23 yr or much over 25 yr. A period of 24 yr has been adopted. Measurements of 52 McCormick plates are in agreement with this assumption.

The time-displacement relations are well represented by a Kepler motion with dynamical elements,

$$P = 24\text{yr}, \quad e = 0.6, \quad T = 1950.$$

The resulting geometric elements correspond to an amplitude of 2.1μ in right ascension and 0.9μ in declination. The resulting value for the semi-axis major of the observed orbit relative to the center of mass is $\alpha = 1.3 \mu = ".0245 = .045$ a.u., while the inclination is $i = \pm 77^\circ$. The probable errors of unit weight, derived from the 25 residuals each in right ascension and declination, amount to

$$\begin{aligned} \text{R.A. } \pm^{\text{mm}}00266 &= \pm ".050, \\ \text{Dec. } \pm^{\text{mm}}00232 &= \pm ".044. \end{aligned}$$

We have adopted a mass of $0.15 \odot$ for Barnard's star, which for a period of 24 yr, yields a semi-axis major of 4.42 a.u., or $2''.41$.

The relative apparent orbit is similar to the apparent orbit of Barnard's star (but differs 180° in phase). The apparent separation is over $2''$ from 1939 to 1946, and again from 1963 to 1970. The companion image should be clear of the image of Barnard's star, certainly on the Sproul plates taken over the interval 1937–1947, and again after 1961. An inspection of the best plates reveals no sign of any companion as indeed is to be expected because of the small mass indicated by the small amplitude of the perturbation.

Assuming, therefore, no blending effect of Barnard's star and its companion because of (1) wide separation and (2) low luminosity, we may write

$$\frac{m}{M} = \frac{\alpha}{a - \alpha} = 0.0103.$$

Hence, for $M = 0.15 \odot$, we find $m = .0015 \odot$ for the mass of Barnard's star B which, therefore, should be classified as a planet, 1.5 times as massive as Jupiter.

Photoelectric Spectrophotometry of Stars. SIDNEY VAN DEN BERGH, *David Dunlap Observatory*.—Spectral scans of over 100 high-velocity and low-velocity stars have been obtained with an effective resolution of $20 \text{ \AA}$. Two classification parameters are derived from the data. One of these is the size of the discontinuity in the stellar energy distribution near $4000 \text{ \AA}$. The size of this discontinuity is found to decrease with decreasing metal abundance. The other classification parameter is the ratio in intensity of the continuous spectrum on the two sides of $H\gamma$. The latter parameter is found to provide an ultrasensitive measure of the metal abundance in

G-type main sequence stars. Measurement of both parameters in reflected sunlight shows that the sun is a metal-rich star.

A Model for the Expansion of the Orion Nebula.

PETER O. VANDERVOORT, *Yerkes Observatory*.—A model for the expansion of the Orion Nebula has been constructed. It is assumed that before the stars in the Trapezium began to ionize and heat the nebula, the nebula consisted of a cloud of neutral gas which was at rest relative to the cluster with a distribution of density given by the isothermal function. The plausibility of these initial conditions is discussed. The gas in the nebula was ionized and heated when the stars in the Trapezium began to radiate in the Lyman continuum. It is assumed that the onset of the ionizing radiation occurred in an interval of time which can be neglected, and on this assumption, one finds that the interval of time in which the nebula became ionized is also negligible. Finally, it is assumed that in the heated gas the gradient of the pressure was large compared with all other forces.

For these initial conditions, the equations governing the isothermal expansion of the nebula have been integrated. The solution is presented as an evolutionary sequence of models in each of which the density and the velocity of expansion are given as functions of the radial distance. Each model in the sequence can be compared with published observational results concerning the distributions of density and velocity, and on the basis of these comparisons, the models which give the best representations of the present state of the nebula can be found. From the parameters characterizing the models which were selected in this way, it is estimated that the age of the Orion Nebula is of the order of 20 000 years.

The effects of turbulence, a magnetic field, and the finite time scale for the onset of the ionizing radiation will be discussed briefly.

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Neutral Hydrogen in the Orion Region. H. VAN WOERDEN, *Kapteyn Astronomical Laboratory, Groningen, Netherlands*.—With the Dwingeloo radio telescope (beamwidth $0^\circ.56$, bandwidth $10 \text{ kc/sec} = 2 \text{ km/sec}$), 21-cm line profiles have been obtained at 400 positions between $l^{\text{I}} = 170^\circ$ and 180° , $b^{\text{I}} = -9^\circ$ and -23° . The accuracy is 0.15 km/sec in velocity, 1°K in intensity, apart from predictable systematic errors due to stray radiation.

At the lower galactic longitudes, in a region of