clusters, and fields. The following are identified by NGC numbers: 1962-5-6-70, 1983, 1984, 1994, 2004, 2011, 2014, 2021, 2074, 2081, 2092, and 2100.

The color-magnitude arrays consist generally of a fairly unbroken vertical main sequence above which a few very luminous stars may be scattered, and, in most cases, of a group of red supergiants. Several of the very luminous blue stars are of type Be or Of. It may be noted that all the identified Wolf-Rayet stars are found at the upper end of the unbroken main sequence. This point has been tentatively identified as the turnoff point.

The interstellar reddening is moderate; the total absorption is generally below $A_V=1$ mag. If the fast evolution of these very young (ages between 3 and 10×10^6 years) and very massive stars is taken into consideration a good agreement is obtained between the observed distribution of stars and the initial luminosity function. The total masses of the clusters and associations appear to be of the same order of magnitude as those of the corresponding galactic objects.

The photometry is based on van Wijk's sequence as revised by P. F. and B. J. Bok and on a sequence established by Eggen and Sandage in Constellation III. Additional photoelectric observations have been carried out with the 30-inch reflector at Mt. Stromlo Observatory. The photographic material consists of plates taken with the 20/26-inch Schmidt telescope at Uppsala Southern Station and with the 74-inch telescope at Mt. Stromlo Observatory.

Astronomical Tests of an Imaging Photomultiplier. W. L. WILCOCK, *Imperial College, London, England*, AND W. A. BAUM, *Mount Wilson and Palomar Observatories, California*.—An imaging photomultiplier tube described by Wilcock, Emberson, and Weekley (*IRE Trans.* **NS-7**, 126–132, 1960) was used experimentally for astronomical observations at the Lowell Observatory in April, 1960. The tube has an antimony-cesium photocathode, five electron-multiplying dynodes, and a blue phosphor screen. The dynodes are extremely thin membranes of the type described by Sternglass (*Rev. Sci. Instr.* **26**, 1202, 1955). Primary electrons incident upon one face of a dynode membrane cause the emission of secondary electrons from the other face. A magnetic field serves to refocus the image from each dynode to the next.

The tube, mounted in a solenoid 19 inches long and 7 inches in diameter, was attached to the $f/16$ Cassegrainian focus of the 24-inch Morgan reflector, where the image scale was 21" per mm. Two 50-mm $f/2$ lenses front-to-front served to transfer the output images from the phosphor screen to photographic plates. The resolution was about 12 line pairs per mm over a total field of 1 cm.

Exposure times required to reach various threshold magnitudes in a field of faint stars in M3 were compared with the exposure for unaided photography. For short unsaturated exposures during mediocre "seeing" (star diameters $\sim 6''$), the speed gains of the tube at 25 and 30 kv were 10-fold and 90-fold, respectively. At 30 kv the ultimate limit was estimated to be about 1.5 mag. less faint than the theoretical limit for unaided photography. This difference suggests that the average number of blackened grains per photoelectron at 30 kv was about 8, an estimate which is not inconsistent with the degree of lumpiness observed in the 30-kv images.

The Bolometric Solar Constant Related to Radiation Pressure Effects on Satellites. RAYMOND H. WILSON, JR., *NASA Goddard Space Flight Center, Code 501.3, Washington 25, D. C.*—Radiation pressure on the 100-foot balloon satellite Echo I (1960 Iota I) has increased its orbital eccentricity from 0.01 to 0.06 in three months. In any precise discussion of this effect, such as has been given for Vanguard I (Musen, Bryant, and Bailie, *Science* **131**, 1935, 1960), the assumed pressure depends directly on the solar constant and related effective temperature. For the latter Wien's law gives 6150°K , implying local $T=419^\circ\text{K}$ at 1 a.u. on a perpendicular black plane (Wilson, *Science* **127**, 811, 1958), and for an isothermal sphere the radiation pressure is $aT^4/4=5.83 \times 10^{-5}$ dynes per cm^2 of cross section, where a is the energy density constant. The corresponding bolometric solar constant is 25% higher than the $2.0 \text{ cal/cm}^2/\text{min}$ assumed by Musen *et al.* However, since their Vanguard I calculations neglected pressure reduction by 20% shadowing and 2% reflected radiation from the earth, the higher solar constant seems equally compatible with the observations. The corresponding solar bolometric absolute magnitude would be brightened by 0.25 to +4.57. Thus Echo-type satellites having very large cross-section-to-mass ratios may serve from studies of their orbital perturbations as precise indicators of fundamental astrophysical constants.

The total pressure found for a black sphere can be shown to hold unchanged by specular reflection, since the integrated reflection from a hemisphere would produce zero resultant force. By similar reasoning the actual satellite temperature governing its reradiative rate will not, since such radiation is isotropic, affect the resultant force, provided the sphere is isothermal. However, nonuniformity of temperature due to spin-axis tilt and slow heat transfer could double the resultant pressure on a hot surface or halve it on a cool surface, the change depending on satellite temperatures. Likewise, it can be shown that for a fraction A of diffuse reflection the pressure would be multiplied by $(1+4A/9)$.

Atmospheric Drag on Artificial Satellites.

PEDRO E. ZADUNAISKY, *Smithsonian Astrophysical Observatory, Cambridge, Massachusetts*.—The rate of decrease of the anomalistic period P of an artificial satellite caused by atmospheric drag can be expressed in the form $dP/dt = -3C_D(S/m)aF(e,\rho)$ where C_D = drag coefficient, S = effective cross section of the satellite's mass of the satellite, a = semimajor axis of satellite's orbit, e = orbital eccentricity and ρ = atmospheric density. The function $F(e,\rho)$ is a certain integral computed along a complete revolution of the satellite on its orbit. To evaluate such an integral it is usually assumed that ρ can be expressed by $\rho = \rho_0 \exp(-Z/H)$ where ρ_0 is the atmospheric density at perigee, Z is the height above perigee and H is the density scale-height. The expression given above can then be used to derive the atmospheric density at perigee, when dP/dt is known, or vice versa, provided that, besides the orbital elements of the satel-

lite, sufficiently accurate values of C_D , S/m , and H are determined or assumed in advance.

According to recent results C_D should depend on the height of the satellite and its shape; if the satellite is nonspherical the value of S depends on the way the satellite tumbles; finally the scale height H experiences variations due to the solar activity through a mechanism which is far from being well known.

In this paper an attempt is made to build up an internally consistent picture of the variation of all these quantities by using orbital data from several satellites simultaneously and covering a period of time of several months. For a correct intercomparison of these data the diurnal effect of solar activity is removed, by assuming a suitable model of the earth's atmosphere.

Some results have been obtained which show a reasonable agreement with experimental evidence drawn from sources not directly related to the drag phenomena.