supply is not regulated. The oscillator, multi-vibrator, and amplifier tubes are all standard radio receiving set types and brands. This clock has been run without stopping since September, 1943, and without adjustment since December, 1943. Its daily rate changed ± 0.002 per day in the period December, 1943, to April, 1944, probably due to aging of the new crystal. Another total change of about ± 0.10 during December, 1944, to March, 1945, perhaps is associated with age of electrical components (the tubes). From April to December, 1944, it ran with an average daily fluctuation of daily rate of less than ± 0.001 , as indicated by time sights. This precision is higher than that of the best Shortt clock at the Observatory.

U. S. Naval Observatory,
Washington, D. C.

Sterne, Theodore E. The accuracy of numerical solutions of differential equations.

In step-by-step numerical integrations of ordinary differential equations random error accumulates through the rounding off of decimals, and systematic error through the employment of only a finite number of difference terms. Some instances of such equations occur in special perturbations, where Brouwer has determined the accumulation of random error, and in theoretical studies of stellar interiors. Both sorts of accumulation may be evaluated numerically, in any ordinary differential equation or system of such equations, by a general method. Variational equations are formed, and the properties are then employed of solutions of the system of equations adjoint to the variational equations. The standard deviation, due to random errors, may be obtained of the variables and of functions of them at the end of the integration. Covariances can be computed also. The accumulated systematic error, from neglected difference terms, can be approximated closely.

Ballistic Research Laboratory,
Aberdeen Proving Ground, Md.

Stewart, John Q. Successful result of a prediction of sunspots.

In papers published in the *Astrophysical Journal* a thorough description was given of methods of representing Wolf numbers for each 11-year cycle or "outburst" of sunspots by a curve of the form Ft^ae^{-bt} , the time t being counted from the assumed epoch of the beginning of the particular outburst. A prediction of the course of the latter

half of cycle 17 was published in a paper by the author and F. C. Eggleston.¹ It is now evident that the prediction was successful within about the expected tolerance. The predicted annual numbers for 1939, 1940, 1941, 1942, 1943, 1944, respectively, were 87, 61, 38, 22, 12, 6. The corresponding observed numbers were 89, 68, 47, 30, 16, 6, the last being for 9 months. An even better result would have been obtained if the parameters of the predicted curve had been adjusted so as to give a somewhat more rapid decrease after maximum. When the residuals of monthly numbers, P-O, are examined, they are found to have a pronounced oscillatory character.

1. *Phys. Rev.* **55**, 1102, 1939; *Publ. A. S. P.* **52**, 379, 1940.

Princeton University Observatory,
Princeton, N. J.

Swann, W. F. Photographic plates for use in astronomical research.

Several minor changes have been made in Eastman Spectroscopic Plates within the past year. Some of these changes have been in the emulsion types, others have been in the sensitizings. Although it is not possible to pick up these changes without careful examination, the quality of the plates has been improved.

An experimental Type I emulsion is now available. This emulsion has higher sensitivity than the present 103 type with slightly coarser granularity. The reciprocity failure is fair but is not as good as the temporarily discontinued spectroscopic emulsion Type 1a. These plates may prove, however, to be very useful where high sensitivity is required and granularity is not of great importance.

The IIa-O Spectroscopic Plate is still proving to be an excellent plate for use where long exposures are required. It has no advantage over the regular Type II-O for short exposures. The 103a emulsion has also been improved and is the fastest emulsion available at the present time for long exposures. This emulsion is susceptible to high temperatures and plates should be stored in refrigeration if they are to be kept for any period of time.

Minor changes have been made in some of the infrared types such as the I-N and I-K. The sensitivity of the I-Z plate has been increased about five times. This increase in sensitivity is gained, however, only by very careful hypersensitization. The most important step in hypersensitization is drying after the ammonia treat-