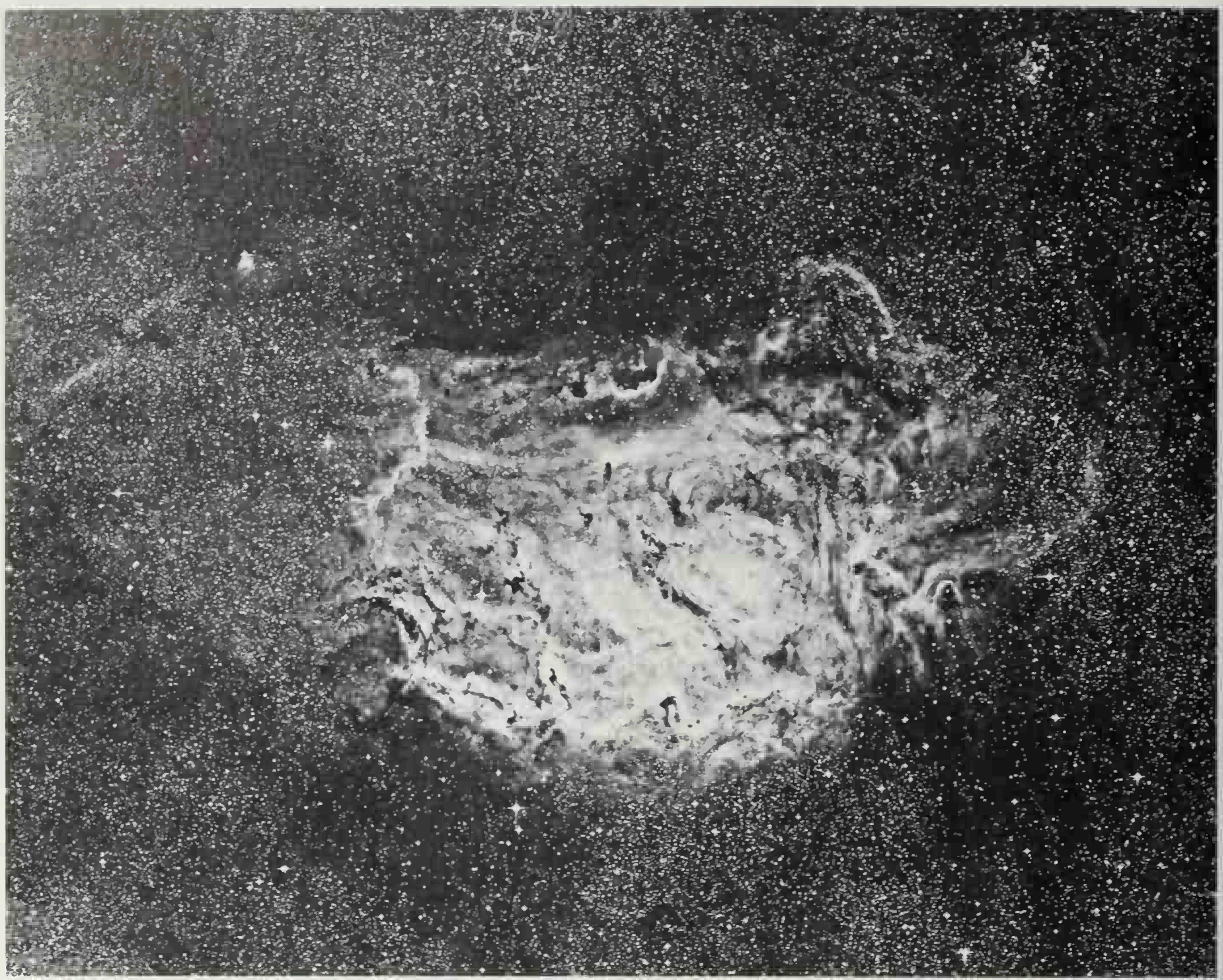
Right:
The Lagoon Nebula in Sagittarius, also shown in colour on page 167.

Opposite page: *The great Orion Nebula, photographed by the 1.2m UK Schmidt telescope in Australia. The vivid colours demonstrate the different processes at work: red from the bright Hα hydrogen emission line, and blue from reflection off dust grains in the nebula.*



The clouds of the Milky Way

Up until now, we have been concerned in the main with the stars of our Galaxy. However, in pursuing a policy of working from the oldest regions inwards, we have now reached a point where there are no stars: only gas, the precursor of stars. This gas is spread thinly throughout the Galaxy in the very innermost plane of the disc, averaging a density of only 1 atom per cm^3, but the distribution of the gas is by no means smooth. In places, it is clumped together in spectacular cloud complexes, where hot, glowing nebulae lit by young stars within contrast starkly with the dramatic, looming outlines of dark, obscuring material. In this section, we shall discuss these clouds and their structure before going on to consider the general nature of the interstellar medium.

Most obvious of all the cosmic clouds are the glowing nebulae. Our Galaxy contains hundreds, many known by fanciful names after the objects they resemble – the Rosette nebula, the Lagoon nebula, the North America nebula. The brightest were listed in Messier's 1784 catalogue of 'objects which could be confused with comets'; a list which also includes such other objects of fuzzy appearance as star clusters and other galaxies. The great Orion nebula, for example, is listed as object number 42 in Messier's catalogue: hence its designation M 42.

These bright clouds are huge regions of heated, ionized gas – gas at a temperature of 10^4 K, whose atoms have been split up into their constituent nuclei and electrons. Because most of the gas in these clouds is hydrogen, they are called **H II regions**, to denote that the hydrogen is in a singly ionized state: that is, with its one electron removed. H II regions are intimately associated with sites of star formation in the Galaxy. The source of their heating and ionization is the ultraviolet radiation from the hot, young OB stars embedded deep inside them. The small Trapezium star cluster, for example, supplies all the energy to ionize the great Orion Nebula, some 5 pc across (Fig. 6·6).

The size of an H II region depends on the density of the gas and the number of energetic young stars inside; the largest H II regions of all measure some 200 pc across. Most are roughly circular, and sharply defined against the sky by an abrupt boundary around their outer edge. This **ionization front** clearly indicates the limited ionizing range of the stars inside the nebula.

As would be expected, the spectral lines emitted by H II regions are those characteristic of a hot, low-density gas. Hydrogen lines of the **Balmer series** are strong, particularly the vivid pink Hα at 656·3 nm, which gives nebulae their distinctive coloration. The greenish tinge noticeable (especially optically) in some H II regions comes from a couple of oxygen [O III] lines at 495·9 and 500·7 nm – at first mis-identified as a new element and called 'nebulium'. These lines arise in what are termed 'forbidden transitions': transitions which would be impossible in the high densities of a terrestrial laboratory, but which occur freely in the near-vacuum of space. The observation of

A view of the Milky Way in the direction of the galactic centre in Sagittarius. Although the centre of our Galaxy is hidden from our view by interstellar dust, our line of sight traverses some of its densest regions when we look in this direction, giving the appearance of vast clouds of stars.