size of the receiving valve approximately constant has necessitated the attainment of considerable precision in the dimensions and spacings of the electrode system, and the valve has therefore become, very largely, a machine-made article.

The purpose of the introduction of the additional electrodes into the triode, and the functions fulfilled by the various types of modern receiving valves, are usefully described by A. L. M. Sowerby in a series of four articles in recent numbers of the *Wireless World* (September 21 and 28, October 12 and November 2). In the first place, the attainable amplification from a three-electrode valve, when used at radio frequencies, is limited by the coupling between the input and output circuits effected through the capacitance between the grid and anode. This difficulty was overcome by the intro-

duction of a screen-grid between these electrodes, and the tetrode is thus available as an efficient high-frequency amplifier. It is also desirable to be able to vary the amplification of a stage without incurring the risk of distortion of the received signals, or of decreasing the effective selectivity. This is conveniently carried out by making the control grid spiral of a non-uniform pitch, so that the amplification depends on the grid bias voltage provided for the valve. Here we have the tetrode with variable mutual conductance between grid and anode circuits (variable-mu tetrode).

The above types of four-electrode valve suffer a limitation in use, which is due to secondary emission effects from the anode. This drawback has been removed by the introduction of a third, or suppressor, grid, which is located between the screen grid and the anode, and is in direct electrical connexion with the cathode. Thus we have arrived at the high-frequency pentode, which may or may not be provided with the variable-mu characteristic. The pentode is also available as an output valve specially designed to deliver audio-frequency power to the loud speaker. This valve is more sensitive and more efficient than the corresponding output triode, but necessitates rather more care in design and operation with a suitable output load.

Wireless receivers of the supersonic-heterodyne type require the provision of a stage in which local oscillations are generated, and of another stage in which these oscillations are suitably combined with the incoming signals to produce oscillations of the beat-frequency for subsequent amplification. The oscillation-mixing process may conveniently be carried out by using a hexode valve provided with two control-grids, one for the incoming signal and one for the local oscillations, and two screen grids to separate them from each other and from the anode. The introduction of a fifth grid will enable the separate triode oscillator valve to be dispensed with, and we thus have the heptode or penta-grid convertor, as a self-contained frequency-changer unit for supersonic-heterodyne reception. If it is desired to be free from the disadvantages of secondary emission, mentioned above, still another suppressor grid is required next to the anode, and we have arrived at the octode. An alternative arrangement of the electrodes in a frequency-changing valve, involving a triode-hexode in one envelope, was referred to in NATURE of October 13, 1934 (p. 577).

The introduction of the variable-mu amplifying valve described above has enabled a system of automatic volume control to be developed, by means of which overloading of the receiver by strong signals from a local station is avoided and also the effects of fading of weaker signals from distant stations are largely counteracted. These results are achieved by making the rectified signal provide the grid bias for the variable-mu valve and so control the amplification of the stage. To obtain the relatively large bias voltages required, it has become necessary to use a diode as detector; further, in order to avoid loss of sensitivity in the receiver as a whole, separate detectors are desirable for the signal rectification and for the automatic volume control. These detectors are provided in the double-diode valve. Such a valve requires a relatively small amount of electron emission, and this may be derived from a portion of the cathode of the triode or tetrode used for audio-frequency amplification of the signals after detection. Thus we have arrived at the double-diode-triode and double-diode-pentode valves used in many commercial receivers of to-day.

The development of these multi-electrode valves has necessitated the use of considerable ingenuity in the design and construction of valve bases and sockets; for, except in certain high-frequency valves in which the connexion to one electrode is led out at the top of the glass envelope, all the electrode connexions are made by pins of the familiar type.

The Deutsche Physikalische Gesellschaft

IN the year 1843, Magnus was professor of natural philosophy at Berlin and created a physical colloquium, or, as the obituary notice in NATURE of June 23, 1870, says, "Graduates and undergraduates assembled round him once a week, to enjoy what he called physical conversations. Here students in turn reported on investigations recently published, the master criticising the report, and opening a discussion on those points which appeared to deserve a fuller explanation". From all accounts, Magnus was an inspiring teacher, and it was under the influence of this colloquium that, two years later, in 1845, six young physicists—Beetz, Brücke, Heintz, Karsten, Knoblauch and Emil du Bois-Reymond—founded a society which had as its object, first the communication of original papers, and secondly the issuing of an annual volume of reports on all publications of a physical nature which should have appeared during the year. The society went by the name of the *Physikalische Gesellschaft zu Berlin*, which in 1899 became the *Deutsche Physikalische Gesellschaft*, to indicate the nation-wide scope which it had attained. This Society is, then, celebrating this year, on January 14, its ninetieth birthday.

Of the names of the original founders, probably